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Refer to:	LIGO-E1300845-v1
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Phase locked loop Board Test Procedure

Test Preparation

Enter Name, Date, Revision, Board Serial Number VCO chassis serial number:

Test Engineer	**Date**	**Pass**
Board	**PLL Board Serial Number**	**VCO chassis serial number**
D1300812		

Required Test and Ancillary Equipment

- 1 – One PLL Tester D1300797
- 1 - Tektronix AFG 3101 Signal Generator or equivalent
- 1 - Tektronix TDS 210 Oscilloscope or equivalent
- 1 – Fluke Multimeter or equivalent
- Calibrator (or DC voltage source)
- 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)
- 1 - 25 pin D sub cable male to female
- 3 – TNC male to BNC female adapters
- 1 – 2 pin lemo to BNC adapter
- 3 – BNC Female to Female Adapters (Barrels)
- 1 - BNC Tee Connector
- 1 – BNC to grabber adapter

- 3 - BNC Female to Double Stacking Banana Plugs
- 1 – SMA to BNC adapter
- 2 – 50 ohm BNC terminations
- 4 – BNC Male to BNC Male Cables

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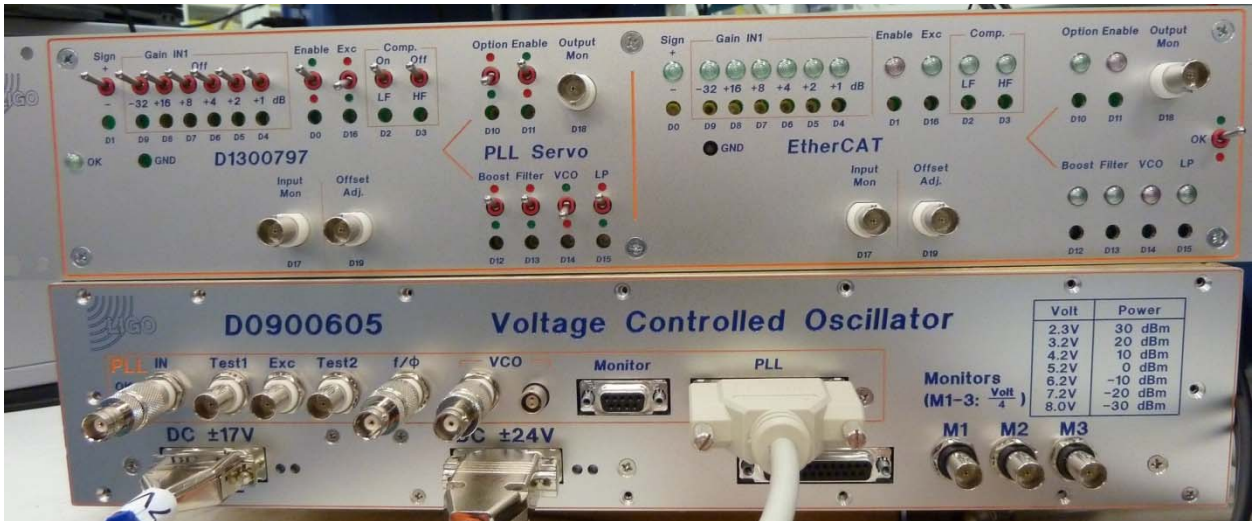
IMPORTANT NOTES:

1. On the PLL Tester (D1300797) front panel, all switches must be returned to default positions (up) after each test and/or step, unless otherwise instructed.

2. Always turn on 24 V power supply before 17 V, and turn off 17 V before 24V.

Picture 1



Rear Panel of D0900605 Voltage Controlled Oscillator and D1300797 PLL Servo Tester.

Tests Part 1.

On the PLL board, **Connect** the positive multimeter test lead to the following test points and **Connect** the negative multimeter test lead to GND.

Record the observed voltages in the data boxes below, place a check if the front panel OK LED is lit.

TP17	**TP18**	**TP19**	**TP20**	**TP21**	**TP22**	**TP23**	**TP24**	**TP25**	**TP26**	**OK**
+15V	-15V	+5V	GND	GND	GND	GNC	GND	GND	GND	lit

Power Supplies

Turn OFF Power Supplies, first turning off 17V then 24V each time.

Connect 25 pin PLL control cable to corresponding jacks on tester (on rear, labeled controls) and VCO chassis rear panel (labeled PLL).

Turn ON Power Supplies

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Check current draw from the ±17V power supply is about 1 Amp.

