

WBSA

Physical Environment Monitor System

R. Weiss, July 21, 1994

Purpose of Document: Provide basis for assumptions and explanatory notes to accompany WBS cost estimate. Parts could be incorporated in WBS dictionary if appropriate.

Name of subsystem: It has been suggested that the name of the subsystem be changed, a list of alternatives:

Non-Gaussian Noise Detection and Diagnostic System (NGNDDS)

Disturbance Veto and Diagnostic System (DVDS)

Disturbance Sensing and Diagnostic System (DSDS)

Of the above, the first is most accurate but also a mouthful.

Scientific Rationale: The Physical Environment Monitor System is designed to carry out several functions:

1. To monitor and record the time and amplitude of disturbances in the physical environment of the interferometers that could produce spurious signals in the gravitational wave record. The primary use of the data is as a veto in the data analysis of the gravitational wave record from one site to reduce the number of candidate events in subsequent coincidence analysis between records from interferometers at different sites.

2. To aid future interferometer subsystem development by determining sensitivities to external disturbances.

3. To set limits on or measure the correlation of disturbances in the environment at separated sites.

4. To be able to provide continuous environmental disturbance records for direct correlation with the gravity wave record in specialized gravitational wave searches such as those for periodic sources and stochastic backgrounds.

5. To provide diagnostic information on the performance of the interferometers and the LIGO facilities.

Functional Requirements: The environmental parameters to be measured, the sensitivity, dynamic range, bandwidth, digital data rate, location and number of instruments.

Seismic Noise:

Low Frequency $0.1 \leq f \leq 10$ Hz

3 axis seismometer; sensitivity: $z(f) \leq \frac{10^{-10}}{f^2}$ m/ $\sqrt{\text{Hz}}$; dynamic range: 100db; bandwidth: 10 Hz; digital data rate: 60 16 bit words/sec. One per building.

2 axis tilt meter; sensitivity: $\theta(f) \leq \frac{2 \times 10^{-9}}{f^2}$ radians/ $\sqrt{\text{Hz}}$; dynamic range: 100db; bandwidth: 10 Hz; digital data rate: 40 16 bit words/sec. One per building.

High Frequency $10 \leq f \leq 1000$ Hz

3 axis PZT accelerometer; sensitivity: $z(f) \leq \frac{10^{-8}}{f^2}$ m/ $\sqrt{\text{Hz}}$; dynamic range: 100db; bandwidth: 1 kHz; digital data rate: 6000 16 bit words/sec. 3 accelerometers/tank, 4 accelerometers/2km beam tube module.

Acoustic noise:

Electret Microphone; sensitivity: $P(f) \leq 10^{-3}$ dynes/cm²/ $\sqrt{\text{Hz}}$; dynamic range: 60db; bandwidth: 1 kHz; digital data rate: 2000 10 bit words/sec. 1 microphone/tank.

Magnetic fields:

3 axis flux gate magnetometer; sensitivity: $B(f) \leq 2 \times 10^{-5}$ gauss/ $\sqrt{\text{Hz}}$; dynamic range: 100db; bandwidth: 1 kHz; digital data rate: 6000 16 bit words/sec. 1 magnetometer/tank.

Radio frequency interference:

Multichannel Receiver: sensitivity: $E \leq 3\mu$ volt/cm; dynamic range: 120 db; overall bandwidth: 1300 MHz; peak detection in 6 bands with millisecond timing; digital data rate: 1000 10 bit words/sec on threshold crossing. 1 receiver/antenna system/building.

Cosmic ray muons:

Scintillation counter; sensitivity: $F(\geq 100\text{Mev}) \leq 10^{-2}$ muons/sec/cm²; dynamic range: 60db; timing resolution: 1 millisecond; digital data rate: 1000 10 bit words/sec on threshold crossing. 1 detector system/building.

Power line fluctuations;

Power line monitor; sensitivity: fractional fluctuations in voltage; long period $\leq .02$, minutes; $\leq .001$, 1 sec to 1 millisecond; harmonic content, $\leq .05$ for line harmonics to 2 KHz; dynamic range: 60db, digital data rate: 1000 10 bit words/sec and increased rate on threshold crossing. 1 detector system/building ?

Residual gas monitor:

Residual gas analyser; sensitivity: partial pressure $\leq 10^{-14}$ torr 1 - 300 amu; dynamic range: 10^9 ; timing resolution on a single mass number: ≤ 10 millisecond; digital data rate: 100 16 bit words/sec under quiescent conditions, 1000 16 bit words/sec on threshold crossing. 1 detector/building and 1 detector/km of beamtube. NOTE: The scientific vacuum instrumentation was included in the 1989 WBS under 2532, 2533, 3532, 3533.

Vacuum contamination monitor:

Crystal deposition monitor and residual gas analyser; Capability to measure deposition of hydrocarbons at the level of a monolayer/week or smaller. Analytic capability provided by: 1) evaporation of adsorbed layer vs temperature of crystal oscillator sample collector, 2) assay of evaporated layer by residual gas analyser with 1 - 300 amu range. Costs presented are an educated place holder, the contamination monitor system needs better definition. Estimate assumes a sampling head/tank and an RGA head/tank. Costing assumes 1 crystal control and RGA control/ building. NOTE: The instrumentation to monitor contamination was included in the 1989 WBS under 2532, 2533, 3532, 3533.

Suggested additional monitors not included in cost estimate

Optical beamtube residual gas monitor:

Molecular resonance absorption monitor; Provision should be made for the system by including 4 inch vacuum ports for windows at both ends of each of the 4 km beamtubes with an unobstructed path through the clear aperture (position in the aperture is not critical). The concept of the scheme is similar to the UV absorption monitor discussed in the 1989 LIGO proposal and is molecule specific. The new element is the use of pulsed lasers and multiple reflection ringdown to enable gas absorption measurements of $\alpha \leq 10^{-8} \text{ cm}^{-1}$ even with noisy lasers. The technique was described at the NIST conference on water in vacuum systems in June 1994 (Romanini, D and Lehmann, K.K Journal of Chemical Physics (1993), 99 p 6287).

Stray light monitor:

Photomultiplier monitors; Photomultipliers with interference filters to transmit the laser wavelength are placed on 3 inch viewports to view the beamtube wall at 2km intervals along the beamtube (3 sensors/leg). The sensors need only DC response and should not require chopping other than the amplitude change that occurs on a laser dropout or cavity lock loss. The monitor provides information on the mirror scattering and beam tube optical properties.

Monitors assumed to be included in the cost of the facilities

Facility Housekeeping Data

Thermometers at the tanks; sensitivity: $\pm 1 \text{ C}$, sample/min

Thermometers on the beamtube at 250 meter interval; sensitivity: $\pm 1 \text{ C}$, sample/min

Relative humidity in the buildings; sensitivity: $\pm 10\%$, sample/hour

Outside wind speed at the buildings; sensitivity: $\pm 1 \text{ mph}$, sample/min

Outside wind direction at the buildings; sensitivity: $\pm 5 \text{ degrees}$, sample/min

LIGO - DATA INPUT FORM

22-Jul-94

WBS NO. 1.2.3.2

TITLE: Auxiliary physics monitor, WA fabrication phase

ESTIMATOR: Weiss

DESCRIPTION:

COMMENT:

BOE: (EE - Engineering/Bottom Up/Parametric, VQ - Vendor Quotation, PO - Place Order, AC - Actual Costs)

NOTE: All Cost are in 1994 Dollars and are to be inputted in K\$.

IN-HOUSE LABOR		BOE	Unit of Measure	1992 QTY	1993 QTY	1994 QTY	1995 QTY	1996 QTY	1997 QTY	1998 QTY	1999 QTY	2000 QTY	Total
Scientist	EE		Manmonth				1						1
Engineer	EE		Manmonth				2						2
Technician	EE		Manmonth				3						3
Grad Student			Manmonth										0
Undergrad Student			Manmonth										0
Management Staff			Manmonth										0
Admin. Support			Manmonth										0
Consultants - K\$			Total Cost										0
Travel - K\$			Total Cost										0

MATERIAL DESCRIPTION	BOE	Unit Cost	Unit of Measure	1992 QTY	1993 QTY	1994 QTY	1995 QTY	1996 QTY	1997 QTY	1998 QTY	1999 QTY	2000 QTY	Total
seismometer	VQ	17.7					5						88.5
tiltmeter	VQ	13.4					5						67
accel/rotation	VQ	9.3				30							279
acoustic	EE	0.3				14							4.2
magnetic	VQ	3.2				14							44.8
RFI	VQ	34.2				5							171
muon	VQ	9				5							45
line/power	VQ	12.2				5							
residual gas	VQ	42.4				13							
contamination controller	EE	51.8				5							
contamination head	EE	16				14							
													0
CONTRACTS DESCRIPTION	BOE	Unit Cost	Unit of Measure	1992 QTY	1993 QTY	1994 QTY	1995 QTY	1996 QTY	1997 QTY	1998 QTY	1999 QTY	2000 QTY	Total
													0
													0
													0
													0
													0
													0
													0
													0
													0

1794.7

LIGO - DATA INPUT FORM

22-Jul-94

WBS NO. 1.2.3.3

TITLE: Auxiliary physics monitor, LA fabrication phase

ESTIMATOR: Weiss

DESCRIPTION:

COMMENT:

BOE: (EE - Engineering/Bottom Up/Parametric, VQ - Vendor Quotation, PO - Place Order, AC - Actual Costs)

NOTE: All Cost are in 1994 Dollars and are to be inputted in K\$.

IN-HOUSE LABOR		BOE	Unit of Measure	1992 QTY	1993 QTY	1994 QTY	1995 QTY	1996 QTY	1997 QTY	1998 QTY	1999 QTY	2000 QTY	Total	
Scientist	EE		Manmonth			1							1	
Engineer	EE		Manmonth			2							2	
Technician	EE		Manmonth			3							3	
Grad Student			Manmonth										0	
Undergrad Student			Manmonth										0	
Management Staff			Manmonth										0	
Admin. Support			Manmonth										0	
Consultants - K\$			Total Cost										0	
Travel - K\$			Total Cost										0	
MATERIAL DESCRIPTION		BOE	Unit Cost	Unit of Measure	1992 QTY	1993 QTY	1994 QTY	1995 QTY	1996 QTY	1997 QTY	1998 QTY	1999 QTY	2000 QTY	Total
seismometer	VQ		17.7				3							0
tiltmeter	VQ		13.4				3							53.1
accel/rotation	VQ		9.3				23							40.2
acoustic	EE		0.3				7							213.9
magnetic	VQ		3.2				7							2.1
RFI	VQ		34.2				3							22.4
muon	VQ		9				3							102.6
line/power	VQ		12.2				3							27
residual gas	VQ		42.4				11	466!						
contamination controller	EE		51.8				3							
contamination head	EE		16				7							
													0	
CONTRACTS DESCRIPTION		BOE	Unit Cost	Unit of Measure	1992 QTY	1993 QTY	1994 QTY	1995 QTY	1996 QTY	1997 QTY	1998 QTY	1999 QTY	2000 QTY	Total
													0	
													0	
													0	
													0	
													0	
													0	
													0	
													0	
													0	
													0	

018.7
1231.7

excludes ~~PS~~ DR conditioning / sampling!

BATCH
START

STAPLE
OR
DIVIDER

file:rwweavogt081794.txt
to: Bill Althouse and Robbie Vogt
from: R. Weiss August 17, 1994
concerning: Revised files for environmental monitor

I have put a revised set of files concerning the environmental monitor system on the LIGO Sun ~~system~~ in the *directory*

~weiss/ligocost94a

The files are:

envl.tex	Tex file containing functional requirements of monitor
envirmoncosta.txt	text file containing equipment, manpower, travel breakdowns used in the estimation for the three phases of the project
rwphymon-design.wk3	Lotus file for the design
rwphymon-fab-wa.wk3	Lotus file for the fabrication for wa site
rwphymon-fab-la.wk3	Lotus file for the fabrication for la site
rwphymon-skdn.wk3	Lotus file for the installation and shakedown both sites combined
rwphysmon-costrev.wk3	Lotus file designed by Shoemaker to give overall costs for subsystem

The Lotus files have been corrected for the error in the number of PZT accelerometers. Travel has been included in the installation and shakedown phase. The description has been simplified to make a single PZT accelerometer the unit rather than the three axis system as was done in the prior estimation.

Physical Environment Monitor System

R. Weiss, July 21, 1994, modified August 16, 1994

Purpose of Document: Provide basis for assumptions and explanatory notes to accompany WBS cost estimate. Parts could be incorporated in WBS dictionary and Baseline 1 document as appropriate.

Name of subsystem: It has been suggested that the name of the subsystem be changed, a list of alternatives:

Non-Gaussian Noise Detection and Diagnostic System (NGNDDS)

Disturbance Veto and Diagnostic System (DVDS)

Disturbance Sensing and Diagnostic System (DSDS)

Of the above, the first is most accurate but also a mouthful.

Scientific Rationale: The Physical Environment Monitor System is designed to carry out several functions:

1. To monitor and record the time and amplitude of disturbances in the physical environment of the interferometers that could produce spurious signals in the gravitational wave record. The primary use of the data is as a veto in the data analysis of the gravitational wave record from one site to reduce the number of candidate events in subsequent coincidence analysis between records from interferometers at different sites.

2. To aid future interferometer subsystem development by determining sensitivities to external disturbances.

3. To set limits on or measure the correlation of disturbances in the environment at separated sites.

4. To be able to provide continuous environmental disturbance records for direct correlation with the gravity wave record in specialized gravitational wave searches such as those for periodic sources and stochastic backgrounds.

5. To provide diagnostic information on the performance of the interferometers and the LIGO facilities.

Functional Requirements: The environmental parameters to be measured, the sensitivity, dynamic range, bandwidth, digital data rate, location and number of instruments.

Seismic Noise:

Low Frequency $0.1 \leq f \leq 10$ Hz

3 axis seismometer; sensitivity: $z(f) \leq \frac{10^{-10}}{f^2}$ m/ $\sqrt{\text{Hz}}$; dynamic range: 100db; bandwidth: 10 Hz; digital data rate: 60 16 bit words/sec. One per building.

2 axis tilt meter; sensitivity: $\theta(f) \leq \frac{2 \times 10^{-9}}{f^2}$ radians/ $\sqrt{\text{Hz}}$; dynamic range: 100db; bandwidth: 10 Hz; digital data rate: 40 16 bit words/sec. One per building.

High Frequency $10 \leq f \leq 1000 \text{ Hz}$

1 axis PZT accelerometer; sensitivity: $z(f) \leq \frac{10^{-8}}{f^2} \text{ m}/\sqrt{\text{Hz}}$; dynamic range: 100db; bandwidth: 1 kHz; digital data rate: 2000 16 bit words/sec. 3 accelerometers mounted on a single block to measure 3 degrees of translation, 3 x 3 accelerometers/tank to measure translation and rotation, 3 x 4 accelerometers/2km beam tube module to measure translation.

Acoustic noise:

Electret Microphone; sensitivity: $P(f) \leq 10^{-3} \text{ dynes/cm}^2/\sqrt{\text{Hz}}$; dynamic range: 60db; bandwidth: 1 kHz; digital data rate: 2000 10 bit words/sec. 1 microphone/tank.

Magnetic fields:

3 axis flux gate magnetometer; sensitivity: $B(f) \leq 2 \times 10^{-5} \text{ gauss}/\sqrt{\text{Hz}}$; dynamic range: 100db; bandwidth: 1 kHz; digital data rate: 6000 16 bit words/sec. 1 magnetometer/tank.

Radio frequency interference:

Multichannel Receiver; sensitivity: $E \leq 3\mu \text{ volt/cm}$; dynamic range: 120 db; overall bandwidth: 1300 MHz; peak detection in 6 bands with millisecond timing; digital data rate: 1000 10 bit words/sec on threshold crossing. 1 receiver/antenna system/building.

Cosmic ray muons:

Scintillation counter; sensitivity: $F(\geq 100 \text{ Mev}) \leq 10^{-2} \text{ muons/sec/cm}^2$; dynamic range: 60db; timing resolution: 1 millisecond; digital data rate: 1000 10 bit words/sec on threshold crossing. 1 detector system/building.

Power line fluctuations;

Power line monitor; sensitivity: fractional fluctuations in voltage; long period $\leq .02$, minutes; $\leq .001$, 1 sec to 1 millisecond; harmonic content, $\leq .05$ for line harmonics to 2 KHz; dynamic range: 60db, digital data rate: 1000 10 bit words/sec and increased rate on threshold crossing. 1 detector system/building

Residual gas monitor:

Residual gas analyser; sensitivity: partial pressure $\leq 10^{-14}$ torr 1 - 300 amu; dynamic range: 10^9 ; timing resolution on a single mass number: ≤ 10 millisecond; digital data rate: 100 16 bit words/sec under quiescent conditions, 1000 16 bit words/sec on threshold crossing. 1 detector/building and 1 detector/km of beamtube. **NOTE: The scientific vacuum instrumentation was included in the 1989 WBS under 2532, 2533, 3532, 3533.**

Vacuum contamination monitor:

Crystal deposition monitor and residual gas analyser; Capability to measure deposition of hydrocarbons at the level of a monolayer/week or smaller. Analytic capability provided by: 1) evaporation of adsorbed layer vs temperature of crystal oscillator sample collector, 2) assay of evaporated layer by residual gas analyser with 1 - 300 amu range. Costs presented

are an educated place holder, the contamination monitor system needs better definition. Estimate assumes a sampling head/tank and an RGA head/tank . Costing assumes 1 crystal control and RGA control/ building. **NOTE: The instrumentation to monitor contamination was included in the 1989 WBS under 2532, 2533, 3532, 3533.**

Suggested additional monitors not included in cost estimate

Optical beamtube residual gas monitor:

Molecular resonance absorption monitor; Provision should be made for the system by including 4 inch vacuum ports for windows at both ends of each of the 4 km beamtubes with an unobstructed path through the clear aperture (position in the aperture is not critical). The concept of the scheme is similar to the UV absorption monitor discussed in the 1989 LIGO proposal and is molecule specific. The new element is the use of pulsed lasers and multiple reflection ringdown to enable gas absorption measurements of $\alpha \leq 10^{-8} \text{ cm}^{-1}$ even with noisy lasers. The technique was described at the NIST conference on water in vacuum systems in June 1994 (Romanini, D and Lehmann, K.K Journal of Chemical Physics (1993), 99 p 6287).

Stray light monitor:

Photomultiplier monitors; Photomultipliers with interference filters to transmit the laser wavelength are placed on 3 inch viewports to view the beamtube wall at 2km intervals along the beamtube (3 sensors/leg). The sensors need only DC response and should not require chopping other than the amplitude change that occurs on a laser dropout or cavity lock loss. The monitor provides information on the mirror scattering and beam tube optical properties.

Monitors assumed to be included in the cost of the facilities

Facility Housekeeping Data

Thermometers at the tanks; sensitivity: $\pm 1 \text{ C}$, sample/min

Thermometers on the beamtube at 250 meter interval; sensitivity: $\pm 1 \text{ C}$, sample/min

Relative humidity in the buildings; sensitivity: $\pm 10\%$, sample/hour

Outside wind speed at the buildings; sensitivity: $\pm 1 \text{ mph}$, sample/min

Outside wind direction at the buildings; sensitivity: $\pm 5 \text{ degrees}$, sample/min

PHYSICS MONITORING SYSTEM

WBS 1.2.3

Cost:

	cost	% cont.	cont.	total
Design				
	\$ 338K	5%	\$ 17K	\$ 355K
Fab				
WA	\$ 1642K	5%	\$ 82K	\$ 1724K
LA	\$ 1114K	5%	\$ 56K	\$ 1169K
TOTAL	\$ 3093K	5%	\$ 155K	\$ 3248K

Function:

Measure time and amplitude of disturbances in the physical environment of the interferometers.

- Veto in burst detection to reduce non-Gaussian noise
- Correlation in periodic and stochastic source detection
- Determine sensitivity to environment for interferometer development
- Provide diagnostic information on interferometer and facility performance
- Measure or set limits on correlation of environmental noise at separated sites

Instruments and requirements:

Seismic noise

3 axis seismometer	10^{-10} m	@ 1Hz	1/bldg
2 axis tiltmeter	10^{-9} rad	@ 1Hz	1/bldg
1 axis accelerometer	10^{-11} m	@ 100Hz	9/tank
1 axis accelerometer	10^{-11} m	@ 100Hz	12/tube module

Acoustic noise

Electret microphone	10^{-8} atm	@ 100Hz	1/tank
---------------------	---------------	---------	--------

Magnetic fields

3 axis magnetometer	10^{-4} gauss	@ 100Hz	1/tank
---------------------	-----------------	---------	--------

Radio Interference

Multichannel receiver	$3\mu\text{volt/cm}$	6 chan	1/bldg
-----------------------	----------------------	--------	--------

Cosmic ray muons

Scintillation detector	10^{-2} $\mu/\text{sec cm}^2$	≤ 100 Mev	1/bldg
------------------------	---------------------------------	----------------	--------

Power line fluct.

Line monitor	10^{-3}	$\geq 10^{-3}$ sec	1/bldg
--------------	-----------	--------------------	--------

Residual gas

Residual gas analyser	$\leq 10^{-14}$ torr	1 - 300 amu	1/bldg
Residual gas analyser	$\leq 10^{-14}$ torr	1 - 300 amu	2/tube module

Contamination

Crystal monitor head	monolayer/week		1/tank
RGA head	$\leq 10^{-14}$ torr	1 - 300 amu	1/tank
Control			1/bldg

DESIGN (1997)

WBS: 1.2.3.1

Tasks:

- **Final definition of system requirements**
- **Define system interface to CDS**
- **Define test program and software algorithm development**
- **System documentation**
- **Test of contamination monitor**

FABRICATION (1998)

WBS: 1.2.3.2, 1.2.3.3

Tasks:

- Instrument procurement
- Fabricate specialized fixtures for facility installation
- Test some of the instruments (Q&A)
- Develop operating software and documentation
- Design facility installation schedule and test program

file:rwvolker072394.txt

to: Volker Schmidt

from: R. Weiss July 23, 1994

concerning: Estimated data rates from Environmental Monitoring System

Data rate estimates

Measurement	bytes/sec	#/wa	#/la	bytes/sec total wa	bytes/sec total la
<hr/>					
Seismic Noise:		14	7		
		5	3		
3 axis seismo	120	5	3	0.6K	0.3K
2 axis tilt	80	5	3	0.4	0.3K
3 axis accelerometers	12K	58	37	696K	444K
<hr/>					
Acoustic Noise:					
Electret microphones	4K	14	7	56K	28K
<hr/>					
Magnetic Fields:					
3 axis magnetometer	12K	14	7	168K	84K
<hr/>					
Radio Frequency Interfer.					
Multichannel receiver	2K	5	3	10K	6K
<hr/>					
Cosmic ray muons					
Scintillation counter	2K	5	3	10K	6K
<hr/>					
Power line fluctuations					
Power line monitor	2K	5	3	10K	6K
<hr/>					
Residual gas monitor					
Residual gas analyser	2K	13	11	26K	22K
<hr/>					
Contamination Monitor					
xtal and rga	3K	5	3	15K	9K
<hr/>					
Facility Housekeeping					
tank thermometers					
beamtube thermometers					
relative humidity					
wind speed					
wind direction					

TOTAL (raw without thresholding) 992K 606K

P2T ACCURACIOUS

3x3 = 9/TANK

3x4 x 4 = 48/TOTAL

SPACED AT 500 meters

WA	LA
126	63
48	48

TANKS FOLLOW

RGA FOR RESIDUAL GAS

1/BLOG

1/1km

WA	LA
8	8
40	3
13	11

RGA FOR CONTAM MON

1/BLOG

5

3

file:envirmoncosta.txt

from: R W em 7/26/94 modified 8/16/94

WBS No 1.2.3.1

Design Phase

Equipment Cost

Crystal monitor: (EE)

Crystal oscillator	\$559	
Sensor head	\$1830	
Shutter assembly	\$800	
Feedthrough	\$605	
Total crystal head assembly		\$3794
Computer interface	\$800	
Control circuit	\$8443	
Total electronics		\$9243
Total Crystal monitor		\$13037

RGA: (VQ)

Balzers

Control and rga head		
BKM18111 QMG421-3	\$35143	
ion counter preamp CP400	\$1709	
ion counter board IC421	\$3088	
network server		
BN882086-T	\$2573	
Total rga system		\$42153

Vacuum system (EE)

Test chamber and stand	\$2000	
100 l/s turbopump and cont.	\$2000	
inline LN2 trap	\$600	
Foreline purge system	\$300	
Pirani gauge and control	\$400	
Penning gauge and control	\$800	
Flanges	\$400	
4"gate valve	\$1100	
Forepump	\$500	
Bake heaters and control	\$300	
Shop time 20hr@\$40/hr	\$800	
Total vacuum system		\$9200

Total contamination monitor for design phase \$64390

Manpower Estimate and Functions

WBS No 1.2.3.1

Design phase

Scientist:

Functions	time man/months
reanalysis of project needs	
conceptualization of how data is to be used	
conceptualization of algorithms	
definition of system requirements	
definition and design of instrument test program	
scientific documentation	6
contamination monitor design	
contamination monitor research and testing	6

Engineer:

vendor interaction	
costing	
facility and CDS interface	
configuration control documentation	6
contamination monitor design and fabrication	3

Technician:

assembly of contamination monitor	
operation of contamination monitor	6

 WBS No 1.2.3.2 and WBS No 1.2.3.3
 Fabrication phase (assigned equally to the two sites)

Equipment Costs

	Total with a/d	Total without a/d
3 axis seismometer:		
Digital Technology Associates Concord, CA		
Seismometer GURALP CMG3T	\$13104	
adapt for 12v operation	\$ 336	
Digitizer DM16/3	\$4256	
	\$17696	\$13440

2 axis tiltmeter		
Applied Geomechanics Santa Cruz, Ca		
Tilt meter Model 520	\$9176	
Digitizer DM16/3	\$4256	
	\$13432	\$9176

1 axis PZT accelerometer		
Endevco San Juan Capistrano, CA		
Single acc 7754-1000	\$845/channel	
Signal conditioner 9 channels 2793	\$121/channel	
Machining costs/mounting block	\$33/ axis	

Analog/digital conversion \$40/ axis
 \$1039 \$999

Electret Microphone
 Tandy Corp

Microphone \$12
 Preamplifier \$100
 Machining mount \$30
 Analog/Digital conversion \$120

\$262 \$142

3 axis magnetometer

Bartington Mag 03MC \$2250
 Power supply \$500
 Machining mount \$30
 Analog/digital conversion \$360

\$3140 \$2780

Radio Freq interference
 Hewlett Packard

Receiver HP 8902A \$29450
 Antenna HP 11966A \$2535
 Antenna HP 11966B \$2535

\$34,220 \$34,220

Muon detector
 Rexon Components
 Beachwood, Ohio

Scintillator and PM tube RP-110 \$2213

EGG/Ortec

PM tube base and preamp EGG 276 \$405
 High Voltage supply EGG 5564 \$1540
 Nimbin EGG 4001A \$1224
 Constant Fraction Disc EGG 584 \$1126
 Pulse Amplifier EGG 575A \$691
 Ratemeter EGG 541 \$671
 Counter EGG 770 \$1093

\$8963 \$8963

Line monitor
 BMI
 Foster City, CA

Powerscope 8800 \$12230

\$12230 \$12230

Vacuum contamination
 Leybolt (Estimated)

Crystal oscillator \$559
 Sensor head \$1830
 Shutter assembly \$800
 Feedthrough \$605

Crystal head	\$3794	
Computer interface	\$800	
Control	\$8443	
	\$9243	\$8443

Residual Gas Analyser
Balzers

RGA head QMA 430	\$12153	
RGA control BKM18111	\$35143	
QMG421-3		

ion counter preamp CP400	\$1709	
ioncounter board IC421	\$3088	
network server BN882086-T	\$2573	

SUUMARY

sensor head and rga head	\$15947	\$15947
control electronics	\$51756	\$48383

Residual gas analyser
Balzers

RGA BKM18111		
QMG421-3	\$35143	
ion counter preamp CP400	\$1709	
ion counter board IC421	\$3088	
network server BN882086-T	\$2573	
	\$42153	\$39580

Manpower estimates and function

Scientist:

scientific qualification, calibration and testing
interact with CDS hardware/software development
design facility installation and shakedown test program
scientific documentation for facility 2

Engineer:

procurement
design in-house fabricated fixtures
track vendors
quality assurance
coordinate assembly
CDS interface
manage test program
establish facility installation schedule
interface documentation 4

Technician:

assemble instruments for test and calibration
run tests
prepare instruments for shipment to sites 6

WBS No 2.2.3

Installation and shakedown

Manpower estimates and functions

Assume an all hands on deck situation with a 65% to 35% split between the WA and LA site. Assume WA site is first. Assume a total manpower load of 12 months each for scientist, engineer and technician.

Range of tasks:

- installation of the equipment
- connection to the CDS system
- self tests and in-situ recalibration of the individual instruments
- compatibility/interaction tests with other equipment in the facility
- live tests of instruments through CDS hardware and software
- test of data archiving and retrieval
- test of software--diagnostic and operations programs
- determination of trends, dynamic range and signal statistics

Travel

2 trips of 2 month duration @ \$7300/man trip 3 people \$44K

file: rwvolker090794.txt
 to: Volker Schmidt
 from: R. Weiss September 7, 1994
 concerning: Counting of channels for environmental monitor system

Volker,
 I get the same numbers I had before.

PZT accelerometers

NOTE: Bill asked me to change the format so that each axis is counted as a PZT accelerometer. What used to be a single three axis accelerometer is now 3 single axis accelerometers mounted on a single block.

PZT accelerometers

The counting rules are

3 x 3 = 9 single axis accelerometers/tank

3 x 4 = 12 single axis accelerometers per 2km section of beam tube
 This means that there are accelerometer cube blocks each containing 3 accelerometers spaced at 500 meter intervals along the beam tube (every second pump port, ie 250, 750, 1250, 1750, 2250, 2750, 3250, 3750 m)

There are then 48 single axis PZT accelerometers on the beam tube at WA and 48 on the beam tube at LA

The number of tanks (HAM are taken as aggregate when distant from a main chamber) 14 at WA and 7 at LA

So the total number of single axis accelerometers is

At WA

48 + 14 * 9 = 174

At LA

48 + 7 * 9 = 111

Residual gas analysers

Note that the residual gas analyser associated with measuring the vacuum may not be the same as that used in the contamination monitor. So these are counted separately.

Counting rules for measuring the residual gas pressure

- 1 RGA per building
- 1 RGA/km of beam tube

Counting rules for the rga associated with the contamination monitor

- 1 RGA per building

Total RGA

At WA

along the beam tube

in the buildings for vacuum 5

TOTAL for vacuum 13

in the buildings for contamination 5

TOTAL for both cont and vac 18

At LA

along the beam tube 8

in the buildings for vacuum 3

TOTAL for vacuum 11

in the buildings for contamination 3

TOTAL for both cont and vac 14

file:rwwel 72694.txt

to: Bill Althouse

from: R. Weiss July 26, 1994

concerning: Uncertainties and assumptions in cost estimate of
Environmental monitoring system

Technical Uncertainties

1) Major uncertainty is in the vacuum contamination monitor. The scheme has been much discussed within in the project but never implemented. The concept is to measure adsorbed contamination layers on quartz crystal oscillator monitors by noting the change in frequency of the oscillator with the additional mass collected on the surface. The analysis of the contaminant is done by evaporation from the crystal surface as a function of temperature in coordination with mass analysis by a residual gas analyser. To evaluate the technique will require a correlation between the cavity ring down measurements, now being used to test contamination on the optical surfaces, with the signals developed by the proposed crystal oscillator/rga system. An assumption being made is that cavity ringdown apparatus mounted in each chamber of the LIGO would be too cumbersome and expensive so that we have to resort to more conventional methods to measure the contamination. Part of the design costs of the environmental monitor are assumed to go into an experimental evaluation of the method.

2) All the other monitors are off the shelf state of the art and should be straight forward to test and install.

Sequencing and interface issues

1) Instrumentation in the beamtube enclosure.

In prior thinking about the LIGO it has been assumed that there is little or no need to operate instrumentation in the beamtube enclosure during the initial phase of the project and in later phases then only when and if pumps are installed at the 250 meter intervals.

I no longer believe this to be true. The need to qualify the leak rate of the beamtubes after bake and the techniques being proposed to make the leak assessment and initial localization by partial pressure measurements will require residual gas analysers and liquid nitrogen traps at all ports of a 2km beam tube module. The bake will require thermometry along the beam tube. There will have to be some instrumentation and data logging capability right at the start.

Once LIGO is in operation, the partial pressure in the beam tubes, both the spatial and crude time dependence, will be needed for diagnostic purposes as well as to establish limits on new leaks. Furthermore, questions concerning the motion of the tubes, especially at unsupported baffles, will inevitably have to be answered. It is also possible that the interferometer will experience noise fluctuations with a daily period which may be related to the temperature of the tube. I now believe that we cannot look at the tubes as an unchanging black box and that some rudimentary information on the conditions in the tubes will be needed. The initial instrumentation (rga and accelerometers) have been included in the cost estimate of the environmental monitor system. The impact on the CDS system has been discussed with Volker and we both realize that it is a major new issue which needs resolution at a project level.

Cost assumptions and uncertainties

1) The vacuum hardware for the rgas: mounting flange, small all metal valve

and auxiliary turbo pumps are assumed to be included in the vacuum equipment and have not been included in the environmental monitoring system cost. John Worden believes that his spares philosophy in the vacuum system costing will cover these.

- 2) The temperature and wind sensors in the facility housekeeping part of the monitoring system are assumed to be covered in other costing.
- 3) The use of the CDS in the low data rate housekeeping signals is not clear. Volker discussed an auxiliary low bandwidth system as a possibility. The cost of such a system is not included in the estimates.
- 4) The wiring of the CDS to the monitor system is not included. The assumption is that CDS analog to digital conversion ports are available at the monitors. The environmental monitoring system is configured to provide low impedance ± 5 volt signals to these ports.

file: rwwea080394.txt
 to: Bill Althouse
 from: R. Weiss August 3, 1994
 concerning: Information requested on environmental monitor costs

Bill,

I am working at home and do not know how to access lotus 123 remotely, so my response to you will necessarily be in text.

 1) Reference for Vacuum contamination monitor numbers used in design phase estimate.

Assumptions:

We have no experience with the contamination monitor proposed so that an experimental test of the apparatus was envisioned during the design phase. The equipment costs are for an rga, the crystal monitor system and a test vacuum system.

Crystal monitor: (EE)

Crystal oscillator	\$559	
Sensor head	\$1830	
Shutter assembly	\$800	
Feedthrough	\$605	
Total crystal head assembly		\$3794
Computer interface	\$800	
Control circuit	\$8443	
Total electronics		\$9243
Total Crystal monitor		\$13037

RGA: (VQ)

Balzers

Control and rga head BKM18111 QMG421-3	\$35143	
ion counter preamp CP400	\$1709	
ion counter board IC421	\$3088	
network server BN882086-T	\$2573	
Total rga system		\$42153

Vacuum system (EE)

Test chamber and stand	\$2000
100 l/s turbopump and cont.	\$2000
inline LN2 trap	\$600
Foreline purge system	\$300
Pirani gauge and control	\$400
Penning gauge and control	\$800
Flanges	\$400
4"gate valve	\$1100
Forepump	\$500
Bake heaters and control	\$300

Shop time 20hr@\$40/hr \$800

Total vacuum system \$9200

Total contamination monitor for design phase \$64390

2) Clarification for the costs of the 3 axis accelerometer and rotation sensors.
 This is easy to clarify since there is a counting mistake in the estimate!!

Assumptions:

Each "associated" chamber assembly is proposed to have 3 of these units to measure both translation and rotation--six degrees of freedom. There are 14 "associated" chambers at the WA site and 7 at the LA site. Along the beam tubes, 4 units are installed for each 2km beam tube module - 16 units at both the WA and LA site.

Mistake:

The mistake was made in the lotus 123 forms by lumping together the chamber and beamtube accelerometers and assigning 3*\$2998 = \$9K as a unit cost. This is fine for the chambers but wrong for the beamtube. Note that the mistake did not carry over to the data rate inventory.

Corrected estimate:

WBS No 1.2.3.2

Material Description

	BOE	Unit cost	Qty	Total
accel/rotation (chambers)	VQ	9K	14	\$126K
accel (beam tube)	VQ	3K	16	\$48K
				<i>/142K</i>

WBS No 1.2.3.3

Material Description

accel/rotation (chambers)	VQ	9K	7	\$63K
accel (beam tube)	VQ	3K	16	\$48K

111K

Overestimate due to mistake \$192K

3) Manpower estimates

WBS No 1.2.3.1

Design phase

Scientist:

Functions	time man/months
reanalysis of project needs	
conceptualization of how data is to be used	
conceptualization of algorithms	
definition of system requirements	
definition and design of instrument test program	
scientific documentation	6
contamination monitor design	
contamination monitor research and testing	6

Engineer:

vendor interaction
 costing
 facility and CDS interface
 configuration control documentation 6

 contamination monitor design and fabrication 3

Technician:

assembly of contamination monitor
 operation of contamination monitor 6

WBS No 1.2.3.2 and WBS No 1.2.3.3

Fabrication phase (assigned equally to the two sites)

Scientist:

scientific qualification, calibration and testing
 interact with CDS hardware/software development
 design facility installation and shakedown test program
 scientific documentation for facility 2

Engineer:

procurement
 design in-house fabricated fixtures
 track vendors
 quality assurance
 coordinate assembly
 CDS interface
 manage test program
 establish facility installation schedule
 interface documentation 4

Technician:

assemble instruments for test and calibration
 run tests
 prepare instruments for shipment to sites 6

WBS No 2.2.3

Installation and shakedown

Assume an all hands on deck situation with a 65% to 35% split between the WA and LA site. Assume WA site is first. Assume a total manpower load of 12 months each for scientist, engineer and technician. Did not include travel in the estimate, a serious omission.

Range of tasks:

installation of the equipment
 connection to the CDS system
 self tests and in-situ recalibration of the individual instruments
 compatibility/interaction tests with other equipment in the facility
 live tests of instruments through CDS hardware and software
 test of data archiving and retrieval
 test of software--diagnostic and operations programs

intefacts
Turn #
#/unit month
1 trip to 2 months stay
#7300/month

determination of trends, dynamic range and signal statistics

file:rwvolker072394.txt

to: Volker Schmidt

from: R. Weiss July 23,1994

concerning: Estimated data rates from Environmental Monitoring System

Data rate estimates

Measurement	bytes/sec	#/wa	#/la	bytes/sec	
				total wa	total la

Seismic Noise:					

3 axis seismo	120	5	3	0.6K	0.3K
2 axis tilt	80	5	3	0.4	0.3K
3 axis accelerometers	12K	58	37	696K	444K
Acoustic Noise:					

Electret microphones	4K	14	7	56K	28K
Magnetic Fields:					

3 axis magnetometer	12K	14	7	168K	84K
Radio Frequency Interfer.					

Multichannel receiver	2K	5	3	10K	6K
Cosmic ray muons					

Scintillation counter	2K	5	3	10K	6K
Power line fluctuations					

Power line monitor	2K	5	3	10K	6K
Residual gas monitor					

Residual gas analyser	2K	13	11	26K	22K
Contamination Monitor					

xtal and rga	3K	5	3	15K	9K
Facility Housekeeping					

tank thermometers					
beamtube thermometers					
relative humidity					
wind speed					
wind direction					
TOTAL (raw without thresholding)				992K	606K

From vosch@ligo.caltech.edu Mon Jul 25 18:02:51 1994
Received: from ligo.caltech.edu by tristan.mit.edu AA14785; Mon, 25 Jul 94 18:02:47 EDT
Received: from pard (pard.ligo.caltech.edu) by ligo.caltech.edu (4.1/SMI-4.1)
id AA03213; Mon, 25 Jul 94 15:02:21 PDT
Received: by pard (5.0/SMI-SVR4)
id AA17852; Mon, 25 Jul 1994 15:01:58 +0800
Date: Mon, 25 Jul 1994 15:01:58 +0800
From: vosch@ligo.caltech.edu (Volker Schmidt)
Message-Id: <9407252201.AA17852@pard>
To: gerry@pard.ligo.caltech.edu, vogt@pard.ligo.caltech.edu,
wea@pard.ligo.caltech.edu, weiss@pard.ligo.caltech.edu
Subject: physics monitoring
Cc: jake@pard.ligo.caltech.edu, jay@pard.ligo.caltech.edu,
rolf@pard.ligo.caltech.edu
X-Sun-Charset: US-ASCII
Content-Length: 920
Status: R

I have the following questions/remarks concerning Rai's list of 21 July:

- 1) I assume that the cost of the preamplifiers to bring the signals to some reasonable level (typically 5v or 10V) is included in the measurement equipment and that the signals are all analogue (i.e. CDS provides the ADC)
- 2) What is "threshold crossing"?
- 3) The list shows some equipment (3 axis PZT accelerometer, RGA, thermometers) to be placed along the beam tube outside the station building. Up to now we have not costed any network connections to those locations. We need a decision on whether or not to cost the items (both the equipment and CDS)
- 4) Facility housekeeping: Are the sensors costed in the buildings? Is CDS to provide independent links to these data sources (independent of the building monitoring system) or can we assume that the building monitoring system makes the data available in the central control area.

Volker

From worden@ligo.caltech.edu Tue Jul 19 19:37:51 1994
 Received: from ligo.caltech.edu by tristan.mit.edu AA00940; Tue, 19 Jul 94 19:37:49 EDT
 Received: from feline.ligo.caltech.edu by ligo.caltech.edu (4.1/SMI-4.1)
 id AA23806; Tue, 19 Jul 94 16:37:29 PDT
 Received: by feline.ligo.caltech.edu (4.1/SMI-4.1)
 id AA22298; Tue, 19 Jul 94 16:37:19 PDT
 Date: Tue, 19 Jul 94 16:37:19 PDT
 From: worden@ligo.caltech.edu (John Worden)
 Message-Id: <9407192337.AA22298@feline.ligo.caltech.edu>
 To: vosch@ligo.caltech.edu, vogt@ligo.caltech.edu, wea@ligo.caltech.edu,
 gerry@ligo.caltech.edu, jay@ligo.caltech.edu, lisa@ligo.caltech.edu,
 rolf@ligo.caltech.edu, jake@ligo.caltech.edu
 Subject: Re: vacuum instrumentation
 Cc: dhs@ligo.caltech.edu, weiss@ligo.caltech.edu
 Status: R

In response to Volker's questions:

- I believe I am looking after most of the devices mentioned:
 WBS 1.1.1.2.1.3.1 WA Instrumentation (old WBS 2532,2533)
 and WBS 1.1.1.2.2.3.1 LA Instrumentation (old WBS 3532,3533)

*Really counted
 is the way WBS also
 in vac eqpt
 Jeybolt*

The above items include the following(both sites):

- Vacuum Diagnostic Instrumentation - Piranis, ion gauges, RGAs
- and Vacuum Test Equipment - Conventional leak detectors, ultrasensitive leak detectors, and gauge calibration stands.

2. I would agree that for Phase A that there need not be any "permanent" RGA's at the 250m ports. AC power is needed for pumps, gauges and RGAs which will be used only for the pumpdown, bakeout, and acceptance testing. Data can be recorded locally.

I would not have expected the CDS to be available at this early stage anyway.

3. I was not planning on temperature sensors. Is someone else doing these, perhaps?

John

*Vacuum Equip 1.1.1
 Beam Tube 1.1.2
 Support 1.1.3
 1.1.4*

*and Beam Tube endcaps
 O'Flaherty*

WA Vacuum equipment

From dhs Tue Jul 19 17:38:26 1994
Received: by taliesin.mit.edu AA01765; Tue, 19 Jul 94 17:38:25 EDT
From: David Shoemaker <dhs>
Subject: instrumentation along beam line
To: vosch@ligo.caltech.edu
Date: Tue, 19 Jul 94 17:38:24 EDT
Cc: weiss (Rainer Weiss)
X-Mailer: ELM [version 2.3 PL11]
Status: R

Volker, I just talked with Rai at some length about the physics monitor and wanted to mention some things.

There is a category of sensing which is called Scientific Vacuum Instrumentation, to be distinguished from more elementary things like valve states and simple pressure measurements. The Scientific Vacuum Instrumentation includes vacuum pressure fluctuations, beam tube temperature measurements, contamination monitoring, and RGA heads.

We are sure that John Worden is taking care of the straightforward instrumentation, but we are not clear if the Scientific Vacuum Instrumentation is in the physics monitor or not. Do you know? It must not fall through the cracks.

Important for the CDS is that CBI is depending on having access in the tube cover every 250 m; that they will need the power and data access to put in RGA heads at each of the spare vacuum pump ports; and that other instrumentation as needed. (With this the temperature monitors I mentioned to you while at Caltech). In fact, CBI may take over the construction of the tube cover (from the A+E contract) to have the control and access they need. But no matter what, there WILL be power and data needs along the line at those 250 m intervals.

Please let me know if I can clarify any of the above. Most of the info comes from Rai.

d.

1/2 Support Aging Oed WBS

1A 8 RGA 30K/RGA WBS 2532

532 .01 1m+ Pinn Cys 50 pair 2K/

Leads Dist	3	33K/	2533
Units Feb Dist	2	100K/	
Gauge Colletts	1	150K/	

$$\frac{1994}{1989} = (1.19)$$

JOHN WOODROW

Left the Health Safety Van Aging in the
WBS ~~So~~ Gauges, Feb Hunter and RGA
So there is now some double counting

Crystal Oscillators 559
 Senior hand 1830
 Shuttles Only 800
 Feed trays 605

CRYSTAL HAND TOTAL 3794

COMPUTER INTRAFLEX 800
 CONTROL 8443

92436

TOTAL XTAL MONITOR 13037

6790

RCA RCA BK4 18111
 @ MG 421-2 35143
 1000 carts Prog 1709
 1000 carts Cont 3088
 Network Sems 2573
 TOTAL 42153

2000
 650
 800
 1000
 800
 150
 200
 200
 200

Totals 55190
~~51396~~ 9210

Went To order of 16,300

AND STAND

Tank Chokes ~~4000~~ 4000 2000

Tank 150 2/5 + CONTROL 2000

IN LINE TRAP ~~800~~ 800

Filter ~~300~~ 300

Flanges ~~1250~~ 400

Mini Case limit and gauge 400

2
 sky line ~~1500~~ 800

Fingery 4 lit/sec 500

~~Filter 150~~

4" Gate Valve ~~1500~~ 800

Ball and handle ad until ~~1200~~ 300

~~1200~~

8/8/79 WBS

COMPARISON TO
OLD ESTIMATE

WA

WBS

LA

Item	Quantity	Unit Price	Total	Quantity	Unit Price	Total
Semi Vit Fullcut	10	7.9	79K	5	7.9	39.5
Palletcut	10	7.9	79K	5	7.9	39.5
Semi	5	6.6	33K	3	6.6	19.8
Acetyl	5	5.7	28.5K	3	5.7	17.1
RFT	5	9.5	47.5K	3	9.5	28.5
Magn	10	8.2	82K	5	8.2	41.0
P	5	18.9		3	18.9	56.7
MAINS	1	10.0	10.0	1	10.0	10.0
TRUP	60	0.4	24K	54	0.4	21.6
HUM	5	0.9	4.5K	3	0.9	2.7
Wells ST	1	6.3	6.3K	1	6.3	6.3K
NSFA LL			57.7			38.8K

TOTAL 622.6K

391.5

- Tey
- HVA C MONITOR
- Wells ST
- Hum

- 24K
- 50.0
- 6.3
- 4.5

- 21.6
- 50.0
- 6.3
- 2.7

RGA	8	30	240
Valves	8	6	48
Roofly Valve	8	1	8

6 x 30 = 180
6 x 6 = 36
6 x 1 = 6

537

= 319

+ 296

222

LABOR

Job	Rate	Hours	Total
SCIENTIST	12	1	12
Equip	9	2	18
Technician	6	3	18

Total ~ 1.3664

July 679.3

PRIME TOTAL → INFLATED 94
2.3154

2)

ELRESTART MICROPHONE

ELRESTART MICROPHONE
 AMPLIFIER
 A/D
 MOUNT

\$12 / channel
 \$100 / AMP
 \$120 / CHANNEL
 \$30 / channel

\$ 2.62 / CHANNEL

1.42 / CHANNEL

NO A/D

MACURTIC FIBROS

BARTINGTON MAG-03MC \$2250
 POWER SUPPLY 500
 A/D 120/CHANNEL 360
 MOUNT 30

GMW
 Redwood City

\$ 3140 / 3 AXES

2780

NO A/D

RFI

HP 8902A RECORDER \$29,450
 HP 11966A H ANTENNA 2535
 HP 11966B E ANTENNA 2235

\$ 34,220 / SYSTEM

Need Job delivery mt of files and Product \$2000 on-site costs

Upon delivery

REXON COMPONENTS AND RGG
 BRACHWOOD, OHIO

RP-110 SCINTILLATOR / PM TUBE \$2,213
 BASE / PREAMP RGG 276 405
 HV SUPPLY RGG 5564 1540
 NIMBON RGG 4001A 930
 CONSTANT PHASE PISA RGG 584 855
 PULSER AMPLIFIER RGG 575A 525
 PATRIMETER RGG 541 510
 COUNTRY RGG 770 830

1987
 cuts

1224
 1126
 691
 671
 1093

\$ 8963 / other

LINE MONITOR

BMI FOSTER CITY CALIF
 MODEL 8800 POWER SCOPE 12,230

12,230 / other

13-782 500 SHEETS, FILLER 5 SQUARE
 42-381 50 SHEETS, EYE-GLASS 5 SQUARE
 42-382 100 SHEETS, EYE-GLASS 5 SQUARE
 42-383 100 SHEETS, EYE-GLASS 5 SQUARE
 42-384 100 SHEETS, EYE-GLASS 5 SQUARE
 42-385 100 SHEETS, EYE-GLASS 5 SQUARE
 42-386 200 RECYCLED WHITE 5 SQUARE
 42-387 200 RECYCLED WHITE 5 SQUARE
 Made in U.S.A.



VAC CONTAMINATION

ESTIMATE FROM LASER 1
AND KRYBOLD 1986 → 1994

VACUUM CONTAMINATION

X TALS	430		
Santa Hand	1300	} 2810 / SANSON	13 / \$ X = 3794 / CRUSON
Santa Hand	6000		
Shells assy	615		
Feed Thru	465		
Cuplas Intifos	615		
Electrics	6495	7110 / ELECTRONICS 21.3	\$ 9243 / ELECTRONICS UNIT

RCA HEAD
BALZRA QMA 430 12153

RCA CONTROL BK M18111 QMG421-3 35143

~~CP400~~
Control Board CP400 1709
ION control board 3088
BN 882086-T NETWORK CORR 2573

SUMMARY

PER TANK	\$	X TAL	
	3794	SANSON	
	12153	RCA	
			\$ 15,947 HANDWANN/TANK

CONTROL

X TAL	35143	\$ 9243	} FOR BUILDING
RCA		\$ 42,513	
		51756	

RGA

BALZRAS	BK M18111	QMG421-3	QMA 430	\$ 35143
	ION CONTROL BOARD		CP 400	1709
	ION CONTROL BOARD		IC 421	3088
	BN 882086		NETWORK	2573

42,513 / RCA

13-782 500 SHEETS, FILLER, 5 SQUARE
42-381 50 SHEETS, FILLER, 5 SQUARE
42-382 20 SHEETS, FILLER, 5 SQUARE
42-383 20 SHEETS, FILLER, 5 SQUARE
42-384 100 RECYCLED WHITE 5 SQUARE
42-385 200 RECYCLED WHITE 5 SQUARE
Made in U.S.A.



1.2.3.1 Days

Vacuum Containment mats for tent
 Dairy 6m SC
 6m 6m
 6m softness

Prototype of Containment mat
 6m Scaled
 3m Tapes

copy

1.2.3.2

3 AXIS SEISMOMETER	17,700	x 5
3 AXIS TILT MATS	13,400	x 5
3 AXIS PZT	3,118	x (3 x 14 + 16)
Acoustic MATS	0.3	x 14
MAGNETIC SENSORS	3,140	x 14
RFI	34,220	x 5
MUON	8,963	x 5
LINE MONITOR	12,230	x 5
RESIDUAL GAS MONITOR	42,513	(x 5 + 8)
CONTAMINATION MONITORS		
Sens + Heads	15,947	x 14
CONTROLLERS	51,756	x 5

13-782 500 SHEETS FILING 5 SQUARE
 42-382 100 SHEETS FILING 5 SQUARE
 42-382 100 SHEETS FILING 5 SQUARE
 42-382 200 SHEETS FILING 5 SQUARE
 42-382 100 RECYCLED WHITE 5 SQUARE
 42-382 200 RECYCLED WHITE 5 SQUARE
 Made in U.S.A.



42
 14
 5

13-782 500 SHEETS, FILLER, 5 SQUARE
 42-381 50 SHEETS, EYE GLASS, 5 SQUARE
 42-382 100 SHEETS, EYE GLASS, 5 SQUARE
 42-383 200 SHEETS, EYE GLASS, 5 SQUARE
 42-384 100 RECYCLED WHITE, 5 SQUARE
 42-385 200 RECYCLED WHITE, 5 SQUARE
 Made in U.S.A.



1.2.3.3

3 AXIS	SKISM	17,700 x 3
3 AXIS	TILT	13,400 x 3
3 AXIS	PZT	3,118 x (3 x 7 + 16)
ACOUSTIC	ORT	0.3 x (7)
MAGNETIC		3140 x (7)
RFI		24,220 x (3)
MUON		8,963 x 3
LINAC	MONITOR	17,230 x 3
RESIDUAL	GPS	42,513 (3 + 8)
CONTAMINATION MONITOR		
	SENSOR HEADS	15,947 x 7
	CONTROLLERS	51,756 x 3

2.2.3 Plym Mmby Integritas / Shale Lens

12mm	Santid
12mm	Equis
12mm	Telium

32

Sitr 1

Centrl Bndly 4/ Isolated beam sections

6 Tanks

Mid Strls 2 TANKS

RND STATIONS 2 TANKS

14 tanks

BUILDING

5 BUILDINGS

SITR 2 2 Isolated beam sections

Centrl Bed 3 tanks

RND STATION 2 tanks

7 tanks

3 BUILDINGS

12-782 500 SHEETS FULLER 5 SQUARE
42-381 50 SHEETS EYE-GLASS 5 SQUARE
42-382 100 SHEETS EYE-GLASS 5 SQUARE
42-383 200 SHEETS EYE-GLASS 5 SQUARE
42-384 300 SHEETS EYE-GLASS 5 SQUARE
42-385 200 RECYCLED WHITE 5 SQUARE
Made in U.S.A.



LISA

Rayburn: - [ayijis
Sensit

Spec

B

Violetes ~ Rayburn Cuts - Spec
10Hz ~

Personal Sensor!

Minghant ~ $\text{dynes/cm}^2/\sqrt{\text{Hz}}$ sensy 0.3Hz \rightarrow 10KHz

AC units $V(+)$ or $PCV_n(+)$ or level

lined: Inyis -

3 AX

	DC \rightarrow 2KHz		
$\pm 70 \mu \times 10^4$	70×10^{-2} gms	700 milligrams	/ FS
		.02 milligrams	Perling Strip
Internal Noise	.1 \rightarrow 10Hz	$80 \times 10^{-12} \times 10^4$	$\sim 80 \times 10^{-8}$
	1Hz - 1KHz	$350 \times 10^{-12} \times 10^4$	350×10^{-8}

2250	2250
	.500
	<hr/>
	2750

Peter Petals

ierd Stylis

Amities

9

7KHz - 30MHz

13K

INTRAPACS

VME BACK PLANE

(32 BITS)

IEEE 48 BUS

8 BIT / BYTE

Processors

Nexon

Cognate

1/2 m x 1/2 m

HAMAMATSU

Philips Smulders

Open Arch: Hard to require elements
Integrated - end of time

list: [Intel
Bull

Tull /

7/19/94

ENVIRONMENTAL MONITOR

INQUIRY

TEMPERATURE

BIRLAS

MIRSONS - AIR SHOWS MONITOR ←

RMI

POWER ACOUSTIC

SEISMIC

$f < 10 \text{ Hz}$

$f > 10 \text{ Hz}$

TILT ?

VAC BUNTS ?

} NRW] VARIABLES

CONTAMINATION MONITORS / CIVILIAN

QUESTIONS

1) INTERRUPTOR CDS

2) INSTALLATION COSTS
TRST, CALIBRATION, SENSITIVITY MONITORING

3) FORM OF ORIGINABLE

4) INSTRUMENT MONITORING SYSTEM
LASRAS
SRVORS
~~ADD~~ INTRAFRA-SONIC STR

500 SHEETS FULLER 5 SQUARE
42-381 50 SHEETS EYE-EASE 5 SQUARE
42-382 100 SHEETS EYE-EASE 5 SQUARE
42-389 200 SHEETS EYE-EASE 5 SQUARE
42-395 100 SHEETS WHITE 5 SQUARE
200 RECYCLED WHITE 5 SQUARE
Made in U.S.A.



TABLE VII-2
ENVIRONMENTAL PARAMETERS TO BE MONITORED

PHENOMENON	MONITOR
Seismic Noise	Translation and rotation: $f < 10$ Hz; 1 seismometer/building $f > 10$ Hz; 3 accelerometers/test mass tank
Acoustic Noise	Microphones at test mass tanks and critical optical components
Magnetic Field Fluctuations	Low frequency: 1 magnetometer/building High frequency: 3 coils/test mass tank
Radio Frequency Interference (RFI)	Multilevel receiver to record rms noise in selected channels, one per building
Cosmic Rays	Shower detector, one per building
Electrical Power	Transient monitor, one per building
Fluctuations in Residual Gas Column Density in Beam Tubes ¹	UV absorption spectroscopy
Housekeeping Data From Facility Control	Temperatures, wind velocity, ion pump currents, etc.

¹ Although not planned for installation at the outset, a monitor for gas may be required based on experiences with the system. The standard vacuum measuring gauges are not sensitive enough to detect column density changes that would be interpreted as gravitational wave signals. A system using UV absorption spectroscopy on the gas column in the beam tubes has been devised which should have sufficient sensitivity to veto gas bursts at the level required to match the sensitivities of the advanced detectors being planned for the LIGO. The gas bursts, should they occur, will have a characteristic pulse signature that depends on the tube diameter and the pumping speed. There is no information that such gas bursts occur, however, the LIGO will be exploring a new measurement regime.

LIGO sites, and for the half-length interferometer operating with half the signal-to-noise ratio of the full-lengths, the sensitivity to kHz-band signals is reduced by at most 30%. This result applies to Gaussian noise, with the optimal setting for trigger thresholds of 4.9 and 6.5 times the rms Gaussian noise level in the full- and half-length interferometers, respectively.

TABLE IV-F-1
REPRESENTATIVE LIST OF SIGNALS¹

SIGNAL	DESCRIPTION	NUMBER	BAND- WIDTH (kHz)	DATA RATE (kbytes/s)
Interferometer Signals				
Interferometer output	Gravitational-wave signal	1	10	40
Symmetric port	Intensity monitor	1	10	(40)
Main cavity lock		2	10	(80)
Beam splitter lock		1	10	(40)
Recycling mirror lock		1	10	(40)
Main frequency lock		1	10	(40)
Trim frequency lock		1	10	(40)
Side arm lock		2	10	(80)
Alignment Signals				
Main cavity angle	2 angles/mirror	8	1	(32)
Beam position	2 axes/mirror	8	1	(32)
Recycling mirror	2 angles, 2 positions	4	1	(16)
Mode cleaner	2 angles, 2 positions	4	1	(16)
Suspension Signals				
Main cavity mirror	5 degrees of freedom	20	0.1	(8)
Deflection mirror	5 degrees of freedom	10	0.1	(4)
Beam splitter	5 degrees of freedom	5	0.1	(2)
Recycling mirror	5 degrees of freedom	5	0.1	(2)
Mode cleaner	5 degrees of freedom	10	0.1	(4)
Auxiliary Monitor Signals				
Low freq. seismic	1/building	3	0.03	0.4
High freq. seismic	3/test-mass chamber	15	0.3	18
Acoustic pressure	1/test-mass chamber	5	2	(40)
Line power	1/building	3	0.1	1.2
Low freq. mag. field	3 axis magnetometer/building	9	0.03	1.1
High freq. mag. field	3 loops/test-mass chamber	15	0.01	0.6
RF interference	1/building	3	0.1	1.2
Cosmic ray showers	1/building	3	0.01	0.12
Housekeeping	Temperatures, voltages, states, etc.	100	0.001	0.4
¹ The table is included to illustrate the scale of the data flow. The signals with data rates in parentheses are not continuously archived. The data rates (kbytes/s) are based on a sampling rate of twice the bandwidth, and a sampling resolution of two bytes.				

LIGO WBS 2500 -- SITE 1 SUPPORT EQUIPMENT -- SUPPORTING DETAIL

	Method	Amount (000)	Subtotal (000)	BOE
2000	Site 1 Facilities & Equipment			
2500	Support Equipment		\$4,124.2	
2510	Laser Equipment		\$414.2	see page C-48
2511	Lasers	4 @ \$79.3K ea	\$317.2	
2512	Laser Cooling Units	4 @ \$7.5K ea	\$30.0	
2513	Laser Table & Mounts	2 @ \$33.5K ea	\$67.0	
2520	Data Acquisition & Recording Equipment		\$479.4	see page C-49
2521	Software		\$15.0	
2522	Hardware		\$444.0	
2523	Cabling & Installation		\$20.4	
2530	Instrumentation		\$2,264.8	
2531	Vacuum System Monitoring & Control		\$291.4	see page C-50
2532	Vacuum Diagnostic Instrumentation		\$396.0	see page C-50
2533	Vacuum Test Equipment		\$449.0	see page C-50
2534	Physical Environment Monitoring		\$627.6	see page C-51
2535	Electronic Test Equipment		\$524.8	see page C-52
2540	Office & Shop Equipment		\$524.8	
2541	Furniture		\$67.4	D
2542	Shipping & Receiving		\$38.4	D
2543	Shop Equipment		\$276.7	D
2544	Telephones & Intercom		\$100.0	C
2545	Security Equipment		\$42.3	D
2550	Spares		\$441.0	D
2551	Mechanical Pump		\$16.0	
2552	Blower		\$13.0	
2553	Turbopump		\$39.0	
2554	Ion Pump Power Supply		\$16.0	
2555	Ion Gage Controller		\$13.0	
2556	Mass Spectrometer		\$47.0	
2557	Control Computer		\$40.0	
2558	Data Acquisition System		\$30.0	
2559	Valves & Other Parts		\$227.0	

LIGO WBS 2534 -- SITE 1 SUPPORT EQUIPMENT, PHYSICAL ENVIRONMENT MONITORING INSTRUMENTATION -- UNIT COST DETAIL

	Qty	Unit Cost (000)	Extension (000)	Subtotal (000)	Subtotal (000)	BOE
2000 Site 1 Facilities & Equipment						
2500 Support Equipment						
2530 Instrumentation						
2534 Physical Environment Monitoring					\$622.6	
2534.01 Seismic Vibration				\$191.0		
2534.01.01 Translational Monitor	10	\$7.9	\$79.0			B,E
2534.01.02 Rotational Monitor	10	\$7.9	\$79.0			B,E
2534.01.03 Seismometer	5	\$6.6	\$33.0			D
2534.02 Acoustic Vibration Monitor	5	\$5.7		\$28.5		B
2534.03 Radiofrequency Interference Monitor	5	\$9.5		\$47.5		E
2534.04 Magnetic Pulse Interference Monitor	10	\$8.2		\$82.0		E
2534.05 Cosmic Ray Veto Detector	5	\$18.9		\$94.5		B,E
2534.06 Temperature & Humidity				\$28.7		
2534.06.01 Temperature Monitor	60	\$0.4	\$24.0			B,E
2534.06.02 Humidity Monitor	5	\$0.9	\$4.5			B,E
2534.06.03 Calibration Set	1	\$0.2	\$0.2			B,E
2534.07 Mains Power				\$10.0		D
2534.08 Housekeeping				\$56.3		
2534.08.01 HVAC Monitor	1	\$50.0	\$50.0			D
2534.08.02 Weather Station	1	\$6.3	\$6.3			B
2534.09 Airborne Particle Counter	8	\$3.3		\$26.4		B
2534.10 Equipment Installation				\$57.7		D

LIGO WBS 3500 -- SITE 2 SUPPORT EQUIPMENT -- SUPPORTING DETAIL

	Method	Amount (000)	Subtotal (000)	BOE
3000 Site 2 Facilities & Equipment				
3500 Support Equipment			\$3,373.2	
3510 Laser Equipment				
3511 Lasers	Ref. WBS 2510		\$207.1	see page C-48
3512 Laser Cooling Units	2 @ \$79.3K ea	\$158.6		
3513 Laser Table & Mounts	2 @ \$7.5K ea	\$15.0		
3520 Data Acquisition & Recording Equipment	1 @ \$33.5K ea	\$33.5		
3521 Software	Ref. WBS 2520		\$479.4	see page C-49
3522 Hardware		\$15.0		
3523 Cabling & Installation		\$444.0		
3530 Instrumentation		\$20.4		
3531 Vacuum System Monitoring & Control			\$1,735.4	
3532 Vacuum Diagnostic Instrumentation		\$268.2		see page C-53
3533 Vacuum Test Equipment		\$298.0		see page C-53
3534 Physical Environment Monitoring Instrumentation	Ref. WBS 2533	\$449.0		see page C-50
3535 Electronic Test Equipment		\$391.5		see page C-54
3540 Office & Shop Equipment				
3541 Furniture			\$510.3	D
3542 Shipping & Receiving		\$63.9		
3543 Shop Equipment		\$34.2		
3544 Telephones & Intercom		\$276.7		
3545 Security Equipment		\$100.0		
3550 Spares		\$35.5		
3551 Mechanical Pump			\$441.0	D
3552 Blower		\$16.0		
3553 Turbopump		\$13.0		
3554 Ion Pump Power Supply		\$39.0		
3555 Ion Gage Controller		\$16.0		
3556 Mass Spectrometer		\$13.0		
3557 Control Computer		\$47.0		
3558 Data Acquisition System		\$40.0		
3559 Valves & Other Parts		\$30.0		
		\$227.0		

LIGO WBS 3534 -- SITE 2 SUPPORT EQUIPMENT, PHYSICAL ENVIRONMENT MONITORING -- UNIT COST DETAIL

	Qty	Unit Cost (000)	Extension (000)	Subtotal (000)	Subtotal (000)	BOE
3000 Site 2 Facilities & Equipment						
3500 Support Equipment						
3530 Instrumentation					\$391.5	
3534 Physical Environment Monitoring				\$98.8		
3534.01 Seismic Vibration						
3534.01.01 Translational Monitor	5	\$7.9	\$39.5			B,E
3534.01.02 Rotational Monitor	5	\$7.9	\$39.5			B,E
3534.01.03 Seismometer	3	\$6.6	\$19.8			D
3534.02 Acoustic Vibration Monitor	3	\$5.7		\$17.1		B
3534.03 Radiofrequency Interference Monitor	3	\$9.5		\$28.5		E
3534.04 Magnetic Pulse Interference Monitor	5	\$8.2		\$41.0		E
3534.05 Cosmic Ray Veto Detector	3	\$18.9	\$56.7	\$56.7		B,E
3534.06 Temperature & Humidity				\$24.5		
3534.06.01 Temperature Monitor	54	\$0.4	\$21.6			B,E
3534.06.02 Humidity Monitor	3	\$0.9	\$2.7			B,E
3534.06.03 Calibration Set	1	\$0.2	\$0.2	*		B,E
3534.07 Mains Power				\$10.0		D
3534.08 Housekeeping				\$56.3		
3534.08.01 HVAC Monitor	1	\$50.0	\$50.0			D
3534.08.02 Weather Station	1	\$6.3	\$6.3			B
3534.09 Airborne Particle Counter	6	\$3.3		\$19.8		B
3534.10 Equipment Installation				\$38.8		D

LIGO WBS 3531, 3532 and 3533 -- SITE 2 SUPPORT EQUIPMENT, VACUUM INSTRUMENTATION -- UNIT COST DETAIL

	Description	Qty	Unit Cost (000)	Extension (000)	Subtotal (000)	BOE
3000	Site 2 Facilities & Equipment					
3500	Support Equipment					
3530	Instrumentation					
3531	Vacuum System Monitoring & Control				\$268.2	
	3531.01 Computer w/ Color Monitor	2	\$28.2	\$56.4		B
	3531.02 Disks, 323 MBYTE	2	\$7.2	\$14.4		C
	3531.03 Tape Drive	1	\$4.0	\$4.0		E
	3531.04 Laserjet Printer, 8PPM	1	\$2.7	\$2.7		C
	3531.05 Software			\$5.0		E
	3531.06 HP-IB Extenders, Single Ended	2	\$1.5	\$3.0		B
	3531.07 HP-IB Extenders, Double Ended	11	\$1.9	\$20.9		B
	3531.08 Fiber Optic Cable, 2 km, incl. connectors	4	\$2.1	\$8.4		C
	3531.09 Data Acquisition System	4	\$11.6	\$46.4		B,E
	3531.10 Software for HP 3852			\$2.0		B
	3531.11 Short HP-IB Fiber Optic Cables			\$8.0		E
	3531.12 Relay Racks	8	\$1.5	\$12.0		E
	3531.13 Graphic Display Panel			\$10.0		E
	3531.14 Uninterruptible Power Supply			\$5.0		E
	3531.15 Installation & Checkout			\$70.0		E
	1,000 hrs @ \$70/hr					
3532	Vacuum Diagnostic Instrumentation					
	3532.01 Ion & Pirani Gages				\$76.0	B,E
	3532.01.01 Corner Station	16	\$2.0	\$32.0		
	3532.01.02 End Stations	10	\$2.0	\$20.0		
	3532.01.03 Reserved			\$0.0		
	3532.01.04 Beam Tube	12	\$2.0	\$24.0		
	3532.02 Mass Spectrometer Unit				\$222.0	
	3532.02.01 Mass Spectrometer	6	\$30.0	\$180.0		E
	3532.02.02 Valves, all metal	6	\$6.0	\$36.0		B
	3532.02.03 Roughing Valve & Tee	6	\$1.0	\$6.0		E
3533	Vacuum Test Equipment					
	3533.01 Leak Detectors				\$299.0	E
	3533.02 Vacuum Gage Calibration Stand				\$150.0	E
	Ref. WBS 2533.01					
	Ref. WBS 2533.02					

LIGO WBS 2531, 2532 and 2533 -- SITE 1 SUPPORT EQUIPMENT, VACUUM SYSTEM INSTRUMENTATION -- UNIT COST DETAIL

		Description	Qty	Unit Cost (000)	Extension (000)	Subtotal (000)	BOE
2000	Site 1 Facilities & Equipment						
2500	Support Equipment						
2530	Instrumentation						
2531	Vacuum System Monitoring & Control						
	2531.01 Computer w/ Color Monitor	HP 98583G OPT 011, HP 370	2	\$28.2	\$56.4	\$291.4	
	2531.02 Disks, 323 MBYTE	HP 7959S	2	\$7.2	\$14.4		B
	2531.03 Tape Drive		1	\$4.0	\$4.0		C
	2531.04 Laserjet Printer, 8PPM	HP 33440A	1	\$2.7	\$2.7		E
	2531.05 Software				\$5.0		C
	2531.06 HP-IB Extenders, Single Ended	HP 37204A OPT 13	2	\$1.5	\$3.0		E
	2531.07 HP-IB Extenders, Double Ended	HP 37204A OPT 14	11	\$1.9	\$20.9		B
	2531.08 Fiber Optic Cable, 2 km, incl. connectors		4	\$2.1	\$8.4		B
	2531.09 Data Acquisition System	HP 3852 + options	6	\$11.6	\$69.6		C
	2531.10 Software for HP 3852	HP 44458A			\$2.0		B, E
	2531.11 Short HP-IB Fiber Optic Cables				\$8.0		B
	2531.12 Relay Racks		8	\$1.5	\$12.0		E
	2531.13 Graphic Display Panel				\$10.0		E
	2531.14 Uninterruptible Power Supply				\$5.0		E
	2531.15 Installation & Checkout	1,000 hrs @ \$70/hr			\$70.0		E
2532	Vacuum Diagnostic Instrumentation						
	2532.01 Ion & Pirani Gages					\$100.0	B, E
	2532.01.01 Corner Station		16	\$2.0	\$32.0		
	2532.01.02 End Stations		10	\$2.0	\$20.0		
	2532.01.03 Mid Stations		12	\$2.0	\$24.0		
	2532.01.04 Beam Tube		12	\$2.0	\$24.0		
	2532.02 Mass Spectrometer Unit					\$296.0	
	2532.02.01 Mass Spectrometer		8	\$30.0	\$240.0		E
	2532.02.02 Valves, all metal		8	\$6.0	\$48.0		B
	2532.02.03 Roughing Valve & Tee		8	\$1.0	\$8.0		E
2533	Vacuum Test Equipment						
	2533.01 Leak Detectors					\$299.0	
	2533.01.01 Conventional, Turbopumped		3	\$33.0	\$99.0		
	2533.01.02 Ultrasensitive		2	\$100.0	\$200.0		E
	2533.02 Vacuum Gage Calibration Stand					\$150.0	
	2533.02.01 Spinning Rotor Gauge		3	\$12.0	\$36.0		E
	2533.02.02 Turbopump		1	\$15.0	\$15.0		E
	2533.02.03 Ion Pump		1	\$15.0	\$15.0		E
	2533.02.04 Design, Build & Checkout				\$84.0		E

C-50

LIGO WBS 3534 -- SITE 2 SUPPORT EQUIPMENT, PHYSICAL ENVIRONMENT MONITORING -- UNIT COST DETAIL

	Qty	Unit Cost (000)	Extension (000)	Subtotal (000)	Subtotal [*] (000)	BOE
3000 Site 2 Facilities & Equipment						
3500 Support Equipment						
3530 Instrumentation						
3534 Physical Environment Monitoring						
3534.01 Seismic Vibration					\$391.5	
3534.01.01 Translational Monitor	5	\$7.9		\$98.8		
3534.01.02 Rotational Monitor	5	\$7.9	\$39.5			B, E
3534.01.03 Seismometer	3	\$6.6	\$19.8			B, E
3534.02 Acoustic Vibration Monitor	3	\$5.7		\$17.1		D
3534.03 Radiofrequency Interference Monitor	3	\$9.5		\$28.5		B
3534.04 Magnetic Pulse Interference Monitor	5	\$8.2		\$41.0		E
3534.05 Cosmic Ray Veto Detector	3	\$18.9	\$56.7	\$56.7		E
3534.06 Temperature & Humidity				\$24.5		B, E
3534.06.01 Temperature Monitor	54	\$0.4	\$21.6			B, E
3534.06.02 Humidity Monitor	3	\$0.9	\$2.7			B, E
3534.06.03 Calibration Set	1	\$0.2	\$0.2			B, E
3534.07 Mains Power				\$10.0		D
3534.08 Housekeeping				\$56.3		
3534.08.01 HVAC Monitor	1	\$50.0	\$50.0			D
3534.08.02 Weather Station	1	\$6.3	\$6.3			B
3534.09 Airborne Particle Counter	1	\$6.3	\$6.3			B
3534.10 Equipment Installation	6	\$3.3		\$19.8		B
				\$38.8		D

From yaron Tue Jul 5 13:01:33 1994
Received: by tycho AA05351; Tue, 5 Jul 94 13:01:32 EDT
From: Yaron Hefetz <yaron>
To: weiss
Subject: Re: Request from Barish
Cc: pf, dhs, yaron
Status: R

Rai,

With one seismometer / building, and eight buildings,
the price for seismic monitoring is: \$60,000.00

Yaron.

----- Begin Included Message -----

>From lisa@ligo.caltech.edu Tue Jul 5 11:26:35 1994
To: yaron
Subject: Re: Request from Barish

The following is info on the seismometers we are buying for the seismic measurements. I will give you the company and price that was quoted.

Digital Technology Ass.
1330-A Galaxy Way
Concord Ca 94520
tel: 510-682-2072

The sensor is a CMG40T Triaxial Broadband Seismometer with a signal range from .1 Hz to 100 Hz. It takes data in 3 axes.

The price with the cabling and power supply is roughly \$7500.

As far as the other things on your list, you might talk to Jake or Volker.

Good luck, Lisa

----- End Included Message -----

TO: David Shoemaker, M.I.T.
Room 20B/45

From: Jill Jones



Determine pitch, roll and level

The dual-axis Model 900 is an inexpensive, gravity-referenced clinometer (tiltmeter) with wide dynamic range. Its small size and high precision make it a versatile choice for many measurement and control applications.

Model 900 measures angular position with respect to the stablest of all external references: the vertical gravity vector. Its advanced design assures high repeatability over a standard 40 degree measurement span (90 degree optional span). Model 900 also features a wide input voltage range and signal conditioned analog



Motion control for factory automation

outputs. Just install Model 900 and connect it to your voltmeter or data acquisition system. You are ready to begin your measurements!

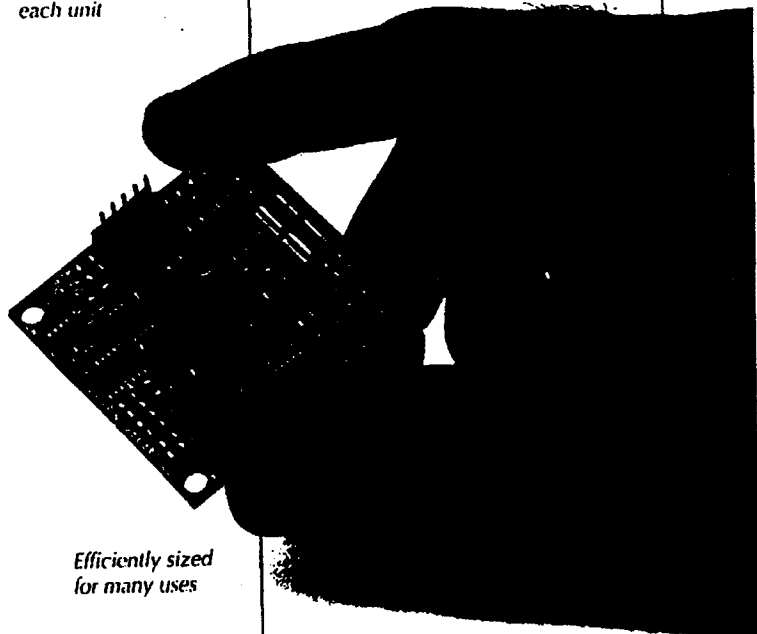
The sensing element within Model 900 is a glass vial half-filled with a conductive liquid. When the sensor is level, fluid covers five internal electrodes to equal depths. When the sensor tilts, the depth of fluid on each electrode changes, altering the electrical resistance between matched pairs of electrodes. Model 900's surface-mount electronics measure these changes, converting them to DC outputs proportional to the tilt angle.

Key features include:

- Measures rotation in two orthogonal vertical planes
- Detailed 21-point calibrations supplied for each axis
- No mechanical moving parts to break or wear out
- Optional temperature sensor.

Call or fax today for a quotation. For greater precision, ask about our 700-Series tiltmeters.

Prewired connector supplied with each unit



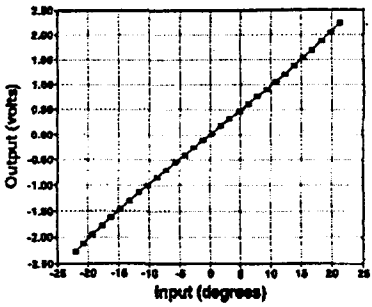
Efficiently sized for many uses

APPLIED GEOMECHANICS

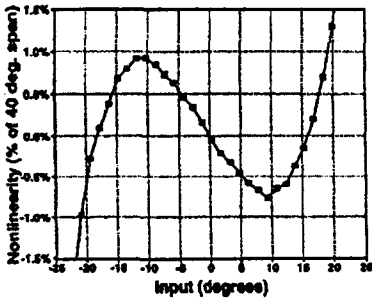
Model 900 Biaxial Clinometer

Use Model 900 for:

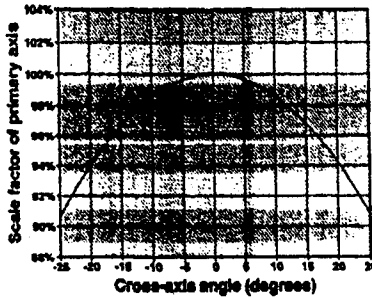
- Factory automation and robotics
- Drilling and mining machinery
- Construction equipment
- Ships, buoys, ROVs, towfish
- Land vehicles
- Aircraft
- Antennae
- Any machine or structure



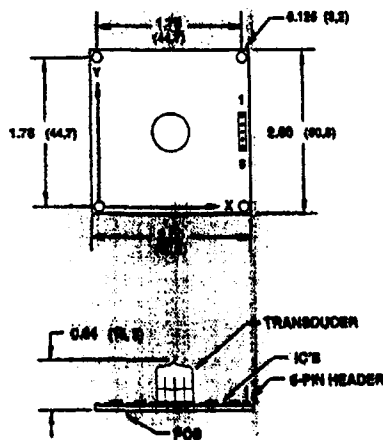
Typical calibration



Typical nonlinearity

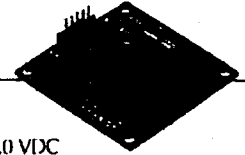


Cross-axis effect on scale factor



Model 900 dimensions, inches (mm)

Specifications



OUTPUT CHANNELS	Two orthogonal tilt angles, ± 2 VDC per channel (single-ended); one temperature channel (optional), -0.4 to +1.0 VDC
ANGULAR RANGE	Standard: ± 20 degrees (40 degree span). Optional: ± 45 degrees (90 degree span)
RESOLUTION	0.01 degree of arc
REPEATABILITY	< 0.02 degree of arc at constant temperature
HYSTERESIS	< 0.02 degree of arc
LINEARITY	± 20 degree unit: 1% over half span; 2.5% over full span. Use of factory-supplied polynomials can improve linearity by factor of 10
TEMPERATURE COEF.	Span: -0.05% of reading per $^{\circ}\text{C}$ typical
SCALE FACTORS	Tilt: (± 20 degree unit): 10 degrees/volt $\pm 20\%$. Temperature: 0.1 $^{\circ}\text{C}/\text{mV}$, $\pm 0.75^{\circ}\text{C}$ accuracy
TIME CONSTANT, T	0.25 second; output is proportional to $1 - e^{-t/T} - 0.001 e^{-t/5000T}$ where t is time in seconds
NATURAL FREQUENCY	10 Hz
OUTPUT IMPEDANCE	270 ohms, short circuit protected
POWER REQUIREMENTS	+8 to +24 VDC @ 7 mA, 250 mV peak-to-peak ripple max., reverse polarity protected
ENVIRONMENTAL	-10 $^{\circ}$ to +50 $^{\circ}\text{C}$ operating and storage, 0-80% humidity
SIZE & WEIGHT	2 x 2 x 0.64 inches (51 x 51 x 17 mm), 0.5 oz (15 grams); 18 inch (450 mm) cable with connector
MOUNTING	Four 0.125 inch (3.2 mm) no. 4 mounting holes, one in each corner
MATERIALS	Liquid-filled glass sensor, fiberglass PC board, unpotted assembly

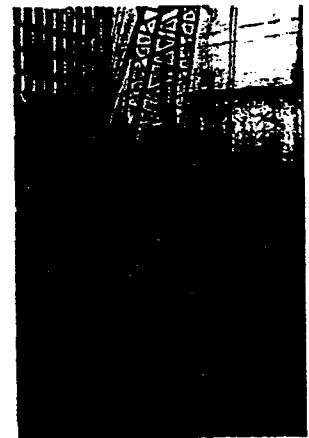
Angle conversion chart

	radians	degrees	arc minutes	arc seconds	μ radians
radians	1	57.30	3438	206265	10^6
degrees	0.01745	1	60	3600	17453
arc minutes	2.909×10^{-1}	0.01667	1	60	290.9
arc seconds	4.848×10^{-6}	2.778×10^{-4}	0.01667	1	4.848
μ radians	10^{-6}	5.730×10^{-5}	3.438×10^{-4}	0.2063	1

Ordering Information

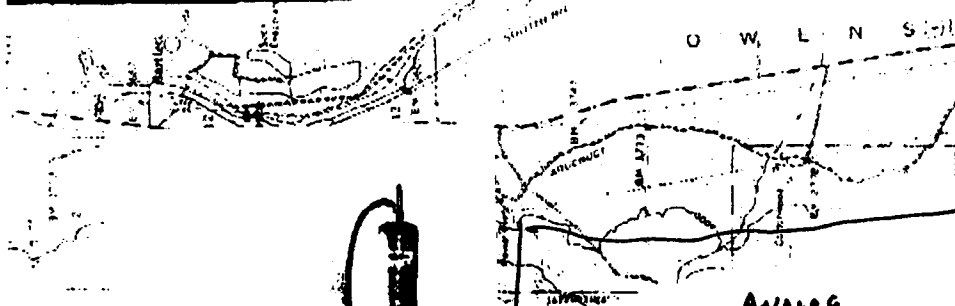
Model 900	± 20 degree range	\$ 200
Model 900-T	Adds temperature sensor	220
Model 900-45	± 45 degree range	250
Model 900-45T	Adds temperature sensor	270

Position masts
and booms



APPLIED
GEOMECHANICS

1336 Brommer Street
Santa Cruz, CA 95062 U.S.A.



TO: David S. Sennel
MIT

APPLIED GEOMECHANICS



510
\$16,471
591 Motor Unit
2,882
Platinum Vains
520
MICRO
~~5,000~~
9,176 *Ready*

15...

Model 510 Geodetic Borehole Tiltmeter

Precision, Stability, Field-Proven Performance

The Model 510 Borehole Tiltmeter is a dual-axis analog output tiltmeter designed for field applications requiring the greatest possible sensitivity, stability and rugged reliability. Applications include measurement of volcanic and tectonic ground movements, long-period seismometry, earth tide studies, hydraulic fracture measurement, and precise monitoring of foundations and structures. Model 510 is the most sensitive electronic tiltmeter known to be available worldwide.

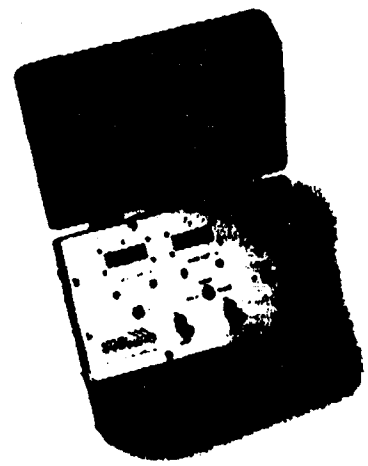
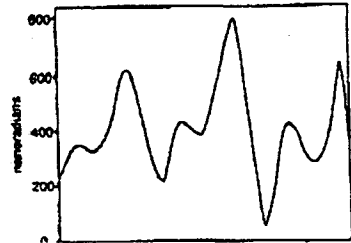
Model 510 senses angular movement in two orthogonal vertical planes using two electrolytic tilt transducers. The transducers can be described as electronic spirit levels. They operate on the principle that a bubble, suspended in a liquid-filled case, tends to remain stationary with respect to the vertical gravity vector. As the instrument tilts, the case moves around the bubble. Platinum electrodes sense changes of resistance as they are alternately covered or uncovered by the conductive liquid. Highly stable circuitry inside the tiltmeter body converts these changes to high-level signals linearly proportional to angular rotation.

transducers to within 1 microradian of null. Nulling the transducers keeps the tiltmeter output on scale at very high gains. The leveling mechanism is controlled by the Model 591 Motor Control Unit, which displays the X and Y tilt outputs and operates two DC motors inside the tiltmeter. Each motor activates a worm gear and a cam that independently adjust one transducer and then passively maintain it in the desired position. To adjust the transducers, you simply plug the Motor Control Unit into the tiltmeter switch box. The Model 591 Motor Control Unit is conveniently transportable from one tiltmeter to the next within an array, so only one unit will normally be required.

Model 510 has two components: the tiltmeter and an external switch box. The tiltmeter houses the transducers, signal conditioning electronics and transducer leveling mechanism within a fully submersible stainless steel body. The switch box contains the tiltmeter power switch, gain and filter switches, and a low-battery indicator light. Connections to your external power supply and recorder are made via a terminal strip in the switch box.

Remote Control Leveling
A remotely controlled leveling

EARTH TIDES MEASURED NEAR CALIFORNIA COAST

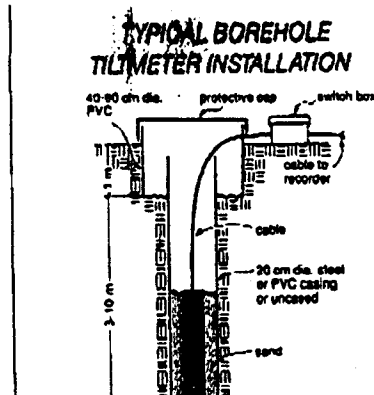
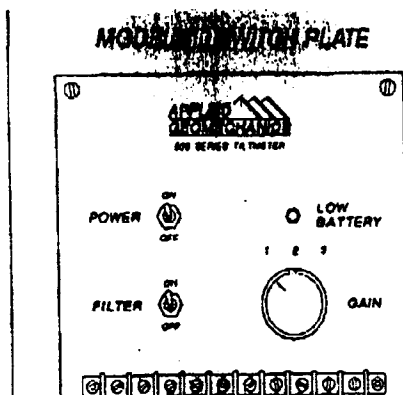


Model 510 Geodetic Borehole Tiltmeter

RESOLUTION	10 nanoradians or better.
SCALE FACTORS	Scale factors are selected with "GAIN" rotary switch in the switch box. Single-ended scale factors are 5, 50 and 500 mV/ μ radian (200, 20 and 2 μ radian/volt) in gain settings "1," "2" and "3" respectively. Differential scale factors are 10, 100 and 1000 mV/ μ radian (100, 10 and 1 μ radian/volt).
OUTPUT VOLTAGE RANGE	Approximately ± 7 VDC single-ended (± 14 VDC differential) in gain setting "1"; approximately ± 8 VDC single-ended (± 16 VDC differential) in gain settings "2" and "3." Both single-ended and differential analog outputs proportional to tilt are provided.
TILT RANGE	Mechanically adjustable through ± 3 degrees. Operating tilt range is approximately ± 900 micro-radians after leveling at gain setting "1."
OUTPUT FILTERS	Two 2-pole Butterworth filters. 90% settling times are 0.1 second (filter "OFF" position) and 30 seconds (filter "ON" position). Filter is selected with toggle switch in switch box.
BANDWIDTH	0-10 Hz in filter "OFF" position.
TEMPERATURE OUTPUT	10 mV/ $^{\circ}$ C (single-ended only), -40° to $+100^{\circ}$ C, $\pm 0.7^{\circ}$ C accuracy.
SCALE FACTOR TEMPERATURE COEFFICIENT	$+0.11\%$ per $^{\circ}$ C typical.
OUTPUT IMPEDANCE	270 ohms, short circuit and surge protected.
POWER REQUIREMENTS	$+11$ to $+15$ VDC and -11 to -15 VDC ($+20$ mA ($+15$ mA typical) and -10 mA (-7 mA typical)); 250 mV peak-to-peak ripple max. Low battery indicator on switch plate.
CONNECTIONS	19-pin quarter-turn connectors on tiltmeter cable and switch box. Standard cable length is 25 m (25 ft). Cable lengths to 1000 m or greater are available. External power and recorder connections are made via terminal strip inside switch box.
LEVELING	Independent leveling of X and Y transducers is performed using Model 591 Motor Control Unit. Transducers can be adjusted through mechanical range of $\pm 3^{\circ}$.
ENVIRONMENTAL	Tiltmeter and switch box: -25° to $+70^{\circ}$ C operational, -30° to $+100^{\circ}$ C storage. Wider ranges available. Tiltmeter is sealed with O-rings and is submersible. Switch box is gasketed and protected from light rain and splashes.
SIZE	Tiltmeter: 76 cm (3 inches) diameter \times 122 cm (48 inches). Switch box: 23 \times 20 \times 14 cm (9 \times 8 \times 5.5 inches).
WEIGHT	Tiltmeter: 18.7 kg (41 lb). Switch box: 1.8 kg (4 lb).
MATERIALS	Tiltmeter: Stainless steel tubing and fasteners, anodized aluminum sensor assemblies (internal), stainless steel gears, rubber O-rings. Cable: Polyurethane jacket, water-blocked, one overall foil shield and one overall braided shield. Switch box: Gray fiberglass, rubber gasket, lockable steel hasp.

Model 591 Motor Control Unit

CONTROLS	Power on/off, X-Y motor select, motor forward-reverse, motor pulse width, motor pulse rate, pulse activate.
DISPLAY CHANNELS	X and Y tilt displayed on dual 3 1/2 digit LCD displays, 12.7 mm (0.5 inch) digit height. X and Y leveling range limits indicated by LED illumination.
DISPLAY ACCURACY	0.2% of full scale (LCD displays).
POWER REQUIREMENTS	$+12$ volts for operating DC motors is supplied from tiltmeter switch box. One 9-volt battery behind front panel operates displays. LCD displays have low-battery indicators.
CONNECTIONS	14-pin connector and jumper cable to tiltmeter switch box.
ENVIRONMENTAL	0° to $+50^{\circ}$ C operational, -20° to $+70^{\circ}$ C storage. 0 to 80% humidity.
SIZE	28 \times 23 \times 20 cm (11 \times 9 \times 8 inches).
WEIGHT	2.1 kg (5 lb).
MATERIALS	Painted aluminum.



**APPLIED
GEOMECHANICS**

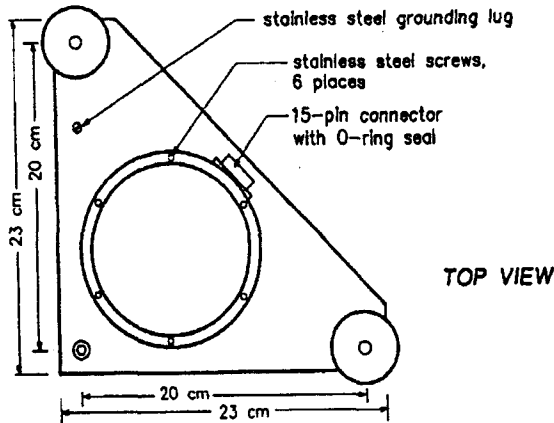
1336 Brommer Street
Santa Cruz, CA 95062 USA

Telephone: (408) 462-2801
FAX: (408) 462-4418

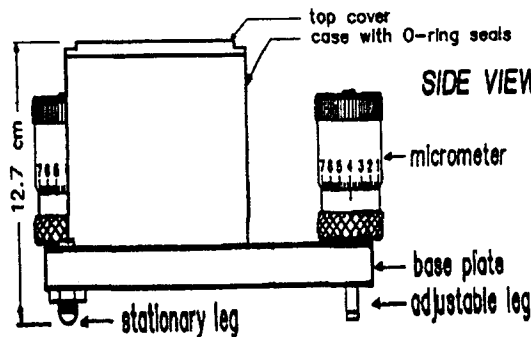
Specifications

RESOLUTION	10 nanoradians or better.
SCALE FACTORS	Scale factors are selected with "GAIN" rotary switch in the switch box. Single-ended scale factors are 5, 50 & 500 mV/ μ radian (200, 20 & 2 μ radian/volt) in gain settings "1," "2" and "3" respectively. Differential scale factors are 10, 100 and 1000 mV/ μ radian (100, 10 & 1 μ radian/volt).
OUTPUT VOLTAGE	Approximately ± 7 VDC single-ended (± 14 VDC differential) in gain setting "1"; approximately ± 8 VDC single-ended (± 16 VDC differential) in gain settings "2" and "3." Single-ended and differential analog outputs proportional to tilt are both provided.
TILT RANGE	Depends on gain setting. Approximately ± 1400 microradians at setting "1."
OUTPUT FILTERS	Two 2-pole Butterworth filters. 90% settling times are 0.1 second (filter "OFF" position) and 30 seconds (filter "ON" position). Filter is selected with toggle switch in switch box.
BANDWIDTH	0-10 Hz in filter "OFF" position.
TEMPERATURE OUTPUT	10 mV/ $^{\circ}$ C (single-ended only), -40° C to $+100^{\circ}$ C, $\pm 0.75^{\circ}$ C accuracy.
SCALE FACTOR TEMP. COEF.	+ 0.11% per $^{\circ}$ C typical.
OUTPUT IMPEDANCE	270 ohms, short circuit and surge protected.
POWER REQUIREMENTS	+ 11 to + 15 VDC and - 11 to - 15 VDC (\approx + 20 mA (+ 15 mA typical) and - 10 mA (- 7 mA typical); 250 mV peak-to-peak ripple max. Low battery indicator on switch plate.
CONNECTIONS	15-pin quarter-turn connectors on tiltmeter and switch box. Tiltmeter and switch box are connected by 3-meter (10 ft.) multiconductor cable. External power and recorder connections are made via terminal strip inside switch box.
LEVELING	Performed with two micrometers, each readable to 0.001 mm, or with two worm gears.
ENVIRONMENTAL	-25° C to $+70^{\circ}$ C operational, -30° C to $+100^{\circ}$ C storage. 0 to 100% humidity. Tiltmeter is sealed with O-rings.
SIZE	Tiltmeter: 23 x 23 cm (9.07 x 9.07 inches) x 12.7 cm (5.0 inches) high; 20 cm (7.87 inches) leg separation. Switch box: 23 x 20 x 14 cm (9 x 8 x 5.5 inches).
WEIGHT	Tiltmeter: 4.5 kg (10 lbs). Switch box: 1.8 kg (4 lbs).
MATERIALS	Tiltmeter: Anodized 6061-T6 aluminum; stainless steel legs and fasteners; rubber O-rings. Switch box: Gray fiberglass.

MODEL 520 TILTMETER

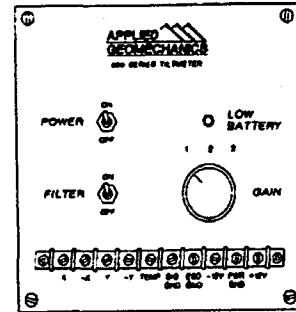


TOP VIEW



SIDE VIEW

MODEL 520 SWITCH PLATE



**APPLIED
GEOMECHANICS**

1336 Brommer Street
Santa Cruz, CA 95062 USA

Telephone: (408) 462-2801
TWX: 510 601 8310
FAX: (408) 462-4418

© 1989 Applied Geomechanics, Inc.
Printed in USA.



July 25, 1994

Prof. Rainer Weiss
M.I.T.
Physics Department
Room 20 B 145
Cambridge MA 02139

Dear Prof. Weiss:

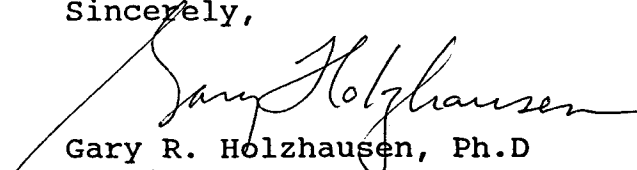
Thank you for requesting details about Applied Geomechanics automated movement sensing systems. Enclosed you will find information about specific options and applications.

If your work requires you to know whether, when and how a structure has moved, and to evaluate the consequences, we offer you state-of-the-art observation and tracking capabilities. Our affordable systems are both powerful and easy to use. Our systems and services are currently providing engineers and scientists worldwide with new levels of awareness, safety and project control.

For more details, feel free to call and ask for me or one of our applications specialists. We will be happy to discuss your specific requirements and provide recommendations or a detailed quotation.

Once again, we appreciate hearing from you and look forward to serving you on your next project.

Sincerely,


Gary R. Holzhausen, Ph.D
President

GRH:jj

Enclosures

*Good speaking with you
today. Hope your proposal
is successful.*

BH

FAX TRANSMITTAL

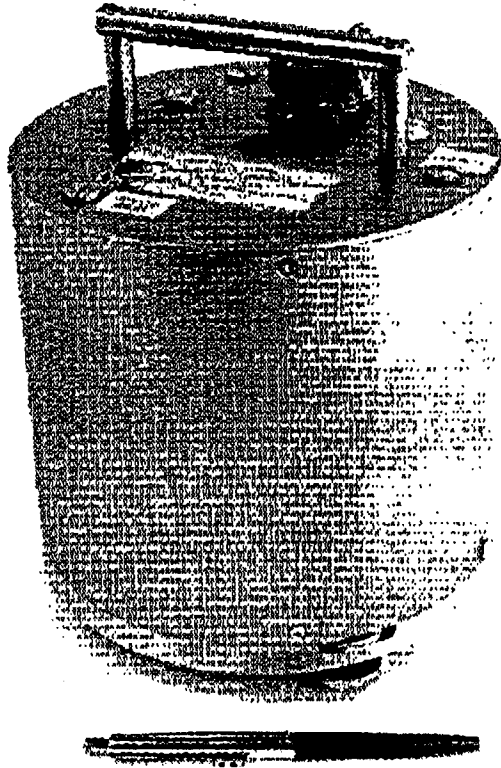
TO: David Shoemaker PAGES TO FOLLOW: 7
 ORG: MIT Ctr for Space Research DATE: 19 July 94
 FAX: 617-253-2014 PHONE: _____
 FROM: Steve Pauly, Digital Technology Associates
 REF: Seismic instr. for LIGO

Thanks for your call!

Pricing, FOB Destination:

<u>CMB-40T</u>	<u>6334.</u>	} <u>10,926.</u>
<u>+12V operation</u>	<u>336.</u>	
<u>DM16/3</u>	<u>4256.</u>	
<u>CMB-3T</u>	<u>13104.</u>	

Guralp CMG-40T
Broadband Seismometer



- Capacitive displacement feedback
- Three-component differential velocity outputs
- Short-period response to 50Hz
- Long-period response to 10, 20, or 30 sec
- Mass clamp not required
- Mass centering not required
- DC-offset adjustment included
- Breakout Box and Handheld Control Unit Available
- 16 and 24-bit digitizer modules, and a storage/acquisition module are available

The Guralp CMG-40T three-component broadband seismometer provides high dynamic range broadband velocity response for a variety of applications. The standard frequency band is 30 sec to 50 Hz with options for long-period response to 20 sec or 10 sec. While the CMG-40 noise floor is higher than that of the CMG-3ESP and CMG-3T sensors, the moderate price makes the instrument an attractive selection for several applications:

- Portable and rapid array mobilizations in which reliability, low power, and installation simplicity are important
- Permanent installation at sites which do not have seismic background close to the USGS Low Noise Model
- Short to medium term installations in which vault temperature and tilt are not as well controlled as for permanent sites

Feb 1994

DIGITAL
TECHNOLOGY
Associates, Inc.

1330-A Galaxy Way, Concord, CA 94520
Tel: (510) 682-2508 Fax: (510) 682-2072
e-mail: dta@netcom.com

CMG-40T TRANSDUCER SPECIFICATIONS

Outputs and Response

Standard velocity output:	800 V/m/s
Optional high-gain output:	8000 V/m/s
Standard frequency band:	0.033 (30 sec) to 50 Hz
Optional frequency bands:	0.050 (20 sec) to 50 Hz 0.100 (10 sec) to 50 Hz
Peak output:	± 10 V (20 V p-p) standard ± 4.5 V (9 V p-p) optional
Clip level and self noise:	See Figure 4 in Reference Data

Controls

External calibration enable & input:	Directly to the sensor connector
DC null adjustment:	Screw adjustment thru case
Optional remote DC adjustment:	Remote operation via dc motors

Power for 3-components

For standard (10 V) output:	± 26 mA @ ± 12 Vdc or + 50 mA @ +12 Vdc
For optional (4.5 V) output:	+ 20 mA @ +12 Vdc

Physical

Case diameter:	6.625"
Case height:	6.5"
O-ring seals:	In lid, base, and portholes
Carrying handle:	On top cap
Cable connection:	Multipin connector on top cap
Lowest spurious resonance:	400Hz
Operating temperature range:	-10 to +65 deg C
Temperature sensitivity:	< 0.6 V/10 deg C
Pressure jacket & cap material:	Stainless
Weight:	20 lbs (9 kg)

Single-component Specifications (models CMG-40V and CMG-40H)

Case diameter:	3.25"
Case height:	6.5"
Cable:	Glass-sealed in base, 1m with connector
Weight:	3 lbs

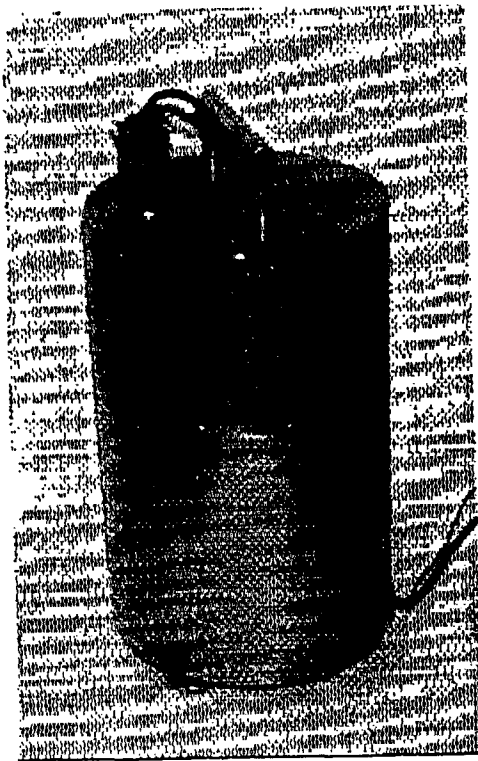
Options, Accessories, & Reference Data

Refer to separate document for Handheld Control Unit, Pascal Universal Breakout Box, and sensor noise information. Refer to separate documents for digitizer and storage module information.

Downhole Accessories

Refer to separate brochure, 'Guralp Downhole Systems for 7-inch and 4-inch Holes'

Guralp CMG-DM16 and CMG-DM24 16 and 24-bit Digitiser Modules



CMG-40T with Digitiser Module

These low noise 16 and 24-bit digitiser modules mate with the Guralp broadband seismometers to provide an integrated sensor/digitiser.

Advantages of the digitiser within the sensor housing include:

- The clean, isolated, pressure and temperature stable sensor environment is ideal for a wide-dynamic range digitiser
- Sensor output cannot be contaminated with external noise, as the output is in digital form
- Wiring and connections between sensor and digitiser are minimized
- Sensor outputs, transfer function, and system responsivity cannot be confused by cable misconnection

Features:

- The DM modules can be added to existing CMG-3ESP, 3T or 40T seismometers
- The CMG-DM16 provides three standard gain and three high-gain 16-bit signals and the CMG-DM24 provides three 24-bit signals, both with no channel skew
- A 20 MHz Motorola M56001 DSP controls acquisition and communication
- Up to 16 Mega sample intermediate storage can be provided in low power RAM
- A causal (non-FIR) decimation filter is used.
- Output is RS232, RS422, Optical, or DPSK/FSK compatible
- Connects to CMG-SAM Storage & Acquisition Module or to user's PC

Nov 1993

DIGITAL
TECHNOLOGY
Associates, Inc.

1330-A Galaxy Way, Concord, CA 94520

Tel: (510) 682-2508

Fax: (510) 682-2072

DIGITISER SPECIFICATIONS**CMG-DM16****CMG-DM24****Inputs**

Basic channels
 High gain channels
 Add'l fast channel
 Environmental channels
 Std. Input (DM Integral with sensor)
 Opt. input (DM external to sensor)
 Input voltage range
 Optional configurations
 Single-channel digitiser
 Three-channels multiplexed
 Four-channel digitiser

3 @ 16 bits
 3 @ 16 bits
 1 @ 16 bits
 16 @ 16 bits
 Single ended
 Differential
 ± 10 V

3 @ 24 bits
 Not applicable
 Optional 3@24 or 3@16 bits
 16 @ 24 bits
 Single ended
 Differential
 ± 10 V

Model DM16/1
 Model DM16/3M

Model DM24/1
 -
 Model DM24/4

Digital Signal Processor

Type and speed
 Hardware sampling rate
 Selectable sample rates
 Anti-alias filters
 Decimation filters
 Out of band rejection
 In band ripple
 Trigger modes

M56001, 20 MHz
 2 kHz
 1, 10, 20, 50, 200 sps
 3 pole
 WDF (wave digital) or FIR
 140 dB
 -140 dB
 STA/LTA

M56001, 20 MHz
 2 kHz
 1, 10, 20, 50, 200 sps
 3 pole
 WDF or FIR
 140 dB
 -140 dB
 STA/LTA

Digitiser Performance

Standard output format
 Optional output format
 Noise-free resolution, p-p, 0.01 to 1 Hz
 Noise-free resolution, p-p, 1 to 200 Hz
 Distortion
 Absolute accuracy, standard
 Absolute accuracy, optional
 Type

16 bits
 24 bits (18-bits noise-free)
 16 bits (96 dB)
 16 bits (96 dB)
 0.001%
 0.5%
 0.1%
 Successive
 approximation
 3-C low-gain signals

24 bits
 Not applicable
 24 bits (144 dB)
 23 bits (138 dB)
 TBD
 0.5%
 0.1%
 5th order single bit
 low pass noise shaper
 3-C signals

Analog transducer outputs

Clock

Standard oscillator
 Optional oscillator (oven-controlled)
 Interface for external receiver
 Sync to external receiver

2×10^{-7}
 5×10^{-8}
 GPS, DCF, MSF
 < 500 usec

2×10^{-7}
 5×10^{-8}
 GPS, DCF, MSF
 < 500 usec

RAM Storage

Optional RAM, megasamples
 Corresp. 3-ch capacity @ 50 sps

1, 2, 4, 8, 16 MS
 36, 72, 144, 288, 576 min

1, 2, 4, 8, 16 MS
 36, 72, 144, 288, 576 min

Power

Customer power supply
 Current at 12 Vdc with 4 MS RAM
 Additional current for OCVXO option

+ 10 to 36 Vdc
 120 mA
 80 mA

+ 10 to 36 Vdc
 120 mA
 80 mA

Physical

Diameter
 Height

6.6 in
 4 in

6.6 in
 4 in

Output Options

RS232
 RS422
 Optical
 DPSK/FSK

100 ft
 500 ft
 10 km
 10 km

100 ft
 500 ft
 10 km
 10 km

HCU/PUBB/Sensor/Recorder Interconnection

Interconnection of a sensor, Breakout Box, and recorder is shown in Figure 2. During checkout, installation and subsequent testing the portable Handheld Control Unit connects to the PUBB, as shown in Figure 3.

HCU-RN for CMG-40T

This control unit includes all of the standard HCU functions plus a toggle switch and component selector to null remotely the individual sensor offsets of the CMG-40T. In DC null mode, the mass position is shown on the HCU-RN analog meter. The HCU-RN can be used with CMG-3T and CMG-3ESP sensors, however the remote null function is not applicable for those units.

→ Noise Levels

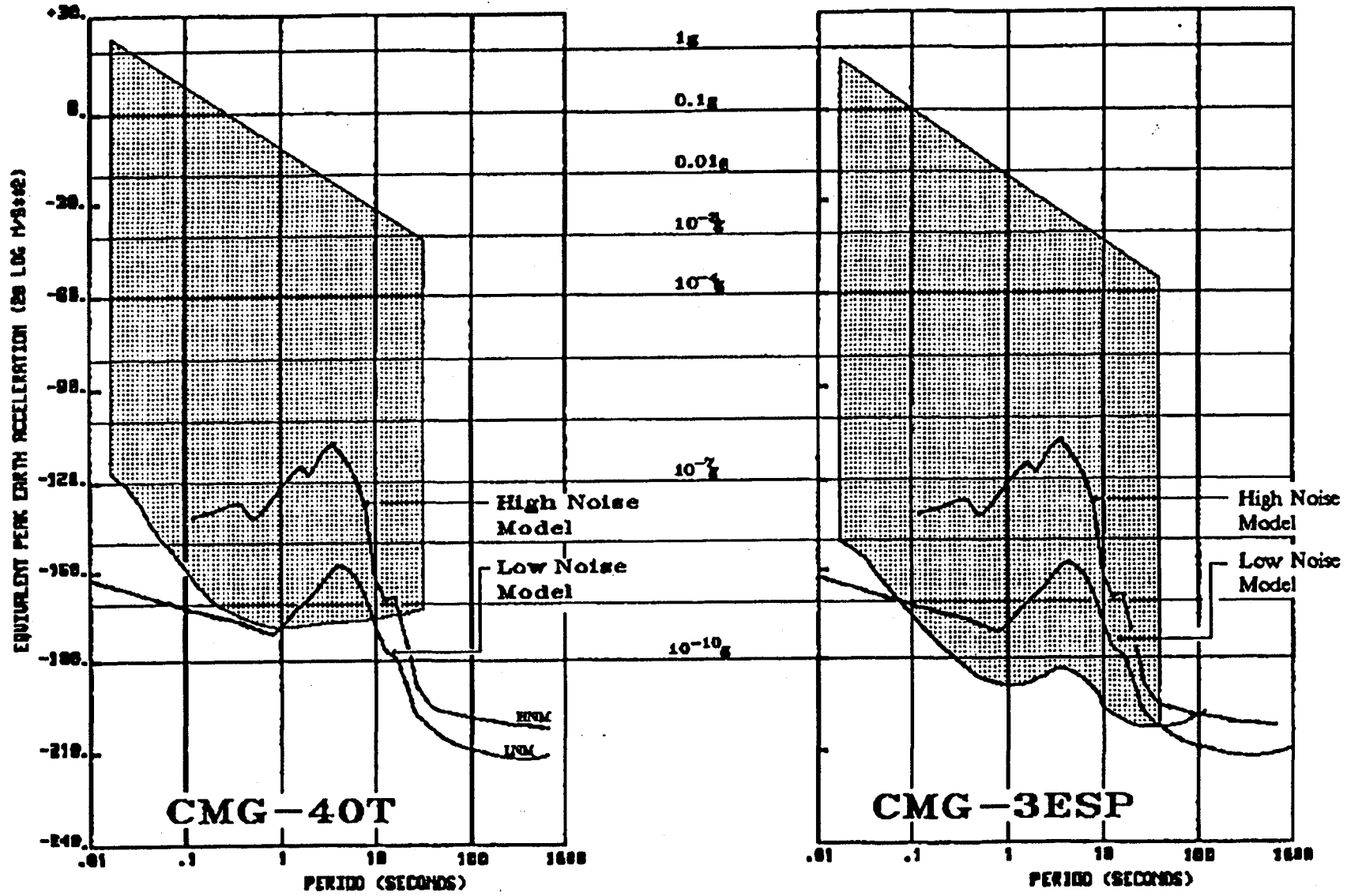
The saturation and the self-noise (non-coherent noise power spectra) data for the Guralp broadband seismometers and accelerometers are shown in Figures 4, 5, and 6. The chart noise levels are peak-to-peak estimates, in m/s^2 , equal to six times the measured RMS acceleration values for a 1/3 octave bandwidth (the USNSN procedure). The USGS Low Noise Model (LNM) is a composite from the best stations in the world at their quietest. The USGS High Noise Model (HNM) is representative of noisy sites (GDSN) at their best.

Downhole Accessories

A downhole lock, lock installer, waterproof cable, and winch/mast system are available. Housings are available for shallow, deep, and hot installation conditions. Refer to the Downhole Systems document.

PUBB-HG Breakout Box with Standard and High-gain Outputs

In addition to the PUBB features, this breakout box amplifies the standard gain outputs and provides high-gain outputs. The standard gain factor (10X) can be modified in the PUBB-HG (a resistor change) by the user.



NOISE , CLIP, AND BANDWIDTH RANGES FOR GURALP SENSORS, Figure 4

Statement of Work for Ambient Ground Vibration Measurements

LIGO Project
2/15/94

TASK I: Characterizing the Ground Motion Before Building Construction at the LIGO Sites

The contractor shall furnish all necessary labor and materials to study, measure, record and document the ambient ground vibration at Hanford Reservation, Washington. The site is intended for construction of two detector facilities for Laser Interferometer Gravitational-Wave Observatory (LIGO). In the performance of these effort the contractor shall:

1. Make a recommendation on the type of sensors and recording equipment needed for completion of the task. The sensors and recording equipment shall cover the frequency band from 0.1 Hz to 100 Hz. System noise shall be at least a factor of 10 below the LIGO standard spectrum (see Appendix A) at all frequencies.
2. Do an overall system calibration including sensor and recorder. The accuracy of results should be $\pm 10\%$ throughout the measurement frequency band.
3. Provide an estimate of the contributions to the measured spectrum from system noise and from airborne acoustic noise for each sensor.
4. Specify the method of coupling the sensors to the ground and the scheme for screening out surface and acoustic effects.
5. Take measurements in 3 orthogonal directions at the corner station and at the two end stations. The measurements in the horizontal directions shall be taken in the directions parallel to each of the LIGO arms.
6. Specify a plan for obtaining the variation of vibration levels over an extended period that covers noisy, typical and quiet times.
7. Perform all measurements using the same techniques and equivalent instrumentation.

Deliverables For TASK 1

All plots of power spectra shall be done in units of $\frac{m}{\sqrt{Hz}}$, in a frequency band between 0.1 to 100 Hz and with several hundred lines of resolution per spectrum. All plots displaying sample height distribution data shall be displayed as histograms with ordinate units of $\log(N)$, where N is the number of samples, and abscissa units of meters, unless otherwise specified.

1. **Phase 1:** Documentation and plots described in Phase 1 shall be submitted to LIGO representative for review and approval before the actual measurements are conducted at the LIGO site.
 - A. Documentation of system calibration
 - B. Calibrated power spectra showing estimate of "sensor noise" due to system noise and airborne acoustic noise for each sensor type.
 - C. Calibrated ground noise power spectra taken at any convenient location for contractor using simple mounting scheme.
2. **Phase 2:** Documentation and plots described in Phase 2 shall be submitted to LIGO representative for review and approval very soon after initial measurements at LIGO site are underway.
 - A. Two sample plots of calibrated ground noise power spectra taken during first set of measurements at LIGO site. One sample plot shall show vertical ground noise and one sample plot shall show horizontal ground noise taken at the first measurement site.
 - B. Time series data taken over a minimum of 24 hours shall be filtered in 2 or 3 bands (e.g. 0.1–1.0 Hz, 1.0–10 Hz and 10 –20. Hz). Each set of filtered data shall be plotted as a histogram to show the normal sample height distribution. Four sample histograms shall be submitted showing vertical and horizontal data taken at the first measurement site and filtered in both frequency bands.
3. **Phase 3:** Results of measurements shall be summarized in a report with 3 copies submitted to LIGO representative. The report shall include all of the plots and documentation described in Phase 1 and the plots and documentation described below. Raw data used to generate plots in both the time domain and frequency domain shall be copied to computer media (e.g. disk) in agreed upon format and submitted to LIGO representative. Format shall be documented.
 - A. Set of calibrated power spectra plots showing the variation of the background seismic noise taken over at least a 24 hour period (e.g.

spectra taken every hour in a 24 hour period). Should include a set of plots for each sensor orientation and each measurement site.

- B. Calibrated power spectra plots showing Max, Min and average ground noise measurements. An example of Max and Min power spectra measurements for the Caltech 40 M Laboratory is given in Figure 1. Method for calculating Max and Min power spectra is to be agreed upon with LIGO representative. There should be a single plot for each sensor orientation and each measurement site.
- C. Time series data taken over a minimum of 24 hours shall be filtered in 2 or 3 bands (e.g. 0.1–1.0 Hz, 1.0–10 Hz and 10 –20. Hz). Each set of filtered data shall be plotted as a histogram to show the normal sample height distribution. There should be a histogram for each sensor orientation, each measurement site and each frequency band.
 - a. After viewing the above set of data, LIGO representative will make decision whether to plot histogram showing event rate versus time (e.g. might choose $\text{Event} = (\text{sample with height} > 3\sigma)$).

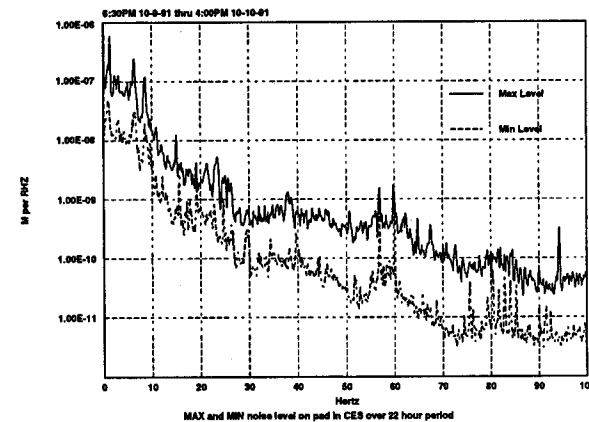


Figure 1. Example plot showing Max and Min power spectra over a 22 hour period Caltech taken in the 40 M Laboratory.

