LIGO Laboratory / LIGO Scientific Collaboration

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OMC Coil Drive Unit Test Plan

R. M. Cutler, University of Birmingham

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This is an internal working note
of the Advanced LIGO Project, prepared by members of the UK team.

Institute for Gravitational Research
University of Glasgow
Phone +44 (0) 141 330 5884
Fax +44 (0) 141 330 6833
E-mail k.strain@physics.gla.ac.uk

Engineering Department
CCLRC Rutherford Appleton Laboratory
Phone +44 (0) 1235 445 297
Fax +44 (0) 1235 445 843
E-mail J.Greenhalgh@rl.ac.uk

School of Physics and Astronomy
University of Birmingham
Phone +44 (0) 121 414 6447
Fax +44 (0) 121 414 3722
E-mail av@star.sr.bham.ac.uk

Department of Physics
University of Strathclyde
Phone +44 (0) 1411 548 3360
Fax +44 (0) 141 552 2891
E-mail N.Lockerbie@phys.strath.ac.uk

http://www.ligo.caltech.edu/

http://www.physics.gla.ac.uk/igr/sus/

http://www.sr.bham.ac.uk/research/gravity/rh,d,2.html
http://www.eng-external.rl.ac.uk/advligo/papers_public/ALUK_Homepage.htm

OMC COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit………………OMC_10……………………Serial No ………………………………
Test Engineer…..Xen…………..………
Date……………..12/11/10..……………

Drive Card ID……OMC_10…………..…
Monitor Card ID…Mon160..……………..

Contents

1. Description

The OMC Driver Unit will be used to control the OMC mirror position in the Advanced LIGO Gravity wave experiment.

It controls the current in the coil which provides the magnetic force which controls the position of the OMC. It works in conjunction with the OSEM coil and position sensor units. One OMC Driver Unit controls four OSEMs.

The OMC Coil Drive Unit contains a Coil Drive board and a Monitor board. The Monitor Board monitors the Output voltage, Output Current, RMS Current and Output Noise from the unit.

The OMC Driver Unit also passes the amplified signals from the Photodiodes, which detect the position of the OMC mirror, back to the control electronics without processing them in any way.

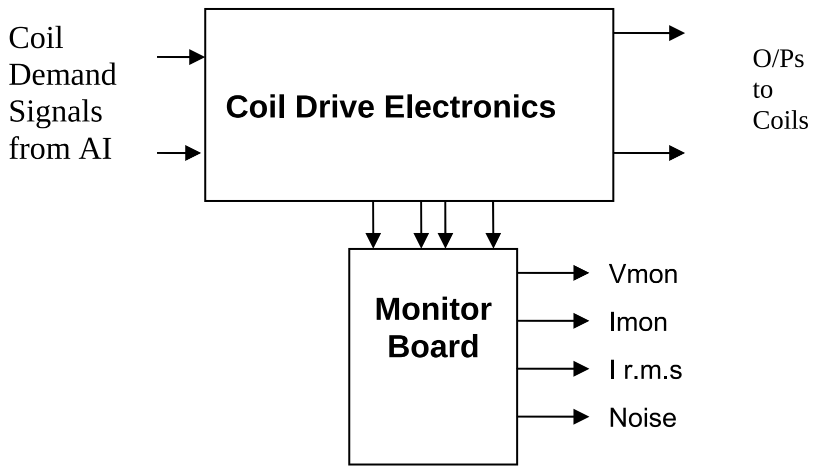

FIG. 1 OMC Driver Unit Block Diagram

Each OMC Driver Unit consists of four identical differential coil drive channels. It also contains the monitor board which monitors the output voltage, current, r.m.s current and noise from each channel

Unit………………OMC_10……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..12/11/10..……………

2. Test Equipment

Power supplies (At least +/- 20v variable, 1A)
Signal generator (capable of delivering 10v peak, 0.1Hz to 10 KHz))
Digital oscilloscope
Analogue oscilloscope
Agilent Dynamic Signal Analyser (or similar)
Low noise Balanced Driver circuit
Relay test box

Record the Models and serial numbers of the test equipment used below.

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	

Unit……………….OMC_10……………………Serial No ………………………………
Test Engineer…..Xen………….……….
Date……………..11/11/10...……………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

Unit………………OMC_10……………………Serial No ………………………………
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4. Continuity Checks

Use a multi-meter to check the connections below.

Photodiode outputs

Pd Out to AA	SIGNAL	DESCRIPTION	Pd in from Sat	OK?
1	PD1P	Photodiode A+	1	√
2	PD2P	Photodiode B+	2	√
3	PD3P	Photodiode C+	3	√
4	PD4P	Photodiode D+	4	√
5	0V	√		
6	PD1N	Photodiode A-	14	√
7	PD2N	Photodiode B-	15	√
8	PD3N	Photodiode C-	16	√
9	PD4N	Photodiode D-	17	√

LED Monitors

LED Mon	SIGNAL	Monitors:	In from Sat	OK?
1	Imon1P	Current Source 1+	5	√
2	Imon2P	Current Source 2+	6	√
3	Imon3P	Current Source 3+	7	√
4	Imon4P	Current Source 4+	8	√
5	0V	√		
6	Imon1N	Current Source 1-	18	√
7	Imon2N	Current Source 2-	19	√
8	Imon3N	Current Source 3-	20	√
9	Imon4N	Current Source 4-	21	√

Power Supply to Satellite box

In from Sat	SIGNAL	DESCRIPTION	DC in Connector	OK?
9	V+	+17v Supply	A1	√
10	V+	+17v Supply	A1	√
11	V-	-17v Supply	A3	√
12	V-	-17v Supply	A3	√
13	0V	Return	A2	√
22	0V	Return	A2	√
23	0V	Return	A2	√
24	0V	Return	A2	√
25	0V	Return	A2	√

Unit……………….OMC_10……………………Serial No ………………………………
Test Engineer…..Xen………..………
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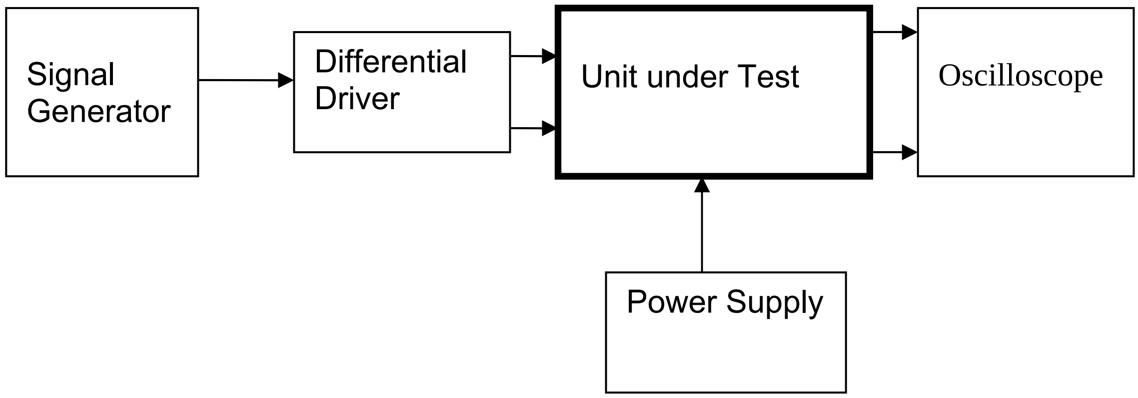
5. Isolation Checks

Check that the driver ICs IC11 and IC12 are isolated from chassis on all channels. Apply a DVM on ohms range and measure the resistance between each transistor tab and the chassis.

IC Tab	Resistance	OK?
IC11 Channel 1	OL	√
IC12 Channel 1	OL	√
IC11 Channel 2	OL	√
IC12 Channel 2	OL	√
IC11 Channel 3	OL	√
IC12 Channel 3	OL	√
IC11 Channel 4	OL	√
IC12 Channel 4	OL	√

6. TEST SET UP



Note:
(1) Input signal to differential amplifier is generally stated in the tests below. There is therefore an inherent gain of 2 in the system.

(2) Some signal generators will indicate 1vpk/pk when the output is in fact 1v Peak into the high impedance Differential driver used. The test procedure refers to the actual voltage out of the signal generator.

Connections:

Differential signal inputs to the Drive Input of the unit under test:
Drive Input pins 1, 2, 3, 4 = positive input
Drive Input pins 6, 7, 8, 9 = negative input
Drive Input pin 5 = ground

Power (depending on connector availability)

Pd In from Sat pin 9, 10 = +16.5v	or DC in A1
Pd In from Sat pin 11, 12 = -16.5	or DC in A3
Pd In from Sat pins 22, 23, 24, 25 = 0v	or DC in A2

Coil Drive Outputs

Ch1+ = Coil out to Sat pin 1	Ch1- = Coil out to Sat pin 9
Ch2+ = Coil out to Sat pin 3	Ch2- = Coil out to Sat pin 11
Ch3+ = Coil out to Sat pin 5	Ch3- = Coil out to Sat pin 13
Ch4+ = Coil out to Sat pin 7	Ch4- = Coil out to Sat pin 15

Voltage, Current and R.M.S monitors

1	Voltage Monitor 4
2	Current Monitor 4
3	R.M.S Current 4
4	Voltage Monitor 3
5	Current Monitor 3
6	R.M.S Current 3
7	Voltage Monitor 2
8	Current Monitor 2
9	R.M.S Current 2
10	Voltage Monitor 1
11	Current Monitor 1
12	R.M.S Current 1
13 to 25	0v

Noise Monitor

1	Channel 1 Noise Monitor
2	Channel 2 Noise Monitor
3	Channel 3 Noise Monitor
4	Channel 4 Noise Monitor
5 to 9	0v

Unit……………….OMC_10……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..11/11/10..……………

7. Power

Check the polarity of the wiring from the 3 pin power connector to each of the boards. Viewed from the back of the unit:

A1	Left pin	Positive	White wire
A2	Middle pin	RTN	Black wire
A3	Right pin	Negative	Green wire

If this is correct,
Connect power to the unit
Set the supplies to 16.5v
Turn on

Record supply currents:

+ 16.5 supply current (mA)	- 16.5 supply current (mA)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

If the power supplies are correct, proceed to the next section.

Unit……………….OMC_10……………………Serial No ………………………………
Test Engineer…..Xen………..……….
Date……………..11/11/10..……………

8. Relay Operation

Operate each relay in turn.
Observe its operation. LEDs should illuminate when the relays are operated.

Filter

Channel	Indicator		OK?
	ON	OFF	
Ch1	√	√	√
Ch2	√	√	√
Ch3	√	√	√
Ch4	√	√	√

TEST SWITCHES

Channel	Indicator		OK?
	ON	OFF	
Ch1	√	√	√
Ch2	√	√	√
Ch3	√	√	√
Ch4	√	√	√

Unit………………OMC_10……………………Serial No ………………………………
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Date……………..11/11/10..……………

9. Current Monitor tests

The purpose of this test is to perform a functionality test on the current monitor and RMS circuits.

To do this, we need to draw a known current from each coil drive output. This is done by plugging the 39 ohm loads into each output, then adjusting the signal generator until the required voltage appears across each load resistor.

Remove all links W4 and W5.

Plug the power 39 ohm dummy load plug into the coil drive output.

Set the signal generator output to 2.5v peak at 100Hz.

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 0.4v peak appears across each resistor.

Record the peak output from each of the current monitors using the true r.m.s d.v.m and each of the RMS circuits with the meter set to d.c.

Channel	Monitor Connector	Parameter	Theoretical Value (+/- .1v)	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	1.39v r.m.s	1.35	√
	Pin 1	RMS Current	1.39v dc	1.35	√
2	Pin 5	Current Monitor	1.39v r.m.s	1.35	√
	Pin 4	RMS Current	1.39v dc	1.35	√
3	Pin 8	Current Monitor	1.39v r.m.s	1.35	√
	Pin 7	RMS Current	1.39v dc	1.34	√
4	Pin 11	Current Monitor	1.39v r.m.s	1.35	√
	Pin 10	RMS Current	1.39v dc	1.35	√

Unit……………..OMC_10……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..11/11/10..……………

10. Voltage Monitor tests

The purpose of this test is to verify and calibrate the Voltage Monitor circuit on each channel.

Switch all filters out. Remove the dummy loads and make differential voltage output measurements on the coil drive outputs at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

Channel	Coil Drive Output pins	Voltage Monitor socket Pin	Monitor output?	Expected value	OK?
1	Pins 1,9	Pin 3	3.32	3.2v to 3.4v	√
2	Pins 3,11	Pin 6	3.32	3.2v to 3.4v	√
3	Pins 5,13	Pin 9	3.32	3.2v to 3.4v	√
4	Pins 7, 15	Pin 12	3.32	3.2v to 3.4v	√

11. Noise Monitor Tests

See Monitor re-test report.

Unit……………..OMC_10……………………Serial No ………………………………
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12. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct.
Ensure that links W4 and W5 are present.

Use the Dynamic Signal Analyser and signal generator.

With the filter switched in, measure the frequency response of each channel in turn between 1 Hz and 1 kHz. Measure the gain at the spot frequencies below and record them. Measure the gain at 0.1 Hz using the signal generator and scope, using a 1v peak input signal, and recording the peak output. In each case the output is measured differentially between TP9 and TP13.
Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.4		
10Hz	-30.0		
100Hz	-42.8		
1KHz	-43.3		

Channel 2

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.3		
10Hz	-30.2		
100Hz	-42.8		
1KHz	-43.3		

Channel 3

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.2		
10Hz	-30.3		
100Hz	-42.8		
1KHz	-43.2		

Channel 4

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.4		
10Hz	-30.0		
100Hz	-42.8		
1KHz	-43.3		

0.1 Hz measurements with the signal generator and oscilloscope

Frequency	Output	Expected O/P	Pass/Fail
Ch1	4.85		
Ch2	4.85		
Ch3	4.85		
Ch4	4.85		

Unit………………OMC_10……………………Serial No ………………………………
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Date……………..12/11/10..……………

13. Distortion

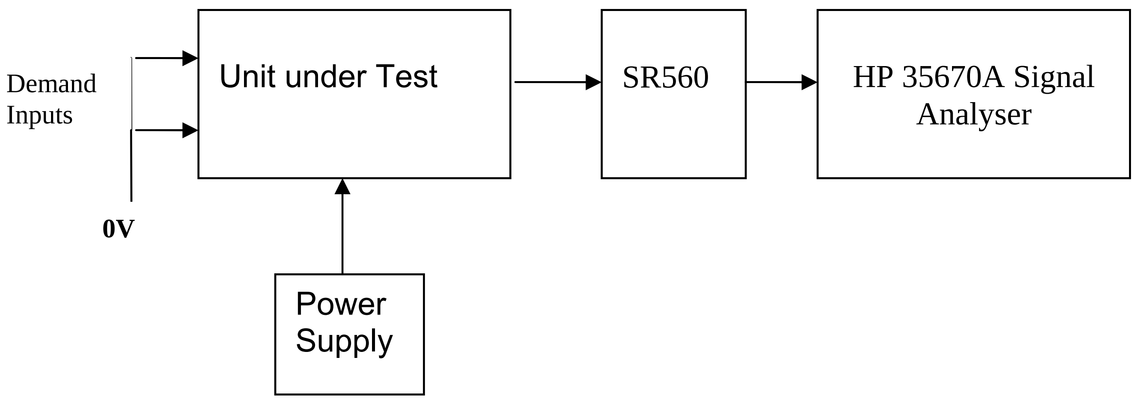
Remove links W4 and W5. Plug in the 5 Watt 39 Ohm dummy loads. Increase input voltage to 10v peak, f = 1KHz. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit……………..OMC_10……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..11/11/10..……………

14. Noise Tests

As the previous test involves non – representative temperature rises, allow the unit to cool before performing this test.
Replace the filter links W4 and W5 on each channel.
Replace the lid of the box, and replace screws.
Connect the filter test box, and switch in all filters.
Switch it out of Test Mode
Use the HP 35670A Dynamic Signal Analyser.
Connect a shorting plug to the demand input to short all positive and negative demands together and to 0v. Connect 39 Ohm loads to the outputs.
Switch the filters in.
Use Stuart Aston's noise measurement set up, loaded from disc.
Measure the noise output from each channel in turn at the amplifier outputs. The Low Pass filter on the SR650 may be used to reduce mains interference, to prevent the Signal Analyser from overloading. Ideally the filter corner frequency should be set to 3 KHz. Set the amplifier gain to 1000, and check that the overload light is not on before each measurement.



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-150.5 dB	-100.0	-160.0
Ch2	-150.5 dB	-101.4	-161.4
Ch3	-150.5 dB	-102.3	-162.3
Ch4	-150.5 dB	-102.0	-162.0

Notes:
Specified noise output current at 10 Hz = 50 pA/√Hz
Total output resistance = 600 Ohms
Amplifier noise voltage should therefore = 30nV/√Hz or -150.5dB

The noise monitor amplifier has an internal gain of 42dB at 10Hz.The noise floor is about -133dB.

Unit………………OMC_10……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..17/11/10..……………

15. Dynamic Range Tests

39 Ohm load resistors should be used, to represent the resistance of the Birmingham OSEM coil.

Plug in the dummy load.

Ensure that the filter links are in place, and the filters switched in circuit.

Drive the unit with a 5v peak sine wave on each channel (10v differential), at the frequencies specified. Measure the peak voltages across the load with an oscilloscope in each case, and compare with the specification

CH	0.5 Hz	0.5Hz Spec (mV)	1 Hz	1Hz Spec (mV)	10 Hz	10Hz Spec (mV)	OK ?
1	625	599 to 651	380	342 to 420	11.0	13 to 16	
2	625	599 to 651	370	342 to 420	10.5	13 to 16	
3	625	599 to 651	370	342 to 420	10.5	13 to 16	
4	625	599 to 651	380	342 to 420	11.0	13 to 16	

Notes: Specification:-

Frequency	Output Current	V across 40 Ohms
Freq < 0.5Hz	10mA peak	400mV
1 Hz	5 mA peak	200mV
10Hz< freq< 100Hz	0.5 mA peak	20mV

Unit……………………….OMC10P………Serial No ………………………………
Test Engineer……………RMC
Date……………………….25/11/10

16. Final Assembly Checks

1. Remove the lid of the box. √

2. Unplug all external connections. √

3. Check that the 9mm pillars are in place in the corners of the Monitor Board towards the centre of the box. √

4. Check that all internal connectors are firmly mated. √

5. Tighten the screw-locks holding all the external connectors. √

6. Check that the nuts holding the tabs of the power drivers are secure – tighten as necessary. Test with a DVM that none of the tabs are shorted to chassis. √

7. Check that all the LEDs are nicely centred. √

8. Check that links W4 and W5 are in place. √

9. Check that the boards are labelled with their Drawing Number, Issue Number, and serial number. Record below:

UoB box ID	OMC10P
Driver board ID	OMC10
Driver board Drawing No/Issue No	D1003116_V2
Driver board Serial Number	OMC10
Monitor board ID	MON160
Monitor board Drawing No/Issue No	D070480_5_K
Monitor board Serial Number	MON160

10. Check the security of any modification wires. √

11. Visually inspect. √

12. Put the lid on and fasten all screws, √

    Check all external screws for tightness. √

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Institute for Gravitational Research
University of Glasgow
Phone +44 (0) 141 330 5884
Fax +44 (0) 141 330 6833
E-mail k.strain@physics.gla.ac.uk
Engineering Department
CCLRC Rutherford Appleton Laboratory
Phone +44 (0) 1235 445 297
Fax +44 (0) 1235 445 843
E-mail J.Greenhalgh@rl.ac.uk

School of Physics and Astronomy
University of Birmingham
Phone +44 (0) 121 414 6447
Fax +44 (0) 121 414 3722
E-mail av@star.sr.bham.ac.uk
Department of Physics
University of Strathclyde
Phone +44 (0) 1411 548 3360
Fax +44 (0) 141 552 2891
E-mail N.Lockerbie@phys.strath.ac.uk

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http://www.sr.bham.ac.uk/research/gravity/rh,d,2.html
http://www.eng-external.rl.ac.uk/advligo/papers_public/ALUK_Homepage.htm

OMC COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit………………OMC_2……………………Serial No ………………………………
Test Engineer…..Xen…………..………
Date……………..18/11/10..……………

Drive Card ID……OMC_2…………..…
Monitor Card ID…Mon157……………..

Contents

1. Description

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It controls the current in the coil which provides the magnetic force which controls the position of the OMC. It works in conjunction with the OSEM coil and position sensor units. One OMC Driver Unit controls four OSEMs.

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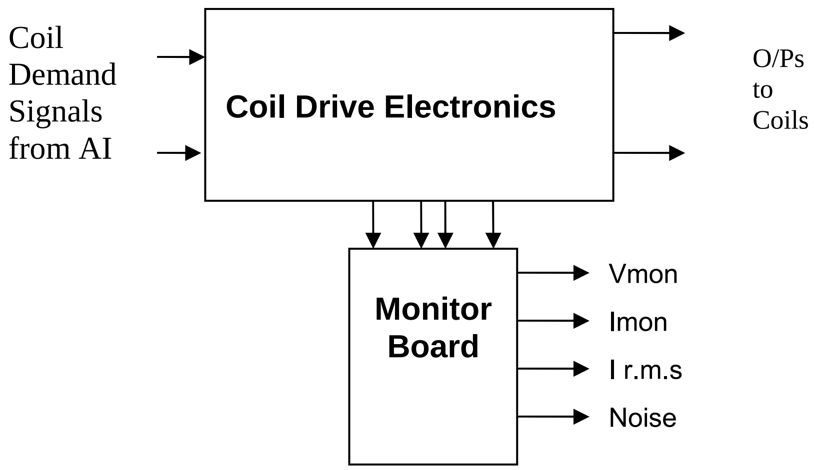

FIG. 1 OMC Driver Unit Block Diagram

Each OMC Driver Unit consists of four identical differential coil drive channels. It also contains the monitor board which monitors the output voltage, current, r.m.s current and noise from each channel

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Date……………..18/11/10..……………

2. Test Equipment

Power supplies (At least +/- 20v variable, 1A)
Signal generator (capable of delivering 10v peak, 0.1Hz to 10 KHz))
Digital oscilloscope
Analogue oscilloscope
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Low noise Balanced Driver circuit
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Record the Models and serial numbers of the test equipment used below.

