Author:	Dani Atkinson / Daniel Sigg
Refer to:	LIGO-E1100429-v3
Date:	April 29, 2011

Common Mode Servo Board Test Procedure

Test Preparation

Enter Name, Date, Revision, Board Serial Number and board to be tested: common mode board (CM), mode cleaner board (**MC**) or an acquisition light system board (ALS).

Test Engineer	**Date**	**Pass**
Board	**Board Serial Number**	
D040180 rev. E	**CM or ALS or MC**	

Required Test and Ancillary Equipment

- 1 - Common Mode Board D1003364 Tester
- 1 - Tektronix AFG 3101 Signal Generator or equivalent
- 1 - Tektronix TDS 210 Oscilloscope or equivalent
- 1 – Fluke Multimeter or equivalent
- 1 - HP 4395A Network analyzer (1Hz to 10MHz) or equivalent
- 1 - Stanford Research Systems Signal Analyzer Model SR785
- 1 - GPIB to Cat5 adapter
- 1 - Cat5 cable
- 1 – Laptop CPU using Windows operating system
- 1 – Folder containing Test File Scripts
- 2 - DC Power Supplies (Five Channels Required. Continuous Supply Voltages: +/- 24VDC, +/- 17VDC, and +5VDC)
- 1 - 17VDC Power Cable
- 1 - 24VDC Power Cable
- 1 – 5VDC Power Cable (Banana Plug to Banana Plug Cable and Jumper)
- 1 - custom cable adapting the DB9 Monitor port on the D0901781 front panel into three BNCs. (Refer to Common Mode Board: DAQ, Number D040180 Rev E, Sheet 17 of 17 for DB9 pinout detail)
- 3 – BNC Female to Female Adapters (Barrels)
- 1 - BNC Tee Connector
- 3 - BNC Female to Double Stacking Banana Plugs
- 1 – BNC Male to Mini Grabber Test Leads Cable
- 2 – 50 ohm BNC terminations
- 4 – BNC Male to BNC Male Cables

Table of Contents

IMPORTANT NOTES:

1. On the Common Mode Servo Tester (D1003364) front panel, all switches must be returned to default positions after each test and/or step, unless otherwise instructed.

2. The default position for most switches is UP, with the exception of switches D22, D25, D28, and D31, which are DOWN.

The switch default positions are shown in Picture 1 below.

Picture 1
Front of D0901781 Common Mode Servo and D1003364 Common Mode Servo Tester in default configuration.

NOTE: Common Mode Servo ALS and MC Variants

1. Unless otherwise marked, nominal values listed are for all boards. Where the ALS and/or MC boards vary from the CM board, those values will be green for ALS or red for MC.

Tests Part 1.

Power Board Voltage (Low Noise Power Circuit Board Assembly D0901846)

Connect +/-17VDC and +/- 24VDC to the Common Mode Servo and +5VDC to the Common Mode Servo Tester.

Turn ON Power Supplies.

On the Low Noise Power Circuit Board Assembly, **Connect** the positive multimeter test lead to the following test points and **Connect** the negative multimeter test lead to GRD.

Record the observed voltages in the data boxes below.

Turn Off Power Supplies.

TP1	TP2	TP3	TP4	TP5	TP6	TP7	TP8	TP9	TP10	TP11	TP12	TP13
+17V	-17V	GND	GND	+5V	-15V	+24V	GND	-24V	GND	+15V	+VREF	-VREF

** Correct voltage indications are: TP14 ~3VDC and front panel OK light lit.

Power Supplies

Turn OFF Power Supplies.

Connect 50 pin Control cables 1 and 2 to corresponding Control Mode Servo Tester and Common Mode Servo jacks.

Turn ON Power Supplies

.

Check current draw from the ±17V power supply is between 0.3A and 0.6A.

On the front panel of Power Supplies, **Observe** and **Record** the amperage displayed.

