Serial Number: ___________________ Date: _____________

Tech: _______________________

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

-LIGO-

CALIFORNIA INSTITUTE OF TECHNOLOGY

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Document Type	DCC Number T080014-01-C	March 4, 2009
UK Top Driver Pre-Production Prototype Test Plan		
J. Heefner		

Distribution of this draft:
This is an internal working note of the LIGO Laboratory

California Institute of Technology
LIGO Project – MS 18-33
Pasadena, CA 91125
Phone (626) 395-2129
Fax (626) 304-9834
E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology
LIGO Project – MS 20B-145
Cambridge, MA 01239
Phone (617) 253-4824
Fax (617) 253-7014
E-mail: info@ligo.mit.edu

www: http://www.ligo.caltech.edu/

Serial Number: ___________________ Date: _____________

Tech: _______________________

1 Introduction

The tests described below will be utilized to test the production prototype of the Adl Quad Suspension Top Coil Driver. These drivers are being designed and build by the UK group located at the University of Birmingham. The design requirements for the driver can be found in LIGO document number T060067-00-C, "AdL Quad Suspension UK Coil Driver Design Requirements".

These tests are not comprehensive and will only be utilized to verify that the driver meets the design requirements. It is assumed that the drivers have been thoroughly tested by the University of Birmingham prior to shipment.

2 Test Equipment

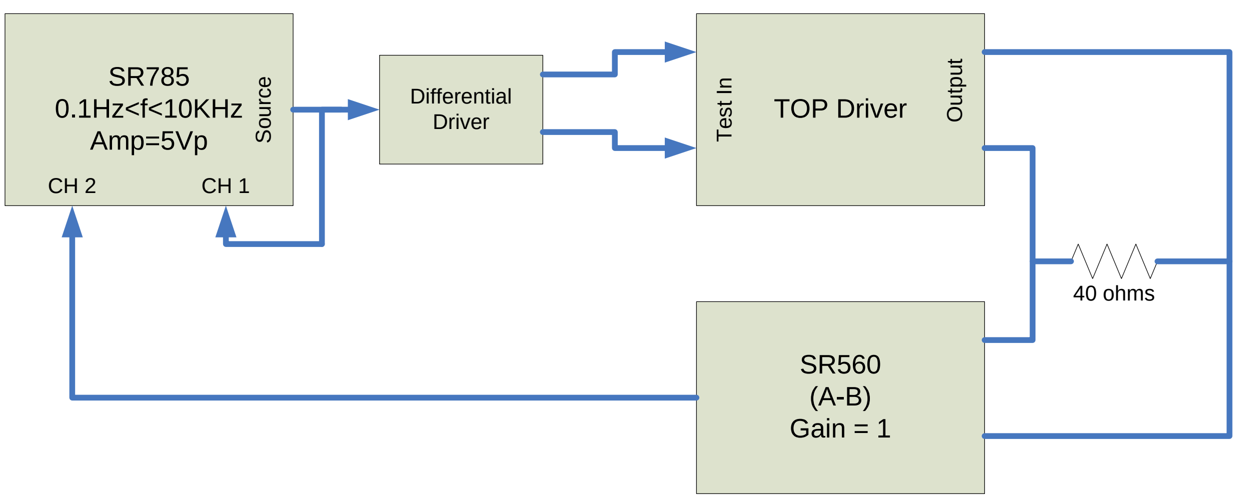
- Stanford Research SR785 analyzer
- Voltmeter
- Oscilloscope
- Board Schematics- TBD

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.

3.1 Dynamic Range and Transfer Function Tests

The transfer function for each mode of operation is measured by injecting a signal into the test input of a channel and measuring the current through a 20 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.



3.1.1 Acquire Mode

In the acquire mode, relay K3 is NOT energized. The nominal response of the coil driver in ACQUIRE mode is a pole at 1Hz, and a zero at 31Hz 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.

