LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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OSEM Drive Electronics
Interface Control Document

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This is an internal working note
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http://www.eng-external.rl.ac.uk/advligo/papers_public/ALUK_Homepage.htm.

1 Introduction

The purpose of this document is to capture the interface definition for the advanced LIGO system. The nature of all Interface Control Documents (ICD) is to describe the design implementation of the requirements in the specifications (requirements and design descriptions) as they relate to interfaces. During the design phases of the program the ICD is a 'living' document; It must be actively maintained and controlled. Once the ICD has achieved a reasonable level of completion (at least for sections related to a few subsystems), it will be released with a Document Change Notice (DCN) which is signed by the leaders/managers for all subsystems involved. This places the ICD under configuration control. For each subsequent revision, a DCN is required. This DCN is initiated by the systems engineering group and signed by all the leaders/managers of the effected subsystems. The DCN lists the changes and the reasons for the changes. The DCN also indicates if the changes effects cost, schedule or performance. It is the responsibility of the systems engineering group to arrange for appropriate review or approval by a Material Review Board (MRB), Technical Review Board (TRB) or the Configuration Control Board (CCB) as required in the process of reviewing the DCN.

The advanced LIGO system is divided into subsystems as listed in Table 1. Of all the possible pair wise interactions, less than half have interface definition, as indicated in Table 1.

Table 1: Subsystem interface matrix

LIGO.4. WBS	Subsystems			FAC	SEI	SUS UK	SUS US	PSL	IO	COC	AOS PhDr	AOS ATC	AOS COS	ISC	DAQ	SUP	LDAS	INS	SYS
1	Facilities		FAC		✓	✓	✓	✓		✓					✓		✓		
2	Seismic Isolation		SEI			✓	✓					✓	✓	✓	✓	✓		✓	✓
3A	Suspensions (SUS)	UK Scope	UK				✓			✓	✓	✓	✓	✓	✓	✓		✓	✓
3B		US Scope	US						✓	✓			✓	✓	✓	✓		✓	✓
4	Pre-Stabilizaed Laser		PSL						✓					✓	✓				
5	Input Optics		IO										✓	✓	✓				✓
6	Core Optics Components		COC																✓
7A	Auxiliary Optics (AOS)	Photon Drive	PhDr											✓	✓				✓
7B		Active Thermal Compensation	ATC											✓	✓				✓
7C		Core Optics Support	COS											✓					✓
8	Interferometer Sensing & Control		ISC												✓				
9	Data Acquisition		DAQ														✓		
10	Support Equipment		SUP																
12	LIGO Data Analysis System		LDAS																✓
13	Installation		INS																
14.5	Systems Engineering		SYS																

Note: The cells in Table 1 should eventually cite the section in which the interface is defined.

The Suspension subsystem is further divided into the United Kingdom (UK) team's scope and the United States (US) team's scope. In this way the interfaces between elements common to the overall assemblies produced by both teams are effectively captured in this ICD.

The Auxiliary Optics Subsystem (AOS) is also divided into its principal subsystem elements, due to the considerably different nature of these various elements, and the likelihood that different groups will address the design of each element.

1.1 Applicability of the System Interface Matrix to the OSEM Drive Electronics

The OSEM Drive Electronics represents a constituent part of the Interferometer Sensing and Control (ISC) subsystem, and as such will interface to a subset of the subsystems (as detailed in table 1) to which the ISC interfaces. This subset is listed below, and is used as the basis for this document.

i) Interferometer Sensing and Control (ISC)

ii) Suspensions (SUS)

iii) Seismic Isolation (SEI)

iv) Support Equipment (SUP)

2 Applicable Documents

Ref No	Document Title	ID Number
	Existing Drive Electronics documentation	
1	LOS Coil Driver & Universal De-whitening Filter Revisions	T030094-01-D
2	SOS Coil Driver Module	D010001-B-C
	LIGO Design Guidelines	
3	LIGO Laboratory Electronics EMC Requirements	E020986-01-D
	AdvLIGO Documents	
4	Satellite Amplifier	D961289-B1-C
5	AdvLIGO OSEM Drive Electronics Test Specification	Exxxxxx
6	AdvLIGO OSEM Drive Electronics Manufacturing and Assy Details	Exxxxxx
7	AdvLIGO OSEM Drive Electronics Subrack Manufacturing and Assy Details	Exxxxxx
8	AdvLIGO OSEM Drive Electronics Subrack Test Specification	Exxxxxx
	AdvLIGO Drawings	
9	AdvLIGO OSEM Drive Electronics PCB Schematic	Dxxxxxx
10	AdvLIGO OSEM Drive Electronics PCB BOM	Dxxxxxx
11	AdvLIGO OSEM Drive Electronics PCB Fabrication Drawing	Dxxxxxx
12	AdvLIGO OSEM Drive Electronics Wiring Details	Dxxxxxx
13	AdvLIGO Subrack Backplane Schematic	Dxxxxxx
14	AdvLIGO Subrack Backplane BOM	Dxxxxxx
15	AdvLIGO Subrack Backplane Fabrication Drawing	Dxxxxxx
16	AdvLIGO Subrack (Complete) Assy	Dxxxxxx
17	AdvLIGO Subrack (Complete) BOM	Dxxxxxx