TASK 2: Monitoring Effects of Wind on Buildings

In the performance of these effort the contractor shall:

1. Identify a building for conducting wind effect measurements and review the choice with LIGO representative. It should be as close to the LIGO corner station as possible (see Appendix B).
2. Acquire wind velocity sensor.
3. Specify method of coupling the ground motion sensors to the floor of the building and a simple scheme for screening out acoustic effects. Specify method for mounting wind velocity sensor and location for mounting.
4. Take measurements in vertical and two horizontal direction at two different locations in building.
5. Specify a plan for obtaining ground measurements on the floor of the building that coincide with windy, average and calm times. We are looking for correlations between wind speed and ground motion in the building, so it is important to include in the plan how we will know whether the observed noise is due to wind or other external disturbances such as traffic of machines (e.g. might be done in an abandoned building or at night).

Deliverables for TASK 2

All plots of power spectra shall be done in units of $\frac{m}{\sqrt{Hz}}$ and with several hundred lines of resolution per spectrum. The appropriate bandwidth for displaying the data (e.g. 0.1–20 Hz or possibly 0.1–100 Hz) shall be determined during the measurement process. All plots displaying sample height distribution data shall be displayed as histograms with ordinate units of $\log(N)$, where N is the number of samples, and abscissa units of meters.

Results of measurements shall be summarized in a report with 3 copies submitted to LIGO representative. The report shall include all of the plots and documentation described below. Raw data used to generate plots in both the time domain and frequency domain shall be copied to computer media (e.g. disk) in agreed upon format and submitted to LIGO representative. Format shall be documented.

1. Set of calibrated power spectra plots showing the variation of the background seismic noise taken over a range of windy to calm times (e.g. spectra taken every hour in a 24 hour period). Average wind velocity, measured simultaneously with power spectra, should be annotated on each trace. There should be a set of plots for each measurement site and each sensor orientation.
2. Calibrated power spectra plot showing ground motion during Max, Min and average wind excitation. Average wind velocity, measured simultaneously with power spectra, should be annotated on each trace. There should be a single plot for each measurement site and each sensor orientation
3. Simultaneous time series data of ground motion and wind velocity taken over equal stretches of time that show variation of peak ground motion due to the variation in wind speed (e.g. time series data of ground motion sensor and wind velocity sensor taken for 1 minute stretches during times of high, low and average wind excitation). Ground motion data shall be filtered in 2 or 3 frequency bands (e.g. 0.1–1.0 Hz, 1.0–10. Hz, and 10.-20. Hz). Each set of filtered data shall be plotted as a histogram to show the normal sample height distribution. The wind velocity data taken simultaneously shall also be plotted and annotated in an agreed upon format. There should be a histogram for each sensor orientation, each mounting location and each frequency band.

TASK 3: Monitoring Effects of Traffic at Corner Station

In the performance of these effort the contractor shall:

1. Conduct a set of four tests at the corner station to show the effect of different levels of traffic on Route 10:
 - Test 1. Measurements at corner station when no traffic on Route 10
 - Test 2. Measurements at corner station when a single car drives past corner station on Route 10
 - Test 3. Measurements at corner station when a single large truck drives past corner station on Route 10
 - Test 4. Measurements at corner station when heavy traffic is driving past corner station on Route 10
2. Take measurements in 3 orthogonal directions for each test. The measurements in the horizontal directions shall be taken in the directions parallel to each of the LIGO arms.

Deliverables for TASK 3

All plots of power spectra shall be done in units of $\frac{m}{\sqrt{Hz}}$ and with several hundred line of resolution per spectrum. The appropriate bandwidth for displaying the data (e.g. 0.1–20 Hz or possibly 0.1–100 Hz) will be determined during the measurement process. All plots displaying sample height distribution data shall be displayed as histograms with ordinate units of $\log(N)$, where N is the number of samples, and abscissa units of meters.

Results of measurements shall be summarized in a report with 3 copies submitted to LIGO representative. The report shall include all of the plots and documentation described below. Raw data used to generate plots in both the time domain and frequency domain shall be copied to computer media (e.g. disk) in agreed upon format and submitted to LIGO representative. Format shall be documented.

1. Calibrated power spectra plot with 4 traces; the four traces are ground motion with single car excitation, ground motion with single truck excitation, ground motion with heavy traffic excitation and ground motion with no excitation at the corner station. There should be a plot for each sensor orientation.
2. Time series data of ground motion at corner station for each excitation source (i.e. single car, single truck, heavy traffic, and no excitation). Ground motion data shall be filtered in 2 or 3 frequency bands (e.g. 0.1–1.0 Hz, 1.0–10. Hz, and 10.-20. Hz) and then processed to show the normal sample height distribution in each band for each stretch of data taken. There should be a histogram for each sensor orientation and each frequency band.

TASK 4: Monitoring Vibration Levels at Corner Station as a Function of Distance from an Excitation Source

In the performance of these effort the contractor shall:

1. Conduct a set of approximately 3–4 tests that show the effect of increasing the radius of an excitation source from the corner station. The earth-moving equipment used during the rough-grading will provide the excitation source. Measurements shall be taken at the corner station while the earth-moving equipment is active at 3 or 4 different locations (e.g. 0.5 km, 1 km, 2 km and 4 km from the corner station) during the rough-grading along one of the arms. The contractor shall decide at the number and location of the test sites, depending on whether signal is observed at the corner station.
2. Take measurements in vertical direction and the horizontal direction parallel to the arm where the rough-grading is occurring.
3. Measurements taken corresponding to the different distances from the excitation source shall have the same source strength (e.g. all measurements have 4 bulldozers moving earth as the excitation). The number and size of the earth-moving equipment in motion during each of the measurements should be recorded.

Deliverables for TASK 4

All plots of power spectra shall be done in units of $\frac{m}{\sqrt{Hz}}$ and with several hundred line of resolution per spectrum. The appropriate bandwidth for displaying the data (e.g. 0.1–20 Hz or possibly 0.1–100 Hz) shall be determined during the measurement process. All plots displaying sample height distribution data shall be displayed as histograms with ordinate units of $\log(N)$, where N is the number of samples, and abscissa units of meters.

Results of measurements shall be summarized in a report with 3 copies submitted to LIGO representative. The report shall include all of the plots and documentation described below. Raw data used to generate plots in both the time domain and frequency domain shall be copied to computer media (e.g. disk) in agreed upon format and submitted to LIGO representative. Format shall be documented.

1. Set of calibrated power spectra traces on a single plot showing measurements at corner station corresponding to rough-grading excitation at different radii from corner station. There shall be a plot for each sensor orientation.
2. Time series data of ground motion at corner station. Ground motion data shall be filtered in 2 or 3 bands (e.g. 0.1–1.0 Hz, 1.0–10. Hz and 10–20 Hz) and then processed to show the normal sample height distribution in each band. There shall be a histogram for each sensor orientation, each frequency band and each different excitation source.

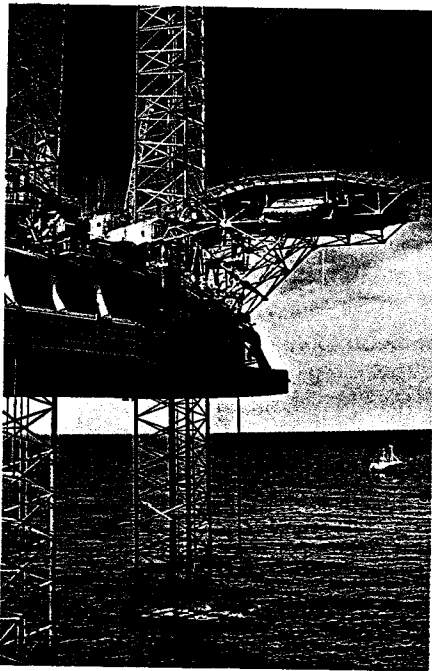
Appendix A: Definition of LIGO Standard Spectrum

The design spectrum that is used to describe the ambient ground noise at the LIGO site is listed in the following table.

FREQUENCY	AMPLITUDE
0.1 - 1.0 Hz	$\frac{10^{-8}}{f^2} \frac{m}{\sqrt{Hz}}$
1.0 - 10 Hz	$10^{-9} \frac{m}{\sqrt{Hz}}$
> 10 Hz	$\frac{10^{-7}}{f^2} \frac{m}{\sqrt{Hz}}$

Appendix B: Description of LIGO Corner Station

The corner station will consist of high bay structure which will house the vacuum equipments and lasers, and attached low bay structure for offices and shops. The high bay area will be a single story structure of different heights with a maximum height of about 55 feet and floor area of about 60,000 square feet. It will be L-shaped with legs about 300 feet long by 120 feet wide. The building will be of steel frame construction with interior and exterior walls made of double-skinned, insulated foam-core panels. It will be constructed on a thick reinforced concrete mat foundation.



Determine pitch, roll and level

The dual-axis Model 900 is an inexpensive, gravity-referenced clinometer (tiltmeter) with wide dynamic range. Its small size and high precision make it a versatile choice for many measurement and control applications.

Model 900 measures angular position with respect to the stablest of all external references: the vertical gravity vector. Its advanced design assures high repeatability over a standard 40 degree measurement span (90 degree optional span). Model 900 also features a wide input voltage range and signal conditioned analog



Motion control for factory automation

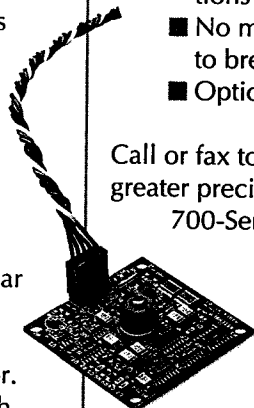
outputs. Just install Model 900 and connect it to your voltmeter or data acquisition system. You are ready to begin your measurements!

The sensing element within Model 900 is a glass vial half-filled with a conductive liquid. When the sensor is level, fluid covers five internal electrodes to equal depths. When the sensor tilts, the depth of fluid on each electrode changes, altering the electrical resistance between matched pairs of electrodes. Model 900's surface-mount electronics measure these changes, converting them to DC outputs proportional to the tilt angle.

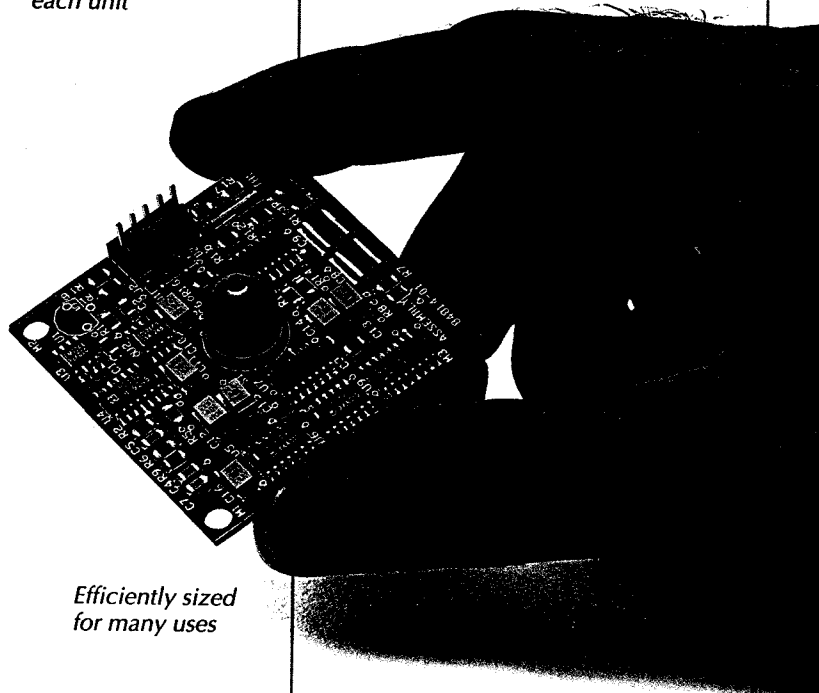
Key features include:

- Measures rotation in two orthogonal vertical planes
- Detailed 21-point calibrations supplied for each axis
- No mechanical moving parts to break or wear out
- Optional temperature sensor.

Call or fax today for a quotation. For greater precision, ask about our 700-Series tiltmeters.



Prewired connector supplied with each unit



Efficiently sized for many uses

APPLIED GEOMECHANICS

Model 900 Biaxial Clinometer

Use Model 900 for:

- Factory automation and robotics
- Drilling and mining machinery
- Construction equipment
- Ships, buoys, ROVs, towfish
- Land vehicles
- Aircraft
- Antennae
- Any machine or structure

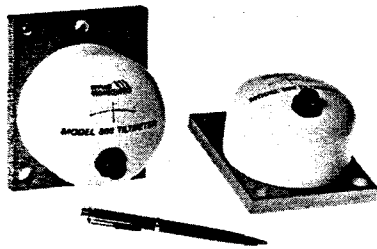
DID IT MOVE, OR DIDN'T IT?

Now it's easier than ever to find out!

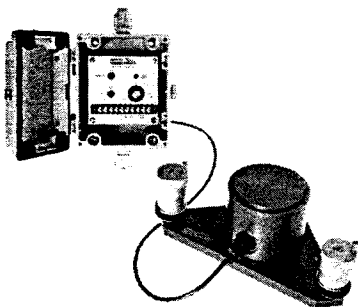
Applied Geomechanics manufactures the world's most sensitive tiltmeters and gravity-referenced angle measurement devices. Choose among our 800-, 700- and 500-Series instruments to meet your full range of movement monitoring requirements. Rugged and field-proven, our instruments are used for structural behavior testing, automated movement detection and alarms, and long-term monitoring. They're ideal for machine positioning and control, and for geophysical research.

Our tiltmeters incorporate electrolytic tilt transducers as the internal sensing elements. Angular movement is referenced to the unchanging vertical gravity vector, eliminating the need for a fixed external datum.

Applied Geomechanics tiltmeters have internal signal conditioning and drive long cable lengths. Unconditioned



Model 800 Tiltmeters



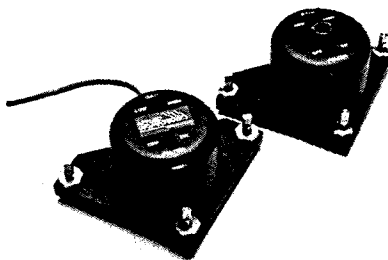
Model 520 Tiltmeter

tilt sensors and stand-alone signal conditioners are also available.

Our instruments are easily interfaced to any standard control or data acquisition system. Contact us about our battery-powered data loggers or PC-controlled real-time data acquisition. Applied Geomechanics also provides system installation, operation and data reporting services.

800-Series Uniaxial Tiltmeters

Model 800 is an economical uniaxial tiltmeter for a wide variety of monitoring and measurement applications. Available in floor, wall or ceiling mount versions, it conveniently installs by bolting



Model 701 Platform Tiltmeters

For use on:

- Bridges
- Buildings
- Dams
- Foundations
- Retaining Walls
- Landslides
- Roofs
- Roadways
- Volcanoes
- Tanks
- Tunnels
- Turbines
- Test Equipment
- Pressure Vessels
- Any Machine or Structure

APPLIED GEOMECHANICS

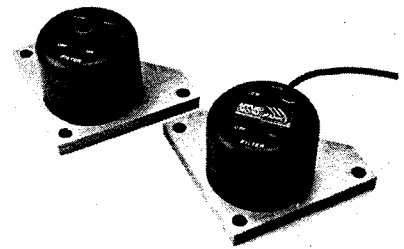
or clamping to any machine or structure. For on-the-spot reading, use the Model 870 Readout Module. This low-cost module plugs into any digital multimeter to display tilt and temperature.

700-Series Biaxial Tiltmeters

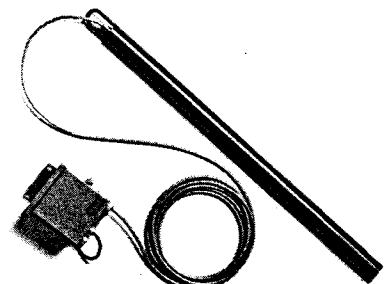
700-Series tiltmeters offer resolution to 0.1 microradian (0.02 arc second) and angular ranges to ± 60 degrees. Corresponding scale factors for these resolution and range values are 0.1 microradian/mV and 10 degrees/volt. The 700-Series includes tiltmeters, digital readout units, power supplies, recording stations and alarm systems.

500-Series Geodetic Tiltmeters

500-Series biaxial tiltmeters are for scientific and engineering projects demanding the ultimate in resolution and stability. The Model



Model 711 Surface Mount Tiltmeters



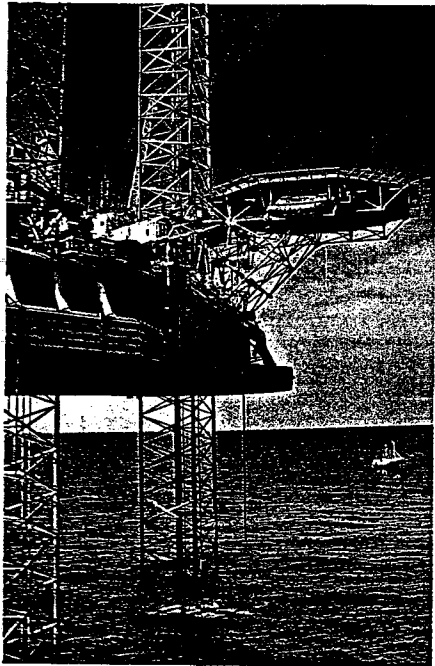
Model 722 Borehole Tiltmeter

Leading engineers and scientists require precise, reliable instrumentation to resolve their concerns about angular movement, position and structural deformation. When monitoring or measuring these parameters, count on Applied Geomechanics to help you answer the critical questions:

- *Did it move or didn't it?*
- *What is the measured change in position?*
- *Is corrective action needed?*

We manufacture and supply tiltmeters, tilt sensors, load cells, extensometers, data acquisition systems, and other high-quality instrumentation. At your request we'll perform installation services, training, data acquisition and data reporting. Call us today for assistance in selecting the best equipment – and technical services – for your testing and monitoring program.

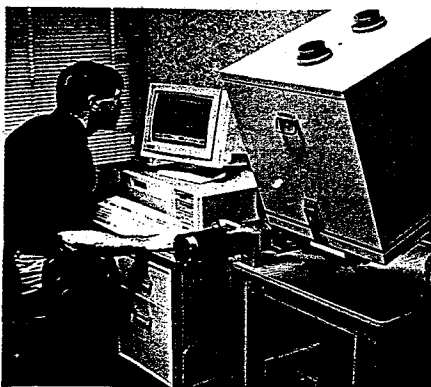
APPLIED 
GEOMECHANICS



Determine pitch, roll and level

The dual-axis Model 900 is an inexpensive, gravity-referenced clinometer (tiltmeter) with wide dynamic range. Its small size and high precision make it a versatile choice for many measurement and control applications.

Model 900 measures angular position with respect to the stablest of all external references: the vertical gravity vector. Its advanced design assures high repeatability over a standard 40 degree measurement span (90 degree optional span). Model 900 also features a wide input voltage range and signal conditioned analog



Motion control for factory automation

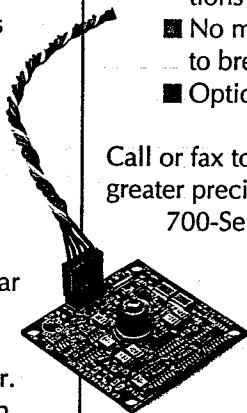
outputs. Just install Model 900 and connect it to your voltmeter or data acquisition system. You are ready to begin your measurements!

The sensing element within Model 900 is a glass vial half-filled with a conductive liquid. When the sensor is level, fluid covers five internal electrodes to equal depths. When the sensor tilts, the depth of fluid on each electrode changes, altering the electrical resistance between matched pairs of electrodes. Model 900's surface-mount electronics measure these changes, converting them to DC outputs proportional to the tilt angle.

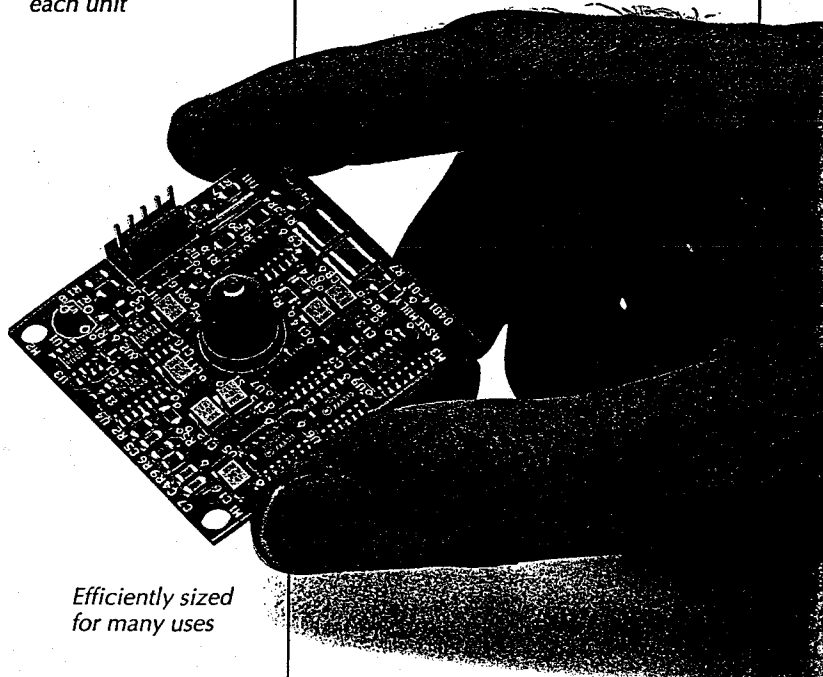
Key features include:

- Measures rotation in two orthogonal vertical planes
- Detailed 21-point calibrations supplied for each axis
- No mechanical moving parts to break or wear out
- Optional temperature sensor.

Call or fax today for a quotation. For greater precision, ask about our 700-Series tiltmeters.



Prewired connector supplied with each unit



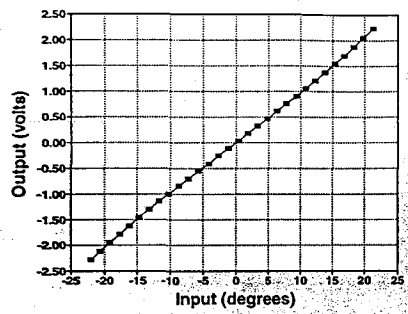
Efficiently sized for many uses

APPLIED GEOMECHANICS

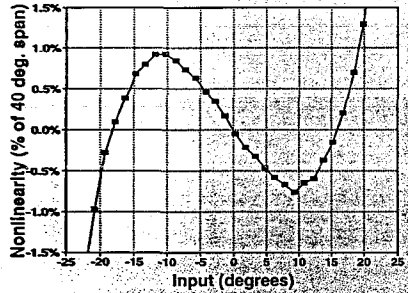
Model 900 Biaxial Clinometer

Use Model 900 for:

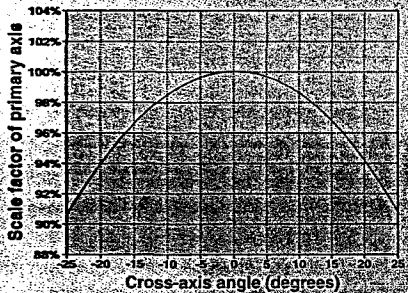
- Factory automation and robotics
- Drilling and mining machinery
- Construction equipment
- Ships, buoys, ROVs, towfish
- Land vehicles
- Aircraft
- Antennae
- Any machine or structure



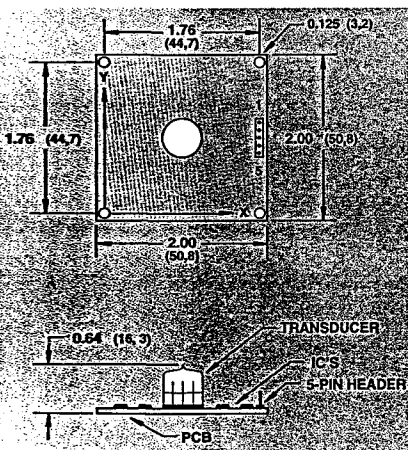
Typical calibration



Typical nonlinearity

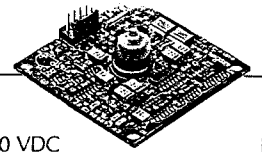


Cross-axis effect on scale factor



Model 900 dimensions, inches (mm)

Specifications



OUTPUT CHANNELS	Two orthogonal tilt angles, ± 2 VDC per channel (single-ended); one temperature channel (optional), -0.4 to $+1.0$ VDC
ANGULAR RANGE	Standard: ± 20 degrees (40 degree span). Optional: ± 45 degrees (90 degree span)
RESOLUTION	0.01 degree of arc
REPEATABILITY	< 0.02 degree of arc at constant temperature
HYSTERESIS	< 0.02 degree of arc
LINEARITY	± 20 degree unit: 1% over half span; 2.5% over full span. Use of factory-supplied polynomials can improve linearity by factor of 10
TEMPERATURE COEF.	Span: -0.05% of reading per $^{\circ}\text{C}$ typical
SCALE FACTORS	Tilt (± 20 degree unit): 10 degrees/volt $\pm 20\%$. Temperature: $0.1^{\circ}\text{C}/\text{mV}$, $\pm 0.75^{\circ}\text{C}$ accuracy
TIME CONSTANT, T	0.25 second; output is proportional to $1 - e^{-t/T} - 0.001e^{-t/5000T}$ where t is time in seconds
NATURAL FREQUENCY	10 Hz
OUTPUT IMPEDANCE	270 ohms, short circuit protected
POWER REQUIREMENTS	$+8$ to $+24$ VDC @ 7 mA; 250 mV peak-to-peak ripple max., reverse polarity protected
ENVIRONMENTAL	-10° to $+50^{\circ}\text{C}$ operating and storage, 0-80% humidity
SIZE & WEIGHT	$2 \times 2 \times 0.64$ inches ($51 \times 51 \times 17$ mm), 0.5 oz (15 grams); 18 inch (450 mm) cable with connector
MOUNTING	Four 0.125 inch (3.2 mm) no. 4 mounting holes, one in each corner
MATERIALS	Liquid-filled glass sensor, fiberglass PC board, unpotted assembly

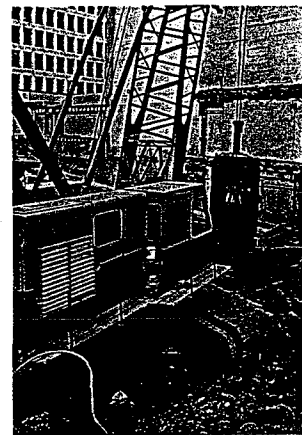
Angle conversion chart

	radians	degrees	arc minutes	arc seconds	μ radians
radians	1	57.30	3438	206265	10^6
degrees	0.01745	1	60	3600	17453
arc minutes	2.909×10^{-4}	0.01667	1	60	290.9
arc seconds	4.848×10^{-6}	2.778×10^{-4}	0.01667	1	4.848
μ radians	10^{-6}	5.730×10^{-5}	3.438×10^{-3}	0.2063	1

Ordering Information

Model 900	± 20 degree range
Model 900-T	Adds temperature sensor
Model 900-45	± 45 degree range
Model 900-45T	Adds temperature sensor

Position masts
and booms



APPLIED GEOMECHANICS

1336 Brommer Street
Santa Cruz, CA 95062 U.S.A.
Telephone: (408) 462-2801
FAX: (408) 462-4418

This document is accurate as of the time of publication. Applied Geomechanics may modify specifications without prior notice to reflect ongoing technical developments.

© 1993 by Applied Geomechanics Inc.

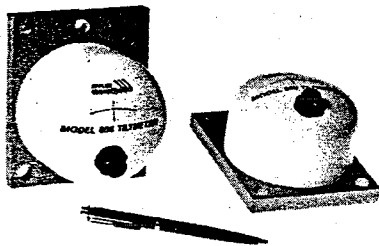
DID IT MOVE, OR DIDN'T IT?

Now it's easier than ever to find out!

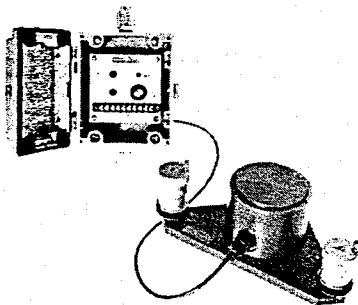
Applied Geomechanics manufactures the world's most sensitive tiltmeters and gravity-referenced angle measurement devices. Choose among our 800-, 700- and 500-Series instruments to meet your full range of movement monitoring requirements. Rugged and field-proven, our instruments are used for structural behavior testing, automated movement detection and alarms, and long-term monitoring. They're ideal for machine positioning and control, and for geophysical research.

Our tiltmeters incorporate electrolytic tilt transducers as the internal sensing elements. Angular movement is referenced to the unchanging vertical gravity vector, eliminating the need for a fixed external datum.

Applied Geomechanics tiltmeters have internal signal conditioning and drive long cable lengths. Unconditioned



Model 800 Tiltmeters



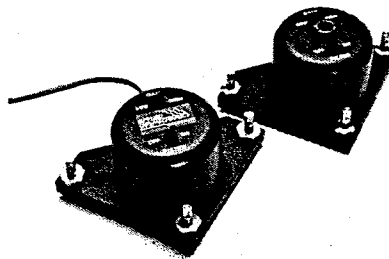
Model 520 Tiltmeter

tilt sensors and stand-alone signal conditioners are also available.

Our instruments are easily interfaced to any standard control or data acquisition system. Contact us about our battery-powered data loggers or PC-controlled real-time data acquisition. Applied Geomechanics also provides system installation, operation and data reporting services.

800-Series Uniaxial Tiltmeters

Model 800 is an economical uniaxial tiltmeter for a wide variety of monitoring and measurement applications. Available in floor, wall or ceiling mount versions, it conveniently installs by bolting



Model 701 Platform Tiltmeters

For use on:

- Bridges
- Buildings
- Dams
- Foundations
- Retaining Walls
- Landslides
- Roofs
- Roadways
- Volcanoes
- Tanks
- Tunnels
- Turbines
- Test Equipment
- Pressure Vessels
- Any Machine or Structure

APPLIED GEOMECHANICS

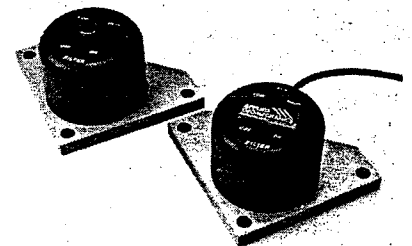
or clamping to any machine or structure. For on-the-spot reading, use the Model 870 Readout Module. This low-cost module plugs into any digital multimeter to display tilt and temperature.

700-Series Biaxial Tiltmeters

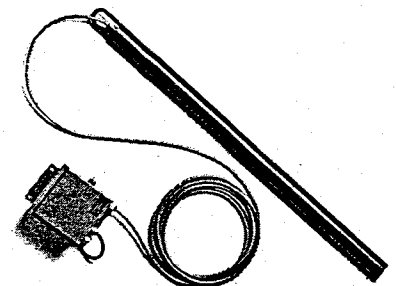
700-Series tiltmeters offer resolution to 0.1 microradian (0.02 arc second) and angular ranges to ± 60 degrees. Corresponding scale factors for these resolution and range values are 0.1 microradian/mV and 10 degrees/volt. The 700-Series includes tiltmeters, digital readout units, power supplies, recording stations and alarm systems.

500-Series Geodetic Tiltmeters

500-Series biaxial tiltmeters are for scientific and engineering projects demanding the ultimate in resolution and stability. The Model



Model 711 Surface Mount Tiltmeters



Model 722 Borehole Tiltmeter

520 Geodetic Platform Tiltmeter is operated on any flat, horizontal surface. The 520 system consists of the tiltmeter, a rugged fiberglass switch box and a 3-meter

interconnect cable. The Model 510 Geodetic Borehole Tiltmeter is used in shallow or deep boreholes to detect even the smallest earth or foundation movements.

A precision leveling mechanism in Model 510, remotely operated with the Model 591 Motor Control Unit, nulls the internal sensors when the tiltmeter is underground.

Specifications

800-SERIES TILTMETERS

RESOLUTION, REPEATABILITY	High-gain option: 0.0001 degree (1.75 microradian) or better; Wide-angle option: 0.004 degree (0.24 arc minute) or better.
ANGULAR RANGE	High-gain option: ± 0.5 degree; Wide-angle option: ± 20 degrees.
SCALE FACTORS	High-gain option: 0.1 degree/volt (single-ended) and 0.05 degree/volt (differential); Wide-angle option: 4.0 degrees/volt (single ended) and 2.0 degrees/volt (differential). Other scale factors may be special ordered.
LINEARITY	High-gain option: 2% at half range, 5% at full range; Wide-angle option: 1% at half range, 2% at full range.
OUTPUT VOLTAGE RANGE	± 5 VDC single-ended and ± 10 VDC differential (both are provided).
OUTPUT FILTER	2-pole Butterworth low-pass filter. Roll-off = 12 db per octave. 90% settling time = 5 seconds. Other settling times may be special ordered.
TEMPERATURE OUTPUT	0.1°C/mV (single-ended) over range of -40°C to +100°C.
OUTPUT IMPEDANCE	270 ohms, short circuit and surge protected.
POWER REQUIREMENTS	+75 to +16 VDC and -75 to -16 VDC @ 6 mA typical; 250 mV peak-to-peak ripple max.
ENVIRONMENTAL	-25°C to +70°C operational, -30°C to +100°C storage. 0 to 100% humidity.
WEIGHT	1.4 kg (3 lbs).
MATERIALS	Base plate: anodized 6061-T6 aluminum. Cover: PVC or ABS plastic. Seals: rubber, silicon rubber.

700-SERIES TILTMETERS

RESOLUTION	To 0.1 microradian (0.02 arc second) depending on scale factors chosen.
REPEATABILITY	To 1 microradian (0.2 arc second), depending on scale factors chosen.
ANGULAR RANGE	To ± 60 degrees, depending on scale factors chosen.
SCALE FACTORS	Each tiltmeter has two switchable scale factors (gains). Scale factors from 25 microradians/volt (40 mV/microradian) to 10 degrees/volt (0.1 volt/degree) are available.
LINEARITY	2% of full-scale range typical.
OUTPUT VOLTAGE RANGE	± 8 VDC single-ended and ± 16 VDC differential (both are provided).
OUTPUT FILTERS	Each tiltmeter has two switchable low-pass filters. Roll-off = 6 db/octave. Standard settling times = 0.1 sec. and 30 sec.
BANDWIDTH	0-10 Hz using 0.1-sec. filter.
TEMPERATURE OUTPUT	0.1°C/mV (single-ended) over range of -40°C to +100°C.
OUTPUT IMPEDANCE	270 ohms, short circuit and surge protected.
POWER REQUIREMENTS	+11 to +15 VDC and -11 to -15 VDC @ +11, -6 mA typical; 250 mV peak-to-peak ripple max.
ENVIRONMENTAL	-25°C to +70°C operational, -30°C to +100°C storage. Water resistant and submersible models are available.
WEIGHT	23 g (0.8 oz) to 6.8 kg (15 lbs), depending on model.
MATERIALS	Stainless steel or anodized aluminum. Platform tiltmeters have invar legs.

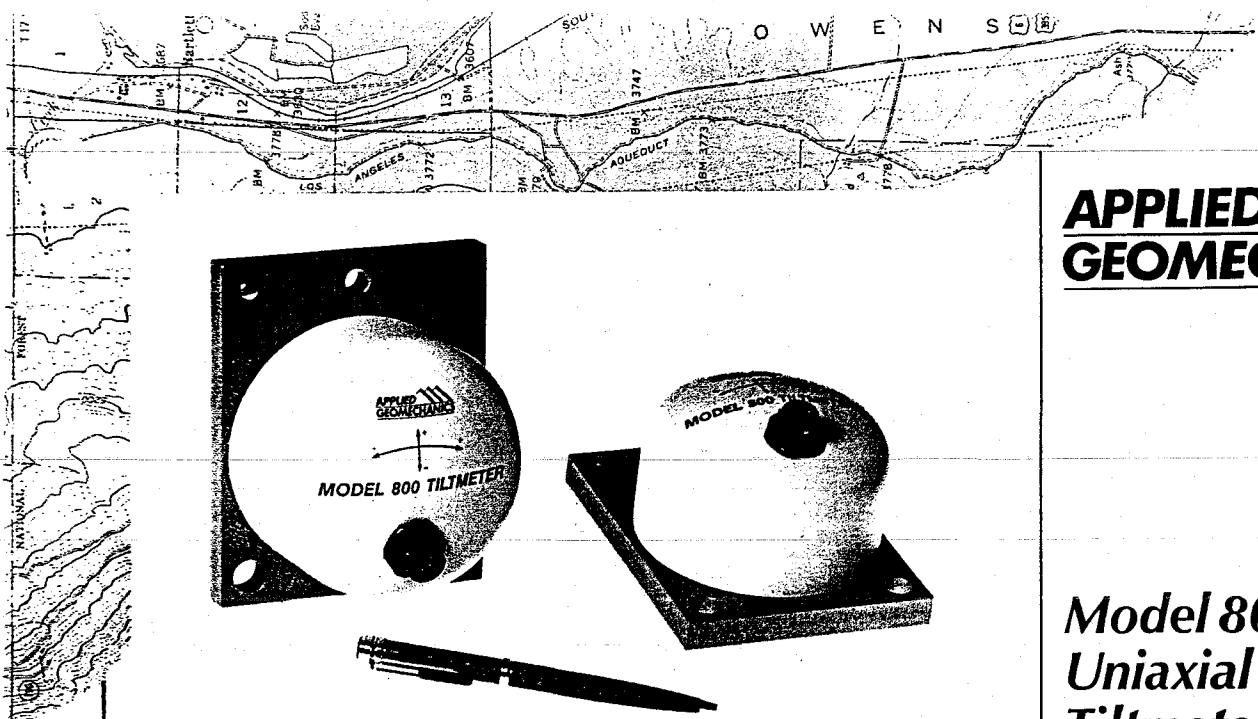
500-SERIES TILTMETERS

RESOLUTION	10 nanoradians (0.01 microradian) or better.
ANGULAR RANGE	Mechanically adjustable to ± 3 degrees.
SCALE FACTORS	Single-ended: 200, 20 & 2 microradian/volt (5, 50 & 500 mV/microradian) in gain settings "1," "2" and "3" respectively. Differential: 100, 10 & 1 microradian/volt (10, 100 and 1000 mV/microradian).
OUTPUT VOLTAGE RANGE	± 8 VDC single-ended and ± 16 VDC differential (both are provided).
OUTPUT FILTERS	Two switchable 2-pole Butterworth low-pass filters. Roll-off = 12 db/octave. 90% settling times = 0.1 sec. and 30 sec.
BANDWIDTH	0-10 Hz using 0.1-sec. filter.
TEMPERATURE OUTPUT	0.1°C/mV (single-ended) over range of -40°C to +100°C.
SCALE FACTOR TEMP. COEF.	+ 0.11% per °C typical.
OUTPUT IMPEDANCE	270 ohms, short circuit and surge protected.
POWER REQUIREMENTS	+11 to +15 VDC and -11 to -15 VDC @ +15, -7 mA typical; 250 mV peak-to-peak ripple max.
ENVIRONMENTAL	-25°C to +70°C operational, -30°C to +100°C storage. 0 to 100% humidity. Model 510 is submersible.
SIZE	Model 510: 76 cm (3 inches) diameter x 122 cm (48 inches) long. Model 520: 23 x 23 cm (9.1 x 9.1 inches) x 12.7 cm (5.0 inches) high. Switch Box: 23 x 20 x 14 cm (9 x 8 x 5.5 inches).
WEIGHT	Model 510: 20 kg (44 lbs). Model 520: 4.5 kg (10 lbs).
MATERIALS	Model 510: stainless steel. Model 520: anodized 6061-T6 aluminum, stainless steel hardware. Switch Box: fiberglass.

**Sensing Structural,
Ground and Machine
Deformation**

**APPLIED
GEOMECHANICS**

1336 Brommer Street
Santa Cruz, CA 95062 USA
Telephone: (408) 462-2801
FAX: (408) 462-4418
© 1992 Applied Geomechanics Inc.



APPLIED GEOMECHANICS

Model 800 Uniaxial Tiltmeter

Detect Structural, Ground or Machine Movement with Unrivalled Ease and Precision

Model 800 is an economical uniaxial tiltmeter for a wide variety of monitoring and measurement applications. It incorporates a high-precision electrolytic tilt transducer as the internal sensing element, offering resolution and stability previously unavailable in a practical engineering instrument. Measured angular movement is referenced to the unchanging vertical gravity vector, eliminating the time and expense of locating an external datum. Model 800 is ideal for structural behavior tests, automated inspection and surveillance, detection of hazardous conditions, and machine positioning and control.

Field-Proven and Reliable

Model 800 is rugged and field-proven—intended for use in harsh outdoor environments, the laboratory or factory floor. High-reliability components and surge protection enhance performance under electrically noisy or transient-prone conditions. A low-pass filter removes vibration effects for static measurements. Optional unfiltered output is available for dynamic measurement requirements. A built-in

temperature sensor provides the data necessary for analysis of thermal deformation and stresses.

Model 800 is available in floor, wall or ceiling mount versions for convenient installation on virtually any structure or machine. The tiltmeter is quickly installed by bolting or clamping to any vertical or horizontal surface. Tiltmeter output is easily interfaced to any conventional recording system. For rapid leveling or on-the-spot reading, use the Model 870 Readout Module. This low-cost module plugs into any digital multimeter to display the tiltmeter output. Model 870 reads tilt and

For Use On:

- Bridges
- Buildings
- Dams
- Landslides
- Foundations
- Retaining Walls
- Roofs
- Roadways
- Tanks
- Tunnels
- Turbines
- Pressure Vessels
- Any Machine or Structure

temperature, and checks its own internal batteries.

When someone asks, "Did it move, or didn't it?" get the answer with a Model 800 tiltmeter. Call today for solutions to your engineering challenges.



Reading tiltmeter with readout module

Specifications

MODEL 800 TILTMETER

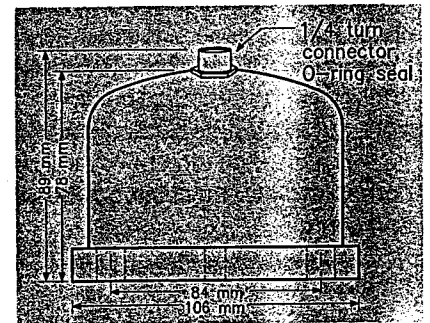
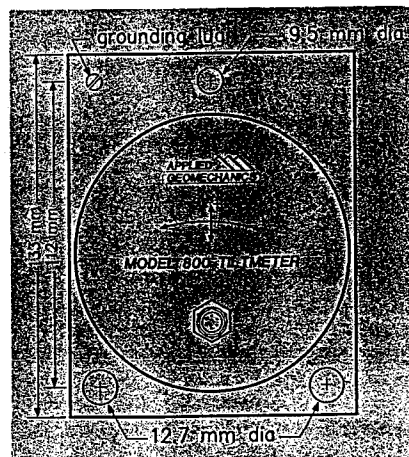
ANGULAR RANGE	High-gain option: ± 0.5 degree; Wide angle option: ± 20 degrees.
SENSITIVITY, REPEATABILITY	High-gain option: 0.0001 degree (1.75 microradian) or better; Wide-angle option: 0.004 degree (0.24 arc minute) or better.
SCALE FACTOR	High-gain option: 0.1 degree per volt (single-ended) and 0.05 degree per volt (differential); Wide-angle option: 4.0 degrees per volt (single-ended) and 2.0 degrees per volt (differential). Other scale factors may be special ordered. Each tiltmeter has both single-ended and differential outputs.
LINEARITY	High-gain option: 2% at half-range, 5% at full range; Wide-angle option: 1% at half range, 2% at full range.
OUTPUT VOLTAGE RANGE	± 5 VDC single-ended and ± 10 VDC differential.
FILTERING	2-pole Butterworth low-pass filter. Roll-off = 12 db per octave. 90% settling time = 5 seconds. Other settling times may be special ordered.
TEMPERATURE OUTPUT	0.1°C per millivolt (single-ended output) over range of -40°C to +100°C.
OUTPUT IMPEDANCE	270 ohms, short circuit and surge protected.
POWER REQUIREMENTS	+75 to +16 VDC and -75 to -16 VDC @ 6mA typical; 250 mV peak-to-peak ripple max.
ENVIRONMENTAL	-25°C to +70°C operational, -30°C to +100°C storage. 0 to 100% humidity.
CONNECTOR	6-pin quarter-turn military-style connector on case, sealed with O-ring.
MOUNTING	Available in floor, wall or ceiling mount style (specify Model 800-F, 800-W or 800-C). Installation is by bolting or clamping to surface, or fastening to threaded stainless steel studs anchored in surface. Tiltmeter can be adjusted on studs for leveling. Mounting studs, nuts and washers are supplied with each tiltmeter.
WEIGHT	1.4 kg (3 lbs).
MATERIALS	Base plate: anodized 6061-T6 aluminum. Cover: PVC or ABS plastic. Seals: rubber, silicon rubber.

MODEL 870 READOUT MODULE

SIZE	111 x 62 x 32 mm (4.4 x 2.4 x 1.3 inches) with 1.2 m (4 ft) cable.
WEIGHT	285 g (0.62 lbs) including batteries.
MATERIALS	ABS plastic.
POWER	Two 9-volt transistor radio batteries.



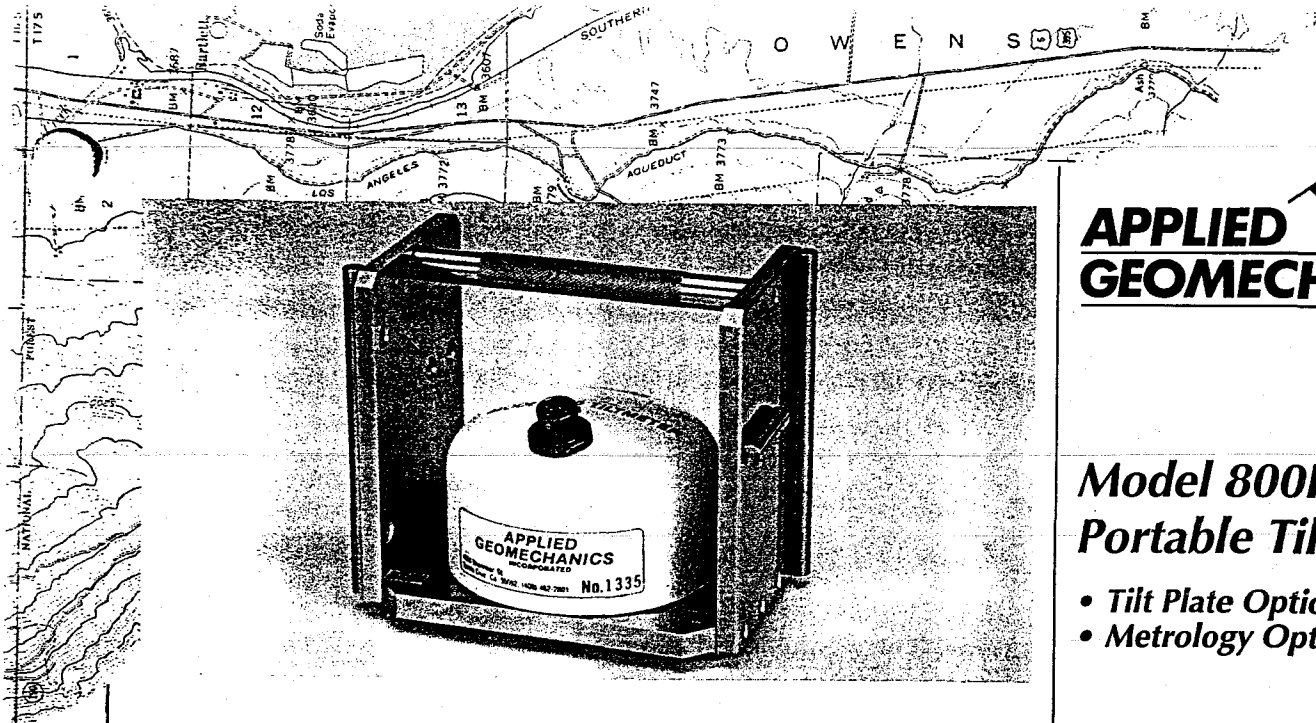
Model 870 readout module



**APPLIED
GEOMECHANICS**

1336 Brommer Street
Santa Cruz, CA 95062 USA

Telephone: (408) 462-2801
FAX: (408) 462-4418



APPLIED GEOMECHANICS

Model 800P Portable Tiltmeter

- Tilt Plate Option
- Metrology Option

Conveniently Measure Movement, Level and Angular Position

Model 800P Portable Tiltmeter is an economical hand-held instrument for a wide variety of monitoring and measurement applications. It offers precision and repeatability previously unavailable in an instrument of this type.

When continuous monitoring is not required, use Model 800P to make scheduled measurements at an unlimited number of points. Applications include monitoring the long-term deformation of structures and foundations, measuring mechanical response to applied loads, and surveying surface level and flatness.

With the *Tilt Plate Option*, measurements are taken from tilt plates that have been cemented or

For Surveying:

- Deformation
- Inclination
- Surface Flatness
- Settlement
- Retaining Walls
- Foundations
- Structures
- Columns
- Roofs
- Tunnels
- Tanks
- Machinery

bolted to any surface—horizontal or vertical. Indexing bars on the bottom and sides of the tiltmeter frame enable you to reposition the tiltmeter exactly, every time.

With the *Metrology Option*, the instrument base and sides each have three steel balls in a triangular pattern. The Metrology Option enables you to measure the flatness or inclination of any surface. Software is available to convert a set of inclination measurements into a contour map of surface relief.

Proven Technology

Model 800P has improved on the sensitivity and repeatability of comparable Swiss-made instruments, yet its price is considerably lower. This superior performance is achieved by using a precision electrolytic transducer as the sensing element.

Similar to a spirit level, the 800P electrolytic transducer converts changes in angular position to resistance changes measured by the tiltmeter's electronics. With no mechanical moving parts to drift or wear out, the sensing element and solid state electronics will provide years of trouble-free operation. Many electrolytic transducers installed in the 1940s are still in use!

Angular position measured with the Model 800P is referenced to the unchanging vertical gravity vector. This important feature eliminates the time and expense of locating a stable external datum. Simply position the tiltmeter on the surface to be surveyed and begin your measurements.

Reading and Recording Data

Your Model 800P Portable Tiltmeter is conveniently read with the easy-to-use Model 870 Readout Module. This unit powers the tiltmeter and plugs into any digital multimeter for display. You simply read the displayed data and record them in your logbook. Graphs of



Measure inclination of any horizontal or vertical surface

movement vs. time and of tilt directions and magnitudes (tilt vectors) are easily generated by entering these data into a PC-based spreadsheet program; see graph below.

The complete 800P Portable Tiltmeter system includes the following components:

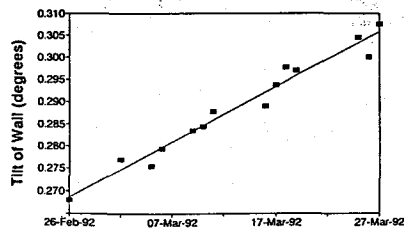
- Model 800P Portable Tiltmeter
- Model 870 Readout Module with batteries and 1.5 meter (5 ft) cable
- 4-digit multimeter for data display



Model 870 Readout Module and multimeter



Model 800P system

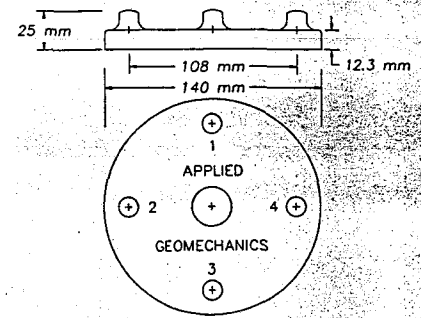


Retaining wall tilt measured with Portable Tiltmeter

- Multimeter probes for other multimeter uses
- Padded, unbreakable carrying case.

When using tilt plates, the following may be ordered for each project:

- Ceramic tilt plates (P/N 1263)
- Bronze tilt plates (P/N 1273)
- Protective covers for tilt plates (P/N 1274)
- Tilt plate cement.



Tilt Plate

Model 800P Portable Tiltmeter

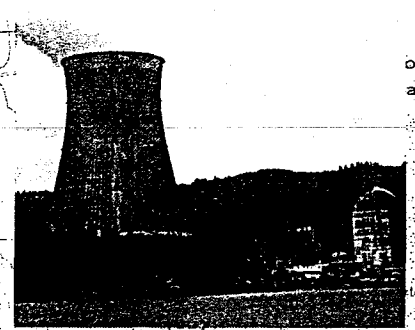
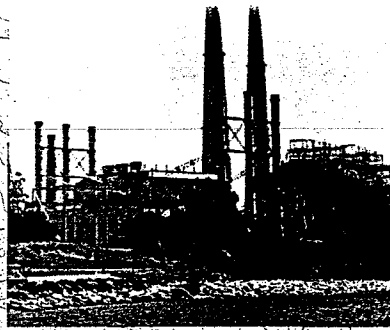
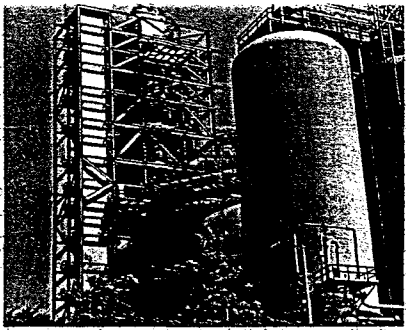
OUTPUT CHANNELS	Inclination, temperature
RESOLUTION	0.0001 arc degree (0.36 arc second)
REPEATABILITY	±0.004 degree typical
ANGULAR RANGE	±5 degrees from null position
LINEARITY	1% of full scale
FILTERING	2-pole Butterworth low-pass filter for removing noise from vibration or jitter
ENVIRONMENTAL	-25°C to +70°C operational, -30°C to +100°C storage Sealed for use in damp environments; nonsubmersible
DIMENSIONS	143 x 102 x 127 mm (5.6 x 4 x 5 inches), l x w x h
WEIGHT	2.7 kg (6 lb)
MATERIALS	Nickel-plated steel frame; PVC or ABS dome; rubber seals

Model 870 Readout Module

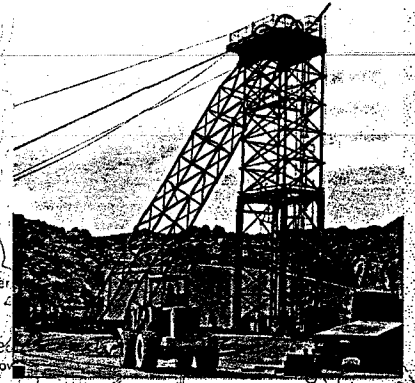
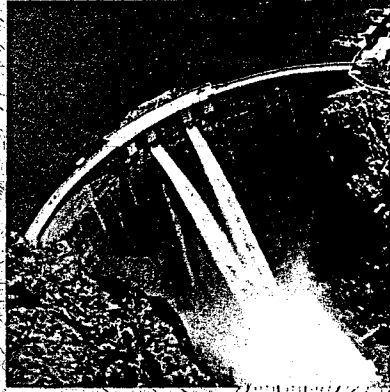
FUNCTION	Powers tiltmeter, switches tiltmeter output to digital multimeter
RESOLUTION	Using four-digit multimeter: 0.001 arc degree (3.6 arc seconds) at tilt greater than 1 arc degree, 0.0001 arc degree (0.36 arc second) at tilt less than 1 arc degree
POWER	Two internal 9-volt batteries provide up to 36 hours of continuous tiltmeter operation
SIZE	111 x 62 x 32 mm (4.4 x 2.4 x 1.3 inches) with 1.5 m (5 ft) cable
WEIGHT	285 g (0.6 lb) including batteries
MATERIALS	ABS plastic

**APPLIED
GEOMECHANICS**

1336 Brommer Street
Santa Cruz, CA 95062 U.S.A.
Telephone: (408) 462-2801
FAX: (408) 462-4418



oint
artlett

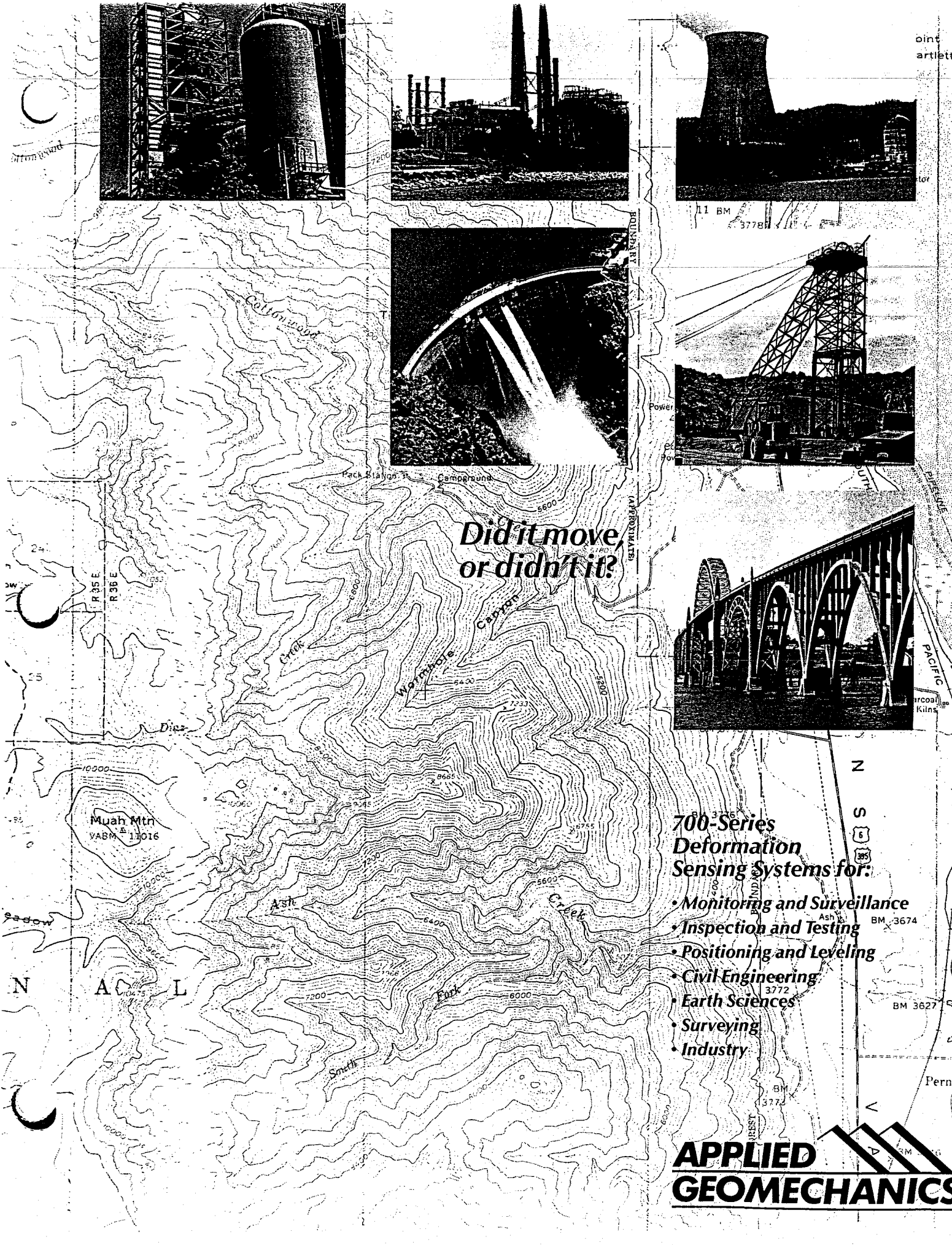


*Did it move,
or didn't it?*

**700-Series
Deformation
Sensing Systems for:**

- Monitoring and Surveillance
- Inspection and Testing
- Positioning and Leveling
- Civil Engineering
- Earth Sciences
- Surveying
- Industry

**APPLIED
GEOMECHANICS**



Movement Measurement: A New Level of Awareness

Sensitive and field proven, Applied Geomechanics' 700-Series instruments give you powerful new capabilities for measuring and monitoring the tilts, bulges, bends and deformations of any structure. They reveal the short- and long-term behavior of dams, mines, bridges, building, tanks and embankments, and the response of engineered structures to applied loads. With sensitivities as great as one part in ten million, they provide precise positioning information for machine control and robotics. Our automated data acquisition systems turn 700-Series instruments into active networks, producing a level of awareness unavailable from other measurement systems.

The 700-Series uses precision electrolytic transducers to detect angular motion. The transducers operate on the fundamental principle that a bubble, suspended in a liquid-filled case, is always bisected by the vertical gravity vector. As the transducer tilts, the case moves around the bubble, linearly changing the electrical resistance measured through the electrolyte. 700-Series circuitry transforms this change into highly accurate readings of even the smallest movements.

Standard instrumentation and data acquisition options are summarized below. For even greater sensitivity, look into our **500-Series tiltmeters**. Do you require **custom instrumentation or software**? Ask. We'll put our talent and experience to work for you. We also operate deformation-sensing systems on a **contract basis** for times when you can't purchase or rent equipment. For additional details about our products and services, call us today.

Tiltmeters

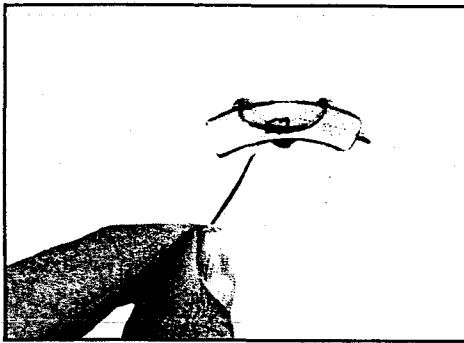
700-Series tiltmeters contain full signal conditioning, providing high-level outputs for long signal transmission lengths. They have two switch-selectable gains and two low-pass filter settings. Standard tiltmeters are biaxial and contain temperature sensors. Single-axis units are also available.

Platform Tiltmeter, Model 701:

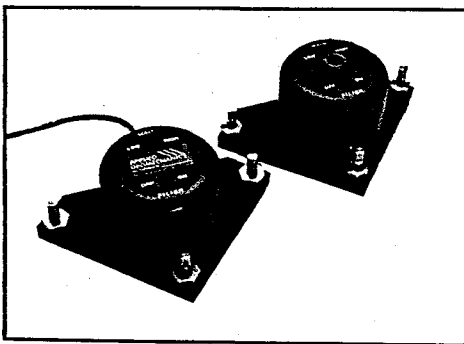
Platform tiltmeters are our most popular design for rapid installation and leveling. Using built-in invar or brass leveling legs, they can be set up and operating on any hard horizontal surface within minutes. Sensors and electronics are mounted within a rugged housing of anodized and painted aluminum that also provides electrical shielding. The two orthogonal tilt sensors parallel the right-angle sides of the base plate. Model 701 is water resistant for protection against light rain and splashes. Available with connector on case (Model 701-1) or pigtail (Model 701-2). 6 × 6 × 4 inches (15.2 × 15.2 × 10.2 cm), 3 lbs. (1.4 kg).

Submersible Platform Tiltmeter, Model 702:

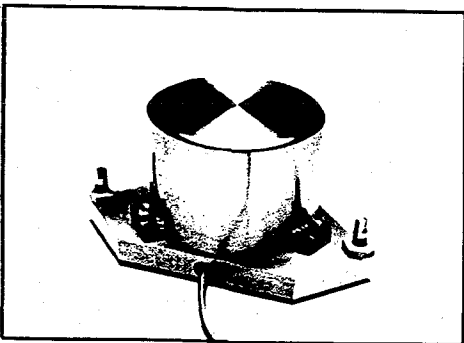
Model 702 is operationally identical to Model 701, but is constructed of heavy stainless steel for extra protection in harsh physical or chemical environments. Originally developed for nuclear power plant applications, Model 702 is sealed and fully submersible. Filter and gain switches are housed under the removable stainless steel dome. Pigtail is premium-grade underwater cable. Specify required pigtail length at time of ordering. 6 × 6 × 4 inches (15.2 × 15.2 × 10.2 cm), 10 lbs. (4.5 kg).



Electrolytic tilt transducer



Models 701-2 and 701-1

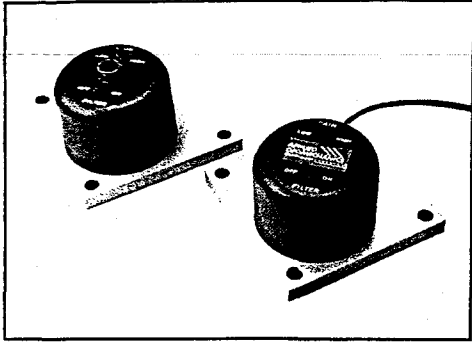


Model 702

Tiltmeters (continued)

Surface Mount Tiltmeters, Models 711-717:

Surface mount tiltmeters bolt or clamp to any surface. They are well-suited for areas of heavy traffic or vibration, and for attachment to floors, walls or ceilings. Our surface mount tiltmeters are identical in design and construction to Models 701 and 702. However, they have 0.5-inch (12.7-mm) diameter holes in their three corners instead of adjustable legs. These holes fit over threaded stainless steel mounting studs that are provided with each order. The tiltmeter is double-nutted to these studs after the studs have been firmly anchored in the mounting surface. Photos on this page show surface mount tiltmeters installed on optional mounting plates and brackets. Aluminum (hard-anodized and epoxy painted) models are water resistant. Stainless steel models are fully submersible.



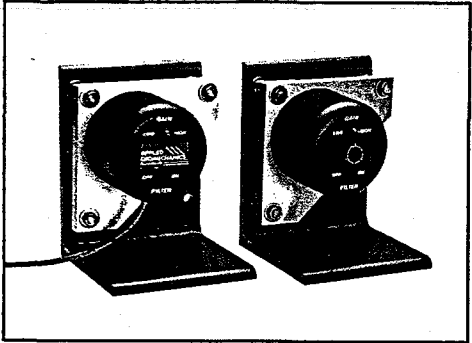
Models 711-1 and 711-2

Floor Mount: Models 711-1 (aluminum, connector on case), 711-2 (aluminum, pigtail), 712 (stainless steel, pigtail).

Ceiling Mount: Models 714-1 (aluminum, connector on case), 714-2 (aluminum, pigtail), 715 (stainless steel, pigtail).

Wall Mount: Models 716-1 (aluminum, connector on case), 716-2 (aluminum, pigtail), 717 (stainless steel, pigtail).

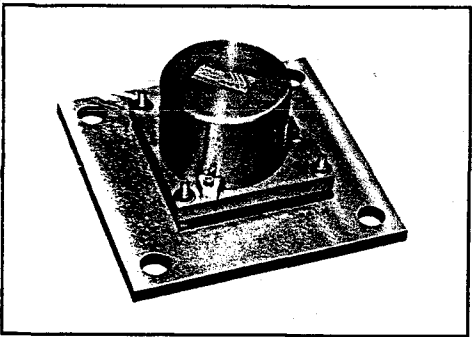
Aluminum models, 3 lbs. (1.4 kg). Stainless steel models: 10 lbs. (4.5 kg).
All models: 6 × 6 × 4 inches (15.2 × 15.2 × 10.2 cm).



Models 716-2 and 716-1 on
Model 719 Universal Mounting Brackets

Mounting Plate, Model 718:

This optional item is helpful for installing platform or surface mount tiltmeters on irregular surfaces. The plate is first bolted to the surface. A surface mount tiltmeter then attaches to the plate with mounting studs. A platform tiltmeter is installed simply by positioning it in the premachined holes in the plate. Aluminum or stainless steel with stainless steel hardware. 10 × 10 × 0.5 inches (25 × 25 × 1.3 cm).



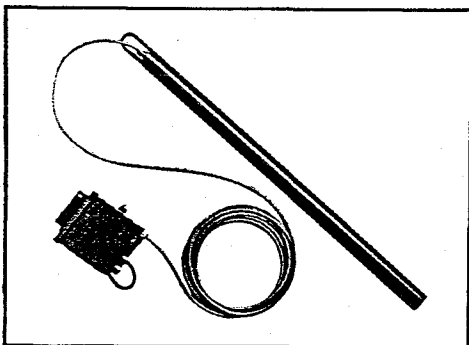
Model 712 on
Model 718 Mounting Plate

Universal Mounting Bracket, Model 719:

This versatile bracket allows a platform, floor or ceiling mount tiltmeter to be attached to a wall, or a wall mount tiltmeter to be attached to a floor or ceiling. Aluminum or steel, stainless steel hardware. Photo gives relative dimensions.

Borehole Tiltmeter, Model 722:

Designed for long-term (days to years) monitoring of earth or foundation movement in vertical or inclined boreholes, Model 722 is widely used in mining, geotechnical and geophysical applications. High mechanical and thermal stability are attained by sanding or grouting the tiltmeter into the borehole. Sanded-in tiltmeters are easily removed for reuse elsewhere. The tiltmeter body is sealed for operation under water. Tiltmeter body: stainless steel, 2.13 × 33.5 inches (5.1 × 85 cm), 15 lbs. (6.8 kg). Electronics box: painted steel, 6 × 6 × 5 inches (15 × 15 × 13 cm), 6 lbs. (2.7 kg).



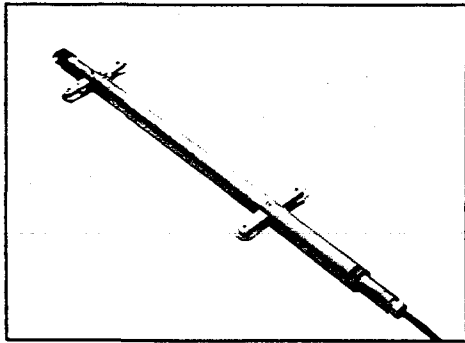
Model 722

Borehole Tiltmeter Installation Kit, Model 729 (no photo):

Kit contains tools and instructions for manually installing, orienting and leveling borehole tiltmeters in holes up to 40 feet (12 meters)-deep.

Inclinometers and Tilt Sensors

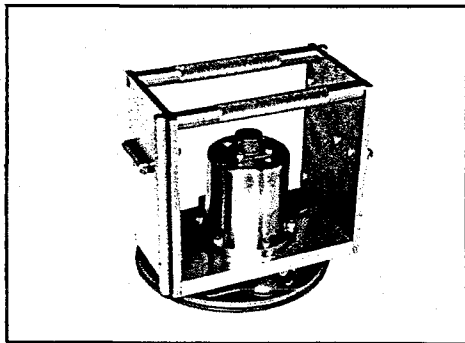
700-Series inclinometers and tilt sensors are operated with our Models 775, 781 or 785 signal conditioners. Standard units are biaxial unless noted otherwise. Uniaxial versions of all models are available.



Model 732

Wheeled Inclinometer, Models 732 and 733:

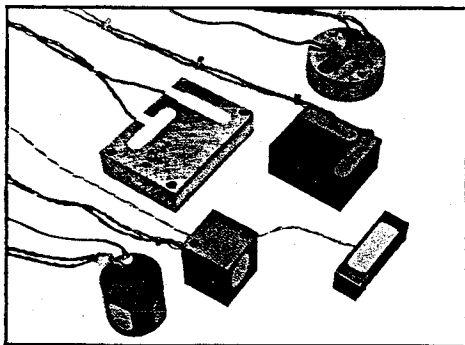
Proven geotechnical tools for periodic inspection of landslides and embankments, wheeled inclinometers operate in holes with slotted casing, which orients the instrument. Casing inclination vs. depth reveals locations of offsets and quantifies slope movement. Our inclinometers have a detachable cable head for easy transport and storage. The Model 775 Readout/Electronics Unit is used to operate wheeled inclinometers during manual field surveys. Our Signal Conditioning Field Module, Model 785, is recommended for continuous monitoring at a constant depth. Model 732: stainless steel. Model 733: brass body with stainless steel hardware. 1.5 × 36 inches (3.8 × 91 cm), 14 lbs. (6.3 kg).



Model 750 on Tilt Plate

Portable Tilt Sensor, Model 750:

This hand-held instrument is used for periodically surveying the deformation of natural and man-made structures. The unit is manually positioned on tilt plates cemented or bolted to the survey surfaces. The angular position of each plate is then read with the Model 775 Readout/Electronics Unit. Stainless steel. 5 × 5.5 × 3.3 inches (12.7 × 14.0 × 8.3 cm), 5.5 lbs. (2.5 kg).



Series 755-757

Miniature Tilt Sensors, Series 755, 756 and 757:

These small, low-cost, single- and dual-axis sensors come in a variety of shapes and dimensions to accommodate a wide range of mounting and space requirements. Ideal for structural testing, positioning and robotics work, they are available with type A high-gain (Series 755), type B mid-range (series 756) or type C wide-angle (Series 757) tilt transducers. Anodized aluminum is standard, other materials on request. Dimensions range from 1 × 0.6 × 0.65 inch (26 × 13 × 17 mm) to 3 × 2.1 × 0.7 inch (55 × 76 × 19 mm); Weights: 0.8 oz. (23 g) to 7 oz. (200 g).



Models 767 and 761

Embedded Tilt Sensors, Models 760-768:

These sensors are used for stable long-term monitoring of concrete and rock structures. They consist of a mounting cylinder, a sensor assembly and a protective cover. The mounting cylinder is cemented into a shallow drill hole. The sensor assembly is then bolted into the mounting cylinder and covered. Sensor units and covers are retrievable for reuse in other locations. Mounting cylinder and sensor assembly: 2 × 3 inches (5.1 × 7.6 cm). Cover: 2 × 3.5 × 5.75 inches (5.1 × 8.9 × 14.6 cm). 0.8 lb. (0.36 kg) to 2.4 lbs. (1.1 kg), depending on material.

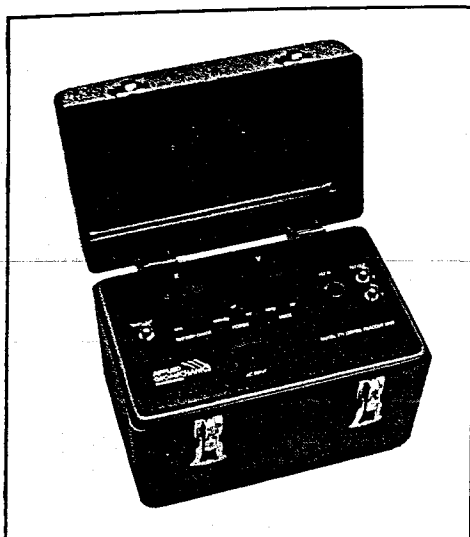
Wall Mount: Models 760 (aluminum), 761 (stainless steel) and 762 (invar).
Ceiling Mount: Models 763 (aluminum), 764 (stainless steel) and 765 (invar).
Floor Mount: Models 766 (aluminum), 767 (stainless steel) and 768 (invar).

Readout, Power and Recording Units

The items below are helpful accessories for set up and operation of your tiltmeter system.

Digital Readout Unit, Model 771:

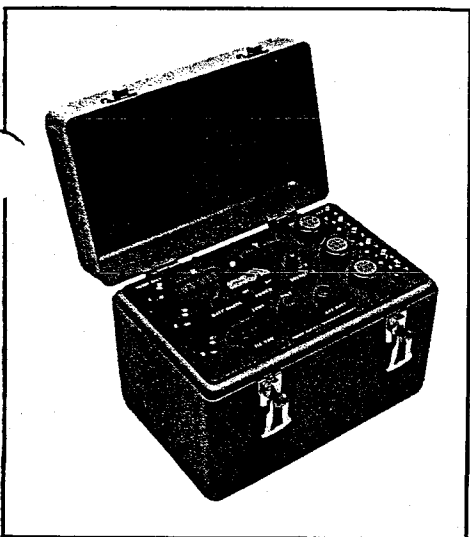
Housed in a rugged and portable case, the DRU powers and reads one biaxial tiltmeter during installation and field checking. It can also be used for continuous tiltmeter operation, powered by its internal rechargeable batteries or 105-250 VAC. Dual liquid crystal displays indicate the tilt and temperature readings, while coaxial connectors provide high-level analog signals to your external recorders. Painted aluminum case. 11 × 9 × 8 inches (28 × 23 × 20 cm), 10.5 lbs. (4.8 kg) with internal batteries.



Model 771

Power Supply/Readout/Interface Unit, Model 772:

The PSRI performs the same functions as the DRU, but for three tiltmeters simultaneously. A rotary switch selects the tiltmeter whose output is sent to the digital displays, while coaxial connectors supply high-level analog signals from all three tiltmeters to your external recorders. The PSRI is an excellent control center for continuous operation of a three-tiltmeter array. Power is provided by the PSRI's internal rechargeable batteries, your external batteries or 105-250 VAC. Painted aluminum case. 11 × 9 × 8 inches (28 × 23 × 20 cm), 13 lbs. (5.9 kg) with internal batteries.



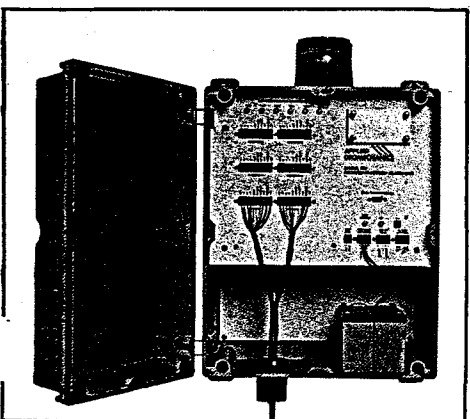
Model 772

Wiring Panel and Power Supply, Model 795 (no photo):

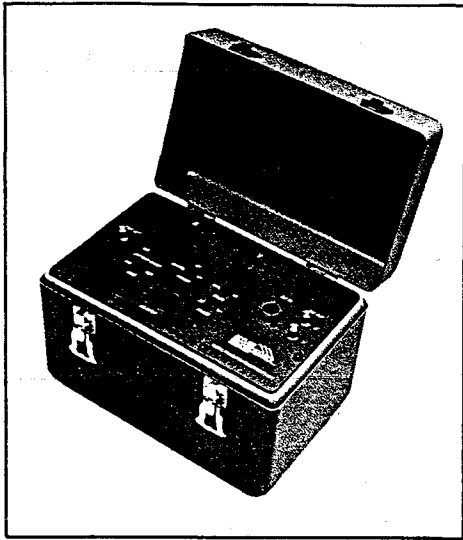
This practical unit provides power and signal junctioning for up to six tiltmeters or signal conditioners. It is designed for operating tiltmeters during short or long periods of continuous measurement. Cables from your tiltmeters and recorders enter the unit via feedthroughs and connect to miniature screw terminals on the internal panel. Model 795 operates from 105-250 VAC or from external batteries or solar cells. Internal batteries provide backup during power outages. Housed in a rugged NEMA 4X enclosure, the unit is protected against rain and splashes. 16 × 12.5 × 8.4 inches (41 × 32 × 21 cm), 19 lbs. (8.6 kg) with internal batteries.

Recording Station and Alarm Unit, Model 796:

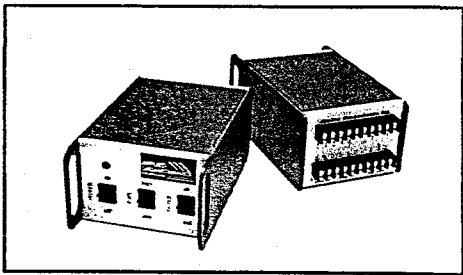
Model 796 is an integrated module for powering and recording multiple tiltmeters or other analog output transducers. It also will trigger external alarms and activate its own flashing strobe light when programmable movement limits or conditions are exceeded. Recording and alarm functions are supervised by a digital data logger and control module inside the unit. Communications with your IBM-compatible computer are via a 9-pin serial connector on the Model 796 control panel. Modems, radio telemetry, coaxial networks and hand-held storage modules are all supported. The 105-250 VAC power supply has battery backup for continuous operation during power outages. When AC power is not available, you can operate Model 796 solely from batteries or from solar cells. Model 796 is housed in a NEMA 4X enclosure that protects it from rain and splashes. 18 × 14.5 × 9.5 inches (47 × 37 × 24 cm), 27 lbs. (12.3 kg) with internal batteries.



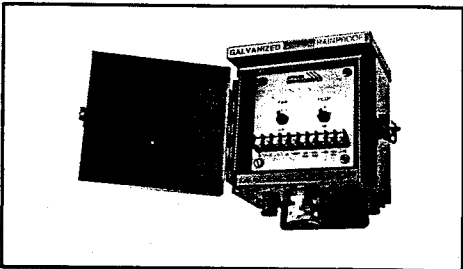
Model 796



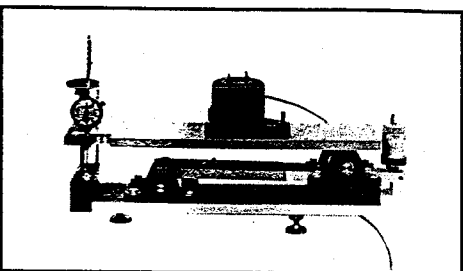
Model 775



Model 781



Model 785



Model 790

Signal Conditioners

These signal conditioners support all 700-Series inclinometers and tilt sensors. Each provides high-level outputs for two tilt channels and one temperature channel. Each has two switch-selectable gains and two low-pass filter settings.

Readout/Electronics Unit, Model 775:

The REU combines signal conditioning with all the practical features of our Model 771 Digital Readout Unit. It is typically used for manual reading of tilt sensors and inclinometers, but can also be used for continuous sensor operation. Two liquid crystal displays simultaneously indicate the readings of both axes of biaxial sensors and inclinometers. Coaxial connectors supply tilt and temperature signals for logging by external recorders. *Painted aluminum case: 11 × 9 × 8 inches (28 × 23 × 20 cm), 10.5 lbs. (4.8 kg) with internal batteries.*

Signal Conditioning Unit, Model 781:

This compact signal conditioner has rear-panel barrier strips for sensor connections, DC power input, and signal output. Gain, filtering and power "on-off" are selected with switches on the front panel. *Painted aluminum case. 3.5 × 5 × 8.4 inches (8.8 × 12.7 × 21.3 cm), 2 lbs. (0.9 kg).*

Signal Conditioning Field Module, Model 785:

This unit is suitable for continuous outdoor use in inclement weather. Housed in a rainproof steel enclosure with a hinged and lockable door, Model 785 has mounting brackets for attaching it to a wall or post. All electrical connections are via a quarter-turn connector on the underside of the module or a barrier strip inside the enclosure (both are provided). *6 × 6 × 5 inches (15 × 15 × 13 cm), 6 lbs. (2.7 kg).*

Calibration Equipment

Calibration Stage, Model 790:

A precision instrument for calibration of any gravity-referenced angle-sensing device, the Calibration Stage can be read to 0.2 microradian with repeatability of 1 microradian. Total angular range is 6 degrees. Three platform or surface mount tiltmeters, or up to 25 miniature tilt sensors can be calibrated simultaneously. *24 × 7 × 8 inches (61 × 18 × 20 cm), 20 lbs. (9 kg).*

Calibration Plate, Model 791 (no photo):

This low-cost device has a range of 60 degrees and can be used with any gravity-referenced angle sensor. Spacers or blocks placed under one end of the plate produce accurate angular rotations. *Anodized aluminum and steel. 13 × 6 × 1 inches (33 × 15 × 2.5 cm), 3 lbs. (1.4 kg).*

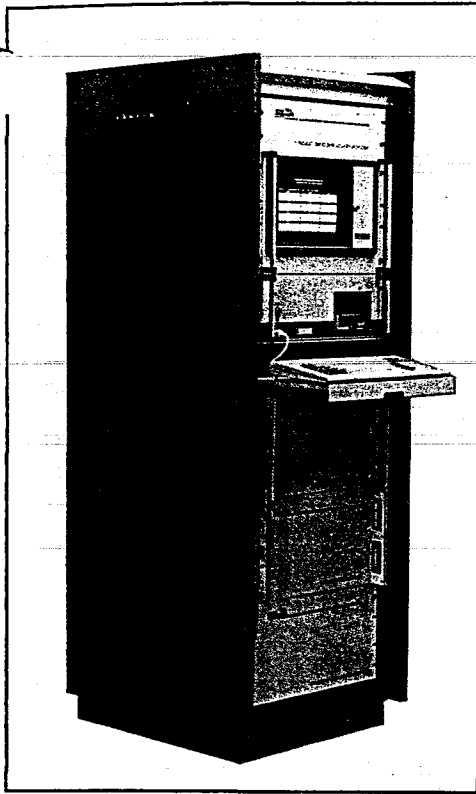
Data Acquisition, Processing, Playback

The diagram below shows three approaches for collecting data from 700-Series instruments. When continuous monitoring is not required, data acquisition can consist simply of visiting each instrument, connecting it to a Model 771, 772 or 775 readout unit and writing down the reading.

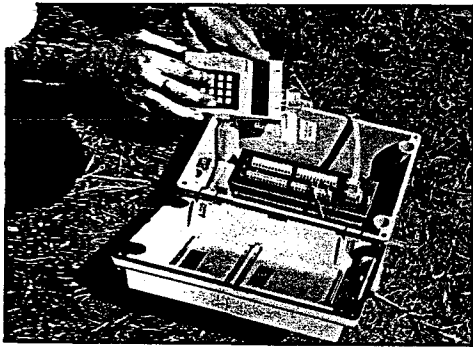
For **real-time monitoring and display**, inquire about our Conquest™ PC-based data acquisition systems. They record up to several hundred channels at 12- or 16-bit A/D precision. Shock mounting, uninterruptible power supplies and other reliability-enhancing features are available. Our TMONITOR™ data acquisition software is fully menu-driven. It records all sensor channels at user-specified intervals and includes plotting and mapping utilities that display structural movement in real time! The data is available for later analysis using the packages resident in TMONITOR or your own data analysis packages. TMONITOR has user-selectable threshold values which, when exceeded, can activate any control or alarm system you connect. Call us to receive a TMONITOR demonstration diskette.

Our **remote monitoring systems** are designed for projects where it is impractical to connect sensors directly to a central computer. Depending on the application, select either a multichannel programmable data logger or the Model 796 Recording Station/Alarm Unit to collect and store data in the field. You retrieve the data **a)** by telephone or radio modem connection anywhere in the world, **b)** over a twisted pair or coaxial cable up to 5 miles (8 km) long or **c)** by visiting the logger and transferring the data to a laptop computer or a hand-held storage module. Our easy-to-use TBASE™ software organizes the data into a computer data base and accesses any portion for your review and analysis upon command.

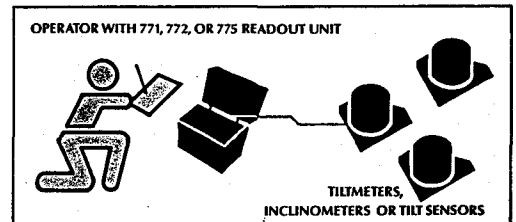
Our data acquisition systems operate with all Applied Geomechanics tiltmeters and sensors and with most standard displacement, strain, pressure, temperature and flow gauges.



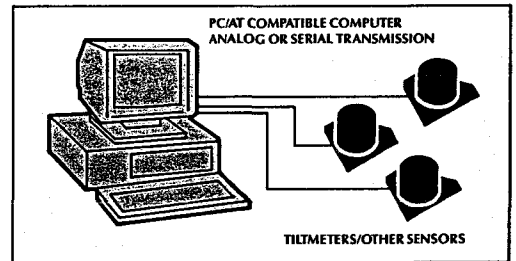
Conquest™ Data Acquisition System



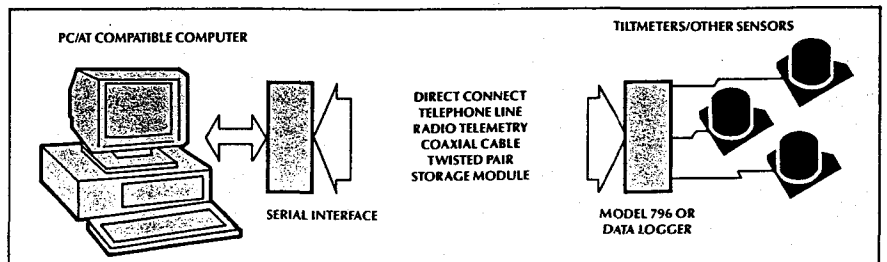
Programming a data logger



Manual Interrogation



Real-Time Monitoring and Display



Remote Data Acquisition

Specifications for tiltmeters and signal conditioner/tilt sensor combinations

RESOLUTION	To 0.1 microradian (0.02 arc second), depending on angular range chosen
REPEATABILITY	To 1 microradian (0.2 arc second), depending on angular range chosen
ANGULAR RANGE	To ± 60 degrees available
SCALE FACTORS	Each tiltmeter has two switchable scale factors (gains). Standard HIGH:LOW scale factor (gain) ratios are 10:1, 5:1 or 2:1.
OUTPUT VOLTAGE RANGE	± 8 VDC signal-ended and ± 16 VDC differential (both are provided)
OUTPUT FILTERS	Each tiltmeter has two switchable low-pass filters. Roll-off = 3 db/octave. Standard settling times = 0.1 and 30 seconds
BANDWIDTH	0-10 Hz using 0.1-second filter
TEMPERATURE OUTPUT	0.1°C/mV (single-ended) over range of -40°C to $+100^{\circ}\text{C}$
OUTPUT IMPEDANCE	270 ohms, short circuit and surge protected
POWER REQUIREMENTS	+11 to +15 VDC and -11 to -15 VDC @ +11 and -6 mA typical; 250 mV peak-to-peak ripple max.
ENVIRONMENTAL	Models 701-768, 781-795: -25°C to $+70^{\circ}\text{C}$ operational, -30°C to $+100^{\circ}\text{C}$ storage. Models 771, 772, 775: 0°C to $+50^{\circ}\text{C}$ operational, -20°C to $+70^{\circ}\text{C}$ storage. Model 796: -25°C to $+50^{\circ}\text{C}$ operational and storage. Wider ranges available.

Standard range and scale factor settings

Choose the settings that are best for your application from the standard values below. Or have us customize the settings for your special requirements.

Range	Resolution	Repeatability	Scale Factor 1	Scale Factor 2	Linearity* (half range)	Linearity* (full range)	Transducer Type
± 800 arc sec	0.02 arc sec	0.2 arc sec	0.01 arc sec/mV	0.1 arc sec/mV	0.75%	1.5%	A
± 8000 μrad	0.1 μrad	1 μrad	0.1 $\mu\text{rad}/\text{mV}$	1.0 $\mu\text{rad}/\text{mV}$	1.5%	3%	A
± 8000 μrad	0.1 μrad	1 μrad	0.5 $\mu\text{rad}/\text{mV}$	1.0 $\mu\text{rad}/\text{mV}$	1.5%	3%	A
± 2.2 deg	0.2 arc sec	0.4 arc sec	0.1 arc sec/mV	1.0 arc sec/mV	1%	1%	B
± 4.6 deg	1 μrad	2 μrad	1.0 $\mu\text{rad}/\text{mV}$	10.0 $\mu\text{rad}/\text{mV}$	1%	1%	B
± 8.0 deg	1 μrad	2 μrad	0.1 deg/volt	1.0 deg/volt	1%	1.5%	B
± 13.3 deg	1 arc sec	1 arc sec	10.0 arc min/volt	100 arc min/volt	0.75%	1%	C
± 40 deg	1 arc sec	1 arc sec	1.0 deg/volt	5.0 deg/volt	1.5%	2.5%	C
± 60 deg	1 arc sec	1 arc sec	1.0 deg/volt	10.0 deg/volt	2%	5%	C

*Greater linearities available

Definitions and abbreviations

- μrad = microradian = 10^{-6} radian.
- Scale factors above are for single-ended outputs. Differential scale factors are half these values.
- Three transducer types (A, B and C) are used in 700-Series tiltmeters, tilt sensors and inclinometers. Each type has a different internal geometry, providing a wide selection of ranges and resolutions, as shown above.
- Linearities are typical values of the greatest deviation of tiltmeter output from a straight line fit to half-range or full-range calibration curves.

Angle conversion chart

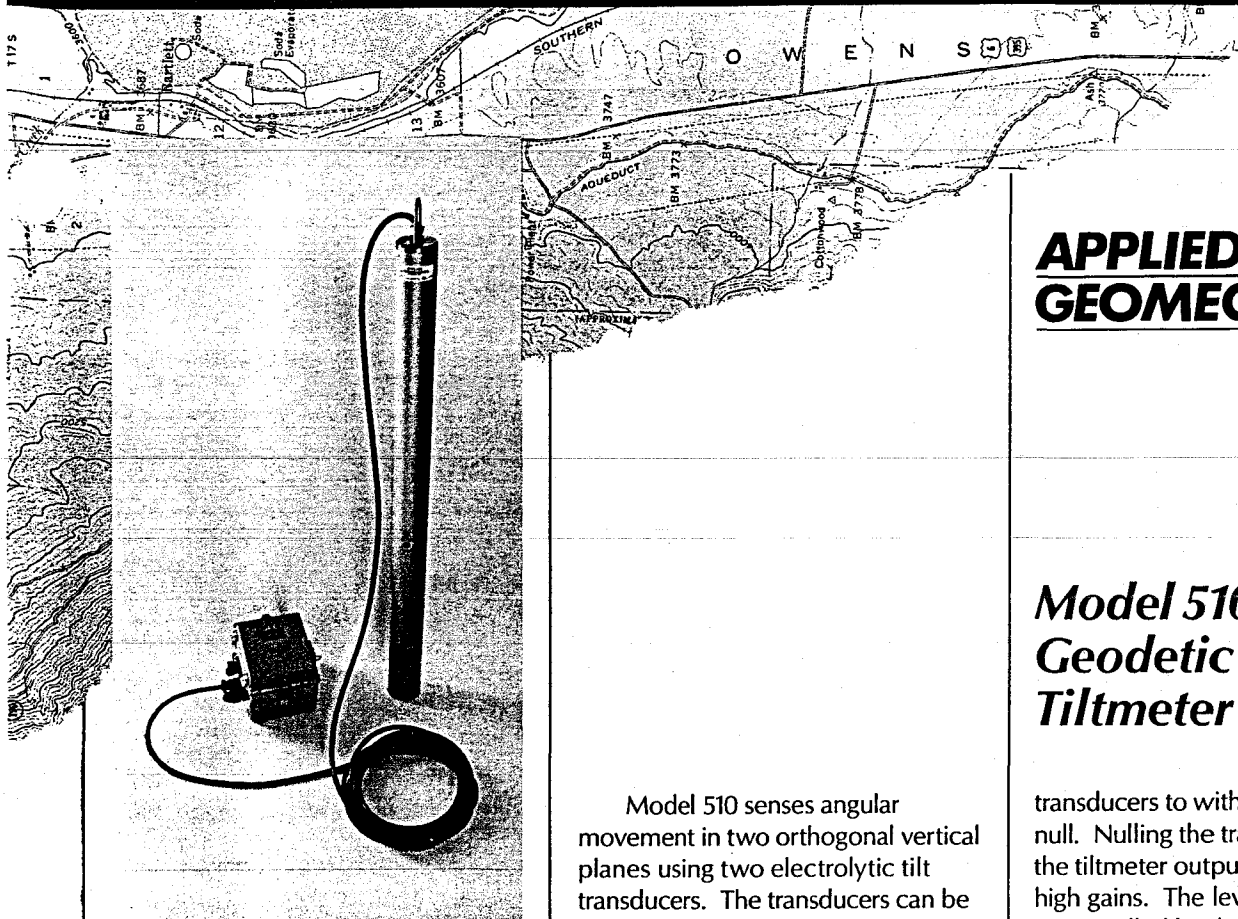
	degrees	arc minutes	arc seconds	$\mu\text{radians}$	mm/meter	inches/ft
degrees	1	60	3600	17453	1745	0.209
arc minutes	0.0167	1	60	291	0.291	3.49E^{-3}
arc seconds	2.78E^{-4}	0.0167	1	4.85	4.85E^{-3}	5.82E^{-5}
$\mu\text{radians}$	5.73E^{-5}	3.44E^{-3}	0.206	1	0.001	1.20E^{-5}
mm/meter	0.0573	3.436	206.2	1000	1	0.012
inches/ft	4.785	286.5	17182	83333	83.33	1



1336 Brommer Street
Santa Cruz, CA 95062
Telephone (408) 462-2801
FAX (408) 462-4418

Printed in U.S.A.

©1990 by Applied Geomechanics Inc. All rights reserved.
IBM is a registered trademark of International Business Machines, Inc.
Dam photo: Bureau of Reclamation

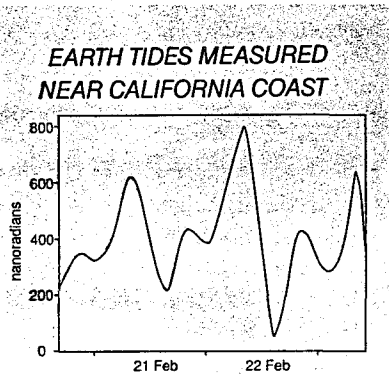


APPLIED GEOMECHANICS

Model 510 Geodetic Borehole Tiltmeter

Precision, Stability, Field-Proven Performance

The Model 510 Borehole Tiltmeter is a dual-axis analog output tiltmeter designed for field applications requiring the greatest possible sensitivity, stability and rugged reliability. Applications include measurement of volcanic and tectonic ground movements, long-period seismometry, earth tide studies, hydraulic fracture measurement, and precise monitoring of foundations and structures. Model 510 is the most sensitive electronic tiltmeter known to be available worldwide.



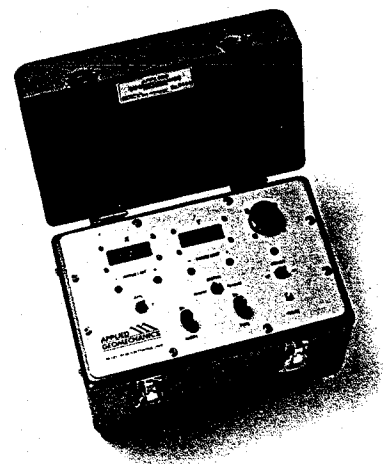
Model 510 senses angular movement in two orthogonal vertical planes using two electrolytic tilt transducers. The transducers can be described as electronic spirit levels. They operate on the principle that a bubble, suspended in a liquid-filled case, tends to remain stationary with respect to the vertical gravity vector. As the instrument tilts, the case moves around the bubble. Platinum electrodes sense changes of resistance as they are alternately covered or uncovered by the conductive liquid. Highly stable circuitry inside the tiltmeter body converts these changes to high-level signals linearly proportional to angular rotation.

Model 510 has two components: the tiltmeter and an external switch box. The tiltmeter houses the transducers, signal conditioning electronics and transducer leveling mechanism within a fully submersible stainless steel body. The switch box contains the tiltmeter power switch, gain and filter switches, and a low-battery indicator light. Connections to your external power supply and recorder are made via a terminal strip in the switch box.

Remote Control Leveling

A remotely controlled leveling mechanism in Model 510 allows stable positioning of the tilt

transducers to within 1 microradian of null. Nulling the transducers keeps the tiltmeter output on scale at very high gains. The leveling mechanism is controlled by the Model 591 Motor Control Unit, which displays the X and Y tilt outputs and operates two DC motors inside the tiltmeter. Each motor activates a worm gear and a cam that independently adjust one transducer and then passively maintain it in the desired position. To adjust the transducers, you simply plug the Motor Control Unit into the tiltmeter switch box. The Model 591 Motor Control Unit is conveniently transportable from one tiltmeter to the next within an array, so only one unit will normally be required.



Model 591 Motor Control Unit

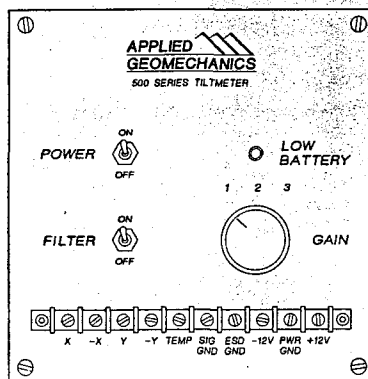
Model 510 Geodetic Borehole Tiltmeter

RESOLUTION	10 nanoradians or better.
SCALE FACTORS	Scale factors are selected with "GAIN" rotary switch in the switch box. Single-ended scale factors are 5, 50 and 500 mV/ μ radian (200, 20 and 2 μ radian/volt) in gain settings "1," "2" and "3" respectively. Differential scale factors are 10, 100 and 1000 mV/ μ radian (100, 10 and 1 μ radian/volt).
OUTPUT VOLTAGE RANGE	Approximately ± 7 VDC single-ended (± 14 VDC differential) in gain setting "1"; approximately ± 8 VDC single-ended (± 16 VDC differential) in gain settings "2" and "3." Both single-ended and differential analog outputs proportional to tilt are provided.
TILT RANGE	Mechanically adjustable through ± 3 degrees. Operating tilt range is approximately ± 900 micro-radians after leveling at gain setting "1."
OUTPUT FILTERS	Two 2-pole Butterworth filters. 90% settling times are 0.1 second (filter "OFF" position) and 30 seconds (filter "ON" position). Filter is selected with toggle switch in switch box.
BANDWIDTH	0–10 Hz in filter "OFF" position.
TEMPERATURE OUTPUT	10 mV/ $^{\circ}$ C (single-ended only), -40° to $+100^{\circ}$ C, $\pm 0.75^{\circ}$ C accuracy.
SCALE FACTOR TEMPERATURE COEFFICIENT	$+0.11\%$ per $^{\circ}$ C typical.
OUTPUT IMPEDANCE	270 ohms, short circuit and surge protected.
POWER REQUIREMENTS	$+11$ to $+15$ VDC and -11 to -15 VDC @ $+20$ mA ($+15$ mA typical) and -10 mA (-7 mA typical); 250 mV peak-to-peak ripple max. Low battery indicator on switch plate.
CONNECTIONS	19-pin quarter-turn connectors on tiltmeter cable and switch box. Standard cable length is 75 m (25 ft). Cable lengths to 1000 m or greater are available. External power and recorder connections are made via terminal strip inside switch box.
LEVELING	Independent leveling of X and Y transducers is performed using Model 591 Motor Control Unit. Transducers can be adjusted through mechanical range of $\pm 3^{\circ}$.
ENVIRONMENTAL	Tiltmeter and switch box: -25° to $+70^{\circ}$ C operational, -30° to $+100^{\circ}$ C storage. Wider ranges available. Tiltmeter is sealed with O-rings and is submersible. Switch box is gasketed and protected from light rain and splashes.
SIZE	Tiltmeter: 76 cm (3 inches) diameter \times 122 cm (48 inches). Switch box: 23 \times 20 \times 14 cm (9 \times 8 \times 5.5 inches).
WEIGHT	Tiltmeter: 18.7 kg (41 lb). Switch box: 1.8 kg (4 lb).
MATERIALS	Tiltmeter: Stainless steel tubing and fasteners, anodized aluminum sensor assemblies (internal), stainless steel gears, rubber O-rings. Cable: Polyurethane jacket, water-blocked, one overall foil shield and one overall braided shield. Switch box: Gray fiberglass, rubber gasket, lockable steel hasp.

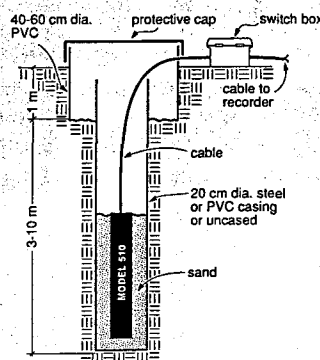
Model 591 Motor Control Unit

CONTROLS	Power on–off, X–Y motor select, motor forward–reverse, motor pulse width, motor pulse rate, pulse activate.
DISPLAY CHANNELS	X and Y tilt displayed on dual 3½ digit LCD displays, 12.7 mm (0.5 inch) digit height. X and Y leveling range limits indicated by LED illumination.
DISPLAY ACCURACY	0.2% of full scale (LCD displays).
POWER REQUIREMENTS	$+12$ volts for operating DC motors is supplied from tiltmeter switch box. One 9-volt battery behind front panel operates displays. LCD displays have low-battery indicators.
CONNECTIONS	14-pin connector and jumper cable to tiltmeter switch box.
ENVIRONMENTAL	0° to $+50^{\circ}$ C operational, -20° to $+70^{\circ}$ C storage. 0 to 80% humidity.
SIZE	28 \times 23 \times 20 cm (11 \times 9 \times 8 inches).
WEIGHT	2.3 kg (5 lb).
MATERIALS	Painted aluminum.

MODEL 510 SWITCH PLATE



TYPICAL BOREHOLE TILTMETER INSTALLATION

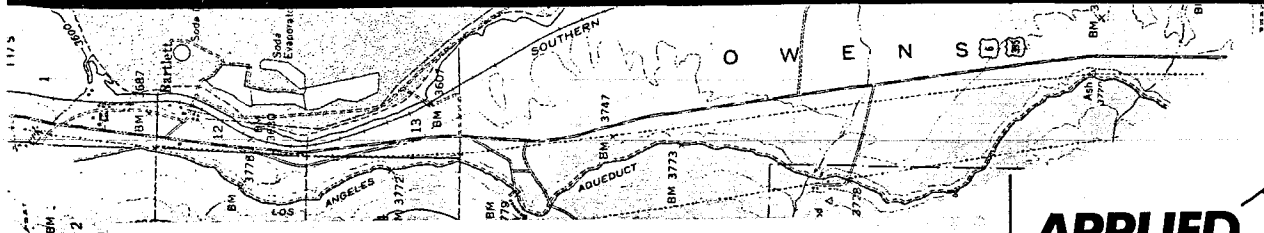


**APPLIED
GEOMECHANICS**

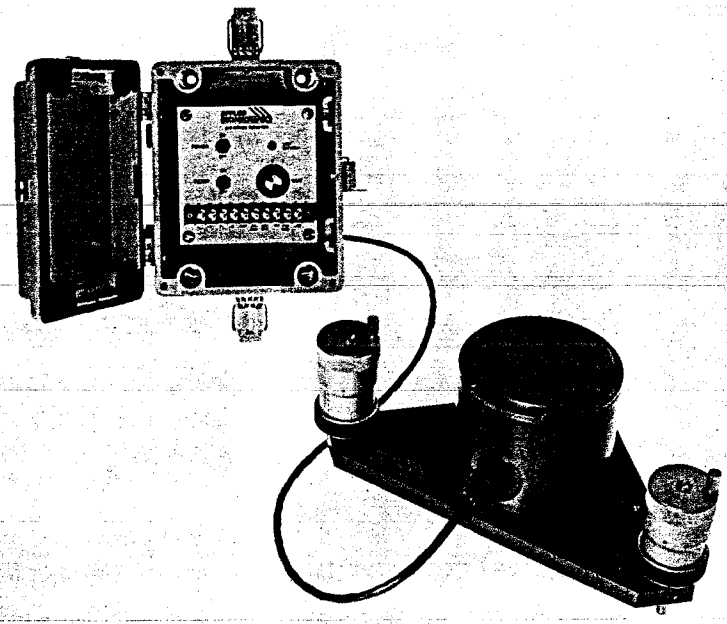
1336 Brommer Street
Santa Cruz, CA 95062 USA

Telephone: (408) 462-2801
FAX: (408) 462-4418

©1990 by Applied Geomechanics Inc.
Printed in U.S.A.



APPLIED GEOMECHANICS



Model 520 Geodetic Platform Tiltmeter

Measure Submicroradian Movements with Unrivalled Ease

Model 520 is a precision biaxial tiltmeter for projects demanding the maximum in resolution and stability. Applications include leveling and positioning of machinery, measurement of earth tides and movement, volcano studies and monitoring the deformations of dams and other critical structures. Model 520 is excellent for use in all static applications, or as a sensitive biaxial low-frequency accelerometer.

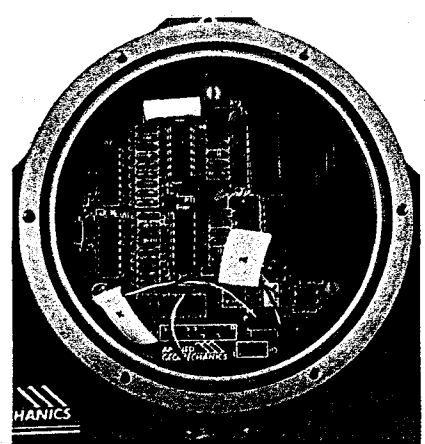
Precise, Practical, Proven

Model 520 is not only sensitive. It's field-proven and simple to use. Each tiltmeter system consists of the tiltmeter itself, a rugged fiberglass switch box and a 3-meter interconnect cable. Leveling and user calibration of the tiltmeter are performed with built-in micrometer or worm gear legs. Three different gains (scale factors) and two low-pass

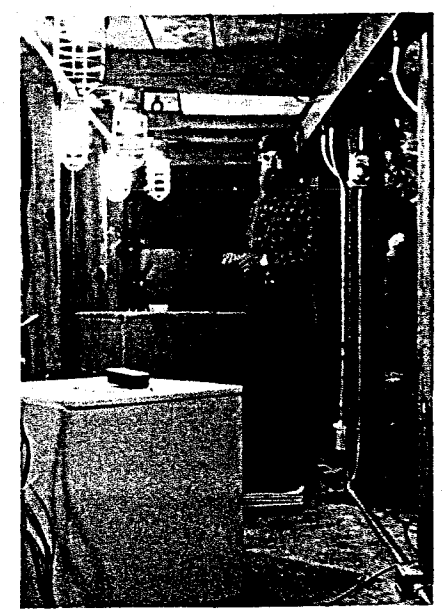
reliable 10-position terminal strip. The tiltmeter, cable and switch box are sealed throughout for operation in wet environments.

For the ultimate in quality and performance, invest in a Model 520 Geodetic Platform Tiltmeter today.

Model 520 senses angular movement with respect to the vertical gravity vector using two electrolytic tilt transducers. Rotations are sensed in two orthogonal vertical planes. The tilt transducers can be described as electronic spirit levels. As the instrument tilts, the transducer moves around the bubble in the internal fluid. Platinum electrodes in the transducer walls sense changes of electrical resistance as they are alternately covered or uncovered by fluid. Precision construction and selection of the highest-quality, low-noise components result in unrivalled sensitivity and long-term stability. filters (2-pole Butterworth) are user selected with switches in the switch box. Connections to external power and recorders are made via a highly



Highest-quality low-noise components are used throughout

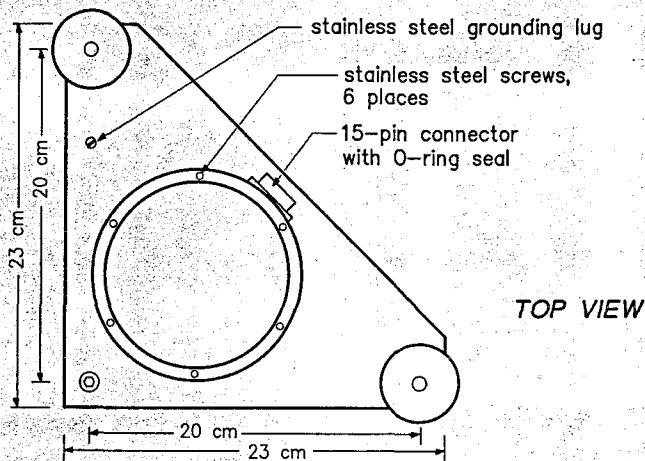


Underground tiltmeter testing vault

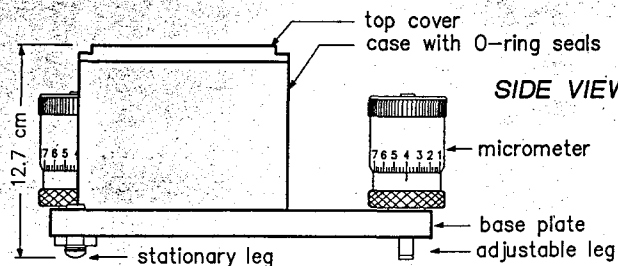
Specifications

RESOLUTION	10 nanoradians or better.
SCALE FACTORS	Scale factors are selected with "GAIN" rotary switch in the switch box. Single-ended scale factors are 5, 50 & 500 mV/ μ radian (200, 20 & 2 μ radian/volt) in gain settings "1," "2" and "3" respectively. Differential scale factors are 10, 100 and 1000 mV/ μ radian (100, 10 & 1 μ radian/volt).
OUTPUT VOLTAGE	Approximately ± 7 VDC single-ended (± 14 VDC differential) in gain setting "1"; approximately ± 8 VDC single-ended (± 16 VDC differential) in gain settings "2" and "3." Single-ended and differential analog outputs proportional to tilt are both provided.
TILT RANGE	Depends on gain setting. Approximately ± 1400 microradians at setting "1."
OUTPUT FILTERS	Two 2-pole Butterworth filters. 90% settling times are 0.1 second (filter "OFF" position) and 30 seconds (filter "ON" position). Filter is selected with toggle switch in switch box.
BANDWIDTH	0-10 Hz in filter "OFF" position.
TEMPERATURE OUTPUT	10 mV/ $^{\circ}$ C (single-ended only), -40° C to $+100^{\circ}$ C, $\pm 0.75^{\circ}$ C accuracy.
SCALE FACTOR TEMP. COEF.	+ 0.11% per $^{\circ}$ C typical.
OUTPUT IMPEDANCE	270 ohms, short circuit and surge protected.
POWER REQUIREMENTS	+11 to +15 VDC and -11 to -15 VDC @ +20 mA (+15 mA typical) and -10 mA (-7 mA typical); 250 mV peak-to-peak ripple max. Low battery indicator on switch plate.
CONNECTIONS	15-pin quarter-turn connectors on tiltmeter and switch box. Tiltmeter and switch box are connected by 3-meter (10 ft.) multiconductor cable. External power and recorder connections are made via terminal strip inside switch box.
LEVELING	Performed with two micrometers, each readable to 0.001 mm, or with two worm gears.
ENVIRONMENTAL	-25° C to $+70^{\circ}$ C operational, -30° C to $+100^{\circ}$ C storage. 0 to 100% humidity. Tiltmeter is sealed with O-rings.
SIZE	Tiltmeter: 23 x 23 cm (9.07 x 9.07 inches) x 12.7 cm (5.0 inches) high; 20 cm (7.87 inches) leg separation. Switch box: 23 x 20 x 14 cm (9 x 8 x 5.5 inches).
WEIGHT	Tiltmeter: 4.5 kg (10 lbs). Switch box: 1.8 kg (4 lbs).
MATERIALS	Tiltmeter: Anodized 6061-T6 aluminum; stainless steel legs and fasteners; rubber O-rings. Switch box: Gray fiberglass.

MODEL 520 TILTMETER

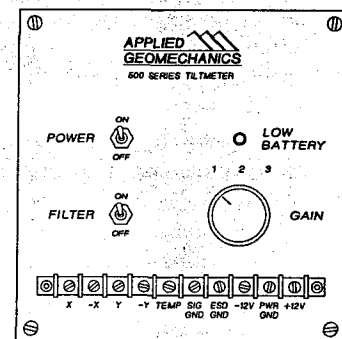


TOP VIEW



SIDE VIEW

MODEL 520 SWITCH PLATE

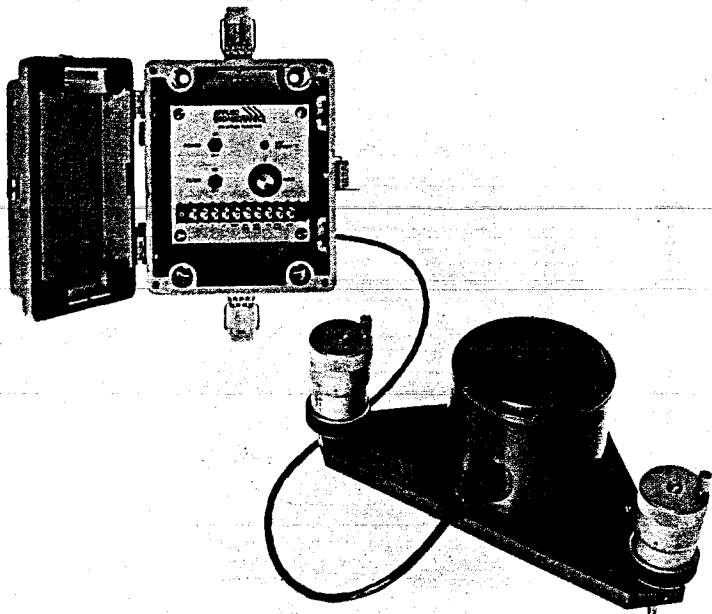
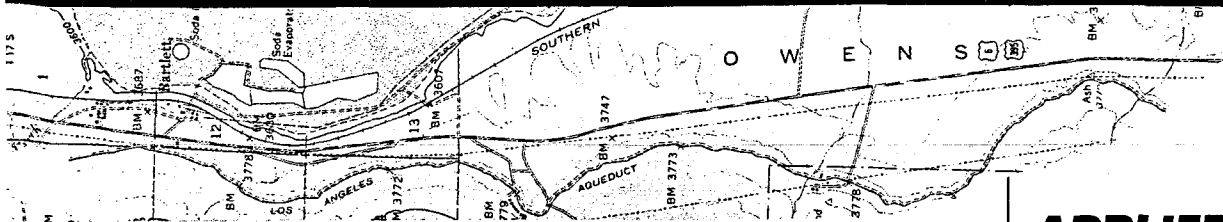


**APPLIED
GEOMECHANICS**

1336 Brommer Street
Santa Cruz, CA 95062 USA

Telephone: (408) 462-2801
TWX: 510 601 8310
FAX: (408) 462-4418

© 1989 Applied Geomechanics, Inc.
Printed in U.S.A.

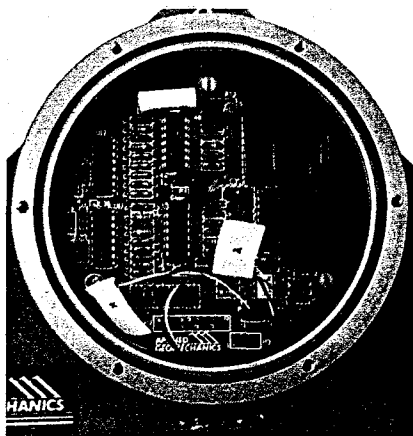


APPLIED GEOMECHANICS

Model 520 Geodetic Platform Tiltmeter

Measure Submicroradian Movements with Unrivalled Ease

Model 520 is a precision biaxial tiltmeter for projects demanding the maximum in resolution and stability. Applications include leveling and positioning of machinery, measurement of earth tides and movement, volcano studies and monitoring the deformations of dams and other critical structures. Model 520 is excellent for use in all static applications, or as a sensitive biaxial low-frequency accelerometer.



HIGHEST-QUALITY LOW-NOISE
COMPONENTS ARE USED THROUGHOUT

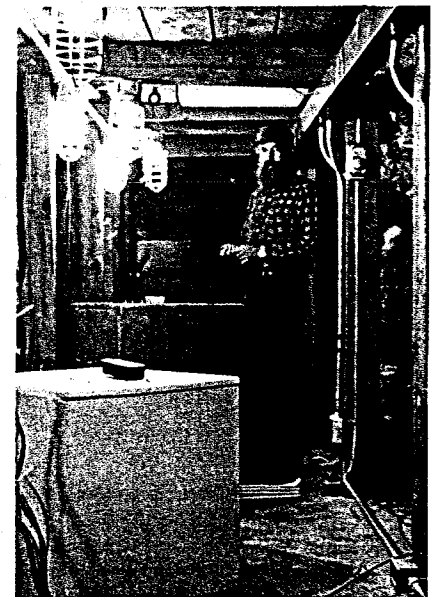
Precise, Practical, Proven

Model 520 is not only sensitive. It's field-proven and simple to use. Each tiltmeter system consists of the tiltmeter itself, a rugged fiberglass switch box and a 3-meter interconnect cable. Leveling and user calibration of the tiltmeter are performed with built-in micrometer or worm gear legs. Three different gains (scale factors) and two low-pass

Model 520 senses angular movement with respect to the vertical gravity vector using two electrolytic tilt transducers. Rotations are sensed in two orthogonal vertical planes. The tilt transducers can be described as electronic spirit levels. As the instrument tilts, the transducer moves around the bubble in the internal fluid. Platinum electrodes in the transducer walls sense changes of electrical resistance as they are alternately covered or uncovered by fluid. Precision construction and selection of the highest-quality, low-noise components result in unrivalled sensitivity and long-term stability. filters (2-pole Butterworth) are user selected with switches in the switch box. Connections to external power and recorders are made via a highly

reliable 10-position terminal strip. The tiltmeter, cable and switch box are sealed throughout for operation in wet environments.