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Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

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Pd Out to AA	SIGNAL	DESCRIPTION	Pd in from Sat	OK?
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LED Monitors

LED Mon	SIGNAL	Monitors:	In from Sat	OK?
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3	Imon3P	Current Source 3+	7	√
4	Imon4P	Current Source 4+	8	√
5	0V	√		
6	Imon1N	Current Source 1-	18	√
7	Imon2N	Current Source 2-	19	√
8	Imon3N	Current Source 3-	20	√
9	Imon4N	Current Source 4-	21	√

Power Supply to Satellite box

In from Sat	SIGNAL	DESCRIPTION	DC in Connector	OK?
9	V+	+17v Supply	A1	√
10	V+	+17v Supply	A1	√
11	V-	-17v Supply	A3	√
12	V-	-17v Supply	A3	√
13	0V	Return	A2	√
22	0V	Return	A2	√
23	0V	Return	A2	√
24	0V	Return	A2	√
25	0V	Return	A2	√

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5. Isolation Checks

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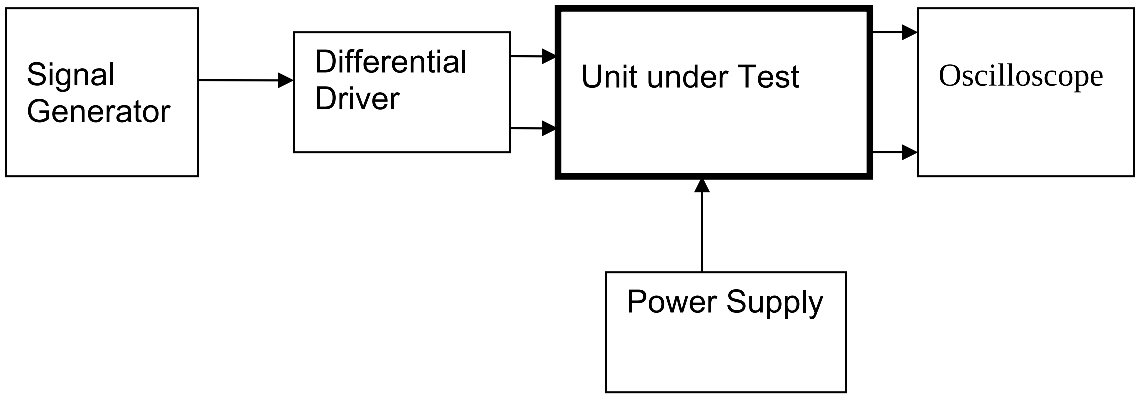
IC Tab	Resistance	OK?
IC11 Channel 1	OL	√
IC12 Channel 1	OL	√
IC11 Channel 2	OL	√
IC12 Channel 2	OL	√
IC11 Channel 3	OL	√
IC12 Channel 3	OL	√
IC11 Channel 4	OL	√
IC12 Channel 4	OL	√

6. TEST SET UP



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Pd In from Sat pin 11, 12 = -16.5 or DC in A3
Pd In from Sat pins 22, 23, 24, 25 = 0v or DC in A2

Coil Drive Outputs
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Ch2+ = Coil out to Sat pin 3
Ch3+ = Coil out to Sat pin 5
Ch4+ = Coil out to Sat pin 7
Ch1- = Coil out to Sat pin 9
Ch2- = Coil out to Sat pin 11
Ch3- = Coil out to Sat pin 13
Ch4- = Coil out to Sat pin 15

Voltage, Current and R.M.S monitors

1	Voltage Monitor 4
2	Current Monitor 4
3	R.M.S Current 4
4	Voltage Monitor 3
5	Current Monitor 3
6	R.M.S Current 3
7	Voltage Monitor 2
8	Current Monitor 2
9	R.M.S Current 2
10	Voltage Monitor 1
11	Current Monitor 1
12	R.M.S Current 1
13 to 25	0v

Noise Monitor

1	Channel 1 Noise Monitor
2	Channel 2 Noise Monitor
3	Channel 3 Noise Monitor
4	Channel 4 Noise Monitor
5 to 9	0v

Unit………………OMC_2……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10..……………

7. Power

Check the polarity of the wiring from the 3 pin power ponnector to each of the boards. Viewed from the back of the unit:

A1	Left pin	Positive	White wire
A2	Middle pin	RTN	Black wire
A3	Right pin	Negative	Green wire

If this is correct,
Connect power to the unit
Set the supplies to 16.5v
Turn on

Record supply currents:

+ 16.5 supply current (mA)	- 16.5 supply current (mA)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

If the power supplies are correct, proceed to the next section.

Unit..................OMC_2.........................Serial No ....
Test Engineer.....Xen.............................
Date..................18/11/10..................

8. Relay Operation

Operate each relay in turn.
Observe its operation. LEDs should illuminate when the relays are operated.

Filter

Channel	Indicator		OK?
	ON	OFF	
Ch1	√	√	√
Ch2	√	√	√
Ch3	√	√	√
Ch4	√	√	√

TEST SWITCHES

Channel	Indicator		OK?
	ON	OFF	
Ch1	√	√	√
Ch2	√	√	√
Ch3	√	√	√
Ch4	√	√	√

Unit………………OMC_2……………………Serial No ………………………………
Test Engineer…..Xen……………..………
Date……………..18/11/10..……………

9. Current Monitor tests

The purpose of this test is to perform a functionality test on the current monitor and RMS circuits.

To do this, we need to draw a known current from each coil drive output. This is done by plugging the 39 ohm loads into each output, then adjusting the signal generator until the required voltage appears across each load resistor.

Remove all links W4 and W5.

Plug the power 39 ohm dummy load plug into the coil drive output.

Set the signal generator output to 2.5v peak at 100Hz.

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 0.4v peak appears across each resistor.

Record the peak output from each of the current monitors using the true r.m.s d.v.m and each of the RMS circuits with the meter set to d.c.

Channel	Monitor Connector	Parameter	Theoretical Value (+/- .1v)	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	1.39v r.m.s	1.35	√
	Pin 1	RMS Current	1.39v dc	1.36	√
2	Pin 5	Current Monitor	1.39v r.m.s	1.35	√
	Pin 4	RMS Current	1.39v dc	1.35	√
3	Pin 8	Current Monitor	1.39v r.m.s	1.35	√
	Pin 7	RMS Current	1.39v dc	1.35	√
4	Pin 11	Current Monitor	1.39v r.m.s	1.35	√
	Pin 10	RMS Current	1.39v dc	1.35	√

Unit………………OMC_2……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..18/11/10……………..

10. Voltage Monitor tests

The purpose of this test is to verify and calibrate the Voltage Monitor circuit on each channel.

Switch all filters out. Remove the dummy loads and make differential voltage output measurements on the coil drive outputs at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

Channel	Coil Drive Output pins	Voltage Monitor socket Pin	Monitor output?	Expected value	OK?
1	Pins 1,9	Pin 3	3.32	3.2v to 3.4v	√
2	Pins 3,11	Pin 6	3.32	3.2v to 3.4v	√
3	Pins 5,13	Pin 9	3.32	3.2v to 3.4v	√
4	Pins 7, 15	Pin 12	3.32	3.2v to 3.4v	√

11. Noise Monitor Tests

See Monitor re-test report.

Unit……………..OMC_2……………………Serial No ………………………………
Test Engineer…..Xen…………..………
Date……………..18/11/10..……………

12. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct.
Ensure that links W4 and W5 are present.

Use the Dynamic Signal Analyser and signal generator.

With the filter switched in, measure the frequency response of each channel in turn between 1 Hz and 1 kHz. Measure the gain at the spot frequencies below and record them. Measure the gain at 0.1 Hz using the signal generator and scope, using a 1v peak input signal, and recording the peak output. In each case the output is measured differentially between TP9 and TP13.
Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.2		
10Hz	-30.2		
100Hz	-42.8		
1KHz	-43.2		

Channel 2

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.2		
10Hz	-30.3		
100Hz	-42.8		
1KHz	-43.3		

Channel 3

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.3		
10Hz	-30.1		
100Hz	-42.8		
1KHz	-43.3		

Channel 4

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.2		
10Hz	-30.2		
100Hz	-42.8		
1KHz	-43.3		

0.1 Hz measurements with the signal generator and oscilloscope

Frequency	Output	Expected O/P	Pass/Fail
Ch1	4.85		
Ch2	4.85		
Ch3	4.85		
Ch4	4.85		

Unit……………..OMC_2……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10..……………

13. Distortion

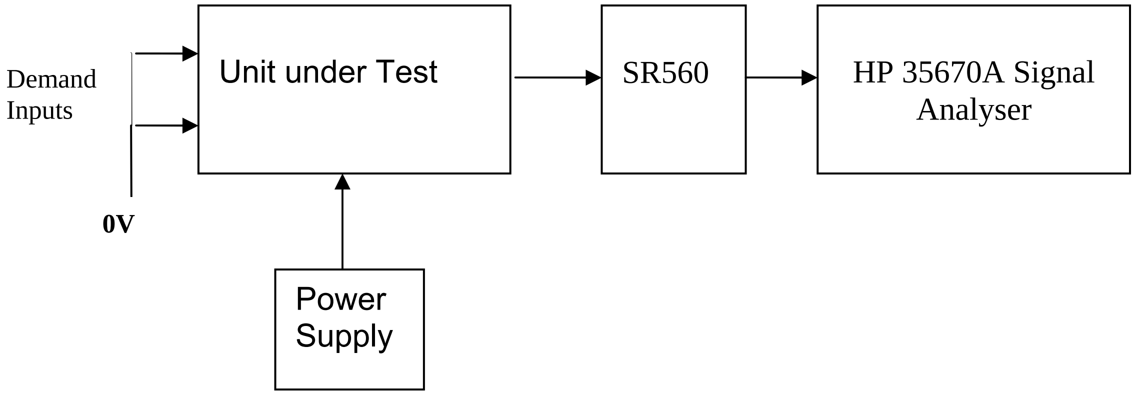
Remove links W4 and W5. Plug in the 5 Watt 39 Ohm dummy loads. Increase input voltage to 10v peak, f = 1KHz. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit……………..OMC_2……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..18/11/10……………..

14. Noise Tests

As the previous test involves non – representative temperature rises, allow the unit to cool before performing this test.
Replace the filter links W4 and W5 on each channel.
Replace the lid of the box, and replace screws.
Connect the filter test box, and switch in all filters.
Switch it out of Test Mode
Use the HP 35670A Dynamic Signal Analyser.
Connect a shorting plug to the demand input to short all positive and negative demands together and to 0v. Connect 39 Ohm loads to the outputs.
Switch the filters in.
Use Stuart Aston's noise measurement set up, loaded from disc.
Measure the noise output from each channel in turn at the amplifier outputs. The Low Pass filter on the SR650 may be used to reduce mains interference, to prevent the Signal Analyser from overloading. Ideally the filter corner frequency should be set to 3 KHz. Set the amplifier gain to 1000, and check that the overload light is not on before each measurement.



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-150.5 dB	-100.7	-160.7
Ch2	-150.5 dB	-100.6	-160.6
Ch3	-150.5 dB	-102.3	-162.3
Ch4	-150.5 dB	-102.7	-162.7

Notes:
Specified noise output current at 10 Hz = 50 pA/√Hz
Total output resistance = 600 Ohms
Amplifier noise voltage should therefore = 30nV/√Hz or -150.5dB

The noise monitor amplifier has an internal gain of 42dB at 10Hz.The noise floor is about -133dB.

Unit……………….OMC_2……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10..……………

15. Dynamic Range Tests

39 Ohm load resistors should be used, to represent the resistance of the Birmingham OSEM coil.

Plug in the dummy load.

Ensure that the filter links are in place, and the filters switched in circuit.

Drive the unit with a 5v peak sine wave on each channel (10v differential), at the frequencies specified. Measure the peak voltages across the load with an oscilloscope in each case, and compare with the specification

CH	0.5 Hz	0.5Hz Spec (mV)	1 Hz	1Hz Spec (mV)	10 Hz	10Hz Spec (mV)	OK ?
1	625	599 to 651	370	342 to 420	10.5	13 to 16	
2	625	599 to 651	370	342 to 420	10.5	13 to 16	
3	625	599 to 651	370	342 to 420	10.5	13 to 16	
4	625	599 to 651	370	342 to 420	10.5	13 to 16	

Notes: Specification:-

Frequency	Output Current	V across 40 Ohms
Freq < 0.5Hz	10mA peak	400mV
1 Hz	5 mA peak	200mV
10Hz< freq< 100Hz	0.5 mA peak	20mV

Unit……………………….OMC2……………Serial No ………………………………
Test Engineer…………..RMC
Date…………………24/11/10

16. Final Assembly Checks

1. Remove the lid of the box.√

2. Unplug all external connections. √

3. Check that the 9mm pillars are in place in the corners of the Monitor Board towards the centre of the box. √

4. Check that all internal connectors are firmly mated. √

5. Tighten the screw-locks holding all the external connectors. √

6. Check that the nuts holding the tabs of the power drivers are secure – tighten as necessary. Test with a DVM that none of the tabs are shorted to chassis. √

7. Check that all the LEDs are nicely centred. √

8. Check that links W4 and W5 are in place. √

9. Check that the boards are labelled with their Drawing Number, Issue Number, and serial number. Record below:

UoB box ID	OMC2P
Driver board ID	OMC2
Driver board Drawing No/Issue No	D1003116_V2
Driver board Serial Number	OMC2
Monitor board ID	MON157
Monitor board Drawing No/Issue No	D070480_5_K
Monitor board Serial Number	MON157

10. Check the security of any modification wires. √

11. Visually inspect. √

12. Put the lid on and fasten all screws, √

Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1000568-v1	Advanced LIGO UK	28 September 2010

OMC Coil Drive Unit Test Plan

R. M. Cutler, University of Birmingham

Distribution of this document:
Inform aligo_sus

This is an internal working note
of the Advanced LIGO Project, prepared by members of the UK team.

Institute for Gravitational Research
University of Glasgow
Phone +44 (0) 141 330 5884
Fax +44 (0) 141 330 6833
E-mail k.strain@physics.gla.ac.uk
Engineering Department
CCLRC Rutherford Appleton Laboratory
Phone +44 (0) 1235 445 297
Fax +44 (0) 1235 445 843
E-mail J.Greenhalgh@rl.ac.uk

School of Physics and Astronomy
University of Birmingham
Phone +44 (0) 121 414 6447
Fax +44 (0) 121 414 3722
E-mail av@star.sr.bham.ac.uk
Department of Physics
University of Strathclyde
Phone +44 (0) 1411 548 3360
Fax +44 (0) 141 552 2891
E-mail N.Lockerbie@phys.strath.ac.uk

http://www.ligo.caltech.edu/

http://www.physics.gla.ac.uk/igr/sus/

http://www.sr.bham.ac.uk/research/gravity/rh,d,2.html
http://www.eng-external.rl.ac.uk/advligo/papers_public/ALUK_Homepage.htm

OMC COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit………………OMC_3……………………Serial No ………………………………
Test Engineer…..Xen…………..………
Date……………..19/11/10..……………

Drive Card ID……OMC_3…………..…
Monitor Card ID…Mon208……………..

Contents

1. Description

The OMC Driver Unit will be used to control the OMC mirror position in the Advanced LIGO Gravity wave experiment.

It controls the current in the coil which provides the magnetic force which controls the position of the OMC. It works in conjunction with the OSEM coil and position sensor units. One OMC Driver Unit controls four OSEMs.

The OMC Coil Drive Unit contains a Coil Drive board and a Monitor board. The Monitor Board monitors the Output voltage, Output Current, RMS Current and Output Noise from the unit.

The OMC Driver Unit also passes the amplified signals from the Photodiodes, which detect the position of the OMC mirror, back to the control electronics without processing them in any way.

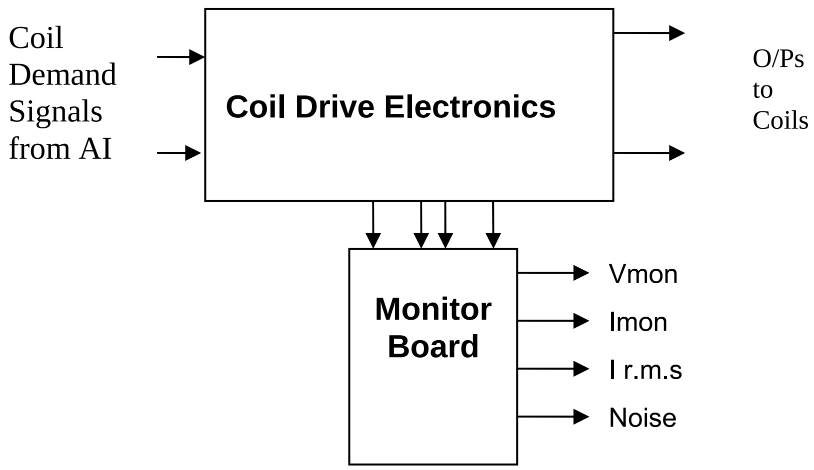


FIG. 1 OMC Driver Unit Block Diagram

Each OMC Driver Unit consists of four identical differential coil drive channels. It also contains the monitor board which monitors the output voltage, current, r.m.s current and noise from each channel

Unit………………OMC_3……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..19/11/10..……………

2. Test Equipment

Power supplies (At least +/- 20v variable, 1A)
Signal generator (capable of delivering 10v peak, 0.1Hz to 10 KHz))
Digital oscilloscope
Analogue oscilloscope
Agilent Dynamic Signal Analyser (or similar)
Low noise Balanced Driver circuit
Relay test box

Record the Models and serial numbers of the test equipment used below.

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	

Unit……………….OMC_3…………………….Serial No ………………………………
Test Engineer…..Xen…………..………
Date……………..18/11/10..……………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

Unit……………….OMC_3……………………Serial No ………………………………
Test Engineer…..Xen……………..………
Date……………..18/11/10...……………

4. Continuity Checks

Use a multi-meter to check the connections below.

Photodiode outputs

Pd Out to AA	SIGNAL	DESCRIPTION	Pd in from Sat	OK?
1	PD1P	Photodiode A+	1	√
2	PD2P	Photodiode B+	2	√
3	PD3P	Photodiode C+	3	√
4	PD4P	Photodiode D+	4	√
5	0V	√		
6	PD1N	Photodiode A-	14	√
7	PD2N	Photodiode B-	15	√
8	PD3N	Photodiode C-	16	√
9	PD4N	Photodiode D-	17	√

LED Monitors

LED Mon	SIGNAL	Monitors:	In from Sat	OK?
1	Imon1P	Current Source 1+	5	√
2	Imon2P	Current Source 2+	6	√
3	Imon3P	Current Source 3+	7	√
4	Imon4P	Current Source 4+	8	√
5	0V	√		
6	Imon1N	Current Source 1-	18	√
7	Imon2N	Current Source 2-	19	√
8	Imon3N	Current Source 3-	20	√
9	Imon4N	Current Source 4-	21	√

Power Supply to Satellite box

In from Sat	SIGNAL	DESCRIPTION	DC in Connector	OK?
9	V+	+17v Supply	A1	√
10	V+	+17v Supply	A1	√
11	V-	-17v Supply	A3	√
12	V-	-17v Supply	A3	√
13	0V	Return	A2	√
22	0V	Return	A2	√
23	0V	Return	A2	√
24	0V	Return	A2	√
25	0V	Return	A2	√

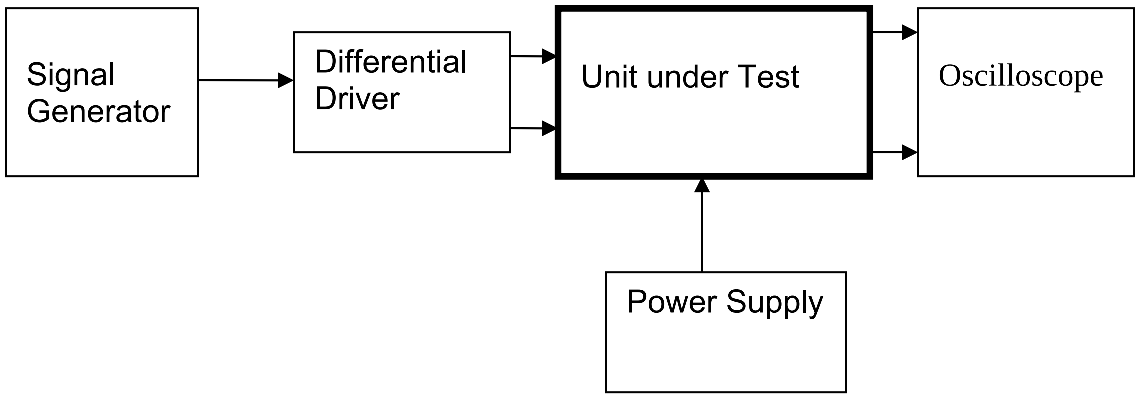
Unit……………….OMC_3……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10..……………

5. Isolation Checks

Check that the driver ICs IC11 and IC12 are isolated from chassis on all channels. Apply a DVM on ohms range and measure the resistance between each transistor tab and the chassis.

IC Tab	Resistance	OK?
IC11 Channel 1	OL	√
IC12 Channel 1	OL	√
IC11 Channel 2	OL	√
IC12 Channel 2	OL	√
IC11 Channel 3	OL	√
IC12 Channel 3	OL	√
IC11 Channel 4	OL	√
IC12 Channel 4	OL	√

6. TEST SET UP



Note:
(1) Input signal to differential amplifier is generally stated in the tests below. There is therefore an inherent gain of 2 in the system.

(2) Some signal generators will indicate 1vpk/pk when the output is in fact 1v Peak into the high impedance Differential driver used. The test procedure refers to the actual voltage out of the signal generator.

Connections:

Differential signal inputs to the Drive Input of the unit under test:
Drive Input pins 1, 2, 3, 4 = positive input
Drive Input pins 6, 7, 8, 9 = negative input
Drive Input pin 5 = ground

Power (depending on connector availability)

Pd In from Sat pin 9, 10 = +16.5v	or DC in A1
Pd In from Sat pin 11, 12 = -16.5	or DC in A3
Pd In from Sat pins 22, 23, 24, 25 = 0v	or DC in A2

Coil Drive Outputs

Ch1+ = Coil out to Sat pin 1	Ch1- = Coil out to Sat pin 9
Ch2+ = Coil out to Sat pin 3	Ch2- = Coil out to Sat pin 11
Ch3+ = Coil out to Sat pin 5	Ch3- = Coil out to Sat pin 13
Ch4+ = Coil out to Sat pin 7	Ch4- = Coil out to Sat pin 15

Voltage, Current and R.M.S monitors

1	Voltage Monitor 4
2	Current Monitor 4
3	R.M.S Current 4
4	Voltage Monitor 3
5	Current Monitor 3
6	R.M.S Current 3
7	Voltage Monitor 2
8	Current Monitor 2
9	R.M.S Current 2
10	Voltage Monitor 1
11	Current Monitor 1
12	R.M.S Current 1
13 to 25	0v

Noise Monitor

1	Channel 1 Noise Monitor
2	Channel 2 Noise Monitor
3	Channel 3 Noise Monitor
4	Channel 4 Noise Monitor
5 to 9	0v

Unit………………OMC_3……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10..……………

7. Power

Check the polarity of the wiring from the 3 pin power connector to each of the boards. Viewed from the back of the unit:

A1	Left pin	Positive	White wire
A2	Middle pin	RTN	Black wire
A3	Right pin	Negative	Green wire

If this is correct,
Connect power to the unit
Set the supplies to 16.5v
Turn on

Record supply currents:

+ 16.5 supply current (mA)	- 16.5 supply current (mA)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

If the power supplies are correct, proceed to the next section.

Unit………………OMC_3……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10..……………

8. Relay Operation

Operate each relay in turn.
Observe its operation. LEDs should illuminate when the relays are operated.

Filter

Channel	**Indicator**		**OK?**
	ON	**OFF**	
Ch1	√	√	√
Ch2	√	√	√
Ch3	√	√	√
Ch4	√	√	√

TEST SWITCHES

Channel	**Indicator**		**OK?**
	ON	**OFF**	
Ch1	√	√	√
Ch2	√	√	√
Ch3	√	√	√
Ch4	√	√	√

Unit………………OMC_3……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..18/11/10..……………

9. Current Monitor tests

The purpose of this test is to perform a functionality test on the current monitor and RMS circuits.

To do this, we need to draw a known current from each coil drive output. This is done by plugging the 39 ohm loads into each output, then adjusting the signal generator until the required voltage appears across each load resistor.

Remove all links W4 and W5.

Plug the power 39 ohm dummy load plug into the coil drive output.

Set the signal generator output to 2.5v peak at 100Hz.

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 0.4v peak appears across each resistor.

Record the peak output from each of the current monitors using the true r.m.s d.v.m and each of the RMS circuits with the meter set to d.c.