Serial Number: ____________________ Date: ______________

Tech: ________________________

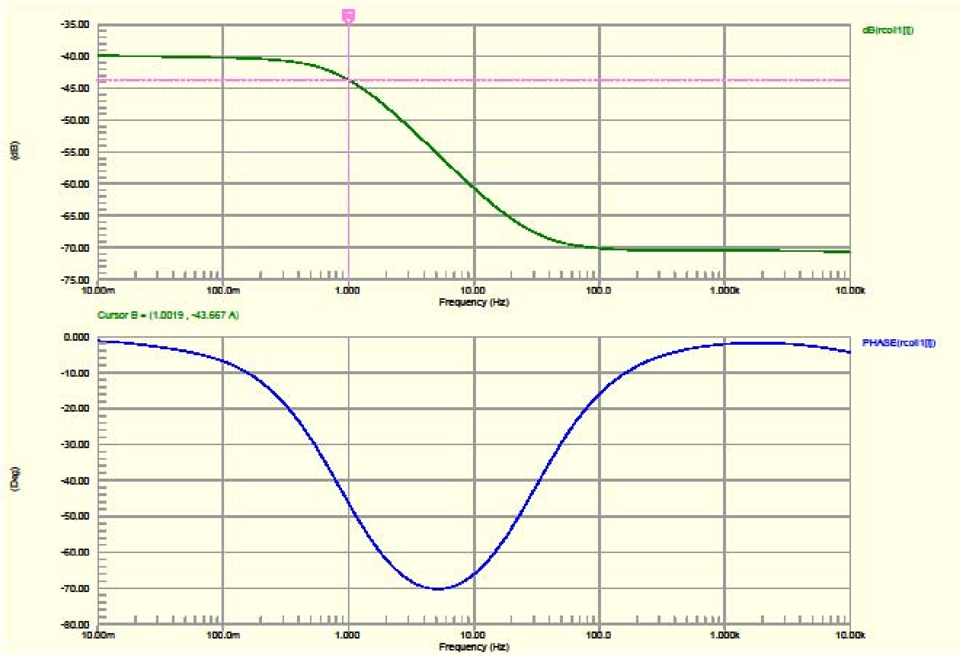


Figure 1: Top Driver Response (Acquire Mode)

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	-40.2	-6.8		
1	-43.7	-46.3		
10	-60.7	-66.1		
100	-70.1	-16.0		
1K	-70.5	-2.1		
10K	-70.7	-4.3		

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	-40.2	-6.8		
1	-43.7	-46.3		
10	-60.7	-66.1		
100	-70.1	-16.0		
1K	-70.5	-2.1		
10K	-70.7	-4.3		

Serial Number: ____________________ Date: ______________

Tech: ________________________

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	-40.2	-6.8		
1	-43.7	-46.3		
10	-60.7	-66.1		
100	-70.1	-16.0		
1K	-70.5	-2.1		
10K	-70.7	-4.3		

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	-40.2	-6.8		
1	-43.7	-46.3		
10	-60.7	-66.1		
100	-70.1	-16.0		
1K	-70.5	-2.1		
10K	-70.7	-4.3		

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

3.1.2 Run Mode

In the acquire mode, relay K3 is energized. The nominal response of the coil driver in RUN mode is two poles at 1Hz, and zeros at 10Hz and 31Hz 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.

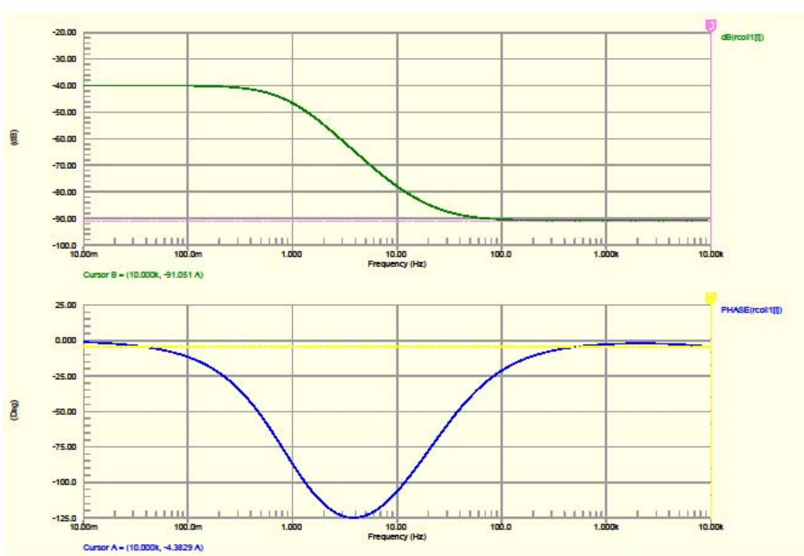


Figure 2: Top Driver Response (Run Mode)

Serial Number: ___________________ Date: _____________

Tech: _______________________

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	-40.0	-11.6		
1	-46.6	-87.6		
10	-78	-106.2		
100	-90.4	-21.2		
1K	-90.8	-2.6		
10K	-91.1	-4.4		

