LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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aLIGO I&Q RF Demodulator Test Procedure

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1 Overview

This test procedure applies to I&Q demodulator circuit board LIGO-D0902745-v3 contained within chassis assembly D0902796. There are two variants of the demodulator chassis, one for LSC photodetectors, and one for ASC (WFS) type photodetectors. A block diagram of the I&Q RF demodulator circuit board common to both variants is shown in Figure 1. Four such demodulator cells are packaged in one chassis. Refer to LIGO-T1000044 for principles of operation.

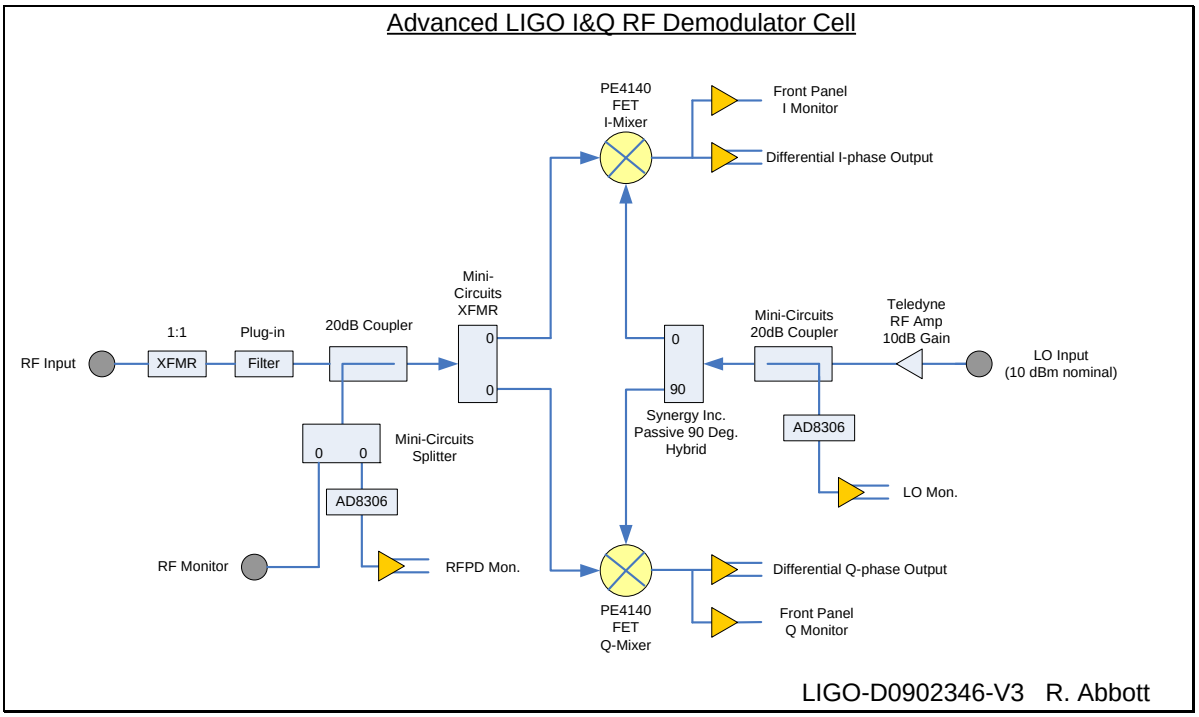

Figure 1 I&Q Demodulator Circuit Block Diagram

2 Testing

Each production chassis must be functionally tested according to the procedure in this document. The test results are to be recorded using the form F1100004. The completed form is to be loaded in the DCC, in the chassis' S-number file card.

Unless otherwise noted, the local oscillator level applied to the rear of the chassis is set to +10dBm, +/-0.2dBm for all RF measurements. It is assumed that the person using this procedure is familiar with RF Network Analyzers, Dynamic Signal Analyzers, and rudimentary test equipment including oscilloscopes and multimeters.

DC Tests

- Apply +/- 18, +/-200 mV Volts DC to the chassis under test and record front panel LED operation, total positive and negative power supply current, internal regulator output voltage and individual circuit board power supply currents as required in F1100004.

RF Tests

- Using a calibrated and normalized RF network analyzer, measure the insertion loss from each of the four front panel RF inputs to the respective RF monitor ports per 4.4. Record the insertion loss at the frequencies specified in F1100004.
- Apply an RF or LO input at the prescribed frequency in accordance with 4.5 F1100004. For each combination, record the DC value of each of the four RF and LO level detector responses.
- Apply an RF or LO input at the prescribed frequencies in accordance with 4.6 and F1100004. For each combination, record the amplitude of the differential IF beat note as specified in F1100004.