For the ultimate in quality and performance, invest in a Model 520 Geodetic Platform Tiltmeter today.

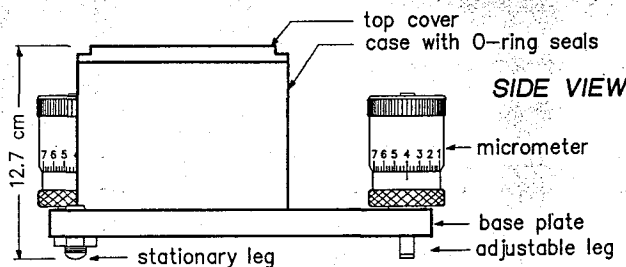
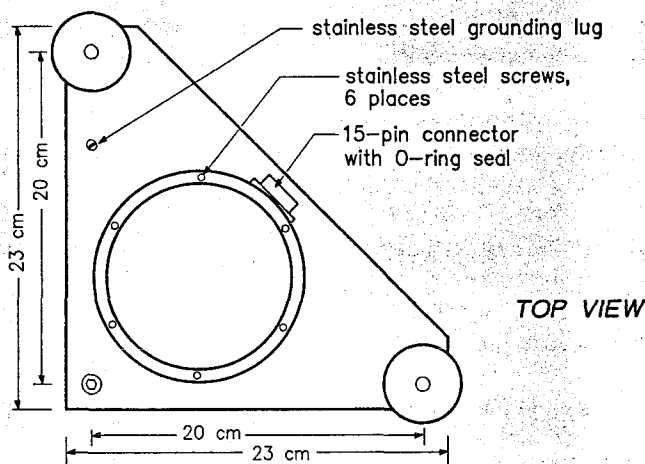


Underground tiltmeter testing vault

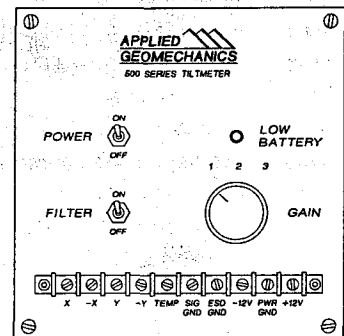
Specifications

RESOLUTION	10 nanoradians or better.
SCALE FACTORS	Scale factors are selected with "GAIN" rotary switch in the switch box. Single-ended scale factors are 5, 50 & 500 mV/ μ radian (200, 20 & 2 μ radian/volt) in gain settings "1," "2" and "3" respectively. Differential scale factors are 10, 100 and 1000 mV/ μ radian (100, 10 & 1 μ radian/volt).
OUTPUT VOLTAGE	Approximately ± 7 VDC single-ended (± 14 VDC differential) in gain setting "1"; approximately ± 8 VDC single-ended (± 16 VDC differential) in gain settings "2" and "3." Single-ended and differential analog outputs proportional to tilt are both provided.
TILT RANGE	Depends on gain setting. Approximately ± 1400 microradians at setting "1."
OUTPUT FILTERS	Two 2-pole Butterworth filters. 90% settling times are 0.1 second (filter "OFF" position) and 30 seconds (filter "ON" position). Filter is selected with toggle switch in switch box.
BANDWIDTH	0-10 Hz in filter "OFF" position.
TEMPERATURE OUTPUT	10 mV/ $^{\circ}$ C (single-ended only), -40° C to $+100^{\circ}$ C, $\pm 0.75^{\circ}$ C accuracy.
SCALE FACTOR TEMP. COEF.	+ 0.11% per $^{\circ}$ C typical.
OUTPUT IMPEDANCE	270 ohms, short circuit and surge protected.
POWER REQUIREMENTS	+ 11 to + 15 VDC and - 11 to - 15 VDC @ + 20 mA (+ 15 mA typical) and - 10 mA (- 7 mA typical); 250 mV peak-to-peak ripple max. Low battery indicator on switch plate.
CONNECTIONS	15-pin quarter-turn connectors on tiltmeter and switch box. Tiltmeter and switch box are connected by 3-meter (10 ft.) multiconductor cable. External power and recorder connections are made via terminal strip inside switch box.
LEVELING	Performed with two micrometers, each readable to 0.001 mm, or with two worm gears.
ENVIRONMENTAL	-25° C to $+70^{\circ}$ C operational, -30° C to $+100^{\circ}$ C storage. 0 to 100% humidity. Tiltmeter is sealed with O-rings.
SIZE	Tiltmeter: 23 x 23 cm (9.07 x 9.07 inches) x 12.7 cm (5.0 inches) high; 20 cm (7.87 inches) leg separation. Switch box: 23 x 20 x 14 cm (9 x 8 x 5.5 inches).
WEIGHT	Tiltmeter: 4.5 kg (10 lbs). Switch box: 1.8 kg (4 lbs).
MATERIALS	Tiltmeter: Anodized 6061-T6 aluminum; stainless steel legs and fasteners; rubber O-rings. Switch box: Gray fiberglass.

MODEL 520 TILTMETER



MODEL 520 SWITCH PLATE



**APPLIED
GEOMECHANICS**

1336 Brommer Street
Santa Cruz, CA 95062 USA

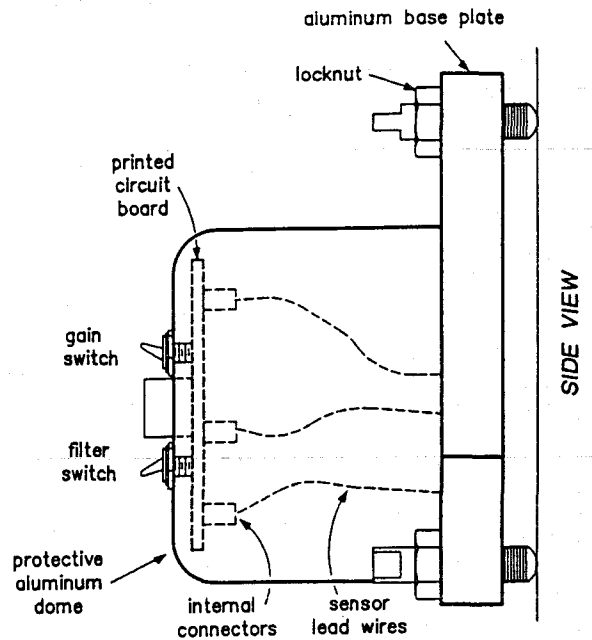
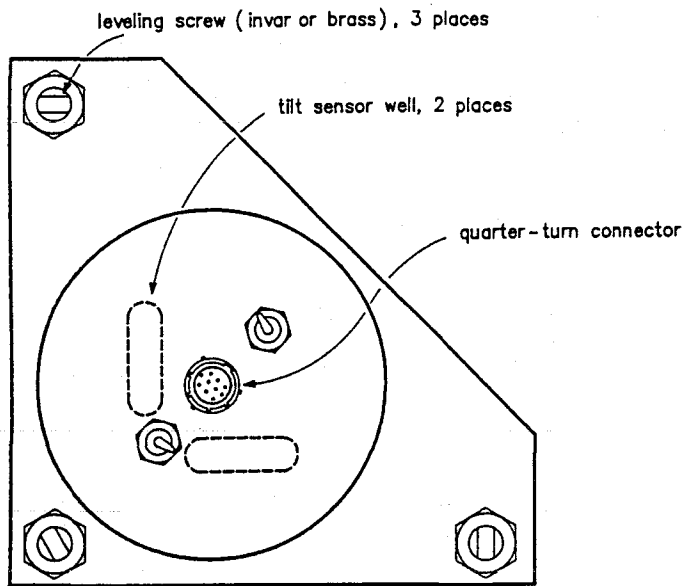
Telephone: (408) 462-2801
TWX: 510 601 8310
FAX: (408) 462-4418

© 1989 Applied Geomechanics, Inc.
Printed in U.S.A.

SPECIFICATIONS: Model 701 Platform Tiltmeter
Model 711 Floor Mount Tiltmeter
Model 714 Ceiling Mount Tiltmeter
Model 716 Wall Mount Tiltmeter

These versatile, high-precision, biaxial tiltmeters are well suited for a wide variety of measurement and monitoring applications.

TILT RANGE	Available to ± 1 degree using high-gain transducer, ± 10 degrees using mid-range transducer or ± 60 degrees using wide-angle transducer
TILT RESOLUTION	0.1 microradian (high-gain transducer), 1 microradian (mid-range transducer) or 5 microradians (wide-angle transducer)
TILT OUTPUT	Two single-ended <i>and</i> two differential analog output channels proportional to tilt. Output range: approx. +8 to -8 VDC (single-ended) and +16 to -16 VDC (differential)
SCALE FACTORS	Set to order. Two switchable scale factors (gains) are provided, 10:1 ratio standard, other ratios on request
OUTPUT FILTERS	Electronic filtering of tilt channels provided by two switchable low-pass integrators. Roll-off: 6 db/octave. Time constants pre-set at 0.05 and 7.5 seconds, other settings on request
TEMP. OUTPUT	0.1°C/mV (single-ended), -40°C to +100°C, $\pm 0.75^\circ\text{C}$ accuracy
OUTPUT IMPEDANCE	All channels: 270 ohms, short circuit and surge protected
POWER REQUIREMENTS	+11 to +15 VDC and -11 to -15 VDC @ +11 and -6 mA typical; 250 mV peak-to-peak ripple max.
OUTPUT CONNECTIONS	Quarter-turn military-style connector on case (specify -1 after model no.), or 10 ft (3 meter) pigtail (specify -2 after model no.). Pigtail is available with or without quarter-turn military-style connector
ENVIRONMENTAL	-25°C to +70°C operational, -30°C to +100°C storage. 0 to 100 % humidity, nonsubmersible
SIZE & WEIGHT	6 x 6 x 4 inches (15 x 15 x 10 cm), 3 lb (1.4 kg)
MATERIALS	Base: 6061-T6 aluminum, hard anodized; Dome: 6061-T6 aluminum, epoxy coated; Seals: Neoprene, silicone rubber. Model 701 only: invar leveling legs, brass locknuts



APPLIED
GEOMECHANICS
INCORPORATED

PLATFORM TILTMETER, MODEL 701-1

DATE
11/30/87

DRAWN
DDC

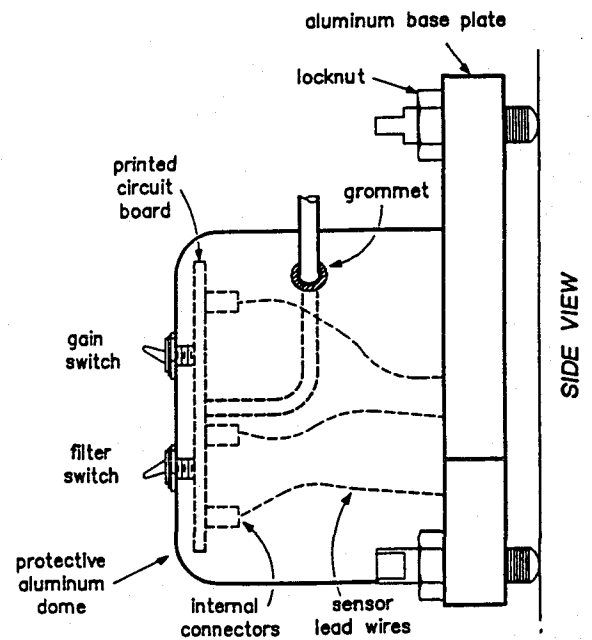
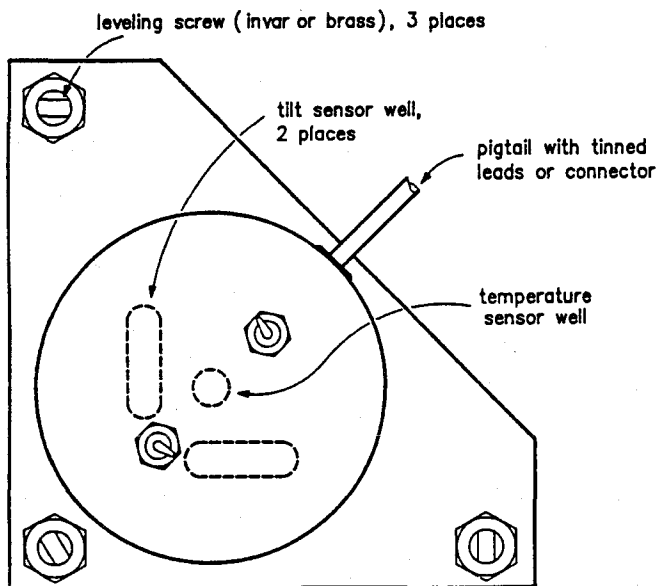
CHECKED
GRH

DWG. No. D-87-1111

REVISION

SCALE
shown

© 1987



APPLIED
GEOMECHANICS
INCORPORATED

PLATFORM TILTMETER, MODEL 701-2

DATE
11/30/87

DRAWN
DDC

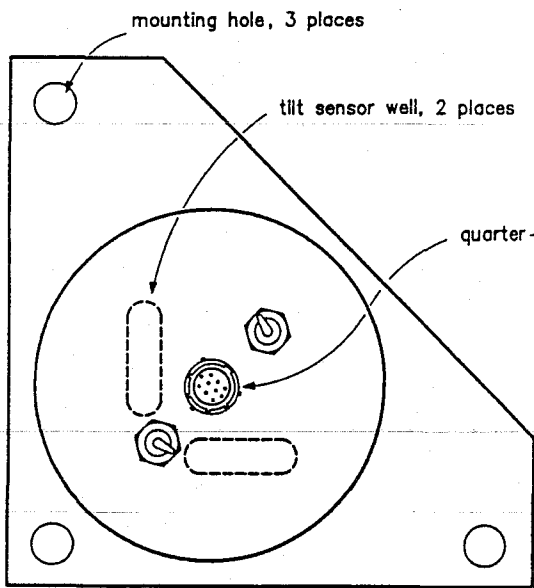
CHECKED
GRH

DWG. No. D-87-1112

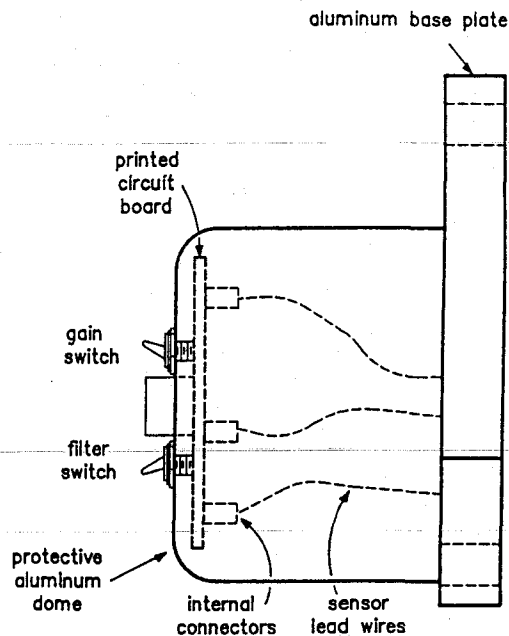
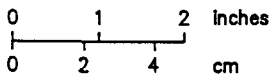
REVISION

SCALE
shown

© 1987



TOP VIEW



SIDE VIEW

APPLIED
GEOMECHANICS
INCORPORATED

FLOOR MOUNT TILTMETER
MODEL 711-1

DATE
12/18/87

DRAWN
DDC

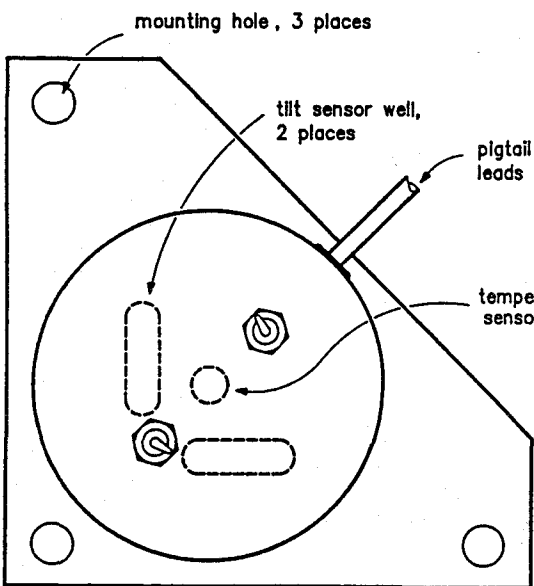
CHECKED
GRH

DWG. No. D - 87-1123

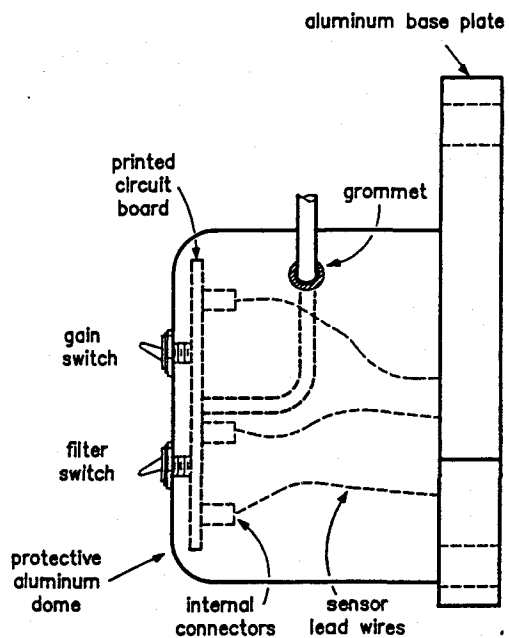
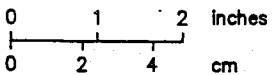
REVISION

SCALE
shown

© 1987



TOP VIEW



SIDE VIEW

APPLIED
GEOMECHANICS
INCORPORATED

FLOOR MOUNT TILTMETER
MODEL 711-2

DATE
12/18/87

DRAWN
DDC

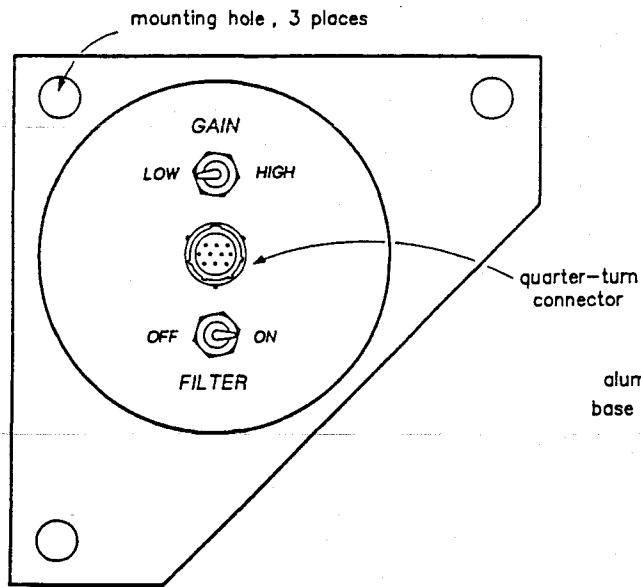
CHECKED
GRH

DWG. No. D - 87-1124

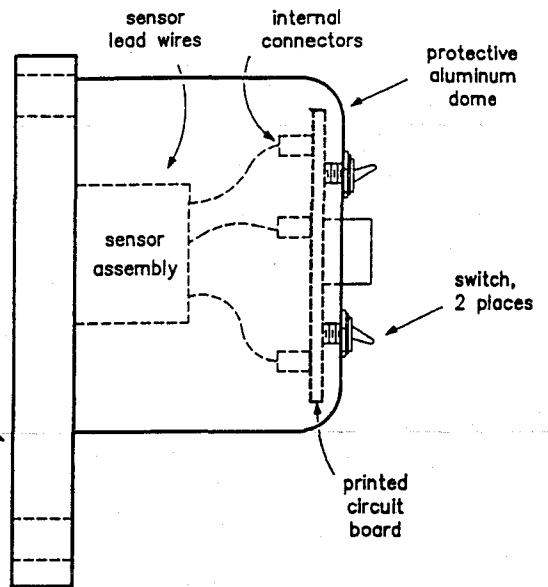
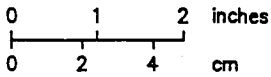
REVISION

SCALE
shown

© 1987



FRONT VIEW



SIDE VIEW

**APPLIED
GEOMECHANICS
INCORPORATED**

WALL MOUNT TILTMETER
MODEL 716-1

DATE
12/18/87

DRAWN
DDC

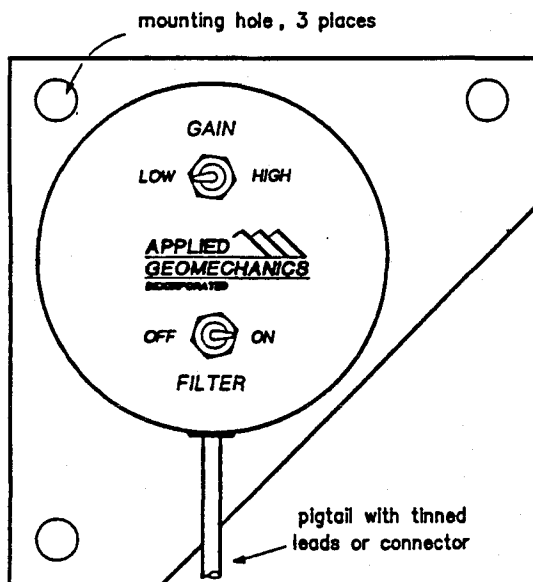
CHECKED
GRH

DWG. No. D - 87-1125

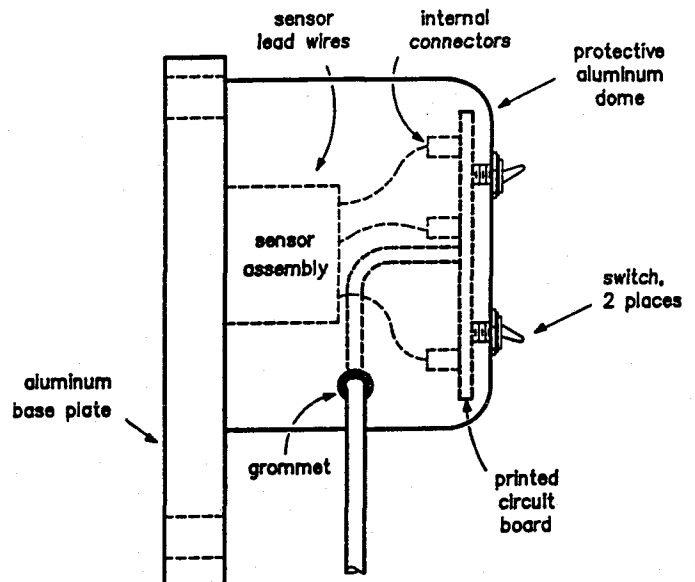
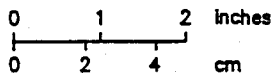
REVISION

SCALE
shown

© 1987



FRONT VIEW



SIDE VIEW

**APPLIED
GEOMECHANICS
INCORPORATED**

WALL MOUNT TILTMETER
MODEL 716-2

DATE
12/18/87

DRAWN
DDC

CHECKED
GRH

DWG. No. D - 87-1126

REVISION

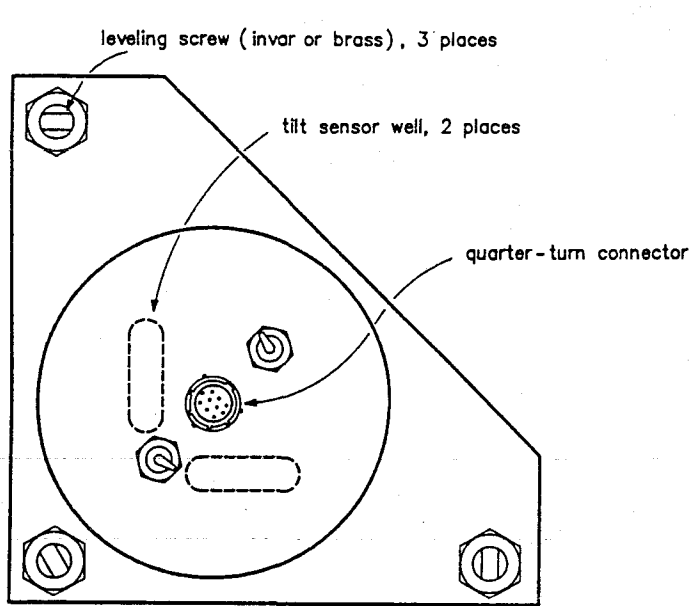
SCALE
shown

© 1987

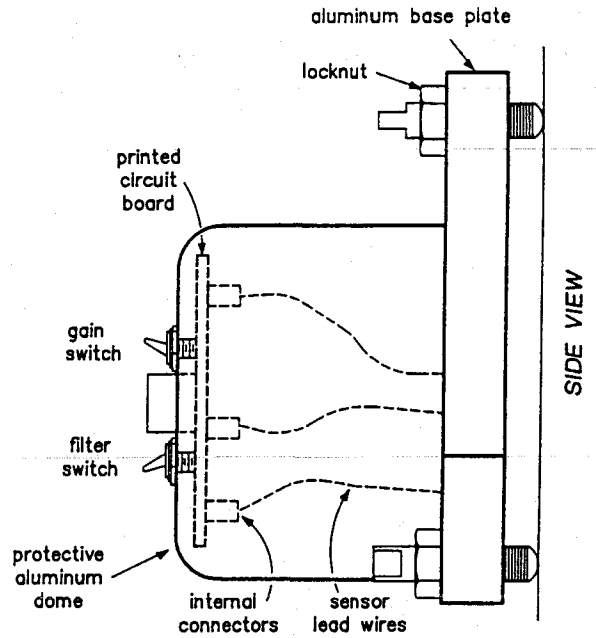
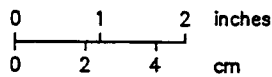
SPECIFICATIONS: Model 701 Platform Tiltmeter
Model 711 Floor Mount Tiltmeter
Model 714 Ceiling Mount Tiltmeter
Model 716 Wall Mount Tiltmeter

These versatile, high-precision, biaxial tiltmeters are well suited for a wide variety of measurement and monitoring applications.

TILT RANGE	Available to ± 1 degree using high-gain transducer, ± 10 degrees using mid-range transducer or ± 60 degrees using wide-angle transducer
TILT RESOLUTION	0.1 microradian (high-gain transducer), 1 microradian (mid-range transducer) or 5 microradians (wide-angle transducer)
TILT OUTPUT	Two single-ended <i>and</i> two differential analog output channels proportional to tilt. Output range: approx. +8 to -8 VDC (single-ended) and +16 to -16 VDC (differential)
SCALE FACTORS	Set to order. Two switchable scale factors (gains) are provided, 10:1 ratio standard, other ratios on request
OUTPUT FILTERS	Electronic filtering of tilt channels provided by two switchable low-pass integrators. Roll-off: 6 db/octave. Time constants preset at 0.05 and 7.5 seconds, other settings on request
TEMP. OUTPUT	0.1°C/mV (single-ended), -40°C to +100°C, $\pm 0.75^\circ\text{C}$ accuracy
OUTPUT IMPEDANCE	All channels: 270 ohms, short circuit and surge protected
POWER REQUIREMENTS	+11 to +15 VDC and -11 to -15 VDC @ +11 and -6 mA typical; 250 mV peak-to-peak ripple max.
OUTPUT CONNECTIONS	Quarter-turn military-style connector on case (specify -1 after model no.), or 10 ft (3 meter) pigtail (specify -2 after model no.). Pigtail is available with or without quarter-turn military-style connector
ENVIRONMENTAL	-25°C to +70°C operational, -30°C to +100°C storage. 0 to 100 % humidity, nonsubmersible
SIZE & WEIGHT	6 x 6 x 4 inches (15 x 15 x 10 cm), 3 lb (1.4 kg)
MATERIALS	Base: 6061-T6 aluminum, hard anodized; Dome: 6061-T6 aluminum, epoxy coated; Seals: Neoprene, silicone rubber. Model 701 only: invar leveling legs, brass locknuts



TOP VIEW



APPLIED
GEOMECHANICS
INCORPORATED

PLATFORM TILTMETER, MODEL 701-1

DATE
11/30/87

DRAWN
DDC

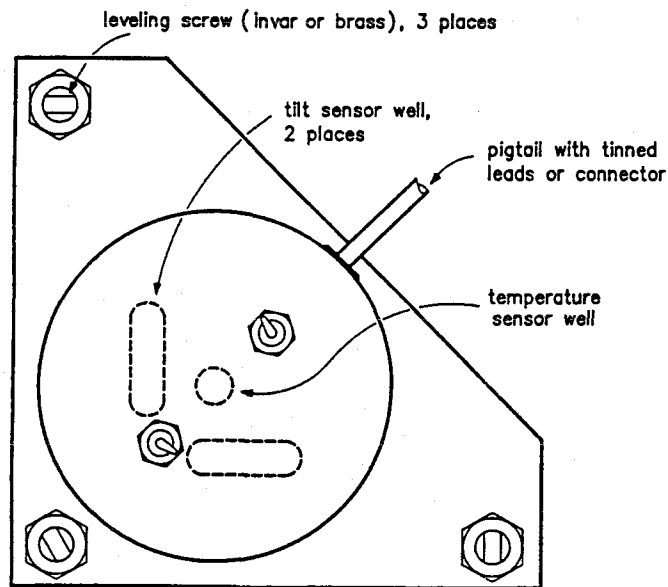
CHECKED
GRH

DWG. No. D - 87 - 1111

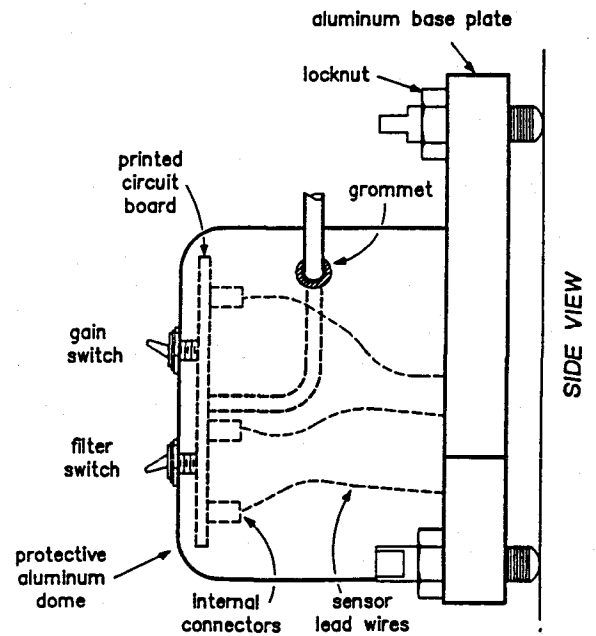
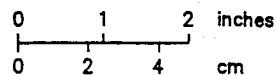
REVISION

SCALE
shown

© 1987



TOP VIEW



APPLIED
GEOMECHANICS
INCORPORATED

PLATFORM TILTMETER, MODEL 701-2

DATE
11/30/87

DRAWN
DDC

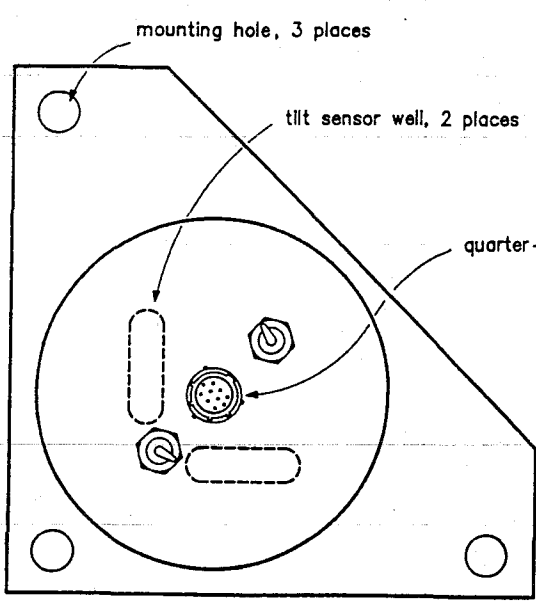
CHECKED
GRH

DWG. No. D - 87 - 1112

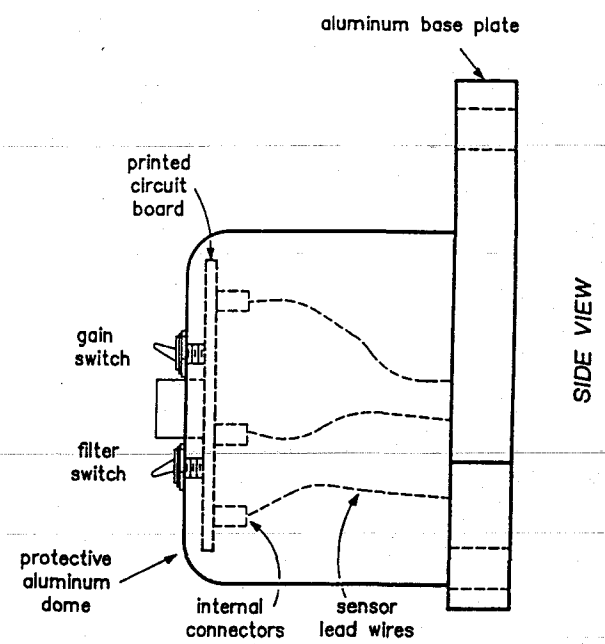
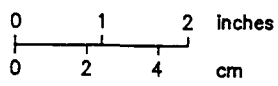
REVISION

SCALE
shown

© 1987



TOP VIEW



SIDE VIEW

APPLIED
GEOMECHANICS
INCORPORATED

FLOOR MOUNT TILTMETER
MODEL 711-1

DATE
12/18/87

DRAWN
DDC

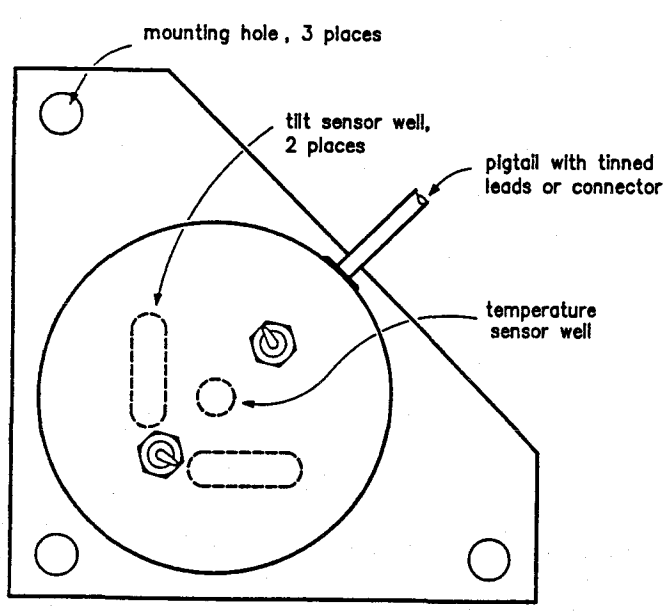
CHECKED
GRH

DWG. No. D - 87-1123

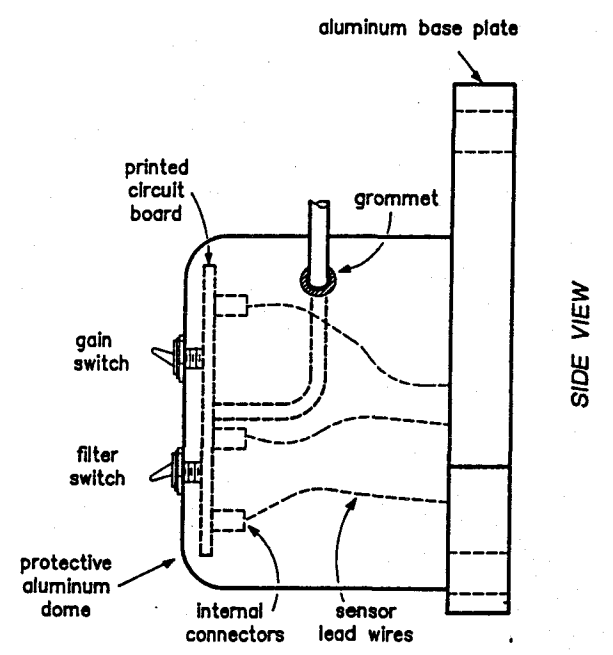
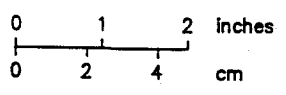
REVISION

SCALE
shown

© 1987



TOP VIEW



SIDE VIEW

APPLIED
GEOMECHANICS
INCORPORATED

FLOOR MOUNT TILTMETER
MODEL 711-2

DATE
12/18/87

DRAWN
DDC

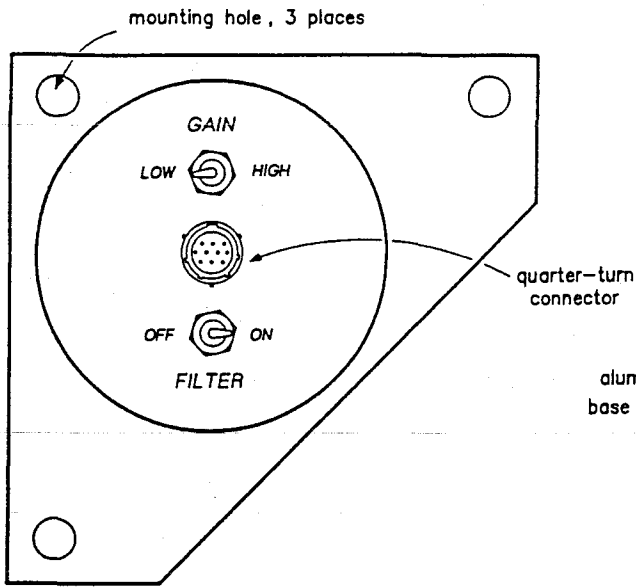
CHECKED
GRH

DWG. No. D - 87-1124

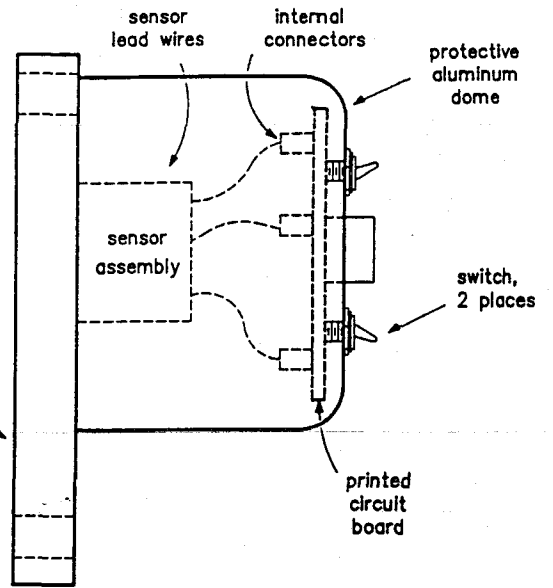
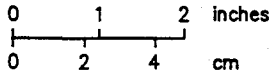
REVISION

SCALE
shown

© 1987



FRONT VIEW



SIDE VIEW

APPLIED
GEOMECHANICS
INCORPORATED

WALL MOUNT TILTMETER
MODEL 716-1

DATE
12/18/87

DRAWN
DDC

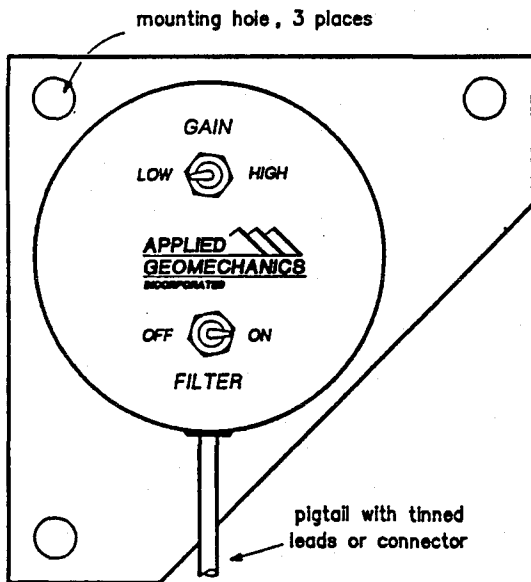
CHECKED
GRH

DWG. No. D-87-1125

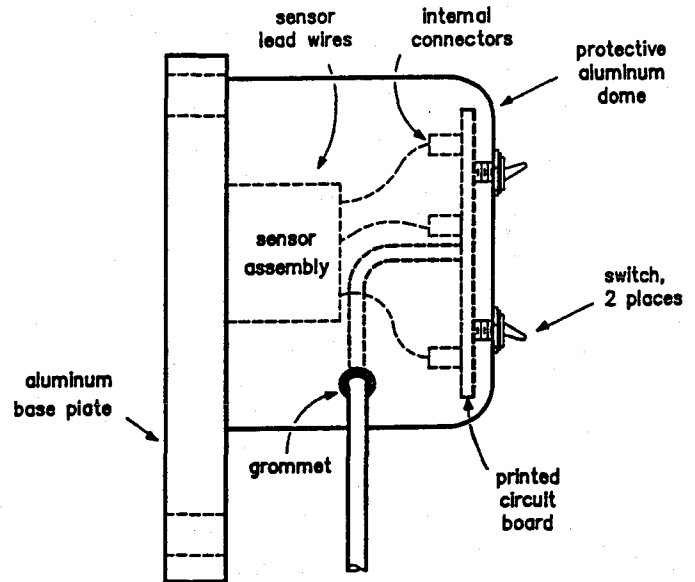
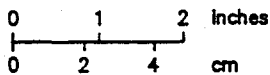
REVISION

SCALE
shown

© 1987



FRONT VIEW



SIDE VIEW

APPLIED
GEOMECHANICS
INCORPORATED

WALL MOUNT TILTMETER
MODEL 716-2

DATE
12/18/87

DRAWN
DDC

CHECKED
GRH

DWG. No. D-87-1126

REVISION

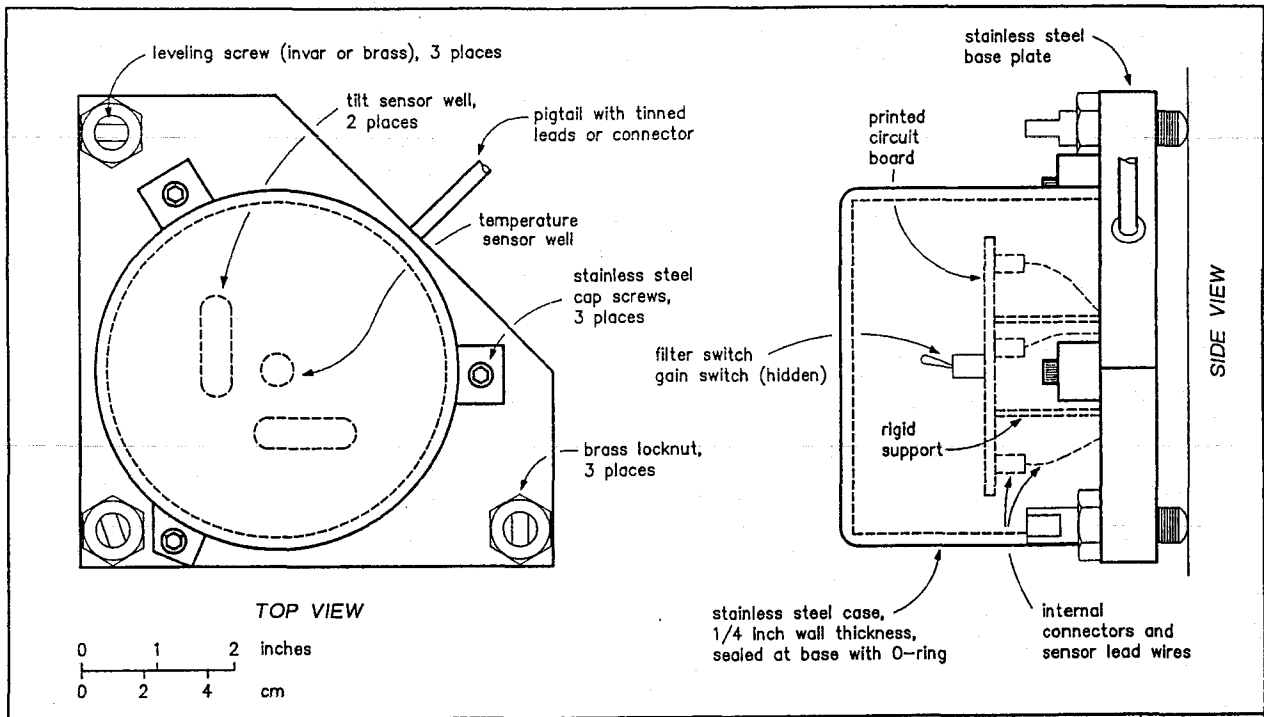
SCALE
shown

© 1987

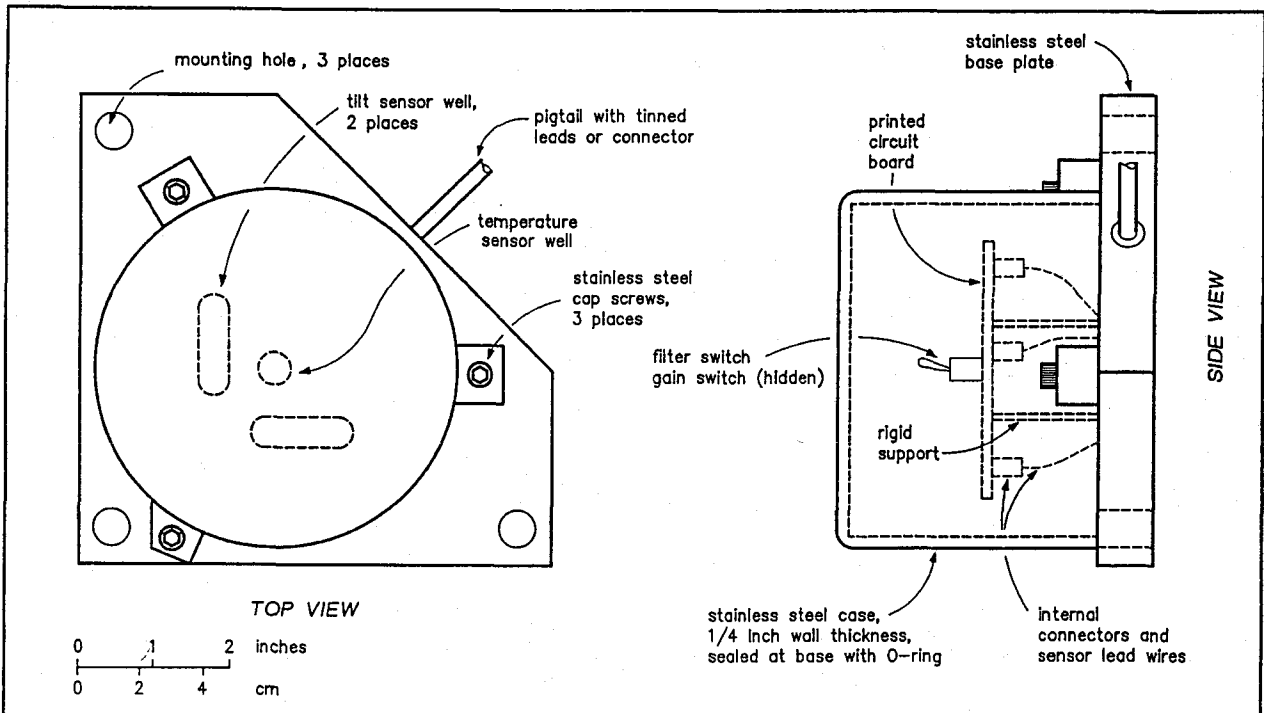
SPECIFICATIONS: Model 702 Platform Tiltmeter
Model 712 Floor Mount Tiltmeter
Model 715 Ceiling Mount Tiltmeter
Model 717 Wall Mount Tiltmeter

These extremely rugged, high-precision, biaxial tiltmeters are well suited for a wide variety of measurement and monitoring applications, including applications involving total submergence.

TILT RANGE	Available to ± 1 degree using high-gain transducer, ± 10 degrees using mid-range transducer or ± 60 degrees using wide-angle transducer
TILT RESOLUTION	0.1 microradian (high-gain transducer), 1 microradian (mid-range transducer) or 5 microradians (wide-angle transducer)
TILT OUTPUT	Two single-ended and two differential analog output channels proportional to tilt. Output range: approx. +8 to -8 VDC (single-ended) and +16 to -16 VDC (differential)
SCALE FACTORS	Set to order. Two switchable scale factors (gains) are provided, 10:1 ratio standard, other ratios on request
OUTPUT FILTERS	Electronic filtering of tilt channels provided by two switchable low-pass integrators. Roll-off: 6 db/octave. Time constants preset at 0.05 and 7.5 seconds, other settings on request
TEMP. OUTPUT	0.1°C/mV (single-ended), -40°C to +100°C, $\pm 0.75^\circ\text{C}$ accuracy
OUTPUT IMPEDANCE	All channels: 270 ohms, short circuit and surge protected
POWER REQUIREMENTS	+11 to +15 VDC and -11 to -15 VDC @ +11 and -6 mA typical; 250 mV peak-to-peak ripple max.
OUTPUT CONNECTIONS	10 ft (3 meter) pigtail standard, greater lengths on request. Pigtail is available with or without quarter-turn military-style connector
ENVIRONMENTAL	-25°C to +70°C operational, -30°C to +100°C storage. 0 to 100 % humidity, fully submersible
SIZE & WEIGHT	6 x 6 x 4 inches (15 x 15 x 10 cm), 10.5 lb (4.8 kg)
MATERIALS	Case: 303/304 stainless steel; O-Ring Seal: buna, EPR or silicone rubber O-ring; Cable: polyurethane jacket. Model 702 only: invar leveling legs, brass locknuts



	PLATFORM TILTMETER, MODEL 702	DATE 12/7/87	DRAWN DDC	CHECKED GRH
	DWG. No. D - 87 - 1114	REVISION	SCALE shown	© 1987



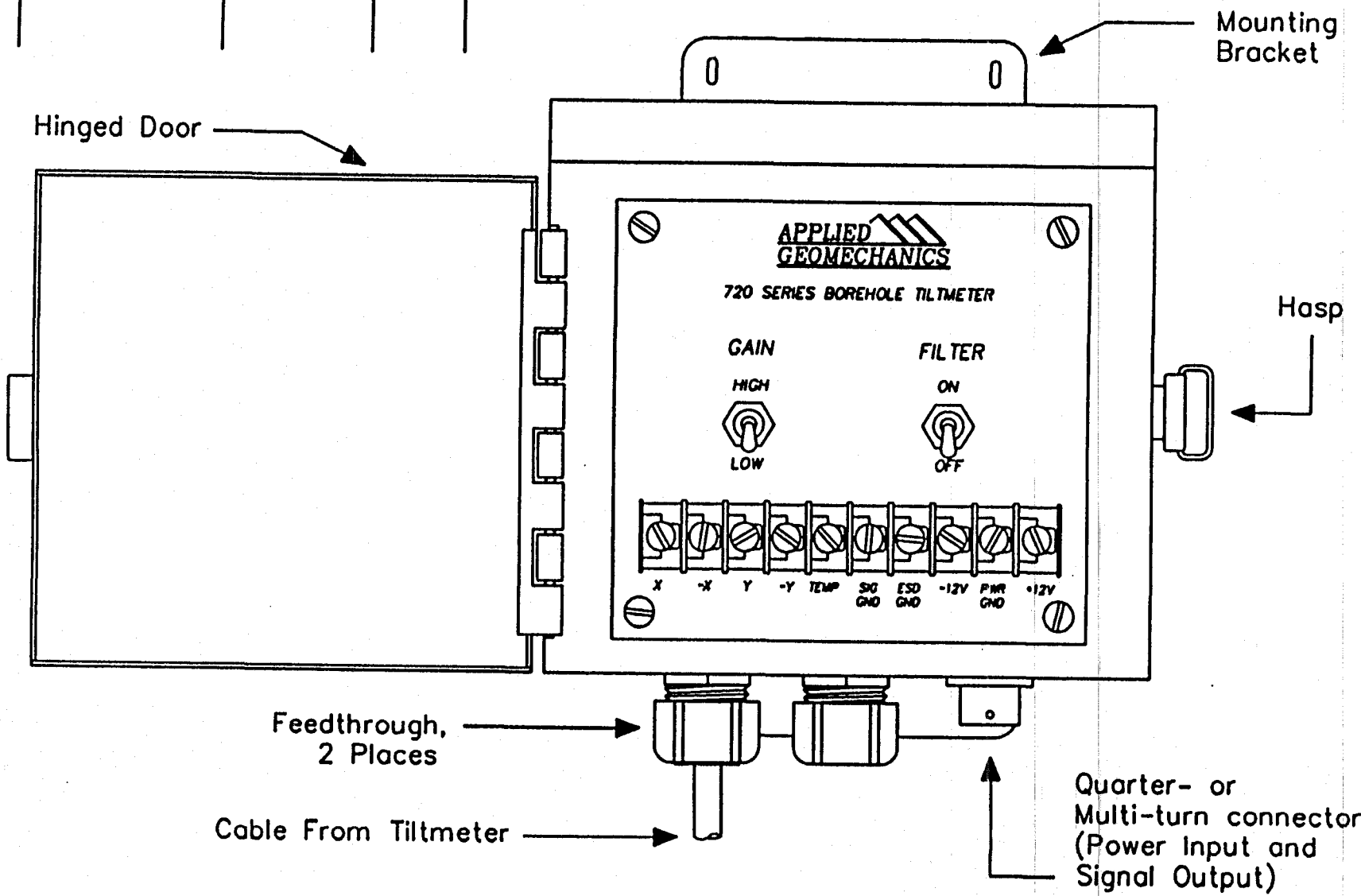
	FLOOR MOUNT TILTMETER MODEL 712	DATE 12/18/87	DRAWN DDC	CHECKED GRH
	DWG. No. D - 87 - 1127	REVISION	SCALE shown	© 1987

SPECIFICATIONS: Model 722 Borehole Tiltmeter

Model 722 is a rugged, biaxial, high-precision borehole tiltmeter for monitoring earth and foundation movement. Electronics are housed inside the tiltmeter body ensuring maximum protection, thermal stability, and signal quality.

TILT RANGE	Available to ± 1 degree using high-gain transducer, ± 10 degrees using mid-range transducer or ± 60 degrees using wide-angle transducer
TILT RESOLUTION	0.1 microradian (high-gain transducer), 1 microradian (mid-range transducer) or 5 microradians (wide-angle transducer)
TILT OUTPUT	Two single-ended and two differential analog output channels proportional to tilt. Output range: approx. +8 to -8 VDC (single-ended) and +16 to -16 VDC (differential)
SCALE FACTORS	Set to order. Two switchable scale factors (gains) are provided, 10:1 ratio standard, other ratios on request
OUTPUT FILTERS	Electronic filtering of tilt channels provided by two switchable low-pass integrators. Roll-off: 6 db/octave. Time constants pre-set at 0.05 and 7.5 seconds, other settings on request
TEMP. OUTPUT	0.1°C/mV (single-ended), -40°C to +100°C, $\pm 0.75^\circ\text{C}$ accuracy
OUTPUT IMPEDANCE	All channels: 270 ohms, short circuit and surge protected
POWER REQUIREMENTS	+11 to +15 VDC and -11 to -15 VDC @ +11 and -6 mA typical; 250 mV peak-to-peak ripple max.
OUTPUT CONNECTIONS	Quarter-turn military-style connector on outside of switch box plus terminal strip inside switch box
ENVIRONMENTAL	-25°C to +70°C operational, -30°C to +100°C storage. Tiltmeter body is submersible. Switch box is rainproof in upright position
SIZE	Tiltmeter body: 2.13 x 33.5 inches (5.4 x 85 cm); Switch box: 6 x 6 x 5 inches (15 x 15 x 13 inches)
WEIGHT	Tiltmeter body: 15 lb (6.8 kg); Switch box: 6 lb (2.7 kg)
MATERIALS	Tiltmeter body: 303/304 stainless steel; Switch box: Painted steel; Seals: EPR, buna, neoprene and/or silicone rubber

REV	DESCRIPTION	DATE	BY



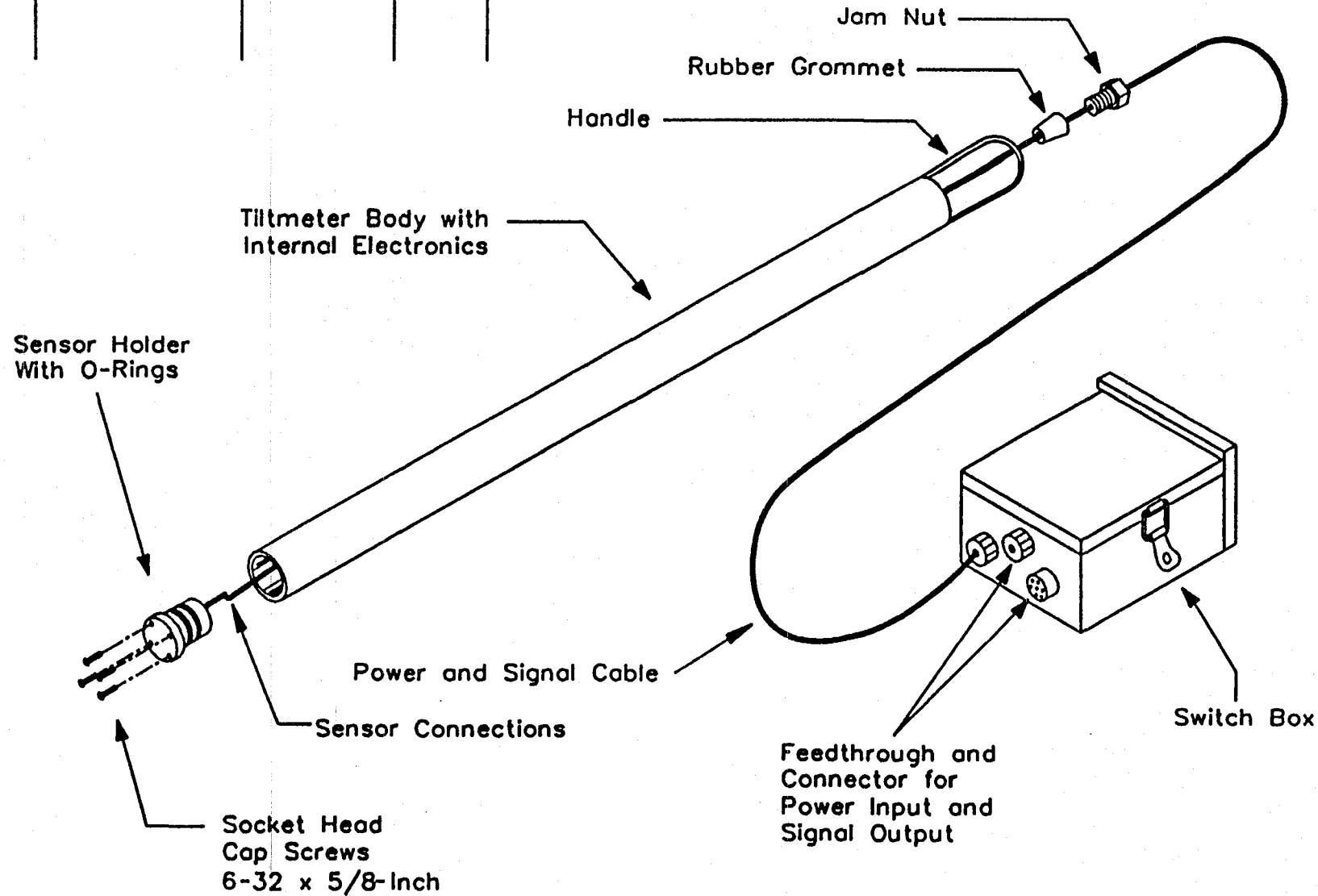
APPLIED
GEOMECHANICS
INCORPORATED


MODEL 722 BOREHOLE TILTMETER,
SWITCH BOX

DWG. No. D-92-1004

DATE 3/5/92	DRAWN HNE	CHECKED GRH
REVISION	SCALE none	© 1992

REV	DESCRIPTION	DATE	BY



APPLIED

GEOMECHANICS
 INCORPORATED

MODEL 722 BOREHOLE TILTMETER
 WITH INTERNAL ELECTRONICS

DATE
 3/5/92

DRAWN
 HNE

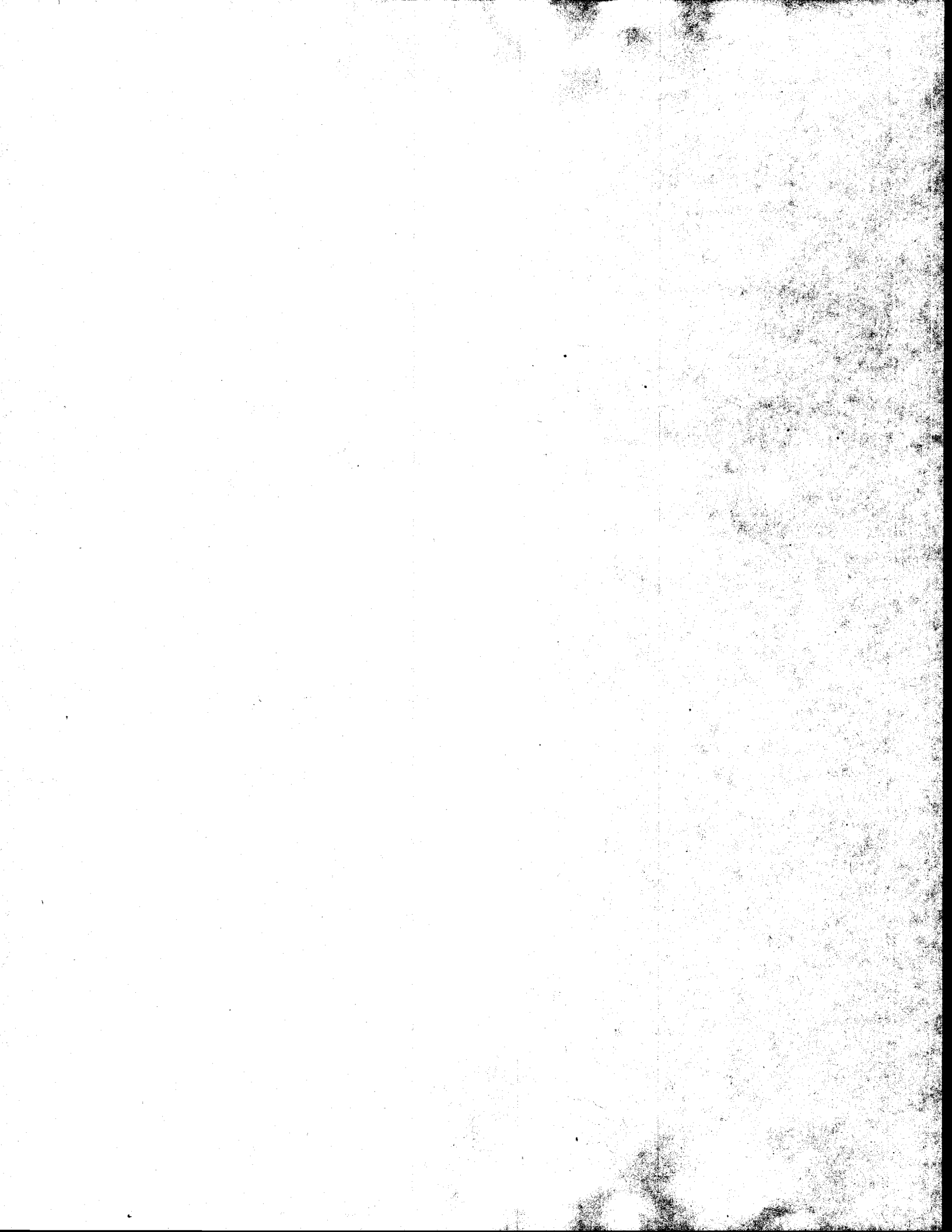
CHECKED
 GRH

DWG. No. D-92-1003

REVISION

SCALE
 none

© 1992

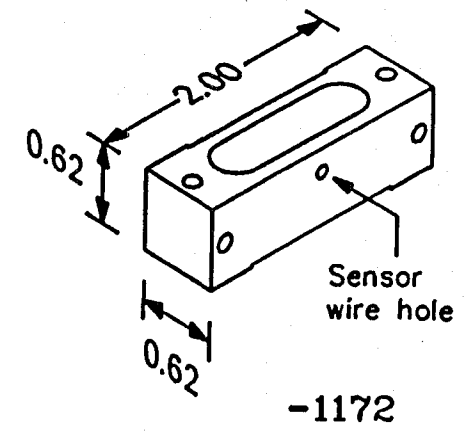
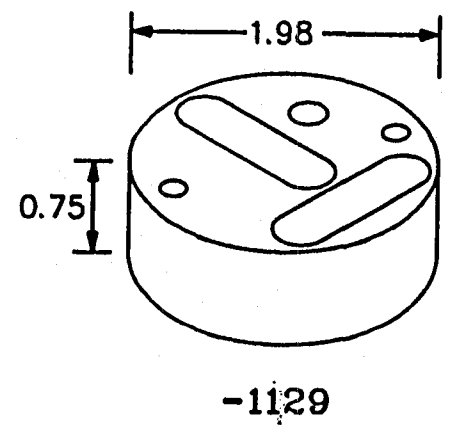
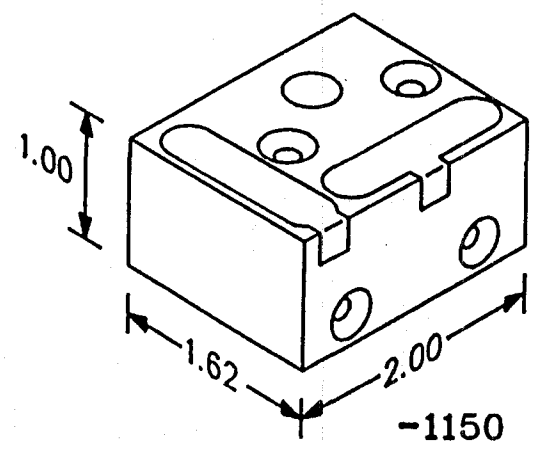
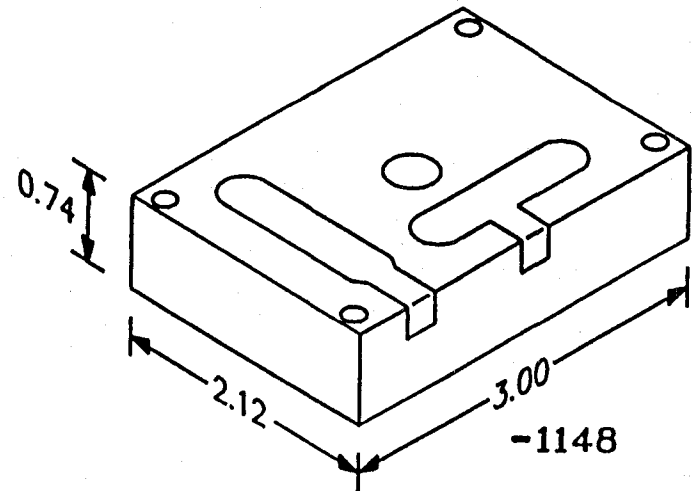
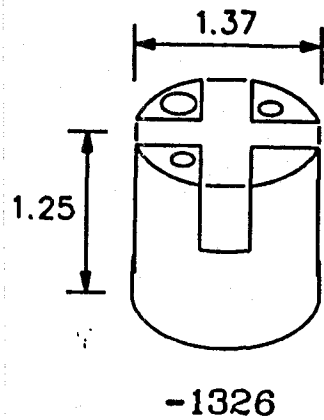


755-Series High-Gain Miniature Tilt Sensors
 756-Series Mid-Range Miniature Tilt Sensors

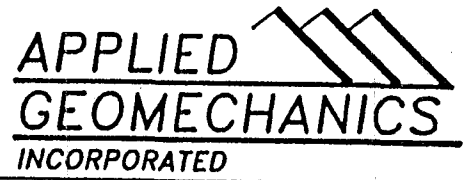
The 755 and 756 Series of Miniature Tilt Sensors include five different sensor packages. Each package consists of a rugged dual-axis or single-axis solid aluminum housing containing Applied Geomechanics precision electrolytic transducers. The housings are in a variety of shapes and dimensions to accommodate a wide range of mounting and space requirements. Mounting holes allow for easy attachment to any vertical or horizontal surface.

RESOLUTION	755 Series: 0.1 microradian (0.02 arc second) 756 Series: 1.0 microradian (0.2 arc second)
TOTAL RANGE	755 Series: ±1 degree; 756 Series: ±10 degrees
REPEATABILITY	755 Series: 1 microradian (0.2 arc second) 756 Series: 2 microradians (0.4 arc second)
LINEARITY	755 Series: Within 0.1 arc minute at an angle of ±10 arc minutes; within 0.5 arc minute at an angle of ±20 arc minutes 756 Series: Within 1.8 arc minutes at an angle of ±3 degrees; within 10 arc minutes at an angle of ±6 degrees
OUTPUT CONNECTIONS	12-inch (30 cm) pigtails with tinned ends or mini connectors
ENVIRONMENTAL	-25°C to +70°C operational, -30°C to +100°C storage, 0 to 100 % humidity
MATERIALS	Anodized 6061-T6 aluminum; stainless steel, invar, brass or ceramic available upon request
SIGNAL CONDITIONING	Provided by Model 83162 Board Level Signal Conditioner, Model 775 Readout/Electronics Unit, Model 781 Signal Conditioning Unit, Model 785 Signal Conditioning Field Module or Model 786 Rack-Mount Signal Conditioning Unit.

MODEL	CHANNELS	MOUNTING	DIMENSIONS	WEIGHT
-1129	2 tilt, 1 temp.	Horiz. surface or vert. tube; hole dia.= 0.18" (4.5 mm)	1.98" dia. cylinder x .75" high (50.3 x 19.1 mm)	4 oz. (114 g)
-1326	2 tilt, 1 temp.	Horiz. surface or vert. tube; mounting hole dia.= 0.15" (3.9 mm)	1.37" dia. cylinder x 1.25" high (34.8 x 31.8 mm)	2.8 oz. (80 g)
-1148	2 tilt, 1 temp.	Horiz. surface; mounting hole dia.= 0.20" (5.1 mm)	2.12" x 3.00" x 0.74" (54.9 x 76.2 x 18.8 mm)	7 oz. (200 g)
-1150	2 tilt, 1 temp.	Horiz. or vert. surface; hole dia.= 0.18" (4.4 mm)	1.62" x 2.00" x 1.00" (41.2 x 50.8 x 25.4 mm)	5 oz. (142 g)
-1172	1 tilt	Horiz. or vert. surface; hole dia.= 0.17" (4.3 mm)	2.00" x 0.62" x 0.62" (50.8 x 15.7 x 15.7 mm)	1.5 oz. (42 g)



Dimensions in inches



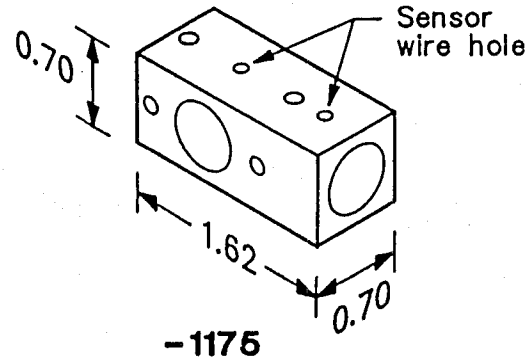
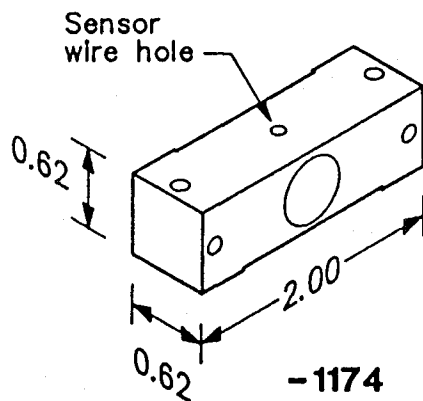
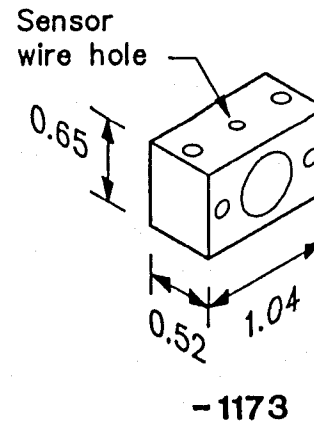
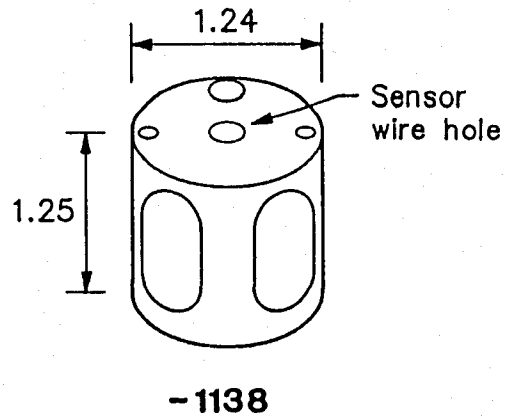
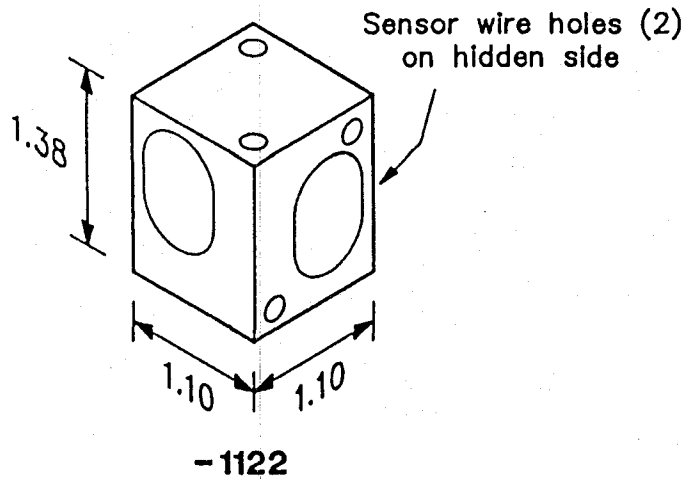
755-SERIES HIGH GAIN MINIATURE TILT SENSORS 756-SERIES MID-RANGE MINIATURE TILT SENSORS	DATE 1/25/93	DRAWN HNE	CHECKED GRH
	DWG. No. D-93-1011	REVISION	SCALE NONE
			© 1993

SPECIFICATIONS: 757-Series Wide-Angle Miniature Tilt Sensors

The 757 Series of Miniature Tilt Sensors includes five different sensor packages. Each package consists of a rugged dual-axis or single-axis solid-aluminum housing containing Applied Geomechanics' wide-angle (Type C) electrolytic transducers. The housings are in a variety of shapes and dimensions to accommodate a wide range of mounting and space requirements. Mounting holes allow for easy attachment to any surface.

- RESOLUTION** 5 microradians (≈ 1 arc second = 0.00028 degree)
- TOTAL RANGE** ± 60 degrees
- REPEATABILITY** 5 microradians (≈ 1 arc second = 0.00028 degree)
- LINEARITY** Within 0.1 degree at an angle of ± 10 degrees, within 1.0 degree at an angle of ± 45 degrees, within 3 degrees at ± 60 degrees
- OUTPUT CONNECTIONS** 12-inch (30 cm) pigtailed with tinned ends or mini connectors
- ENVIRONMENTAL RANGE** -25°C to $+70^{\circ}\text{C}$ operational, -30°C to $+100^{\circ}\text{C}$ storage, 0 to 100 % humidity
- MATERIALS** Anodized 6061-T6 aluminum; stainless steel, invar, brass or ceramic available upon request
- SIGNAL CONDITIONING** Provided by Model 83162 Board Level Signal Conditioner, Model 775 Readout/Electronics Unit, Model 781 Signal Conditioning Unit, Model 785 Signal Conditioning Field Module or Model 786 Rack-Mount Signal Conditioning Unit.

MODEL	CHANNELS	MOUNTING	DIMENSIONS	WEIGHT
-1122	2 tilt	Horiz. or vert. surface; hole dia.= 0.18" (4.4 mm)	1.10" x 1.10" x 1.38" (27.9 x 27.9 x 35.1 mm)	2.5 oz. (71 g)
-1138	2 tilt, 1 temp.	Horiz. surface or vert. tube; mounting hole dia.= 0.14" (3.7 mm)	1.24" dia. cylinder x 1.25" high (31.5 x 31.8 mm)	2.5 oz. (71 g)
-1173	1 tilt	Horiz. or vert. surface; hole dia.= 0.17" (4.3 mm)	1.04" x 0.52" x 0.65" (26.4 x 13.3 x 16.6 mm)	0.8 oz. (23 g)
-1174	1 tilt	Horiz. or vert. surface; hole dia.= 0.17" (4.3 mm)	2.00" x 0.62" x 0.62" (50.8 x 15.7 x 15.7 mm)	1.5 oz. (42 g)
-1175	2 tilt	Horiz. or vert. surface; hole dia.= 0.17" (4.3 mm)	1.62" x 0.70" x 0.70" (41.3 x 17.8 x 17.8 mm)	1.5 oz. (42 g)



Dimensions in inches

APPLIED
GEOMECHANICS
INCORPORATED

757-SERIES
WDE-ANGLE MINIATURE TILT SENSORS

DWG. No. D-88-1002

DATE
1/14/88

REVISION

DRAWN
LDR

SCALE
shown

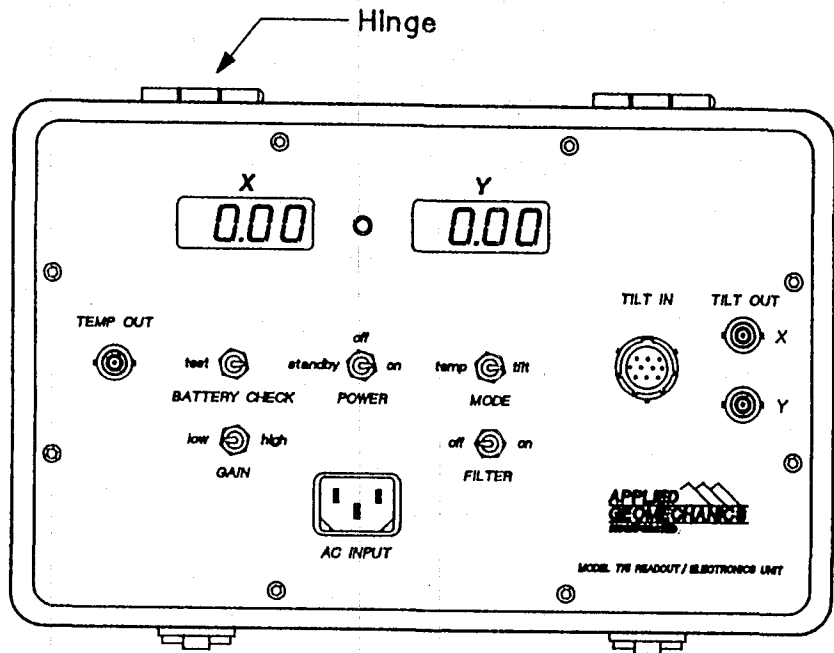
CHECKED
GRH

© 1988

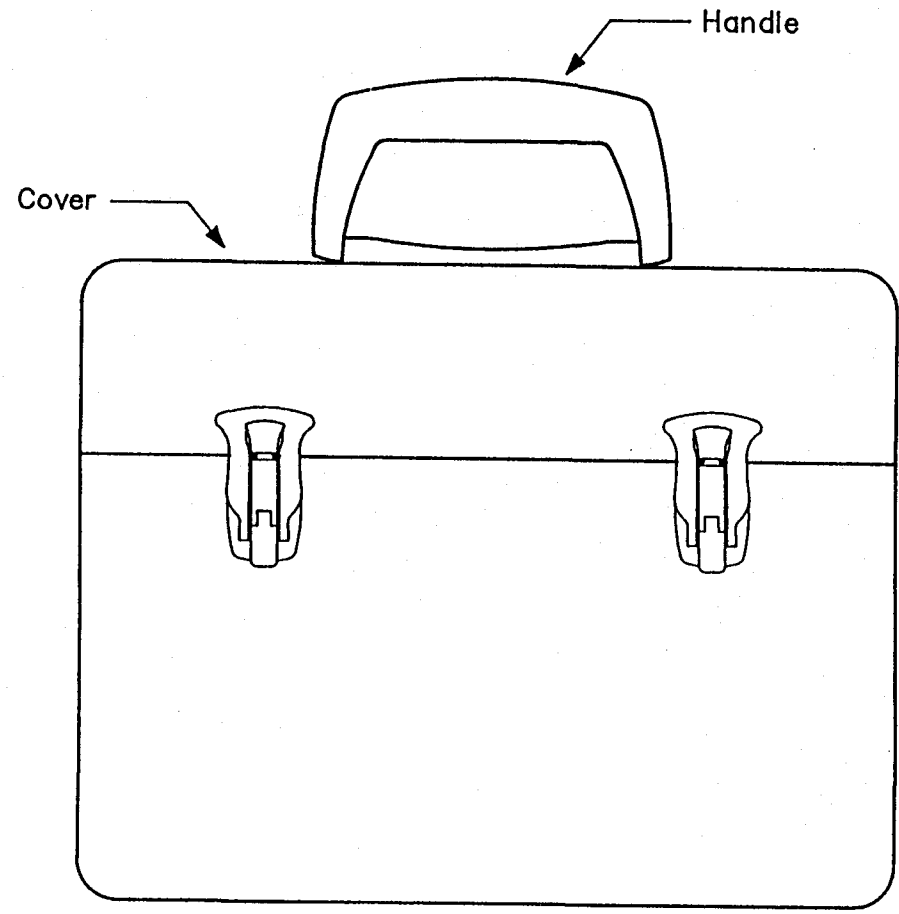
SPECIFICATIONS: Model 775 Readout/Electronics Unit (REU)

Model 775 provides excitation, signal conditioning and digital display of the output of single- or dual-axis tilt sensors. Connectors on the front panel supply conditioned output for external recorders. Model 775 supports all Miniature Tilt Sensors, Model 750 Portable Tilt Sensor, and 760 Series Embedded Tilt Sensors.

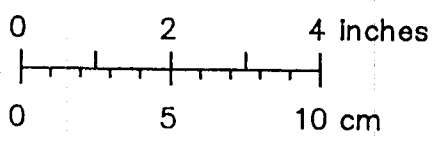
DISPLAY	Dual 3 1/2 digit LCD, 0.5 inch (12.7 mm) digit height; +19.99 to -19.99 VDC or +1.999 to -1.999 VDC range; 0.2 % full scale accuracy
DISPLAY CHANNELS	X tilt, Y tilt, temperature, and internal battery voltages
INPUT CHANNELS	Two electrolytic transducers, one LM-35 temperature sensor
OUTPUT CHANNELS	X tilt and Y tilt, each ± 8 VDC single-ended, scale factors set to order; temperature @ $0.1^{\circ}\text{C}/\text{mV}$, single-ended, -40° to $+100^{\circ}\text{C}$, $\pm 0.75^{\circ}\text{C}$ accuracy
OUTPUT IMPEDANCE	All channels: 270 ohms, short circuit and surge protected
OUTPUT GAINS	Two switchable gains provided, 10:1 ratio standard, other ratios on request
OUTPUT FILTERS	Two switchable low-pass integrators. Roll-off = 6 db/octave. Time constants preset at 0.05 and 7.5 seconds, other settings on request
INTERNAL POWER	Two 12 VDC, 1.2 amp-hour batteries to operate signal conditioning electronics; one AC-to-DC power converter for recharging the 12 VDC batteries; one 9-volt battery to operate digital voltmeters and LCD displays
EXTERNAL POWER	110-120 VAC American version or 220-240 VAC European version, both 47 - 63 Hz. Unit will operate on internal batteries without external power
CONNECTIONS	Tilt and temperature transducers: Quarter-turn military-style connector; Output: BNC (coaxial); Power: grounded, 3-conductor connector
ENVIRONMENTAL	0° to $+50^{\circ}\text{C}$ operational, -20° to $+70^{\circ}\text{C}$ storage; 0 to 80% humidity (noncondensing)
MECHANICAL	Materials: formed, painted aluminum carrying case with handle; Size: 11 x 9 x 8 inches (28 x 23 x 20 cm); Weight: 10.5 lb (4.8 kg)




TOP



FRONT



APPLIED

GEOMECHANICS
 INCORPORATED

MODEL 775 READOUT/ELECTRONICS UNIT

DATE
12/87

DRAWN
LDR

CHECKED
GRH

DWG. No. D-87-1118

REVISION

SCALE
shown

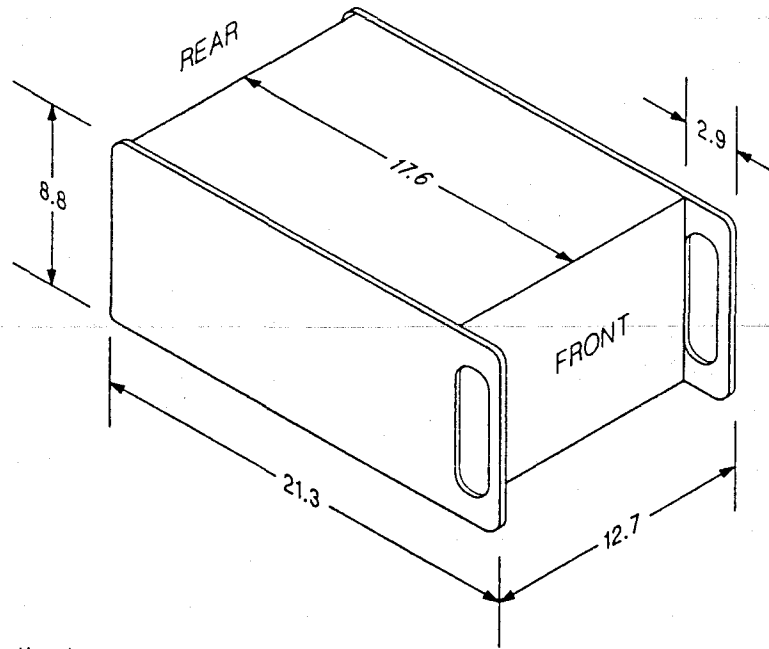
© 1987

SPECIFICATIONS: Model 781 Signal Conditioning Unit (SCU)

Model 781 provides excitation and signal conditioning for all Applied Geomechanics single- or dual-axis tilt sensors. It is a popular signal conditioner for 755-, 756- and 757-Series Miniature Tilt Sensors. Model 781 is housed in a rugged aluminum enclosure designed for indoor use. For applications requiring continuous operation out-of-doors, we recommend our Model 785 Signal Conditioning Field Module.

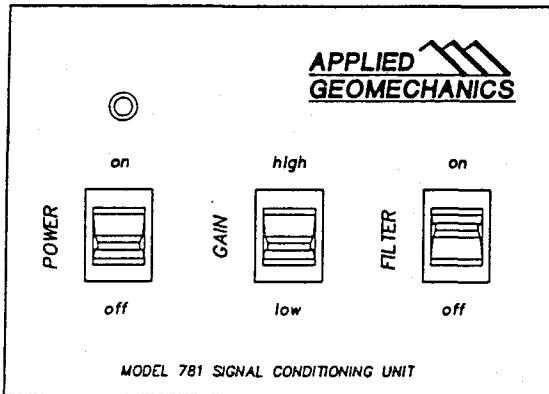
INPUT CHANNELS	Two electrolytic tilt sensors, one LM-35 temperature sensor
TILT OUTPUT CHANNELS	Two single-ended <i>and</i> two differential analog output channels proportional to tilt. Scale factors set to order. A variety of scale factors is available
OUTPUT VOLTAGE RANGE	Approx. ± 8 VDC (single-ended), ± 16 VDC (differential)
OUTPUT GAINS	Two switchable gains provided, 10:1 ratio standard, other ratios on request
OUTPUT FILTERS	Two switchable low-pass integrators. Roll-off = 6 db/octave. Time constants preset at 0.05 and 7.5 seconds, other settings on request
TEMPERATURE OUTPUT	One channel, $0.1^{\circ}\text{C}/\text{mV}$ (single-ended) over -40°C to $+100^{\circ}\text{C}$, $\pm 0.75^{\circ}\text{C}$ accuracy
OUTPUT IMPEDANCE	All channels: 270 ohms, short circuit and surge protected
POWER REQUIREMENTS	+11 to +15 VDC, -11 to -15 VDC @ +11 and -6 mA typical; 250 mV maximum peak-to-peak ripple
EXTERNAL CONNECTIONS	Dual screw-terminal barrier strips
TEMPERATURE RANGE	-25°C to $+70^{\circ}\text{C}$ operational, -30°C to $+100^{\circ}\text{C}$ storage
HUMIDITY RANGE	0 to 100%; noncondensing
SIZE	3.5 x 5 x 8.4 inches (8.8 x 12.7 x 21.3 cm)
WEIGHT	2 lb (0.9 kg)
MATERIALS	Case: painted aluminum

REV	DESCRIPTION	DATE	BY
A	Redrawn	12/10/87	GRH



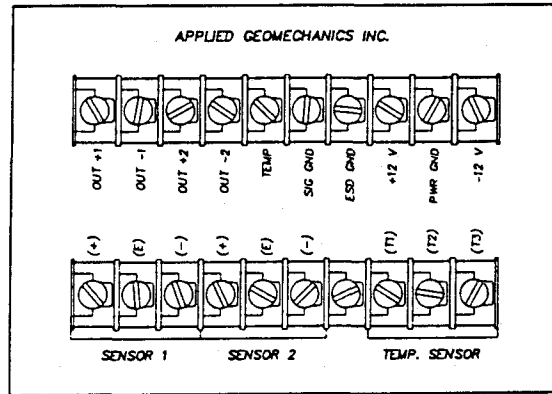
Dimensions in centimeters

	MODEL 781 SIGNAL CONDITIONING UNIT DIMENSIONS	DATE 8/21/87	DRAWN LDR	CHECKED GRH
	DWG. No. D - 87 - 1071	REVISION A	SCALE shown	© 1987

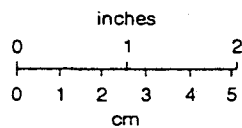


MODEL 781 SIGNAL CONDITIONING UNIT

FRONT



REAR

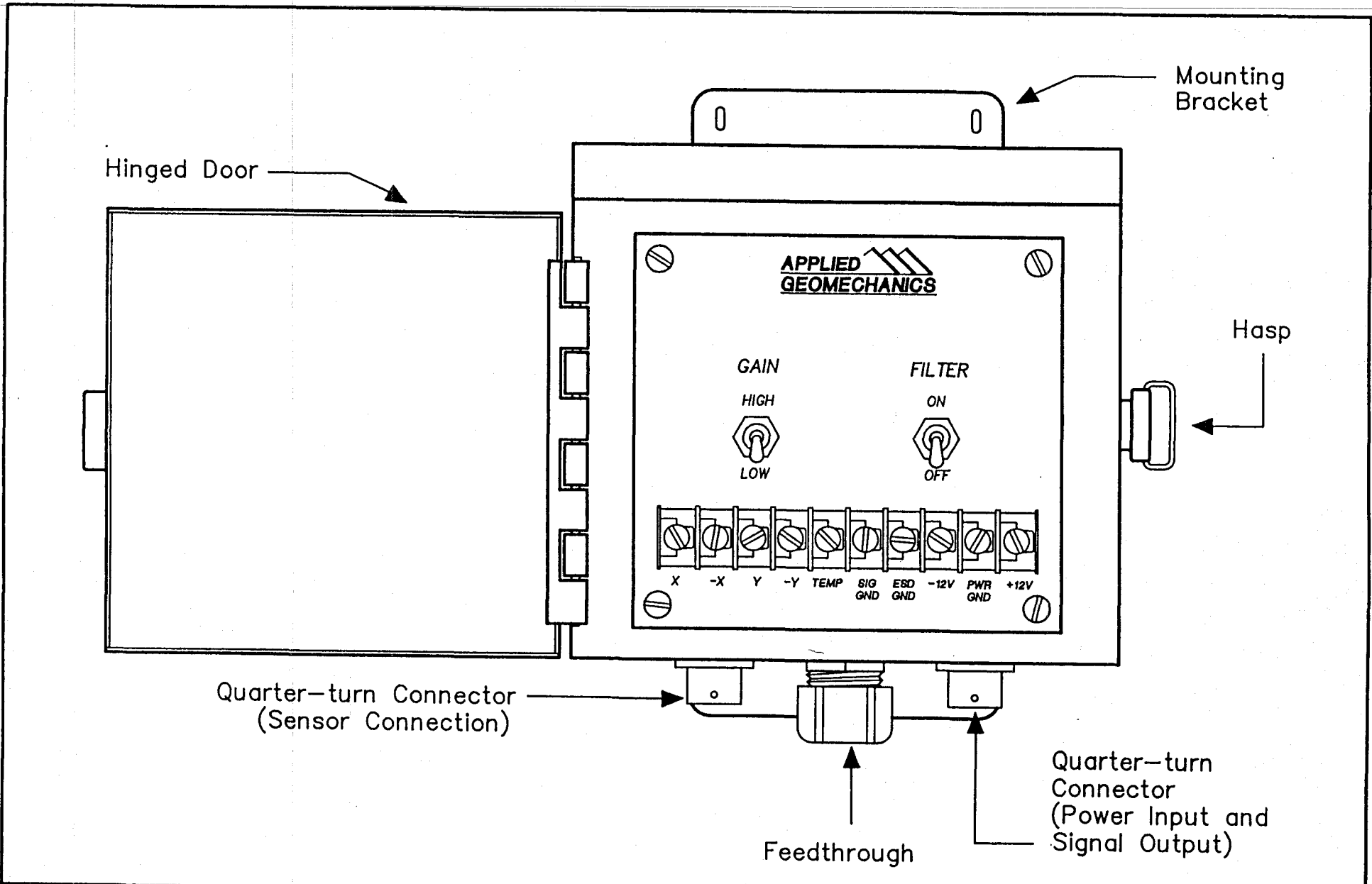


	MODEL 781 SIGNAL CONDITIONING UNIT, FRONT AND REAR PANELS	DATE 12/14/87	DRAWN LDR	CHECKED GRH
	DWG. No. D - 87 - 1115	REVISION	SCALE none	© 1987

SPECIFICATIONS: Model 785 Signal Conditioning Field Module

Model 785 provides excitation and signal conditioning for single- and dual-axis tilt sensors. Housed in a rainproof steel enclosure, the unit is suitable for outdoor operation in harsh weather conditions. Mounting brackets on the enclosure permit attachment to a wall or post for easy access during field surveys. Model 785 supports all Miniature Tilt Sensors, 760-Series Embedded Tilt Sensors, and Model 732 Wheeled Inclinometer

INPUT CHANNELS	Two electrolytic tilt sensors, one LM-35 temperature sensor
TILT OUTPUT CHANNELS	Two single-ended <i>and</i> two differential analog output channels proportional to tilt. Scale factors set to order. A variety of scale factors is available
OUTPUT VOLTAGE RANGE	Approx. ± 8 VDC (single-ended), ± 16 VDC (differential)
OUTPUT GAINS	Two switchable gains provided, 10:1 ratio standard, other ratios on request
OUTPUT FILTERS	Two switchable low-pass integrators. Roll-off = 6 db/octave. Time constants preset at 0.05 and 7.5 seconds, other settings on request
TEMPERATURE OUTPUT	One channel, $0.1^{\circ}\text{C}/\text{mV}$ (single-ended) over -40°C to $+100^{\circ}\text{C}$, $\pm 0.75^{\circ}\text{C}$ accuracy
OUTPUT IMPEDANCE	All channels: 270 ohms, short circuit and surge protected
POWER REQUIREMENTS	+11 to +15 VDC, -11 to -15 VDC @ +11 and -6 mA typical; 250 mV maximum peak-to-peak ripple
EXTERNAL CONNECTIONS	Quarter-turn connector on enclosure for connection to tilt and temperature sensors; nonmatching quarter-turn connector on enclosure for connection to external power supply and record device; screw-terminal barrier strip on internal panel for additional power and signal connections
ENVIRONMENTAL	-25°C to $+70^{\circ}\text{C}$ operational, -30°C to $+100^{\circ}\text{C}$ storage. 0 to 100% humidity, nonsubmersible
SIZE	6 x 6 x 5 inches (15 x 15 x 13 cm)
WEIGHT	6 lb (2.7 kg)
MATERIALS	Enclosure: painted steel. Internal panel: painted aluminum



APPLIED
GEOMECHANICS
INCORPORATED

MODEL 785
SIGNAL CONDITIONING FIELD MODULE

DWG. No. D-87-1119

DATE
12/18/87

REVISION

DRAWN
LDR

SCALE
none

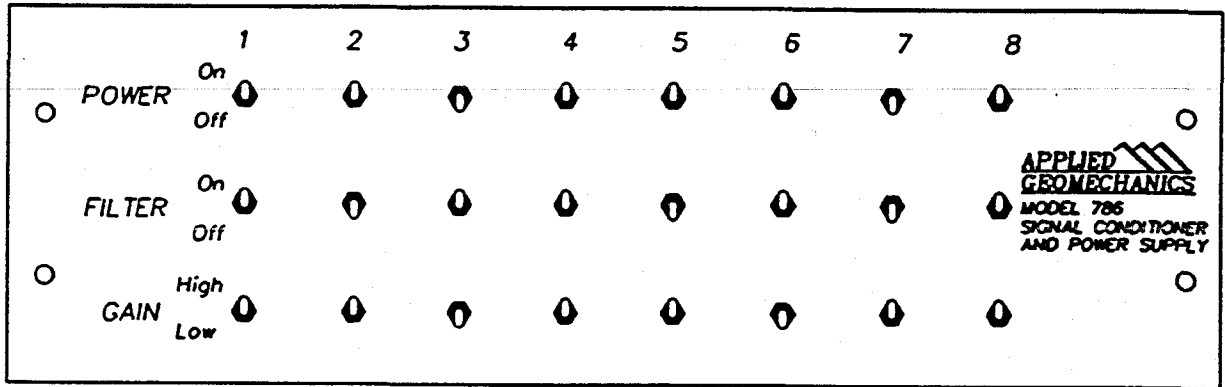
CHECKED
GRH

© 1987

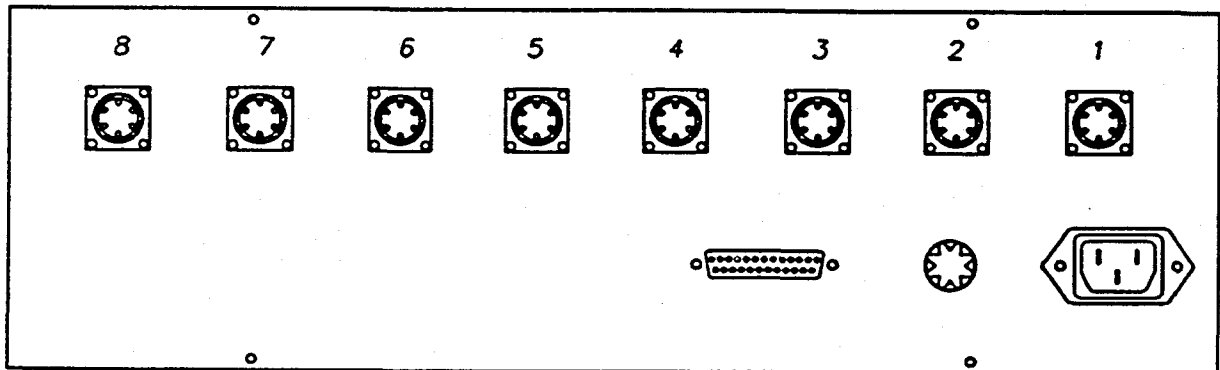
SPECIFICATIONS: Model 786 Signal Conditioning Unit

The Model 786 Signal Conditioning Unit is a rack mount module that may be used with all Applied Geomechanics tilt sensors. It is well suited for any application where machine or structural tilt must be measured in multiple locations. Internal electronics provide simultaneous excitation of two to sixteen electrolytic tilt transducers and condition the returned signals into analog DC voltages. Model 786 also takes temperature readings from National Semiconductor LM35 temperature sensors. One temperature channel is provided per pair of tilt channels.

INPUT CHANNELS	Expandable in pairs from two to sixteen electrolytic tilt sensors. One LM-35 temperature sensor per pair of tilt channels. Number of channels is specified when ordering
TILT OUTPUT CHANNELS	Two to sixteen single-ended <i>and</i> two to sixteen differential analog output channels proportional to tilt. Scale factors set to order. A variety of scale factors is available
OUTPUT VOLTAGE RANGE	Approx. ± 8 VDC (single-ended), ± 16 VDC (differential)
OUTPUT GAINS	Two switchable gains provided per pair of tilt channels, 10:1 ratio standard, other ratios on request
OUTPUT FILTERS	Two switchable low-pass integrators. Roll-off = 6 db/octave. Time constants preset at 0.05 and 7.5 seconds, other settings on request
TEMPERATURE OUTPUT	One to eight channels, $0.1^{\circ}\text{C}/\text{mV}$ (single-ended) over -40°C to $+100^{\circ}\text{C}$, $\pm 0.75^{\circ}\text{C}$ accuracy
OUTPUT IMPEDANCE	All channels: 270 ohms, short circuit and surge protected
POWER REQUIREMENTS	Standard 110-120 VAC, 50/60 Hz, fused to 0.5 amp. 220-240 VAC version available
EXTERNAL CONNECTIONS	Quarter-turn connectors for tilt sensors. "D" panel connectors for output. All connections made on rear panel
ENVIRONMENTAL	-25°C to $+70^{\circ}\text{C}$ operational, -30°C to $+100^{\circ}\text{C}$ storage. 0 to 80 % humidity, noncondensing and nonsubmersible
SIZE & WEIGHT	19 x 5 x 15 inch (483 x 127 x 381 mm), EIA standard 19-inch rack mount; 8.5 lb (3.9 kg)
MATERIALS	Case: painted aluminum and steel



Front Panel



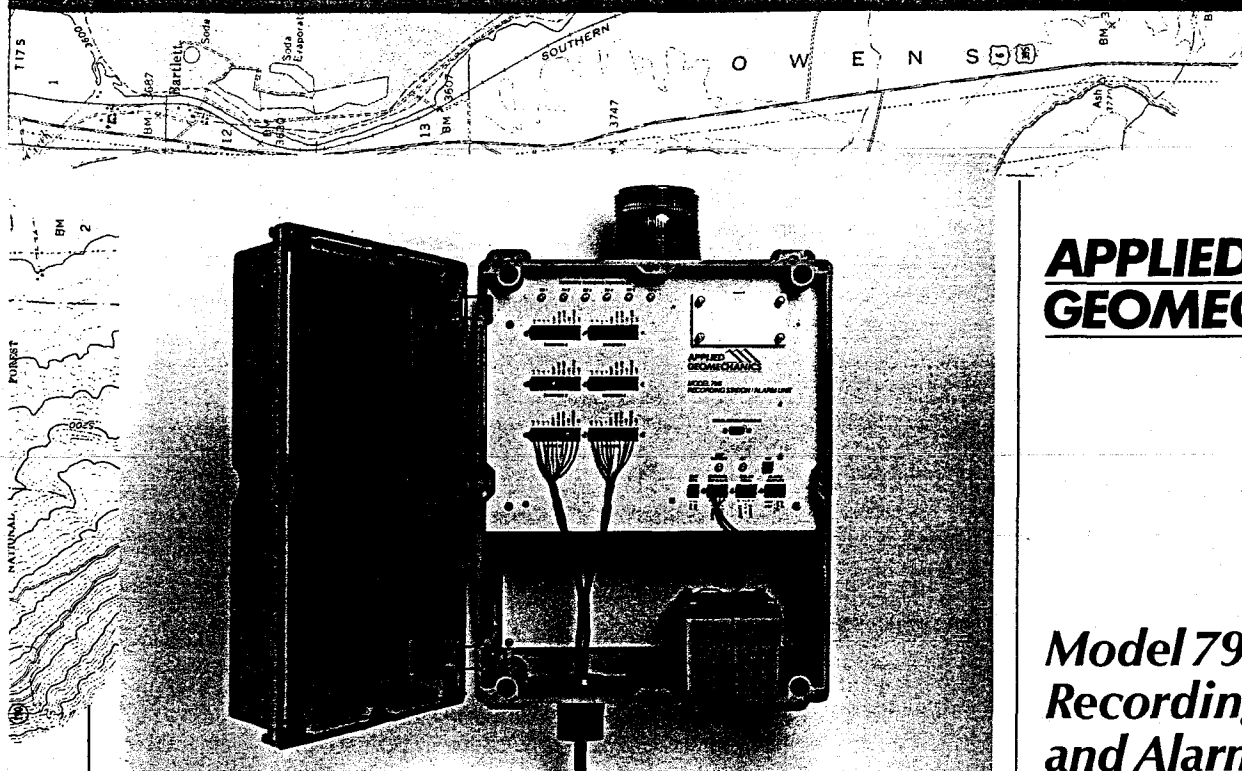
Rear Panel

	Model 786 Signal Conditioning Unit			DRAWN DS	CHECKED GRH
	DWG. No. D-92-1015	DATE 06/04/92	REV	SCALE None	©

SPECIFICATIONS: Model 83162 Board Level Signal Conditioner

Model 83162 is a printed circuit assembly that provides excitation and signal conditioning for two electrolytic tilt transducers and one LM-35 temperature sensor. It can be used with 755-, 756- and 757-Series Miniature Tilt Sensors and all other Applied Geomechanics tilt transducers. Four mounting holes allow easy packaging in customer products. Model 83162 is a high-precision circuit that is well suited for engineering and scientific applications requiring a board level signal conditioner.

INPUT CHANNELS	Two electrolytic tilt sensors, one LM-35 temperature sensor
TILT OUTPUT CHANNELS	Two single-ended <i>and</i> two differential analog output channels proportional to tilt. Scale factors set to order. A variety of scale factors is available
OUTPUT VOLTAGE RANGE	Approx. ± 8 VDC (single-ended), ± 16 VDC (differential)
OUTPUT GAINS	Two switchable gains provided, 10:1 ratio standard, other ratios on request. Toggle switch mounted on board (switch can be omitted on request)
OUTPUT FILTERS	Two switchable low-pass integrators. Roll-off = 6 db/octave. Time constants preset at 0.05 and 7.5 seconds, other settings on request. Toggle switch mounted on board (switch can be omitted on request)
TEMPERATURE OUTPUT	One channel, $0.1^{\circ}\text{C}/\text{mV}$ (single-ended) over -40°C to $+100^{\circ}\text{C}$, $\pm 0.75^{\circ}\text{C}$ accuracy
OUTPUT IMPEDANCE	All channels: 270 ohms, short circuit and surge protected
POWER REQUIREMENTS	+11 to +15 VDC, -11 to -15 VDC @ +11 and -6 mA typical; 250 mV maximum peak-to-peak ripple
CONNECTIONS	Power input and signal output: Pigtail or quarter-turn military-style connector. Sensor connections: Gold-plated Fujitsu header pins
ENVIRONMENTAL	-25°C to $+70^{\circ}\text{C}$ operational, -30°C to $+100^{\circ}\text{C}$ storage; 0 to 80% humidity
SIZE & WEIGHT	Round circuit board, 4 inches (10.1 cm) diameter; approx. 30 grams
MATERIALS	Fiberglass printed circuit board with soldered components



APPLIED GEOMECHANICS

Model 796 Recording Station and Alarm Unit

Automated Monitoring with Alarm Capabilities

Model 796 is a central control station that enables you to automatically monitor the behavior of any structure—simply, affordably and reliably. Model 796 simultaneously powers and records multiple tiltmeters or other analog output transducers. You can instruct Model 796 to trigger alarms if allowable movements or other parameters are exceeded. Its wide-ranging applications include monitoring the effects of riverbed scour on bridges, monitoring ground stability during grading, and tracking the behavior of roofs, arches and retaining walls.

For Monitoring of:

- Bridges
- Buildings
- Dams
- Landslides
- Volcanoes
- Foundations
- Retaining Walls
- Roofs
- Roadways
- Tanks
- Tunnels
- Turbines
- Pressure Vessels
- Any Structure

Model 796 continuously records the readings of the transducers connected to it while checking measured behavior against allowable limits. Data are stored in digital format readable by an IBM-compatible microcomputer. You set sample rates and alarm thresholds using programs supplied with the unit, or by writing your own programs. An internal microprocessor-based controller regulates clock, logic and recording functions.

Model 796 is supplied with its own flashing strobe alarm light, as well as switch closure connections for auxiliary remote alarms. Designed for outdoor or indoor use, Model 796 will operate from AC power, batteries or solar cells.

Flexible Data Retrieval

When you are ready to download data into your computer for graphing, review and presentation, Model 796 offers a variety of data retrieval options. Take a laptop computer to the field and connect it directly to the unit via a serial interface. Or, retrieve the data from your office using a telephone line and modem. If you are within several kilometers of the Model 796 Recording Station/Alarm Unit, data may be transmitted over twisted pair wires or coaxial cable. If land connections are not feasible,

you may retrieve data by radio telemetry or by visiting the site with a hand-held storage module.

The data communications options outlined above also apply when you program Model 796 or modify existing program parameters. Advise us of your data communications preference and we will provide the necessary communications accessories.

The Model 796 Recording Station/Alarm Unit combines affordability with superior performance. Call or write today for a quotation or additional details.

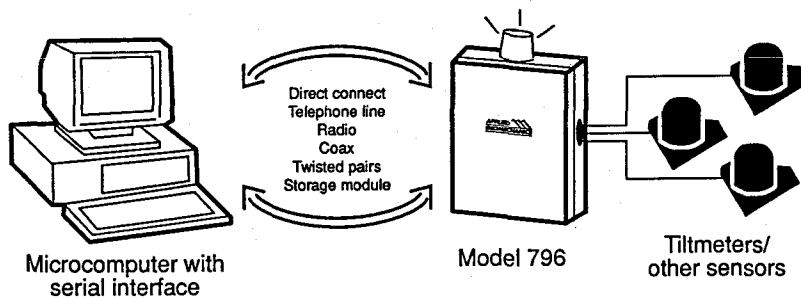


Monitor effects of bridge scour

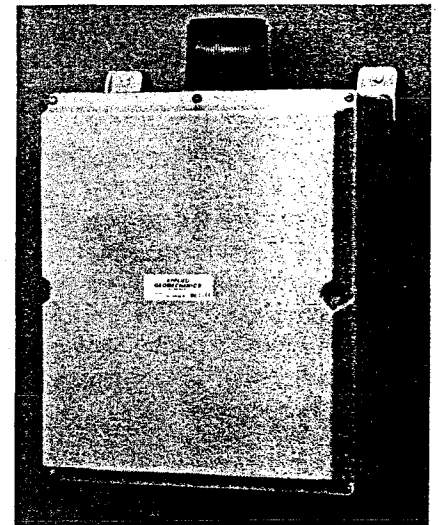
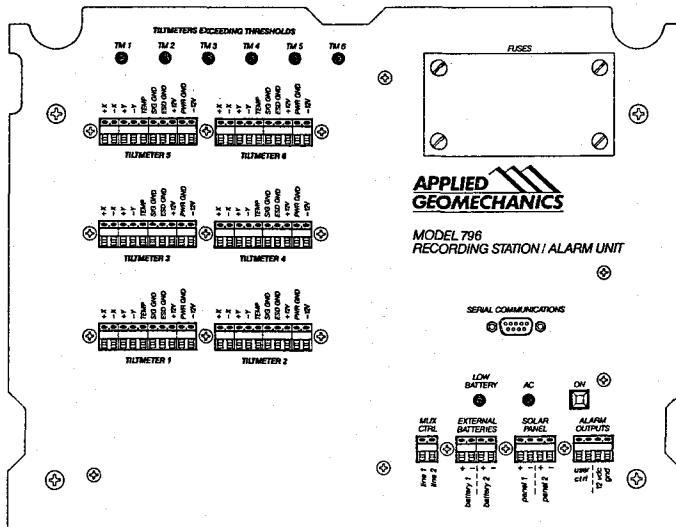
Specifications

SIGNAL INPUT	Differential or single-ended. Standard configuration: Four 700-Series biaxial tiltmeters, six 800-Series uniaxial tiltmeters or twelve voltage inputs from other transducers. Multiplexed configuration: Up to forty 700-Series tiltmeters, sixty 800-Series tiltmeters or 120 voltage inputs from other transducers.
INPUT CONNECTIONS	Miniature screw terminals. Up to ± 2.5 volt input range.
POWER REQUIREMENTS	110–120 VAC or 220–240 VAC @ 47–63 Hz. Unit also operates from two external 12-volt batteries or solar cells.
POWER OUTPUT	± 12 VDC. Two internal 12-volt rechargeable batteries provide backup power during AC power outages.
PROGRAMMING	Data collection, processing and alarm functions are fully programmable from an IBM-compatible microcomputer or hand-held keypad. Prewritten data acquisition and alarm programs are provided with each unit.
DATA STORAGE	Stores 29,900 data values at 13-bit resolution. Expanded storage to 2,864,000 data values is available using solid state modules.
DATA RETRIEVAL	Downloading to an IBM-compatible microcomputer via 9-pin serial cable (direct connect), telephone modem, radio telemetry, coaxial cable, two twisted pairs or hand-held storage module.
ALARM FEATURES	All alarm circuits are activated by solid state relays. The following features are provided: 1. Six LEDs on interior panel indicate tiltmeters/transducers that exceed their alarm limits. 2. One external strobe light flashes when any limit is exceeded. 3. One two-wire control port activates user-supplied alarm systems (valve closure, sirens, etc).
ENVIRONMENTAL	-25°C to $+50^{\circ}\text{C}$ operational and storage. Wider ranges available. 0% to 100% humidity (noncondensing). Protected from transients using spark gaps or tranzorbs.
ENCLOSURE	Wall-mountable NEMA 4X fiberglass enclosure, gasketed and rainproof.
SIZE	47 x 37 x 24 cm (18 x 14.5 x 9.5 inches).
WEIGHT	Approx. 12.3 kg (27 lbs) with internal batteries.

TWO-WAY COMMUNICATIONS



CONTROL AND WIRING PANEL



Installed unit with warning light

**APPLIED
GEOMECHANICS**

1336 Brommer Street
Santa Cruz, CA 95062 USA

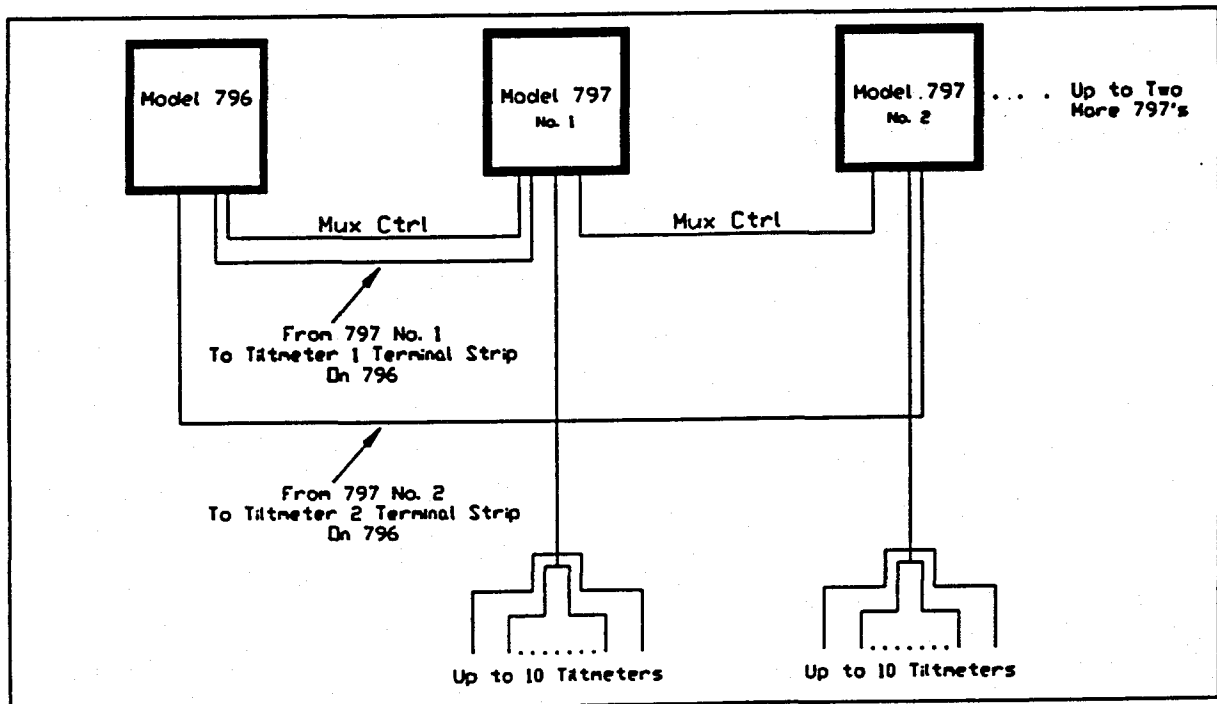
Telephone: (408) 462-2801
FAX: (408) 462-4418

©1990 Applied Geomechanics Inc. All rights reserved.
IBM is a registered trademark of International Business Machines, Inc. Printed in USA

SPECIFICATIONS: Model 797 Multiplexer Unit

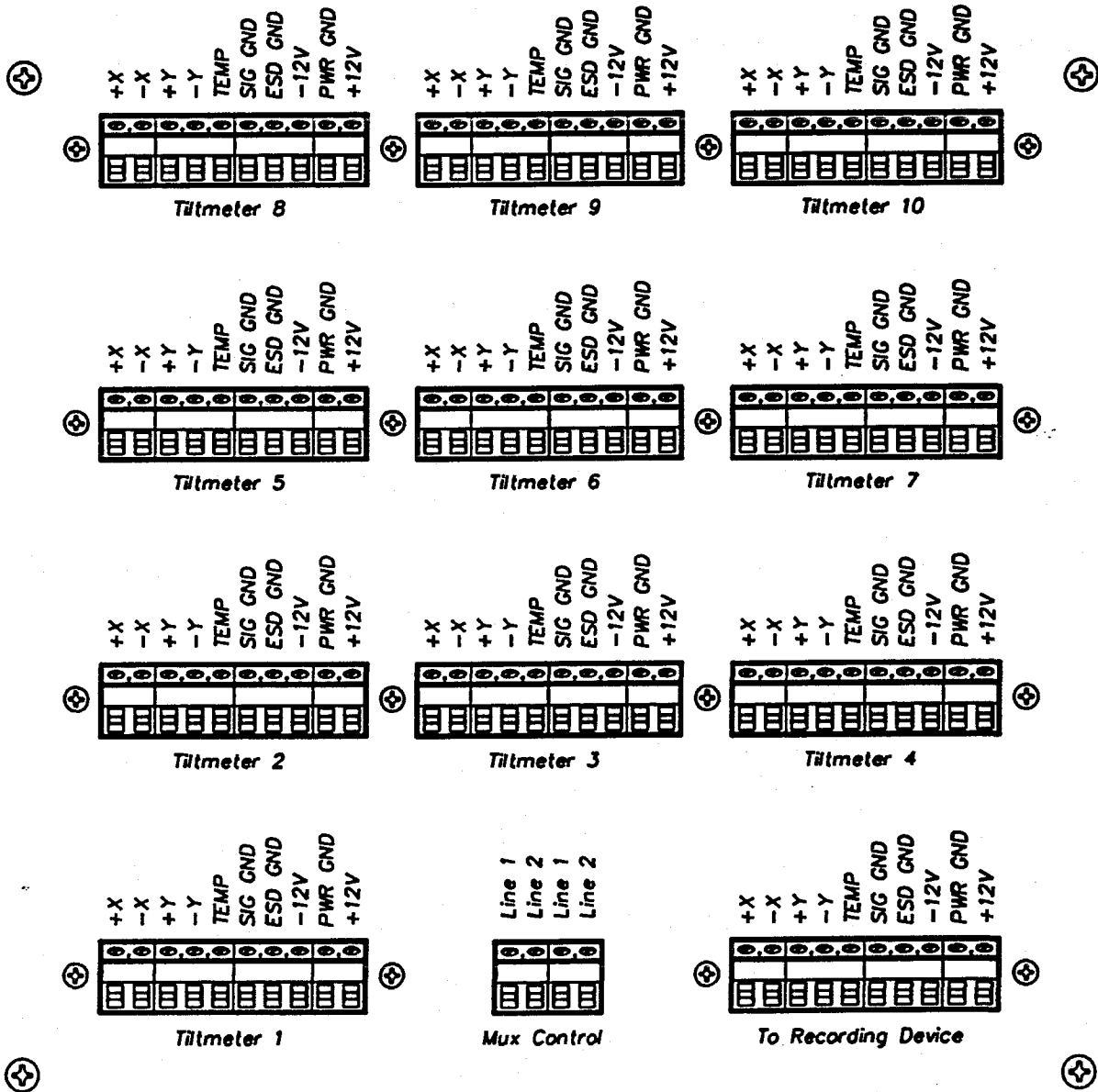
The Model 797 Multiplexer Unit is an add-on module for powering and multiplexing tiltmeters. It is designed to expand the input capabilities of our Model 796 Recording Station/Alarm Unit. Each Model 797 can supply power to and multiplex up to 10 tiltmeters. Power is supplied to the unit by the Model 796. Model 797 can also be used with data acquisition systems made by other vendors for distributing power and multiplexing tiltmeter signals.

