LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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Test Procedure for RF AM detector

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1 Introduction

The following Test Procedure describes the test of proper operation of the RFAM measurement unit. This unit utilizes the same technology as the AM stabilized EOM/AOM driver. Further information can be found on the wiki page.

S/N ____________________ Tester ______________ Date __________________

2 Test Equipment

- Voltmeter
- Oscilloscope
- Stanford Research SR785 analyzer
- RF Network Analyzer (Agilent AG4395A or equivalent)
- RF Spectrum Analyzer (Agilent AG4395A is OK)
- RF function generator with AM modulation (e.g. Stanford Research DS345)
- Mini-circuits power splitter (BNC or SMA connector type)
- RF Power Meter (Agilent E4418A, Gigatronics 3410A, or similar)
- DB9 breakout board
- Two dual bench power supply (for +/–31Volts, +/– 17 Volts)
- Diagrams / Board Schematics, LIGO D0900891, D0900761, D0900848

3 Terminology

The left and right RF inputs are called Input A and Input B, respectively. The left MON and BIAS monitors are called MON A and BIAS A in this document. Note that they are noted as MON2 and BIAS2 in the schematic. Similarly, the right MON and BIAS monitors are called MON B and BIAS B. They are MON1 and BIAS1 in the schematic.

4 Tests

The RFAM measurement uses the RF AM Stabilization Power (D0900848, rev A) with the RF AM Stabilization Controller (D0900761, rev A). This test procedure assumes that the modification to fix the power supply issues are already applied. Details are found in: http://nodus.ligo.caltech.edu:8080/OMC_Lab/231 *and* http://nodus.ligo.caltech.edu:8080/OMC_Lab/234.

Power Supply Test

1) Verify the proper current draw:

Use a bench DC supplies to apply +/–31 Volts and +/–17 Volts to P1 of the *RF AM Stabilization Power (D0900848) at the front panel*. Measure the current draw of the box.

Supply	With RF output SW "OFF"	
Voltage	**Current**	**Nominal**
+31V	________	0.06A
-31V	________	0.05A
+17V	________	0.17A
-17V	________	0.12A

2) Verify the internal supply voltages:

On the power board: check the voltage between TP 1 (GND) and the following test points.

Test Point	Nominal V	Measurement	Test Point	Nominal V	Measurement
TP12	-5V	________	TP2	+31V	________
TP11	-15V	________	TP3	+17V	________
TP10	-23.7V	________	TP8	+10V	________
TP9	-10V	________	TP16	+28V	________
TP5	-17V	________	TP13	+23.7V	________
TP6	-31V	________	TP14	+15V	________
			TP15	+5V	________

On the control board: check the voltage between TP22 or TP23 (GND) and the following test points.

Test Point	Nominal V	Measurement	Test Point	Nominal V	Measurement
TP16	-5V	________	TP17	+5V	________
TP18	-15V	________	TP19	+15V	________
TP20	-23.7V	________	TP21	+23.7V	________
			TP4	+3.3V	________
			TP5	+1.8V	________

3) Verify supply OK logic:

Turn off the external power supply. Disconnect the power supply connector from the front panel. Remove the front panel. Remove the top board (D0900761) from the inter PCB connector. Expose the D0900848 board. Make sure two boards have proper electrical isolation from the chassis or other conductive material. Connect and turn on the power supply again. If above TP 5, 6, 2, and 3 are correct then pin 5 on U1 and U4, which are connected to R22 and R23, should be

Logic high ~3Volts. Confirm ____________________

Gradually reduce one of the supply voltages and record the threshold voltage to cause the transition of the "OK" voltage from high to low. Restore the reduced voltage to the nominal one, and repeat the test for all the supply voltages.

Voltage Supply	Threshold [V]	Nominal [V]
+31V	__________	+27.5
-31V	__________	-25.2
+17V	__________	+15.2
-17V	__________	-15.4

4) Verify noise levels of the internal power supply voltages:

Turn off and disconnect the power supplies from the front panel connector. Restore the control board and the front panel. Reconnect and turn on the power supplies. Measure the noise levels of the following test points with an FFT analyzer. Note that the noise on the following test points should be measured with the unit of Vrms/rtHz.

