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LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

-LIGO-

CALIFORNIA INSTITUTE OF TECHNOLOGY

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AdL Triple Acquisition Driver Board Prototype Test Plan		
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1 Introduction

The tests described below will be utilized to test the first prototype of the AdL Triple Suspension Acquisition Coil Driver. These drivers are being designed by the US and build by the UK group located at the University of Birmingham. These boards will be used to drive the mirror stage of the cavity/IMC triple suspensions and the middle stage of the beam splitter suspensions. The design requirements for the driver can be found in LIGO document number T080065-E-C, “AdL Beam Splitter, Input Mode Cleaner, Large Recycling and Small Recycling Triple Suspension Electronics Requirements”.

These tests are not comprehensive and will only be utilized to verify that the driver board meets the design requirements. It is assumed that a more comprehensive test of the assembled production chassis will be conducted by the UK prior to shipment.

2 Test Equipment

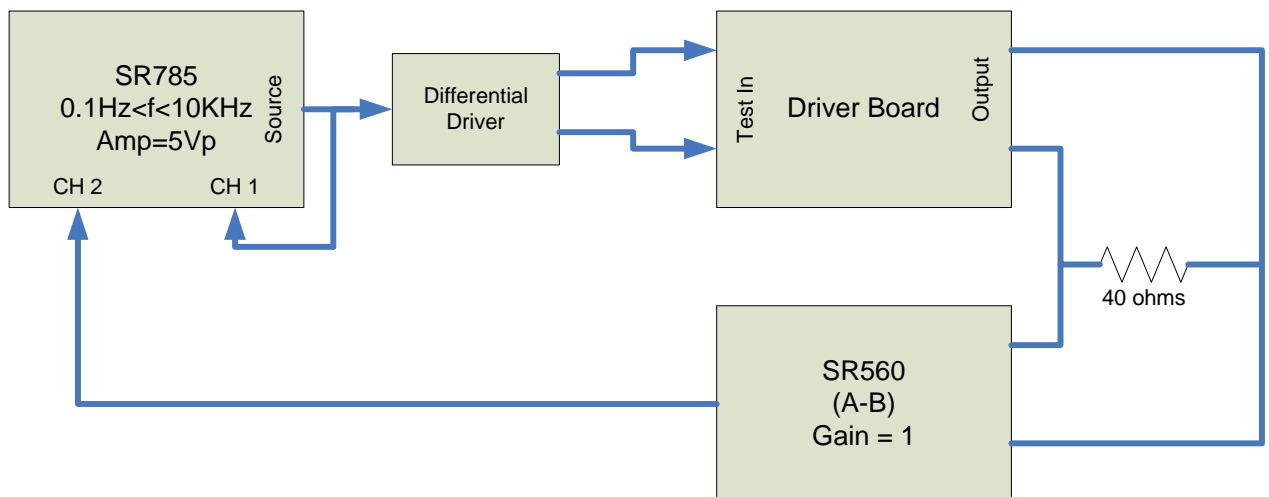
- Stanford Research SR785 analyzer
- Voltmeter
- Oscilloscope
- Board Schematics- TBD

3 Tests

The tests are broken into the same categories used in the design requirements document, noise, dynamic range and monitors/controls. The tests for each of these categories are described in the sections below. It should be noted that the driver design has two variations based on the different requirements for the BS triple and the IMC/Cavity triple suspensions. This test plan has been written for the BS/FM configuration. The only difference between the designs is the values of resistors R10 and R11. Note that jumper W2 should be installed in each channel for all tests. The tests also assume that relay K1 (input enable) is energized for each channel.

3.1 Dynamic Range and Transfer Function Tests

The transfer function for each mode of operation is measured by injecting a signal into the input of a channel and measuring the current through a 40 ohm resistor connected across the corresponding channel output. Measurements are made for frequencies from 0.1Hz to 10KHz. A block diagram of the test setup is shown in the figure below.



