LIGO Laboratory / LIGO Scientific Collaboration

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UIM1P Drive Unit Test Results

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

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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

UIM DRIVE
COMPLETED UNIT TEST PLAN

Unit…………UIM1………………Serial No ……UIM1P
Test Engineer ………XEN
Date …………………2/9/09

Drive Card ID……………UIM1
Monitor Card ID ………..MON1(P)

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1. Description

2. Test Equipment

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5. Test Set Up

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7. Relay operation

8. Current Monitor Tests

9. Voltage Monitor Tests

10. Corner Frequency Tests

11. Noise Tests

12. Distortion

13. Final Assembly Tests

1. Description

The UIM Driver Unit will be used to control the 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 UIM mirror in a Quad assembly. It works in conjunction with the OSEM coil and position sensor units. One UIM unit controls four OSEMs.

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

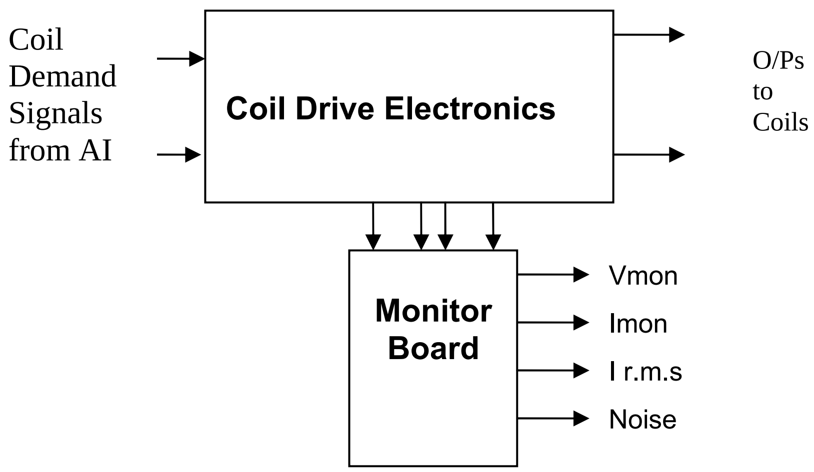


FIG. 1 UIM Driver Unit Block Diagram

Each UIM 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…………UIM1………………Serial No ……UIM1P
Test Engineer ………XEN
Date …………………2/9/09

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
DVM	FLUKE	115	
V/I Calibrator	Time Electronics	1044	
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-Tech	ISR622	
PSU x 2	Farnell	L30-2	

Unit…………UIM1………………Serial No ……UIM1P
Test Engineer ………XEN
Date …………………2/9/09
…

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment:

Good

Links:

Check that links W3, W4 and W5 are present on each channel of the Drive board. If not, connect them.

Unit…………UIM1………………Serial No ……UIM1P
Test Engineer ………XEN
Date …………………2/9/09

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	√

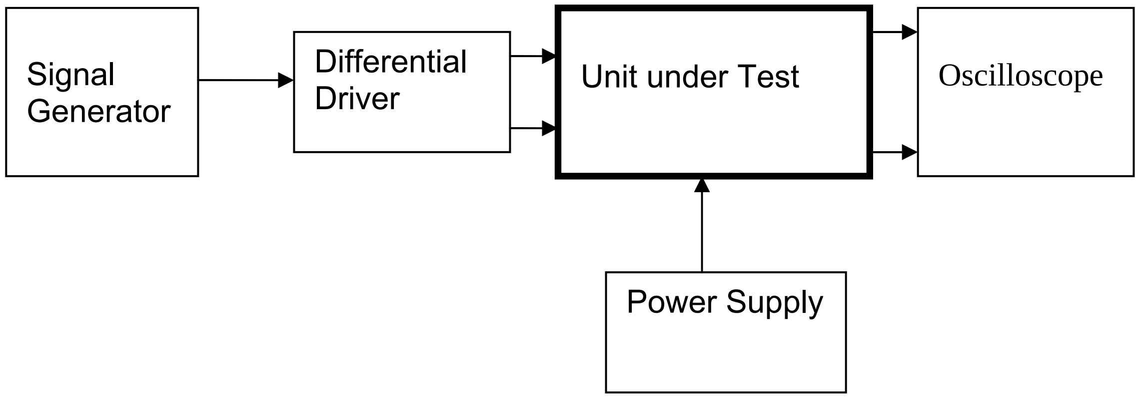
LED Monitors

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	√

5. 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…………UIM1………………Serial No ……UIM1P
Test Engineer ………XEN
Date …………………2/9/09

6. 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)
500mA	400mA

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…………UIM1………………Serial No ……UIM1P
Test Engineer ………XEN
Date …………………2/9/09

7. Relay Operation

Connect the test unit to the Binary IO inputs.
Operate switches and check that LEDs are on when the relays are switched on, and off when they are switched off:

Relay	LED Operation					
	Filter 1		Filter 2		Filter 2	
	ON	OFF	ON	OFF	ON	OFF
Ch1	√	√	√	√	√	√
Ch2	√	√	√	√	√	√
Ch3	√	√	√	√	√	√
Ch4	√	√	√	√	√	√

This indicates that the relays are operating, and that the talk back contacts work OK.

Unit…………UIM1………………Serial No ……UIM1P
Test Engineer ………XEN
Date …………………2/9/09

8. Current Monitor tests

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

Connect the 39 ohm dummy loads to the coil drive output. Connect the differential driver to the input, fed by the signal generator. Set the signal generator to 4v at 100 Hz.

Switch out the filters.
Use the true r.m.s meter to measure the r.m.s voltage between test points TP7 and TP11 on the drive board. Adjust the signal generator unit the until this voltage is 3v r.m.s.

Connect a scope probe to each end of one of the load resistors. Set up the scope to differentially observe the voltage across the load resistor. Check that it is a sine wave.

Measure and record the output from each current monitors, and each of the RMS circuits. Set the meter to r.m.s for the "current monitor" readings (ac signal), and to dc when measuring the r.m.s outputs (dc signal).

The theoretical output is 0.995v.

Ch.	Monitor Connector	Parameter	Theoretical Value	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	0.95v to 1.05 v r.m.s	0.9964	√
	Pin 1	RMS Current	0.95 v to 1.05 v dc	0.9998	√
2	Pin 5	Current Monitor	0.95 v to 1.05 v r.m.s	0.9965	√
	Pin 4	RMS Current	0.95 v to 1.05 v dc	0.9974	√
3	Pin 8	Current Monitor	0.95 v to 1.05 v r.m.s	0.9962	√
	Pin 7	RMS Current	0.95 v to 1.05 v dc	0.9953	√
4	Pin 11	Current Monitor	0.95 v to 1.05 v r.m.s	0.9953	√
	Pin 10	RMS Current	0.95 v to 1.05 v dc	0.9976	√

Unit…………UIM1………………Serial No ……UIM1P
Test Engineer ………XEN
Date …………………2/9/09

9. 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 TP7 and TP11 at 100 Hz.
Adjust the signal generator to give a voltage to 3v r.m.s 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	0.990	0.95v to 1.05v	√
2	Pins 3,11	Pin 6	0.996	0.95v to 1.05v	√
3	Pins 5,13	Pin 9	0.996	0.95v to 1.05v	√
4	Pins 7, 15	Pin 12	0.999	0.95v to 1.05v	√

Measurements may be used using a 25 way break out box, or a 25 way connector on the V, I and r.m.s connector.

10. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct. There are two possible ways of performing this test depending on available equipment. Either 8.1 or 8.2 should be conducted (it is not necessary to do both).

10.1 Using a Signal Generator

Apply a signal to the input, amplitude 1v peak, Frequency 100Hz via the differential driver, to the Drive Input.

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Switch out all the filter stages. Measure and record the peak differential output between the outputs of each channel, using two oscilloscope channels in differential mode.

	Coil Drive output pins	Pk/pk Output	Specification	Pass/Fail
Ch1	1 and 9		4.8v to 5v	
Ch2	3 and 11		4.8v to 5v	
Ch3	5 and 13		4.8v to 5v	
Ch4	7 and 15		4.8v to 5v	

Switch in each filter in turn and measure and record the peak output at 1Hz, 10 Hz, and 1 KHz.

1Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				3.3v to 3.7v	
Ch2	3 and 11				3.3v to 3.7v	
Ch3	5 and 13				3.3v to 3.7v	
Ch4	7 and 15				3.3v to 3.7v	

10Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.48 to 0.75v	
Ch2	3 and 11				0.48 to 0.75v	
Ch3	5 and 13				0.48 to 0.75v	
Ch4	7 and 15				0.48 to 0.75v	

1 KHz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.4v to 0.5v	
Ch2	3 and 11				0.4v to 0.5v	
Ch3	5 and 13				0.4v to 0.5v	
Ch4	7 and 15				0.4v to 0.5v	

Unit…………UIM1………………Serial No ……UIM1P
Test Engineer ………XEN
Date …………………2/9/09

10.2. Using the Dynamic Signal Analyser

With all filters switched in, measure the frequency response of each channel in turn between 0.1 Hz and 1KHz. If a fast turn around is required, limit the measurement to the frequency range to between 1 Hz and 1KHz. Measure the gain at the spot frequencies below and record them.

Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	+8.4	6.6 to 8.7	√
1Hz	-0.9	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 2

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	+8.4	6.6 to 8.7	√
1Hz	-0.9	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 3

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	+8.2	6.6 to 8.7	√
1Hz	-0.9	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 4

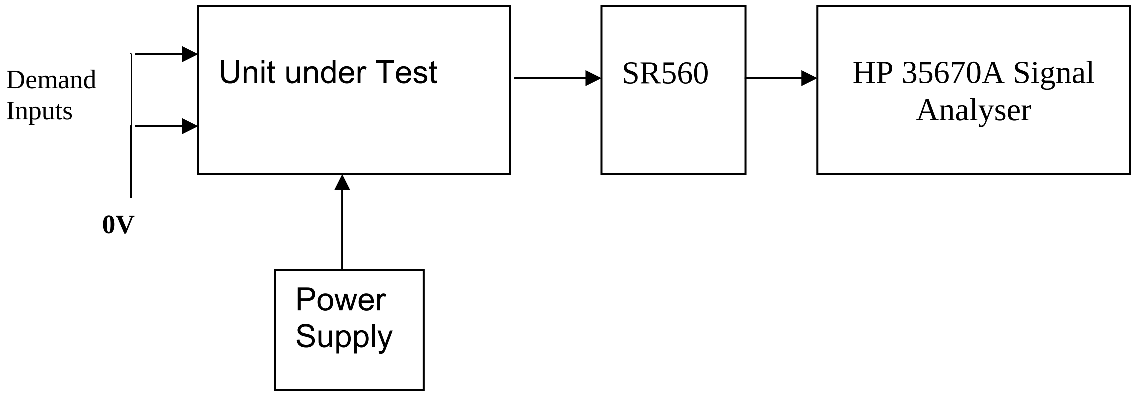
Frequency	Gain (dB)	Expected Gain	Pass/Fail
0.1 Hz	+8.5	6.6 to 8.7	√
1Hz	-0.8	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Unit…………UIM1………………Serial No ……UIM1P
Test Engineer ………XEN
Date …………………2/9/09

11. Noise Tests

Ensure the filter links W2, W3, W4 and W5 are present on each channel.

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, and readings should be made when the ambient noise is low. 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	-152.6	-93.7	-153.7dB
Ch2	-152.6	-96.5	-156.6dB
Ch3	-152.6	-95.5	-155.5dB
Ch4	-152.6	-94	-154dB

All channels are within specification.

The specification at 10 Hz is a noise current of 3 pA per root Hz. The total load resistance is 7.8k. The permitted noise voltage from the amplifiers is therefore 23.4 nA/ /√Hz or -152.6 dB. The SR560 is set to a gain of 1000 (60dB) so 60dB needs to be subtracted from the reading.

Unit…………UIM1………………Serial No ……UIM1P
Test Engineer ………XEN
Date …………………2/9/09

12. Distortion

No filters. Increase input voltage to 10v peak, f = 1KHz. Dummy 39 Ohm loads. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit…………UIM1………………Serial No ……UIM1P
Test Engineer ………RMC
Date …………………23/9/09

13. Final Assembly Tests

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 all the LEDs are nicely centred. √

7. Check that links W3, W4 and W5 are in place. √

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

UoB box ID	UIM1
Driver board ID	UIM1P
Driver board Drawing No/Issue No	D070481-4-K
Driver board Serial Number	UIM1P
Monitor board ID	UIM MON1 (P)
Monitor board Drawing No/Issue No	D070480-4-K
Monitor board Serial Number	UIM MON1 P

9. Check the security of any modification wires. *None*

10. Visually inspect. √

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

    Check all external screws for tightness. √

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UIM2P Drive Unit Test Results

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of the Advanced LIGO Project, prepared by members of the UK team.

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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

UIM DRIVE
COMPLETED UNIT TEST PLAN

Unit……………UIM2……………Serial No ……………UIM2P……………
Test Engineer ………XEN
Date …………………3/9/09

Drive Card ID……………UIM2
Monitor Card ID ………..MON2(P)

Contents

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1. Description

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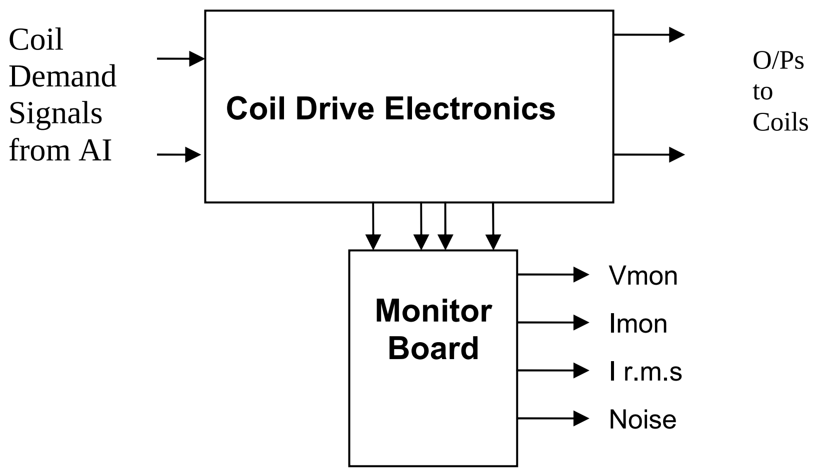

FIG. 1 UIM Driver Unit Block Diagram

Each UIM 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……………UIM2……………Serial No ……………UIM2P……………
Test Engineer ………XEN
Date …………………3/9/09

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.

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DVM	FLUKE	115	
V/I Calibrator	Time Electronics	1044	
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PSU x 2	Farnell	L30-2	

Unit……………UIM2……………Serial No ……………UIM2P……………
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3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment:

Good

Links:

Check that links W3, W4 and W5 are present on each channel of the Drive board. If not, connect them.

Unit……………UIM2……………Serial No ……………UIM2P……………
Test Engineer ………XEN
Date …………………3/9/09

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	√

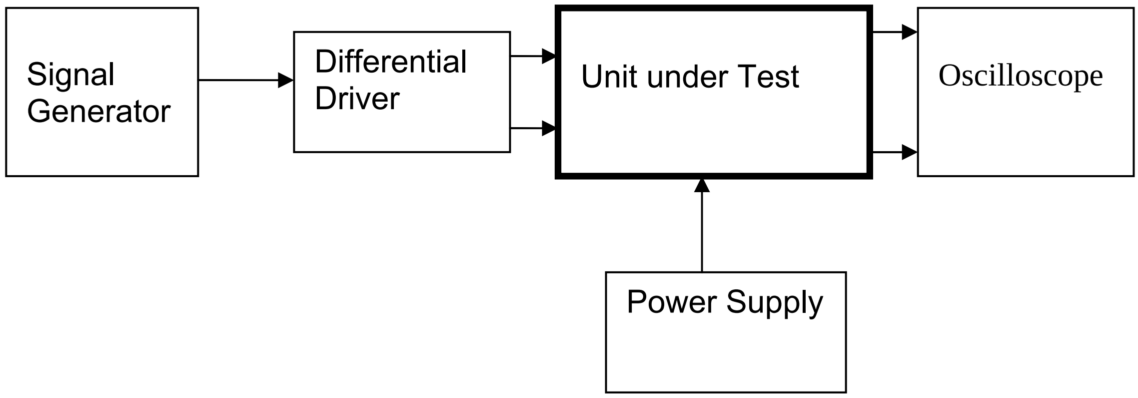
LED Monitors

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	√

5. 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……………UIM2……………Serial No ……………UIM2P……………
Test Engineer ………XEN
Date …………………3/9/09

6. 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)
500mA	400mA

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……………UIM2……………Serial No ……………UIM2P……………
Test Engineer ………XEN
Date …………………3/9/09

7. Relay Operation

Connect the test unit to the Binary IO inputs.

Operate switches and check that LEDs are on when the relays are switched on, and off when they are switched off:

Relay	**LED Operation**					
	Filter 1		**Filter 2**		**Filter 2**	
	ON	**OFF**	**ON**	**OFF**	**ON**	**OFF**
Ch1	√	√	√	√	√	√
Ch2	√	√	√	√	√	√
Ch3	√	√	√	√	√	√
Ch4	√	√	√	√	√	√

This indicates that the relays are operating, and that the talk back contacts work OK.

Unit……………UIM2……………Serial No ……………UIM2P……………
Test Engineer ………XEN
Date …………………3/9/09

8. Current Monitor tests

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

Connect the 39 ohm dummy loads to the coil drive output. Connect the differential driver to the input, fed by the signal generator. Set the signal generator to 4v at 100 Hz.

Switch out the filters.
Use the true r.m.s meter to measure the r.m.s voltage between test points TP7 and TP11 on the drive board. Adjust the signal generator unit the until this voltage is 3v r.m.s.

Connect a scope probe to each end of one of the load resistors. Set up the scope to differentially observe the voltage across the load resistor. Check that it is a sine wave.

Measure and record the output from each current monitors, and each of the RMS circuits. Set the meter to r.m.s for the “current monitor” readings (ac signal), and to dc when measuring the r.m.s outputs (dc signal).

The theoretical output is 0.995v.

Ch.	Monitor Connector	Parameter	Theoretical Value	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	0.95v to 1.05 v r.m.s	0.9969	√
	Pin 1	RMS Current	0.95 v to 1.05 v dc	0.9998	√
2	Pin 5	Current Monitor	0.95 v to 1.05 v r.m.s	0.9975	√
	Pin 4	RMS Current	0.95 v to 1.05 v dc	0.9984	√
3	Pin 8	Current Monitor	0.95 v to 1.05 v r.m.s	0.9970	√
	Pin 7	RMS Current	0.95 v to 1.05 v dc	0.9973	√
4	Pin 11	Current Monitor	0.95 v to 1.05 v r.m.s	0.9971	√
	Pin 10	RMS Current	0.95 v to 1.05 v dc	0.9966	√

Unit……………UIM2……………Serial No ……………UIM2P……………
Test Engineer ………XEN
Date …………………3/9/09

9. 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 TP7 and TP11 at 100 Hz.
Adjust the signal generator to give a voltage to 3v r.m.s 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	1.0012	0.95v to 1.05v	√
2	Pins 3,11	Pin 6	1.0018	0.95v to 1.05v	√
3	Pins 5,13	Pin 9	1.0026	0.95v to 1.05v	√
4	Pins 7, 15	Pin 12	1.0019	0.95v to 1.05v	√

Measurements may be used using a 25 way break out box, or a 25 way connector on the V, I and r.m.s connector.

10. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct. There are two possible ways of performing this test depending on available equipment. Either 8.1 or 8.2 should be conducted (it is not necessary to do both).

10.1 Using a Signal Generator

Apply a signal to the input, amplitude 1v peak, Frequency 100Hz via the differential driver, to the Drive Input.

.

Switch out all the filter stages. Measure and record the peak differential output between the outputs of each channel, using two oscilloscope channels in differential mode.

	Coil Drive output pins	Pk/pk Output	Specification	Pass/Fail
Ch1	1 and 9		4.8v to 5v	
Ch2	3 and 11		4.8v to 5v	
Ch3	5 and 13		4.8v to 5v	
Ch4	7 and 15		4.8v to 5v	

Switch in each filter in turn and measure and record the peak output at 1Hz, 10 Hz, and 1 KHz.

1Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				3.3v to 3.7v	
Ch2	3 and 11				3.3v to 3.7v	
Ch3	5 and 13				3.3v to 3.7v	
Ch4	7 and 15				3.3v to 3.7v	

10Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.48 to 0.75v	
Ch2	3 and 11				0.48 to 0.75v	
Ch3	5 and 13				0.48 to 0.75v	
Ch4	7 and 15				0.48 to 0.75v	

1 KHz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.4v to 0.5v	
Ch2	3 and 11				0.4v to 0.5v	
Ch3	5 and 13				0.4v to 0.5v	
Ch4	7 and 15				0.4v to 0.5v	

Unit...............UIM2...............Serial No ....UIM2P...............
Test Engineer ....XEN
Date 3/9/09

10.2. Using the Dynamic Signal Analyser

With all filters switched in, measure the frequency response of each channel in turn between 0.1 Hz and 1KHz. If a fast turn around is required, limit the measurement to the frequency range to between 1 Hz and 1KHz. Measure the gain at the spot frequencies below and record them.

Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	+8.3	**6.6 to 8.7**	√
1Hz	-1.1	**-0.2 to -2**	√
10Hz	-44	**-41 to -52**	√
100Hz	-53	**-51 to -58**	√
1KHz	-53	**-51 to -58**	√

Channel 2

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	+8.3	**6.6 to 8.7**	√
1Hz	-1.0	**-0.2 to -2**	√
10Hz	-44	**-41 to -52**	√
100Hz	-53	**-51 to -58**	√
1KHz	-53	**-51 to -58**	√

Channel 3

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	+8.5	**6.6 to 8.7**	√
1Hz	-0.8	**-0.2 to -2**	√
10Hz	-44	**-41 to -52**	√
100Hz	-53	**-51 to -58**	√
1KHz	-53	**-51 to -58**	√

Channel 4

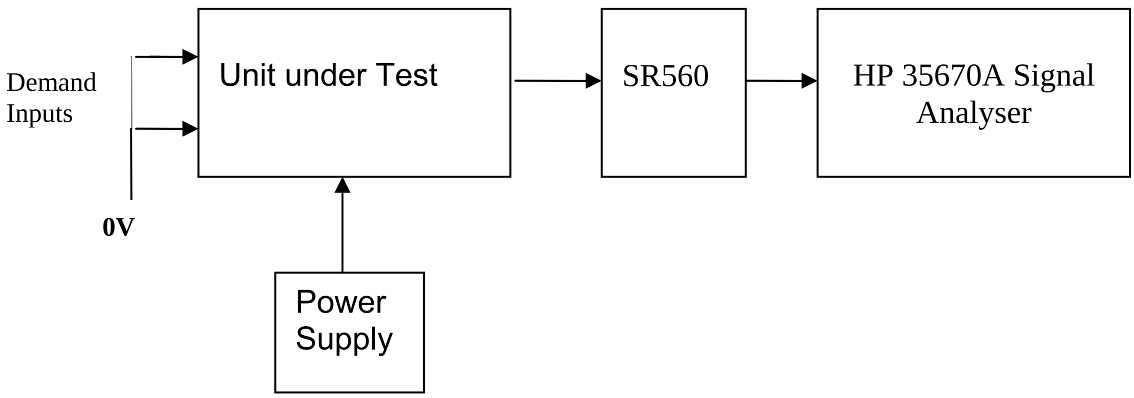
Frequency	Gain (dB)	Expected Gain	Pass/Fail
0.1 Hz	+8.2	**6.6 to 8.7**	√
1Hz	-0.7	**-0.2 to -2**	√
10Hz	-44	**-41 to -52**	√
100Hz	-53	**-51 to -58**	√
1KHz	-53	**-51 to -58**	√

Unit……………UIM2……………Serial No ……………UIM2P……………
Test Engineer …RMC……
Date ……………24/9/9

11. Noise Tests

Ensure the filter links W2, W3, W4 and W5 are present on each channel.

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, and readings should be made when the ambient noise is low. 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	-152.6	-93.11	-153.11
Ch2	-152.6	-94.23	-154.23
Ch3	-152.6	-94.37	-154.37
Ch4	-152.6	-93.6	-153.6

All channels are within specification.

The specification at 10 Hz is a noise current of 3 pA per root Hz. The total load resistance is 7.8k. The permitted noise voltage from the amplifiers is therefore 23.4 nA/ /√Hz or -152.6 dB. The SR560 is set to a gain of 1000 (60dB) so 60dB needs to be subtracted from the reading.

Unit……………UIM2……………Serial No ……………UIM2P……………
Test Engineer ………XEN
Date …………………3/9/09

12. Distortion

No filters. Increase input voltage to 10v peak, f = 1KHz. Dummy 39 Ohm loads. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit……………UIM2……………Serial No ……………UIM2P……………
Test Engineer ………RMC
Date …………………29/9/09

13. Final Assembly Tests

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 all the LEDs are nicely centred. √

7. Check that links W3, W4 and W5 are in place. √

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

UoB box ID	UIM2
Driver board ID	UIM2P
Driver board Drawing No/Issue No	D0704814-K
Driver board Serial Number	UIM2P
Monitor board ID	MON2
Monitor board Drawing No/Issue No	D070480-4-K
Monitor board Serial Number	UIMMON2P

9. Check the security of any modification wires.

10. Visually inspect. √

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

    Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T0900236-v3 Advanced LIGO UK 4 September 2009

UIM3P Drive Unit Test Results

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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.

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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

UIM DRIVE
COMPLETED UNIT TEST PLAN

Unit…………UIM3………………Serial No ………UIM3P………..
Test Engineer ………XEN
Date …………………4/9/09

Drive Card ID……………UIM3P
Monitor Card ID ………..MON3P

Contents

1. Description

2. Test Equipment

3. Inspection

4. Continuity Checks

5. Test Set Up

6. Power

7. Relay operation

8. Current Monitor Tests

9. Voltage Monitor Tests

10. Corner Frequency Tests

11. Noise Tests

12. Distortion

13. Final Assembly Tests

1. Description

The UIM Driver Unit will be used to control the 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 UIM mirror in a Quad assembly. It works in conjunction with the OSEM coil and position sensor units. One UIM unit controls four OSEMs.

