LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-E1200140-v2 *LIGO* 12/04/2012

Test Procedure for ALS Fiber Distribution

Alexa Staley, Bram Slagmolen, Max Factourovich

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1 Testing information

BOARD SERIAL S1202528

TEST DATE 2012.12.03

TESTING RESULT: **PASSED** **FAILED**

2 Introduction

The following Test Procedure describes the test of proper operation of the ALS fiber distribution. The RF amplifier should always be connected to an output before supplying power. Further information can be found on the wiki page.

3 Test Equipment

1. Voltmeter
2. 9kHz – 1.2Ghz Signal Generator
3. EPM Series Power Meter (N1914A)
4. 10dBm BNC to SMA attenuator
5. RF Cable Hand Formable SMA
6. Oz optics fiber-coupled laser (OZ-2000-1064-6/125-S-40-3A-3-1-10)
7. OPHIR Vega Laser Power Monitor
8. ThorLabs Fiber Cable APC
9. 25-Pin cable
10. VCO Tester D1100545-v1
11. Current Source
12. Stanford Research Systems model SR785 Spectrum Analyzer
13. Board Schematics, LIGO D1200136-v1

4 Tests

The ALS Fiber Distribution uses the Low Noise Power Module (D0901846, rev D) with the RF Distribution Amplifier Interface (D1000064, rev A).

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 and fill in the table below.

TEST POINT:	+24 V	– 24 V	+ 17 V	– 17 V
Nominal current (A):	<1	~ 0	< 1	~ 0
Measured current (A):	0.89	0.02	0.14	0.04

2) On the low noise power module check the voltage on TP 1-13.

TP1 (+17V)	+17.2	TP2 (–17V)	-17.0
TP3, 4 (GND)	<0.02	TP5 (+5V)	+5.1
TP6 (–15V)	-15.0	TP7 (+24V)	+24.0
TP8 (GND)	<0.02	TP9 (–24V)	-24.1
TP10 (GND)	<0.02	TP11 (+15V)	+15.0
TP12 (+VREF)	+10.0	TP13 (–VREF)	-10.0

3) If TP 1 , 2, 7 , 9 and 8 are correct then pin 5 on U1 and U7, (OK, TP14) should be logic HIGH ~3Volts. Confirm: +3.6V

4) The noise on TP 12, 13, 11 and 6 should be measured with a SR785 using RMS power spectrum. Fill in the table below with noise readings at ~144Hz.

TEST POINT:	TP12	TP13	TP11	TP6
Nominal noise, $nV_{RMS}/\sqrt{Hz}$:	<20	< 20	< 20	~ 30
Measured noise, $nV_{RMS}/\sqrt{Hz}$:	~9	~12	~10	~19

5) Measure the External Monitor and output voltage M3 (back panel and through controls channel via VCO tester).

a. Using the onboard DIP switch, set the Gain to 30dB;

b. Connect the External PD Input BNC on front panel to GND via 100kΩ resistor.

Input Current (µA)	External Monitor (V)	M3 Back Panel (V)	M3 VCO Tester (V)	Expected M3 (V)	Expected M3 VCO (V)
50	3.13	3.13	12.6	3	12

Nominal Gain for VCO: ~4 **Expected Gain: 4**

6) Ensure the "OK" LED on VCO tester lights up when power is supplied.

Confirm: YES

7) Measure the noise spectrum at the internal and external monitor.

Internal Monitor noise 103 less than 200 $nV_{RMS}/\sqrt{Hz}$ at 144 Hz

External Monitor noise 85 less than 20 $nV_{RMS}/\sqrt{Hz}$ at 144 Hz

8) Test the power from the <u>internal</u> RF coupler output (net S3, unit B4 on page 1 of D1200136) to the AOM. Measure the output voltage M1 through the RF detector and the output voltage M1 through the controls output channel with the VCO tester.

- **a. Use the signal generator (2) at 158.8MHz with RF power as in column 1.**
- **b. Set the signal generator (2) RF power to 0dBm. Connect the power meter (3) and the attenuator (4) to the signal generator. Adjust the offset to read 0dBm (nominal offset: +11.4dBm).**
- **c. Connect the power meter (3) and attenuator (4) to coupler.**
- **d. Connect signal generator (2) output to chassis "AOM Input" on front panel.**
- **e. Connect the VCO tester (10) with 25-pin cable (9) to the rear of the chassis.**

NOTE: Run test concurrently with step #6.