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3.1.1 Acquire Mode

In the acquire mode, relay K4 (input dewatering) is NOT energized and relays K2 and K3 ARE energized. The nominal response of the coil driver in ACQUIRE mode is a zero at 1Hz, and a pole at 75Hz and is shown in the plot below. Note that the transfer function is in units of volts in to amps output into a 40 ohm load, so if the transfer function is measured by measuring the voltage across the load resistor 32dB must be subtracted from the measurement to convert to dBA/V.

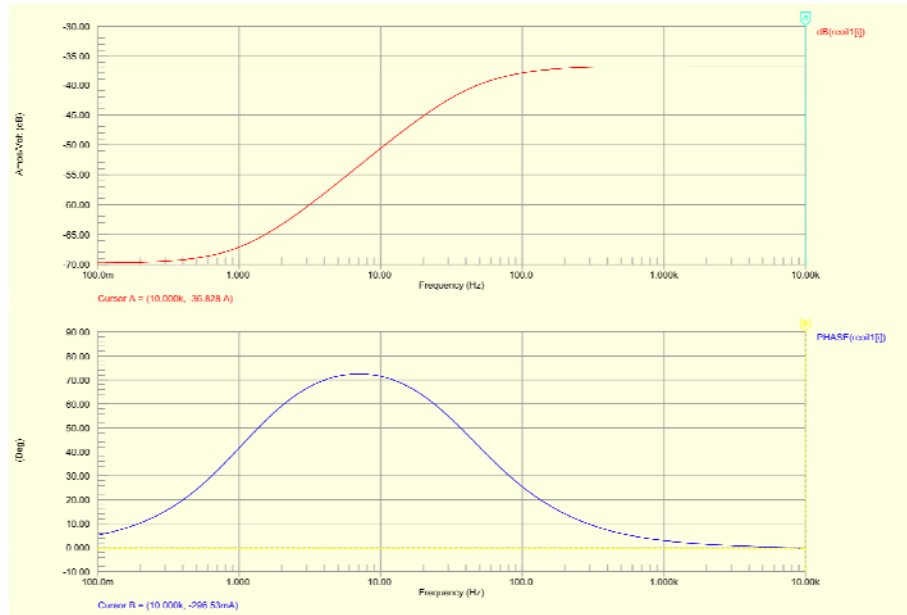


Figure 1: Acquire Mode Transfer Function

In the tables below, record the measured magnitude and phase of the response for each channel. In addition, save the transfer function for one representative channel to disk and record the file name in space provided below.

Table 1: Channel 1 Transfer Function Measurements

Freq (Hz)	Nominal Gain (dBamps/Volt)	Nominal Phase (Degrees)	Actual Gain (dBamps/Volt)	Actual Phase (Degrees)
0.1	-69.8	5.2		
1	-67.1	41.6		
10	-50.6	71.5		
100	-38.0	25.5		
1K	-36.8	2.9		
10K	-36.8	-0.3		

Table 2: Channel 2 Transfer Function Measurements

Freq (Hz)	Nominal Gain (dBamps/Volt)	Nominal Phase (Degrees)	Actual Gain (dBamps/Volt)	Actual Phase (Degrees)
0.1	-69.8	5.2		
1	-67.1	41.6		
10	-50.6	71.5		
100	-38.0	25.5		
1K	-36.8	2.9		

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10K	-36.8	-0.3		
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Table 3: Channel 3 Transfer Function Measurements

Freq (Hz)	Nominal Gain (dBamps/Volt)	Nominal Phase (Degrees)	Actual Gain (dBamps/Volt)	Actual Phase (Degrees)
0.1	-69.8	5.2		
1	-67.1	41.6		
10	-50.6	71.5		
100	-38.0	25.5		
1K	-36.8	2.9		
10K	-36.8	-0.3		