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

Power supply	**Current**	**Nominal**
+24V		0.1
-24V		0.02
+17V		1
-17V		0.26

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	**Test1**	**Test2**	**f/φ**	**VCO (TNC)**	**VCO(Lemo)**	**Tester Input Mon (D17)**	**Tester Output Mon (D18)**
CheckBox							

Adjust DC Bias

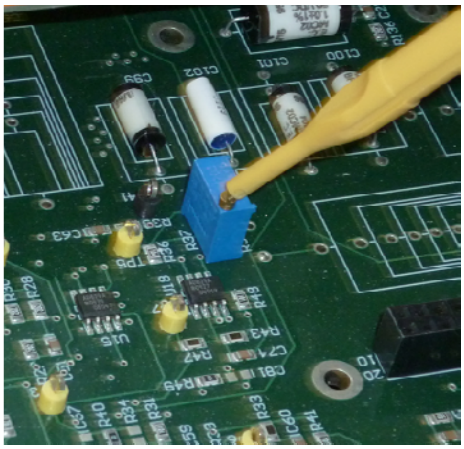

Figure 1: Potentiometer similar to R46

Set Oscilloscope coupling to DC Coupling.

Connect On tester connect Input Mon (D17) to the oscilloscope.

Ground IN using a BNC 50 ohm termination.

Adjust DC bias (R46) for zero volts observed at Input Mon.

Connect Multimeter to VCO output, disable LF compensation filter by flipping D2 down. Readjust R46 for 0V observed at VCO output.

Enable the first compensation filter, flipping D2 up. Adjust R46 for zero volts observed at VCO out.

Enable the second compensation filter, flipping D3 down. Adjust R46 for zero volts observed at VCO out.

Return switches to defaults.

Use a voltage calibrator to send a voltage into Offset Adjust (D19) on the tester.

Input to Offset Adjust (D19)	0V	10V	-10V
Input Mon (D17)			
Nominal Input Mon	0	55mV	-55mV

Connect Function Generator Output (sine wave, 100Hz, 1 Vpp, 1 V offset) to PLL IN jack.

Connect Test1 to the oscilloscope.

Toggle Sign (Input polarity, D1) on tester, and check that polarity of the signal on oscilloscope flips. Circle here if correct.

Toggle Enable (D0), check that signal goes to zero when disabled. Circle here if correct.

Gain slider:
Set offset on function generator to 0V.

Individually, **Toggle** each switch down (GND) and **Record** observed voltage. After each voltage observation, **Return** the switch to default position. Tolerance is +/-0.5dB (6%).

Binary input (Switch Setting)	Measured Vpp	Nominal Vpp
—(0dB)		1
D4 (1dB)		1.12
D5 (2dB)		1.26
D6 (4dB)		1.59
D7 (8dB)		2.51
D8 (16dB)		6.31
D7 & D8 (24dB)		15.9
D9 (-32dB)		0.025
D9 & D7 (-24dB)		0.063
D9 & D8 (-16dB)		0.159
D9 & D7 & D8 (-8dB)		0.398

Excitation

Leaving the excitation from the function generator on the input, measure the signal at Test2. If signal is the same as at Test 1 and input (1Vpp, 100Hz) circle here.

Set D2 down (turn off LF comp) , all other switches should be up.

Inject a 100Hz/1Vpp **Sine wave** to A:EXC (remove input from IN). **Measure** and **Record** the voltage at Test2 and VCO while toggling the switches **Down**. ** Tolerance is +/-0.5dB.

Binary input	A:TEST2	Nominal Vpp	VCO	Nominal Vpp
D2 down		Off		Off
D2+D16 (exc enable) down		0.10		0.10
D2+D16 & D10 (option) down		0.10		Off

Set all switches up. **Inject** a 100Hz/1Vpp **Sine wave** to IN. **Measure** and **Record** the voltage at f/phi and VCO while toggling the switches **Down**. ** Tolerance is +/-0.5dB.

Binary input	f/φ	Nominal Vpp	VCO	Nominal Vpp
—		3.9		17.4V

D2 (LF comp)		0.2		1.00
D2+D3 (LF +HF comp)		2		10.0
D12 (boost)		3.9 (may have DC offset)		17.8
D13 (filter)		3.9		17.8
D14 (VCO)		3.6		17.8
D15 (low pass)		1.6		17.8

Connect SMA to BNC adapter to J7 (towards rear of board). With 100Hz/1Vpp Sine wave still injected into IN, observe signal at J7.

Binary input	**J7**	**Nominal Vpp**
D2		1.0
D2 and D11		off

EPICS Readbacks

Inject a 1Hz/0.1V pp or 100Hz/1Vpp **Sine wave** to IN and **Record** the observed voltage.
**The voltage tolerance is 1 dB of the nominal value.