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

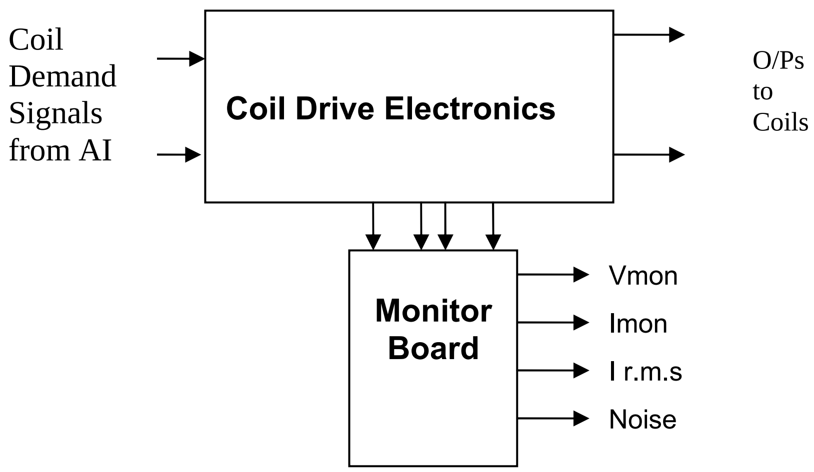


FIG. 1 UIM Driver Unit Block Diagram

Each UIM 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…………UIM3………………Serial No ………UIM3P…………
Test Engineer ………XEN
Date …………………4/9/09

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
DVM	FLUKE	115	
V/I Calibrator	Time Electronics	1044	
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-Tech	ISR622	
PSU x 2	Farnell	L30-2	

Unit…………UIM3………………Serial No ………UIM3P…………
Test Engineer ………XEN
Date …………………4/9/09

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment:

Good

Links:

Check that links W3, W4 and W5 are present on each channel of the Drive board. If not, connect them.

Unit…………UIM3………………Serial No ………UIM3P…………
Test Engineer ………XEN
Date …………………4/9/09

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	√

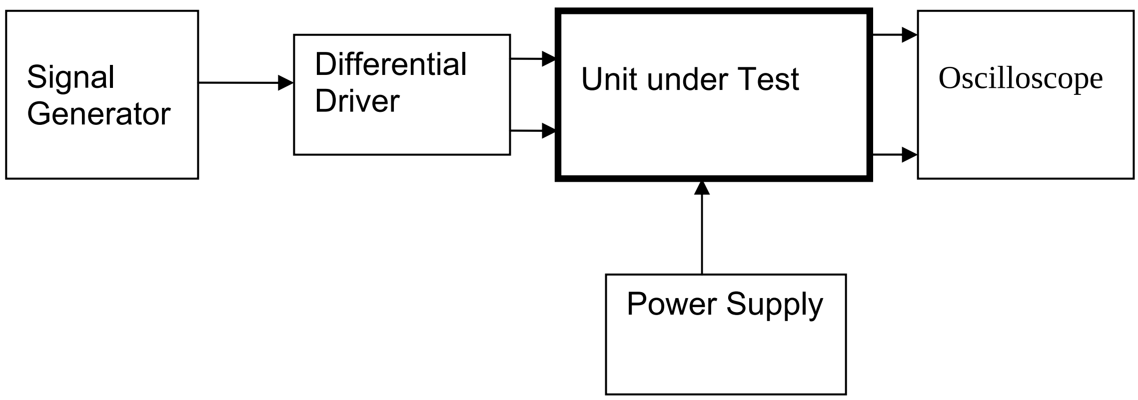
LED Monitors

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	√

5. 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…………UIM3………………Serial No ………UIM3P…………
Test Engineer ………XEN
Date …………………4/9/09

6. 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)
500mA	400mA

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…………UIM3………………Serial No ………UIM3P…………
Test Engineer ………XEN
Date …………………4/9/09

7. Relay Operation

Connect the test unit to the Binary IO inputs.

Operate switches and check that LEDs are on when the relays are switched on, and off when they are switched off:

Relay	LED Operation					
	Filter 1		Filter 2		Filter 2	
	ON	OFF	ON	OFF	ON	OFF
Ch1	√	√	√	√	√	√
Ch2	√	√	√	√	√	√
Ch3	√	√	√	√	√	√
Ch4	√	√	√	√	√	√

This indicates that the relays are operating, and that the talk back contacts work OK.

Unit…………UIM3………………Serial No ………UIM3P………..
Test Engineer ………XEN
Date …………………4/9/09

8. Current Monitor tests

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

Connect the 39 ohm dummy loads to the coil drive output. Connect the differential driver to the input, fed by the signal generator. Set the signal generator to 4v at 100 Hz.

Switch out the filters.
Use the true r.m.s meter to measure the r.m.s voltage between test points TP7 and TP11 on the drive board. Adjust the signal generator unit the until this voltage is 3v r.m.s.

Connect a scope probe to each end of one of the load resistors. Set up the scope to differentially observe the voltage across the load resistor. Check that it is a sine wave.

Measure and record the output from each current monitors, and each of the RMS circuits. Set the meter to r.m.s for the “current monitor” readings (ac signal), and to dc when measuring the r.m.s outputs (dc signal).

The theoretical output is 0.995v.

Ch.	Monitor Connector	Parameter	Theoretical Value	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	0.95v to 1.05 v r.m.s	0.9966	√
	Pin 1	RMS Current	0.95 v to 1.05 v dc	1.0015	√
2	Pin 5	Current Monitor	0.95 v to 1.05 v r.m.s	0.9978	√
	Pin 4	RMS Current	0.95 v to 1.05 v dc	1.0026	√
3	Pin 8	Current Monitor	0.95 v to 1.05 v r.m.s	0.9965	√
	Pin 7	RMS Current	0.95 v to 1.05 v dc	0.9997	√
4	Pin 11	Current Monitor	0.95 v to 1.05 v r.m.s	0.9967	√
	Pin 10	RMS Current	0.95 v to 1.05 v dc	0.9994	√

Unit…………UIM3………………Serial No ………UIM3P…………
Test Engineer ………XEN
Date …………………4/9/09

9. 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 TP7 and TP11 at 100 Hz.
Adjust the signal generator to give a voltage to 3v r.m.s 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	1.0019	0.95v to 1.05v	√
2	Pins 3,11	Pin 6	1.0020	0.95v to 1.05v	√
3	Pins 5,13	Pin 9	1.0050	0.95v to 1.05v	√
4	Pins 7, 15	Pin 12	1.0015	0.95v to 1.05v	√

Measurements may be used using a 25 way break out box, or a 25 way connector on the V, I and r.m.s connector.

10. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct. There are two possible ways of performing this test depending on available equipment. Either 8.1 or 8.2 should be conducted (it is not necessary to do both).

10.1 Using a Signal Generator

Apply a signal to the input, amplitude 1v peak, Frequency 100Hz via the differential driver, to the Drive Input.

.

Switch out all the filter stages. Measure and record the peak differential output between the outputs of each channel, using two oscilloscope channels in differential mode.

	Coil Drive output pins	Pk/pk Output	Specification	Pass/Fail
Ch1	1 and 9		4.8v to 5v	
Ch2	3 and 11		4.8v to 5v	
Ch3	5 and 13		4.8v to 5v	
Ch4	7 and 15		4.8v to 5v	

Switch in each filter in turn and measure and record the peak output at 1Hz, 10 Hz, and 1 KHz.

1Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				3.3v to 3.7v	
Ch2	3 and 11				3.3v to 3.7v	
Ch3	5 and 13				3.3v to 3.7v	
Ch4	7 and 15				3.3v to 3.7v	

10Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.48 to 0.75v	
Ch2	3 and 11				0.48 to 0.75v	
Ch3	5 and 13				0.48 to 0.75v	
Ch4	7 and 15				0.48 to 0.75v	

1 KHz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.4v to 0.5v	
Ch2	3 and 11				0.4v to 0.5v	
Ch3	5 and 13				0.4v to 0.5v	
Ch4	7 and 15				0.4v to 0.5v	

Unit…………UIM3………………Serial No ………UIM3P…………
Test Engineer ………XEN
Date …………………4/9/09

10.2. Using the Dynamic Signal Analyser

With all filters switched in, measure the frequency response of each channel in turn between 0.1 Hz and 1KHz. If a fast turn around is required, limit the measurement to the frequency range to between 1 Hz and 1KHz. Measure the gain at the spot frequencies below and record them.

Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.3	**6.6 to 8.7**	√
1Hz	-0.9	**-0.2 to -2**	√
10Hz	-44	**-41 to -52**	√
100Hz	-53	**-51 to -58**	√
1KHz	-53	**-51 to -58**	√

Channel 2

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.4	**6.6 to 8.7**	√
1Hz	-1.0	**-0.2 to -2**	√
10Hz	-44	**-41 to -52**	√
100Hz	-53	**-51 to -58**	√
1KHz	-53	**-51 to -58**	√

Channel 3

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.5	**6.6 to 8.7**	√
1Hz	-1.1	**-0.2 to -2**	√
10Hz	-44	**-41 to -52**	√
100Hz	-53	**-51 to -58**	√
1KHz	-53	**-51 to -58**	√

Channel 4

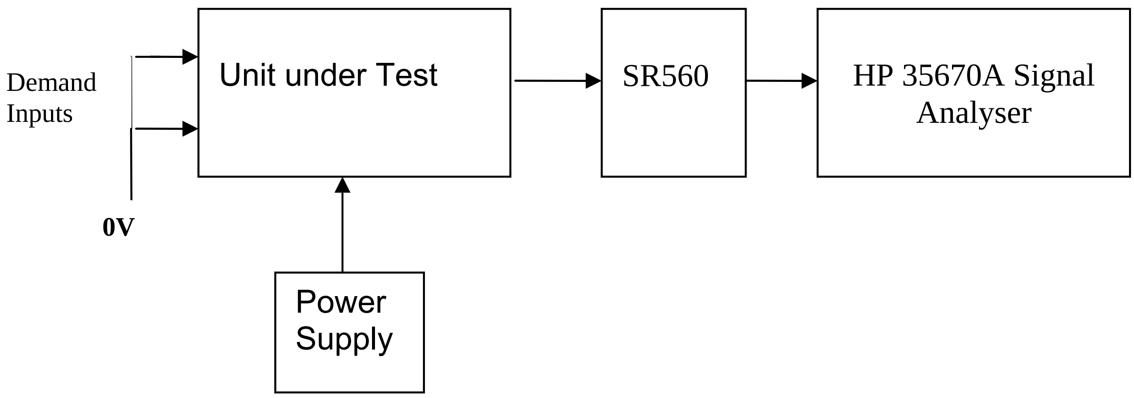
Frequency	Gain (dB)	Expected Gain	Pass/Fail
0.1 Hz	8.4	**6.6 to 8.7**	√
1Hz	-.9	**-0.2 to -2**	√
10Hz	-44	**-41 to -52**	√
100Hz	-53	**-51 to -58**	√
1KHz	-53	**-51 to -58**	√

Unit…………UIM3………………Serial No ………UIM3P…………
Test Engineer ………RMC
Date …………………24/9/09

11. Noise Tests

Ensure the filter links W2, W3, W4 and W5 are present on each channel.

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, and readings should be made when the ambient noise is low. 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	-152.6	-94.3	-154.3
Ch2	-152.6	-93.25	-153.25
Ch3	-152.6	-93.5	-153.5
Ch4	-152.6	-94.2	-154.2

All channels are within specification.

The specification at 10 Hz is a noise current of 3 pA per root Hz. The total load resistance is 7.8k. The permitted noise voltage from the amplifiers is therefore 23.4 nA/ /√Hz or -152.6 dB. The SR560 is set to a gain of 1000 (60dB) so 60dB needs to be subtracted from the reading.

Unit…………UIM3………………Serial No ………UIM3P…………
Test Engineer ………XEN
Date …………………4/9/09

12. Distortion

No filters. Increase input voltage to 10v peak, f = 1KHz. Dummy 39 Ohm loads. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit…………UIM3………………Serial No ………UIM3P…………
Test Engineer ………RMC
Date …………………29/9/09

13. Final Assembly Tests

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 all the LEDs are nicely centred. √

7. Check that links W3, W4 and W5 are in place. √

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

UoB box ID	UIM3P
Driver board ID	UIM3P
Driver board Drawing No/Issue No	D070481-4-K
Driver board Serial Number	UIM3P
Monitor board ID	MON3P
Monitor board Drawing No/Issue No	D070480-4-K
Monitor board Serial Number	UIM UIM3P

9. Check the security of any modification wires. None

10. Visually inspect. √

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

Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T0900236-v3 Advanced LIGO UK 7 September 2009

UIM4P Drive Unit Test Results

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.

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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

UIM DRIVE
COMPLETED UNIT TEST PLAN

Unit……………….UIM4…………Serial No ………UIM4P…………..
Test Engineer ………XEN
Date …………………7/9/09

Drive Card ID…………… UIM4P
Monitor Card ID ……….. MON4P

Contents

1. Description

2. Test Equipment

3. Inspection

4. Continuity Checks

5. Test Set Up

6. Power

7. Relay operation

8. Current Monitor Tests

9. Voltage Monitor Tests

10. Corner Frequency Tests

11. Noise Tests

12. Distortion

13. Final Assembly Tests

1. Description

The UIM Driver Unit will be used to control the 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 UIM mirror in a Quad assembly. It works in conjunction with the OSEM coil and position sensor units. One UIM unit controls four OSEMs.

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

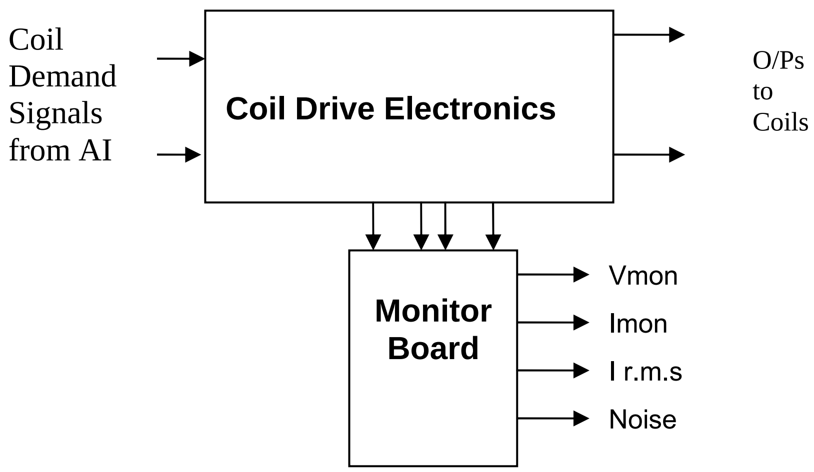


FIG. 1 UIM Driver Unit Block Diagram

Each UIM 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..................UIM4............Serial No ....UIM4P..............
Test Engineer ....XEN
Date 7/9/09

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
DVM	FLUKE	115	
V/I Calibrator	Time Electronics	1044	
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-Tech	ISR622	
PSU x 2	Farnell	L30-2	

Unit……………….UIM4………..Serial No ………UIM4P…………..
Test Engineer ………XEN
Date …………………7/9/09

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment:

Good

Links:

Check that links W3, W4 and W5 are present on each channel of the Drive board. If not, connect them.

Unit……………….UIM4…………Serial No ………UIM4P…………..
Test Engineer ………XEN
Date …………………7/9/09

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	√

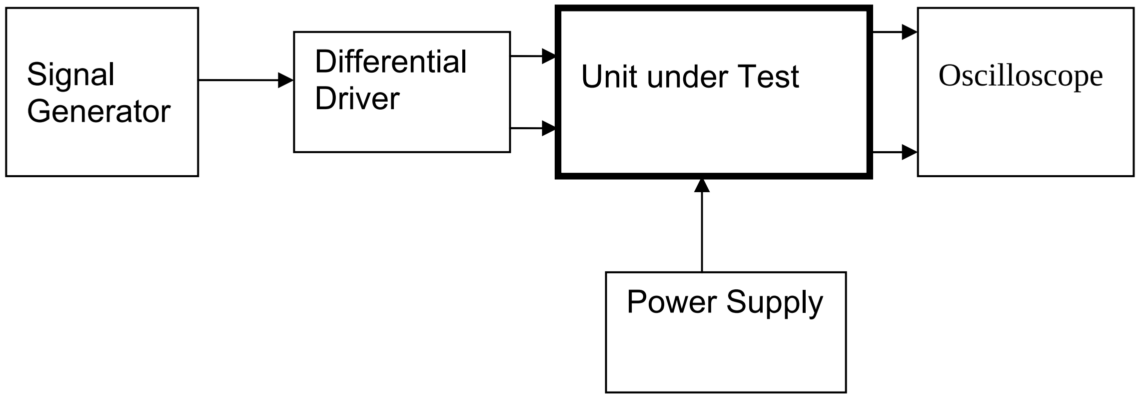
LED Monitors

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	√

5. 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……………….UIM4………..Serial No ………UIM4P…………..
Test Engineer ………XEN
Date …………………7/9/09

6. 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)
500mA	400mA

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………………UIM4…………Serial No ………UIM4P……………
Test Engineer ………XEN
Date …………………7/9/09

7. Relay Operation

Connect the test unit to the Binary IO inputs.

Operate switches and check that LEDs are on when the relays are switched on, and off when they are switched off:

Relay	LED Operation					
	Filter 1		Filter 2		Filter 2	
	ON	OFF	ON	OFF	ON	OFF
Ch1	√	√	√	√	√	√
Ch2	√	√	√	√	√	√
Ch3	√	√	√	√	√	√
Ch4	√	√	√	√	√	√

This indicates that the relays are operating, and that the talk back contacts work OK.

Unit………………UIM4…………Serial No ………UIM4P…………..
Test Engineer ………XEN
Date …………………7/9/09

8. Current Monitor tests

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

Connect the 39 ohm dummy loads to the coil drive output. Connect the differential driver to the input, fed by the signal generator. Set the signal generator to 4v at 100 Hz.

Switch out the filters.
Use the true r.m.s meter to measure the r.m.s voltage between test points TP7 and TP11 on the drive board. Adjust the signal generator unit the until this voltage is 3v r.m.s.

Connect a scope probe to each end of one of the load resistors. Set up the scope to differentially observe the voltage across the load resistor. Check that it is a sine wave.

Measure and record the output from each current monitors, and each of the RMS circuits. Set the meter to r.m.s for the "current monitor" readings (ac signal), and to dc when measuring the r.m.s outputs (dc signal).

The theoretical output is 0.995v.

Ch.	Monitor Connector	Parameter	Theoretical Value	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	0.95v to 1.05 v r.m.s	0.9950	√
	Pin 1	RMS Current	0.95 v to 1.05 v dc	0.9979	√
2	Pin 5	Current Monitor	0.95 v to 1.05 v r.m.s	0.9940	√
	Pin 4	RMS Current	0.95 v to 1.05 v dc	0.9993	√
3	Pin 8	Current Monitor	0.95 v to 1.05 v r.m.s	0.9939	√
	Pin 7	RMS Current	0.95 v to 1.05 v dc	0.9963	√
4	Pin 11	Current Monitor	0.95 v to 1.05 v r.m.s	0.9937	√
	Pin 10	RMS Current	0.95 v to 1.05 v dc	0.9973	√

Unit………………UIM4…………Serial No ………UIM4P……………
Test Engineer ………XEN
Date …………………7/9/09

9. 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 TP7 and TP11 at 100 Hz.
Adjust the signal generator to give a voltage to 3v r.m.s 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	1.0021	0.95v to 1.05v	√
2	Pins 3,11	Pin 6	1.0026	0.95v to 1.05v	√
3	Pins 5,13	Pin 9	1.0026	0.95v to 1.05v	√
4	Pins 7, 15	Pin 12	1.0010	0.95v to 1.05v	√

Measurements may be used using a 25 way break out box, or a 25 way connector on the V, I and r.m.s connector.

10. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct. There are two possible ways of performing this test depending on available equipment. Either 8.1 or 8.2 should be conducted (it is not necessary to do both).

10.1 Using a Signal Generator

Apply a signal to the input, amplitude 1v peak, Frequency 100Hz via the differential driver, to the Drive Input.

.

Switch out all the filter stages. Measure and record the peak differential output between the outputs of each channel, using two oscilloscope channels in differential mode.

	Coil Drive output pins	Pk/pk Output	Specification	Pass/Fail
Ch1	1 and 9		4.8v to 5v	
Ch2	3 and 11		4.8v to 5v	
Ch3	5 and 13		4.8v to 5v	
Ch4	7 and 15		4.8v to 5v	

Switch in each filter in turn and measure and record the peak output at 1Hz, 10 Hz, and 1 KHz.

1Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				3.3v to 3.7v	
Ch2	3 and 11				3.3v to 3.7v	
Ch3	5 and 13				3.3v to 3.7v	
Ch4	7 and 15				3.3v to 3.7v	

10Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.48 to 0.75v	
Ch2	3 and 11				0.48 to 0.75v	
Ch3	5 and 13				0.48 to 0.75v	
Ch4	7 and 15				0.48 to 0.75v	

1 KHz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.4v to 0.5v	
Ch2	3 and 11				0.4v to 0.5v	
Ch3	5 and 13				0.4v to 0.5v	
Ch4	7 and 15				0.4v to 0.5v	

Unit………………UIM4…………Serial No ………UIM4P……………
Test Engineer ………XEN
Date …………………7/9/09

10.2. Using the Dynamic Signal Analyser

With all filters switched in, measure the frequency response of each channel in turn between 0.1 Hz and 1KHz. If a fast turn around is required, limit the measurement to the frequency range to between 1 Hz and 1KHz. Measure the gain at the spot frequencies below and record them.

Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.5	6.6 to 8.7	√
1Hz	-0.8	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 2

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.2	6.6 to 8.7	√
1Hz	-0.7	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 3

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.3	6.6 to 8.7	√
1Hz	-0.9	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 4

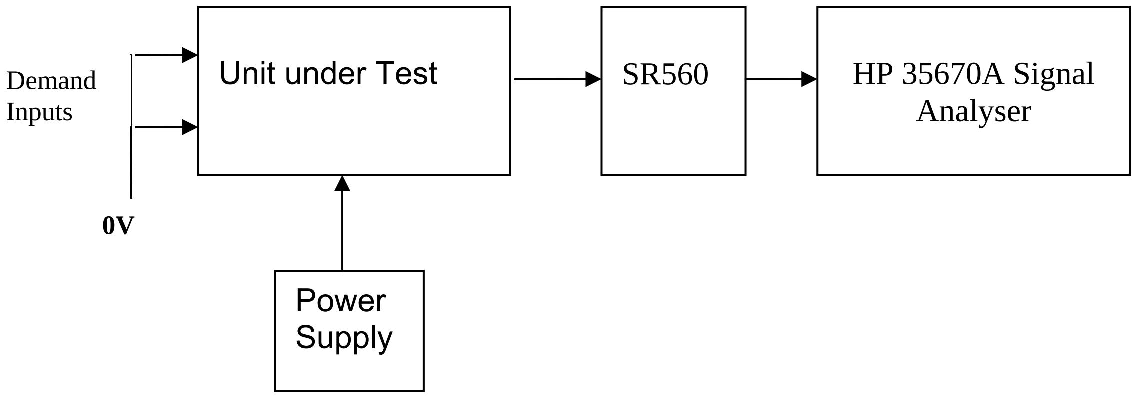
Frequency	Gain (dB)	Expected Gain	Pass/Fail
0.1 Hz	8.5	6.6 to 8.7	√
1Hz	-0.8	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Unit..................UIM4............Serial No ....UIM4P..............
Test Engineer ....RMC
Date 24/9/09

11. Noise Tests

Ensure the filter links W2, W3, W4 and W5 are present on each channel.

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, and readings should be made when the ambient noise is low. 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	-152.6	-93.6	-153.6
Ch2	-152.6	-95.6	-153.6
Ch3	-152.6	-95.6	-153.6
Ch4	-152.6	-93.6	-153.6

All channels are within specification

The specification at 10 Hz is a noise current of 3 pA per root Hz. The total load resistance is 7.8k. The permitted noise voltage from the amplifiers is therefore 23.4 nA/ /√Hz or -152.6 dB. The SR560 is set to a gain of 1000 (60dB) so 60dB needs to be subtracted from the reading.

Unit……………..UIM4…………Serial No ………UIM4P…………..
Test Engineer ………XEN
Date …………………7/9/09
…

12. Distortion

No filters. Increase input voltage to 10v peak, f = 1KHz. Dummy 39 Ohm loads. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit………………UIM4…………Serial No ………UIM4P…………..
Test Engineer ………RMC
Date …………………29/9/09

13. Final Assembly Tests

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 all the LEDs are nicely centred. √

7. Check that links W3, W4 and W5 are in place. √

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

UoB box ID	UIM4P
Driver board ID	UIM4P
Driver board Drawing No/Issue No	D070481-4-K
Driver board Serial Number	UIM4P
Monitor board ID	MON4P
Monitor board Drawing No/Issue No	D070480-4-K
Monitor board Serial Number	UIM MON4P

9. Check the security of any modification wires. None

10. Visually inspect. √

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

Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T0900236-v3 Advanced LIGO UK 7 September 2009

UIM5P Drive Unit Test Results

R. M. Cutler, University of Birmingham

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of the Advanced LIGO Project, prepared by members of the UK team.

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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

UIM DRIVE
COMPLETED UNIT TEST PLAN

Unit………………UIM5…………Serial No ………………… UIM5P
Engineer ………XEN
Date ……………7/9/09

Drive Card ID……………UIM5
Monitor Card ID ………..MON5P

Contents

1. Description

2. Test Equipment

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1. Description

The UIM Driver Unit will be used to control the 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 UIM mirror in a Quad assembly. It works in conjunction with the OSEM coil and position sensor units. One UIM unit controls four OSEMs.