Table 4: Channel 4 Transfer Function Measurements

Freq (Hz)	Nominal Gain (dBamps/Volt)	Nominal Phase (Degrees)	Actual Gain (dBamps/Volt)	Actual Phase (Degrees)
0.1	-69.8	5.2		
1	-67.1	41.6		
10	-50.6	71.5		
100	-38.0	25.5		
1K	-36.8	2.9		
10K	-36.8	-0.3		

File Name for transfer function measurement (Acquire Mode): _____

3.1.2 Run (Low Noise) Mode

In the RUN mode, relay K4 (input dewatering) is energized and relays K2 and K3 are NOT energized. The nominal response of the coil driver in RUN mode is poles at 1Hz and 200Hz, and zeros at 10Hz and 20Hz and is shown in the plot below. Note that the transfer function is in units of volts in to amps output into a 40 ohm load, so if the transfer function is measured by measuring the voltage across the load resistor 32dB must be subtracted from the measurement to convert to dBA/V.

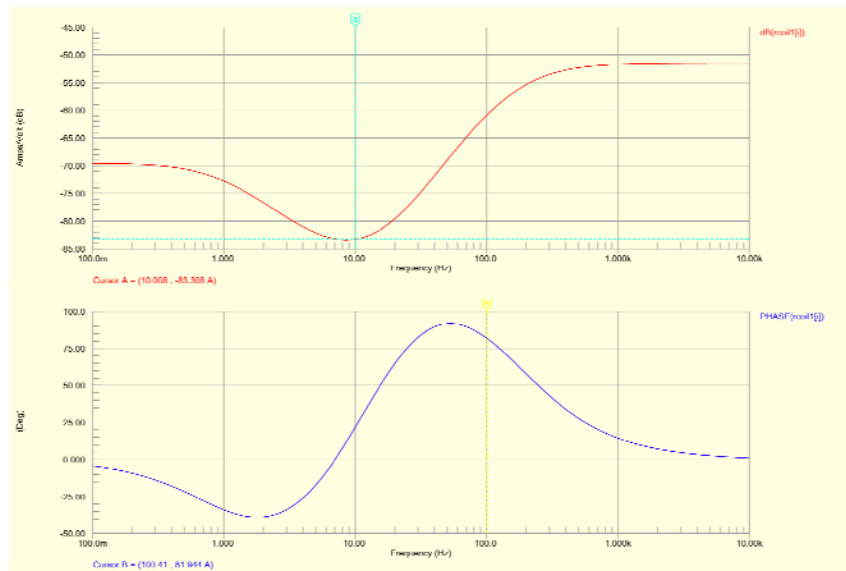


Figure 2: Run (Low Noise) Mode Transfer Function

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In the tables below, record the measured magnitude and phase of the response for each channel. In addition, save the transfer function for one representative channel to disk and record the file name in space provided below.

Table 5: Channel 1 Transfer Function Measurements

Freq (Hz)	Nominal Gain (dBamps/Volt)	Nominal Phase (Degrees)	Actual Gain (dBamps/Volt)	Actual Phase (Degrees)
0.1	-69.6	-4.2		
1	-72.8	-34.0		
10	-83.3	21.8		
100	-60.9	81.9		
1K	-51.7	14.4		
10K	-51.5	0.9		

Table 6: Channel 2 Transfer Function Measurements

Freq (Hz)	Nominal Gain (dBamps/Volt)	Nominal Phase (Degrees)	Actual Gain (dBamps/Volt)	Actual Phase (Degrees)
0.1	-69.6	-4.2		
1	-72.8	-34.0		
10	-83.3	21.8		
100	-60.9	81.9		
1K	-51.7	14.4		
10K	-51.5	0.9		

Table 7: Channel 3 Transfer Function Measurements

Freq (Hz)	Nominal Gain (dBamps/Volt)	Nominal Phase (Degrees)	Actual Gain (dBamps/Volt)	Actual Phase (Degrees)
0.1	-69.6	-4.2		
1	-72.8	-34.0		
10	-83.3	21.8		
100	-60.9	81.9		
1K	-51.7	14.4		
10K	-51.5	0.9		