Channel	Monitor Connector	Parameter	Theoretical Value (+/- .1v)	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	1.39v r.m.s	1.35	√
	Pin 1	RMS Current	1.39v dc	1.35	√
2	Pin 5	Current Monitor	1.39v r.m.s	1.35	√
	Pin 4	RMS Current	1.39v dc	1.35	√
3	Pin 8	Current Monitor	1.39v r.m.s	1.35	√
	Pin 7	RMS Current	1.39v dc	1.35	√
4	Pin 11	Current Monitor	1.39v r.m.s	1.35	√
	Pin 10	RMS Current	1.39v dc	1.35	√

Unit………………OMC_3……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10...……………

10. Voltage Monitor tests

The purpose of this test is to verify and calibrate the Voltage Monitor circuit on each channel.

Switch all filters out. Remove the dummy loads and make differential voltage output measurements on the coil drive outputs at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

Channel	Coil Drive Output pins	Voltage Monitor socket Pin	Monitor output?	Expected value	OK?
1	Pins 1,9	Pin 3	3.32	3.2v to 3.4v	√
2	Pins 3,11	Pin 6	3.32	3.2v to 3.4v	√
3	Pins 5,13	Pin 9	3.32	3.2v to 3.4v	√
4	Pins 7, 15	Pin 12	3.32	3.2v to 3.4v	√

11. Noise Monitor Tests

See Monitor re-test report.

Unit……………..OMC_3……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..19/11/10………………

12. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct.
Ensure that links W4 and W5 are present.

Use the Dynamic Signal Analyser and signal generator.

With the filter switched in, measure the frequency response of each channel in turn between 1 Hz and 1 kHz. Measure the gain at the spot frequencies below and record them. Measure the gain at 0.1 Hz using the signal generator and scope, using a 1v peak input signal, and recording the peak output. In each case the output is measured differentially between TP9 and TP13. Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.2		
10Hz	-30.4		
100Hz	-42.9		
1KHz	-43.3		

Channel 2

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.1		
10Hz	-30.3		
100Hz	-42.9		
1KHz	-43.3		

Channel 3

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.3		
10Hz	-30.1		
100Hz	-42.8		
1KHz	-43.3		

Channel 4

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.0		
10Hz	-30.5		
100Hz	-42.8		
1KHz	-43.3		

0.1 Hz measurements with the signal generator and oscilloscope

Frequency	Output	Expected O/P	Pass/Fail
Ch1	4.85		
Ch2	4.85		
Ch3	4.85		
Ch4	4.85		

Unit………………OMC_3……………………Serial No ………………………………
Test Engineer…..Xen…………..………
Date……………..19/11/10..……………

13. Distortion

Remove links W4 and W5. Plug in the 5 Watt 39 Ohm dummy loads. Increase input voltage to 10v peak, f = 1KHz. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

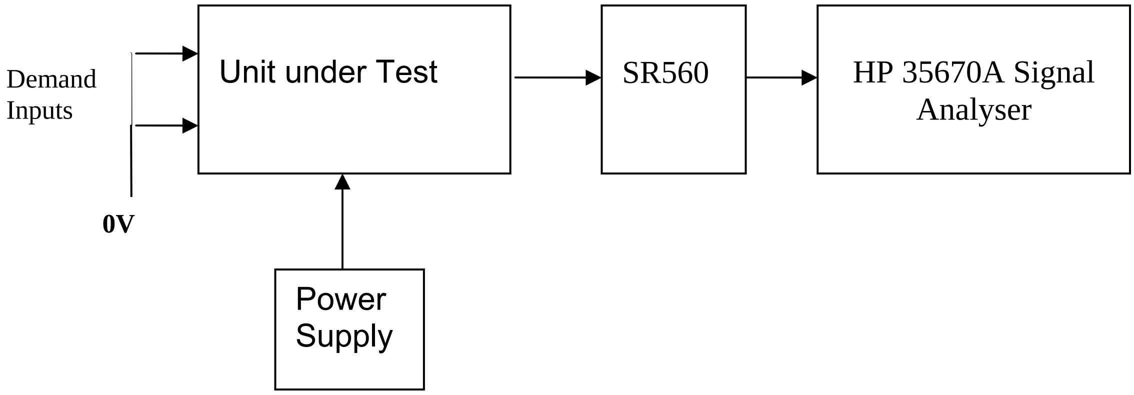
Unit……………..OMC_3……………………Serial No ………………………………
Test Engineer…..Xen……………..………
Date……………..18/11/10..……………

14. Noise Tests

As the previous test involves non – representative temperature rises, allow the unit to cool before performing this test.

Replace the filter links W4 and W5 on each channel.
Replace the lid of the box, and replace screws.
Connect the filter test box, and switch in all filters.
Switch it out of Test Mode

Use the HP 35670A Dynamic Signal Analyser.
Connect a shorting plug to the demand input to short all positive and negative demands together and to 0v. Connect 39 Ohm loads to the outputs.
Switch the filters in.
Use Stuart Aston's noise measurement set up, loaded from disc.
Measure the noise output from each channel in turn at the amplifier outputs. The Low Pass filter on the SR650 may be used to reduce mains interference, to prevent the Signal Analyser from overloading. Ideally the filter corner frequency should be set to 3 KHz. Set the amplifier gain to 1000, and check that the overload light is not on before each measurement.



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-150.5 dB	-100.4	-160.4
Ch2	-150.5 dB	-99.6	-159.6
Ch3	-150.5 dB	-99.7	-159.7
Ch4	-150.5 dB	-101.1	-161.1

Notes:
Specified noise output current at 10 Hz = 50 pA/√Hz
Total output resistance = 600 Ohms
Amplifier noise voltage should therefore = 30nV/√Hz or -150.5dB

The noise monitor amplifier has an internal gain of 42dB at 10Hz.The noise floor is about -133dB.

Unit……………..OMC_3……………………Serial No ………………………………
Test Engineer…..Xen……………..………
Date……………..19/11/10...……………

15. Dynamic Range Tests

39 Ohm load resistors should be used, to represent the resistance of the Birmingham OSEM coil.

Plug in the dummy load.

Ensure that the filter links are in place, and the filters switched in circuit.

Drive the unit with a 5v peak sine wave on each channel (10v differential), at the frequencies specified. Measure the peak voltages across the load with an oscilloscope in each case, and compare with the specification

CH	0.5 Hz	0.5Hz Spec (mV)	1 Hz	1Hz Spec (mV)	10 Hz	10Hz Spec (mV)	OK ?
1	625	599 to 651	370	342 to 420	10.5	13 to 16	
2	625	599 to 651	370	342 to 420	10.5	13 to 16	
3	625	599 to 651	380	342 to 420	11.0	13 to 16	
4	625	599 to 651	370	342 to 420	10.5	13 to 16	

Notes: Specification:-

Frequency	Output Current	V across 40 Ohms
Freq < 0.5Hz	10mA peak	400mV
1 Hz	5 mA peak	200mV
10Hz< freq< 100Hz	0.5 mA peak	20mV

Unit…………………………OMC3…………Serial No ………………………………
Test Engineer……………..RMC
Date………………………25/11/10

16. Final Assembly Checks

1. Remove the lid of the box.√

2. Unplug all external connections. √

3. Check that the 9mm pillars are in place in the corners of the Monitor Board towards the centre of the box. √

4. Check that all internal connectors are firmly mated. √

5. Tighten the screw-locks holding all the external connectors. √

6. Check that the nuts holding the tabs of the power drivers are secure – tighten as necessary. Test with a DVM that none of the tabs are shorted to chassis. √

7. Check that all the LEDs are nicely centred. √

8. Check that links W4 and W5 are in place. √

9. Check that the boards are labelled with their Drawing Number, Issue Number, and serial number. Record below:

UoB box ID	OMC3P
Driver board ID	OMC3
Driver board Drawing No/Issue No	D1003116_ V2
Driver board Serial Number	OMC3
Monitor board ID	MON208
Monitor board Drawing No/Issue No	D070480_5_K
Monitor board Serial Number	MON208

10. Check the security of any modification wires. √

11. Visually inspect. √

12. Put the lid on and fasten all screws, √

Check all external screws for tightness.

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1000568-v1	Advanced LIGO UK	28 September 2010

OMC Coil Drive Unit Test Plan

R. M. Cutler, University of Birmingham

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This is an internal working note
of the Advanced LIGO Project, prepared by members of the UK team.

Institute for Gravitational Research
University of Glasgow
Phone +44 (0) 141 330 5884
Fax +44 (0) 141 330 6833
E-mail k.strain@physics.gla.ac.uk
Engineering Department
CCLRC Rutherford Appleton Laboratory
Phone +44 (0) 1235 445 297
Fax +44 (0) 1235 445 843
E-mail J.Greenhalgh@rl.ac.uk

School of Physics and Astronomy
University of Birmingham
Phone +44 (0) 121 414 6447
Fax +44 (0) 121 414 3722
E-mail av@star.sr.bham.ac.uk
Department of Physics
University of Strathclyde
Phone +44 (0) 1411 548 3360
Fax +44 (0) 141 552 2891
E-mail N.Lockerbie@phys.strath.ac.uk

http://www.ligo.caltech.edu/

http://www.physics.gla.ac.uk/igr/sus/

http://www.sr.bham.ac.uk/research/gravity/rh,d,2.html
http://www.eng-external.rl.ac.uk/advligo/papers_public/ALUK_Homepage.htm

OMC COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit………………OMC_4……………………Serial No ………………………………
Test Engineer…..Xen…………..………
Date……………..18/11/10..……………

Drive Card ID……OMC_4…………..…
Monitor Card ID…Mon154……………..

Contents

1. Description

The OMC Driver Unit will be used to control the OMC mirror position in the Advanced LIGO Gravity wave experiment.

It controls the current in the coil which provides the magnetic force which controls the position of the OMC. It works in conjunction with the OSEM coil and position sensor units. One OMC Driver Unit controls four OSEMs.

The OMC Coil Drive Unit contains a Coil Drive board and a Monitor board. The Monitor Board monitors the Output voltage, Output Current, RMS Current and Output Noise from the unit.

The OMC Driver Unit also passes the amplified signals from the Photodiodes, which detect the position of the OMC mirror, back to the control electronics without processing them in any way.

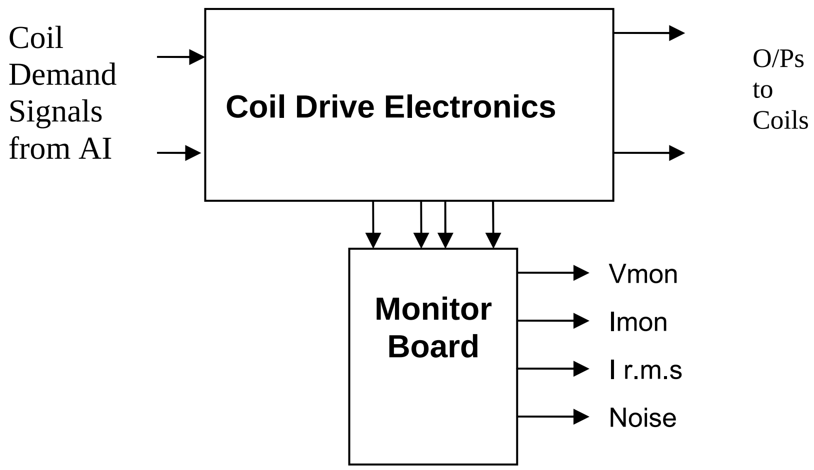


FIG. 1 OMC Driver Unit Block Diagram

Each OMC Driver Unit consists of four identical differential coil drive channels. It also contains the monitor board which monitors the output voltage, current, r.m.s current and noise from each channel

Unit………………OMC_4……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10..……………

2. Test Equipment

Power supplies (At least +/- 20v variable, 1A)
Signal generator (capable of delivering 10v peak, 0.1Hz to 10 KHz))
Digital oscilloscope
Analogue oscilloscope
Agilent Dynamic Signal Analyser (or similar)
Low noise Balanced Driver circuit
Relay test box

Record the Models and serial numbers of the test equipment used below.

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	

Unit……………..OMC_4……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10..……………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

Unit……………….OMC_4……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10..……………

4. Continuity Checks

Use a multi-meter to check the connections below.

Photodiode outputs

Pd Out to AA	SIGNAL	DESCRIPTION	Pd in from Sat	OK?
1	PD1P	Photodiode A+	1	√
2	PD2P	Photodiode B+	2	√
3	PD3P	Photodiode C+	3	√
4	PD4P	Photodiode D+	4	√
5	0V	√		
6	PD1N	Photodiode A-	14	√
7	PD2N	Photodiode B-	15	√
8	PD3N	Photodiode C-	16	√
9	PD4N	Photodiode D-	17	√

LED Monitors

LED Mon	SIGNAL	Monitors:	In from Sat	OK?
1	Imon1P	Current Source 1+	5	√
2	Imon2P	Current Source 2+	6	√
3	Imon3P	Current Source 3+	7	√
4	Imon4P	Current Source 4+	8	√
5	0V	√		
6	Imon1N	Current Source 1-	18	√
7	Imon2N	Current Source 2-	19	√
8	Imon3N	Current Source 3-	20	√
9	Imon4N	Current Source 4-	21	√

Power Supply to Satellite box

In from Sat	SIGNAL	DESCRIPTION	DC in Connector	OK?
9	V+	+17v Supply	A1	√
10	V+	+17v Supply	A1	√
11	V-	-17v Supply	A3	√
12	V-	-17v Supply	A3	√
13	0V	Return	A2	√
22	0V	Return	A2	√
23	0V	Return	A2	√
24	0V	Return	A2	√
25	0V	Return	A2	√

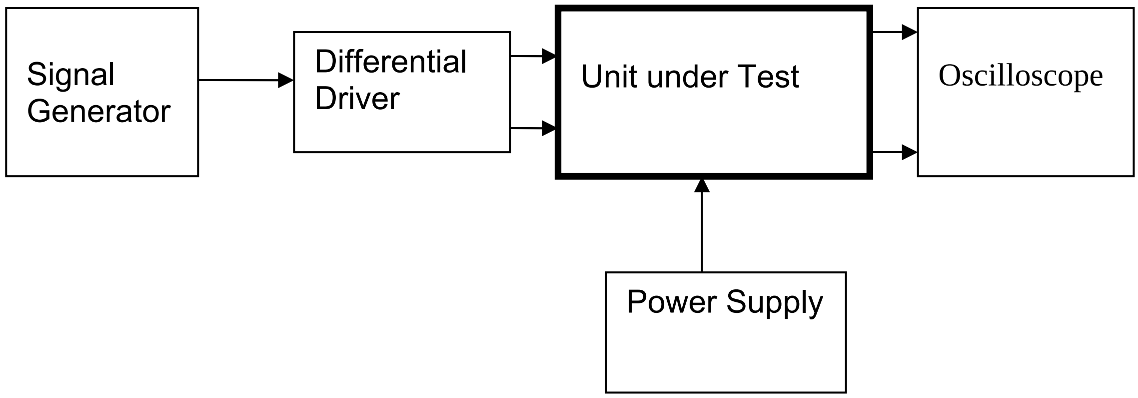
Unit………………OMC_4……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10..……………

5. Isolation Checks

Check that the driver ICs IC11 and IC12 are isolated from chassis on all channels. Apply a DVM on ohms range and measure the resistance between each transistor tab and the chassis.

IC Tab	Resistance	OK?
IC11 Channel 1	OL	√
IC12 Channel 1	OL	√
IC11 Channel 2	OL	√
IC12 Channel 2	OL	√
IC11 Channel 3	OL	√
IC12 Channel 3	OL	√
IC11 Channel 4	OL	√
IC12 Channel 4	OL	√

6. TEST SET UP



Note:
(1) Input signal to differential amplifier is generally stated in the tests below. There is therefore an inherent gain of 2 in the system.

(2) Some signal generators will indicate 1vpk/pk when the output is in fact 1v Peak into the high impedance Differential driver used. The test procedure refers to the actual voltage out of the signal generator.

Connections:

Differential signal inputs to the Drive Input of the unit under test:
Drive Input pins 1, 2, 3, 4 = positive input
Drive Input pins 6, 7, 8, 9 = negative input
Drive Input pin 5 = ground

Power (depending on connector availability)

Pd In from Sat pin 9, 10 = +16.5v	or DC in A1
Pd In from Sat pin 11, 12 = -16.5	or DC in A3
Pd In from Sat pins 22, 23, 24, 25 = 0v	or DC in A2

Coil Drive Outputs

Ch1+ = Coil out to Sat pin 1	Ch1- = Coil out to Sat pin 9
Ch2+ = Coil out to Sat pin 3	Ch2- = Coil out to Sat pin 11
Ch3+ = Coil out to Sat pin 5	Ch3- = Coil out to Sat pin 13
Ch4+ = Coil out to Sat pin 7	Ch4- = Coil out to Sat pin 15

Voltage, Current and R.M.S monitors

1	Voltage Monitor 4
2	Current Monitor 4
3	R.M.S Current 4
4	Voltage Monitor 3
5	Current Monitor 3
6	R.M.S Current 3
7	Voltage Monitor 2
8	Current Monitor 2
9	R.M.S Current 2
10	Voltage Monitor 1
11	Current Monitor 1
12	R.M.S Current 1
13 to 25	0v

Noise Monitor

1	Channel 1 Noise Monitor
2	Channel 2 Noise Monitor
3	Channel 3 Noise Monitor
4	Channel 4 Noise Monitor
5 to 9	0v

Unit………………OMC_4……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10..……………

7. Power

Check the polarity of the wiring from the 3 pin power connector to each of the boards. Viewed from the back of the unit:

A1	Left pin	Positive	White wire
A2	Middle pin	RTN	Black wire
A3	Right pin	Negative	Green wire

If this is correct,
Connect power to the unit
Set the supplies to 16.5v
Turn on

Record supply currents:

+ 16.5 supply current (mA)	- 16.5 supply current (mA)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

If the power supplies are correct, proceed to the next section.

Unit………………OMC_4……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10..……………

8. Relay Operation

Operate each relay in turn.
Observe its operation. LEDs should illuminate when the relays are operated.

Filter

Channel	Indicator		OK?
	ON	OFF	
Ch1	√	√	√
Ch2	√	√	√
Ch3	√	√	√
Ch4	√	√	√

TEST SWITCHES

Channel	Indicator		OK?
	ON	OFF	
Ch1	√	√	√
Ch2	√	√	√
Ch3	√	√	√
Ch4	√	√	√

Unit………………OMC_4……………………Serial No ………………………………
Test Engineer…..Xen…………..………
Date……………..18/11/10..……………

9. Current Monitor tests

The purpose of this test is to perform a functionality test on the current monitor and RMS circuits.

To do this, we need to draw a known current from each coil drive output. This is done by plugging the 39 ohm loads into each output, then adjusting the signal generator until the required voltage appears across each load resistor.

Remove all links W4 and W5.

Plug the power 39 ohm dummy load plug into the coil drive output.

Set the signal generator output to 2.5v peak at 100Hz.

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 0.4v peak appears across each resistor.

Record the peak output from each of the current monitors using the true r.m.s d.v.m and each of the RMS circuits with the meter set to d.c.

Channel	Monitor Connector	Parameter	Theoretical Value (+/- .1v)	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	1.39v r.m.s	1.35	√
	Pin 1	RMS Current	1.39v dc	1.35	√
2	Pin 5	Current Monitor	1.39v r.m.s	1.35	√
	Pin 4	RMS Current	1.39v dc	1.35	√
3	Pin 8	Current Monitor	1.39v r.m.s	1.35	√
	Pin 7	RMS Current	1.39v dc	1.35	√
4	Pin 11	Current Monitor	1.39v r.m.s	1.35	√
	Pin 10	RMS Current	1.39v dc	1.34	√

Unit……………..OMC_4……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10...……………

10. Voltage Monitor tests

The purpose of this test is to verify and calibrate the Voltage Monitor circuit on each channel.

Switch all filters out. Remove the dummy loads and make differential voltage output measurements on the coil drive outputs at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

Channel	Coil Drive Output pins	Voltage Monitor socket Pin	Monitor output?	Expected value	OK?
1	Pins 1,9	Pin 3	3.32	3.2v to 3.4v	√
2	Pins 3,11	Pin 6	3.32	3.2v to 3.4v	√
3	Pins 5,13	Pin 9	3.32	3.2v to 3.4v	√
4	Pins 7, 15	Pin 12	3.32	3.2v to 3.4v	√

11. Noise Monitor Tests

See Monitor re-test report.

Unit……………….OMC_4……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10..……………

12. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct.
Ensure that links W4 and W5 are present.

Use the Dynamic Signal Analyser and signal generator.

With the filter switched in, measure the frequency response of each channel in turn between 1 Hz and 1 kHz. Measure the gain at the spot frequencies below and record them. Measure the gain at 0.1 Hz using the signal generator and scope, using a 1v peak input signal, and recording the peak output. In each case the output is measured differentially between TP9 and TP13.
Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.2		
10Hz	-30.3		
100Hz	-42.8		
1KHz	-43.3		

Channel 2

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.5		
10Hz	-29.8		
100Hz	-42.8		
1KHz	-43.3		

Channel 3

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.3		
10Hz	-30.1		
100Hz	-42.8		
1KHz	-43.3		

Channel 4

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.1		
10Hz	-30.4		
100Hz	-42.9		
1KHz	-43.3		

0.1 Hz measurements with the signal generator and oscilloscope

Frequency	Output	Expected O/P	Pass/Fail
Ch1	4.85		
Ch2	4.85		
Ch3	4.85		
Ch4	4.85		

Unit……………….OMC_4……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10..……………

13. Distortion

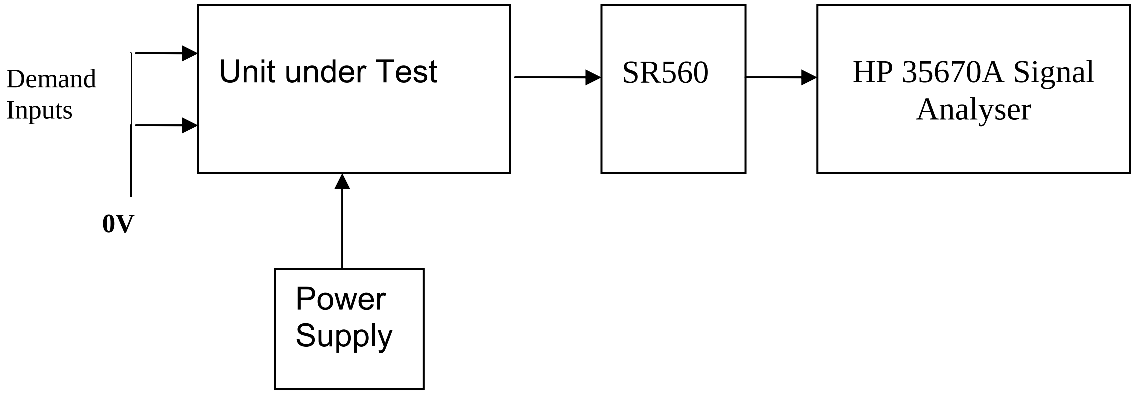
Remove links W4 and W5. Plug in the 5 Watt 39 Ohm dummy loads. Increase input voltage to 10v peak, f = 1KHz. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit……………..OMC_4……………………Serial No ………………………………
Test Engineer…..Xen…………..………
Date……………..18/11/10...……………

14. Noise Tests

As the previous test involves non – representative temperature rises, allow the unit to cool before performing this test.
Replace the filter links W4 and W5 on each channel.
Replace the lid of the box, and replace screws.
Connect the filter test box, and switch in all filters.
Switch it out of Test Mode
Use the HP 35670A Dynamic Signal Analyser.
Connect a shorting plug to the demand input to short all positive and negative demands together and to 0v. Connect 39 Ohm loads to the outputs.
Switch the filters in.
Use Stuart Aston's noise measurement set up, loaded from disc.
Measure the noise output from each channel in turn at the amplifier outputs. The Low Pass filter on the SR650 may be used to reduce mains interference, to prevent the Signal Analyser from overloading. Ideally the filter corner frequency should be set to 3 KHz. Set the amplifier gain to 1000, and check that the overload light is not on before each measurement.



