LIGO Laboratory / LIGO Scientific Collaboration

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Test Procedure for EOM/AOM Driver

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1 Introduction

The following Test Procedure describes the test of proper operation of the EOM/AOM Drive. **The RF output port 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
- Oscilloscope
- Stanford Research SR785 analyzer
- RF Network Analyzer (Agilent AG4395A or equivalent)
- RF Spectrum Analyzer (Agilent AG4395A is OK)
- RF function generator (Tektronix AFG3101, or equivalent)
- AF function generator (Stanford Research DS335/340/345 or similar)
- RF Power Meter (Agilent E4418A, Gigatronics 3410A, or similar)
- D1500091 EtherCAT EOM Driver Test Rig with DB25 Male/Male cable
- DB9 breakout board
- Two dual bench power supply (for +/–24Volts, +/– 18 Volts)
- Single bench power supply (for +5V)
- Diagrams / Board Schematics, LIGO D0900760, D0900761, D0900847, D0900848

3 Tests

The EOM/AOM Driver uses the RF AM Stabilization Power (D0900848, rev B) with the RF AM Stabilization Controller (D0900761, rev B) and RF AM Stabilization Servo (D0900847, rev B).

Power Supply Test

1) **Verify the proper current draw with the output switch off:**

   Turn off the excitation (left) and output (right) switches. Using a bench DC supply apply +/–24Volts and +/– 18 Volts to P1 of the *RF AM Stabilization Power (D0900848) at the front panel*. Measure the current draw of the box. **Confirm the RF output port is terminated.** Turn on the output switch and measure the current draw of the box.

Supply	With RF output SW "OFF"		With RF output SW "ON"	
Voltage	Current	Nominal	Current	Nominal
+24V	__________	0.08A	__________	0.53A
-24V	__________	0.07A	__________	0.07A
+18V	__________	0.29A	__________	0.21A
-18V	__________	0.24A	__________	0.26A

2) **Verify the internal supply voltages:**

On the 2nd PCB of 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
TP13	-5V	__________	TP2	+24V	__________
TP12	-15V	__________	TP3	+18V	__________
TP11	-21V	__________	TP9	+10V	__________
TP10	-10V	__________	TP17	+24V	__________
TP5	-18V	__________	TP14	+21V	__________
TP6	-24V	__________	TP15	+15V	__________
			TP16	+5V	__________

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 two board 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 should be

Logic high ~3Volts. **Confirm.____________________**

4) **Verify the relays for the power supply sequencing:**

Turn off +/-24 V. Confirm Pin 5 of K1 and K2 are not energized to +/-18V.

Confirm __________

Turn on +/-24 V again. Confirm Pin 5 of K1 and K2 are now energized to +/-18V.

Confirm __________

5) **Verify noise levels of the internal power supply voltages:**

Turn off +/-24 V. Disconnect the power supply from the front panel connector. Restore the two boards and the front panel. The noise on the following test points should be measured with a SR785 using an rms power spectrum.

TP13 noise ____________________ less than 15 nVrms/sqrt Hz at 140 Hz

TP12 noise ____________________ less than 30 nVrms/sqrt Hz at 140 Hz

TP11 noise ____________________ less than 40 nVrms/sqrt Hz at 140 Hz

TP10 noise ____________________ less than 20 nVrms/sqrt Hz at 140 Hz.

TP9 noise ____________________ less than 20 nVrms/sqrt Hz at 140 Hz.

TP14 noise ____________________ less than 30 nVrms/sqrt Hz at 140 Hz.

TP15 noise ____________________ less than 20 nVrms/sqrt Hz at 140 Hz.

TP16 noise ____________________ less than 15 nVrms/sqrt Hz at 140 Hz.

RF Test

6) **Recognize the target RF frequency of the unit**

Check the center frequency of Lark Engineering bandpass filter (U11 of D0900760 Rev B)

Center frequency ___________MHz

7) **Test output switch functionality:**

Make sure the output switch is off. Connect the RF function generator to the input connector. Provide the RF signal at the center frequency at the power level of 10dBm. Connect the RF power monitor to the output connector. Set the output adjustment switches to have 13dBm output (i.e. 12dBm & 1.0dBm)

Confirm there is no output at this point.