Power supply	Current	Nominal
+24V		0.02
-24V		0.02
+17V		.45
-17V		.45

Oscillations

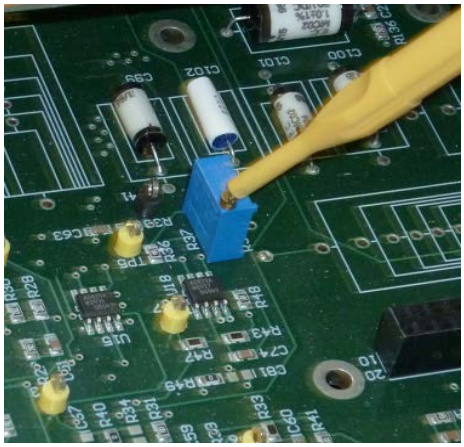
Connect oscilloscope and **Set** oscilloscope coupling to **AC Coupling**.

Connect oscilloscope probe to the following outputs. Ensure no oscillating wave forms are observed.

Place checkmark in corresponding box below each output.

Outputs	**OUT1**	**OUT2**	**SERVO**	**A:TST1**	**A:TST2**	**B:TST1**	**B:TST2**
CheckBox							
Outputs	D32 Input Mon	D33 Split Mon	D34 Fast Mon	D39 Slow FB Mon	D40 Output Mon		
CheckBox							
Outputs	IMON	FMON	SMON				
CheckBox							

Adjust DC Bias



Picture 2

Set Oscilloscope coupling to DC Coupling.

Connect Input Mon (D32) and Offset Adj. (D36) to the oscilloscope.

Ground IN1 using a BNC 50 ohm termination.

Adjust DC bias (R54) for zero volts observed at Input Mon (D32) ensure D32 remains zero when D36 is removed.

Connect FB Mon (D39) and Offset Adj. (D37) to oscilloscope.

Adjust R137 to zero volts observed at FB Mon (D39) when D37 is removed.

Connect OUT1 to oscilloscope.

Turn ON D15 (switch down).

Adjust R54 for zero volts observed.

Return D15 to default position.

Turn ON D16 (switch down).

Adjust R54 for zero volts observed.

Turn ON D15 and D16.

Adjust R54 for zero volts observed at OUT1.

Return switches to default positions.

Record observations below.

Zero D32 via R54.	VDC
Zero D39 via R137.	VDC
Zero OUT1 via R54 with D15 enabled.	VDC
Zero OUT1 via R54 with D16 enabled.	VDC
Zero OUT1 via R54 with both D15 and D16 enabled.	VDC

Signal Gain

Gain slider A (Gain IN1):

Toggle switch D14 **Down** (IN1 position).

Connect OUT2 to the oscilloscope.

Connect Function Generator Output to Common Mode Servo IN1 jack.

Set Function Generator to frequency 100Hz, **Sine wave** and an Amplitude of 1 Vpp.

Inject a 100Hz / 1Vpp **Sine wav**e signal.

Measure the voltage at 0dB (all switches in default position) and **Record**.

Individually, **Toggle** each switch down (GND) and **Record** observed voltage. After each voltage observation, **Return** the switch to default position.

Continue to **Toggle** each switch, **Record** the observed voltage and **Return** each switch to default position.

Return D14 to the default position.

** Tolerance is + / - 1.059 V (+/-0.5dB).

Binary input (Switch Setting)	**Measured Vpp**	**Nominal Vpp**
—(0dB)		1
D0 (1dB)		1.12
D1 (2dB)		1.26
D2 (4dB)		1.59
D3 (8dB)		2.51
D4 (16dB)		6.31
D3 & D4 (24dB)		15.9
D5 (-32dB)		0.025
D5 & D3 (-24dB)		0.063
D5 & D4 (-16dB)		0.159
D5 & D3 & D4 (-8dB)		0.398

Gain slider B (Gain IN2):

Toggle switch D13 down (D14 is in the default position IN2).

Connect OUT2 to an oscilloscope.

Set Function Generator to frequency 100Hz, **Sine wave** and an Amplitude of 1 Vpp.

Connect Function Generator Output to Common Mode Servo IN2 jack.

Inject a 100Hz / 1Vpp **Sine wave** signal into IN2.

Measure the voltage at 0dB (all switches in default position) and **Record**.

Toggle each switch individually **Down** (GND) and **Record** observed voltage. **Return** the switch to default position.

Continue to **Toggle** each switch, **Record** the observed voltage and **Return** each switch to default position.

Return D13 to the default position.