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

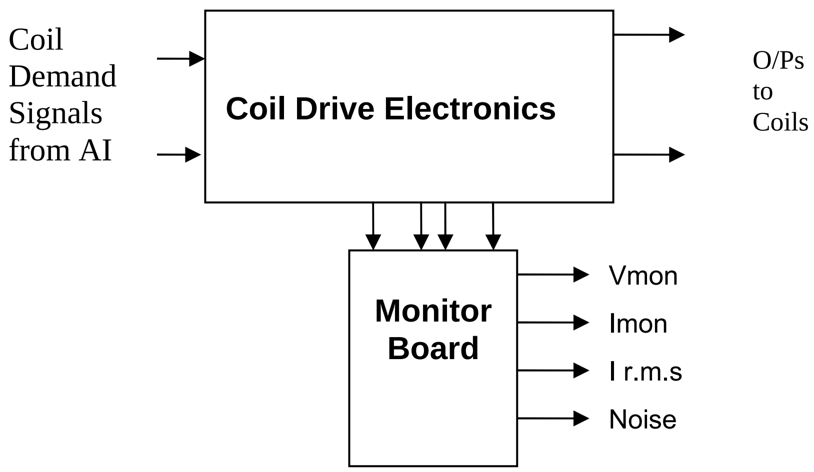


FIG. 1 UIM Driver Unit Block Diagram

Each UIM 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………………UIM5…………Serial No ………………… UIM5P
Engineer ………XEN
Date ……………7/9/09

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
DVM	FLUKE	115	
V/I Calibrator	Time Electronics	1044	
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-Tech	ISR622	
PSU x 2	Farnell	L30-2	

Unit……………….UIM5………..Serial No ………………… UIM5P
Engineer ………XEN
Date ……………7/9/09

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment:

Good

Links:

Check that links W3, W4 and W5 are present on each channel of the Drive board. If not, connect them.

Unit………………UIM5…………Serial No ………………… UIM5P
Engineer ………XEN
Date ……………7/9/09

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	√

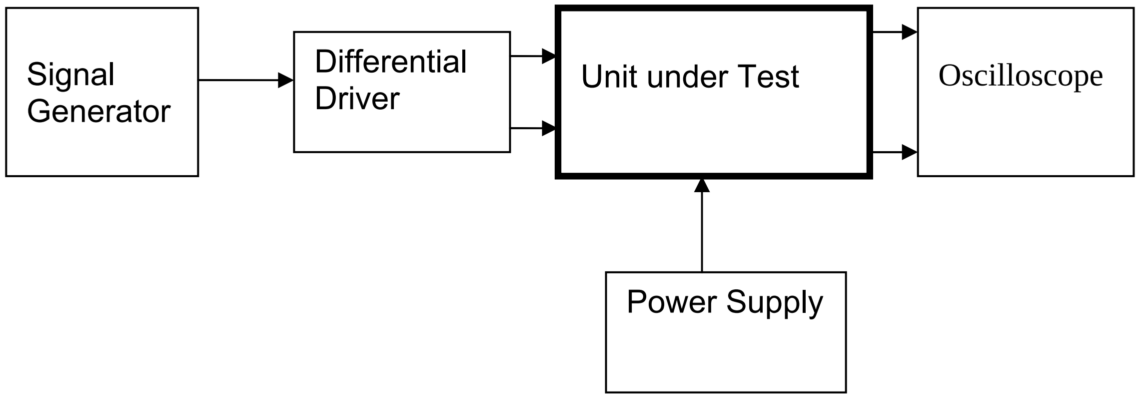
LED Monitors

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	√

5. 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………………UIM5…………Serial No ………………… UIM5P
Engineer ………XEN
Date ……………7/9/09

6. 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)
500mA	400mA

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………………UIM5…………Serial No ………………… UIM5P
Engineer ………XEN
Date ……………7/9/09

7. Relay Operation

Connect the test unit to the Binary IO inputs.

Operate switches and check that LEDs are on when the relays are switched on, and off when they are switched off:

Relay	LED Operation					
	Filter 1		Filter 2		Filter 2	
	ON	OFF	ON	OFF	ON	OFF
Ch1	√	√	√	√	√	√
Ch2	√	√	√	√	√	√
Ch3	√	√	√	√	√	√
Ch4	√	√	√	√	√	√

This indicates that the relays are operating, and that the talk back contacts work OK.

Unit………………UIM5…………Serial No ………………… UIM5P
Engineer ………XEN
Date ……………7/9/09

8. Current Monitor tests

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

Connect the 39 ohm dummy loads to the coil drive output. Connect the differential driver to the input, fed by the signal generator. Set the signal generator to 4v at 100 Hz.

Switch out the filters.
Use the true r.m.s meter to measure the r.m.s voltage between test points TP7 and TP11 on the drive board. Adjust the signal generator unit the until this voltage is 3v r.m.s.

Connect a scope probe to each end of one of the load resistors. Set up the scope to differentially observe the voltage across the load resistor. Check that it is a sine wave.

Measure and record the output from each current monitors, and each of the RMS circuits. Set the meter to r.m.s for the "current monitor" readings (ac signal), and to dc when measuring the r.m.s outputs (dc signal).

The theoretical output is 0.995v.

Ch.	Monitor Connector	Parameter	Theoretical Value	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	0.95v to 1.05 v r.m.s	0.9967	√
	Pin 1	RMS Current	0.95 v to 1.05 v dc	0.9985	√
2	Pin 5	Current Monitor	0.95 v to 1.05 v r.m.s	0.9970	√
	Pin 4	RMS Current	0.95 v to 1.05 v dc	0.9997	√
3	Pin 8	Current Monitor	0.95 v to 1.05 v r.m.s	0.9972	√
	Pin 7	RMS Current	0.95 v to 1.05 v dc	0.9984	√
4	Pin 11	Current Monitor	0.95 v to 1.05 v r.m.s	0.9970	√
	Pin 10	RMS Current	0.95 v to 1.05 v dc	0.9992	√

Unit………………UIM5…………Serial No ………………… UIM5P
Engineer ………XEN
Date ……………7/9/09

9. 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 TP7 and TP11 at 100 Hz.
Adjust the signal generator to give a voltage to 3v r.m.s 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	1.0009	0.95v to 1.05v	√
2	Pins 3,11	Pin 6	1.0025	0.95v to 1.05v	√
3	Pins 5,13	Pin 9	1.0013	0.95v to 1.05v	√
4	Pins 7, 15	Pin 12	1.0022	0.95v to 1.05v	√

Measurements may be used using a 25 way break out box, or a 25 way connector on the V, I and r.m.s connector.

10. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct. There are two possible ways of performing this test depending on available equipment. Either 8.1 or 8.2 should be conducted (it is not necessary to do both).

10.1 Using a Signal Generator

Apply a signal to the input, amplitude 1v peak, Frequency 100Hz via the differential driver, to the Drive Input.

.

Switch out all the filter stages. Measure and record the peak differential output between the outputs of each channel, using two oscilloscope channels in differential mode.

	Coil Drive output pins	Pk/pk Output	Specification	Pass/Fail
Ch1	1 and 9		4.8v to 5v	
Ch2	3 and 11		4.8v to 5v	
Ch3	5 and 13		4.8v to 5v	
Ch4	7 and 15		4.8v to 5v	

Switch in each filter in turn and measure and record the peak output at 1Hz, 10 Hz, and 1 KHz.

1Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				3.3v to 3.7v	
Ch2	3 and 11				3.3v to 3.7v	
Ch3	5 and 13				3.3v to 3.7v	
Ch4	7 and 15				3.3v to 3.7v	

10Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.48 to 0.75v	
Ch2	3 and 11				0.48 to 0.75v	
Ch3	5 and 13				0.48 to 0.75v	
Ch4	7 and 15				0.48 to 0.75v	

1 KHz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.4v to 0.5v	
Ch2	3 and 11				0.4v to 0.5v	
Ch3	5 and 13				0.4v to 0.5v	
Ch4	7 and 15				0.4v to 0.5v	

Unit..................UIM5............Serial No UIM5P
Engineer ....XEN
Date 7/9/09

10.2. Using the Dynamic Signal Analyser

With all filters switched in, measure the frequency response of each channel in turn between 0.1 Hz and 1KHz. If a fast turn around is required, limit the measurement to the frequency range to between 1 Hz and 1KHz. Measure the gain at the spot frequencies below and record them.

Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.4	**6.6 to 8.7**	√
1Hz	-0.9	**-0.2 to -2**	√
10Hz	-44	**-41 to -52**	√
100Hz	-53	**-51 to -58**	√
1KHz	-53	**-51 to -58**	√

Channel 2

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.5	**6.6 to 8.7**	√
1Hz	-0.8	**-0.2 to -2**	√
10Hz	-44	**-41 to -52**	√
100Hz	-53	**-51 to -58**	√
1KHz	-53	**-51 to -58**	√

Channel 3

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.5	**6.6 to 8.7**	√
1Hz	-0.9	**-0.2 to -2**	√
10Hz	-44	**-41 to -52**	√
100Hz	-53	**-51 to -58**	√
1KHz	-53	**-51 to -58**	√

Channel 4

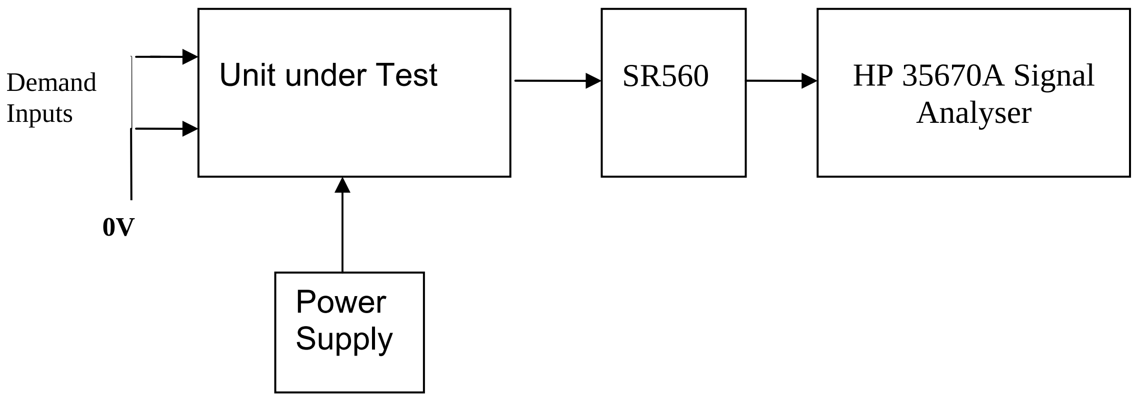
Frequency	Gain (dB)	Expected Gain	Pass/Fail
0.1 Hz	8.5	**6.6 to 8.7**	√
1Hz	-0.9	**-0.2 to -2**	√
10Hz	-44	**-41 to -52**	√
100Hz	-53	**-51 to -58**	√
1KHz	-54	**-51 to -58**	√

Unit..................UIM5............Serial No UIM5P
Engineer ....RMC
Date 24/9/09

11. Noise Tests

Ensure the filter links W2, W3, W4 and W5 are present on each channel.

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, and readings should be made when the ambient noise is low. 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	-152.6	-94.9	-154.9
Ch2	-152.6	-94.7	-154.7
Ch3	-152.6	-93.3	-153.3
Ch4	-152.6	-95.2	-155.2

The specification at 10 Hz is a noise current of 3 pA per root Hz. The total load resistance is 7.8k. The permitted noise voltage from the amplifiers is therefore 23.4 nA/ /√Hz or -152.6 dB. The SR560 is set to a gain of 1000 (60dB) so 60dB needs to be subtracted from the reading.

Unit………………UIM5…………Serial No ………………… UIM5P
Engineer ………XEN
Date ……………7/9/09

12. Distortion

No filters. Increase input voltage to 10v peak, f = 1KHz. Dummy 39 Ohm loads. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit………………UIM5…………Serial No ………………… UIM5P
Engineer ………RMC
Date ……………29/9/09
…

13. Final Assembly Tests

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 all the LEDs are nicely centred. √

7. Check that links W3, W4 and W5 are in place. √

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

UoB box ID	UIM5P
Driver board ID	UIM5P
Driver board Drawing No/Issue No	D070481-4-K
Driver board Serial Number	UIM5P
Monitor board ID	MON5P
Monitor board Drawing No/Issue No	D070480-4-K
Monitor board Serial Number	UIMMON5P

9. Check the security of any modification wires. None

10. Visually inspect. √

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

Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T0900236-v3 Advanced LIGO UK 8 September 2009

UIM6P Drive Unit Test Results

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.

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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

UIM DRIVE
COMPLETED UNIT TEST PLAN

Unit…………………UIM6…………Serial No ………UIM6P
Engineer ………XEN
Date ……………8/9/09

Drive Card ID…………… UIM6P
Monitor Card ID ………..MON6P

Contents

1. Description

2. Test Equipment

3. Inspection

4. Continuity Checks

5. Test Set Up

6. Power

7. Relay operation

8. Current Monitor Tests

9. Voltage Monitor Tests

10. Corner Frequency Tests

11. Noise Tests

12. Distortion

13. Final Assembly Tests

1. Description

The UIM Driver Unit will be used to control the 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 UIM mirror in a Quad assembly. It works in conjunction with the OSEM coil and position sensor units. One UIM unit controls four OSEMs.

The UIM 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.

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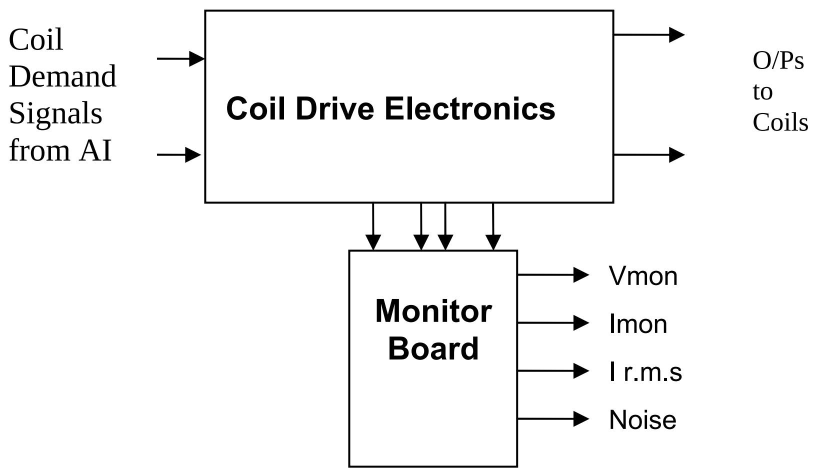

FIG. 1 UIM Driver Unit Block Diagram

Each UIM 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…………………UIM6…………Serial No ………UIM6P
Engineer ………XEN
Date ……………8/9/09

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.

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DVM	FLUKE	115	
V/I Calibrator	Time Electronics	1044	
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-Tech	ISR622	
PSU x 2	Farnell	L30-2	

Unit…………………UIM6…………Serial No ………UIM6P
Engineer ………XEN
Date ……………8/9/09

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment:

Good

Links:

Check that links W3, W4 and W5 are present on each channel of the Drive board. If not, connect them.

Unit…………………UIM6…………Serial No ………UIM6P
Engineer ………XEN
Date ……………8/9/09

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	√

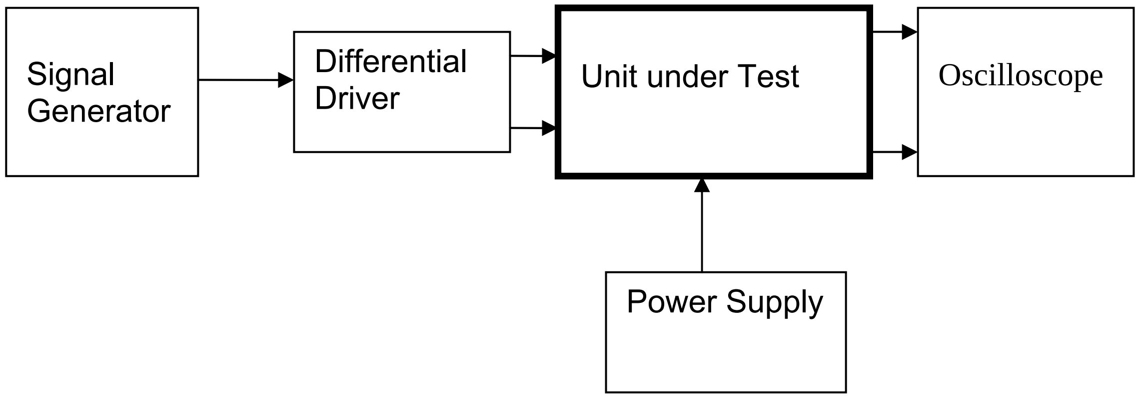
LED Monitors

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	√

5. 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…………………UIM6…………Serial No ………UIM6P
Engineer ………XEN
Date ……………8/9/09

6. 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)
500mA	400mA

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…………………UIM6…………Serial No ………UIM6P
Engineer ………XEN
Date ……………8/9/09

7. Relay Operation

Connect the test unit to the Binary IO inputs.

Operate switches and check that LEDs are on when the relays are switched on, and off when they are switched off:

Relay	**LED Operation**					
	Filter 1		**Filter 2**		**Filter 2**	
	ON	**OFF**	**ON**	**OFF**	**ON**	**OFF**
Ch1	√	√	√	√	√	√
Ch2	√	√	√	√	√	√
Ch3	√	√	√	√	√	√
Ch4	√	√	√	√	√	√

This indicates that the relays are operating, and that the talk back contacts work OK.

Unit…………………UIM6…………Serial No ………UIM6P
Engineer ………XEN
Date ……………8/9/09

8. Current Monitor tests

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

Connect the 39 ohm dummy loads to the coil drive output. Connect the differential driver to the input, fed by the signal generator. Set the signal generator to 4v at 100 Hz.

Switch out the filters.
Use the true r.m.s meter to measure the r.m.s voltage between test points TP7 and TP11 on the drive board. Adjust the signal generator unit the until this voltage is 3v r.m.s.

Connect a scope probe to each end of one of the load resistors. Set up the scope to differentially observe the voltage across the load resistor. Check that it is a sine wave.

Measure and record the output from each current monitors, and each of the RMS circuits. Set the meter to r.m.s for the “current monitor” readings (ac signal), and to dc when measuring the r.m.s outputs (dc signal).

The theoretical output is 0.995v.

Ch.	Monitor Connector	Parameter	Theoretical Value	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	0.95v to 1.05 v r.m.s	0.9977	√
	Pin 1	RMS Current	0.95 v to 1.05 v dc	1.0022	√
2	Pin 5	Current Monitor	0.95 v to 1.05 v r.m.s	0.9970	√
	Pin 4	RMS Current	0.95 v to 1.05 v dc	1.0033	√
3	Pin 8	Current Monitor	0.95 v to 1.05 v r.m.s	0.9972	√
	Pin 7	RMS Current	0.95 v to 1.05 v dc	1.0015	√
4	Pin 11	Current Monitor	0.95 v to 1.05 v r.m.s	0.9972	√
	Pin 10	RMS Current	0.95 v to 1.05 v dc	1.0056	√

Unit…………………UIM6…………Serial No ………UIM6P
Engineer ………XEN
Date ……………8/9/09

9. 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 TP7 and TP11 at 100 Hz. Adjust the signal generator to give a voltage to 3v r.m.s 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	1.0019	0.95v to 1.05v	√
2	Pins 3,11	Pin 6	1.0011	0.95v to 1.05v	√
3	Pins 5,13	Pin 9	1.0018	0.95v to 1.05v	√
4	Pins 7, 15	Pin 12	1.0016	0.95v to 1.05v	√

Measurements may be used using a 25 way break out box, or a 25 way connector on the V, I and r.m.s connector.

10. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct. There are two possible ways of performing this test depending on available equipment. Either 8.1 or 8.2 should be conducted (it is not necessary to do both).

10.1 Using a Signal Generator

Apply a signal to the input, amplitude 1v peak, Frequency 100Hz via the differential driver, to the Drive Input.

.

Switch out all the filter stages. Measure and record the peak differential output between the outputs of each channel, using two oscilloscope channels in differential mode.

	Coil Drive output pins	Pk/pk Output	Specification	Pass/Fail
Ch1	1 and 9		4.8v to 5v	
Ch2	3 and 11		4.8v to 5v	
Ch3	5 and 13		4.8v to 5v	
Ch4	7 and 15		4.8v to 5v	

Switch in each filter in turn and measure and record the peak output at 1Hz, 10 Hz, and 1 KHz.

1Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				3.3v to 3.7v	
Ch2	3 and 11				3.3v to 3.7v	
Ch3	5 and 13				3.3v to 3.7v	
Ch4	7 and 15				3.3v to 3.7v	

10Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.48 to 0.75v	
Ch2	3 and 11				0.48 to 0.75v	
Ch3	5 and 13				0.48 to 0.75v	
Ch4	7 and 15				0.48 to 0.75v	

1 KHz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.4v to 0.5v	
Ch2	3 and 11				0.4v to 0.5v	
Ch3	5 and 13				0.4v to 0.5v	
Ch4	7 and 15				0.4v to 0.5v	

Unit…………………UIM6…………Serial No ………UIM6P
Engineer ………XEN
Date ……………8/9/09

10.2. Using the Dynamic Signal Analyser

With all filters switched in, measure the frequency response of each channel in turn between 0.1 Hz and 1KHz. If a fast turn around is required, limit the measurement to the frequency range to between 1 Hz and 1KHz. Measure the gain at the spot frequencies below and record them.

Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.3	6.6 to 8.7	√
1Hz	-1.1	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 2

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.5	6.6 to 8.7	√
1Hz	-0.9	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 3

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.5	6.6 to 8.7	√
1Hz	-0.6	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 4

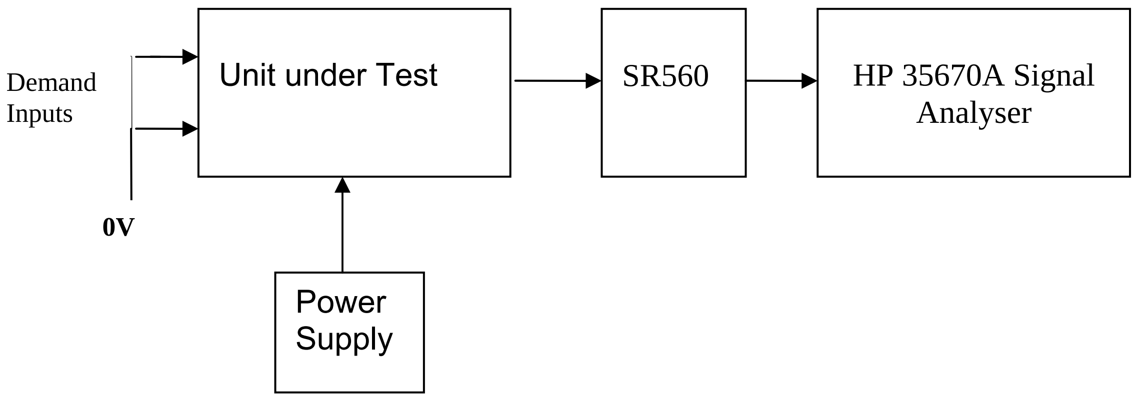
Frequency	Gain (dB)	Expected Gain	Pass/Fail
0.1 Hz	8.5	6.6 to 8.7	√
1Hz	-1.1	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Unit…………………UIM6…………Serial No ………UIM6P
Engineer ………RMC
Date ……………24/9/09

11. Noise Tests

Ensure the filter links W2, W3, W4 and W5 are present on each channel.

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, and readings should be made when the ambient noise is low. 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	-152.6	-94.5	-154.5
Ch2	-152.6	-95.5	-155.5
Ch3	-152.6	-93.6	-153.6
Ch4	-152.6	-93.6	-153.6

All channels are within specification

The specification at 10 Hz is a noise current of 3 pA per root Hz. The total load resistance is 7.8k. The permitted noise voltage from the amplifiers is therefore 23.4 nA/ /√Hz or -152.6 dB. The SR560 is set to a gain of 1000 (60dB) so 60dB needs to be subtracted from the reading.

Unit…………………UIM6…………Serial No ………UIM6P
Engineer ………XEN
Date ……………8/9/09

12. Distortion

No filters. Increase input voltage to 10v peak, f = 1KHz. Dummy 39 Ohm loads. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit…………………UIM6…………Serial No ………UIM6P
Engineer ………RMC
Date ……………29/9/9

13. Final Assembly Tests

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 all the LEDs are nicely centred. √

7. Check that links W3, W4 and W5 are in place. √

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

UoB box ID	UIM6P
Driver board ID	UIM6P
Driver board Drawing No/Issue No	D070481-4-K
Driver board Serial Number	UIM6P
Monitor board ID	MON6P
Monitor board Drawing No/Issue No	D070480-4-K
Monitor board Serial Number	UIM6 MON P

9. Check the security of any modification wires.

10. Visually inspect. √

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

    Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T0900236-v3 Advanced LIGO UK 8 September 2009

UIM7P Drive Unit Test Results

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.

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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

UIM DRIVE
COMPLETED UNIT TEST PLAN

Unit……………UIM7……………Serial No …………………UIM7P
Engineer …………XEN
Date ………………8/9/09

Drive Card ID…………… UIM7P
Monitor Card ID ……….. MON7P

Contents

1. Description

2. Test Equipment

3. Inspection

4. Continuity Checks

5. Test Set Up

6. Power

7. Relay operation

8. Current Monitor Tests

9. Voltage Monitor Tests

10. Corner Frequency Tests

11. Noise Tests

12. Distortion

13. Final Assembly Tests

1. Description

The UIM Driver Unit will be used to control the 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 UIM mirror in a Quad assembly. It works in conjunction with the OSEM coil and position sensor units. One UIM unit controls four OSEMs.

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

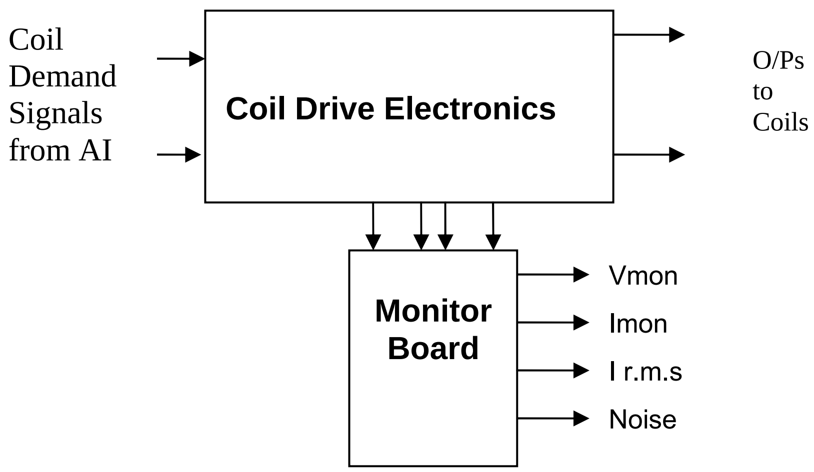


FIG. 1 UIM Driver Unit Block Diagram

Each UIM 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……………UIM7……………Serial No …………………UIM7P
Engineer …………XEN
Date ………………8/9/09

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
DVM	FLUKE	115	
V/I Calibrator	Time Electronics	1044	
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-Tech	ISR622	
PSU x 2	Farnell	L30-2	

Unit……………UIM7……………Serial No …………………UIM7P
Engineer …………XEN
Date ………………8/9/09

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment:

Good

Links:

Check that links W3, W4 and W5 are present on each channel of the Drive board. If not, connect them.