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	-40.0	-11.6		
1	-46.6	-87.6		
10	-78	-106.2		
100	-90.4	-21.2		
1K	-90.8	-2.6		
10K	-91.1	-4.4		

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	-40.0	-11.6		
1	-46.6	-87.6		
10	-78	-106.2		
100	-90.4	-21.2		
1K	-90.8	-2.6		
10K	-91.1	-4.4		

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	-40.0	-11.6		
1	-46.6	-87.6		
10	-78	-106.2		
100	-90.4	-21.2		
1K	-90.8	-2.6		
10K	-91.1	-4.4		

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

Channel Number for saved file: ________

Serial Number: ____________________ Date: _____________

Tech: ________________________

3.1.3 Dynamic Range Tests

The dynamic range requirement for the Top Driver is almost completely driven by the need to statically align the mass and correct for slow drift. The maximum output current requirement for the driver is +/- 200mA continuous. The tests below will verify that the design meets this requirement. In addition the chassis and 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 (DC), 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. In an effort to save test setup and execution time, this test may be conducted in conjunction with the current monitor testing described in section 3.3.3 below.

Table 9: Channel 1 Output Current vs. Input Voltage

Input Voltage	Nominal Output Current (mA)	Actual Output Current (mA)	Notes
+1V	10.1		
-1V	-10.1		
+5V	50.5		
-5V	-50.5		
+10V	101		
-10V	-101		
+20V	202		
-20V	-202		

Table 10: Channel 2 Output Current vs. Input Voltage

Input Voltage	Nominal Output Current (mA)	Actual Output Current (mA)	Notes
+1V	10.1		
-1V	-10.1		
+5V	50.5		
-5V	-50.5		
+10V	101		
-10V	-101		
+20V	202		
-20V	-202		

Table 11: Channel 3 Output Current vs. Input Voltage

Input Voltage	Nominal Output Current (mA)	Actual Output Current (mA)	Notes
+1V	10.1		
-1V	-10.1		
+5V	50.5		
-5V	-50.5		
+10V	101		
-10V	-101		
+20V	202		
-20V	-202		

Table 12: Channel 4 Output Current vs. Input Voltage

Input	Nominal Output	Actual Output	Notes

Serial Number: ____________________ Date: ______________

Tech: ________________________

Voltage	Current (mA)	Current (mA)	
+1V	10.1		
-1V	-10.1		
+5V	50.5		
-5V	-50.5		
+10V	101		
-10V	-101		
+20V	202		
-20V	-202		

3.2 Noise Tests

The most stringent noise requirement for the Top Driver comes at 10Hz where the output noise current from the driver needs to be less than 73 pA/√Hz. Measuring the actual noise current into the 40 ohm load 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 (TP9 and TP13). The total series resistance in the output of the driver including the 40 ohm load is 120 ohms. The means that the output voltage noise measured between TP9 and TP13 needs to be less than 8.7nV/√Hz at 10Hz. A plot of the simulated noise versus frequency is shown in the figure below.

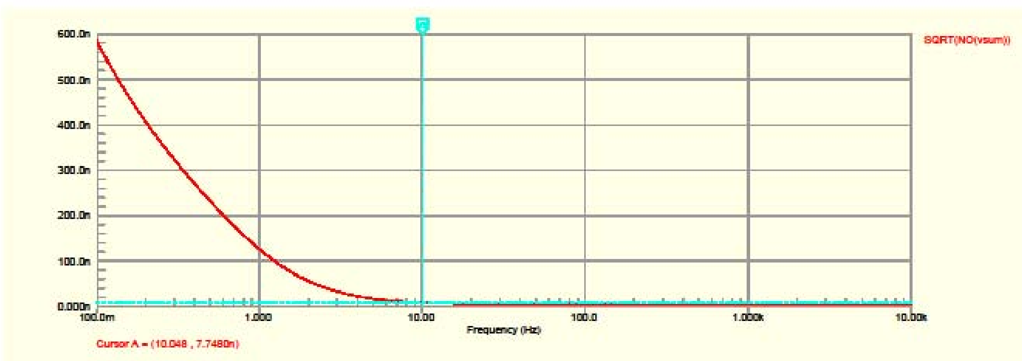


Figure 3: Top Driver Output Noise

The simulation predicts that the noise at 10Hz should be approximately 7.7nV/√Hz. In the table below, record the output noise at 10Hz measured between TP9 and TP13 for each channel. The inputs to the channel under test should be tied to circuit ground and relay K3 should be energized (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.