Signal Gen. output power (dBm)	Coupler OUT to AOM (dBm)	Expected RF Power (dBm)	M1 Back Panel (Volts)	M1 VCO tester (Volts)	Expected M1 (Volts)
0	22.0	**22**	1.00	4.03	**1.000**
1	22.9	**23**	0.97	3.93	**0.975**
2	23.8	**24**	0.95	3.83	**0.950**
3	24.8	**25**	0.92	3.73	**0.925**
4	25.7	**26**	0.90	3.63	**0.900**
5	26.6	**27**	0.87	3.52	**0.875**
6	27.5	**28**	0.85	3.42	**0.850**
7	28.3	**29**	0.82	3.32	**0.825**
8	29.2	**30**	0.80	3.21	**0.800**
9	30.1	**31**	0.77	3.11	**0.775**
10	30.9	**32**	0.75	3.02	**0.750**
11	31.8	**33**	0.72	2.92	**0.725**

Deviation from expected: ±2dB and ±0.1V, respectively.

Nominal Slope (mV/dBm): -27 Expected Slope: -25mV/dBm

Nominal Gain: 4 Expected Gain: 4

Nominal Offest (Volts): 1 Expected Offset (Volts): 1V

9) Measure Temperature Monitor 1 on VCO tester (10).

Temp. Mon 1 (Volts): 5.49

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10) Measure the optical power out of X-arm with the PSL input at 5mW, while varying the AOM RF drive power at 158.8MHz.

a. Use fiber-coupled laser (6) and adjust the knob to carry 5mW.

b. Use the power meter to measure the coupling efficiency through the PSL coupling:

Power from the laser (mW): 5.0

Power through PSL coupling (mW): 4.3

PSL coupling efficiency (%): 86

c. Use optical power monitor (7) to measure the output powers.

AOM Drive Power (dBm)	Observed X-arm Power (µW)
0	100
1	120
2	150
3	180
4	210
5	250

AOM Drive Power (dBm)	Observed X-arm Power (µW)
6	300
7	340
8	370
9	400
10	410
11	400

11) Measure power from sample, X-arm, Y-arm, and squeezer with PSL input set at nominal 5mW. Drive the Input with 158.8MHz signal at +10.0dBm.

a. Use fiber-coupled laser (6) and adjust the knob to carry 5mW.

b. Use optical power monitor (7) to measure to output power.

	Sample	X-arm	Y-arm	Squeezer
Power (mW):	0.54	0.41	0.36	0.33
Ratio:	11%	8.2%	7.2%	6.6%
Expected:	20%	5%	5%	5%

12) Measure the voltage output from M2 (back panel and through controls channel via VCO tester) and Int. Mon (TNC front panel) with various PSL input powers.

a. Use fiber-coupled laser (6) and adjust the knob to carry the output powers.

b. Use optical power monitor (7) to measure to output power (at each power setting).

c. Set trans-impedance to 100kΩ by setting the gain to its maximum level (30dB).

PSL Input (mW)	M2 Back Panel (V)	M2 VCO Tester (V)	Internal Monitor (V)	Expected M2 VCO (V)	Expected Int. Mon (V)
2	0.12	0.50	0.12	0.48	0.12
4	0.23	0.94	0.23	0.96	0.24
6	0.35	1.47	0.36	1.44	0.36
8	0.51	2.06	0.50	1.92	0.48
10	0.63	2.55	0.63	2.40	0.60
10.5	0.64	2.58	0.65	2.46	0.63

Nominal Gain for VCO: 4 **Expected Gain: 4**

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1 Testing information

BOARD SERIAL S1202529

TEST DATE 2012.12.03

TESTING RESULT: **PASSED** ◉ **FAILED** ○

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2 Introduction

The following Test Procedure describes the test of proper operation of the ALS fiber distribution. The RF amplifier should always be connected to an output before supplying power. Further information can be found on the wiki page.

3 Test Equipment

1. Voltmeter
2. 9kHz – 1.2Ghz Signal Generator
3. EPM Series Power Meter (N1914A)
4. 10dBm BNC to SMA attenuator
5. RF Cable Hand Formable SMA
6. Oz optics fiber-coupled laser (OZ-2000-1064-6/125-S-40-3A-3-1-10)
7. OPHIR Vega Laser Power Monitor
8. ThorLabs Fiber Cable APC
9. 25-Pin cable
10. VCO Tester D1100545-v1
11. Current Source
12. Stanford Research Systems model SR785 Spectrum Analyzer
13. Board Schematics, LIGO D1200136-v1

4 Tests

The ALS Fiber Distribution uses the Low Noise Power Module (D0901846, rev D) with the RF Distribution Amplifier Interface (D1000064, rev A).

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 and fill in the table below.

TEST POINT:	+24 V	– 24 V	+ 17 V	– 17 V
Nominal current (A):	<1	~ 0	< 1	~ 0
Measured current (A):	0.89	0.02	0.13	0.04

2) On the low noise power module check the voltage on TP 1-13.

