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
- HP 4395A network analyzer
- 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 bandwidth of the discriminator output circuit.** Using a HP4395A network analyzer with the rf drive applied to either U2 pin 7 or U2 pin 14 through a 1k resistor using a 1X probe. The analyzer rf out should be split with one output going to the analyzer R in and the other applied to U2 as described above. The I-MON output is applied to either the A or B analyzer input. The rf drive level is 3dBm, the BW is 1 kHz, the start frequency is 100 kHz and the stop frequency is 10 MHz. The transfer function of a good output network is -69.6 dB @ 100 kHz , -72.6 dB @ 503 kHz , -85.7 dB @ 3.0 MHz and -106.5 dB @ 5.3 MHz. The 3 dB point is at about 503 kHz. The phases are 163.6, 112.2, -98.5 and -47.6 degrees. The tolerances are 1.5dB in magnitude and 5 degree in phase. The purpose of this measurement is to confirm that the correct components have been loaded. The display should be recorded on a 3.5" floppy disc for future reference.

Channel 1:

Frequency	Magnitude	Phase
100 kHz		
503 kHz		
3 MHz		
5.3 MHz		

Channel 2:

Frequency	Magnitude	Phase
100 kHz		
503 kHz		
3 MHz		
5.3 MHz		

Channel 1 output correct ____________________

Channel 2 output correct ____________________

9) **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.