LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

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Test Procedure for Low Noise VCO

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1   Introduction

The following Test Procedure describes the test of proper operation of the Low Noise VCO. The unused RF outputs should always be properly terminated with 50 Ohms. Further information can be found on the wiki page.

2   Test Equipment

- Voltmeter
- Oscilloscope
- Stanford Research SR785 analyzer
- Tektronix AFG3101 function generator
- RF Power Meter Agilent E4418A
- RF Frequency counter Agilent 53131A
- VCO tester, LIGO D1100545-v1
- Board Schematics, LIGO D0900605-v2 and D0900609-v2

3   Tests

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The Low Noise VCO uses the Low Noise Power Module (D0901846, rev D) with the RF Distribution Amplifier Interface (D1000064, rev A).

1) **Verify the proper current draw.** Using a bench DC supply apply +- 24Volts to P7 and +- 17 Volts to P6 of the low noise power Module (D0901846). Measure the current draw of the board.

+24 Volt current _____.06_____   0.1 A Nom.

-24 Volt current _____.02_____   0.0 A Nom.

+17 Volt current _____1.33_____   less than 1.1 A

-17 Volt current _____.12_____   less than 0.01 A

2) **On the low noise power module check the voltage on TP 1-13.**

TP1 (+17V) __+17__   TP2 (-17V) __−17__

TP3 , 4 (GND)   TP5 (+ 5V) __+5__

TP6 (-15V) __−15__   TP7 (+24V) __+24__

TP8 (GND)   TP9 (-24V) __−24__

TP10 (GND)   TP11 (+15V) __+15__

TP12 (+VREF) __+10__   TP13 (-VREF) __−10__

3) **If TP 1 , 2, 7 , 9 and 8 are correct then pin 5 on U1 and U7, (OK, TP14) should be Logic high ~3Volts.   Confirm.__OK__**

4) **The noise on TP 12, 13, 11 and 6 should be measured with a SR785 using an rms power spectrum.**

TP12 noise ___7.2___ less than 20 nVrms/sqrt Hz at 140 Hz

TP13 noise ___13.26___ less than 20 nVrms/sqrt Hz at 140 Hz

TP11 noise ___11.1___ less than 20 nVrms/sqrt Hz at 140 Hz

TP6 noise ___15.3___ less than 30 nVrms/sqrt Hz at 140 Hz.

5) **Test the power monitors by applying a 30 MHz, 10 dBm rf signal through an attenuator to each of the RF detectors.** Measure the output voltages mon1, mon2 and mon3 and with a RF power meter measure the RF power applied to the detector input.

Mon1

Nom input pwr	Measured Pwr dBm	Monitor Voltage (M)	Measured Volt
+10 dBm	-6	4.2 Volts (1.05)	4.2
+5 dBm	-11	4.7 Volts (1.175)	4.7
0 dBm	-16	5.2 Volts (1.30)	5.2
-5 dBm	-21	5.7 Volts (1.425)	5.7
-10 dBm	-26	6.2 Volts (1.55)	6.2

Mon 2

Nom input pwr	Measured Pwr dBm	Monitor Voltage (M)	Measured Volt
+10 dBm	-6	4.2 Volts (1.05)	4.2
+5 dBm	-11	4.7 Volts (1.175)	4.7
0 dBm	-16	5.2 Volts (1.30)	5.2
-5 dBm	-21	5.7 Volts (1.425)	5.7
-10 dBm	-26	6.2 Volts (1.55)	6.2

Mon 3

Nom input pwr	Measured Pwr dBm	Monitor Voltage (M)	Measured Volt
+10 dBm	-6	4.2 Volts (1.05)	4.2
+5 dBm	-11	4.7 Volts (1.175)	4.7
0 dBm	-16	5.2 Volts (1.30)	5.2
-5 dBm	-21	5.7 Volts (1.425)	5.7
-10 dBm	-26	6.2 Volts (1.55)	6.2

We now move on to the Low Noise VCO: Oscillator Source (D0900609).

6) **On the Low Noise VCO: Oscillator Source (D0900609) check the voltage on TP1-6, TP8, TP10P, TP20P, TPREF and TPREF5.** Terminate the tune input with 50 ohms.