TP1 (+17V)	+17.2	TP2 (–17V)	-17.1
TP3, 4 (GND)	<0.02	TP5 (+5V)	+5.1
TP6 (–15V)	-15.0	TP7 (+24V)	+24.0
TP8 (GND)	<0.02	TP9 (–24V)	-24.1
TP10 (GND)	<0.02	TP11 (+15V)	+15.0
TP12 (+VREF)	10.0	TP13 (–VREF)	-10.0

3) If TP 1 , 2, 7 , 9 and 8 are correct then pin 5 on U1 and U7, (OK, TP14) should be logic HIGH ~3Volts. Confirm: +3.6V

4) The noise on TP 12, 13, 11 and 6 should be measured with a SR785 using RMS power spectrum. Fill in the table below with noise readings at ~144Hz.

TEST POINT:	TP12	TP13	TP11	TP6
Nominal noise, $nV_{RMS}/\sqrt{Hz}$:	<20	< 20	< 20	~ 30
Measured noise, $nV_{RMS}/\sqrt{Hz}$:	~7	~13	~12	~18

5) Measure the External Monitor and output voltage M3 (back panel and through controls channel via VCO tester).

a. Using the onboard DIP switch, set the Gain to 30dB;

b. Connect the External PD Input BNC on front panel to GND via 100kΩ resistor.

Input Current (µA)	External Monitor (V)	M3 Back Panel (V)	M3 VCO Tester (V)	Expected M3 (V)	Expected M3 VCO (V)
50	3.14	3.14	12.6	3	12

Nominal Gain for VCO: 4 **Expected Gain: 4**

6) Ensure the "OK" LED on VCO tester lights up when power is supplied.

Confirm: YES

7) Measure the noise spectrum at the internal and external monitor.

Internal Monitor noise 99 less than 200 $nV_{RMS}/\sqrt{Hz}$ at 144 Hz

External Monitor noise 79 less than 200 $nV_{RMS}/\sqrt{Hz}$ at 144 Hz

8) Test the power from the internal RF coupler output (net S3, unit B4 on page 1 of D1200136) to the AOM. Measure the output voltage M1 through the RF detector and the output voltage M1 through the controls output channel with the VCO tester.

- **a. Use the signal generator (2) at 158.8MHz with RF power as in column 1.**
- **b. Set the signal generator (2) RF power to 0dBm. Connect the power meter (3) and the attenuator (4) to the signal generator. Adjust the offset to read 0dBm (nominal offset: +11.4dBm).**
- **c. Connect the power meter (3) and attenuator (4) to coupler.**
- **d. Connect signal generator (2) output to chassis "AOM Input" on front panel.**
- **e. Connect the VCO tester (10) with 25-pin cable (9) to the rear of the chassis.**

NOTE: Run test concurrently with step #6.

Signal Gen. output power (dBm)	Coupler OUT to AOM (dBm)	Expected RF Power (dBm)	M1 Back Panel (Volts)	M1 VCO tester (Volts)	Expected M1 (Volts)
0	21.7	**22**	0.995	4.016	**1.000**
1	22.6	**23**	0.970	3.917	**0.975**
2	23.5	**24**	0.945	3.818	**0.950**
3	24.5	**25**	0.920	3.716	**0.925**
4	25.4	**26**	0.895	3.615	**0.900**
5	26.3	**27**	0.870	3.513	**0.875**
6	27.2	**28**	0.844	3.409	**0.850**
7	28.1	**29**	0.819	3.307	**0.825**
8	28.9	**30**	0.794	3.206	**0.800**
9	29.8	**31**	0.769	3.107	**0.775**
10	30.7	**32**	0.745	3.010	**0.750**
11	31.5	**33**	0.722	2.916	**0.725**

Deviation from expected: ±2dB and ±0.1V, respectively.

Nominal Slope (mV/dBm): -27 Expected Slope: -25mV/dBm

Nominal Gain: 4 Expected Gain: 4

Nominal Offest (Volts): 1 Expected Offset (Volts): 1V

9) Measure Temperature Monitor 1 on VCO tester (10).

Temp. Mon 1 (Volts): 5.46

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10) Measure the optical power out of X-arm with the PSL input at 5mW, while varying the AOM RF drive power at 158.8MHz.

a. Use fiber-coupled laser (6) and adjust the knob to carry 5mW.

b. Use the power meter to measure the coupling efficiency through the PSL coupling:

Power from the laser (mW): 5.0

Power through PSL coupling (mW): >4.6

PSL coupling efficiency (%): >92%

c. Use optical power monitor (7) to measure the output powers.

AOM Drive Power (dBm)	Observed X-arm Power (µW)
0	80
1	100
2	120
3	150
4	180
5	210

AOM Drive Power (dBm)	Observed X-arm Power (µW)
6	250
7	290
8	330
9	360
10	370
11	370

11) Measure power from sample, X-arm, Y-arm, and squeezer with PSL input set at nominal 5mW. Drive the Input with 158.8MHz signal at +10.0dBm.

a. Use fiber-coupled laser (6) and adjust the knob to carry 5mW.

b. Use optical power monitor (7) to measure to output power.

