LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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Test Procedure for Phase-Frequency Discriminator

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1 Introduction

The following Test Procedure describes the test of proper operation of the Phase-Frequency Discriminator. The unused outputs should always be properly terminated.

2 Test Equipment

- Voltmeter
- Oscilloscope Tektronix TDS 3034B
- Stanford Research SR785 analyzer
- Tektronix AFG3102 function generator
- Schematic--PhaseFrequencyDiscriminator or D1002476-v1.

3 Tests

The Phase-Frequency Discriminator is powered with the Low Noise Power Module (D0901846, rev D) and the Demodulator Power Interface (D1000185, rev B).

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 1.1 A
–17 Volt current _____	less than 0.01 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 TP14 (OK, pin 5 on U1 and U7) 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 the RF IN (J2, on D1002471) and the LO IN (J4, on D1000184).** Measure the output voltages on TP2 (RF IN) and TP1(LO IN), on D1000184. The rf power detected will be 23dB less than applied to the RF IN and 20 dB less than applied to the LO IN. The voltage at the TP is given by 0.06 x (dBm +95).

RF IN (J2)

INPUT (dBm)	Nom. Output (Volts)	Measured Output (Volts)	
		Channel 1	Channel 2
10	4.92		
3	4.50		
0	4.32		
-10	3.72		

LO IN (J4)

INPUT (dBm)	Nom. Output (Volts)	Measured Output (Volts)	
		Channel 1	Channel 2
10	5.10		
0	4.50		
-10	3.90		
-20	3.30		
-30	2.70		

6) **Test the RF IN sensitivity by applying a 30 MHz, -50 dBm signal to J2 on D1002471 and look at pin 1 or 2 on U1A with a X10 probe.** You should see a full ECL logic swing.

Channel 1 confirm. _____

Channel 2 confirm. _____

7) **Test the phase detector by applying two 30 MHz, 10 dBm signals to RF IN (J2, on D1002471) and LO IN (J4, on D1000184).** Measure the output voltage on J6 as a function of the phase difference of the two input signals. The Tektronix AFG 3102 will generate both signals with an adjustable phase difference. Remember to align the two phases and monitor them on a scope. Suggest 45 degree steps for a general check. The offset is the output voltage when the phase difference is zero and the phase sensitivity is best measured for phase differences near zero not more than plus or minus 135 degrees. The corrected output voltage is the output voltage with the offset removed.

Channel 1:

Phase Difference	Output Voltage	Corrected Output Voltage
180		
135		
90		
45		
0		
-45		
-90		
-135		
-180		

Phase sensitivity _____degree/Volt (36 degree/Volt)

Offset _____Volt

Channel 2:

Phase Difference	Output Voltage	Corrected Output Voltage
180		
135		
90		
45		
0		
-45		
-90		
-135		
-180		

Phase sensitivity _____ degree/Volt (36 degree/Volt)

Offset _____ Volt

8) Test the frequency discriminator by applying two 30 MHz, 10 dBm signals to RF IN (J2, on D1002471) and LO IN (J4, on D1000184). Set the frequency of the signal applied to the RF IN a few Hz higher than the signal applied to the LO IN, then a few Hz lower, looking at the difference frequency on the output J6. The output level should shift positive or negative depending on whether RF IN is a higher or lower frequency than LO IN and will pulse to ground at a frequency related to the difference between the two input frequencies. The sign of the output J6 is inverted when the sign input is grounded. Verify proper operation including the sign.

Channel 1 Frequency Discriminator working _____

Channel 1 Sign working _____

Channel 2 Frequency Discriminator working _____

Channel 2 Sign working _____

9) **Measure the IF bandwidth.** Apply the same 30 MHz/10 dBm signal to both the RF IN (J2, on D1002471) and LO IN (J4, on D1000184). Set the RF IN channel to external phase modulation. Use the SR785 to measure a swept sine from 100 kHz down to 10 Hz. Determine the 3dB point and write down magnitude and phase values.

Channel 1: 3dB frequency _____ kHz (100kHz ± 10kHz).

Channel 1: Phase at 3dB point _____ degree (45 degree ± 5 degree).

Channel 2: 3dB frequency _____ kHz (100kHz ± 10kHz).

Channel 2: Phase at 3dB point _____ degree (45 degree ± 5 degree).

Channel 1:

Frequency	Magnitude	Phase
10 Hz		
100 Hz		
1 kHz		
100 kHz		

Channel 2:

Frequency	Magnitude	Phase
10 Hz		
100 Hz		
1 kHz		
100 kHz		

10) **Measure the phase-frequency discriminator noise.** Apply the same 10 dBm signal to both the RF IN (J2, on D1002471) and LO IN (J4, on D1000184) measure the noise on output J6 with a SR785 using rms power spectrum. A Wenzel crystal oscillator with 13 dBm output can be split to provide both 10 dBm signals. Try to match the cable length as closely as possible to achieve an output offset as small as possible (~0 degree phase).

Channel 1: IMon out _____less than 100 nVrms/sqrt Hz at 140 Hz.

Channel 2: IMon out _____less than 100 nVrms/sqrt Hz at 140 Hz.