- INPUT CHANNELS** Up to ten 700-Series biaxial tiltmeters or 800-Series uniaxial tiltmeters
- CONNECTIONS** Miniature (Phoenix style) screw terminal strips on interior panel
- POWER** ±12VDC normally supplied by Model 796. Unit will also operate from two external 12-volt batteries or dual power supply if Model 796 is not used. Power is constantly provided to all tiltmeters
- CONTROL LOGIC** Two digital input lines select the tiltmeter for output by the Model 797 Multiplexer Unit
- ENCLOSURE** Wall-mountable NEMA 4X fiberglass, gasketed and weatherproof
- SIZE & WEIGHT** 356 x 267 x 191 mm (14 x 10.5 x 7.5 inches); 5 kg (11 lb)



APPLIED
GEOMECHANICS
INCORPORATED

Model 797
Multiplexer Unit

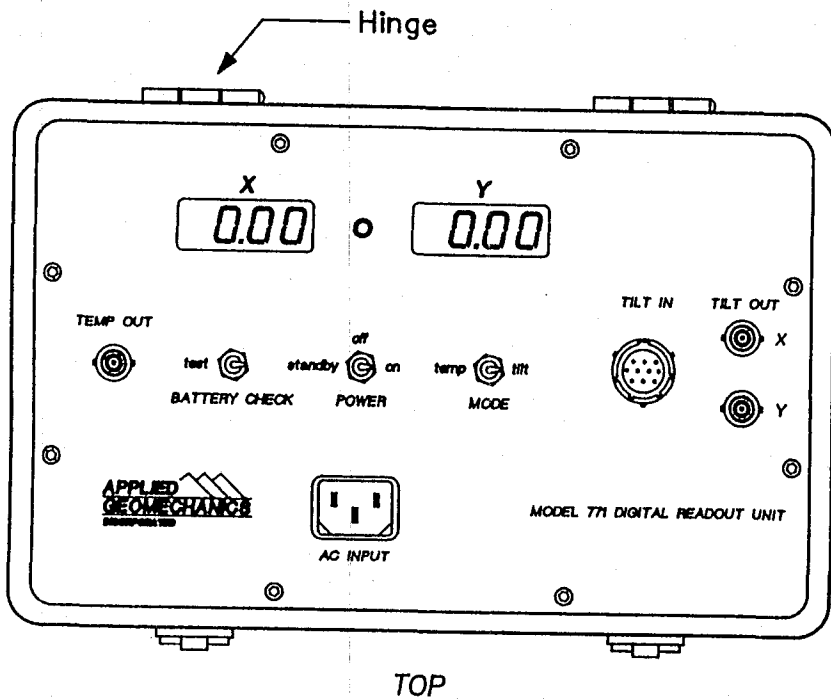


View of Front Panel

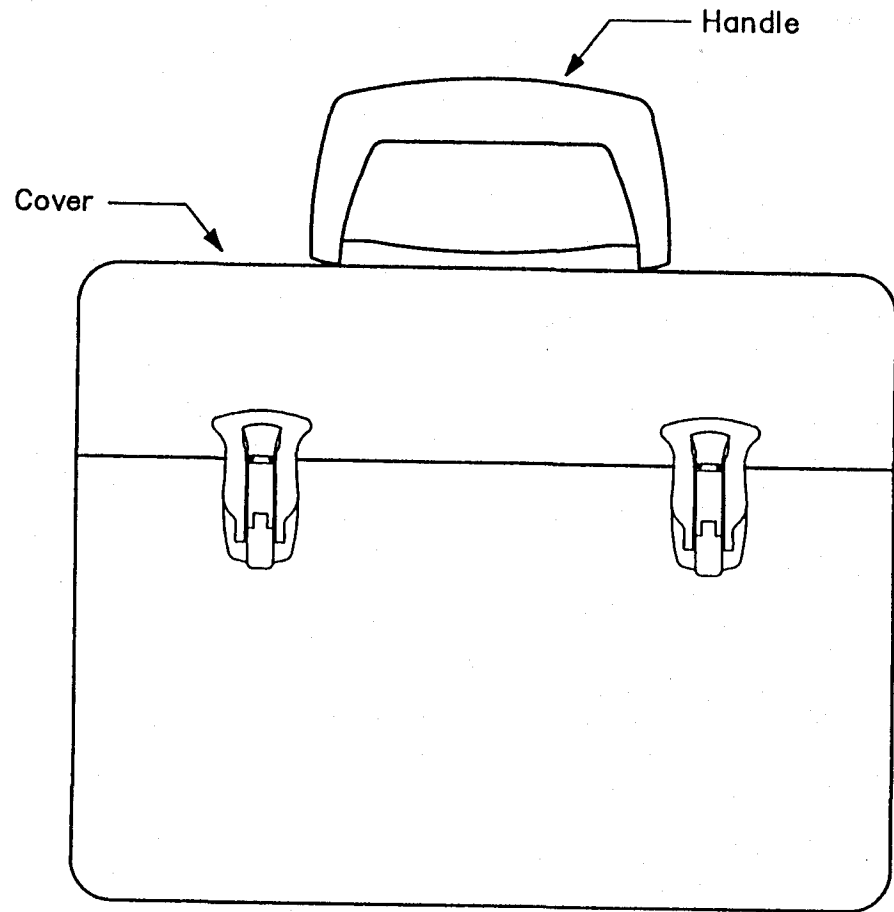
SPECIFICATIONS: Model 771 Digital Readout Unit (DRU)

The Model 771 Digital Readout Unit is used for installing, releveling, periodic field checking and troubleshooting Applied Geomechanics tiltmeters. The DRU powers the tiltmeter and displays the conditioned output received from the tiltmeter on two digital panel meters. Separate connectors supply conditioned output for external recorders. Model 771 supports tiltmeter Models 701 through 722 and Model 800.

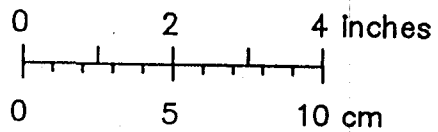
DISPLAY	Dual 3 1/2 digit LCD, 0.5 inch (12.7 mm) digit height
DISPLAY RANGE	+19.99 to -19.99 VDC or +1.999 to -1.999 VDC
DISPLAY ACCURACY	0.2 % full scale
DISPLAY CHANNELS	X tilt, Y tilt, temperature, and internal battery voltages
INPUT CHANNELS	Two tilt channels and one temperature channel
INPUT CONNECTORS	Quarter-turn military-style connector
OUTPUT CHANNELS	X tilt, Y tilt, temperature (all single-ended)
OUTPUT CONNECTORS	BNC
INTERNAL POWER	Two 12 VDC, 1.2 amp-hour batteries to operate tiltmeter; one AC-to-DC power converter for recharging the 12 VDC batteries; one 9-volt battery to operate digital voltmeters and LCD displays
EXTERNAL POWER	110-120 VAC American version or 220-240 VAC European version, both 47 - 63 Hz. Unit will operate on internal batteries without external power
POWER CONNECTOR	Grounded, 3-conductor connector
TEMPERATURE RANGE	0° to +50°C operational, -20° to +70°C storage
HUMIDITY RANGE	0 to 80 % (noncondensing)
MATERIALS	Formed, painted aluminum carrying case with handle
SIZE	11 x 9 x 8 inches (28 x 23 x 20 cm)
WEIGHT	10.5 lb (4.8 kg)



TOP



FRONT



APPLIED
GEOMECHANICS
 INCORPORATED

MODEL 771 DIGITAL READOUT UNIT

DWG. No. D-87-1116

DATE
12/87

REVISION

DRAWN
LDR

SCALE
shown

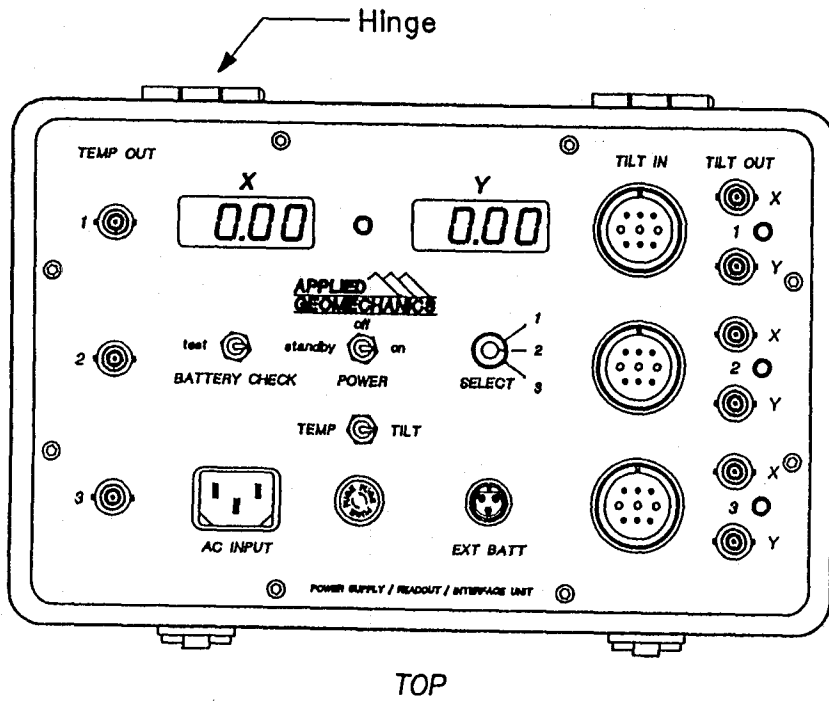
CHECKED
GRH

© 1987

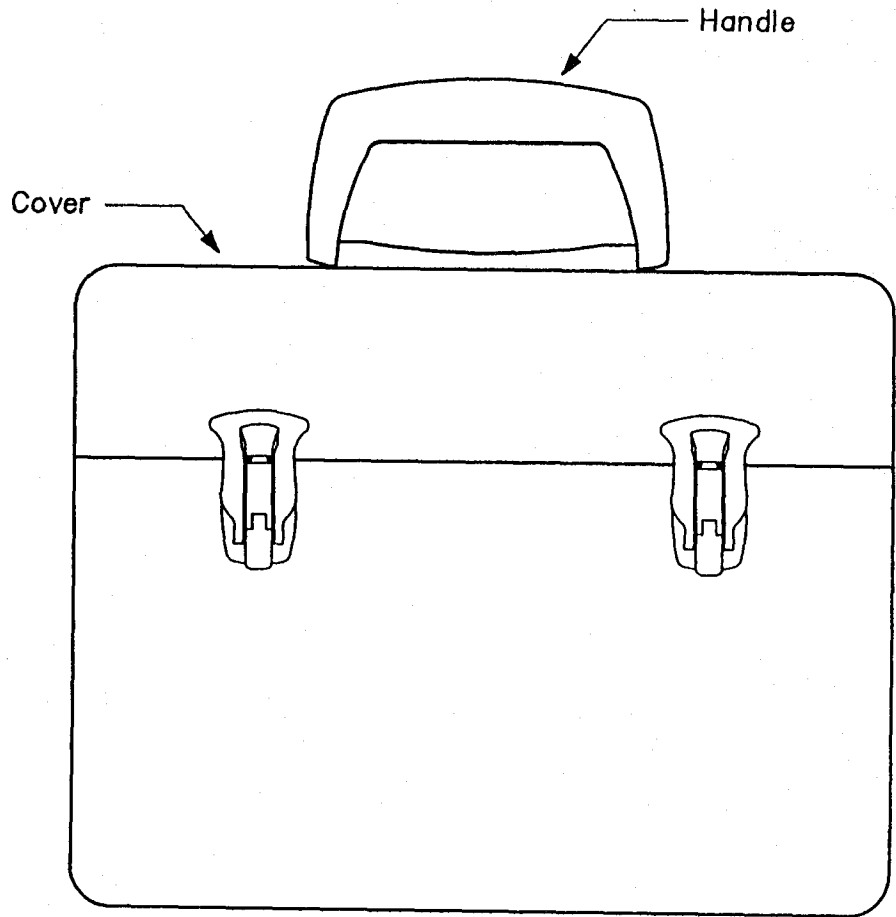
Model 772 Power Supply/Readout/Interface
Unit (PSRI)

Model 772 provides remote power and digital display for up to three biaxial or uniaxial tiltmeters. A rotary switch selects the tiltmeter for output display. Connectors on the front panel supply conditioned tiltmeter outputs for external recorders. This unit is a practical and convenient power, display and interface module for installing and operating a small array of tiltmeters. Model 772 supports tiltmeter Models 701 through 722 and Model 800.

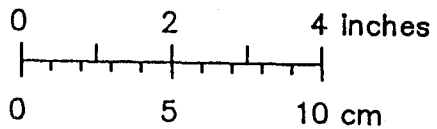
DISPLAY	Dual 3 1/2 digit LCD, 0.5 inch (12.7 mm) digit height
DISPLAY RANGE	+19.99 to -19.99 VDC or +1.999 to -1.999 VDC
DISPLAY ACCURACY	0.2 % full scale
DISPLAY CHANNELS	X tilt, Y tilt, temperature, and internal battery voltages
INPUT CHANNELS	Three biaxial or uniaxial tiltmeters (up to six tilt and two temperature inputs)
INPUT CONNECTORS	Quarter-turn military-style connectors
OUTPUT CHANNELS	X tilt, Y tilt, and temperature (all single-ended) for three tiltmeters simultaneously
OUTPUT CONNECTORS	BNC
INTERNAL POWER	Two 12 VDC, 1.2 amp-hour batteries to operate tiltmeters; one AC-to-DC power converter for recharging the 12 VDC batteries; one 9-volt battery to operate digital voltmeters and LCD displays
EXTERNAL POWER	110-120 VAC American version or 220-240 VAC European version, both 47 - 63 Hz. Unit also will operate from ± 12 VDC power supply or two 12 volt batteries, or from internal batteries without external power
POWER CONNECTOR	Grounded, 3-conductor connector
TEMPERATURE RANGE	0° to +50°C operational, -20° to +70°C storage
HUMIDITY RANGE	0 to 80 % (noncondensing)
MATERIALS	Formed, painted aluminum carrying case with handle
SIZE & WEIGHT	11 x 9 x 8 inches (28 x 23 x 20 cm), 13 lb (5.9 kg)



TOP



FRONT



APPLIED
GEOMECHANICS
 INCORPORATED

MODEL 772
 POWER SUPPLY/READOUT/INTERFACE UNIT

DWG. No. D-87-1117

DATE
 12/87

REVISION

DRAWN
 LDR

SCALE
 shown

CHECKED
 GRH

© 1987



From yaron Wed Jul 6 13:51:38 1994
Received: by tycho AA05497; Wed, 6 Jul 94 13:51:37 EDT
From: Yaron Hefetz <yaron>
To: weiss
Subject: Re: accelerometers.
Cc: yaron, pf, dhs
Status: RO

Rai,

I have just received a Fax with information on the accelerometers.

It looks like one needs a

"Constant Current Supply / Signal Conditioner " to be used with these accelerometers.

The company offers:

Model 2792B : \$1,795.00
9 channels
with: Sensitivity Normalization (variable gain)
LED Status indicator

Model 2793 : \$1,295.00
16 channels
Selectable gain of 1 or 10.

The 2793 looks more attractive (\$81 / channel vs. \$112)

We will need (test mass only):

one unit in each End mirror building.

one unit in each central building.

total: 8 units -> \$10,360.00

or (all optical components)

one unit in each End mirror building.

four units in the central building (two interferometers)

Two units in the central building (one interferometer)

total: 12 units -> \$15,540.00

add these sums to the price:

Test mass only : 10360 + 30420 = \$40,780.00
All optics : 15540 + 91260 = \$106,800.00

Yaron.

> From yaron Wed Jul 6 10:53:47 1994

> To: weiss

> Subject: Re: accelerometers.

> Cc: pf, dhs, yaron

>

> Rai,

>

> The proposal calls for 3 accelerometer per test mass tank.

>

> That comes to:
> 4 masses * 3 accelerometers * 3 interferometer = 36
>
> If we want to monitor other optical components I can think of:
>
> 2 relay mirror tanks
> 1 beam splitter
> 1 recycling mirror
> 1 telescope
> 2 mode cleaners mirror tanks
> 1 laser table
>
> total of 8 additional tanks per interferometer or 72 accelerometers.
>
>
>
> total number of accelerometers is: 36 for test mass only
> or 108 for all critical tanks.
>
>
> In the past we got accelerometers from
> Endevo
> Mystic CT 06355
> (203) 572-0571
>
> The model that we got was:
>
> 7703-1000 accelerometer \$710.00 (each for order of more then 30)
> 2771-1 charge converter \$235.00 (each for order of more then 30)
> \$945.00 total
>
> They now have a new product that combine the two in one unit:
>
> 7754-1000 accelerometer with built in amplifier \$845.00
> (each for order of more then 30)
>
> finally: total price is 845.00 * 36 = \$30,420.00
> or 845.00 * 108 = \$91,260.00
>
> Yaron
>
>
>
>

From Yaron Wed Jul 6 10:53:47 1994

Received: by tycho AA05477; Wed, 6 Jul 94 10:53:45 EDT

From: Yaron Hefetz <yaron>

To: weiss

Subject: Re: accelerometers.

Cc: pf, dhs, yaron

Status: R

Rai,

The proposal calls for 3 accelerometer per test mass tank.

That comes to:

4 masses * 3 accelerometers * 3 interferometer = 36

If we want to monitor other optical components I can think of:

- 2 relay mirror tanks
- 1 beam splitter
- 1 recycling mirror
- 1 telescope
- 2 mode cleaners mirror tanks
- 1 laser table

total of 8 additional tanks per interferometer or 72 accelerometers.

total number of accelerometers is: 36 for test mass only
or 108 for all critical tanks.

In the past we got accelerometers from

Endevco
Mystic CT 06355
(203) 572-0571

The model that we got was:

7703-1000 accelerometer \$710.00 (each for order of more then 30)
2771-1 charge converter \$235.00 (each for order of more then 30)
\$945.00 total

They now have a new product that combine the two in one unit:

7754-1000 accelerometer with built in amplifier \$845.00
(each for order of more then 30)

finally: total price is 845.00 * 36 = \$30,420.00
or 845.00 * 108 = \$91,260.00

Yaron

Please Send Invoices In
TRIPPLICATE TO:
 Massachusetts Institute of Technology
 J. Box 69
 Cambridge, MA 02139

PURCHASE ORDER
Massachusetts Institute of Technology
 Cambridge, Massachusetts 02139

PURCHASE ORDER NUMBER
 SC-A-191298
 This Number Must Appear on Invoices,
 B/L's, Shipping Memos and All Packages.

Date: 04/10/91

ACCOUNT NUMBER 70539
OBJ. CODE 617

Requisition #: 0A20258

ENDEVCO
 20 HOLMES STREET
 MYSTIC, CT 06355

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Receiving Room, Bldg 3
 Address: 60 Vassar Street
 Cambridge, MA 02139

For: **CONNIE WEIDNER**
 Room No.: 37-2861 Tel. No.: 253-8631

514521

FURNISH THE FOLLOWING MATERIALS OR SERVICES:

ALL OF THE ABOVE MUST APPEAR ON OUTSIDE LABEL.

REQUIRED	SHIP VIA	F.O.B.*	PRE PAY AND ADD	TERMS	TOTAL ITEM PRICE
	UPS			Net/30	

QUANTITY	UNIT OF MEASURE	PRICE PER UNIT	TOTAL ITEM PRICE
6	EACH	745.00	\$4,470.00

7703A-1000 ACCELEROMETERS (1000 PC/G)

1 EACH 245.00

1A-1 REMOTE CHARGE CONVERTER

CONFIRMATION ON 4/8 WITH AL REID FOR DELIVERY
 ITEM #1 IN [15] WEEKS
 ITEM #2 IN [4] WEEKS

**PLEASE FORWARD
 PACKING SLIP TO**

37-276

* IF NOT F.O.B. DESTINATION—SHIP PREPAID—INCLUDE SHIPPING CHARGES ON INVOICE

order is exempt from Massachusetts Sales e Tax. Exemption Number E 042 103 594	TOTAL PRICE
	ESTIMATED \$4,715.00

a corporation, show your Internal Revenue Service
 Social Security Number) on all invoices.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
 M.I.T. is an equal opportunity employer and has an Affirmative Action Plan

IS ALSO SUBJECT TO THE TERMS AND CONDITIONS ON THE REVERSE

Buyer Connstance M. Weidner (617) 253-6116

SIGNED

AGENT

Massachusetts Institute of Technology

USE IN CENTER FOR SPACE RESEARCH ONLY

ACQUISITION TO

P. O. NO.

Req. A No. 20258

DATE	DATE REQUIRED	ACCOUNT NO.	APPROVED BY	QUANTITY	CAT. NO.	DESCRIPTION OF MATERIAL OR SERVICES	INDICATE: TECHNICAL REQUIREMENT <input type="checkbox"/> M I T STANDARD <input type="checkbox"/> OR EQUAL <input type="checkbox"/>	UNIT	AMOUNT
4 Apr 91		70539	<i>Michael Burka</i>						
SUGGESTED VENDOR		ROOM NO.	EXT. NO.						
Michael Burka		20F-101	6413						
Endevco 20 Holmes St., Mystic CT 06355 203-572-0571 Al Reid									
6		7703A-1000	accelerometers (1000 pc/g)					835	4,470.00
1		2771-1	Remote charge converter					245.00	245.00
<p><i>7754-1601 DEVCO</i></p> <p><i>test mass only</i></p> <p><i>4 x 3 x 3 = 36 accelerometers</i></p> <p><i>↑ masses per tank</i></p> <p><i>interferometer</i></p> <p><i>6 x 3 x 3 = 72</i></p> <p><i>all optics</i></p> <p><i>2 relay tank</i></p> <p><i>1 Beam splitter</i></p> <p><i>1 Recycle...</i></p> <p><i>1 telescope</i></p> <p><i>2 HeNe Clean</i></p> <p><i>1 Laser</i></p> <p><i>total: 108</i></p>									
8		7754-1000	(Built in applications)					845	\$4,715.00
<p>EST. TOTAL <input checked="" type="checkbox"/> OR QUOTED PRICE <input type="checkbox"/></p> <p>TOTAL</p>									

DO NOT WRITE BELOW - FOR PURCHASING AGENCY USE

SOLE SOURCE	ESTABLISHED COMPETITIVE SOURCE	FOREIGN SOURCE	BIDS AND/OR QUOTES	FIXED PRICE	TIME AND MATERIAL	CPFF
DATE REQD	SHIP VIA	DATE	RECEIVED BY	TERMS	DATE	

Do Not Separate Copies 1 and 2: Forward as a Unit - Blue Copy - Requisitioner

SPECIFICATIONS

The following performance specifications conform to ISA-SP-37.2 (1984) and are typical values, referenced at +75°F (+24°C), 4 mA, and 100 Hz, unless otherwise noted. Calibration data, traceable to National Institute of Standards and Technology (NIST), is supplied.

DYNAMIC CHARACTERISTICS	Units	±6
RANGE	g	1000
VOLTAGE SENSITIVITY	mV/g	1000
± 0.5%		
FREQUENCY RESPONSE (ref @ 20 Hz)		
Resonance Frequency [1]	kHz	0
Amplitude Response	Hz	0.05 to 800
± 1dB	Hz	0.2 to 400
± 0.5%		
Phase Response	Hz	0.2 to 100
± 5°		± 5
TRANSVERSE SENSITIVITY	%	
TEMPERATURE RESPONSE, ±5%	°F (°C)	-25 to +105 (-32 to +45)
AMPLITUDE NONLINEARITY	%	1
to full scale		

OUTPUT CHARACTERISTICS

OUTPUT POLARITY	Acceleration directed into base produces positive output.	
DC OUTPUT BIAS VOLTAGE	V _{DC}	+11 to +13
OUTPUT IMPEDANCE	Ω	± 500
FULL SCALE OUTPUT VOLTAGE	V	± 6
RESIDUAL NOISE		
broadband, 0.1 Hz to 100 Hz, typical	equiv. g rms	0.00001
narrow band, per IFSO, @ 10 Hz	equiv. g rms/√Hz	0.0000005
OVERLOAD RECOVERY	sec	± 50
GROUNDING		Signal ground connected to case

POWER REQUIREMENT

COMPLIANCE VOLTAGE	V _{CC}	+18 to +24
SUPPLY CURRENT	mA	+2 to +20
WARM-UP TIME	sec	< 80

ENVIRONMENTAL CHARACTERISTICS

TEMPERATURE RANGE		-67°F to +165°F (-55°C to +85°C)
HUMIDITY		Hermetically sealed
BASE STRAIN SENSITIVITY	eq. g/strain	0.02
A1 250 μstrain		30
SINUSOIDAL VIBRATION LIMIT	g pk	1000
BHOOK LIMIT [2]	g pk	

PHYSICAL CHARACTERISTICS

DIMENSIONS	See Outline Drawing	
WEIGHT	gm (oz)	115 (4)
CASE MATERIAL		Stainless Steel
CONNECTOR		Side mounted 10-32, mates with Endevco 3000 series cables.
MOUNTING TORQUE	in-lb (Nm)	18 (2)

CALIBRATION

SUPPLIED:		
SENSITIVITY @ 20 Hz	mV/g	1 Hz to 10 Hz
MAXIMUM TRANSVERSE SENSITIVITY	%	
FREQUENCY RESPONSE	%	

ACCESSORIES

MOUNTING STUD, 10-32 to 10-32
ACOUSTIC BOOT [2]
CABLE ASSEMBLY
Model 3001-120 (10 ft)

OPTIONAL ACCESSORIES

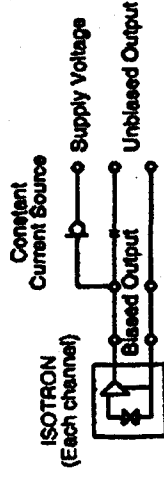
ISOLATING ADAPTOR, 10-32 to 1/4-28
MAGNETIC MOUNTING ADAPTOR
Model 2958MS
Model 2958MG

OPTIONAL CALIBRATION

LOW FREQUENCY CALIBRATION
FROM 0.1 Hz

NOTES

1. A built-in low-pass filter is incorporated in the hybrid electronics to suppress unwanted high-level signals due to sensor resonance.
2. The Acoustic Boot should always be used as a protective capsule during handling and transportation.



304

Continued product improvement necessitates that Endevco reserve the right to modify these specifications without notice. Endevco maintains a program of constant surveillance over all products to ensure a high level of reliability. This program includes attention to reliability factors during product design, the support of stringent quality control requirements, and compulsory corrective action procedures. These measures, together with conservative specifications have made the name Endevco synonymous with reliability.

ENDEVCO CORPORATION, 30705 RANCHO VIEJO ROAD, SAN JUAN CAPISTRANO, CA 92675 USA (714) 923-5181 fax: (714) 981-7231



ENDEVCO



30700 Rancho Viejo Road
 San Juan Capistrano
 California 92675
 USA
 telephone (714) 493-8181
 fax (714) 661-7231
 telex 68-5608 ENDEVCO SJU

C U S T O M E R

MASS. INSTITUTE OF TECHNOLOGY
 DR YARON HEFETZ
 RM 20 B-145
 CAMBRIDGE MA 02139

QUOTATION NUMBER	E16162
DATE	JUL 06, 1994
CUSTOMER REFERENCE	RFQ

IN RESPONSE TO YOUR INQUIRY, ENDEVCO QUOTES THE FOLLOWING:

M	QTY	MODEL NUMBER	DESCRIPTION	UNIT PRICE	EXTENDED AMOUNT	WILL SHIP
1	36	7703A-1000	HIGH OUTPUT PE ACCEL REMOTE CHG CONVERTER ISOTRON ACCELEROMETER DR. YARON HEFETZ 617-253-6413 FAX: 617-253-7014	710.00	25,560.00	15/STK
2	1	2771A-1		275.00	275.00	STOCK
3	36	7754-1000		845.00	30,420.00	5/STK

THANK YOU FOR YOUR INQUIRY - PLEASE REFERENCE THE ABOVE QUOTE NO. IN YOUR ORDER FOR FUTURE CORRESPONDENCE.

FOR INFORMATION ON THIS QUOTATION PLEASE CALL:

Dolores Ridill

**DOLORIS RIDILL
 ACCOUNT REPRESENTATIVE**

SHIPMENT SCHEDULE IS QUOTED FROM RECEIPT OF ORDER, SUBJECT TO PRIOR SALE.

NET TERMS ARE NET 30 DAYS FROM DATE OF INVOICE, SUBJECT TO APPROVAL.

ALL PRICES QUOTED ARE FIRM FOR 90 DAYS AND FOR DOMESTIC USE. PRODUCTS PURCHASED FOR EXPORT OR WITH THE INTENT OF EXPORT OUTSIDE THE TERRITORIAL LIMITS OF THE UNITED STATES OR CANADA ARE SUBJECT TO SPECIAL QUOTATION.

ALL ITEMS ARE QUOTED F.O.B. **SAN JUAN CAPISTRANO, CALIFORNIA**

THE ENDEVCO TERMS & CONDITIONS FOUND ON THE REVERSE SIDE OF THIS FORM ARE TO BE A PART OF THIS QUOTATION AND ANY RESULTING ORDER.

ITEMS QUOTED ARE NOT SOLD UNDER IDENTICAL CONDITIONS FOR LESS THAN THE QUANTITY TO BE ORDERED.

94/07/06
14:22:11

2

From yaron Wed Jul 6 11:39:13 1994
To: weiss
Subject: Re: Microphones
Cc: yaron, dhs, pf

Rai,

The proposal calls for one Acoustic Pressure monitor per test mass tank.

That comes to:
4 masses * 3 interferometer = 12 Microphones.

If we want to monitor other optical components I can think of:

- 2 relay mirror tanks
- 1 beam splitter
- 1 recycling mirror
- 1 telescope
- 2 mode cleaners mirror tanks
- 1 laser table

total of 8 additional tanks per interferometer or 24 Microphones.

total number of Microphones is: 12 for test mass only
or 36 for all critical tanks.

We can get microphones from:

Radio Shack
Mass. Av, Boston.
(617) 547-7332

Catalog # 33-1067 \$5.99 each

finally: total price is: 5.99 * 12 = \$ 71.88

or 5.99 * 36 = \$215.64

Yaron

From yaron Wed Jul 6 13:51:38 1994
To: weiss
Subject: Re: accelerometers.
Cc: yaron, pf, dhs

Rai,

I have just received a Fax with information on the accelerometers.

It looks like one needs a
"Constant Current Supply / Signal Conditioner" to be used with
these accelerometers.

The company offers:

Model 2792B : \$1,795.00
9 channels
with: Sensitivity Normalization (variable gain)
LED Status indicator

Model 2793 : \$1,295.00
16 channels
Selectable gain of 1 or 10.

The 2793 looks more attractive (\$81 / channel vs. \$112)

We will need (test mass only):
one unit in each End mirror building.
one unit in each central building.
total: 8 units -> \$10,360.00

or (all optical components)
one unit in each End mirror building.
four units in the central building (two interferometers)
Two units in the central building (one interferometer)

total: 12 units -> \$15,540.00

add these sums to the price:

Test mass only : 10360 + 30420 = \$40,780.00
All optics : 15540 + 91260 = \$106,800.00

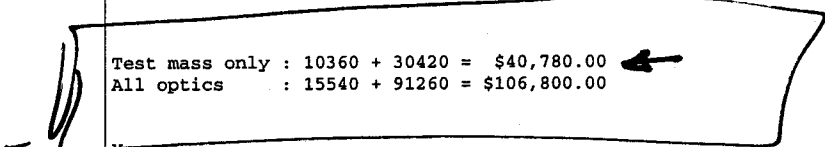
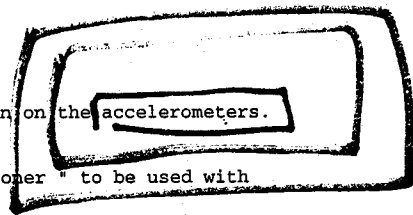
Yaron.

> From yaron Wed Jul 6 10:53:47 1994
> To: weiss
> Subject: Re: accelerometers.
> Cc: pf, dhs, yaron
>
>

> Rai,

> The proposal calls for 3 accelerometer per test mass tank.

> That comes to:
> 4 masses * 3 accelerometers * 3 interferometer = 36
>



94/07/06
14:22:11

1

From yaron Tue Jul 5 13:01:33 1994
To: weiss
Subject: Re: seismometers
Cc: pf, dhs, yaron

Rai,

With one seismometer / building, and eight buildings,
the price for seismic monitoring is: \$60,000.00

Yaron.

----- Begin Included Message -----

>From lisa@ligo.caltech.edu Tue Jul 5 11:26:35 1994
To: yaron
Subject: Re: Request from Barish

The following is info on the seismometers we are buying for the seismic measurements.
I will give you the company and price that was quoted.

Digital Technology Ass.
1330-A Galaxy Way
Concord Ca 94520
tel: 510-682-2072

The sensor is a CMG40T Triaxial Broadband Seismometer with a signal range from .1 Hz to
100 Hz.
It takes data in 3 axes.

The price with the cabling and power supply is roughly \$7500.

As far as the other things on your list, you might talk to Jake or Volker.

Good luck, Lisa

----- End Included Message -----

From yaron Wed Jul 6 10:53:47 1994
To: weiss
Subject: Re: accelerometers.
Cc: pf, dhs, yaron

Rai,

The proposal calls for 3 accelerometer per test mass tank.

That comes to:
4 masses * 3 accelerometers * 3 interferometer = 36

If we want to monitor other optical components I can think of:

2 relay mirror tanks
1 beam splitter
1 recycling mirror
1 telescope
2 mode cleaners mirror tanks
1 laser table

total of 8 additional tanks per interferometer or 72 accelerometers.

total number of accelerometers is: 36 for test mass only
or 108 for all critical tanks. •

In the past we got accelerometers from
Endevco
Mystic CT 06355
(203) 572-0571

The model that we got was:

7703-1000 accelerometer \$710.00 (each for order of more than 30)
2771-1 charge converter \$235.00 (each for order of more than 30)
\$945.00 total

They now have a new product that combine the two in one unit:

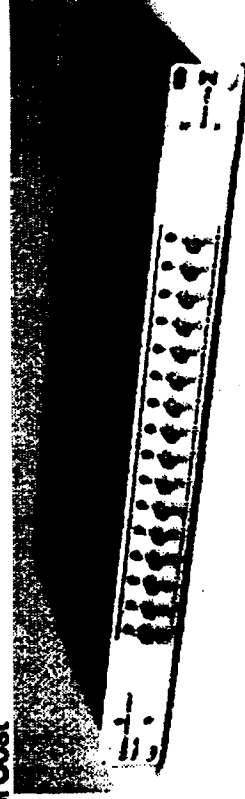
7754-1000 accelerometer with built in amplifier \$845.00
(each for order of more than 30)

finally: total price is 845.00 * 36 = \$30,420.00
or 845.00 * 108 = \$91,260.00

Yaron

NEW!**ISOTRON® Signal Conditioner****Model 2793**

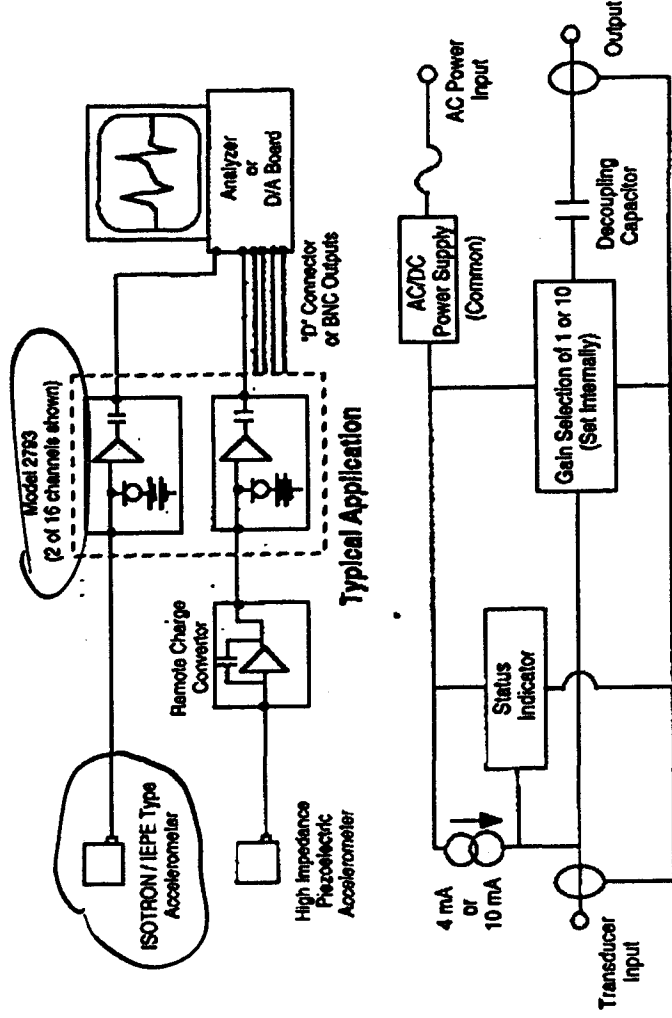
- 16-Channel Constant Current Supply/Amplifier for ISOTRON (Piezoelectric Voltage Mode) Accelerometers or Remote Charge Converters
- "D" Output Connector for Simple Connection to D/A Board
- Wide Frequency Range: 1 Hz to 30 kHz, LED Status Indicators
- Low Per Channel Cost



Not actual size

DESCRIPTION

The ENDEVCO® Model 2793 16-channel signal conditioner is an economical power supply/buffer amplifier for ISOTRON accelerometers or other piezoelectric voltage mode transducers. It can also power Remote Charge Converters (RCC) in a high impedance piezoelectric measurement system. Each channel provides a constant current excitation (4mA or 10mA) for the transducer or the RCC, and all outputs are buffered for driving long cables. Amplifier gain of 1 or 10 is set by an internal jumper. Individual LED status indicator informs the user of a short, open, or normal conditions.

**MEGGITT**
AEROSPACE**ENDEVCO**

ENDEVCO MODEL 7703A-200 -1000

Piezoelectric Accelerometer

SPECIFICATIONS

The following performance specifications conform to ISA RP-37.2 (1984) and are typical values, referenced at +75°F (+24°C) and 100 Hz, unless otherwise noted. Calibration data, traceable to National Institute of Standards and Technology (NIST), is supplied.

DYNAMIC CHARACTERISTICS		Units	-200	-1000
CHARGE SENSITIVITY		pC/g	200	1000
TYPICAL		pC/g	180	900
MINIMUM				
FREQUENCY RESPONSE		Hz	17	1 to 2 k
RESONANCE FREQUENCY		Hz	1 to 4 k	
AMPLITUDE RESPONSE (1)			See Typical Amplitude Response	
1.5%				
TEMPERATURE RESPONSE			See Typical Curve	
TRANSVERSE SENSITIVITY		%	±3	
AMPLITUDE LINEARITY		%	1/125 g	1/25 g
Up to vibration limit				

ELECTRICAL CHARACTERISTICS

OUTPUT POLARITY	Acceleration directed into base of unit produces positive output at center socket of receptacle.	
RESISTANCE	Ohm	2 10
ISOLATION	Ohm	2 1
CAPACITANCE	PF	5000
GROUNDING	Signal return isolated from case	

ENVIRONMENTAL CHARACTERISTICS

TEMPERATURE RANGE	-87°F to +550°F (-260°C to +260°C)	
HUMIDITY	Hermetically sealed	
SINUSOIDAL VIBRATION LIMIT	g pk	500
SHOCK LIMIT (2)	g pk	2000
BASE STRAIN SENSITIVITY	equiv. g physical strain	0.0004
ELECTROMAGNETIC SENSITIVITY	equiv. g rms/gauss	0.0002
THERMAL TRANSIENT SENSITIVITY	equiv. g pk/°F (°C)	0.002 (0.004)
RADIATION	rad	Up to 10 ⁶
INTEGRATED GAMMA FLUX	N/cm ²	Up to 10 ⁶

PHYSICAL CHARACTERISTICS

DIMENSIONS		See Outline Drawing	120 (4.9)
WEIGHT	gm (oz)	62 (2.2)	
CASE MATERIAL		Stainless Steel	
CONNECTOR		Coaxial receptacle with 10-32 UNF threads designed to mate with Endevco Model 3000 series cables.	
MOUNTING TORQUE	lbf in (Nm)		18 (2)

CALIBRATION

SUPPLIED:			
CHARGE FREQUENCY RESPONSE	%	20 to 4 kHz	20 to 2 kHz
	dB	4 kHz thru resonance	2 kHz thru resonance

CHARGE SENSITIVITY

MAXIMUM TRANSVERSE SENSITIVITY	pC/g	
CAPACITANCE	pF	

ACCESSORIES

Model 3090C-120 (10 ft)	CABLE ASSEMBLY for use to +500°F (+260°C)
Model 2081-3	MOUNTING STUD, 10-32 to 10-32
OPTIONAL ACCESSORIES	
Model 3075M6-120 (10 ft)	CABLE ASSEMBLY for use above +500°F (+260°C)
Model 2081-4	MOUNTING STUD, 10-32 to M5

NOTES

1. Low-end response of the transducer is a function of its associated electronics.
2. Shock pulses of short duration may excite transducer resonance. Shock level above the sinusoidal vibration limit may produce temporary zero shift which will result in erroneous velocity or displacement data after integration.

Continued product improvement necessitates that Endevco reserve the right to modify these specifications without notice. Endevco maintains a program of constant surveillance over all products to ensure a high level of reliability. This program includes attention to reliability factors during product design, the support of stringent Quality Control requirements, and compulsory corrective action procedures. These measures, together with conservative specifications have made the name Endevco synonymous with reliability.

ENDEVCO CORPORATION, 30700 RANCHO VIEJO ROAD, SAN JUAN CAPISTRANO, CA 92675 USA (714) 952-8161 FAX (714) 861-7231

0492

Remote Charge Converter

Model 2771A

- Rugged Small Package
- Two-Wire System
- Low Noise
- Wide Frequency Response
- Three Different Gains

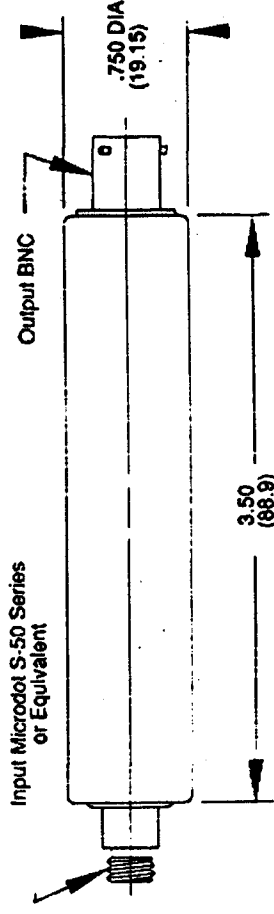
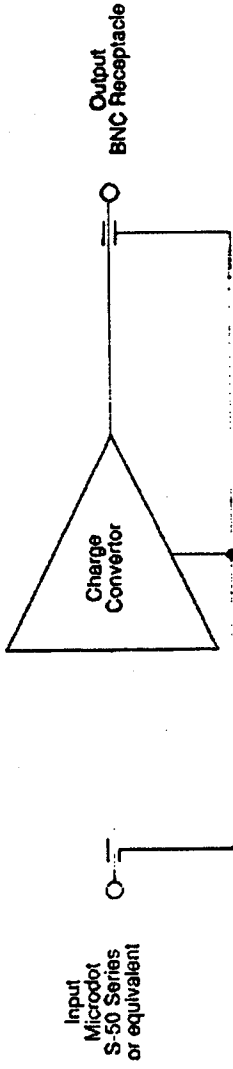


Not actual size

DESCRIPTION

The ENDEVCO® Model 2771A-XX Remote Charge Converter (RCC) is a low noise, two-wire, single-ended device designed for use with piezoelectric transducers. This device transforms the transducer's high impedance charge output to a low impedance voltage proportional to the transducer's charge. The signal output from the RCC is less susceptible to noise pick-up because of its low impedance voltage. Also, the shunt capacitance of the cable connecting the RCC to the main conditioner does not significantly affect the noise and sensitivity of the system.

The RCC is a two-wire, single-ended device. The signal output from the RCC and the current to the RCC are carried with the same wire. The 2771A has fixed gains of 0.1 mV/pC, 1.0 mV/pC, or 10 mV/pC. This is a low noise device, with a frequency response of 1 to 50 kHz. It operates within a constant current range of 4 to 20 mA.



STANDARD TOLERANCE
INCHES (MILLIMETERS)
.XX = +/- .02 (.X = +/- .5)
.XXX = +/- .010 (.XX = +/- .25)

Endevco Corporation
30700 Rancho Viejo Road
San Juan Capistrano, CA 92675
(714) 492-8181 FAX (714) 861-7231

ENDEVCO

ISOTRON Signal Conditioner

SPECIFICATIONS

INPUTS	Single-ended, constant current two-wire system
INPUT IMPEDANCE	>20 k Ω
EXCITATION CURRENT	4 mA or 10 mA \pm 10%, set by internal jumper, per channel
COMPLIANCE VOLTAGE	>18 V. This voltage is the sum of AC and DC components.

OUTPUTS	Single-ended one side connected to circuit ground
TYPE	<10 Ω , in series with at least 40 μ F
OUTPUT IMPEDANCE	<10 Ω , in series with at least 40 μ F
LINEAR OUTPUT VOLTAGE	10 V pk-pk (3.635 V rms) or greater
LINEAR OUTPUT CURRENT	2.0 mA pk-pk or greater

TRANSFER CHARACTERISTICS	
GAIN	1 or 10 controlled by internal jumper, per channel
Accuracy	\pm 1.5% (excluding variation with temperature and time)
FREQUENCY RESPONSE	Flat within \pm 5% from 1 Hz to 30 kHz, reference at 100 Hz
Lower Cutoff Frequency	-5% at 1 Hz, -3dB at 0.3 Hz (Typical)
Upper Cutoff Frequency	-5% at 30 kHz, -3dB at 60 kHz (Typical)
AMPLITUDE LINEARITY	1% of reading from best-fit straight line approximation
RESIDUAL NOISE	45 μ V rms maximum RTI with input shunted with 100 ohms or 100 μ V rms RTI, whichever is greater.
TOTAL HARMONIC DISTORTION	Less than 1% for signals of full scale or less at any gain from .5 to 20.0
CROSSTALK	20.0 mV rms maximum RTI or 1.0 mV rms RTI whichever is greater
	Crosstalk specification is valid for the following conditions: One channel set at 100% of nominal sensitivity and x1 gain Adjacent channel set at any gain up to 20.0 (eg. 50% nominal sensitivity and x10 gain) with a 260 Ω shunt resistor at the input

ENVIRONMENTAL CHARACTERISTICS	
TEMPERATURE	Operating 32°F to 122°F (0°C to 50°C) Storage -65°F to 185°F (-64°C to 85°C)
HUMIDITY	95% R.H.

POWER	100V/20/220/240 VAC 60 to 60 Hz (switch selectable)
LINE VOLTAGE	

PHYSICAL	
DIMENSIONS	1" rack mounting, 1.73" h x 19.00" w x 9.45" d (44mm x 483mm x 240mm)
WEIGHT	3.97 lbs. (1.8 kg)
FRONT PANEL FEATURES	LED indicates when power is applied LED will light green, when the transducer is connected properly. The LED will light red when the input is shorted. The LED will not light when the input is open.
Power Indicator	
Status Indicators	
Output Connectors	BNC
REAR PANEL FEATURES	
Input Connectors	BNC
Output Connector	28-pin "D" (in parallel with front BNC's)

NOTES

ACCESSORIES
Instruction Manual
EW509 AC Power Cord

For ultra-low noise application, Model 2793M1 offers the same basic design but without the gain stage.

Continued product improvement necessitates that Endevco reserve the right to modify these specifications without notice. Endevco maintains a program of constant surveillance over all products to ensure a high level of reliability. This program includes attention to reliability factors during product design, the support of stringent Quality Control requirements, and compulsory corrective action procedures. These measures, together with conservative specifications have made the name Endevco synonymous with reliability.

ENDEVCO CORPORATION, 30700 RANCHO VIEJO ROAD, SAN JUAN CAPISTRANO, CA 92676 USA (714) 493-6191 fax: (714) 961-7231

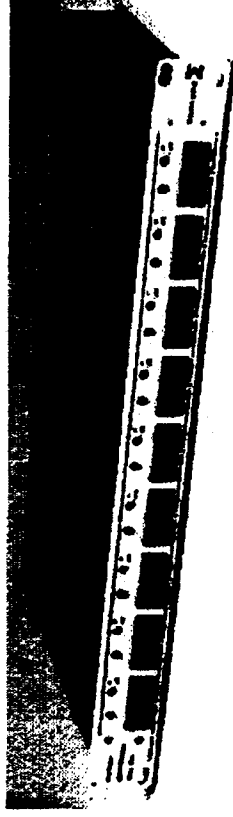
NEW!

ISOTRON® Signal Conditioner

Model 2792B

ENDEVCO
MODEL
2792B

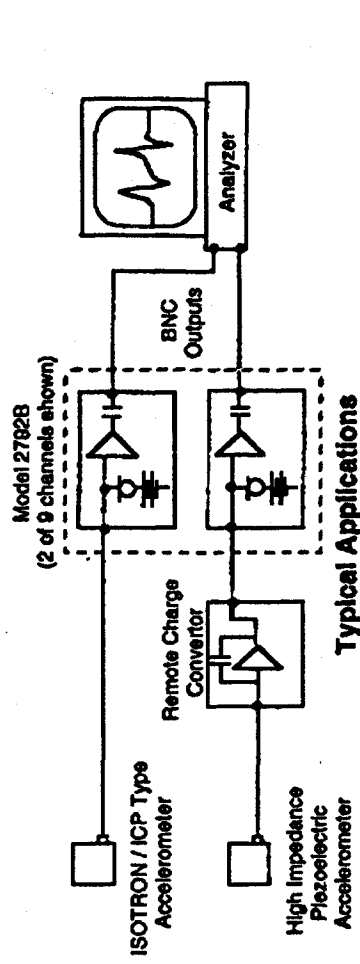
- 9-Channel Constant Current Supply/Amplifier for ISOTRON (Piezoelectric Voltage Mode) Accelerometers or Remote Charge Convertors
- Transducer Sensitivity Normalization and LED Status Indicators
- Wide Frequency Range: 1 Hz to 30 kHz



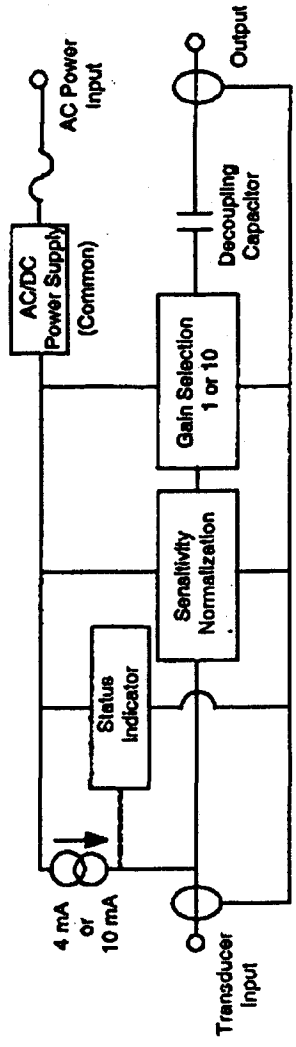
Not actual size

DESCRIPTION

The ENDEVCO® Model 2792B nine-channel signal conditioner is a versatile power supply/amplifier for ISOTRON accelerometers and other piezoelectric voltage mode transducers. It can also power Remote Charge Convertors (RCC) in a high impedance piezoelectric measurement system. Each channel provides a constant current excitation (4mA or 10mA) for the transducer or the RCC, input sensitivity normalization, and a switched gain output. Amplifier gain of 1 or 10 is set by a recessed front panel switch. Individual LED status indicator informs the user of a short, open, or normal conditions.



Typical Applications



Model 2792B Block Diagram, per channel

MEGGITT
AEROSPACE

ENDEVCO

ENDEVCO
MODEL
2771A

Remote Charge Converter

SPECIFICATIONS

INPUTS

Piezoelectric single-ended with one side connected to signal ground.
10 k Ω minimum to meet all specifications
30 μ F maximum to meet all specifications

OUTPUTS

Single ended with one side connected to signal ground.
50 Ω maximum
Operation up to 100 nF maximum
9 to 11 V over the temperature range -40°C to 100°C
12 V pk-pk minimum for the -10 unit. The -01 and -1 units are dependent upon the signal frequency
20 V pk-pk with 22 VDC minimum compliance voltage

TRANSFER CHARACTERISTICS

GAIN ACCURACY
FREQUENCY RESPONSE

-3dB		Lower Cutoff	Upper Cutoff	Source	Gain
Frequency	Frequency	Frequency	Capacitance		
0.2 Hz	1 Hz	50 kHz	20 nF		0.1
0.2 Hz	1 Hz	60 kHz	20 nF		1.0
2 Hz	6 Hz	40 kHz	5 nF		10

The maximum residual noise RTI is expressed in the following formula at ambient temperature with BW of 1 Hz to 60 kHz.

$$\text{Noise (pC rms)} = \sqrt{C_s^2 \cdot R_s}$$

$$C_s (\text{pC rms}) = 0.005 + 0.002 C_s$$

$$C_s (\text{pC rms}) = 50 \sqrt{f_s}$$

$$C_s = \text{Source Capacitance in nF}$$

$$R_s = \text{Source Resistance in } \Omega$$

GAIN STABILITY WITH TEMPERATURE

$\pm 1\%$ referred to 25°C at 100 Hz from -40°C to 100°C.

$\pm 0.01\%$ over bias current of 4 mA to 20 mA.

TOTAL HARMONIC DISTORTION

Less than 0.5% for output signals

120 sec. maximum for the 01 and 1 units. 240 sec. maximum for the -10 unit.

ENVIRONMENTAL

TEMPERATURE

Operating -40°F to 212°F (-40°C to 100°C)

Storage -78°F to 267°F (-65°C to 125°C)

95% R.H.

20 g pk from 65 Hz to 2000 Hz.

100 g pk with 3.8 ms trapezoidal pulse

10⁻⁶ Rads (integrated Gamma)

POWER

4 mA to 20 mA

18 to 36 V. This voltage represents the maximum of AC plus DC components.

PHYSICAL

DIMENSIONS

3.5" length x 0.75 diameter (88.9 mm x 19.5 mm). Connector's length not included.

3.0 oz (85 gm) maximum

CASE MATERIAL

Cold rolled steel with tin dip

CONNECTOR

Low temperature solder (Sn63) used to solder output connector to case.

Input BNC Coaxial Connector.

MOUNTING

Unit can be mounted with a cable harness clamp.

CASE ISOLATION

Unit case is completely isolated with a clear Teflon sleeve.

ACCESSORIES

EHM486

Cap. Protective

EHM892

Cap. Protective

25503-4-6

Bag, Antistatic

25503-90

Closure Label

24728-1

Shipping Box System

21875

Label, Shipping

Continued product improvement necessitates that Endevco reserve the right to modify these specifications without notice. Endevco maintains a program of constant surveillance over all products to ensure a high level of reliability. This program includes attention to reliability factors during product design, the support of stringent Quality Control requirements, and compulsory corrective action procedures. These measures, together with conservative specifications, have made the name Endevco synonymous with reliability.

ENDEVCO CORPORATION, 30700 RANCHO VIEJO ROAD, SAN JUAN CAPISTRANO, CA 92675 USA (714) 493-9181 FAX (714) 961-7231

0492

MEMO

TO: DR. YARON HEFETZ
MIT ROOM 20 B-145
CAMBRIDGE, MA 02139

FROM: AL REID
ENDEVCO

AR 7/6/94

PRODUCT	PRICE
7703A-1000	\$710 IN QTYS 25-49
7754-1000	\$845 " " "
2771A-01/10	\$260 " " "
2792B	\$1,795 IN QTYS 1-10
2793	\$1,295 " " "

A QUOTE FROM OUR CALIFORNIA OFFICE WILL FOLLOW.

THANK YOU FOR CONSIDERING ENDEVCO

ISOTRON Signal Conditioner

SPECIFICATIONS

INPUTS	
TYPE	Single-ended, constant current two-wire system
INPUT IMPEDANCE	>20 k Ω
EXCITATION CURRENT	4 mA or 10 mA \pm 10%, set by internal jumper, per channel
COMPLIANCE VOLTAGE	>18 V. This voltage is the sum of AC and DC components

OUTPUTS	
TYPE	Single-ended one side connected to circuit ground
OUTPUT IMPEDANCE	<10 Ω , in series with at least 40 μ F
LINEAR OUTPUT VOLTAGE	10 V pk-pk (3.855 V rms) or greater
LINEAR OUTPUT CURRENT	2.0 mA pk-pk or greater

TRANSFER CHARACTERISTICS	
GAIN	1 or 10 controlled by front panel switch 0.1 to 1000 controlled by sensitivity switch \pm 1.5% (including variation with temperature and time)
ACCURACY	Flat within 25% from 1 Hz to 30 kHz, reference at 100 Hz
FREQUENCY RESPONSE	-0% at 1 Hz, -3dB at 0.3 Hz (typical)
Lower Cutoff Frequency	-5% at 30 kHz, -5dB at 60 kHz (typical)
Upper Cutoff Frequency	1% of reading, from best fit straight line approximation
AMPLITUDE LINEARITY	45 μ V rms maximum RTI with input shunted with 100 ohms or 100 μ V rms RTI, whichever is greater.
RESIDUAL NOISE	Less than 1% for signals of full scale or less at any gain from .5 to 80.0
TOTAL HARMONIC DISTORTION	20.0 mV rms maximum RTI or 1.0 mV rms RTI whichever is greater
CROSSTALK	Crosstalk specification is valid for the following conditions: One channel set at 100% of nominal sensitivity and x1 gain Adjacent channel set at any gain up to 80.0 (eg. 60% nominal sensitivity and x10 gain) with a 250 Ω shunt resistor at the input

ENVIRONMENTAL CHARACTERISTICS	
TEMPERATURE	Operating 32°F to 122°F (0°C to 50°C) Storage -65°F to 165°F (-54°C to 65°C)
HUMIDITY	95% RH

POWER	100/120/220/240 VAC 60 to 60 Hz (switch selectable)
-------	---

PHYSICAL	
DIMENSIONS	19" rack mounting, 1.73" h x 19.00" w x 9.45" d (44mm x 483mm x 240mm)
WEIGHT	3.07 lbs. (1.39 kg)
FRONT PANEL FEATURES	LED indicator when power is applied Two-position, recessed switch for gain of 1 or 10 Four-digit pushbutton switch. See example below. LED will light green, when the transducer is connected properly. The LED will light red when the input is shunted. The LED will not light when the input is open.
REAR PANEL FEATURES	BNC Input Connectors Output Connectors

ACCESSORIES
Instruction Manual
EW569 AC Power Cord

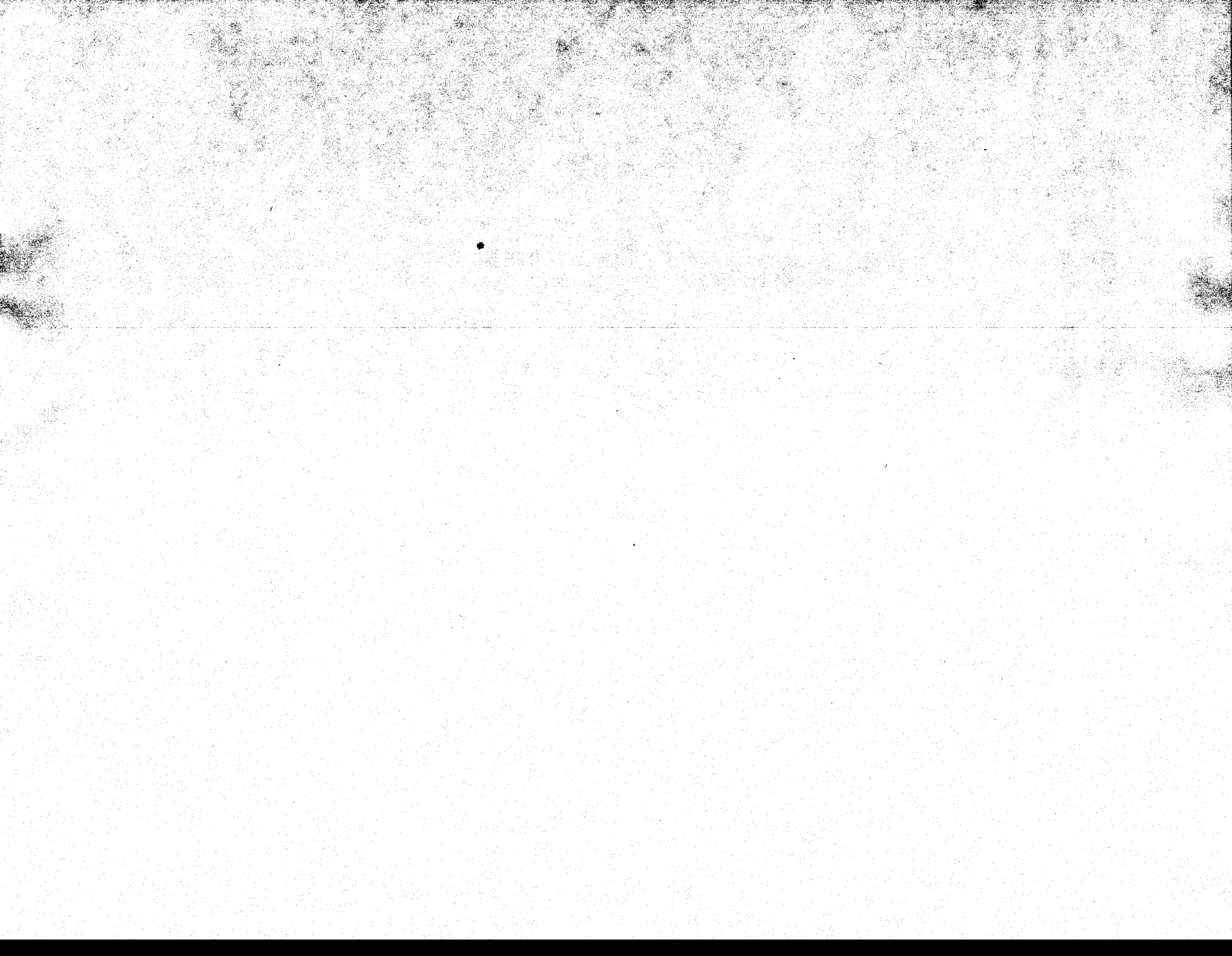
SENSITIVITY NORMALIZATION/ADJUSTMENT:

A four digit push button switch is used to normalize each channel to allow for variation in nominal sensitivity of the transducer. The switch is set to read the actual percentage of nominal (desired) sensitivity. For example, if the nominal (desired) sensitivity is 10.0 mV/g and the actual sensitivity is 10.21 mV/g, set Percentage of Nominal Sensitivity Switch to 102.1; Gain Switch to x1. If nominal (desired) sensitivity is 100 mV/g and the actual sensitivity is 10.21 mV/g, set Percentage of Nominal Sensitivity Switch to 10.21 and Gain Switch to x10.

3/94

Continued product improvement necessitates that Endevco reserve the right to modify these specifications without notice. Endevco maintains a program of constant surveillance over all products to ensure a high level of reliability. This program includes attention to reliability factors during product design, the support of stringent Quality Control requirements, and computerized corrective action procedures. These measures, together with conservative specifications have made the name Endevco synonymous with reliability.

ENDEVCO CORPORATION, 30700 RANCHO VIEJO ROAD, SAN JUAN CAPISTRANO, CA 92675 USA (714) 493-8181 fax: (714) 861-7231



From Yaron Wed Jul 6 11:39:13 1994
Received: by tycho AA05483; Wed, 6 Jul 94 11:39:12 EDT
From: Yaron Hefetz <yaron>
To: weiss
Subject: Re: microphones
Cc: yaron, dhs, pf
Status: RO

Rai,

The proposal calls for one Acoustic Pressure monitor per test mass tank.

That comes to:

4 masses * 3 interferometer = 12 Microphones.

If we want to monitor other optical components I can think of:

- 2 relay mirror tanks
- 1 beam splitter
- 1 recycling mirror
- 1 telescope
- 2 mode cleaners mirror tanks
- 1 laser table

total of 8 additional tanks per interferometer or 24 Microphones.

total number of Microphones is: 12 for test mass only
or 36 for all critical tanks.

We can get microphones from:

Radio Shack
Mass. Av, Boston.
(617) 547-7332

Catalog # 33-1067 \$5.99 each

finally: total price is: 5.99 * 12 = \$ 71.88

or 5.99 * 36 = \$215.64

Yaron

dhsenv070694.txt

Wed Jul 6 23:41:44 1994

1

From dhs Wed Jul 6 12:21:59 1994
Received: by taliesin.mit.edu AA02227; Wed, 6 Jul 94 12:21:59 EDT
From: David Shoemaker <dhs>
Subject: Re: accelerometers.
To: yaron (Yaron Hefetz)
Date: Wed, 6 Jul 94 12:21:58 EDT
Cc: weiss (Rainer Weiss), pf (Peter Fritschel), yaron (Yaron Hefetz)
In-Reply-To: <no.id>; from "Yaron Hefetz" at Jul 6, 94 10:53 am
X-Mailer: ELM [version 2.3 PL11]
Status: RO

Yaron, for accelerometers, we might consider the thing that Barry uses---iht be more sensitive in the frequency range we want, and less expensive/easier to amplify. Peter has the data on them.

d.

From dhs Wed Jul 6 12:24:09 1994
Received: by taliesin.mit.edu AA02238; Wed, 6 Jul 94 12:24:08 EDT
From: David Shoemaker <dhs>
Subject: Re: microphones
To: yaron (Yaron Hefetz)
Date: Wed, 6 Jul 94 12:24:08 EDT
Cc: pf (Peter Fritschel), weiss (Rainer Weiss), dhs (David Shoemaker)
In-Reply-To: <no.id>; from "Yaron Hefetz" at Jul 6, 94 11:39 am
X-Mailer: ELM [version 2.3 PL11]
Status: RO

While I agree that the electret microphones will do just fine and can even be calibrated well, a box to interface them with the outside world will be needed---so I would guess more like 100\$/unit.

d.

94/07/06
14:22:11

From Yaron Wed Jul 6 11:39:13 1994
To: weiss
Subject: Re: Microphones
Cc: Yaron, pf, dhs
Yaron, dhs, pf
Re: Microphones

proposal calls for one Acoustic Pressure monitor per test mass
comes to:
asses * 3 interferometer = 12 Microphones.
e want to monitor other optical components I can think of:

relay mirror tanks
beam splitter
recycling mirror
telescope
mode cleaners mirror tanks
laser table

1 of 8 additional tanks per interferometer or 24 Microphones.
1 number of Microphones is: 12 for test mass only
36 for all critical tanks.

can get microphones from:

Shack
ss. Av, Boston.
(17) 547-7332
Log # 33-1067 \$5.99 each

total price is: 5.99 * 12 = \$ 71.88
5.99 * 36 = \$215.64

From Yaron Wed Jul 6 13:51:38 1994

To: weiss
Subject: Re: accelerometers.
Cc: Yaron, pf, dhs

Rat,
I have just received a Fax with information on the accelerometers.

It looks like one needs a
"Constant Current Supply / Signal Conditioner " to be used with
these accelerometers.

The company offers:

Model 2792B : \$1,795.00
9 channels
with: Sensitivity Normalization (variable gain)
LED Status Indicator

Model 2793 : \$1,295.00
16 channels

Selectable gain of 1 or 10

The 2793 looks more attractive (\$81 / channel vs. \$112)

We will need (test mass only):

one unit in each End mirror building.
one unit in each central building.
total: 8 units -> \$10,560.00

(all optical components)
or

one unit in each End mirror building.
four units in the central building (two interferometers)
Two units in the central building (one interferometer)

total: 12 units -> \$15,540.00

add these sums to the price:

Test mass only : 10360 + 30420 = \$40,780.00
All optics : 15540 + 91260 = \$106,800.00

Yaron.

> From Yaron Wed Jul 6 10:53:47 1994

> To: weiss

> Subject: Re: accelerometers.

> Cc: pf, dhs, Yaron

> Rat,

> The proposal calls for 3 accelerometers per test mass tank.

> That comes to:

> 4 masses * 3 accelerometers * 3 interferometer = 36

94/07/19
14:53:30

om dhs Wed Jul 6 12:24:09 1994

bject: Re: microphones

: Yaron (Yaron Hefetz)

: pf (Peter Fritschel), weiss (Ratner Weiss), dhs (David Shoemaker)

I agree that the electret microphones will do just fine and can
en be calibrated well, a box to interface them with the outside world
ll be needed---so I would guess more like 100\$/unit

Ⓞ \$500 → \$1000 for Nim.
what about installation at \$50/m ?



Magnetometers:

GMW

PO Box 2578
Redwood City, CA 94064
415-368-4884

Mike Duffy

Bartington Fluxgate magnetometers

DC-1kHz, 3 axes

Available in several user-definable maximum ranges, up to 5 gauss
\$2250 + \$500 power supply

This may be sufficient for low and high frequency monitoring.

They also make Hall effect sensors. Single axis/probe. Available in
0.3 - 3 kgauss full scale. Digitally corrected probes. DC or AC mode.
DTM141: \$2860 for meter, \$1080 for probe.

Literature is coming.

OR, for high frequency, HP's 11966K Magnetic Field Pickup Coil,
20Hz - 50 kHz, \$670.

RFI monitors:

HP:

The HP8902A, Measuring receiver, 150 kHz to 1300 MHz, looks like it may
do the job. Instrument probably looks at one frequency at a time but can
be scanned over several band fairly quickly (?).
Price: \$29,450 (there are many options available)

Antennas: 11966A, Active loop H-field, 10kHz-30MHz, \$2535
11966B, Active Rod E-field, 100Hz-50MHz, \$2235

OR, one can buy a spectrum analyzer, using one of the above antennas,
and read out the full sweep. These start at \$8995, for the HP 8590D.

Anritsu:

Interference/Field strength meters:

ML428B: 9 kHz - 30 MHz, \$18,100

ML518A: 25-520 MHz, \$13,025

EMI probes: MA 2601B/C (5-1000MHz/1-50MHz): \$210

MP415B Rod Antenna 9kHz-30MHz, \$2820

Air shower detectors:

Rexon Components, Inc.
24500 Highpoint Rd.
Beachwood, Ohio
216-292-7373

Vic Berner

Plastic scintillators w/ PMT (see data sheet): \$2,213 per unit.

Needs: PMT base w/ preamp, EG&G 276: \$405

PMT bias supply, EG&G 556H: \$1540 (bench top, 3 kV, 10ma)

EG&G 478: \$1080 (mounts in NIM bin, 2kV, 1ma)

Total: \$2213 + 405 + 1540 = \$4158 / unit.

GMW

July 14, 1994

Peter Fritschel
MIT
Bldg. 20B-145
Cambridge, MA 02139

Dear Peter:

Thank you for your call requesting information on low-level magnetic field measurement instrumentation.

The Bartington MAG-03MC Fluxgate three-axis Magnetic Field Sensor is a compact, cylindrical probe of 25mm diameter by 202mm length (1" x 8"). It has output voltages of 0 to $\pm 10V$ proportional to the three field components Bx, By and Bz. Frequency response is flat from dc to almost 2kHz. Output noise at full bandwidth is less than 2nT (0.02mG) and may be further reduced by restricting the bandwidth to the frequency region of interest. A cable length of 5m is standard but up to 600m is possible for remote monitoring.

We stock the MAG-03MC in full-scale field ranges of $\pm 100\mu T(1G)$ and $\pm 500\mu T$. It is available to special order in field ranges of $\pm 70\mu T$ and $\pm 250\mu T$. A square section version, the MAG-03MS, is also available.

Because of its high resolution and dc stability the MAG-03MC is particularly useful for precision mapping of magnetically shielded enclosures or providing the error inputs for dynamic magnetic shielding systems utilizing coil arrays. The broad and flat frequency response enables monitoring of ac and dc environmental fields for magnetically sensitive equipment or biological studies.

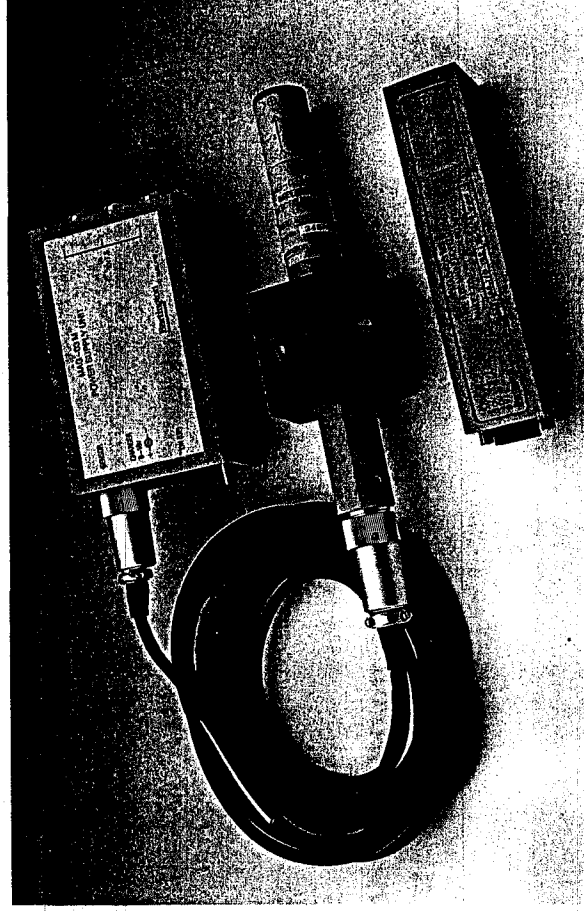
An alternative mechanical package of the MAG-03MC is the MAG-03IE in which the three individual sensors are connected to the electronics board by flying leads. This enables user configuration of the three sensors in alternative geometries. Both $\pm 100\mu T$ and $\pm 500\mu T$ range versions are available at a one off price of \$1920.

Multiwave™ System II, a portable monitoring system for characterizing magnetic fields in residential and occupational environments, which is based on the MAG-03MC, is available from Electric Research and Management. We have enclosed a Multiwave brochure for your information.

continued...

MAG-03MC MAG-03MS

Three Axis Magnetic Field Sensors



The MAG-03MC (cylindrical version) and MAG-03MS (square-section configuration) are compact, high performance sensors with integral electronics for the measurement of static and alternating magnetic fields in three axes. Powered from any $\pm 12V$ to $\pm 15V$ supply, output is in the form of three analog voltages from 0 to $\pm 10V$, proportional to Bx, By and Bz. They are available in measuring ranges of $70\mu T$, $100\mu T$, $250\mu T$ and $500\mu T$.

These sensors have a wide range of applications in environmental research, geophysical exploration, physics and the industrial and defence market. The $70\mu T$ version is ideal for geomagnetic observatories and geotechnical studies. The $100\mu T$ and $500\mu T$ versions are used in engineering applications and bioelectromagnetics. The $250\mu T$ version is suitable for magnetic signature analysis in military applications. Further information on these applications is detailed in the enclosed leaflet.

A submersible version with square-section packaging, type MAG-03MSS, is available for operation to depths of 100 metres. Comprehensive technical specifications for this product are featured in a separate brochure.

Sanitising

MAG-03MC MAG-03MS

Features

- MAG-03MC - suitable for downhole applications
- MAG-03MS - ideal for installation on reference surfaces
- Three orthogonal sensing elements
- Rugged packaging - for use in adverse environments; can be operated in a vacuum
- Powered from any $\pm 12V$ to $\pm 15V$ dual supply
- Operation over cables to 600 metres in length
- Wide bandwidth - dc to 2kHz
- Superb linearity - error of $<0.0015\%$
- High accuracy - offset, scaling and frequency response are individually calibrated
- Low noise - $<80\text{pT RMS}$ from 0.1Hz to 10Hz, $<350\text{pT RMS}$ from 1Hz to 1kHz
- Buffered output - low impedance

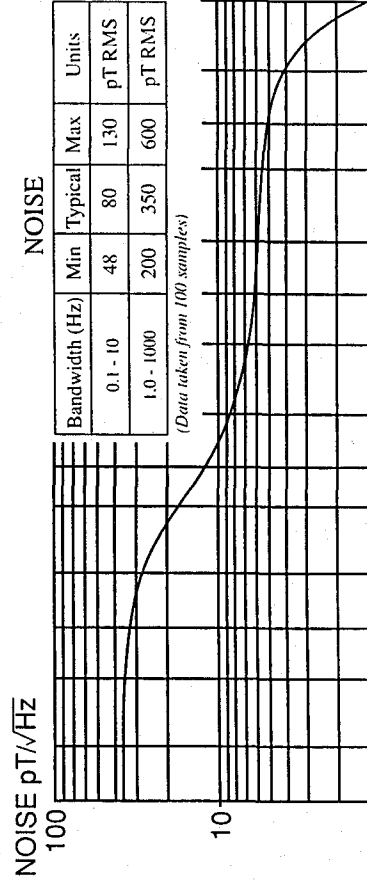
Accessories

- MAG-03M power supply unit
- Data logger and software
- Mounting bracket (MAG-03MC)

Options (MAG-03MC)

- MAG-03MC FL - version with flying leads
- MAG-03MC ES - version with environmentally sealed connector - for continuous operation in wet conditions (not submersible)

Typical Noise Spectrum



Technical Specifications

Mechanical

Enclosure : reinforced epoxy

Dimensions
MAG-03MC : 202mm x 25mm diameter
MAG-03MS : 152mm x 32mm x 32mm

Weight
MAG-03MC : 100g
MAG-03MS : 150g

Markings : measuring range and axis orientation

Mounting
MAG-03MS : 2 x M5 clearance holes on 50mm centres

Performance (scaling independent)

Linearity error : <0.0015%

Bandwidth : 0 to 1kHz maximally flat.
Above 1kHz max. ripple 5%
-3dB point at >2kHz,
-12dB/octave roll off

Calibration accuracy : $\pm 0.5\%$

Orthogonality error : $\leq \pm 0.5^\circ$

MAG-03MS available with orthogonality error $\leq 0.1^\circ$
- price on request

Z axis/reference face error over full temperature range
MAG-03MC : $\pm 0.5^\circ$
MAG-03MS : $\pm 0.1^\circ$

Internal noise
0.1Hz to 10Hz : 80pT RMS typical
1Hz to 1kHz : 350pT RMS typical

Electrical

Supply voltage : $\pm 12V$ nom, $\pm 17V$ max, $\pm 8V$ min - unregulated

Analog output : swings to within 2V of supply voltage

Power supply rejection ratio : $5\mu V/V$

Current : +20mA, -8mA

Output impedance : <1ohm

Connector
MAG-03MC : HRS plug RM15TRD10P
MAG-03MS : Cannon 9 pin D type plug

Mating connector
MAG-03MC : HRS socket RM15TPD10S
MAG-03MS : Cannon 9 pin D type socket

Connector pin out
MAG-03MC: Connector pin out
MAG-03MS: MAG-03MS:

1 X out	1 supply +ve
2 Y out	2 supply -ve
3 Z out	3 signal/power ground
4 common	4 signal/power ground
5 0V	5 Z out
6 +12V	6 X out
7 -12V	7 NC
8,9,10 NC	8 Y out
	9 NC

Environmental

Operating temperature range
MAG-03MC : $-40^\circ C$ to $+85^\circ C$
MAG-03MS : $-40^\circ C$ to $+70^\circ C$

Humidity : 0-90% (non - condensing)

Performance (scaling dependent)

Measuring Range ($\pm 12V$ supply)	± 70	± 50	± 500	μT
($\pm 17V$ supply)	± 105	± 370	± 735	μT
Offset error	± 5	± 12	± 25	nT
Offset temperature coefficient	+0.1	+0.2	+0.33	nT/ $^\circ C$
Scaling temperature coefficient	+20	+100	+200	ppm/ $^\circ C$
Dynamic supply current burden at full scale near axis	1.0	3.6	6.5	mA

Accessories

MAG-03M power supply unit

This unit provides power for the sensors and converts the analog signals to be output via three BNC sockets for easy connection to data loggers and oscilloscopes.

A low and high pass filter are included in each of the x,y and z signal channels. The low pass filter is pre-set to have a -3dB response at 1.5kHz, to remove any HF noise pick-up associated with long cable lengths from the sensor. In doing this the frequency dependent amplitude response will be reduced by 15% at 1kHz.

The high pass filter is supplied with fixed component values to provide a -3dB response at 0.1Hz. The high pass filter provides an ac response only above this frequency but can be switched out of circuit using individual internal jacks when full dc operation is required.

The power supply unit contains a rechargeable battery and voltage converter which produces a fully isolated 12V supply. The battery can be charged from the 12V mains adaptor provided or from any 9-18V dc source. Discharge of batteries is indicated by an audible alarm; recharge is completed within a few hours.

Technical Specifications

Mechanical

Materials : high strength ABS
Dimensions : 133mm length x 84mm width x 46mm depth
Weight : 550g

Electrical

Sensor input : 10 pole HRS plug type RMI5TRD10P
x,y and z analog outputs : 3 BNC connectors
Battery : sealed lead/acid - provides up to 10 hours continuous use before re-charge
Battery charger input : 2.1mm dc socket

MAG-03M cable

This cable provides connection of either sensor to the MAG-03M power supply unit. It is a 6-way conductor and screen, standard length 5 metres; alternative lengths to 600 metres are available on request. A cable for connection of the environmentally sealed version of the MAG-03MC to the MAG-03M power supply unit is also available.

Mating connectors

These are supplied when a sensor is purchased without the MAG-03M power supply unit.

Manufactured from reinforced epoxy resin; it has a length and width of 55mm and a height of 36mm.

MAG-03MC mounting bracket

Operation/service manual supplied

Specifications of the products described in this brochure may be subject to change without prior notice

Bartington
instruments Ltd.

10 Thorney Leys Business Park
Witney, Oxford. OX8 7GE England

Agent/Distributor

GMW

P.O. Box 2578, Redwood City, CA 94064
Tel (415) 368-4884 Fax (415) 368-0816



Page 2 of 2

We also offer the MAG-01 and MAG-01H Fluxgate Teslameters for single axis magnetic field measurement. These provide a 4½ digit, auto ranging field display and a chart recorder output with frequency response from dc to 10Hz. Additional features on the MAG-01H include digital offset in 10 μ T(0.1G) steps and a x10 sensitivity switch to give an effective resolution of 0.1nT(1 μ G).

Several different pre-calibrated, single-axis probes can be used with the MAG-01 or MAG-01H without any instrument or probe adjustment. Full-scale field ranges are 0.2mT(2G) or 2mT(20G) and probes are available in axial or transverse geometries. "Naked" fluxgate sensors are available for cryogenic applications or special mechanical configurations.

The single axis probes have been used for analyzing the magnetic properties of thick films; the investigation of the effects of magnetic fields on biological samples; the measurement of flux penetration and flux creep in high Tc superconductors as well as a broad range of geophysics and general low field measurements.

Technical and pricing data on the MAG-03MC, MAG-03IE and MAG-01 are enclosed. The GMW product line also includes Hall effect, fluxmeter and NMR instrumentation. Again, thank you for your inquiry.

Sincerely,

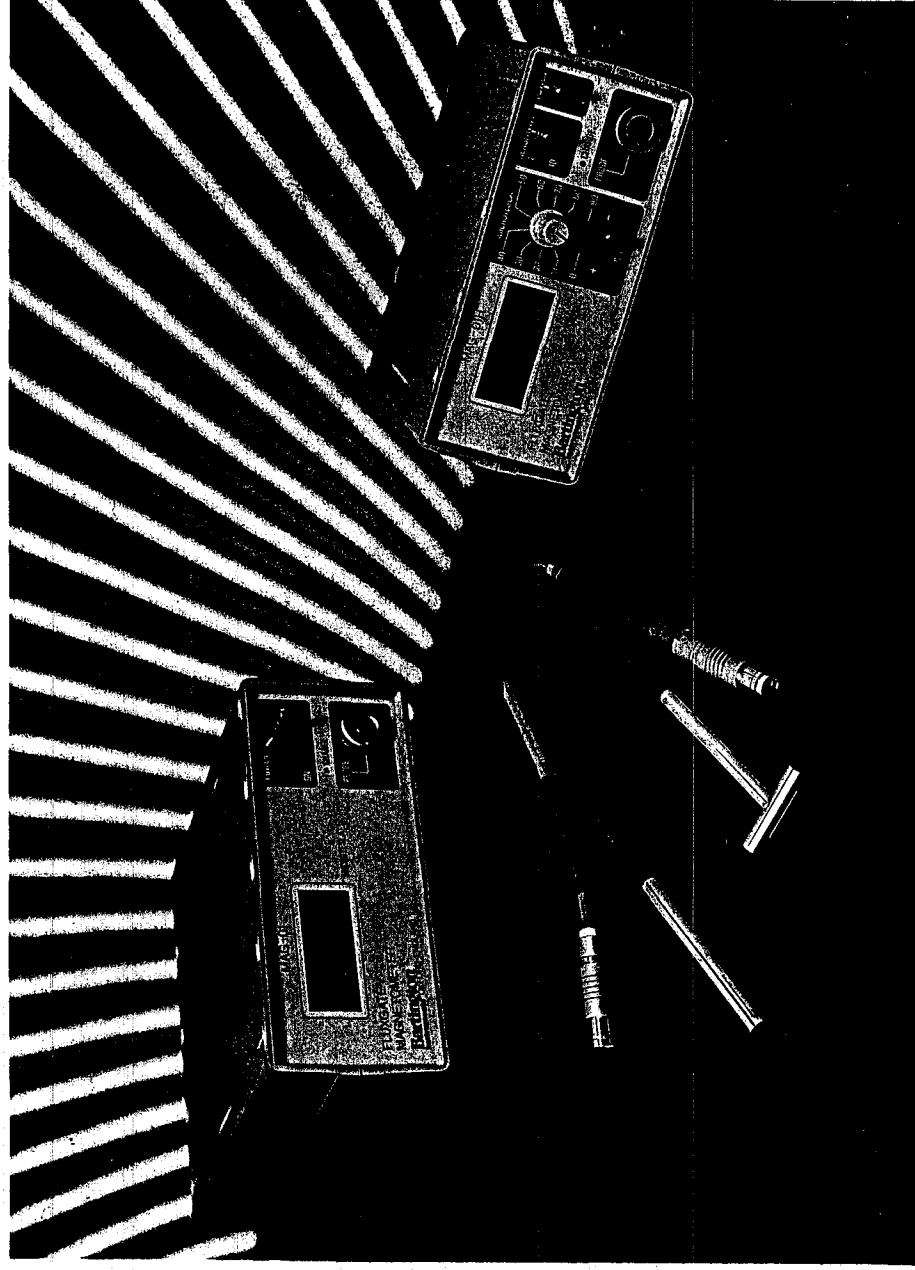
Bob Christensen
Customer Liaison Manager
For GMW Associates

Encl:

Bairington

MAG-01 MAG-01H

2 Single Axis Fluxgate Magnetometers



■ MONITORING OF MAGNETIC FIELDS GENERATED IN THE LABORATORY - on a short or long term basis

■ MONITORING EXTRANEOUS ENVIRONMENTAL MAGNETIC FIELDS - eg. in site surveys for MRI installations

■ MEASUREMENTS OF MAGNETIC FIELDS AT LOW TEMPERATURES - cryogenic applications

■ USE IN SERVO CONTROLLED FIELD CANCELLATION SYSTEMS

■ TESTING THE EFFECTIVENESS OF MAGNETIC SHIELDS

Vantier

MAG-01 and MAG-01H

Single Axis Fluxgate Magnetometers

Features

- **Versatile** - choice of instruments and probes for measurements from 0.1nT to 2mT, digital and analog outputs.
- **High performance** - instruments feature superb linearity and calibration accuracy.
- **Portable** - lightweight instruments powered from mains or internal rechargeable battery.
- **Small measurement volume of probes** - permits detailed field plotting.
- **Individually calibrated probes** - fully interchangeable between MAG-01 and MAG-01H with no adjustments.
- **Very low offset drift** - with time and temperature.

The MAG-01 and MAG-01H are used in conjunction with one of a wide range of probes for the measurement of the direction and intensity of magnetic fields. The MAG-01 measures over the range 1nT - 2mT (10^{-5} G - 20G), autoranging. In the MAG-01H, sensitivity can be increased by a factor of 10 so that approximate measurements of fields down to 0.1nT are made using the low field probes.

The measuring range and resolution achievable using these instruments with the full range of probes is shown in Table 2.

Both instruments have a digital display and analog output, and run on a non-magnetic rechargeable battery. The display is updated at 2 readings per second which permits monitoring of fields changing at a moderate speed as well as static fields.

Power supply/battery

The instruments are powered either continuously from the mains via the power supply unit or from the internal rechargeable battery. The battery provides more than 16 hours continuous use. It can be recharged at 12V either from the mains or from a vehicle battery; recharging is completed in 5 hours.

Battery voltage is continuously monitored; an audible bleeper gives advance warning of discharged batteries. Battery voltage is also shown on the LCD for 5 seconds after switch-on.

A charge indicator on the front panel is illuminated whilst the external supply is connected.

Principles of Operation

The probes consist of amorphous metal cores wound with 2 excitation coils and a combined detection and feedback coil. The drive coils are supplied by the magnetometer with a high purity AC current to generate an alternating magnetic field. This continuously drives the metal in and out of saturation, gating in and out the axial component of any external field intercepted by the sensor. The resulting alternating flux is detected by the precision pick-up coil, to which the magnetometer circuit returns a feedback current that maintains the sensor in null field. This current is converted to a precise linear voltage, which is the measurement of field strength. It is drift-free and stable over a wide measurement range. This analog voltage is then sent to the auto-ranging digit display and analog output socket.

Note: Performance specifications are expressed in Tesla, refer to Table 1 for Gauss equivalents.

Table 1

0.1nT	≡	1μG
1nT	≡	10μG
10nT	≡	100μG
100nT	≡	1mG
1μT	≡	10mG
10μT	≡	100mG
100μT	≡	1G
1mT	≡	10G
10mT	≡	100G

Table 2

MEASURING RANGE/RESOLUTION (LCD DISPLAY)

MAG-01	MAG-01H
Probes B/C/F	Probes B/C/F
0T - 20μT/1nT	0T - 2μT/0.1nT
20μT - 200μT/10nT	2μT - 100μT/1nT
	100μT - 290μT/10nT
Probes D/E/G	Probes D/E/G
0T - 200μT/10nT	0T - 20μT/2nT
200μT - 2mT/100nT	20μT - 1mT/10nT
	1mT - 2mT/100nT

MAG-01 Electronics Unit

This compact, value-for-money instrument is used in routine applications in the laboratory where the high resolution of the MAG-01H is not required.

Technical specifications

MECHANICAL

Dimensions:
15.5cm x 17cm x 6.8cm

Materials:
high impact ABS

Weight:
1.5kg

FRONT PANEL CONTROLS/SOCKETS

- (1) **On/Off switch:**
switches on the internal battery
- (2) **Probe input:**
via 6 pole waterproof Fischer connector
- (3) **Charge indicator:**
LED illuminated when external supply is connected

ENVIRONMENTAL

Operating temperature range:
-10°C to +50°C

Relative humidity:
80% maximum

REAR PANEL SOCKETS

Battery charger inlet:
2.1mm socket dc 0.5A max.
polarity protected 6-18V
continuous or intermittent use

PERFORMANCE

Measuring range:
1nT to 2mT (dependent on probe)

Bandwidth (low field probes):
d.c.to -3dB at 10Hz, 20μT P-P,
-12dB per octave roll off

Calibration accuracy:
1%

Temperature coefficient:
<10ppm/°C

Liquid crystal display:
4½ digit autoranging

displays 0-±20μT with 1nT
resolution and 20μT-±200μT
with 10nT resolution

For high field probes multiply reading
on display by 10 to obtain true value

Analog output:
5 volts full scale via 2 x 4mm rear
panel insulated sockets

Low field probes:
5 volts full scale 100μT/V
High field probes:
2 volts full scale 1mT/V

Output impedance:
1kohm

Probes: Technical Specifications

Operating temperature range:

-30°C to +75°C

Calibration accuracy:

1%

Linearity:

0.01%

Connecting cable:

4 core screened 5 metre with
integral 6 pole Fischer connector

Alternative lengths of cable
(maximum length 25 metres) are
available on request

Environmental sealing:

submersible in water to 10
metres

Shock resistance:

drop tested from 0.5 metre onto
PVC floor 3 times

Materials of enclosure:

gold plated brass

Dimensions:

refer to Diagram 1
(Probe construction)

Measuring range/resolution:

refer to Table 2

Probe alignment:

better than 0.2 degrees

LOW FIELD MAG PROBES

TYPE B, C AND F

**Temperature coefficient of
calibration:**

±10ppm/°C over full range of
operating temperatures

Offset error:

<1nT over full range of
operating temperatures

Sensitive volume of metal cores:

0.02cm³

Excitation power:

26 mW

ACCESSORIES

Power supply:

ac mains battery charger, 110V
or 220/240V

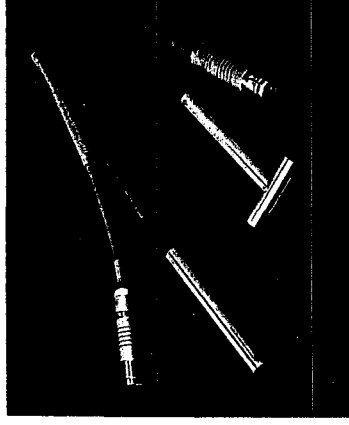
Vehicle dashboard connector:

12V dc (if requested)

**Terylene carrying bag for instrument
and probes**

Operation Manual

**Service Manual (can be purchased
on request)**



HIGH FIELD MAG PROBES TYPE D,

E AND G

**Temperature coefficient of
calibration:**

±30ppm/°C over full range of
operating temperatures

Offset error:

<20nT over full range of
operating temperatures

Sensitive volume of metal cores:

0.0036cm³

Excitation power:

16 mW

Some specifications of the products described in this brochure may be subject to change without prior notice

Agent/distributor

GMW

P.O. Box 2578, Redwood City, CA 94064

Tel (415) 368-4884 Fax (415) 368-0816

Bartington

instruments Ltd

10 Thorney Leys Business Park, Witney, Oxford. OX8 7GE. England

Tel: +44 993 706566 Fax: +44 993 774813

MACOFF Electronics Unit

This higher performance model is used in more rigorous applications where a wider measuring range and additional resolution are required.

The offset control permits the measurement of magnetic fields usually outside the measuring range of the instrument by the addition or subtraction of a selected value to the field under investigation. This brings it within the measuring range of the instrument.

MECHANICAL

Dimensions

15.5cm x 17cm x 6.8cm

Materials

high impact ABS

Weight

1.5kg

ENVIRONMENTAL

Operating temperature range

-10°C to +50°C

Relative humidity

80% maximum

PERFORMANCE

Measuring range

0.1nT - 2mT (dependent on probe)

Bandwidth - x1 sensitivity (low field probes)

d.c. to 3dB at 10Hz, 20µT P-P
-12dB per octave roll off

Calibration accuracy

1%

Maximum resolution

0.1nT (low field probes)

Zero field offset

±5nT at room temperature

Offset drift

0.01 nT/°C

Calibration temperature coefficient

<10 ppm/°C

Liquid crystal display

4½ digit autoranging

Low field probes on x1 sensitivity

displays 0 - ±20µT with 1nT resolution and 20µT - ±200µT with 10nT resolution

Technical specifications

Low field probes on x10 sensitivity

displays 0 - ±2µT with 0.1nT resolution and 2 - ±20µT with 1nT resolution. When used in

conjunction with the offset

control will resolve to 0.1nT for values lying in the range 10µT (x1-9) ±2µT

±10nT steps to be subtracted from the field experienced by the probe

(5) Sensitivity control

increases the sensitivity of the magnetometer by a factor of 10

REAR PANEL SOCKETS

Battery charger inlet

2.1mm socket dc 0.5A max polarity protected 6-18V continuous or intermittent use

Analog output

5 volts full scale via 2 x 4mm rear panel insulated sockets

x1 sensitivity (low field probes):

100µT/V ±500µT max, 1nT resolution

x10 sensitivity (low field probes):

10µT/V ±50µT max, 0.1nT resolution

Offset can be used to increase range

Output impedance

1kohm

FRONT PANEL CONTROLS/SOCKETS

(1) On/Off switch

switches on the internal battery supply

(2) Probe input

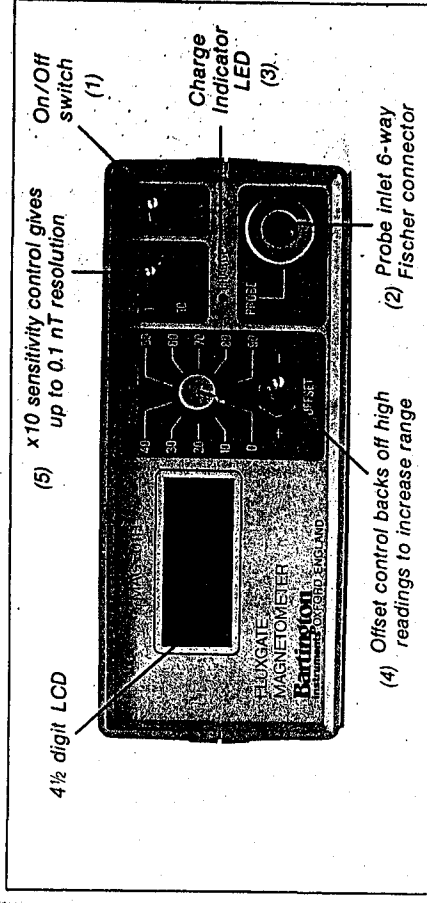
via 6-pole waterproof Fischer connector

(3) Charge indicator

LED illuminated when external supply is connected

(4) Offset Control (low field probes)

allows a preselected field strength between ±90µT in



Probes

MAG-01 and MAG-01H

Four types of MAG probe B, C, D and E are available for axial and transverse measurements at low (0.2mT maximum) and high (2mT maximum) field strengths.

MAG Probe elements type F (low field) and G (high field) are also available for cryogenic applications. These elements are supplied with a standard 5 metre probe cable with the inclusion of 1 metre of 4 x 0.2mm wire adjacent to the element.

The axis of detection of axial field probes type B and D is in line with the cylindrical enclosure. The axis of detection of the 'T' shaped transverse field probes type C and E is perpendicular to the direction of cable entry. The magnetic detection axis and centre of sensitive volume are clearly marked on each probe. Probe dimensions and sensitive volumes are illustrated in Diagram 1.

Probes are individually calibrated and fully interchangeable between the MAG-01 and MAG-01H with no adjustments and no offset errors.

Construction

Probe components are mounted in compact rugged enclosures with integral leads, standard length 5 metres, variable on request. The final assembly is shock-resistant and hermetically sealed. Probes are immersible in water to a depth of 10 metres; immersion in solvents is not recommended. Please enquire for price and availability of probes for immersion to greater depths.

Performance

The probes are notable for their very small sensitive volumes which permit the detailed exploration of complex field patterns. Their outstanding performance derives from superior quality control in the selection and preparation of materials used in their manufacture, and the precision feedback system which gives high linearity and accuracy of measurement.

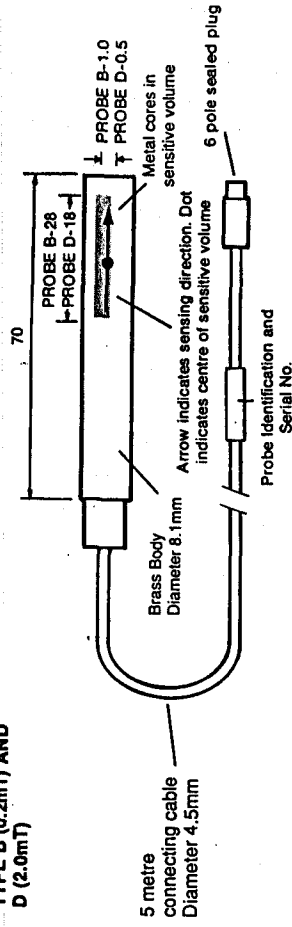
Probes are calibrated to a standard probe which has been calibrated to a reference proton magnetometer.

Accidental exposure of probes to fields as high as 1T will not affect their performance. Exposure to fields above this is not

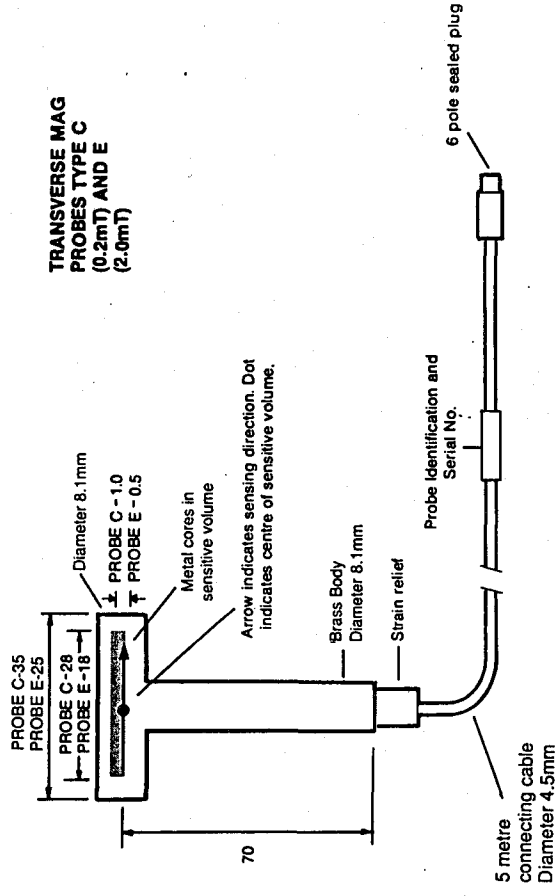
Diagram 1

PROBE CONSTRUCTION

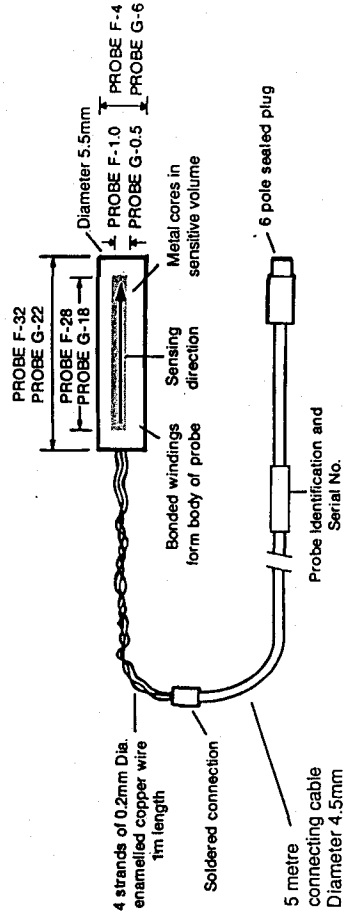
AXIAL MAG PROBES TYPE B (0.2mT) AND D (2.0mT)



TRANSVERSE MAG PROBES TYPE C (0.2mT) AND E (2.0mT)



LOW TEMPERATURE MAG PROBES TYPE F (0.2mT) AND G (2.0mT)



Indicates probe active region All dimensions in mm Not to scale

MAG-03IE

A 94064
68-0816

Three-Axis Fluxgate Magnetometer with Independent Elements

The MAG-03IE comprises a compact magnetometer with three individual sensors connected by flying leads. It is ideally suited to those applications where the positioning of the individual sensors needs to be determined by the user. The unit is suitable for OEM applications where the magnetometer forms an integral part of a larger assembly. Connecting cables between the sensors and electronics module can be 500mm or 750mm. Alternative lengths to 5 metres are available at an additional cost.

An analog output voltage proportional to the strength of the magnetic field is provided for each of the three axes. The unit requires a power supply of ± 12 V with a capability of 20 mA.

The MAG-03IE is suitable for use in equipment requiring magnetic fields to be monitored in three axes such as electron microscopes and medical equipment.

Specification

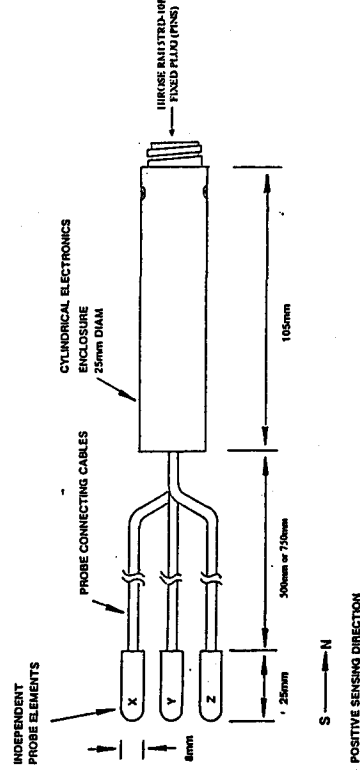
Range	$\pm 70, \pm 100, \pm 250$ or $\pm 500 \mu\text{T}$
Output	$0.1 \text{ V}/\mu\text{T}$
Accuracy	$\pm 0.5\%$
Linearity	$\pm 0.0015\%$
Bandwidth	0-2 kHz maximally flat
Roll off	-12 dB/octave above 2 kHz
Noise	$35 \text{ pT}/\sqrt{\text{Hz}}$ (0.1 - 10 Hz)
Offset	$\pm 5 \text{ nT}$ (100 μT range)
Offset TC*	$\pm 0.1 \text{ nT}/^\circ\text{C}$ (100 μT range)
Output TC*	$\pm 30 \text{ ppm}/^\circ\text{C}$ (100 μT range)
Supply	$\pm 12 \text{ V}$ ($\pm 17 \text{ V}$ maximum)
Current	$\pm 20, -8 \text{ mA}$ maximum
Sensor size	8 mm square, 25 mm long
Electronics size	25 mm dia, 105 mm long
Weight	100 g
Connector	10 way Hirose
Temperature	-40°C to $+85^\circ\text{C}$
Humidity	0 to 90% (non condensing)
*Temperature coefficient	

Connector detail

The unit is supplied with an Hirose connector to suit the MAG-03M power supply unit via a MAG-03 to MAG-03M PSU cable.

HRS type

1	X out
2	Y out
3	Z out
4	common
5	Gnd/shield
6	+12 V
7	-12 V
8/10	NC



MAG-03IE General Assembly

These specifications are provisional and are liable to change without notice.

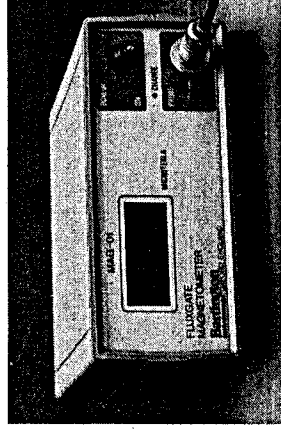
May 1994

Bartington

FLUXGATE NANOTESLAMETERS

High Sensitivity measurements of low-level magnetic fields

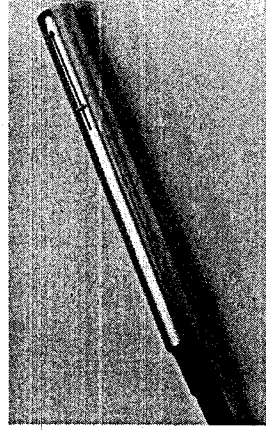
The Bartington Fluxgate Nanoteslameters allow high stability, high-reliability measurement of low-level dc and ac magnetic fields. Applications include mapping of magnetically shielded enclosures, monitoring installation sites for magnetically sensitive equipment, providing an input to active field cancellation systems, and measuring fringing fields from magnets, transformers and inductors.



MAG-01

MAG-01 and MAG-01H Single-Axis Nanoteslameters

These are portable, lightweight instruments powered from an internal rechargeable battery or from the ac line. They are intended for the measurement of dc fields. The field reading is available as a digital display and analog output. Probes are individually calibrated and fully interchangeable without zeroing or recalibration. Probes are supplied with 5m cable length. Special lengths are available to 25m.



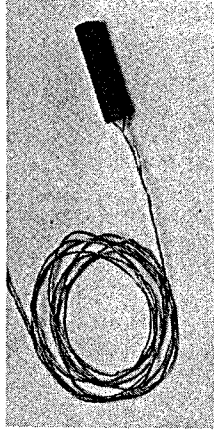
Probe B, Probe D

	MAG-01	MAG-01H
Liquid crystal display	4 1/2 digit (auto ranging)	4 1/2 digit (auto ranging)
Field range/resolution (x1/10)		$\pm 2\mu\text{T}/0.1\text{nT}$ $\pm 20\mu\text{T}/1\text{nT}$
(x1)		$\pm 20\mu\text{T}/1\text{nT}$ $\pm 200\mu\text{T}/10\text{nT}$ $\pm 200\mu\text{T}/10\text{nT}$ $\pm 2\text{mT}/100\text{nT}$
(With Probe D or E x 10)		
Analog output	$\pm 5\text{V fs}$ dc to 10Hz (-3dB) 1 kohm	$\pm 5\text{V fs}$ dc to 10Hz (-3dB) 1 kohm
Offset		$\pm 90\mu\text{T}$ in 10 μT steps
Battery life	>16 hour	>16 hour
Recharging	12V or 115Vac	12V or 115Vac
Operating temperature	-10°C to +50°C	-10°C to +50°C
Dimensions (inch)	6.7Wx6.1Dx2.7H	6.7Wx6.1Dx2.7H
Weight (lb)	3.3	3.3



Probe C, Probe E

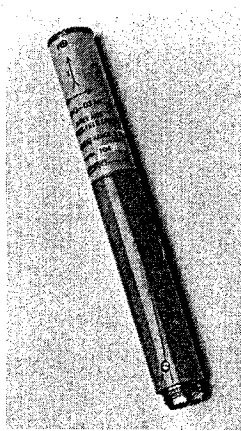
PROBES	Probe B	Probe C	Probe D	Probe E	Probe F	Probe G
Axial	•		•		•	•
Transverse		•		•		
Range 200 $\mu\text{T fs}$	•	•			•	
Range 2mT fs			•		•	•
Cryogenic operation						•



Probe F, Probe G

MAG-03MC Three-Axis Fluxgate Sensors

Specifically developed as self-contained sensors for total description of magnetic fields from dc to over 1kHz for input to data loggers or chart recorders. Features very low current drain of +20mA, and -8mA (maximum) from nominal $\pm 12\text{V}$ supply rails. Full-current output is three $\pm 10\text{V}$ full-scale signals corresponding to Bx, By, and Bz. Output impedance is less than 1ohm and cables may be up to 600m length.



MAG-03MC

	MAG-03MC100	MAG-03MC500
Scaling value	10 $\mu\text{T/V}$	50 $\mu\text{T/V}$
Measuring range ($\pm 12\text{V}$ supply)	$\pm 100\mu\text{T}$	$\pm 500\mu\text{T}$
Calibration accuracy	$\pm 0.5\%$	$\pm 0.5\%$
Angular alignment	$\pm 0.5^\circ$	$\pm 0.5^\circ$
Equivalent noise (1Hz to 1kHz)	<1.0nT rms	<1.0nT rms
Operating temperature	-40°C to +85°C	-40°C to +85°C
Dimensions (inch)	1.0Dx8.0L	1.0Dx8.0L
Weight (lb)	0.22	0.22

Field units: 0.1nT = 1 μG , 100nT = 1mG, 100 μT = 1G, 1mT = 10G, 1T = 10,000G

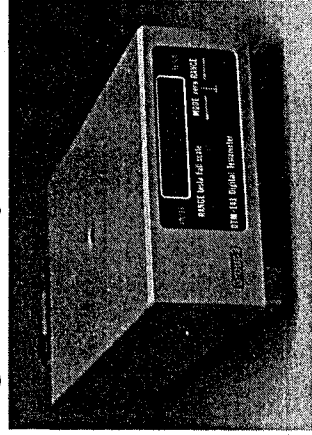
Refer to EEM Section 5500 for Precision Current Transducers

GMW

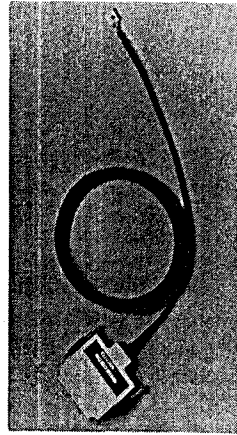
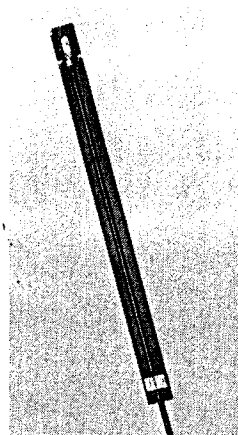
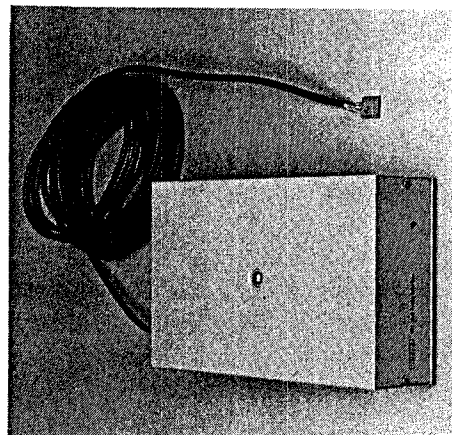
P.O. Box 2578, Redwood City, CA 94064. Tel (415) 368-4884. Fax (415) 368-0816.

High accuracy measurements of magnetic fields

Group 3 Teslameters provide superior accuracy and long term measurement reliability combined with digital interfacing options not found on any other commercial instruments. All Group 3 Probes are precalibrated against an NMR (nuclear magnetic resonance) measured field. An EPROM in the probe cable connector stores the unique field and temperature characteristics of each probe.

**DTM-141****DTM-132 and DTM-141 Single Axis Teslameters**

Two field measurement resolution alternatives are offered in the same compact package with high visibility LED display. The DTM-132 has 12-bit resolution with a 4 1/2 digit display and the DTM-141 has 16-bit resolution with a 5 1/2 digit display. Field units may be tesla or gauss. Digital interfacing options are RS-232-C and serial fiber optic or IEEE-488. Since all probes are individually calibrated they may be interchanged without calibration.

**Probe LPT-141****Probe Holder****HPI**

	DTM-132	DTM-141
Display, high brightness LED	4 1/2 digit	5 1/2 digit
Field range/resolution with standard range probes	0.3T/0.05mT 0.6T/0.1mT 1.2T/0.2mT 3.0T/0.5mT	0.3T/0.005mT 0.6T/0.01mT 1.2T/0.02mT 3.0T/0.05mT
Measurement rate	30/sec	10/sec
Peak hold mode	digital	digital
Digital Filtering	selectable	selectable
Analog Output	±3V fs (not corrected) dc to 9kHz(-3dB)	±3V fs (not corrected) dc to 3kHz(-3dB)
Digital interface options	RS-232-C, IEEE-488	RS-232-C, IEEE-488
Power	9V to 12V, 900mA 115Vac plugpack incl.	9V to 12V, 900mA 115Vac plugpack incl.
Operating temperature	0°C to 50°C	0°C to 50°C
Dimensions (inch)	4.9Wx8.5Dx2H	4.9Wx8.5Dx2H
Weight (lb)	2.6	2.6
PROBES	LPT-230 LPT-231 LPT-130 LPT-141	
Ranges, full-scale (T)	0.03, 0.06, 0.12, 0.3	0.3, 0.6, 1.2, 3.0
Precision (% of full-scale)	0.03	0.03
Temperature coefficient (ppm/°C)	500	25
		100
		0.03
		0.01
		10

HPI Hall Probe Interface

The HPI may be used to provide high-stability, high resolution interfacing of Hall probes to analog data acquisition systems. It provides a very stable 100mA, 19.2kHz control current and includes phase sensitive detection for the Hall voltage. Four gain settings may be selected. An analog output corresponding to temperature is also provided when used with Group 3 probes including temperature sensors. Calibration tables are offered as an option.

Magnetic field analog output	±3V, overrange to ±6V dc to 3kHz (-3dB)
Temperature analog output	50mV/°C
Gain control	3 inputs to select 4 gains
Power	9 to 12V, 200mA, ac or dc
Operating Temperature	0 to 50°C
Dimensions (inch)	4.9Wx8.5Dx2H
Weight (lb)	2.0

Field units: 0.1nT = 1µG, 100nT = 1mG, 100µT = 1G, 1mT = 10G, 1T = 10,000G

Refer to EEM Section 5500 for Precision Current Transducers

GMW

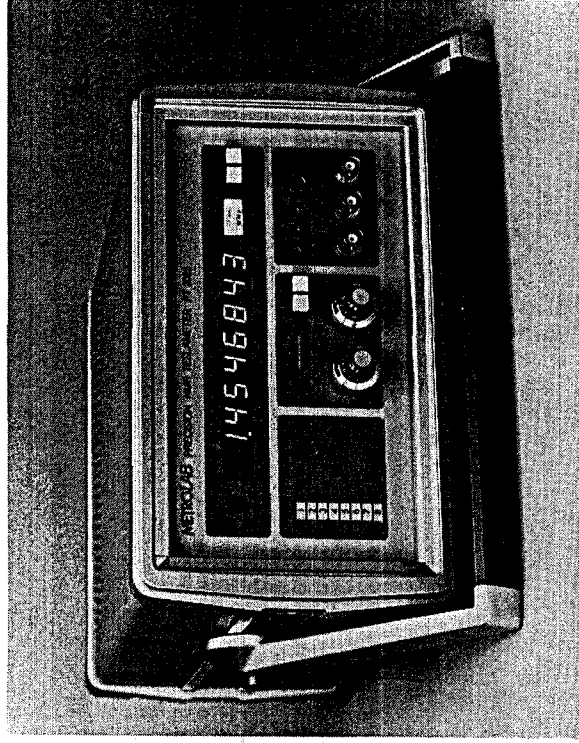
P.O. Box 2578, Redwood City, CA 94064. Tel (415) 368-4884. Fax (415) 368-0816.

METROLAB

NMR TESLAMETER AND DIGITAL VOLTAGE INTEGRATOR

Very high accuracy and stability measurements of magnetic fields

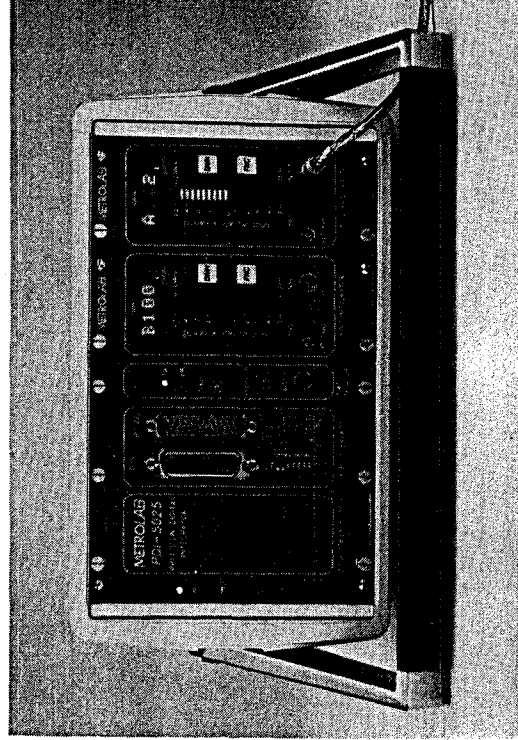
When absolute accuracy and high resolution magnetic field measurements are critical NMR (Nuclear Magnetic Resonance) Teslometers become the instrument of choice. Important applications are the calibration of magnetic sensors, mapping very uniform magnetic fields such as MRI (magnetic resonance imaging) magnets and to provide the field input for closed-loop stabilization of magnet systems.