Table 2-1

Note: ICD INFORMATION: The drawings listed in table 2-1 contain interface information. Revisions must be coordinated with a revision to E03xxxx and with LIGO systems engineering

3 OSEM Drive Electronics to Interferometer Sensing and Control (ISC) Interfaces

3.1 Electrical Interface

3.1.1 OSEM Drive Electronics Module Input Connector Details and Pin Allocation

The Electrical Connection to the OSEM Drive Electronics Module is via a Male Normal Density 25 way D type connector TBC mounted on the front face of the rack-mounted unit. The pin allocations are as shown below:-

Pin Number	Signal Name	Description
1	Signal Ground Return	
2	DLD1+	Ch1 Differential Line Driver, + (o/p)
14	DLD1-	Ch1 Differential Line Driver, - (o/p)
3	DLD2+	Ch2 Differential Line Driver, + (o/p)
15	DLD2-	Ch2 Differential Line Driver, - (o/p)
4	DLD3+	Ch3 Differential Line Driver, + (o/p)
16	DLD3-	Ch3 Differential Line Driver, - (o/p)
5	DLD4+	Ch4 Differential Line Driver, + (o/p)
17	DLD4-	Ch4 Differential Line Driver, - (o/p)
6	DLD5+	Ch5 Differential Line Driver, + (o/p)
18	DLD5-	Ch5 Differential Line Driver, - (o/p)
7	DLD6+	Ch6 Differential Line Driver, + (o/p)
19	DLD6-	Ch6 Differential Line Driver, - (o/p)
8	DLR1+	Ch1 Differential Line Receiver, + (i/p)
20	DLR1-	Ch1 Differential Line Receiver, - (i/p)
9	DLR2+	Ch2 Differential Line Receiver, + (i/p)
21	DLR2-	Ch2 Differential Line Receiver, - (i/p)
10	DLR3+	Ch3 Differential Line Receiver, + (i/p)
22	DLR3-	Ch3 Differential Line Receiver, - (i/p)
11	DLR4+	Ch4 Differential Line Receiver, + (i/p)
23	DLR4-	Ch4 Differential Line Receiver, - (i/p)
12	DLR5+	Ch5 Differential Line Receiver, + (i/p)
24	DLR5-	Ch5 Differential Line Receiver, - (i/p)
13	DLR6+	Ch6 Differential Line Receiver, + (i/p)
25	DLR6-	Ch6 Differential Line Receiver, - (i/p)

Table 3.1.1-1

3.2 Electrical Properties

Each OSEM Drive Electronics Module will process 6 OSEM (sensor and actuator) channels.

The input/output common mode range shall be ±10 Volts TBC

3.2.1 Cabling Requirements

The control input to the electronics will be via Screened Multiple Twisted Pair Cable.

Each output sensor output to the ISC shall be capable of driving a cable with the following properties:-

Maximum Cable Capacitance Each Wire to Ground (Driver Output):-3000 pF TBC

Maximum Cable Capacitance Twisted Wire Pair (Driver Output):- 3000 pF TBC

Maximum Driven Cable Length (Driver Output):- 30 m TBC

3.2.2 Electronics Bandwidth Requirements

The Electronics Module bandwidths shall be as follows:-

Sensor Electronics Bandwidth 5KHz TBC

Actuator Electronics Bandwidth 5KHz TBC

3.2.3 Noise Performance

The Electronics Module Noise and OSEM combined noise performance shall be as follows:-

Sensor Electronics Noise 4uV/√Hz TBC

(Equivalent to 3×10^{-10}m/√Hz)

Actuator Current Noise 100pA/√Hz TBC

(Equivalent to TBD N/√Hz)

3.3 Physical Interfaces

The OSEM Drive Electronics PCBs will be designed to allow mounting in TBD style Subrack suitable for mounting in a 19'' Rack system.

The OSEM Drive Electronics PCBs required for a complete suspension will be supplied mounted in a TBD Subrack Assy, comprising backplane with inlet connector for connection of low voltage supply.

Each Subrack may be installed in a Satellite or 'main instrumentation' location.