Confirm ___________

Turn on the output switch. Confirm there is the RF output about 13dBm.

Confirm ___________

8) **Check stabilization servo stability:**

Turn off the RF output switch and connect the output to the oscilloscope with a 50 Ohm terminator. Turn the RF output again. Confirm the waveform is sinusoidal and there is no obvious amplitude oscillation.

Confirm ___________

Observe the TP1 signal with the oscilloscope and SR785. Confirm there is no oscillation.

Confirm ___________

Observe the CTRL signal with the oscilloscope and SR785. Confirm there is no oscillation.

Confirm ___________

9) **Check exc port functionality:**

Observe the TP1 signal with the oscilloscope. Connect 1kHz 2Vpk signal from the audio frequency function generator to the exc port.

Turn off the exc switch and confirm there is no obvious 1kHz component on the TP1 signal.

Confirm ___________

Turn on the exc switch and confirm there is visible 1kHz component on the TP1 signal.

Confirm ___________

10) **Openloop transfer function measurement:**

Connect TP1 and TP2 to ChA and ChB of the network analyzer, respectively. Connect the signal generator output of the network analyzer to Exc. Turn on the exc switch.

Sweep the signal of 0dBm from 1kHz to 2MHz (801 line).

Measure the transfer function and check the frequency where the magnitude is 0dB (i.e. UGF: unity gain frequency). Check the phase at the UGF (i.e. P.M.: phase margin). Confirm the UGF is above 100kHz and the phase is more than 30deg.

Unity Gain Frequency ___________ (80~100kHz nom)

Phase Margin ___________ (>60deg nom)

11) **Output calibration:**

Turn off the output switch. Connect the output to the power meter. Turn on the output switch again. The power adjustment is set to be 13dBm (12dBm+1dBm). Rotate the trimmer R6 on the front panel until the output becomes 13.00dBm+/-0.01dBm.

Confirm ___________

12) Check the output power with other output values:

Set the power adjustment to 4dBm+0dBm. Measure and record the RF output power with the power meter, while sweeping the output from 4+0dBm to 26+0dBm.

Setting (dBm)	Measurement (dBm)	Nominal (dBm)
4.0	________	4.0+/-0.1
6.0	________	6.0+/-0.1
8.0	________	8.0+/-0.1
10.0	________	10.0+/-0.1
12.0	________	12.0+/-0.1
14.0	________	14.0+/-0.1
16.0	________	16.0+/-0.1
18.0	________	18.0+/-0.1
20.0	________	20.0+/-0.1
22.0	________	22.0+/-0.1
24.0	________	>23.5
26.0	________	>24.0

Set the coarse power adjustment to 4dBm, 16dBm, 22dBm and scan the fine adjustment from 0dBm to 2.2dBm. For each scan, measure and record the RF output power with the power meter.

4dBm			16dBm			26dBm		
Setting (dBm)	Measurement (dBm)	Nominal (dBm)	Setting (dBm)	Measurement (dBm)	Nominal (dBm)	Setting (dBm)	Measurement (dBm)	Nominal (dBm)
+0.0	________	4.0+/-0.1	+0.0	________	16.0+/-0.1	+0.0	________	>24.5
+0.2	________	4.2+/-0.1	+0.2	________	16.2+/-0.1	+0.2	________	>24.5
+0.4	________	4.4+/-0.1	+0.4	________	16.4+/-0.1	+0.4	________	>24.5
+0.6	________	4.6+/-0.1	+0.6	________	16.6+/-0.1	+0.6	________	>24.5
+0.8	________	4.8+/-0.1	+0.8	________	16.8+/-0.1	+0.8	________	>24.5
+1.0	________	5.0+/-0.1	+1.0	________	17.0+/-0.1	+1.0	________	>24.5
+1.2	________	5.2+/-0.1	+1.2	________	17.2+/-0.1	+1.2	________	>24.5
+1.4	________	5.4+/-0.1	+1.4	________	17.4+/-0.1	+1.4	________	~4.0
+1.6	________	5.6+/-0.1	+1.6	________	17.6+/-0.1	+1.6	________	~4.0
+1.8	________	5.8+/-0.1	+1.8	________	17.8+/-0.1	+1.8	________	~4.0
+2.0	________	6.0+/-0.1	+2.0	________	18.0+/-0.1	+2.0	________	~4.0
+2.2	________	6.2+/-0.1	+2.2	________	18.2+/-0.1	+2.2	________	~4.0