TP12 noise ____________________ less than 35 nVrms/sqrt Hz at 140 Hz

TP11 noise ____________________ less than 25 nVrms/sqrt Hz at 140 Hz

TP10 noise ____________________ less than 40 nVrms/sqrt Hz at 140 Hz

TP9 noise ____________________ less than 15 nVrms/sqrt Hz at 140 Hz.

TP8 noise ____________________ less than 10 nVrms/sqrt Hz at 140 Hz.

TP16 noise ____________________ less than 30 nVrms/sqrt Hz at 140 Hz.

TP13 noise ____________________ less than 30 nVrms/sqrt Hz at 140 Hz.

TP14 noise ____________________ less than 15 nVrms/sqrt Hz at 140 Hz.

TP15 noise ____________________ less than 15 nVrms/sqrt Hz at 140 Hz.

RF Test

5) Test power select switch

Rotate power select switches from 0dBm to 22dBm and 0dBm to 2.2dBm. Check if Bias B monotonically varies from ~0.5V to 10V along with the power setting.

Confirm ___________

6) Input calibration:

Connect the RF function generator to Input B. The frequency of the signal should be 9.1MHz or 45.5MHz. The output power of the function generator has to be calibrated by the power meter to be 13dBm. Turn the power selector to be 13dBm.

Connect Mon B to the oscilloscope. Rotate calibration trimmer until Mon B voltage becomes as close to zero as possible.

Confirm ___________

7) Check the power calibration:

Keep the function generator connected to Input B. Set fine power select switch to be 0dBm. Scan coarse power select switch from 0dBm to 22dBm while adjusting the function generator output to realize Mon B to be zero volt. Record the actual power of the function generator using the RF power meter.

Setting (dBm)	**Measurement (dBm)**	**Nominal (dBm)**
0.0	________	0.0+/-0.3
2.0	________	2.0+/-0.3
4.0	________	4.0+/-0.3
6.0	________	6.0+/-0.3
8.0	________	8.0+/-0.3
10.0	________	10.0+/-0.3
12.0	________	12.0+/-0.3
14.0	________	14.0+/-0.3
16.0	________	16.0+/-0.3
18.0	________	18.0+/-0.3
20.0	________	20.0+/-0.3
22.0	________	22.0+/-0.3

Set the coarse power select to 0dBm, 10dBm, 22dBm and scan the fine adjustment from 0.4dBm to 2.0dBm with 0.4dBm increment. For each setting, adjust the function generator power setting to have zero voltage at Mon B. Record the RF output power with the power meter.

0dBm			10dBm			22dBm		
Setting (dBm)	Measurement (dBm)	Nominal (dBm)	Setting (dBm)	Measurement (dBm)	Nominal (dBm)	Setting (dBm)	Measurement (dBm)	Nominal (dBm)
+0.4	________	0.4+/-0.3	+10.4	________	10.4+/-0.3	+0.4	________	22.4+/-0.3
+0.8	________	0.8+/-0.3	+10.8	________	10.8+/-0.3	+0.8	________	22.8+/-0.3
+1.2	________	1.2+/-0.3	+11.2	________	11.2+/-0.3	+1.2	________	23.2+/-0.3
+1.6	________	1.6+/-0.3	+11.6	________	11.6+/-0.3	+1.6	________	23.6+/-0.3
+2.0	________	2.0+/-0.3	+12.0	________	12.0+/-0.3	+2.0	________	24.0+/-0.3

Stability Test

8) MON signal calibration:

Split the function generator output with the power splitter. Adjust and confirm the split output power is about 10dBm each. Keep the RF output connected to the power meter. Set the output level at 10dBm. Turn on the AM modulation with the modulation amplitude and frequency of 1% and 1kHz. The modulation amplitude is not necessary to be precise.

Adjust the power select switch to have MON B voltage as small as possible.

Check the signal amplitude of the MON A and MON B at 1kHz using SR785. Note: PSD Unit (/rtHz) should be turned **off** when reading the numbers.

Channel	Measurement [Vrms]
MON A	________(8A)
MON B	________(8B)

9) Calibration 2

Keep the above excitation setting. Reconnect the function generator to the RF spectrum analyzer. Measure the peak height of the carrier power and upper and lower sideband power (+/-1kHz offset from the carrier).