EPICS readback	**1Hz/0.1Vpp**	**Nominal Vpp**	**100Hz/1Vpp**	**Nominal Vpp**
D17 (input mon)		0.09		0.080
D18 (output mon)		4.8		1.6

Tests Part 2: SR785 Signal Analyzer Tests

Important Notes: 1.Switch LF comp and VCO comp to off on the tester (D2 and D14 down) for all the measurements in this section, unless otherwise directed. 2. Closely Read and follow all On-Screen prompts.

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

Save Test Scripts in PLL_TEST_DATA. Test scripts are available as a zip file attached to this procedure in the DCC.

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.

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 IN to the indicated monitor channels on the tester and **Record** the data in the table below. When the command line

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

Boost #	@1Hz	Nominal	@10Hz	Nominal	@100Hz	Nominal
Input Mon (D17)		-0.4dB 173deg		-4.5dB 129deg		-22dB 91deg
Output Mon (D18)		-0.4dB -7deg		-4.5dB 52deg		-22dB 85deg

Offset Adjustment Channel Filtering (SR785AdjustmentTFs.bat)

Type SR785AdjustmentTFs

Test the transfer functions at 10kHz to 1Hz on the offset adjust channel on the tester to VCO output. Verify filtering of at least -60dB at 100Hz and **Record** levels below in the boxes below.

Offset Adj.(D19)	

Distortion (SR785DistortionMeasurement.bat)

Type SR785DistortionMeasurement **Inject** a 1kHz/1Vrms sine wave to IN1. Use a spectrum analyzer (SR785) to measure the harmonic components at VCO; see Appendix 4. On the SR785, **Press** Marker to display THD level on right side of SR785 screen, and set cursor to 992Hz. **Repeat** the measurement using the f/phi output. **Record** the measurements in the boxes below.

	VCO out	SERVO	f/phi	SERVO
Total Harmonic Distortion (THD)		<-70dB		<-70dB

Noise Spectra (SR785NoiseMeasurements.bat)

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

Terminate IN using a 50 ohm terminatior. **Measure** the noise density at VCO out and f/phi. **Record** the values at 100Hz, 1kHz, 10kHz and 100kHz in the table below. See Appendix A1 for typical examples.

Frequency	**VCO**	**< [nV/√Hz]**	**f/φ**	**< [nV/√Hz]**
100Hz		40		30
1kHz		40		30
10kHz		40		30
100kHz		40		30

Basic Transfer Functions (SR785BasicTFs.bat)

Type SR785BasicTFs

Sweep the frequency from 100kHz down to 10Hz with 10mV source amplitude and **Measure** the transfer function from IN1 to VCO, with D3 down (HF comp) and all other switches on tester up (including D2, LF comp). Then repeat measurement from IN to f/phi with D2 down, D3 up, D12, D13 and D14 down (all other switches up), using a 500mV source amplitude. Then repeat measurement from IN to f/phi with D2 down, D3 up, D12, D13 and D14 up and D15 down (all other switches up), using a 500mV source amplitude. **Record** the values at 1Hz, 100Hz, 1kHz, 10kHz and 100kHz in the table below. See Appendix 5 for typical examples.
** Tolerances must be within 1dB and 5deg of nominal.

VCO out/IN	**dB**	**Nom**	**deg**	**Nom**
5Hz		54dB		172deg
100Hz		45dB		111deg
1kHz		25dB		95deg
10kHz		6.3dB		117deg
100kHz		0.0dB		163deg

f/φ/IN(D2, D12, D13, D14 down)	**dB**	**Nom**	**deg**	**Nom**
1Hz		12dB		-31deg

10Hz		-2dB		-67deg
100Hz		-14dB		-22deg
1kHz		-15dB		-3deg
10kHz		-15dB		0deg
100kHz		-15dB		-6deg

f/φ/IN(D2 and D15 down)	**dB**	**Nom**	**deg**	**Nom**
1Hz		12dB		-33deg
10Hz		-3dB		-80deg
100Hz		-22.6dB		-85.7deg
1kHz		-41dB		-90deg
10kHz		-61dB		-90deg
100kHz		-81dB		-90deg

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
CNTRLMON		–dB, –deg		6dB, 180deg

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)

These measurements should be done with D2 and D14 down, all other switches up.

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. See Appendix A3 for typical examples.

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

Frequency	**VCO/IN [dB]**	**Nominal**	**VCO/IN [deg]**	**Nominal**
100kHz		0dB		170deg
300kHz		0dB		150deg
1MHz		-5dB		52deg

Check for gain peaking around 4-5 MHz. If there is none, circle here.

Frequency	**VCO/IN [dB]**	**Nominal**	**VCO/IN [deg]**	**Nominal**
100kHz		-15dB		-9deg
300kHz		-15dB		-28deg
1MHz		-16.3dB		-90deg

Check for gain peaking around 4-5 MHz. If there is none, circle here.