LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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aLIGO ISC QPD Transimpedance Amplifier Test Procedure

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1 Overview

This test procedure applies to ISC QPD Transimpedance Amplifier circuit board LIGO-D1001974-v2 contained within chassis assembly D1002481. A block diagram of the ISC QPD Transimpedance circuit board is shown in Figure 1. Two such QPD Transimpedance Amps and one ISC QPD Transimpedance Amplifier Interface are packaged in one chassis.

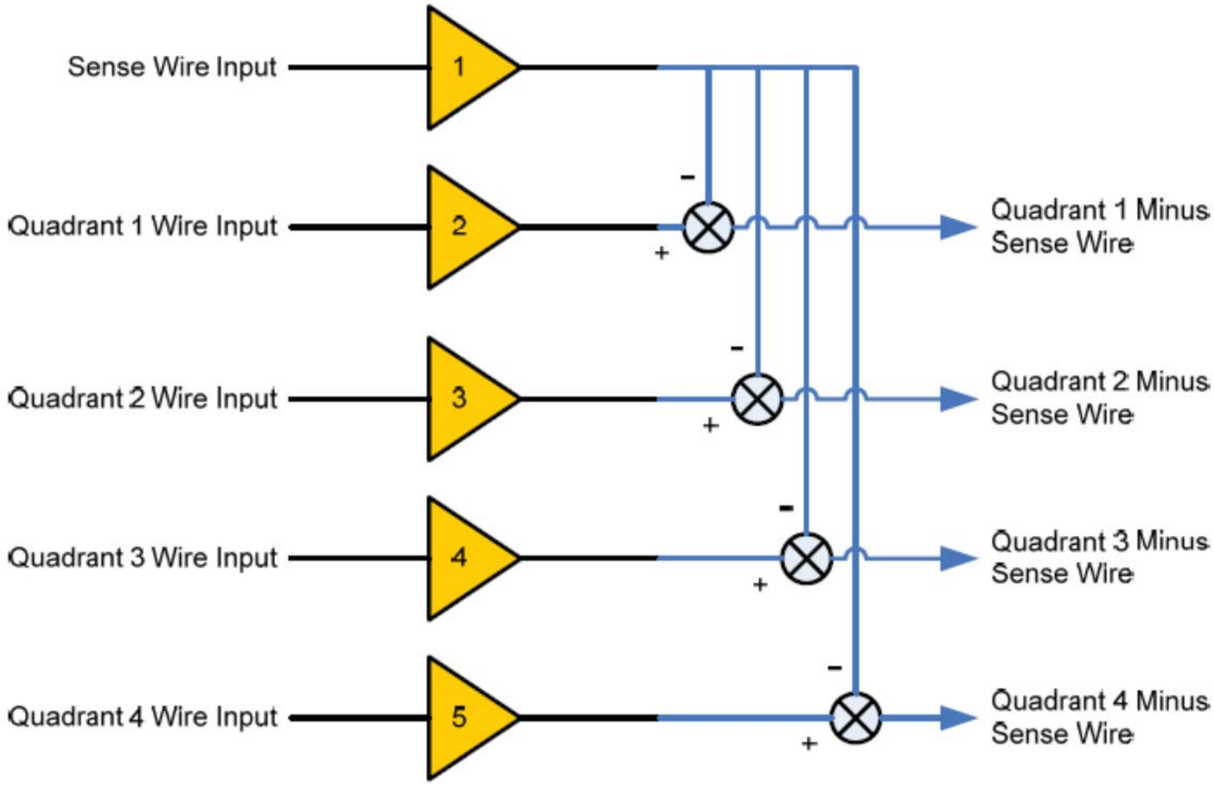


Figure 1 QPD Transimpedance Amplifier Circuit Block Diagram

2 Testing

Each production chassis must be functionally tested and the results recorded in Section 4. It is assumed that the person using this procedure is familiar with Dynamic Signal Analyzers, and rudimentary test equipment including oscilloscopes and multimeters.

Serial Number Data

- Record all serial number data in Table 1

DC Tests

Apply +/- 18, +/-200 mV Volts DC to the chassis under test and record front panel LED operation, total positive and negative power supply current, internal regulator output voltage and individual circuit board power supply currents as required in

- Table 2.