IF Tests

- As detailed in Section 4.7, use the cross correlation setup in an SR785 and measure the I&Q balance at the front panel BNC outputs and record the results per F1100004.
- Use an SR785 to measure the IF output noise, with the associated RF input terminated in 50 ohms per 4.8. Record results as required in F1100004.
- Using a pair of RF signal generators and an oscilloscope, measure the -3dB bandwidth of the IF chain per 4.9. Record the results in F1100004.

3 Reference for chassis front and rear panel layout

Figure 2, Demodulator Front Panel

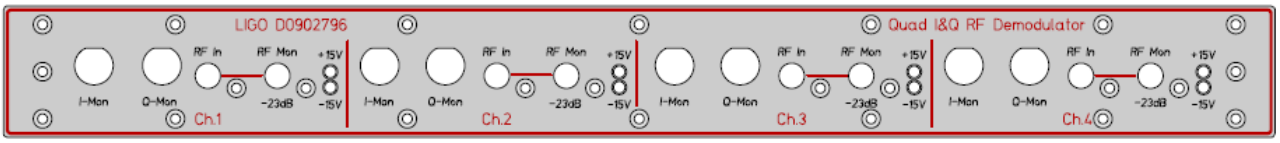

Figure 3, LSC Demodulator Rear Panel

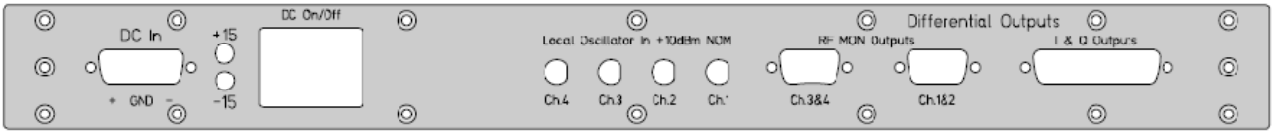

Figure 4, ASC Demodulator Rear Panel

3.1 Rear Panel D-sub connector pinouts

Some of the measurements below are made on the rear panel D-sub connector outputs. Use the standard D-sub breakout cables that are available for this. The pinouts for these connectors are shown below.

Table 1. Pinout for Rear Panel RF Mon Outputs, 9-pin D-sub connectors.

Pin No.	Function
1	Ch. 1 (Ch. 3) LO +
6	Ch. 1 (Ch. 3) LO –
2	Ch. 1 (Ch. 3) RF +
7	Ch. 1 (Ch. 3) RF –
3	Ch. 2 (Ch. 4) LO +
8	Ch. 2 (Ch. 4) LO –
4	Ch. 2 (Ch. 4) RF +
9	Ch. 2 (Ch. 4) RF –

Table 2. Pinout for Rear Panel I & Q Outputs, 25-pin D-sub connector.

Pin No.	Function	Pin No.	Function
1	Ch. 1, Q (+)	5	Ch. 3, Q (+)
14	Ch. 1, Q (–)	18	Ch. 3, Q (–)
2	Ch. 1, I (+)	6	Ch. 3, I (+)
15	Ch. 1, I (–)	19	Ch. 3, I (–)
3	Ch. 2, Q (+)	7	Ch. 4 Q (+)
16	Ch. 2, Q (–)	20	Ch. 4, Q (–)
4	Ch. 2, I (+)	8	Ch. 4, I (+)
17	Ch. 2, I (–)	21	Ch. 4, I (–)

4 Test Data Tables

4.1 Serial Numbers

Record all serial number data on the cover page of F1100004.

4.2 DC Power Supply Data

Measure and record the total chassis and individual circuit board quiescent current draws. For the individual circuit boards, unplug all but one board at a time and record the chassis current draw of the +/- 18VDC supply. Use caution in believing the digital readouts of laboratory triple output power supplies. Their meters are not highly accurate. When in doubt, use a multimeter on the appropriate scale in series with the supply to be measured.

4.3 DC Offsets on Each IF Output

As a general measure of the health, the DC offset at the differential outputs for each channel must be measured. Apply LO of 45MHz, 10dBm +/- 0.2dB to the channel under test. Using a multimeter, measure the DC offset at each differential output on the associated rear panel D-sub connector. Record the results in F1100004.