Unit……………UIM7……………Serial No …………………UIM7P
Engineer …………XEN
Date ………………8/9/09

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	√

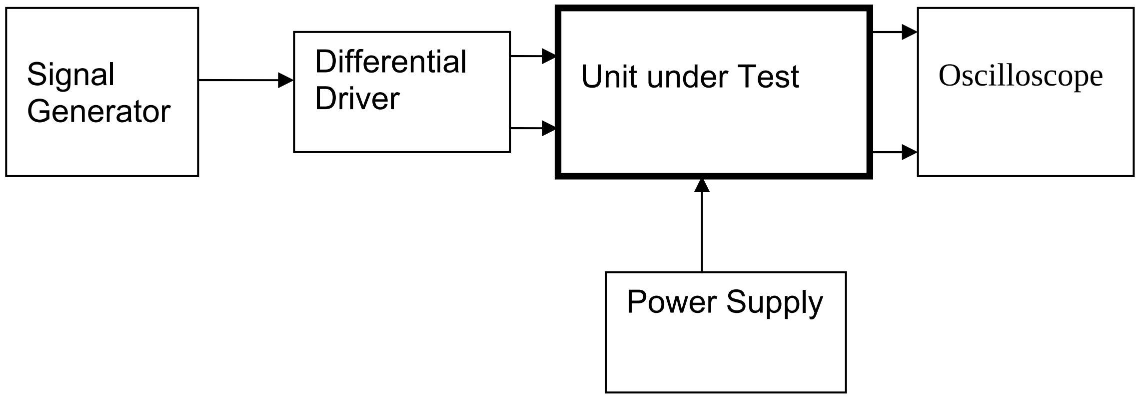
LED Monitors

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	√

5. 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……………UIM7……………Serial No …………………UIM7P
Engineer …………XEN
Date ………………8/9/09

6. 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)
500mA	400mA

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……………UIM7……………Serial No …………………UIM7P
Engineer …………XEN
Date ………………8/9/09

7. Relay Operation

Connect the test unit to the Binary IO inputs.

Operate switches and check that LEDs are on when the relays are switched on, and off when they are switched off:

Relay	LED Operation					
	Filter 1		Filter 2		Filter 2	
	ON	OFF	ON	OFF	ON	OFF
Ch1	√	√	√	√	√	√
Ch2	√	√	√	√	√	√
Ch3	√	√	√	√	√	√
Ch4	√	√	√	√	√	√

This indicates that the relays are operating, and that the talk back contacts work OK.

Unit……………UIM7……………Serial No …………………UIM7P
Engineer …………XEN
Date ………………8/9/09

8. Current Monitor tests

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

Connect the 39 ohm dummy loads to the coil drive output. Connect the differential driver to the input, fed by the signal generator. Set the signal generator to 4v at 100 Hz.

Switch out the filters.
Use the true r.m.s meter to measure the r.m.s voltage between test points TP7 and TP11 on the drive board. Adjust the signal generator unit the until this voltage is 3v r.m.s.

Connect a scope probe to each end of one of the load resistors. Set up the scope to differentially observe the voltage across the load resistor. Check that it is a sine wave.

Measure and record the output from each current monitors, and each of the RMS circuits. Set the meter to r.m.s for the "current monitor" readings (ac signal), and to dc when measuring the r.m.s outputs (dc signal).

The theoretical output is 0.995v.

Ch.	Monitor Connector	Parameter	Theoretical Value	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	0.95v to 1.05 v r.m.s	0.9968	√
	Pin 1	RMS Current	0.95 v to 1.05 v dc	0.9993	√
2	Pin 5	Current Monitor	0.95 v to 1.05 v r.m.s	0.9965	√
	Pin 4	RMS Current	0.95 v to 1.05 v dc	1.0002	√
3	Pin 8	Current Monitor	0.95 v to 1.05 v r.m.s	0.9966	√
	Pin 7	RMS Current	0.95 v to 1.05 v dc	0.9981	√
4	Pin 11	Current Monitor	0.95 v to 1.05 v r.m.s	0.9942	√
	Pin 10	RMS Current	0.95 v to 1.05 v dc	0.9981	√

Unit……………UIM7……………Serial No …………………UIM7P
Engineer …………XEN
Date ………………8/9/09

9. 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 TP7 and TP11 at 100 Hz.
Adjust the signal generator to give a voltage to 3v r.m.s 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	1.0027	0.95v to 1.05v	√
2	Pins 3,11	Pin 6	1.0020	0.95v to 1.05v	√
3	Pins 5,13	Pin 9	1.0017	0.95v to 1.05v	√
4	Pins 7, 15	Pin 12	1.0013	0.95v to 1.05v	√

Measurements may be used using a 25 way break out box, or a 25 way connector on the V, I and r.m.s connector.

10. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct. There are two possible ways of performing this test depending on available equipment. Either 8.1 or 8.2 should be conducted (it is not necessary to do both).

10.1 Using a Signal Generator

Apply a signal to the input, amplitude 1v peak, Frequency 100Hz via the differential driver, to the Drive Input.

.

Switch out all the filter stages. Measure and record the peak differential output between the outputs of each channel, using two oscilloscope channels in differential mode.

	Coil Drive output pins	Pk/pk Output	Specification	Pass/Fail
Ch1	1 and 9		4.8v to 5v	
Ch2	3 and 11		4.8v to 5v	
Ch3	5 and 13		4.8v to 5v	
Ch4	7 and 15		4.8v to 5v	

Switch in each filter in turn and measure and record the peak output at 1Hz, 10 Hz, and 1 KHz.

1Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				3.3v to 3.7v	
Ch2	3 and 11				3.3v to 3.7v	
Ch3	5 and 13				3.3v to 3.7v	
Ch4	7 and 15				3.3v to 3.7v	

10Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.48 to 0.75v	
Ch2	3 and 11				0.48 to 0.75v	
Ch3	5 and 13				0.48 to 0.75v	
Ch4	7 and 15				0.48 to 0.75v	

1 KHz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.4v to 0.5v	
Ch2	3 and 11				0.4v to 0.5v	
Ch3	5 and 13				0.4v to 0.5v	
Ch4	7 and 15				0.4v to 0.5v	

Unit...............UIM7...............Serial No UIM7P
Engineer ....XEN
Date 8/9/09

10.2. Using the Dynamic Signal Analyser

With all filters switched in, measure the frequency response of each channel in turn between 0.1 Hz and 1KHz. If a fast turn around is required, limit the measurement to the frequency range to between 1 Hz and 1KHz. Measure the gain at the spot frequencies below and record them.

Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.5	6.6 to 8.7	√
1Hz	-0.8	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 2

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.5	6.6 to 8.7	√
1Hz	-1.0	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 3

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.2	6.6 to 8.7	√
1Hz	-0.8	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 4

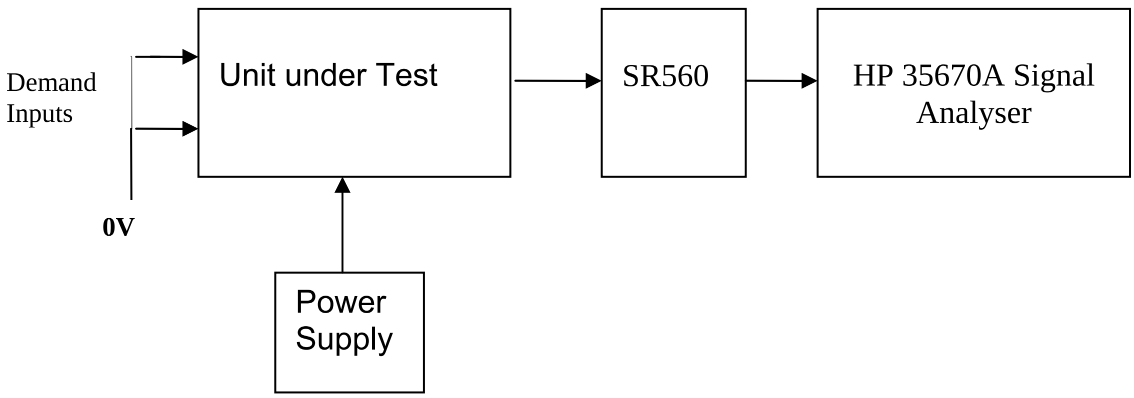
Frequency	Gain (dB)	Expected Gain	Pass/Fail
0.1 Hz	8.5	6.6 to 8.7	√
1Hz	-1.0	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Unit...............UIM7...............Serial No UIM7P
Engineer ....RMC
Date 24/9/09

11. Noise Tests

Ensure the filter links W2, W3, W4 and W5 are present on each channel.

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, and readings should be made when the ambient noise is low. 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	-152.6	-94.7	-154.7
Ch2	-152.6	-94.3	-154.3
Ch3	-152.6	-93.1	-153.1
Ch4	-152.6	-94.4	-154.4

All channels are in specification.

The specification at 10 Hz is a noise current of 3 pA per root Hz. The total load resistance is 7.8k. The permitted noise voltage from the amplifiers is therefore 23.4 nA/ /√Hz or -152.6 dB. The SR560 is set to a gain of 1000 (60dB) so 60dB needs to be subtracted from the reading.

Unit……………UIM7……………Serial No …………………UIM7P
Engineer …………XEN
Date ………………8/9/09

12. Distortion
No filters. Increase input voltage to 10v peak, f = 1KHz. Dummy 39 Ohm loads. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit……………UIM7……………Serial No …………………UIM7P
Engineer …………RMC
Date ………………29/9/09

13. Final Assembly Tests

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 all the LEDs are nicely centred. √

7. Check that links W3, W4 and W5 are in place. √

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

UoB box ID	UIM7P
Driver board ID	UIM7P
Driver board Drawing No/Issue No	D070481-4-K
Driver board Serial Number	UIM7P
Monitor board ID	MON7P
Monitor board Drawing No/Issue No	D070480-4-K
Monitor board Serial Number	UIM MON7P

9. Check the security of any modification wires. √

10. Visually inspect. √

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

    Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T0900236-v3 Advanced LIGO UK 8 September 2009

UIM8P Drive Unit Test Results

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.

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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

UIM DRIVE
COMPLETED UNIT TEST PLAN

Unit………UIM8…………………Serial No ………UIM8P………………………
Test Engineer ………XEN
Date …………………8/9/09

Drive Card ID…………… UIM8P
Monitor Card ID ………..MON8P

Contents

1. Description

2. Test Equipment

3. Inspection

4. Continuity Checks

5. Test Set Up

6. Power

7. Relay operation

8. Current Monitor Tests

9. Voltage Monitor Tests

10. Corner Frequency Tests

11. Noise Tests

12. Distortion

13. Final Assembly Tests

1. Description

The UIM Driver Unit will be used to control the 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 UIM mirror in a Quad assembly. It works in conjunction with the OSEM coil and position sensor units. One UIM unit controls four OSEMs.

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

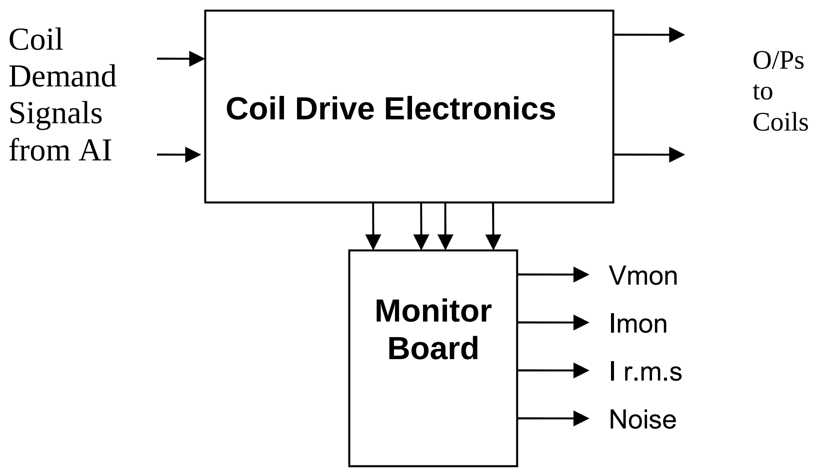


FIG. 1 UIM Driver Unit Block Diagram

Each UIM 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………UIM8…………………Serial No ………UIM8P………………………
Test Engineer ………XEN
Date …………………8/9/09

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
DVM	FLUKE	115	
V/I Calibrator	Time Electronics	1044	
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-Tech	ISR622	
PSU x 2	Farnell	L30-2	

Unit………UIM8…………………Serial No ………UIM8P………………………
Test Engineer ………XEN
Date …………………8/9/09

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment:

Good

Links:

Check that links W3, W4 and W5 are present on each channel of the Drive board. If not, connect them.

Unit………UIM8…………………Serial No ………UIM8P………………………
Test Engineer ………XEN
Date …………………8/9/09

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	√

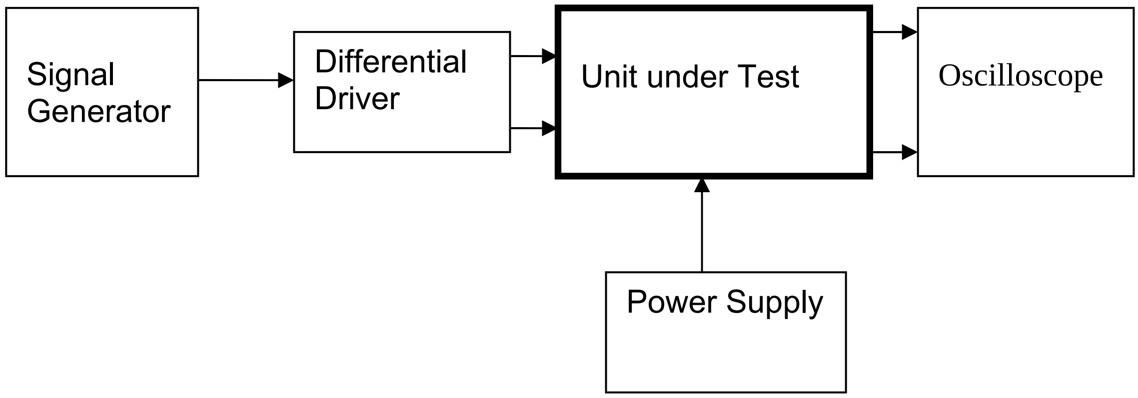
LED Monitors

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	√

5. 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………UIM8…………………Serial No ………UIM8P………………………
Test Engineer ………XEN
Date …………………8/9/09

6. 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)
500mA	400mA

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………UIM8…………………Serial No ………UIM8P………………………
Test Engineer ………XEN
Date …………………8/9/09

7. Relay Operation

Connect the test unit to the Binary IO inputs.

Operate switches and check that LEDs are on when the relays are switched on, and off when they are switched off:

Relay	LED Operation					
	Filter 1		Filter 2		Filter 2	
	ON	OFF	ON	OFF	ON	OFF
Ch1	√	√	√	√	√	√
Ch2	√	√	√	√	√	√
Ch3	√	√	√	√	√	√
Ch4	√	√	√	√	√	√

This indicates that the relays are operating, and that the talk back contacts work OK.

Unit………UIM8…………………Serial No ………UIM8P……………………….
Test Engineer ………XEN
Date …………………8/9/09

8. Current Monitor tests

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

Connect the 39 ohm dummy loads to the coil drive output. Connect the differential driver to the input, fed by the signal generator. Set the signal generator to 4v at 100 Hz.

Switch out the filters.
Use the true r.m.s meter to measure the r.m.s voltage between test points TP7 and TP11 on the drive board. Adjust the signal generator unit the until this voltage is 3v r.m.s.

Connect a scope probe to each end of one of the load resistors. Set up the scope to differentially observe the voltage across the load resistor. Check that it is a sine wave.

Measure and record the output from each current monitors, and each of the RMS circuits. Set the meter to r.m.s for the "current monitor" readings (ac signal), and to dc when measuring the r.m.s outputs (dc signal).

The theoretical output is 0.995v.

Ch.	Monitor Connector	Parameter	Theoretical Value	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	0.95v to 1.05 v r.m.s	0.9974	√
	Pin 1	RMS Current	0.95 v to 1.05 v dc	0.9997	√
2	Pin 5	Current Monitor	0.95 v to 1.05 v r.m.s	0.9963	√
	Pin 4	RMS Current	0.95 v to 1.05 v dc	0.9998	√
3	Pin 8	Current Monitor	0.95 v to 1.05 v r.m.s	0.9970	√
	Pin 7	RMS Current	0.95 v to 1.05 v dc	0.9996	√
4	Pin 11	Current Monitor	0.95 v to 1.05 v r.m.s	0.9964	√
	Pin 10	RMS Current	0.95 v to 1.05 v dc	0.9982	√

Unit………UIM8…………………Serial No ………UIM8P………………………
Test Engineer ………XEN
Date …………………8/9/09

9. 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 TP7 and TP11 at 100 Hz.
Adjust the signal generator to give a voltage to 3v r.m.s 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	1.0014	0.95v to 1.05v	√
2	Pins 3,11	Pin 6	1.0014	0.95v to 1.05v	√
3	Pins 5,13	Pin 9	1.0027	0.95v to 1.05v	√
4	Pins 7, 15	Pin 12	1.0016	0.95v to 1.05v	√

Measurements may be used using a 25 way break out box, or a 25 way connector on the V, I and r.m.s connector.

10. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct. There are two possible ways of performing this test depending on available equipment. Either 8.1 or 8.2 should be conducted (it is not necessary to do both).

10.1 Using a Signal Generator

Apply a signal to the input, amplitude 1v peak, Frequency 100Hz via the differential driver, to the Drive Input.

.

Switch out all the filter stages. Measure and record the peak differential output between the outputs of each channel, using two oscilloscope channels in differential mode.

	Coil Drive output pins	Pk/pk Output	Specification	Pass/Fail
Ch1	1 and 9		4.8v to 5v	
Ch2	3 and 11		4.8v to 5v	
Ch3	5 and 13		4.8v to 5v	
Ch4	7 and 15		4.8v to 5v	

Switch in each filter in turn and measure and record the peak output at 1Hz, 10 Hz, and 1 KHz.

1Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				3.3v to 3.7v	
Ch2	3 and 11				3.3v to 3.7v	
Ch3	5 and 13				3.3v to 3.7v	
Ch4	7 and 15				3.3v to 3.7v	

10Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.48 to 0.75v	
Ch2	3 and 11				0.48 to 0.75v	
Ch3	5 and 13				0.48 to 0.75v	
Ch4	7 and 15				0.48 to 0.75v	

1 KHz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.4v to 0.5v	
Ch2	3 and 11				0.4v to 0.5v	
Ch3	5 and 13				0.4v to 0.5v	
Ch4	7 and 15				0.4v to 0.5v	

Unit………UIM8…………………Serial No ………UIM8P………………………
Test Engineer ………XEN
Date …………………8/9/09

10.2. Using the Dynamic Signal Analyser

With all filters switched in, measure the frequency response of each channel in turn between 0.1 Hz and 1KHz. If a fast turn around is required, limit the measurement to the frequency range to between 1 Hz and 1KHz. Measure the gain at the spot frequencies below and record them.

Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.4	**6.6 to 8.7**	√
1Hz	-0.7	**-0.2 to -2**	√
10Hz	-44	**-41 to -52**	√
100Hz	-53	**-51 to -58**	√
1KHz	-53	**-51 to -58**	√

Channel 2

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.3	**6.6 to 8.7**	√
1Hz	-1.0	**-0.2 to -2**	√
10Hz	-44	**-41 to -52**	√
100Hz	-53	**-51 to -58**	√
1KHz	-53	**-51 to -58**	√

Channel 3

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.4	**6.6 to 8.7**	√
1Hz	-1.2	**-0.2 to -2**	√
10Hz	-44	**-41 to -52**	√
100Hz	-53	**-51 to -58**	√
1KHz	-53	**-51 to -58**	√

Channel 4

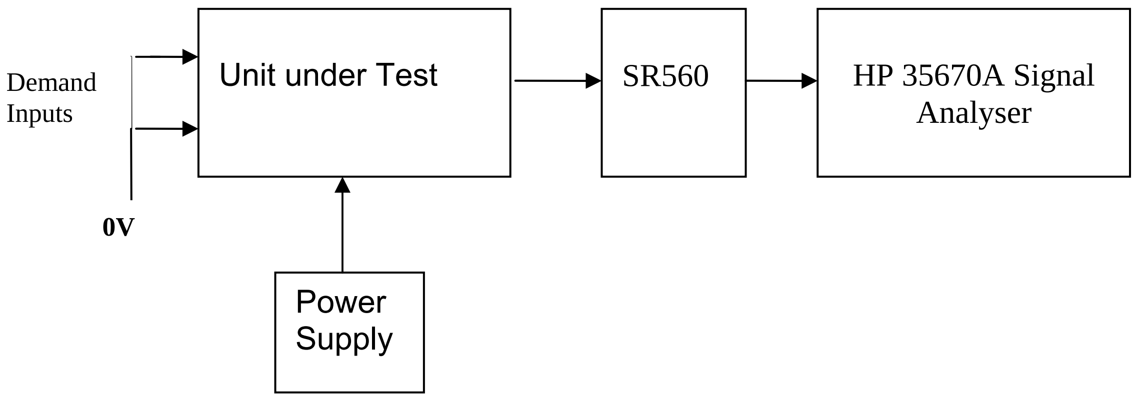
Frequency	Gain (dB)	Expected Gain	Pass/Fail
0.1 Hz	8.4	**6.6 to 8.7**	√
1Hz	-0.9	**-0.2 to -2**	√
10Hz	-44	**-41 to -52**	√
100Hz	-53	**-51 to -58**	√
1KHz	-53	**-51 to -58**	√

Unit………UIM8…………………Serial No ………UIM8P………………………
Test Engineer ………RMC
Date …………………24/9/09

11. Noise Tests

Ensure the filter links W2, W3, W4 and W5 are present on each channel.

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, and readings should be made when the ambient noise is low. 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	-152.6	-94.7	-154.7
Ch2	-152.6	-93.3	-153.3
Ch3	-152.6	-93.3	-153.3
Ch4	-152.6	-93.2	-153.2

All channels are within specification.

The specification at 10 Hz is a noise current of 3 pA per root Hz. The total load resistance is 7.8k. The permitted noise voltage from the amplifiers is therefore 23.4 nA/ /√Hz or -152.6 dB. The SR560 is set to a gain of 1000 (60dB) so 60dB needs to be subtracted from the reading.

Unit………UIM8…………………Serial No ………UIM8P………………………
Test Engineer ………XEN
Date …………………8/9/09

12. Distortion

No filters. Increase input voltage to 10v peak, f = 1KHz. Dummy 39 Ohm loads. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit………UIM8…………………Serial No ………UIM8P………………………
Test Engineer ………RMC
Date …………………12/9/09

13. Final Assembly Tests

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 all the LEDs are nicely centred. √

7. Check that links W3, W4 and W5 are in place. √

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

UoB box ID	UIM8P
Driver board ID	UIM8P
Driver board Drawing No/Issue No	D070481-4-K
Driver board Serial Number	UIM8P
Monitor board ID	MON8P
Monitor board Drawing No/Issue No	D070481-4-K
Monitor board Serial Number	UIM MON8P

9. Check the security of any modification wires. None

10. Visually inspect. √

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

    Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T0900236-v3 **Advanced LIGO UK** 9 September 2009

UIM9P Drive Unit Test Results

R. M. Cutler, University of Birmingham

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of the Advanced LIGO Project, prepared by members of the UK team.

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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

UIM DRIVE
COMPLETED UNIT TEST PLAN

Unit………UIM9…………………Serial No …………… UIM9P
Test Engineer ………XEN
Date …………………9/9/9

Drive Card ID……………UIM9P
Monitor Card ID ………..MON9(P)

Contents

1. Description

2. Test Equipment

3. Inspection

4. Continuity Checks

5. Test Set Up

6. Power

7. Relay operation

8. Current Monitor Tests

9. Voltage Monitor Tests

10. Corner Frequency Tests

11. Noise Tests

12. Distortion

13. Final Assembly Tests

1. Description

The UIM Driver Unit will be used to control the 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 UIM mirror in a Quad assembly. It works in conjunction with the OSEM coil and position sensor units. One UIM unit controls four OSEMs.

The UIM 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.

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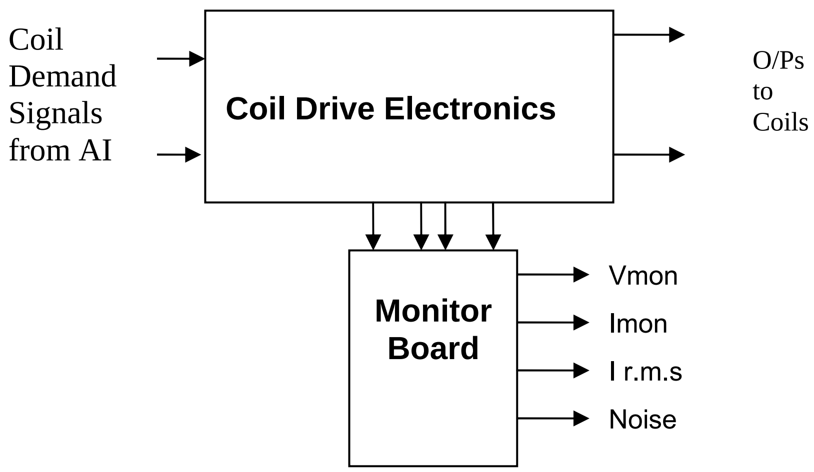


FIG. 1 UIM Driver Unit Block Diagram

Each UIM 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………UIM9…………………Serial No …………… UIM9P
Test Engineer ………XEN
Date …………………9/9/9

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**
DVM	FLUKE	115	
V/I Calibrator	Time Electronics	1044	
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-Tech	ISR622	
PSU x 2	Farnell	L30-2	

Unit………UIM9…………………Serial No …………… UIM9P
Test Engineer ………XEN
Date …………………9/9/9

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment:

Good

Links:

Check that links W3, W4 and W5 are present on each channel of the Drive board. If not, connect them.