3 Reference for chassis front and rear panel layout

Figure 2: QPD Transimpedance Amplifier Chassis Front Panel

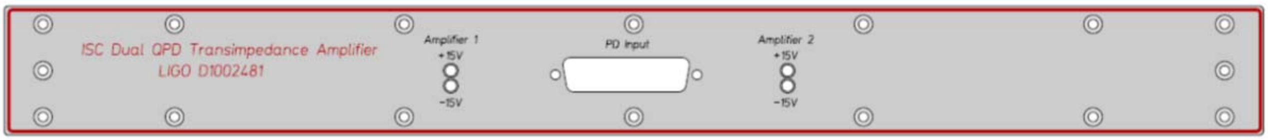
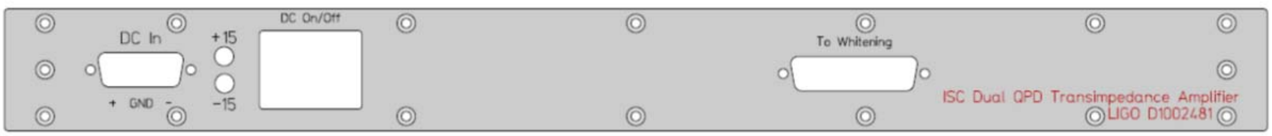


Figure 3: QPD Transimpedance Amplifier Chassis Rear Panel



4 Test Data Tables

4.1 General Information

Tested By		Date	

Table 1 Serial Number Data

Chassis Serial Number	DC PWR Board PCB Serial #	Amplifier 1 PCB Serial #	Amplifier 2 PCB Serial #	Interface Board PCB Serial #

4.2 DC Power Supply Data

Total chassis and individual circuit board quiescent current draw is recorded in

Table 2. For the individual circuit boards, unplug all but one board at a time and record the chassis current draw of the +/- 18VDC supply. Use caution in believing the digital readouts of laboratory triple output power supplies. Their meters are not highly accurate. When in doubt, use a multimeter on the appropriate scale in series with the supply to be measured.

Table 2, Record of DC Test Data

Parameter	Typical Value	Allowable Range	Measured Value
Front Panel +/- 15VDC Power LEDs	Both Lit	N/A	
Rear Panel +/- 15VDC Power LEDs	Both Lit	N/A	
+18VDC, +/-0.2VDC **TOTAL** supply current	270 mA	+/- 50mA	
-18VDC, +/-0.2VDC **TOTAL** supply current	240 mA	+/- 50mA	
Regulated Internal DC Voltage under full load (both boards)	15 VDC	+/- 0.5VDC	
Regulated Internal DC Voltage under full load (both boards)	-15 VDC	+/- 0.5VDC	

4.3 DC Offsets on Each Differential Output

As a general measure of the health, the DC offset at the differential outputs for each channel must be measured. Using a multimeter, measure the DC offset at each differential output on the associated rear panel D-sub connector. The input connector is to be left open. Record the results in Table 3.

Table 3, Differential Output DC Offset

Differential DC Measurement Point	*Typical DC Offset*	*Allowable Range*	*Measured DC Offset*	
			Amplifier 1	**Amplifier 2**
Channel 1	0VDC	+/- 5mV		
Channel 2	0VDC	+/- 5mV		
Channel 3	0VDC	+/- 5mV		
Channel 4	0VDC	+/- 5mV		

4.4 Transimpedance

Calculate the transimpedance by using the laboratory Voltage/Current calibrator Model IVC-222HP 11.

Inject 1mA DC into the appropriate anode input of the QPD. Measure the DC Voltage at the differential output; calculate the transimpedance of the circuit by:

Transimpedance = Vout / 1mA

Table 4, Differential Output Transimpedance

Differential DC Measurement Point	*Transimpedance*	*Allowable Range*	*Calculated Transimpedance*	
			Amplifier 1	**Amplifier 2**
Channel 1	1K	+/- 5mΩ		
Channel 2	1K	+/- 5mΩ		
Channel 3	1K	+/- 5mΩ		
Channel 4	1K	+/- 5mΩ		

4.5 Frequency Response

The transfer function of each channel of the amplifier should be measured using an SR785 dynamic signal analyzer. The input impedance to all channels of this circuit is 10 ohms. Due to this low impedance, a 1kΩ resistor is required to be placed in series with the SR785 source. A simple set of clip leads and a breakout board is sufficient. The SR785 input drive level is 10mV for all swept sine measurements.

Measure the magnitude and the phase differentially at the rear panel D-sub output for each channel as required. Record the results the following tables.