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-150.5 dB	-100.6	-160.6
Ch2	-150.5 dB	-101.9	-161.9
Ch3	-150.5 dB	-100.3	-160.3
Ch4	-150.5 dB	-101.2	-161.2

Notes:
Specified noise output current at 10 Hz = 50 pA/√Hz
Total output resistance = 600 Ohms
Amplifier noise voltage should therefore = 30nV/√Hz or -150.5dB

The noise monitor amplifier has an internal gain of 42dB at 10Hz.The noise floor is about -133dB.

Unit………………OMC_4……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10..……………

15. Dynamic Range Tests

39 Ohm load resistors should be used, to represent the resistance of the Birmingham OSEM coil.

Plug in the dummy load.

Ensure that the filter links are in place, and the filters switched in circuit.

Drive the unit with a 5v peak sine wave on each channel (10v differential), at the frequencies specified. Measure the peak voltages across the load with an oscilloscope in each case, and compare with the specification

CH	0.5 Hz	0.5Hz Spec (mV)	1 Hz	1Hz Spec (mV)	10 Hz	10Hz Spec (mV)	OK ?
1	625	599 to 651	370	342 to 420	10.5	13 to 16	
2	625	599 to 651	390	342 to 420	11.0	13 to 16	
3	625	599 to 651	380	342 to 420	10.8	13 to 16	
4	625	599 to 651	370	342 to 420	10.5	13 to 16	

Notes: Specification:-

Frequency	Output Current	V across 40 Ohms
Freq < 0.5Hz	10mA peak	400mV
1 Hz	5 mA peak	200mV
10Hz< freq< 100Hz	0.5 mA peak	20mV

Unit……………………….OMC4……………Serial No ………………………………
Test Engineer…………….RMC
Date……………………….25/11/10

16. Final Assembly Checks

1. Remove the lid of the box. √

2. Unplug all external connections. √

3. Check that the 9mm pillars are in place in the corners of the Monitor Board towards the centre of the box. √

4. Check that all internal connectors are firmly mated. √

5. Tighten the screw-locks holding all the external connectors. √

6. Check that the nuts holding the tabs of the power drivers are secure – tighten as necessary. Test with a DVM that none of the tabs are shorted to chassis. √

7. Check that all the LEDs are nicely centred. √

8. Check that links W4 and W5 are in place. √

9. Check that the boards are labelled with their Drawing Number, Issue Number, and serial number. Record below:

UoB box ID	OMC4P
Driver board ID	OMC4
Driver board Drawing No/Issue No	D100316_V2
Driver board Serial Number	OMC4
Monitor board ID	MON154
Monitor board Drawing No/Issue No	D070480_5_K
Monitor board Serial Number	MON154

10. Check the security of any modification wires. √

11. Visually inspect. √

12. Put the lid on and fasten all screws, √

    Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1000568-v1 Advanced LIGO UK 28 September 2010

OMC Coil Drive Unit Test Plan

R. M. Cutler, University of Birmingham

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This is an internal working note
of the Advanced LIGO Project, prepared by members of the UK team.

Institute for Gravitational Research
University of Glasgow
Phone +44 (0) 141 330 5884
Fax +44 (0) 141 330 6833
E-mail k.strain@physics.gla.ac.uk

Engineering Department
CCLRC Rutherford Appleton Laboratory
Phone +44 (0) 1235 445 297
Fax +44 (0) 1235 445 843
E-mail J.Greenhalgh@rl.ac.uk

School of Physics and Astronomy
University of Birmingham
Phone +44 (0) 121 414 6447
Fax +44 (0) 121 414 3722
E-mail av@star.sr.bham.ac.uk

Department of Physics
University of Strathclyde
Phone +44 (0) 1411 548 3360
Fax +44 (0) 141 552 2891
E-mail N.Lockerbie@phys.strath.ac.uk

http://www.ligo.caltech.edu/

http://www.physics.gla.ac.uk/igr/sus/

http://www.sr.bham.ac.uk/research/gravity/rh,d,2.html
http://www.eng-external.rl.ac.uk/advligo/papers_public/ALUK_Homepage.htm

OMC COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit………………OMC_5……………………Serial No ………………………………
Test Engineer…..Xen…………..………
Date……………..11/11/10..……………

Drive Card ID……OMC_5…………..…
Monitor Card ID…Mon218……………..

Contents

1. Description

The OMC Driver Unit will be used to control the OMC mirror position in the Advanced LIGO Gravity wave experiment.

It controls the current in the coil which provides the magnetic force which controls the position of the OMC. It works in conjunction with the OSEM coil and position sensor units. One OMC Driver Unit controls four OSEMs.

The OMC Coil Drive Unit contains a Coil Drive board and a Monitor board. The Monitor Board monitors the Output voltage, Output Current, RMS Current and Output Noise from the unit.

The OMC Driver Unit also passes the amplified signals from the Photodiodes, which detect the position of the OMC mirror, back to the control electronics without processing them in any way.

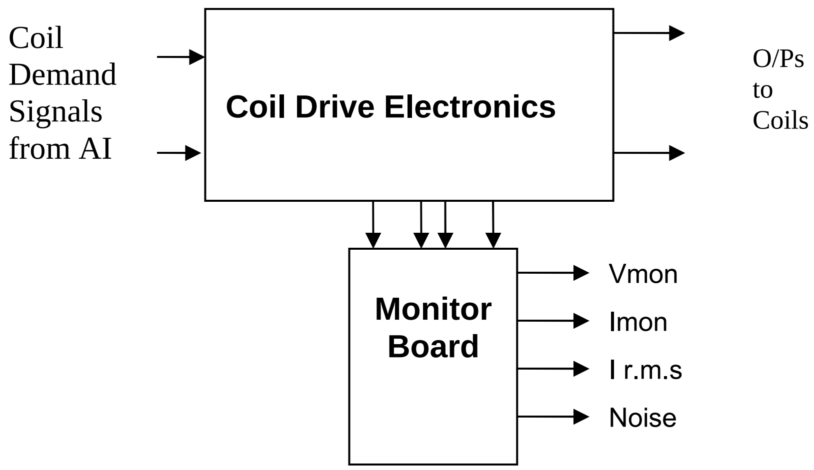


FIG. 1 OMC Driver Unit Block Diagram

Each OMC Driver Unit consists of four identical differential coil drive channels. It also contains the monitor board which monitors the output voltage, current, r.m.s current and noise from each channel

Unit……………….OMC_5……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..11/11/10..……………

2. Test Equipment

Power supplies (At least +/- 20v variable, 1A)
Signal generator (capable of delivering 10v peak, 0.1Hz to 10 KHz))
Digital oscilloscope
Analogue oscilloscope
Agilent Dynamic Signal Analyser (or similar)
Low noise Balanced Driver circuit
Relay test box

Record the Models and serial numbers of the test equipment used below.

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	

Unit……………….OMC_5……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..10/11/10..……………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

Unit……………….OMC_5……………………Serial No ………………………………
Test Engineer…..Xen……………..………
Date……………..10/11/10..……………

4. Continuity Checks

Use a multi-meter to check the connections below.

Photodiode outputs

Pd Out to AA	SIGNAL	DESCRIPTION	Pd in from Sat	OK?
1	PD1P	Photodiode A+	1	√
2	PD2P	Photodiode B+	2	√
3	PD3P	Photodiode C+	3	√
4	PD4P	Photodiode D+	4	√
5	0V	√		
6	PD1N	Photodiode A-	14	√
7	PD2N	Photodiode B-	15	√
8	PD3N	Photodiode C-	16	√
9	PD4N	Photodiode D-	17	√

LED Monitors

LED Mon	SIGNAL	Monitors:	In from Sat	OK?
1	Imon1P	Current Source 1+	5	√
2	Imon2P	Current Source 2+	6	√
3	Imon3P	Current Source 3+	7	√
4	Imon4P	Current Source 4+	8	√
5	0V	√		
6	Imon1N	Current Source 1-	18	√
7	Imon2N	Current Source 2-	19	√
8	Imon3N	Current Source 3-	20	√
9	Imon4N	Current Source 4-	21	√

Power Supply to Satellite box

In from Sat	SIGNAL	DESCRIPTION	DC in Connector	OK?
9	V+	+17v Supply	A1	√
10	V+	+17v Supply	A1	√
11	V-	-17v Supply	A3	√
12	V-	-17v Supply	A3	√
13	0V	Return	A2	√
22	0V	Return	A2	√
23	0V	Return	A2	√
24	0V	Return	A2	√
25	0V	Return	A2	√

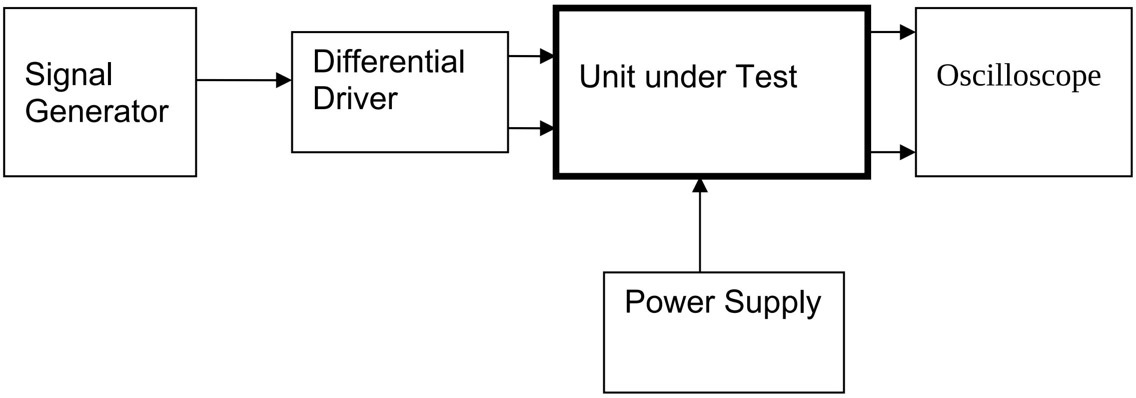
Unit………………OMC_5……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..10/11/10..……………

5. Isolation Checks

Check that the driver ICs IC11 and IC12 are isolated from chassis on all channels. Apply a DVM on ohms range and measure the resistance between each transistor tab and the chassis.

IC Tab	Resistance	OK?
IC11 Channel 1	OL	√
IC12 Channel 1	OL	√
IC11 Channel 2	OL	√
IC12 Channel 2	OL	√
IC11 Channel 3	OL	√
IC12 Channel 3	OL	√
IC11 Channel 4	OL	√
IC12 Channel 4	OL	√

6. TEST SET UP



Note:
(1) Input signal to differential amplifier is generally stated in the tests below. There is therefore an inherent gain of 2 in the system.

(2) Some signal generators will indicate 1vpk/pk when the output is in fact 1v Peak into the high impedance Differential driver used. The test procedure refers to the actual voltage out of the signal generator.

Connections:

Differential signal inputs to the Drive Input of the unit under test:
Drive Input pins 1, 2, 3, 4 = positive input
Drive Input pins 6, 7, 8, 9 = negative input
Drive Input pin 5 = ground

Power (depending on connector availability)

Pd In from Sat pin 9, 10 = +16.5v	or DC in A1
Pd In from Sat pin 11, 12 = -16.5	or DC in A3
Pd In from Sat pins 22, 23, 24, 25 = 0v	or DC in A2

Coil Drive Outputs

Ch1+ = Coil out to Sat pin 1	Ch1- = Coil out to Sat pin 9
Ch2+ = Coil out to Sat pin 3	Ch2- = Coil out to Sat pin 11
Ch3+ = Coil out to Sat pin 5	Ch3- = Coil out to Sat pin 13
Ch4+ = Coil out to Sat pin 7	Ch4- = Coil out to Sat pin 15

Voltage, Current and R.M.S monitors

1	Voltage Monitor 4
2	Current Monitor 4
3	R.M.S Current 4
4	Voltage Monitor 3
5	Current Monitor 3
6	R.M.S Current 3
7	Voltage Monitor 2
8	Current Monitor 2
9	R.M.S Current 2
10	Voltage Monitor 1
11	Current Monitor 1
12	R.M.S Current 1
13 to 25	0v

Noise Monitor

1	Channel 1 Noise Monitor
2	Channel 2 Noise Monitor
3	Channel 3 Noise Monitor
4	Channel 4 Noise Monitor
5 to 9	0v

Unit……………….OMC_5……………………Serial No ………………………………
Test Engineer…..Xen…………..………
Date……………..10/11/10..……………

7. Power

Check the polarity of the wiring from the 3 pin power connector to each of the boards. Viewed from the back of the unit:

A1	Left pin	Positive	White wire	
A2		Middle pin	RTN	Black wire
A3	Right pin	Negative	Green wire	

If this is correct,
Connect power to the unit
Set the supplies to 16.5v
Turn on

Record supply currents:

+ 16.5 supply current (mA)	- 16.5 supply current (mA)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

If the power supplies are correct, proceed to the next section.

Unit………………OMC_5……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..10/11/10..……………

8. Relay Operation

Operate each relay in turn.
Observe its operation. LEDs should illuminate when the relays are operated.

Filter

Channel	Indicator		OK?
	ON	OFF	
Ch1	√	√	√
Ch2	√	√	√
Ch3	√	√	√
Ch4	√	√	√

TEST SWITCHES

Channel	Indicator		OK?
	ON	OFF	
Ch1	√	√	√
Ch2	√	√	√
Ch3	√	√	√
Ch4	√	√	√

Unit……………….OMC_5……………………Serial No ………………………………
Test Engineer…..Xen……………..………
Date……………..10/11/10..……………

9. Current Monitor tests

The purpose of this test is to perform a functionality test on the current monitor and RMS circuits.

To do this, we need to draw a known current from each coil drive output. This is done by plugging the 39 ohm loads into each output, then adjusting the signal generator until the required voltage appears across each load resistor.

Remove all links W4 and W5.

Plug the power 39 ohm dummy load plug into the coil drive output.

Set the signal generator output to 2.5v peak at 100Hz.

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 0.4v peak appears across each resistor.

Record the peak output from each of the current monitors using the true r.m.s d.v.m and each of the RMS circuits with the meter set to d.c.

Channel	Monitor Connector	Parameter	Theoretical Value (+/- .1v)	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	1.39v r.m.s	1.35	√
	Pin 1	RMS Current	1.39v dc	1.35	√
2	Pin 5	Current Monitor	1.39v r.m.s	1.35	√
	Pin 4	RMS Current	1.39v dc	1.35	√
3	Pin 8	Current Monitor	1.39v r.m.s	1.35	√
	Pin 7	RMS Current	1.39v dc	1.35	√
4	Pin 11	Current Monitor	1.39v r.m.s	1.35	√
	Pin 10	RMS Current	1.39v dc	1.35	√

Unit………………OMC_5……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..10/11/10..……………

10. Voltage Monitor tests

The purpose of this test is to verify and calibrate the Voltage Monitor circuit on each channel.

Switch all filters out. Remove the dummy loads and make differential voltage output measurements on the coil drive outputs at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

Channel	Coil Drive Output pins	Voltage Monitor socket Pin	Monitor output?	Expected value	OK?
1	Pins 1,9	Pin 3	3.32	3.2v to 3.4v	√
2	Pins 3,11	Pin 6	3.32	3.2v to 3.4v	√
3	Pins 5,13	Pin 9	3.32	3.2v to 3.4v	√
4	Pins 7, 15	Pin 12	3.32	3.2v to 3.4v	√

11. Noise Monitor Tests

See Monitor re-test report.

Unit……………….OMC_5……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..10/11/10..……………

12. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct.
Ensure that links W4 and W5 are present.

Use the Dynamic Signal Analyser and signal generator.

With the filter switched in, measure the frequency response of each channel in turn between 1 Hz and 1 kHz. Measure the gain at the spot frequencies below and record them. Measure the gain at 0.1 Hz using the signal generator and scope, using a 1v peak input signal, and recording the peak output. In each case the output is measured differentially between TP9 and TP13.
Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.4		
10Hz	-30.0		
100Hz	-42.8		
1KHz	-43.3		

Channel 2

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.2		
10Hz	-30.4		
100Hz	-42.9		
1KHz	-43.3		

Channel 3

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.3		
10Hz	-30.1		
100Hz	-42.8		
1KHz	-43.3		

Channel 4

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.3		
10Hz	-30.1		
100Hz	-42.8		
1KHz	-43.3		

0.1 Hz measurements with the signal generator and oscilloscope

Frequency	Output	Expected O/P	Pass/Fail
Ch1	4.85		
Ch2	4.85		
Ch3	4.85		
Ch4	4.85		

Unit……………..OMC_5……………………Serial No ………………………………
Test Engineer…..Xen………….………
Date……………..10/11/10..……………

13. Distortion

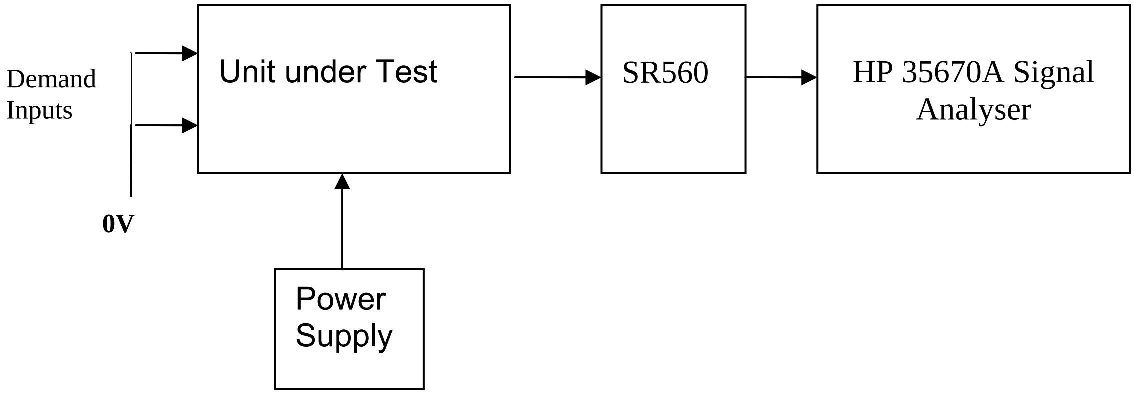
Remove links W4 and W5. Plug in the 5 Watt 39 Ohm dummy loads. Increase input voltage to 10v peak, f = 1KHz. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit……………..OMC_5……………………Serial No ……………………………
Test Engineer…..Xen…………..………
Date……………..10/11/10..……………

14. Noise Tests

As the previous test involves non – representative temperature rises, allow the unit to cool before performing this test.
Replace the filter links W4 and W5 on each channel.
Replace the lid of the box, and replace screws.
Connect the filter test box, and switch in all filters.
Switch it out of Test Mode
Use the HP 35670A Dynamic Signal Analyser.
Connect a shorting plug to the demand input to short all positive and negative demands together and to 0v. Connect 39 Ohm loads to the outputs.
Switch the filters in.
Use Stuart Aston's noise measurement set up, loaded from disc.
Measure the noise output from each channel in turn at the amplifier outputs. The Low Pass filter on the SR650 may be used to reduce mains interference, to prevent the Signal Analyser from overloading. Ideally the filter corner frequency should be set to 3 KHz. Set the amplifier gain to 1000, and check that the overload light is not on before each measurement.



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-150.5 dB	-100.9	-160.9
Ch2	-150.5 dB	-101.1	-161.1
Ch3	-150.5 dB	-102.7	-162.7
Ch4	-150.5 dB	-100.7	-160.7

Notes:
Specified noise output current at 10 Hz = 50 pA/√Hz
Total output resistance = 600 Ohms
Amplifier noise voltage should therefore = 30nV/√Hz or -150.5dB

The noise monitor amplifier has an internal gain of 42dB at 10Hz.The noise floor is about -133dB.

Unit……………..OMC_5……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..17/11/10..……………

15. Dynamic Range Tests

39 Ohm load resistors should be used, to represent the resistance of the Birmingham OSEM coil.

Plug in the dummy load.

Ensure that the filter links are in place, and the filters switched in circuit.

Drive the unit with a 5v peak sine wave on each channel (10v differential), at the frequencies specified. Measure the peak voltages across the load with an oscilloscope in each case, and compare with the specification.

CH	0.5 Hz	0.5Hz Spec (mV)	1 Hz	1Hz Spec (mV)	10 Hz	10Hz Spec (mV)	OK ?
1	625	599 to 651	380	342 to 420	11	13 to 16	
2	625	599 to 651	370	342 to 420	10.5	13 to 16	
3	625	599 to 651	370	342 to 420	10.5	13 to 16	
4	625	599 to 651	380	342 to 420	10.8	13 to 16	

Notes: Specification:-

Frequency	Output Current	V across 40 Ohms
Freq < 0.5Hz	10mA peak	400mV
1 Hz	5 mA peak	200mV
10Hz< freq< 100Hz	0.5 mA peak	20mV

Unit……………………………OMC5P……Serial No ………………………………
Test Engineer……………..RMC
Date………………………25/11/10

16. Final Assembly Checks

1. Remove the lid of the box.√

2. Unplug all external connections. √

3. Check that the 9mm pillars are in place in the corners of the Monitor Board towards the centre of the box. √

4. Check that all internal connectors are firmly mated. √

5. Tighten the screw-locks holding all the external connectors. √

6. Check that the nuts holding the tabs of the power drivers are secure – tighten as necessary. Test with a DVM that none of the tabs are shorted to chassis. √

7. Check that all the LEDs are nicely centred. √

8. Check that links W4 and W5 are in place. √

9. Check that the boards are labelled with their Drawing Number, Issue Number, and serial number. Record below:

UoB box ID	OMC5P
Driver board ID	OMC5
Driver board Drawing No/Issue No	D1003116_V2
Driver board Serial Number	OMC5
Monitor board ID	MON218
Monitor board Drawing No/Issue No	D070480_5_K
Monitor board Serial Number	MON218

10. Check the security of any modification wires. √

11. Visually inspect. √

12. Put the lid on and fasten all screws,

    Check all external screws for tightness.

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1000568-v1 Advanced LIGO UK 28 September 2010

OMC Coil Drive Unit Test Plan

R. M. Cutler, University of Birmingham

Distribution of this document:
Inform aligo_sus

This is an internal working note
of the Advanced LIGO Project, prepared by members of the UK team.

Institute for Gravitational Research
University of Glasgow
Phone +44 (0) 141 330 5884
Fax +44 (0) 141 330 6833
E-mail k.strain@physics.gla.ac.uk
Engineering Department
CCLRC Rutherford Appleton Laboratory
Phone +44 (0) 1235 445 297
Fax +44 (0) 1235 445 843
E-mail J.Greenhalgh@rl.ac.uk

School of Physics and Astronomy
University of Birmingham
Phone +44 (0) 121 414 6447
Fax +44 (0) 121 414 3722
E-mail av@star.sr.bham.ac.uk
Department of Physics
University of Strathclyde
Phone +44 (0) 1411 548 3360
Fax +44 (0) 141 552 2891
E-mail N.Lockerbie@phys.strath.ac.uk

http://www.ligo.caltech.edu/

http://www.physics.gla.ac.uk/igr/sus/

http://www.sr.bham.ac.uk/research/gravity/rh,d,2.html
http://www.eng-external.rl.ac.uk/advligo/papers_public/ALUK_Homepage.htm

OMC COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit………………OMC_6……………………Serial No ………………………………
Test Engineer…..Xen…………..………
Date……………..19/11/10...…………..