** Tolerance is + / - 1.059 V (+/-0.5dB).

Binary Input (slider gain)	**Measured Vpp**	**Nominal Vpp**
—		1
D6 (1dB)		1.12
D7 (2dB)		1.26
D8 (4dB)		1.59
D9 (8dB)		2.51
D10 (16dB)		6.31
D9 & D10 (24dB)		15.9
D11 (-32dB)		0.025
D11 & D9 (-24dB)		0.063
D11 & D10 (-16dB)		0.159
D11 & D9 & D10 (-8dB)		0.398

Crossbar switches

Inject a 100Hz/1Vpp **Sine wave** to IN1. Individually, **Toggle** each Crossbar switches **Down**. Using an oscilloscope, **Record** the voltage states at OUT1 and OUT2. Voltage states are either **ON** or **OFF**.

Binary input	**OUT1**	**Nominal**	**OUT2**	**Nominal**
Switches in Default Positions		On		Off
D12 (input 1 disabled)		Off		Off
D13 (input 2 enabled)		On		Off
D14 (output switch)		On		On

Inject a 100Hz/1Vpp **Sine wave** to IN2. **Record** the voltage states at OUT1 and OUT2 while toggling the switches **Down**. Voltages states are either **ON** or **OFF**.

Binary input	**OUT1**	**Nominal**	**OUT2**	**Nominal**
Switches in Default Positions		Off		On
D12 (input 1 disabled)		Off		On
D13 (input 2 enabled)		On		On
D14 (output switch)		Off		Off

Excitation A

Inject a 100Hz/1Vpp **Sine wave** to IN1. **Measure** and **Record** the voltage at A:TEST1 and A:TEST2 while toggling the switches **Down**. ** Tolerance is +/-0.5dB.

Binary input	**A:TEST1**	**Nominal Vpp**	**A:TEST2**	**Nominal Vpp**
Switches in Default		1.00		-1.00

Inject a 100Hz/1Vpp **Sine wave** to A:EXC. **Measure** and **Record** the voltage at A:TEST2 and OUT1 while toggling the switches **Down**. ** Tolerance is +/-0.5dB. (Red = MC)

Binary input	**A:TEST2**	**Nominal Vpp**	**OUT1**	**Nominal Vpp**
Default		Off		Off
D18 (com exc enable)		-0.10		0.10 / 0.50
D18 & D19 (com option)		-0.10		Off

Split

Inject a 100Hz/1Vpp **Sine wave** to IN1. **Measure** and **Record** the voltage at OUT1 and SERVO while toggling the switches **Down**. ** Tolerance is +/-0.5dB.

Binary input	**OUT1**	**Nominal Vpp**	**SERVO**	**Nominal Vpp**
—		-1.00		-1.00
Lift D22 (disable fast)		-1.00		Off
D21 (common filter)		-1.00		-1.00
D23 (fast polarity)		-1.00		+1.00
D20 (slow polarity)		1.00		-1.00
D24 (slow option)		Off		-1.00
Lift D28 (slow comp)		3.98 (phase offset)		-1.00
D29 (slow boost)		4.12 (phase offset)		-1.00
D30 (slow filter)		-1.00		-1.00
D25 (slow bypass)		1.00		-1.00
D27 (slow offset enable)		1.00 (change offset with slow offset D38)		-1.00
D27 and D26 (slow 5V offset)		1.00 (5 V offset)		-1.00

Latching

Inject a 100Hz/1Vpp **Sine wave** to IN1. **Toggle Down** LE switch (P1/11 latch enable). **Measure** and **Record** the voltage at SERVO.

Toggle D12 **Down** (IN1 1 enable) and make sure the signal at the output stays on all the time.

Return LE switch and D12 switch to default positions.

SERVO	**Vpp**
Check	

Excitation B

Inject a 100Hz/1Vpp **Sine wave** to IN1. **Measure** the voltage at B:TEST1 and B:TEST2 while toggling the switches **Down**. Tolerance is +/-0.5dB.

Binary input	B:TEST1	Nominal Vpp	B:TEST2	Nominal Vpp
—		-1.00		1.00
Lift D22		Off		Off
D49 (fast/slow) and lift D22		-1.00		1.00

Inject a 100Hz/1Vpp **Sine wave** to B:EXC. **Measure** the voltage at OUT1 and SERVO while toggling the switches **Down**. Tolerance is +/-0.5dB.