Table 5, Noise Cancellation Amp

Measurement Frequency	**Magnitude (dB)**	**Allowable Range**	**Phase (deg)**	**Allowable Range**	**Measured Magnitude**	**Measured Phase**	**Pass/Fail**
10Hz	34	+/- 1dB	73.6	+/- 5 deg			
100Hz	45	+/- 1dB	21.4	+/- 5 deg			
1KHz	46	+/- 1dB	0.9	+/- 5 deg			
10KHz	46	+/- 1dB	-12.8	+/- 5 deg			
100KHz	38	+/- 1dB	-76.1	+/- 5 deg			

Table 6, Frequency Response Amp 1_Quadrant 1

Measurement Frequency	Magnitude (dB)	Allowable Range	Phase (deg)	Allowable Range	Measured Magnitude	Measured Phase	Pass/Fail
10Hz	34	+/- 1dB	-106	+/- 5 deg			
100Hz	45	+/- 1dB	-159	+/- 5 deg			
1KHz	46	+/- 1dB	-179	+/- 5 deg			
10KHz	46	+/- 1dB	168	+/- 5 deg			
100KHz	38	+/- 1dB	108	+/- 5 deg			

Table 7, Frequency Response Amp 1_Quadrant 2

Measurement Frequency	Magnitude (dB)	Allowable Range	Phase (deg)	Allowable Range	Measured Magnitude	Measured Phase	Pass/Fail
10Hz	34	+/- 1dB	-106	+/- 5 deg			
100Hz	45	+/- 1dB	-159	+/- 5 deg			
1KHz	46	+/- 1dB	-179	+/- 5 deg			
10KHz	46	+/- 1dB	168	+/- 5 deg			
100KHz	38	+/- 1dB	108	+/- 5 deg			

Table 8, Frequency Response Amp 1_Quadrant 3

Measurement Frequency	Magnitude (dB)	Allowable Range	Phase (deg)	Allowable Range	Measured Magnitude	Measured Phase	Pass/Fail
10Hz	34	+/- 1dB	-106	+/- 5 deg			
100Hz	45	+/- 1dB	-159	+/- 5 deg			
1KHz	46	+/- 1dB	-179	+/- 5 deg			
10KHz	46	+/- 1dB	168	+/- 5 deg			
100KHz	38	+/- 1dB	108	+/- 5 deg			

Table 9, Frequency Response Amp 1_Quadrant 4

Measurement Frequency	Magnitude (dB)	Allowable Range	Phase (deg)	Allowable Range	Measured Magnitude	Measured Phase	Pass/Fail

10Hz	34	+/- 1dB	-106	+/- 5 deg			
100Hz	45	+/- 1dB	-159	+/- 5 deg			
1KHz	46	+/- 1dB	-179	+/- 5 deg			
10KHz	46	+/- 1dB	168	+/- 5 deg			
100KHz	38	+/- 1dB	108	+/- 5 deg			

Table 10, Frequency Response Amp2_Quadrant 1

Measurement Frequency	Magnitude (dB)	Allowable Range	Phase (deg)	Allowable Range	Measured Magnitude	Measured Phase	Pass/Fail
10Hz	34	+/- 1dB	-106	+/- 5 deg			
100Hz	45	+/- 1dB	-159	+/- 5 deg			
1KHz	46	+/- 1dB	-179	+/- 5 deg			
10KHz	46	+/- 1dB	168	+/- 5 deg			
100KHz	38	+/- 1dB	108	+/- 5 deg			

Table 11, Frequency Response Amp 2_Quadrant 2

Measurement Frequency	Magnitude (dB)	Allowable Range	Phase (deg)	Allowable Range	Measured Magnitude	Measured Phase	Pass/Fail
10Hz	34	+/- 1dB	-106	+/- 5 deg			
100Hz	45	+/- 1dB	-159	+/- 5 deg			
1KHz	46	+/- 1dB	-179	+/- 5 deg			
10KHz	46	+/- 1dB	168	+/- 5 deg			
100KHz	38	+/- 1dB	108	+/- 5 deg			

Table 12, Frequency Response Amp2_Quadrant 3

Measurement Frequency	Magnitude (dB)	Allowable Range	Phase (deg)	Allowable Range	Measured Magnitude	Measured Phase	Pass/Fail
10Hz	34	+/- 1dB	-106	+/- 5 deg			
100Hz	45	+/- 1dB	-159	+/- 5 deg			
1KHz	46	+/- 1dB	-179	+/- 5 deg			
10KHz	46	+/- 1dB	168	+/- 5 deg			