Unit………UIM9…………………Serial No …………… UIM9P
Test Engineer ………XEN
Date …………………9/9/9

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	√

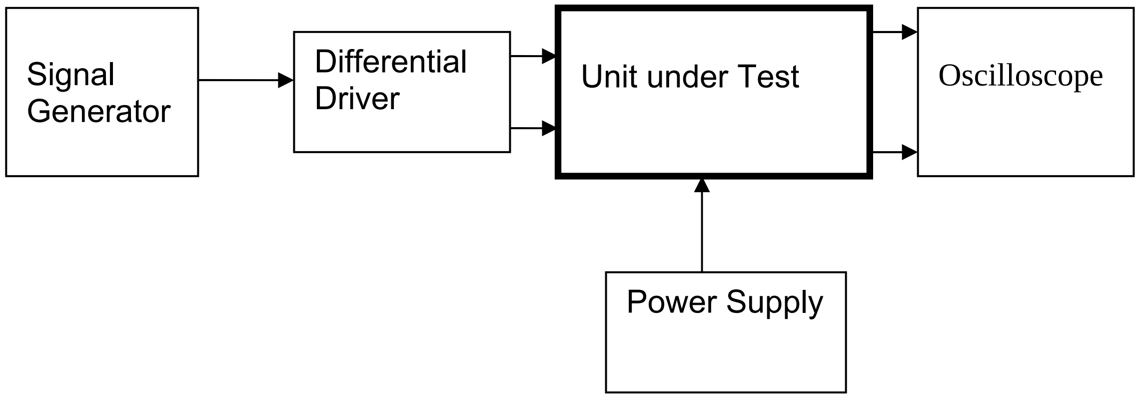
LED Monitors

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	√

5. 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………UIM9…………………Serial No …………… UIM9P
Test Engineer ………XEN
Date …………………9/9/9

6. 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)
500mA	400mA

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………UIM9…………………Serial No …………… UIM9P
Test Engineer ………XEN
Date …………………9/9/9

7. Relay Operation

Connect the test unit to the Binary IO inputs.

Operate switches and check that LEDs are on when the relays are switched on, and off when they are switched off:

Relay	LED Operation					
	Filter 1		Filter 2		Filter 2	
	ON	OFF	ON	OFF	ON	OFF
Ch1	√	√	√	√	√	√
Ch2	√	√	√	√	√	√
Ch3	√	√	√	√	√	√
Ch4	√	√	√	√	√	√

This indicates that the relays are operating, and that the talk back contacts work OK.

Unit………UIM9…………………Serial No …………… UIM9P
Test Engineer ………XEN
Date …………………9/9/9

8. Current Monitor tests

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

Connect the 39 ohm dummy loads to the coil drive output. Connect the differential driver to the input, fed by the signal generator. Set the signal generator to 4v at 100 Hz.

Switch out the filters.
Use the true r.m.s meter to measure the r.m.s voltage between test points TP7 and TP11 on the drive board. Adjust the signal generator unit the until this voltage is 3v r.m.s.

Connect a scope probe to each end of one of the load resistors. Set up the scope to differentially observe the voltage across the load resistor. Check that it is a sine wave.

Measure and record the output from each current monitors, and each of the RMS circuits. Set the meter to r.m.s for the "current monitor" readings (ac signal), and to dc when measuring the r.m.s outputs (dc signal).

The theoretical output is 0.995v.

Ch.	Monitor Connector	Parameter	Theoretical Value	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	0.95v to 1.05 v r.m.s	0.9972	√
	Pin 1	RMS Current	0.95 v to 1.05 v dc	0.9981	√
2	Pin 5	Current Monitor	0.95 v to 1.05 v r.m.s	0.9982	√
	Pin 4	RMS Current	0.95 v to 1.05 v dc	0.9971	√
3	Pin 8	Current Monitor	0.95 v to 1.05 v r.m.s	0.9962	√
	Pin 7	RMS Current	0.95 v to 1.05 v dc	0.9974	√
4	Pin 11	Current Monitor	0.95 v to 1.05 v r.m.s	0.9990	√
	Pin 10	RMS Current	0.95 v to 1.05 v dc	0.9989	√

Unit………UIM9…………………Serial No …………… UIM9P
Test Engineer ………XEN
Date …………………9/9/9

9. 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 TP7 and TP11 at 100 Hz. Adjust the signal generator to give a voltage to 3v r.m.s 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	1.0027	0.95v to 1.05v	√
2	Pins 3,11	Pin 6	1.0024	0.95v to 1.05v	√
3	Pins 5,13	Pin 9	1.0019	0.95v to 1.05v	√
4	Pins 7, 15	Pin 12	1.0025	0.95v to 1.05v	√

Measurements may be used using a 25 way break out box, or a 25 way connector on the V, I and r.m.s connector.

10. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct. There are two possible ways of performing this test depending on available equipment. Either 8.1 or 8.2 should be conducted (it is not necessary to do both).

10.1 Using a Signal Generator

Apply a signal to the input, amplitude 1v peak, Frequency 100Hz via the differential driver, to the Drive Input.

.

Switch out all the filter stages. Measure and record the peak differential output between the outputs of each channel, using two oscilloscope channels in differential mode.

	Coil Drive output pins	Pk/pk Output	Specification	Pass/Fail
Ch1	1 and 9		4.8v to 5v	
Ch2	3 and 11		4.8v to 5v	
Ch3	5 and 13		4.8v to 5v	
Ch4	7 and 15		4.8v to 5v	

Switch in each filter in turn and measure and record the peak output at 1Hz, 10 Hz, and 1 KHz.

1Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				3.3v to 3.7v	
Ch2	3 and 11				3.3v to 3.7v	
Ch3	5 and 13				3.3v to 3.7v	
Ch4	7 and 15				3.3v to 3.7v	

10Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.48 to 0.75v	
Ch2	3 and 11				0.48 to 0.75v	
Ch3	5 and 13				0.48 to 0.75v	
Ch4	7 and 15				0.48 to 0.75v	

1 KHz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.4v to 0.5v	
Ch2	3 and 11				0.4v to 0.5v	
Ch3	5 and 13				0.4v to 0.5v	
Ch4	7 and 15				0.4v to 0.5v	

Unit………UIM9…………………Serial No …………… UIM9P
Test Engineer ………XEN
Date …………………9/9/9

10.2. Using the Dynamic Signal Analyser

With all filters switched in, measure the frequency response of each channel in turn between 0.1 Hz and 1KHz. If a fast turn around is required, limit the measurement to the frequency range to between 1 Hz and 1KHz. Measure the gain at the spot frequencies below and record them.

Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.4	6.6 to 8.7	√
1Hz	-0.8	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 2

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.5	6.6 to 8.7	√
1Hz	-0.8	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 3

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.3	6.6 to 8.7	√
1Hz	-0.9	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 4

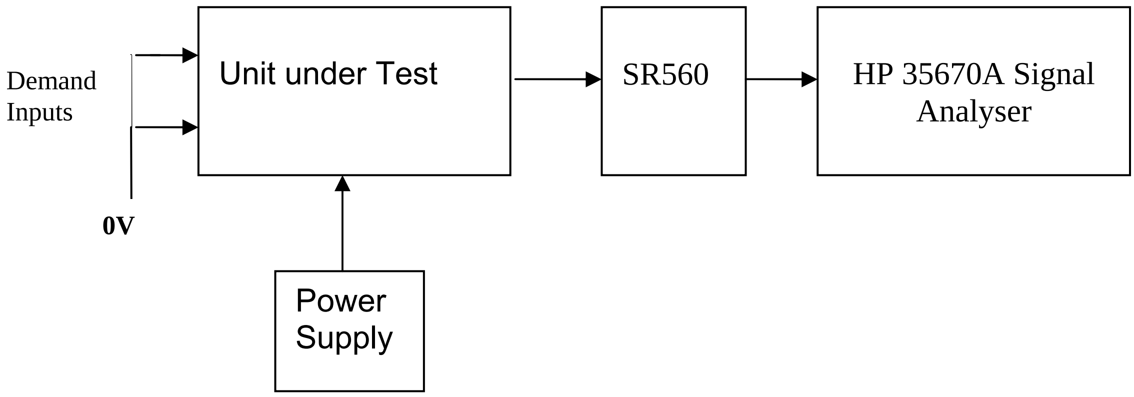
Frequency	Gain (dB)	Expected Gain	Pass/Fail
0.1 Hz	8.5	6.6 to 8.7	√
1Hz	-0.8	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Unit………UIM9…………………Serial No …………… UIM9P
Test Engineer ………RMC
Date …………………24/9/9

11. Noise Tests

Ensure the filter links W2, W3, W4 and W5 are present on each channel.

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, and readings should be made when the ambient noise is low. 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	-152.6	-93.8	-153.8
Ch2	-152.6	-93.38	-153.38
Ch3	-152.6	-95.5	-155.5
Ch4	-152.6	-93.3	-153.3

All channels are within specification.

The specification at 10 Hz is a noise current of 3 pA per root Hz. The total load resistance is 7.8k. The permitted noise voltage from the amplifiers is therefore 23.4 nA/ /√Hz or -152.6 dB. The SR560 is set to a gain of 1000 (60dB) so 60dB needs to be subtracted from the reading.

Unit………UIM9…………………Serial No …………… UIM9P
Test Engineer ………XEN
Date …………………9/9/9

12. Distortion

No filters. Increase input voltage to 10v peak, f = 1KHz. Dummy 39 Ohm loads. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit………UIM9…………………Serial No …………… UIM9P
Test Engineer ………
Date …………………

13. Final Assembly Tests

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 all the LEDs are nicely centred. √

7. Check that links W3, W4 and W5 are in place. √

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

UoB box ID	UIM9P
Driver board ID	UIM9P
Driver board Drawing No/Issue No	D070481-4-K
Driver board Serial Number	UIM9P
Monitor board ID	UIM MON9P
Monitor board Drawing No/Issue No	D070480-4-K
Monitor board Serial Number	UIM MON9P

9. Check the security of any modification wires. None

10. Visually inspect. √

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

Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T0900236-v3 **Advanced LIGO UK** 9 September 2009

UIM10P Drive Unit Test Results

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.

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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

UIM DRIVE
COMPLETED UNIT TEST PLAN

Unit…………UIM10…………………Serial No …………UIM10P
Test Engineer ………XEN
Date …………………9/9/9

Drive Card ID……………UIM10P
Monitor Card ID ………..MON10P

Contents

1. Description

2. Test Equipment

3. Inspection

4. Continuity Checks

5. Test Set Up

6. Power

7. Relay operation

8. Current Monitor Tests

9. Voltage Monitor Tests

10. Corner Frequency Tests

11. Noise Tests

12. Distortion

13. Final Assembly Tests

1. Description

The UIM Driver Unit will be used to control the 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 UIM mirror in a Quad assembly. It works in conjunction with the OSEM coil and position sensor units. One UIM unit controls four OSEMs.

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

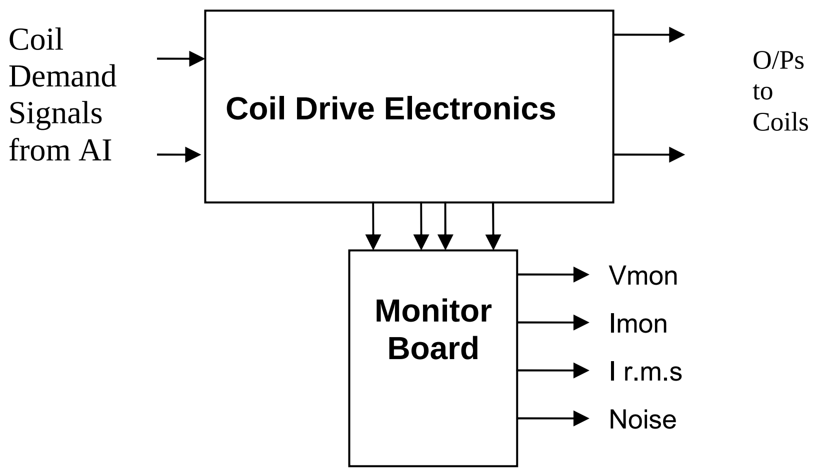


FIG. 1 UIM Driver Unit Block Diagram

Each UIM 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…………UIM10…………………Serial No …………UIM10P
Test Engineer ………XEN
Date …………………9/9/9

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
DVM	FLUKE	115	
V/I Calibrator	Time Electronics	1044	
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-Tech	ISR622	
PSU x 2	Farnell	L30-2	

Unit…………UIM10…………………Serial No …………UIM10P
Test Engineer ………XEN
Date …………………9/9/9

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment:

Good

Links:

Check that links W3, W4 and W5 are present on each channel of the Drive board. If not, connect them.

Unit…………UIM10…………………Serial No …………UIM10P
Test Engineer ………XEN
Date …………………9/9/9

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	√

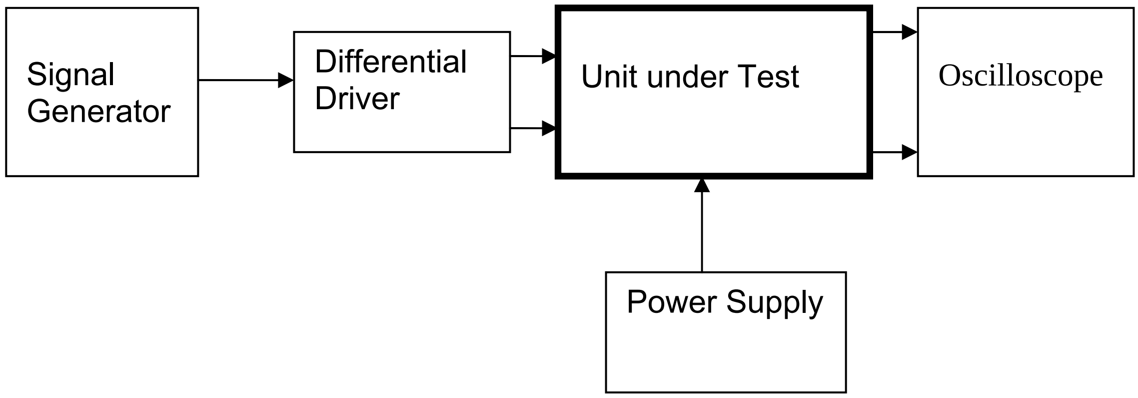
LED Monitors

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	√

5. 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…………UIM10…………………Serial No …………UIM10P
Test Engineer ………XEN
Date …………………9/9/9

6. 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)
500mA	400mA

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…………UIM10…………………Serial No …………UIM10P
Test Engineer ………XEN
Date …………………9/9/9

7. Relay Operation

Connect the test unit to the Binary IO inputs.

Operate switches and check that LEDs are on when the relays are switched on, and off when they are switched off:

Relay	**LED Operation**					
	Filter 1		**Filter 2**		**Filter 2**	
	ON	**OFF**	**ON**	**OFF**	**ON**	**OFF**
Ch1	√	√	√	√	√	√
Ch2	√	√	√	√	√	√
Ch3	√	√	√	√	√	√
Ch4	√	√	√	√	√	√

This indicates that the relays are operating, and that the talk back contacts work OK.

Unit…………UIM10…………………Serial No …………UIM10P
Test Engineer ………XEN
Date …………………9/9/9

8. Current Monitor tests

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

Connect the 39 ohm dummy loads to the coil drive output. Connect the differential driver to the input, fed by the signal generator. Set the signal generator to 4v at 100 Hz.

Switch out the filters.
Use the true r.m.s meter to measure the r.m.s voltage between test points TP7 and TP11 on the drive board. Adjust the signal generator unit the until this voltage is 3v r.m.s.

Connect a scope probe to each end of one of the load resistors. Set up the scope to differentially observe the voltage across the load resistor. Check that it is a sine wave.

Measure and record the output from each current monitors, and each of the RMS circuits. Set the meter to r.m.s for the “current monitor” readings (ac signal), and to dc when measuring the r.m.s outputs (dc signal).

The theoretical output is 0.995v.

Ch.	Monitor Connector	Parameter	Theoretical Value	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	0.95v to 1.05 v r.m.s	0.9975	√
	Pin 1	RMS Current	0.95 v to 1.05 v dc	1.0006	√
2	Pin 5	Current Monitor	0.95 v to 1.05 v r.m.s	1.0301	√
	Pin 4	RMS Current	0.95 v to 1.05 v dc	1.0288	√
3	Pin 8	Current Monitor	0.95 v to 1.05 v r.m.s	0.9975	√
	Pin 7	RMS Current	0.95 v to 1.05 v dc	0.9977	√
4	Pin 11	Current Monitor	0.95 v to 1.05 v r.m.s	0.9966	√
	Pin 10	RMS Current	0.95 v to 1.05 v dc	0.9967	√

Unit…………UIM10…………………Serial No …………UIM10P
Test Engineer ………XEN
Date …………………9/9/9

9. 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 TP7 and TP11 at 100 Hz.
Adjust the signal generator to give a voltage to 3v r.m.s 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	1.0012	0.95v to 1.05v	√
2	Pins 3,11	Pin 6	1.0338	0.95v to 1.05v	√
3	Pins 5,13	Pin 9	1.0020	0.95v to 1.05v	√
4	Pins 7, 15	Pin 12	1.0015	0.95v to 1.05v	√

Measurements may be used using a 25 way break out box, or a 25 way connector on the V, I and r.m.s connector.

10. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct. There are two possible ways of performing this test depending on available equipment. Either 8.1 or 8.2 should be conducted (it is not necessary to do both).

10.1 Using a Signal Generator

Apply a signal to the input, amplitude 1v peak, Frequency 100Hz via the differential driver, to the Drive Input.

.

Switch out all the filter stages. Measure and record the peak differential output between the outputs of each channel, using two oscilloscope channels in differential mode.

	Coil Drive output pins	Pk/pk Output	Specification	Pass/Fail
Ch1	1 and 9		4.8v to 5v	
Ch2	3 and 11		4.8v to 5v	
Ch3	5 and 13		4.8v to 5v	
Ch4	7 and 15		4.8v to 5v	

Switch in each filter in turn and measure and record the peak output at 1Hz, 10 Hz, and 1 KHz.

1Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				3.3v to 3.7v	
Ch2	3 and 11				3.3v to 3.7v	
Ch3	5 and 13				3.3v to 3.7v	
Ch4	7 and 15				3.3v to 3.7v	

10Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.48 to 0.75v	
Ch2	3 and 11				0.48 to 0.75v	
Ch3	5 and 13				0.48 to 0.75v	
Ch4	7 and 15				0.48 to 0.75v	

1 KHz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.4v to 0.5v	
Ch2	3 and 11				0.4v to 0.5v	
Ch3	5 and 13				0.4v to 0.5v	
Ch4	7 and 15				0.4v to 0.5v	

Unit…………UIM10…………………Serial No …………UIM10P
Test Engineer ………XEN
Date …………………9/9/9

10.2. Using the Dynamic Signal Analyser

With all filters switched in, measure the frequency response of each channel in turn between 0.1 Hz and 1KHz. If a fast turn around is required, limit the measurement to the frequency range to between 1 Hz and 1KHz. Measure the gain at the spot frequencies below and record them.

Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.5	6.6 to 8.7	√
1Hz	-1.0	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 2

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.5	6.6 to 8.7	√
1Hz	-1.0	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 3

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.3	6.6 to 8.7	√
1Hz	-0.8	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 4

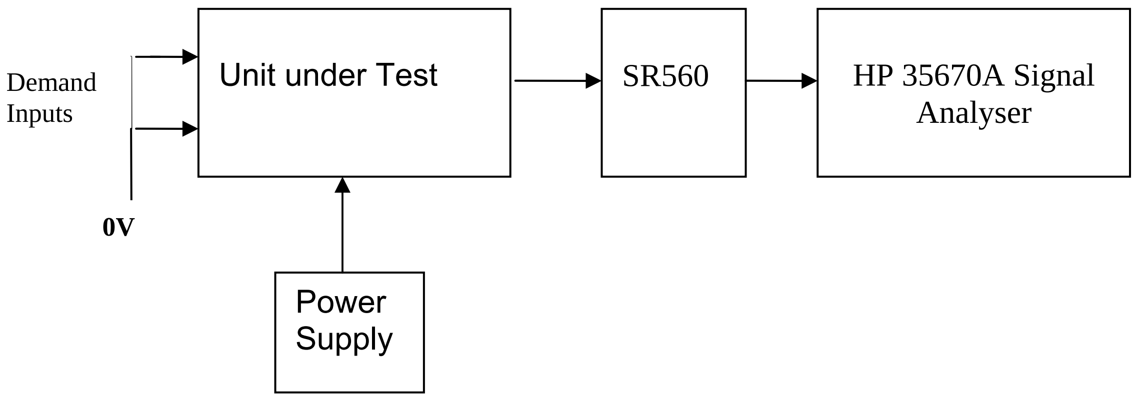
Frequency	Gain (dB)	Expected Gain	Pass/Fail
0.1 Hz	8.5	6.6 to 8.7	√
1Hz	-0.7	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Unit…………UIM10…………………Serial No …………UIM10P
Test Engineer ………RMC
Date …………………24/9/9

11. Noise Tests

Ensure the filter links W2, W3, W4 and W5 are present on each channel.

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, and readings should be made when the ambient noise is low. 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	-152.6	-94.2	-154.2
Ch2	-152.6	-93.6	-153.6
Ch3	-152.6	-95.4	-155.4
Ch4	-152.6	-96.8	-156.8

All channels are within specification

The specification at 10 Hz is a noise current of 3 pA per root Hz. The total load resistance is 7.8k. The permitted noise voltage from the amplifiers is therefore 23.4 nA/ /√Hz or -152.6 dB. The SR560 is set to a gain of 1000 (60dB) so 60dB needs to be subtracted from the reading.

Unit…………UIM10…………………Serial No …………UIM10P
Test Engineer ………XEN
Date …………………9/9/9

12. Distortion

No filters. Increase input voltage to 10v peak, f = 1KHz. Dummy 39 Ohm loads. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit…………UIM10…………………Serial No …………UIM10P
Test Engineer ………RMC
Date …………………29/9/9

13. Final Assembly Tests

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 all the LEDs are nicely centred. √

7. Check that links W3, W4 and W5 are in place. √

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

UoB box ID	UIM10P
Driver board ID	UIM10P
Driver board Drawing No/Issue No	D070481-4-K
Driver board Serial Number	UIM10P
Monitor board ID	MON10P
Monitor board Drawing No/Issue No	D070480-4-K
Monitor board Serial Number	UIM MON10P

9. Check the security of any modification wires.

10. Visually inspect. √

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

    Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T0900236-v3 Advanced LIGO UK 10 September 2009

UIM11P Drive Unit Test Results

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.

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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

UIM DRIVE
COMPLETED UNIT TEST PLAN

Unit....................UIM11............Serial No UIM11P
Test Engineer ....XEN
Date 10/9/9

Drive Card ID............UIM11P
Monitor Card ID MON11P

Contents

1. Description

2. Test Equipment

3. Inspection

4. Continuity Checks

5. Test Set Up

6. Power

7. Relay operation

8. Current Monitor Tests

9. Voltage Monitor Tests

10. Corner Frequency Tests

11. Noise Tests

12. Distortion

13. Final Assembly Tests

1. Description

The UIM Driver Unit will be used to control the 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 UIM mirror in a Quad assembly. It works in conjunction with the OSEM coil and position sensor units. One UIM unit controls four OSEMs.

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

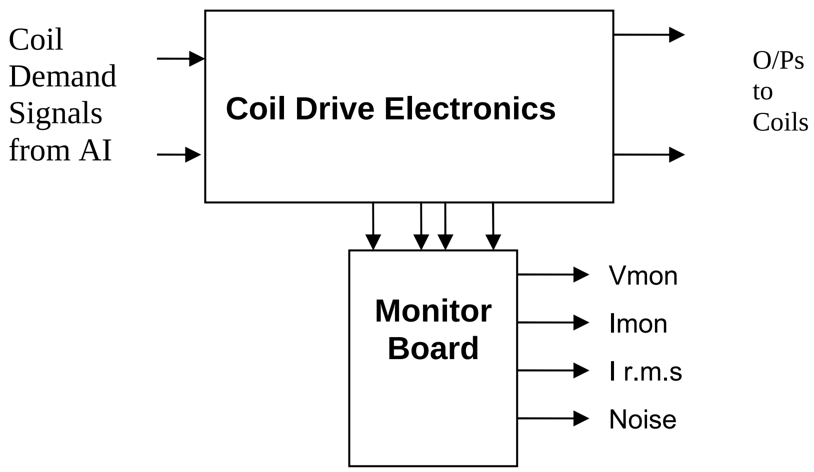


FIG. 1 UIM Driver Unit Block Diagram

Each UIM 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…………………UIM11…………Serial No ………UIM11P
Test Engineer ………XEN
Date …………………10/9/9

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
DVM	FLUKE	115	
V/I Calibrator	Time Electronics	1044	
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-Tech	ISR622	
PSU x 2	Farnell	L30-2	

Unit…………………UIM11…………Serial No ………UIM11P
Test Engineer ………XEN
Date …………………10/9/9

3. Inspection

Remove the lid of the case.

Workmanship
Inspect the general workmanship standard and comment:

Good

Links:
Check that links W3, W4 and W5 are present on each channel of the Drive board. If not, connect them.