	Sample	X-arm	Y-arm	Squeezer
Power (mW):	0.66	0.38	0.41	0.41
Ratio:	13%	7.6%	8.2%	8.2%
Expected:	20%	5%	5%	5%

12) Measure the voltage output from M2 (back panel and through controls channel via VCO tester) and Int. Mon (TNC front panel) with various PSL input powers.

a. Use fiber-coupled laser (6) and adjust the knob to carry the output powers.

b. Use optical power monitor (7) to measure to output power (at each power setting).

c. Set trans-impedance to 100kΩ by setting the gain to its maximum level (30dB).

PSL Input (mW)	M2 Back Panel (V)	M2 VCO Tester (V)	Internal Monitor (V)	Expected M2 VCO (V)	Expected Int. Mon (V)
2	0.16	0.65	0.16	0.48	0.12
4	0.31	1.27	0.31	0.96	0.24
6	0.43	1.76	0.44	1.44	0.36
8	0.60	2.45	0.61	1.92	0.48
10	0.78	3.15	0.78	2.40	0.60
11.2	0.89	3.56	0.88	>2.57	>0.68

Nominal Gain for VCO: 4 **Expected Gain: 4**

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1 Testing information

BOARD SERIAL S1202530

TEST DATE 2012.12.03

TESTING RESULT: **PASSED** **FAILED**

2 Introduction

The following Test Procedure describes the test of proper operation of the ALS fiber distribution. The RF amplifier should always be connected to an output before supplying power. Further information can be found on the wiki page.

3 Test Equipment

1. Voltmeter
2. 9kHz – 1.2Ghz Signal Generator
3. EPM Series Power Meter (N1914A)
4. 10dBm BNC to SMA attenuator
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6. Oz optics fiber-coupled laser (OZ-2000-1064-6/125-S-40-3A-3-1-10)
7. OPHIR Vega Laser Power Monitor
8. ThorLabs Fiber Cable APC
9. 25-Pin cable
10. VCO Tester D1100545-v1
11. Current Source
12. Stanford Research Systems model SR785 Spectrum Analyzer
13. Board Schematics, LIGO D1200136-v1

4 Tests

The ALS Fiber Distribution uses the Low Noise Power Module (D0901846, rev D) with the RF Distribution Amplifier Interface (D1000064, rev A).

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 and fill in the table below.

TEST POINT:	+24 V	– 24 V	+ 17 V	– 17 V
Nominal current (A):	<1	~ 0	< 1	~ 0
Measured current (A):	0.89	0.02	0.13	0.04

2) On the low noise power module check the voltage on TP 1-13.

TP1 (+17V)	+17.2	TP2 (–17V)	-17.0
TP3, 4 (GND)	<0.02	TP5 (+5V)	+5.1
TP6 (–15V)	-15.0	TP7 (+24V)	+24.0
TP8 (GND)	<0.02	TP9 (–24V)	-24.0
TP10 (GND)	<0.02	TP11 (+15V)	+15.0
TP12 (+VREF)	+10.0	TP13 (–VREF)	-10.0

3) If TP 1 , 2, 7 , 9 and 8 are correct then pin 5 on U1 and U7, (OK, TP14) should be logic HIGH ~3Volts. Confirm: +3.6V

4) The noise on TP 12, 13, 11 and 6 should be measured with a SR785 using RMS power spectrum. Fill in the table below with noise readings at ~144Hz.

TEST POINT:	TP12	TP13	TP11	TP6
Nominal noise, $nV_{RMS}/\sqrt{Hz}$:	<20	< 20	< 20	~ 30
Measured noise, $nV_{RMS}/\sqrt{Hz}$:	~7	~12	~10	~19

5) Measure the External Monitor and output voltage M3 (back panel and through controls channel via VCO tester).

a. Using the onboard DIP switch, set the Gain to 30dB;

b. Connect the External PD Input BNC on front panel to GND via 100kΩ resistor.

Input Current (µA)	External Monitor (V)	M3 Back Panel (V)	M3 VCO Tester (V)	Expected M3 (V)	Expected M3 VCO (V)
50	3.13	3.13	12.6	3	12

Nominal Gain for VCO: 4 **Expected Gain: 4**

6) Ensure the "OK" LED on VCO tester lights up when power is supplied.

Confirm: YES

7) Measure the noise spectrum at the internal and external monitor.

Internal Monitor noise 98 less than 200 $nV_{RMS}/\sqrt{Hz}$ at 144 Hz

External Monitor noise 74 less than 20 $nV_{RMS}/\sqrt{Hz}$ at 144 Hz

8) Test the power from the internal RF coupler output (net S3, unit B4 on page 1 of D1200136) to the AOM. Measure the output voltage M1 through the RF detector and the output voltage M1 through the controls output channel with the VCO tester.