100KHz	38	+/- 1dB	108	+/- 5 deg			

Table 13, Frequency Response Amp 2_Quadrant 4

Measurement Frequency	Magnitude (dB)	Allowable Range	Phase (deg)	Allowable Range	Measured Magnitude	Measured Phase	Pass/Fail
10Hz	34	+/- 1dB	-106	+/- 5 deg			
100Hz	45	+/- 1dB	-159	+/- 5 deg			
1KHz	46	+/- 1dB	-179	+/- 5 deg			
10KHz	46	+/- 1dB	168	+/- 5 deg			
100KHz	38	+/- 1dB	108	+/- 5 deg			

Table 14, Noise Cancellation Amp 2

Measurement Frequency	Magnitude (dB)	Allowable Range	Phase (deg)	Allowable Range	Measured Magnitude	Measured Phase	Pass/Fail
10Hz	34	+/- 1dB	73.6	+/- 5 deg			
100Hz	45	+/- 1dB	21.4	+/- 5 deg			
1KHz	46	+/- 1dB	0.9	+/- 5 deg			
10KHz	46	+/- 1dB	-12.8	+/- 5 deg			
100KHz	38	+/- 1dB	-76.1	+/- 5 deg			

4.6 Output Noise Spectra

The output noise voltage of each channel of the amplifier should be measured using the dynamic signal analyzer SR785. This measurement should be made while the input is open, and the frequency range is set from 1Hz to 100 KHz.

Measure the output referred noise differentially at the rear panel D-sub output for each channel as required. Record the results in Table to

Table

Table 15, Amp 1_Quadrant 1 Noise

Measurement Frequency	Typical Amplitude dBVrms/√Hz	Allowable Range	Measured Amplitude dBVrms/√Hz	Pass/Fail
10Hz	-129	+/- 3dB		
100Hz	-118	+/- 3dB		
1KHz	-118	+/- 3dB		
10KHz	-118	+/- 3dB		

Table 16, Amp 1_Quadrant 2 Noise

Measurement Frequency	Typical Amplitude dBVrms/√Hz	Allowable Range	Measured Amplitude dBVrms/√Hz	Pass/Fail
10Hz	-129	+/- 3dB		
100Hz	-118	+/- 3dB		
1KHz	-118	+/- 3dB		
10KHz	-118	+/- 3dB		

Table17, Amp 1_Quadrant 3 Noise

Measurement Frequency	Typical Amplitude dBVrms/√Hz	Allowable Range	Measured Amplitude dBVrms/√Hz	Pass/Fail
10Hz	-129	+/- 3dB		
100Hz	-118	+/- 3dB		
1KHz	-118	+/- 3dB		
10KHz	-118	+/- 3dB		

Table 18, Amp 1_Quadrant 4 Noise

Measurement Frequency	Typical Amplitude dBVrms/√Hz	Allowable Range	Measured Amplitude dBVrms/√Hz	Pass/Fail
10Hz	-129	+/- 3dB		
100Hz	-118	+/- 3dB		
1KHz	-118	+/- 3dB		
10KHz	-118	+/- 3dB		

Table 19, Amp 2_Quadrant 1 Noise

Measurement Frequency	Typical Amplitude dBVrms/√Hz	Allowable Range	Measured Amplitude dBVrms/√Hz	Pass/Fail
10Hz	-129	+/- 3dB		
100Hz	-118	+/- 3dB		
1KHz	-118	+/- 3dB		
10KHz	-118	+/- 3dB		

Table 20, Amp2_Quadrant 2 Noise

Measurement Frequency	Typical Amplitude dBVrms/√Hz	Allowable Range	Measured Amplitude dBVrms/√Hz	Pass/Fail
10Hz	-129	+/- 3dB		
100Hz	-118	+/- 3dB		
1KHz	-118	+/- 3dB		
10KHz	-118	+/- 3dB		

Table 21, Amp2_Quadrant 3 Noise

Measurement Frequency	Typical Amplitude dBVrms/√Hz	Allowable Range	Measured Amplitude dBVrms/√Hz	Pass/Fail
10Hz	-129	+/- 3dB		

100Hz	-118	+/- 3dB		
1KHz	-118	+/- 3dB		
10KHz	-118	+/- 3dB		

Table 22, Amp2_Quadrant 4 Noise

Measurement Frequency	Typical Amplitude dBVrms/√Hz	Allowable Range	Measured Amplitude dBVrms/√Hz	Pass/Fail
10Hz	-129	+/- 3dB		
100Hz	-118	+/- 3dB		
1KHz	-118	+/- 3dB		
10KHz	-118	+/- 3dB		