Channel Number	Measured Noise at 10Hz
1	
2	
3	
4	

File Name for noise measurement (Run Mode):___________________
Channel Number for saved file: ________

Serial Number: ___________________ Date: _____________

Tech: _______________________

3.3 Monitors, Controls and Circuit Protection

3.3.1 Noise Monitor Transfer Function Tests

The noise monitor board in the driver chassis provides a low-noise, AC coupled monitor of the voltage output of each channel. The nominal transfer function of the monitor is 4 zeros at DC, 4 poles at 5Hz and 2 poles at 5KHz which are added to the response of the driver channel. These tests measure the transfer function from the input of a particular driver channel to the corresponding noise monitor output. The coil driver output should be load with 40 ohms during the tests. Relay K3 should be energized during the tests. The figure below shows the response nominal response.

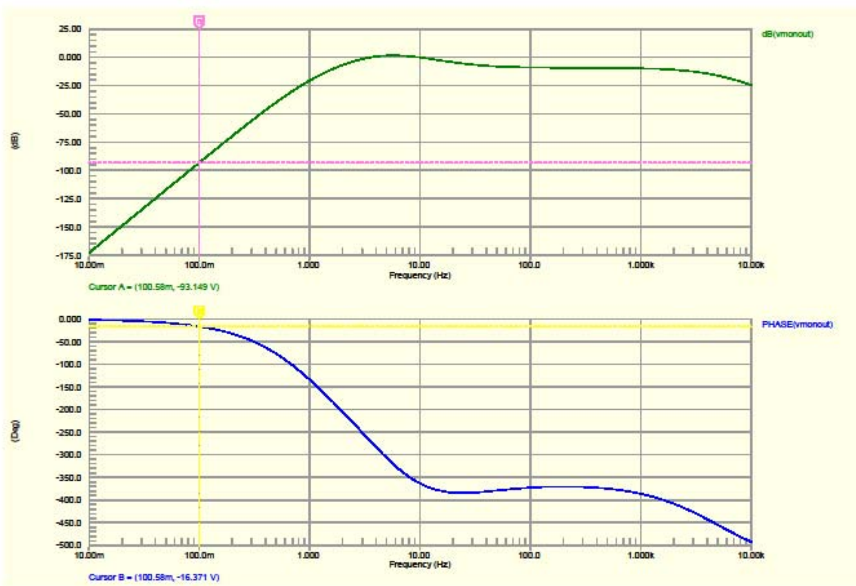


Figure 4: Top Driver Response at Monitor Output

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 13: Channel 1 Noise Monitor Transfer Function Measurements

Freq (Hz)	Nominal Gain (dBV/Volt)	Nominal Phase (Degrees)	Actual Gain (dBV/Volt)	Actual Phase (Degrees)
0.1	-93	-16.4		
1	-20.6	-133.4		
10	-0.3	-363.4		
100	-8.9	-372.6		
1K	-9.7	-386.3		
10K	-24.3	-492.3		

Table 14: Channel 2 Noise Monitor Transfer Function Measurements

Freq (Hz)	Nominal Gain (dBV/Volt)	Nominal Phase (Degrees)	Actual Gain (dBV/Volt)	Actual Phase (Degrees)
0.1	-93	-16.4		
1	-20.6	-133.4		

10	-0.3	-363.4		
100	-8.9	-372.6		
1K	-9.7	-386.3		
10K	-24.3	-492.3		

Table 15: Channel 3 Noise Monitor Transfer Function Measurements

Freq (Hz)	Nominal Gain (dBV/Volt)	Nominal Phase (Degrees)	Actual Gain (dBV/Volt)	Actual Phase (Degrees)
0.1	-93	-16.4		
1	-20.6	-133.4		
10	-0.3	-363.4		
100	-8.9	-372.6		
1K	-9.7	-386.3		
10K	-24.3	-492.3		

Table 16: Channel 4 Noise Monitor Transfer Function Measurements

Freq (Hz)	Nominal Gain (dBV/Volt)	Nominal Phase (Degrees)	Actual Gain (dBV/Volt)	Actual Phase (Degrees)
0.1	-93	-16.4		
1	-20.6	-133.4		
10	-0.3	-363.4		
100	-8.9	-372.6		
1K	-9.7	-386.3		
10K	-24.3	-492.3		

File Name for Noise Monitor Measurement:__________________
Channel number for saved file: __________

3.3.2 Noise Monitor Output Noise Tests

A plot of the simulated noise versus frequency is shown in the figure below.