TP1 _____ O _____ nominal 0.0V

TP2 _____ O _____ nominal 0.0V

TP3 _____ +11 _____ nominal +11.0V, trim R25 to nominal voltage.

TP4 _____ +11 _____ nominal +11.0V

TP5 _____ -2.5 _____ adjusted

TP6 _____ +11 _____ nominal +11.0V

TP8 _____ +11 _____ nominal +11.0V

Monitor _____ nominal 0V (front panel)

TP24P _____ +24 _____ nominal +24V

TP24N _____ -24 _____ nominal -24V

TP15P _____ +15 _____ nominal +15V

TP15N _____ -15 _____ nominal -15V

TPVCC _____ +3.3 _____ nominal +~~5V~~ +3.3V

TP10P _____ +10 _____ nominal +10V

TP20P _____ +20 _____ nominal +20V

TPREF _____ +10 _____ nominal +10V

TPREF5 _____ +5.5 _____ nominal +5.46V

7) **The noise on TP1-6, TP8, TP10P, TP20P and TPREF should be measured with a SR785 using an rms power spectrum.**

TP1 noise ___20.3___   less than 30 nVrms/sqrt Hz at 140 Hz.

TP2 noise ___22.5___   less than 30 nVrms/sqrt Hz at 140 Hz.

TP3 noise ___28.4___   less than 30 nVrms/sqrt Hz at 140 Hz.

TP4 noise ___18.6___   less than 30 nVrms/sqrt Hz at 140 Hz.

TP5 noise ___21.6___   less than 30 nVrms/sqrt Hz at 140 Hz.

TP8 noise ___9.4___   less than 30 nVrms/sqrt Hz at 140 Hz.

Monitor noise ___200___   less than 30 nVrms/sqrt Hz at 140 Hz (front panel).

TP6 noise ___8.1___   less than 10 nVrms/sqrt Hz at 140 Hz.

TP10P noise ___10.4___   less than 30 nVrms/sqrt Hz at 140 Hz.

TP20P noise ___12.2___   less than 30 nVrms/sqrt Hz at 140 Hz.

TPREF noise ___13.1___   less than 20 nVrms/sqrt Hz at 140 Hz.

We now move on to the full assembly of the Low Noise VCO (D0900605).

8) **Measure the transfer function of the tune input.** Use a SR785 in network mode. Take the following transfer functions:

- Tune input to monitor output
- Excitation input to the monitor output
- Tune input to TP6

The first two transfer function should be flat at 6 dB and -20 dB, respectively. The third transfer function should show a pole at 1.5 Hz and a zero at 40 Hz. The DC gain is 3 dB, whereas the high frequency gain is around -25 dB. Save the transfer functions on floppy.

Magnitude/Phase response

Frequency	Monitor/Tune		Monitor/Exc		TP6/Tune	
	Meas.	Nom.	Meas.	Nom.	Meas.	Nom.
0.5 Hz	6dB / 0°	6 dB/0°	-20dB / 0°	0 dB/0°	2.6dB /-4°	3 dB/-4°
1 Hz	6dB / 0°	6 dB/0°	-20dB / 0°	0 dB/0°	1.5dB /-31°	1.5 dB/-32°
10 Hz	6dB / 0°	6 dB/0°	-20dB / 0°	0 dB/0°	-13dB / -67°	-13 dB/-67°
100 Hz	6dB / 0°	6 dB/0°	-20dB / 0°	0 dB/0°	-24dB /-20°	-24 dB/-21°
1 kHz	6dB / 0°	6 dB/0°	-20dB / 0°	0 dB/0°	-25dB /-2°	-25 dB/-2°
10 kHz	6dB / 0°	6 dB/0°	-20dB / 0°	0 dB/0°	-25dB / 0°	-25 dB/0°
100 kHz	6dB / 0°	6 dB/-3°	-20dB / 0°	0 dB/-3°	-25dB /-4°	-25 dB/-3°

9) **Measure RF powers and RF frequencies.** Hook a 10dBm/71.000 MHz OCXO source to the Ref input. For all but the measurements on VCO connector, connect the VCO output to the DIV input. Terminate the Tune input. Always terminate the open outputs.