Binary input	OUT1	Nominal Vpp	SERVO	Nominal Vpp
—		Off		Off
D47 (exc. enable)		Off		0.10
D47 & D48 (fast option)		Off		Off
D47 & D49		0.10		Off
D47, D49, & D24		Off		Off

Limiter

Inject a 100Hz/10Vpp **Sine wave** to IN1. **Measure** the voltage at SERVO while toggling switch D31/35 **UP** (on the tester, red is on and green is off for this switch). The measured voltage should be within 25% of the nominal value.

Binary input	Measured Vpp	Nominal Vpp
-		20.0 Vpp
D31 (fast limiter)		6.6 Vpp

Gain slider C

Inject a 100Hz/1Vpp **Sine wave** to IN1. **Measure** the voltage at SERVO while toggling the switches **Down**. Tolerance is +/-0.5dB.

Binary input (slider gain)	Measured Vpp	Nominal Vpp
—		1
D41 (1dB)		1.12
D42 (2dB)		1.26
D43 (4dB)		1.59
D44 (8dB)		2.51
D45 (16dB)		6.31
D44 & D45 (24dB)		15.9
D46 (-32dB)		0.025
D46 & D44 (-24dB)		0.063
D46 & D45 (-16dB)		0.159
D46 & D45 & D44 (-8dB)		0.398

EPICS Readbacks

Inject a 1Hz/1Vpp **Sine wave** to IN1. **Observe** analog outputs for a peak to peak value and **Record** the observed voltage.

Inject a 100Hz/1Vpp **Sine wave** to IN1 and **Record** the observed voltage.

**The voltage tolerance is 1 dB (6dB for D34) of the nominal value.
(Red = MC) (Green = ALS)

EPICS readback	1Hz	Nominal Vpp	100Hz	Nominal Vpp
D32 (input mon)		-1.00		0.080
D33 (split mon)		-1.00		0.080
D34 (fast mon)		-0.4 / **7.5** / **7.5**		0.80
D39 (slow FB mon)		1.00		
D40 (output mon)		-1.00		

Limit indicator

Inject a 0.1Hz/10Vpp **Square wave** to IN1. **Observe** D35 Indicator Light (limit indicator) is **ON** and **Record** the observed voltage. Compare with the nominal response; see Appendix A6.

D35 Indicator Light Check	
Voltage	

Inject a 100Hz **Sine wave** to IN1. Increase injected signal amplitude from 0.0V, in 0.1V steps, until D35 Indicator Light goes from high (**ON**) to low (**OFF**). **Record** the observed voltage.

Binary input	**Measured [Vpp]**	**Nominal [Vpp]**
—		Approx. 6.0 Vpp

Tests Part 2: SR785 Signal Analyzer Tests

Important Notes: 1. Ensure all Common Mode Servo Tester switches are in the default position. 2. Closely Read and follow all On-Screen prompts.

On a Windows operating system laptop, **Create** and **Save** a file called TEST_DATA to C: drive. The path is C:\Test_DATA\.

Save Test Scripts in TEST_DATA.

Connect an SR785 Signal Analyzer to the laptop with a GPIB to Cat5 adapter.

From the DOS CMD window, **Type** cd.. , Enter, **Type** cd.. ,Enter and **Type cd** TEST_DATA.

Type and **Run** 'setgpib.bat' and **Enter** the adapter's IP address (which should be labeled on the adapter).

Reset the SR785's settings with 'resetSR785.bat'. If the SR785 resets when the script is run, the SR785 is properly connected to the PC.

Power Board Noise (SR785PowerBoardNoise.bat)

One pair of probes (MiniGrabbers) are required to check the noise levels at 140Hz on the low noise power board.

In the DOS CMD window, **Type** SR785PowerBoardNoise.

Read and **Follow** the On-Screen prompts for proper test equipment configuration and procedure.

Record the collected On-Screen data in the boxes below.