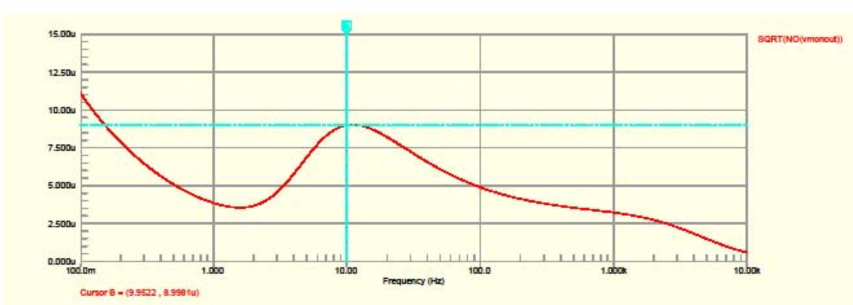


Figure 5: Monitor Output Noise

As can be seen from the plot, the noise at 10Hz at the monitor output should be approximately 9uV/√Hz. In the table below, record the output noise at 10Hz. The inputs to the channel under test should be tied to circuit ground and relay K3 should be energized (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.

Serial Number: ____________________ Date: ______________

Tech: ________________________

Channel Number	Measured Noise at 10Hz
1	
2	
3	
4	

File Name for noise measurement:___________________
Channel Number for saved file: ________

3.3.3 Output Voltage and Current Monitor Tests

The monitor board connected to the Top Driver board inside the chassis provides continuous monitors of the output voltage and current (FC) and rms current (SC) for each channel. These monitors are tested in this section. These tests can be conducted in conjunction with the dynamic range tests described in section 3.1.3 of this document. In the tables below, record the current and voltage monitor output for each input voltage.

Table 17: Channel 1 Monitor Output Tests

Input Voltage	Nominal Voltage Monitor	Nominal Current Monitor (FC)	Nominal rms Current Mon (SC)	Actual Voltage Monitor (Volts)	Actual Current Monitor (Volts)	Actual Current rms Monitor (Volts)
+1V	0.407	0.271	0.271			
-1V	-0.407	-0.271	0.271			
+5V	2.03	1.36	1.36			
-5V	-2.03	-1.36	1.36			
+10V	4.07	2.71	2.71			
-10V	-4.07	-2.71	2.71			
+20V	8.13	5.42	5.42			
-20V	-8.13	-5.42	5.42			

Table 18: Channel 2 Monitor Output Tests

Input Voltage	Nominal Voltage Monitor	Nominal Current Monitor (FC)	Nominal rms Current Mon (SC)	Actual Voltage Monitor (Volts)	Actual Current Monitor (Volts)	Actual Current rms Monitor (Volts)
+1V	0.407	0.271	0.271			
-1V	-0.407	-0.271	0.271			
+5V	2.03	1.36	1.36			
-5V	-2.03	-1.36	1.36			
+10V	4.07	2.71	2.71			
-10V	-4.07	-2.71	2.71			
+20V	8.13	5.42	5.42			
-20V	-8.13	-5.42	5.42			

Table 19: Channel 3 Monitor Output Tests

Input Voltage	Nominal Voltage	Nominal Current	Nominal rms	Actual Voltage	Actual Current	Actual Current rms Monitor

Serial Number: ____________________ Date: ______________

Tech: ________________________

	Monitor	Monitor (FC)	Current Mon (SC)	Monitor (Volts)	Monitor (Volts)	(Volts)
+1V	0.407	0.271	0.271			
-1V	-0.407	-0.271	0.271			
+5V	2.03	1.36	1.36			
-5V	-2.03	-1.36	1.36			
+10V	4.07	2.71	2.71			
-10V	-4.07	-2.71	2.71			
+20V	8.13	5.42	5.42			
-20V	-8.13	-5.42	5.42			

Table 20: Channel 4 Monitor Output Tests

Input Voltage	Nominal Voltage Monitor	Nominal Current Monitor (FC)	Nominal rms Current Mon (SC)	Actual Voltage Monitor (Volts)	Actual Current Monitor (Volts)	Actual Current rms Monitor (Volts)
+1V	0.407	0.271	0.271			
-1V	-0.407	-0.271	0.271			
+5V	2.03	1.36	1.36			
-5V	-2.03	-1.36	1.36			
+10V	4.07	2.71	2.71			
-10V	-4.07	-2.71	2.71			
+20V	8.13	5.42	5.42			
-20V	-8.13	-5.42	5.42			