Port	Tune	Power (dBm)	Freq. (MHz)	Nominal
VCO	0V	15	130	~13 dBm/136 MHz
OUT1	0V	19	79.1	>13 dBm/79.5 MHz
OUT2	0V	19	79.1	>13 dBm/79.5 MHz

10) **Measure RF powers and RF frequencies as function of the tuning voltage.** Hook a 10dBm/71.000 MHz OCXO source to the Ref input. Connect the VCO output to the DIV input. Always terminate the open RF outputs. Around zero the tuning sensitivity should be around 250 MHz/V.

Port	Tune	Power (dBm)	Freq. (MHz)	Nominal
OUT1	-7V	19	77.8	>13 dBm/78.11 MHz
OUT1	-6V	19	77.9	>13 dBm/78.22 MHz
OUT1	-5V	19	78.0	>13 dBm/78.38 MHz
OUT1	-4V	19	78.1	>13 dBm/78.57 MHz
OUT1	-3V	19	78.2	>13 dBm/78.79 MHz
OUT1	-2V	19	78.6	>13 dBm/79.02 MHz
OUT1	-1V	19	78.5	>13 dBm/79.27 MHz
OUT1	0V	19	79.1	>13 dBm/79.53 MHz
OUT1	+1V	18.9	79.6	>13 dBm/79.79 MHz
OUT1	+2V	18.8	79.8	>13 dBm/80.05 MHz
OUT1	+3V	18.7	79.9	>13 dBm/80.29 MHz
OUT1	+4V	18.6	80.1	>13 dBm/80.51 MHz
OUT1	+5V	18.5	80.2	>13 dBm/80.71 MHz
OUT1	+6V	18.5	80.3	>13 dBm/80.88 MHz
OUT1	+7V	18.5	80.4	>13 dBm/80.92 MHz

11) **Use the VCO tester and check the signals through the rear connector.** Terminate the tune input at the front panel and use the frequency counter on Out1.

Check that the OK LED is on ___Yes___ .

Check that the Excitation switch and the excitation readback LED toggle together ___Yes___ .

Write down the power and temperature monitors. For the off-value disable the two power switches at the front panel.

Signal	Value	Off value	Nominal
RF power (M1)	3.8	8.64	5.6 V / >8 V
Temperature (M1)	5.5	5.5	6.2 V
RF power (M2)	2.8	6.1	4.9 V / >8 V
Temperature (M2)	5.6	5.6	6.2 V
RF power (M3)	3.7	8.5	<5.4 V / >8 V
Temperature (M3)	5.5	5.6	6.2 V

Set the manual tuning frequency and check the VCO tune monitor as well as the frequency on Out1. The tuning sensitivity should be around 12.5 kHz/V.

Manual Freq Tune	VCO tune monitor		Out Frequency	
	Value	Nominal	Value	Nominal
+10 V	9.0	100 mV	80.4	79.40 MHz
0 V	5.0	0 mV	79.1	79.53 MHz
-10 V	1.0	-100 mV	78.9	79.66 MHz

12) Measure the Phase noise of the Low Noise VCO Output (Out1 or Out2) using the Wenzel single channel phase noise measurement technique (3.5.3), Figure 3.5.2-1, which can be found at

http://www.wenzel.com/pdffiles1/BP1000Manual/BP_1000_v101_2_.pdf.

A reasonable FFT analyzer is the SR785, which can be set to measure power units if you start in Display Setup. A Reference Source must be provided which can be just a Wenzel crystal oscillator of frequency 78.89 MHz, properly powered and connected to the Wenzel phase noise measurement system. The output of the Low Noise VCO will need to be attenuated by about 3 dB to provide the amplitude needed by the Wenzel phase noise measurement system (about 10 dBm).

- 3.25U

Out1 or Out2

Offset freq. Hz	Phase noise spec.	Ref osc. phase noise	LN VCO noise
10 Hz	-60 dBc/Hz	-90 dBc/Hz	-99
100 Hz	-97 dBc/Hz	-110 dBc/Hz	-116
1 kHz	-128 dBc/Hz	-140 dBc/Hz	-135