4.4 Coupling Factor for Front Panel Monitors

Using a calibrated and normalized RF network analyzer, measure the insertion loss from each front panel SMA RF input to its respective RF monitor. Use a drive level of 0dBm +/- 0.2dB at each of the required frequencies. Record the test data in F1100004.

4.5 RF Level Detector Calibration Data

The boards contain level monitors for both the RF and LO inputs. Calibrate these monitors by applying a signal of the indicated magnitudes to the RF or LO input on the front and rear chassis SMA connectors, as specified in F1100004. Using a multimeter, record the DC voltage as measured differentially at the differential RF monitor outputs on the rear of the chassis (see Section 3, Reference for chassis front and rear panel layout). The ASC version of the chassis contains an internal four-way power splitter on the LO input; this leads to smaller values of the LO detector output, as indicated in F1100004.

4.6 IF Beat note Measurements

Using a pair of RF signal generators, apply the indicated amplitude and frequency signals to the chassis under test, as specified in F1100004. There is a single rear panel LO input for the ASC (wavefront sensor) variant of the demodulator chassis. For the LSC version, the LO cable must be moved from channel to channel as needed

The IF beat note is measured differentially at the rear panel D-sub outputs for each channel under test using an SR785. Be sure to set the dynamic signal analyzer FFT window function to “flat top” during this amplitude measurement in order to accurately measure the peak-to-peak voltage at each beat note frequency. The typical beat note amplitudes are a little smaller for the ASC version due to the internal four-way power splitter on the LO input. Utilize the typical values dictated by the chassis type under test.

4.7 IQ Amplitude and Phase Balance

When measuring the IF beat note, the I and Q IF outputs should ideally be exactly equal in magnitude, and 90 degrees out of phase. This test measures the deviation from this ideal behavior.

Section 5 of this document has a printout of the settings file for the SR785 Dynamic Signal Analyzer used to perform an I and Q balance measurement. These settings can be restored to the machine by obtaining the machine setup file from the DCC and loading them onto the SR785 via a floppy disk. LIGO Document T1100087 is actually this file.

Once the settings file is loaded into the SR785, apply an LO and RF signal at the frequencies indicated in F1100004. The LO signal level should be 10dBm +/- 0.2dB, and the RF signal level should be 0dBm +/- 0.2dB.

The I/Q amplitude/phase balance measurements are made using the front panel BNC monitoring jacks. These are IF monitors of the I and Q demodulated outputs. Apply the I monitor signal to the SR785 Channel 1, A input. Apply the Q monitor signal to the SR785 Channel 2, A input. Record data as required in F1100004.

4.8 IF Output Noise Spectra

With an LO of 45MHz, 10dBm +/- 0.2dB applied; terminate each of the RF inputs under test in 50 ohms. Measure the IF output noise differentially at the rear panel D-sub output for each channel as required. Record the results in F1100004.

4.9 IF -3dB Bandwidth

Apply a fixed 45MHz RF generator at 0dBm +/- 0.2dB as the front panel RF input, and a variable frequency LO starting at a frequency of 45.001MHz and a fixed level of 10dBm +/- 0.2dB applied to the LO input on the rear of the chassis under test. Use a dual channel oscilloscope with a pair of probes to view the IF beat note differentially on the rear panel D-sub for the channel under test. Increment the LO frequency until a 3dB decrease in the IF beat note is observed. Record the frequency corresponding to the -3dB frequency in F1100004.

5 Appendix

The SR785 Settings associated with the I and Q phase and magnitude balance measurement.

Input	**Ch 1**	**Ch 2**
Source	Analog	Analog
Config	Dual Chan.	Dual Chan.
Mode	A	A
Ground	Float	Float
Coupling	AC	AC
Range	6 dBVpk	6 dBVpk
AA Filter	On	On
A-Wt Filter	Off	Off
Auto Range	Up Only	Up Only
Auto Offset	On	On
EU	Off	Off
EU Label	m/s	m/s
EU/Volt	1 EU/V	1 EU/V

User Label	EU	EU
Tachs/Rev	1	1
Tach Level	0.00 V	0.00 V
Tach Trigger	TTL	TTL
Tach Slope	Rising	Rising
Tach Holdoff	Off	Off
ShowTach	Off	Off
Xdcr Convert	m/s	m/s