Drive Card ID……OMC_6…………..…
Monitor Card ID…Mon204……………..

Contents

1. Description

The OMC Driver Unit will be used to control the OMC mirror position in the Advanced LIGO Gravity wave experiment.

It controls the current in the coil which provides the magnetic force which controls the position of the OMC. It works in conjunction with the OSEM coil and position sensor units. One OMC Driver Unit controls four OSEMs.

The OMC Coil Drive Unit contains a Coil Drive board and a Monitor board. The Monitor Board monitors the Output voltage, Output Current, RMS Current and Output Noise from the unit.

The OMC Driver Unit also passes the amplified signals from the Photodiodes, which detect the position of the OMC mirror, back to the control electronics without processing them in any way.

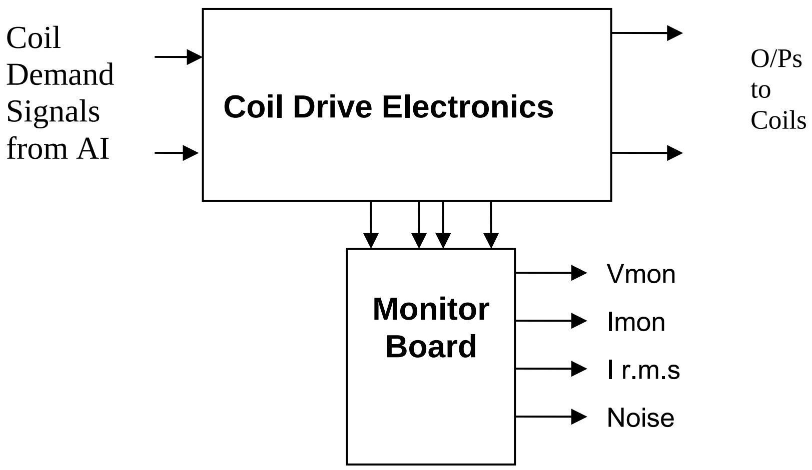


FIG. 1 OMC Driver Unit Block Diagram

Each OMC Driver Unit consists of four identical differential coil drive channels. It also contains the monitor board which monitors the output voltage, current, r.m.s current and noise from each channel

Unit………………OMC_6……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..19/11/10..……………

2. Test Equipment

Power supplies (At least +/- 20v variable, 1A)
Signal generator (capable of delivering 10v peak, 0.1Hz to 10 KHz))
Digital oscilloscope
Analogue oscilloscope
Agilent Dynamic Signal Analyser (or similar)
Low noise Balanced Driver circuit
Relay test box

Record the Models and serial numbers of the test equipment used below.

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	

Unit……………….OMC_6……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..19/11/10..……………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

Unit……………..OMC_6……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..19/11/10..……………

4. Continuity Checks

Use a multi-meter to check the connections below.

Photodiode outputs

Pd Out to AA	SIGNAL	DESCRIPTION	Pd in from Sat	OK?
1	PD1P	Photodiode A+	1	√
2	PD2P	Photodiode B+	2	√
3	PD3P	Photodiode C+	3	√
4	PD4P	Photodiode D+	4	√
5	0V	√		
6	PD1N	Photodiode A-	14	√
7	PD2N	Photodiode B-	15	√
8	PD3N	Photodiode C-	16	√
9	PD4N	Photodiode D-	17	√

LED Monitors

LED Mon	SIGNAL	Monitors:	In from Sat	OK?
1	Imon1P	Current Source 1+	5	√
2	Imon2P	Current Source 2+	6	√
3	Imon3P	Current Source 3+	7	√
4	Imon4P	Current Source 4+	8	√
5	0V	√		
6	Imon1N	Current Source 1-	18	√
7	Imon2N	Current Source 2-	19	√
8	Imon3N	Current Source 3-	20	√
9	Imon4N	Current Source 4-	21	√

Power Supply to Satellite box

In from Sat	SIGNAL	DESCRIPTION	DC in Connector	OK?
9	V+	+17v Supply	A1	√
10	V+	+17v Supply	A1	√
11	V-	-17v Supply	A3	√
12	V-	-17v Supply	A3	√
13	0V	Return	A2	√
22	0V	Return	A2	√
23	0V	Return	A2	√
24	0V	Return	A2	√
25	0V	Return	A2	√

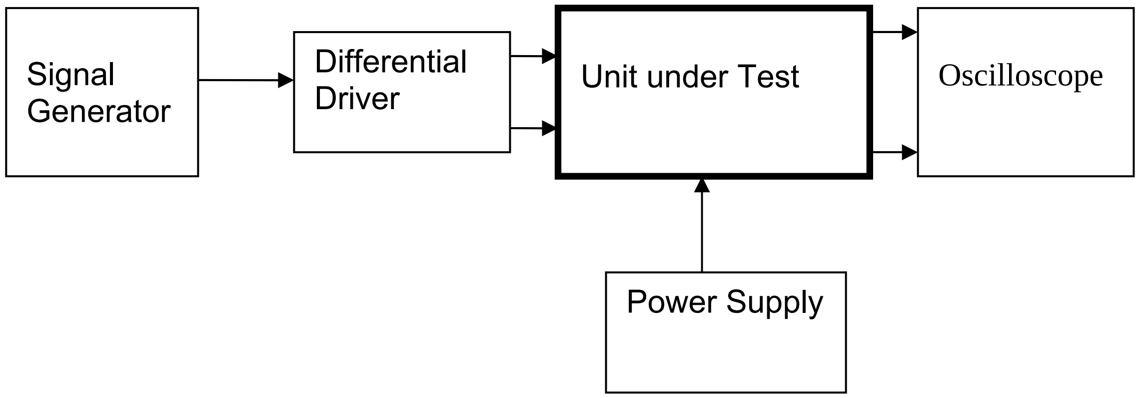
Unit………………OMC_6……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..19/11/10..……………

5. Isolation Checks

Check that the driver ICs IC11 and IC12 are isolated from chassis on all channels. Apply a DVM on ohms range and measure the resistance between each transistor tab and the chassis.

IC Tab	Resistance	OK?
IC11 Channel 1	OL	√
IC12 Channel 1	OL	√
IC11 Channel 2	OL	√
IC12 Channel 2	OL	√
IC11 Channel 3	OL	√
IC12 Channel 3	OL	√
IC11 Channel 4	OL	√
IC12 Channel 4	OL	√

6. TEST SET UP



Note:
(1) Input signal to differential amplifier is generally stated in the tests below. There is therefore an inherent gain of 2 in the system.

(2) Some signal generators will indicate 1vpk/pk when the output is in fact 1v Peak into the high impedance Differential driver used. The test procedure refers to the actual voltage out of the signal generator.

Connections:

Differential signal inputs to the Drive Input of the unit under test:
Drive Input pins 1, 2, 3, 4 = positive input
Drive Input pins 6, 7, 8, 9 = negative input
Drive Input pin 5 = ground

Power (depending on connector availability)

Pd In from Sat pin 9, 10 = +16.5v	or DC in A1
Pd In from Sat pin 11, 12 = -16.5	or DC in A3
Pd In from Sat pins 22, 23, 24, 25 = 0v	or DC in A2

Coil Drive Outputs

Ch1+ = Coil out to Sat pin 1	Ch1- = Coil out to Sat pin 9
Ch2+ = Coil out to Sat pin 3	Ch2- = Coil out to Sat pin 11
Ch3+ = Coil out to Sat pin 5	Ch3- = Coil out to Sat pin 13
Ch4+ = Coil out to Sat pin 7	Ch4- = Coil out to Sat pin 15

Voltage, Current and R.M.S monitors

1	Voltage Monitor 4
2	Current Monitor 4
3	R.M.S Current 4
4	Voltage Monitor 3
5	Current Monitor 3
6	R.M.S Current 3
7	Voltage Monitor 2
8	Current Monitor 2
9	R.M.S Current 2
10	Voltage Monitor 1
11	Current Monitor 1
12	R.M.S Current 1
13 to 25	0v

Noise Monitor

1	Channel 1 Noise Monitor
2	Channel 2 Noise Monitor
3	Channel 3 Noise Monitor
4	Channel 4 Noise Monitor
5 to 9	0v

Unit………………OMC_6……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..19/11/10..……………

7. Power

Check the polarity of the wiring from the 3 pin power connector to each of the boards. Viewed from the back of the unit:

A1	Left pin	Positive	White wire
A2	Middle pin	RTN	Black wire
A3	Right pin	Negative	Green wire

If this is correct,
Connect power to the unit
Set the supplies to 16.5v
Turn on

Record supply currents:

+ 16.5 supply current (mA)	- 16.5 supply current (mA)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

If the power supplies are correct, proceed to the next section.

Unit……………….OMC_6……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..19/11/10..……………

8. Relay Operation

Operate each relay in turn.
Observe its operation. LEDs should illuminate when the relays are operated.

Filter

Channel	Indicator		OK?
	ON	OFF	
Ch1	√	√	√
Ch2	√	√	√
Ch3	√	√	√
Ch4	√	√	√

TEST SWITCHES

Channel	Indicator		OK?
	ON	OFF	
Ch1	√	√	√
Ch2	√	√	√
Ch3	√	√	√
Ch4	√	√	√

Unit……………….OMC_6……………………Serial No ………………………………
Test Engineer…..Xen……………..………
Date……………..19/11/10..……………

9. Current Monitor tests

The purpose of this test is to perform a functionality test on the current monitor and RMS circuits.

To do this, we need to draw a known current from each coil drive output. This is done by plugging the 39 ohm loads into each output, then adjusting the signal generator until the required voltage appears across each load resistor.

Remove all links W4 and W5.

Plug the power 39 ohm dummy load plug into the coil drive output.

Set the signal generator output to 2.5v peak at 100Hz.

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 0.4v peak appears across each resistor.

Record the peak output from each of the current monitors using the true r.m.s d.v.m and each of the RMS circuits with the meter set to d.c.

Channel	Monitor Connector	Parameter	Theoretical Value (+/- .1v)	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	1.39v r.m.s	1.35	√
	Pin 1	RMS Current	1.39v dc	1.35	√
2	Pin 5	Current Monitor	1.39v r.m.s	1.35	√
	Pin 4	RMS Current	1.39v dc	1.35	√
3	Pin 8	Current Monitor	1.39v r.m.s	1.35	√
	Pin 7	RMS Current	1.39v dc	1.34	√
4	Pin 11	Current Monitor	1.39v r.m.s	1.35	√
	Pin 10	RMS Current	1.39v dc	1.35	√

Unit……………..OMC_6……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..19/11/10………………

10. Voltage Monitor tests

The purpose of this test is to verify and calibrate the Voltage Monitor circuit on each channel.

Switch all filters out. Remove the dummy loads and make differential voltage output measurements on the coil drive outputs at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

Channel	Coil Drive Output pins	Voltage Monitor socket Pin	Monitor output?	Expected value	OK?
1	Pins 1,9	Pin 3	3.32	3.2v to 3.4v	√
2	Pins 3,11	Pin 6	3.32	3.2v to 3.4v	√
3	Pins 5,13	Pin 9	3.32	3.2v to 3.4v	√
4	Pins 7, 15	Pin 12	3.32	3.2v to 3.4v	√

11. Noise Monitor Tests

See Monitor re-test report.

Unit……………..OMC_6…………………..Serial No ……………………………
Test Engineer…..Xen………..………
Date……………..19/11/10..……………

12. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct.
Ensure that links W4 and W5 are present.

Use the Dynamic Signal Analyser and signal generator.

With the filter switched in, measure the frequency response of each channel in turn between 1 Hz and 1 kHz. Measure the gain at the spot frequencies below and record them. Measure the gain at 0.1 Hz using the signal generator and scope, using a 1v peak input signal, and recording the peak output. In each case the output is measured differentially between TP9 and TP13. Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.3		
10Hz	-30.2		
100Hz	-42.8		
1KHz	-43.3		

Channel 2

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.4		
10Hz	-30.0		
100Hz	-42.8		
1KHz	-43.3		

Channel 3

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.1		
10Hz	-30.4		
100Hz	-42.9		
1KHz	-43.3		

Channel 4

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.2		
10Hz	-30.2		
100Hz	-42.8		
1KHz	-43.3		

0.1 Hz measurements with the signal generator and oscilloscope

Frequency	Output	Expected O/P	Pass/Fail
Ch1	4.85		
Ch2	4.85		
Ch3	4.85		
Ch4	4.85		

Unit……………….OMC_6……………………Serial No ………………………………
Test Engineer…..Xen………….………
Date……………..19/11/10..……………

13. Distortion

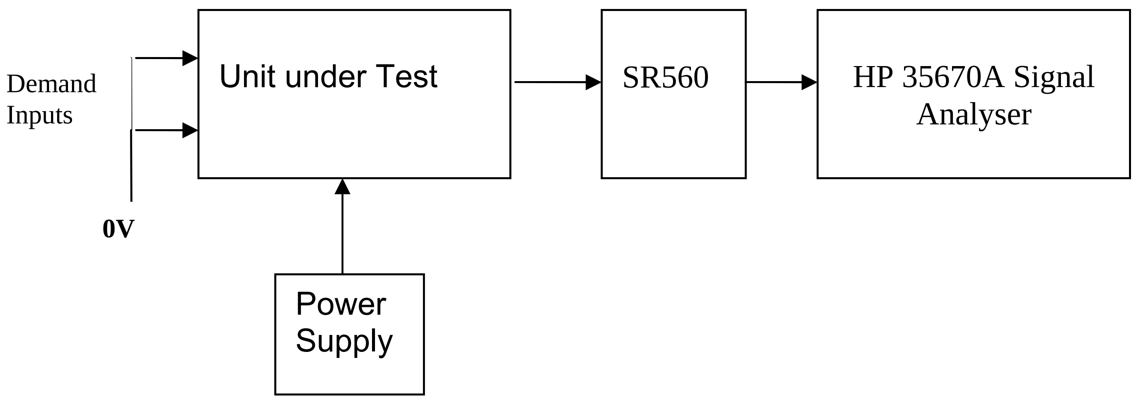
Remove links W4 and W5. Plug in the 5 Watt 39 Ohm dummy loads. Increase input voltage to 10v peak, f = 1KHz. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit……………..OMC_6……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..19/11/10……………..

14. Noise Tests

As the previous test involves non – representative temperature rises, allow the unit to cool before performing this test.
Replace the filter links W4 and W5 on each channel.
Replace the lid of the box, and replace screws.
Connect the filter test box, and switch in all filters.
Switch it out of Test Mode
Use the HP 35670A Dynamic Signal Analyser.
Connect a shorting plug to the demand input to short all positive and negative demands together and to 0v. Connect 39 Ohm loads to the outputs.
Switch the filters in.
Use Stuart Aston's noise measurement set up, loaded from disc.
Measure the noise output from each channel in turn at the amplifier outputs. The Low Pass filter on the SR650 may be used to reduce mains interference, to prevent the Signal Analyser from overloading. Ideally the filter corner frequency should be set to 3 KHz. Set the amplifier gain to 1000, and check that the overload light is not on before each measurement.



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-150.5 dB	-102.1	-162.1
Ch2	-150.5 dB	-99.2	-159.2
Ch3	-150.5 dB	-100.5	-160.5
Ch4	-150.5 dB	-100.0	-160.0

Notes:
Specified noise output current at 10 Hz = 50 pA/√Hz
Total output resistance = 600 Ohms
Amplifier noise voltage should therefore = 30nV/√Hz or -150.5dB

The noise monitor amplifier has an internal gain of 42dB at 10Hz.The noise floor is about -133dB.

Unit……………….OMC_6……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..19/11/10..……………

15. Dynamic Range Tests

39 Ohm load resistors should be used, to represent the resistance of the Birmingham OSEM coil.

Plug in the dummy load.

Ensure that the filter links are in place, and the filters switched in circuit.

Drive the unit with a 5v peak sine wave on each channel (10v differential), at the frequencies specified. Measure the peak voltages across the load with an oscilloscope in each case, and compare with the specification

CH	0.5 Hz	0.5Hz Spec (mV)	1 Hz	1Hz Spec (mV)	10 Hz	10Hz Spec (mV)	OK ?
1	625	599 to 651	380	342 to 420	11.0	13 to 16	
2	625	599 to 651	380	342 to 420	11.0	13 to 16	
3	625	599 to 651	370	342 to 420	10.5	13 to 16	
4	625	599 to 651	370	342 to 420	10.5	13 to 16	

Notes: Specification:-

Frequency	Output Current	V across 40 Ohms
Freq < 0.5Hz	10mA peak	400mV
1 Hz	5 mA peak	200mV
10Hz< freq< 100Hz	0.5 mA peak	20mV

Unit…………………………OMC6P…………Serial No ………………………………
Test Engineer…………….RMC
Date………………………25/11/10

16. Final Assembly Checks

1. Remove the lid of the box. √

2. Unplug all external connections. √

3. Check that the 9mm pillars are in place in the corners of the Monitor Board towards the centre of the box. √

4. Check that all internal connectors are firmly mated. √

5. Tighten the screw-locks holding all the external connectors. √

6. Check that the nuts holding the tabs of the power drivers are secure – tighten as necessary. Test with a DVM that none of the tabs are shorted to chassis. √

7. Check that all the LEDs are nicely centred. √

8. Check that links W4 and W5 are in place. √

9. Check that the boards are labelled with their Drawing Number, Issue Number, and serial number. Record below:

UoB box ID	OMC6P
Driver board ID	OMC6
Driver board Drawing No/Issue No	D1003116_V2
Driver board Serial Number	OMC6
Monitor board ID	MON204
Monitor board Drawing No/Issue No	D070480_5_K
Monitor board Serial Number	MON204

10. Check the security of any modification wires. √

11. Visually inspect. √

12. Put the lid on and fasten all screws, √

Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1000568-v1 Advanced LIGO UK 28 September 2010

OMC Coil Drive Unit Test Plan

R. M. Cutler, University of Birmingham

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This is an internal working note
of the Advanced LIGO Project, prepared by members of the UK team.

Institute for Gravitational Research
University of Glasgow
Phone +44 (0) 141 330 5884
Fax +44 (0) 141 330 6833
E-mail k.strain@physics.gla.ac.uk

Engineering Department
CCLRC Rutherford Appleton Laboratory
Phone +44 (0) 1235 445 297
Fax +44 (0) 1235 445 843
E-mail J.Greenhalgh@rl.ac.uk

School of Physics and Astronomy
University of Birmingham
Phone +44 (0) 121 414 6447
Fax +44 (0) 121 414 3722
E-mail av@star.sr.bham.ac.uk

Department of Physics
University of Strathclyde
Phone +44 (0) 1411 548 3360
Fax +44 (0) 141 552 2891
E-mail N.Lockerbie@phys.strath.ac.uk

http://www.ligo.caltech.edu/

http://www.physics.gla.ac.uk/igr/sus/

http://www.sr.bham.ac.uk/research/gravity/rh,d,2.html
http://www.eng-external.rl.ac.uk/advligo/papers_public/ALUK_Homepage.htm

OMC COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit………………OMC_7……………………Serial No ………………………………
Test Engineer…..Xen…………..………
Date……………..11/11/10..……………

Drive Card ID……OMC_7…………..…
Monitor Card ID…Mon206……………..

Contents

1. Description

The OMC Driver Unit will be used to control the OMC mirror position in the Advanced LIGO Gravity wave experiment.

It controls the current in the coil which provides the magnetic force which controls the position of the OMC. It works in conjunction with the OSEM coil and position sensor units. One OMC Driver Unit controls four OSEMs.

The OMC Coil Drive Unit contains a Coil Drive board and a Monitor board. The Monitor Board monitors the Output voltage, Output Current, RMS Current and Output Noise from the unit.

The OMC Driver Unit also passes the amplified signals from the Photodiodes, which detect the position of the OMC mirror, back to the control electronics without processing them in any way.

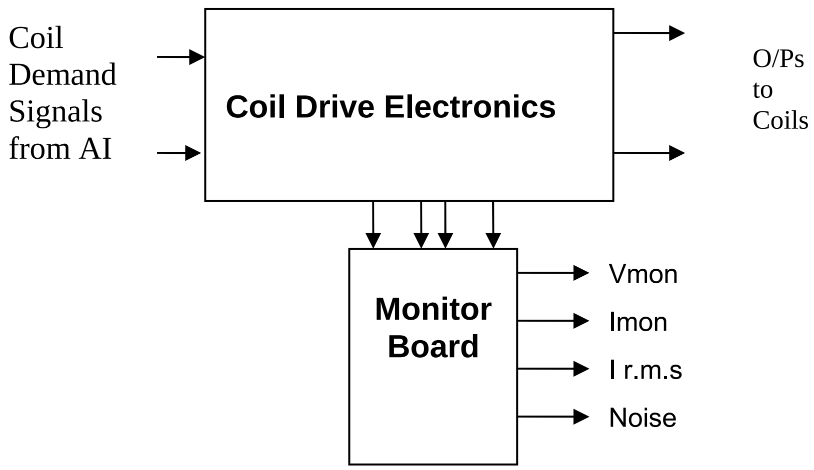


FIG. 1 OMC Driver Unit Block Diagram

Each OMC Driver Unit consists of four identical differential coil drive channels. It also contains the monitor board which monitors the output voltage, current, r.m.s current and noise from each channel

Unit………………OMC_7……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..11/11/10..……………

2. Test Equipment

Power supplies (At least +/- 20v variable, 1A)
Signal generator (capable of delivering 10v peak, 0.1Hz to 10 KHz))
Digital oscilloscope
Analogue oscilloscope
Agilent Dynamic Signal Analyser (or similar)
Low noise Balanced Driver circuit
Relay test box

Record the Models and serial numbers of the test equipment used below.

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	

Unit………………OMC_7……………………Serial No ………………………………
Test Engineer…..Xen…………..………
Date……………..11/11/10..……………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

Unit……………….OMC_7……………………Serial No ………………………………
Test Engineer…..Xen……………..………
Date……………..11/11/10...……………

4. Continuity Checks

Use a multi-meter to check the connections below.