Signal	Measurement [dBm]
Carrier	________(9A)
Upper Sideband	________(9B)
Lower Sideband	________(9C)

10) Power Spectral Density and coherence

Now turn off the AM modulation of the source. Measure power spectral density of the following signals at the listed frequencies with SR785. Note: PSD Unit (/rtHz) should be turned **on** when reading the numbers.

	Measurement [V/rtHz]			
Channel	**10Hz**	**100Hz**	**1kHz**	**10kHz**
MONB	________(10A)	________(10B)	________(10C)	________(10D)
MONA	________(10E)	________(10F)	________(10G)	________(10H)

Keep the above setting. Change the measurement item of SR785 to coherence. Measure coherence of MON1 and MON2 at the following frequencies.

	Coherence			
Channel	**10Hz**	**100Hz**	**1kHz**	**10kHz**
MON A, MON B	________(10I)	________(10J)	________(10K)	________(10L)

11) Calibration ~ Calculation

Copy numbers from above calibration measurements and fill the blanks. Confirm the final numbers if they fulfill the requirements

Carrier Sideband ratio

R_{dBc} = (________(9B) + ________(9C)) /2 – ________(9A) = ________ [dBc(SSB)]

R = 10^(R_{dBc} / 20) = ________

Calibrations of the monitor channels

cal_{MONB} = ________(10B) / R = ________ [Vrms] (per Carrier Sideband Ratio)

cal_{MONA} = ________(10A) / R = ________ [Vrms] (per Carrier Sideband Ratio)

Calibrated power spectral densities

MON B

10Hz: ______(11A) / cal_{MONB} = ______ [1/rtHz]

100Hz: ______(11B) / cal_{MONB} = ______ [1/rtHz]

1kHz: ______(11C) / cal_{MONB} = ______ [1/rtHz]

10kHz: ______(11D) / cal_{MONB} = ______ [1/rtHz]

MON A

10Hz: ______(11E) / cal_{MONA} = ______ [1/rtHz]

100Hz: ______(11F) / cal_{MONA} = ______ [1/rtHz]

1kHz: ______(11G) / cal_{MONA} = ______ [1/rtHz]

10kHz: ______(11H) / cal_{MONA} = ______ [1/rtHz]

These should agree within ~50%. Confirm ________

Noise level estimate

10Hz: 20 $\log_{10}${______$_{(11A)}$ / cal_{MONB} * Sqrt[1−Sqrt(______$_{(11I)}$)]}
= ______ [$dBc_{(SSB)}$/Hz] … less than −175 $dBc_{(SSB)}$/Hz

100Hz: 20 $\log_{10}${______$_{(11B)}$ / cal_{MONB} * Sqrt[1−Sqrt(______$_{(11J)}$)]}
= ______ [$dBc_{(SSB)}$/Hz] … less than −175 $dBc_{(SSB)}$/Hz

1kHz: 20 $\log_{10}${______$_{(11C)}$ / cal_{MONB} * Sqrt[1−Sqrt(______$_{(11K)}$)]}
= ______ [$dBc_{(SSB)}$/Hz] … less than −170 $dBc_{(SSB)}$/Hz

10kHz: 20 $\log_{10}${______$_{(11D)}$ / cal_{MONB} * Sqrt[1−Sqrt(______$_{(11L)}$)]}
= ______ [$dBc_{(SSB)}$/Hz] … less than −150 $dBc_{(SSB)}$/Hz

DAQ channel Test

12) Check functionality of the DAQ port

Measure the transfer functions between the following ports with SR785 with no excitation injected. The two pins of the DAQ port signals should be measured differentially: Use "A-B" input mode of the SR785. Connect two signal clips to the SR785 inputs and clip the signals with the positive clips.

Transfer Function			
From (BNC Port)	**To (DAQ DSUB Port)**	**Measurement**	**Nominal Gains**
MON B	Pin1(+) and Pin6 (-)	________________	1
N/A	Pin2(+) and Pin7 (-)	N/A	N/A
MON A	Pin3(+) and Pin8 (-)	________________	1
BIAS A	Pin4(+) and Pin9 (-)	________________	1