Unit…………………UIM11…………Serial No ………UIM11P
Test Engineer ………XEN
Date …………………10/9/9

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	√

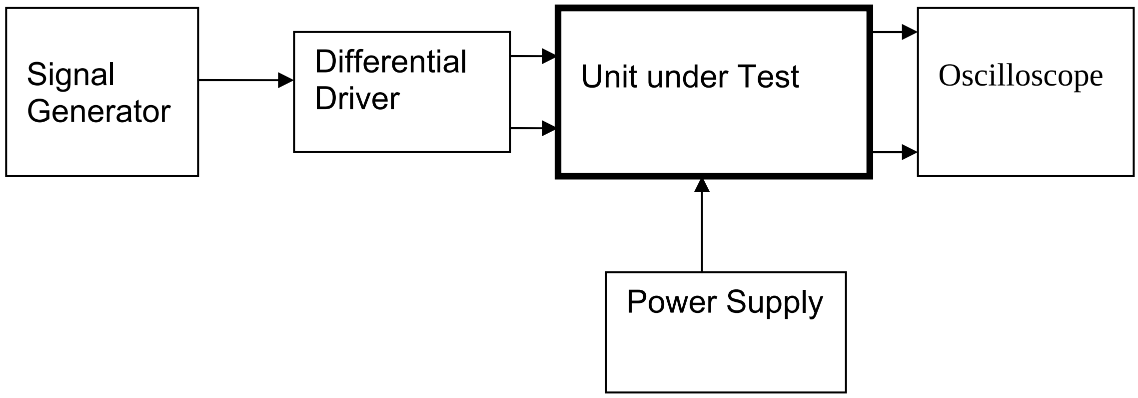
LED Monitors

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	√

5. 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…………………UIM11…………Serial No ………UIM11P
Test Engineer ………XEN
Date …………………10/9/9

6. 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)
500mA	400mA

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…………………UIM11…………Serial No ………UIM11P
Test Engineer ………XEN
Date …………………10/9/9

7. Relay Operation

Connect the test unit to the Binary IO inputs.

Operate switches and check that LEDs are on when the relays are switched on, and off when they are switched off:

Relay	**LED Operation**					
	Filter 1		**Filter 2**		**Filter 2**	
	ON	**OFF**	**ON**	**OFF**	**ON**	**OFF**
Ch1	√	√	√	√	√	√
Ch2	√	√	√	√	√	√
Ch3	√	√	√	√	√	√
Ch4	√	√	√	√	√	√

This indicates that the relays are operating, and that the talk back contacts work OK.

Unit…………………UIM11…………Serial No ………UIM11P
Test Engineer ………XEN
Date …………………10/9/9

8. Current Monitor tests

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

Connect the 39 ohm dummy loads to the coil drive output. Connect the differential driver to the input, fed by the signal generator. Set the signal generator to 4v at 100 Hz.

Switch out the filters.
Use the true r.m.s meter to measure the r.m.s voltage between test points TP7 and TP11 on the drive board. Adjust the signal generator unit the until this voltage is 3v r.m.s.

Connect a scope probe to each end of one of the load resistors. Set up the scope to differentially observe the voltage across the load resistor. Check that it is a sine wave.

Measure and record the output from each current monitors, and each of the RMS circuits. Set the meter to r.m.s for the "current monitor" readings (ac signal), and to dc when measuring the r.m.s outputs (dc signal).

The theoretical output is 0.995v.

Ch.	Monitor Connector	Parameter	Theoretical Value	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	0.95v to 1.05 v r.m.s	0.9950	√
	Pin 1	RMS Current	0.95 v to 1.05 v dc	0.9964	√
2	Pin 5	Current Monitor	0.95 v to 1.05 v r.m.s	0.9983	√
	Pin 4	RMS Current	0.95 v to 1.05 v dc	0.9995	√
3	Pin 8	Current Monitor	0.95 v to 1.05 v r.m.s	0.9977	√
	Pin 7	RMS Current	0.95 v to 1.05 v dc	0.9984	√
4	Pin 11	Current Monitor	0.95 v to 1.05 v r.m.s	0.9977	√
	Pin 10	RMS Current	0.95 v to 1.05 v dc	0.9991	√

Unit…………………UIM11…………Serial No ………UIM11P
Test Engineer ………XEN
Date …………………10/9/9

9. 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 TP7 and TP11 at 100 Hz.
Adjust the signal generator to give a voltage to 3v r.m.s 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	1.0023	0.95v to 1.05v	√
2	Pins 3,11	Pin 6	1.0029	0.95v to 1.05v	√
3	Pins 5,13	Pin 9	1.0028	0.95v to 1.05v	√
4	Pins 7, 15	Pin 12	1.0032	0.95v to 1.05v	√

Measurements may be used using a 25 way break out box, or a 25 way connector on the V, I and r.m.s connector.

10. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct. There are two possible ways of performing this test depending on available equipment. Either 8.1 or 8.2 should be conducted (it is not necessary to do both).

10.1 Using a Signal Generator

Apply a signal to the input, amplitude 1v peak, Frequency 100Hz via the differential driver, to the Drive Input.

.

Switch out all the filter stages. Measure and record the peak differential output between the outputs of each channel, using two oscilloscope channels in differential mode.

	Coil Drive output pins	Pk/pk Output	Specification	Pass/Fail
Ch1	1 and 9		4.8v to 5v	
Ch2	3 and 11		4.8v to 5v	
Ch3	5 and 13		4.8v to 5v	
Ch4	7 and 15		4.8v to 5v	

Switch in each filter in turn and measure and record the peak output at 1Hz, 10 Hz, and 1 KHz.

1Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				3.3v to 3.7v	
Ch2	3 and 11				3.3v to 3.7v	
Ch3	5 and 13				3.3v to 3.7v	
Ch4	7 and 15				3.3v to 3.7v	

10Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.48 to 0.75v	
Ch2	3 and 11				0.48 to 0.75v	
Ch3	5 and 13				0.48 to 0.75v	
Ch4	7 and 15				0.48 to 0.75v	

1 KHz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.4v to 0.5v	
Ch2	3 and 11				0.4v to 0.5v	
Ch3	5 and 13				0.4v to 0.5v	
Ch4	7 and 15				0.4v to 0.5v	

Unit…………………UIM11…………Serial No ………UIM11P
Test Engineer ………XEN
Date …………………10/9/9

10.2. Using the Dynamic Signal Analyser

With all filters switched in, measure the frequency response of each channel in turn between 0.1 Hz and 1KHz. If a fast turn around is required, limit the measurement to the frequency range to between 1 Hz and 1KHz. Measure the gain at the spot frequencies below and record them.

Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.4	6.6 to 8.7	√
1Hz	-0.9	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 2

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.4	6.6 to 8.7	√
1Hz	-0.9	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 3

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.4	6.6 to 8.7	√
1Hz	-0.9	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 4

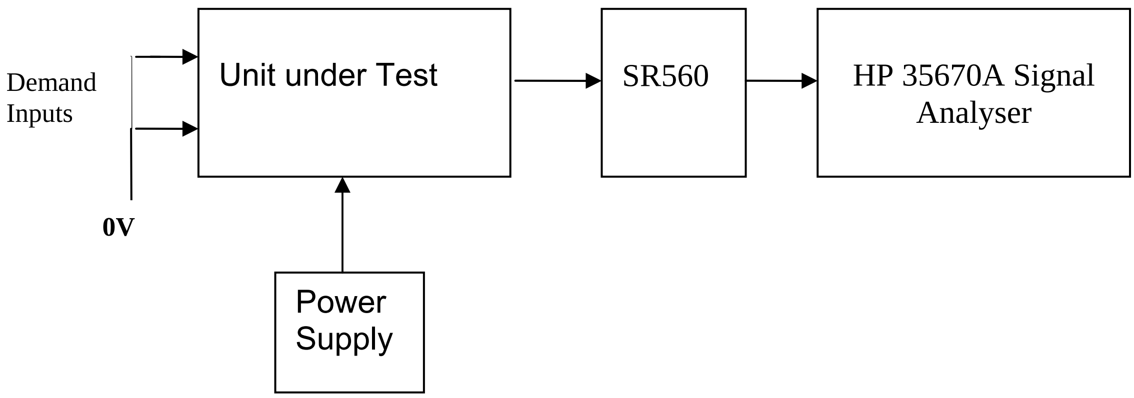
Frequency	Gain (dB)	Expected Gain	Pass/Fail
0.1 Hz	8.3	6.6 to 8.7	√
1Hz	-0.7	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Unit.....................UIM11............Serial No UIM11P
Test Engineer ....RMC
Date 24/9/9

11. Noise Tests

Ensure the filter links W2, W3, W4 and W5 are present on each channel.

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, and readings should be made when the ambient noise is low. 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	-152.6	-99.5	-159.5
Ch2	-152.6	-93.3	-153.3
*Ch3	-152.6	-90.5	-150.5
Ch4	-152.6	-93.7	-153.7

* Ch 3 is slightly out of specification.

The specification at 10 Hz is a noise current of 3 pA per root Hz. The total load resistance is 7.8k. The permitted noise voltage from the amplifiers is therefore 23.4 nA/ /√Hz or -152.6 dB. The SR560 is set to a gain of 1000 (60dB) so 60dB needs to be subtracted from the reading.

Unit…………………UIM11…………Serial No ………UIM11P
Test Engineer ………XEN
Date …………………10/9/9

12. Distortion

No filters. Increase input voltage to 10v peak, f = 1KHz. Dummy 39 Ohm loads. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit…………………UIM11…………Serial No ………UIM11P
Test Engineer ………RMC
Date …………………30/9/9

13. Final Assembly Tests

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 all the LEDs are nicely centred. √

7. Check that links W3, W4 and W5 are in place. √

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

UoB box ID	UIM11P
Driver board ID	UIM11P
Driver board Drawing No/Issue No	D070481-4-K
Driver board Serial Number	UIM11P
Monitor board ID	MON11P
Monitor board Drawing No/Issue No	D070480-4-K
Monitor board Serial Number	UIM MON11P

9. Check the security of any modification wires. None

10. Visually inspect. √

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

    Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T0900236-v3 Advanced LIGO UK 11 September 2009

UIM12P Drive Unit Test Results

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.

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

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http://www.eng-external.rl.ac.uk/advligo/papers_public/ALUK_Homepage.htm

UIM DRIVE
COMPLETED UNIT TEST PLAN

Unit…………………UIM12………Serial No …………UIM12P
Test Engineer ………XEN
Date …………………11/9/9

Drive Card ID……………UIM12P
Monitor Card ID ………..MON12P

Contents

1. Description

2. Test Equipment

3. Inspection

4. Continuity Checks

5. Test Set Up

6. Power

7. Relay operation

8. Current Monitor Tests

9. Voltage Monitor Tests

10. Corner Frequency Tests

11. Noise Tests

12. Distortion

13. Final Assembly Tests

1. Description

The UIM Driver Unit will be used to control the 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 UIM mirror in a Quad assembly. It works in conjunction with the OSEM coil and position sensor units. One UIM unit controls four OSEMs.

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

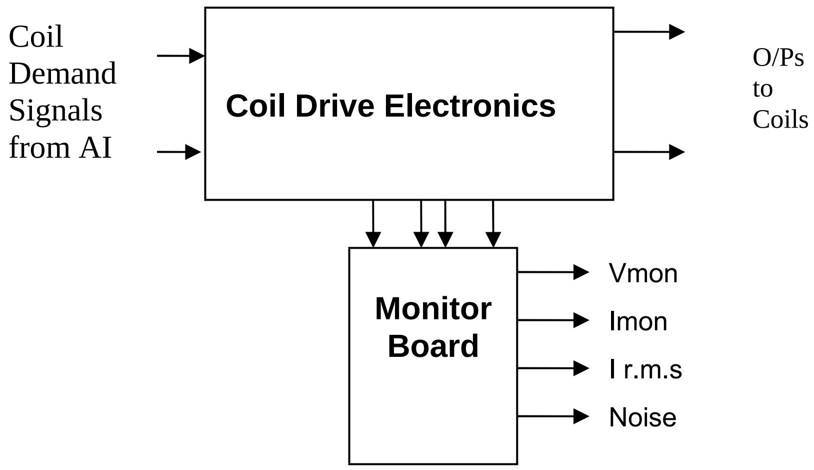


FIG. 1 UIM Driver Unit Block Diagram

Each UIM 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…………………UIM12………Serial No …………UIM12P
Test Engineer ………XEN
Date …………………11/9/9

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
DVM	FLUKE	115	
V/I Calibrator	Time Electronics	1044	
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-Tech	ISR622	
PSU x 2	Farnell	L30-2	
DVM	FLUKE	115	

Unit…………………UIM12………Serial No …………UIM12P
Test Engineer ………XEN
Date …………………11/9/9

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment:

Good

Links:

Check that links W3, W4 and W5 are present on each channel of the Drive board. If not, connect them.

Unit…………………UIM12………Serial No …………UIM12P
Test Engineer ………XEN
Date …………………11/9/9

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	√

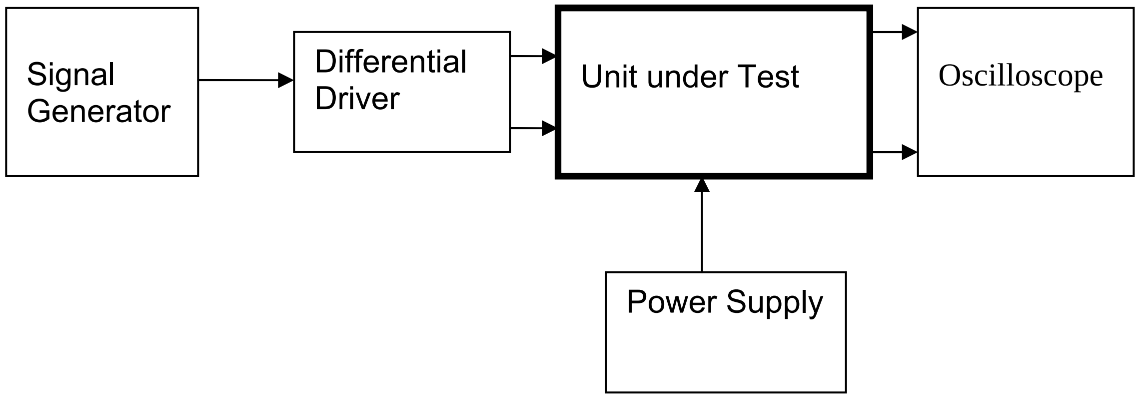
LED Monitors

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	√

5. 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…………………UIM12………Serial No …………UIM12P
Test Engineer ………XEN
Date …………………11/9/9

6. 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)
500mA	400mA

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…………………UIM12………Serial No …………UIM12P
Test Engineer ………XEN
Date …………………11/9/9

7. Relay Operation

Connect the test unit to the Binary IO inputs.

Operate switches and check that LEDs are on when the relays are switched on, and off when they are switched off:

Relay	**LED Operation**					
	Filter 1		**Filter 2**		**Filter 2**	
	ON	**OFF**	**ON**	**OFF**	**ON**	**OFF**
Ch1	√	√	√	√	√	√
Ch2	√	√	√	√	√	√
Ch3	√	√	√	√	√	√
Ch4	√	√	√	√	√	√

This indicates that the relays are operating, and that the talk back contacts work OK.

Unit…………………UIM12………Serial No …………UIM12P
Test Engineer ………XEN
Date …………………11/9/9

8. Current Monitor tests

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

Connect the 39 ohm dummy loads to the coil drive output. Connect the differential driver to the input, fed by the signal generator. Set the signal generator to 4v at 100 Hz.

Switch out the filters.
Use the true r.m.s meter to measure the r.m.s voltage between test points TP7 and TP11 on the drive board. Adjust the signal generator unit the until this voltage is 3v r.m.s.

Connect a scope probe to each end of one of the load resistors. Set up the scope to differentially observe the voltage across the load resistor. Check that it is a sine wave.

Measure and record the output from each current monitors, and each of the RMS circuits. Set the meter to r.m.s for the “current monitor” readings (ac signal), and to dc when measuring the r.m.s outputs (dc signal).

The theoretical output is 0.995v.

Ch.	Monitor Connector	Parameter	Theoretical Value	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	0.95v to 1.05 v r.m.s	0.9978	√
	Pin 1	RMS Current	0.95 v to 1.05 v dc	0.9977	√
2	Pin 5	Current Monitor	0.95 v to 1.05 v r.m.s	0.9987	√
	Pin 4	RMS Current	0.95 v to 1.05 v dc	0.9974	√
3	Pin 8	Current Monitor	0.95 v to 1.05 v r.m.s	0.9992	√
	Pin 7	RMS Current	0.95 v to 1.05 v dc	1.0000	√
4	Pin 11	Current Monitor	0.95 v to 1.05 v r.m.s	0.9983	√
	Pin 10	RMS Current	0.95 v to 1.05 v dc	1.0002	√

Unit…………………UIM12………Serial No …………UIM12P
Test Engineer ………XEN
Date …………………11/9/9

9. 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 TP7 and TP11 at 100 Hz.
Adjust the signal generator to give a voltage to 3v r.m.s 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	1.0027	0.95v to 1.05v	√
2	Pins 3,11	Pin 6	1.0030	0.95v to 1.05v	√
3	Pins 5,13	Pin 9	1.0036	0.95v to 1.05v	√
4	Pins 7, 15	Pin 12	1.0034	0.95v to 1.05v	√

Measurements may be used using a 25 way break out box, or a 25 way connector on the V, I and r.m.s connector.

10. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct. There are two possible ways of performing this test depending on available equipment. Either 8.1 or 8.2 should be conducted (it is not necessary to do both).

10.1 Using a Signal Generator

Apply a signal to the input, amplitude 1v peak, Frequency 100Hz via the differential driver, to the Drive Input.

.

Switch out all the filter stages. Measure and record the peak differential output between the outputs of each channel, using two oscilloscope channels in differential mode.

	Coil Drive output pins	Pk/pk Output	Specification	Pass/Fail
Ch1	1 and 9		4.8v to 5v	
Ch2	3 and 11		4.8v to 5v	
Ch3	5 and 13		4.8v to 5v	
Ch4	7 and 15		4.8v to 5v	

Switch in each filter in turn and measure and record the peak output at 1Hz, 10 Hz, and 1 KHz.

1Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				3.3v to 3.7v	
Ch2	3 and 11				3.3v to 3.7v	
Ch3	5 and 13				3.3v to 3.7v	
Ch4	7 and 15				3.3v to 3.7v	

10Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.48 to 0.75v	
Ch2	3 and 11				0.48 to 0.75v	
Ch3	5 and 13				0.48 to 0.75v	
Ch4	7 and 15				0.48 to 0.75v	

1 KHz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.4v to 0.5v	
Ch2	3 and 11				0.4v to 0.5v	
Ch3	5 and 13				0.4v to 0.5v	
Ch4	7 and 15				0.4v to 0.5v	

Unit…………………UIM12………Serial No …………UIM12P
Test Engineer ………XEN
Date …………………11/9/9

10.2. Using the Dynamic Signal Analyser

With all filters switched in, measure the frequency response of each channel in turn between 0.1 Hz and 1KHz. If a fast turn around is required, limit the measurement to the frequency range to between 1 Hz and 1KHz. Measure the gain at the spot frequencies below and record them.

Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.4	6.6 to 8.7	√
1Hz	-1.0	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 2

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.5	6.6 to 8.7	√
1Hz	-0.9	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 3

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.2	6.6 to 8.7	√
1Hz	-0.9	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 4

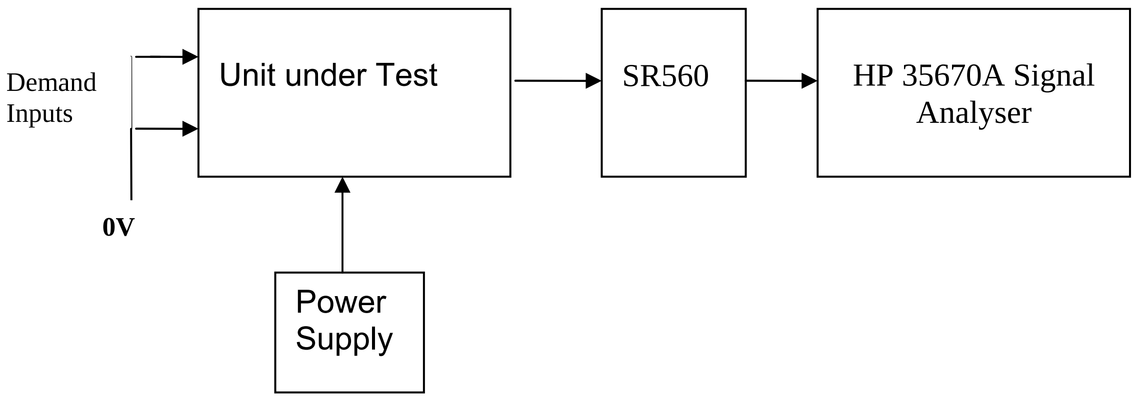
Frequency	Gain (dB)	Expected Gain	Pass/Fail
0.1 Hz	8.4	6.6 to 8.7	√
1Hz	-0.8	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Unit…………………UIM12………Serial No …………UIM12P
Test Engineer ………RMC
Date …………………24/9/9

11. Noise Tests

Ensure the filter links W2, W3, W4 and W5 are present on each channel.

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, and readings should be made when the ambient noise is low. 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	-152.6	-93.7	-153.7
Ch2	-152.6	-93.2	-153.2
Ch3	-152.6	-93.7	-153.7
Ch4	-152.6	-93.7	-153.7

All channels are within specification

The specification at 10 Hz is a noise current of 3 pA per root Hz. The total load resistance is 7.8k. The permitted noise voltage from the amplifiers is therefore 23.4 nA/ /√Hz or -152.6 dB. The SR560 is set to a gain of 1000 (60dB) so 60dB needs to be subtracted from the reading.

Unit…………………UIM12………Serial No …………UIM12P
Test Engineer ………XEN
Date …………………11/9/9

12. Distortion

No filters. Increase input voltage to 10v peak, f = 1KHz. Dummy 39 Ohm loads. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit…………………UIM12………Serial No …………UIM12P
Test Engineer ………RMC
Date …………………30/9/9

13. Final Assembly Tests

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 all the LEDs are nicely centred. √

7. Check that links W3, W4 and W5 are in place. √

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

UoB box ID	UIM12P
Driver board ID	UIM12P
Driver board Drawing No/Issue No	D070481P-4-K
Driver board Serial Number	UIM12P
Monitor board ID	MON12P
Monitor board Drawing No/Issue No	D070480P-4-K
Monitor board Serial Number	UIMMON12P

9. Check the security of any modification wires. None

10. Visually inspect. √

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

    Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T0900236-v3 Advanced LIGO UK 14 September 2009

UIM13P Drive Unit Test Results

R. M. Cutler, University of Birmingham

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of the Advanced LIGO Project, prepared by members of the UK team.

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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

UIM DRIVE
COMPLETED UNIT TEST PLAN

Unit…………………UIM13…………Serial No ………UIM13P
Test Engineer ………XEN
Date …………………14/9/9

Drive Card ID……………UIM13P
Monitor Card ID ………..MON13P

Contents

1. Description

2. Test Equipment

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13. Final Assembly Tests

1. Description

The UIM Driver Unit will be used to control the 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 UIM mirror in a Quad assembly. It works in conjunction with the OSEM coil and position sensor units. One UIM unit controls four OSEMs.

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

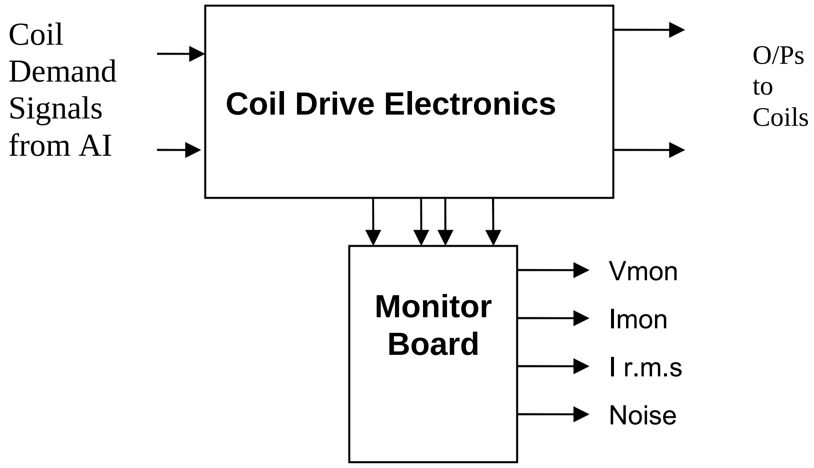


FIG. 1 UIM Driver Unit Block Diagram

Each UIM 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…………………UIM13…………Serial No ………UIM13P
Test Engineer ………XEN
Date …………………14/9/9

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
DVM	FLUKE	115	
V/I Calibrator	Time Electronics	1044	
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-Tech	ISR622	
PSU x 2	Farnell	L30-2	

Unit…………………UIM13…………Serial No ………UIM13P
Test Engineer ………XEN
Date …………………14/9/9

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment:

Good

Links:

Check that links W3, W4 and W5 are present on each channel of the Drive board. If not, connect them.

Unit…………………UIM13…………Serial No ………UIM13P
Test Engineer ………XEN
Date …………………14/9/9

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	√

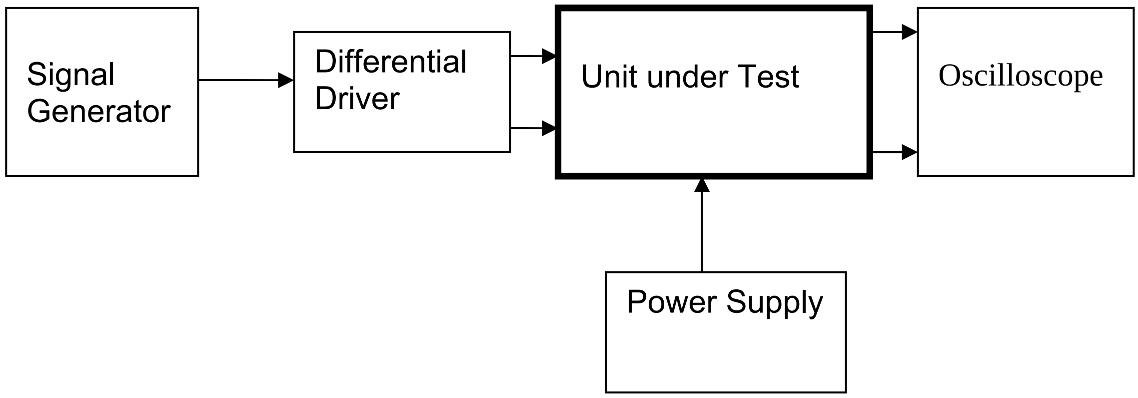
LED Monitors

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	√

5. 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…………………UIM13…………Serial No ………UIM13P
Test Engineer ………XEN
Date …………………14/9/9

6. 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)
500mA	400mA

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…………………UIM13…………Serial No ………UIM13P
Test Engineer ………XEN
Date …………………14/9/9

7. Relay Operation

Connect the test unit to the Binary IO inputs.