Photodiode outputs

Pd Out to AA	SIGNAL	DESCRIPTION	Pd in from Sat	OK?
1	PD1P	Photodiode A+	1	√
2	PD2P	Photodiode B+	2	√
3	PD3P	Photodiode C+	3	√
4	PD4P	Photodiode D+	4	√
5	0V	√		
6	PD1N	Photodiode A-	14	√
7	PD2N	Photodiode B-	15	√
8	PD3N	Photodiode C-	16	√
9	PD4N	Photodiode D-	17	√

LED Monitors

LED Mon	SIGNAL	Monitors:	In from Sat	OK?
1	Imon1P	Current Source 1+	5	√
2	Imon2P	Current Source 2+	6	√
3	Imon3P	Current Source 3+	7	√
4	Imon4P	Current Source 4+	8	√
5	0V	√		
6	Imon1N	Current Source 1-	18	√
7	Imon2N	Current Source 2-	19	√
8	Imon3N	Current Source 3-	20	√
9	Imon4N	Current Source 4-	21	√

Power Supply to Satellite box

In from Sat	SIGNAL	DESCRIPTION	DC in Connector	OK?
9	V+	+17v Supply	A1	√
10	V+	+17v Supply	A1	√
11	V-	-17v Supply	A3	√
12	V-	-17v Supply	A3	√
13	0V	Return	A2	√
22	0V	Return	A2	√
23	0V	Return	A2	√
24	0V	Return	A2	√
25	0V	Return	A2	√

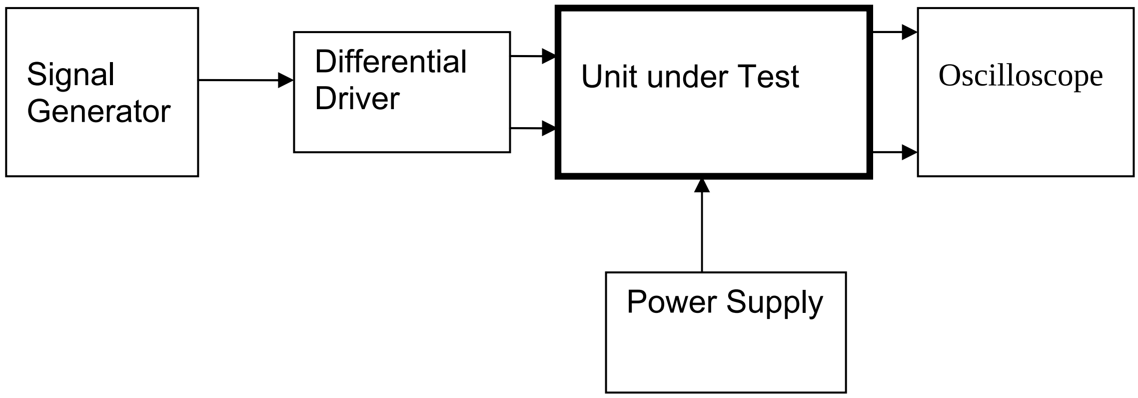
Unit………………OMC_7……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..11/11/10..……………

5. Isolation Checks

Check that the driver ICs IC11 and IC12 are isolated from chassis on all channels. Apply a DVM on ohms range and measure the resistance between each transistor tab and the chassis.

IC Tab	Resistance	OK?
IC11 Channel 1	OL	√
IC12 Channel 1	OL	√
IC11 Channel 2	OL	√
IC12 Channel 2	OL	√
IC11 Channel 3	OL	√
IC12 Channel 3	OL	√
IC11 Channel 4	OL	√
IC12 Channel 4	OL	√

6. TEST SET UP



Note:
(1) Input signal to differential amplifier is generally stated in the tests below. There is therefore an inherent gain of 2 in the system.

(2) Some signal generators will indicate 1vpk/pk when the output is in fact 1v Peak into the high impedance Differential driver used. The test procedure refers to the actual voltage out of the signal generator.

Connections:

Differential signal inputs to the Drive Input of the unit under test:
Drive Input pins 1, 2, 3, 4 = positive input
Drive Input pins 6, 7, 8, 9 = negative input
Drive Input pin 5 = ground

Power (depending on connector availability)

Pd In from Sat pin 9, 10 = +16.5v	or DC in A1
Pd In from Sat pin 11, 12 = -16.5	or DC in A3
Pd In from Sat pins 22, 23, 24, 25 = 0v	or DC in A2

Coil Drive Outputs

Ch1+ = Coil out to Sat pin 1	Ch1- = Coil out to Sat pin 9
Ch2+ = Coil out to Sat pin 3	Ch2- = Coil out to Sat pin 11
Ch3+ = Coil out to Sat pin 5	Ch3- = Coil out to Sat pin 13
Ch4+ = Coil out to Sat pin 7	Ch4- = Coil out to Sat pin 15

Voltage, Current and R.M.S monitors

1	Voltage Monitor 4
2	Current Monitor 4
3	R.M.S Current 4
4	Voltage Monitor 3
5	Current Monitor 3
6	R.M.S Current 3
7	Voltage Monitor 2
8	Current Monitor 2
9	R.M.S Current 2
10	Voltage Monitor 1
11	Current Monitor 1
12	R.M.S Current 1
13 to 25	0v

Noise Monitor

1	Channel 1 Noise Monitor
2	Channel 2 Noise Monitor
3	Channel 3 Noise Monitor
4	Channel 4 Noise Monitor
5 to 9	0v

Unit………………OMC_7……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..11/11/10..……………

7. Power

Check the polarity of the wiring from the 3 pin power ponnector to each of the boards. Viewed from the back of the unit:

A1	Left pin	Positive	White wire
A2	Middle pin	RTN	Black wire
A3	Right pin	Negative	Green wire

If this is correct,
Connect power to the unit
Set the supplies to 16.5v
Turn on

Record supply currents:

+ 16.5 supply current (mA)	- 16.5 supply current (mA)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

If the power supplies are correct, proceed to the next section.

Unit……………….OMC_7……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..11/11/10..……………

8. Relay Operation

Operate each relay in turn.
Observe its operation. LEDs should illuminate when the relays are operated.

Filter

Channel	Indicator		OK?
	ON	OFF	
Ch1	√	√	√
Ch2	√	√	√
Ch3	√	√	√
Ch4	√	√	√

TEST SWITCHES

Channel	Indicator		OK?
	ON	OFF	
Ch1	√	√	√
Ch2	√	√	√
Ch3	√	√	√
Ch4	√	√	√

Unit………………OMC_7……………………Serial No ………………………………
Test Engineer…..Xen……………..………
Date……………..11/11/10..……………

9. Current Monitor tests

The purpose of this test is to perform a functionality test on the current monitor and RMS circuits.

To do this, we need to draw a known current from each coil drive output. This is done by plugging the 39 ohm loads into each output, then adjusting the signal generator until the required voltage appears across each load resistor.

Remove all links W4 and W5.

Plug the power 39 ohm dummy load plug into the coil drive output.

Set the signal generator output to 2.5v peak at 100Hz.

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 0.4v peak appears across each resistor.

Record the peak output from each of the current monitors using the true r.m.s d.v.m and each of the RMS circuits with the meter set to d.c.

Channel	**Monitor Connector**	**Parameter**	**Theoretical Value (+/- .1v)**	**Measured Value**	**Pass/ Fail**
1	Pin 2	Current Monitor	1.39v r.m.s	1.35	√
	Pin 1	RMS Current	1.39v dc	1.35	√
2	Pin 5	Current Monitor	1.39v r.m.s	1.35	√
	Pin 4	RMS Current	1.39v dc	1.35	√
3	Pin 8	Current Monitor	1.39v r.m.s	1.35	√
	Pin 7	RMS Current	1.39v dc	1.35	√
4	Pin 11	Current Monitor	1.39v r.m.s	1.35	√
	Pin 10	RMS Current	1.39v dc	1.35	√

Unit……………….OMC_7……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..11/11/10..……………

10. Voltage Monitor tests

The purpose of this test is to verify and calibrate the Voltage Monitor circuit on each channel.

Switch all filters out. Remove the dummy loads and make differential voltage output measurements on the coil drive outputs at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

Channel	Coil Drive Output pins	Voltage Monitor socket Pin	Monitor output?	Expected value	OK?
1	Pins 1,9	Pin 3	3.32	3.2v to 3.4v	√
2	Pins 3,11	Pin 6	3.32	3.2v to 3.4v	√
3	Pins 5,13	Pin 9	3.32	3.2v to 3.4v	√
4	Pins 7, 15	Pin 12	3.32	3.2v to 3.4v	√

11. Noise Monitor Tests

See Monitor re-test report.

Unit……………..OMC_7……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..11/11/10..……………

12. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct.
Ensure that links W4 and W5 are present.

Use the Dynamic Signal Analyser and signal generator.

With the filter switched in, measure the frequency response of each channel in turn between 1 Hz and 1 kHz. Measure the gain at the spot frequencies below and record them. Measure the gain at 0.1 Hz using the signal generator and scope, using a 1v peak input signal, and recording the peak output. In each case the output is measured differentially between TP9 and TP13.
Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.3		
10Hz	-30.2		
100Hz	-42.8		
1KHz	-43.2		

Channel 2

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.2		
10Hz	-30.3		
100Hz	-42.9		
1KHz	-43.3		

Channel 3

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.1		
10Hz	-30.3		
100Hz	-42.8		
1KHz	-43.3		

Channel 4

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.3		
10Hz	-30.1		
100Hz	-42.8		
1KHz	-43.2		

0.1 Hz measurements with the signal generator and oscilloscope

Frequency	Output	Expected O/P	Pass/Fail
Ch1	4.85		
Ch2	4.85		
Ch3	4.85		
Ch4	4.85		

Unit………………OMC_7……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..11/11/10..……………

13. Distortion

Remove links W4 and W5. Plug in the 5 Watt 39 Ohm dummy loads. Increase input voltage to 10v peak, f = 1KHz. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

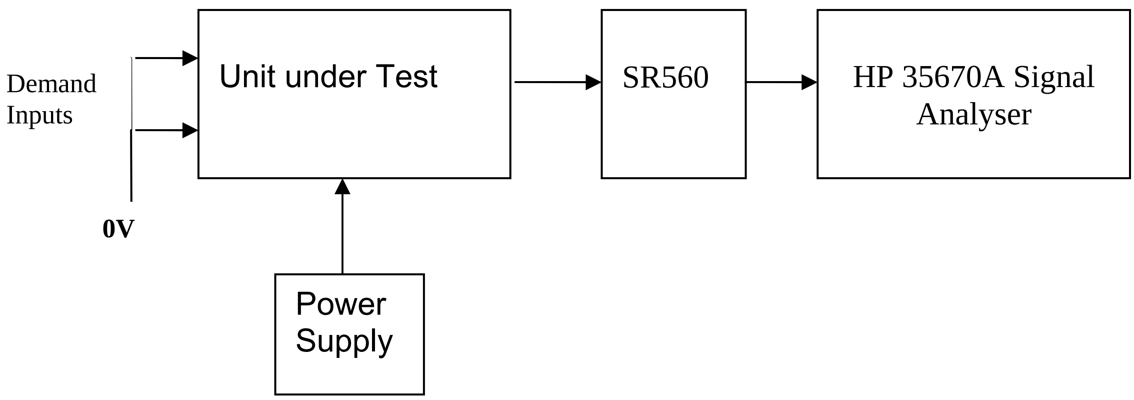
Unit……………..OMC_7……………………Serial No ……………………………
Test Engineer…..Xen………..………
Date……………..11/11/10..……………

14. Noise Tests

As the previous test involves non – representative temperature rises, allow the unit to cool before performing this test.

Replace the filter links W4 and W5 on each channel.
Replace the lid of the box, and replace screws.
Connect the filter test box, and switch in all filters.
Switch it out of Test Mode

Use the HP 35670A Dynamic Signal Analyser.
Connect a shorting plug to the demand input to short all positive and negative demands together and to 0v. Connect 39 Ohm loads to the outputs.
Switch the filters in.
Use Stuart Aston's noise measurement set up, loaded from disc.
Measure the noise output from each channel in turn at the amplifier outputs. The Low Pass filter on the SR650 may be used to reduce mains interference, to prevent the Signal Analyser from overloading. Ideally the filter corner frequency should be set to 3 KHz. Set the amplifier gain to 1000, and check that the overload light is not on before each measurement.



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-150.5 dB	-100.5	-160.5
Ch2	-150.5 dB	-101.1	-161.1
Ch3	-150.5 dB	-101.4	-161.4
Ch4	-150.5 dB	-100.6	-160.6

Notes:
Specified noise output current at 10 Hz = 50 pA/√Hz
Total output resistance = 600 Ohms
Amplifier noise voltage should therefore = 30nV/√Hz or -150.5dB

The noise monitor amplifier has an internal gain of 42dB at 10Hz.The noise floor is about -133dB.

Unit……………….OMC_7……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..17/11/10..……………

15. Dynamic Range Tests

39 Ohm load resistors should be used, to represent the resistance of the Birmingham OSEM coil.

Plug in the dummy load.

Ensure that the filter links are in place, and the filters switched in circuit.

Drive the unit with a 5v peak sine wave on each channel (10v differential), at the frequencies specified. Measure the peak voltages across the load with an oscilloscope in each case, and compare with the specification

CH	0.5 Hz	0.5Hz Spec (mV)	1 Hz	1Hz Spec (mV)	10 Hz	10Hz Spec (mV)	OK ?
1	625	599 to 651	380	342 to 420	10.8	13 to 16	
2	625	599 to 651	370	342 to 420	10.5	13 to 16	
3	625	599 to 651	370	342 to 420	10.5	13 to 16	
4	625	599 to 651	380	342 to 420	11.0	13 to 16	

Notes: Specification:-

Frequency	Output Current	V across 40 Ohms
Freq < 0.5Hz	10mA peak	400mV
1 Hz	5 mA peak	200mV
10Hz< freq< 100Hz	0.5 mA peak	20mV

Unit……………………….OMC7P………Serial No ………………………………
Test Engineer…………...RMC
Date……………………25/11/10

16. Final Assembly Checks

1. Remove the lid of the box. √

2. Unplug all external connections. √

3. Check that the 9mm pillars are in place in the corners of the Monitor Board towards the centre of the box. √

4. Check that all internal connectors are firmly mated. √

5. Tighten the screw-locks holding all the external connectors. √

6. Check that the nuts holding the tabs of the power drivers are secure – tighten as necessary. Test with a DVM that none of the tabs are shorted to chassis. √

7. Check that all the LEDs are nicely centred. √

8. Check that links W4 and W5 are in place. √

9. Check that the boards are labelled with their Drawing Number, Issue Number, and serial number. Record below:

UoB box ID	OMC7P
Driver board ID	OMC7
Driver board Drawing No/Issue No	D1003116_V2
Driver board Serial Number	OMC7
Monitor board ID	MON206
Monitor board Drawing No/Issue No	D070480_5_K
Monitor board Serial Number	MON206

10. Check the security of any modification wires. √

11. Visually inspect. √

12. Put the lid on and fasten all screws, √

    Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1000568-v1 Advanced LIGO UK 28 September 2010

OMC Coil Drive Unit Test Plan

R. M. Cutler, University of Birmingham

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This is an internal working note
of the Advanced LIGO Project, prepared by members of the UK team.

Institute for Gravitational Research
University of Glasgow
Phone +44 (0) 141 330 5884
Fax +44 (0) 141 330 6833
E-mail k.strain@physics.gla.ac.uk
Engineering Department
CCLRC Rutherford Appleton Laboratory
Phone +44 (0) 1235 445 297
Fax +44 (0) 1235 445 843
E-mail J.Greenhalgh@rl.ac.uk

School of Physics and Astronomy
University of Birmingham
Phone +44 (0) 121 414 6447
Fax +44 (0) 121 414 3722
E-mail av@star.sr.bham.ac.uk
Department of Physics
University of Strathclyde
Phone +44 (0) 1411 548 3360
Fax +44 (0) 141 552 2891
E-mail N.Lockerbie@phys.strath.ac.uk

http://www.ligo.caltech.edu/

http://www.physics.gla.ac.uk/igr/sus/

http://www.sr.bham.ac.uk/research/gravity/rh,d,2.html
http://www.eng-external.rl.ac.uk/advligo/papers_public/ALUK_Homepage.htm

OMC COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit………………OMC_8……………………Serial No ………………………………
Test Engineer…..Xen…………..………
Date……………..11/11/10..……………

Drive Card ID……OMC_8…………..…
Monitor Card ID…Mon63……………..

Contents

1. Description

The OMC Driver Unit will be used to control the OMC mirror position in the Advanced LIGO Gravity wave experiment.

It controls the current in the coil which provides the magnetic force which controls the position of the OMC. It works in conjunction with the OSEM coil and position sensor units. One OMC Driver Unit controls four OSEMs.

The OMC Coil Drive Unit contains a Coil Drive board and a Monitor board. The Monitor Board monitors the Output voltage, Output Current, RMS Current and Output Noise from the unit.

The OMC Driver Unit also passes the amplified signals from the Photodiodes, which detect the position of the OMC mirror, back to the control electronics without processing them in any way.

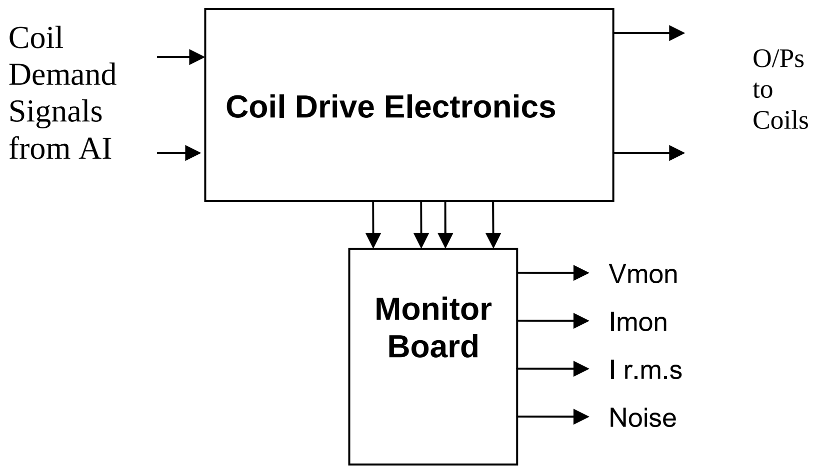


FIG. 1 OMC Driver Unit Block Diagram

Each OMC Driver Unit consists of four identical differential coil drive channels. It also contains the monitor board which monitors the output voltage, current, r.m.s current and noise from each channel

Unit………………OMC_8……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..11/11/10..……………

2. Test Equipment

Power supplies (At least +/- 20v variable, 1A)
Signal generator (capable of delivering 10v peak, 0.1Hz to 10 KHz))
Digital oscilloscope
Analogue oscilloscope
Agilent Dynamic Signal Analyser (or similar)
Low noise Balanced Driver circuit
Relay test box

Record the Models and serial numbers of the test equipment used below.

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	

Unit………………OMC_8……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..11/11/10..……………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

Unit………………OMC_8……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..11/11/10..……………

4. Continuity Checks

Use a multi-meter to check the connections below.

Photodiode outputs

Pd Out to AA	SIGNAL	DESCRIPTION	Pd in from Sat	OK?
1	PD1P	Photodiode A+	1	√
2	PD2P	Photodiode B+	2	√
3	PD3P	Photodiode C+	3	√
4	PD4P	Photodiode D+	4	√
5	0V	√		
6	PD1N	Photodiode A-	14	√
7	PD2N	Photodiode B-	15	√
8	PD3N	Photodiode C-	16	√
9	PD4N	Photodiode D-	17	√

LED Monitors

LED Mon	SIGNAL	Monitors:	In from Sat	OK?
1	Imon1P	Current Source 1+	5	√
2	Imon2P	Current Source 2+	6	√
3	Imon3P	Current Source 3+	7	√
4	Imon4P	Current Source 4+	8	√
5	0V	√		
6	Imon1N	Current Source 1-	18	√
7	Imon2N	Current Source 2-	19	√
8	Imon3N	Current Source 3-	20	√
9	Imon4N	Current Source 4-	21	√

Power Supply to Satellite box

In from Sat	SIGNAL	DESCRIPTION	DC in Connector	OK?
9	V+	+17v Supply	A1	√
10	V+	+17v Supply	A1	√
11	V-	-17v Supply	A3	√
12	V-	-17v Supply	A3	√
13	0V	Return	A2	√
22	0V	Return	A2	√
23	0V	Return	A2	√
24	0V	Return	A2	√
25	0V	Return	A2	√

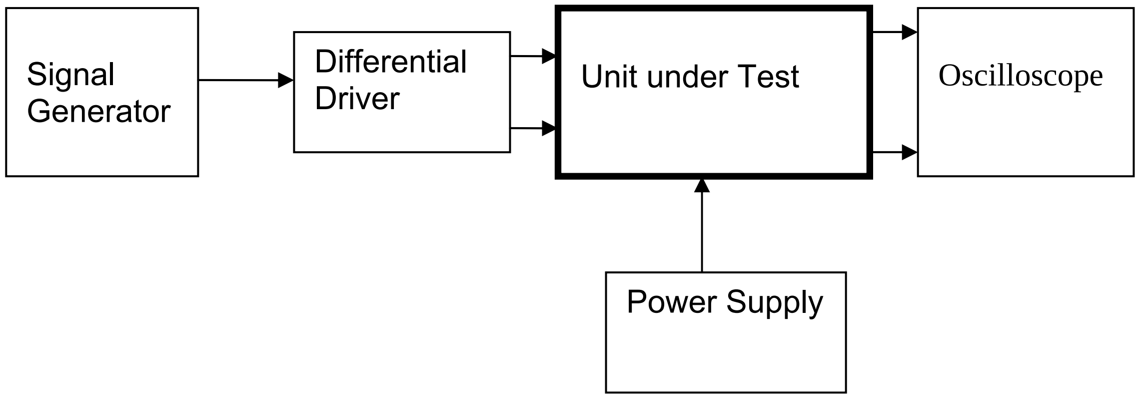
Unit………………OMC_8……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..11/11/10..……………

5. Isolation Checks

Check that the driver ICs IC11 and IC12 are isolated from chassis on all channels. Apply a DVM on ohms range and measure the resistance between each transistor tab and the chassis.

IC Tab	Resistance	OK?
IC11 Channel 1	OL	√
IC12 Channel 1	OL	√
IC11 Channel 2	OL	√
IC12 Channel 2	OL	√
IC11 Channel 3	OL	√
IC12 Channel 3	OL	√
IC11 Channel 4	OL	√
IC12 Channel 4	OL	√

6. TEST SET UP



Note:
(1) Input signal to differential amplifier is generally stated in the tests below. There is therefore an inherent gain of 2 in the system.

(2) Some signal generators will indicate 1vpk/pk when the output is in fact 1v Peak into the high impedance Differential driver used. The test procedure refers to the actual voltage out of the signal generator.

Connections:

Differential signal inputs to the Drive Input of the unit under test:
Drive Input pins 1, 2, 3, 4 = positive input
Drive Input pins 6, 7, 8, 9 = negative input
Drive Input pin 5 = ground

Power (depending on connector availability)
Pd In from Sat pin 9, 10 = +16.5v or DC in A1
Pd In from Sat pin 11, 12 = -16.5 or DC in A3
Pd In from Sat pins 22, 23, 24, 25 = 0v or DC in A2

Coil Drive Outputs
Ch1+ = Coil out to Sat pin 1
Ch2+ = Coil out to Sat pin 3
Ch3+ = Coil out to Sat pin 5
Ch4+ = Coil out to Sat pin 7
Ch1- = Coil out to Sat pin 9
Ch2- = Coil out to Sat pin 11
Ch3- = Coil out to Sat pin 13
Ch4- = Coil out to Sat pin 15

Voltage, Current and R.M.S monitors

1	Voltage Monitor 4
2	Current Monitor 4
3	R.M.S Current 4
4	Voltage Monitor 3
5	Current Monitor 3
6	R.M.S Current 3
7	Voltage Monitor 2
8	Current Monitor 2
9	R.M.S Current 2
10	Voltage Monitor 1
11	Current Monitor 1
12	R.M.S Current 1
13 to 25	0v

Noise Monitor

1	Channel 1 Noise Monitor
2	Channel 2 Noise Monitor
3	Channel 3 Noise Monitor
4	Channel 4 Noise Monitor
5 to 9	0v

Unit………………OMC_8……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..11/11/10..……………

7. Power

Check the polarity of the wiring from the 3 pin power ponnector to each of the boards. Viewed from the back of the unit:

A1	Left pin	Positive	White wire
A2	Middle pin	RTN	Black wire
A3	Right pin	Negative	Green wire

If this is correct,
Connect power to the unit
Set the supplies to 16.5v
Turn on

Record supply currents:

+ 16.5 supply current (mA)	- 16.5 supply current (mA)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

If the power supplies are correct, proceed to the next section.

Unit………………OMC_8……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..11/11/10..……………

8. Relay Operation

Operate each relay in turn.
Observe its operation. LEDs should illuminate when the relays are operated.