Table 8: Channel 4 Transfer Function Measurements

Freq (Hz)	Nominal Gain (dBamps/Volt)	Nominal Phase (Degrees)	Actual Gain (dBamps/Volt)	Actual Phase (Degrees)
0.1	-69.6	-4.2		
1	-72.8	-34.0		
10	-83.3	21.8		
100	-60.9	81.9		
1K	-51.7	14.4		
10K	-51.5	0.9		

File Name for transfer function measurement (Run Mode): _____

Channel Number for saved file: _____

Serial Number: _____

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3.1.3 Dynamic Range Tests

The dynamic range requirement for the Triple Acquisition Driver is derived from the need to supply higher frequency currents to the corresponding suspension stage during lock acquisition. The maximum output current requirement for the driver is 125mA peak for 100Hz<frequency<1KHz. The tests below will verify that the design meets this requirement. In addition the board components will be checked for overheating. The tests for all channels should be conducted simultaneously and each test step/reading should be held for a minimum of 5 minutes to allow the temperature of the chassis and components to stabilize. In the tables below, record the output current versus input voltage (both peak), note any component heating and if possible the temperature of the component. Output current should be measured across the 40 ohm load resistor connected to the channel under test. The input signal used for this should be a 1KHz sine wave. The driver board should be in the ACQUIRE mode configuration used in section 3.1.1 of this test plan.

Table 9: Channel 1 Output Current vs. Input Voltage

Input Voltage Peak (1KHz)	Nominal Output Current (mApeak)	Actual Output Current (mApeak)	Notes
1V	14.4		
10V	144		

Table 10: Channel 2 Output Current vs. Input Voltage

Input Voltage Peak (1KHz)	Nominal Output Current (mApeak)	Actual Output Current (mApeak)	Notes
1V	14.4		
10V	144		

Table 11: Channel 3 Output Current vs. Input Voltage

Input Voltage Peak (1KHz)	Nominal Output Current (mApeak)	Actual Output Current (mApeak)	Notes
1V	14.4		
10V	144		

Table 12: Channel 4 Output Current vs. Input Voltage

Input Voltage Peak (1KHz)	Nominal Output Current (mApeak)	Actual Output Current (mApeak)	Notes
1V	14.4		
10V	144		

3.2 Noise Tests

The most stringent noise requirement for the Triple Acquisition Driver comes at 10Hz where the output noise current from the driver needs to be less than 50 pA/ $\sqrt{\text{Hz}}$ (BS/FM version) and less than 10 pA/ $\sqrt{\text{Hz}}$ (Cavity and IMC version). Measuring the actual noise current into the 40 ohm load

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resistor is a very difficult measurement, so the noise current must be implied by measuring the output noise voltage of the driver using test points on the board (TP4 and TP5). The output noise voltage measured between TP4 and TP5 needs to be less than 330nV/√Hz at 10Hz to meet the current noise requirement (BS/FM). A plot of the simulated noise versus frequency is shown in the figure below. Note that noise is well below the requirement and corresponds to approximately 6pA/√Hz at 10Hz.