2025 NMR Teslometer

2025 NMR Teslometer	8 1/2 digit, tesla or MHz
High brightness LED	0.043 to 13.6T
Field range	0.1 μ T or 1Hz
Resolution	\pm 5ppm
Absolute Accuracy	<2ppm
Stability (10°C to 40°C)	1/sec, 10/sec
Aging (1 year)	RS-232-C & IEEE-488
Reading rate	110/220Vac, 50/60Hz,
Interfaces	10.2Wx13.3Dx5.7H
Input power	15
Dimensions (inch)	
Weight (lb)	

Measurements of magnetic flux change can be achieved by integration of the emf across the terminals of a sensing coil. Using appropriately configured coils the integrator can be used to map regions of magnetic field or to measure magnetic flux changes in magnetic material hysteresis measurements.



5025 Precision Digital Integrator

5025 Precision Digital Integrator	1 or 2
Integration channels	\pm 5mV to \pm 5V
Input voltage	1, 2, 5, 10, 20, 50,
Programmable gain	100, 200, 500, 1000
Input impedance	2 Mohm
Integration interval	1ms to 10 ²³ ms
External trigger	TTL
Motor drive (for mapping)	\pm 12V or \pm 24V, 500mA
Encoder	2 up/down counter channels and 1 indexed channel.
Stability	1.5ppm/°C at gain of 100
Linearity	\pm 20ppm at gain of 100
Noise	\pm 3ppm at gain of 100
Resolution	2x10 ⁻⁷ v.s at gain of 100
Interfaces	RS-232-C & IEEE-488
Dimensions (inch)	10.2Wx10.2Dx5.7H
Weight (lb)	12

Field units: 0.1nT = 1 μ G, 100nT = 1mG, 100 μ T = 1G, 1mT = 10G, 1T = 10,000G

Refer to EEM Section 5500 for Precision Current Transducers

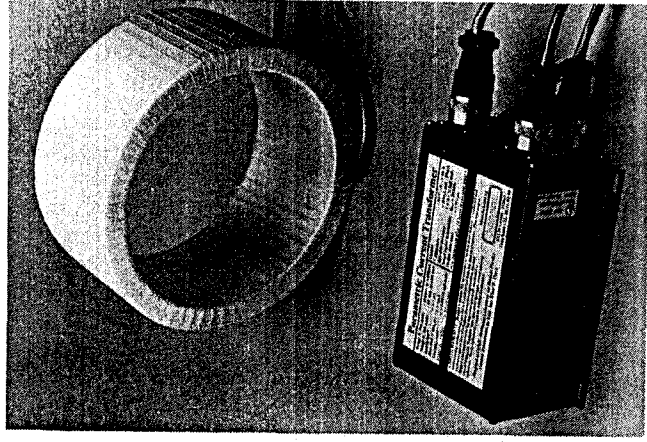
GMW

P.O. Box 2578, Redwood City, CA 94064. Tel (415) 368-4884. Fax (415) 368-0816.

CURRENT TRANSFORMERS

High Sensitivity, non-contacting measurement of electric current and charge

Bergoz Current Transformers have been developed for the non-destructive measurement of dc and pulse currents in particle accelerators and electron beam devices. They may be applied to the measurement of any electric current where ohmic isolation is desired.



PCT with 178mm Head

PCT, Parametric Current Transformer

The PCT is a stand-alone instrument using the zero flux principle with very high sensitivity magnetic cores. It can be used to measure dc currents with resolution to better than $10\mu\text{A}$.

PCT CONTROL

Polarity		true bipolar
Output	(fs)	$\pm 10\text{V}$
Calibration	(% of fs)	<0.1
Linearity	(% of fs)	<0.01
Stability	($\mu\text{A}/^\circ\text{C}$)	< ± 10
	($\mu\text{A}/\text{month}$)	< ± 30
Output noise	(μA_{rms})	<5(dc to 1Hz)
Operating temp ($^\circ\text{C}$)		10 to 40

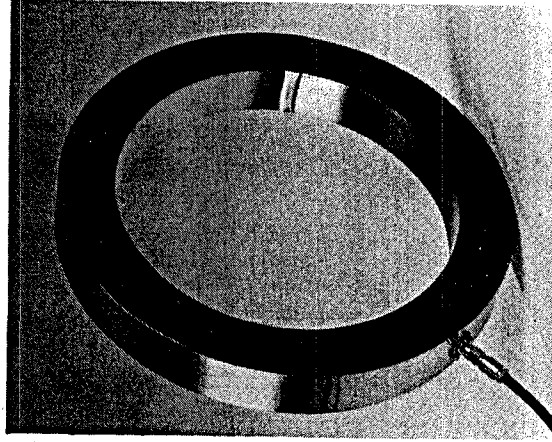
TRANSDUCER HEAD

Head current	(fs)	10mA, 100mA, 1A or 10A
Frequency response	(kHz)	dc to 20 (-3dB)
Operating temp	($^\circ\text{C}$)	0 to 60
Axial length	(mm)	102
Hole diameter	(mm)	28,55,82,122 or 178

FCT, Fast Current Transformer

These are passive ac transformers designed for displaying fast current pulses.

Current ratio	(input/output)	20,10 or 5
Input rise time	(nsec)	<1
Droop	(%/ μsec)	<2
Peak current	(A max)	100
Output signal into 50 ohm	(V/A)	1.25,2.5,5
Operating temp	($^\circ\text{C}$)	0 to 60
Axial length	(mm)	22
Hole diameter	(mm)	28,55,88,122 or 178



FCT, ICT

ICT, Integrating Current Transformer

The ICT is a capacitively shorted transformer and a fast current transformer with a common high-sensitivity core. Very fast current pulses are integrated on the secondary capacitance and read out as a current accurately proportional to the integral of the signal current, ie the pulse charge.

Current ratio	(input/output)	100, 20, 10
Input rise time	(psec)	<1
Input pulse length	(nsec)	<5
Linearity error	(%)	<0.1
Output signal into 50 ohm	(mV/nC)	10, 50, 100
Operating temp	($^\circ\text{C}$)	0 to 60
Axial length	(mm)	32
Hole diameter	(mm)	28, 55, 88, 122 or 178

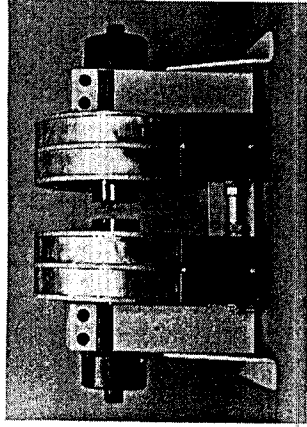
Refer to EEM Section 2900 for Magnetic Field Measurement

GMW

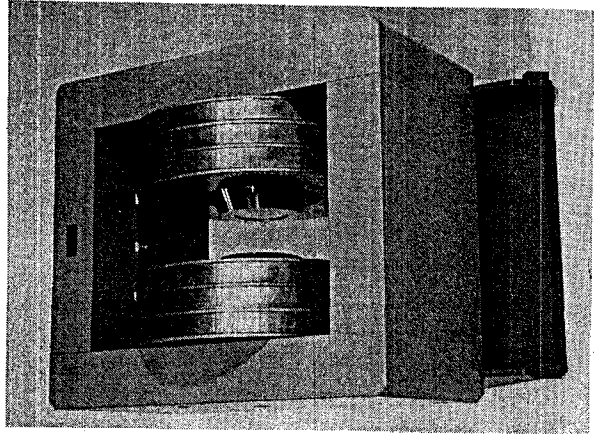
LABORATORY ELECTROMAGNETS

Variable-field electromagnet systems for magnetic property studies

These variable-field electromagnets are suitable for Hall-effect studies, magneto-optics, ferromagnetic resonance, B-H curves, magnetic sensor calibration, magnetic separation and ESR/NMR spectroscopy. The smaller magnets (3470, 5403, 5403AC) have "C-frame" yokes for ease of access and simplicity. A rectangular "H-frame" yoke is used for the larger magnets to obtain mechanical stability and high field uniformity. All the magnets have changeable pole caps with different pole face diameters and all except the 5414 have continuously adjustable pole gaps. This enables optimization for the geometry and field requirements of a particular application. The 5403AC magnet is laminated for fast field ramp and rapid settling.



5403



5414

Versatility. The yoke and coils are designed for maximum access to the working region and mounts are available for either horizontal or vertical field orientation. For the H-frame magnets, 45° Mounting Angles are available to incline the magnet yoke back at 45° from the vertical. This allows equipment to be inserted into the magnet gap from the horizontal or vertical directions. Provision is included for axial viewing or access holes in one or both Pole Caps.

Reliability. GMW magnet coils are the most reliable commercially available. They are wound from precision slit, high conductivity copper strip with mylar interturn insulation & a glass fiber outer wrap. Cooling is achieved by separately cooled heat sinks integrated with the coil. The complete coil assembly is vacuum impregnated with epoxy resin to produce a void-free structure which will not degrade with full power continuous or cycled operation. Protective overtemperature interlocks are mounted on all heat sinks and the H-frame magnets also have coolant flow interlocks.

Systems. Complete Electromagnet Systems can be configured to meet the specific application. Power Supplies can be unipolar, true bipolar or unipolar with reversing switch and stabilities from 500ppm to better than 1ppm. Digital Hall or NMR Testimeters provide field measurement capability and computer control is implemented using RS-232-C or IEEE-488 interfaces.

GMW also offers special electromagnet systems for ion beams, magnetic tape alignment, & semiconductor processing.

Model Number	3470	5403	5403AC	3472	3473	3474	5414
Yoke type	C	C	C	H	H	H	H
Pole diameter (mm)	45	76	76	100	150	250	350
Pole diameter (inch)	1 3/4	3	3	4	6	10	14
Pole gap (mm)	0 to 75	0 to 76	12 to 76	0 to 115	0 to 125	0 to 160	25 to 125
Pole gap (inch)	0 to 3	0 to 3	1/2 to 3	0 to 4.5	0 to 5	0 to 6.3	1 to 5
Pole face diameter (mm)	variable	variable	variable	variable	variable	variable	fixed
Pole face diameter (mm)	20, 40	38, 76	38, 76	25, 50, 75, 100	25, 50, 100, 150	25, 50, 100	as spec
Coil power (continuous)	5A, 44V	50A, 25V	50A, 25V	50A, 36V	50A, 41V	280A, 38V	212, 76V
Cooling water (l/min)	1	2	2	3	3	15	30
Mass (kg)	38	124	124	350	600	1800	3200
Mass (lb)	85	275	275	770	1320	3970	7000
Typical field (T)	0.9	1.1	1.1	1.5	1.7	1.8	2.7
gap (mm)	10	25	25	25	25	50	50
pole face (mm)	40	76	76	100	100	200	230
Typical power supply							
Unipolar	10A, 60V	60A, 40V	60A, 60V	60A, 40V	60A, 60V	320A, 40V	240A, 80V
Bipolar	8A, 50V	40A, 20V	40A, 40V	40A, 40V	-	-	-
Reversing Switch	-	-	-	-	80A	400A	250A

Field units: 0.1nT = 1μG, 100nT = 1mG, 100μT = 1G, 1mT = 10G, 1T = 10,000G

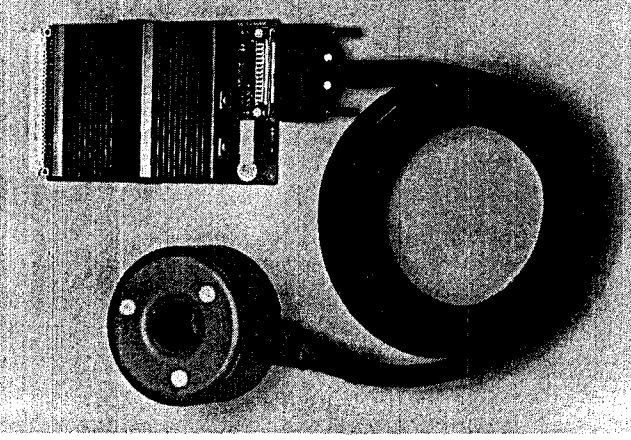
Refer to EEM Section 5500 for Precision Current Transducers

GMW P.O. Box 2578, Redwood City, CA 94064. Tel (415) 368-4884. Fax (415) 368-0816.

**DANFYSIK****ULTRASTAB CURRENT TRANSDUCERS**

Very high accuracy, non-contacting measurements of electric current

Danfysik ULTRSTAB Current Transducers operate on the zero flux principle and enable precision current measurements to 2000A with flat frequency response from dc to over 300kHz. The compensation current can be measured directly or converted to a voltage in a "burden" resistor. Zero flux current transducers are extremely linear and have excellent temperature and long-term stability. They enable current measurement without ohmic connection to the measured circuit and without the resistive power loss of a shunt. Even at high currents the ULTRASTAB Current Transducers do not require water cooling.

**864U and 300A Head****864U and 864I Eurocard ULTRASTAB Current Transducers**

These are Eurocard board Transducers designed for use as the current sensing element in high-precision, current regulated power supplies. They offer very high stability combined with excellent frequency response.

EUROCARD BOARD	864I	864U
Polarity	true bipolar	true bipolar
Output (fs)	±1A	±10V
Calibration (ppm of fs)	<50	<50
Linearity (ppm of fs)	<1	<10
Stability (ppm/°C)	<0.1	<2
(ppm/month)	<1	<5
Offset (ppm of fs)	<5	<5
Output noise (ppm of fs)	<5(dc to 50kHz)	<8(dc to 50kHz)
Operating temp (°C)	10 to 40	10 to 40
Dimensions (mm)	160x100x37	160x100x37
(inch)	6.3x4x1.5	6.3x4x1.5

TRANSDUCER HEAD

	600A	2000A
Head Current (A)	200,400,600	1000,1500,2000
Upper Frequency (kHz)	500(-3dB)	300(-3dB)
Test Voltage (kV)	2	2
Operating Temp (°C)	0 to 60	0 to 60
Dimensions (mm)	90Dx30L	150Dx45L
Hole diameter (mm)	30	60
Weight (kg/lb)	1.4/3.1	3.1/6.9

860 ULTRASTAB Current Transducer

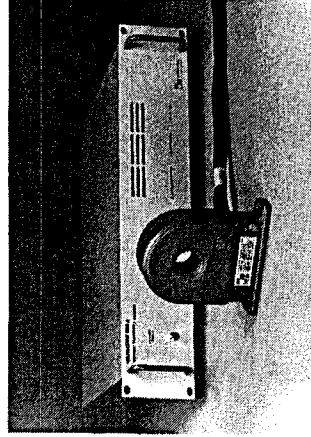
This is a self-contained, 19 inch rack-mounting instrument with an internal, temperature controlled burden resistor. It is particularly suitable for measuring dc and pulse performance of current regulated power supplies.

860R CONTROL

Polarity	true bipolar
Output (fs)	±10V
Calibration (ppm of fs)	<50
Linearity (ppm of fs)	<5
Stability (ppm/°C)	<1
(ppm/month)	<5
Offset (ppm of fs)	<2
Output noise (ppm of fs)	<4(dc to 50kHz)
Operating temp (°C)	10 to 40
Dimensions (inch)	19Wx11.8Dx3.5H
Weight (kg/lb)	5.1/11.3

TRANSDUCER HEAD

	600A	2000A
Head current (A)	40 to 600 in 40A steps	125 to 2000 in 125A steps
Upper frequency (kHz)	300(-3dB)	150(-3dB)
Test voltage (kV)	5	5
Operating Temp (°C)	0 to 60	0 to 60
Dimensions (mm)	127Dx48L	160Dx55L
Hole diameter (mm)	26	50
Weight (kg/lb)	1.4/3.1	3.3/7.3

**860R and 600A Head**

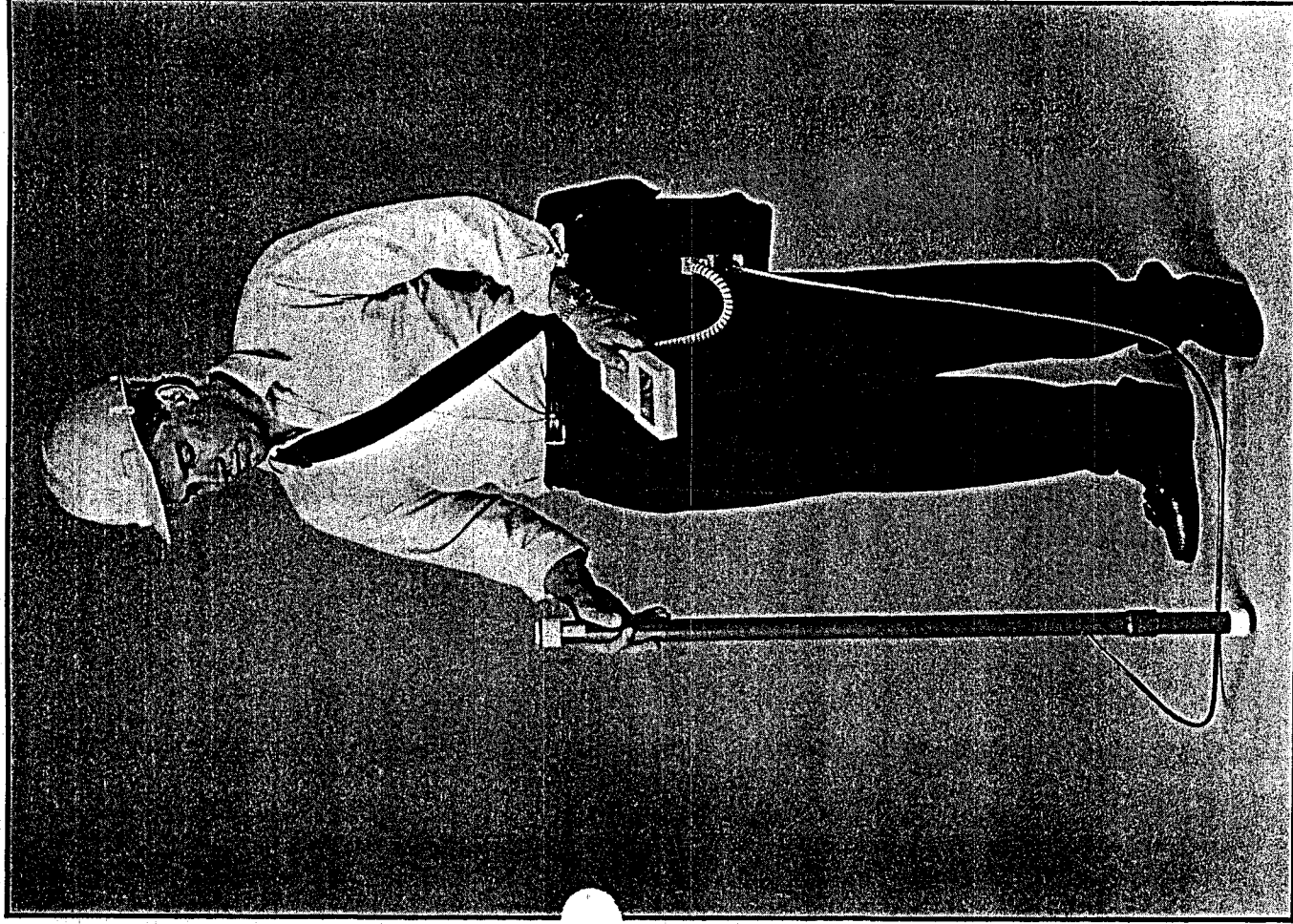
Refer to EEM Section 2900 for Magnetic Field Measurement

GMW

P.O. Box 2578, Redwood City, CA 94064. Tel (415) 368-4884. Fax (415) 368-0816.

Electric Research and Management, Inc.

MultiWave[®] System II



**Portable Monitor for
Characterizing
Magnetic Fields in
Residential and
Occupational
Environments**

Residential

Commercial

Industrial

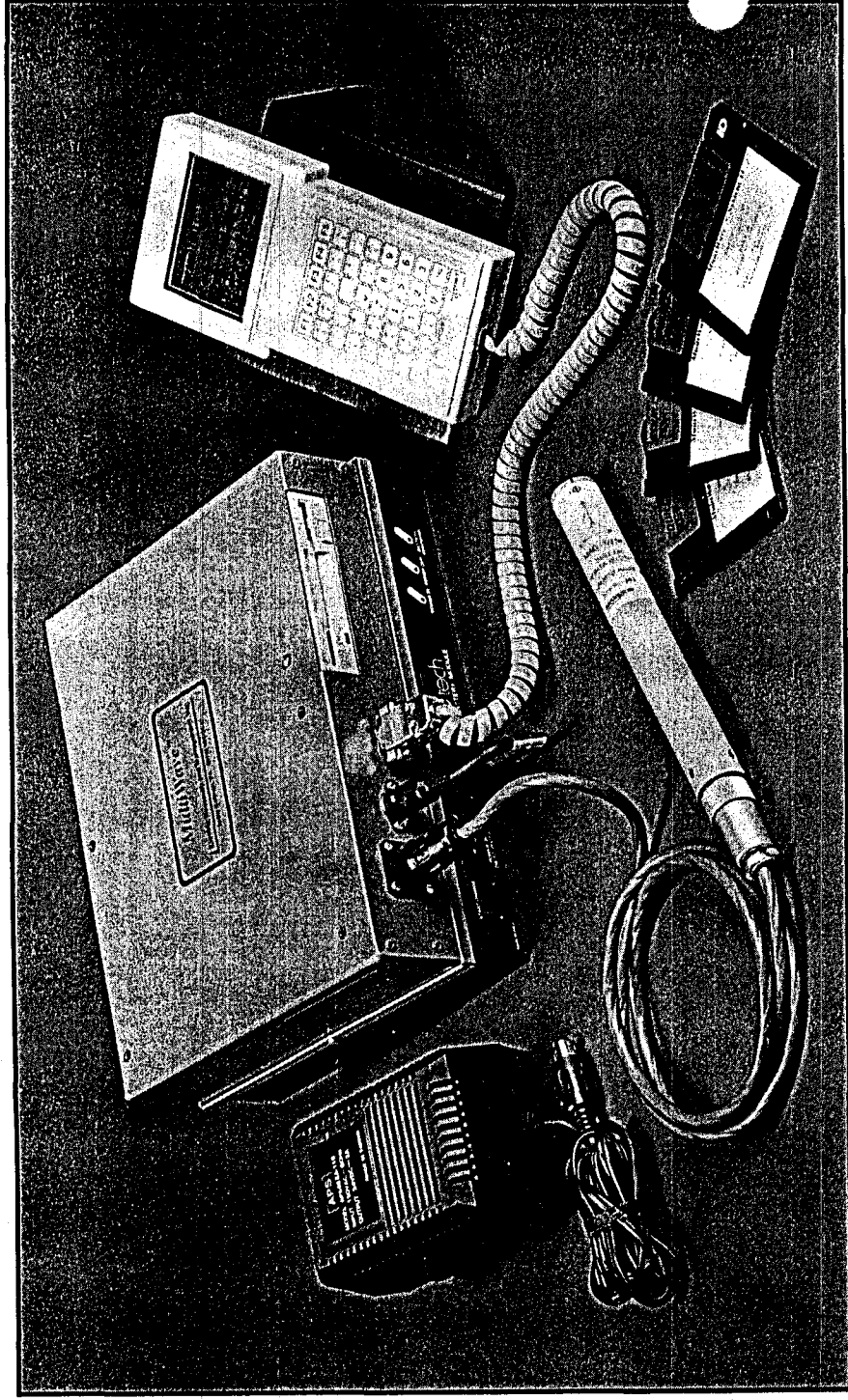
Utility

**Electric
Transportation**

P.O. BOX 165 • STATE COLLEGE, PA 16804 • (814) 466-3031

6630 HWY 9, SUITE 203 • FELTON, CA 95018 • (408) 335-9061

MultiWave® System II Equipment Package



- * Tri-axial sensor by Bartington
- * Hand-held controller
- * 10 lbs (4.5 kg) with four-hour-plus battery
- * 9 by 12 by 4 inches (23 by 30 by 10 cm)
- * Data storage on 3.5-inch diskettes
- * Shielded for electric fields and RFI
- * Field-replaceable battery — two-hour recharge time

- * DC to 3000 Hz bandwidth
- * FFT analysis in discrete frequencies from 3 kHz down to 3 Hz
- * 0.05 mG to 5 G (5 nT to .5 mT) peak in two ranges
- * Automatic gain selection
- * User-defined calculations of dc, power frequency, harmonics and non-harmonics

- * Profiler wheel to trigger recording by distance traveled
- * One-meter-high staff for consistent height and vertical orientation of measurements
- * Calibration coil to verify operation before taking measurements
- * Transient monitoring with level triggers
- * Clamp-on current probe for simultaneous current measurements

- * Advanced calculation program for:
 - Calculations over defined frequency ranges
 - Polarization calculations
 - Angle of ac fields to dc fields
 - Magnitude of ac field parallel and perpendicular to dc field
 - Spatial orientation of resultant at specified frequencies

Available Options

Hand-held Controller

- * Provides time, ID information
- * Displays calculations from last point taken
- * Minimum key interaction — pressing a single function key initiates most operations
- * Available functions shown over function keys

Selects

Spot Measurement Mode — Records a sample each time the specified key is pressed.

Long-term Mode — Records a specified number of samples at predetermined intervals. Total samples limited only by available disk space.

Timed Mode — Records samples at predetermined intervals between specified start and end times (hour-min-sec, day-month-year).
Display Mode — Any of the above modes can be set to sample and perform calculations without recording data.

Calculation Mode — Any of the above modes can be set to store calculations instead of waveform data. Significantly reduces the amount of disk space used for a data set.

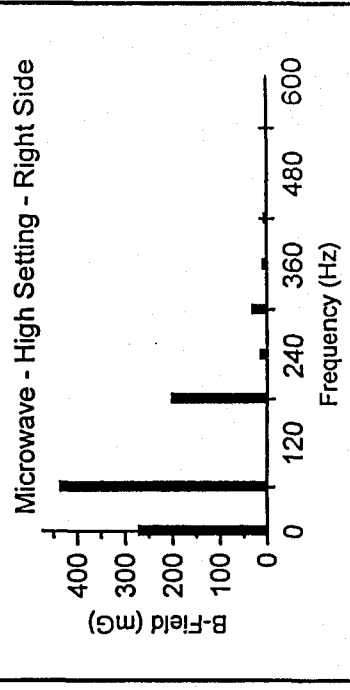
Calculates

Up to three different calculations may be displayed simultaneously, including:

- * AC rms of each axis or of resultant
- * DC of each axis or of resultant
- * Magnitude or phase of selected harmonics
- * Dominant frequency of waveform
- * Total harmonic distortion of each axis or of resultant
- * Up to three user-defined calculations

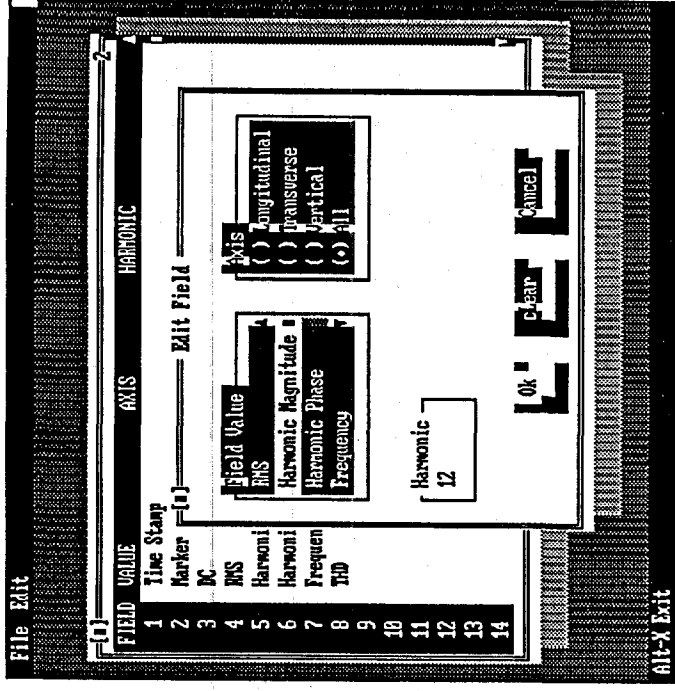
Spot Measurement Mode Storage(On) 100CS7	
DC—A—	512.5 MG
PMAG—A—	32.8 MG
HMAG—A001	27.5 MG
F1-Sample F2-Exit	
F3-Mode F4-View F5-Store	

F1	F2	F3	F4	F5
A	B	C	D	E
F	G	H	I	J
K	L	M	N	O
P	Q	7	8	9
R	S	4	5	6
T	U	1	2	3
V	W	X	0	CTRL
Y	Z	SPACE	ENTER	SHIFT



Software Features

- * Data output on 3.5-inch diskette for compatibility with PC computers.
- * DOS program to convert waveform data into dBase IV format with up to 250 definable fields.
- * All calculations available at monitor are available to database converter.
- * Allows user access to C++ libraries to construct user-defined functions.
- * Allows filtering of FFT analysis for comparison to other monitors.



MultiWave® System II Provides Configuration Programs for:

- * Portable Monitor
 - Enter sample frequency
 - Select calculations to be displayed
 - Enter start times, stop times, intervals for long-term monitoring
- * Digital Filter Setup
- * Database Program Calculations
- * Field Definitions
- * Calibration Constants

This product incorporates technology developed for the electric power industry under the sponsorship of EPRI, the Electric Power Research Institute.

For further information, please contact:

Electric Research and Management, Inc.

P.O. Box 165
State College, PA 16804
(814) 466-3031
Fax (814) 466-2393

6630 Hwy. 9, Suite 203
Felton, CA 95018
(408) 335-9061
Fax (408) 335-9065



Magnetometers:

GMW

PO Box 2578
Redwood City, CA 94064
415-368-4884

Mike Duffy

Bartington Fluxgate magnetometers

DC-1kHz, 3 axes

Available in several user-definable maximum ranges, up to 5 gauss
\$2250 + \$500 power supply

This may be sufficient for low and high frequency monitoring.

They also make Hall effect sensors. Single axis/probe. Available in
0.3 - 3 kgauss full scale. Digitally corrected probes. DC or AC mode.
DTM141: \$2860 for meter, \$1080 for probe.

Literature is coming.

OR, for high frequency, HP's 11966K Magnetic Field Pickup Coil,
20Hz - 50 kHz, \$670.

RFI monitors:

HP:

The HP8902A, Measuring receiver, 150 kHz to 1300 MHz, looks like it may
do the job. Instrument probably looks at one frequency at a time but can
be scanned over several band fairly quickly (?).
Price: \$29,450 (there are many options available)

Antennas: 11966A, Active loop H-field, 10kHz-30MHz, \$2535
11966B, Active Rod E-field, 100Hz-50MHz, \$2235

OR, one can buy a spectrum analyzer, using one of the above antennas,
and read out the full sweep. These start at \$8995, for the HP 8590D.

Anritsu:

Interference/Field strength meters:

ML428B: 9 kHz - 30 MHz, \$18,100

ML518A: 25-520 MHz, \$13,025

EMI probes: MA 2601B/C (5-1000MHz/1-50MHz): \$210

MP415B Rod Antenna 9kHz-30MHz, \$2820

Air shower detectors:

Rexon Components, Inc.
24500 Highpoint Rd.
Beachwood, Ohio
216-292-7373

Vic Berner

Plastic scintillators w/ PMT (see data sheed): \$2,213 per unit.

seeds: PMT base w/ preamp, EG&G 276: \$405

PMT bias supply, EG&G 556H: \$1540 (bench top, 3 kV, 10ma)

EG&G 478: \$1080 (mounts in NIM bin, 2kV, 1ma)

Total: \$2213 + 405 + 1540 = \$4158 y unit.

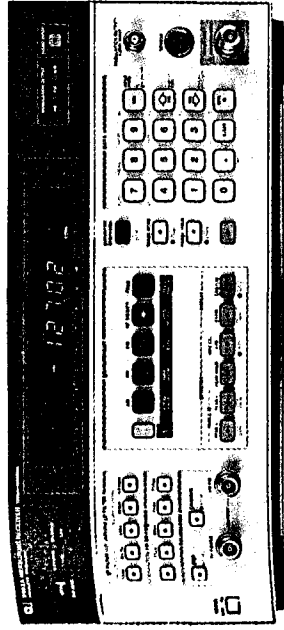
SIGNAL ANALYZERS

Measuring Receiver, 150 kHz to 1300 MHz

HP 8902A

273

- RF power: digital power meter accuracy
- Tuned RF level: 0 to -127 dBm dynamic range
- Carrier noise: AM and phase noise measurements to -140 dBc/Hz



HP 8902A



HP 8902A Measuring Receiver

The HP 8902A Measuring Receiver combines 6 precise measurement functions into one fully automatic, HP-IB programmable instrument. It accurately measures RF power, tuned RF level, carrier noise/adjacent channel power, modulation, and RF frequency, and characterizes audio signals. For precise signal analysis, the HP 8902A measuring receiver provides the performance you need.

Metrology and Calibration

The HP 8902A measuring receiver makes signal generator and operator calibration easier than ever before. The HP 8902A provides exceptional accuracy, wide dynamic range, and a broad range of measurements.

It quickly and accurately measures your signal generator's RF frequency, RF level flatness, output level accuracy to -127 dBm, AM and FM with 1% accuracy, incidental and residual AM, FM and phase modulation, and carrier noise down to -140 dBc/Hz, and characterizes the demodulated audio signals.

For attenuator calibration and other relative measurements, the HP 8902A gives you great accuracy and dynamic range. Option 050 provides $\pm(0.015 \text{ dB} + 0.005 \text{ dB/10 dB})$ relative power accuracy to test attenuators to the most stringent specifications.

RF Signal Characterization

The HP 8902A measuring receiver is an excellent lab and production tool for accurately characterizing RF signals from 150 kHz to 1300 MHz.

Level measurements down to -127 dBm with superb accuracy make the HP 8902A ideal for testing devices such as antennas, multiplexers, log/linear amplifiers, filters, and mixers. Unlike diode detectors, the HP 8902A's power meter accurately measures signals with harmonics and spurious.

The HP 8902A makes accurate AM-to- \emptyset M and FM-to-AM conversion measurements of phase- and amplitude-sensitive devices, such as bandpass filters and multiple-channel receivers. Excellent isolation between AM and FM makes it simple to separate the AM and \emptyset M of AM stereo, the incidental AM of FM transmitters, and the AM, FM, and \emptyset M components of complex signals.

Automatic Test Systems

The HP 8902A is an important component of automatic RF test systems. All functions—power, level, frequency count, carrier noise, modulation, audio analysis—are fully automatic and easily programmed. With these measurements combined in one instrument, interfacing requirements, hardware costs, and software development time are reduced.

- AM and FM: 1% accuracy; \emptyset M: 3% accuracy
- RF frequency: 1 Hz resolution
- Audio: level, frequency, and distortion

HP 8902A Specifications

RF Power (with HP 11722A Sensor Module)

Range: +30 dBm (1W) to -20 dBm (10 μ W)
Frequency Range: 0.1 MHz to 2.6 GHz
Linearity: ± 0.02 dB (within range) ± 0.02 dB per range change from reference range ± 1 count LSD
Input SWR: <1.15

Tuned RF Level

Range: 0 to -127 dBm
Frequency Range: 2.5 to 1300 MHz
Relative Accuracy: ± 0.02 dB ± 0.02 dB per IF range change ± 0.04 dB per RF range change ± 1 digit
Worst-Case Cumulative Relative Power Accuracy (with Opt 050²): ± 0.005 dB/10 dB step (0 to -100 dBm) ± 0.050 dB/10 dB step (-100 to -120 dBm) ± 0.015 dB ± 1 digit

Selective Power Measurements (Carrier Noise, Options 030 to 037)

Frequency Range: 10 to 1300 MHz
Carrier Power Range:
+30 dBm to -20 dBm: 12.5 kHz, 25 kHz and 30 kHz filters
+30 dBm to -10 dBm: carrier noise filter
Relative Measurement Accuracy:
 ± 0.5 dB; levels > -95 dBc: 12.5 kHz, 25 kHz and 30 kHz filters
 ± 0.5 dB; levels > -129 dBc/Hz: carrier noise filter
Filter Bandwidths: 2.5 kHz, carrier noise filter: 8.0 kHz, 12.5 kHz filter; 16.0 kHz, 25 kHz filter; 30.0 kHz, cellular radio filter

RF Frequency

Range: 150 kHz to 1300 MHz
Maximum Resolution: 1 Hz

Amplitude Modulation

Rates: 20 Hz to 100 kHz
Depths: To 99%
Accuracy: $\pm 1\%$ of reading ± 1 digit, for rates 50 Hz to 50 kHz and depths $\geq 5\%$

Frequency Modulation

Rates: 20 Hz to 200 kHz
Deviations: To 400 kHz
Accuracy: $\pm 1\%$ of reading ± 1 digit, for rates 50 Hz to 100 kHz

Phase Modulation

Rates: 200 Hz to 20 kHz
Deviations: To 400 radians
Accuracy: $\pm 3\%$ of reading ± 1 digit

Audio Level, Frequency, and Distortion Capability

Audio Level Accuracy: $\pm 4\%$ of reading, 100 mV to 3 V
Audio Frequency Display Resolution: 6 digits, to 250 kHz
Audio Distortion Accuracy: ± 1 dB, 400 Hz and 1 kHz

¹Specifications are warranted when using a Hewlett-Packard synthesized source with less than 100 Hz peak residual FM measured in a 3 kHz post-detection bandwidth over a 30-second period.

²Accuracy specifications do not include mismatch uncertainty.

SIGNAL ANALYZERS

Measuring Receiver, Sensor Module, Verification Kit

HP 8902A, 11812A, 11722A, 8902S, 11793A, 11792A

Ordering Information

HP 8902A Measuring Receiver¹

Opt 001 Rear Panel Instead of Front Panel Connections for Input, Modulation Output, and Calibrators

Opt 002 1×10^{-6} Day Internal Reference Oscillator

Opt 003 Rear Panel External LO Connectors

Opt 004 Operation from 48 to 440 Hz Power Line (temp. $< 40^\circ \text{C}$)

Opt 021 Add HP 11722A Sensor Module

Opt 030 High Selectivity (select only two filter options)

(Options 032 to 037 require Option 030. Option 030 includes Option 003 connections for external local oscillator.)

Opt 032 12.5 kHz Filter

Opt 033 25.0 kHz Filter

Opt 035 Cellular Radio Filter

Opt 037 Carrier Noise Filter

Opt 050 Increased Power Measurement Accuracy

Opt 907 Front Handle Kit (5061-9690)

Opt 908 Rack Flange Kit (5061-9678)

Opt 909 Rack Flange Kit (5061-9684) with Front Handles

Opt 910 Additional Operation and Calibration

Manual (08902-90029) and 2 Service Manuals (08902-90031)

Opt 915 Add Service Manual (08902-90031)

Opt W30 Extended Repair Service (see page 624)

Opt W32 Calibration Service (see page 624)

¹For off-the-shelf shipment, call 800-452-4844.

²HP-IB cables not included. For description and prices, see page 86.

Price
\$29,450
+ \$265

+ \$895
+ \$500
+ \$335
+ \$2,520
+ \$2,905

\$0
\$0
\$0
\$0
+ \$4,225
+ \$67
+ \$36
+ \$93
+ \$370
+ \$155
\$380
\$570

HP 11722A Sensor Module (100 kHz to 2.6 GHz)
The HP 11722A sensor module was designed for use with HP 8901B modulation analyzer and the HP 8902A measuring receiver. The HP 11722A contains a silicon monolithic thermocouple power-sensing element.

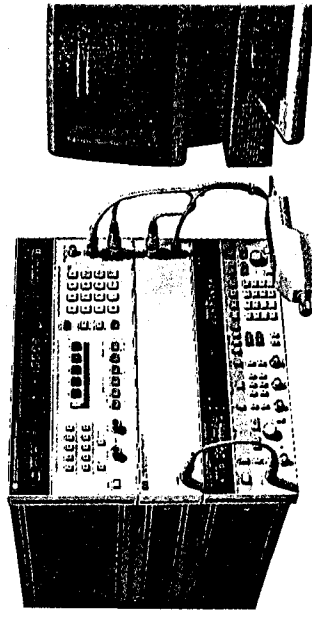
With the HP 11722A sensor module, you get all the performance of the HP 8901B or HP 8902A, plus superb power-measurement accuracy, at a single connector. You can characterize a signal with switching back and forth between the power sensor and the analyzer RF input.

Ordering Information

HP 11722A Sensor Module (100 kHz to 1300 MHz)

P1 \$2

Extend the HP 8902A to Microwave with the HP 8902S Measurement System



HP 8902S System

The HP 8902S system extends the frequency range of the HP 8902A by adding the HP 11793A microwave converter and a local oscillator. With the HP 11792A sensor module, the system delivers the accuracy and resolution of a high-performance power meter to 26.5 GHz from +30 to -100 dBm. The extended system counts signals to 26.5 GHz with 10 Hz resolution and excellent long-term frequency stability.

HP 11793A Microwave Converter

The HP 11793A microwave converter downconverts microwave signals to the frequency range of the HP 8902A measuring receiver. For signals above 1.3 GHz, the HP 11793A routes the signal through an internal mixer. Below 1.3 GHz, signals are routed directly to the input of the HP 8902A.

The HP 11793A requires +8 dBm leveled output from the local oscillator. For LOs with insufficient power above 18 GHz, the HP 11793A offers an optional 18 to 26.5 GHz amplifier.

HP 11792A Sensor Module (50 MHz to 26.5 GHz)

The HP 11792A sensor module gives you all the performance of the HP 8902S system, plus superb power-measurement accuracy, at a single connector. You can characterize a signal without manual switching between the power sensor and the receiver input.

Ordering Information

HP 8902S Measuring System

HP 11793A Microwave Downconverter

Opt 001 Add 18 to 26.5 GHz Amplifier

Opt 010 Front Right LO Input Connector

Opt 011 Amplifier and Front Right LO Connector

Opt 020 Rear Panel Connector

Opt 021 Amplifier and Rear Panel Connector

Opt 907 Front Handle Kit (5062-3988)

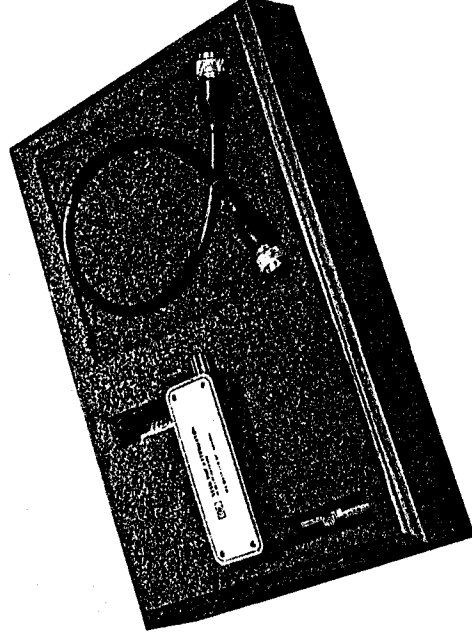
Opt 908 Rack Mount Flange Kit (5062-3974)

Opt 909 Handles w/Rack Mount Flange Kit (5062-3975)

HP 11792A Sensor Module (50 MHz to 26.5 GHz)

For complete ordering information see HP 8902S Measurement System Ordering Information guide, or call your HP sales office.

¹Each HP 11722A and HP 11792A sensor module is individually calibrated, traceable to the National Institute of Standards and Technology. The calibration factors are printed on the sensor module for fast reference. Enter these factors into the HP 8902A's non-volatile memory, and the instrument automatically compensates for the power sensor's efficiency and



HP 11812A

HP 11812A Verification Kit

The HP 11812A verification kit is available to verify the performance of the HP 8902A. Option 050 tuned RF level function to $\pm(0.015 \text{ dB} + 0.010 \text{ dB}/10 \text{ dB step})$. The kit consists of a step attenuator, two 10 dB pads semi-permanently attached, a cable, and a case.

HP 11812A Specifications

Frequency: 30 MHz

HP 11812A Accuracy: $\pm(0.003 \text{ dB} + 0.003 \text{ dB}/10 \text{ dB step})$

Option 050 Worst-Case Cumulative Tuned RF Level Accuracy Verified with the HP 11812A:

$\pm 0.010 \text{ dB}/10 \text{ dB step}$ (0 to -100 dBm)

$\pm 0.050 \text{ dB}/10 \text{ dB step}$ (-100 to -120 dBm)

$\pm 0.015 \text{ dB} \pm 1 \text{ digit}$

Ordering Information

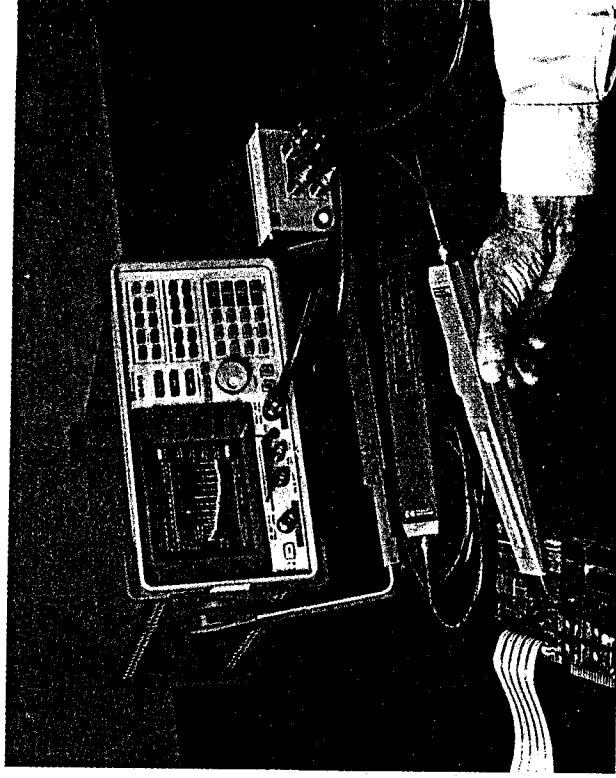
HP 11812A Verification Kit

Price
\$2,350

SIGNAL ANALYZERS

EMC Development Products and Accessories

Various Models



HP can show you how to design for electromagnetic compatibility.

HP 11950X EMC Design Course

"Designing for EMC" is a custom course for engineers who face issues of electromagnetic compatibility. Emphasis is placed on evaluating and solving EMC problems early in the design phase of a product, rather than during final EMC compliance testing. Expert instruction and many demonstrations provide EMC fundamentals, methods of measuring EMC, and principles of incorporating proven EMC design into products.

The course covers the following topics: overview of EMC design, non-conducted coupling, common impedance coupling, radiation from digital circuits, cables, advanced cables, conducted emissions, susceptibility, electrostatic discharge, shielding, and diagnostics. The 11-chapter handbook used in class becomes a permanent reference.

The HP 11950X EMC design course is offered for a fixed fee at the site of your choice. For more information, contact your local HP sales office (listed on page 654).

EMC Accessories Catalog

More complete descriptions and specifications for HP's growing line of accessories and transducers can be found in the EMC Accessories Catalog, HP literature number 5952-1791. This free catalog is available from your HP local sales office (listed on page 654).

HP 11940A and 11941A Close-Field Probes

These handheld probes are designed to measure magnetic-field radiation from surface currents, slots, cables, and ICs for EMC diagnostic and troubleshooting measurements. Their unique design results in a high level of electric-field rejection. This significantly reduces errors, thus allowing calibrated and repeatable measurements.

The HP 11941A operates from 9 kHz to 30 MHz; the HP 11940A, from 30 MHz to 1 GHz. Five antenna factors appear on each probe for calculating absolute magnetic-field strength (dB μ A/m) from the dB μ V reading of a spectrum analyzer. Each probe is calibrated and comes with a 2-meter RG-223 coaxial cable, an SMA(f)-to-type-N(m) adapter, and an SMA(f)-to-BNC(m) adapter.

HP 11945A Close-Field Probe Set

The close-field probe set includes both the HP 11940A and 11941A probes for full coverage from 9 kHz to 1 GHz. Option E51 adds the HP 8447F Option H64 dual preamplifier, a 36-in (914-mm) Type N cable, and a carrying bag for storage and protection of the entire set.

HP 11947A Transient Limiter

This limiter protects a spectrum analyzer input from damage caused by high-level transients from line impedance stabilization networks (LISNs) during EMI testing for conducted emissions. Frequency range is 9 kHz to 200 MHz and insertion loss is 10 dB. The transient limiter can withstand inputs as high as 10 kW for 10 μ s, or 2.5 W of average power. The built-in high-pass filter helps reduce 60 Hz line feedthrough that could impede conducted-emission measurements. This limiter is not required for HP 8573B and 8574B EMI receivers or other systems employing the HP 85685A RF preselector.

HP 11951A Infrared Controller

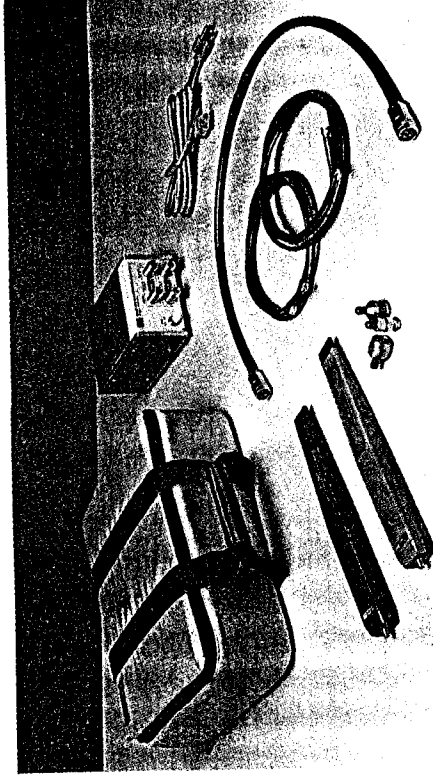
This IR controller allows an HP 8590 E-Series spectrum analyzer to be controlled remotely from up to 30 feet. It eliminates the need to leave the test chamber to make changes to the spectrum analyzer settings. The IR receiver unit connects to the keyboard input of the analyzer, and the operator activates functions using a handheld IR transmitter, which is aimed at the spectrum analyzer through a chamber window.

HP 11966 Series Antennas

These antennas are individually calibrated and shipped with a calibration certificate showing actual performance data. The series includes the following products:

HP Model

HP 11966A Active Loop H-Field Antenna	Frequency Range	10 kHz to 30 MHz
HP 11966B Active Rod E-Field Antenna		100 Hz to 50 MHz
HP 11966C Biconical Antenna		30 to 300 MHz
HP 11966D Log Periodic Antenna		200 MHz to 1 GHz
HP 11966E Double-Ridged Waveguide Horn Antenna		1 to 18 GHz
HP 11966F Conical Log Spiral Antenna		200 MHz to 1 GHz
HP 11966G Conical Log Spiral Antenna		1 to 10 GHz
HP 11966H Dipole Antenna Set		28 MHz to 1 GHz
HP 11966I Double-Ridged Waveguide Horn Antenna		200 MHz to 2 GHz
HP 11966J Double-Ridged Waveguide Horn Antenna		18 to 40 GHz
HP 11966K Magnetic Field Pickup Coil		20 Hz to 50 kHz
HP 11966L Coax Cable, Type N		10m
HP 11966M Coax Cable, BNC		10m
HP 11966N Log Periodic Antenna		200 MHz to 5 GHz



HP 11967 Series Current Probes

This series is designed for MIL-STD 461/462 conducted-emission measurements on power and interconnecting leads. Used with 10 μ F capacitors, HP p/n 0160-6683.

- HP Model**
11967A Current Probe 15 kHz to 50 MHz, dc to 60 Hz powerlines
11967B Current Probe 20 Hz to 2 MHz, dc to 400 Hz powerlines

HP 11967C Line Impedance Stabilization Network

Used for commercial, CISPR-based conducted emission measurements, this single-phase unit meets the requirements of the FCC and other conducted emission testing. Includes color-coded pin plugs instructing a power cord to connect with the LISN.

HP 11968 Series Positioning Devices

This series includes motorized and manually operated antenna masts and turntables.

- HP Model** **Description**
11968B Manually operated antenna-positioning mast
11968C Non-metallic antenna tripod; minimizes unwanted reflections in the test environment
11968E Manually operated turntable
11968G Motorized, HP-IB programmable antenna-positioning mast for use with HP 11968F controller
11968H Motorized, HP-IB programmable equipment-testing turntable for use with HP 11968F controller

HP 11968F Tower/Turntable Controller

The HP 11968F tower/turntable controller consists of a special board that plugs into the HP Vectra or an IBM-compatible PC ISA bus and a converter that interfaces with a motorized tower or turntable. Any two of these peripherals can be controlled simultaneously using the HP 85875A, 85876A, or 85877A general commercial EMI compliance software. The controller supports both types of tower and turntable designs (one- and two-cable interconnection between peripheral and controller).

11729-60014 Low-Noise Preamplifier

This amplifier provides the sensitivity needed for MIL-STD 461C CE-06 receiver/transmitter key-up testing. Frequency range is 10 Hz to 25 MHz.

HP 8447F Option H64 Dual Preamplifier

Improve receiver and spectrum analyzer sensitivity for more accurate radiated-emission measurements. This dual preamplifier is ideal for use with the HP 11940A and 11941A close-field probes to detect low-level signals from a device under test. Frequency range is 9 kHz to 5 Hz.

HP 8449B Microwave Preamplifier

This high-gain, low-noise preamplifier adds sensitivity for MIL-STD radiated measurements. Frequency range is 1 to 26.5 GHz (see page 396).

Ordering Information

- HP 11950X "Designing for EMC" Course (per site)
HP 8566B/8568B Opt 462.6 dB Bandwidths
HP 11940A Close-Field Probe, 30 MHz to 1 GHz
HP 11941A Close-Field Probe, 9 kHz to 30 MHz
HP 11945A Close-Field Probe Set, 9 kHz to 1 GHz
Opt 001 Rotary Joints
Opt 003 Delete Cables and Adapters (2 sets)
Opt E51 Add HP 8447F Option H64 Preamplifier, Carrying Bag, 36-in Type N Cable
HP 11947A Transient Limiter, 9 kHz to 200 MHz
HP 11951A Infrared Controller
HP 11966A Active Loop H-Field Antenna, 10 kHz to 30 MHz



\$510

\$940

\$2,535

\$2,225

\$1,650

\$1,920

\$3,310

\$1,975

\$1,815

\$3,850

\$6,500

\$4,500

\$670

\$245

\$215

\$3,800

\$1,250

\$1,350

\$2,880

\$19,500

\$3,075

\$775

\$12,600

\$2,000

\$4,000

\$0

\$15,000

\$7,800

\$525

\$2,790

\$7,750



Opt 222 Replace standard single cable interconnection with dual cable interconnection (for compatibility with HP 11968A tower and HP 11968D turntable)

- HP 11968G Motorized Antenna-Positioning Mast
HP 11968H Motorized Equipment-Testing Turntable
11729-60014 Low-Noise Preamplifier, 10 Hz to 25 MHz
HP 8447F Option H64 Dual Preamplifier, 9 kHz to 1.3 GHz

- HP 8449B Microwave Preamplifier, 1 to 26.5 GHz

☎ For off-the-shelf shipment, call 800-452-4844.



REXON COMPONENTS INC.24500 Highpoint Rd.
Beachwood, Ohio 44122Phone- 216-292-7373
FAX- 216-292-7714

12 July 94

Reference Rexon Quotation Number 3414

Mr. Peter Fritschel
M.I.T.

Dear Mr. Fritschel,

In reference to our conversation on 11 July 94, we are pleased to quote on your requirement for eight plastic scintillators to be used as cosmic ray shower monitors. A technical description of the detectors follows:

- 1- The plastic scintillator of choice is RP-110. Please see the attached technical data sheet for further information on this material.
- 2- The active scintillator dimensions will be 50cm X 50cm X 5.1 cm thick.
- 3- The PMT of choice is the Hamamatsu R-878 ten stage, two inch diameter, selected for high gain and low dark current.
- 4- A flange containing the PMT light shield will be center mounted to the 50 cm X 5.1cm side. The PMT will be terminated in a standard 14 pin base configuration.
- 5- The PMT will be wrapped with mu-foil in order to protect it from the effects of any stray magnetic fields.

The price for the detectors as described is \$2,213 each, for a total of \$17,704 for eight units. Delivery would be in the ten to twelve weeks ARO timeframe. Our terms are NET 30 days, FOB shipping point. REXON Components is listed as a Minority Owned Small Disadvantaged Business.

If you should have any further questions, please do not hesitate to call. We appreciate your interest in our company, and look forward to working with you.

Best Regards,
Victor G. Berner
Victor G. Berner
Senior Scientist

cc: quote file

EG46:

226: bme/v/ price: \$405

470 \$1000 : 2kV, 1ma, bin-mount

500 \$1540 3kV, 10mA, stand-alone

2,213
405

1540

$$\begin{array}{r} 2,213 \\ 405 \\ \hline \$4,158 \end{array}$$
 / detector

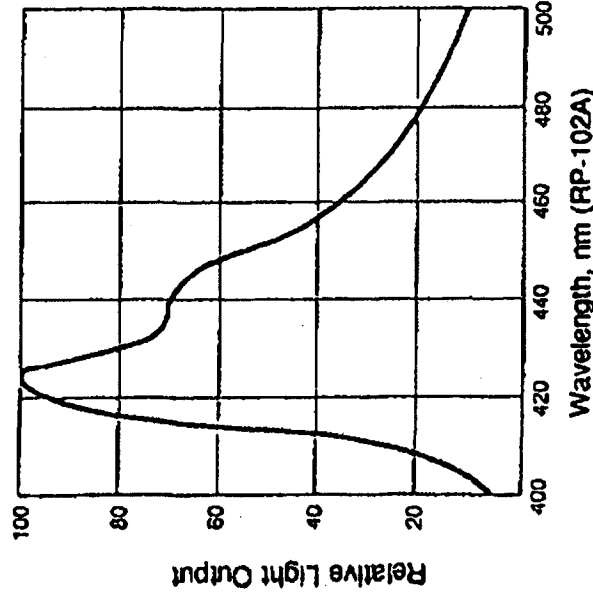
Technical Information

RAYON

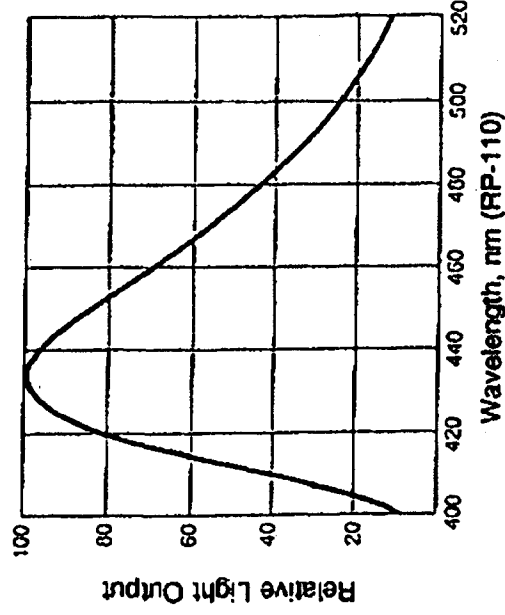
Components, Inc.

Plastic Scintillators RP-102A & RP-110

RP-102A Has an excellent balance of properties - high light output (65% of anthracene), good light transmission (2.5 meters) and a fast decay time (2.4 nsec.)



RP-110 Has an outstanding light transmission of over 4 meters with a decay time of 3.7 nsec. It is particularly suitable for larger detector applications and has long been established as the industry standard.



Physical Constants

Constants

Density	1.032	1.032
Refractive Index	1.58	1.58
Melting, Softening, Boiling Point C	75 Deg.	75 Deg.
Light Output (% Anthracene)	65	60
Rise Time ns	0.9	1.0
Decay Time ns	2.4	3.3
Wavelength of Max. Emission nm	423	434
Pulse Width FWHM ns	2.7	4.2
Light Attenuation Length cm	250	400
No. of C Atoms per cubic cm x 10E22	4.74	4.74
No. of H Atoms per cubic cm x 10 E22	5.23	5.23
Ratio H:C Atoms	1.103	1.104

RP Scintillators are identical to NE Scintillators. Rexon is a distributor of NE Technology Limited. The pioneers of Plastic Scintillators in the world.

RP-102A

RP-110

env_monitor

Tue Jul 19 14:05:25 1994

2

~~ML428B: 9 kHz - 30 MHz, \$18,100~~

~~ML518A: 25-520 MHz, \$13,025~~

~~EMI probes: MA 2601B/C (5-1000MHz/1-50MHz): \$210~~

~~MP415B Rod Antenna 9kHz-30MHz, \$2820~~

Air shower detectors:

Rexon Components, Inc.
24500 Highpoint Rd.
Beachwood, Ohio
216-292-7373

Vic Berner

Plastic scintillators w/ PMT (see data sheet): \$2,213 per unit.

eds: PMT base w/ preamp, EG&G 276: \$405

PMT bias supply, EG&G 556H: \$1540 (bench top, 3 kV, 10ma)

EG&G 478: \$1080 (mounts in NIM bin, 2kV, 1ma)

Total: \$2213 + 405 + 1540 = \$4158 / unit.



Price List

for

Nuclear Electronics

from

EG&G ORTEC

and

EG&G ORTEC/ESN

September 1987

Domestic

EG&G ORTEC/ESN Electronic Products

Model No.	Description	Module Width	Price
CCF8000	Octal Constant-Fraction Discriminator (Includes 8 of the standard 10-ns delay. Order optional delay plug-ins separately.)	CAM-1	\$3355
CCF8000 Options			
	CFD-Delay-5 ns	Delay Plug-in	40
	CFD-Delay-10 ns	Delay Plug-in	40
	CFD-Delay-30 ns	Delay Plug-in	40
	CFD-Delay-50 ns	Delay Plug-in	40
CF4000	Quad Constant-Fraction Discriminator*	NIM-1	1695
CF8000	Octal Constant-Fraction Discriminator (Includes 8 of the standard 10-ns delay. Order optional delay plug-ins separately.)*	NIM-1	2745
CF8000 Options			
	CFD-Delay-5 ns	Delay Plug-in	40
	CFD-Delay-10 ns	Delay Plug-in	40
	CFD-Delay-30 ns	Delay Plug-in	40
	CFD-Delay-50 ns	Delay Plug-in	40
CO1600	16-Channel 3-Input Overlap Coincidence*	NIM-1	1595
CO4010	4-Fold 4-Input Logic Unit*	NIM-1	1395
DL6001	Cable Delay (2.5-66 ns, Lemo connector)	NIM-1	495
DL8000	Octal Logic Delay (20-380 ns)*	NIM-1	2295
DL8010	Octal ECL Logic Delay (20-380 ns)*	NIM-1	2245
DV8000	Octal Variable Logic Delay (10-50 ns)*	NIM-1	1695
EC1600	16-Channel ECL-NIM-ECL Converter (two 2 x 17 ECL Connectors)*	NIM-1	1545
EC1601	16-Channel ECL-NIM-ECL Converter (four 2 x 8 ECL Connectors)*	NIM-1	1545
FTA410A	Quad Fast Timing Amplifier (200 gain, non-inverting)	NIM-1	845
FTA410B	Quad Fast Timing Amplifier (200 gain, inverting)	NIM-1	845
FTA410C	Quad Fast Timing Amplifier (200 gain, non-inverting)	NIM-1	845
FTA810A	Octal Fast Timing Amplifier (200 gain, non-inverting)	NIM-1	1295
FTA810B	Octal Fast Timing Amplifier (200 gain, inverting)	NIM-1	1295
FTA810C	Octal Fast Timing Amplifier (15 gain, non-inverting)	NIM-1	1295
GG8000	Octal Gate and Delay Generator*	NIM-1	2295
LA8000	Octal Level Adapter*	NIM-1	1095
LF4000	Quad Logic Fan-In/Fan-Out*	NIM-1	875
P1010	Pulse Generator*	NIM-1	2295
RD2000	Dual Fast Rate Divider*	NIM-1	1295
VT110A	Fast Timing Amplifier (200 gain, non-inverting)	PREAMP	395
VT110B	Fast Timing Amplifier (200 gain, inverting)	PREAMP	395
VT110C	Fast Timing Amplifier (15 gain, non-inverting)	PREAMP	395

VT110A/B/C Accessories

C-VT110 Power Cable Assembly for VT110A/B/C (1-m length)

60

*Requires 6 V power.

EG&G ORTEC Electronic Products

Model No.	Description	Module Width	Price
AD811	Analog-to-Digital Converter	CAM-1	\$2520
AN308/NL	Dual Mixer*	NIM-1	840
B-576	B-PAD: Preamplifier, Amplifier, Discriminator, and Bias Supply	NIM-1	**
DB463	Delay Box	RACK	970
113	Scintillation Preamplifier		225
114	Preamplifier Power Supply		565
142A	Preamplifier		665
142B	Preamplifier		665
142C	Preamplifier		665
142AG	Preamplifier		775
142AH	Preamplifier		795
142IH	Preamplifier		385
142PC	Preamplifier		665
210	Detector Control		1895
218	Magnetic Shield		155
265	Photomultiplier Base		595
266	Photomultiplier Base		190
269	Photomultiplier Base		630
276	Photomultiplier Base with Preamplifier		315
400A	Blank NIM Module	NIM-1	65
400B	Blank NIM Module	NIM-2	70
400C	Blank NIM Module	NIM-3	75
402D	Power Supply (± 6 V, ± 12 V, ± 24 V)		1105
408A	Biased Amplifier	NIM-1	595
414A	Fast Coincidence	NIM-2	800
416A	Gate and Delay Generator	NIM-1	470
418A	Universal Coincidence	NIM-1	490
419	Precision Pulse Generator	NIM-2	665
425A	Nanosecond Delay	NIM-1	365
426	Linear Gate	NIM-1	380
427A	Delay Amplifier	NIM-1	570
428	Detector Bias Supply	NIM-2	785
436	100-MHz Discriminator	NIM-1	995
439	Digital Current Integrator	NIM-3	1950
444	Gated Biased Amplifier	NIM-2	1550
448	Research Pulser	NIM-3	3095
449	Log/Lin Ratemeter	NIM-2	850
449-2	Log/Lin Ratemeter (with audible output option)	NIM-2	925
450	Research Amplifier	NIM-3	2530
457	Biased Time-to-Amplitude Converter	NIM-2	1790
458	Pulse Shape Analyzer	NIM-2	2140

*Requires 6 V power.

**See Detector Price List.

EG&G ORTEC Electronic Products (continued)

Model No.	Description	Module Width	Price
459	5-kV Detector Bias Supply	NIM-1	\$ 690
460	Delay Line Amplifier (with standard 1- μ s delay lines)	NIM-1	865
	Delay Line Amplifier (with special 1/4-, 1/2-, or 2- μ s delay lines)	NIM-1	†
461	Alarm Control	NIM-1	690
462	Time Calibrator	NIM-2	1525
464	Position-Sensitive Detector Analyzer	NIM-1	1690
473A	Constant-Fraction Discriminator	NIM-1	1025
474	Timing Filter Amplifier	NIM-1	785
476-4	Multiplexer/Router (4 input channels)	NIM-2	1165
476-8	Multiplexer/Router (8 input channels)	NIM-2	1830
476-16	Multiplexer/Router (16 input channels)	NIM-2	2265
478	2-kV Bias Voltage Supply	NIM-1	740
480	Pulser	NIM-1	385
495	Power Supply (6 V)	NIM-1	615
533	Dual Sum and Invert Amplifier	NIM-1	325
535	Quad Fast Amplifier	NIM-1	1185
541	Rate-meter (linear)	NIM-1	510
542	Linear Gate and Stretcher	NIM-1	645
550	Single-Channel Analyzer	NIM-1	395
551	Timing Single-Channel Analyzer	NIM-1	675
552	Pulse-Shape Analyzer/Timing SCA	NIM-1	1075
553	Timing Single-Channel Analyzer	NIM-1	595
556	High Voltage Power Supply (3 kV)	NIM-2	995
556H	High Voltage Power Supply (3 kV)		1185
566	Time-to-Amplitude Converter	NIM-1	895
567	Time-to-Amplitude Converter/SCA	NIM-2	1165
570	Amplifier (spectroscopy)	NIM-1	750
571	Amplifier (spectroscopy)	NIM-1	1085
572	Amplifier (spectroscopy)	NIM-1	1260
574	Timing Amplifier	NIM-1	900
575A	Amplifier (spectroscopy)	NIM-1	525
576A-xxxx	Alpha Spectrometer	NIM-2	**
579	Fast-Filter Amplifier	NIM-1	1405
583	Constant-Fraction Differential Discriminator/SCA	NIM-1	1540
584	Constant-Fraction Discriminator	NIM-1	855
590A	Amplifier and Timing SCA	NIM-1	840
673	Spectroscopy Amplifier and Gated Integrator	NIM-2	1645
676	ALPHA-KING™ Single Channel Alpha Spectrometer	NIM-2	**
719	Timer (non-printing)	NIM-1	415
729A	Liquid Nitrogen Level Monitor	NIM-1	**

*Requires 6 V power.

**See Detector Price List.

†Contact factory for price.

EG&G ORTEC Electronic Products (continued)

Model No.	Description	Module Width	Price
770	Counter (See 77X- for options)	NIM-2	\$ 830
771	Timer-Counter (See 77X- for options)	NIM-2	1130
772	Counter	NIM-1	765
773	Timer-Counter	NIM-1	915
776	Counter and Timer	NIM-2	1130
777A	Line Printer	NIM-3	1620
777A Accessories			
777A-P1	Electrosensitive Printer Paper for 777A; Box of 25 rolls		80
777A-P2	Electrosensitive Printer Paper for 777A; Box of 5 Rolls		20
778	Dual Counter	NIM-2	1055
770 Series Options			
77X-01	Buffer Memory (for 770 and 771)		265
77X-02	Parallel Data Output (for 770 and 771)		255
77X-03	Parallel Data Output (for 770 and 771 to drive the 9325 DAC)		335
785	Automatic Liquid Nitrogen Fill Controller	NIM-1	**
786	Automatic Liquid Nitrogen Fill Expansion Control	NIM-1	**
800	Analog-to-Digital Converter*	NIM-2	2135
850	Quad Single-Channel Analyzer	NIM-1	1080
855	Dual Amplifier (spectroscopy)	NIM-1	955
863	Quad Timing Filter Amplifier	NIM-1	1895
871	Timer and Counter (non-printing)	NIM-2	875
872	Quad Counter/Timer (non-printing)	NIM-2	1600
875	Counter (non-printing)	NIM-1	475
878	Counter and Timer (20-mA serial output)	NIM-2	1300
879	Buffered Interface	NIM-2	1195
903	Geiger-Mueller Tube		230
904	Proportional Detector		850
905-1	NaI Scintillation Detector, 1- by 1-in. crystal, 2-in. PM tube		450
905-2	NaI Scintillation Detector, 1.5- by 1.5-in. crystal, 2-in. PM tube		540
905-3	NaI Scintillation Detector, 2- by 2-in. crystal, 2-in. PM tube		585
905-3W	NaI Scintillation Detector, 2- by 2-in. crystal with well, 2-in. PM tube		655
905-4	NaI Scintillation Detector, 3- by 3-in. crystal, 3-in. PM tube		1430
905-4W	NaI Scintillation Detector, 3- by 3-in. crystal with well, 3-in. PM tube		1590
905-5	BC418 Plastic Scintillator Detector, 1- by 1-in. right circular cylinder scintillator with RCA 6342A (or equivalent) PM tube		†
905-11	BC418 Plastic Scintillator Detector, 12.9 cm ³ truncated cone scintillator with RCA 8575 PM tube		†
906	Geiger-Mueller Pulse Inverter		160
909A	Bin Cover		395
917	ADCAM® CCNIM™ Multichannel Buffer* with 4K ADC and memory	NIM-2	††
918A	ADCAM® CCNIM™ Multichannel Buffer* with 8K ADC and memory	NIM-2	††

*Requires 6 V power.

**See Detector Price List.

†Contact factory for current prices.

††See Systems Price List.

EG&G ORTEC Electronic Products (continued)

Model No.	Description	Module Width	Price
934	Quad Constant-Fraction Discriminator*	NIM-1	\$1805
972	CCNIM™ Amplifier*	NIM-2	2975
974	CCNIM™ Quad 100-MHz Counter/Timer*	NIM-2	2470
980	CCNIM™ General Purpose Interface/Controller (GP I/C)* (See 980 Options)	NIM-2	1725
980-1	980 (with ADC option installed)*	NIM-2	2890
980-2	980 (with ADC and Dual-port Memory options installed)*	NIM-2	3750
980 Options			
980-C6	980 Relay Output Cable (5-m length)		120
A81-BI	MCA Emulation Software Package [for use of the 980-2 with the IBM® PC (consult the factory for hardware requirements)]		750
990	Digital Spectrum Stabilizer*	NIM-1	††
994	CCNIM™ Dual Counter and Timer (See 99X- options)	NIM-2	995
995	CCNIM™ Dual Counter (See 99X- options)	NIM-2	815
994 and 995 Options			
99X-1	RS-232-C Interface Option (Requires C-75 Cable)		385
99X-2	IEEE-488 Interface Option (Requires C-488-1 or C-488-4 Cable)		360
99X-3	Print Loop Interface Option		295
99X-4	Internal +6-V Supply Option		125
C-75	RS-232-C Null Modem Cable, female-to-female (3-m length)		55
C-80	RS-232-C Extension Cable, male-to-female (3-m length)		55
C-488-1	IEEE-488 Interface Cable (1-m length)		140
C-488-4	IEEE-488 Interface Cable (4-m length)		165
4001A	NIM Bin		495
4001A/ 402D	NIM Bin and Power Supply (±6 V, ±12 V, ±24 V)		1495
4001A/ 4002A	NIM Bin and Power Supply (±12 V, ±24 V)		935
4001C	NIM Bin (with copper bus bars)		590
4001C/ 402D	NIM Bin and Power Supply (±6 V, ±12 V, ±24 V)		1595
4001C/ 4002A	NIM Bin and Power Supply (±12 V, ±24 V)		1030
4001M	Minibin and Power Supply		895
4001M Options:			
OPT-1-S	Handle		60
OPT-2-S	Cover		115
OPT-1-S + OPT-2-S	Handle with Cover		125
4002A	Power Supply for NIM Bin (±12 V, ±24 V)		595

*Requires 6 V power.

††See Systems Price List.

EG&G ORTEC Electronic Products (continued)

Model No.	Description	Module Width	Price
4890	Preamplifier/Amplifier/SCA		
9201	Photomultiplier Housing	NIM-1	\$ 910
9301	Fast Preamplifier		910
9302	Amplifier and Discriminator		295
9305	Fast Preamplifier	NIM-1	1160
9310	Dual \div 10 Prescaler		450
9315	Photon Counter	NIM-1	755
9320	Sampling/Control Unit	NIM-3	3485
9325	Digital-to-Analog Converter	NIM-3	4960
9349	Log/Lin Ratemeter	NIM-1	955
		NIM-2	1200

Cables, Connectors and Accessories

AX10	Impedance Adapter		\$ 70
BL050	BNC/LEMO Adapter with male BNC and female LEMO		15
C-13	BNC to Microdot Vacuum Feedthrough with female BNC and female microdot		30
C-16	Microdot to BNC Adapter with male microdot and female BNC		40
C-17	BNC to Microdot Adapter with male BNC and female Microdot		60
C-18-0	Microdot 100- Ω miniature cable with two Microdot male plugs; 2-in. length		45
C-18-2	Same as above; 2-ft length		50
C-19-2	Microdot 100- Ω miniature cable with one BNC male plug and one Microdot male plug; 2-ft length		75
C-21	Microdot 293-3913 Miniature 100- Ω Cable; specify length		\$10+
C-22	Microdot Male Plug for Miniature 100- Ω cable		\$1.00/ft
C-23	Assembly Tool for C-21 and C-22, Microdot T32-11		10
C-24-1/2	RG-62A/U 93- Ω Cable with two BNC Male Plugs, 6-in. length		80
C-24-1	Same as above, 1-ft length		15
C-24-2	Same as above, 2-ft length		15
C-24-4	Same as above, 4-ft length		15
C-24-8	Same as above, 8-ft length		15
C-24-12	Same as above, 12-ft length		15
C-25-1/2	RG-58A/U 50- Ω Cable with two BNC Male Plugs, 6-in. length		15
C-25-1	Same as above, 1-ft length		15
C-25-2	Same as above, 2-ft length		15
C-25-4	Same as above, 4-ft length		15
C-25-8	Same as above, 8-ft length		15
C-25-12	Same as above, 12-ft length		15
C-27	Terminator, 100 Ω , BNC Male Plug		15
C-28	Terminator, 50 Ω , BNC Male Plug		15
			20

Cables, Connectors and Accessories (continued)

Model No.	Description	Price
C-29	BNC Tee Connector	\$ 12
C-30	BNC to Microdot Adapter with male BNC and female Microdot	10
C-31	BNC to Microdot Adapter with male BNC and male Microdot	70
C-34-12	RG-59A/U 75-Ω Cable with one SHV Female Plug and one MHV Male Plug, 12-ft length	40
C-36-12	RG-59A/U 75-Ω Cable with two SHV Female Plugs, 12-ft length	45
C-37	SHV Female Plug	20
C-38	SHV Male Bulkhead Jack	12
C-46	SHV Tee Connector	65
C-75	RS-232-C Null Modem Cable, female-to-female (3-m length)	55
C-80	RS-232-C Extension Cable, male-to-female (3-m length)	55
C-488-1	IEEE-488 Interface Cable (1-m length)	140
C-488-4	IEEE-488 Interface Cable (4-m length)	165
EX100/N	Module Extender	375
IT100	Inverting Transformer	35
LB050	LEMO/BNC Adapter with male LEMO and female BNC	15
LL174-0	RG-174 50-Ω Cable with two LEMO Male Plugs, 0.1-m length	45
LL174-1	Same as above, 0.25-m length	45
LL174-2	Same as above, 0.5-m length	50
LL174-3	Same as above, 1-m length	50
LL174-4	Same as above, 2-m length	55
LT050	50-Ω Terminator, LEMO	20
M127/N-1	NIMFAN®, 117 V ac	465
MT050	50-Ω Matched Tee Signal Splitter	40
T50	50-Ω Terminator, BNC	50
TA050	Tee Adapter, LEMO	40
TF50	50-Ω Feedthrough Terminator, BNC	35
121-C1	Preamplifier Power Cable Extender, 10-ft length	55
400-1B	Blank Panel, single-width NIM	20
400-2B	Blank Panel, double-width NIM	25
400-3B	Blank Panel, triple-width NIM	35
400-4B	Blank Panel, quadruple-width NIM	40
401-C3	Module Extender Cable, 3-ft length	130
430-C1	Print Loop Cable for 770, 771, 777A, and 779; 18-in. length with a connector on each end to plug into the specified models	55
432-C1	Print Loop Cable for 770, 771, 777A, and 779; 36-in. length with a connector on each end to plug into the specified models	60
772-C1	Print Loop Cable for 772, 773, 776, 778, 994, and 995. Consists of an adapter block that plugs into the IN/OUT connector on specified models and provides the IN connector, plus a 12-in. cable with the OUT connector on the end	165
777A-P1	Electrosensitive Printer Paper for 777A; box of 25 rolls	80
777A-P2	Electrosensitive Printer Paper for 777A; box of 5 rolls	20

Special Cables

The following custom-built cables can be ordered by specifying the desired length in feet in place of an X in the model number. For example, to order a 25-ft-long C-18-X-S cable, specify C-18-25-S on the order.

Model No.	Description	Price
C-18-X-S	Microdot 100-Ω Miniature Cable with two Microdot Male Plugs	\$55+ \$1.20/ft
C-19-X-S	Microdot 100-Ω Miniature Cable with one Microdot Male Plug and one BNC Male Plug	\$95+ \$1.20/ft
C-24-X-S	RG-62A/U 93-Ω Cable with two BNC Male Plugs	\$40+ \$0.20/ft
C-25-X-S	RG-58A/U 50-Ω Cable with two BNC Male Plugs	\$40+ \$0.20/ft
C-34-X-S	RG-59A/U 75-Ω Cable with one SHV Female Plug and one MHV Male Plug	\$70+ \$0.20/ft
C-36-X-S	RG-59A/U 75-Ω Cable with two SHV Female Plugs	\$70+ \$0.20/ft
C-43-X-S	RG-59A/U 75-Ω Cable with one SHV Female Plug and one open end	\$55+ \$0.20/ft
C-45-X-S	RG-62A/U 93-Ω Cable with one SHV Male Plug and one BNC Male Plug; mates 807 Vacuum Chamber to 142AH, 142IH, and 142PC preamplifiers	\$65+ \$0.20/ft
121-C1-X-S	Preamplifier Power Cable Extender	\$75+ \$1.00/ft
401-C3-X-S	Module Extender Cable	\$130+ \$1.00/ft
401-C4-X-S	PG-12 to PG-14 Slave Bin Power Cable	\$125+ \$3.00/ft
401-C5-X-S	PG-13 to PG-14 Cable to remote bin from power supply	\$115+ \$7.00/ft
430-C1-X-S	See 432-C1-X-S	\$60+ \$1.00/ft
432-C1-X-S	Print Loop Cable for 770, 771, 777A, and 779; length = X ft, with a connector on each end to plug into the specified models	
772-C1-X-S	Print Loop Cable for 772, 773, 776, 778, 994, and 995; consists of an adapter block that plugs into the IN/OUT connector on specified models and provides the IN connector, plus a cable having a length of X feet with the OUT connector on the end	\$165+ \$1.00/ft

Prices

All prices listed herein are in U.S. currency, f.o.b. Oak Ridge, Tennessee U.S.A. These prices apply only to the U.S.A. and are subject to change without notice. Prices listed do not include shipping or local taxes. **Minimum Order: \$50.00. Payment Terms: 1/2% 10 days; net 30 days.**

Ordering Address

For the proper ordering address see the back cover of this price list.

Shipping Methods

We normally ship by UPS, air post, or air freight. Other shipping methods will be followed at your request.

Return/Restocking Charges

A restocking fee of 15% of the listed price will be charged for unused items returned to EG&G ORTEC within 30 days of the shipment date. EG&G ORTEC subjects all returned products to rigorous inspection and the full quality control tests performed on new instruments. The instrument is returned to stock in new product condition. The restocking fee is necessary to cover this extra cost. **Specially modified products cannot be accepted for restocking.**

The restocking fee does not apply if EG&G ORTEC determines that the return is necessary because of an error on the part of EG&G ORTEC. **Neither unused items returned after 30 days nor used items will be accepted for restocking.**

Quality Control

Before being approved for shipment, each EG&G ORTEC nuclear electronics instrument must pass a stringent set of quality control tests designed to expose any flaws in materials or workmanship. Permanent records of these tests are maintained for use in warranty repair and as a source of statistical information for design improvements.

2-YEAR WARRANTY

Because of exceptional quality in product design and manufacturing, EG&G ORTEC offers an unparalleled **2-year** limited warranty on all electronic products that are manufactured by EG&G ORTEC or its subsidiaries and priced in this listing. An explicit warranty statement is provided in the instruction manual supplied with each instrument. On products manufactured by a different company and distributed by EG&G ORTEC, the warranty of the original manufacturer applies.

Repair Service

If it becomes necessary to return this instrument for repair, it is essential that Customer Services be contacted in advance of its return so that a Return Authorization Number can be assigned to the unit. Also, EG&G ORTEC must be informed, either in writing, by telephone (615-482-4411) or by telex 499-3119 EGG OKRE UI, of the nature of the fault in the instrument being returned and of the model, serial, and revision ("Rev" on rear panel) numbers. Failure to do so may cause unnecessary delays in getting the unit repaired.

The EG&G ORTEC standard procedure requires that instruments returned for repair pass the same quality control tests that are used for new-production instruments.

Instruments that are returned should be packed so that they will withstand normal transit handling and must be shipped PREPAID via United Parcel Service, air parcel post, or air freight to the nearest EG&G ORTEC repair center. The address label and the package must include the Return Authorization Number assigned.

EG&G ORTEC will pay shipment costs both ways if the instrument does not function at the time of purchase. Instruments being returned that are damaged in transit due to inadequate packing will be repaired at the sender's expense, and it will be the sender's responsibility to make claim with the shipper. Instruments not in warranty will be repaired at the standard charge unless they have been grossly misused or mishandled, in which case the user will be notified prior to the repair being done. A quotation will be sent with the notification.

Damage In Transit

Shipments should be examined immediately upon receipt for evidence of external or concealed damage. The carrier making delivery should be notified immediately of any such damage, since the carrier is normally liable for damage in shipment. Packing materials, waybills, and other such documentation should be preserved in order to establish claims. After such notification to the carrier, please notify EG&G ORTEC of the circumstances so that assistance can be provided in making damage claims and in providing replacement equipment if necessary.



... a company its people are proud of. Born at the very beginning of the commercial nuclear age, EG&G ORTEC today stands second to none as a developer and supplier of nuclear radiation detectors and associated electronic processing equipment. Its products, ranging from discrete nuclear instrumentation modules to complete, highly sophisticated systems, are found in advanced government and industrial laboratories as well as in remote geophysical exploration sites throughout the world. Not the least of the reasons for this exceptional acceptance of EG&G ORTEC and its products is the dedication and advanced professional skills of its people — scientists, engineers, and technicians who are proud of their purpose and its achievement: to build the finest instruments possible. This dedication has led to substantial growth throughout the company's history. Beginning in the late 1950s with a handful of scientific employees, the company now has subsidiaries in Great Britain, Netherlands, France, West Germany, Italy, Canada, and Japan. As a division of EG&G, it is part of a "FORTUNE 500" scientific company with over \$1 Billion in sales and over 23,000 employees.

If you require more complete product information, such as specifications or performance data, ask for our Full-Line Catalog or individual data sheets. For answers to any nuclear instrumentation need, all EG&G ORTEC resources are at your service. Simply contact your nearest EG&G ORTEC representative — solving your problems is what our business is all about.

United States:

EG&G ORTEC
100 Midland Road
Oak Ridge, TN 37831-0895 U.S.A.
Telephone: (615) 482-4411
Telex: 499-3119 EGG OKRE UI

Canada:

EG&G Instruments Division
EG&G Canada, Ltd.
205 Riviera Drive, Suite 5
Markham, Ontario L3R 2L6
Telephone: (416) 475-8420
Telex: 6966615 EGGI CAN MKHM

W. Germany:

EG&G GmbH
Hohenlindener Str. 12
D-8000 Munich 80
Telephone: 089-926920
Telex: 528257 EGGI D

United Kingdom:

EG&G Instruments, Ltd.
Doncastle House, Doncastle Road
Bracknell, Berks RG12 4PG
Telephone: 0344-423931
Telex: 847164 EGGBDL G

Italy:

EG&G Instruments s.r.l.
Via Monte Suello 9, 20133 Milan
Telephone: 02-7610267
Telex: 320377 EGG SRL I

France:

EG&G Instruments SARL
Z.I. Petite Montagne Nord
2 Place De La Vanolise, C.E. 1439
91020 Evry Cedex
Telephone: 01-60.77.93.66
Telex: 690785 EGG SARL F

The Netherlands:

EG&G Instruments B.V.
P.O. Box 86, 3430 AB Nieuwegein
Telephone: 030-887520
Telex: 40830 EGG BV NL

Japan:

SEIKO EG&G Co., Ltd.
31-1, Kameldo, 6-Chome
Koto-Ku, Tokyo, 136
Telephone: 03-638-1506
Telex: 02622232 ESEIKO J

People's Republic of China:

EG&G China Representative Office
Room 1000, Xuanwumen Hotel
Xuanwumen, Beijing
Telephone: 342855
Telex: 22737 EGG BJ CN

Other Representatives Worldwide.

HOT LINE

(800) 251-9750

Photomultiplier Base with Preamp

- Built-in low-noise preamplifier
- Both preamplifier output and anode output
- Test input for system testing
- Protection circuit for internal transistors
- Internal gain adjustment

The EG&G ORTEC 276 Photomultiplier Tube Base and Preamplifier incorporates an integral low-noise preamplifier, a photomultiplier tube base with voltage divider network, and a focus control for optimum performance in scintillation detector applications. The unit provides two outputs: the preamplifier output for energy analysis and the anode output for either timing or auxiliary energy analysis. The preamplifier is dc-coupled to simplify pole-zero cancellation in the main amplifier. A Test input accepts the output of a pulse generator to calibrate and test the preamplifier and the following system.

The 276 has a diode protection network to prevent damage to the internal transistors due to sudden application or removal of high voltage to the unit. A simple internal modification in the unit allows the gain to be adjusted for any value desired by the user. The 276 is powered from any EG&G ORTEC main amplifier or preamplifier power supply.

The 276 is directly compatible with all of the following photomultiplier tubes:

RCA: 4518, 5819, 6217, 6342A, 6655A, 7326, 8053, 8054, and 8055.

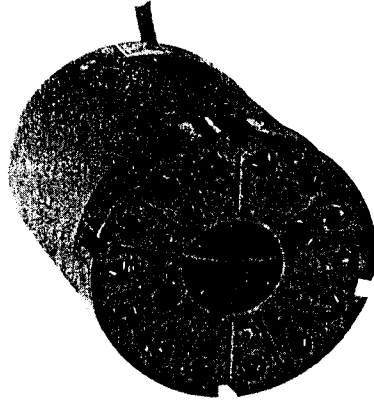
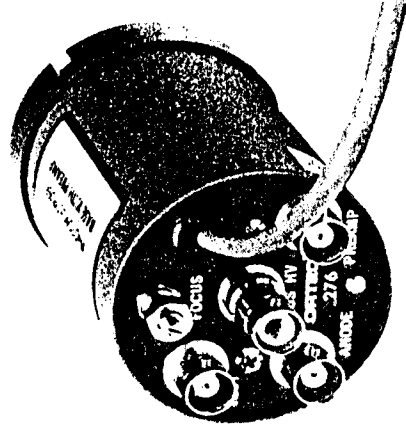
EMI: 9536 Series, 9578 Series, 9579 Series, and 9708 Series.

Phillips: XP-1000 to 1005 and XP-1031 to 1033.

CBS: 7817, 7818, 7819, and CL-1004 to 1012.

Dumont: 6292, 6363, and 6364.

The 276 is also compatible with other 10-stage tubes not listed above. Compatibility may be determined by comparison with those listed.



Specifications

PERFORMANCE

INTEGRAL NONLINEARITY $< \pm 0.02\%$, 0 to +10 V.
TEMPERATURE INSTABILITY $< \pm 0.005\%$ °C, 0 to 50°C.
OUTPUT RISE TIME < 100 ns for test input or fast scintillator.

OUTPUT FALL TIME Time constant of 50 μ s.

OUTPUT NOISE < 50 μ V rms with EG&G ORTEC 572 Amplifier and time constant of 1 μ s.

CONVERSION GAIN Nominally 5 μ V/eV with 2-by 2-in. NaI(Tl) crystal and PMT gain of 10^6 ; the typical output for a 511-keV γ ray with a 10-stage PMT will be ~ 250 mV.

SATURATION LEVEL +10 V into an open circuit; +5 V into 93- Ω load.

VOLTAGE DIVIDER Resistor-divider connected to 10-stage PMT base. Total resistance 1.49 M Ω , resulting in bleeder current of 0.6 mA with typical high voltage of 1 kV. The distribution is linear to all stages with the focus adjustment on the grid.

CONTROL

FOCUS Single-turn locking potentiometer on panel for external adjustment of photomultiplier tube grid potential.

INPUTS

POS HV SHV connector, AMP 51494-2, for distribution of positive high voltage to photomultiplier tube base: +2000 V maximum.

TEST BNC connector, UG-1094/U, accepts pulses from an EG&G ORTEC pulse generator for testing and calibration.

SIGNAL Preamplifier input is connected internally to dynode 10.

POWER Captive 3 m (10 ft) power cable terminated in Amphenol 17-20090 connector accepts preamplifier operating power, compatible with all EG&G ORTEC main amplifiers and the 114 Preamplifier Power Supplies.

PM SOCKET JEDEC B14-38, Amphenol 417.

OUTPUTS

PREAMP BNC connector, UG-1094/U, furnishes preamplifier positive output pulse to an EG&G ORTEC main shaping amplifier for linear energy analysis; $Z_0 = 93 \Omega$, dc-coupled.

ANODE BNC connector, UG-1094/U, furnishes negative anode output pulse for use either in timing or auxiliary energy analysis; $Z_0 = 1$ k Ω , ac-coupled.

ELECTRICAL AND MECHANICAL

POWER REQUIRED For preamplifier +24 V, 16 mA; -24 V, 16 mA; for PMT base +2000 V maximum (use rated voltage for tube that is installed).

WEIGHT

Net 0.65 kg (1.5 lb).

Shipping 1.3 kg (3.0 lb).

DIMENSIONS 5.58 cm (2.2 in.) diam x 10 cm (4 in.) long plus 3 m (10 ft) captive power cable.

Preamplifiers

Contents

Introduction	4-21
Preamplifier Types	4-21
Preamplifier Applications Guide	4-23
Preamplifier Selection Chart	4-24
113 Scintillation Preamplifier	4-25
142A/B/C Preamplifiers	4-26
142AG Preamplifier	4-28
142AH Preamplifier	4-29
142IH Preamplifier	4-31
142PC Preamplifier	4-32
4890 Preamplifier/Amplifier/SCA	4-33

Introduction

A preamplifier is specifically designed to accept the signal from a detector with minimum shaping in order to preserve the maximum signal-to-noise ratio. The configuration of the preamplifier and the characteristics of the detector being used, and in some cases, the type of signal processing that follows the preamplifier.

Types of detectors most frequently used in nuclear physics are germanium planar, silicon planar, germanium silicon charged-particle, scintillator-photomultiplier, and gas proportional counter.

ORTEC manufactures a preamplifier to fit your detector for your application, and your budget. Consult the selection chart at the end of this section.

PREAMPLIFIER TYPES

There are three basic types of preamplifiers that are normally used: voltage sensitive, current sensitive, and charge sensitive.

VOLTAGE SENSITIVE PREAMPLIFIERS

Voltage sensitive preamplifiers are not widely used for spectroscopy applications since gain is dependent on detector capacitance. Detector capacitance does not remain constant when the detector voltage and other parameters change. Therefore the stability of the voltage sensitive preamplifier results in unacceptable line broadening for spectroscopy.

CURRENT SENSITIVE PREAMPLIFIERS

Current sensitive preamplifiers are amplifying instruments with relatively low input impedances designed to convert fast current pulses such as those originating at the anode of a photomultiplier to a voltage pulse. The output of the current preamplifier can drive several feet of coaxial cable to deliver the pulse to a fast amplifier with minimum distortion. The EG&G ORTEC 9301 is a current preamplifier with 50- Ω input impedance with a gain expressed as

$$\frac{E_{out}}{I_{in}} = 50 \times 10 = 500 \text{ mV/mA.} \quad (1)$$

CHARGE SENSITIVE PREAMPLIFIERS

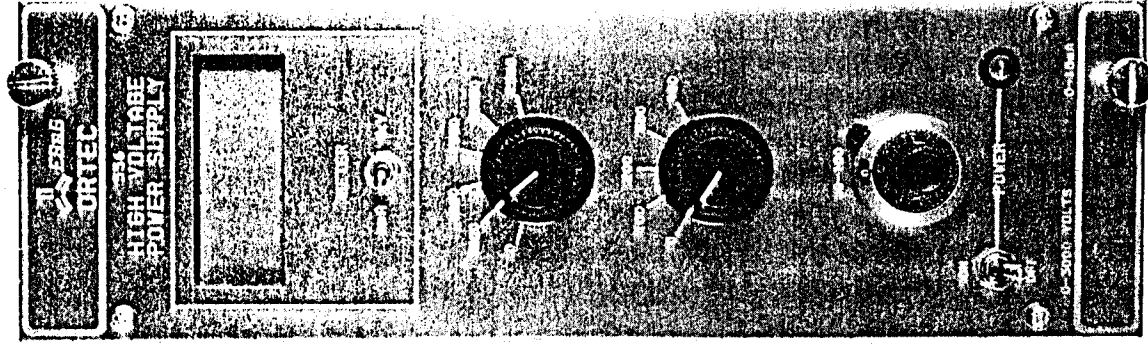
Charge sensitive preamplifiers are preferred for most spectroscopy applications. The signal from a semiconductor detector or ion chamber is a quantity of charge amounting to a current pulse lasting from 10^{-9} to 10^{-5} s, depending on the type detector and its size. For most applications the quantity of charge and/or the time of occurrence of an event are the parameters of interest. A charge sensitive preamplifier can measure either or both parameters since it integrates the charge on the feedback capacitor; its gain is not sensitive to a change in detector capacitance, and the rise time of the output pulse is equal to the detector current pulse width in the ideal case. The output voltage from the preamplifier has an amplitude, V_o , and a decay time constant, τ , given respectively by

$$V_o = \frac{Q_b}{C_f} \text{ and } \tau = R_f C_f \quad (2)$$

where Q_b is the charge released by the detector, C_f is the feedback capacitor (0.1 to 5 pF), and R_f is the feedback resistor. R_f is a noise source and is made as large as possible consistent with the signal energy-rate product and the detector leakage current in the direct-coupled system. The preamplifier package is kept small to permit mounting it as close as practical to the detector, thus reducing input capacitance caused by cabling and decreasing microphonic noise. Ground

556/556H High Voltage Power Supplies

- Low-noise output ± 10 to 3000 V, 0 to 10 mA
- Digital meter reads output voltage or current
- Output controllable over full range by an external 0 to ± 6.9 V input
- 115 or 230 V ac input power
- Overload and short circuit protected



The 556 and 556H High Voltage Power Supplies, designed and fabricated at EG&G ORTEC, supply the noise-free, well-regulated, very stable high voltage necessary for proper operation of photomultipliers, ionization chambers, semiconductor detectors, electron multipliers, and many other devices. The 556 is housed in a double-width NIM module [per TID-20893 (Rev)]. The 556H is a stand-alone instrument designed for bench-top operation. The low-noise output is continuously adjustable from ± 10 to 3000 V dc with 0 to 10 mA load current. Noise on the output is < 10 mV peak-to-peak, thereby ensuring the highest performance in high-resolution, semiconductor or scintillation spectroscopy systems.

The front panel digital meter allows visual monitoring of either the output voltage or the output current.

The output voltage can be controlled from ± 10 to 3000 V by application of an external input voltage of 0 to 6.9 V dc. This feature is desirable for control applications and is standard on all units.

The input power for the 556 and 556H is taken directly from the ac line, either 115 or 230 V ac, 47 to 63 Hz.

Overload and short-circuit protection networks permit operation into short circuits without damage to the instrument.

Specifications

PERFORMANCE

OUTPUT POLARITY Positive or negative, selected by switch on rear panel.

OUTPUT RANGE 50 to 3000 V; minimum usable voltage 10 V.

OUTPUT LOAD CAPACITY 0 to 10 mA.

REGULATION $\leq 0.0025\%$ variation in output voltage for combined line and load variations within operating range at constant ambient temperature.

TEMPERATURE INSTABILITY $\leq \pm 50$ ppm/°C after 30 minute warmup; operating range 0 to 50° C.

LONG-TERM DRIFT $< 0.01\%$ /hour and $< 0.03\%$ /24-hour variation in output voltage at constant input line voltage, load, and ambient temperature after 30-minute warmup.

OUTPUT RIPPLE < 10 mV peak-to-peak, 20 Hz to 20 MHz.

OVERLOAD PROTECTION Internal circuitry protects against overloads including short circuits. Maximum overload current is ~ 16 mA.

RESETTABLE Output voltage can be reset to within 0.1%.

CONTROLS

POWER Front-panel toggle switch energizes unit when power cord is connected to appropriate source, and an adjacent red LED lamp indicates when power is applied.

OUTPUT LEVEL One 6-position switch, one 5-position switch, and one 10-turn precision potentiometer; output level is the sum of the 3 settings $\pm 0.25\%$.

METER Front-panel toggle switch selects display of output voltage in kV or load current in mA.

POLARITY Rear-panel switch selects either positive or negative output polarity.

CONTROL Rear-panel locking toggle switch selects the reference source for the output voltage.

Int Selects the internal reference source; the front-panel controls select the output amplitude.

Ext Selects the external reference source; output voltage is proportional to magnitude of reference input.

AC VOLTAGE Rear-panel slide switch selects either 115 V or 230 V ac-input voltage.

584 Constant-Fraction Discriminator

The unique design of the EG&G ORTEC 584 Constant-Fraction Discriminator allows excellent time resolution to be obtained from all commonly used detectors such as HPGe, surface barrier, fast plastic, NaI(Tl), and photomultiplier tubes. Three timing modes are provided in the 584: constant fraction, constant fraction with slow rise time reject, and leading edge. This economical unit has a minimum threshold of -5 mV allowing excellent timing measurements to very low energies. The maximum input signal acceptable without saturation is -5 V which provides a 1000:1 input dynamic range. The 584 is useful in high count rate applications to 50 MHz with ≤ 20 ns pulse-pair resolving time. The time walk of the 584 is ≤ 100 ps for a 100:1 input dynamic range and ≤ 150 ps for a 200:1 input dynamic range. The excellent timing resolution versus dynamic range is shown in Fig. 1.

A variety of controls are provided allowing a precision 10-turn potentiometer sets the threshold from -5 mV to -1 V. The Blocking Time and Blocking Output Width are continuously adjustable from ≤ 10 ns to ≥ 1000 ns. A front panel LED indicates that the discriminator has been triggered and can therefore be used to set the threshold just above the noise. Walk is adjusted by a front panel 20-turn potentiometer. The Constant Fraction Monitor on the front panel can be used to optimize walk adjustment. Since the constant-fraction shaping delay is selected by external cable, the optimum delay for a specific detector application is easily selected.

Four NIM-standard output signals are available from the 584. The positive output signal is continuously variable from ≤ 0.5 μ s to ≥ 2.5 μ s by means of a printed wiring board (PWB) potentiometer. The polarity of the positive output is PWB selectable to be either a NIM-standard positive output signal or the complement signal. The two timing output signals are NIM-standard fast negative logic signals, each having a 2 ns rise and a 5 ns width FWHM. The block output signal is a NIM-standard fast negative logic signal whose width is adjustable from ≤ 10 ns to ≥ 1000 ns.

The 584 can be gated externally. A rear panel locking toggle switch selects either Gated or Ungated operation. In the Gated Mode, a printed wiring board jumper selects the Bin Gate line in the NIM bin, a NIM-standard positive signal via the rear panel BNC connector, or a NIM-standard negative signal via the rear panel BNC connector.

Logic current for the 584 is selected from either the -6 V or -12 V NIM supply by means of a rear panel locking toggle switch. The 584 is within the allotment of current for a single-width NIM module for a NIM Class V power supply when the logic current is obtained from the -6 V supply.

- Three timing modes
- 5 mV minimum threshold
- 1000:1 dynamic range
- High count rate capability (50 MHz)
- Time walk $\leq \pm 100$ ps for 100:1 dynamic range
- Four independent simultaneous outputs

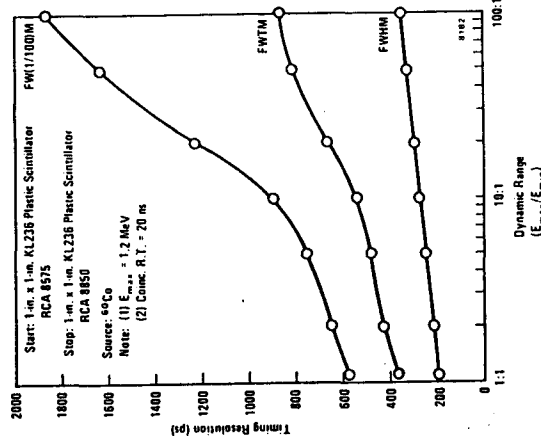
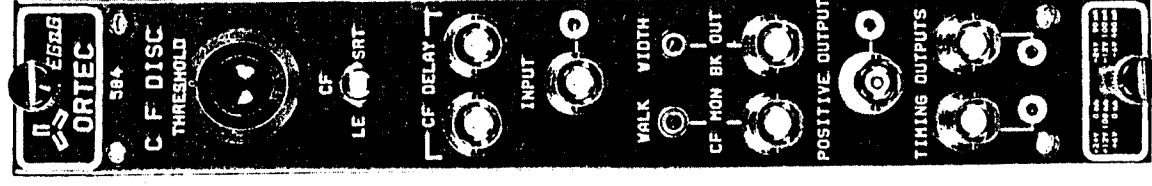


Fig. 1. Timing Resolution as a Function of Dynamic Range for Two Constant-Fraction Discriminators in a Fast/Slow Timing Coincidence System.

Specifications

PERFORMANCE

- INPUT** Accepts negative input signals from 0 V to -5 V without saturation; dc-coupled; $Z_{in} = 50 \Omega$; reflections $\leq \pm 5\%$ for $t_r \leq 2$ ns.
- THRESHOLD RANGE** -5 mV to -1 V.
- THRESHOLD INTEGRAL NONLINEARITY** $\leq \pm 0.25\%$ of full scale.
- THRESHOLD INSTABILITY** $\leq \pm 100 \mu\text{V}/^\circ\text{C}$, 0°C to 50°C .



Constant-Fraction Discriminator (continued)

PROPAGATION DELAY Nominally 25 ns, with external CF Delay ≈ 2 ns.

MINIMUM PULSE-PAIR RESOLUTION ≤ 20 ns.

DEAD TIME Nominally 20 ns or Blocking Output Width, whichever is greater.

BLOCKING OUTPUT WIDTH Adjustable from ≤ 10 ns to ≥ 1000 ns.

TIME WALK $\leq \pm 100$ ps for the 100:1 input range from -20 mV to -2 V; $\leq \pm 150$ ps for the 200:1 input range from -10 mV to -2 V. Conditions: External CF Delay ≈ 2 ns; input rise time ≤ 1 ns; input pulse width ≈ 10 ns.

CONTROLS

THRESHOLD Front panel 10-turn precision locking potentiometer determines the discriminator threshold setting in the range from -5 mV to -1 V.

TIMING MODE SWITCH Front panel 3-position locking toggle switch selects one of the three timing modes:

CF (Constant Fraction) Attenuation factor is internally set at $f = 0.2$ (can be changed upon request). An external 50- Ω coaxial cable must be provided for the constant-fraction shaping delay (CF Delay).

SRT (Slow Rise Time Reject) Provides constant-fraction timing and inhibits output signals that would be produced by leading-edge timing from the leading-edge arming discriminator. An input signal that does not cross the discriminator threshold before the constant-fraction zero-crossing time does not produce an output pulse.

LE (Leading Edge) Inhibits timing from the constant-fraction circuitry. The timing is derived as the leading edge of the input signal crosses the discriminator threshold level.

CF DELAY Two front panel BNC connectors accept 50- Ω coaxial cable to set the required constant-fraction shaping delay for the CF and SRT Modes: total delay is ≈ 0.8 ns plus the delay of the external cable. In the LE Mode, the user may either connect a piece of 50- Ω coaxial cable between these two connectors or connect a 50- Ω termination to each of the two connectors.

WALK Front panel 20-turn screwdriver adjustment sets the walk compensation for each application.

CF MON Front panel BNC connector permits observation of the constant-fraction bipolar timing signal; $Z_{in} = 50 \Omega$. 50- Ω coaxial cable required; 50- Ω termination suggested.

WIDTH Front panel 20-turn screwdriver adjustment sets the width of the Blocking Output pulse. Variable from ≤ 10 ns to ≥ 1000 ns. Sets the instrument dead time for widths greater than nominally 20 ns.

GATING MODE SWITCH Rear panel 2-position locking toggle switch controls the use of the Gate Inputs. (One of three Gate Input signal paths is selected by a PWB jumper.)

Gated A "true" logic level from the selected Gate Input permits output signals to be generated by the discriminator. A "false" logic level from the selected Gate Input inhibits output signals from being generated by the discriminator. A set of Output signals already in progress is not terminated prematurely by a logic "false" signal from the selected Gate Input.

Ungated The signal level of the selected Gate Input does not inhibit normal generation of output signals from the discriminator (i.e., the discriminator is always enabled).

LOGIC CURRENT SWITCH Rear panel 2-position locking toggle switch selects either the -6 V or the -12 V NIM supply line for providing current for the high-speed ECL logic used in the discriminator.

NOTES:

(1) The module is within the current allotment for a single NIM width when using the -6 V position with a NIM Class V Power Supply or equivalent.

(2) The module exceeds the current allotment for a single NIM width on the -12 V supply when using the -12 V position. However, this position permits using the discriminator in bins with power supplies not providing -6 V.

GATE INPUT JUMPER (G⁺, G⁻, or BG) PWB jumper selects one of three Gate Input signal paths.

G⁺ Selects the rear panel BNC Gate Input connector to accept slow positive NIM input signal levels for gating; dc-coupled; $Z_{in} > 1$ k Ω .

G⁻ Selects the rear panel BNC Gate Input connector to accept fast negative NIM input signal levels for gating; dc-coupled; $Z_{in} = 50 \Omega$.

BG Selects the Bin Gate line (pin 36 of the NIM power connector block) to accept slow positive NIM input signal levels $> +2$ V for gating; dc-coupled; $Z_{in} > 1$ k Ω .

POSITIVE OUTPUT WIDTH (+ Width) PWB 4-turn potentiometer sets the width of the slow positive NIM output signal in the range from $\leq 0.5 \mu$ s to $\geq 2.5 \mu$ s.

POSITIVE OUTPUT SIGNAL POLARITY (PO OR PO) PWB jumper selects the slow positive NIM output signal (PO) or the complementary output signal (PO).

INPUTS

INPUT Front panel BNC connector accepts fast negative input signals from 0 V to -5 V without saturation; dc-coupled; $Z_{in} = 50 \Omega$; reflections $\leq \pm 5\%$ for $t_r \geq 2$ ns.

GATE INPUT Rear panel BNC connector; input signals accepted according to PWB Gate Input Jumper.

G⁺ Jumper Position Accepts slow positive NIM input signal levels for gating; dc-coupled; $Z_{in} > 1$ k Ω .

G⁻ Jumper Position Accepts fast negative NIM input signal levels for gating; dc-coupled; $Z_{in} = 50 \Omega$.

OUTPUTS

TIMING Two front panel BNC connectors provide simultaneous NIM-standard fast negative logic signals; $t_r \approx 2$ ns; $t_f \approx 3$ ns; $t_d \approx 5$ ns.

BK OUT Front panel BNC connector provides a NIM-standard fast negative logic pulse that occurs simultaneously with the Timing Outputs; width variable by front panel adjustment from ≤ 10 ns to ≥ 1000 ns; $t_r \approx 2$ ns.

POSITIVE Front panel BNC connector provides NIM-standard slow positive logic pulse simultaneously with Timing Outputs; $Z_{in} < 10 \Omega$; width variable by PWB width adjustment from $\leq 0.5 \mu$ s to $\geq 2.5 \mu$ s. The associated LED is triggered for approximately 3 ms (updating) by each positive output pulse.

ELECTRICAL AND MECHANICAL

WEIGHT

Net 1.2 kg (2.6 lb).

Shipping 2.25 kg (5.0 lb).

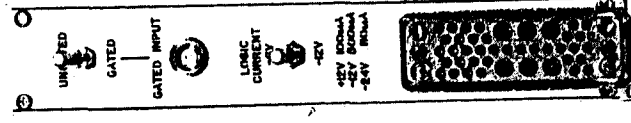
DIMENSIONS NIM-standard single-width module 3.43 x 22.13 cm (1.35 x 8.714 in.) per TID-20893 (Rev).

POWER REQUIRED

Logic Current Switch*

	Position
	-6 V
	-12 V
+12 V	100
-12 V	100
+6 V	0
-6 V	400
+24 V	0
-24 V	80
117 V ac	0

*See "NOTES" on Logic Current Switch. "Controls" Section of Specifications.



575A Amplifier

Specifications

The 575A Amplifier is EG&G ORTEC's most economical, general-purpose NIM amplifier. The functional design of the unit incorporates integrated circuits and provides many features not available on more expensive amplifiers. The low input noise, selectable shaping time constants, and gain range allow operation with semiconductor detectors, proportional counters, and scintillation detectors in a variety of applications. The performance capability of the 575A, coupled with its low cost, allows a wide range of uses in such fields as research, environmental monitoring, and teaching.

The 575A incorporates an automatic gated baseline restorer (BLR) that causes the system resolution to be nearly independent of input counting rates. The gated baseline restorer includes a discriminator that operates the sensing circuits which normally establish the baseline reference for the multi-channel analyzer. Performance of the spectrometer often depends on the position of the setting of the BLR threshold. The 575A offers the convenience of an automatic threshold control that typically gives results as good as, or better than, those the most experienced operator could achieve manually.

The pulse-shaping networks in the 575A produce semigaussian-shaped output pulses resulting in improved noise performance and reduced amplifier resolving time. The shorter resolving time permits higher counting rates than in amplifiers with classical RC pulse-shaping networks. The 575A provides a 10-V linear output with excellent dc stability for both unipolar and bipolar output pulses.

PERFORMANCE

GAIN RANGE Continuously adjustable from 5 to 1250.

PULSE SHAPE Semigaussian on all ranges with peaking time equal to 2.2 τ , 50% pulse width equal to 3.3 τ , and pulse width at 0.1% level equal to 4.0 times the peaking time. Bipolar crossover = 1.5 τ .

INTEGRAL NONLINEARITY For 1.5 μ s shaping time, $\leq \pm 0.05\%$.

NOISE $< 5 \mu$ V rms referred to the input using 3 μ s unipolar shaping; $< 7 \mu$ V using 1.5 μ s shaping; both for a gain ≥ 100 .

TEMPERATURE INSTABILITY

Gain $\leq \pm 0.0075\%$ /°C, 0 to 50° C.
Dc Level $\leq \pm 30 \mu$ V/°C, 0 to 50° C.

WALK $\leq \pm 5$ ns at 0.5 μ s shaping for 50:1 dynamic range, including contribution of an EG&G ORTEC 551 or 552 Constant-Fraction Timing Single-Channel Analyzer.

OVERLOAD RECOVERY Recovers to within 2% of rated output from X300 overload in 2.5 nonoverload pulse widths using maximum gain for unipolar output. Same recovery from X500 overload for bipolar.

RESTORER Gated active baseline stabilizer with automatic threshold circuit to provide the threshold level as a function of signal noise to the baseline restorer discriminator.

SPECTRUM BROADENING* Typically $< 10\%$ FWHM for a ^{60}Co 1.33-MeV gamma line at 85% of full scale for an incoming count rate of 1 to 50k cps. Unipolar output, 1.5 μ s shaping.

SPECTRUM SHIFT* Peak position shifts typically $< 0.02\%$ for a ^{60}Co 1.33-MeV gamma line at 85% of full scale (measured at the unipolar output, 1.5 μ s shaping, 1 to 50k cps).

CONTROLS

FINE GAIN Ten-turn precision potentiometer with graduated dial for continuously variable direct-reading gain factor of X2.5 to X12.5.

COARSE GAIN Six-position switch selects feedback resistors for gain factors of 2, 4, 10, 20, 40, and 100.

SHAPING TIME Three-position printed wiring board (PWB) jumpers, easily accessible through side panel, select time constants for active pulse-shaping filter network of 0.5, 1.5, or 3 μ s.

*These count rate specifications were measured with a 10% HPGe detector. Detectors with a large number of slow, rise-time signals will most likely give poorer results.

- Automatic baseline restorer threshold control
- Excellent dc stability
- Positive or negative input with low input noise
- Gated active baseline restorer for high count rate applications
- Selectable shaping time constants



575A Amplifier (continued)

POS/NEG Toggle switch selects either Pos or Neg input pulse polarity.

PZ ADJ Screwdriver adjustable potentiometer to set the pole-zero cancellation to compensate input decay times from 30 μ s to ∞ .

INPUT

INPUT BNC (UG-1094-A/U) front and rear panel connectors accept either positive or negative pulses with rise times of 10 to 650 ns and decay times of 30 μ s to ∞ ; $Z_{in} = 1000 \Omega$ dc-coupled; linear maximum 2 V; absolute maximum 20 V.

OUTPUTS

UNI Front panel BNC connector with $Z_o < 1 \Omega$ and rear panel connector with $Z_o = 93 \Omega$. Short-circuit proof; full-scale linear range of 0 to +10 V; active filter shaped; dc-restored with dc level adjustable to ± 15 mV.

BI Front panel BNC connector with $Z_o < 1 \Omega$ and rear panel connector with $Z_o = 93 \Omega$. Short-circuit proof; positive lobe leading and full-scale linear range of 0 to +10 V; active filter shaped.

PREAMP POWER Rear panel standard EG&G ORTEC power connector (Amphenol 17-10090) mates with captive and noncaptive power cords on all EG&G ORTEC preamplifiers.

RELATED EQUIPMENT

The EG&G ORTEC 575A Amplifier accepts linear pulses from, and furnishes power to, any standard EG&G ORTEC preamplifier or equivalent. Its output pulses may be used for linear signal analysis, using any of the EG&G ORTEC modular instruments and multichannel analyzers.

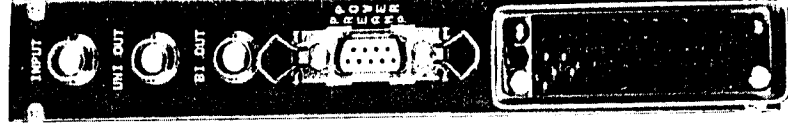
ELECTRICAL AND MECHANICAL POWER REQUIRED

+24 V, 55 mA; -24 V, 40 mA;
+12 V, 70 mA; -12 V, 75 mA.

WEIGHT

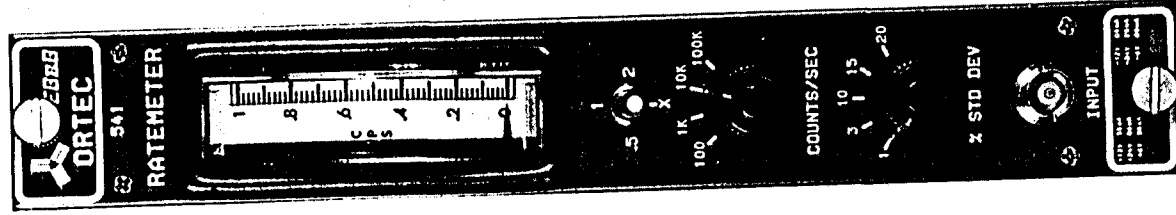
Net 1.5 kg (3.3 lb).
Shipping 3.1 kg (7.0 lb).

DIMENSIONS Standard single-width NIM module 3.43 x 22.13 cm (1.35 x 8.714 in.) per TID-20893 (Rev).



541 Ratemeter

- Accurate, stable, and reliable linear ratemeter
- 12 ranges of input counting rates from 50 to 200,000 counts/s
- Compatible with almost all nuclear instruments



The EG&G ORTEC 541 is a highly accurate, stable, and reliable linear count ratemeter packaged in a NIM-standard, single-width module. The experimenter can select the range of statistical accuracy necessary for his experiment rather than having to select a "time constant." The standard deviation error switch allows a choice of the fastest possible time response consistent with the required accuracy.

Twelve ranges of input counting rates from 50 to 200,000 counts/s can be accepted, and the input pulse requirements are easily met by almost all nuclear instruments. The output span for a recorder is adjustable over a wide range. Long-term stability and reliability are assured by the use of integrated circuit amplifier and logic circuits and matched field-effect transistors.

Specifications

PERFORMANCE

NONLINEARITY $< \pm 0.5\%$ of full scale.
STABILITY $> \pm 0.05\%$ of full scale per day at constant temperature.
TEMPERATURE COEFFICIENT $\pm 0.05\%$ of full scale per °C, 0 to 50°C.

CONTROLS

COUNTS/SEC Front panel 4-position switch for selecting 100, 1000, 10,000, and 100,000 counts/s with a multiplier of 0.5, 1, and 2 for total ranges of 50, 100, 200, 500, 1k, 2k, 5k, 10k, 20k, 50k, 100k, and 200k counts/s full scale.

% STD DEV Front panel 5-position switch; nominally 1%, 3%, 10%, 15%, and 20% at full scale.

RECORDER OUTPUT SPAN ADJ Potentiometer for 0 to 100 mV Recorder Output.