** Test values must be less than the values indicated in the table below.

TP12	**< [nV/√Hz]**	**TP13**	**< [nV/√Hz]**	**TP11**	**< [nV/√Hz]**	**TP6**	**< [nV/√Hz]**
	20		30		30		30

Monitor Channel Filtering (SR785MonitorTFs.bat)

In the DOS CMD window, **Type** SR785MonitorTFs

Read and **Follow** the On-Screen prompts for proper test equipment configuration and procedure.

Measure test transfer functions at 100Hz to 1Hz on IN1 to the indicated monitor channels on the tester and **Record** the data in the table below.

** Tolerances for Lowpass filtering are +/-1dB and +/-5deg from nominal.

Boost #	**@1Hz**	**Nominal**	**@10Hz**	**Nominal**	**@100Hz**	**Nominal**
Input Mon (D32)		-0.1dB 173deg		-4.1dB 129deg		-22dB 95deg
Split Mon (D33)		-0.1dB 173deg		-4.1dB 129deg		-22dB 95deg
Fast Mon (D34) (CM)		-8.8dB 150deg		10.5dB 5deg		-2.5dB -79deg
D34 (MC/ALS)		19.9dB -7deg		15.9dB -51deg		-2.0dB -85deg
FB Mon (D39)		-0.1dB -7deg		-4.1dB -51deg		-22dB -85deg
Output Mon (D40)		-0.1dB 173deg		-4.1dB 129deg		-22dB 95deg

Return all Common Mode Servo Tester switches to the default position.

Adjustment Channel Filtering (SR785AdjustmentTFs.bat)

Type SR785AdjustmentTFs

Test the transfer functions at 10kHz to 1Hz on the indicated adjustment channels on the tester to OUT1. **Toggle Down** D27 when testing D38. Verify filtering of at least -60dB at 100Hz for each channel and **Record** levels below in the boxes below.

Return switch D27 to default position.

Offset Adj.(D36)		**Offset Adj. (D37)**		**Output Adj. (D38)**	

Distortion (SR785DistortionMeasurement.bat)

Type SR785DistortionMeasurement

Inject a 1kHz/1Vrms sine wave to IN1. Use a spectrum analyzer (SR785) to measure the harmonic components at SERVO; see Appendix A7. On the SR785, **Press** Marker to display THD level. **Repeat** the measurement for IN2 (D13 on). **Record** the measurements in the boxes below.

Return D13 to the default position.

	IN1	**SERVO**	**IN2**	**SERVO**
Total Harmonic Distortion (THD)		<-70dB		<-70dB

Noise Spectra (SR785NoiseMeasurements.bat)

Type resetSR785 and **Allow** the SR785 to reset. **Type** SR785NoiseMeasurements

Terminate IN1 and IN2 using 50 ohm terminations. **Measure** the noise density at OUT1, OUT2 and SERVO. **Record** the values at 100Hz, 1kHz, 10kHz and 100kHz in the table below. See Appendix A1 for typical examples.

Frequency	**OUT1**	**< [nV/√Hz]**	**OUT2**	**< [nV/√Hz]**	**SERVO**	**< [nV/√Hz]**
10Hz						
100Hz		40		30		50
1kHz		30		30		40
10kHz		30		30		40
100kHz		30		30		40

Basic Transfer Functions (SR785BasicTFs.bat)

Type SR785BasicTFs

Sweep the frequency from 100kHz down to 1Hz with 100mV source amplitude and **Measure** the transfer function from IN1 to OUT1, from IN1 to SERVO and from IN2 to OUT2. **Record** the values at 10Hz, 100Hz, 1kHz, 10kHz and 100kHz in the table below. See Appendix A2 for typical examples.

** Tolerances must be within 1dB and 5deg of nominal. See Appendix A2 for typical examples.

OUT1/IN1	**dB**	**Nom (CM MC ALS)**	**deg**	**Nom (CM MC ALS)**
1Hz		0.0dB 14.0dB 0.0dB		180deg 180deg 180deg
10Hz		0.0dB 14.0dB 0.0dB		180deg 180deg 179deg
100Hz		0.0dB 14.0dB -0.2dB		180deg 177deg 169deg
1kHz		0.0dB 13.0dB -7.0dB		180deg 153deg 117deg
10kHz		0.0dB -0.2dB -26.0dB		175deg 102deg 94deg
100kHz		-3.0dB -20.0dB -46.0dB		130deg 86deg 85deg