Stabilization Test

13) Check monitor values:

Keep the RF output connected to the power meter. Set the output level at 13dBm.
Check voltage values of the monitor channels with the voltage meter.

Note: BIAS1 and MON1 are located at the right half of the top monitor BNC connectors. BIAS2 and MON2 are at the left half.

Channel	Measurement	Nominal
CTRL	________	~3V
BIAS1	________	1.7~1.8V
MON1	________	< +/-15mV
BIAS2	________	1.7~1.8V
MON2	________	< +/-15mV

14) Closed loop transfer function of the internal loop for the 2nd RFAM detector

Keep 13dBm output of the unit on the power meter. Connect the signal generator of SR785 to the exc port and inject 5Vpk random noise. Set the frequency range upto 25Hz and 800lines. Turn on the exc switch. Measure the transfer function from MON1 to MON2.

Confirm the transfer function is 0 dB +/- 0.5 dB above 10Hz.

Confirm ___________

15) Power Spectral Density

Keep 13dBm output of the unit on the power meter. Make sure that the exc switch is off and the signal generator of SR785 is disconnected from the exc port. Measure power spectral density of the following signals at the listed frequencies. Note: RMS and PSD Unit should be turned **on** when reading the numbers in order to set the measurement unit to be Vrms/rtHz.

	Measurement [Vrms/rtHz]			
Channel	**10Hz**	**100Hz**	**1kHz**	**10kHz**
CTRL	________	________	________	________
BIAS1	________	________	________	________
MON1	________(15A)	________(15B)	________(15C)	________(15D)
BIAS2	________	________	________	________
MON2	________(15E)	________(15F)	________(15G)	________(15H)

16) Calibration 1

Keep 13dBm output of the unit on the power meter. Connect the signal generator of SR785 to the exc port and inject 5Vpk 1kHz sinusoidal signal. Turn on the exc switch. Check the signal amplitude of the following ports at 1kHz. Note: PSD Unit (/rtHz) should be turned **off** when reading the numbers.

Channel	Measurement [mVrms]	Nominal
CTRL	____________	~3mVrms
MON1	_________(16A)	~700mVrms
MON2	_________(16B)	~700mVrms

17) Calibration 2

Keep the above excitation setting. Turn off the output switch and connect the output to the spectrum analyzer. Turn on the output switch again. Measure the peak height of the carrier power at the center frequency and sideband power at +/-1kHz from the center frequency.

Signal	Measurement [dBm]
Carrier	_________(17A)
Upper Sideband	_________(17B)
Lower Sideband	_________(17C)

18) 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} = (_________(17B) + _________(17C)) /2 – _________(17A) = _________ [dBc(SSB)]

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

Calibrations of the monitor channels

cal_{MON1} = _________(16A) / R = _________ [Vrms] (per Carrier Sideband Ratio)
cal_{MON2} = _________(16B) / R = _________ [Vrms] (per Carrier Sideband Ratio)

Calibrated power spectral densities

MON1 (In-loop)

10Hz: $20*\log_{10}$(______(15A) / cal_{MON1}) = ______ [dBc(SSB)/Hz], less than 155dBc/Hz

100Hz: $20*\log_{10}$(______(15B) / cal_{MON1}) = ______ [dBc(SSB)/Hz], less than 165dBc/Hz