INPUT

INPUT Front and rear panel BNC connectors:
Amplitude +2 V to operate; ± 100 V maximum pulse amplitude; ± 30 V maximum average.
Rise Time < 1 ms/V at +2 V level.
Width No maximum limit, minimum width of 200 ns, input dc-coupled with impedance of $\sim 2500 \Omega$.

OUTPUTS

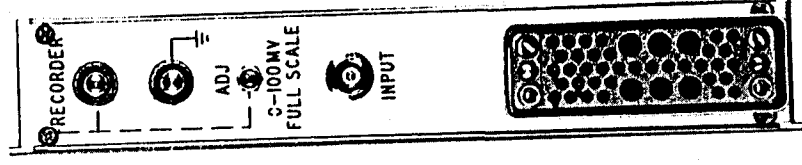
RECORDER OUTPUT Binding post connectors on rear panel for connection to 100 mV full-scale Recorder.

METER 5.08 cm (2 in.) edge reading meter with 2% meter movement.

ELECTRICAL AND MECHANICAL POWER REQUIRED +12 V, 65 mA; -24 V, 25 mA.

WEIGHT
Net 0.68 kg (1.5 lb).
Shipping 1.59 kg (3.5 lb).

DIMENSIONS NIM-standard single-width module 3.43 x 22.13 cm (1.35 x 8.714 in.) per TID-20893 (Rev).



770 Counter

The EG&G ORTEC 770 Counter meets the need for a high-speed data acquisition instrument. The basic unit is for operation in automatic standard printing systems; however, two parallel data output options allow it to be used in parallel access computer-based systems or with any other output device requiring parallel data format. The counter can be used in a zero dead time system by adding a buffer memory option, which permits simultaneous data accumulation and output. The 770 incorporates a unique integrated circuit design in a double-width NIM package and is compatible with all NIM-standard signals.

A 6-decade, 7-segment, long-lasting LED display increases the visibility and includes a unique leading-zero-suppression circuit to make the 770 easier to read because it displays only the actual counting data. When the Display Test pushbutton is depressed, all "8s" are illuminated on the display.

The 770 will count positive input pulses at a rate of 20 million counts/s (20 MHz) and negative input pulses at 100 million counts/s (100 MHz). The positive pulses can be as narrow as 20 ns with a pulse pair resolution of 50 ns and the fast negative NIM pulses as narrow as 4 ns with a pulse pair resolution of 10 ns. This high-speed capability is a very desirable feature for single-photon counting and other applications. In general, this unit usually high counting capability results in improved counting statistics and greater pulse detection.

Accepting positive unipolar and bipolar input signals of 100 mV to 10 V, an input dynamic range of 100:1, the 770 provides input threshold level control over

the entire range. This important design feature eliminates unwanted noise, thereby providing the discriminator function needed in every counting system.

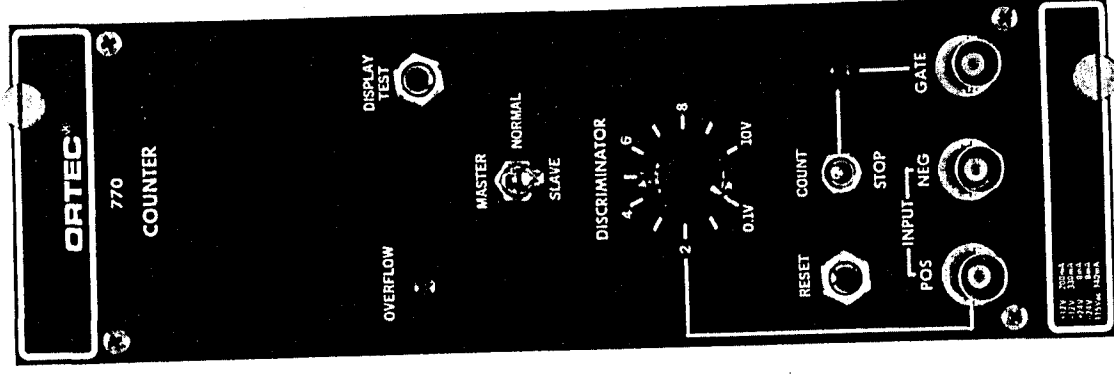
The negative input accepts standard fast negative logic pulses above a 250 mV threshold. A wide input voltage range and high sensitivity permit signals to be used with a minimum of amplification.

Counting can be inhibited two ways: electronically by a Gate input whose LED indicator is illuminated when the unit is counting and manually by a Count/Stop switch. The 770 is easily reset to zero either with the front panel Reset button or with an external signal to the rear panel Reset input connector. Many different timing combinations are made possible by these features; they also permit the 770 to be used as either master or slave in a printing or computer-based system.

When the 6-decade counter capacity is exceeded an LED indicates counter overflow, and a standard logic signal available from the rear panel can be used to cascade counters when high counting rates and long-duration unattended counting are required.

Three options are available which extend the use of the 770: a buffer memory and two parallel data outputs. The options are mutually exclusive, plug-in printed wiring boards (PWBs) that can be added at a later date if desired. The buffer memory permits counting while the unit is reading out so that critical information will not be lost during data transfer. This option also includes the circuitry for automatic recycle after preset. The parallel data output options provide batch data transfer, with all six decades being transferred simultaneously over 24 BCD data lines, plus counter control and strobe lines for operation with high-speed parallel printers and computer-based systems. Without these options the 770 outputs data serially, each decade being sequentially transferred over four BCD data lines, for use in a standard EG&G ORTEC printing system.

- 20 MHz positive and 100 MHz negative input counting capability
- Parallel data output plug-in options for high-speed systems
- Buffer memory plug-in option
- Large 6-decade LED display with leading-zero suppression and positive Display Test
- Input threshold level control
- LED Gate and Overflow indicators



770 Counter (continued)

Specifications

PERFORMANCE

COUNT CAPACITY 6 decades, for 0 through 999,999.

MAXIMUM COUNTING RATES Negative input 100 MHz; positive input 20 MHz.

PULSE PAIR RESOLUTION Positive input 50 ns; negative input 10 ns; minimum duty cycle of 40% at maximum counting rate.

INPUT DISCRIMINATOR Negative input has a fixed trigger level of -250 mV. Positive input has an adjustable trigger level; range $+100$ mV to $+10$ V; drift $<0.01\%$ of full scale per $^{\circ}\text{C}$. 0 to 50°C .

AUTOMATIC CLEAR Generated when power is turned on initially or after a power failure.

INDICATORS

DISPLAY 6 direct-reading, 7-segment LED digits with a leading-zero suppression circuit.

OVERFLOW LED illuminated from first overflow until reset.

GATE LED illuminated while unit is in counting condition.

CONTROLS

DISPLAY TEST Pushbutton switch lights all 7 segments of each digit in the display when pressed for a reading of 888,888.

MASTER/SLAVE/NORMAL 3-position locking toggle switch selects the counter function when the module is connected in a data acquisition system:

Master Allows control over all slaves within the data acquisition system through the gate and reset lines.

Slave Subordinates this module to some other module in the system loop that is operating as a master.

Normal Isolates the gate and reset lines from the system lines even when connected in a printing system. This permits the counter to be used independently of the rest of the system. The unit will, however, print out when the total system prints out.

DISCRIMINATOR Single-turn potentiometer sets discrimination level for the positive input signal from 100 mV to 10 V.

RESET Pushbutton switch resets display and internal logic to an initial condition when pressed.

COUNT/STOP Toggle switch selects counting or noncounting condition of the unit manually.

CONNECTORS

POSITIVE INPUT Front and rear panel BNC connectors accept positive unipolar or bipolar signals to ± 25 V maximum. Input amplitude must exceed adjusted threshold level for 20 ns minimum to be counted. $Z_{in} = 1$ k Ω to ground, dc-coupled.

NEGATIVE INPUT Front panel BNC connector accepts NIM-standard fast negative signals, 14 mA into Z_{in} of 50 Ω . Minimum width 4 ns; 250 mV fixed threshold. Input protected to ± 100 V at 10% duty cycle.

GATE BNC connectors on front and rear panels accept NIM-standard positive logic signal to control counter gate and its associated indicator. Open circuit of ≥ -3 V to allow counting; $\leq +1.5$ V to inhibit counting; 25 V maximum; driving source must be capable of sinking 0.5 mA of positive current.

RESET Rear panel BNC connector accepts standard positive logic signal to reset the unit to initial zero condition; $\geq +3$ V resets; $\leq +1.5$ V does not reset; 25 V maximum; 100 ns minimum width; $Z_{in} = 2$ k Ω to ground, dc-coupled.

OVERFLOW Rear panel BNC connector furnishes standard positive logic output; $+5$ V for 2 μs when the counter overflows from 999,999 to 0. Driving source impedance ≤ 10 Ω , dc-coupled.

IN/OUT Rear panel Amphenol 57-40140 connectors for use with EG&G ORTEC standard printing system logic and data interconnections.

DATA 36-pin Amphenol 57-40360 connector. Outputs are negative TTL logic-open collector; nominally 0 V for "true" or "1" logic level; nominally +5 V for "false" or "0" logic level. Data connector contains provisions for the following signals: strobe, negative logic; system preset, "0" when preset is reached; system reset 0 V; data outputs, 6 decades of parallel BCD output; data are present for the duration of the strobe signal.

OPTIONS

77X-01 BUFFER MEMORY This option consists of an accessory Buffer Memory. The plug-in PWB with a 24-bit memory allows readout operation with negligible dead time (<1 μs); option also includes the circuitry for automatic recycle after preset.

77X-02 PARALLEL DATA OUTPUT This option consists of a negative logic PWB with attached wiring harness and multipin connector which fits into the Data output on the rear panel of the module. This optional board includes all the logic required to strobe all 24 BCD bits of data through the output simultaneously, and is an additional output capability that does not interfere in any way with the standard printing capabilities of the unit.

77X-03 PARALLEL OUTPUT This option is a positive logic PWB with 24 BCD bits of data. The board contains all necessary logic to strobe the data through the output connector simultaneously without interfering with the standard printing capabilities of the unit.

While its primary purpose is to transfer parallel data to the EG&G ORTEC 9325 DAC, the 24 data bits are available for transfer to the DAC or to any other external accessory. A jumper is available on the PWB to strobe the data to either the DAC or to the external accessory.

ELECTRICAL AND MECHANICAL

POWER REQUIRED $+12$ V, 190 mA; -12 V, 330 mA; 117 V ac, 105 mA, 50 or 60 Hz.

WEIGHT

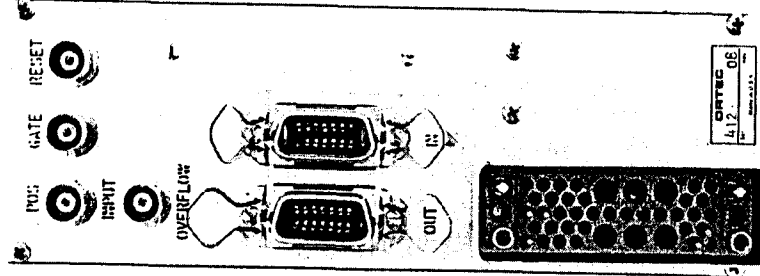
Net 2.3 kg (5.0 lb)

Shipping 3.4 kg (7.5 lb)

DIMENSIONS NIM-standard double-width module 6.90 x 22.13 cm (2.70 x 8.714 in.) per TID-20893 (Rev).

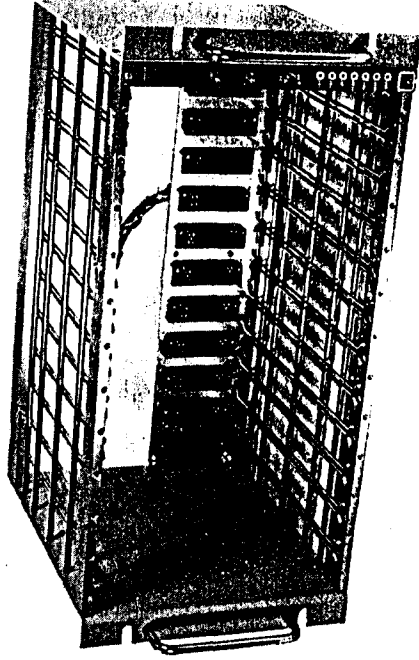
ACCESSORY INCLUDED Printing system control cable for use with an EG&G ORTEC standard printing loop.

RELATED EQUIPMENT In an EG&G ORTEC standard data acquisition system one or more 770s are connected through an EG&G ORTEC 879 Buffered Interface to a printer or directly to a 777A Line Printer.

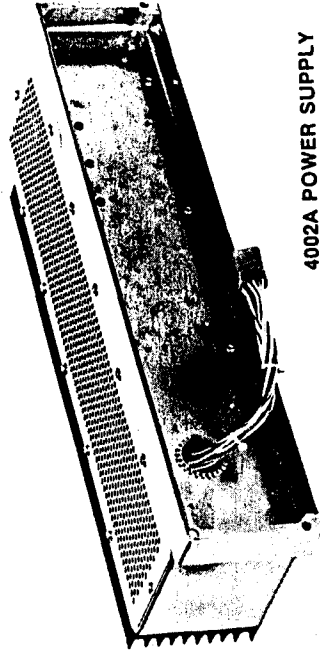


4001/4002/402 Bins and Power Supplies

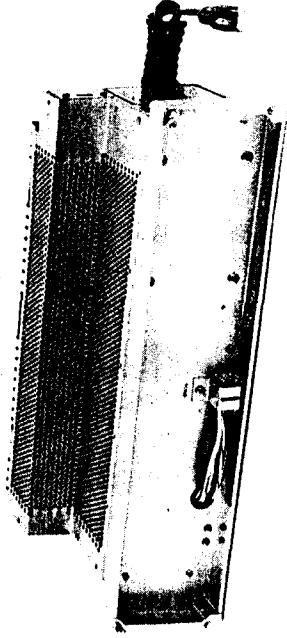
- Exceeds recommended specifications
- Adjustment-free bin construction
- Low-impedance power distribution
- Use with 100, 120, 220, or 240 V ac power mains
- Choice of power supplies



4001A or 4001C BIN



4002A POWER SUPPLY



402D POWER SUPPLY

EG&G ORTEC offers NIM bins and power supplies to accommodate any equipment modules that have been manufactured to NIM standards as defined in TID-20893 (Rev).

The EG&G ORTEC 4001A or 4001C Bin is constructed of wire-form grids to ensure unimpeded ventilation for the instruments that are operated in the bin. The adjustment-free module guides are superior to the requirements specified in TID-20893 (Rev 4). These hardened steel guides feature generous openings, and because of their highly-polished nickel plating, offer a low friction coefficient. Aluminum alloy side plates are precision-formed and protected with a painted finish. Either the 4002A or 402D power supply may be attached to the precision-stamped plated-steel connector mounting plate.

The EG&G ORTEC 4001A bin distributes all dc and ac power levels from the power supply to the module connectors through a wiring harness. The 4001C bin distributes the power through heavy-duty copper bus bars, wire, and printed wiring board (PWB), ensuring a uniform voltage output to even high-power modules.

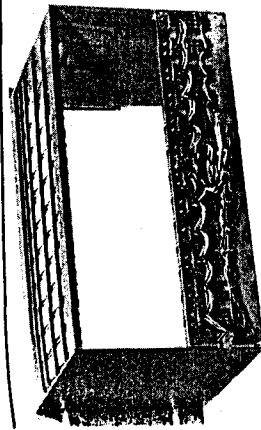
Either the 4002A or 402D power supply can be mated to your choice of 4001A or 4001C bin for a complete rack-mountable assembly or for table-top use housed in an optional EG&G ORTEC 909A bin cover.

The EG&G ORTEC 4002A Power Supply complies with specifications for Type 1, Class A power supplies as defined in TID-20893 (Rev 4), Appendix A. The input voltage can be 100, 120, 220, or 240 V ac, and an internationally-approved primary circuit connector allows the use of many types of power plugs. The dc-output power levels that are furnished to the mating bin are +12 and -12 V at up to 2 A each and +24 and -24 V at up to 1 A each. The maximum output power is 96 W at +50° C ambient temperature. A 117-V ac power output is also distributed to the bin. Each dc-output voltage is adjustable over a ± 1 V range from its nominal rating. The outputs are short-circuit protected by current-foldback limiting.

The EG&G ORTEC 402D Power Supply is designed to exceed recommended power supply specifications for Type V-H supplies as defined in TID-20893 (Rev 4), Appendix A. The input power can be either 117 or 230 V, furnished through fused input circuits and a 3-conductor NEMA-standard power cord that is included. The dc-output power levels furnished to the mating bin are +6 and -6 V at up to 8 A each, +12 and -12 V at up to 2 A each, and +24 and -24 V at up to 1 A each, with a combined maximum rating of 132 W at 50° C. Each dc-output voltage is adjustable over a $\pm 2\%$ range from its nominal rating by a 20-turn precision potentiometer. The outputs are regulated, short-circuit protected, current limited, and thermal protected.

4001/4002/402 Bins and Power Supplies

Specifications



4001A BIN

MODULE CONNECTORS 12 each as specified by TID-20893 (Rev).

INSTALLED WIRING All connectors wired in parallel for +12 V, -12 V, +24 V, -24 V, +6 V, -6 V, high-quality ground, power-return ground, and 117 V ac, in accordance with TID-20893 (Rev) pin assignments. An interface connector is supplied as required by TID-20893 (Rev) for connecting control and power supply.

CONTROL PANEL A control panel with On-Off switch, power-indicating lamp, and thermal warning lamp provided for mating power supply. The thermal warning lamp is illuminated when the operating temperature approaches the design limit. Voltage test points are provided for convenient monitoring of the power supply outputs.

CONSTRUCTION Aluminum alloy side plates with nickel-chromium-plated handles on front panel mounting flanges. Top and bottom members are high-tensile steel rod weldments, nickel plated, containing module guides. Rear connector plate is steel, cadmium plated.

4001C BIN

MECHANICAL Identical to 4001A bin.

ELECTRICAL Meets specifications for laminated busses as outlined in TID-20893 (Rev 4) under section F.F.2, "Bussing."

4002A POWER SUPPLY

INPUT 88-110, 103-129, 191-239, or 206-258 V ac, 47-63 Hz. At nominal input voltages efficiency is typically 44%.

DC OUTPUT +12 V at 2 A, -12 V at 2 A, +24 V at 1 A, -24 V at 1 A, combined maximum output power 96 W at +50°C; derates to 72 W at +60°C.

117-V AC OUTPUT Limited only by supply fuses when operating on 117-V ac mains; limited to 50 VA when dc load is 96 VA, operating on 230-V ac mains.

REGULATION $\leq \pm 0.05\%$ over combined range of zero to full load and input voltage of 88% to 110% of rated input over any 24-h period at constant ambient temperature after a 60-min warmup.

INSTABILITY $\leq \pm 0.3\%$ over a 6-month period at constant line, load, and ambient temperature after a 24-h warmup.

OUTPUT IMPEDANCE $< 0.3 \Omega$ at any frequency up to 100 kHz.

TEMPERATURE COEFFICIENT $< 0.01\%$ °C from 0 to 60°C.

NOISE AND RIPPLE < 3 mV peak-to-peak, as observed on 50-MHz bandwidth oscilloscope.

VOLTAGE ADJUSTMENT $\pm 0.5\%$ minimum range, resettable $\pm 0.05\%$ of supply voltage (typical ± 1 V).

RECOVERY TIME $< 50 \mu\text{s}$ to return to within $\pm 0.1\%$ of rated voltage for any change in rated input voltage and load current from 10% to 100% full load.

CIRCUIT PROTECTION Input power line fused; power supply is automatically cut off by an internal switch if the temperature exceeds a maximum safe limit; also electronic output current foldback limiting with automatic recovery when demand is removed.

402D POWER SUPPLY

INPUT 100-129 V ac, 47-63 Hz, or 200-258 V ac, 47-63 Hz. Input current at 117 V ac is 3.5 A for a 132-W dc output.

DC OUTPUTS +6 V, 8 A; -6 V, 8 A; +12 V, 2 A; -12 V, 2 A; +24 V, 1 A; -24 V, 1 A; max output power, 0 to 50°C ambient, 132 W; derates $\leq 3\%/^{\circ}\text{C}$ from 50 to 60°C.

117-V AC OUTPUT Limited only by supply fuses when operating on 117-V ac mains; limited to 50 VA when dc load is 132 W, operating on 230-V ac mains.

REGULATION $\pm 0.1\%$ (typically $\pm 0.05\%$) for ± 12 and ± 24 V, and $\pm 0.2\%$ (typically $\pm 0.1\%$) for ± 6 V, over the combined range of zero to full load with specified input range for measurements made within 1-min period; $\pm 0.3\%$ for ± 12 and ± 24 V, and $\pm 0.6\%$ for ± 6 V, over any 24-h period at constant ambient temperature for same load and input ranges after a 60-min warmup.

INSTABILITY $\leq \pm 0.5\%$ after a 60-min warmup over a 6-month period at constant load, line, and ambient temperature.

OUTPUT IMPEDANCE $< 0.15 \Omega$ for ± 6 V and $< 0.3 \Omega$ for all others at any frequency up to 100 kHz.

TEMPERATURE COEFFICIENT $< 0.02\%$ °C, 0 to 60°C.

NOISE AND RIPPLE < 3 mV peak-to-peak for any output as observed on 50-MHz bandwidth oscilloscope.

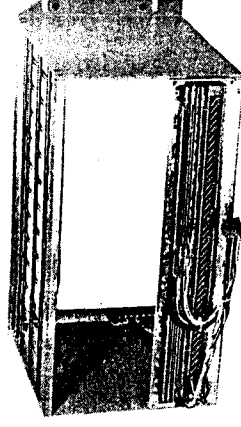
VOLTAGE ADJUSTMENTS $\pm 2\%$ min. range; resettable $\pm 0.05\%$ of supply voltage.

RECOVERY TIME $< 100 \mu\text{s}$ to return to within $\pm 0.1\%$ of rated voltage for all 6 outputs for any change in rated input voltage and load current from 10% to 100% of full load.

CIRCUIT PROTECTION Both input power lines fused; power supply is automatically cut off by an internal switch if the temperature exceeds a maximum safe limit; also electronic output current foldback limiting with automatic recovery when demand is removed; over-voltage protection for ± 6 V prevents these outputs from exceeding ± 7.5 V max.

ORDERING INFORMATION

	Dimensions (in.)			Weight (approx.)	
	H	W	D	Shipping	Net
4001A or 4001C Bin	8-3/4	19	10-3/4	18 lb 8.2 kg	11 lb 5.0 kg
4002A Power Supply ± 12 V, ± 24 V	3-3/8	16-7/8	5-1/2	22 lb 10.0 kg	15 lb 6.8 kg
402D Power Supply ± 6 V, ± 12 V, ± 24 V	5	16-7/8	7-1/2	29 lb 13.2 kg	22 lb 10.0 kg
4001A/4002A (Assembled) 4001C/4002A	8-3/4	19	16	34 lb 15.9 kg	26 lb 11.8 kg
4001A/402D (Assembled) 4001C/402D	8-3/4	19	18	41 lb 18.6 kg	33 lb 15.0 kg
909A Bin Cover	9-3/4	19-1/2	21-5/8	29 lb 13.2 kg	21 lb 9.5 kg



4001C BIN



HOLADAY INDUSTRIES, INC.

MEMBER OF THE BOWTHORPE GROUP
14825 MARTIN DRIVE • EDEN PRAIRIE, MN 55344
PHONE (612) 934-4920 • FAX: (612) 934-3604

July 13, 1994

Yaron Hefetz
MIT
Room 20B - 145
Cambridge, MA 02139

Dear Sir:

Thank you for your interest in our products. Enclosed is some information you requested on our equipment.

For price and delivery information, please contact our distributor in your area:

A.J. Abrams Co.
315 Main St.
Westport, CT 06881

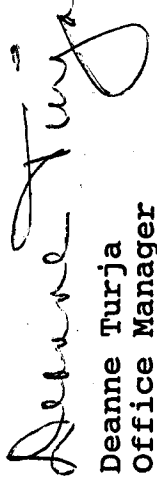
Telephone: 800/842-3011
203/226-3010
Fax: 203/226-8289.

I will send them a copy of your request for follow up.

Holaday Industries has provided a broad line of EMF measurement instruments to the health and safety industry for more than 25 years. These include devices for measuring low frequency ELF and VLF electric and magnetic fields as well as for RF and Microwave non-ionizing radiation. If we can be of further assistance, please contact either Bob Hericks or Michael Leighton.

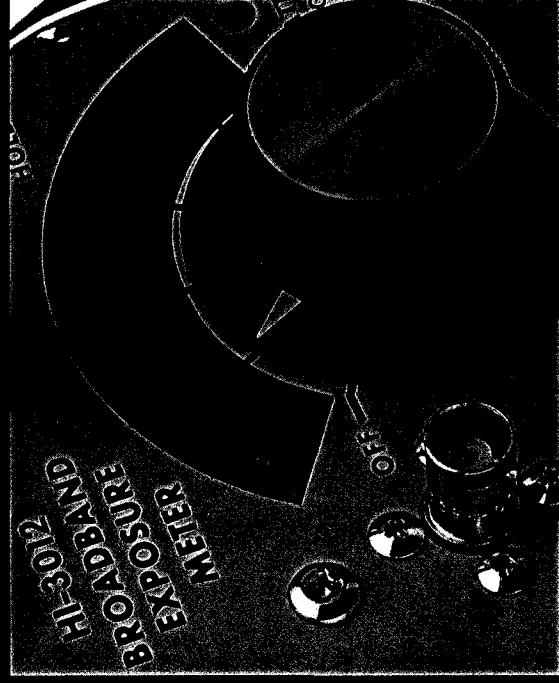
Sincerely,

HOLADAY INDUSTRIES, INC.

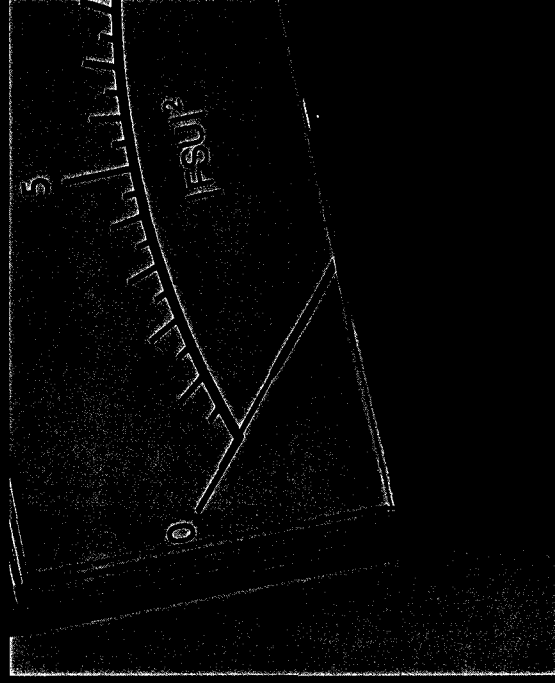

Deanne Turja
Office Manager



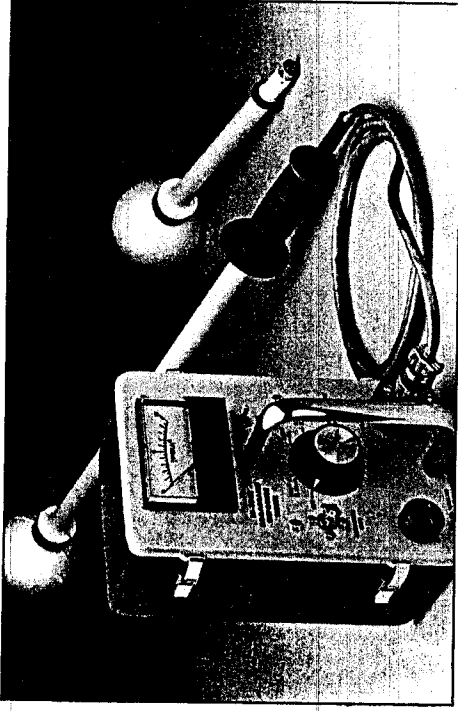
BROADBAND RF INSTRUMENTATION



Isotropic Field
Strength Meters For
Measuring Non-ionizing
Electromagnetic Fields



Isotropic Broadband Field Strength Meters



HI-3000 Family of Isotropic Broadband Field Strength Meters.

The Holiday Industries, Inc. HI-3000 family of Isotropic Broadband Field Strength Meters is designed for maximum accuracy, durability, and ease of operation. The probe design is based on development work done by the electromagnetic fields division of the National Institute of Standards and Technology (NIST).

Our patented instrument includes a completely automatic self-zeroing circuit for accurate measurements in any RF/Microwave field environment.

Basic Features and Specifications of the HI-3000 Family of Broadband meters:

1. Full-Time Automatic Zero, even while performing measurements.
2. PEAK HOLD memory circuit.
3. LED indicators for overload and battery status.
4. Acoustic Headset Output; tick rate is proportional to meter reading.
5. Recorder Output, 0-1 volt, corresponding to meter deflection.
6. Provides protection from sensor burn-out in high fields; CW (continuous wave) fields to 800% of full-scale reading.

7. Accuracy at calibration frequencies: ± 0.5 dB.
8. Includes 14 C-size alkaline batteries (NiCad optional), acoustic headset, carrying case, and operation manual.
9. Probe Handle Length: 75 cm (30 inches) with 1.5 meter (60 inch) probe cable.
10. Size of instrumentation package: 21 W x 13.2 H x 11cm D (8-1/8 X 5-1/8 X 4-7/8 inches).
11. Weight: 6.5 pounds.

Model HI-3001

The HI-3001 Broadband RF Field Strength meter measures electric fields only over a wide dynamic range. Two E field probes, the GRE and STE, together provide a 60 dB total dynamic measurement range in six switch selectable ranges. An Auxiliary range allows the selection of an additional optional probe (refer to the chart on the facing page). In applications above 300 MHz where magnetic field measurements are not required, the HI-3001 is the instrument of choice. For low level measurements the GRE probe is especially useful. The standard readout is in the square of the field strength (V^2/M^2), while the model HI-3001A displays readings in volts/meter (V/M).

Frequency Response: .5 MHz to 6 GHz, ± 2 dB

Dynamic Range:

HI-3001	GRE Probe:	10 to	10^4	V^2/M^2
	STE Probe:	10^4 to	10^7	V^2/M^2
HI-3001A	GRE Probe:	3 to	100	V/M
	STE Probe:	100 to	3,000	V/M

Model HI-3002

The HI-3002 is a general purpose Broadband RF Field Strength meter with moderate sensitivity for measuring compliance with the ANSI C95.1-1982 RF Exposure Standard. The instrument is equipped with one electric field probe and one magnetic field probe to measure RF electromagnetic fields generated by a wide range of equipment including RF Heat Sealers, RF/Microwave equipment. The HI-3002 is calibrated in units of $(FSU)^2$ (field strength units squared); volts squared/meter squared for electric fields and amperes squared/meter squared for magnetic fields.

For many applications, the HI-3002 has been replaced by the HI-3012.

Frequency Response:

E-Field: .5 MHz to 6 GHz, ± 2 dB
H-Field: 5 MHz to 300 MHz, ± 2 dB
with optional LFH Probe: .5 MHz to 10 MHz ± 2 dB

Dynamic Range:

STE Probe: 10^3 to 10^7 V^2/M^2
CH Probe: .01 to 100 A^2/M^2
Optional LFH Probe: .1 to 1000 A^2/M^2

Model HI-3003

Designed for laboratory and research use, the HI-3003 has three axis switches to select any combination of probe antenna orientations for determining field polarization. The HI-3003 is custom configured with a choice of available probes and corresponding readout units. The HI-3003 does include a probe as standard equipment. Probes are ordered separately. The HI-3003 standard configuration includes a NiCad battery pack and external charger, and a standard probe handle and cable. Consult with a Holaday Customer Information Specialist for details.

Frequency response and dynamic range depend on probe selection. Typical specifications are shown for the IME electric field probe:

Frequency Response: .5 MHz to 1 GHz, ± 2 dB
Dynamic Range: 2mW/cm² to 100 mW/cm²

Model HI-3004

The HI-3004 is designed for EMC/EMI (electromagnetic compatibility and interference) measurements, computer site surveys, and other measurements where low level fields may interfere with operation of sensitive electronic equipment. The adjustable probe clip on the side of the instrument allows one-hand or hands-free operation. The probe can withstand a CW signal up to 200% of full scale of the maximum probe range (60 V/M) without sensor damage. The probe ball is 19cm (7-1/2") in diameter. An optional STE probe can be added to extend the range to 3000 V/M. The HI-3004 is calibrated in units of volts/meter.

Frequency Response:
 E Field: .5MHz to 1.5 GHz, ± 2 dB
 with optional STE Probe: .5MHz to 6 GHz \pm dB

Dynamic Response:
 HSE Probe: .1 to 30 V/M
 Optional STE Probe: 30 to 3000 V/M

Model HI-3005

The HI-3005 is a Broadband Magnetic Field meter for measuring magnetic fields near RF induction heaters, RF heat sealers, broadcast installations, and similar radio frequency sources. Two magnetic field probes (CH and LFH) allow field measurements over a wide frequency range. The Isotropic Field Sensor can withstand a CW signal up to 200% of full scale of the maximum probe range. Three axis switches select any combination of probe antenna orientations for determining field polarization. The HI-3005 is calibrated in units of IFSUJ² (field strength units squared); amperes squared/meter squared.

Frequency Response:
 CH Probe: 5 MHz to 300 MHz, ± 2 dB
 LFH Probe: .3 MHz to 10 MHz, ± 2 dB

Dynamic Range:
 CH Probe: .01 to 10 A²/M²
 LFH Probe: .1 to 1000 A²/M²

Model HI-3012

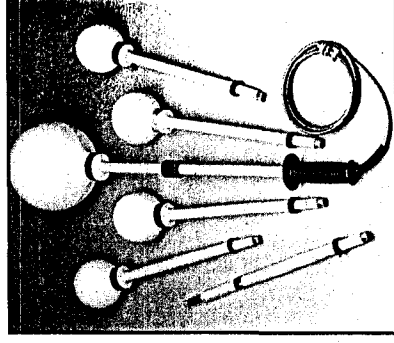
The HI-3012 is a new higher sensitivity, general purpose Broadband RF Field Strength meter. New electric and magnetic field sensing probes allow measurements down to 0.04 mW/cm² to meet the lower requirements of the new ANSI standards for uncontrolled environments. The HI-3012 is ideal for measuring the electromagnetic fields generated by a wide range of equipment: RF heat sealers, RF/Microwave processing equipment, broadcast stations, and medical equipment. An optional low frequency magnetic field probe (LFH) is available to extend the low frequency magnetic field range down to 500 KHz for RF induction heating and AM broadcast applications. The HI-3012 is calibrated in units of IFSUJ² (field strength units squared); volts squared/meter squared for electric fields and amperes squared/meter squared for magnetic fields.

Frequency Response:
 E Field: .5 MHz to 5 GHz, ± 2 dB
 H Field: 5 MHz to 300 MHz, ± 2 dB
 with optional LFH probe: .5 MHz to 10 MHz, ± 2 dB

Dynamic Range:
 MSE Probe: 10² to 10⁶ V²/M²
 HCH Probe: .001 to 10 A²/M²
 Optional LFH Probe: .1 to 1000 A²/M²

Probes for HI-3000 Broadband Meters

Holaday offers a wide range of probes for electric and magnetic field measurements. Each HI-3000 series instrument has eight input channels. These eight channels are used to store information on the specific probes for the instrument. This provides improved linearity over the full dynamic range of each probe. Probes are not interchangeable between instruments.



One optional probe can be added to an HI-3000 Broadband Meter.

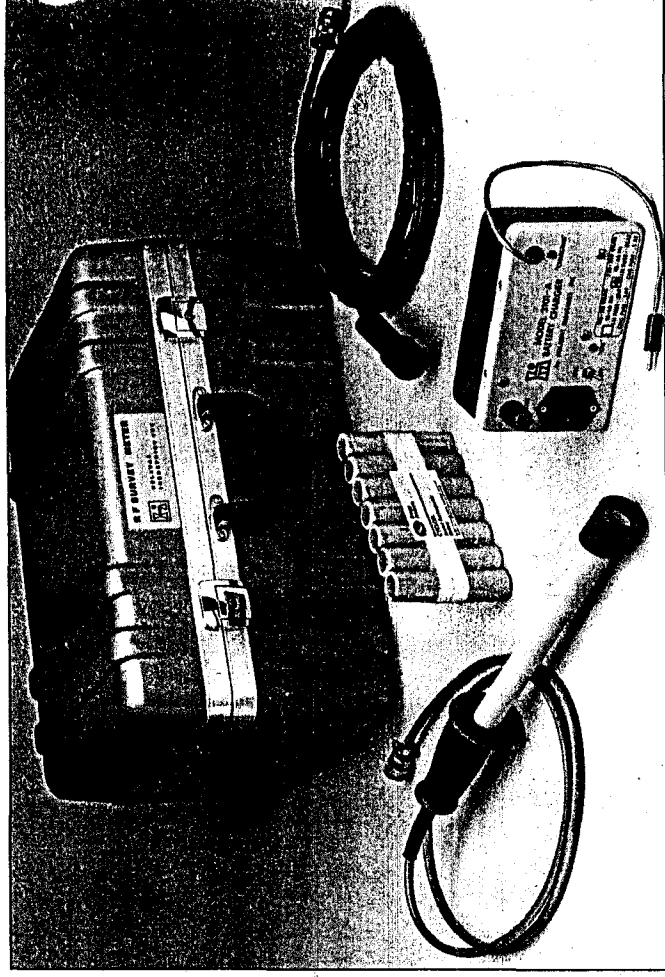
Probe Selection Matrix

MODEL NO.	PROBES							
	HSE	GRE	CH	LFH	IME	STE	HCH	MSE
HI-3001	OPT	STD	OPT	OPT		STD		
HI-3001A	OPT	STD	OPT	OPT		STD		
HI-3002			STD	OPT		STD		
HI-3003	OPT	OPT	OPT	OPT	OPT	OPT	OPT	OPT
HI-3004	STD					OPT		
HI-3005			STD	STD				
HI-3012				OPT			STD	STD

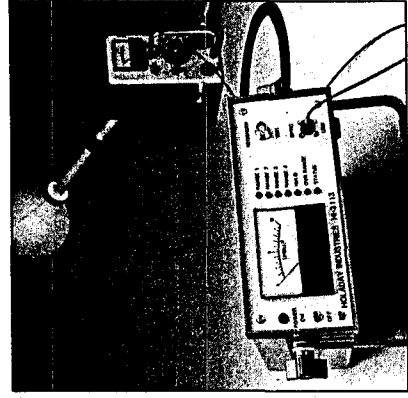
Accessories for Broadband Field Strength Meters



1. Replacement Handle/Cable that fits any broadband meter. (P/N 490333)
2. Extra Heavy Duty Case formfitted to the size of the broadband meter and probes. (P/N 490988)
3. NiCad Rechargeable Battery Pack. (P/N 30490310)
4. Battery Charger, Model HI-3101A, which plugs into the instrument to recharge the NiCad battery pack. The complete NiCad Battery Option includes the NiCad Battery Pack and the HI-3101A Charger.
5. A Probe Extension Cable. Available in 2, 5, 10, 15, 20, foot lengths. Adding an extension cable requires recalibration of the instrument.
6. Foam Spacer (not shown) - Interlocking sections fit over probe ball to provide nominal 10 cm spacing for "Hot Spot" measurements per FCC guidelines. (P/N 491002.)

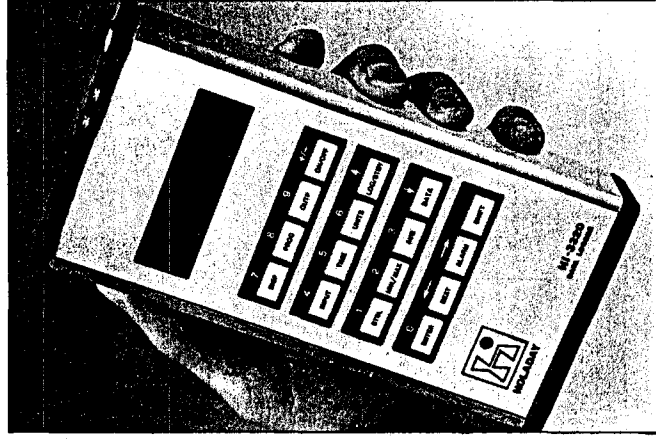


Model HI-3113 Fiber Optic Link



The HI-3113 shown at left, provides remote readout capability for the HI-3000 Broadband meter family. The HI-3113 includes the readout unit, 15 meter plastic optical cable, an optical transmitter installed in the HI-3000 meter, and the instruction manual. For distances longer than 15 meters, an optional glass fiber cable is available in custom lengths up to 300 meters. The glass cable is a factory installed option. An IEEE-488 digital output is available as an option. (P/N 380197)

Model HI-3320 Datalogger



Holiday Industries has developed the HI-3320 Datalogger for data collection when measuring RF and microwave fields for hazard evaluation and for determining compliance with the six minute time-averaging provision of the ANSI RF Exposure Standard, C95.1. Accurate time-averaged readings are important when high level exposures occur for short periods such as in RF heat sealing operations, or when workers climb through high field areas on broadcast antenna towers.

Combined with any HI-3000 series broadband field strength meter, the HI-3320 Datalogger will display the current 6 minute average, while logging data. This system allows monitoring both the instantaneous exposure level and the time-averaged level. The HI-3320 calculates, displays, and records the minimum, maximum, average, or current six minute average values of the measured fields. The Datalogger also provides a number of output formats either viewed on the Datalogger display or output to any serial input printer (RS-232C compatible) or an external computer.

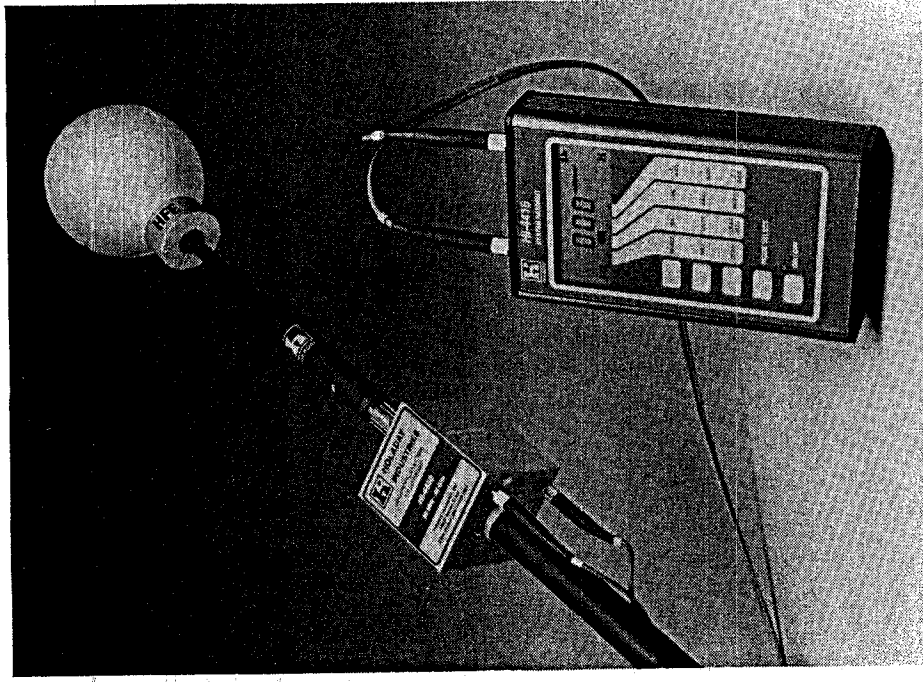


To order, contact Holiday Industries, Inc., 14825 Martin Drive, Eden Prairie, Minnesota 55344 (612) 934-4920 Fax (612) 934-3604

HI-4000

OPTICALLY ISOLATED RF / MICROWAVE HAZARD MEASUREMENT SYSTEM

NEW FROM HOLIDAY



The HI-4000 RF / Microwave Hazard Measurement System introduces fiber optic technology to minimize field perturbation in RF / microwave hazard measurements. At the heart of the system is the HI-4416 System Readout. This fiber optically isolated remote readout/control can be used with a family of Holaday electric and magnetic field sensors to provide a wide range (10 KHz to 40 GHz) of field measurements.

The HI-4000 System capabilities include datalogging, recorder output, and a custom LCD readout with bar graph, as standard features. The datalogging feature captures up to 150 field readings for later review using front panel controls. All selection and control functions are input from a front panel membrane switch pad. The recorder output (0-5 VDC) is proportional to the indicated field value. An optional computer interface is available.

Standard Features:

- Rugged Aluminum Housing
- Custom LCD Readout
- 2 Meter Fiber Optic Cable
- Battery Charger (110/220 V)
- Recorder Output
- Dielectric Handle

The HI-4000 RF / Microwave Hazard Measurement System gives you the option of selecting from the following components:

- HI-4416 System Readout
- HI-4422 Electric Field Sensor
(10 KHz - 1 GHz)
- HI-4450 Electric Field Sensor
(80 MHz - 40 GHz)
- HI-4433 HCH Magnetic Field Sensor
(5 - 300 MHz)
- HI-4433 LFH Magnetic Field Sensor
(300 KHz - 10 MHz)
- HI-4433 HSE Electric Field Sensor
(.5 - 30 V/m,
500 KHz - 1.5 GHz)
- HI-4433 STE Electric Field Sensor
(30 - 3000 V/m,
500 KHz - 6GHz)

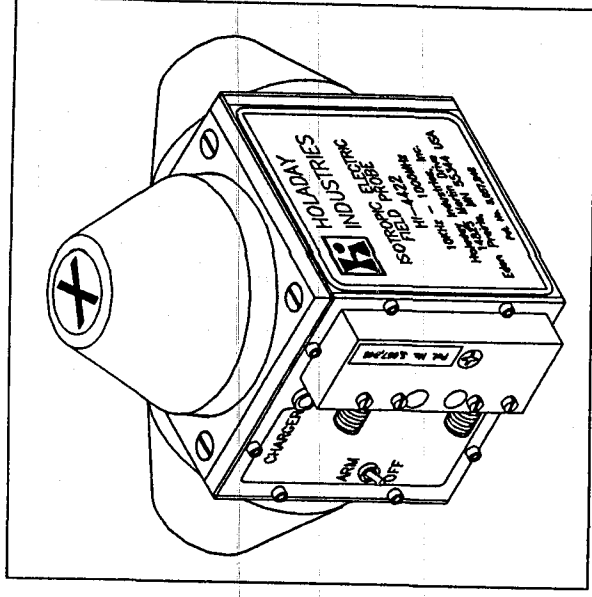


HOLIDAY INDUSTRIES, INC.
14825 Martin Drive
Eden Prairie, MN 55344
Telephone: (612) 934-4920
Fax: (612) 934-3604

SPECIFICATIONS:

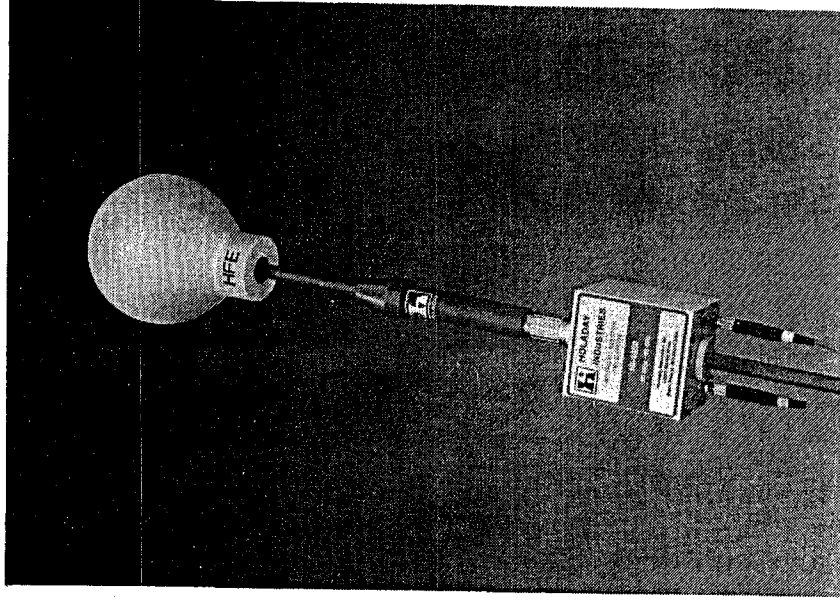
HI-4422

Sensitivity:	1 to 300 Volts/meter (V/m)
Frequency Response:	10 KHz to 250 MHz \pm 0.5 dB 250 MHz to 1.0 GHz \pm 1.0 dB
Linearity:	\pm 0.5 dB Full Scale \pm 2 least significant bits (LSBs) of A/D converter
Isotropy:	\pm 0.5 dB
Overload Withstand:	1000 Volts/meter (V/m) on any range
Sensors:	64 mm (2.5 inches) cube with sensor domes on three sides
Weight:	0.4 kg (14 oz.)



HI-4450

Sensitivity:	1 to 300 volts/meter (V/m)
Frequency Response:	80 MHz to 26 GHz \pm 1.5 dB 26 GHz to 40 GHz \pm 3.0 dB
Linearity:	\pm 0.5 dB Full Scale \pm 2 least significant bits (LSBs) of A/D converter
Isotropy:	\pm 1 dB
Average Overload:	6x Full Scale
Operating Temp:	10° to 40° C
Size:	Length 432 mm (17.0 in) Probe Diameter 102 mm (4.0 in)
Weight:	.54 kg (19 oz)



SPECIFICATIONS:

HI-4433-HCH

SPECIFICATION, HCH H-FIELD PROBE

Range 1 0.01 A²/m² Full Scale

Range 2 0.10 A²/m² Full Scale

Range 3 1.0 A²/m² Full Scale

Range 4 10.0 A²/m² Full Scale

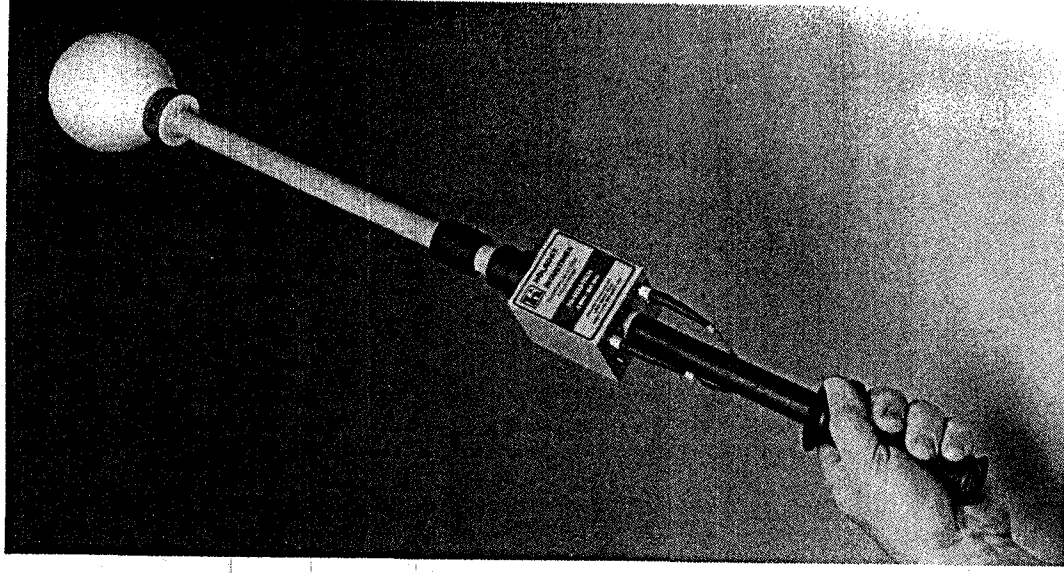
Frequency Response: 5 MHz to 300 MHz +2/-3 dB

Isotropy: ± 0.5 dB

Calibration Accuracy: ± 0.5 dB
(at calibration frequencies)

Size: Length 559 mm (22.0 in)
Probe Diameter 102 mm (4.0 in)

Weight: .51 kg (18 oz)



HI-4433-LFH

SPECIFICATION, LFH H-FIELD PROBE

Range 1 1.0 A²/m² Full Scale

Range 2 10.0 A²/m² Full Scale

Range 3 100.0 A²/m² Full Scale

Range 4 1000.0 A²/m² Full Scale

Frequency Response: 0.3 MHz to 30 MHz +2/-3 dB

Isotropy: ± 0.5 dB

Calibration Accuracy: ± 0.5 dB
(at calibration frequencies)

Size: Length 559 mm (22.0 in)
Probe Diameter 102 mm (4.0 in)

Weight: .57 kg (20 oz)



HOLADAY INDUSTRIES, INC.

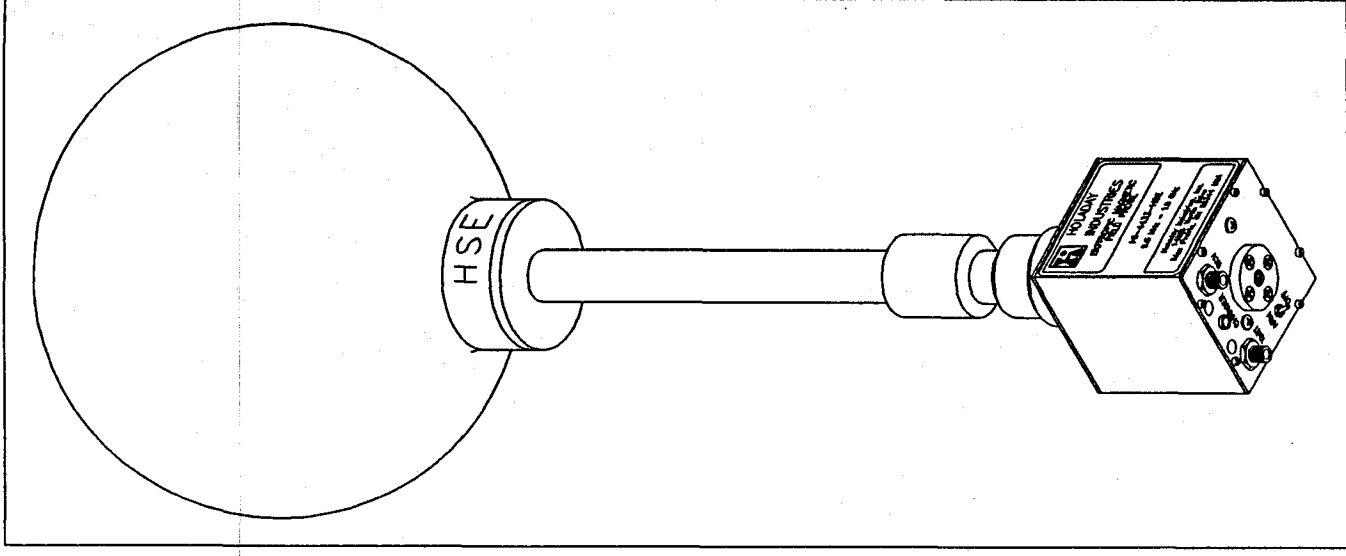
14825 Martin Drive
Eden Prairie, MN 55344
Telephone: (612) 934-4920
Fax: (612) 934-3604

SPECIFICATIONS:

HI-4433-HSE

SPECIFICATION, HSE E-FIELD PROBE

Range 1	1 V/M	Full Scale
Range 2	3 V/M	Full Scale
Range 3	10 V/M	Full Scale
Range 4	30 V/M	Full Scale
Frequency Response:	0.5 MHz to 1.5 GHz +2/-3 dB	
Isotropy:	± 0.5 dB	
Calibration Accuracy: (at calibration frequencies)	± 0.5 dB	
Size:	Length 559 mm (22.0 in) Probe Diameter 190 mm (7.5 in)	
Weight:	.54 kg (19 oz)	



HI-4433-STE

SPECIFICATION, STE E-FIELD PROBE

Range 1	100 V/M	Full Scale
Range 2	300 V/M	Full Scale
Range 3	1000 V/M	Full Scale
Range 4	3000 V/M	Full Scale
Frequency Response:	0.5 MHz to 5 GHz +2/-3 dB	
Isotropy:	± 0.5 dB	
Calibration Accuracy: (at calibration frequencies)	± 0.5 dB	
Size:	Length 559 mm (22.0 in) Probe Diameter 102 mm (4.0 in)	
Weight:	.54 kg (19 oz)	

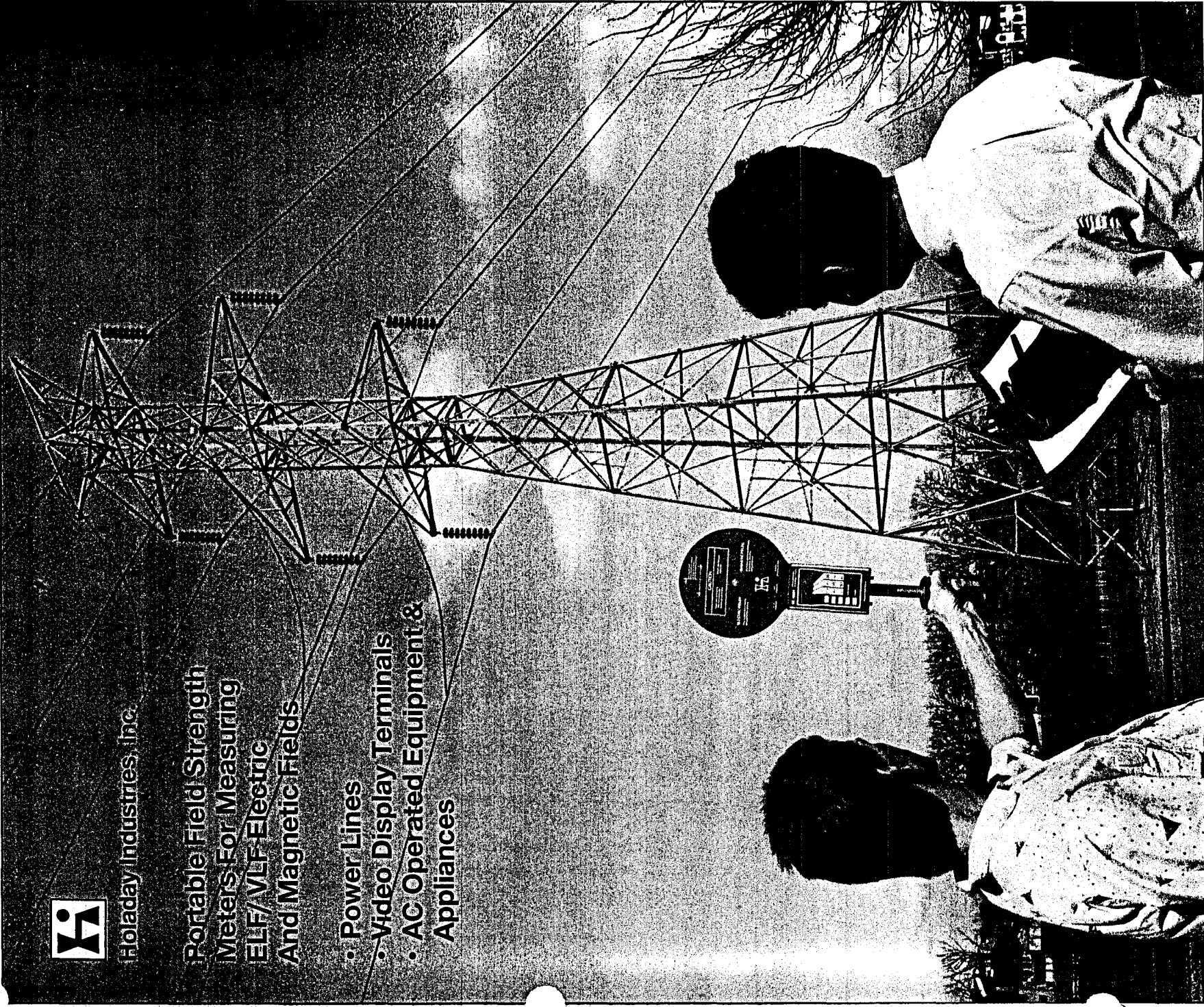
LOW FREQUENCY EMF INSTRUMENTATION



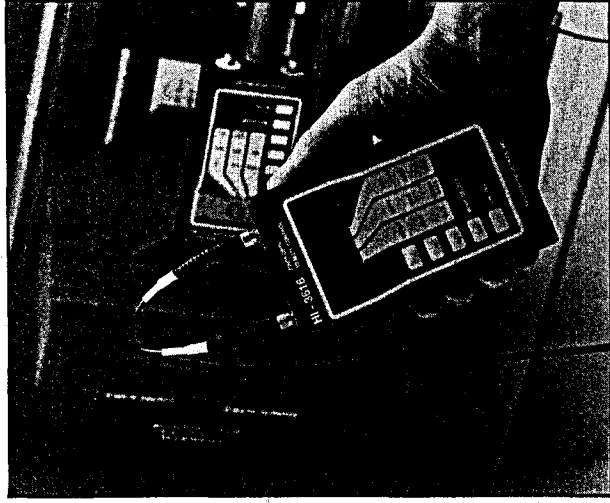
Holaday Industries, Inc.

Portable Field Strength
Meters For Measuring
ELF/VLF Electric
And Magnetic Fields

- Power Lines
- Video Display Terminals
- AC Operated Equipment & Appliances



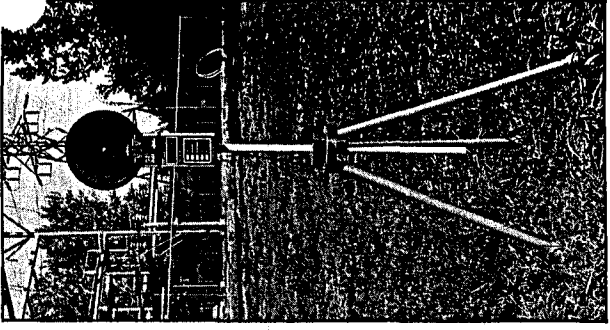
Accessories Available for the Low Frequency Meters



HI-3616 Fiber Optic Remote Control

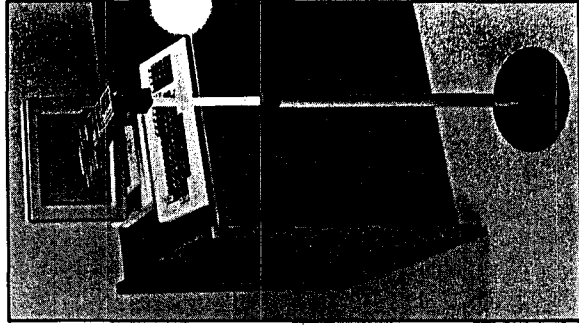
Foam spacer shown in background.

The HI-3616 Fiber Optic Remote Control is invaluable for electric field measurements where the surveyor must be isolated from the instrument. Such isolation is necessary to avoid perturbation of the ambient field. The HI-3616 is also helpful when the instrument orientation makes the display difficult to read. All control options of the basic instrument, including datalogging, are available at the Remote Control. A Recorder Output jack on the Remote Control provides a dc voltage proportional to the displayed field level for connection to a chart recorder or other external datalogging device. A three meter duplex fiber optic cable connects the meter with the Remote Control.



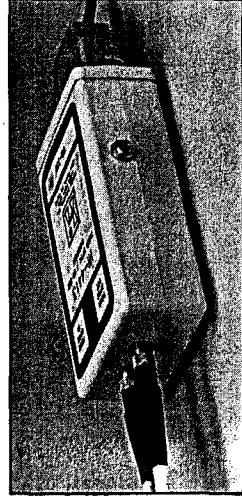
Dielectric Tripod and Floorstand

The dielectric tripod and floorstand provide a means of accurately locating the meter in an electric field while making accurate and repeatable measurements. Both the tripod and floorstand have adjustable heights and allow the meter to be oriented for either electric or magnetic field measurements.



HI-4413 RS-232 Adapter

The HI-4413 RS-232 Adapter converts the fiber optic signal from the HI-3603 or HI-3604 to an RS-232/PC compatible signal. Direct connection is now possible between the meter and a PC or other RS-232 communication device through the Adapter and the fiber optic ports. The command set allows remote control and data gathering from the field meter to PC. A wall plug power transformer is included - *Fiber optic cable not included.*



Exclusive from Holaday Industries, Inc.



The Complete Low Frequency Measurement System

Holaday Industries, Inc. has combined the HI-3603 VDT Radiation Survey Meter and the HI-3604 ELF/Power Frequency EMF Survey Meter into a Low Frequency Measurement System. This system is ideal for the radiation safety officer or industrial hygienist who needs to measure the low frequency spectrum.

The Low Frequency Measurement System includes:

HI-3603 VDT Radiation Survey Meter, with dielectric handle

HI-3604 ELF/Power Frequency Survey Meter

HI-3616 Fiber Optic Receiver, fiber optic cable

Double-Sided Carrying Case, #490979, which includes the foam spacer.



To order, contact **Holaday Industries, Inc.**, 14825 Martin Drive,
Eden Prairie, Minnesota 55344 (612) 934-4920 Fax (612) 934-3604

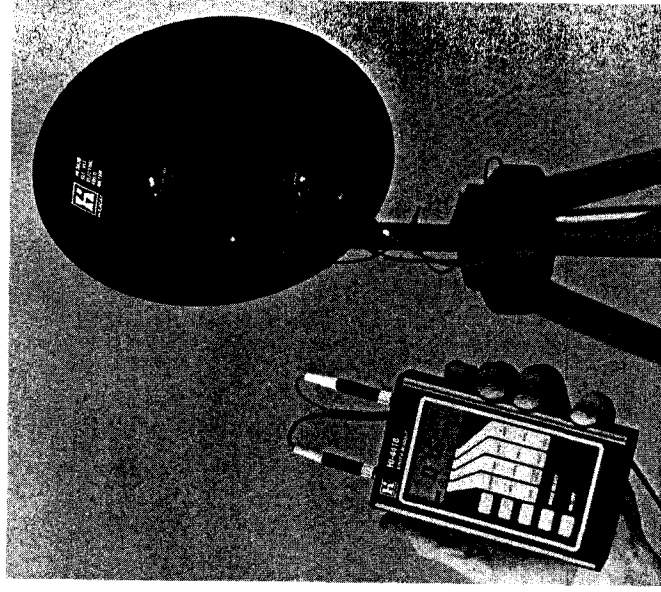
HI-3638

ELF/VLF ELECTRIC FIELD METER

NEW FROM HOLIDAY

Standard Features:

- Meets Swedish MPR Band I and II Requirements
- ELF: 5 Hz - 2 kHz
- VLF: 2 - 400 kHz
- Dynamic Range: 0.4 V/M - 40 kV/M
- Fully Isolated (fiber optic link)
- Digital Remote Readout (included)



Measure ELF and VLF Electric Fields with the HI-3638 Electric Field Survey Meter. Full ELF and VLF capability to the Swedish MPR and the proposed IEEE P1140 test requirements in a single meter makes electric field testing quick and simple. The HI-4416 Digital Readout included with the HI-3638 is fully isolated from the sensor by a two meter fiber optic cable. Full control and readout is available with the HI-4416 or with the optional HI-4413G RS-232 Serial Data Converter for connecting the HI-3638 Sensor directly to a computer.

Measurements as low as 0.4 V/M and up to 40 kV/M are possible with the HI-3638. The instrument is useful in low field measurements such as VDT's and computer monitors and in higher field environments such as near power transmission lines and industrial locations.

SPECIFICATIONS:

Frequency Response: Band I (ELF) 5 - 2,000 Hz

Band II (VLF) 2 - 400 kHz

Dynamic Range: 0.4 V/M - 40 kV/M (each band)

Full Scale Ranges: 4, 40, 400, 40k, 40 kV/M

Accuracy: ± 0.5 dB (at calibration frequencies)

Linearity: $\pm 5\%$ of full scale

Isotropy: Single Axis

Response: True RMS (Max Crest Factor = 3)

Wave Form Output (not isolated):

1 volt / f.s. range (3.5 mm phone jack)

Battery: NiCd, approx 40 hours operation on full charge.
15 hour recharge with standard charger

Operating Temp: 10 - 40 °C (50 - 104 °F)

Humidity: 5 - 95% RH, non-condensing

Size: 305 mm Dia, 102 mm High
(12 in x 4 in)

Weight: 1 KG (2.2 lb.)

Sensor Mount: 1/4 - 20 tripod thread

Complete with HI-3638 ELF/VLF Sensor, HI-4416 Digital Readout, 2 meter fiber optic cable, battery charger, fitted carry case and user manual.



HOLIDAY INDUSTRIES, INC.

14825 Martin Drive
Eden Prairie, MN 55344
Telephone: (612) 934-4920
Fax: (612) 934-3604

3-AXIS ELF Magnetic Field Meter

FROM HOLIDAY

Model HI-3627



Standard Features:

- Three Orthogonal Field Sensors
- True RMS Detection
- 100 dB Dynamic Range (0.2 milligauss-20 gauss)
- Remote Sensor
- Recorder Output
- Low Cost

Accurate ELF/Powerline Magnetic Field Measurements

Make isotropic measurements simply and economically with the HI-3627 3-Axis ELF Magnetic Field Meter. Signals from three orthogonal sensing coils are combined in a vector sum to provide accurate magnetic field measurements from any ELF magnetic field source. These include single or polyphase electrical circuits, VDT's, household wiring, and appliances.

Get true isotropic ELF magnetic field measurement capability in a low-cost, easy to use, yet accurate meter. The HI-3627 with its remote sensor and analog meter make quick work of finding ELF magnetic field distributions in any application. With its wide dynamic range (0.2 milligauss to 20 gauss), the HI-3627 is useful for measurement applications from home ambient environments to high current factory locations. Connect a datalogger or chart recorder to the recorder output and monitor field variation over time.

The 2 kHz upper cutoff frequency allows accurate measurements of more than 30 harmonics of a 60 Hz power frequency field.

The switch selectable low frequency cutoff provides either 5 Hz as specified by the Swedish Guidelines and the IEEE P-1140 Protocol or 30 Hz, recommended when searching for peak power frequency fields.

Specifications:

1. **5 Ranges:** (2, 20, 200 milligauss, 2, 20 gauss full scale)
2. **Sensor:** 3 concentric, orthogonal, shielded sensing coils; each 110 mm id X 116 mm od, (0.01 M²). Overall: 127 mm spherical diameter, 300 mm handle with 1.2M (4 ft) cable.
Optional: Single-axis sensor (110 mm id X 116 mm od) with 1.2M cable. Useful for determining field direction and source location.
3. **Frequency Response:** (switch selectable) 30-2000 Hz \pm 3 dB and 5-2000 Hz \pm 3 dB
4. **Recorder Output:** 1/4" phone jack, 0-5 VDC (1 mA max) proportional to meter deflection.
5. Powered by one 9.6V NiCad rechargeable battery (included). Approximately 30 hours of operation when fully charged.
6. **Instrument Dimensions:** 156 x 95 x 57mm (HxWxD)
7. **Weight:** Meter - .65 kg (23 oz)
Probe - .65 kg (23 oz)
8. Complete with battery charger, user manual, and custom fitted carrying case.

See HI-3624 Reverse Side

ELF/Power Frequency Magnetic Field Meter

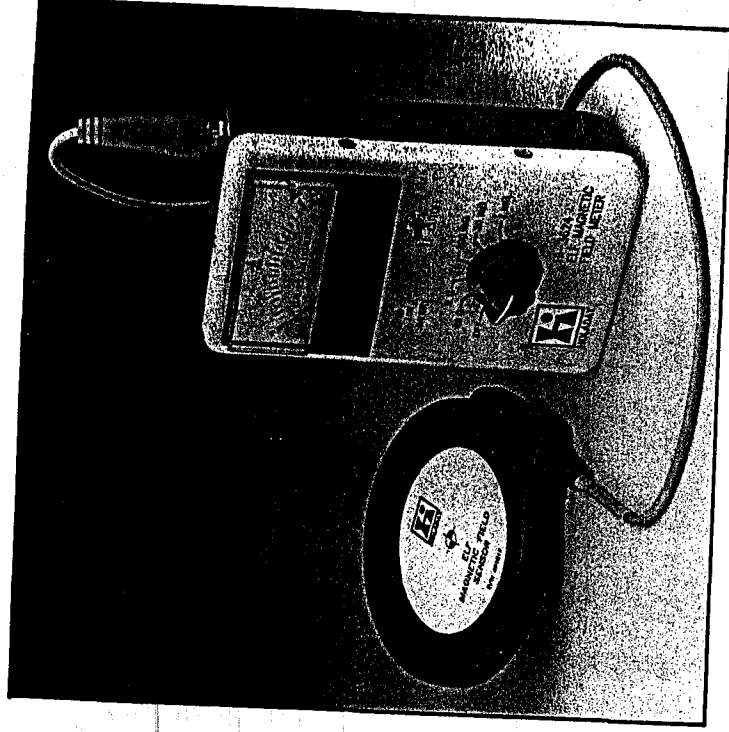
FROM HOLIDAY

Model HI-3624

Holiday Industries announces its Model HI-3624 ELF Magnetic Field meter specifically designed as a low cost, easy to use instrument for measuring ELF Magnetic Fields.

Standard Features:

- Low Cost
- True RMS Detection
- 100 dB Dynamic Range (0.2 milligauss-20 gauss)
- Remote Sensor for Easy Peak Readings
- Model HI-3624A meets Swedish ELF Requirements for Office Equipment Testing



Accurate ELF/Powerline Magnetic Field Measurements Made Easy With The Low Cost HI-3624 From Holiday

The Holiday HI-3624 ELF Magnetic Field Survey meter combines 25 years of Holiday experience in measuring Electromagnetic Fields with a low cost configuration resulting in an affordable, easy to use magnetic field meter for both field and laboratory measurements.

The standard configuration provides a wide 30-2000 Hz frequency response with stable readings when probing for peak field orientations. The 2000 Hz upper cutoff frequency allows accurate measurements of more than 30 harmonics of a 60 Hz power frequency field. The HI-3624A is available configured to meet the Swedish requirements for ELF magnetic field measurements. In the HI-3624A, a switch selectable low frequency cutoff gives either the 30-2000 Hz response for field testing or the 5 Hz to 2000 Hz frequency range specified by the Swedish testing protocol for office equipment.

Specifications:

1. 5 Ranges: (0 - 2, 20, 200 milligauss, 2, 20 gauss)
2. Sensor: 110mm id X 116mm od, (0.01M²)
Shielded Coil with 1.2M (4 ft) cable
3. Frequency Response:
HI-3624: 30 - 2,000 Hz \pm 3 dB
HI-3624A: 30 - 2,000 Hz \pm 3 dB and
5 - 2,000 Hz \pm 3 dB
(Switch Selectable)
4. Powered by two (2) nine volt batteries (included)
5. Instrument Dimensions: 156 x 95 x 52mm (HxWxD)
6. Both instruments come complete with User Manual. HI-3624A includes custom fitted carrying case.



HOLIDAY INDUSTRIES, INC.
14825 Martin Drive
Eden Prairie, MN 55344
Telephone: (612) 934-4920
Fax: (612) 934-3604

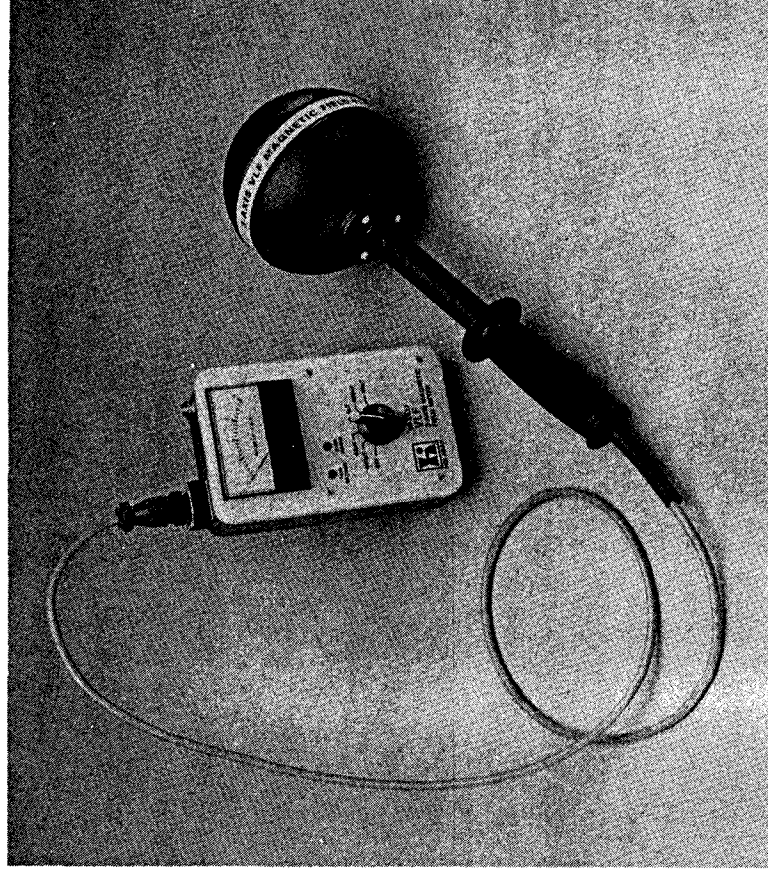
3637

VLF MAGNETIC FIELD METER

NEW FROM HOLIDAY

Features:

Orthogonal Field Sensors
MS Detection
Sensor
er Output



Accurate VLF Magnetic Field Measurements Made Easy With the New, 3-Axis HI-3637 From Holaday

Measurements simply and accurately with the HI-3637 3-Axis VLF Magnetic Field Meter. Three Orthogonal sensors are combined in a vector sum to provide accurate magnetic field measurements from any magnetic field source.

Isotropic VLF magnetic field measurements with the capability in a low cost, easy to use meter. The HI-3637 with its recorder or analog meter makes finding VLF magnetic field sources any application. With its wide range the HI-3637 is useful for many applications from VDT's and

SPECIFICATIONS:

1. Sensitivity: (in five ranges)
w/ Std. Sensor: 6 nT - 400 μ T (0.06 mG - 4 G)
w/ 100 X Sensor: 600 nT - 40 mT (60 mG - 400 G)
2. Sensor: 3 Concentric, Orthogonal, Shielded Sensor Coils each 110mm id. X 116mm od., (0.01 m²)
Overall: 127mm spherical diameter, 292mm Handle with 1.2 m (4 ft) Cable
3. Frequency Response: 2 kHz - 400 kHz \pm 3 dB w/ rolloff per SWEDAC
4. Recorder Output: 0-5 VDC (50 μ A Max) proportional to meter indication.
5. Powered by one (1) 12 V Rechargeable Battery (included).
6. Instrument dimensions: 6.62 x 4.12 x 2.75 in. H x W x D (168 x 105 x 70 mm)

HI-3550

MAGNETIC FIELD MONITOR

NEW FROM HOLIDAY

Standard Features:

- Measures Static (DC) and ELF AC Magnetic Fields
- 3-Axis Sensing for any field orientation (0 to 1000 Hz)
- Instantaneous and time-integrated measurements
- Wide measurement range: 0.1 to 300 mT (1 to 3000 gauss)
- User settable Alarm
- Compact size fits pocket or belt pack

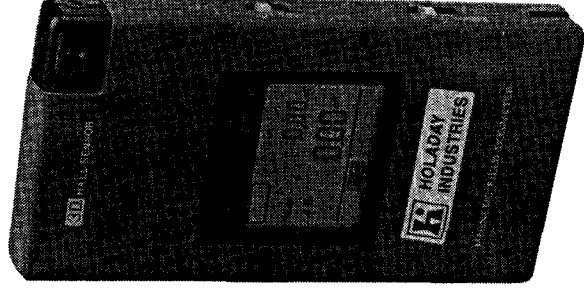
Monitor static (DC) magnetic fields in the workplace using the Holiday Industries HI-3550 Magnetic Field Monitor. Measure instantaneous (updated every 3 seconds) fields up to 0.3 Teslas. Concurrently use the time-integrating feature to track 8-hour average exposure according to the ACGIH (American Conference of Governmental Industrial Hygienists) TLV for static magnetic fields.

ELF AC magnetic field monitoring to ACGIH or IRPA (International Radiation Protection Association) guidelines for both instantaneous and time-averaged exposures is easily accomplished with the HI-3550.

3-Axis (Isotropic) sensing measures the actual resultant field regardless of instrument orientation. Measuring only 13.2x7.4x2 cm (5.2 x 2.9 x 0.8 inches) and weighing only 5 ounces, the HI-3550 fits conveniently in a pocket or in the included belt pack.

APPLICATIONS:

- MRI/NMR Installations (monitor and map 5 gauss contours according to pending IEC Guidelines)
- Research Laboratories (Magnets and High Current DC applications)
- Electro-chemical Processing Industries - (electroplating, electro-galvanizing, electro-refining operations)



SPECIFICATIONS:

Sensor: InAs Hall Effect Sensor, three-axis (isotropic) response

Measurement range:

0.1 mT to 0.3 T

DC Measurement accuracy:

0.1 mT to 0.5 mT: ± 0.05 mT

0.5 mT to 0.3 T: $\pm 10\%$

Measurement update period:

3 seconds

Measurement modes:

Instantaneous (with peak hold function)

Integrating (mT-hours)

Alarm function:

Instantaneous & Time Integrating

Operating Temperature Range:

0 °C to 50 °C

Battery:

4 Size AAA alkaline battery cells

Outside dimensions:

13.2 X 7.35 X 2.0 cm

(5.2 X 2.9 X 0.8 in)

Weight:

Approximately 150 g (5.3 oz)

Complete with batteries, user manual and belt pack case. Contact Holiday Industries for detailed specifications.



HOLIDAY INDUSTRIES, INC.

14825 Martin Drive
Eden Prairie, MN 55344
Telephone: (612) 934-4920
Fax: (612) 934-3604

HI-3520

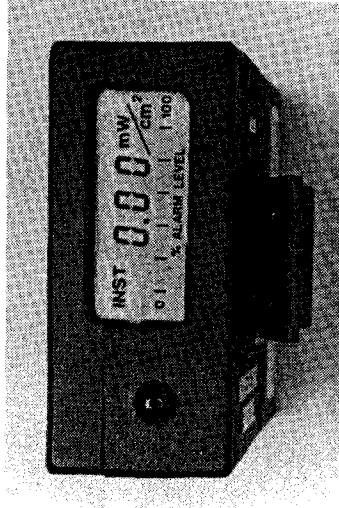
MICROWAVE MONITOR

NEW FROM HOLIDAY

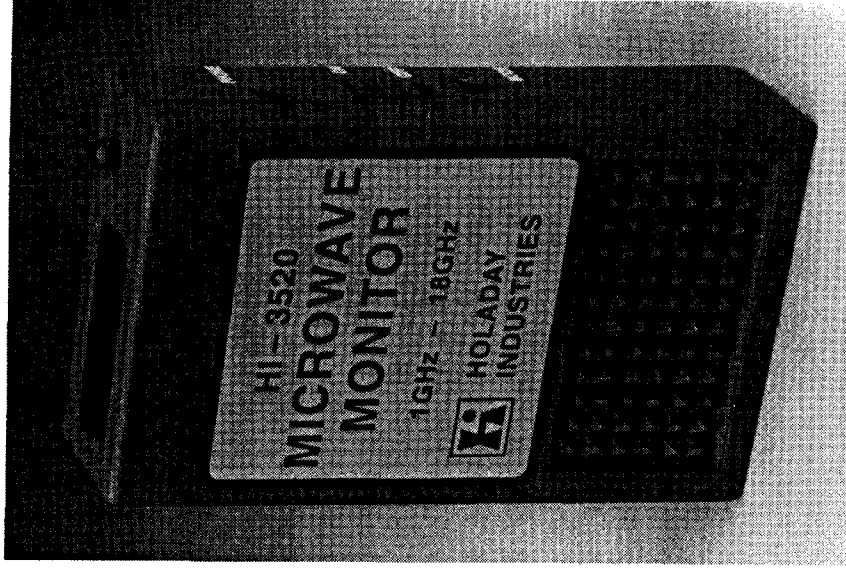
The HI-3520 Microwave Monitor is a pocket sized, battery operated, non-ionizing radiation hazard detector intended for personal use. It detects electromagnetic radiation from RF and microwave sources in the frequency range from 1 to 18 GHz and alerts the user to potentially hazardous fields. The HI-3520 enables the user to set the alarm warning level anywhere in the range from 0.2 to 20 mW/cm², using either of two measurement modes: instantaneous exposure level or a six minute average measurement. Both modes are displayed on a three digit LCD readout along with a ten segment bar graph normalized to the selected alarm warning level. Acoustic earphone included for use in noisy environments. Electrical, mechanical and performance characteristics are described in the table below.

The HI-3520 is intended for use by personnel who work with or service RF and microwave equipment such as:

- Microwave Ovens
- Medical Equipment
- Radar Installations
- Microwave Heaters and Dryers
- Communication Systems
- Electronic Warfare Systems



LCD READOUT



SPECIFICATIONS:

FREQUENCY RANGE: 1 to 18 GHz
POWER DENSITY RANGE: 0.01 to 20 mW/cm ²
MAX AVERAGE: 0.5 W/cm ²
MAX PEAK: 100 W/cm ²
MAX PULSE: 150 W-μsec/cm ²
ALARM ACCURACY: ± 2dB
OPERATING TEMPERATURE:	.. -10°C to +50°C
BATTERY: Lithium, typical life 1000 hours
SIZE: inches 2.40 x 3.75 x 1.00 mm 61.0 x 95.3 x 25.4
WEIGHT: oz 4.8 gm 136


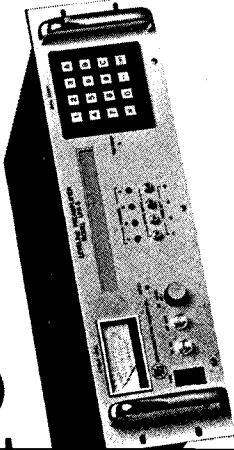



HOLIDAY INDUSTRIES, INC.

14825 Martin Drive
Eden Prairie, MN 55344
Telephone: (612) 934-4920
Fax: (612) 934-3604

AMPLIFIERS  ANTENNA

00  E-FIELD  

E-FIELD ROOM  

EMC TESTS  M400

EPA SERIES  AMPLIFI

SOLID STATE  AMPLIFIERS

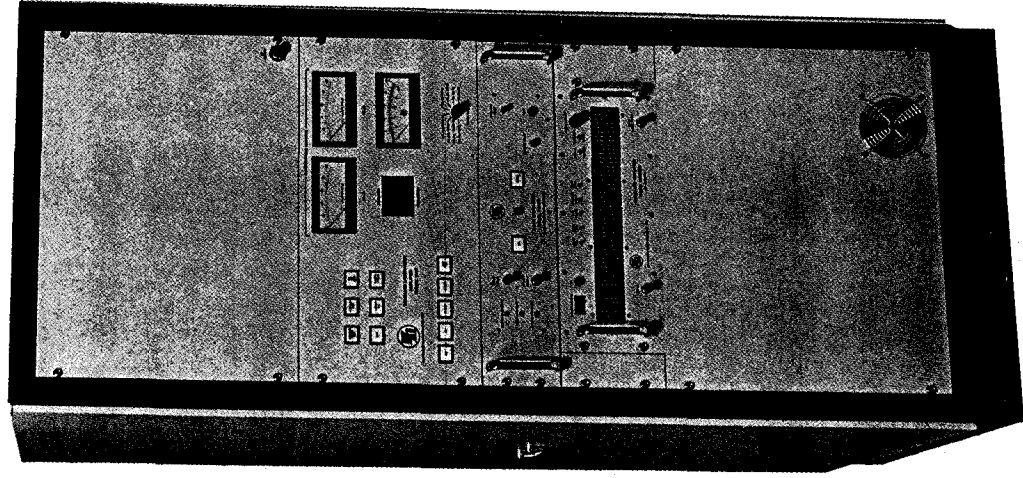
AMPLIFIERS  TEM CELLS 

 TEM CELLS  WIDE BAND

 WIDE BAND SENSOR

 E-FIELD  ANTENNA

POWER Amplifiers



FEATURES

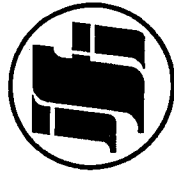
- Flat response 0.01 MHz - 220 MHz
- Linear, amplifies all forms of modulation
- High power gain, drive with signal generator
- No tuning, no bandswitching
- Fully protected and metered
- Modular design
- Pulse capability

APPLICATIONS

- RF/EMI susceptibility testing
- NMR, ENDOR spectroscopy
- Driving higher power amplifiers
- Broadband communications
- Component and material testing
- Immunity testing
- Antenna Testing
- Driving electro-optical modulations
- Biological research
- SAE specifications
- EMP simulation
- Ionospheric research and instrumentation
- Testing shielding effectiveness
- Boeing specifications
- Test equipment calibration
- IEC-801-3
- DO 160
- MIL-STD 461/462

HIGH POWER Amplifier Series of broadband amplifiers provide a choice of power outputs to 15,000 Watts over a broadband width from 0.01 MHz to 220 MHz when driven by typical signal generators, sweepers or synthesizers. Any signals within the passband are

amplified without frequency discrimination. No tuning or band switching is necessary. All forms of modulation are faithfully preserved. The **Power Amplifier Series** will operate into any mismatch load.



Instruments for Industry, Inc.
731 Union Parkway
Ronkonkoma, New York 11779
516 467 8400 Fax: 516 467 8558

OUR QUOTE NO. 212-00

07/13/94

MIT
CENTER FOR SPACE RESEARCH
ROOM 20B-145
CAMBRIDGE, MA 02139

ATTN: MR YARON HEFETZ

QUOTATION

DUPLICATE

We are pleased to submit the following price quotation in response to your referenced request:

QUANTITY QUOTED	U/M	ITEM NO.	PART DESCRIPTION	UNIT PRICE	TOTAL PRICE
1.00	EA	01	EFS-3 E-FIELD SENSOR 0.01 TO 220 MHZ DELIVERY: SIX TO EIGHT WEEKS Rev. 00	1350.00	1350.00
				TOTAL	1350.00

CONTACT YARON HEFETZ PHONE 617 256 6412
FAX 617 253 7014

This quote with brochure and data sheets will be mailed to you.

If you have any questions, please call at your convenience.

I will call you for a follow up in approximately one week.

LEAD TIME:

The lead time on this quotation is based on year round average delivery times. The actual lead time for this item will depend on our production and inventory status at the time of receipt of purchase order.

TERMS & CONDITIONS:

This quote is subject to the standard terms and conditions of Instruments For Industry, Inc.

Shipments are made FOB Ronkonkoma, New York.

The payments terms are net thirty (30) days to rated accounts.

This proposal may be considered valid for a period of sixty (60) days, after which time it shall be subject to review.

CUSTOMER

Instruments For Industry, Inc. is classified as a small business concern under the provisions of the Small Business Act.

Thank you for your interest and the opportunity to quote on this requirement.

Best Regards,

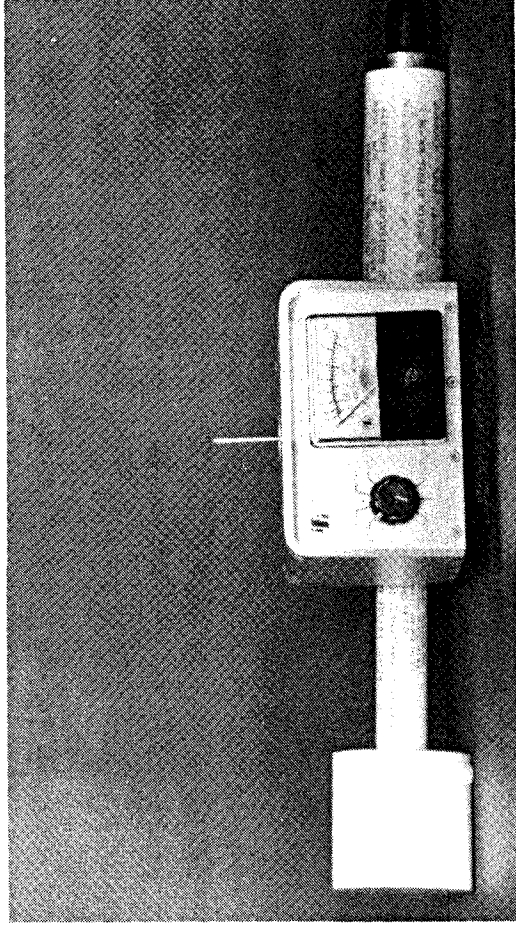
A handwritten signature in cursive script, appearing to read "R. Janiec".

Richard Janiec
Sales/Marketing

EFS-5

E-Field Sensor

10 kHz to 40 GHz



EFS-5 Shown With External Probe

FEATURES

- Direct Reading in Volts/Meter
- CW Capability
- Continuous Auto Zero
- Broadband Coverage
- No Tuning
- Rechargeable Batteries
- Negligible Field Distortion
- Can be used with IFI Accessories—Remote Readout—Fiber Optic Data Link, etc.

APPLICATIONS

- RFI Susceptibility Testing
- Measuring and Controlling Field Strength
- Transmitting Antenna Field Plotting and Checking
- Quantitative "ON THE AIR" Monitoring
- Surveying Installation Sites for Sensitive Equipment
- Monitoring Electromagnetic Environment in Hazardous areas
- Locating Sources of Electromagnetic Interference

DESCRIPTION

The EFS-5 E-Field Sensor is a highly versatile self contained test instrument that measures electric fields from 10 kHz to 40 GHz. The EFS-5 allows reading field strength directly in volts per meter (V/M) from 10 kHz to 500 MHz using its own integral antennas; and up to 40 GHz using external probes (frequency range determined by probe model). Refer to Table 1.

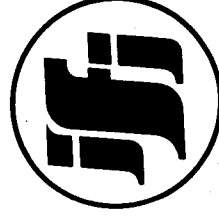
The EFS-5 has the capability of measuring electric fields up to 300 V/M (the EFS-50301 external probe can measure to 1000 V/M from 300 kHz to 1.0 GHz). Each antenna or probe covers a 30 dB dynamic range. When the antennas are used from 10 kHz to 500 MHz no tuning, bandswitching, or other frequency adjustments are required. Also, when the external probes are used over their respective frequency range no tuning, bandswitching, or frequency adjustments are required. Refer to Table 2.

The EFS-5 is ideal for radiated susceptibility tests. It is the basic building block of a series of system oriented modules that provide a wide range of instrumentation capabilities for making simple direct field measurements to fully automatic constant-field swept or stepped frequency systems.

A companion Light Modulator Transmitter is also available for remote reading and control using fiber optic data links to avoid field distortion and erroneous readings due to the presence of conductive interconnecting cables.

INSTRUMENTS FOR INDUSTRY, INC.

731 UNION PARKWAY RONKONKOMA, NY 11779
 TEL 516-467-8400 FAX 516-467-8558



EFS-5 SPECIFICATIONS

Frequency Range: 10 kHz to 40 GHz

Integral Antennas: 10 kHz to 500 MHz

External Probes: 300 kHz to 40 GHz

< 5% of full scale

Meter Accuracy:

Direct reading - Volts per meter

Meter Scale:

30 dB dynamic range with each

antenna or probe. Front panel range selector

Meter Zero:

Continuous Auto Zero

Power:

Internal rechargeable NICAD battery (charger included)

Typically 24 hours minimum fully charged (8 hour recharge time)

Front panel Battery Test Selector

3.0 x 4.0 x 5.25 in

7.6 x 10.2 x 13.3 cm

Plus Antennas/Probes

1 lb 13 oz (0.71 kg)

Compatibility:

Compatible with all the accessories used with the EFS-1, 2, or 3 E-Field Sensors.

EFS-5 FULL SCALE SENSITIVITY/RANGE SELECTOR SETTING

RANGE SELECTOR SETTING >	3 V/M	10 V/M	30 V/M
INTEGRAL ANTENNAS	ACTUAL MEASUREMENT RANGE		
5" (12.7 cm)	3 V/M	10 V/M	30 V/M
1" (2.54 cm)	30 V/M	100 V/M	300 V/M

RANGE SELECTOR SETTING >	3 V/M	10 V/M	30 V/M
PROBE	ACTUAL MEASUREMENT RANGE		
0301-S (300 kHz - 1.0 GHz)	1 V/M	3 V/M	10 V/M
0301 (300 kHz - 1.0 GHz)	30 V/M	100 V/M	300 V/M
0301-H (300 kHz - 1.0 GHz)	100 V/M	300 V/M	1000 V/M
3040 (300 MHz - 40.0 GHz)	30 V/M	100 V/M	300 V/M

TABLE 1

EFS-5 EXTERNAL PROBES

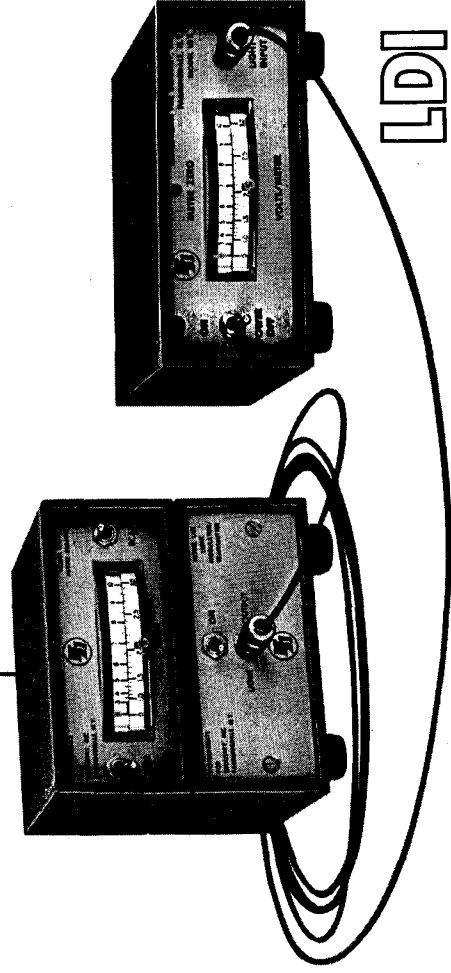
PROBE	EFS-5-0301-S	EFS-5-0301	EFS-5-0301-H	EFS-5-3040
FREQUENCY RANGE	300 kHz to 1.0 GHz			
FIELD STRENGTH RANGE (FULL SCALE)	1, 3, 10 V/M	30, 100, 300 V/M	100, 300, 1000 V/M	30, 100, 300 V/M
SIZE	17.75" (45 cm) Long			
CABLE LENGTH	4.0' (123 cm) Long			

TABLE 2

COMPARISON CHART

	EFS-1	EFS-2	EFS-3
Frequency Range 10kHz-220 MHz	X	X	X
Field Strength Range 1 V/M-300 V/M	X	X	X
Uses 9V Throw Away Battery	X		
Can Operate with LMT, LDI or LPA-2	X	X	X
Uses Rechargeable Nicaid Cells		X	X
Measures CW Signals	X	X	X
Measures Peak Value of a Train of Pulses		X	X
Measures and Holds (≥30 secs.) Peak Value of Single Pulse (such as EMP)			X

EFS-1/LMT



LDI

MODEL LMT DESCRIPTION

The LMT Light Modulator-Transmitter is an accessory unit to the EFS-1 E-Field Sensor. It attaches directly to the underside of the EFS-1 and converts the voltage output of the Sensor to an optical signal which is coupled away from the field under test by means of an electrically non-conducting fiber optic "light pipe" for remote reading and control.

Like the EFS-1, the LMT is completely self-contained and operates on rechargeable nicad batteries. It produces telemetering light flashes by means of a light-emitting diode modulated by a stable voltage-controlled oscillator. These light flashes may be counted for digital use or applied to a frequency-to-voltage converter for analog indication and control. Frequency and light intensity are directly compatible with control inputs of IF1 Leveling Power Amplifiers for constant-level swept-frequency susceptibility systems.

The **LDI Light Demodulator-Indicator** is another accessory which is identical in size and similar in appearance to the EFS-1. In operation, it reverses the process of the LMT. It accepts the light-flash input from the LMT fiber optic link and converts it to a meter indication reading directly in volts/meter and provides an analog output proportional to the remote field sensor reading.

LMT SPECIFICATIONS

Input: 0 to 5.8 volts from EFS-1 (coaxial pigtail provided)
Output: 1500 to 3000Hz red light flashes proportional in frequency to EFS-1 meter reading
Power: Rechargeable batteries. Charger supplied.
Dimensions: Identical to EFS-1; 4" x 4" x 2"
Weight: 10 ounces
Mounting: Attaches beneath EFS-1

LDI SPECIFICATIONS

Input: 1500 to 3000Hz red light flashes proportional in frequency to EFS-1 meter reading.
Output: 0 to 5.5 volts (Upper limit adjustable)
Accuracy: Better than 5% of full scale
Calibration: Direct reading in volts per meter
Input Power: 115/230 VAC, 50/60Hz
Dimensions: 5" x 4" x 2"
Weight: 2 lbs.

APPLICATIONS DATA

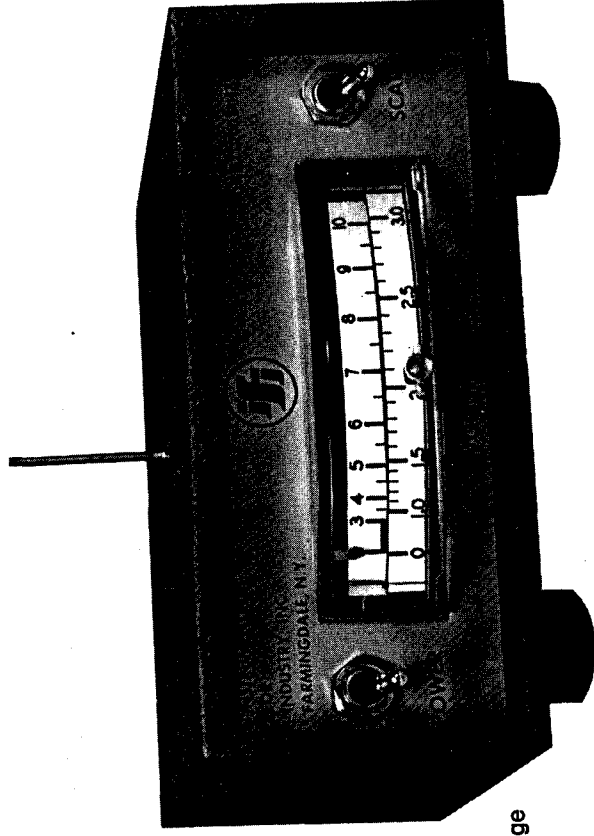
MEASURING POTENTIALLY HAZARDOUS ELECTROMAGNETIC RADIATION

In recent years there has developed an increasing awareness of the possibility of human biological effects caused by electromagnetic fields. While there is a great deal of research, investigation and quantifying of this data yet to be done, enough work has been done in this country and abroad to develop some current standards for the exposure of personnel to electromagnetic energy.

IFI has been making for a number of years, a direct reading broadband field strength meter which is calibrated in volts per meter. It is designed to respond uniformly to fields in the frequency range between 10 kHz and 220 MHz.

It is designed to measure fields ranging between 1 volt per meter and 300 volts per meter and requires no tuning or calibration. The EFS-1 responds to the electric component of the field and is normally used to measure a field whose polarization is vertical. By using the optional dielectric handle, the EFS-1 can be aligned with the electric field, (by finding the maximum meter reading). The polarization of the field is then immediately apparent as well as the field strength of the electric field component.

The RHM-1 and RHM-2 (pg. 4) were developed in response to requests for an isotropic meter, which performs as the EFS-1, but without the polarization sensitivity. It consists of the equivalent of three EFS-1 units with the field probes arranged in a mutually orthogonal fashion, and the outputs being processed so as to indicate the vector sum of the orthogonal components on the meter. Therefore the RHM-1 and RHM-2 will indicate the value of the field regardless of its polarization. Its chief advantage is that it does not have to be aligned with the field in order to obtain an accurate reading. The difference between the RHM-1 and RHM-2 is that the RHM-2 contains the built-in light modulator transmitter for driving a fiber optic coupling link to permit remote reading.



FEATURES

- Direct Reading in Volts/Meter
- Broadband Coverage
- No Tuning
- No Bandswitching
- Compact, Battery Operated
- Negligible Field Distortion
- System Compatibility
- Useful for Reading & Control
- Five Meter Ranges for Easy Reading
- Approved for MIL-STD-461, 462
- No Calibration Curves or Tables
- Inexpensive

APPLICATIONS

- RFI Susceptibility Testing
- Measuring and Controlling Field Strength
- Transmitting Antenna Field Plotting and Checking
- Quantitative "on the air" Monitoring
- Surveying Installation Sites for Sensitive Equipment
- Monitoring Electromagnetic Environment in Hazardous areas
- Locating Sources of Electromagnetic Interference
- Visualizing Field Polarization and Distribution in Research and Educational Laboratories

EFS-1 SPECIFICATIONS

Frequency Range:	Direct reading from 10kHz to 220MHz	
Accuracy:	Better than 5% of full scale	
Calibration:	Direct reading in volts per meter	
Input Power:	Two 9-volt transistor radio type batteries	
Battery Drain:	Less than 10 milliamperes, each	
Dimensions:	Width and Depth, 4 inches Height, 2 inches plus antenna	
Weight:	15 ounces, including batteries	
Ranges:		
Antenna Range	Full Scale	Useful Range
5"	LO 3 V/M	1 to 3 V/M
5"	HI 10 V/M	3 to 10 V/M
1"	LO 30 V/M	10 to 30 V/M
1"	HI 100 V/M	30 to 100 V/M
3/8"	HI 300 V/M	100 to 300 V/M

EFS-1
EFS-2
EFS-3
E-FIELD SENSORS

LMT
LIGHT MODULATOR TRANSMITTER

LDI
LIGHT DEMODULATOR INDICATOR

RHM-1
RHM-2
RADIATION HAZARD MONITORS

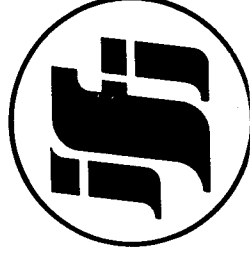
EFS-1 E-FIELD SENSOR

The EFS-1 E-Field Sensor is a highly versatile, low cost test instrument for measuring strong electric fields in the VLF, LF, MF, HF and VHF regions of the spectrum. No tuning, bandswitching or other frequency-related adjustments are required. It is calibrated directly in volts per meter with four convenient ranges for direct reading of 1 to 300 volts/meter from 10kHz to 220MHz. Because the EFS-1 is physically small and self-contained (powered by two standard 9-volt batteries) its effect on the field being measured is negligible.

The EFS-1 is ideal for radiated susceptibility tests. It is the basic building block of a series of system-oriented modules that provide a wide range of instrumentation capabilities for making simple, direct field measurements to fully automatic constant-field swept or stepped frequency systems.

It costs a small fraction of alternate methods and yet provides faster, more accurate readings with vastly improved convenience and resultant dependability. Because of its low cost, several can be used at multiple locations to check a field for uniformity.

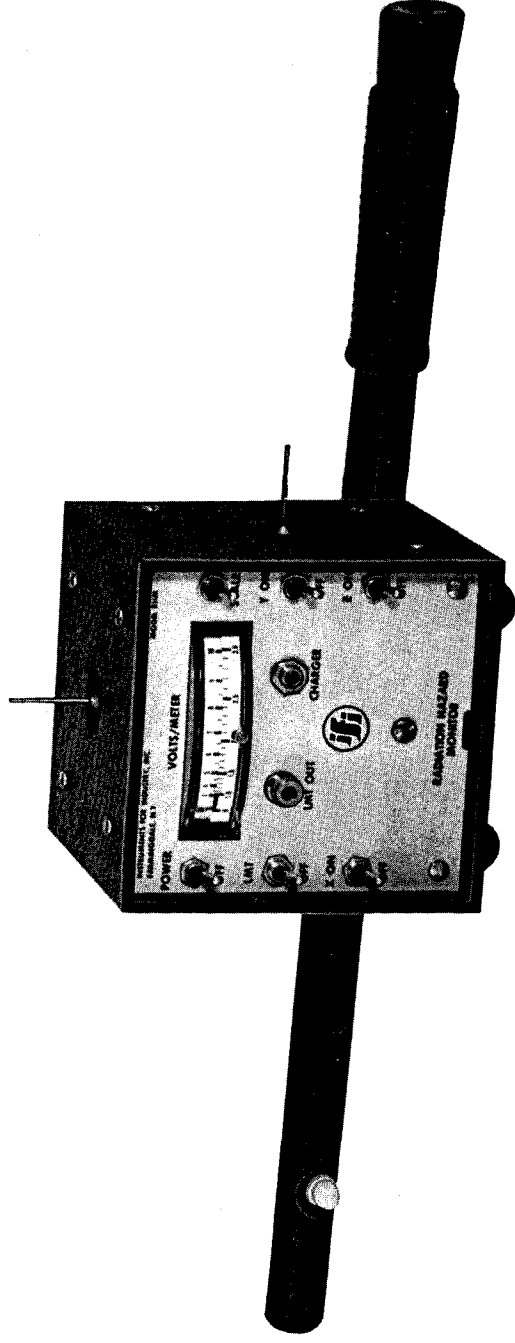
A companion Light Modulator-Transmitter is also available for remote reading and control using fiber optic data links to avoid field distortion and erroneous readings due to the presence of conductive interconnecting cables.



INSTRUMENTS FOR INDUSTRY, INC.

731 UNION PARKWAY RONKONKOMA, N.Y. 11779

TEL 516 467-8100 FAX 516-467-8558



RHM-1, RHM-2

RADIATION HAZARD MONITORS

The IFI RHM-1 and RHM-2 are easy to use, low cost, highly versatile instruments for the measuring of strong electric fields in the VLF, LF, MF, HF, and VHF regions of the spectrum. No tuning, bandswitching, or other frequency related adjustments are required. It is calibrated directly in volts per meter with four convenient ranges for direct reading between 1 and 300 volts per meter over the frequency range from 10 kHz to 220 MHz. Because the RHM-1 and RHM-2 are physically small, and self-contained, their effect on the field being measured is negligible.

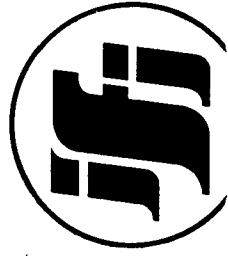
The RHM-1 and RHM-2 are derived from the widely used and highly successful IFI EFS-1 E-Field Sensors. They are specifically designed to provide an isotropic response which is not polarization sensitive. As such, the RHM-1 or RHM-2 may be placed on any convenient shelf, bracket, or table at the site where measurement is desired. Because of its broadband nature, it will respond to the entire frequency spectrum of interest and thus permit the measurement of the effective electric field of a complex multi-frequency environment. The optional dielectric handle will permit it to be used as a probing device for determining the source of radiation. Individual axis switches permit the measurement of the individual field components in the three orthogonal planes.

The RHM-2 contains the optional driver circuitry for driving a fiber optic link to permit remote readout of the field data using the remote LDI (Light Demodulator Indicator).

The RHM-1 and RHM-2, together with the EFS-1 are offered to industry for the measurement of potentially hazardous electric fields, and the protection of personnel from such exposure.

FEATURES

- Direct Reading in Volts
- Broadband Coverage
- No Band Switching
- Compact, Battery Operated
- Negligible Field Distortion
- System Compatibility
- Useful for Reading & Control
- Low Cost
- No Calibration Curves or Tables
- Select individual axis or combine multiple inputs for composite readout.



INSTRUMENTS FOR INDUSTRY, INC.

731 UNION PARKWAY RONKONKOMA, N.Y. 11779

TEL. 516.467.0100 FAX 516.467.0550

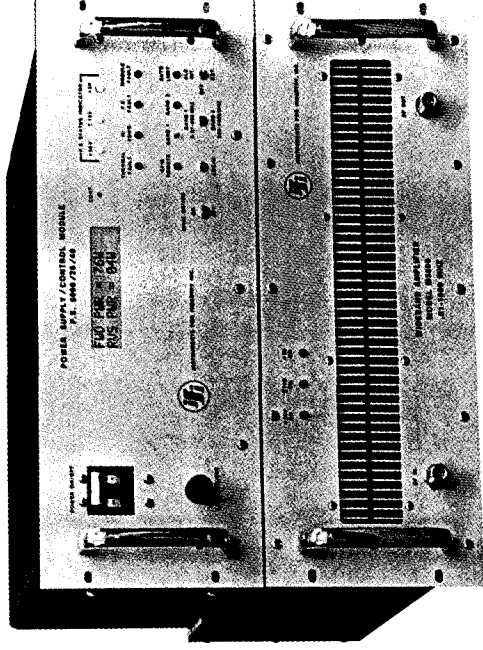
SOLID STATE

Amplifiers

SOLID STATE Amplifiers are self-contained ultra broadband amplifiers with frequency operation from 0.01 MHz to 1000 MHz. They have internal/external electronic gain control with built-in capability for automatic leveling control. They are unconditionally stable and cannot be damaged by any mismatch load.

FEATURES

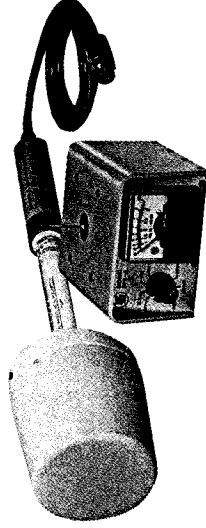
- Solid state design
- ALC for external leveling
- Internal amplitude leveling
- Forward/reverse power indicator
- On board diagnostics
- Mismatch load protection



APPLICATIONS

- Perfect for IEC 801 testing
- MIL-STD radiated susceptibility testing
- Bulk cable current injection
- Evaluate anechoic rooms and shielding effectiveness
- Perfect for use with GTEM cell
- General lab applications (VLF to UHF in one package)

E-Field Sensors



The EFS-SERIES of E-Field Sensors provide a versatile self contained test instrument to measure E-Fields from 1 to 300 V/m over the frequency range of 10 kHz to 40 GHz depending on model.

Control of E-Fields can be accomplished by fiber optic links when used with an associated Light Modulator Transmitter feeding either a remote Light Modulator Indicator, or the LPA-5 Leveling Preamplifier.

FEATURES

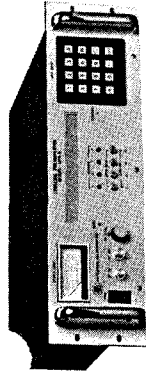
- Fast response
- Direct reading V/m
- Broadband coverage
- Portable
- Highly reliable
- No tuning
- No bandswitching
- No field distortion
- Battery operated

APPLICATIONS

- EMI/RFI
- Controlling field strength
- Monitoring EMC environment
- Noise source location
- Immunity testing
- Hazard testing

LPA Series

Microprocessor controlled leveling pre-amplifiers that permit up to 8 E-Field Sensors in a closed loop leveling system. The LPA Series can perform complex calculations and vary the gain of a power source to maintain a constant field. The user can select individual channel inputs and specify upper control limits on each channel for screen room or test chamber immunity testing.



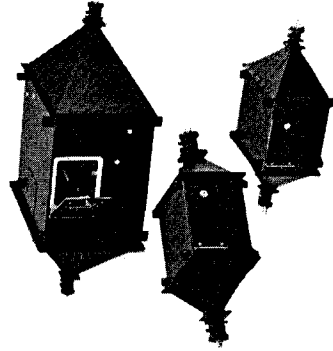
- Flatness (Unleveled):
(Leveled):
 - ± 1.0 dB
 - ± 0.25 dB
- Gain:
 - 6 dB, typical
 - >40 dB (continuous)
 - <1.0 dB at 1 mW (0 dBm)
- Intercept Point:
 - 4.0 dBm
 - < -25 dBc (0 dBm output)
 - 30 dB
- Third-order IMD:
 - 8 db at 0 attenuation
 - 500 samples/channel per second

FEATURES

- Freq. Range (single band): 10 kHz to 40 GHz
- Internal: 10 kHz to 1 GHz
- External: see note

Note: External control - Above 1 GHz, the LPA-5 provides an analog output voltage via the ALC output that can be used as a leveling signal. Also, if the IEEE-488 option is installed the field strength indications can be obtained via the bus interface.

TEM Cells



The TEM Cell Series enable generation of E-fields within their own shielded chambers for an entire frequency range, or for the difficult 0.01 MHz to 100 MHz frequency band where antennas are inadequate, or impractical.

TEM Cells are available up to 1000 MHz, however the upper frequency limit is inversely proportional to the test object size. New developments in mode suppression with absorber or ferrite now allow almost doubling the TEM Cell frequency range to permit testing larger test objects.

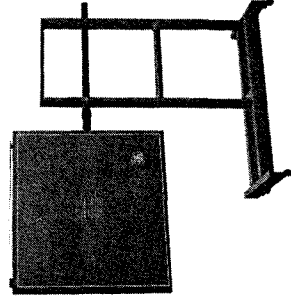
FEATURES

- High V/M testing with less power
- Simplifies emission and susceptibility testing
- Eliminates shielded room problems
- Requires less floor space
- Protection from hazardous radiation
- Extended range

APPLICATIONS

- Controlled tests for emission/susceptibility measurements
- Calibration chamber for power meters and field intensity meters
- Product sampling/in process testing
- Verification source

EFG-3 Antennas



The EFG-3 E-Field Generating antenna is designed to generate strong electric field intensities for immunity testing systems from 0.01 MHz to 220 MHz.

The EFG-3 Antenna is able to perform efficiently due to the physical configuration as a radiating transmission line. It also allows you to test those odd over size test samples which makes the EFG-3 extremely adaptable.

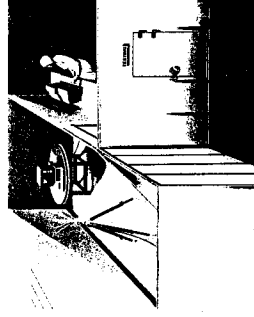
FEATURES

- 1000 Watt power handling
- Ultra broadband 0.01 MHz - 220 MHz
- Uniform load to power source
- Broad area to useful field
- High power to E-field conversion efficiency
- Parallel plate mode for E-field testing

APPLICATIONS

- EMC/RFI susceptibility testing
- Controlled power transmitting
- Verification source
- Product sampling/in process testing

EMC Test Room



FEATURES

- Anechoic chamber/measurement room
- Completely shielded
- > 80dB ambient free environment
- Controlled/repeatable test conditions
- In-house on site capability
- Only 400 sq. ft. floor space
- Real time measurements
- Reduced test costs

APPLICATIONS

- Designed for efficient EMC/RFI product engineering - design- testing
- Emission/susceptibility conducted measurements
- Open field test site correlation
- Research/design center

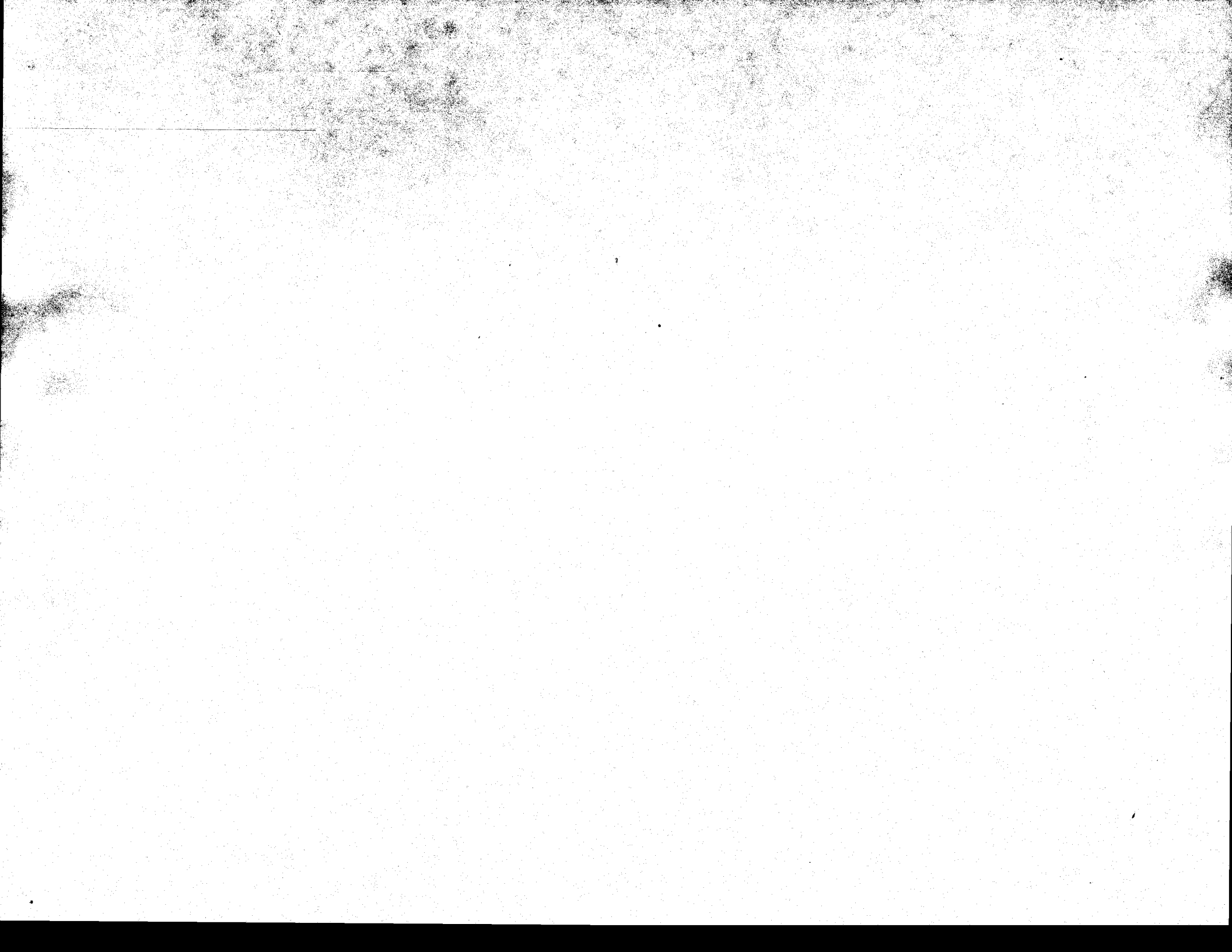


INSTRUMENTS FOR INDUSTRY

731 Union Parkway, Ronkonkoma, NY 11779

Tel: 516-467-8400 • Fax: 516-467-8558





> Eastern System
> (508) 366-3220
>
> There are two models:
>
> One phase: 130PQ, \$2,000.
>
> Three phases: PQ-Node 8010-12 \$8,100.
>
> A current probe may be needed at \$500. per phase.
>
> Each phase is monitored for:
>
> Voltage
> Current
> impulses
> harmonic distortion
>
> Connection to a computer through RS232 or a modem is provided
> as well as battery back up.
>
> Since we have a heavy load (vacuum pumps etc.), We probably need
>
> 8 of the three phase monitors for a total of:
>
> 8 * (\$500 * 3 + \$8,100) = \$48,00.00
>
> Specifications and quotation in the mail.
>
> Yaron
>

----- End Included Message -----

From Yaron Wed Jul 6 14:21:31 1994
Received: by tycho AA05503; Wed, 6 Jul 94 14:21:30 EDT
From: Yaron Hefetz <yaron>
To: weiss
Subject: Re: Power Line Monitors
Cc: yaron, dhs, pf
Status: RO

Rai,

I have just received information about Power Line Monitors.