Filter

Channel	Indicator		OK?
	ON	OFF	
Ch1	√	√	√
Ch2	√	√	√
Ch3	√	√	√
Ch4	√	√	√

TEST SWITCHES

Channel	Indicator		OK?
	ON	OFF	
Ch1	√	√	√
Ch2	√	√	√
Ch3	√	√	√
Ch4	√	√	√

Unit……………….OMC_8……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..11/11/10..……………

9. Current Monitor tests

The purpose of this test is to perform a functionality test on the current monitor and RMS circuits.

To do this, we need to draw a known current from each coil drive output. This is done by plugging the 39 ohm loads into each output, then adjusting the signal generator until the required voltage appears across each load resistor.

Remove all links W4 and W5.

Plug the power 39 ohm dummy load plug into the coil drive output.

Set the signal generator output to 2.5v peak at 100Hz.

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 0.4v peak appears across each resistor.

Record the peak output from each of the current monitors using the true r.m.s d.v.m and each of the RMS circuits with the meter set to d.c.

Channel	Monitor Connector	Parameter	Theoretical Value (+/- .1v)	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	1.39v r.m.s	1.35	√
	Pin 1	RMS Current	1.39v dc	1.36	√
2	Pin 5	Current Monitor	1.39v r.m.s	1.35	√
	Pin 4	RMS Current	1.39v dc	1.36	√
3	Pin 8	Current Monitor	1.39v r.m.s	1.35	√
	Pin 7	RMS Current	1.39v dc	1.35	√
4	Pin 11	Current Monitor	1.39v r.m.s	1.35	√
	Pin 10	RMS Current	1.39v dc	1.35	√

Unit………………OMC_8……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..11/11/10..……………

10. Voltage Monitor tests

The purpose of this test is to verify and calibrate the Voltage Monitor circuit on each channel.

Switch all filters out. Remove the dummy loads and make differential voltage output measurements on the coil drive outputs at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

Channel	Coil Drive Output pins	Voltage Monitor socket Pin	Monitor output?	Expected value	OK?
1	Pins 1,9	Pin 3	3.32	3.2v to 3.4v	√
2	Pins 3,11	Pin 6	3.32	3.2v to 3.4v	√
3	Pins 5,13	Pin 9	3.32	3.2v to 3.4v	√
4	Pins 7, 15	Pin 12	3.32	3.2v to 3.4v	√

11. Noise Monitor Tests

See Monitor re-test report.

Unit……………….OMC_8……………………Serial No ………………………………
Test Engineer…..Xen……………..………
Date……………..11/11/10..……………

12. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct.
Ensure that links W4 and W5 are present.

Use the Dynamic Signal Analyser and signal generator.

With the filter switched in, measure the frequency response of each channel in turn between 1 Hz and 1 kHz. Measure the gain at the spot frequencies below and record them. Measure the gain at 0.1 Hz using the signal generator and scope, using a 1v peak input signal, and recording the peak output. In each case the output is measured differentially between TP9 and TP13.
Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.2		
10Hz	-30.4		
100Hz	-42.8		
1KHz	-43.3		

Channel 2

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.4		
10Hz	-30.0		
100Hz	-42.8		
1KHz	-43.3		

Channel 3

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.2		
10Hz	-30.2		
100Hz	-42.8		
1KHz	-43.3		

Channel 4

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.3		
10Hz	-30.1		
100Hz	-42.8		
1KHz	-43.3		

0.1 Hz measurements with the signal generator and oscilloscope

Frequency	Output	Expected O/P	Pass/Fail
Ch1	4.85		
Ch2	4.85		
Ch3	4.85		
Ch4	4.85		

Unit……………….OMC_8……………………Serial No ………………………………
Test Engineer…..Xen………..……….
Date……………..11/11/10..……………

13. Distortion

Remove links W4 and W5. Plug in the 5 Watt 39 Ohm dummy loads. Increase input voltage to 10v peak, f = 1KHz. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

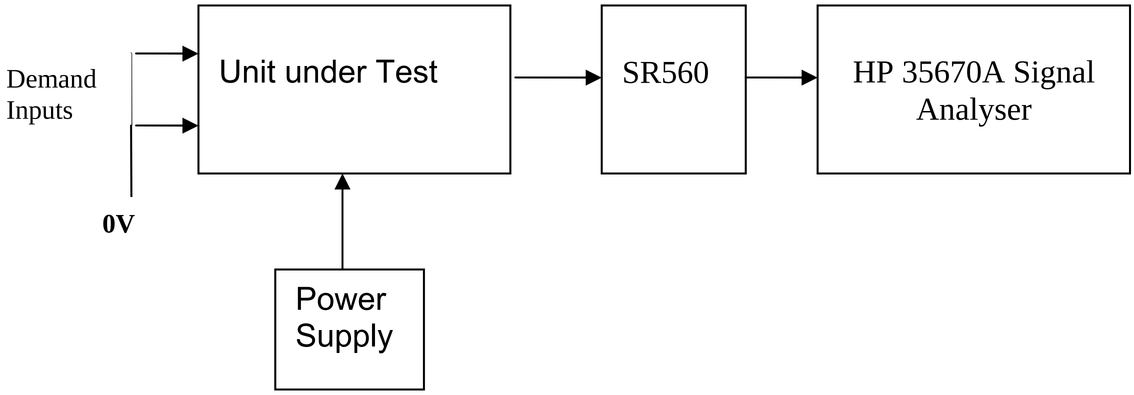
Unit……………….OMC_8……………………Serial No ………………………………
Test Engineer…..Xen……………..………
Date……………..11/11/10..……………

14. Noise Tests

As the previous test involves non – representative temperature rises, allow the unit to cool before performing this test.

Replace the filter links W4 and W5 on each channel.
Replace the lid of the box, and replace screws.
Connect the filter test box, and switch in all filters.
Switch it out of Test Mode

Use the HP 35670A Dynamic Signal Analyser.
Connect a shorting plug to the demand input to short all positive and negative demands together and to 0v. Connect 39 Ohm loads to the outputs.
Switch the filters in.
Use Stuart Aston's noise measurement set up, loaded from disc.
Measure the noise output from each channel in turn at the amplifier outputs. The Low Pass filter on the SR650 may be used to reduce mains interference, to prevent the Signal Analyser from overloading. Ideally the filter corner frequency should be set to 3 KHz. Set the amplifier gain to 1000, and check that the overload light is not on before each measurement.



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-150.5 dB	-100.4	-160.4
Ch2	-150.5 dB	-96.7	-156.7
Ch3	-150.5 dB	-100.1	-160.1
Ch4	-150.5 dB	-100.6	-160.6

Notes:
Specified noise output current at 10 Hz = 50 pA/√Hz
Total output resistance = 600 Ohms
Amplifier noise voltage should therefore = 30nV/√Hz or -150.5dB

The noise monitor amplifier has an internal gain of 42dB at 10Hz.The noise floor is about -133dB.

Unit………………OMC_8……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..17/11/10..……………

15. Dynamic Range Tests

39 Ohm load resistors should be used, to represent the resistance of the Birmingham OSEM coil.

Plug in the dummy load.

Ensure that the filter links are in place, and the filters switched in circuit.

Drive the unit with a 5v peak sine wave on each channel (10v differential), at the frequencies specified. Measure the peak voltages across the load with an oscilloscope in each case, and compare with the specification

CH	0.5 Hz	0.5Hz Spec (mV)	1 Hz	1Hz Spec (mV)	10 Hz	10Hz Spec (mV)	OK ?
1	625	599 to 651	370	342 to 420	10.5	13 to 16	
2	625	599 to 651	380	342 to 420	11.0	13 to 16	
3	625	599 to 651	370	342 to 420	10.5	13 to 16	
4	625	599 to 651	370	342 to 420	10.5	13 to 16	

Notes: Specification:-

Frequency	Output Current	V across 40 Ohms
Freq < 0.5Hz	10mA peak	400mV
1 Hz	5 mA peak	200mV
10Hz< freq< 100Hz	0.5 mA peak	20mV

Unit……………………OMC8………………Serial No ………………………………
Test Engineer…………RMC
Date……………………25/11/10

16. Final Assembly Checks

1. Remove the lid of the box. √

2. Unplug all external connections. √

3. Check that the 9mm pillars are in place in the corners of the Monitor Board towards the centre of the box. √

4. Check that all internal connectors are firmly mated. √

5. Tighten the screw-locks holding all the external connectors. √

6. Check that the nuts holding the tabs of the power drivers are secure – tighten as necessary. Test with a DVM that none of the tabs are shorted to chassis. √

7. Check that all the LEDs are nicely centred. √

8. Check that links W4 and W5 are in place. √

9. Check that the boards are labelled with their Drawing Number, Issue Number, and serial number. Record below:

UoB box ID	OMC8P
Driver board ID	OMC8
Driver board Drawing No/Issue No	D1003116_V2
Driver board Serial Number	OMC8
Monitor board ID	MON63
Monitor board Drawing No/Issue No	D070480_5_K
Monitor board Serial Number	MON63

10. Check the security of any modification wires. √

11. Visually inspect. √

12. Put the lid on and fasten all screws, √

    Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1000568-v1 Advanced LIGO UK 28 September 2010

OMC Coil Drive Unit Test Plan

R. M. Cutler, University of Birmingham

Distribution of this document:
Inform aligo_sus

This is an internal working note
of the Advanced LIGO Project, prepared by members of the UK team.

Institute for Gravitational Research
University of Glasgow
Phone +44 (0) 141 330 5884
Fax +44 (0) 141 330 6833
E-mail k.strain@physics.gla.ac.uk
Engineering Department
CCLRC Rutherford Appleton Laboratory
Phone +44 (0) 1235 445 297
Fax +44 (0) 1235 445 843
E-mail J.Greenhalgh@rl.ac.uk

School of Physics and Astronomy
University of Birmingham
Phone +44 (0) 121 414 6447
Fax +44 (0) 121 414 3722
E-mail av@star.sr.bham.ac.uk
Department of Physics
University of Strathclyde
Phone +44 (0) 1411 548 3360
Fax +44 (0) 141 552 2891
E-mail N.Lockerbie@phys.strath.ac.uk

http://www.ligo.caltech.edu/

http://www.physics.gla.ac.uk/igr/sus/

http://www.sr.bham.ac.uk/research/gravity/rh,d,2.html
http://www.eng-external.rl.ac.uk/advligo/papers_public/ALUK_Homepage.htm

OMC COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit………………OMC_12……………………Serial No ………………………………
Test Engineer…..Xen…………..………
Date……………..12/11/10..……………

Drive Card ID……OMC_9…………..…
Monitor Card ID…Mon194……………..

Contents

1. Description

The OMC Driver Unit will be used to control the OMC mirror position in the Advanced LIGO Gravity wave experiment.

It controls the current in the coil which provides the magnetic force which controls the position of the OMC. It works in conjunction with the OSEM coil and position sensor units. One OMC Driver Unit controls four OSEMs.

The OMC Coil Drive Unit contains a Coil Drive board and a Monitor board. The Monitor Board monitors the Output voltage, Output Current, RMS Current and Output Noise from the unit.

The OMC Driver Unit also passes the amplified signals from the Photodiodes, which detect the position of the OMC mirror, back to the control electronics without processing them in any way.

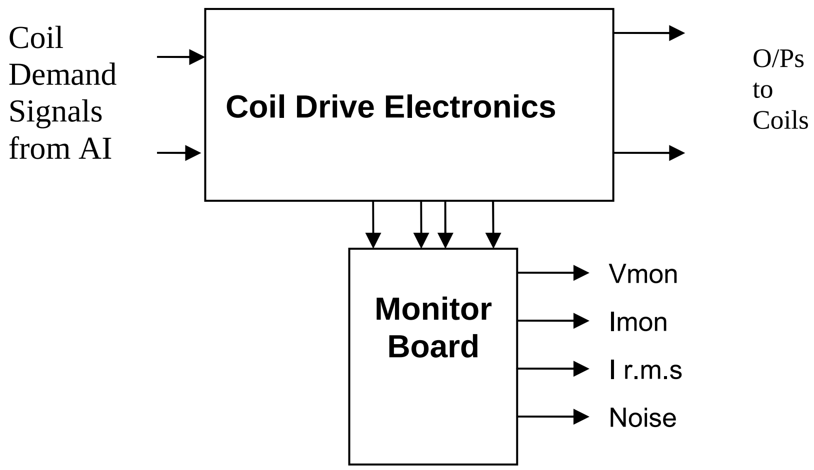


FIG. 1 OMC Driver Unit Block Diagram

Each OMC Driver Unit consists of four identical differential coil drive channels. It also contains the monitor board which monitors the output voltage, current, r.m.s current and noise from each channel

Unit………………OMC_12……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..12/11/10..……………

2. Test Equipment

Power supplies (At least +/- 20v variable, 1A)
Signal generator (capable of delivering 10v peak, 0.1Hz to 10 KHz))
Digital oscilloscope
Analogue oscilloscope
Agilent Dynamic Signal Analyser (or similar)
Low noise Balanced Driver circuit
Relay test box

Record the Models and serial numbers of the test equipment used below.

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	

Unit………………OMC_12……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..12/11/10..……………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

Unit……………..OMC_12……………………Serial No ……………………………
Test Engineer…..Xen………..………
Date……………..12/11/10..……………

4. Continuity Checks

Use a multi-meter to check the connections below.

Photodiode outputs

Pd Out to AA	SIGNAL	DESCRIPTION	Pd in from Sat	OK?
1	PD1P	Photodiode A+	1	√
2	PD2P	Photodiode B+	2	√
3	PD3P	Photodiode C+	3	√
4	PD4P	Photodiode D+	4	√
5	0V	√		
6	PD1N	Photodiode A-	14	√
7	PD2N	Photodiode B-	15	√
8	PD3N	Photodiode C-	16	√
9	PD4N	Photodiode D-	17	√

LED Monitors

LED Mon	SIGNAL	Monitors:	In from Sat	OK?
1	Imon1P	Current Source 1+	5	√
2	Imon2P	Current Source 2+	6	√
3	Imon3P	Current Source 3+	7	√
4	Imon4P	Current Source 4+	8	√
5	0V	√		
6	Imon1N	Current Source 1-	18	√
7	Imon2N	Current Source 2-	19	√
8	Imon3N	Current Source 3-	20	√
9	Imon4N	Current Source 4-	21	√

Power Supply to Satellite box

In from Sat	SIGNAL	DESCRIPTION	DC in Connector	OK?
9	V+	+17v Supply	A1	√
10	V+	+17v Supply	A1	√
11	V-	-17v Supply	A3	√
12	V-	-17v Supply	A3	√
13	0V	Return	A2	√
22	0V	Return	A2	√
23	0V	Return	A2	√
24	0V	Return	A2	√
25	0V	Return	A2	√

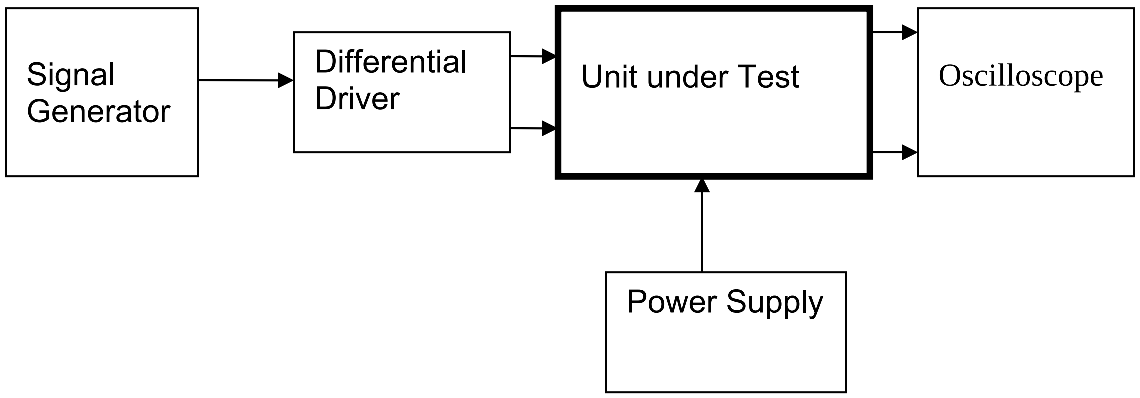
Unit……………….OMC_12……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..12/11/10..……………

5. Isolation Checks

Check that the driver ICs IC11 and IC12 are isolated from chassis on all channels. Apply a DVM on ohms range and measure the resistance between each transistor tab and the chassis.

IC Tab	Resistance	OK?
IC11 Channel 1	OL	√
IC12 Channel 1	OL	√
IC11 Channel 2	OL	√
IC12 Channel 2	OL	√
IC11 Channel 3	OL	√
IC12 Channel 3	OL	√
IC11 Channel 4	OL	√
IC12 Channel 4	OL	√

6. TEST SET UP



Note:
(1) Input signal to differential amplifier is generally stated in the tests below. There is therefore an inherent gain of 2 in the system.

(2) Some signal generators will indicate 1vpk/pk when the output is in fact 1v Peak into the high impedance Differential driver used. The test procedure refers to the actual voltage out of the signal generator.

Connections:

Differential signal inputs to the Drive Input of the unit under test:
Drive Input pins 1, 2, 3, 4 = positive input
Drive Input pins 6, 7, 8, 9 = negative input
Drive Input pin 5 = ground

Power (depending on connector availability)

Pd In from Sat pin 9, 10 = +16.5v	or DC in A1
Pd In from Sat pin 11, 12 = -16.5	or DC in A3
Pd In from Sat pins 22, 23, 24, 25 = 0v	or DC in A2

Coil Drive Outputs

Ch1+ = Coil out to Sat pin 1	Ch1- = Coil out to Sat pin 9
Ch2+ = Coil out to Sat pin 3	Ch2- = Coil out to Sat pin 11
Ch3+ = Coil out to Sat pin 5	Ch3- = Coil out to Sat pin 13
Ch4+ = Coil out to Sat pin 7	Ch4- = Coil out to Sat pin 15

Voltage, Current and R.M.S monitors

1	Voltage Monitor 4
2	Current Monitor 4
3	R.M.S Current 4
4	Voltage Monitor 3
5	Current Monitor 3
6	R.M.S Current 3
7	Voltage Monitor 2
8	Current Monitor 2
9	R.M.S Current 2
10	Voltage Monitor 1
11	Current Monitor 1
12	R.M.S Current 1
13 to 25	0v

Noise Monitor

1	Channel 1 Noise Monitor
2	Channel 2 Noise Monitor
3	Channel 3 Noise Monitor
4	Channel 4 Noise Monitor
5 to 9	0v

Unit.................OMC_12.......................Serial No ....
Test Engineer.....Xen.......................
Date................12/11/10................

7. Power

Check the polarity of the wiring from the 3 pin power ponnector to each of the boards. Viewed from the back of the unit:

A1	Left pin	Positive	White wire
A2	Middle pin	RTN	Black wire
A3	Right pin	Negative	Green wire

If this is correct,
Connect power to the unit
Set the supplies to 16.5v
Turn on

Record supply currents:

+ 16.5 supply current (mA)	- 16.5 supply current (mA)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

If the power supplies are correct, proceed to the next section.

Unit……………….OMC_12……………………Serial No ………………………………
Test Engineer…..Xen………..……….
Date……………..12/11/10..……………

8. Relay Operation

Operate each relay in turn.
Observe its operation. LEDs should illuminate when the relays are operated.

Filter

Channel	Indicator		OK?
	ON	OFF	
Ch1	√	√	√
Ch2	√	√	√
Ch3	√	√	√
Ch4	√	√	√

TEST SWITCHES

Channel	Indicator		OK?
	ON	OFF	
Ch1	√	√	√
Ch2	√	√	√
Ch3	√	√	√
Ch4	√	√	√

Unit……………….OMC_12……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..12/11/10..……………

9. Current Monitor tests

The purpose of this test is to perform a functionality test on the current monitor and RMS circuits.

To do this, we need to draw a known current from each coil drive output. This is done by plugging the 39 ohm loads into each output, then adjusting the signal generator until the required voltage appears across each load resistor.

Remove all links W4 and W5.

Plug the power 39 ohm dummy load plug into the coil drive output.

Set the signal generator output to 2.5v peak at 100Hz.

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 0.4v peak appears across each resistor.

Record the peak output from each of the current monitors using the true r.m.s d.v.m and each of the RMS circuits with the meter set to d.c.

Channel	Monitor Connector	Parameter	Theoretical Value (+/- .1v)	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	1.39v r.m.s	1.35	√
	Pin 1	RMS Current	1.39v dc	1.35	√
2	Pin 5	Current Monitor	1.39v r.m.s	1.35	√
	Pin 4	RMS Current	1.39v dc	1.35	√
3	Pin 8	Current Monitor	1.39v r.m.s	1.35	√
	Pin 7	RMS Current	1.39v dc	1.35	√
4	Pin 11	Current Monitor	1.39v r.m.s	1.35	√
	Pin 10	RMS Current	1.39v dc	1.35	√

Unit……………..OMC_12……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..12/11/10……………..

10. Voltage Monitor tests

The purpose of this test is to verify and calibrate the Voltage Monitor circuit on each channel.

Switch all filters out. Remove the dummy loads and make differential voltage output measurements on the coil drive outputs at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

Channel	Coil Drive Output pins	Voltage Monitor socket Pin	Monitor output?	Expected value	OK?
1	Pins 1,9	Pin 3	3.32	3.2v to 3.4v	√
2	Pins 3,11	Pin 6	3.32	3.2v to 3.4v	√
3	Pins 5,13	Pin 9	3.32	3.2v to 3.4v	√
4	Pins 7, 15	Pin 12	3.32	3.2v to 3.4v	√

11. Noise Monitor Tests

See Monitor re-test report.

Unit……………….OMC_12……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..12/11/10……………

12. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct.
Ensure that links W4 and W5 are present.

Use the Dynamic Signal Analyser and signal generator.

With the filter switched in, measure the frequency response of each channel in turn between 1 Hz and 1 kHz. Measure the gain at the spot frequencies below and record them. Measure the gain at 0.1 Hz using the signal generator and scope, using a 1v peak input signal, and recording the peak output. In each case the output is measured differentially between TP9 and TP13.
Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.1		
10Hz	-30.2		
100Hz	-42.9		
1KHz	-43.3		

Channel 2

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.3		
10Hz	-30.2		
100Hz	-42.8		
1KHz	-43.2		

Channel 3

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.2		
10Hz	-30.2		
100Hz	-42.8		
1KHz	-43.3		

Channel 4

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.2		
10Hz	-30.2		
100Hz	-42.8		
1KHz	-43.3		

0.1 Hz measurements with the signal generator and oscilloscope

Frequency	Output	Expected O/P	Pass/Fail
Ch1	4.85		
Ch2	4.85		
Ch3	4.85		
Ch4	4.85		

Unit……………….OMC_12……………………Serial No ………………………………
Test Engineer…..Xen…………..………
Date……………..12/11/10..……………

13. Distortion

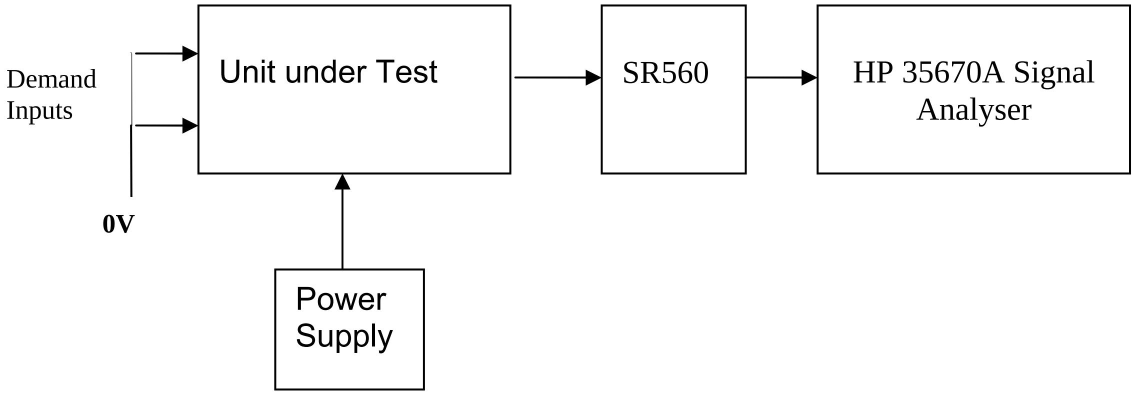
Remove links W4 and W5. Plug in the 5 Watt 39 Ohm dummy loads. Increase input voltage to 10v peak, f = 1KHz. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit……………….OMC_12…………………….Serial No ……………………………….
Test Engineer…..Xen……………..………
Date……………..12/11/10..……………

14. Noise Tests

As the previous test involves non – representative temperature rises, allow the unit to cool before performing this test.
Replace the filter links W4 and W5 on each channel.
Replace the lid of the box, and replace screws.
Connect the filter test box, and switch in all filters.
Switch it out of Test Mode
Use the HP 35670A Dynamic Signal Analyser.
Connect a shorting plug to the demand input to short all positive and negative demands together and to 0v. Connect 39 Ohm loads to the outputs.
Switch the filters in.
Use Stuart Aston's noise measurement set up, loaded from disc.
Measure the noise output from each channel in turn at the amplifier outputs. The Low Pass filter on the SR650 may be used to reduce mains interference, to prevent the Signal Analyser from overloading. Ideally the filter corner frequency should be set to 3 KHz. Set the amplifier gain to 1000, and check that the overload light is not on before each measurement.