1kHz: $20*\log_{10}$(______(15C) / cal_{MON1}) = ______ [dBc(SSB)/Hz], less than 165dBc/Hz

10kHz: $20*\log_{10}$(______(15D) / cal_{MON1}) = ______ [dBc(SSB)/Hz], less than 165dBc/Hz

MON2 (Out-of-loop)

10Hz: $20*\log_{10}$(______(15E) / cal_{MON2}) = ______ [dBc(SSB)/Hz], less than 155dBc/Hz

100Hz: $20*\log_{10}$(______(15F) / cal_{MON2}) = ______ [dBc(SSB)/Hz], less than 165dBc/Hz

1kHz: $20*\log_{10}$(______(15G) / cal_{MON2}) = ______ [dBc(SSB)/Hz], less than 165dBc/Hz

10kHz: $20*\log_{10}$(______(15H) / cal_{MON2}) = ______ [dBc(SSB)/Hz], less than 165dBc/Hz

<u>DAQ channel Test</u>

19) 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
MON1	Pin1(+) and Pin6 (-)	________________	20
CTRL	Pin2(+) and Pin7 (-)	________________	2 (f<1Hz), 100 (f>1kHz)
MON2	Pin3(+) and Pin8 (-)	________________	20
BIAS2	Pin4(+) and Pin9 (-)	________________	2

Test with Remote Control Rig

20) **Check indicators of EtherCAT EOM Driver Test Rig**

Continue to use the 13dBm output setting.

Turn off the exc and output switches. Make sure the Int/Ext switch on the main unit is at "Int". Connect the test rig to the control connector with a DB25 M/M cable.

Make sure the Latch switch on the test rig is at "Dis".

Toggle the Int/Ext switch on the main unit. Confirm the indicator "Int" on the test rig correctly shows the state. **Confirm ___________**

Turn the Int/Ext switch on the main unit to "Ext".

Toggle the RF output switch on the main unit. Confirm the indicator "RF" on the test rig correctly shows the state. **Confirm ___________**

Make sure the exc switch is off. Toggle the Exc Enable on and off. Confirm the indicator "Exc Readback" on the test rig correctly shows the state. **Confirm ___________**

21) Power setting test

Turn off the RF output switch on the main unit. Connect the power meter to the RF output port. Then turn on the RF output switch. Turn off (up) all the value switches.

Turn the Latch switch on the test rig to the "En (Enable)" position.

Make sure the RF output power is now about 4dBm

Confirm ___________

Measure the RF output while turning on the switches one by one. (i.e. Only one switch is on at a time). Note: The panel marking (+1dB, +2dB, …) is obsolete and they should be scaled by a factor of 0.2. (i.e. +1dB = +0.2dB, +2dB = +0.4dB, and so on)

Switch	Measurement	Nominal [dBm]
+1dB on	________________	4.2+/-0.1
+2dB on	________________	4.4+/-0.1
+4dB on	________________	4.8+/-0.1
+8dB on	________________	5.6+/-0.1
+16dB on	________________	7.2+/-0.1
+32dB on	________________	10.4+/-0.1
+64dB on	________________	16.8+/-0.1
+128dB on	________________	~4.0

22) Test on the signals via the test rig

Turn on the +1, +4, +8, and +32dB switches on the test rig. This should yield the output of 13dBm. Measure the transfer functions between the following ports with SR785.

Transfer Function			
From (BNC Port)	**To (TEST RIG Port)**	**Measurement**	**Nominal Gains**
BIAS1	BIAS1	________________	1
BIAS2	BIAS2	________________	1
CTRL	CTRL	________________	Bandpass shape top 15.4dB@45Hz

Change History

V1 (July 25, 2015): The initial version

V2 (Aug 30, 2015): Updated the dBc/Hz calibration procedure

V3 (Sep 6, 2015): Reflected the change due to the modification E1500353

V4 (Jan 15, 2016): Test 3: Power supply "OK" is now checked with TP8