We can get them from:

BMI
Foster City CA.
(408) 970-3700

through their representative :

Eastern System
(508) 366-3220

There are two models:

One phase: 130PQ, \$2,000.

Three phases: PQ-Node 8010-12 \$8,100.

A current probe may be needed at \$500. per phase.

Each phase is monitored for:

Voltage
Current
impulses
harmonic distortion

Connection to a computer through RS232 or a modem is provided
as well as battery back up.

Since we have a heavy load (vacuum pumps etc.), We probably need

8 of the three phase monitors for a total of:

$(\$500 * 3 + \$8,100) = \$48,00.00$

Specifications and quotation in the mail.

Yaron

94/07/19
15:02:03

From Yaron Tue Jul 12 15:56:29 1994
To: weiss
Subject: Re: Power Line Monitors, Temp, Humidity & RFI
Cc: dhs, Yaron, pl

> There are two models:
> One phase: 130PQ, \$2,000.
> Three phases: PQ-Node 8010-12 \$8,100.
> A current probe may be needed at \$500. per phase.
> Each phase is monitored for:

> Voltage
> Current
> Impulses
> harmonic distortion
> Connection to a computer through RS232 or a modem is provided
> as well as battery back up.
> Since we have a heavy load (vacuum pumps etc.), we probably need
> 8 of the three phase monitors for a total of:
> 8 * (\$500 * 3 + \$8,100) = \$48,000.00

> Their 8800 powerScope, (\$12,230.00) can actually measure:
> RMS Voltage, 4 channels (3 phase + return)
> RMS Current, 4 channels (Current probe \$500.00 each)
> For each voltage channel:
> Voltage frequency
> Voltage and Current Swells and Sags
> Voltage Impulses
> Line Waveshape faults
> High frequency noise on the line
> 3.5" Disk drive (comes with harmonic option \$2,270.00) to measure
> Harmonic Distortion and Spectrum analysis

> Yaron
> Specifications and quotation in the mail.
> ----- End Included Message -----

> Environmental (up to 8 channels total):
> Temperature probe (\$300.00 each probe)
> Humidity and Temperature (\$1,000.00 each probe)
> Radiated Radio Frequency Interference
> RFI probes are from:
> Hotalay Industries [B. Hericks (612) 934-4920]
> Model # HI-3004, E-field RMS in 3 axes
> Range: 0.1 -> 300 V/m, 0.5 -> 3000 MHZ
> \$3,925.00
> Instruments for Industry [(516) 467-8400]
> Model # EFS-3, E-field RMS in 3 axes
> Range: 0.1 -> 300 V/m, 10 -> 2200 KHZ
> \$1,350.00
> RS232 is included, Internal Modem is (\$600.00)

> From Yaron Wed Jul 6 14:21:31 1994
> To: weiss
> Subject: Re: Power Line Monitors
> Cc: Yaron, dhs, pl
> Re:
> I have just received information about Power Line Monitors.
> We can get them from:

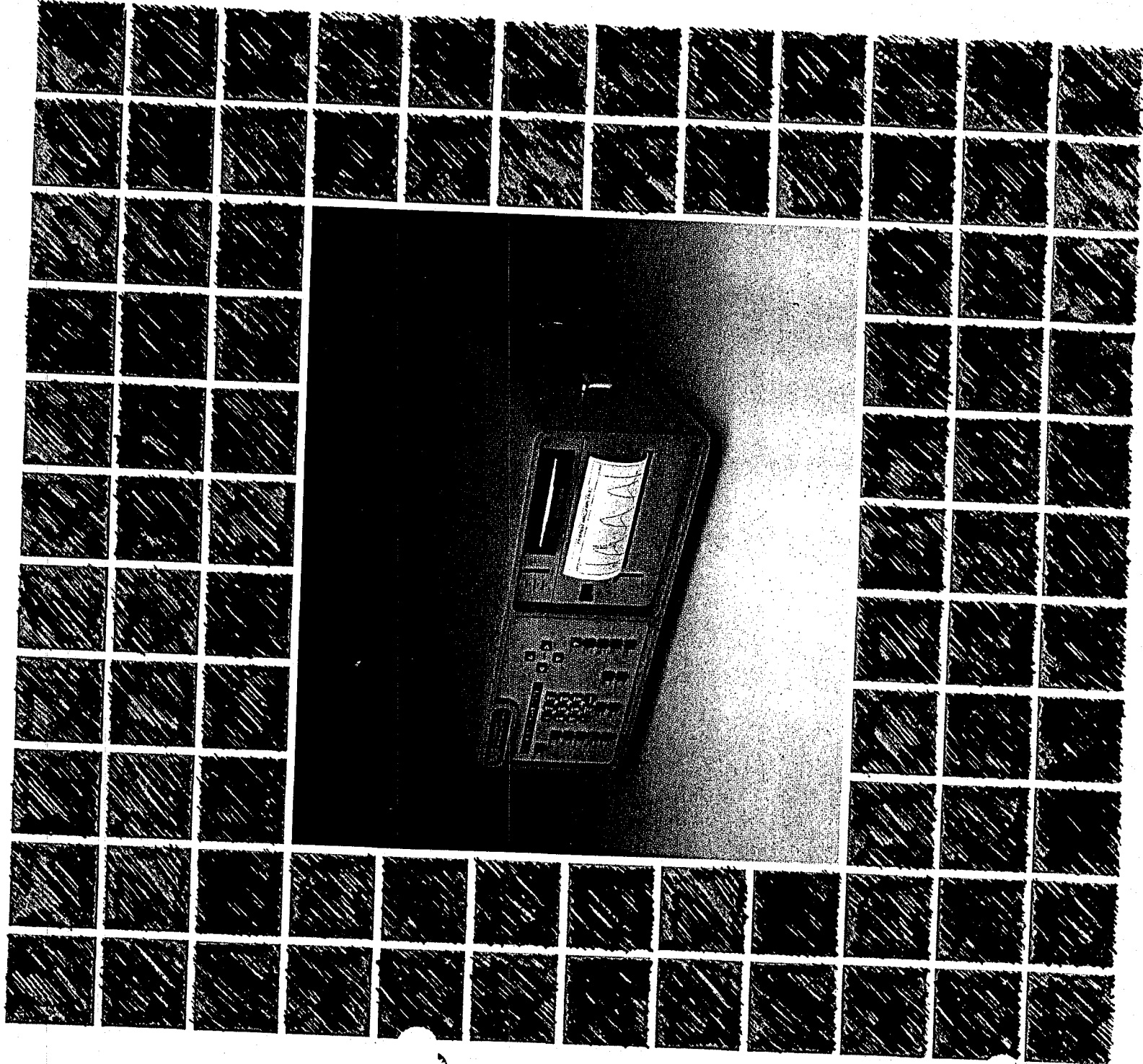
> BMI
> Foster City CA.
> (408) 970-3700
> through their representative :
> Eastern System
> (508) 366-3220

8800 PowerScope®

BMI

The Power of Quality

Performance, productivity, and practicality
for power disturbance analysis.



The 8800 — An Advanced, Cost-Effective PowerScope...

No matter what type of power problems you have, accurate information is the key to solving them. The new 8800 PowerScope lets you detect power problems where they occur and provides better information faster — for more productive power quality monitoring.

With the PowerScope, get answers through detailed graphs and reports. Automatic calculations and reporting features help you make more effective use of PowerScope information. And if your productivity depends on harmonics analysis, data storage, communication, and networking, you can have any or all of them with the PowerScope's options.

A Tool for Productivity...

Here is what the PowerScope offers for troubleshooting and analyzing electric power disturbances:

- Measurements that provide accurate information about voltage, current, and environmental conditions on a full range of disturbances and faults; monitor temperature, relative humidity, and their rates-of-change; understand how conditions interact to affect power quality.
- Fast results through easy-to-read "snapshots", summary graphs, and status reports.
- Many features designed for field applications — in a portable, rugged, self-contained unit.
- Convenience and ease of use with a friendly front-panel, menu-driven set-up, recall of preset thresholds and parameters, and on-line help messages.
- Sophistication and intelligence to meet tomorrow's analysis and data-management requirements: options for harmonics analysis, data storage, and communication.
- A smart investment — high performance, flexibility, and superior measurement technology at a reasonable price.



The PowerScope comes in a single, rugged package, ready to deliver the answers. It's ideal for recording and analyzing power disturbances and environmental conditions in a variety of "real-world" situations.

...With Unique Advantages

The PowerScope offers you unique detection and analysis functions that you'll find nowhere else:

- Simultaneous voltage and current monitoring and display.
- 4 MHz impulse sampling — twice as fast as any other power monitor.
- Automatic zoom — disturbances are zoomed to highest resolution and printed automatically.
- Meter readings for viewing instantaneous conditions.
- Patented, proven BMI technology; waveshape fault detection and impulse measurement techniques; highly accurate SmartProbes™.

Unparalleled Troubleshooting with Simultaneous Voltage and Current

Only BMI offers simultaneous voltage and current monitoring that helps detect and define your power quality problems more quickly than ever before.

The PowerScope's eight main input channels record and graph voltage and current on all three phases of a power system. With voltage and current on one graph, you can tell whether the power fault is occurring upstream or downstream of the monitoring point.

Knowing the relative location of a disturbance saves valuable time and money. If you had only the voltage signature you couldn't tell if the power disturbance was load or utility related. You would have to monitor at various points throughout the system or ask the utility to check its record of disturbance activity. With simultaneous voltage and current monitoring, your search for the source of the problem can be reduced — in some cases by weeks.

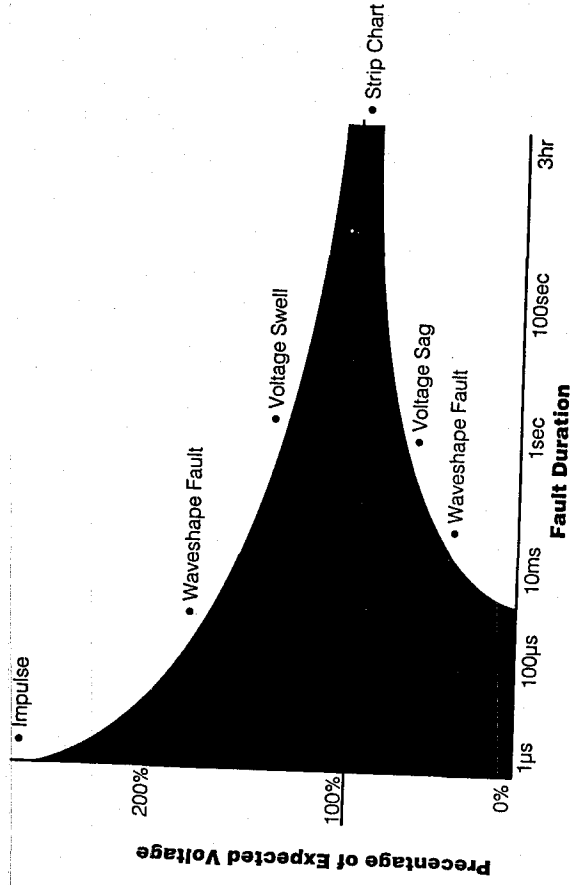
...That Helps Solve Today's Power Quality Problems

Why Monitor Power?

Today's computers, adjustable-speed drives, and electronic and industrial instruments demand better quality electric power than equipment of the past. Besides being disruptive, power quality problems can cause downtime, equipment malfunction and damage, and can increase repair and maintenance costs. It pays to monitor power to determine what the problems are, how often, where, and why they occur, and what to do about them.

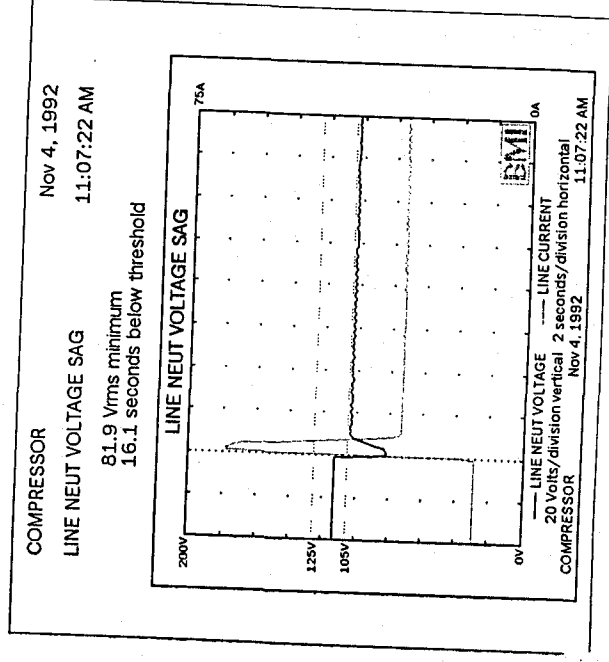
Why the PowerScope?

The PowerScope can simultaneously monitor three phases of voltage and current, including neutral, plus up to eight environmental channels. It provides information needed to characterize power conditions from the occasional impulse to harmonic distortion. Add the PowerScope to your know-how, and detect and solve power quality problems more quickly and effectively.

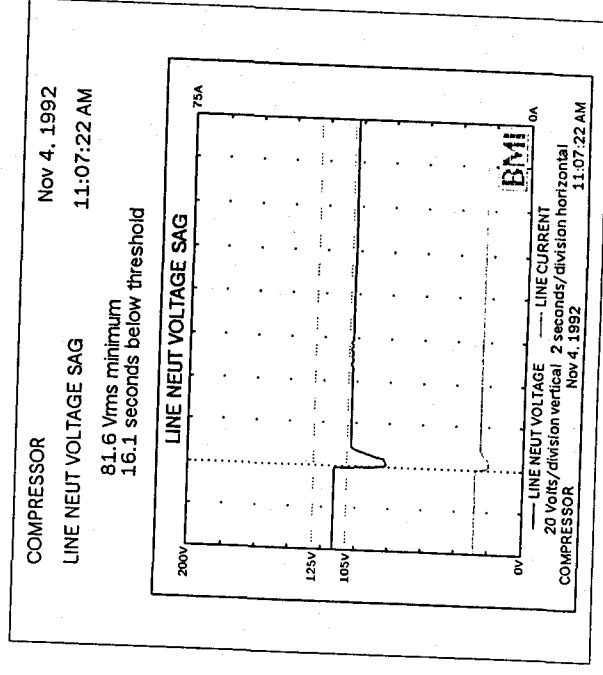


Whether variations and disturbances in power affect electronic equipment, and to what degree, depends on the severity and duration of these conditions. The PowerScope gives you valuable summary graphs and information about specific disturbances, so problems can be isolated and corrected.

Simultaneous Voltage and Current Graphs Give You the Complete Picture



Simultaneous voltage and current graphs tell you where to look for the offending load. In this graph, the increase in current that occurs simultaneously with a decrease in voltage indicates the load is downstream from the monitoring point.



A graph showing little or no change in current indicates the disturbance originates upstream from the monitoring location.

The PowerScope's Measurements Provide the Answers....

New, and Still Compatible

The PowerScope has new features, from eight main input channels and eight environmental channels to a speedier printer for publication-quality graphs and reports all in a new, compact chassis. And, the 8800 PowerScope can work alongside previous PowerScopes. It accepts the same environmental probes, which helps keep capital costs low. A familiar front panel and user interface make learning the 8800 fast and easy. So specify the 8800 as a trouble-free addition to your set of power monitoring tools.

Fast, Accurate Impulse Information

The PowerScope samples impulses at 4 MHz, twice as fast as other power monitors. The increased sampling rate lets you capture higher frequency components of an impulse disturbance so you get a more accurate picture of what happened. Impulse monitoring has also been enhanced by a larger memory buffer to capture multiple impulses, so important events won't be missed.

LINE-NEUT: 120.2V RMS

LINE: 75.8V RMS

LINE-NEUT: 60.0HZ

LINE-NEUT: 1.2VPP

Push a button to view actual RMS voltage and current, frequency, high frequency noise, and environmental conditions while the PowerScope is monitoring.

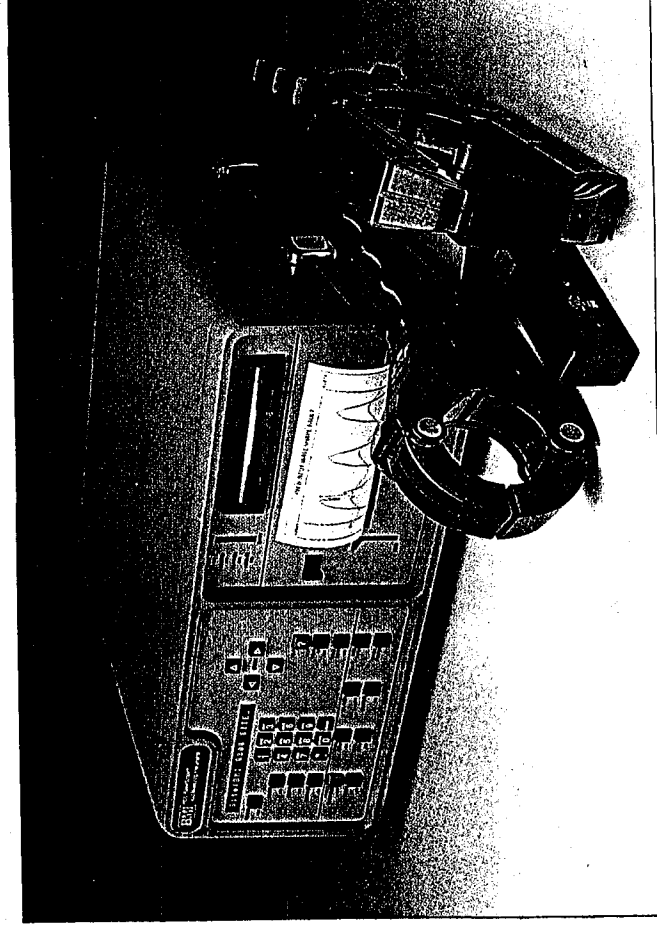
Complete frequency information is available from the PowerScope's frequency measurement on all voltage channels. And, eight environmental channels come standard with each PowerScope, ready to provide information about a number of conditions that could affect power quality.

With its harmonics option, the PowerScope performs voltage and current harmonics analysis, including

total harmonic distortion (THD) text and complete spectrum analysis up to the 33rd harmonic at 60 Hz, and the 40th harmonic at 50 Hz. This option gives a more comprehensive view of power quality and helps identify problems due to high neutral currents, overheated transformers, and non-linear loads such as computer systems, adjustable speed drives, and UPS systems.

Variety in Viewing Data

There are many convenient ways to see results with a PowerScope. The meters function displays real-time measurements of many input conditions. You can even perform experiments by manipulating loads and instantly seeing how the system responds. Press the snapshot button to print real-time graphs of RMS voltage and current. Use the status function to print readouts of all environmental conditions being measured. Instruct the PowerScope to automatically print strip charts of any signal recorded, in a range of time frames.



Use the PowerScope in its basic configuration or add options for harmonics analysis, data storage, and communication. The PowerScope is flexible enough to meet your unique performance and budget requirements.

Summary of Measurements

Power

- RMS voltage (up to 4 channels)
- RMS current (up to 4 channels)
- Voltage frequency (up to 4 channels)
- Voltage and current swells
- Voltage and current sags
- Voltage impulses
- High frequency noise
- Voltage waveshape faults

Environmental (with optional probes)

- Temperature and rate-of-change
- Humidity and rate-of-change
- Radiated radio frequency interference

Harmonics Option

- Total harmonic distortion
- Spectrum analysis

...Quickly and Productively

High Performance in the Field for Many Fields		
Application	Tasks	Benefits
Computer and Field Service	Identification of disruptive power problems distinguish between system failure and customer site problems.	Reduce no-trouble trouble reports, improve mean time between failure, mean time to repair, equipment reliability, customer satisfaction, save travel time and cost.
Utilities	Problem determination and location, safety, monitoring, code compliance.	Build customer loyalty, simplify problem explanations to non-technical customers.
Electrical Construction and Maintenance	Check for damaging environmental conditions, monitor power and power conditioning equipment.	Determine whether power is "computer grade" if existing wiring and transformers can be used, increase revenue and prevent damage.
Plant and Facility Engineering	Survey power before moving or installing computers or specifying power conditioning equipment; prevent problems with controllers, drives, and motors.	Reduce downtime, disruptions, and maintenance costs.
Hospitals and Medical Labs	Document back-up power performance, track alternate power switching, analyze effect of equipment on system.	Ensure instrument accuracy and dependability, reduce service calls.
Telecommunications	Monitor system, switch room, and facility power.	Ensure performance to specifications, reduce site visits.

Comprehensive, Comprehensible Data

The PowerScope delivers data well suited for use in problem solving. All disturbances are presented in formats compatible with those in the *Handbook of Power Signatures*, BMI's useful reference of power disturbances. Graphs, which are packed with quantitative and visual information, can be compared with those in this book, for easier identification of problems. The PowerScope's publication-quality printer generates clear, easy-to-read text and graphics that can be directly included in other reports. And, you get printed output fast — in seconds rather than the minutes required with many other monitors.

Never Miss an Event

The PowerScope performs many functions simultaneously. Units with the storage option automatically save disturbances to a floppy diskette without interfering with monitoring. The PowerScope remains "on line" while you print reports and continues to store data in its internal memory, so there is no loss of disturbance data, no waiting, and no sacrifice of productivity.

Faster Answers

The PowerScope's many automated features ensure that all pertinent information about disturbances is instantly available. Calculations are done automatically — from scaling of graphs to computing the energy content of impulses — reducing time-consuming manual analysis.

Disturbance information is automatically "zoomed" to its highest resolution before printing. This can make a difference in your productivity, because there is no need to manually sort through hours of data to find the significant portion of the disturbance event.

To enhance your understanding of power conditions, the PowerScope also gives you summary information. Simply specify the nature of the summary information you want printed, and which disturbances and environmental parameters are covered, and the PowerScope automatically does the rest. Select 1, 3, 6, 12, or 24-hour increments for strip chart reports — no need to request individual printouts. And, when equipped with the storage option, the PowerScope can be set up to store summary graphs automatically.

Easy to Learn and Use

Operate the PowerScope from the user-friendly front panel with guidance from simple menus. The 8800's operation is similar to BMI's 4800 PowerScope, so those familiar with the 4800 can learn the 8800 quickly. For assistance, on-line help prints explanations of all front-panel functions, as well as information about how to connect and set up the PowerScope.

Convenient and Economical

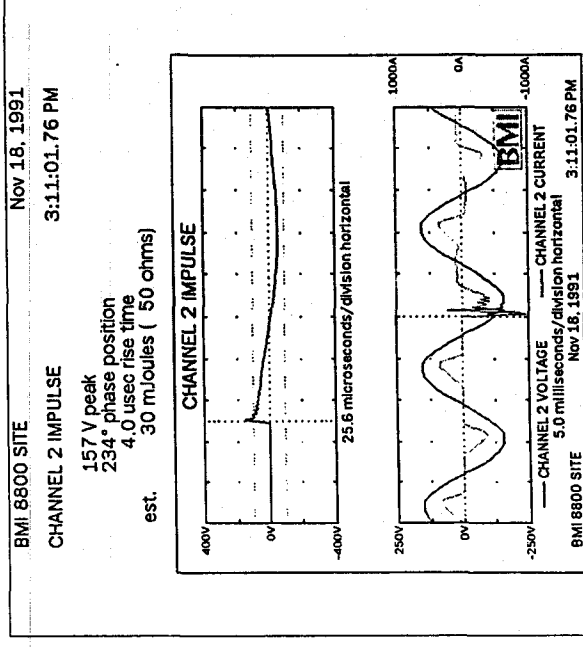
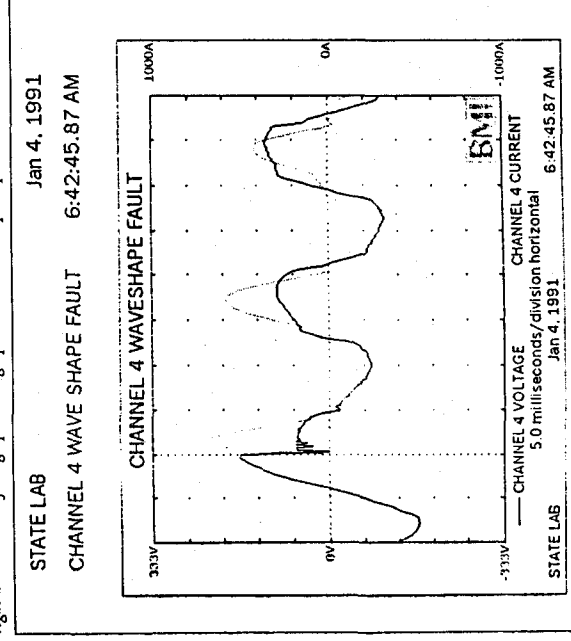
Many features and options make the PowerScope exceptionally convenient to use. Save time setting up the monitor by specifying up to three sets of measurement and report parameters and saving them in memory for easy recall. The PowerScope's storage option adds flexibility to disturbance viewing and information management. Archive data onto a floppy diskette for later printing or viewing on your PC. Equip two or more PowerScopes with the communication option to set up a network of monitors and reduce travel time to remote locations.

Printed Reports from the PowerScope ...

PowerScope graphs and strip charts offer valuable numerical data to help analyze the disturbances or conditions pictured. These reports provide accurate technical content for the seasoned professional, yet also assist less experienced people in identifying power problems. The various reports offer:

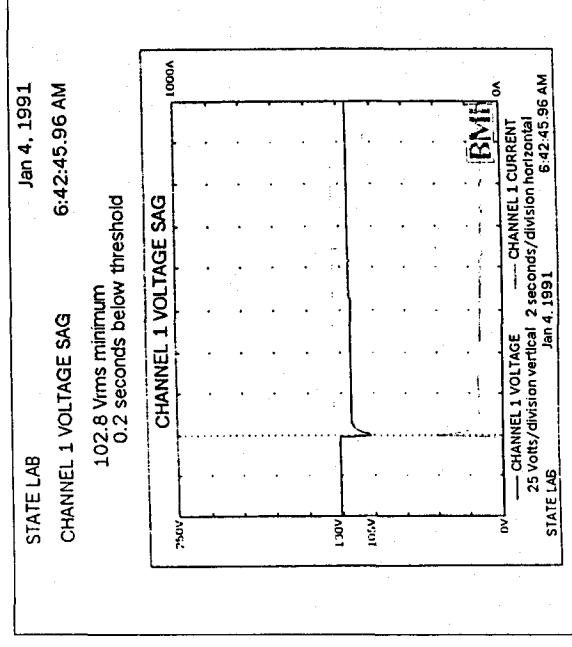
- Flexibility — when setting up a PowerScope, you establish the preferred thresholds for all disturbances, and the type and length of all summary reports.
- Ease of interpretation — reports are compatible in format with the *Handbook of Power Signatures*.
- Automatic calculations — eliminate manual work and searching through data; disturbances are automatically zoomed to their highest resolution, and calculated parameters appear on reports.
- Real-time capabilities — view voltage and current readings on the front panel display, print snapshots of voltage, current, and environmental conditions, and status reports of instrument parameters and configurations.

BMI's patented technology allows voltage and current waveshape graphs to be printed whenever there is a change in the voltage waveform (when a new cycle differs from the previous cycle by more than a specified threshold). A vertical trigger line shows the point in time when the fault occurred. The date and time of the fault are printed at the upper right-hand corner of the graph. This graph shows an inadequate power source.

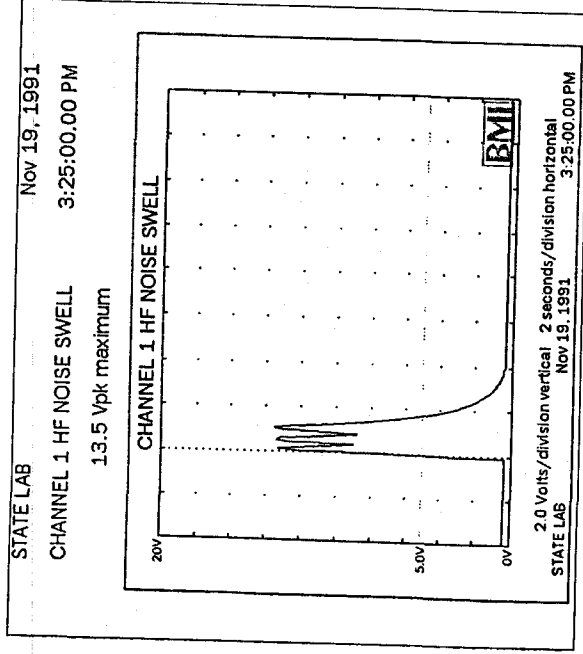


When an impulse is detected, the PowerScope generates two graphs. The lower graph shows the voltage and current waveforms before and after the impulse. The upper graph shows the actual impulse automatically zoomed to its highest resolution. Calculations of the peak impulse voltage, phase position, impulse rise time, and estimated impulse energy are also printed. This is an example of a capacitive load switching online.

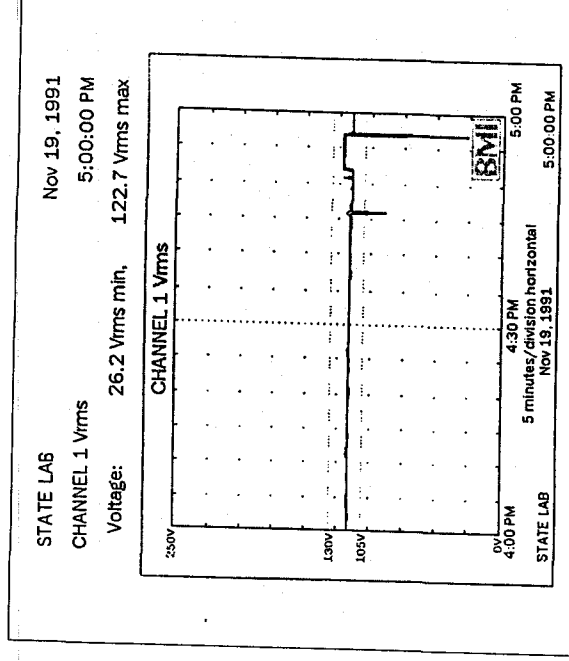
The PowerScope prints the 4 seconds preceding and 16 seconds following a sag or swell disturbance. If the event lasted more than 16 seconds, a "swell ended" or "sag ended" graph prints when true RMS voltage or current returns to within preset thresholds. The graph also shows the minimum or maximum voltage or current of the sag or swell, and its duration. Horizontal dotted lines indicate preset thresholds, and a vertical line indicates the point at which the event was triggered. This graph shows a motor start.



...Meaningful, Sophisticated, and Easy to Understand

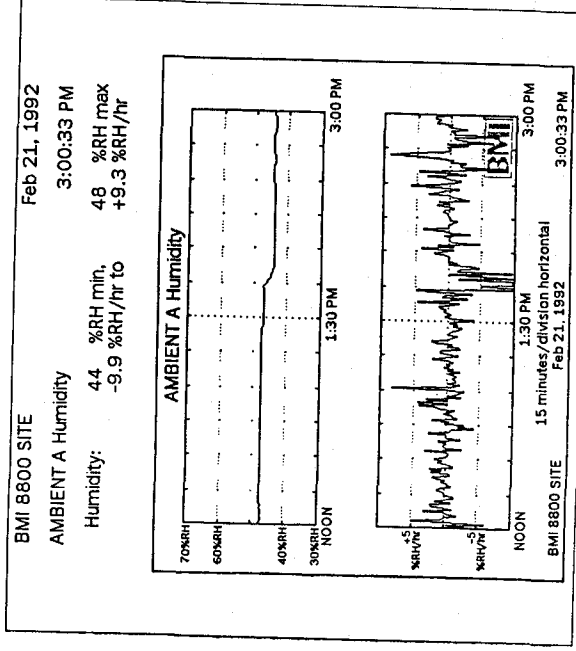


This type of graph shows episodes of ongoing, low-amplitude noise (HFN) on the voltage waveform. The vertical dotted line indicates the trigger point. The maximum peak-to-peak voltage is also shown.



The PowerScope can be set up to print strip charts of any signal recorded. One, three, six, twelve, or twenty-four hours of information can be displayed on the chart. Typical strip charts include channel name, date and time, minimum and maximum values recorded, and threshold line(s).

The PowerScope's environmental channels accept signals from external probes for measuring temperature, humidity, and radio frequency interference. The A-003 Temperature/Humidity Probe graphs ambient humidity and temperature and their rates-of-change.



Here's a sample of the parameters you can define:

The PowerScope comes preset with commonly used thresholds and other set-up values. You can change these as needed. In addition, three complete configurations can be set up and stored in memory for later recall with the push of a button. For maximum flexibility for your application, specify the following:

- Power type
- Nominal frequency and tolerance
- Voltage and current swell thresholds
- Voltage and current sag thresholds
- Impulse threshold and range
- High frequency noise threshold
- Ambient temperature and rate-of-change thresholds
- Relative humidity and rate-of-change thresholds
- One, three, six, twelve, or twenty-four-hour length strip charts (or "off") for any recorded power or environmental signal

Advanced Options Provide Higher Performance...

Harmonics Option Provides a Complete Power Picture

Detects Today's Power Problems

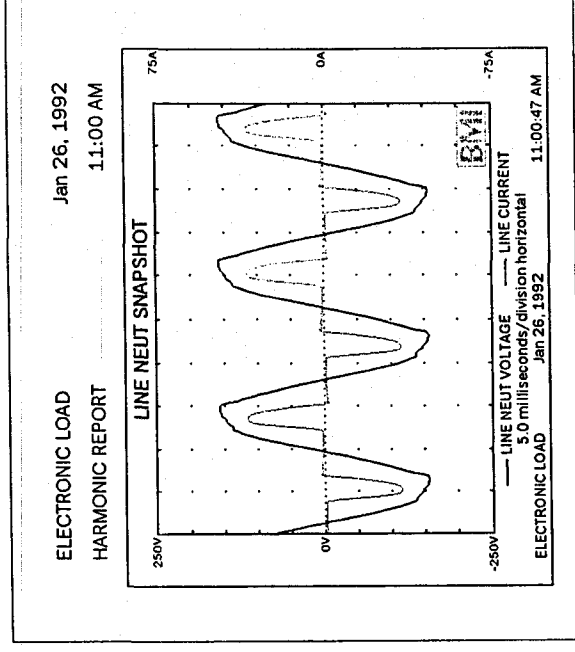
Many modern electronic devices draw current non-linearly which leaves facilities vulnerable to overloaded neutrals. This poses special challenges in maintaining electric power quality. If you have computers, electronic equipment, or adjustable-speed drives, understanding the harmonic characteristics of your voltage and current is necessary for problem determination. BMI's harmonics option turns the PowerScope into a harmonics analyzer that provides information for solutions.

A Range of Capabilities

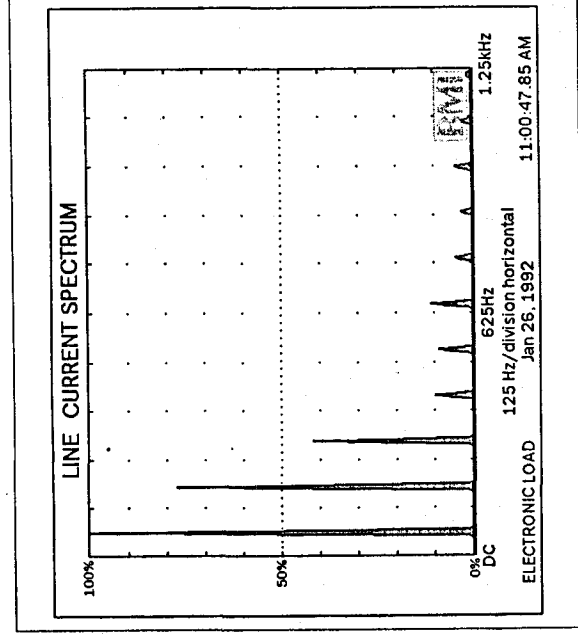
The harmonics option provides text of total harmonic distortion and complete spectrum analysis up to the 33rd harmonic at 60 Hz and the 40th harmonic at 50 Hz for both voltage and current.

Simple to Use

This software option requires no attachments or new procedures. When the harmonics option is installed, simply press a couple of keys on the front panel and the 8800 automatically prints a snapshot of the voltage and current waveforms, the harmonic spectra, and THD reports.



When you request a harmonics report, the PowerScope also prints a snapshot of the voltage and current waveforms being analyzed.



Using the Fourier Analysis technique, waveforms are broken down at different frequencies and amplitudes. This enables better evaluation of the impact of a distorted waveform. The spectrum analysis graph plots amplitude against frequency, so it can show non-harmonic content as well.

ELECTRONIC LOAD
LINE CURRENT SPECTRUM
Fundamental frequency: 60.0 Hz
Jan 26, 1992
11:00:47.85 AM

Harmonic Percent Phase	Sine	Harmonic Percent Phase	Sine
Fund	100.0%	0°	2nd
3rd	77.3%	164°	4th
5th	41.5%	332°	6th
7th	9.6%	151°	8th
9th	8.7%	107°	10th
11th	10.7%	281°	12th
13th	4.3%	96°	14th
15th	2.4%	48°	16th
17th	4.1%	221°	18th
19th	2.0%	10°	20th
21st	1.1%	48°	22nd
23rd	1.7%	177°	24th
25th	0.8%	290°	26th
27th	1.1%	354°	28th
29th	1.1%	123°	30th
31st	0.5%	210°	32nd
33rd	0.8%	277°	
Odd:	89.6%	Even:	0.0%
Thd:	89.6%		

The THD report includes a list of harmonics, which always shows the fundamental as having 100% amplitude, and a number representing total harmonic distortion. Total harmonic distortion is the geometric sum of the even and odd harmonics.

...With Maximum Flexibility

Storage Option Maximizes Data-Management Power

Equip the PowerScope with the ability to store and manage data for you with the storage option. This option consists of a 720 Kbyte, 3.5 inch DOS format floppy disk drive built into the PowerScope. The drive archives data for approximately 600 disturbances for later printing or viewing. Information is available from the diskette when you want it, without having to visit the monitor frequently or print every disturbance.

Convenience

With the storage option, set up the PowerScope to save time and effort. Select the record mode from the front panel, and disturbances are automatically saved on the diskette until you change the mode. There is no "dead time" during data storage; the PowerScope monitors and saves data simultaneously, so no disturbances are missed. When you want hard copies of disturbance data, either print everything stored on the diskette, or see a list of files and print them selectively.

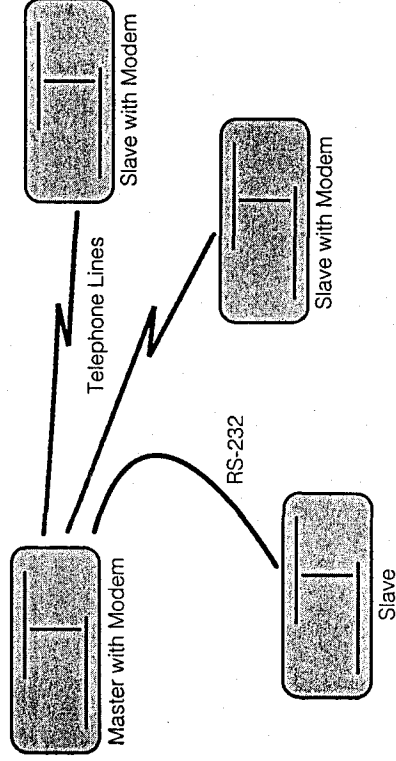
Information Viewing

The storage option also lets you view graphs without printing. Included in this option is 8800View™ software, which works on an IBM-compatible PC in the Microsoft Windows™ 3.0 environment. When it is installed on your computer, you can look at disturbance data from the diskette on your PC's monitor.



In the record mode, the PowerScope's disk drive automatically stores disturbance data while the unit keeps on monitoring. Use the playback mode at your convenience to print data previously stored on a diskette.

Communication Option Streamlines the Most Complex Applications



Create your own PowerScope network with one master unit and remote slaves. All slave PowerScopes on the network report voltage, current and environmental disturbances to the master, which can be placed right on your desk.

Flexible Networking

Make large power surveys or monitoring at multiple locations more efficient with the PowerScope's communication option. This option equips the PowerScope with an internal modem that you can set to 300, 1200, or 2400 baud. With communication options, two or more PowerScopes become a network controlled by a master unit. PowerScope networking with this option makes a wise investment in productivity. For example, equip one unit, the master, with the storage and communication options, economize on the slave PowerScopes with communication options only, and still benefit from the data-storage capabilities.

Saves Valuable Time

Setting up a PowerScope network is easy and requires just a few menu commands. There are many advantages; you can reduce the number of site visits to collect data, and configure PowerScopes consistently with control of most aspects of operation from an accessible master unit. Have remote units transmit all disturbance data via modem to the master PowerScope, where it can be saved with the storage option and printed at your convenience.

Probes, Supplies, and Accessories

(612) 934 3604

B. Hericks

HI 3004

Holiday Industries

SmartProbes

A-115

60 Amp AC Clamp-on SmartProbe

Use this clamp-on probe to take quick measurements of CTs and for monitoring individual loads up to 60 amps (individual branch circuits, personal computers, fractional horsepower motors, etc.).

Range: 1.0 - 60 Arms
Usable bandwidth: 45 - 1 kHz
Isolation: 3000 V
Max. cable diameter: 0.47 in (12 mm)



A-116

600 Arms AC Clamp-on SmartProbe

The general-purpose current probe for most applications.

Working voltage: 600 V
Range: 1 - 600 Arms
Usable bandwidth: 45 - 3000 Hz
Isolation: 2000 V
Max. cable diameter: 2 in (54 mm)

A-120

3000 Amp AC Clamp-on SmartProbe

Use this large probe for measuring high-current bus bars.

Range: 10 - 3000 Arms
Usable bandwidth: 30 - 3 kHz
Isolation: 4000 V

Jaw window: cable-2.56 in (65 mm), bus bar-1.97 x 3.31 in (50 x 135mm), bus bar-2.56 x 3.94 in (65 x 100 mm)

A-121

Current Transformer Interface SmartProbe (CTIP)

This window type CT includes open terminals to allow the user to add the needed interface.

Range: 0.1 - 20 Arms (28 Apk)
Usable bandwidth: 50 Hz - 3 kHz

Optional Environmental Probes and More

A-002

Temperature Probe

Graph ambient temperature and temperature rate of change.

Range: 0° - 100° C, and 1° - 99° C/h
32° - 212° F, and 1° - 99° F/h

A-003

Temperature/Humidity Probe

Graph ambient humidity, ambient temperature, and their rates of change.

Range: 0° - 80° C, and 1° - 80° C/h
32° - 176° F,
and 33° - 176° F/h
0 - 100% RH, 1-99% RH/h

A-005

50-Volt Proportional Supply Probe

This handheld, battery-operated unit monitors the output of 50-volt DC reference supplies on IBM mainframes and displays digital readouts of average voltage and superimposed ripple voltage. With the PowerScope, it provides strip charts and text disturbance reports.

Range: 0 - 100 V (avg), 0 - 75 V (ripple)

A-009

Contact Closure Probe

Provides two-second relay closure when trigger thresholds are exceeded (for external alarms).

Contact ratings: 125 Vac @ 0.5 Arms,
or 30 Vdc @ 2.0 Arms

A-012

RFI Probe Interface Cable

This is an interface for the Instruments for Industry model EFS-3 probe.

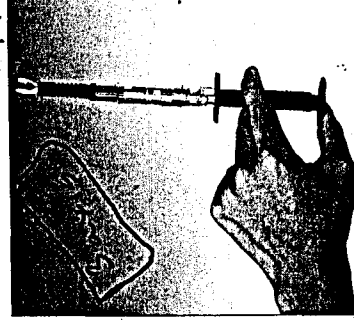
Range: 0.1 - 300 V/M 1350.00
10 - 2200 kHz

A-014

RFI Probe Interface Cable

This is an interface for the Holiday Industries HI-3004 probe.

Range: 0.1 - 300 V/M 399.5
0.5 - 3000 MHz \$ 4.6



A-023

FuseClip™ Voltage Connector

Reduce the risk of personal injury or instrument damage. The spring loaded clamping jaws attach quickly and securely. Each FuseClip has a 600 volt, 2 amp, 100 kAmp high interrupting capacity fuse.

Compatible with all BMI equipment, or any instrument that utilizes MC style safety connectors.

Includes four fuse clips, four fuses and one set of red, blue, yellow, and white cables. Replacement fuses are also available from BMI.

Supplies, Accessories, and Starter Kits

A-010S

The Handbook of Power Signatures
An informative companion to all PowerScopes.

A-801

Rack Mount

For permanent installations; fits standard 19-inch racks.

G-012

PowerScope Cart

Transports shipping cases and supplies.

G-081

Carry Bag

Tough canvas bag with large, zippered pockets carry PowerScope and cables.

G-801

Shipping Container

International orange case protects PowerScope during shipping.

S-601

Diskettes

Box of ten (10) 3.5 inch, double-sided, double-density diskettes.

S-801, S-803

Thermal Paper

Case of twelve (12) rolls (S-801), or three (3) rolls (S-803).

S-804

Starter Kit

Includes one case of paper, carry bag, and the *Handbook of Power Signatures*.

S-805

Starter Kit

Includes all items in S-804 and a one year warranty extension.

C-151

BMI Education Course

"Problem Solving with the 8800 PowerScope"

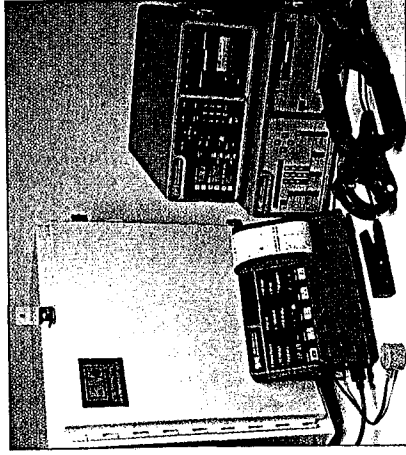
Learn basic and advanced skills in using the 8800. Extensive hands-on laboratory work, case study, and classroom instruction.

BMI - Powerful Systems for Power Monitoring

Leadership in Power Monitors

Look to BMI when you want accurate information about your electric power. We provide what's needed to solve today's power problems. Numerous industries, including electric utilities, electronics and computer companies, and plants and facilities throughout the world, get the answers from BMI.

From rugged, reliable, easy-to-use power monitoring equipment, to effective PowerTalk® software for easy remote monitoring and report preparation, you get products of quality and value from BMI. Select among a wide range: the economical Powervisa™, advanced PowerScope and PowerProfiler™ analyzers, and the integrated PQNode™ system.



BMI offers a full range of power monitoring instruments and systems, from the economical Powervisa to the advanced PowerScope and PowerProfiler analyzers, to the highly integrated PQNode system. Whatever your needs, BMI meets them with products of quality and value.

Customer Service through Technical Support and Education

Our support begins with information: the *Handbook of Power Signatures*, published as a companion to the PQNode, PowerScope, and Powervisa disturbance analyzers. This book contains over 100 examples of the most frequently experienced power disturbances and offers explanations, solutions, and advice on conducting your own power quality survey. It has become the leading reference tool in the electric power industry.

More specific help is at hand, too. For assistance with data interpretation and applications, telephone BMI's applications personnel or fax questions to our Technical Support Engineers. And, professional instructors teach courses that combine hands-on lab experience, practical field surveys, and classroom work. BMI's training can even be customized and brought to your location.

Companies that rely on BMI

ADP • AMX • American Airlines • Apple • Boeing • CEGE • Chrysler • Gray Research • Data General • Dow Chemical • Duke Power • EDP • Eastman Kodak • Emerson Electric • Exxon • Fisher Control • Florida Power and Light • Ford Aerospace • Ford Motor Company • GTE • General Electric • General Motors • Georgia Power • Grumman Aerospace • Hewlett-Packard • Honeywell • Hydro-Quebec • IBM • Jet Propulsion Lab • Kaiser Permanente • Kimberly Clark • Lawrence Livermore National Lab • Liebert • Los Alamos National Lab • Lucas-Film • Martin Marietta • McDonnell Douglas • McGraw-Hill • MCI • Measures • Merrill Lynch • Minolta • MIT • Mobil • NCR • Northrup • Pacific Gas & Electric • Phillips Medical • PRIME • RJR Reynolds • Ricoh • Rockwell • Röm • San Diego Gas & Electric • Siemens • SP • Sorbus • Southern California Edison • Tektronix • Teledyne • 3M • Unisys • Unocal • US Army Corps of Engineers • Vartecfall • Wang • Westinghouse

Look for BMI Power Monitors in These Applications and Industries:

Aerospace • Assembly Lines • Broadcasting • Building Management • Cellular Telephone • Cogeneration Facilities • Computer Service • Computer Room Operations • Electrical Contractors • Electrical Service • Electric Trains and Transportation • Energy Conservation • Facilities Management • Facilities Service • HVAC Installation and Service • Hospitals and Medical Clinics • Manufacturing Lines • Multi-Tenant Office Buildings • Nuclear Power Plants • Office Automation • Printing Operations • Robotics • Smart Homes • Telephone Switching Stations • Telecommunications • Television • Testing Laboratories • Transmission and Distribution of Power • Utilities • and more!

You can rent BMI products from these companies:

In the US
Commercial Resources 1-800-343-4688
Electro Rent 1-800-423-2337
in California 1-800-421-4848
GE Rent 1-800-GE-Rent
Genstar Rental Electronics 1-800-227-8409
in California 1-800-331-3440
Lexameric 1-800-553-2255
Telogy 1-800-835-6494
IR Instrument Rentals (USIR) 1-800-USIR-123

In Europe
Euro Rent, Germany 06151 26635
Euro Rent, Holland 080 776644
Locameasure S.A., France 1 46 87 33 38
Livingston Hire Ltd., U.K. free phone 0800 886000
Microlease, U.K. 01 427 8822

Summary of PowerScope Capabilities

Any Power Configuration
Measures many types of power systems.

Meters
Shows real-time channel measurements in the display window.

Snapshots
Print graphs of RMS voltage and current instantaneously.

Easy to Use
The most commonly used thresholds are preset.

Store Set-Ups
Save and recall up to three complete parameter set-ups.

Safety Connectors
Connect SmartProbes quickly and easily.

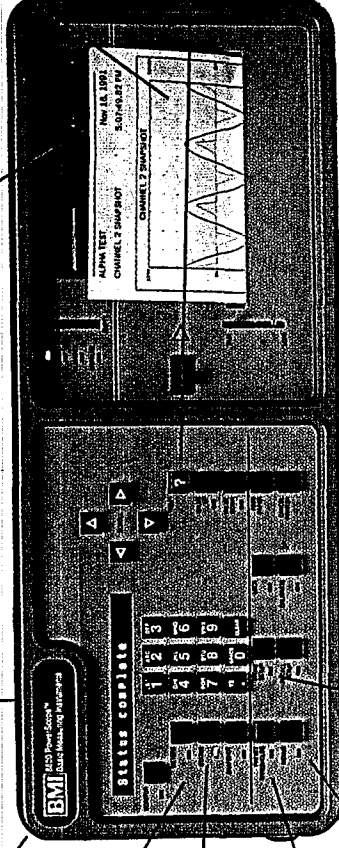
Independent Connections
Separate connections allow for simultaneous voltage and current monitoring.

50/60 Hz
For use anywhere in the world.

Light, Portable, and Rugged
Built to be used wherever it's needed.

Disk Storage
Save graphs and reports to disk for playback later (720 Kbyte).

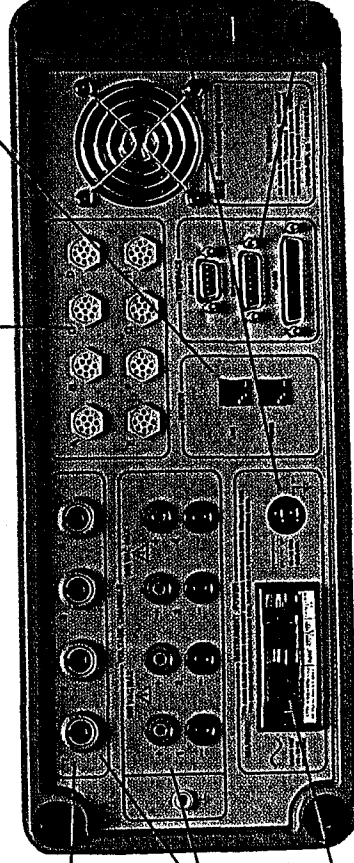
High-Resolution Printer
Provides publication-quality graphs and reports, fast.



HELP! Messages
In doubt? Press the button.

Environmental Channels
Monitor temperature, humidity, and RFI on up to eight channels using optional probes.

Modem
Optional internal modem for remote communication over phone lines.



Internal UPS
Provides 15 minutes of backup power.

DC Power Input
Can operate using external batteries.

RS-232 Port
Connect PowerScopes to external modems or to each other.

*\$12230 Vact
\$2270 Disk + Harmonics
\$500 Port & current probe each
\$300 Temp*



Basic Measuring Instruments
335 Lakeside Drive
Foster City, CA 94404
USA

Tel. 415 570-5355
FAX 415 574-2176

RFI -

P/N 89002939, Rev. 1A
Printed in USA



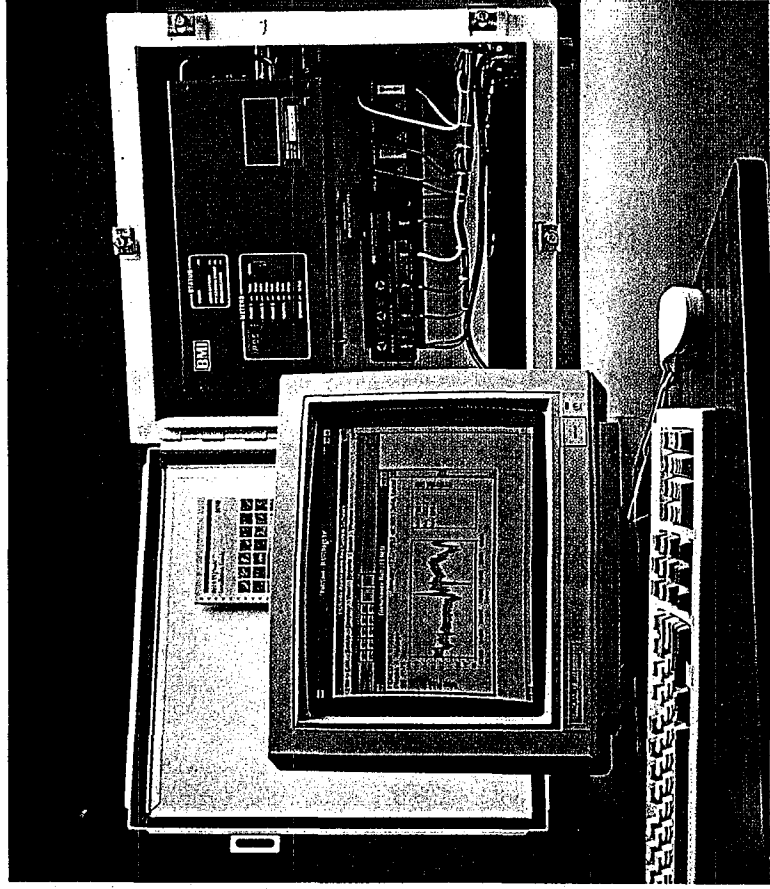
8010 PQNode™

BMI

An integrated measurement solution
for power quality analysis.

*Developed in cooperation
with*

Electrotek



8010 PQNode

The 8010 PQNode is a distributed hardware and software system for electric power and power disturbance monitoring. Basic technology from BMI's field-proven PowerScope™ and PowerProfiler™ portable instruments were incorporated into one package. These basic capabilities were then improved and expanded upon to provide a rugged package with superior performance for permanent or semi-permanent power monitoring installations. The PQNode is designed to be used indoors or outdoors in a variety of locations, such as substations, pole-mounted applications, buildings, plants, and facility feeders, or anywhere power quality is a concern.

The Electric Power Research Institute (EPRI) has installed PQNode modules at over 200 sites for the largest power quality survey ever conducted in the U.S. The PQNode meets EPRI's rigid specifications, and it can meet yours. When it comes to disturbance analysis for improving power quality, you won't find a more flexible system, or one with more capabilities, than the PQNode.

Functional, Flexible, Reliable

The PQNode offers all you would expect in a power quality monitoring system:

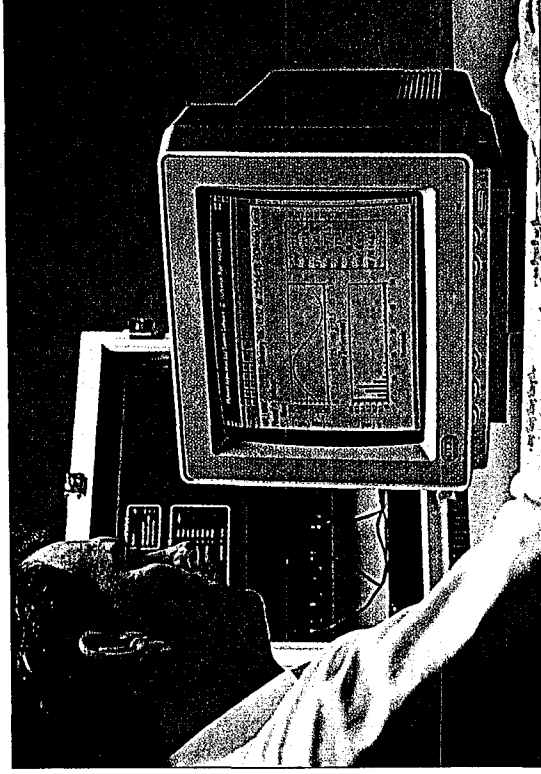
- Comprehensive, accurate measurement of disturbances and steady states; measures both voltage and current on all four channels — the most in any system.
- Easy to configure, modify, and update any or all instruments through the host personal computer.
- Flexible enough for a variety of applications in outdoor and indoor locations — from several to several hundred PQNodes in a system.
- Highly reliable operation — no hardware adjustments, many diagnostic aids and hardware safeguards, field maintainable.
- Credible, proven suppliers — BMI hardware and measurement software, Electrotek system and applications software.
- Cost-effective — for all this capability, flexibility, and reliability, a valuable investment.

Advantages in Hardware and Software

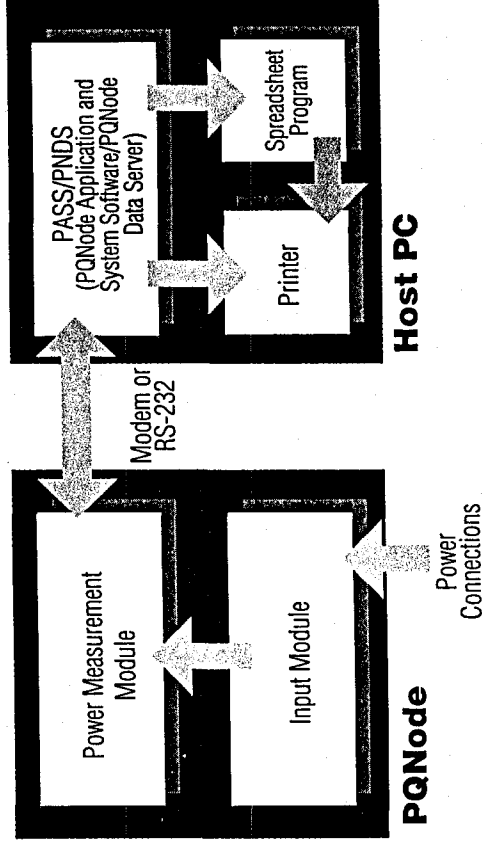
The PQNode provides advanced features in a practical package, for each function from installation

to data export. The PQNode measurement module, a computer in itself, offers a wide range of measurement capabilities. It and other PQNode hardware is rugged, easy to install, and functions with minimal maintenance. Sophisticated measurement algorithms and data storage, reduction, and

communication programs reside in the measurement module. You gain access to all this power with the click of a mouse from the host personal computer. Friendly PASS (PQNode Application and System Software) makes it easy to view data and generate a variety of valuable reports and displays.



PQNode and PASS Operating Relationship



Once installed, the PQNode system operates almost unnoticed, until you wish to access information. The electric power to be analyzed flows into an input module and then into the measurement module, a sophisticated computer containing the measurement software. Power disturbances and ongoing conditions are measured, recorded, and stored in this module's RAM disk memory. Information is downloaded into the host personal computer, usually by modem, on a scheduled or as-needed basis. The applications software manages the system and generates graphic or written data for viewing or printing. Data stored in the PASS database can even be exported to spreadsheet and word processing programs.

Specifications

Operating Characteristics:

- Power In:
 - Voltage Range: 150-280 V_{rms}
 - Frequency: 50/60 Hz
 - Maximum Power Consumption: 6 VA max.
- Power Out:
 - Voltage Range: 150-280 V_{rms}
 - Frequency: 50/60 Hz
 - Maximum Power Consumption: 6 VA max.

Physical Characteristics:

- Width x Length x Height:
 - 9 in. (22.86 cm) x 6.75" (19.15 cm) x 2" (5.08 cm)
- Weight: 3.2 lbs (1.46 kg), battery installed.

Environmental Characteristics:

- Temperature range: 0°C to 50°C (32°F to 122°F)

Measurement Characteristics:

- AC Voltage:
 - L-N Input Range, Low Scale: 75-150 V_{rms}
 - L-N Input Range, High Scale: 150-280 V_{rms}
 - N-G Input Range, Low Scale: 0-3 V_{rms}
 - Measurement Accuracy: 0.5% of reading, ±1% of full scale

• Impulse Peak Voltage:

- For IEEE BiWave
- Input Range Tolerated: 2 KV
- Input Range Measured: 50 - 1000 V
- Measurement Accuracy: 10% of reading, ±2% of full scale

• AC Frequency:

- Input Range: 45 - 65 Hz
- Measurement Accuracy: ± 0.1 Hz
- AC Current (Requires optional current probe):
 - Low Range: 1-15 A_{rms}
 - High Range: 15-120 A_{rms}
 - Crest Factor (Maximum): 1.7
 - Measurement Accuracy: 5% of reading, ±1% of full scale

• Temperature (Requires optional temperature probe):

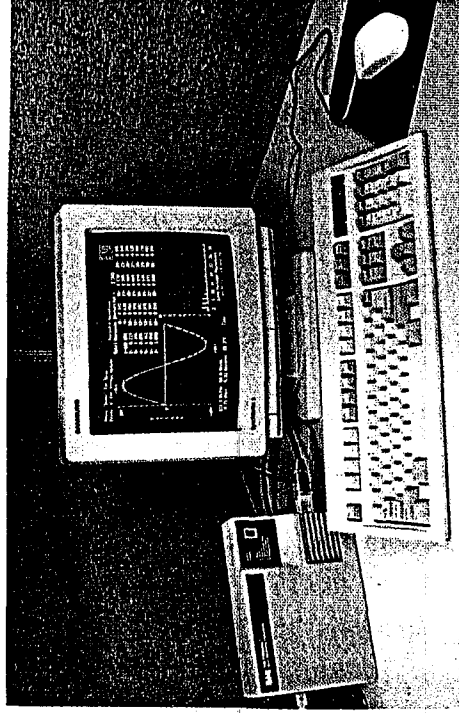
- Range: -20°C to 100°C (-4°F to 212°F)
- Harmonics:
 - Voltage and current: Up to the 31st harmonic

Communications Specifications:

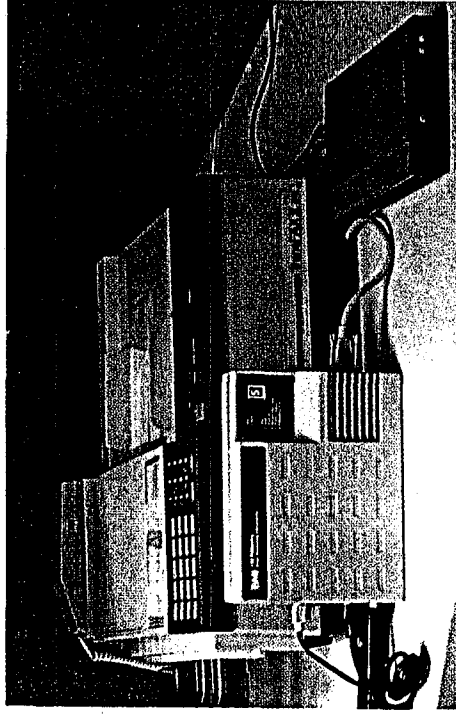
- RS-232
 - Voltage Isolation: 6000 V
 - Communication Rates: 300, 600, 1200, 2400, 4800, 9600 baud
- Modem:
 - May be used with appropriate user-supplied modem.

† Requires additional hardware and software options.

• Specifications subject to change without notice.



On-site monitoring: Recorded data can be transferred to your PC by a direct serial link. Using the menu-driven PQSentry software, you can download disturbance and steady-state data from the instrument to your PC, store the data on a floppy or hard disk, and display and print reports and graphs.



Remote monitoring: You can access real-time disturbance data by using an external modem while monitoring sensitive loads at many sites simultaneously. Using PQSentry software, you can download data from each PQSentry as desired.

Minimum System Requirements:

- Hardware: IBM PC or compatible - 286, 386, or 486; DOS 3.x or higher
- Storage: One hard drive and one high-density, 3.5" floppy disk drive
- Memory: 640 K RAM
- Display: CGA, EGA, or VGA monitor

BMI

Basic Measuring Instruments
The Power of Quality

8010 PQNode™

BMI

A power disturbance analyzer, power flow measurement and base-line survey tool.

Developed in
cooperation with

Electrotek

Introducing the PQNode

The 8010 PQNode is the newest power measurement tool from BMI. Incorporating eight channels – four voltage and four current – the 8010 allows simultaneous monitoring of voltage and current across all channels. The PQNode uses the proven technologies present in the BMI PowerScope™ and PowerProfiler™ families to provide both disturbance monitoring and power flow measurements. Current measurements are taken using internal toroids, providing complete isolation between the power line and the instrument, thereby eliminating the possible hazard of an open CT. And, the PQNode's unity power factor supply assures that you won't affect the characteristics of the power line you are monitoring.

The PQNode is housed in a lockable enclosure for permanent installation. An optional all-weather enclosure is ideally suited for outdoor applications.

Power Disturbance Analyzer

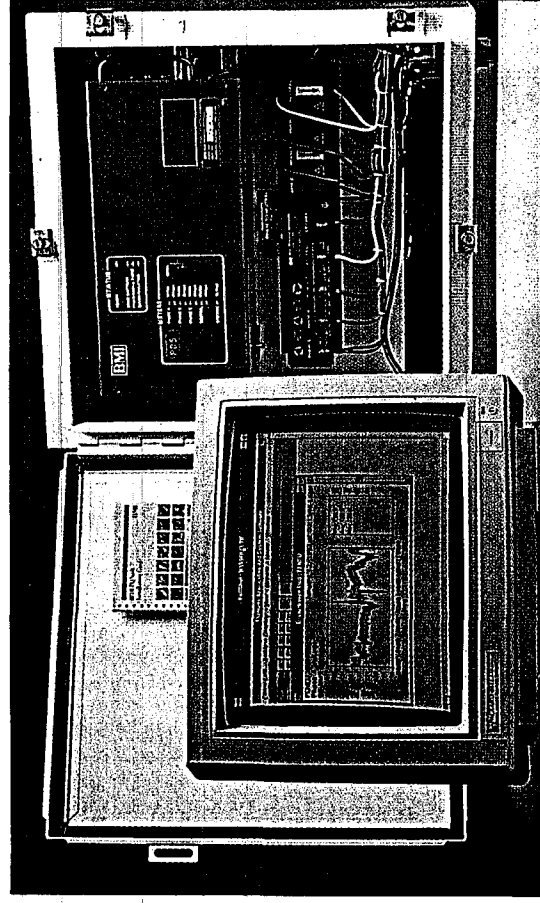
The PQNode monitors your power continuously for all potentially damaging disturbances. This data is stored in the Power Measurement Module until transferred to a host PC. The user sets thresholds and other key factors via the PC. The control software interprets and formats the collected data for output on a local printer or for viewing on your PC screen. The user is also able to select the desired pre- and post-trigger data amounts – the number of cycles before and after the disturbance.

The PQNode monitors for impulses, swells, sags, waveshape faults, outages, cold-load pick-up, and captures waveshape samples upon user request or at programmed intervals.

Power Flow Measurements

Using the information collected on a continuous basis, the PQNode reports RMS voltage and current, apparent power, VAR, and true power factor at user defined intervals. Harmonic analysis is performed on both voltage and current.

The user can also establish a connection between the PQNode and a PC and use the interface software to provide real-time and steady-state views on the PC screen of the power being monitored.



The 8010 PQNode is software configurable for both power quality and power flow measurements.

Applications Flexibility

Because your electric power analysis applications are unique, you need a monitor that can adapt and change to meet your requirements. The PQNode is a PC-based power monitor that provides complete flexibility while maintaining high standards of accuracy, reliability, and quality.

Separate modules are used for connecting to power and for the collection and storage of data. The measurement module is removable, making the mounting of the enclosure and the servicing of the monitor easier. Current probes are an integral part of the Input Module. Make your voltage connections to the terminals on the front of the module, then run your current conductors through the appropriate tubes in the top of the module. Not only does this connect the PQNode to the power source you wish to monitor, but it also provides the operating power for the unit.

The Power Measurement Module accepts the power data from the Input Module, stores the disturbance and report data requested by the user, and transmits the information to the host PC. Report intervals, pre- and post-trigger data, thresholds, and setup procedures are established using this PC at your desk or other convenient location. The PQNode

communicates with your PC via RS-232 or an optional internal modem.

A Base-Line Survey Tool

The PQNode was developed jointly with Electrotek Concepts under contract for the Electric Power Research Institute (EPRI). More than 200 EPRI PQNode units will be placed across the country as part of the largest study of power quality ever conducted.

This study, taking place over the course of two years, will involve more than 50 major utilities. At each of the more than 200 selected sites, a PQNode will be installed to collect data and report back to a central location.

About BMI and Electrotek

BMI power monitors are in use all over the world by companies, service organizations, and utilities. BMI instruments are rugged, reliable, and easy to use.

Electrotek is a nationally recognized engineering firm with the corporate capability to implement hardware and software systems for meeting the challenges of today's electric utility and industrial environments.

PQNode Hardware

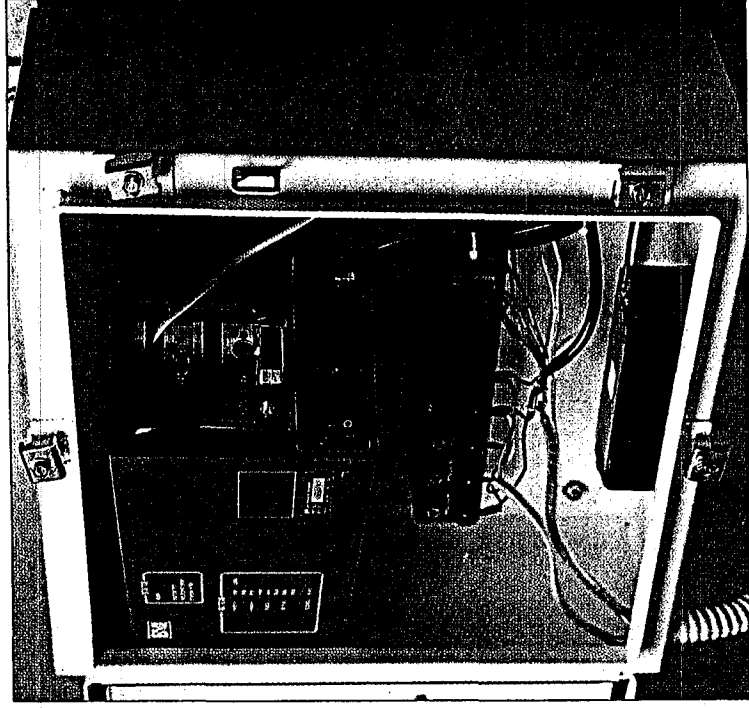
Maximum Reliability

The PQNode performs dependably week after week, month after month. Each hardware component is built for uninterrupted operation, even in the toughest, most remote environments — at temperatures from -30°C to $+50^{\circ}\text{C}$ (-22°F to $+122^{\circ}\text{F}$). Optional back-up batteries provide operating power to the PQNode: the short-life battery for 15 minutes, and the long-life battery for up to 8 hours. Both maintain the PQNode data memory for two days. Proven modular design builds reliability in, and many other features help the PQNode stay reliable:

- A "smart" uninterruptible power supply lets the PQNode operate during outages and monitors the state of the back-up battery.
- A temperature-compensated internal battery charger extends battery life over the full range of operating temperatures.
- An internal temperature monitor records internal temperatures; this information can be correlated with specific events and conditions.

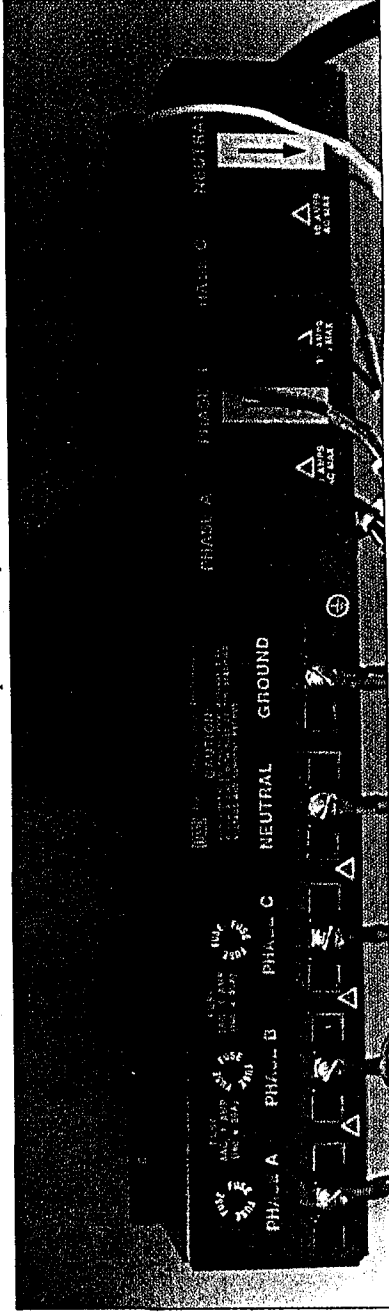
Sturdy and Safe

Rugged enclosures built to NEMA standards protect PQNodes from dirt and debris, and can be locked to prevent unauthorized access. In outdoor installations, the rust-resistant NEMA 4 guards against damage from rain, snow, and ice. For safety, the PQNode uses a single-wire current connection system: sealed, pass-through current inputs. The PQNode has been designed to meet UL and CSA requirements and has received the FCC Class B certifications; you can be assured of safe, clean, quiet operation.



Simple, self-contained PQNode hardware consists of the measurement module (top), which contains the electronics and software for measuring and storing power disturbance data, a small input module (center) to which power is connected, and an optional back-up battery (bottom). To protect the hardware, choose one of two sealable NEMA-type enclosures — splash-resistant NEMA 12 for indoor environments, or waterproof NEMA 4 for outdoor use.

Damage resistant and designed for safety, the input module links outside power to the measurement module. A single wire passes through sealed current inputs to eliminate electrical hazards from open current transformers.



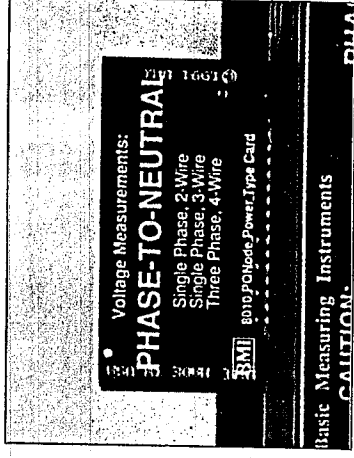
Combines Rugged Practicality with Advanced Design

Installation Almost Foolproof

Setting up PQNodes is quick and problem-free. Here's how it works:

- Enclosures containing input modules are mounted and secured in place first, so there is no risk of damage to sensitive components in the measurement module.
- Phase voltage connections are screwed directly to the input module. Current connections are made by running a single wire through each current input from each of the current transformers, thereby reducing the possibility of an open CT.
- The measurement module snaps in place; then, simply plug in standard connectors.
- The intuitive, step-through status panel on the measurement module verifies installation.
- Set the phase selection (phase-to-phase or phase-to-neutral) with a plug-in card.

That's all there is to the installation. All other parameters for PQNode hardware operation are set using the PASS software on the host personal computer.

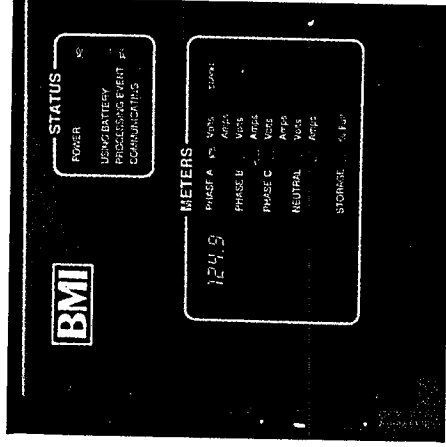


Simplified PQNode hardware design reduces the likelihood of installation errors. To specify phase selection, the installer inserts a card with the desired setting facing toward them.

Easy to Maintain and Upgrade

Working reliably day after day, the PQNode hardware demands little time or effort on your part. Internal diagnostics keep the system operating precisely and accurately without physically adjusting the equipment. And, maintaining, upgrading, or servicing a module requires minimal downtime. Simply remove a module that needs service and replace it with another.

The PQNode software is "field upgradable": most maintenance and upgrading tasks can be done from the host personal computer through modem or RS-232 communication. Software upgrades are uploaded into the measurement module's state-of-the-art programmable memory chips ("flash" EPROMs). A PQNode analysis system can grow with you and remain cost-effective.



During installation, the status panel on the PQNode measurement module quickly indicates that the module is working properly. Once the system is operating, the panel readily provides information for voltage and current readings.



Most PQNode software maintenance and upgrades can be done remotely via modem or RS-232. Should hardware service be required, the measurement module can be replaced without disrupting other hardware or system operation.

The Brains of the PQNode

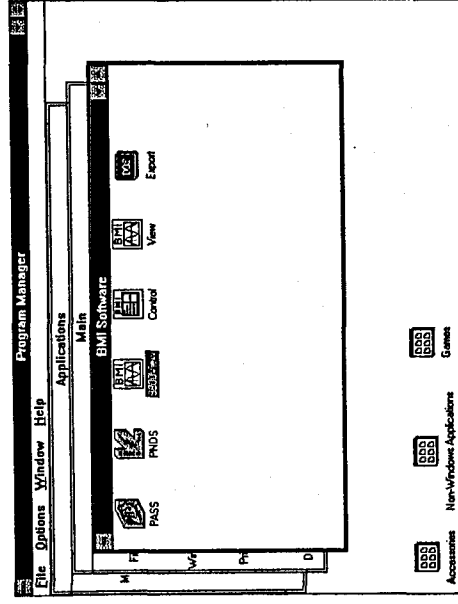
Flexible and User-Friendly

At the heart of the PQNode is PASS software, which runs under the popular Windows* operating system. Learn this menu-driven program quickly and easily. Point and click with a mouse, or use the keyboard. PASS provides flexibility, giving you the power to set and change many parameters according to your application. For example, specify the criteria for what constitutes a disturbance, your reporting preferences, and download schedule.

Automation for Convenience

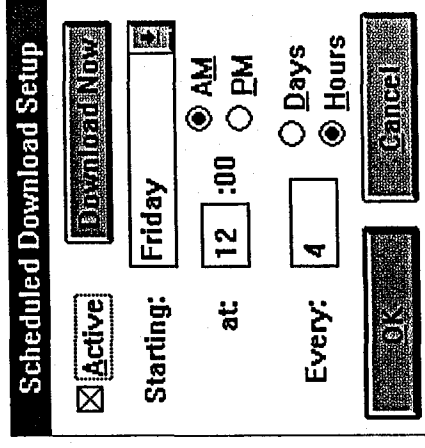
With PASS, specify parameters for the system, the PQNode, measurements, and reports just once. The software automatically uses these criteria until you change them. Even novice users can access the full power of the PQNode by pulling down a few menus. PASS automatically organizes many complex functions and programs, including file management and data communication, under one interface in the Windows operating system.

For example, when you request a real-time display, the parallel processor architecture in the measurement module simultaneously captures disturbance data, stores it, and communicates it to PASS for formatting and display.

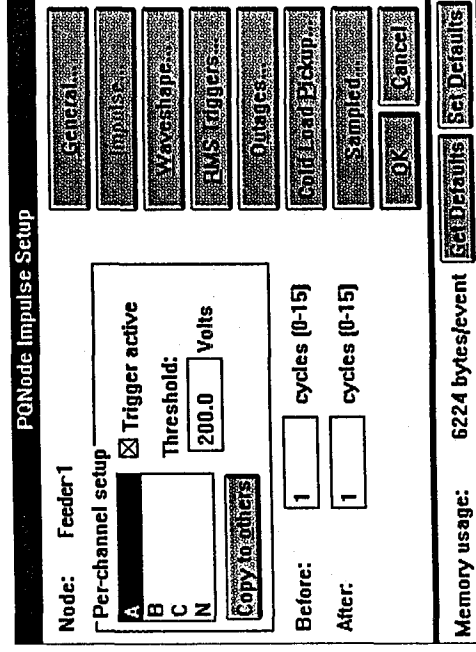


PASS software has a standard Windows graphical user interface. Open menus, choose menu items, select buttons, and set boxes with the click of a mouse. Open various windows, move and resize them as you would with any Windows-type program.

*Windows Graphical Environment and Excel are registered trademarks of Microsoft Corporation.



Automatic, periodic downloading of information from the measurement module to the host PC is exceptionally simple with this setup screen. The PQNode provides data compatible with your study format, whenever you need it.



Instruct the PQNode system how to define and analyze specific events, waveform distortions, and RMS variations. In this screen, threshold voltage and number of cycles provided for each channel establish triggering information for disturbances. By selecting the "Advanced" field, you can instruct the PQNode to measure long-term disturbances. The "Copy to" selection lets you set these parameters for other PQNode channels without having to reenter the information.

Powerful, Simple PASS Application and System Software

PQNode Setup	
Node	Class
Feeder1	MODEM
Driver	DIALUP
<div style="display: flex; justify-content: space-between;"> <div> <p>Add Copy</p> <p>Delete</p> <p>Update</p> </div> <div> <p>Exit</p> <p>Update All</p> <p>Send Changes</p> </div> </div>	
<div style="display: flex; justify-content: space-between;"> <div> <p>General</p> <p>Inputs</p> <p>Waveforms</p> <p>BVS Triggers</p> <p>Outputs</p> <p>Serial Board Pickup</p> <p>Sampling</p> <p>Communications</p> </div> </div>	

Configure each PQNode on your system with a few simple commands. Specify data communication method (modem or serial port), activate or disable voltage and current channels, and set criteria for periodic sampling. PQNodes can be configured individually, or settings used for more than one module.

Based on Proven Expertise

PASS was developed by Electrotek, an engineering firm with a reputation for leadership in applications software for today's electric utilities and industries. With PASS, you get a password protection system that prevents unauthorized access and changing of data. PASS also includes clear, complete documentation.

Standard, Economical PC Architecture

The PQNode and PASS are based on the IBM PC architecture, so you can make the most of your existing investment in IBM PC technology. Keep costs down and flexibility up by using industry-standard boards, modems, and other options. This architecture also enables simple "file-to-file" transfer of data between PCs.

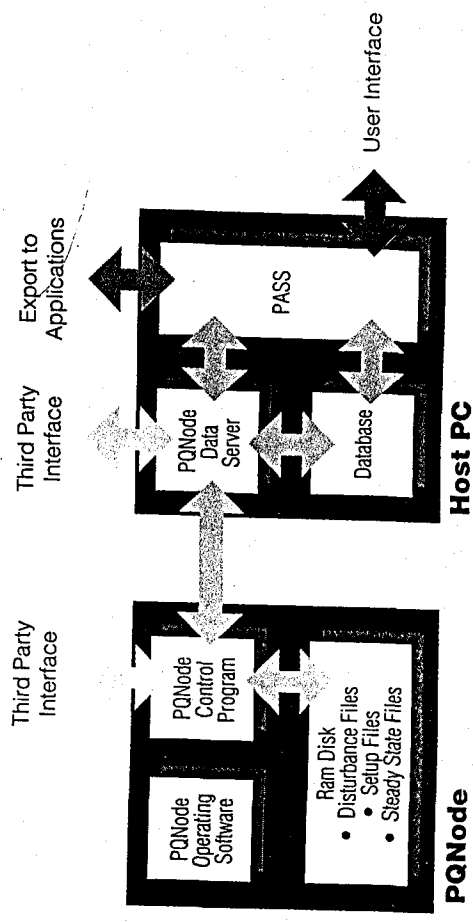
PQNode Advanced Setup

Node:	DEV_ID	
<input type="checkbox"/> Instantaneous RMS	RMS Waveform Capture	
Before <input type="text" value="10"/> Cycles (0 - 31)	Before <input type="text" value="1"/> Cycles (-1 - 7)	
After <input type="text" value="120"/> Cycles (0 - 255)	After <input type="text" value="3"/> Cycles (-1 - 15)	
Min/Avg/Max RMS Envelope	Memory usage: 40584 bytes/event	
Cycles	Duration (Sec)	Count
1 <input type="text" value="6"/>	<input type="text" value="8"/>	<input type="text" value="80"/>
2 <input type="text" value="30"/>	<input type="text" value="20"/>	<input type="text" value="40"/>
3 <input type="text" value="60"/>	<input type="text" value="90"/>	<input type="text" value="90"/>
<div style="display: flex; justify-content: space-between;"> <div> <p>Set Defaults</p> <p>Set Defaults</p> <p>OK</p> </div> <div> <p>Cancel</p> </div> </div>		

Advanced features allow recording rates to vary based on the length of the disturbance. RMS swells, rms sags, and cold load pickup events utilize this capability for optimum characterization.

Compatible and Customizable

PASS makes study data even more useful with customized reports. The software allows the exporting of disturbance data to other programs, including the Excel* spreadsheet, and to word processing programs in ASCII text files. PASS has an "open" architecture, so that it can be modified by utilities, plants, or third parties for specialized applications. Well defined technical interface points simplify the task. Contact BMI for more information about this important software capability.



The PQNode's software architecture combines benefits for users and computer programmers. Users learn one simple interface for the applications software — the Windows operating system. All the other PQNode programs become "transparent" to anyone operating PASS. Third-party developers can access software in the host PC and in the PQNode measurement module itself for flexibility in making modifications. Full documentation for developers, including data and file formats and communications protocols, is available from BMI and Electrotek.

Power Quality Data at Its Most Useful...

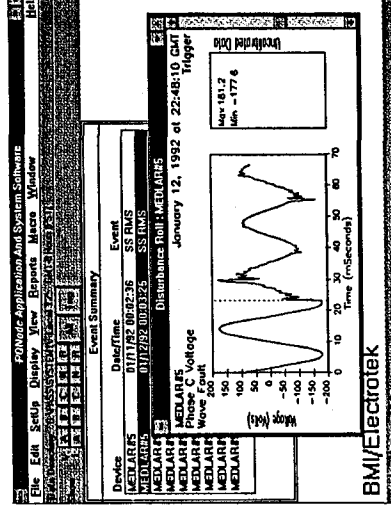
A Full Range of Information

Here's what you can get from the PQNode:

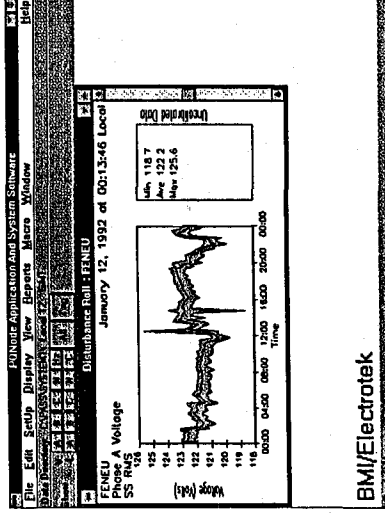
- Event summaries — concise lists of what happened, when and where.
- Disturbance rolls with chronological plots corresponding to impulses, waveshape faults, RMS variations, outages, cold load pickup.
- Trend charts for real, reactive, and apparent power, true power factor, RMS magnitudes of harmonic orders, Total Harmonic Distortion, and more.
- Real time displays — voltage and current snapshots available on demand.
- Voltage and current readings for all disturbances on any channel — up to eight in all.
- Logs of downloading information and errors which serve as diagnostic aids.

Organized for Your Study Application

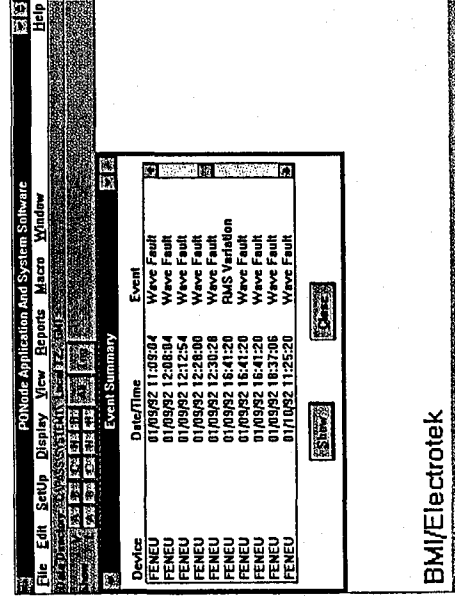
Structure PQNode information the way it is useful to you: real-time information, trends, snapshots, or detailed recaps. And, select what you want to see in precise detail. Look at data on the computer screen or print a hard copy. View events by device, type of event, and range of dates, and create disturbance rolls for specific events or time periods. The PQNode gives you all the flexibility you need to create meaningful reports and displays, in forms as simple or involved as your application requires.



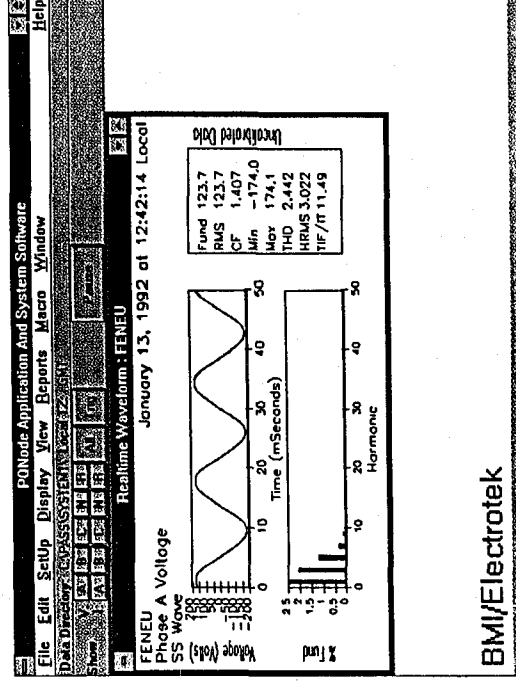
This display provides a graphical plot of the event, the date and time it occurred, and voltage and other relevant information. As with a paper tape, you can scroll through events, moving forward and backward in time. But for convenience superior to paper tape, the PQNode lets you select the time periods and event types you want to view.



Trend charts are displayed from the PQNode's periodic samples, over a time period you select. Create plots for a number of harmonic or steady-state trends and, as in other types of plots, view different channels.

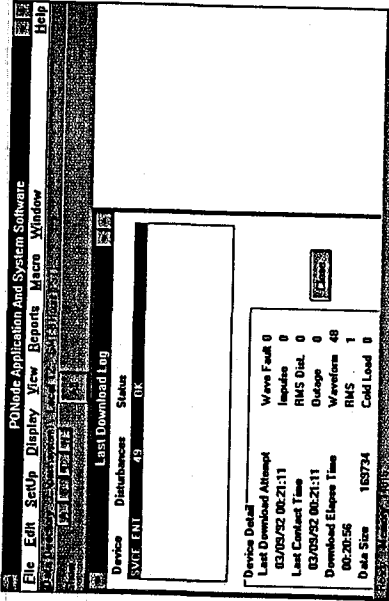


Event summaries provide a written recap by type of event. Scroll through a summary of events for a specified time period or PQNode. To create a plot of the event, highlight it on the list and click the "Show" box.

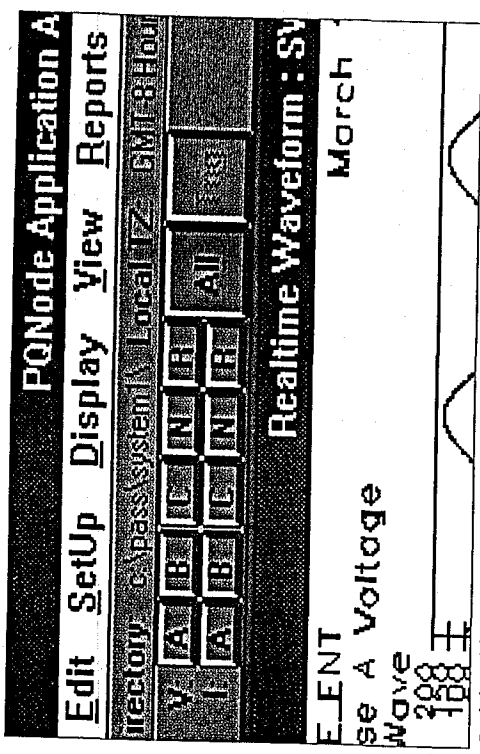


In this mode, the PQNode provides informative snapshots of various conditions. Specify the PQNode to contact, the number of cycles to be displayed, and the update interval. The "Latest Disturbance" option captures the most recent event and displays it until the next event is recorded.

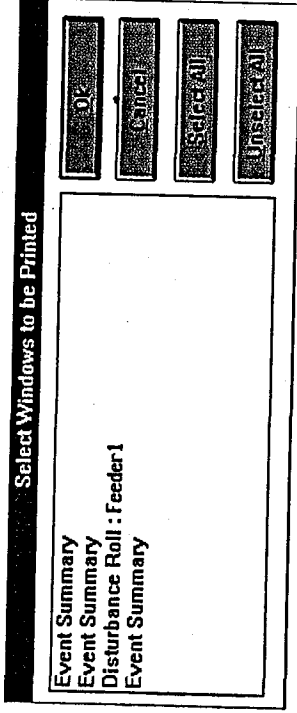
...with Clear Reports and Displays



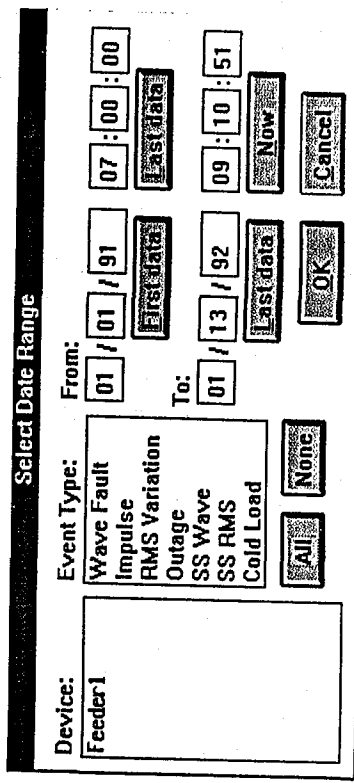
Convenient log screens like the Last Download log provide access to information about system operation. This screen shows all PQNodes contacted during the most recent download, time and duration, and numbers of each type of event recorded since the previous download.



By clicking different buttons near the top left portion of a data display window, you can view voltages and currents on any channel during that specific event or sequence.



To print displays, make a few simple menu selections. Choose to print the active window, an inactive window, or several windows at once.



This screen shows options for displaying a disturbance roll and the many combinations available. Other menus allow control over report page layouts, windows to be printed, data exporting, and viewing of logs that display information about the system.

Selection menu screens allow precise specifications for viewing the desired disturbance data. You can view disturbance rolls for one PQNode at a time, but can select more than one event type.

Summary of Capabilities

Measurement Types

- Impulses
- Waveshape faults
- RMS Variations — swells, sags
- Outages
- Cold load pickup (for power coming on in the aftermath of outages longer than a user-defined interval)
- Periodic sampling — RMS voltage, RMS current, apparent power, real power, reactive power, true power factor
- Complete harmonic analysis
- Voltage and current
- Frequency
- Internal temperature

Measurement Range

Number of channels
8 total — 4 voltage, 4 current

Voltage RMS and waveshape
10-600 Vrms, 1000 V peak (10-170 Vrms, 280 Vpk optional), 45-65 Hz fundamental, harmonic analysis up to 100th harmonic

Voltage impulse
50-6kV peak

Current RMS and waveshape
0.01-2 Arms, 5 A peak, or 0.1-10 Arms, 25 Apk, harmonic analysis up to 50th harmonic

Summary of Reports and Displays

- Event summaries
- Disturbance rolls: impulses, waveshape faults, RMS variations, outages, cold load pickup
- Trend charts: real, reactive, and apparent power, true power factor, RMS magnitudes of specific harmonics, Total Harmonic Distortion
- Real time displays
- Downloading and error logs

Host PC Configurations for Running PASS

	Minimum	Recommended
Computer	386	386/36 or 386/36
Operating System	DOSS 2.0 or greater	DOSS 3.0 or greater
RAM	2MB	4MB
Hard disk storage	11 MB	30 MB or bigger
Windows	3.0 or greater	3.0 or greater
Numeric processor	80387/387	30387 (or 386/36)
Modem	14.4K compatible with MNP 5 capability	14.4K compatible with MNP 5 capability
Other	Windows compatible graphics adapter, printer, and mouse	VGA monitor with Windows compatible adapter card

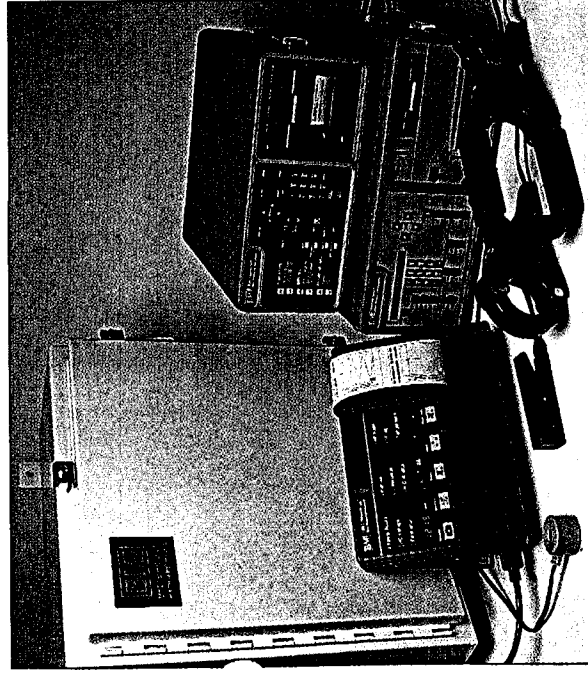
PASS may not be fully compatible with other software. Contact BMT Technical Support for more information.

BMI

Powerful Systems for Power Monitoring

Leadership in Power Monitors

Look to BMI when you want accurate information about your electric power. We provide what's needed to solve today's power problems — from rugged, reliable, easy-to-use power monitoring equipment, to effective PowerTalk™ software for easy remote monitoring and report preparation. Electric utilities, electronics companies, and industrial plants throughout the world get the answers from BMI.



BMI offers a full range of power monitoring instruments and systems, from the economical PowerVisa™, to the advanced PowerScope™ and PowerProfiler™ analyzers, to the highly integrated PQNode system. Whatever your needs, BMI meets them with products of quality and value.

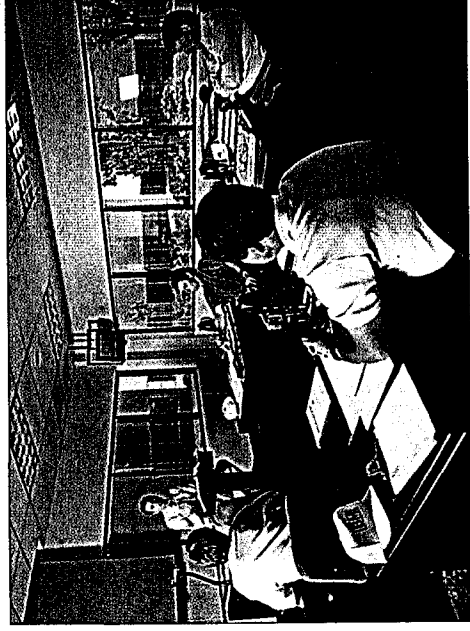
A Partnership for Software

To make the PQNode system's applications software powerful and easy to use, BMI has teamed up with Electrotek, a nationally recognized firm in the field of hardware and software systems for utilities and industry. Electrotek is a leader in developing software for obtaining information and solving problems associated with the steady-state, harmonic, and transient behavior of electrical systems.

Customer Service through Technical Support and Education

Our support begins with information: the *Handbook of Power Signatures*, published as a companion to the PQNode, PowerScopes, and PowerVisa disturbance analyzers. This book contains over 100 examples of the most frequently experienced power disturbances and offers explanations, solutions, and advice on conducting your own power quality survey. It has become the leading reference tool in the electric power industry.

More specific help is at hand, too. For assistance with data interpretation and applications, telephone BMI's applications personnel or fax questions to our Technical Support Engineers. And, professional instructors teach courses that combine hands-on lab experience, practical field surveys, and classroom work. BMI's training can be customized and even brought to your location.



Customers receive hands-on training in BMI's Education Center at corporate headquarters, located near San Francisco.

94/07/12 15:56:43

Temp, Humidity & RFI

magnetics

From Yaron Tue Jul 12 15:56:39 1994
To: Weiss
Subject: Re: Power Line Monitors
cc: dhs, yaron, pf

Three phases: PG-Node 8010-12 \$8,100.
One phase: 130PQ, \$2,000.
A current probe may be needed at \$500. per phase.
Each phase is monitored for:

> Voltage
> Current
> Impulses
> harmonic distortion
> Connection to a computer through RS232 or a modem is provided
> as well as battery back up.
> Since we have a heavy load (vacuum pumps etc.), we probably need
> 8 of the three phase monitors for a total of:

> 8 * (\$500 * 3 + \$8,100) = \$48,000.00

> Specifications and quotation in the mail.

> Yaron

their 8800 PowerScope, (\$12,230.00) can actually measure:
IS Voltage, 4 channels (3 phase + return)
IS Current, 4 channels (Current probe \$500.00 each)
Voltage frequency
Voltage and Current Swells and Sags
Voltage Impulses
Wave shape faults
High frequency noise on the line
5" Disk drive (comes with harmonic option \$2,270.00) to measure
rmonic Distortion and Spectrum analysis
Environmental (up to 8 channels total):
Temperature probe (\$300.00 each probe)
Humidity and Temperature (\$1,000.00 each probe)
Radiated Radio Frequency Interference
RFI probes are from:

→ Holaday Industries [B. Hericks (612) 934-4920]
Model # HI-3004, E-Field RMS in 3 axes
Range: 0.1-> 300 V/m, 0.5 -> 3000 MHZ
\$3,925.00

or

← Instruments for Industry [(516) 467-8400]
Model # EFS-3, E-Field RMS in 3 axes
Range: 0.1-> 300 V/m, 10 -> 2200 KHz
\$1,350.00

232 is included, Internal Modem is (\$600.00)

From Yaron Wed Jul 6 14:21:31 1994
To: Weiss
Subject: Re: Power Line Monitors
Cc: Yaron, dhs, pf

Hi,
I have just received information about Power Line Monitors.
We can get them from:

BMI
Foster City CA.
(408) 970-3700

through their representative :

Eastern System
(508) 366-3220

----- End Included Message -----

94/07/19
15:02:03

From Yaron Tue Jul 12 15:56:29 1994
To: wels
Subject: Re: Power Line Monitors, Temp, Humidity & RFI
Cc: dhs, Yaron, pl

I have just received the package from BMI.

Their 8800 PowerScope, (\$12,230.00) can actually measure:

RMS Voltage, 4 channels (3 phase + return)
RMS Current, 4 channels (Current probe \$500.00 each)
50e each voltage channel:

Voltage frequency

Voltage and Current Swells and Sags

Voltage impulses

Line WaveShape faults

High frequency noise on the line

1.5" Disk drive (comes with harmonic option \$2,270.00) to measure

harmonic Distortion and Spectrum analysis

Environmental (up to 8 channels total):

Temperature probe (\$300.00 each probe)

Humidity and Temperature (\$1,000.00 each probe)

Radiated Radio Frequency interference

RFI probes are from:

Holiday Industries [B. Hericks (612) 934-4920]

Model # HI-3004,E-field RMS in 3 axes

Range: 0.1-> 300 V/m, 0.5 -> 3000 MHZ

\$3,925.00

Instruments for Industry [(516) 467-8400

Model # EFS-3, E-field RMS in 3 axes

Range: 0.1-> 300 V/m, 10 -> 2200 KHZ

\$1,350.00

RS232 is included, Internal Modem is (\$600.00)

From Yaron Wed Jul 6 14:21:31 1994

To: wels

Subject: Re: Power Line Monitors

Cc: Yaron, dhs, pl

Rai,

I have just received information about Power Line Monitors.

We can get them from:

BMI

Poster City CA.

(408) 970-3700

through their representative :

Eastern System

(508) 366-3220

----- End Included Message -----

> Yaron

> Specifications and quotation in the mail.

> 8 * (\$500 * 3 + \$8,100) = \$48,00.00

> 8 of the three phase monitors for a total of:

> Since we have a heavy load (vacuum pumps etc.), We probably need

> as well as battery back up.

> Connection to a computer through RS232 or a modem is provided

> harmonic distortion

> impulses

> Current

> Voltage

> Each phase is monitored for:

> A current probe may be needed at \$500. per phase.

> Three phases: PQ-Node 8010-12 \$8,100.

> One phase: 130PQ, \$2,000.

> There are two models:

Live Monitors

from Jacke

DRANE TZ

818-395-2160

(201) 287-3680
(908)

Foster City CA.

BMI

290

(415) 570-5355
(408) 970-3700

→ Rms V to 4ch \$8000 ? ! ?
" I " " " "

frig " " " "

swell " " " " " " \$800

power scope

Brown

Impulsases

Hight d Noise

Har monic distortion

no bag +
1-800- chart recorder - comp "

RS232

Line monitors

DAI

(415) 570-5355

\$20,000

single phone \$2000

Model 130 PQ Conty

V, I, f, inputs; harmonic

Model Serial computer interface

(Model)

3b PQ Node 8010-12

Modem \$8100

Current Probe 45007

EASTERN SYSTEMS INC.

Representing electronic manufacturers

P.O. Box 1087
Westboro, MA 01581-6087
(508) 366-3220
FAX (508) 366-1520

FAX TRANSMISSION

TO: Yaron Hefetz

CC: _____

@: MIT

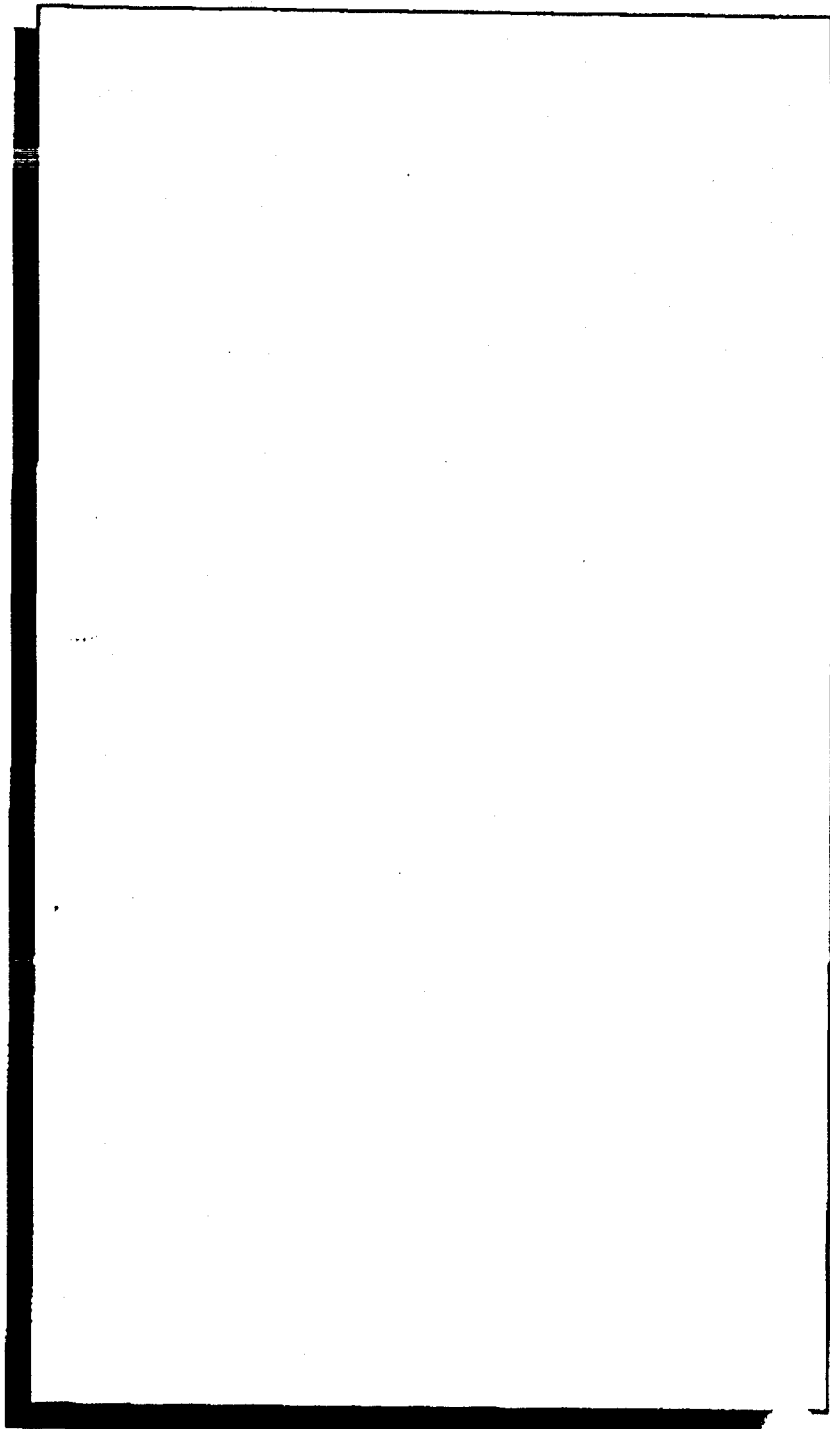
FAX #: 617-253-7014

Total # of pages including this header 1

FROM: Cheryl CaraDonna

DATE: 7/6/94

Comments:



If there is a problem with this transmission please contact Cheryl CaraDonna at (508) 366-3220.

8010 PQNode™

BMI

A power disturbance analyzer, power flow measurement and base-line survey tool.

Developed in
cooperation with

Electrotek

Introducing the PQNode

The 8010 PQNode is the newest power measurement tool from BMI. Incorporating eight channels - four voltage and four current - the 8010 allows simultaneous monitoring of voltage and current across all channels. The PQNode uses the proven technologies present in the BMI PowerScope™ and PowerProfiler™ families to provide both disturbance monitoring and power flow measurements. Current measurements are taken using internal toroids, providing complete isolation between the power line and the instrument, thereby eliminating the possible hazard of an open CT. And, the PQNode's unity power factor supply assures that you won't affect the characteristics of the power line you are monitoring.

The PQNode is housed in a lockable enclosure for permanent installation. An optional all-weather enclosure is ideally suited for outdoor applications.

Power Disturbance Analyzer

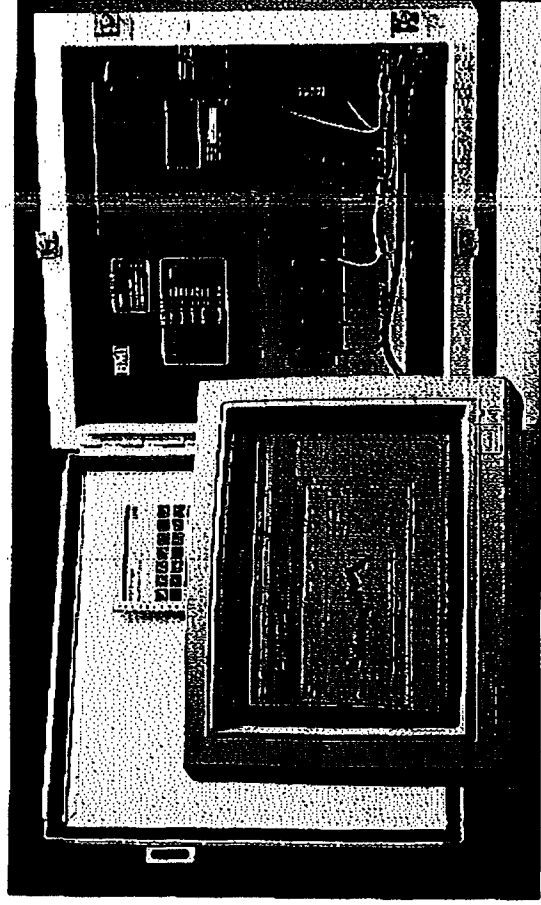
The PQNode monitors your power continuously for all potentially damaging disturbances. This data is stored in the Power Measurement Module until transferred to a host PC. The user sets thresholds and other key factors via the PC. The control software interprets and formats the collected data for output on a local printer or for viewing on your PC screen. The user is also able to select the desired pre- and post-trigger data amounts - the number of cycles before and after the disturbance.

The PQNode monitors for impulses, swells, sags, waveshape faults, outages, cold-fund pick-up, and captures waveshape samples upon user request or at programmed intervals.

Power Flow Measurements

Using the information collected on a continuous basis, the PQNode reports RMS voltage and current, apparent power, VAR, and true power factor at user defined intervals. Harmonic analysis is performed on both voltage and current.

The user can also establish a connection between the PQNode and a PC and use the interface software to



The 8010 PQNode is software configurable for both power quality and power flow measurements.

Applications Flexibility

Because your electric power analysis applications are unique, you need a monitor that can adapt and change to meet your requirements. The PQNode is a PC-based power monitor that provides complete flexibility while maintaining high standards of accuracy, reliability, and quality.

Separate modules are used for connecting to power and for the collection and storage of data. The measurement module is removable, making the mounting of the enclosure and the servicing of the monitor easier. Current probes are an integral part of the Input Module. Make your voltage connections to the terminals on the front of the module, then run your current conductors through the appropriate tubes in the top of the module. Not only does this connect the PQNode to the power source you wish to monitor, but it also provides the operating power for the unit.

The Power Measurement Module accepts the power data from the Input Module, stores the disturbance and report data requested by the user, and transmits the information to the host PC. Report intervals, min. and maximum data thresholds and even

communicates with your PC via RS-232 or an optional internal modem.

A Base-Line Survey Tool

The PQNode was developed jointly with Electrotek Concepts under contract for the Electric Power Research Institute (EPRI). More than 200 EPRI PQNode units will be placed across the country as part of the largest study of power quality ever conducted.

This study, taking place over the course of two years, will involve more than 50 major utilities. At each of the more than 200 selected sites, a PQNode will be installed to collect data and report back to a central location.

About BMI and Electrotek

BMI power monitors are in use all over the world by companies, service organizations, and utilities. BMI instruments are rugged, reliable, and easy to use.

Electrotek is a nationally recognized engineering firm with the corporate capability to implement hardware and software systems for meeting the challenges of today's electric utility and industrial environments.

provide real-time and steady-state views on the PC screen of the power being monitored.

procedures are established using this PC at your desk or other convenient location. The PQNode



The Power of Quality

130 PQSentry™

Provides continuous analysis of single-phase voltage and current.

BMI's 130 PQSentry is a single-phase power disturbance analyzer, harmonics analyzer, and power line monitor. It continuously monitors, analyzes, and records voltage and current to verify proper AC characteristics, measure harmonics, and to detect and record potential problem-causing disturbances.

A versatile monitoring tool

The PQSentry is ideal for anyone who needs to investigate customer power problems quickly and efficiently. The PQSentry is an inexpensive way to monitor sensitive loads and to perform pre-site surveys to determine the quality of power before electronic equipment is installed. It is also a useful tool for determining if there is a correlation between equipment problems and power disturbances. No matter what the application, the PQSentry will help you quickly identify problem-causing disturbances.

User-defined thresholds

Monitoring is easy with the PQSentry. There are no buttons to push or complicated programs to master. Prior to monitoring, thresholds are set on an IBM PC or compatible using the DOS-based PQSentry software. Thresholds are then stored in the instrument's battery-backed RAM.

Easy to use - just plug it in!

After setup is complete, the PQSentry can be disconnected from the host PC and carried or shipped to the monitoring point. To begin monitoring, simply plug in the PQSentry anywhere and leave it to capture disturbances and steady state rms data.

Events stored in memory

Events are detected as they occur and automatically stored by the PQSentry until they are transferred to your PC for further analysis. A blinking LED on the front panel tells you at a glance what disturbances have been recorded (whether a sag, swell, impulse, waveshape fault, power outage, or frequency deviation).



Single-Phase Measurements:

- Line-to-neutral rms voltage
- Neutral-to-ground rms voltage
- rms current
- Total harmonic distortion for voltage and current
- Harmonic spectrum analysis to the 31st harmonic
- Voltage sags
- Voltage swells
- Impulses
- Waveshape faults
- Power outages
- Frequency deviations
- Temperature

View data at your PC and print reports
After monitoring, the PQSentry can be unplugged and returned to the host computer. Stored data can then be transferred to your PC by a direct serial link. Using the menu-driven PQSentry software, you can download disturbance and steady state data from the instrument to your PC, store the data on a floppy or hard disk, and display and print reports and graphs.