Operate switches and check that LEDs are on when the relays are switched on, and off when they are switched off:

Relay	LED Operation					
	Filter 1		Filter 2		Filter 2	
	ON	OFF	ON	OFF	ON	OFF
Ch1	√	√	√	√	√	√
Ch2	√	√	√	√	√	√
Ch3	√	√	√	√	√	√
Ch4	√	√	√	√	√	√

This indicates that the relays are operating, and that the talk back contacts work OK.

Unit…………………UIM13…………Serial No ………UIM13P
Test Engineer ………XEN
Date …………………14/9/9

8. Current Monitor tests

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

Connect the 39 ohm dummy loads to the coil drive output. Connect the differential driver to the input, fed by the signal generator. Set the signal generator to 4v at 100 Hz.

Switch out the filters.
Use the true r.m.s meter to measure the r.m.s voltage between test points TP7 and TP11 on the drive board. Adjust the signal generator unit the until this voltage is 3v r.m.s.

Connect a scope probe to each end of one of the load resistors. Set up the scope to differentially observe the voltage across the load resistor. Check that it is a sine wave.

Measure and record the output from each current monitors, and each of the RMS circuits. Set the meter to r.m.s for the “current monitor” readings (ac signal), and to dc when measuring the r.m.s outputs (dc signal).

The theoretical output is 0.995v.

Ch.	Monitor Connector	Parameter	Theoretical Value	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	0.95v to 1.05 v r.m.s	0.9969	√
	Pin 1	RMS Current	0.95 v to 1.05 v dc	0.9981	√
2	Pin 5	Current Monitor	0.95 v to 1.05 v r.m.s	0.9965	√
	Pin 4	RMS Current	0.95 v to 1.05 v dc	0.9978	√
3	Pin 8	Current Monitor	0.95 v to 1.05 v r.m.s	0.9967	√
	Pin 7	RMS Current	0.95 v to 1.05 v dc	0.9993	√
4	Pin 11	Current Monitor	0.95 v to 1.05 v r.m.s	0.9968	√
	Pin 10	RMS Current	0.95 v to 1.05 v dc	0.9956	√

Unit…………………UIM13…………Serial No ………UIM13P
Test Engineer ………XEN
Date …………………14/9/9

9. 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 TP7 and TP11 at 100 Hz.
Adjust the signal generator to give a voltage to 3v r.m.s 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	1.0015	0.95v to 1.05v	√
2	Pins 3,11	Pin 6	1.0012	0.95v to 1.05v	√
3	Pins 5,13	Pin 9	1.0020	0.95v to 1.05v	√
4	Pins 7, 15	Pin 12	1.0013	0.95v to 1.05v	√

Measurements may be used using a 25 way break out box, or a 25 way connector on the V, I and r.m.s connector.

10. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct. There are two possible ways of performing this test depending on available equipment. Either 8.1 or 8.2 should be conducted (it is not necessary to do both).

10.1 Using a Signal Generator

Apply a signal to the input, amplitude 1v peak, Frequency 100Hz via the differential driver, to the Drive Input.

.

Switch out all the filter stages. Measure and record the peak differential output between the outputs of each channel, using two oscilloscope channels in differential mode.

	Coil Drive output pins	Pk/pk Output	Specification	Pass/Fail
Ch1	1 and 9		4.8v to 5v	
Ch2	3 and 11		4.8v to 5v	
Ch3	5 and 13		4.8v to 5v	
Ch4	7 and 15		4.8v to 5v	

Switch in each filter in turn and measure and record the peak output at 1Hz, 10 Hz, and 1 KHz.

1Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				3.3v to 3.7v	
Ch2	3 and 11				3.3v to 3.7v	
Ch3	5 and 13				3.3v to 3.7v	
Ch4	7 and 15				3.3v to 3.7v	

10Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.48 to 0.75v	
Ch2	3 and 11				0.48 to 0.75v	
Ch3	5 and 13				0.48 to 0.75v	
Ch4	7 and 15				0.48 to 0.75v	

1 KHz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.4v to 0.5v	
Ch2	3 and 11				0.4v to 0.5v	
Ch3	5 and 13				0.4v to 0.5v	
Ch4	7 and 15				0.4v to 0.5v	

Unit.....................UIM13............Serial No UIM13P
Test Engineer ....XEN
Date 14/9/9

10.2. Using the Dynamic Signal Analyser

With all filters switched in, measure the frequency response of each channel in turn between 0.1 Hz and 1KHz. If a fast turn around is required, limit the measurement to the frequency range to between 1 Hz and 1KHz. Measure the gain at the spot frequencies below and record them.

Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.4	6.6 to 8.7	√
1Hz	-0.8	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 2

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.3	6.6 to 8.7	√
1Hz	-0.7	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 3

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.5	6.6 to 8.7	√
1Hz	-0.8	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 4

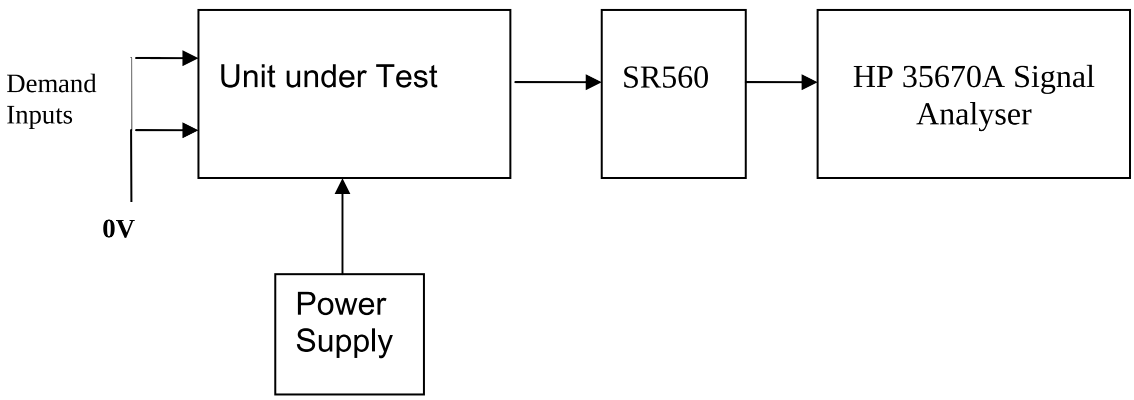
Frequency	Gain (dB)	Expected Gain	Pass/Fail
0.1 Hz	8.4	6.6 to 8.7	√
1Hz	-0.8	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Unit…………………UIM13…………Serial No ………UIM13P
Test Engineer ………RMC
Date …………………30/9/9

11. Noise Tests

Ensure the filter links W2, W3, W4 and W5 are present on each channel.

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, and readings should be made when the ambient noise is low. 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	-152.6	-94.4	-154.4
Ch2	-152.6	-94.7	-154.7
Ch3	-152.6	-93	-153
Ch4	-152.6	-94	-154

The specification at 10 Hz is a noise current of 3 pA per root Hz. The total load resistance is 7.8k. The permitted noise voltage from the amplifiers is therefore 23.4 nA/ /√Hz or -152.6 dB. The SR560 is set to a gain of 1000 (60dB) so 60dB needs to be subtracted from the reading.

Unit…………………UIM13…………Serial No ………UIM13P
Test Engineer ………XEN
Date …………………14/9/9

12. Distortion

No filters. Increase input voltage to 10v peak, f = 1KHz. Dummy 39 Ohm loads. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit…………………UIM13…………Serial No ………UIM13P
Test Engineer ………RMC
Date …………………30/9/9

13. Final Assembly Tests

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 all the LEDs are nicely centred. √

7. Check that links W3, W4 and W5 are in place. √

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

UoB box ID	UIM13P
Driver board ID	UIM13P
Driver board Drawing No/Issue No	D070481-4-K
Driver board Serial Number	UIM13P
Monitor board ID	MON13P
Monitor board Drawing No/Issue No	D070481-4-K
Monitor board Serial Number	UIM MON13P

9. Check the security of any modification wires. None

10. Visually inspect. √

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

Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T0900236-v3 Advanced LIGO UK 14 September 2009

UIM14P Drive Unit Test Results

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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.

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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

UIM DRIVE
COMPLETED UNIT TEST PLAN

Unit………………UIM14…………Serial No ……………UIM14P
Test Engineer ………XEN
Date …………………14/9/9

Drive Card ID……………UIM14P
Monitor Card ID ………..MON14P

Contents

1. Description

2. Test Equipment

3. Inspection

4. Continuity Checks

5. Test Set Up

6. Power

7. Relay operation

8. Current Monitor Tests

9. Voltage Monitor Tests

10. Corner Frequency Tests

11. Noise Tests

12. Distortion

13. Final Assembly Tests

1. Description

The UIM Driver Unit will be used to control the 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 UIM mirror in a Quad assembly. It works in conjunction with the OSEM coil and position sensor units. One UIM unit controls four OSEMs.

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

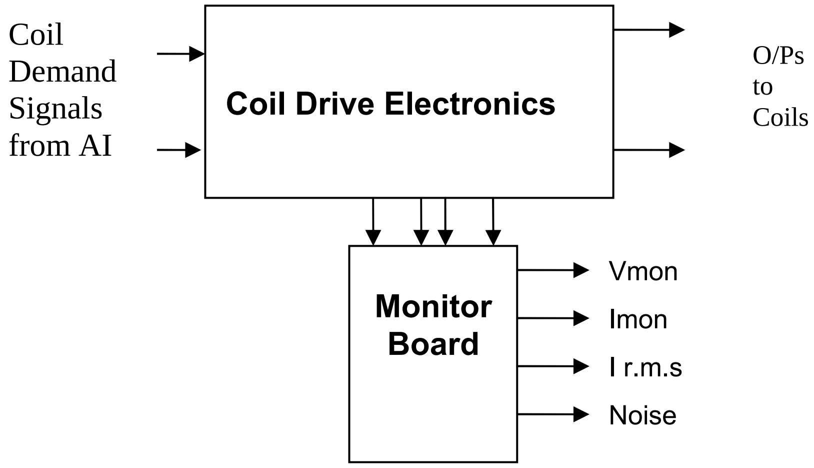


FIG. 1 UIM Driver Unit Block Diagram

Each UIM 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..................UIM14............Serial No UIM14P
Test Engineer ....XEN
Date 14/9/9

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
DVM	FLUKE	115	
V/I Calibrator	Time Electronics	1044	
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-Tech	ISR622	
PSU x 2	Farnell	L30-2	

Unit……………….UIM14…………Serial No ……………UIM14P
Test Engineer ………XEN
Date …………………14/9/9

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment:

Good

Links:

Check that links W3, W4 and W5 are present on each channel of the Drive board. If not, connect them.

Unit………………UIM14…………Serial No ……………UIM14P
Test Engineer ………XEN
Date …………………14/9/9

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	√

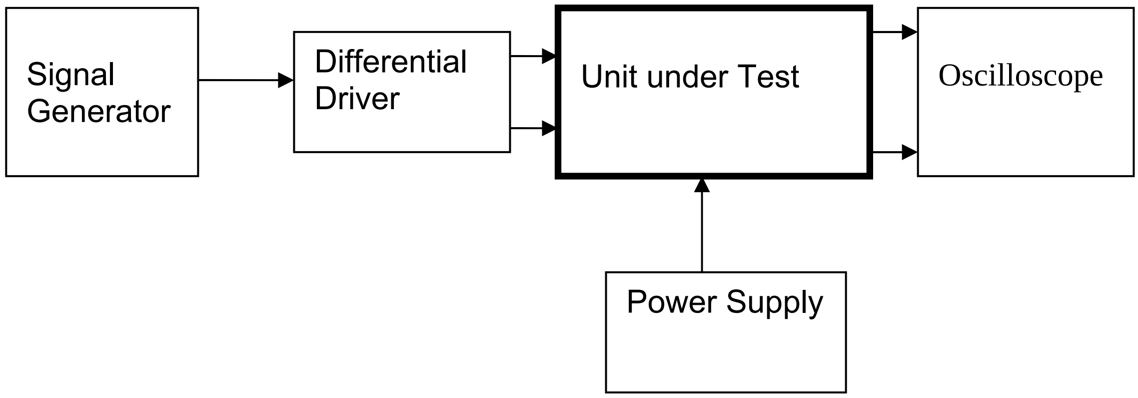
LED Monitors

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	√

5. 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……………….UIM14…………Serial No ……………UIM14P
Test Engineer ………XEN
Date …………………14/9/9

6. 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)
500mA	400mA

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………………UIM14…………Serial No ……………UIM14P
Test Engineer ………XEN
Date …………………14/9/9

7. Relay Operation

Connect the test unit to the Binary IO inputs.

Operate switches and check that LEDs are on when the relays are switched on, and off when they are switched off:

Relay	**LED Operation**					
	Filter 1		**Filter 2**		**Filter 2**	
	ON	**OFF**	**ON**	**OFF**	**ON**	**OFF**
Ch1	√	√	√	√	√	√
Ch2	√	√	√	√	√	√
Ch3	√	√	√	√	√	√
Ch4	√	√	√	√	√	√

This indicates that the relays are operating, and that the talk back contacts work OK.

Unit………………UIM14…………Serial No ……………UIM14P
Test Engineer ………XEN
Date …………………14/9/9

8. Current Monitor tests

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

Connect the 39 ohm dummy loads to the coil drive output. Connect the differential driver to the input, fed by the signal generator. Set the signal generator to 4v at 100 Hz.

Switch out the filters.
Use the true r.m.s meter to measure the r.m.s voltage between test points TP7 and TP11 on the drive board. Adjust the signal generator unit the until this voltage is 3v r.m.s.

Connect a scope probe to each end of one of the load resistors. Set up the scope to differentially observe the voltage across the load resistor. Check that it is a sine wave.

Measure and record the output from each current monitors, and each of the RMS circuits. Set the meter to r.m.s for the "current monitor" readings (ac signal), and to dc when measuring the r.m.s outputs (dc signal).

The theoretical output is 0.995v.

Ch.	Monitor Connector	Parameter	Theoretical Value	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	0.95v to 1.05 v r.m.s	0.9974	√
	Pin 1	RMS Current	0.95 v to 1.05 v dc	1.0011	√
2	Pin 5	Current Monitor	0.95 v to 1.05 v r.m.s	0.9986	√
	Pin 4	RMS Current	0.95 v to 1.05 v dc	1.0023	√
3	Pin 8	Current Monitor	0.95 v to 1.05 v r.m.s	0.9979	√
	Pin 7	RMS Current	0.95 v to 1.05 v dc	0.9977	√
4	Pin 11	Current Monitor	0.95 v to 1.05 v r.m.s	0.9971	√
	Pin 10	RMS Current	0.95 v to 1.05 v dc	0.9988	√

Unit………………UIM14…………Serial No ……………UIM14P
Test Engineer ………XEN
Date …………………14/9/9

9. 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 TP7 and TP11 at 100 Hz.
Adjust the signal generator to give a voltage to 3v r.m.s 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	1.0015	0.95v to 1.05v	√
2	Pins 3,11	Pin 6	1.0022	0.95v to 1.05v	√
3	Pins 5,13	Pin 9	1.0016	0.95v to 1.05v	√
4	Pins 7, 15	Pin 12	1.0026	0.95v to 1.05v	√

Measurements may be used using a 25 way break out box, or a 25 way connector on the V, I and r.m.s connector.

10. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct. There are two possible ways of performing this test depending on available equipment. Either 8.1 or 8.2 should be conducted (it is not necessary to do both).

10.1 Using a Signal Generator

Apply a signal to the input, amplitude 1v peak, Frequency 100Hz via the differential driver, to the Drive Input.

.

Switch out all the filter stages. Measure and record the peak differential output between the outputs of each channel, using two oscilloscope channels in differential mode.

	Coil Drive output pins	Pk/pk Output	Specification	Pass/Fail
Ch1	1 and 9		4.8v to 5v	
Ch2	3 and 11		4.8v to 5v	
Ch3	5 and 13		4.8v to 5v	
Ch4	7 and 15		4.8v to 5v	

Switch in each filter in turn and measure and record the peak output at 1Hz, 10 Hz, and 1 KHz.

1Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				3.3v to 3.7v	
Ch2	3 and 11				3.3v to 3.7v	
Ch3	5 and 13				3.3v to 3.7v	
Ch4	7 and 15				3.3v to 3.7v	

10Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.48 to 0.75v	
Ch2	3 and 11				0.48 to 0.75v	
Ch3	5 and 13				0.48 to 0.75v	
Ch4	7 and 15				0.48 to 0.75v	

1 KHz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.4v to 0.5v	
Ch2	3 and 11				0.4v to 0.5v	
Ch3	5 and 13				0.4v to 0.5v	
Ch4	7 and 15				0.4v to 0.5v	

Unit………………UIM14…………Serial No ……………UIM14P
Test Engineer ………XEN
Date …………………14/9/9

10.2. Using the Dynamic Signal Analyser

With all filters switched in, measure the frequency response of each channel in turn between 0.1 Hz and 1KHz. If a fast turn around is required, limit the measurement to the frequency range to between 1 Hz and 1KHz. Measure the gain at the spot frequencies below and record them.

Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.3	6.6 to 8.7	√
1Hz	0.9	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 2

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.2	6.6 to 8.7	√
1Hz	0.9	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 3

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.5	6.6 to 8.7	√
1Hz	0.8	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 4

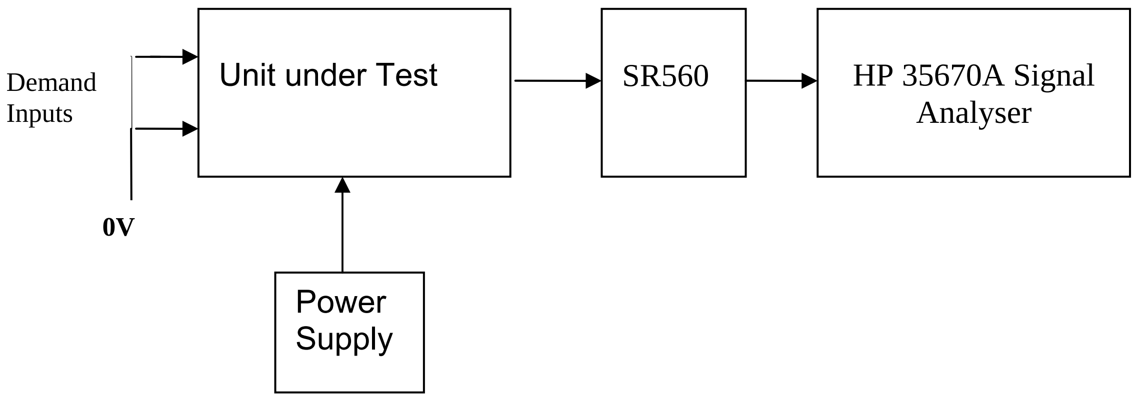
Frequency	Gain (dB)	Expected Gain	Pass/Fail
0.1 Hz	8.4	6.6 to 8.7	√
1Hz	0.7	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Unit………………UIM14…………Serial No ……………UIM14P
Test Engineer ………RMC
Date …………………28/9/9

11. Noise Tests

Ensure the filter links W2, W3, W4 and W5 are present on each channel.

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, and readings should be made when the ambient noise is low. 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	-152.6	-91	-151
Ch2	-152.6	-95.1	-155.1
Ch3	-152.6	-94	-154
Ch4	-152.6	-93.5	-153.5

Noise on channel 1 is 1.6 dB high

The specification at 10 Hz is a noise current of 3 pA per root Hz. The total load resistance is 7.8k. The permitted noise voltage from the amplifiers is therefore 23.4 nA/ /√Hz or -152.6 dB. The SR560 is set to a gain of 1000 (60dB) so 60dB needs to be subtracted from the reading.

Unit………………UIM14…………Serial No ……………UIM14P
Test Engineer ………XEN
Date …………………14/9/9

12. Distortion

No filters. Increase input voltage to 10v peak, f = 1KHz. Dummy 39 Ohm loads. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit..................UIM14............Serial No UIM14P
Test Engineer ....RMC
Date 30/9/9

13. Final Assembly Tests

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 all the LEDs are nicely centred. √

7. Check that links W3, W4 and W5 are in place. √

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

UoB box ID	UIM14P
Driver board ID	UIM14P
Driver board Drawing No/Issue No	D070481-4-K
Driver board Serial Number	UIM14P
Monitor board ID	MON14P
Monitor board Drawing No/Issue No	D070480-4-K
Monitor board Serial Number	UIM UIM14P

9. Check the security of any modification wires. None

10. Visually inspect. √

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

    Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T0900236-v3 Advanced LIGO UK 14 September 2009

UIM15P Drive Unit Test Results

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.

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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

UIM DRIVE
COMPLETED UNIT TEST PLAN

Unit……………UIM15P……………Serial No ………… UIM15P
Test Engineer ………XEN
Date …………………14/9/09

Drive Card ID…………… UIM15P
Monitor Card ID ……….. MON15P

Contents

1. Description

2. Test Equipment

3. Inspection

4. Continuity Checks

5. Test Set Up

6. Power

7. Relay operation

8. Current Monitor Tests

9. Voltage Monitor Tests

10. Corner Frequency Tests

11. Noise Tests

12. Distortion

13. Final Assembly Tests

1. Description

The UIM Driver Unit will be used to control the 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 UIM mirror in a Quad assembly. It works in conjunction with the OSEM coil and position sensor units. One UIM unit controls four OSEMs.

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

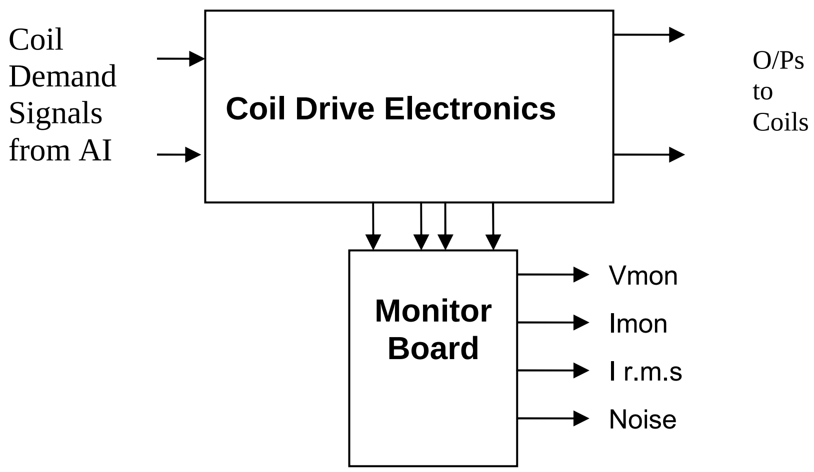


FIG. 1 UIM Driver Unit Block Diagram

Each UIM 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……………UIM15P……………Serial No ………… UIM15P
Test Engineer ………XEN
Date …………………14/9/09

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
DVM	FLUKE	115	
V/I Calibrator	Time Electronics	1044	
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-Tech	ISR622	
PSU x 2	Farnell	L30-2	

Unit……………UIM15P……………Serial No ………… UIM15P
Test Engineer ………XEN
Date …………………14/9/09

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment:

Good

Links:

Check that links W3, W4 and W5 are present on each channel of the Drive board. If not, connect them.

Unit……………UIM15P……………Serial No ………… UIM15P
Test Engineer ………XEN
Date …………………14/9/09

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	√

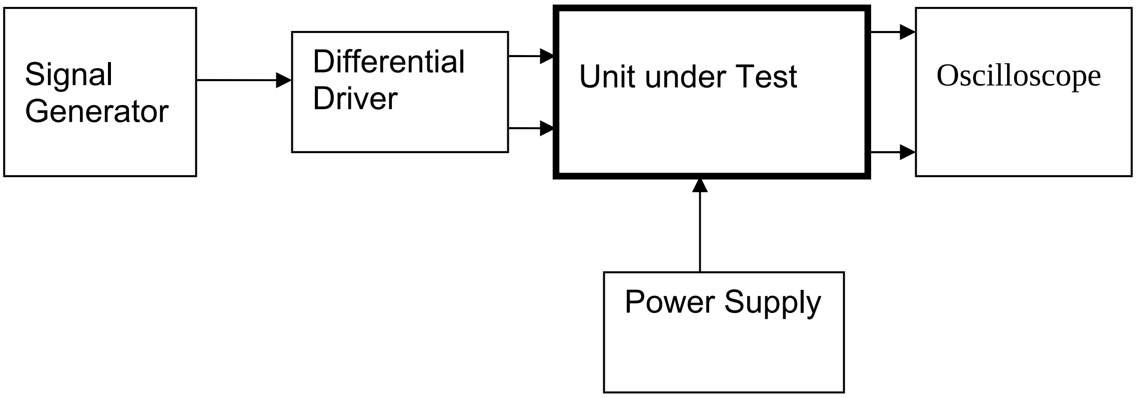
LED Monitors

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	√

5. 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……………UIM15P……………Serial No ………… UIM15P
Test Engineer ………XEN
Date …………………14/9/09

6. 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)
500mA	400mA

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...............UIM15P...............Serial No UIM15P
Test Engineer ....XEN
Date 14/9/09

7. Relay Operation

Connect the test unit to the Binary IO inputs.

Operate switches and check that LEDs are on when the relays are switched on, and off when they are switched off:

Relay	**LED Operation**					
	Filter 1		**Filter 2**		**Filter 2**	
	ON	**OFF**	**ON**	**OFF**	**ON**	**OFF**
Ch1	√	√	√	√	√	√
Ch2	√	√	√	√	√	√
Ch3	√	√	√	√	√	√
Ch4	√	√	√	√	√	√

This indicates that the relays are operating, and that the talk back contacts work OK.

Unit……………UIM15P……………Serial No ………… UIM15P
Test Engineer ………XEN
Date …………………14/9/09

8. Current Monitor tests

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

Connect the 39 ohm dummy loads to the coil drive output. Connect the differential driver to the input, fed by the signal generator. Set the signal generator to 4v at 100 Hz.