- **a. Use the signal generator (2) at 158.8MHz with RF power as in column 1.**
- **b. Set the signal generator (2) RF power to 0dBm. Connect the power meter (3) and the attenuator (4) to the signal generator. Adjust the offset to read 0dBm (nominal offset: +11.4dBm).**
- **c. Connect the power meter (3) and attenuator (4) to coupler.**
- **d. Connect signal generator (2) output to chassis "AOM Input" on front panel.**
- **e. Connect the VCO tester (10) with 25-pin cable (9) to the rear of the chassis.**

NOTE: Run test concurrently with step #6.

Signal Gen. output power (dBm)	Coupler OUT to AOM (dBm)	Expected RF Power (dBm)	M1 Back Panel (Volts)	M1 VCO tester (Volts)	Expected M1 (Volts)
0	22.1	**22**	1.01	4.09	**1.000**
1	23.0	**23**	0.99	3.99	**0.975**
2	23.9	**24**	0.96	3.89	**0.950**
3	24.8	**25**	0.94	3.79	**0.925**
4	25.7	**26**	0.91	3.68	**0.900**
5	26.6	**27**	0.89	3.58	**0.875**
6	27.5	**28**	0.86	3.48	**0.850**
7	28.4	**29**	0.83	3.37	**0.825**
8	29.2	**30**	0.81	3.27	**0.800**
9	30.1	**31**	0.78	3.17	**0.775**
10	31.0	**32**	0.76	3.07	**0.750**
11	31.8	**33**	0.74	2.98	**0.725**

Deviation from expected: ±2dB and ±0.1V, respectively.

Nominal Slope (mV/dBm): -27 Expected Slope: -25mV/dBm

Nominal Gain: 4 Expected Gain: 4

Nominal Offest (Volts): 1 Expected Offset (Volts): 1V

9) Measure Temperature Monitor 1 on VCO tester (10).

Temp. Mon 1 (Volts): 5.44

---

10) Measure the optical power out of X-arm with the PSL input at 5mW, while varying the AOM RF drive power at 158.8MHz.

a. Use fiber-coupled laser (6) and adjust the knob to carry 5mW.

b. Use the power meter to measure the coupling efficiency through the PSL coupling:

Power from the laser (mW): 4.3

Power through PSL coupling (mW): 5.0

PSL coupling efficiency (%): 86%

c. Use optical power monitor (7) to measure the output powers.

AOM Drive Power (dBm)	Observed X-arm Power (µW)
0	80
1	90
2	110
3	140
4	160
5	190

AOM Drive Power (dBm)	Observed X-arm Power (µW)
6	230
7	260
8	290
9	320
10	330
11	330

11) Measure power from sample, X-arm, Y-arm, and squeezer with PSL input set at nominal 5mW. Drive the Input with 158.8MHz signal at +10.0dBm.

a. Use fiber-coupled laser (6) and adjust the knob to carry 5mW.

b. Use optical power monitor (7) to measure to output power.

	Sample	X-arm	Y-arm	Squeezer
Power (mW):	0.54	0.33	0.37	0.36
Ratio:	11%	6.6%	7.4%	7.2%
Expected:	20%	5%	5%	5%

12) Measure the voltage output from M2 (back panel and through controls channel via VCO tester) and Int. Mon (TNC front panel) with various PSL input powers.

a. Use fiber-coupled laser (6) and adjust the knob to carry the output powers.

b. Use optical power monitor (7) to measure to output power (at each power setting).

c. Set trans-impedance to 100kΩ by setting the gain to its maximum level (30dB).

PSL Input (mW)	M2 Back Panel (V)	M2 VCO Tester (V)	Internal Monitor (V)	Expected M2 VCO (V)	Expected Int. Mon (V)
2	0.12	0.49	0.12	0.48	0.12
4	0.23	0.94	0.23	0.96	0.24
6	0.32	1.31	0.33	1.44	0.36
8	0.46	1.87	0.46	1.92	0.48
10	0.57	2.30	0.57	2.40	0.60
11.2	0.65	2.62	0.64	2.54	0.67

Nominal Gain for VCO: 4 **Expected Gain: 4**

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-E1200140-v2 *LIGO* 12/04/2012

Test Procedure for ALS Fiber Distribution

Alexa Staley, Bram Slagmolen, Max Factourovich

Distribution of this document:
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1 Testing information

BOARD SERIAL TBD [002]

TEST DATE 2012.12.03

TESTING RESULT: **PASSED** **FAILED**

2 Introduction

The following Test Procedure describes the test of proper operation of the ALS fiber distribution. The RF amplifier should always be connected to an output before supplying power. Further information can be found on the wiki page.

3 Test Equipment

1. Voltmeter
2. 9kHz – 1.2Ghz Signal Generator
3. EPM Series Power Meter (N1914A)
4. 10dBm BNC to SMA attenuator
5. RF Cable Hand Formable SMA
6. Oz optics fiber-coupled laser (OZ-2000-1064-6/125-S-40-3A-3-1-10)
7. OPHIR Vega Laser Power Monitor
8. ThorLabs Fiber Cable APC
9. 25-Pin cable
10. VCO Tester D1100545-v1
11. Current Source
12. Stanford Research Systems model SR785 Spectrum Analyzer
13. Board Schematics, LIGO D1200136-v1

4 Tests

The ALS Fiber Distribution uses the Low Noise Power Module (D0901846, rev D) with the RF Distribution Amplifier Interface (D1000064, rev A).