Set up a network of PQSentries
You can access real-time disturbance data by using an external modem. When connected in

An easy and affordable way to analyze electric power: BMI's low-cost PQSentry is a versatile tool for continuous monitoring of voltage and current. No matter what your application, the PQSentry will help you capture disturbances and steady state rms data quickly and efficiently. Using external modems, you can communicate with a system of PQSentries to monitor critical power at many sites simultaneously.

this way, you can monitor critical power at many sites simultaneously. Using the PQSentry software, you can download data from each PQSentry as desired.

Capture real-time data

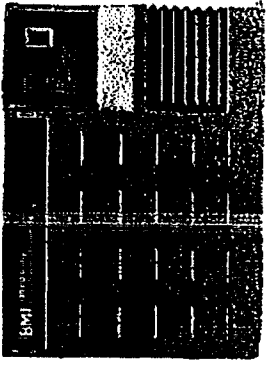
Real-time waveforms can be viewed for L-N voltage, N-G voltage, and current. THD and harmonic spectrum analysis is also continuously updated when viewing real-time waveforms.

Specifications are listed on the reverse side.

Part No.	Item/Description	Price	✓
A-725S	250 Amp, 500 Amp, 1000 Amp Switchable Clamp-on Current Probe Range 2 Amps to 1000 Amps in.	\$ 495.	
A-025T	Input Cable for PQNode Current Probe Length: 75' (4.6 meters)	\$ 125.	
B-801	Replacement Battery Provides 15 minutes of operation in the event of power failure, plus two days of data storage and five years of setup storage.	\$ 150.	
B-802	Battery - Extended Life Provides eight hours of operation in the event of power failure, plus two days of data storage and five years of setup storage. Not available for the 8010-T PQNode (in lieu of B-801).	\$ 420.	
B-803	Battery Provides 1 hour of operation in the event of power failure, plus two days of data storage and five years of setup storage. For use with 8010-4, 8010-12, 8010-S, and 8010-T PQNodes (in lieu of B-801).	\$ 215.	
G-810	PASS Software Distribution Kit Includes one #1/2 PASS software disk and one #1100 PASS User Guide.	\$ 495.	
CS-803	BMI PQNode Controller #1 For small to medium-sized PQNode systems. Includes PASS Software License and one PASS Software Distribution Kit.	\$ 3,223.	
CS-804	BMI PQNode Controller #2 For larger PQNode systems (or for faster, more powerful computing). Includes PASS Software License and one PASS Software Distribution Kit.	\$ 4,623.	
LP-810	Laser Printer For PQNode Controller #1 and PQNode Controller #2. Includes all cables, software and documentation.	\$ 1,699.	
A-010S	Handbook of Power Signature (See color portion for text and graphics) A soft-bound reference book that shows cable symptoms and solutions for hundreds of power disturbances.	\$ 35.	
A-810	PASS User's Guide for the 8010 PQNode (One copy is shipped with each PASS Software Distribution Kit)	\$ 100.	
A-810I	8010 PQNode Instruction Guide (One copy is shipped with each unit)	\$ 50.	
A-810T	8010-T Transmutable PQNode Connection Guide (One copy is shipped with each unit)	\$ 25.	

Probes and Cables**Batteries** (one required)**Software****System Controller****Documentation**

130 PQSentry™



BMI's 130 PQSentry is a single-phase power disturbance and harmonics analyzer. Each unit is shipped with a piggy-back monitoring cord, NiCAD battery, and bracket mounting assembly. New units are covered by a 12-month warranty.

Part No.	Item/Description	Price
130	PQSentry Includes three-channel analyzer, piggy-back power monitoring cord, NiCAD battery, and bracket mounting assembly.	\$ 1,495.
PQS-226	PQSentry Software Distribution Kit Includes 130 PQSentry software on 3.5" diskette, user's guide, and RS-232 cable/modem adapter.	\$ 175.
A-017	Panel Probe Power cord that enables fused connection to distribution panel (240 V _{max} maximum rating).	\$ 160.
P-130	150 Amp Current Probe Clamp-on current probe (aperture size: .5" round) for use only with BMI's 130 PQSentry.	\$ 245.
PQS-002	Temperature Probe Monitors temperature over the 20° C to 100° C range.	\$ 75.
PQS-401	Soft Carry Case Soft-side, canvas-type material with velcro front pocket.	\$ 135.
PQS-402	Hard Carry Case High-impact plastic; 18" x 13" x 5.75"; holds the PQSentry and accessories.	\$ 195.
A-0105	Handbook of Power Signatures (Second edition, revised and expanded) A soft-bound reference book that shows causes, symptoms, and solutions for hundreds of power disturbances.	\$ 35.
A-130	130 PQSentry User's Guide (One copy is shipped with each unit)	\$ 75.

TO ORDER BY PHONE, CALL BMI AT (408) 970-3700.

Specifications

Operating Characteristics:

- Power In:
 - Voltage Range: *Low* 75-150 V_{rms} *High* 150-280 V_{rms}
 - Frequency: 50/60 Hz
 - Maximum Power Consumption: 6 VA max. 6 VA max.

Physical Characteristics:

- Width x Length x Height: 9 in. (22.86 cm) x 6.75" (17.15 cm) x 2" (5.08 cm)
- Weight: 3.2 lbs (1.46 kg), battery installed.

Environmental Characteristics:

- Temperature range: 0°C to 50°C (32°F to 122°F)

Measurement Characteristics:

- AC Voltage:
 - L-N Input Range, Low Scale: 75-150 V_{rms}
 - L-N Input Range, High Scale: 150-280 V_{rms}
 - N-G Input Range, Low Scale: 0-3 V_{rms}
 - Measurement Accuracy: 0.5% of reading, ±1% of full scale
- Impulse Peak Voltage:
 - For IEEE BiWave
 - Input Range Tolerated: 2 KV
 - Input Range Measured: 50 - 1000 V
 - Measurement Accuracy: 10% of reading, ±2% of full scale
- AC Frequency:
 - Input Range: 45 - 65 Hz
 - Measurement Accuracy: ±0.1 Hz
- AC Current (Requires optional current probe):
 - Low Range: 1-15 A_{rms}
 - High Range: 15-120 A_{rms}
 - Crest Factor (Maximum): 1.7
 - Measurement Accuracy: 5% of reading, ±1% of full scale

Temperature (Requires optional temperature probe):

- Range: -20°C to 100°C (-4°F to 212°F)

• Harmonics:

- Voltage and current: Up to the 31st harmonic

Communications Specifications:

- RS-232
 - Voltage Isolation: 6000 V
 - Communication Rates: 300, 600, 1200, 2400, 4800, 9600 baud

• Modem:

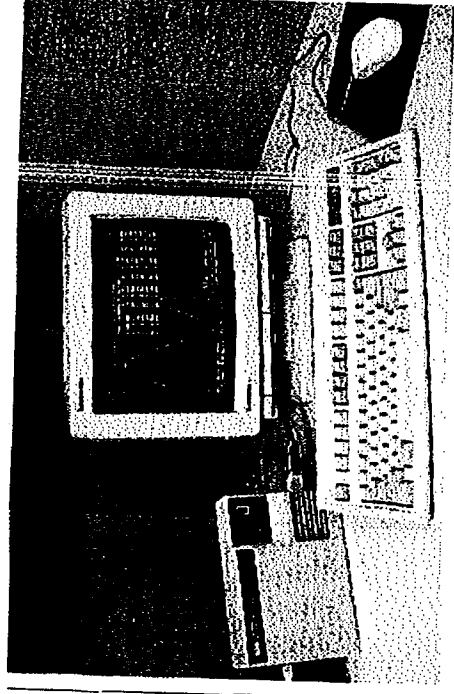
- May be used with appropriate user-supplied modem.

* Requires additional hardware and software options.

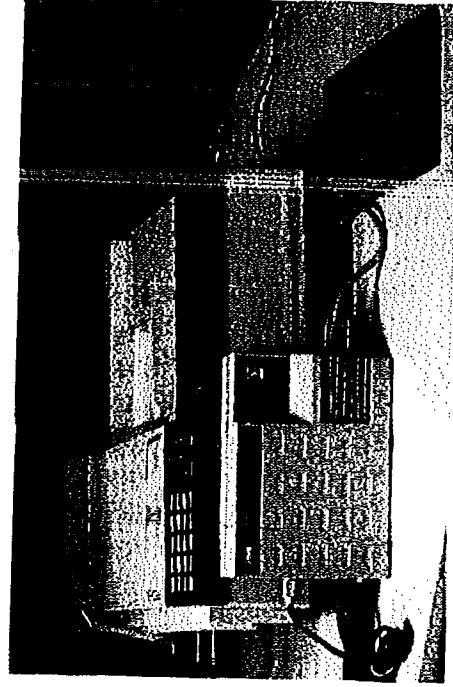
Specifications subject to change without notice.

BMI

Basic Measuring Instruments
The Power of Quality



On-site monitoring: Recorded data can be transferred to your PC by a direct serial link. Using the menu-driven PQSentry software, you can download disturbance and steady-state data from the instrument to your PC, store the data on a floppy or hard disk, and display and print reports and graphs.

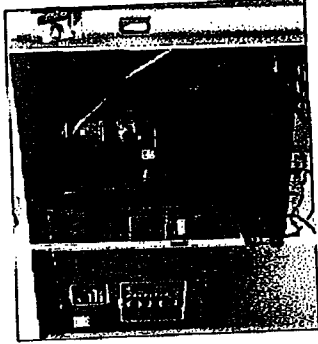
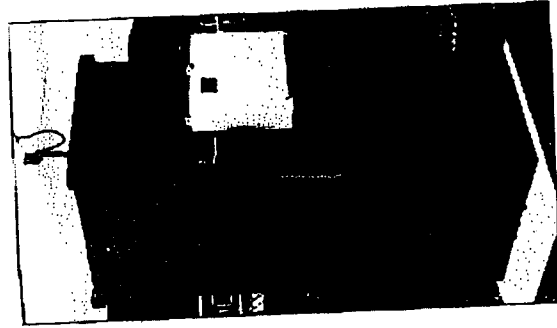


Remote monitoring: You can access real-time disturbance data by using an external modem while monitoring sensitive loads at many sites simultaneously. Using PQSentry software, you can download data from each PQSentry as desired.

Minimum System Requirements:

- Hardware: IBM PC or compatible - 286, 386, or 486; DOS 3.x or higher
- Storage: One hard drive and one high-density, 3.5" floppy disk drive
- Memory: 640 K RAM
- Display: CGA, EGA, or VGA monitor

PQNode Specifications



The removable Power Measurement Module makes installation and service easy (above). The NEMA 4 enclosure provides protection from the elements for outdoor installation (left). The NEMA 12 enclosure provides a lockable enclosure for indoor installations (not shown).

Accuracy

RMS Voltage

RMS Current

Voltage Impulse

Specifications at 20°C (50°F): 5% full scale - 60% full scale; Temperature coefficient: 200 ppm full scale/°C; drift less than 10 ppm full scale/day; maximum time to zero accuracy: 60 minutes; note: less than 0.05% RMS full scale resolution; 51.5 display count.

Environmental

Operating Temperature

Operating Humidity

Storage Temperature

Storage Humidity

50°C (122°F)

35% non-condensing with NEMA 4

40 to 97°C (104 to 167°F)

95% non-condensing

±0.02% full scale ±0.2% offsetting

±0.04% full scale ±0.2% offsetting

±0.7% of full scale ±0.6% offsetting

±0.7% of full scale ±0.6% offsetting

±0.02% full scale ±0.2% offsetting

±0.04% full scale ±0.2% offsetting

±0.7% of full scale ±0.6% offsetting

±0.7% of full scale ±0.6% offsetting

Power Measurement Module

Operating Power

AC Voltage: 90 - 290 Vrms

Frequency: 55 - 65 Hz

Power Consumption: Less than 40 VA

Power Source: 50/60

Measurement Range

Number of Channels: 3

Voltage: RMS and Waveshape

10 - 600 Vrms, 1000 V peak optional,

100 - 200 Vrms, 250 V peak optional,

45 - 65 Hz fundamental harmonic,

analysis up to the 10th harmonic.

50 - 600 V peak

0.01 - 2 A rms, 5 A peak, up to 10 Arms,

5 A peak harmonic analysis up to the

30th harmonic

Phase-to-phase ampere technique employed

Input Characteristics

Type

Voltage - solid state differential

DC coupled; Current transformer

isolation; AC coupled

Voltage - 1 MΩ input impedance

< 50 kΩ to ground

Current - 0.0025 V

± 0.5 A, 10 ohms

Voltage - zero term (d)

Current - polysubstrate tube

1/8" (0.57 cm) inner diameter,

up to #14 AWG wire

Voltage only phase A/B, C, and neutral

wave shape full, Vrms, Vrms sag

power failure, and in pulse. Also manual

and periodic verification of current

total meter selectable

Pre- and Post-Trigger Bus

Triggers

Optional Batteries (Recommended)

Note: For use with setup computer software.

Short Life

24 Vdc, 2.4 Ah, minimum operation 2 hr; data storage with 0.5 without battery

7 inches x 2.7 inches x 2.4 inches (17.8 mm x 6.9 cm x 6.1 cm) (WX, HxD)

Low Life

24 Vdc, 1.5 Ah, 8 hour operation at 25°C; 2 day data storage

4.5 inches x 3 inches x 2 inches (36 mm x 76 mm x 51 mm) (WX, HxD)

Specifications subject to change without notice.



Basic Measuring Instruments

335 Lakeside Drive

Foster City, CA 94404

USA

Tel. 415 570-5355

FAX 415 574-2176



QMG

Fri Jul 22 09:06:48 1994

1

RAI WEISS;

Attached are pages from BALZER,s cat and price lists.

John

Possible Balzers RGAs;

0-300	BK M18111 QMG421-3 QMA 430	\$35143
	CP400 ion counter preamp	1709
	IC421 ion counter board	3088

→ INCLUSORS HEAD

0-128	BK M22107 QMG421-5 QMA 410	\$46769
	CP400 ion counter preamp	1709
	IC421 ion counter board	3088

0-340	BK M22117 QMG421-5 QMA 410	\$48739
	CP400 ion counter preamp	1709
	IC421 ion counter board	3088

Parts	QMA 430 head	\$12153
	QMA 410 head	\$21020

software

Quadstar BN882085 \$5661 >need if connected to PCs

BN882086-T 2573 >needed for networked?

BN882088-T 2573 >needed for networked?

IS 420 ion source supply
The ion source supply is used for operating the various ion sources of the quadrupole analyzers. All parameters can be set either via the control unit or the QUADSTAR™ 421 software.

Ion source supply
Programming 9 potentials
Emission 4 x 6 ion source parameter sets
Degas 0 - 2 mA
Filament supply, max. 0 - 20 mA/500 - 800 V
Filament changeover FIL V/FIL 2/FIL 1+2¹⁾

Ordering data
IS 420 BG 512 800-T
Cable IS 420/QMA BG 548 082-T
3 m BG 548 083-T
10 m

High voltage supply
The high-voltage supply produces the operating voltage for the secondary electron multiplier.

	HV 420	HV 421
Detection of Positive ions (with electrometer or ion counter)	SEV 217	SEV 217
Positive or negative ions (with ion counter)	0 to -3.5 kV	0 to -3.5 kV
Positive ions (with electrometer)	-	SEV 218 with separate conversion dynode 0 to -3.5 kV -6/+3.2 kV (to ground)
Positive ions (with electrometer)	-	SEV 218 with separate conversion dynode 0 to -3.5 kV -6/+3.2 kV (to ground)

Ordering data
High-voltage supply BG 548 040-T
High-voltage cable BG 442 250-T
HV/SEV 1x BG 541 978-T 2x BG 541 978-T
3 m 1x BG 541 979-T 2x BG 541 979-T
10 m

Supplementary modules

AO 421	AI 421	DO 420	DI 420	PI 420	PE 420
Analog Output	Analog Input	Digital Output	Digital Input	Parent module	Penning module
12 channels Signal range ± 10.24 V Resolution 12 bits	16 inputs Signal range ± 10.24 V Resolution 12 bits	32 outputs	32 inputs		
Supplementary board BG 442 328-T ²⁾					BG 512 726-T
Plug-in board BG 442 240-T ²⁾		BG 548 004-T ²⁾	BG 574 700-T ²⁾	BG 512 715-T	
Connection box AB 021					
TPR 010				BG 002 270	
Parent gauge head IKR 020					BG 612 830
Penning gauge head				BG 548 651-T	BG 548 313-T
Cable, 3 m					

Ion counter
Detection limit $< 2 \cdot 10^{-10}$ mbar. For detecting very small ion currents, the QMG 421 or QMG 421-C can be equipped with an ion counter. Pulses triggered by positive or negative ions striking a secondary electron multiplier (SEM) are counted. The IC 421 ion counter is a supplementary board that plugs directly into the QC 421 quadrupole controller of the control unit. The CP 400 ion counter preamplifier is installed directly on the SEM flange of the 90° off-axis analyzer.

IC 421 ion counter (incl. AO 421)

Counting width 12 bit
Counting frequency, max. 50 MHz
Pulse width, min. 10 ns

CP 400 ion counter preamplifier

Pulse width 10 ns typ.
Double pulse resolution 520 ns
Discriminator threshold adjustable via QMS or QUADSTAR

Ordering data

IC 421 BG 442 320-T
CP 400 BG 442 210-T
Cable CP 400/QC 421 BG 448 134-T
3 m BG 448 199-T
PL 410⁴⁾ power supply and logic converter BG 574 085-T
(ECL/TTL) to CP 400

CLA 421 chopper lock-in amplifier
Supplementary unit for eliminating unwanted background signals in trace gas analysis. The gas sample is injected into the ion source in the form of a chopped molecular beam.

Ordering data

CLA 421 incl. pico chopper BG 572 324-T
CLA 421 with TTL reference input BG 572 335-T

- ¹⁾ e.g. 1 in operation, 2 preheated
²⁾ Transition from 25-pin D-type connector to 2 mm banana plug
³⁾ Incl. connector
⁴⁾ Used when operating the CP 400 via customer-supplied counting device (not IC 421)



EP 112 electrometer preamplifier

The EP 112 is a high-speed, high-sensitivity current-to-voltage converter

Ordering data
EP 112

BG 528 755 -U
BG 548 152 -T
BG 548 153 -T

Ranges 10⁻⁷/10⁻⁷/10⁻⁹/10⁻¹¹ A.f.s.

Rise times 10 - 90%

Output signal 40 μ s/100 μ s/1.5 ms/80 ms

Input 0 - \pm 10 V

BNC socket.

protected to 250 V

Weight, approx.

100 g

Radio-frequency generator

The quartz-stabilized radio-frequency generator supplies the required voltages to the mass filter. The connection to the analyzer is established via 2 x 0.7 m RF cables. The connection cable to the control units has a length of 3 m.

QMH 400-5 QMH 400-1 QMH 410-1 QMH 410-2 QMH 410-3

Mass range with

QMA 430 amu 1-300

QMA 400 amu 1-512

QMA 410 amu -

Radio frequency MHz 1-128

RF cable length m 2.05

Weight kg 0.7

4.5

Ordering data

Radio frequency generator

RF cable, 0.7 m⁵⁾

Field axis cable QMH/QMA, 0.7 m²⁾

Extension cable to QMS, 7 m

BG M23 066

BG M23 067

BG 541960 -T

BG 541962 -T

BG 448 175 -T

BG M40 566

BG M40 567

BG 541960 -T

BG 541962 -T

BG 448 175 -T

BG M40 566

BG M40 567

BG 541960 -T

BG 541962 -T

BG 448 175 -T

BG M40 566

BG 541960 -T

BG 541962 -T

BG 448 175 -T

Analyzers

The analyzer comprises the mass filter, detector and ion source. The high-precision mass filter achieves a high degree of linearity and reproducibility. With the appropriate combination of a detector and ion source, a suitable configuration can be selected for each application.

With Faraday cup

The Faraday cup is a simple, stable ion current

detector.

Sensitivity¹⁾ 10⁻⁴ A/mbar

Max. bakeout temperature 400 °C

Admissible operating temp. 200 °C

With 90° off-axis SEV 217 secondary electron multiplier³⁾

The 17-stage SEM is used for measuring small ion currents and high-speed processes. An optimum signal-to-noise ratio is achieved through the 90° off-axis arrangement.

Number of stages 17

Dynode material Cu/Be

Voltage divider

(both ends terminated externally) 1 MC/stage

Gain, typ. > 10⁵ at 3.5 kV

Admissible current 10⁻⁸ A

Max. bakeout temperature 400 °C

Admissible operating temp. at < 1 kV

Ordering data

SEV 217⁴⁾

SEV 218⁴⁾

8G 521 011 -X

BG 444 220 -T

8 4728 89189

Short-circuit connector

QMH-fastening clamp for

DN 63 CF

DN 100 CF

Mounting block for QMA

BG 546 510 -T

BG 546 511 -T

BG 548 470 -X

QMA 430 QMA 400 QMA 410

Rod system

Length mm 200

Diameter mm 8

Material Stainless steel

Weight with Molybdenum

Faraday cup kg 2.8

90° off-axis SEV 217 kg 10.5

Ordering data

Analyzer with Faraday cup and

axial ion source

Gas-tight axial ion source

Crossbeam ion source

Gas-tight crossbeam

ion source

Grid ion source

Crossbeam ion source

with molecular beam device

and collimation magnet

without ion source

Analyzer with 90° off-axis SEV 217 and

axial ion source

Gas-tight axial ion source

Crossbeam ion source

Gas-tight crossbeam

ion source

Grid ion source

Crossbeam ion source with

molecular beam device

and collimation magnet

2-lens ion optics

Crossbeam ion source with

3-lens ion optics, with beam stop

with beam stop

Without ion source

300

16

8

8

2.9

10.7

BK M08 500

BK M07 500

BK M09 501

BK M07 501

BK M08 502

BK M07 502

BK M08 526

BK M07 582

BK M07 511

BK M08 518

BK M08 508

BK M07 507

BK M08 508

BK M07 508

BK M08 510

BK M08 526

BK M07 582

BK M07 511

BK M08 518

BK M08 508

BK M07 507

BK M08 508

BK M07 508

BK M08 510

BK M08 526

BK M07 582

BK M07 511

BK M08 518

BK M08 508

BK M07 507

BK M08 508

BK M07 508

BK M08 510

BK M08 526

BK M07 582

BK M07 511

BK M08 518

BK M08 508

BK M07 507

BK M08 508

BK M07 508

BK M08 510

BK M08 526

BK M07 582

BK M07 511

BK M08 518

¹⁾ 2 cables included with RF generator

²⁾ 1 cable included with RF generator

³⁾ Standard analyzers and equipment

configurations are equipped with the

SEV 217

⁴⁾ SEV 217 and SEV 218 are not inter-

changeable!

⁵⁾ Isolated mounting

⁶⁾ Axial ion source, unit resolution,

at 1-300/1-512 amu

	Axis	Gas-tight axial	Crossbeam	Gas-tight Crossbeam	Grid
Characteristics	- High sensitivity - Rugged	- Low gas consumption - Fast response - Low fractionation	- Open design - Fast response to changes in the gas composition - Long life	- Low gas consumption - Fast response - Low fractionation - Long life	- Open design - Low degassing rate - Easy to degas
Filament	1 x Re ¹	1 x Re ¹	2 x Re ¹	2 x Re ¹	2 x W
Applications, e.g.	- General gas analysis - Residual gas analysis	- Gases and solvents in liquids - Respiration gas analysis - Toxic substances	- Qualitative and quantitative gas analysis - Corrosive gas measurement - Isotope measurement - Vapor beam measurement	- Gases and solvents in liquids - Respiration gas analysis - Toxic substances	- Residual gas measurements in UHV - Desorption measurement
Ordering data	BN 845 055 -T	BK 371 940 -T	BN 845 346 -T BN 845 121 -T	BK 353 333 -W	BN 845 097 -T
Collimation magnet					
Replacement cathode					
Rhenium (Re)	BN 845 059 -T	BN 845 059 -T	BN 845 062 -T	BN 845 062 -T	
1 pc.	BN 845 022 -T	BN 845 022 -T			
2 pcs.					
5 pcs.					
Tungsten (W)	BN 845 060 -T	BN 845 060 -T	BN 845 088 -T	BN 845 088 -T	BN 845 096 -T
1 pc.	BN 845 024 -T	BN 845 024 -T			
2 pcs.					
5 pcs.					
Thoriated indium (Ir-ThO ₂)	BN 845 057 -T	BN 845 057 -T	BN 845 282 -T	BN 845 282 -T	
1 pc.					
2 pcs.					
Characteristics	- Crossbeam with molecular beam device and collimation magnet - Produces a narrowly focused gas beam - No contact between gas and ion source surface	- Crossbeam with 2-lens ion optics - Detection of charged and neutral species	- Crossbeam with 3-lens ion optics with beam stop - Detection of charged and neutral species - Background minimization through elimination of fast ions	- 3-Lens ion optics with beam stop - Detection of charged species (positive and negative ions)	
Applications	- Measurement of aggressive substances	- Plasma technology - SIMS	- Plasma technology - SIMS	- Secondary emission (SIMS) - Photoionization - Electron-induced desorption - Plasmas	
Ordering data	BK 371 650 -T	BK 352 328 -T	BK 352 328 -W like crossbeam	BK 362 439 -T	
Ion source/ion optics	BN 845 088 -T				
Replacement cathodes					

¹ Option W, Ir-ThO₂

Quadrupole mass spectrometer¹⁾ QMG 421-3 QMG 421-4 QMG 421-4 QMG 421-4 QMG 421-5 QMG 421-5 QMG 421-C-5 QMG 421-C-5

Comprising:
Control unit (alternative) QMS 421 QMS 421-C QMS 421-C QMS 421 QMS 421 QMS 421
High-frequency generator QMH 400-5 QMS 421-C QMS 421-C QMS 421 QMS 421 QMS 421
Electrometer EP 112 EP 112 EP 112 EP 112 EP 112 EP 112 EP 112
Preamplifier QMA 430 QMA 400 QMA 400 QMA 400 QMA 410 QMA 410 QMA 410
Analyzer QMA 400 QMA 400 QMA 400 QMA 400 QMA 410 QMA 410 QMA 410

Mass range amu 1-300 1-512 1-1024 1-2048 1-128 1-340

Detection limit
Faraday cup mbar $<2.5 \cdot 10^{-12}$
90° off-axis SEM mbar $<10^{-15}$

Minimum detectable concentrations
Faraday cup ppm <0.1
90° off-axis SEM ppb <0.5

Dynamic range with
Faraday cup 10^6
90° off-axis SEM 10^8

Maximum operating pressure
Faraday cup mbar 10^{-4}
90° off-axis SEM mbar 10^{-5}

Contribution to neighboring mass (40/41) ppm 6 1 5
(332/333) ppm 0.1 0.1

Peak location on the mass scale \pm 1/64 Mass unit
(over 8 hours) 1/64 Mass unit

Sensitivity with axial ion source A/mbar $3 \cdot 10^{-4}$ 4 · 10⁻⁴ 1 · 10⁻³

Peak ratio reproducibility over 8 hours

(N₂ and Ar from air) Faraday cup $\pm\%$ 0.2 0.1 0.05

Transmission 20 30 10 2 >50 >40

Rod system
Diameter mm 8 8 8 16 16
Length mm 200 200 200 300 300
Material Stainless steel Molybdenum Molybdenum Molybdenum Molybdenum

Contamination susceptibility relative to 6 mm rod system 0.5 0.5 0.05

Ion sources²⁾

Axial • • • • •
Gas-tight axial • • • • •
Crossbeam • • • • •

Crossbeam with molecular beam device and collimation

magnet • • • • •
Grid • • • • •
Gas-tight crossbeam • • • • •

Crossbeam with

2-lens ion optics • • • • •

Crossbeam with

3-lens ion optics • • • • •

with beam stop

3-lens ion optics • • • • •

with beam stop

3-lens ion optics • • • • •

¹⁾The QMG 421-C configurations include the QMS 421-C and QUADSTARTM 421 software.
²⁾Configurations with other ion sources on request.

Balzers quadrupole mass spectrometers of the series 421 are designed for general analysis applications.

- Mass ranges between 128 and 2048 amu
- Filter rod diameter 8 or 16 mm
- Various types of ion sources
- Faraday collector or SEM in 90° off-axis arrangement including Faraday cup

- QUADSTARTM 421 software running under WINDOWSTM

Expansion modules for:

- Control sequences, quantitative analyses and communication with host computer are available so that the mass spectrometer can be optimally tailored to the application.

All Balzers mass spectrometers feature:

- High stability, reproducibility, and high sensitivity

- Low contribution to neighboring mass
- Low detection limit
- Large dynamic range

QMG 421-C quadrapole mass spectrometer

Designed for the most stringent requirements with respect to reproducibility, stability and detection limits

Trace analysis

Detection of positive and negative ions, as well as neutral particles

Ultrasecutive leak testing

Partial pressure measurement down to $<2 \cdot 10^{-10}$ mbar

Process monitoring and control

Quality control

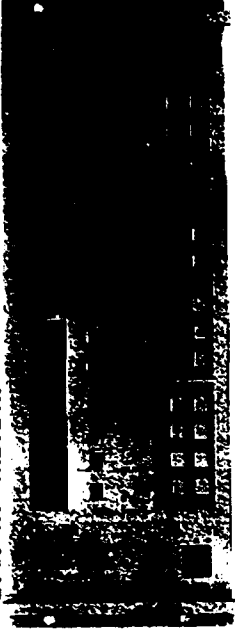
High measurement speed through multiprocessor technology
Extremely high measurement speeds achieved through parallel data acquisition and sequence control.

Measurement channels and large measurement data memory
64 measurement channels are individually programmable. 256 K-Byte are available for storing measurement data.

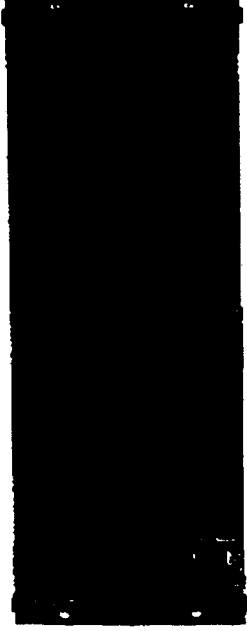
Counting mode
For detecting very small ion currents an ion counter can be integrated in the control unit.

LAN and RS 232 interface
Universal RS 232 standard interface of any type of PC. LAN interface for extremely fast data transmission at 5 M-bit/s.

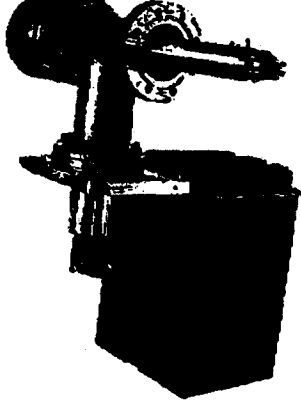
Service aids
The internal spectrum simulation shows the effect of different parameter settings. The QMG 421 supports diagnosis via modem.



QMG 421



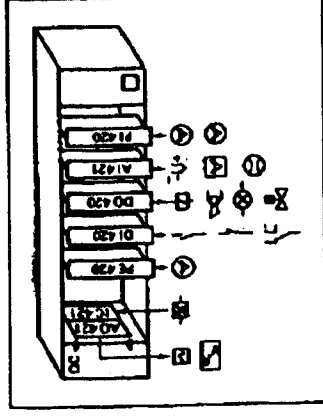
QMG 421-C



QMG 400 analyzer with 90° off-axis SEM crossbeam ion source with QMG 400-5 RF-generator

Measurement and control via supplementary modules and switching functions

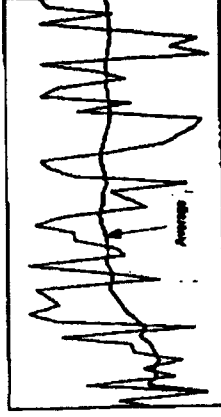
For inputting and outputting digital and analog signals, the QMG 421 (-C) can be enhanced with supplementary modules. 128 switching points (2 per measurement channel) can be used for threshold monitoring.



Optimized raw data acquisition
Adaptation to the measurement problem through different operating modes such as scan, scan with FIR filter, sample, stair, and routines such as peak processing and automatic peak maximum setting.

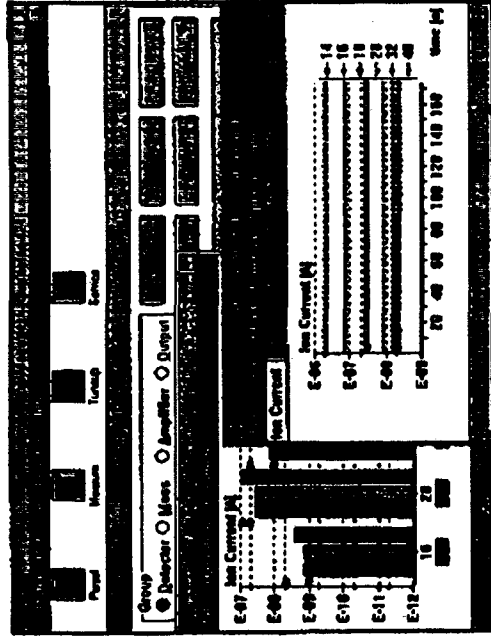
Measurement algorithms
Measurement algorithms such as moving averages, automatic measurement range search and peak jumping in steps of 1 amu simplify and improve the measurement data processing.

Moving averages
Simplifies the data interpretation for very low ion currents near the detection limit and/or for very fast measurements. Through continuous averaging of noisy signals, an average is available even after the first few measurements.



QUADSTAR™ 421 software

The QUADSTAR™ 421 software package from Balzers provides support for quantitative and qualitative gas analysis. The basic QUADSTAR™ 421 software can be enhanced with 3 supplementary modules.



QUADSTAR™ 421 runs under Windows™ 3.1 (or higher) and offers all advantages of this application environment, for example:

- Evaluation of a stored measurement data file while measurement continues in the background.
- Simple transfer of measurement data to word processing programs and spreadsheets for documentation purposes.
- Operation via mouse and keyboard.
- Utilization of the printer drivers supported by Windows.

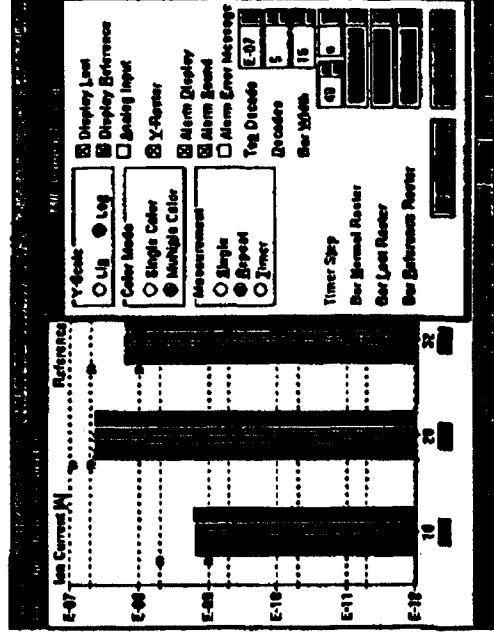
QUADSTAR™ 421

The easy operation and clear screen formatting provides maximum convenience for capturing, displaying and formatting the data of the QMG 421, QMG 421-C and QMG 421-I mass spectrometers.

- Qualitative gas analysis
- Convenient operation
- Powerful measurement programs, e.g.

Analog mode

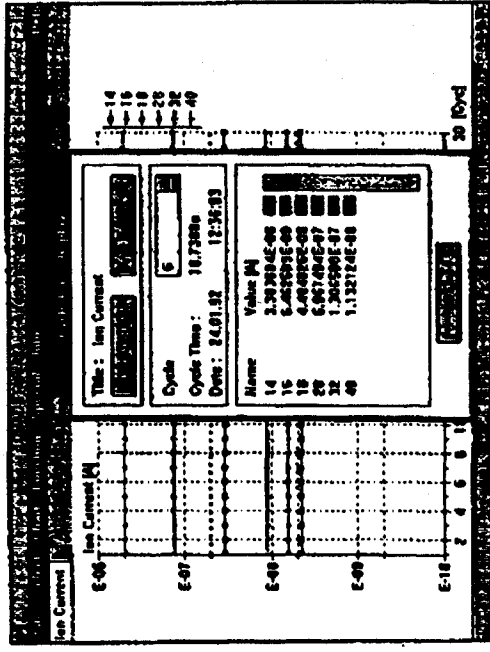
Bargraph mode intensity versus time - up to 64 different signals can be measured online and displayed graphically as a function of time, as a bargraph or as a table.



Comparison of the current measurement data with the previously measured values and with reference values. The parameters are selected via the setup menu. The markers A and B

next to the bar show the switching thresholds.

- Leak test mode; total pressure measurement
- Determination of the mass spectrometer background
- Mass scale calibration
- Spectrum library with interpretation assistance
- Visualization of the stored data
- Storable parameter sets
- Convenient evaluation of stored measurement data files, supported by cursor and magnify function
- Help functions



ion currents can be determined at any position of the data file. The data window shows the values of a selected measurement cycle.

- Statistical functions
- Optimum documentation of the measurement results

Process Control Module (PCM)

With the aid of this software module users can define their own measurement and control sequences for automatic analysis and integration into system controls.

- Control of gas inlets
- Calibration of the MS
- Data storage
- Control signals

QUADSTAR 421 is a prerequisite for using this module.

Quantitative Analysis Module (QAM)

Software module for quantitative gas analysis with all required functions such as determination of the mass spectrometer sensitivity for various gases as well as their cracking patterns.

- Quantitative gas analysis
- Analysis matrix for calculating the concentration of individual gas components

QUADSTAR 421 is a prerequisite for using this module.

HOST Communication Module (HCM)

This software module supports communication with a HOST computer.

QUADSTAR 421 and the Process Control Module are prerequisites for using this module.

Ordering date	BN 882 085-T	→
QUADSTAR™ 421	BN 882 086-T	→
Process control module	BN 882 086-T	
Quantitative analysis module	BN 882 087-T	
HOST communication module	BN 882 088-T	→

Part No.	Price \$	Part No.	Price \$
PE 420 Penning Supply	1,117.50	Spares Filaments	
IKR 020, DN 40 ISO-KF, Vion	438.00	For Axial and Gas-Tight Axial Ion Source	
Connecting Cable 3M (To IKR 020)	114.00	Rhenium Filament (1 Piece)	BN 845 061-T 39.00
Ion Counting Unit		Rhenium Filament (5 Pieces)	BN 845 018-T 180.00
IC 421 Ion Counter	3,088.00	Tungsten Cathode (1 Piece)	BN 845 082-T 39.00
CP 400 Ion Counter Pre-amplifier	1,709.00	Tungsten Cathode (5 Pieces)	BN 845 031-T 160.00
Cable 3M, CP 400/OC 421	132.00	Thoriated Inidium Cathode	BN 845 166-T 101.50
Cable 10M, CP 400/OC 421	230.00	For Grid Ion Source	
PL 410 for CP 400	789.00	Tungsten Cathode (1 Piece)	BN 845 291-T 121.50
Electrometer Pre-amplifier		For Cross Beam and Gas-Tight Cross Beam Ion Source	
EP 112 Electrometer Amplifier	1,031.50	Rhenium Cathode on Ceramic Block	BN 845 052-T 230.00
Ion Current Cable 0.1M; EP/Analyzer	68.00	(2 Pieces)	
Ion Current Cable 0.5M; EP/Analyzer	79.50	Tungsten Cathode on Ceramic Block	BN 845 089-T 230.00
(2 Pieces)		Thoriated Inidium Cathode	BN 845 282-T 329.50
(2 Pieces)		Additional Units	
Secondary Electron Multiplier		OMN 112 Remote Power Unit	BG M68 000 1,580.50
SEM 217	1,301.50	OMN 112 Remote Power Unit Insulated	BG M68 020 3,465.50
Channeltron	2,676.50	OMU 112 Multiplexer Unit	BG M21 313 4,927.50
Analyzers OMA 125		Cable Set OMS(I)OMU, 1.5M	BG 574 668-T 243.50
OMA 125 with Axial Ion Source, Faraday Cup, DN 40 CF-F	3,885.50	J20 Analysis Equipment	
OMA 125 with Grid Ion Source, Faraday Cup, DN 40 CF-F	4,631.50	Quadrupole Mass Spectrometer OMG 421/421-C for Analysis	
OMA 125 with Gas-Tight Axial Ion Source, Faraday Cup, DN 40 CF-F	4,631.50	Software	
OMA 125 with Cross Beam Ion Source, Faraday Cup, DN 40 CF-F	4,631.50	Quasdar 421	BN 882 085-T 5,661.00
OMA 125 with Axial Ion Source, Channeltron, DN 40 CF-F	6,871.00	Process Control Module	BN 882 086-T 2,573.00
OMA 125 with Grid Ion Source, Channeltron, DN 40 CF-F	7,620.50	Quantitative Analysis Module	BN 882 087-T 3,602.50
OMA 125 with Gas-Tight Axial Ion Source, Channeltron, DN 40 CF-F	7,620.50	Host Communication Module	BN 882 088-T 2,573.00
OMA 125 with Cross Beam Ion Source, Channeltron, DN 40 CF-F	7,620.50	J21 Combinations OMG 421	
OMA 125 with Axial Ion Source, 90 Deg. Off Axis SEM, DN 63 CF-F	8,362.50	OMG 421-3, Mass Range 1-300 Consisting of: OMS 421, OMN 400-5, EP 112 and OMA 430 with:	
OMA 125 with Grid Ion Source, 90 Deg. Off Axis SEM, DN 63 CF-F	9,104.50	Faraday Cup and	
OMA 125 with Gas-Tight Axial Ion Source, 90 Deg. Off Axis SEM DN 63 CF-F	9,104.50	Axial Ion Source 220V	BK M18 000 28,377.00
OMA 125 with Cross Beam Ion Source, 90 Deg. Off Axis SEM, DN 63 CF-F	9,104.50	Axial Ion Source 110V	BK M18 100 28,377.00
OMA 125 Vacuum Annealed with Grid Ion Source, 90 Deg. Off Axis SEM, DN 63 CF-F	10,603.00	Axial Ion Source Gas-Tight 220V	BK M18 001 29,035.50
Short Circuit Plug	31.50	Axial Ion Source Gas-Tight 110V	BK M18 101 29,035.50
OME 125 Support, DN 40 CF	243.50	Cross Beam Ion Source 220V	BK M18 092 29,035.50
OME 125 Support, DN 63 CF	152.00	Cross Beam Ion Source 110V	BK M18 102 29,035.50
J15 Ion Sources for OMA 125		SEM 90 Deg. Off Axis/Faraday and	
Axial Ion Source	532.00	Axial Ion Source 220V	BK M18 007 34,161.50
Grid Ion Source	1,284.60	Axial Ion Source 110V	BK M18 107 34,161.50
Gas-Tight Axial Ion Source (1 Connection)	1,284.50	Axial Ion Source Gas-Tight 220V	BK M18 008 34,814.50
Gas-Tight Axial Ion Source (2 Connections)	1,436.00	Axial Ion Source Gas-Tight 110V	BK M18 108 34,814.50
Cross Beam Ion Source	1,284.50	Cross Beam Ion Source 220V	BK M18 009 34,814.50
Cross Beam Ion Source Gas-Tight	2,069.50	Cross Beam Ion Source 110V	BK M18 109 34,814.50
		Cross Beam Ion Source with Molecular Beam Device and Magnet 220V	BK M18 010 39,093.00
		Cross Beam Ion Source with Molecular Beam Device and Magnet 110V	BK M18 110 39,093.00
		Grid Ion Source 220V	BK M18 011 36,143.60
		Grid Ion Source 110V	BK M18 111 36,143.60

Part No.	Price \$	Part No.	Price \$
OMG 421-4, Mass Range 1-912 Consisting of: QMS 421, QMH 400-5, EP 112 and QMA 400 with:			
Faraday Cup and			
Axial Ion Source 220V	BK M20 000	Cross Beam Ion Source Gas-Tight 110V	BK M20 127
Axial Ion Source 110V	BK M20 100	Ion Optics 3 Lenses with Beam Stop 220V	BK M20 028
Axial Ion Source Gas-Tight 220V	BK M20 001	Ion Optics 3 Lenses with Beam Stop 110V	BK M20 128
Axial Ion Source Gas-Tight 110V	BK M20 101	OMG 421-4, Mass Range 1-2048 Consisting of: QMS 421, QMH 410-2, EP 112 and QMA 400 with:	
Cross Beam Ion Source 220V	BK M20 002	SEM 90 Deg. Off Axis/Faraday and	
Cross Beam Ion Source 110V	BK M20 102	Cross Beam Ion Source 220V	BK M20 029
Cross Beam Ion Source with Molecular Beam Device and Magnet 220V	BK M20 003	Cross Beam Ion Source 110V	BK M20 129
Cross Beam Ion Source with Molecular Beam Device and Magnet 110V	BK M20 103	OMG 421-5, Mass Range 1-128 Consisting of: QMS 421, QMH 400-1, EP 112 and QMA 410 with:	
Cross Beam Ion Source Gas-Tight 220V	BK M20 005	Faraday Cup and	
Cross Beam Ion Source Gas-Tight 110V	BK M20 105	Axial Ion Source 220V	BK M22 000
SEM 90 Deg. Off Axis/Faraday and			
Axial Ion Source 220V	BK M20 007	Axial Ion Source 110V	BK M22 100
Axial Ion Source 110V	BK M20 107	Cross Beam Ion Source 220V	BK M22 002
Axial Ion Source Gas-Tight 220V	BK M20 009	Cross Beam Ion Source 110V	BK M22 102
Axial Ion Source Gas-Tight 110V	BK M20 108	Cross Beam Ion Source Gas-Tight 220V	BK M22 003
Cross Beam Ion Source 220V	BK M20 008	Cross Beam Ion Source Gas-Tight 110V	BK M22 103
Cross Beam Ion Source 110V	BK M20 109	SEM 90 Deg. Off Axis/Faraday and	
Cross Beam Ion Source with Molecular Beam Device and Magnet 220V	BK M20 010	Axial Ion Source 220V	BK M22 007
Cross Beam Ion Source with Molecular Beam Device and Magnet 110V	BK M20 110	Axial Ion Source 110V	BK M22 107
Grid Ion Source 220V	BK M20 011	Cross Beam Ion Source 220V	BK M22 009
Grid Ion Source 110V	BK M20 111	Cross Beam Ion Source 110V	BK M22 109
Cross Beam Ion Source Gas-Tight 220V	BK M20 012	Cross Beam Ion Source Gas-Tight 220V	BK M22 010
Cross Beam Ion Source Gas-Tight 110V	BK M20 112	Cross Beam Ion Source Gas-Tight 110V	BK M22 110
Cross Beam Ion Source with Ion Optics 2 Lenses 220V	BK M20 013	Cross Beam Ion Source Gas-Tight 220V	BK M22 008
Cross Beam Ion Source with Ion Optics 2 Lenses 110V	BK M20 113	Cross Beam Ion Source 220V	BK M22 108
Cross Beam Ion Source and Ion Optics 3 Lenses with Beam Stop, Insulated Design 220V	BK M20 021	Cross Beam Ion Source 110V	BK M22 108
Cross Beam Ion Source and Ion Optics 3 Lenses with Beam Stop, Insulated Design 110V	BK M20 121	Cross Beam Ion Source Gas-Tight 220V	BK M22 015
Ion Optics 3 Lenses with Beam Stop 220V	BK M20 022	Cross Beam Ion Source 110V	BK M22 115
Ion Optics 3 Lenses with Beam Stop 110V	BK M20 122	Cross Beam Ion Source Gas-Tight 220V	BK M22 016
Without Ion Source Insulated Design 220V	BK M20 023	Cross Beam Ion Source Gas-Tight 110V	BK M22 116
Without Ion Source Insulated Design 110V	BK M20 123	SEM 90 Deg. Off Axis/Faraday and	
OMG 421-4, Mass Range 1-1024 Consisting of: QMS 421, QMH 410-1, EP 112 and QMA 400 with:			
SEM 90 Deg. Off Axis/Faraday and			
Axial Ion Source 220V	BK M20 024	Axial Ion Source 220V	BK M22 014
Axial Ion Source 110V	BK M20 124	Axial Ion Source 110V	BK M22 114
Cross Beam Ion Source 220V	BK M20 025	Cross Beam Ion Source 220V	BK M22 015
Cross Beam Ion Source 110V	BK M20 125	Cross Beam Ion Source 110V	BK M22 115
Grid Ion Source 220V	BK M20 026	Cross Beam Ion Source Gas-Tight 220V	BK M22 016
Grid Ion Source 110V	BK M20 126	Cross Beam Ion Source Gas-Tight 110V	BK M22 116
Cross Beam Ion Source Gas-Tight 220V	BK M20 027	Cross Beam Ion Source 220V	BK M22 017
		Axial Ion Source 110V	BK M22 117
		Cross Beam Ion Source 220V	BK M22 018
		Cross Beam Ion Source 110V	BK M22 118
		Cross Beam Ion Source Gas-Tight 220V	BK M22 019
		Cross Beam Ion Source Gas-Tight 110V	BK M22 119
		Cross Beam Ion Source with Ion Optics 2 Lenses 220V	BK M22 020
		Cross Beam Ion Source with Ion Optics 2 Lenses 110V	BK M22 120
		Cross Beam Ion Source and Ion Optics 3 Lenses with Beam Stop 220V	BK M22 021
		Cross Beam Ion Source and Ion Optics 3 Lenses with Beam Stop 110V	BK M22 121

Part No.	Price \$	Part No.	Price \$	Single Components	Part No.	Price \$
Cross Beam Ion Source 220V	BK M23 009	49,596.00	J22	Single Components	BG D26 500	10,641.50
Cross Beam Ion Source 110V	BK M23 109	49,596.00		<i>Control Units (Without Software)</i>	BG D26 501	10,641.50
Cross Beam Ion Source Gas-Tight 220V	BK M23 010	50,254.50		OMS 421, 220V	BG D26 563	9,196.00
Cross Beam Ion Source Gas-Tight 110V	BK M23 110	50,254.50		OMS 421, 110V	BG D26 584	9,196.00
OMS 421C-5, Mass Range 1-340 Consisting of: OMS 421C, Quadstar 421, OMH 410-3, EP 112 and OMA 410 with:				<i>Interface (Without Software)</i>		
Faraday Cup and				OMI 421, 220V	BG D27 250	6,241.00
Axial Ion Source 220V	BK M23 014	45,656.50		OMI 421, 110V	BG D27 251	6,241.00
Axial Ion Source 110V	BK M23 114	45,656.50		Modules		
Cross Beam Ion Source 220V	BK M23 015	46,309.50	J23	IS 420 Ion Source Supply	BG 512 900-T	4,666.00
Cross Beam Ion Source 110V	BK M23 115	46,309.50		Ion Source Connection Cable 3M	BG 548 082-T	496.60
Cross Beam Ion Source Gas-Tight 220V	BK M23 016	46,968.00		Ion Source Connection Cable 10M	BG 548 083-T	631.00
Cross Beam Ion Source Gas-Tight 110V	BK M23 116	46,968.00		HV 420 SEM Supply	BG 546 040-T	1,379.50
SEM 90 Deg. Off Axis/Faraday end				HV 421 SEM Supply	BG 442 250-T	3,166.00
Axial Ion Source 220V	BK M23 017	50,907.60		MES High Tension Cable 3M	BG 541 978-T	172.50
Axial Ion Source 110V	BK M23 117	50,907.60		MES High Tension Cable 10M	BG 541 878-T	402.50
Cross Beam Ion Source 220V	BK M23 018	51,566.00		<i>Additional Modules</i>		
Cross Beam Ion Source 110V	BK M23 118	51,566.00		AD 421 Analog Output	BG 442 328-T	1,379.50
Cross Beam Ion Source Gas-Tight 220V	BK M23 019	52,224.00		Connecting Box AB 021 to AD 421	BG 442 380-T	526.00
Cross Beam Ion Source Gas-Tight 110V	BK M23 119	52,224.00		AI 421 Analog Input	BG 442 240-T	1,215.50
Cross Beam Ion Source with Ion Optics 2 Lenses 220V	BK M23 020	53,076.00		DO 420 Digital Output	BG 546 004-T	667.50
Cross Beam Ion Source with Ion Optics 2 Lenses 110V	BK M23 120	53,076.00		DI 420 Digital Input	BG 574 700-T	657.50
Cross Beam Ion Source and Ion Optics 3 Lenses with Beam Stop 220V	BK M23 021	54,852.50		PI 420 Pirani Supply	BG 512 715-T	756.00
Cross Beam Ion Source and Ion Optics 3 Lenses with Beam Stop 110V	BK M23 121	54,852.50		TPR 010, DN 10 ISO-KF, Standard	BG G02 270	170.50
SIMS Mass Spectrometer Systems				Connecting Cable 3M (To TPR 010)	BG 548 651-T	173.60
SIMS mass spectrometer systems for the analysis of positive ions. Includes OMS421C with Quadstar421 software base module, OMH400-5 rf generator (500amu), OMA400 analyzer with 3-lens ion optics, 110V/60Hz	BK M23 022	52,553.50		PE 420 Penning Supply	BG 512 726-T	1,117.80
SIMS mass spectrometer systems for the analysis of positive ions. Includes OMS421C with Quadstar421 software base module, OMH410-1 rf generator (102amu), OMA400 analyzer with 3-lens ion optics, 110V/60Hz	BK M23 122	52,553.50		IKR 020, DN 40 ISO-KF, Viton	BG G12 530	498.00
SIMS mass spectrometer systems for the analysis of positive ions. Includes OMS421C with Quadstar421 software base module, OMH410-1 rf generator (102amu), OMA400 analyzer with 3-lens ion optics, 110V/60Hz	BK M23 022	52,553.50		Connecting Cable 3M (To IKR 020)	BG 548 313-T	114.00
SIMS mass spectrometer systems for the analysis of positive ions. Includes OMS421C with Quadstar421 software base module, OMH410-1 rf generator (102amu), OMA400 analyzer with 3-lens ion optics, 110V/60Hz	BK M23 122	52,553.50		Ion Counting Unit		
SIMS mass spectrometer systems for the analysis of positive ions. Includes OMS421C with Quadstar421 software base module, OMH410-1 rf generator (102amu), OMA400 analyzer with 3-lens ion optics, 110V/60Hz	BK M23 022	52,553.50		IC 421 Ion Counter	BG 442 320-T	3,088.00
SIMS mass spectrometer systems for the analysis of positive ions. Includes OMS421C with Quadstar421 software base module, OMH410-1 rf generator (102amu), OMA400 analyzer with 3-lens ion optics, 110V/60Hz	BK M23 122	52,553.50		CP 400 Ion Counter Pre-amplifier	BG 442 210-T	1,709.00
SIMS mass spectrometer systems for the analysis of positive ions. Includes OMS421C with Quadstar421 software base module, OMH410-1 rf generator (102amu), OMA400 analyzer with 3-lens ion optics, 110V/60Hz	BK M23 022	52,553.50		Cable 3M, CP 400/QC 421	BG 448 134-T	132.00
SIMS mass spectrometer systems for the analysis of positive ions. Includes OMS421C with Quadstar421 software base module, OMH410-1 rf generator (102amu), OMA400 analyzer with 3-lens ion optics, 110V/60Hz	BK M23 122	52,553.50		Cable 10M, CP 400/QC 421	BG 448 198-T	230.00
SIMS mass spectrometer systems for the analysis of positive ions. Includes OMS421C with Quadstar421 software base module, OMH410-1 rf generator (102amu), OMA400 analyzer with 3-lens ion optics, 110V/60Hz	BK M23 022	52,553.50		PL 410 for CP 400	BG 574 085-T	789.00
SIMS mass spectrometer systems for the analysis of positive ions. Includes OMS421C with Quadstar421 software base module, OMH410-1 rf generator (102amu), OMA400 analyzer with 3-lens ion optics, 110V/60Hz	BK M23 122	52,553.50		Chopper Lock In Amplifier CLA 421	BG 572 334-T	4,666.00
SIMS mass spectrometer systems for the analysis of positive ions. Includes OMS421C with Quadstar421 software base module, OMH410-1 rf generator (102amu), OMA400 analyzer with 3-lens ion optics, 110V/60Hz	BK M23 022	52,553.50		CLA 421 Chopper Lock-In Amplifier with TTL-Input	BG 572 335-T	4,666.00
SIMS mass spectrometer systems for the analysis of positive ions. Includes OMS421C with Quadstar421 software base module, OMH410-1 rf generator (102amu), OMA400 analyzer with 3-lens ion optics, 110V/60Hz	BK M23 122	52,553.50		Electrometer Amplifier		
SIMS mass spectrometer systems for the analysis of positive ions. Includes OMS421C with Quadstar421 software base module, OMH410-1 rf generator (102amu), OMA400 analyzer with 3-lens ion optics, 110V/60Hz	BK M23 022	52,553.50		EP 112 Electrometer Amplifier	BG 528 755-U	1,031.50
SIMS mass spectrometer systems for the analysis of positive ions. Includes OMS421C with Quadstar421 software base module, OMH410-1 rf generator (102amu), OMA400 analyzer with 3-lens ion optics, 110V/60Hz	BK M23 122	52,553.50		Ion Current Cable 0.1M; EP/Analyzer	BG 548 152-T	66.00
SIMS mass spectrometer systems for the analysis of positive ions. Includes OMS421C with Quadstar421 software base module, OMH410-1 rf generator (102amu), OMA400 analyzer with 3-lens ion optics, 110V/60Hz	BK M23 022	52,553.50		Ion Current Cable 0.5M; EP/Analyzer	BG 548 153-T	79.50
SIMS mass spectrometer systems for the analysis of positive ions. Includes OMS421C with Quadstar421 software base module, OMH410-1 rf generator (102amu), OMA400 analyzer with 3-lens ion optics, 110V/60Hz	BK M23 122	52,553.50		High Frequency Generator OMH 400-5, for OMA 400, Mass Range 1-912/300	BG M23 086	9,196.00
SIMS mass spectrometer systems for the analysis of positive ions. Includes OMS421C with Quadstar421 software base module, OMH410-1 rf generator (102amu), OMA400 analyzer with 3-lens ion optics, 110V/60Hz	BK M23 022	52,553.50		OMH 400-1, for OMA 410, Mass Range 1-128	BG M23 087	9,196.00
SIMS mass spectrometer systems for the analysis of positive ions. Includes OMS421C with Quadstar421 software base module, OMH410-1 rf generator (102amu), OMA400 analyzer with 3-lens ion optics, 110V/60Hz	BK M23 122	52,553.50		OMH 410-1, for OMA 400, Mass Range 1-1024	BG M40 566	11,495.00
SIMS mass spectrometer systems for the analysis of positive ions. Includes OMS421C with Quadstar421 software base module, OMH410-1 rf generator (102amu), OMA400 analyzer with 3-lens ion optics, 110V/60Hz	BK M23 022	52,553.50		OMH 410-2, for OMA 400, Mass Range 1-2048	BG M40 567	13,141.00
SIMS mass spectrometer systems for the analysis of positive ions. Includes OMS421C with Quadstar421 software base module, OMH410-1 rf generator (102amu), OMA400 analyzer with 3-lens ion optics, 110V/60Hz	BK M23 122	52,553.50		OMH 410-3, for OMA 400, Mass Range 1-340	BG M40 568	11,495.00
SIMS mass spectrometer systems for the analysis of positive ions. Includes OMS421C with Quadstar421 software base module, OMH410-1 rf generator (102amu), OMA400 analyzer with 3-lens ion optics, 110V/60Hz	BK M23 022	52,553.50		HF Cable 0.7M, (2 Pieces)	BG 541 980-T	64.00
SIMS mass spectrometer systems for the analysis of positive ions. Includes OMS421C with Quadstar421 software base module, OMH410-1 rf generator (102amu), OMA400 analyzer with 3-lens ion optics, 110V/60Hz	BK M23 122	52,553.50		Cable OMH/OMA 0.7M (Field Axis)	BG 541 982-T	162.00

For the ability to analyze positive AND negative ions add the following to either of the three packages listed above.

qty 1 IC421 ion counter BG 442 320-T 3,088.00

qty 1 CP400 ion counter and preamplifier BG 442 210-T 1,709.00

qty 1 cable, 3m, CP-400 to QC-421 BG 448 134-T 132.00

qty 1 HV421 high voltage supply BG 442 250-T 3,156.00

note: additional cost HV421 = (cost HV421) - (cost HV420, BGS46040T)

qty 2 cable, 3m, high voltage cable BG 541 978-T 172.50

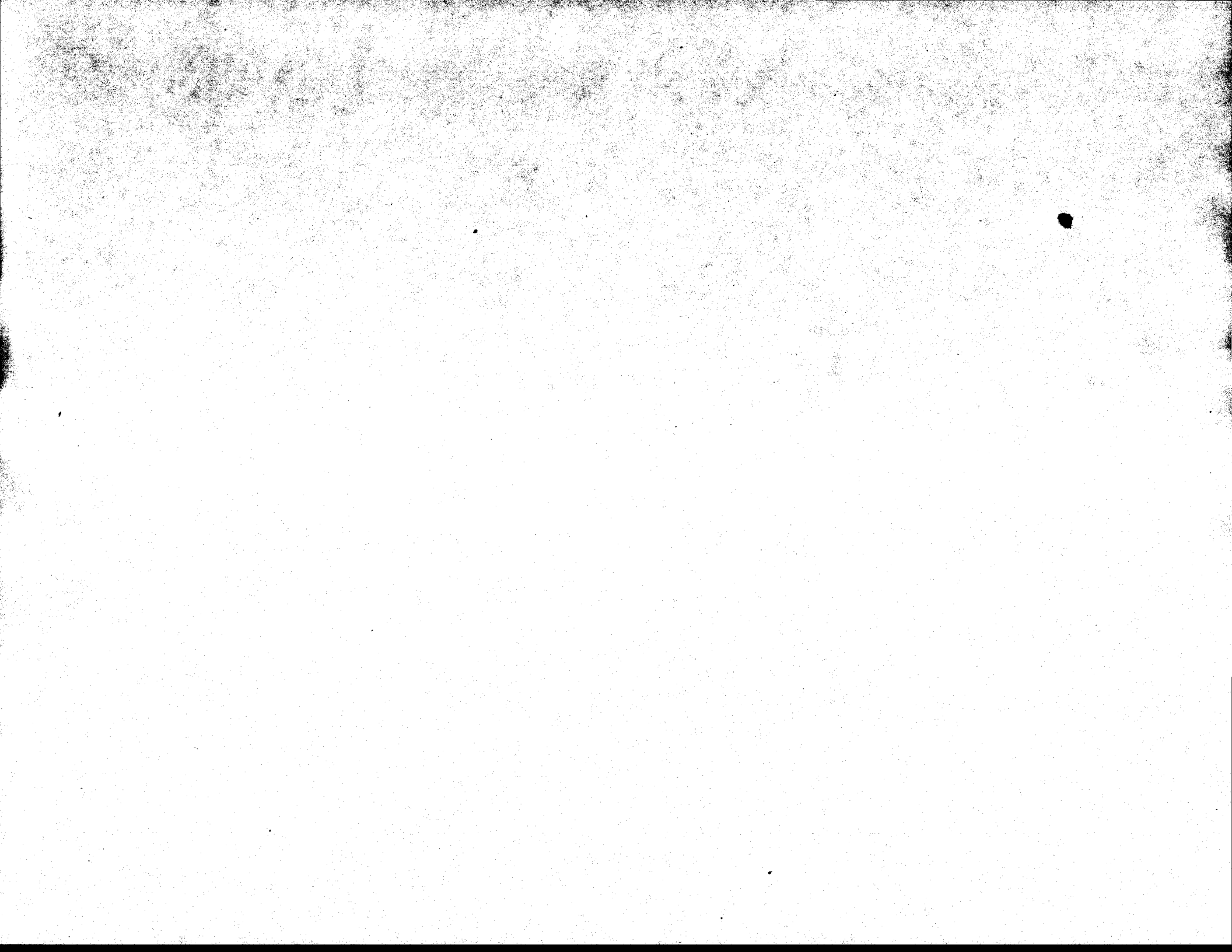
Ion Counting Unit
 IC 421 Ion Counter
 CP 400 Ion Counter Pre-amplifier
 Cable 3M, CP 400/QC 421
 Cable 10M, CP 400/QC 421
 PL 410 for CP 400
 Chopper Lock In Amplifier CLA 421
 CLA 421 Chopper Lock-In Amplifier Incl. Piezo-Chopper
 CLA 421 Chopper Lock-In Amplifier with TTL-Input

balzers

Part No.	Price \$	Part No.	Price \$
Extension Cable OMS/OMH, 7M	152.00	BK 448 175-T	15,768.50
Short Circuit Plug	31.50	B 4728 891 B9	
OMH Fixing Ring for DN 83 CF	152.00	BG 548 510-T	14,123.50
OMH Fixing Ring for DN 100 CF	381.50	BG 546 511-T	
Mounting Frame for OMA	199.00	BG 546 470-X	
Secondary Electron Multiplier SEM			
SEM 217	1,301.50	BG 521 611-X	15,440.00
SEM 218	1,630.50	BG 444 220-T	16,093.00
Analyzers OMA 430 with Massfilter 8mm (Stainless Steel)			
OMA 430 with Axial Ion Source, Faraday Cup	6,573.50	BK M08 500	16,093.00
OMA 430 with Gas-Tight Axial Ion Source, Faraday Cup	7,226.50	BK M08 501	16,751.50
OMA 430 with Cross Beam Ion Source, Faraday Cup	7,226.50	BK M08 502	14,782.00
OMA 430 with Axial Ion Source, 90 Deg. Off Axis SEM	11,171.50	BK M08 507	21,020.50
OMA 430 with Gas-Tight Axial Ion Source, 90 Deg. Off Axis SEM	11,824.50	BK M08 508	21,678.00
OMA 430 with Cross Beam Ion Source, 90 Deg. Off Axis SEM	11,824.50	BK M08 509	21,679.00
OMA 430 with Grid Ion Source, 90 Deg. Off Axis SEM	12,153.50	BK M08 510	22,327.00
OMA 430 with Gas-Tight Cross Beam Ion Source, with Molecular Beam Device and Magnet Guide			
Device and 90 Deg. Off Axis SEM	16,093.00	BK M08 513	23,189.00
Analyzers OMA 400 with Massfilter 6mm (Molybdenum)			
OMA 400 with Axial Ion Source, Faraday Cup	9,196.00	BK M08 514	24,995.50
OMA 400 with Gas-Tight Axial Ion Source, Faraday Cup	9,854.50	BK M08 515	22,666.50
OMA 400 with Cross Beam Ion Source, Faraday Cup	9,854.50	BK M08 517	20,367.50
OMA 400 with Gas-Tight Cross Beam Ion Source, Faraday Cup	10,513.00	BN 845 055-T	658.50
OMA 400 with Grid Ion Source, Faraday Cup	10,184.00	BK 371 940-T	1,317.00
OMA 400 with Cross Beam Ion Source with Molecular Beam Device and Magnet Guide Device,		BN 845 058-T	42.00
Faraday Cup	14,123.50	BN 845 022-T	167.50
OMA 400 without Ion Source, Faraday Cup	6,543.00	BN 845 060-T	42.00
OMA 400 with Axial Ion Source, 90 Deg. Off Axis SEM	13,794.00	BN 845 024-T	167.50
OMA 400 with Gas-Tight Axial Ion Source, 90 Deg. Off Axis SEM	14,462.50	BN 845 057-T	99.50
OMA 400 with Cross Beam Ion Source, 90 Deg. Off Axis SEM	14,462.50	BN 845 346-T	1,317.00
OMA 400 with Cross Beam Ion Source, 90 Deg. Off Axis SEM	14,452.50	BN 845 121-T	857.00
OMA 400 with Gas-Tight Cross Beam Ion Source, 90 Deg. Off Axis SEM	15,111.00	BK 353 333-W	1,975.50
OMA 400 with Grid Ion Source, 90 Deg. Off Axis SEM	14,782.00	BN 845 052-T	230.00
OMA 400 with Cross Beam Ion Source with Molecular Beam Inlet and Special Accessory, 90 Deg. Off Axis SEM		BN 845 088-T	230.00
Accessory, 90 Deg. Off Axis SEM	18,721.50	BN 845 282-T	329.50
OMA 400 with Cross Beam Ion Source with Ion Optics 2 Lenses 90 Deg. Off Axis SEM	16,422.50	BN 845 087-T	1,646.00
OMA 400 with Cross Beam Ion Source with Ion Optics 3 Lenses and Beam Stop, Insulated Design, 90 Deg. Off Axis SEM	18,392.00	BN 845 095-T	136.00
		BK 371 860-T	5,586.00
		BK 362 439-T	1,646.00
		BK 352 328-W	3,287.00
		BK 352 329-T	2,299.00

J25 Ion Sources/Spares Cathodes

Axial Ion Source	658.50
Gas-Tight Axial Ion Source	1,317.00
Rhenium Cathode (1 Piece)	42.00
Rhenium Cathode (5 Pieces)	167.50
Tungsten Cathode (1 Piece)	42.00
Tungsten Cathode (5 Pieces)	167.50
Thoriated Iridium Cathode (1 Piece)	99.50
Cross Beam Ion Source	1,317.00
Magnet-Guide-Addition for Cross Beam Ion Source for OMA 400/410 and 430	857.00
Gas-Tight Cross Beam Ion Source	1,975.50
Rhenium Cathode on Ceramic Block (2 Pieces)	230.00
Tungsten Cathode on Ceramic Block (2 Pieces)	230.00
Thoriated Iridium Cathode (2 Pieces)	329.50
Grid Ion Source	1,646.00
Tungsten Cathode	136.00
Cross Beam Ion Source with Molecular Beam Device and Ion Optic with 3 Lenses, and Beam Stop	5,586.00
Cross Beam Ion Source with Ion Optic with 3 Lenses, and Beam Stop	1,646.00
Cross Beam Ion Source with Ion Optic with 2 Lenses	3,287.00



21 Film Thickness

QUARTZ CRYSTAL

THIN FILM MONITOR & CONTROLLER

K/L Models
QXM500, QXC1000

Model QXM500 is our quartz crystal monitor and model QXC1000 the corresponding controller for thin film deposition and etching. (See Technical Notes for details on operation.) Both are an excellent value, incorporating features typically found in more expensive units such as:

The capacity to store parameters for 8 separate film layers in battery-backed memory.

Dual sensor channels that can act as primary and back-up, or two primaries. The ability to monitor negative readings, permitting control of etch processes as easily as deposition processes.

Negative frequency shifts, allowing the user to observe flash-heating effects in the crystal.

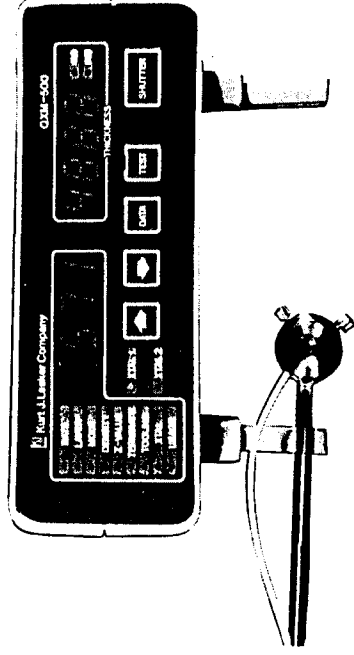
The QXM500 and QXC1000 include a back-up sensor mode that utilizes a dual crystal shuttered sensor head. If the first sensor fails, the second fresh crystal is exposed, allowing deposition to continue uninterrupted.

The QXC1000 thin film controller controls any deposition according to a specific material program—a list of answers provided to specific prompts displayed on the LCD panel during set-up. The first group of prompts lets the user specify material and sensor parameters such as material density, acoustic impedance, tooling factors, number of sensors, etc. The second group requests first and second rise times, soaks, and evaporation power, while the final group asks for the PID feedback parameters and maximum/minimum power, sampling frequency, and deposition rate.

The QXC1000 stores up to eight such independent material programs, any of which can be recalled by specifying the single digit code for the material required. The controller's RS232 serial communication port allows material programs to be downloaded from a host computer. Its built-in digital input channels are used when the controller must wait for external signals to indicate a particular status of other equipment or other QXC1000's.

The QXC1000 is distinguished from other low-cost controllers in that it can sequence a turret evaporation source through four positions. The sampling rate of both monitor and controller varies between one and four times per second and is automatically selected to optimize the signal-to-noise ratio. Crystal life is displayed in kHz shift from the 6MHz frequency of a new crystal, with a crystal fail frequency of 5.1MHz.

Note: The quartz crystal sensor head is ordered separately. All sensors are mounted on a feedthrough flange (or coupling) with cooling water tubes attached, and shipped with an oscillator and cables for sensor/oscillator and oscillator/chassis interconnections. We recommend standard Intellemetrics sensor head models for our monitor and controller. We list two heads in the Ordering Information table. However, both monitor and controller will operate with all Intellemetrics shuttered and special sensor heads described later in this section, since they are compatible with other manufacturers' 6MHz sensor heads and allow addition of the electronics only.



QXM500 Monitor

TECHNICAL DATA

	QXM500 Monitor	QXC1000 Controller
Materials	1 - 8	1 - 8
Sensor Channels	2	2
Display	Two 4-digit LEDs	High intensity back-lite LCD
Rate (+ & -)	0.1 - 999.9 Å/sec	0.1 - 999.9 Å/sec
Thickness (+ & -)	0.1 - 999.9 kÅ	0.1 - 999.9 kÅ
Time	n/a	00:00 - 99:59 (min/sec)
Power	n/a	0.0 - 99.99%
Resolutions		
Rate	1.0 Å/sec (0.1 Å/sec)*	0.1 Å/sec
Thickness	1.0 Å	0.1 Å
Tooling Factor	0.01 - 99.9	0.1-5.00
Termination Thickness	1.0 Å - 999.9 kÅ	0.1 Å - 999.9 kÅ
Density (g/cc)	0.1 - 99.9	0.5 - 50.00
Acoustic Impedance (factor)	0.1 - 15	0.1 - 15
Sampling Rate (sec)	0.25 - 1 (auto)	0.25 - 1 (auto)
Analog Output (V) (Rate or Thickness)	0-1 (8-bit)(40 levels), 0-10V (12-bit)	0-5, 0-10 (12-bit)
Source Control Output (V)	n/a	7/10
Digital Input/Output	1/1	
Shutters		
Source	n/a	.5A/250 VAC
Substrate	2A/250 VAC	.5A/250 VAC
RS232	Optional	Standard
Operating Temp.	0-45°	0-45°
Dimensions (in.)	8.07W x 3.46H x 10.24D	3½" x 19" half rack
Power	110/220VAC, 50/60Hz, 50VA	110/220VAC, 50/60Hz

**QUARTZ
CRYSTAL**

**THIN FILM
MONITOR &
CONTROLLER**

KIL Models QXM500,
QXC1000

* 0.4 Å/sec for TFD less than or equal to .115

ORDERING INFORMATION

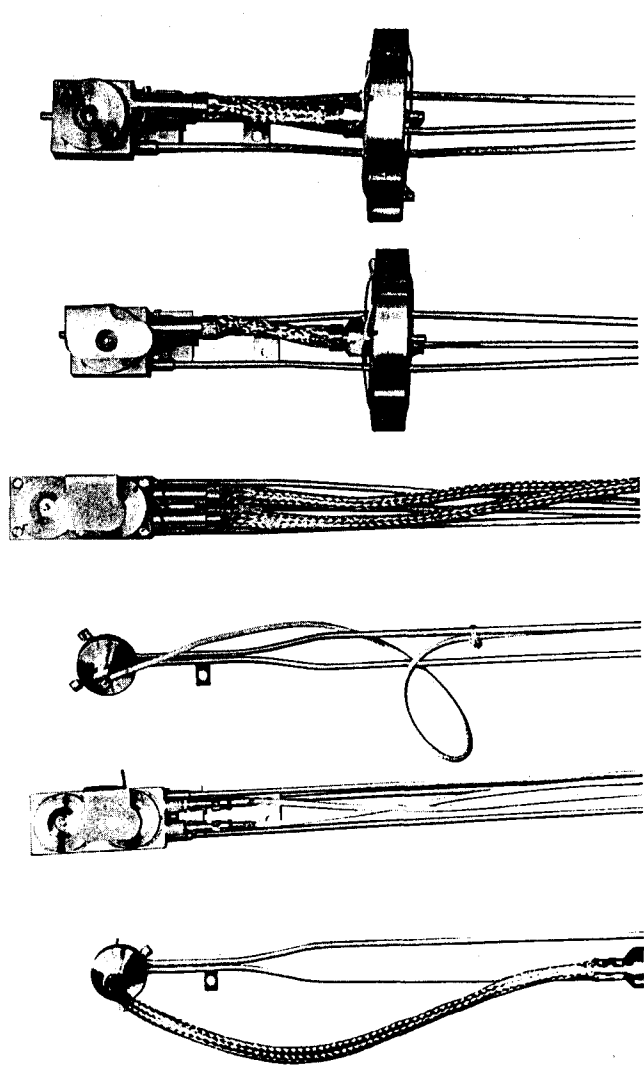
Description	Part No.	Price \$
Thickness/Rate Monitor	QXM500	1295.00
Thickness/Rate Monitor w/ RS232	QXM500R	1395.00
Thickness/Rate Controller	QXC1000	1995.00
Rack Mount for Monitor	QXMRACK	65.00
Rack Mount for Controller	QXCRACK	150.00
HV Sensor Head mounted on 1" O-ring feedthrough, 21" tubes, cables & oscillator	ILSSET3	775.00
HV Sensor Head mounted on 2¾"CF feedthrough, 21" tubes, cables & oscillator	ILSSET3CF	825.00
UHV Sensor Head (bakeable) mounted on 2.75"CF, 10" tubes, cables and oscillator	ILSSU25	1295.00
UHV Sensor Head (bakeable) mounted on 2.75"CF flange, 20" tubes, cables & oscillator	ILSSU50	1295.00
Gold-coated Crystal, pkg of 10 (6MHz)	ILCRYSTALS	67.00



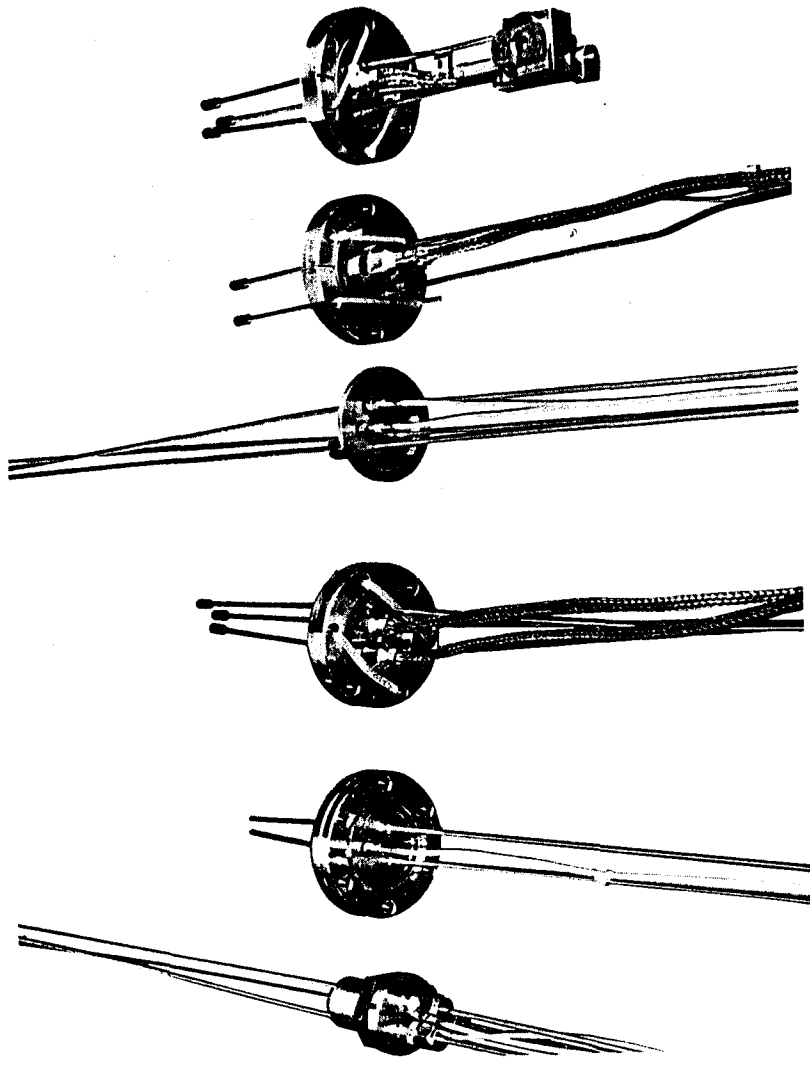
21 Film Thickness

QUARTZ CRYSTAL

SENSOR HEADS



INTELLEMETRICS Standard Cassette Sensors



Intellectrics 630 series of quartz crystal sensor heads incorporates innovative features which extend their application to processes requiring rapid crystal changes or where shuttered sensor heads are needed to protect the crystal from heavy deposition. The Model 630 sensor head is a stainless steel investment casting with 1/8" OD stainless steel water tubes. The maximum temperature of the sensor designed for high vacuum use is 100°C.

Changing crystals in the 630 sensor head takes only seconds. A sensor crystal is pre-loaded into a sturdy cassette which snaps in and out of place on the sensor head. The operator never handles a bare crystal, with all the maneuvering and breakage difficulties involved. Cassettes are made of stainless steel, alumina ceramic and gold-plated Be-Cu electrodes. The crystal is 6.0-MHz, AT-cut plano convex quartz.

Shuttered sensors have given users many problems in the past. The deposition that the shutter eliminated from the crystal surface clogged the shutter's pivoting mechanism. Shutters all too readily froze in place.

Intellectrics solved this problem by actuating the shutter with the linear motion of

a bellows extended against a return spring by compressed air. The bellows and spring are completely enclosed and cannot be frozen by heavy deposition. Test assemblies have been checked under heavy deposition conditions and shown to give over 5000 operations without adjustment or failure.

The shutter assembly is an integral part of the double crystal sensor head and can be fitted to a single sensor head for sample and hold operations. The shutter is supplied complete with a solenoid which is driven directly from all compatible QX and IL series monitors and controllers without any modification or extra interface boards.

When ordering, select the type of sensor by its part number and specify the tube length (distance between sensor and feedthrough) if the standard length is not permissible. The sensor head, tubes and vacuum feedthrough will be welded together and checked for leaks and operation before shipping. Sensor heads are supplied with necessary oscillators and interconnection cables (including cables and tube for solenoids if shuttered sensor is purchased).

QUARTZ CRYSTAL SENSOR HEADS

INTELLECTRICS
Standard
Cassette Sensors

ORDERING INFORMATION

Single or Dual	Feedthrough	Shutter & Actuator	Bakeout	Part No.	Price \$
S	1" Port O-ring	No	No	ILSN6311550	POR
S	1" Port O-ring	Yes	No	ILSN6321550	POR
S	2 3/4" CF Flange	No	No	ILSN6312550	POR
S	2 3/4" CF Flange	Yes	No	ILSN6322550	POR
D	1" Port O-ring	Yes	No	ILSN6331550	POR
D	2 3/4" CF Flange	Yes	No	ILSN6332550	POR
S	2 3/4" CF Flange	No	350°C	ILSN6412550	POR
S	2 3/4" CF Flange	Yes	350°C	ILSN6422550	POR
D	2 3/4" CF Flange	Yes	350°C	ILSN6432550	POR
	(Crystals, Gold Coat, pkg 10)	—	—	ILCRYSTALS	67.00



21 Film Thickness

QUARTZ CRYSTAL MONITOR & CONTROLLER

Ferrofluidics/AP&T's LDC series deposition controllers are inexpensive, micro-processor based instruments for complete automatic control of vacuum deposited films. A quartz crystal is exposed to the evaporant or the sputter source, and the changes in its frequency (caused by the deposition of material) are used to compute the deposition rate and thickness of the film.

The 1-LDC is designed to control an industry standard single layer deposition using one quartz sensor and one deposition source. The 4-LDC features multiple programs (4 maximum), with 4-source selector outputs to allow the deposition of multi-layers from one source (i.e. multi-hearth e-beam gun) monitored by one quartz crystal sensor. On both units a hand-held remote control allows manual power control for setup. A bi-directional RS232 interface is optional. Both support the operation of 5MHz and 6MHz quartz crystals and come with a 19" rack assembly, single unit rack or double unit rack.

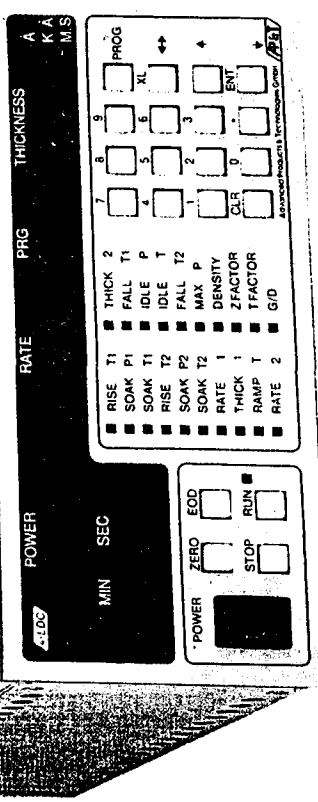
New!

FERROFLUIDICS/AP&T
1-LDC & 4-LDC

The LDC units are easy to operate, having four control switches: START and STOP, ZERO to reset the current thickness value to zero, and EOD (End of Deposit) to terminate a deposition by simulating the thickness set-point (i.e. for use with optical thickness monitors). Fourteen I/O signals permit easy interfacing to new or existing vacuum systems. Twenty set-points are supported in a deposition program, with battery back-up standard. Each set-point is printed on the front panel, with indicators lighted in sequence to allow the operator to follow the operation of the instrument during a deposition cycle. Numeric LED displays are provided for TIME, POWER, THICKNESS and RATE.

Sixteen push buttons are used for programming, with set-point selection driven by UP, DOWN, LEFT and RIGHT keys. Programming is fast and easy. No set-point requires more than five key strokes to select. When not used in programming, the XL key allows display of the remaining crystal life.

Crystal failure is indicated by 'F' on the RATE display, and a green LED tells the operator when the instrument is in the RUN mode. Altering the set-points during RUN is possible, except for material related set-points such as DENSITY, Z-FACTOR and TOOLING FACTOR.



The 1-LDC features a programmable sample and hold option that greatly extends the service life of the sensor crystal. This is especially useful in applications such as sputtering, where the crystal would receive vast amounts of deposit due to long process time or small distances to the source. Sample and hold can be programmed for both sample and hold times independently from 1 to 99 minutes. During sample time the unit will monitor and control deposition rate. During hold the crystal is obscured by a shutter and the source controlled to a constant power level that corresponds to the averaged power settings of the last sample period. The 1-LDC provides an output for automatic shutter control during sample and hold.

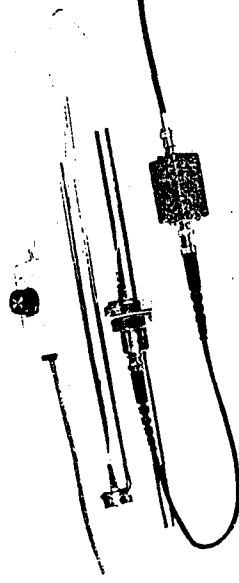
TECHNICAL DATA

Programs-Layers	1 program for 1 layer 4 programs for 4 layers
1-LDC	Battery
4-LDC	
RAM Back-up	
Sensor	5 or 6 MHz +12 VDC
Frequency	4/sec
Power	5/sec
Sampling Rate	1 A to 999.9 kA
@ 5 MHz	1 A to 9.999 kA
@ 6 MHz	10 A to 99.99 kA
Thickness Range	100 A to 999.9 kA
Thickness Resolution	0.1 A/sec to 999 A/sec
Rate Range	0.1 to 24.9 A/sec, 25 to 999 A/sec
Rate Resolution	1 to 999 A/sec
TF/D ≤25	0 to +5 V
TF/D >25	0 to ±10 V
Analog Outputs	
Rate (10-bit)	0.00 to 99.59 (minutes:seconds)
Source Control (10-bit)	0 to 99% power
Set-point Limits	0.0 to 24.9, 25 to 999 A/sec
All Timers	1.0 to 99.9 g/cm ²
All Powers	0.100 to 9.999
Rate (1 & 2)	10 to 499 (100 = tooling factor 1)
Density	01 to 99 (10 = gain factor 1)
Z-Factor	3.5 x 8.0 x 11.25
Tooling Factor	Bench, single or double rack
Gain/Damping	110/220 VAC 50/60 Hz, <50 W
Size (HxWxD inches)	RS232, Remote: start & programming, data logging
Mounting	
Power	
Options	

**QUARTZ
CRYSTAL
MONITOR &
CONTROLLER**

FERROFLUIDICS/AP&T
1-LDC & 4-LDC

NEW!



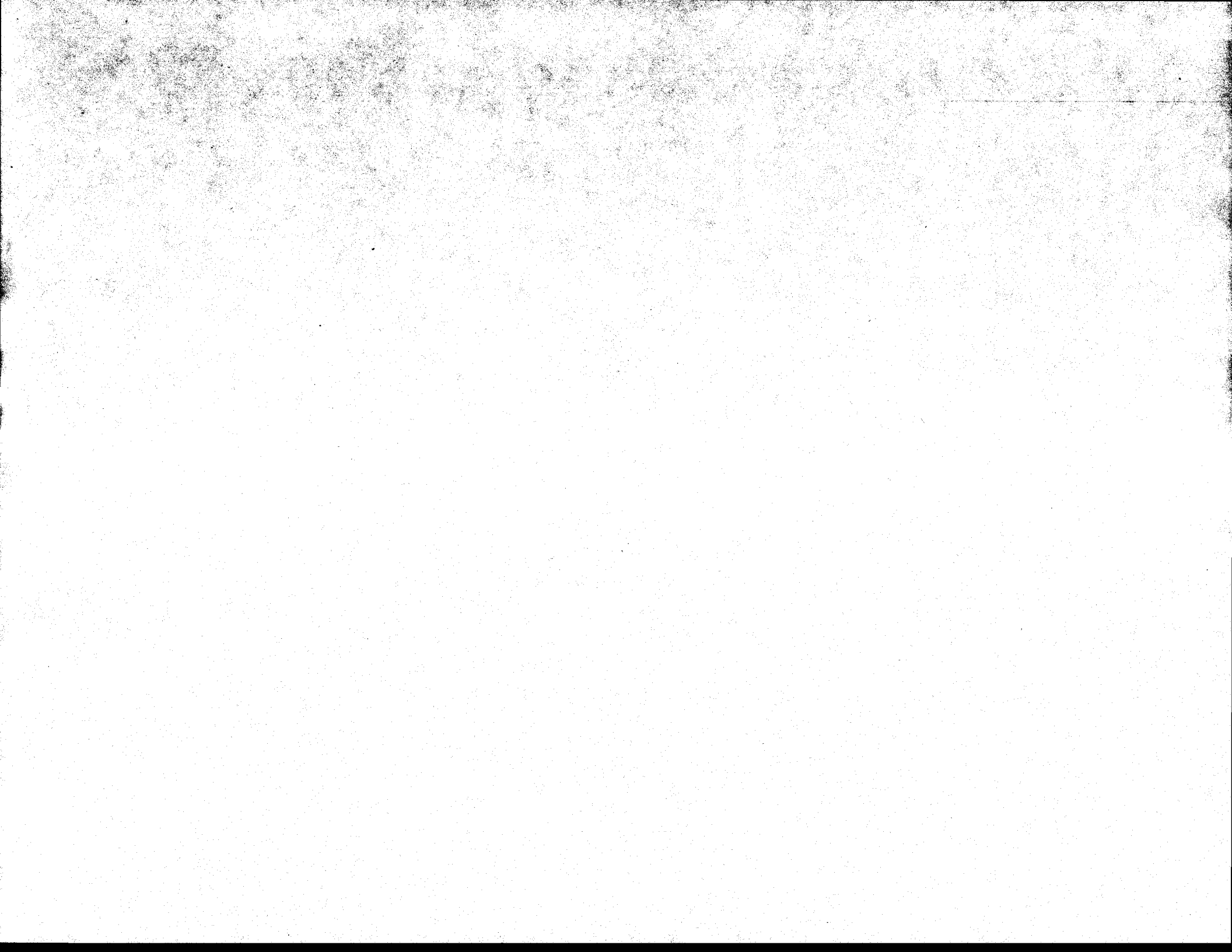
**ORDERING INFORMATION -
Deposition Control Accessories**

Description	Part No.	Price \$
LDC Series sensor head switcher	FEE403001	POR
LDC Series RS232 interface	FEE400151	POR
Oscillator set (5/6MHz)	FEE402001	POR
Standard sensor, side water lines	FEE6000010	POR
Standard sensor, rear water lines	FEE6000011	POR
Shuttered dual sensor set	FEE600101	POR
UHV compatible sensor head	FEE601002	POR
Standard vacuum feedthrough	FEE320001	POR
2 3/4" CF vacuum feedthrough	FEE320011	POR
2-Sensor vacuum feedthrough	FEE321001	POR
2 3/4" CF 2-Sensor vacuum feedthrough	FEE321011	POR

21

**ORDERING INFORMATION -
Deposition Controllers**

Description	Part No.	Price \$
1-LDC Deposition Controller	FEE400011	POR
4-LDC Deposition Controller	FEE400041	POR



THE TEMPERATURE HANDBOOK

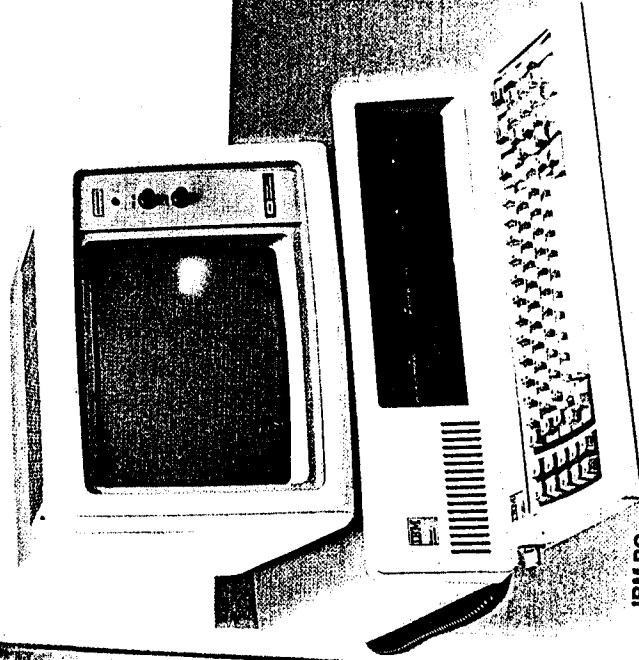


Ω OMEGA

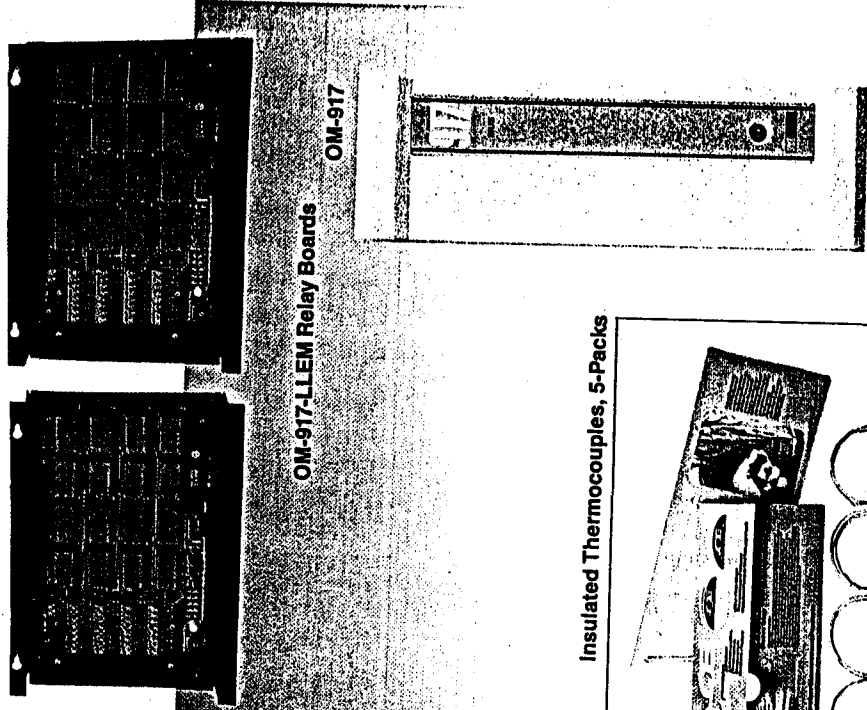
an OMEGA Technologies Company

High-Capacity 256-Point Temperature Monitoring System

NEW!



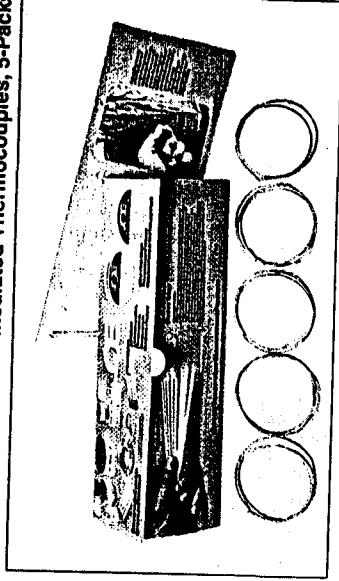
IBM PC
Not Included



OM-917-LLEM Relay Boards

OM-917

Insulated Thermocouples, 5-Packs



DSK-007

\$23,632

For monitoring large numbers of temperature points, the DSK-007 is one of the most economical, reliable, and accurate systems available. The key to this system is the OMEGA OM-900 interface and OM-917 multiplexer modules. The system accepts up to 256 thermocouple inputs at an extremely low dollar-per-channel cost. Each OM-917-LLEM accepts up to 16 inputs and multiplexes the inputs to the one output channel.

The OM-917-LLEM resides externally to the main OM-900 system and is connected to the main system through an OM-917 module. The output channel of the OM-917-LLEM is connected to one of the eight inputs on the OM-931 thermocouple input module. Up to eight OM-917-LLEM's may be attached to one OM-917 module, providing 128 thermocouple or low level analog inputs.

The system works with an IBM PC (not included). Supplied with the system are enough thermocouples and wire for all the temperature measurements. For simple programming-free operation, LTControl software provides complete monitoring, control, display, and data logging capabilities.

System Includes:

1	OM-992 Central Processing Unit Module	\$1350
1	OM-903 115/236 Vac supply, 60 W capacity	595
2	OM-917 Low Level Multiplexer Controller (\$575 each)	1150
16	OM-917-LLEM Low Level Multiplexer Relay Board (\$600 each)	9600
2	OM-931 8-Channel Thermocouple Input Module (\$1350 each)	2700
10	EXPP-K-20-1000, 1000' Thermocouple Wire (\$230 each less 20% for quantity)	1840
52	5TC-GG-K-20-36 Thermocouples, 5-Packs (\$39 each less 20% for quantity)	1622
260	SMP-K-MF Thermocouple Connector Pairs (\$4 each less 25% for quantity)	780
1	SWD-LCT-1 LTControl Software	3995

Order No. DSK-007

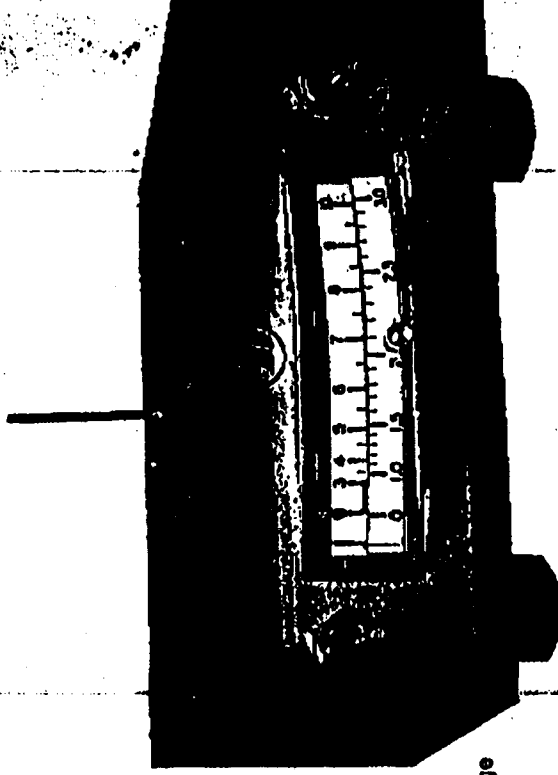
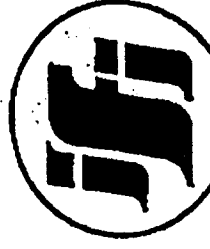
\$23,632

EFS-1
EFS-2
EFS-3
E-FIELD
SENSORS

LMT
LIGHT
MODULATOR
TRANSMITTER

LDI
LIGHT
DEMODULATOR
INDICATOR

RHM-1
RHM-2
RADIATION
HAZARD
MONITORS



FEATURES

- Direct Reading in Volts/Meter
- Broadband Coverage
- No Tuning
- No Bandswitching
- Compact, Battery Operated
- Negligible Field Distortion
- System Compatibility
- Useful for Reading & Control
- Five Meter Ranges for Easy Reading
- Approved for MIL-STD-461, 462
- No Calibration Curves or Tables
- Inexpensive

APPLICATIONS

- RFI Susceptibility Testing
- Measuring and Controlling Field Strength
- Transmitting Antenna Field Plotting and Checking
- Quantitative "on the air" Monitoring
- Surveying Installation Sites for Sensitive Equipment
- Monitoring Electromagnetic Environment in Hazardous Areas
- Locating Sources of Electromagnetic Interference
- Visualizing Field Polarization and Distribution in Research and Educational Laboratories

EFS-1 SPECIFICATIONS

Frequency Direct reading from 10kHz Range: 220MHz
Accuracy: Better than 5% of full scale
Calibration: Direct reading in volts per meter
Input Power: Two 9-volt transistor radio type batteries
Battery Drain: Less than 10 milliamperes, each
Dimensions: Width and Depth, 4 inches
 Height, 2 inches plus antenna
Weight: 15 ounces, including batteries

Ranges:

Antenna Range	Full Scale	Useful Range
5"	3 V/M	1 to 3 V/M
5"	10 V/M	3 to 10 V/M
1"	30 V/M	10 to 30 V/M
1"	100 V/M	30 to 100 V/M
3/8"	300 V/M	100 to 300 V/M

EFS-1 E-FIELD SENSOR

The EFS-1 E-Field Sensor is a highly versatile, low cost test instrument for measuring strong electric fields in the V, L, F, MF, HF, and VHF regions of the spectrum. No tuning, bandswitching or other frequency-related adjustments are required. It is calibrated directly in volts per meter with four convenient ranges for direct reading of 1 to 300 volts/meter from 10kHz to 220MHz. Because the EFS-1 is physically small and self-contained (powered by two standard 9-volt batteries) its effect on the field being measured is negligible.

The EFS-1 is ideal for radiated susceptibility tests. It is the basic building block of a series of system-oriented modules that provide a wide range of instrumentation capabilities for making simple, direct field measurements to fully automatic constant-field swept or stepped frequency systems.

It costs a small fraction of alternate methods and yet provides faster, more accurate readings with vastly improved convenience and resultant dependability. Because of its low cost, several can be used at multiple locations to check a field for uniformity.

A companion Light Modulator-Transmitter is also available for remote reading and control using fiber optic data links to avoid field distortion and erroneous readings due to the presence of conductive interconnecting cables.


INSTRUMENTS FOR INDUSTRY, INC.

731 UNION PARKWAY □ RONKONKOMA, N.Y. 11779

Instruments For Industry, Inc. is classified as a small business concern under the provisions of the Small Business Act.

Thank you for your interest and the opportunity to quote on this requirement.

Best Regards,



Richard Janiec
Sales/Marketing

OUR QUOTE NO. 212-00



Instruments for Industry, Inc.
731 Union Parkway
Ronkonkoma, New York 11779
516 467 8400 Fax: 516 467 8558

07/13/94

MIT
CENTER FOR SPACE RESEARCH
ROOM 20B-145
CAMBRIDGE, MA 02139

ATTN: MR YARON HEFETZ

QUOTATION

DUPLICATE

We are pleased to submit the following price quotation in response to your referenced request:

QUANTITY QUOTED	U/M	ITEM NO.	PART DESCRIPTION	UNIT PRICE	TOTAL PRICE
1.00	EA	01	EFS-3 E-FIELD SENSOR 0.01 TO 220 MHZ DELIVERY: SIX TO EIGHT WEEKS Rev. 00	1350.00	1350.00
			TOTAL		1350.00

CONTACT YARON HEFETZ PHONE 617 256 6412
FAX 617 253 7014

This quote with brochure and data sheets will be mailed to you.

If you have any questions, please call at your convenience.

I will call you for a follow up in approximately one week.

LEAD TIME:

The lead time on this quotation is based on year round average delivery times. The actual lead time for this item will depend on our production and inventory status at the time of receipt of purchase order.

TERMS & CONDITIONS:

This quote is subject to the standard terms and conditions of Instruments For Industry, Inc.

Shipments are made FOB Ronkonkoma, New York.

The payments terms are net thirty (30) days to rated accounts.

This proposal may be considered valid for a period of sixty (60) days, after which time it shall be subject to review.

CUSTOMER

INSTRUMENTS FOR INDUSTRY, INC.
731 UNION PARKWAY
ROCKONKOMA, NEW YORK 11779
516-467-8400
FAX: 516-467-8558

DATE: 13 July 1994 PAGES: 4

TO: Yaron Hefetz

COMPANY: MIT Cntr Space Resch, Ma.

FAX/PHONE: 617 253 7014, 617 256 6412

FROM: Barbara Hoos, Sales

SUBJECT: Your Request For Quotation

REFERENCE: Quotation No. 212

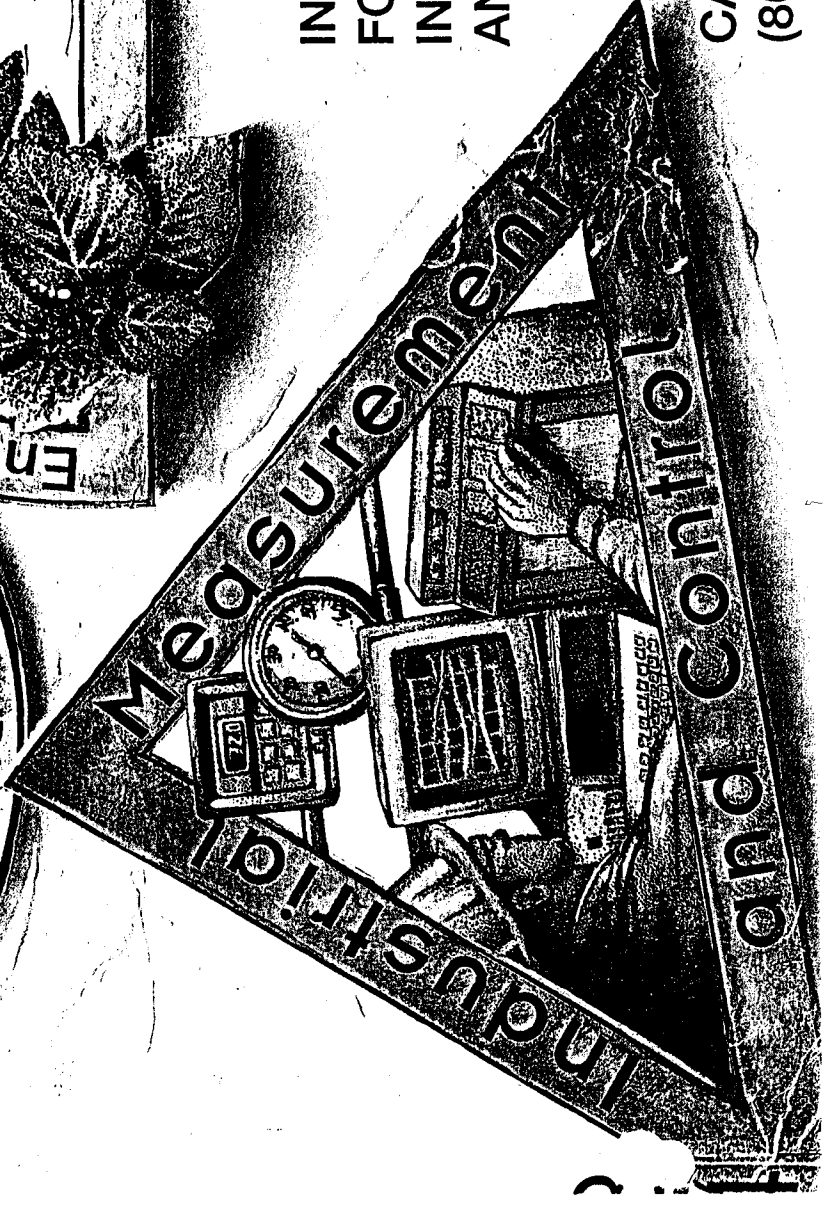
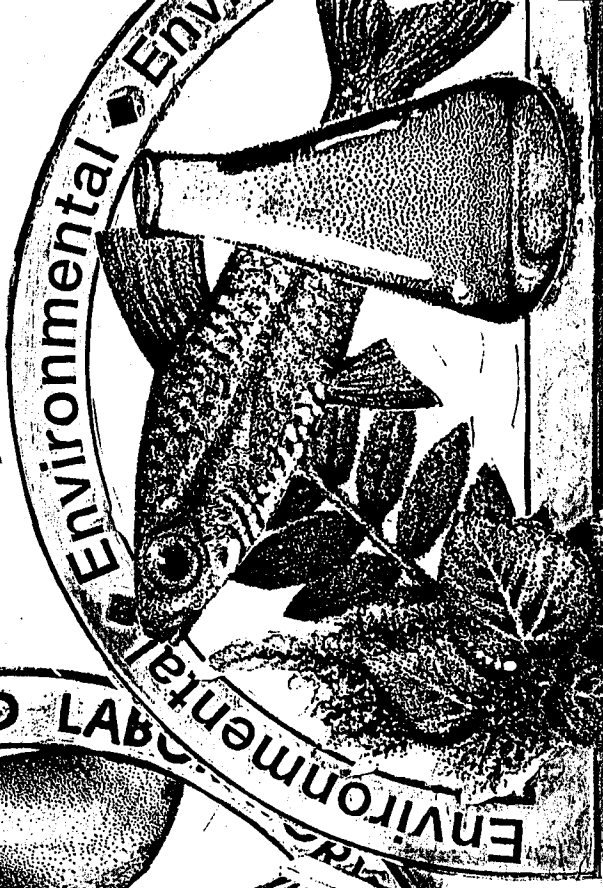
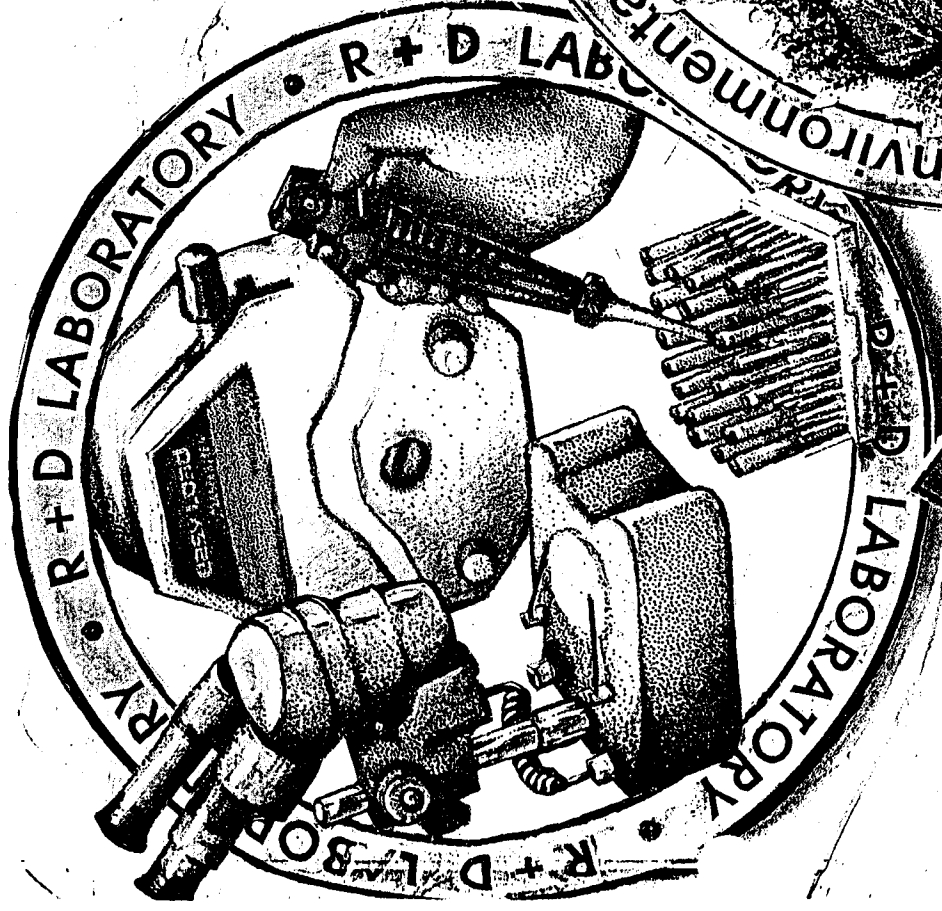
Attached, please find the above referenced quotation.

Thank you and best regards.

COLE-PARMER

INSTRUMENT COMPANY

1993 - 1994



INSTRUMENTS
FOR RESEARCH,
INDUSTRY,
AND EDUCATION

CALL TOLL-FREE
(800) 323-4340

NEW VAISALA HUMIDITY DATA PROCESSOR

- Measures relative humidity and temperature
- Calculates dew point, mixing ratio, and absolute humidity
- Data logging with serial output

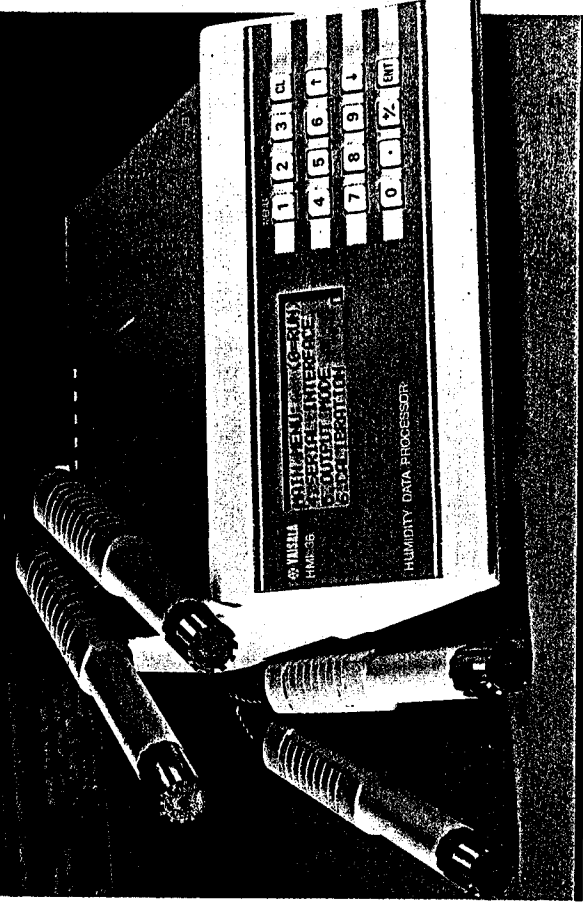
Conduct simultaneous humidity-related measurements with this new humidity data processor. Unit accurately measures relative humidity and temperature—then calculates dew point, mixing ratio, and absolute humidity. Accepts input from up to four humidity probes (model 37301-70); order separately below. Large, menu-driven LCD guides you through setup. Simultaneously displays four readings from one probe, one reading from four separate probes, or your desired combination—in either metric or English units.

Data logging feature lets you store up to 2500 readings. Serial output allows data to be transferred to your computer or printer. Use the keypad to set logging interval and times, and probe order.

Includes 3 ft cord with plug for 115 VAC operation. Optional 220 VAC adapter and optional 15 VDC battery pack are sold separately below.

- G-37301-00 Humidity data processor.**
Shpg wt 8 lbs (3.6 kg)\$225.00
- G-37301-55 Optional AC adapter; 220 VAC, 50/60 Hz.** Shpg wt 3 lbs (1.4 kg)\$50.00
- G-37301-60 Optional battery pack, 15 VDC.**
Shpg wt 5 lbs (2.3 kg)\$150.00
- G-37301-70 Humidity probe for Vaisala humidity data processor.** Shpg wt 3 lbs (1.4 kg)\$485.00
- G-03329-80 Sintered bronze filter;**
37 μ , 18.5 mm dia\$30.00
- G-03329-81 Sintered bronze filter;**
216 μ , 18.5 mm dia\$30.00

Connect up to four humidity probes.



MAIN MENU: COERUND
HUMIDITY MODE
SERIAL LOGGING

Unit easily guides you through setup and displays up to four readings.

REL RH = 19.9 %
RH = 23.1 °C
RH Td = 51.2 °C
DUEX = 3.46 g/kg

SPECIFICATIONS

Mode	Range	Resolution	Accuracy
Humidity	0.0 to 100.0% RH	0.1% RH	$\pm 0.1\%$ RH (at 20°C)
Temperature	-40.0 to 320.0°F (-40.0 to 160.0°C)	0.1°F (0.1°C)	$\pm 0.2^\circ\text{F}$ ($\pm 0.1^\circ\text{C}$)
Dew point	-112.0 to 320°F (-80.0 to 160.0°C)	0.1°F (0.1°C)	$\pm 0.2^\circ$ at -4°F and 100% RH; $\pm 1.7^\circ$ at 140°F and 10% RH
Mixing ratio	0 to 9999 g H ₂ O/kg dry air (0 to 9999 grains/lb)	0.01 g H ₂ O/kg dry air (0.01 grains/lb)	± 0.01 g H ₂ O/kg dry air at -4°F and 10% RH; ± 2.76 g H ₂ O/kg dry air at 140°F and 100% RH
Absolute humidity	0 to 9999 g H ₂ O/m ³ (0 to 9999 grains/ft ³)	0.01 g H ₂ O/m ³ (0.01 grains/ft ³)	± 0.01 g H ₂ O/m ³ at -4°F and 10% RH; ± 1.86 g H ₂ O/kg dry air at 140°F and 100% RH

Display: 4 x 20 character alphanumeric LCD
Power: 115 VAC, 50/60 Hz (220 VAC with optional adapter, or 15 VDC with optional battery pack)

Battery life: 7 hours Output: RS-232-C or RS-485, D89(F) ASCII
Dimensions: 11 $\frac{1}{2}$ " L x 7 $\frac{1}{2}$ " W x 3 $\frac{3}{4}$ " H

Specifications for humidity probe (model 37301-70)

Range: 0.0 to 100.0% RH

Accuracy: $\pm 2\%$ RH from 0.0 to 90.0%; $\pm 3\%$ RH from 90.0 to 100.0%
Repeatability: better than 1% RH

Temperature limits: -40.0 to 140.0°F (-40.0 to 60.0°C)

Probe type

Material: HUMICAP® capacitive thin-film

Response time: 5 seconds (90% response)

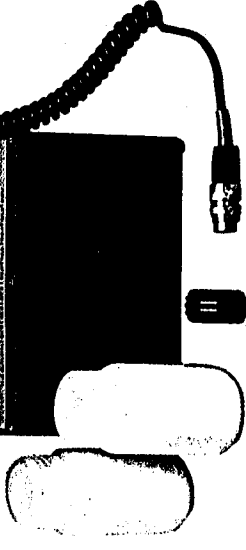
Cable: 59" L x 18.5 mm dia, with 59" L cable

Reg. TM Vaisala Inc.

Temperature: 100 Ω Pt RTD

CALIBRATION KIT

Use this calibration kit with the Vaisala data processor above, all Vaisala humidity meters, and the Tri-Sense™ meter on page 525. Accepts 12-, 18.5-, and 22-mm dia probes; and 5 x 20 mm rectangular probes. Kit includes their mometer and 4 oz bottles of 12% and 75% RH salts.



- G-03335-00 Calibration kit.** Shpg wt 5 lbs (2.3 kg)\$325.00
- G-03335-50 Replacement calibration salt, 12% RH (LiCl).**
4 oz bottle\$60.00
- G-03335-52 Replacement calibration salt, 75% RH (NaCl).**
4 oz bottle\$30.00
- G-03335-51 Calibration salt, 97% RH (K₂SO₄).**
4 oz bottle\$40.00

Tri-Sense—TM Cole-Parmer Instrument Co.

Call-free at 1-800-323-4340