Measure	**Display A**	**Display B**
Measurement	Cross Spec.	FFTUsrFn1
View	Phase	Log Mag
Units	deg	dB
dB Units	Off	On
Peak Units	pk	off
PSD Units	Off	Off
Phase Units	deg	deg
dBm Ref	50	50
Base Freq	102.4 kHz	102.4 kHz
Span	400 Hz	400 Hz
Start Freq	9.8 kHz	9.8 kHz
Lines	800	800
Window	BMH	BMH
Force	3.90625 ms	3.90625 ms
Expo	50.00%	50.00%

Average	**Display A**	**Display B**
Comp. Average	Yes	Yes
Type	Exp. / Cont.	Exp. / Cont.
Display	RMS	RMS
Number	20	20
Time Incr	100.00%	100.00%
Reject	Off	Off
Preview	Off	Off
Prv Time	2 s	2 s

Display	**Display A**	**Display B**
Ymax	250	50
Y/div	50	10
Xcenter	2.86479 k	50
X/div polar	572.958	10
Ycenter	2.86479 k	50
Y/div polar	572.958	10
Pan	0	0
Zoom	x1	x1
Format	Dual	Dual
X Axis	Linear	Linear
Grid	On	On

Grid Div	10	10
Grid Type	Rectangular	Rectangular
Phase Suppress	0.00E+00	0.00E+00
d/dx Window	0.5	0.5

Marker	**Display A**	**Display B**
Marker	On	On
Mode	Normal	Normal
Seeks	Mean	Mean
Width	Spot	Spot
Relative	Off	Off
X Relative	Off	Off
X Rel	0	0
Y Rel	0	0
# Harmonics	1	1
Display	Fundamental	Fundamental
Readout	Absolute	Absolute
Sideband Sep	0	0
# Sidebands	10	10
Band Exclude	none	none
Band Ratio	/	/

Waterfall	**Display A**	**Display B**
Wfall Display	Normal	Normal
Wfall Storage	Off	Off
Storage Mode	All	All
Total Count	253	253
Skip	30	30
View Count	10	10
Trace Height	70%	70%
Angle	-26	-26
Fast Angles	Off	Off
Threshold	0%	0%
Hidden Lines	Invisible	Invisible
Paused Draw	Normal	Normal

Source		
Source	0	[0=Off, 1=On]
Type	0	[0=Sine, 1=Chirp, 2=Noise, 3=Arb]
Sine Freq 1	10.24 kHz	
Sine Amp 1	500.0 mVpk	
Sine Freq 2	51.2 kHz	
Sine Amp 2	0.0 mVpk	
Sine Offset	0.0 mV	
Chirp Amp	1000.0 mV	
Chirp Burst	100.00%	
Source Display	Display A	
Noise Amp	1000.0 mV	

Noise Type	BL White	
Noise Burst	100.00%	
Arb Amp	100.00%	
Arb Rate	262.1 kHz	
Arb Source	Arb. Buffer	
Arb Start	0	
Arb Length	4 kPts	

Trigger		
Arming Mode	Auto Arm	
Trigger Source	Cont	
Trigger Level	0%	
Trigger Slope	Rising	
Delay1	0 s	
Delay2	0 s	
Source Mode	Continuous	
Start RPM	Off	
Start RPM	50	
Delta RPM	Abs. Change	
Delta RPM	10	
Time Step	100 ms	

Capture		
Capt Channels	Ch1+Ch2	
Capt Mode	1 Shot	
Capt Length	2024 kPts/ch	
Capt Rate	262.1 kHz	
Auto Pan	On	
Playback Start	0	
Playback Len	2024 kPts/ch	
Playback Mode	1-Shot	
Playback Speed	Normal	

Memory		
Capt Memory	2025 Blks	
Wfall Memory	2024 Blks	
Arb Memory	2 Blks	

System		
Output To	RS232	
GPIB Address	10	
Overide REM	Yes	
Baud Rate	9600 bd	
Word Length	8 bits	
Parity	None	
Key Click	Off	
Alarms	On	
Alarm Vol	Noisy	

Done Vol	Noisy	
Audible Ovld	On	
Screen Saver	On	
Saver Delay	10 m	
Freq Format	Exact Bin	
Node Info	No	

Output		
Print Screen Key	ASCII Dump	
Printer Type	PCX 8 bit	
Bitmap Area	Graphs	
Plotter Type	PostScript	
Destination	Disk File	
GPIB Control	SR785	
Plotter Address	2	
Print Bright	12%	
Print Dim	White	
Print Black	Black	
Print Graph	Black on White	
Text Pen	1	
Grid Pen	1	
Trace Pen	1	
Marker Pen	1	