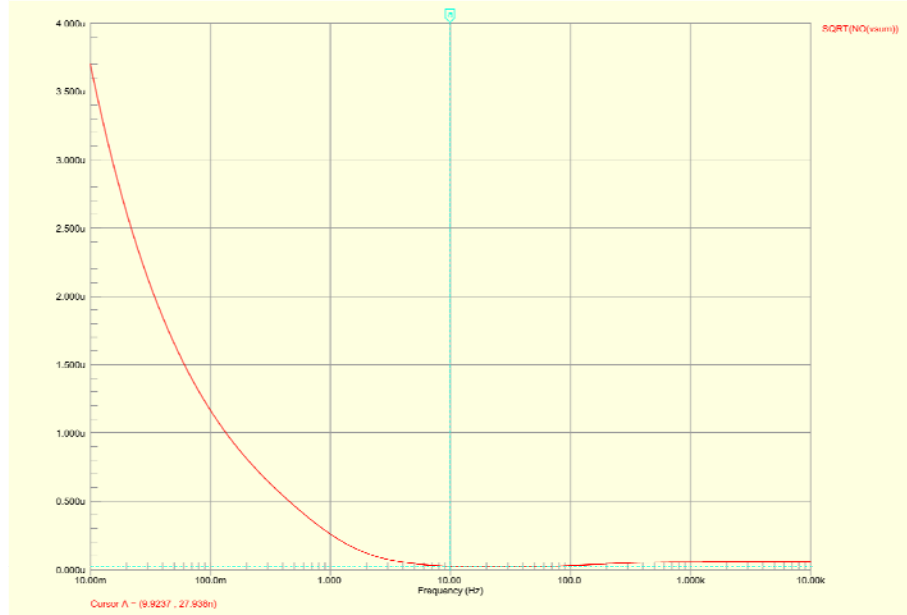


Figure 3: Run Mode Output Noise Voltage

The simulation predicts that the noise at 10Hz should be approximately 27nV/√Hz. In the table below, record the output noise at 10Hz measured between TP4 and TP5 for each channel. The inputs to the channel under test should be tied to circuit ground and relay K4 should be energized and relays K2 and K3 (Run Mode). In addition, save the noise data for one representative channel to disk and record the file name in space provided below. The frequency range for the saved file should be from 0.1Hz to 100Hz.

Table 13: Noise Monitor Test Results

Channel Number	Measured Noise at 10Hz
1	
2	
3	
4	

File Name for noise measurement (Run Mode): _____

Channel Number for saved file: _____

3.3 Monitors, Controls and PD and LED Signal Pass Through

3.3.1 Relay Command and Monitors

Each relay used in the design has been provided with a separate monitor of its state. These tests will verify the proper operation of the relay status monitors. In the tables below document the operation of the monitors for each relay. Note that each relay is energized by grounding the appropriate pin on

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connector J7. The status reading for the all relays are high when the relay is not energized and low when the relay is energized.

Table 14: Channel Enable Relay Monitors

Channel/ Pin on J7	Monitor pin on J6	Relay Enabled- Monitor Low?	Relay Disabled- Monitor High?
CH 1 / J7-3	J6-3		
CH 2 / J7-6	J6-6		
CH 3 / J7-9	J6-9		
CH 4 / J7-12	J6-12		

Table 14: Dewhitening Filter Enable Relay Monitors

Channel/ Pin on J7	Monitor pin on J6	Relay Enabled- Monitor Low?	Relay Disabled- Monitor High?
CH 1 / J7-1	J6-1		
CH 2 / J7-4	J6-4		
CH 3 / J7-7	J6-7		
CH 4 / J7-10	J6-10		

Table 14: Acquire Enable Relay Monitors

Channel/ Pin on J7	Monitor pin on J6	Relay Enabled- Monitor Low?	Relay Disabled- Monitor High?
CH 1 / J7-2	J6-2		
CH 2 / J7-5	J6-5		
CH 3 / J7-8	J6-8		
CH 4 / J7-11	J6-11		

3.3.2 PD and LED Signal Pass Through

The coil driver also provides a path for connecting the PD and LED monitor signals from the Satellite Amplifier to the AA chassis. These are just traces on the board that route signals from connector J1 to the appropriate pins on connectors J2 and J5. A meter is used to verify continuity of the connections. The tables below are used to record the results.

Table 18: PD Signals

Pin on J1	Pin on J2	Continuity?
1	1	
14	6	
2	2	
15	7	
3	3	
16	8	
4	4	
17	9	

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Table 18: LED Signals

Pin on J1	Pin on J3	Continuity?
5	1	
18	6	
6	2	
19	7	
7	3	
20	8	
8	4	
21	9	