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Test Procedure for New Low Noise VCO

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1 Introduction

The following Test Procedure describes the test of proper operation of the new 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 and Oscilloscope
- Stanford Research SR785 analyzer
- Tektronix AFG3101 function generator
- RF Power Meter Agilent E4418A
- RF Frequency counter Agilent 53131A
- VCO tester, LIGO D1100545
- Schematics, LIGO D2100570 and D0600609-v3 (version 3 or higher)
- Wenzel Bluephase

3 Tests

The new Low Noise VCO, D2100570, 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 _____ 0.0 A Nom.

+17 Volt current _____ less than 0.6 A

-17 Volt current _____ less than 0.2 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 20dB 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.

   Depending on variant, not all monitors are equipped with RF power detectors!

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 the following test points.** Terminate the tune input with 50 ohms.

TP1_____ nominal 0.0V

TP2 _____ nominal 0.0V

TP3 _____ adjust to +10.0V by trimming R25.

TP4 _____ nominal +10.0V with adjusted R25.

TP5 _____ nominal −11.7V with adjusted R25.

TP6 _____ nominal +5.0V

TP8 _____ nominal +10.0V

Monitor _____ nominal 0V (front panel)

TP24P _____ nominal +24V

TP24N _____ nominal −24V

TP15P _____ nominal +15V

TP15N _____ nominal −15V

TP VDD _____ nominal +3.33V

TP VCC _____ nominal +3.33V Check for oscillations

TP PVCO _____ nominal +12V (1600 variant) Check for oscillations

TP P20 _____ nominal +20V Check for oscillations

TP REF _____ nominal +10V

TP TREF _____ nominal +4.22V (1600 variant)

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 40 nVrms/sqrt Hz at 140 Hz.

TP2 noise _____ less than 40 nVrms/sqrt Hz at 140 Hz.

TP3 noise _____ less than 40 nVrms/sqrt Hz at 140 Hz.

TP4 noise _____ less than 40 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 500 nVrms/sqrt Hz at 140 Hz (front panel).

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

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

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

TP P20 noise _____ less than 30 nVrms/sqrt Hz at 140 Hz.

TP TREF noise _____ less than 20 nVrms/sqrt Hz at 140 Hz.

We now move on to the full assembly of the Low Noise VCO (D2100570).

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°		−20 dB/0°		−3 dB/-4°
1 Hz		6 dB/0°		−20 dB/0°		−4.5 dB/-32°
10 Hz		6 dB/0°		−20 dB/0°		−19 dB/-67°
100 Hz		6 dB/0°		−20 dB/0°		−30 dB/-21°
1 kHz		6 dB/0°		−20 dB/0°		−31 dB/-2°
10 kHz		6 dB/0°		−20 dB/0°		−31 dB/0°
100 kHz		6 dB/-5°		−20dB/-7°		−31 dB/-5°

Monitor/Tune has an additional minus sign.

9) **Measure RF powers and RF frequencies.** Terminate the Tune input. Always terminate the open outputs. Make sure the on/off switches are on (front panel).

Port	**Tune**	**Power (dBm)**	**Freq. (MHz)**	**Nominal**
OUT1	**0V**			>13 dBm/79.02 MHz
OUT2	**0V**			>13 dBm/79.02 MHz

10) Measure RF powers and RF frequencies as function of the tuning voltage. 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/77.24 MHz
OUT1	**-6V**			>13 dBm/77.33 MHz
OUT1	**-5V**			>13 dBm/77.69 MHz
OUT1	**-4V**			>13 dBm/77.99 MHz
OUT1	**-3V**			>13 dBm/78.27 MHz
OUT1	**-2V**			>13 dBm/78.53 MHz
OUT1	**-1V**			>13 dBm/78.78 MHz
OUT1	**0V**			>13 dBm/79.02 MHz
OUT1	**+1V**			>13 dBm/79.26 MHz
OUT1	**+2V**			>13 dBm/79.50 MHz
OUT1	**+3V**			>13 dBm/79.73 MHz
OUT1	**+4V**			>13 dBm/79.97 MHz
OUT1	**+5V**			>13 dBm/80.19 MHz
OUT1	**+6V**			>13 dBm/80.40 MHz
OUT1	**+7V**			>13 dBm/80.48 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_____ (front panel / tester).

Check that the front panel excitation and the excitation readback

front panel LED _____ and tester 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)			3.6 V / >8 V
Temperature (M1)			5.6 V
RF power (M2)			3.6 V / >8 V
Temperature (M2)			5.6 V
RF power (M3)			3.6 V / >8 V
Temperature (M3)			5.6 V

Test the relay by toggling the "excitation enable" switch on the tester (with the two power switches at the front panel in the on states) _____.

Write down the voltage at the RF power/Spare readback (with the two power switches at the front panel in different states). Clip to pins 12/25 by a DB25 breakout board.

Signal	Value	Nominal
Both power switches off		< -1.5V
VCO power switch on / FDD (right) off		> -1.5V & < -4.5V
VCO power switches off / FDD (right) on		> -4.5V & < -7.5V
Both power switches on		> -7.5V

Set the manual tuning frequency and check the VCO tune monitor as well as the frequency on Out1. The tuning sensitivity should be around 125 kHz/V.

Manual Freq Tune	**VCO tune monitor**		**Out Frequency**	
	Value	**Nominal**	**Value**	**Nominal**
+10 V		8.6 V		80.18 MHz
0 V		5.0 V		79.02 MHz
-10 V		1.4 V		77.70 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	-45 dBc/Hz	-90 dBc/Hz	
100 Hz	-80 dBc/Hz	-110 dBc/Hz	
1 kHz	-110 dBc/Hz	-140 dBc/Hz	
10 kHz	-140 dBc/Hz	-160 dBc/Hz	