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 and fill in the table below.

TEST POINT:	+24 V	– 24 V	+ 17 V	– 17 V
Nominal current (A):	<1	~ 0	< 1	~ 0
Measured current (A):	0.90	0.02	0.13	0.04

2) On the low noise power module check the voltage on TP 1-13.

TP1 (+17V)	+17.2	TP2 (–17V)	-17.0
TP3, 4 (GND)	<0.02	TP5 (+5V)	+5.1
TP6 (–15V)	-15.0	TP7 (+24V)	+24.0
TP8 (GND)	<0.02	TP9 (–24V)	-24.1
TP10 (GND)	<0.02	TP11 (+15V)	+15.0
TP12 (+VREF)	+10.0	TP13 (–VREF)	-10.0

3) If TP 1 , 2, 7 , 9 and 8 are correct then pin 5 on U1 and U7, (OK, TP14) should be logic HIGH ~3Volts. Confirm: +3.6V

4) The noise on TP 12, 13, 11 and 6 should be measured with a SR785 using RMS power spectrum. Fill in the table below with noise readings at ~144Hz.

TEST POINT:	TP12	TP13	TP11	TP6
Nominal noise, $nV_{RMS}/\sqrt{Hz}$:	<20	< 20	< 20	~ 30
Measured noise, $nV_{RMS}/\sqrt{Hz}$:	~7	~13	~19	~20

5) Measure the External Monitor and output voltage M3 (back panel and through controls channel via VCO tester).

a. Using the onboard DIP switch, set the Gain to 30dB;

b. Connect the External PD Input BNC on front panel to GND via 100kΩ resistor.

Input Current (µA)	External Monitor (V)	M3 Back Panel (V)	M3 VCO Tester (V)	Expected M3 (V)	Expected M3 VCO (V)
50	3.13	3.13	12.6	3	12

Nominal Gain for VCO: ~4 **Expected Gain: 4**

6) Ensure the "OK" LED on VCO tester lights up when power is supplied.

Confirm: YES

7) Measure the noise spectrum at the internal and external monitor.

Internal Monitor noise 103 less than 200 $nV_{RMS}/\sqrt{Hz}$ at 144 Hz

External Monitor noise 87 less than 20 $nV_{RMS}/\sqrt{Hz}$ at 144 Hz

8) Test the power from the internal RF coupler output (net S3, unit B4 on page 1 of D1200136) to the AOM. Measure the output voltage M1 through the RF detector and the output voltage M1 through the controls output channel with the VCO tester.

- **a. Use the signal generator (2) at 158.8MHz with RF power as in column 1.**
- **b. Set the signal generator (2) RF power to 0dBm. Connect the power meter (3) and the attenuator (4) to the signal generator. Adjust the offset to read 0dBm (nominal offset: +11.4dBm).**
- **c. Connect the power meter (3) and attenuator (4) to coupler.**
- **d. Connect signal generator (2) output to chassis "AOM Input" on front panel.**
- **e. Connect the VCO tester (10) with 25-pin cable (9) to the rear of the chassis.**

NOTE: Run test concurrently with step #6.

Signal Gen. output power (dBm)	Coupler OUT to AOM (dBm)	Expected RF Power (dBm)	M1 Back Panel (Volts)	M1 VCO tester (Volts)	Expected M1 (Volts)
0	21.9	**22**	1.000	4.037	**1.000**
1	22.8	**23**	0.975	3.936	**0.975**
2	23.8	**24**	0.950	3.836	**0.950**
3	24.7	**25**	0.924	3.733	**0.925**
4	25.6	**26**	0.899	3.630	**0.900**
5	26.5	**27**	0.873	3.527	**0.875**
6	27.4	**28**	0.847	3.422	**0.850**
7	28.2	**29**	0.821	3.318	**0.825**
8	29.1	**30**	0.796	3.216	**0.800**
9	30.0	**31**	0.771	3.116	**0.775**
10	30.8	**32**	0.747	3.018	**0.750**
11	31.7	**33**	0.723	2.924	**0.725**

Deviation from expected: ±2dB and ±0.1V, respectively.

Nominal Slope (mV/dBm): -27 Expected Slope: -25mV/dBm

Nominal Gain: 4 Expected Gain: 4

Nominal Offest (Volts): 1 Expected Offset (Volts): 1V

9) Measure Temperature Monitor 1 on VCO tester (10).