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-150.5 dB	-102.1	-162.1
Ch2	-150.5 dB	-101.6	-161.6
Ch3	-150.5 dB	-103.0	-163.0
Ch4	-150.5 dB	-102.8	-162.8

Notes:
Specified noise output current at 10 Hz = 50 pA/√Hz
Total output resistance = 600 Ohms
Amplifier noise voltage should therefore = 30nV/√Hz or -150.5dB

The noise monitor amplifier has an internal gain of 42dB at 10Hz.The noise floor is about -133dB.

Unit……………….OMC_12……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..17/11/10..……………

15. Dynamic Range Tests

39 Ohm load resistors should be used, to represent the resistance of the Birmingham OSEM coil.

Plug in the dummy load.

Ensure that the filter links are in place, and the filters switched in circuit.

Drive the unit with a 5v peak sine wave on each channel (10v differential), at the frequencies specified. Measure the peak voltages across the load with an oscilloscope in each case, and compare with the specification.

CH	0.5 Hz	0.5Hz Spec (mV)	1 Hz	1Hz Spec (mV)	10 Hz	10Hz Spec (mV)	OK ?
1	625	599 to 651	370	342 to 420	10.5	13 to 16	
2	625	599 to 651	380	342 to 420	10.5	13 to 16	
3	625	599 to 651	370	342 to 420	10.5	13 to 16	
4	625	599 to 651	370	342 to 420	10.5	13 to 16	

Notes: Specification:-

Frequency	Output Current	V across 40 Ohms
Freq < 0.5Hz	10mA peak	400mV
1 Hz	5 mA peak	200mV
10Hz< freq< 100Hz	0.5 mA peak	20mV

Unit……………………OMC9P…………Serial No ………………………………
Test Engineer…………RMC
Date…………………25/11/10

16. Final Assembly Checks

1. Remove the lid of the box.√

2. Unplug all external connections. √

3. Check that the 9mm pillars are in place in the corners of the Monitor Board towards the centre of the box. √

4. Check that all internal connectors are firmly mated. √

5. Tighten the screw-locks holding all the external connectors. √

6. Check that the nuts holding the tabs of the power drivers are secure – tighten as necessary. Test with a DVM that none of the tabs are shorted to chassis. √

7. Check that all the LEDs are nicely centred. √

8. Check that links W4 and W5 are in place. √

9. Check that the boards are labelled with their Drawing Number, Issue Number, and serial number. Record below:

UoB box ID	OMC9P
Driver board ID	OMC9
Driver board Drawing No/Issue No	D1003116_V2
Driver board Serial Number	OMC9
Monitor board ID	MON194
Monitor board Drawing No/Issue No	D070480_4_K
Monitor board Serial Number	MON194

10. Check the security of any modification wires. √

11. Visually inspect. √

12. Put the lid on and fasten all screws, √

Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1000568-v1 Advanced LIGO UK 28 September 2010

OMC Coil Drive Unit Test Plan

R. M. Cutler, University of Birmingham

Distribution of this document:
Inform aligo_sus

This is an internal working note
of the Advanced LIGO Project, prepared by members of the UK team.

Institute for Gravitational Research
University of Glasgow
Phone +44 (0) 141 330 5884
Fax +44 (0) 141 330 6833
E-mail k.strain@physics.gla.ac.uk
Engineering Department
CCLRC Rutherford Appleton Laboratory
Phone +44 (0) 1235 445 297
Fax +44 (0) 1235 445 843
E-mail J.Greenhalgh@rl.ac.uk

School of Physics and Astronomy
University of Birmingham
Phone +44 (0) 121 414 6447
Fax +44 (0) 121 414 3722
E-mail av@star.sr.bham.ac.uk
Department of Physics
University of Strathclyde
Phone +44 (0) 1411 548 3360
Fax +44 (0) 141 552 2891
E-mail N.Lockerbie@phys.strath.ac.uk

http://www.ligo.caltech.edu/

http://www.physics.gla.ac.uk/igr/sus/

http://www.sr.bham.ac.uk/research/gravity/rh,d,2.html
http://www.eng-external.rl.ac.uk/advligo/papers_public/ALUK_Homepage.htm

OMC COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit……………….OMC_1……………………Serial No ………………………………
Test Engineer…..Xen…………..………
Date……………..18/11/10..……………

Drive Card ID……OMC_1…………..…
Monitor Card ID…Mon153……………..

Contents

1. Description

The OMC Driver Unit will be used to control the OMC mirror position in the Advanced LIGO Gravity wave experiment.

It controls the current in the coil which provides the magnetic force which controls the position of the OMC. It works in conjunction with the OSEM coil and position sensor units. One OMC Driver Unit controls four OSEMs.

The OMC Coil Drive Unit contains a Coil Drive board and a Monitor board. The Monitor Board monitors the Output voltage, Output Current, RMS Current and Output Noise from the unit.

The OMC Driver Unit also passes the amplified signals from the Photodiodes, which detect the position of the OMC mirror, back to the control electronics without processing them in any way.

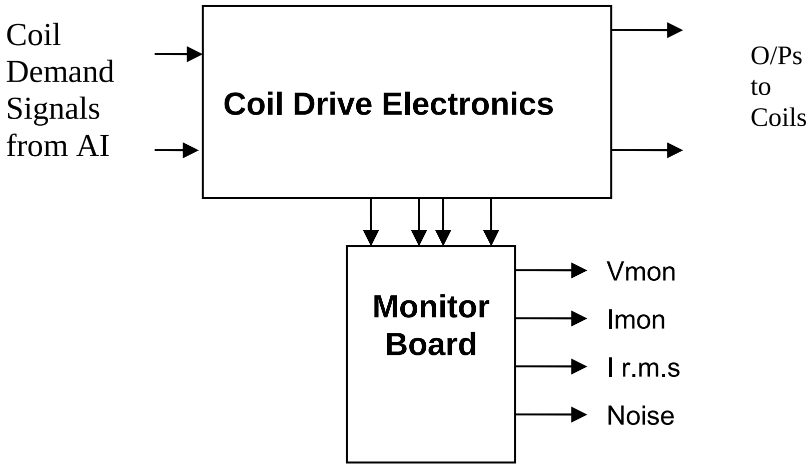


FIG. 1 OMC Driver Unit Block Diagram

Each OMC Driver Unit consists of four identical differential coil drive channels. It also contains the monitor board which monitors the output voltage, current, r.m.s current and noise from each channel

Unit………………OMC_1……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10..……………

2. Test Equipment

Power supplies (At least +/- 20v variable, 1A)
Signal generator (capable of delivering 10v peak, 0.1Hz to 10 KHz))
Digital oscilloscope
Analogue oscilloscope
Agilent Dynamic Signal Analyser (or similar)
Low noise Balanced Driver circuit
Relay test box

Record the Models and serial numbers of the test equipment used below.

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	

Unit………………OMC_1……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10..……………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

Unit……………..OMC_1……………………Serial No ………………………………
Test Engineer…..Xen…………..………
Date……………..18/11/10..……………

4. Continuity Checks

Use a multi-meter to check the connections below.

Photodiode outputs

Pd Out to AA	SIGNAL	DESCRIPTION	Pd in from Sat	OK?
1	PD1P	Photodiode A+	1	√
2	PD2P	Photodiode B+	2	√
3	PD3P	Photodiode C+	3	√
4	PD4P	Photodiode D+	4	√
5	0V	√		
6	PD1N	Photodiode A-	14	√
7	PD2N	Photodiode B-	15	√
8	PD3N	Photodiode C-	16	√
9	PD4N	Photodiode D-	17	√

LED Monitors

LED Mon	SIGNAL	Monitors:	In from Sat	OK?
1	Imon1P	Current Source 1+	5	√
2	Imon2P	Current Source 2+	6	√
3	Imon3P	Current Source 3+	7	√
4	Imon4P	Current Source 4+	8	√
5	0V	√		
6	Imon1N	Current Source 1-	18	√
7	Imon2N	Current Source 2-	19	√
8	Imon3N	Current Source 3-	20	√
9	Imon4N	Current Source 4-	21	√

Power Supply to Satellite box

In from Sat	SIGNAL	DESCRIPTION	DC in Connector	OK?
9	V+	+17v Supply	A1	√
10	V+	+17v Supply	A1	√
11	V-	-17v Supply	A3	√
12	V-	-17v Supply	A3	√
13	0V	Return	A2	√
22	0V	Return	A2	√
23	0V	Return	A2	√
24	0V	Return	A2	√
25	0V	Return	A2	√

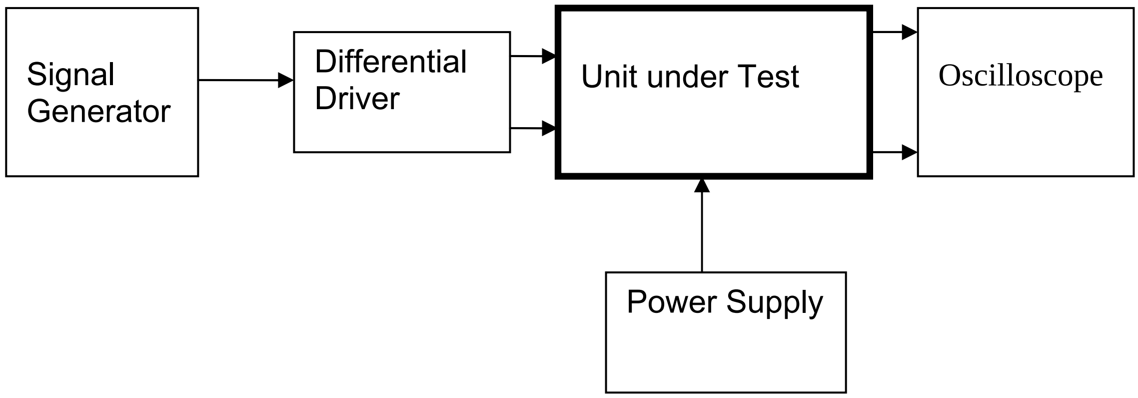
Unit………………OMC_1……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10..……………

5. Isolation Checks

Check that the driver ICs IC11 and IC12 are isolated from chassis on all channels. Apply a DVM on ohms range and measure the resistance between each transistor tab and the chassis.

IC Tab	Resistance	OK?
IC11 Channel 1	OL	√
IC12 Channel 1	OL	√
IC11 Channel 2	OL	√
IC12 Channel 2	OL	√
IC11 Channel 3	OL	√
IC12 Channel 3	OL	√
IC11 Channel 4	OL	√
IC12 Channel 4	OL	√

6. TEST SET UP



Note:
(1) Input signal to differential amplifier is generally stated in the tests below. There is therefore an inherent gain of 2 in the system.

(2) Some signal generators will indicate 1vpk/pk when the output is in fact 1v Peak into the high impedance Differential driver used. The test procedure refers to the actual voltage out of the signal generator.

Connections:

Differential signal inputs to the Drive Input of the unit under test:
Drive Input pins 1, 2, 3, 4 = positive input
Drive Input pins 6, 7, 8, 9 = negative input
Drive Input pin 5 = ground

Power (depending on connector availability)
Pd In from Sat pin 9, 10 = +16.5v or DC in A1
Pd In from Sat pin 11, 12 = -16.5 or DC in A3
Pd In from Sat pins 22, 23, 24, 25 = 0v or DC in A2

Coil Drive Outputs
Ch1+ = Coil out to Sat pin 1
Ch2+ = Coil out to Sat pin 3
Ch3+ = Coil out to Sat pin 5
Ch4+ = Coil out to Sat pin 7
Ch1- = Coil out to Sat pin 9
Ch2- = Coil out to Sat pin 11
Ch3- = Coil out to Sat pin 13
Ch4- = Coil out to Sat pin 15

Voltage, Current and R.M.S monitors

1	Voltage Monitor 4
2	Current Monitor 4
3	R.M.S Current 4
4	Voltage Monitor 3
5	Current Monitor 3
6	R.M.S Current 3
7	Voltage Monitor 2
8	Current Monitor 2
9	R.M.S Current 2
10	Voltage Monitor 1
11	Current Monitor 1
12	R.M.S Current 1
13 to 25	0v

Noise Monitor

1	Channel 1 Noise Monitor
2	Channel 2 Noise Monitor
3	Channel 3 Noise Monitor
4	Channel 4 Noise Monitor
5 to 9	0v

Unit……………….OMC_1……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10..……………

7. Power

Check the polarity of the wiring from the 3 pin power connector to each of the boards. Viewed from the back of the unit:

A1	Left pin	Positive	White wire
A2	Middle pin	RTN	Black wire
A3	Right pin	Negative	Green wire

If this is correct,
Connect power to the unit
Set the supplies to 16.5v
Turn on

Record supply currents:

+ 16.5 supply current (mA)	- 16.5 supply current (mA)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

If the power supplies are correct, proceed to the next section.

Unit……………….OMC_1……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10..……………

8. Relay Operation

Operate each relay in turn.
Observe its operation. LEDs should illuminate when the relays are operated.

Filter

Channel	Indicator		OK?
	ON	OFF	
Ch1	√	√	√
Ch2	√	√	√
Ch3	√	√	√
Ch4	√	√	√

TEST SWITCHES

Channel	Indicator		OK?
	ON	OFF	
Ch1	√	√	√
Ch2	√	√	√
Ch3	√	√	√
Ch4	√	√	√

Unit………………OMC_1……………………Serial No ………………………………
Test Engineer…..Xen……………..……
Date……………..18/11/10..……………

9. Current Monitor tests

The purpose of this test is to perform a functionality test on the current monitor and RMS circuits.

To do this, we need to draw a known current from each coil drive output. This is done by plugging the 39 ohm loads into each output, then adjusting the signal generator until the required voltage appears across each load resistor.

Remove all links W4 and W5.

Plug the power 39 ohm dummy load plug into the coil drive output.

Set the signal generator output to 2.5v peak at 100Hz.

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 0.4v peak appears across each resistor.

Record the peak output from each of the current monitors using the true r.m.s d.v.m and each of the RMS circuits with the meter set to d.c.

Channel	Monitor Connector	Parameter	Theoretical Value (+/- .1v)	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	1.39v r.m.s	1.35	√
	Pin 1	RMS Current	1.39v dc	1.35	√
2	Pin 5	Current Monitor	1.39v r.m.s	1.35	√
	Pin 4	RMS Current	1.39v dc	1.36	√
3	Pin 8	Current Monitor	1.39v r.m.s	1.35	√
	Pin 7	RMS Current	1.39v dc	1.35	√
4	Pin 11	Current Monitor	1.39v r.m.s	1.35	√
	Pin 10	RMS Current	1.39v dc	1.34	√

Unit……………….OMC_1……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10...……………

10. Voltage Monitor tests

The purpose of this test is to verify and calibrate the Voltage Monitor circuit on each channel.

Switch all filters out. Remove the dummy loads and make differential voltage output measurements on the coil drive outputs at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

Channel	Coil Drive Output pins	Voltage Monitor socket Pin	Monitor output?	Expected value	OK?
1	Pins 1,9	Pin 3	3.32	3.2v to 3.4v	√
2	Pins 3,11	Pin 6	3.32	3.2v to 3.4v	√
3	Pins 5,13	Pin 9	3.32	3.2v to 3.4v	√
4	Pins 7, 15	Pin 12	3.32	3.2v to 3.4v	√

11. Noise Monitor Tests

See Monitor re-test report.

Unit………………OMC_1……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10..……………

12. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct.
Ensure that links W4 and W5 are present.

Use the Dynamic Signal Analyser and signal generator.

With the filter switched in, measure the frequency response of each channel in turn between 1 Hz and 1 kHz. Measure the gain at the spot frequencies below and record them. Measure the gain at 0.1 Hz using the signal generator and scope, using a 1v peak input signal, and recording the peak output. In each case the output is measured differentially between TP9 and TP13.
Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.1		
10Hz	-30.5		
100Hz	-42.9		
1KHz	-43.3		

Channel 2

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.2		
10Hz	-30.3		
100Hz	-42.9		
1KHz	-43.3		

Channel 3

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.4		
10Hz	-30.0		
100Hz	-42.8		
1KHz	-43.3		

Channel 4

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.3		
10Hz	-30.2		
100Hz	-42.8		
1KHz	-43.3		

0.1 Hz measurements with the signal generator and oscilloscope

Frequency	Output	Expected O/P	Pass/Fail
Ch1	4.85		
Ch2	4.85		
Ch3	4.85		
Ch4	4.85		

Unit……………….OMC_1……………………Serial No ………………………………
Test Engineer…..Xen…………..………
Date……………..18/11/10..……………

13. Distortion

Remove links W4 and W5. Plug in the 5 Watt 39 Ohm dummy loads. Increase input voltage to 10v peak, f = 1KHz. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit………………OMC_1……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..18/11/10……………

14. Noise Tests

As the previous test involves non – representative temperature rises, allow the unit to cool before performing this test.

Replace the filter links W4 and W5 on each channel.

Replace the lid of the box, and replace screws.

Connect the filter test box, and switch in all filters.

Switch it out of Test Mode

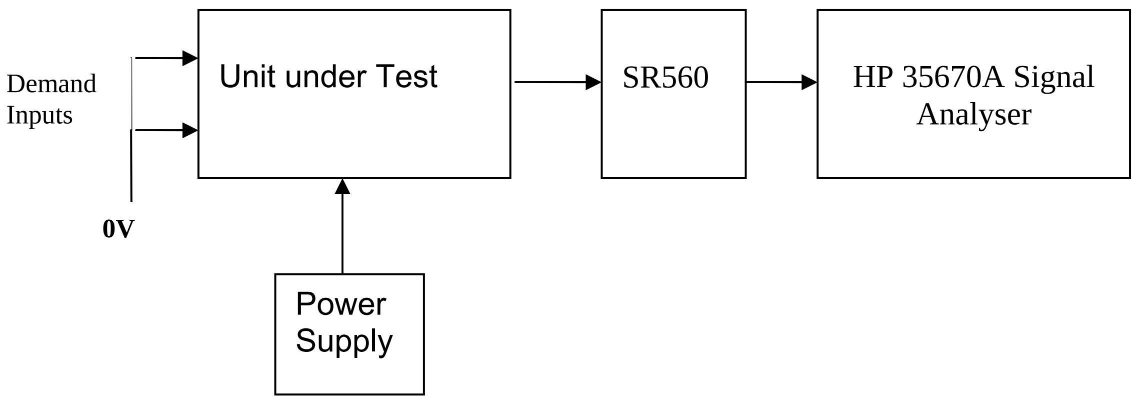
Use the HP 35670A Dynamic Signal Analyser.

Connect a shorting plug to the demand input to short all positive and negative demands together and to 0v. Connect 39 Ohm loads to the outputs.

Switch the filters in.

Use Stuart Aston's noise measurement set up, loaded from disc.

Measure the noise output from each channel in turn at the amplifier outputs. The Low Pass filter on the SR650 may be used to reduce mains interference, to prevent the Signal Analyser from overloading. Ideally the filter corner frequency should be set to 3 KHz. Set the amplifier gain to 1000, and check that the overload light is not on before each measurement.



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-150.5 dB	-103.2	-163.2
Ch2	-150.5 dB	-98.6	-158.6
Ch3	-150.5 dB	-101.8	-161.8
Ch4	-150.5 dB	-101.5	-161.5

Notes:
Specified noise output current at 10 Hz = 50 pA/√Hz
Total output resistance = 600 Ohms
Amplifier noise voltage should therefore = 30nV/√Hz or -150.5dB

The noise monitor amplifier has an internal gain of 42dB at 10Hz.The noise floor is about -133dB.

Unit……………….OMC_1……………………Serial No ………………………………
Test Engineer…..Xen………..………
Date……………..18/11/10..……………

15. Dynamic Range Tests

39 Ohm load resistors should be used, to represent the resistance of the Birmingham OSEM coil.

Plug in the dummy load.

Ensure that the filter links are in place, and the filters switched in circuit.

Drive the unit with a 5v peak sine wave on each channel (10v differential), at the frequencies specified. Measure the peak voltages across the load with an oscilloscope in each case, and compare with the specification.

CH	0.5 Hz	0.5Hz Spec (mV)	1 Hz	1Hz Spec (mV)	10 Hz	10Hz Spec (mV)	OK ?
1	625	599 to 651	370	342 to 420	10.5	13 to 16	
2	625	599 to 651	370	342 to 420	10.5	13 to 16	
3	625	599 to 651	380	342 to 420	11.0	13 to 16	
4	625	599 to 651	380	342 to 420	11.0	13 to 16	

Notes: Specification:-

Frequency	Output Current	V across 40 Ohms
Freq < 0.5Hz	10mA peak	400mV
1 Hz	5 mA peak	200mV
10Hz< freq< 100Hz	0.5 mA peak	20mV

Unit……………………….OMC1……………Serial No ………………………………
Test Engineer……………RMC
Date……………………23/11/10

16. Final Assembly Checks

1. Remove the lid of the box.√

2. Unplug all external connections. √

3. Check that the 9mm pillars are in place in the corners of the Monitor Board towards the centre of the box. √

4. Check that all internal connectors are firmly mated. √

5. Tighten the screw-locks holding all the external connectors. √

6. Check that the nuts holding the tabs of the power drivers are secure – tighten as necessary. Test with a DVM that none of the tabs are shorted to chassis. √

7. Check that all the LEDs are nicely centred. √

8. Check that links W4 and W5 are in place. √

9. Check that the boards are labelled with their Drawing Number, Issue Number, and serial number. Record below:

UoB box ID	OMC1P
Driver board ID	OMC1
Driver board Drawing No/Issue No	D1003116_V2
Driver board Serial Number	OMC1
Monitor board ID	MON153
Monitor board Drawing No/Issue No	D070480_5_K
Monitor board Serial Number	MON153

10. Check the security of any modification wires. √

11. Visually inspect. √

12. Put the lid on and fasten all screws, √

Check all external screws for tightness. √