SERVO/IN1	**dB**	**Nom (CM MC ALS)**	**deg**	**Nom (CM MC ALS)**
1Hz		-28.3dB 0.0dB 0.0dB		-23deg -180deg 180deg
10Hz		-1.9dB 0.0dB 0.0dB		-127deg -180deg 180deg
100Hz		0.0dB 0.0dB 0.0dB		-174deg -180deg 180deg
1kHz		0.0dB 0.0dB 0.0dB		-180deg -180deg 180deg
10kHz		0.0dB 0.1dB 0.0dB		89deg -177deg 89deg
100kHz		0.0dB 3.0dB 0.0dB		81deg -170deg 81deg

OUT2/IN2	**dB**	**Nom (CM MC ALS)**	**deg**	**Nom (CM MC ALS)**
1Hz		0.0dB 0.0dB 0.0dB		180deg 180deg 180deg
10Hz		0.0dB 0.0dB 0.0dB		180deg 180deg 180deg
100Hz		0.0dB 0.0dB 0.0dB		180deg 180deg 180deg
1kHz		0.0dB 0.0dB 0.0dB		180deg 180deg 180deg
10kHz		0.0dB 0.0dB 0.0dB		180deg 180deg 180deg
100kHz		0.0dB 0.0dB 0.0dB		177deg 177deg 177deg

Transfer Functions of Boost Gain Stages (SR785BoostGainTFs.bat)

Type SR785BoostGainTFs

Note: 1. Switch D5 must be **Down** (low) for **all** measurements.
2. All other switches are in default unless prompted otherwise

It is also possible to measure these boost stages by using TP3, TP8, TP9, TP10 and TP11A. See Appendix A4 for typical examples.

** Tolerances must be within 1dB and 5deg of nominal.

Boost #	**@10Hz**	**Nom**	**@100Hz**	**Nom**	**@1kHz**	**Nom**
Common Comp. (D17)		39.7dB -14deg		31.4dB -67deg		12.3dB -74deg
1. (D15)		26.3dB -1deg		26.3dB -5deg		23.4dB -42deg
2. (D16)		26.3dB -1deg		26.3dB -5deg		23.4dB -42deg
3. (D15+D16)		23.5dB -2deg		23.1dB -17deg		12.9dB -61deg
Lift D28 (slow comp)		31.3dB -68deg		11.9dB -88deg		-8.1dB -90deg
D29 (slow boost)		31.4dB -67deg		12.3dB -74deg		0.6dB -22deg

Transfer Functions of DAQ Channels (SR785DAQTFs.bat)

Type SR785DAQTFs

Measure the transfer function from SR785 CH1 A to D0901781 Monitor jack (DAQ channels). **Sweep** the frequency from 10kHz down to 1Hz at 1mV source amplitude. **Record** the values at 1Hz and 10kHz in the table below. See Appendix A5 for typical examples.
** Tolerances must be within 1dB and 5deg of nominal.

Frequency	**1Hz**	**Nominal**	**10kHz**	**Nominal**
IMON		26dB, 0deg		26dB, 0deg
FMON		–dB, –deg		46dB, -180deg
SMON		-26dB, 0deg		26dB, -12deg

Tests Part 3: 4395A Network/Spectrum Analyzer

Connect the 4395A in a similar fashion to the SR785, with a GPIB to Cat5 adapter.

High Frequency Transfer Function (AG4395AHighFreqTF.bat)

Type AG4395AHighFreqTF

Use a network analyzer to measure the transfer function from IN1 to SERVO. Sweep the frequency from 10MHz down to 10kHz with –20dBm source. To remove cable delays first measure the transfer function against a BNC barrel and use as a reference. **Record** the displayed values at 100kHz, 300kHz and 1MHz in the table below. Nominal values are given for CM. See Appendix A3 for typical examples.

** Tolerances are within 1dB and 5deg of nominal.

Frequency	**SERVO/IN1 [dB]**	**Nominal**	**SERVO/IN1 [deg]**	**Nominal**
100kHz		0dB		170deg
300kHz		0dB		150deg
1MHz		2dB		75deg