Temp. Mon 1 (Volts): 5.45

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10) Measure the optical power out of X-arm with the PSL input at 5mW, while varying the AOM RF drive power at 158.8MHz.

a. Use fiber-coupled laser (6) and adjust the knob to carry 5mW.

b. Use the power meter to measure the coupling efficiency through the PSL coupling:

Power from the laser (mW): 4.5

Power through PSL coupling (mW): 5

PSL coupling efficiency (%): 90

c. Use optical power monitor (7) to measure the output powers.

AOM Drive Power (dBm)	Observed X-arm Power (µW)
0	80
1	90
2	110
3	140
4	170
5	200

AOM Drive Power (dBm)	Observed X-arm Power (µW)
6	230
7	270
8	310
9	340
10	360
11	370

11) Measure power from sample, X-arm, Y-arm, and squeezer with PSL input set at nominal 5mW. Drive the Input with 158.8MHz signal at +10.0dBm.

a. Use fiber-coupled laser (6) and adjust the knob to carry 5mW.

b. Use optical power monitor (7) to measure to output power.

	Sample	X-arm	Y-arm	Squeezer
Power (mW):	0.70	0.36	0.35	0.33
Ratio:	14%	7.2%	7.0%	6.6%
Expected:	20%	5%	5%	5%

12) Measure the voltage output from M2 (back panel and through controls channel via VCO tester) and Int. Mon (TNC front panel) with various PSL input powers.

a. Use fiber-coupled laser (6) and adjust the knob to carry the output powers.

b. Use optical power monitor (7) to measure to output power (at each power setting).

c. Set trans-impedance to 100kΩ by setting the gain to its maximum level (30dB).

PSL Input (mW)	M2 Back Panel (V)	M2 VCO Tester (V)	Internal Monitor (V)	Expected M2 VCO (V)	Expected Int. Mon (V)
2	0.12	0.51	0.13	0.48	0.12
4	0.24	0.95	0.23	0.96	0.24
6	0.34	1.44	0.36	1.44	0.36
8	0.49	1.98	0.49	1.92	0.48
10	0.56	2.28	0.56	2.40	0.60
11.0	0.65	2.63	0.65	2.64	0.66

Nominal Gain for VCO: 4 **Expected Gain: 4**

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1 Testing information

BOARD SERIAL TBD [004]

TEST DATE 2012.12.03

TESTING RESULT: **PASSED** ◉ **FAILED** ○

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2 Introduction

The following Test Procedure describes the test of proper operation of the ALS fiber distribution. The RF amplifier should always be connected to an output before supplying power. Further information can be found on the wiki page.

3 Test Equipment

1. Voltmeter
2. 9kHz – 1.2Ghz Signal Generator
3. EPM Series Power Meter (N1914A)
4. 10dBm BNC to SMA attenuator
5. RF Cable Hand Formable SMA
6. Oz optics fiber-coupled laser (OZ-2000-1064-6/125-S-40-3A-3-1-10)
7. OPHIR Vega Laser Power Monitor
8. ThorLabs Fiber Cable APC
9. 25-Pin cable
10. VCO Tester D1100545-v1
11. Current Source
12. Stanford Research Systems model SR785 Spectrum Analyzer
13. Board Schematics, LIGO D1200136-v1

4 Tests

The ALS Fiber Distribution uses the Low Noise Power Module (D0901846, rev D) with the RF Distribution Amplifier Interface (D1000064, rev A).

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 and fill in the table below.

TEST POINT:	+24 V	– 24 V	+ 17 V	– 17 V
Nominal current (A):	<1	~ 0	< 1	~ 0
Measured current (A):	0.90	0.02	0.14	0.04

2) On the low noise power module check the voltage on TP 1-13.

TP1 (+17V)	+17.2	TP2 (–17V)	-17.0
TP3, 4 (GND)	<0.02	TP5 (+5V)	+5.1
TP6 (–15V)	-15.0	TP7 (+24V)	+24.0
TP8 (GND)	<0.02	TP9 (–24V)	-24.1
TP10 (GND)	<0.02	TP11 (+15V)	+15.0
TP12 (+VREF)	+10.0	TP13 (–VREF)	-10.0

3) If TP 1 , 2, 7 , 9 and 8 are correct then pin 5 on U1 and U7, (OK, TP14) should be logic HIGH ~3Volts. Confirm: 3.7V

4) The noise on TP 12, 13, 11 and 6 should be measured with a SR785 using RMS power spectrum. Fill in the table below with noise readings at ~144Hz.

TEST POINT:	TP12	TP13	TP11	TP6
Nominal noise, $nV_{RMS}/\sqrt{Hz}$:	<20	< 20	< 20	~ 30
Measured noise, $nV_{RMS}/\sqrt{Hz}$:	~7	~12	~11	~18

5) Measure the External Monitor and output voltage M3 (back panel and through controls channel via VCO tester).

a. Using the onboard DIP switch, set the Gain to 30dB;

b. Connect the External PD Input BNC on front panel to GND via 100kΩ resistor.

