LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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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.

S/N _____ Tester _____ Date _____

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

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 _____ 0.1 A Nom.

-24 Volt current _____ 0.02 A Nom.

+17 Volt current _____ less than 1.1 A

-17 Volt current _____ less than 0.1 A

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

TP1 (+17V) _____ TP2 (-17V) _____

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

TP6 (-15V) _____ TP7 (+24V) _____

TP8 (GND) TP9 (-24V) _____

TP10 (GND) TP11 (+15V) _____

TP12 (+VREF) _____ TP13 (-VREF) _____

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._____

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

TP12 noise _____less than 20 nVrms/sqrt Hz at 140 Hz

TP13 noise _____less than 20 nVrms/sqrt Hz at 140 Hz

TP11 noise _____ less than 20 nVrms/sqrt Hz at 140 Hz

TP6 noise _____ 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		4.2 Volts (1.05)	
+5 dBm		4.7 Volts (1.175)	
0 dBm		5.2 Volts (1.30)	
-5 dBm		5.7 Volts (1.425)	
-10 dBm		6.2 Volts (1.55)	

Mon 2

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

Mon 3

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

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_____ nominal 0.0V

TP2 _____ nominal 0.0V

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

TP4 _____ nominal +11.0V

TP5 _____ adjusted

TP6 _____ nominal +11.0V

TP8 _____ nominal +11.0V

Monitor _____ nominal 0V (front panel)

TP24P _____ nominal +24V

TP24N _____ nominal -24V

TP15P _____ nominal +15V

TP15N _____ nominal -15V

TPVCC _____ nominal +3.3V

TP10P _____ nominal +10V

TP20P _____ nominal +20V

TPREF _____ nominal +10V

TPREF5 _____ 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 _____ less than 30 nVrms/sqrt Hz at 140 Hz.

TP2 noise _____ less than 30 nVrms/sqrt Hz at 140 Hz.

TP3 noise _____ less than 30 nVrms/sqrt Hz at 140 Hz.

TP4 noise _____ less than 30 nVrms/sqrt Hz at 140 Hz.

TP5 noise _____ less than 30 nVrms/sqrt Hz at 140 Hz.

TP8 noise _____ less than 30 nVrms/sqrt Hz at 140 Hz.

Monitor noise_____ less than 300 nVrms/sqrt Hz at 140 Hz (front panel).

TP6 noise _____ less than 10 nVrms/sqrt Hz at 140 Hz.

TP10P noise _____ less than 30 nVrms/sqrt Hz at 140 Hz.

TP20P noise _____ less than 30 nVrms/sqrt Hz at 140 Hz.

TPREF noise _____ 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

	Monitor/Tune		**Monitor/Exc**		**TP6/Tune**	
Frequency	**Meas.**	**Nom.**	**Meas.**	**Nom.**	**Meas.**	**Nom.**
0.1 Hz		6 dB/0°		0 dB/0°		3 dB/-4°
1 Hz		6 dB/0°		0 dB/0°		1.5 dB/-32°
10 Hz		6 dB/0°		0 dB/0°		-13 dB/-67°
100 Hz		6 dB/0°		0 dB/0°		-24 dB/-21°
1 kHz		6 dB/0°		0 dB/0°		-25 dB/-2°
10 kHz		6 dB/0°		0 dB/0°		-25 dB/0°
100 kHz		6 dB/-3°		0 dB/-3°		-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**			~13 dBm/136 MHz
OUT1	**0V**			>13 dBm/79.5 MHz
OUT2	**0V**			>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**			>13 dBm/78.11 MHz
OUT1	**-6V**			>13 dBm/78.22 MHz
OUT1	**-5V**			>13 dBm/78.38 MHz
OUT1	**-4V**			>13 dBm/78.57 MHz
OUT1	**-3V**			>13 dBm/78.79 MHz
OUT1	**-2V**			>13 dBm/79.02 MHz
OUT1	**-1V**			>13 dBm/79.27 MHz
OUT1	**0V**			>13 dBm/79.53 MHz
OUT1	**+1V**			>13 dBm/79.79 MHz
OUT1	**+2V**			>13 dBm/80.05 MHz
OUT1	**+3V**			>13 dBm/80.29 MHz
OUT1	**+4V**			>13 dBm/80.51 MHz
OUT1	**+5V**			>13 dBm/80.71 MHz
OUT1	**+6V**			>13 dBm/80.88 MHz
OUT1	**+7V**			>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_____.

Check that the Excitation switch and the excitation readback LED toggle together_____.

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)			5.6 V / >8 V
Temperature (M1)			6.2 V
RF power (M2)			4.9 V / >8 V
Temperature (M2)			6.2 V
RF power (M3)			<5.4 V / >8 V
Temperature (M3)			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		-11V		79.40 MHz
0 V		0 mV		79.53 MHz
-10 V		+13V		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).

Out1 or Out2

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