3.4 Subrack Power Interface

The low voltage power inlet connector for the Subrack will be of type TBC and pinout as follows. The Connector is located on the Subrack backplane PCB:-

Pin Number	Signal Name	Description
TBC		

Table 3.4-1

3.5 Power Interface Electrical Properties

The OSEM drive electronics module low voltage supply shall comply with the following specifications:

Positive Supply:-	TBD ± TBD Vdc
Positive Supply Current:-	TBD A (Max)
Negative Supply:-	TBD ± TBD Vdc
Negative Supply Current:-	TBD A (Max)
Regulation:-	TBD
Noise:-	TBD mV rms

4 OSEM Drive Electronics to Suspensions (SUS) and Seismic Isolation (SEI) Interfaces

4.1 Electrical Interfaces

4.1.1 OSEM Drive Electronics Module Output Connector Details and Pin Allocation

Electrical Output Connection to the OSEM Drive Electronics Module is via a Female Normal Density 37 way D type connector mounted on the front of the unit. The pin allocations are as shown below (TBC):-

Pin Number	Signal Name	Description
1	PD-A1	Ch1 Photodiode Anode
20	PD-K1	Ch1 Photodiode Cathode
2	LED-A1	Ch1 Infra-Red LED Anode

21	LED-K1	Ch1 Infra-Red LED Cathode
3	ST-1	Ch1 Actuator Coil Driver, Start
22	FN-1	Ch1 Actuator Coil Driver, Finish
4	PD-A2	Ch2 Photodiode Anode
23	PD-K2	Ch2 Photodiode Cathode
5	LED-A2	Ch2 Infra-Red LED Anode
24	LED-K2	Ch2 Infra-Red LED Cathode
6	ST-2	Ch2 Actuator Coil Driver, Start
25	FN-2	Ch2 Actuator Coil Driver, Finish
7	PD-A3	Ch3 Photodiode Anode
26	PD-K3	Ch3 Photodiode Cathode
8	LED-A3	Ch3 Infra-Red LED Anode
27	LED-K3	Ch3 Infra-Red LED Cathode
9	ST-3	Ch3 Actuator Coil Driver, Start
28	FN-3	Ch3 Actuator Coil Driver, Finish
10	PD-A4	Ch4 Photodiode Anode
29	PD-K4	Ch4 Photodiode Cathode
11	LED-A4	Ch4 Infra-Red LED Anode
30	LED-K4	Ch4 Infra-Red LED Cathode
12	ST-4	Ch4 Actuator Coil Driver, Start
31	FN-4	Ch4 Actuator Coil Driver, Finish
13	PD-A5	Ch5 Photodiode Anode
32	PD-K5	Ch5 Photodiode Cathode
14	LED-A5	Ch5 Infra-Red LED Anode
33	LED-K5	Ch5 Infra-Red LED Cathode
15	ST-5	Ch5 Actuator Coil Driver, Start
34	FN-5	Ch5 Actuator Coil Driver, Finish
16	PD-A6	Ch6 Photodiode Anode
35	PD-K6	Ch6 Photodiode Cathode
17	LED-A6	Ch6 Infra-Red LED Anode
36	LED-K6	Ch6 Infra-Red LED Cathode
18	ST-6	Ch6 Actuator Coil Driver, Start

37 19	FN-6 Screen	Ch6 Actuator Coil Driver, Finish

Table 4.1.1-1

4.2 Electrical Properties

OSEM Drive Electronics Output shall comply with the following requirements:-

Maximum LED Drive Current:- 55mA TBC

Maximum Coil Current:- 150mA TBC

The Actuator Output shall be capable of driving the following cable, whilst maintaining adequate phase margin for stable operation:-

Maximum Cable Capacitance Each Wire to Ground:- 3000 pF TBC

Maximum Cable Capacitance Twisted Wire Pair:- 3000 pF TBC

Maximum Driven Cable Length (Output to OSEM):- 20 m TBC

4.3 Finished Item Packaging for Storage and Shipping

Sub Rack units will be packaged for storage and shipping by enclosing in anti-static wrap, and secured in packing crates. Shipping crate format TBC.

4.4 Handling

Finished parts should only be handled in a static safe working environment, using standard static safe handling precautions.

5 OSEM Drive Electronics to Support Equipment (SUP) Interfaces

5.1 Automatic Test Equipment

Due to the number of channels to be manufactured, finished product setup and test will be assisted by a PC based Automated test system. The system will measure and record the following parameters:-

i) Sensor LED Drive Current

ii) Photodiode input to differential Output transfer function (Transimpedance)

iii) Coil Driver differential input to Coil output transfer function (Transconductance)

iv) Photodiode input to differential Output noise (TBC)

v) Coil Driver Current noise (TBC)

vi) Sensor Output noise (TBC)

Test results will be provided with the finished product.

6 Quality Assurance

6.1 Requirements Verification Matrix

A Verification Matrix will be added once the format and content of the document are agreed