Input Current (µA)	External Monitor (V)	M3 Back Panel (V)	M3 VCO Tester (V)	Expected M3 (V)	Expected M3 VCO (V)
50	3.13	3.13	12.6	3	12

Nominal Gain for VCO: 4 **Expected Gain: 4**

6) Ensure the "OK" LED on VCO tester lights up when power is supplied.

Confirm: YES

7) Measure the noise spectrum at the internal and external monitor.

Internal Monitor noise 106 less than 200 $nV_{RMS}/\sqrt{Hz}$ at 144 Hz

External Monitor noise 78 less than 200 $nV_{RMS}/\sqrt{Hz}$ at 144 Hz

8) Test the power from the <u>internal</u> RF coupler output (net S3, unit B4 on page 1 of D1200136) to the AOM. Measure the output voltage M1 through the RF detector and the output voltage M1 through the controls output channel with the VCO tester.

- **a. Use the signal generator (2) at 158.8MHz with RF power as in column 1.**
- **b. Set the signal generator (2) RF power to 0dBm. Connect the power meter (3) and the attenuator (4) to the signal generator. Adjust the offset to read 0dBm (nominal offset: +11.4dBm).**
- **c. Connect the power meter (3) and attenuator (4) to coupler.**
- **d. Connect signal generator (2) output to chassis "AOM Input" on front panel.**
- **e. Connect the VCO tester (10) with 25-pin cable (9) to the rear of the chassis.**

NOTE: Run test concurrently with step #6.

Signal Gen. output power (dBm)	Coupler OUT to AOM (dBm)	Expected RF Power (dBm)	M1 Back Panel (Volts)	M1 VCO tester (Volts)	Expected M1 (Volts)
0	22.0	**22**	0.990	3.999	**1.000**
1	22.9	**23**	0.965	3.898	**0.975**
2	23.8	**24**	0.941	3.799	**0.950**
3	24.7	**25**	0.917	3.703	**0.925**
4	25.6	**26**	0.892	3.602	**0.900**
5	26.5	**27**	0.866	3.499	**0.875**
6	27.4	**28**	0.841	3.395	**0.850**
7	28.3	**29**	0.815	3.292	**0.825**
8	29.2	**30**	0.790	3.191	**0.800**
9	30.0	**31**	0.765	3.091	**0.775**
10	30.9	**32**	0.741	2.994	**0.750**
11	31.7	**33**	0.718	2.900	**0.725**

Deviation from expected: ±2dB and ±0.1V, respectively.

Nominal Slope (mV/dBm): -27 Expected Slope: -25mV/dBm

Nominal Gain: 4 Expected Gain: 4

Nominal Offest (Volts): 1 Expected Offset (Volts): 1V

9) Measure Temperature Monitor 1 on VCO tester (10).

Temp. Mon 1 (Volts): 5.48

---

10) Measure the optical power out of X-arm with the PSL input at 5mW, while varying the AOM RF drive power at 158.8MHz.

a. Use fiber-coupled laser (6) and adjust the knob to carry 5mW.

b. Use the power meter to measure the coupling efficiency through the PSL coupling:

Power from the laser (mW): 5.0

Power through PSL coupling (mW): 4.4

PSL coupling efficiency (%): 88%

c. Use optical power monitor (7) to measure the output powers.

AOM Drive Power (dBm)	Observed X-arm Power (µW)
0	110
1	140
2	170
3	200
4	240
5	290

AOM Drive Power (dBm)	Observed X-arm Power (µW)
6	330
7	370
8	400
9	410
10	400
11	380

11) Measure power from sample, X-arm, Y-arm, and squeezer with PSL input set at nominal 5mW. Drive the Input with 158.8MHz signal at +10.0dBm.

a. Use fiber-coupled laser (6) and adjust the knob to carry 5mW.

b. Use optical power monitor (7) to measure to output power.

	Sample	X-arm	Y-arm	Squeezer
Power (mW):	0.73	0.41	0.44	0.44
Ratio:	15%	8.2%	8.8%	8.8%
Expected:	20%	5%	5%	5%

12) Measure the voltage output from M2 (back panel and through controls channel via VCO tester) and Int. Mon (TNC front panel) with various PSL input powers.

a. Use fiber-coupled laser (6) and adjust the knob to carry the output powers.

b. Use optical power monitor (7) to measure to output power (at each power setting).

c. Set trans-impedance to 100kΩ by setting the gain to its maximum level (30dB).

PSL Input (mW)	M2 Back Panel (V)	M2 VCO Tester (V)	Internal Monitor (V)	Expected M2 VCO (V)	Expected Int. Mon (V)
2	0.11	0.47	0.11	0.48	0.12
4	0.23	0.93	0.23	0.96	0.24
6	0.38	1.51	0.37	1.44	0.36
8	0.50	2.05	0.51	1.92	0.48
10	0.55	2.23	0.56	2.40	0.60
11.4	0.72	2.90	0.73	2.57	0.69

Nominal Gain for VCO: 4 **Expected Gain: 4**