Switch out the filters.
Use the true r.m.s meter to measure the r.m.s voltage between test points TP7 and TP11 on the drive board. Adjust the signal generator unit the until this voltage is 3v r.m.s.

Connect a scope probe to each end of one of the load resistors. Set up the scope to differentially observe the voltage across the load resistor. Check that it is a sine wave.

Measure and record the output from each current monitors, and each of the RMS circuits. Set the meter to r.m.s for the "current monitor" readings (ac signal), and to dc when measuring the r.m.s outputs (dc signal).

The theoretical output is 0.995v.

Ch.	Monitor Connector	Parameter	Theoretical Value	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	0.95v to 1.05 v r.m.s	0.9972	√
	Pin 1	RMS Current	0.95 v to 1.05 v dc	0.9985	√
2	Pin 5	Current Monitor	0.95 v to 1.05 v r.m.s	0.9967	√
	Pin 4	RMS Current	0.95 v to 1.05 v dc	0.9978	√
3	Pin 8	Current Monitor	0.95 v to 1.05 v r.m.s	0.9967	√
	Pin 7	RMS Current	0.95 v to 1.05 v dc	0.9955	√
4	Pin 11	Current Monitor	0.95 v to 1.05 v r.m.s	0.9970	√
	Pin 10	RMS Current	0.95 v to 1.05 v dc	0.9961	√

Unit...............UIM15P...............Serial No UIM15P
Test Engineer ....XEN
Date 14/9/09

9. 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 TP7 and TP11 at 100 Hz. Adjust the signal generator to give a voltage to 3v r.m.s 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	1.0027	0.95v to 1.05v	√
2	Pins 3,11	Pin 6	1.0018	0.95v to 1.05v	√
3	Pins 5,13	Pin 9	1.0013	0.95v to 1.05v	√
4	Pins 7, 15	Pin 12	1.0019	0.95v to 1.05v	√

Measurements may be used using a 25 way break out box, or a 25 way connector on the V, I and r.m.s connector.

10. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct. There are two possible ways of performing this test depending on available equipment. Either 8.1 or 8.2 should be conducted (it is not necessary to do both).

10.1 Using a Signal Generator

Apply a signal to the input, amplitude 1v peak, Frequency 100Hz via the differential driver, to the Drive Input.

.

Switch out all the filter stages. Measure and record the peak differential output between the outputs of each channel, using two oscilloscope channels in differential mode.

	Coil Drive output pins	Pk/pk Output	Specification	Pass/Fail
Ch1	1 and 9		4.8v to 5v	
Ch2	3 and 11		4.8v to 5v	
Ch3	5 and 13		4.8v to 5v	
Ch4	7 and 15		4.8v to 5v	

Switch in each filter in turn and measure and record the peak output at 1Hz, 10 Hz, and 1 KHz.

1Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				3.3v to 3.7v	
Ch2	3 and 11				3.3v to 3.7v	
Ch3	5 and 13				3.3v to 3.7v	
Ch4	7 and 15				3.3v to 3.7v	

10Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.48 to 0.75v	
Ch2	3 and 11				0.48 to 0.75v	
Ch3	5 and 13				0.48 to 0.75v	
Ch4	7 and 15				0.48 to 0.75v	

1 KHz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.4v to 0.5v	
Ch2	3 and 11				0.4v to 0.5v	
Ch3	5 and 13				0.4v to 0.5v	
Ch4	7 and 15				0.4v to 0.5v	

Unit……………UIM15P……………Serial No ………… UIM15P
Test Engineer ………XEN
Date …………………14/9/09

10.2. Using the Dynamic Signal Analyser

With all filters switched in, measure the frequency response of each channel in turn between 0.1 Hz and 1KHz. If a fast turn around is required, limit the measurement to the frequency range to between 1 Hz and 1KHz. Measure the gain at the spot frequencies below and record them.

Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.4	6.6 to 8.7	√
1Hz	-0.9	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 2

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.5	6.6 to 8.7	√
1Hz	-0.9	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 3

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.4	6.6 to 8.7	√
1Hz	-1.0	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 4

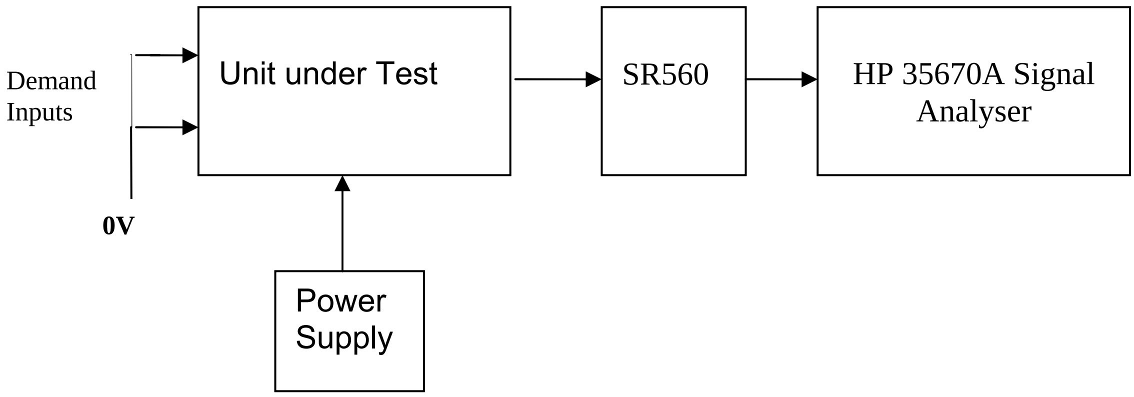
Frequency	Gain (dB)	Expected Gain	Pass/Fail
0.1 Hz	8.5	6.6 to 8.7	√
1Hz	-0.9	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Unit……………UIM15P……………Serial No ………… UIM15P
Test Engineer ………RMC
Date …………………28/9/9

11. Noise Tests

Ensure the filter links W2, W3, W4 and W5 are present on each channel.

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, and readings should be made when the ambient noise is low. 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	-152.6	-93.1	-153.1
Ch2	-152.6	-93.4	-153.4
Ch3	-152.6	-94.3	-154.3
Ch4	-152.6	-93	-153

All channels are in specification

The specification at 10 Hz is a noise current of 3 pA per root Hz. The total load resistance is 7.8k. The permitted noise voltage from the amplifiers is therefore 23.4 nA/ /√Hz or -152.6 dB. The SR560 is set to a gain of 1000 (60dB) so 60dB needs to be subtracted from the reading.

Unit...............UIM15P...............Serial No UIM15P
Test Engineer ....XEN
Date 14/9/09

12. Distortion

No filters. Increase input voltage to 10v peak, f = 1KHz. Dummy 39 Ohm loads. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit……………UIM15P……………Serial No ………… UIM15P
Test Engineer ………RMC
Date …………………30/9/9

13. Final Assembly Tests

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 all the LEDs are nicely centred. √

7. Check that links W3, W4 and W5 are in place. √

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

UoB box ID	UIM15P
Driver board ID	UIM15P
Driver board Drawing No/Issue No	D070481-4-K
Driver board Serial Number	UIM15P
Monitor board ID	MON15P
Monitor board Drawing No/Issue No	D070480-4-K
Monitor board Serial Number	UIM MON15P

9. Check the security of any modification wires. None

10. Visually inspect. √

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

Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T0900236-v3 Advanced LIGO UK 15 September 2009

UIM16P Drive Unit Test Results

R. M. Cutler, University of Birmingham

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of the Advanced LIGO Project, prepared by members of the UK team.

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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

UIM DRIVE
COMPLETED UNIT TEST PLAN

Unit……………………UIM16P………Serial No ……… UIM16P
Test Engineer ………XEN
Date …………………15/9/9

Drive Card ID…………… UIM16P
Monitor Card ID ………. MON16P

Contents

1. Description

2. Test Equipment

3. Inspection

4. Continuity Checks

5. Test Set Up

6. Power

7. Relay operation

8. Current Monitor Tests

9. Voltage Monitor Tests

10. Corner Frequency Tests

11. Noise Tests

12. Distortion

13. Final Assembly Tests

1. Description

The UIM Driver Unit will be used to control the 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 UIM mirror in a Quad assembly. It works in conjunction with the OSEM coil and position sensor units. One UIM unit controls four OSEMs.

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

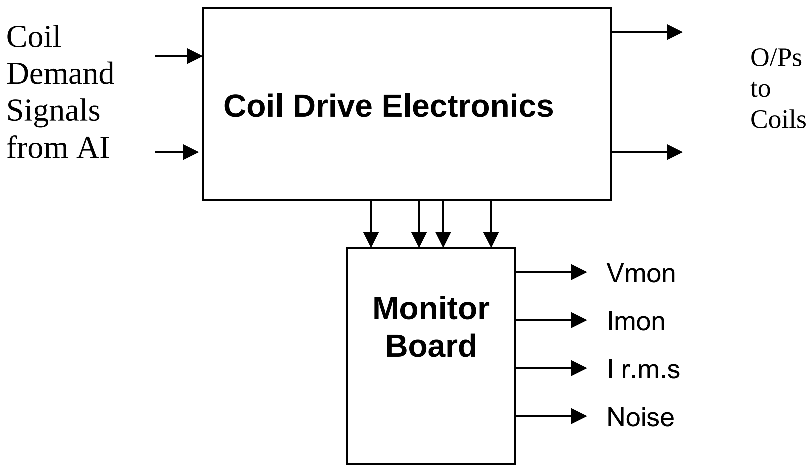


FIG. 1 UIM Driver Unit Block Diagram

Each UIM 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……………………UIM16P………Serial No ……… UIM16P
Test Engineer ………XEN
Date …………………15/9/9

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
DVM	FLUKE	115	
V/I Calibrator	Time Electronics	1044	
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-Tech	ISR622	
PSU x 2	Farnell	L30-2	

Unit……………………UIM16P………Serial No ……… UIM16P
Test Engineer ………XEN
Date …………………15/9/9

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment:

Good

Links:

Check that links W3, W4 and W5 are present on each channel of the Drive board. If not, connect them.

Unit……………………UIM16P………Serial No ……… UIM16P
Test Engineer ………XEN
Date …………………15/9/9

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	√

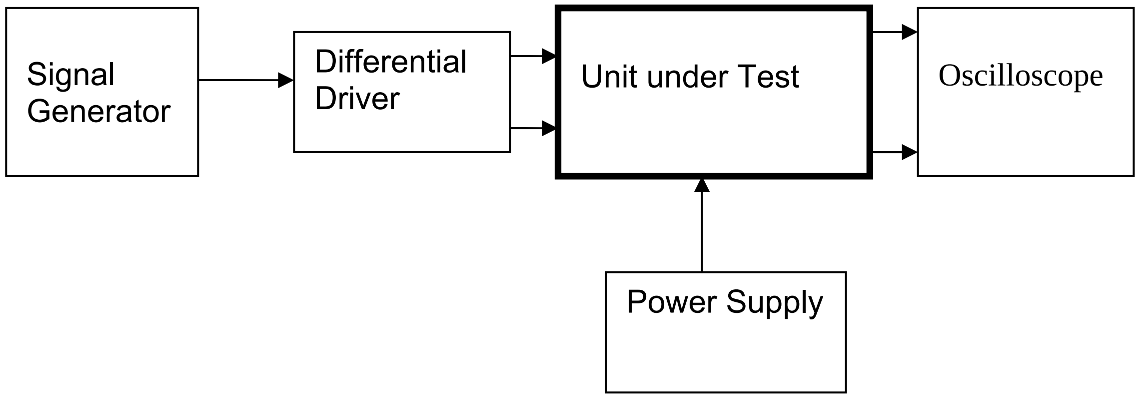
LED Monitors

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	√

5. 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……………………UIM16P………Serial No ……… UIM16P
Test Engineer ………XEN
Date …………………15/9/9

6. 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)
500mA	400mA

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……………………UIM16P………Serial No ……… UIM16P
Test Engineer ………XEN
Date …………………15/9/9

7. Relay Operation

Connect the test unit to the Binary IO inputs.

Operate switches and check that LEDs are on when the relays are switched on, and off when they are switched off:

Relay	**LED Operation**					
	Filter 1		**Filter 2**		**Filter 2**	
	ON	**OFF**	**ON**	**OFF**	**ON**	**OFF**
Ch1	√	√	√	√	√	√
Ch2	√	√	√	√	√	√
Ch3	√	√	√	√	√	√
Ch4	√	√	√	√	√	√

This indicates that the relays are operating, and that the talk back contacts work OK.

Unit……………………UIM16P………Serial No ……… UIM16P
Test Engineer ………XEN
Date …………………15/9/9

8. Current Monitor tests

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

Connect the 39 ohm dummy loads to the coil drive output. Connect the differential driver to the input, fed by the signal generator. Set the signal generator to 4v at 100 Hz.

Switch out the filters.
Use the true r.m.s meter to measure the r.m.s voltage between test points TP7 and TP11 on the drive board. Adjust the signal generator unit the until this voltage is 3v r.m.s.

Connect a scope probe to each end of one of the load resistors. Set up the scope to differentially observe the voltage across the load resistor. Check that it is a sine wave.

Measure and record the output from each current monitors, and each of the RMS circuits. Set the meter to r.m.s for the "current monitor" readings (ac signal), and to dc when measuring the r.m.s outputs (dc signal).

The theoretical output is 0.995v.

Ch.	Monitor Connector	Parameter	Theoretical Value	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	0.95v to 1.05 v r.m.s	0.9977	√
	Pin 1	RMS Current	0.95 v to 1.05 v dc	1.0009	√
2	Pin 5	Current Monitor	0.95 v to 1.05 v r.m.s	0.9980	√
	Pin 4	RMS Current	0.95 v to 1.05 v dc	0.9995	√
3	Pin 8	Current Monitor	0.95 v to 1.05 v r.m.s	0.9975	√
	Pin 7	RMS Current	0.95 v to 1.05 v dc	0.9985	√
4	Pin 11	Current Monitor	0.95 v to 1.05 v r.m.s	0.9968	√
	Pin 10	RMS Current	0.95 v to 1.05 v dc	0.9989	√

Unit……………………UIM16P………Serial No ……… UIM16P
Test Engineer ………XEN
Date …………………15/9/9

9. 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 TP7 and TP11 at 100 Hz.
Adjust the signal generator to give a voltage to 3v r.m.s 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	1.0020	0.95v to 1.05v	√
2	Pins 3,11	Pin 6	1.0031	0.95v to 1.05v	√
3	Pins 5,13	Pin 9	1.0023	0.95v to 1.05v	√
4	Pins 7, 15	Pin 12	1.0012	0.95v to 1.05v	√

Measurements may be used using a 25 way break out box, or a 25 way connector on the V, I and r.m.s connector.

10. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct. There are two possible ways of performing this test depending on available equipment. Either 8.1 or 8.2 should be conducted (it is not necessary to do both).

10.1 Using a Signal Generator

Apply a signal to the input, amplitude 1v peak, Frequency 100Hz via the differential driver, to the Drive Input.

.

Switch out all the filter stages. Measure and record the peak differential output between the outputs of each channel, using two oscilloscope channels in differential mode.

	Coil Drive output pins	Pk/pk Output	Specification	Pass/Fail
Ch1	1 and 9		4.8v to 5v	
Ch2	3 and 11		4.8v to 5v	
Ch3	5 and 13		4.8v to 5v	
Ch4	7 and 15		4.8v to 5v	

Switch in each filter in turn and measure and record the peak output at 1Hz, 10 Hz, and 1 KHz.

1Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				3.3v to 3.7v	
Ch2	3 and 11				3.3v to 3.7v	
Ch3	5 and 13				3.3v to 3.7v	
Ch4	7 and 15				3.3v to 3.7v	

10Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.48 to 0.75v	
Ch2	3 and 11				0.48 to 0.75v	
Ch3	5 and 13				0.48 to 0.75v	
Ch4	7 and 15				0.48 to 0.75v	

1 KHz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.4v to 0.5v	
Ch2	3 and 11				0.4v to 0.5v	
Ch3	5 and 13				0.4v to 0.5v	
Ch4	7 and 15				0.4v to 0.5v	

Unit……………………UIM16P………Serial No ……… UIM16P
Test Engineer ………XEN
Date …………………15/9/9

10.2. Using the Dynamic Signal Analyser

With all filters switched in, measure the frequency response of each channel in turn between 0.1 Hz and 1KHz. If a fast turn around is required, limit the measurement to the frequency range to between 1 Hz and 1KHz. Measure the gain at the spot frequencies below and record them.

Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.4	6.6 to 8.7	√
1Hz	-1.0	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 2

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.4	6.6 to 8.7	√
1Hz	-0.8	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 3

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.2	6.6 to 8.7	√
1Hz	-0.9	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 4

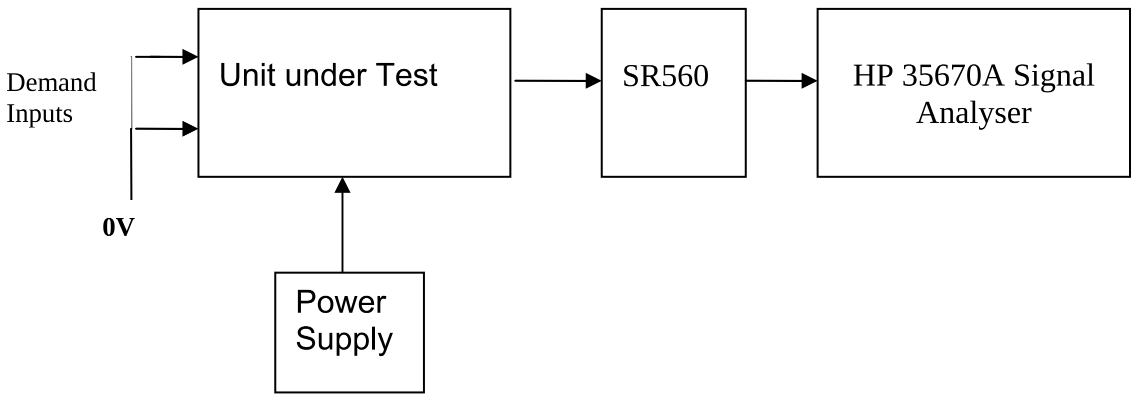
Frequency	Gain (dB)	Expected Gain	Pass/Fail
0.1 Hz	8.5	6.6 to 8.7	√
1Hz	-1.0	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Unit……………………UIM16P………Serial No ……… UIM16P
Test Engineer ………RMC
Date …………………28/9/9

11. Noise Tests

Ensure the filter links W2, W3, W4 and W5 are present on each channel.

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, and readings should be made when the ambient noise is low. 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	-152.6	-95.7	-155.7
Ch2	-152.6	-89.7	-149.7
Ch3	-152.6	-93.7	-153.7
Ch4	-152.6	-94.9	-154.9

Channel 2 is out of specification by 2.9dB

The specification at 10 Hz is a noise current of 3 pA per root Hz. The total load resistance is 7.8k. The permitted noise voltage from the amplifiers is therefore 23.4 nA/ /√Hz or -152.6 dB. The SR560 is set to a gain of 1000 (60dB) so 60dB needs to be subtracted from the reading.

Unit……………………UIM16P………Serial No ……… UIM16P
Test Engineer ………XEN
Date …………………15/9/9

12. Distortion

No filters. Increase input voltage to 10v peak, f = 1KHz. Dummy 39 Ohm loads. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit……………………UIM16P………Serial No ……… UIM16P
Test Engineer ………RMC
Date …………………1/10/9

13. Final Assembly Tests

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 all the LEDs are nicely centred. √

7. Check that links W3, W4 and W5 are in place. √

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

UoB box ID	UIM16P
Driver board ID	UIM16P
Driver board Drawing No/Issue No	D070481-4-K
Driver board Serial Number	UIM16P
Monitor board ID	MON16P
Monitor board Drawing No/Issue No	D070480-4-K
Monitor board Serial Number	UIM MON16P

9. Check the security of any modification wires. None

10. Visually inspect. √

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

Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T0900236-v3 Advanced LIGO UK 15 September 2009

UIM17P Drive Unit Test Results

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.

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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

UIM DRIVE
COMPLETED UNIT TEST PLAN

Unit………………UIM17P……………Serial No ……… UIM17P
Test Engineer ………XEN
Date …………………15/9/9

Drive Card ID…………… UIM17P
Monitor Card ID ……….. MON17P

Contents

1. Description

2. Test Equipment

3. Inspection

4. Continuity Checks

5. Test Set Up

6. Power

7. Relay operation

8. Current Monitor Tests

9. Voltage Monitor Tests

10. Corner Frequency Tests

11. Noise Tests

12. Distortion

13. Final Assembly Tests

1. Description

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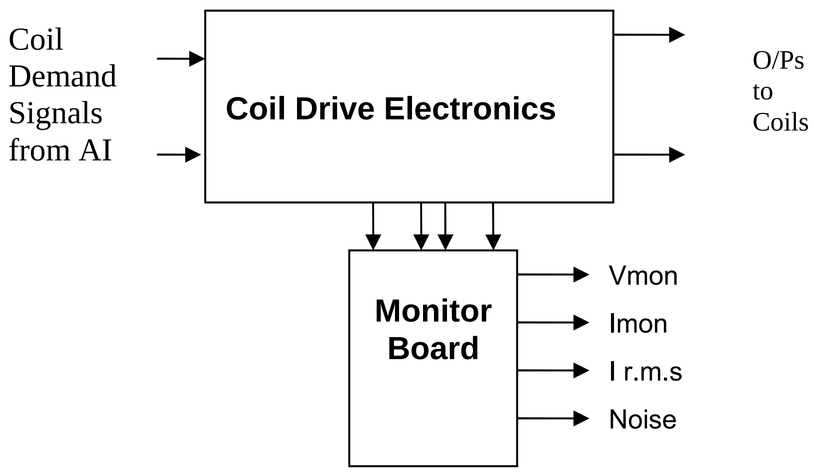

FIG. 1 UIM Driver Unit Block Diagram

Each UIM 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………………UIM17P……………Serial No ……… UIM17P
Test Engineer ………XEN
Date …………………15/9/9

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
Relay test box

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

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Signal Generator	Agilent	33250A	
Oscilloscope	ISO-Tech	ISR622	
PSU x 2	Farnell	L30-2	

Unit………………UIM17P……………Serial No ……… UIM17P
Test Engineer ………XEN
Date …………………15/9/9

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment:

Good

Links:

Check that links W3, W4 and W5 are present on each channel of the Drive board. If not, connect them.

Unit………………UIM17P……………Serial No ……… UIM17P
Test Engineer ………XEN
Date …………………15/9/9

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	√

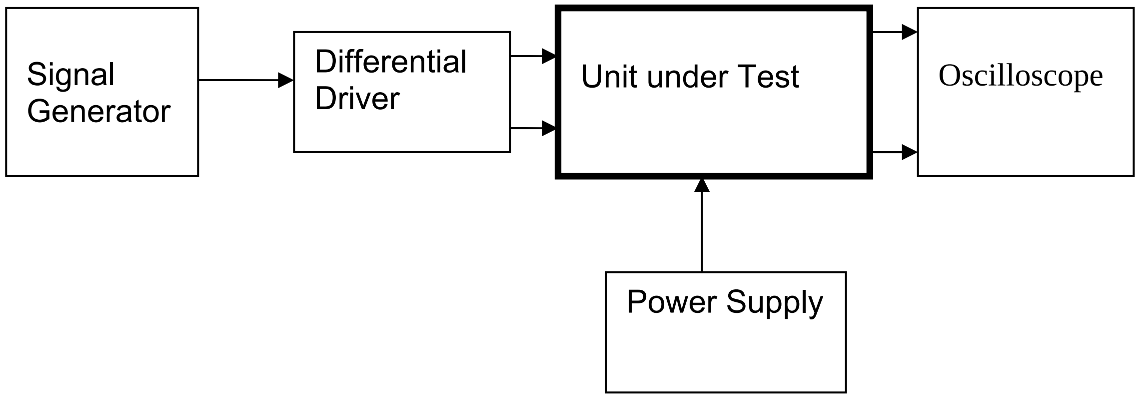
LED Monitors

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	√

5. 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………………UIM17P……………Serial No ……… UIM17P
Test Engineer ………XEN
Date …………………15/9/9

6. 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)
500mA	400mA

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………………UIM17P……………Serial No ……… UIM17P
Test Engineer ………XEN
Date …………………15/9/9

7. Relay Operation

Connect the test unit to the Binary IO inputs.

Operate switches and check that LEDs are on when the relays are switched on, and off when they are switched off:

Relay	LED Operation					
	Filter 1		Filter 2		Filter 2	
	ON	OFF	ON	OFF	ON	OFF
Ch1	√	√	√	√	√	√
Ch2	√	√	√	√	√	√
Ch3	√	√	√	√	√	√
Ch4	√	√	√	√	√	√

This indicates that the relays are operating, and that the talk back contacts work OK.

Unit………………UIM17P……………Serial No ……… UIM17P
Test Engineer ………XEN
Date …………………15/9/9

8. Current Monitor tests

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

Connect the 39 ohm dummy loads to the coil drive output. Connect the differential driver to the input, fed by the signal generator. Set the signal generator to 4v at 100 Hz.

Switch out the filters.
Use the true r.m.s meter to measure the r.m.s voltage between test points TP7 and TP11 on the drive board. Adjust the signal generator unit the until this voltage is 3v r.m.s.

Connect a scope probe to each end of one of the load resistors. Set up the scope to differentially observe the voltage across the load resistor. Check that it is a sine wave.

Measure and record the output from each current monitors, and each of the RMS circuits. Set the meter to r.m.s for the “current monitor” readings (ac signal), and to dc when measuring the r.m.s outputs (dc signal).

The theoretical output is 0.995v.

Ch.	Monitor Connector	Parameter	Theoretical Value	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	0.95v to 1.05 v r.m.s	0.9968	√
	Pin 1	RMS Current	0.95 v to 1.05 v dc	0.9967	√
2	Pin 5	Current Monitor	0.95 v to 1.05 v r.m.s	0.9977	√
	Pin 4	RMS Current	0.95 v to 1.05 v dc	0.9977	√
3	Pin 8	Current Monitor	0.95 v to 1.05 v r.m.s	0.9974	√
	Pin 7	RMS Current	0.95 v to 1.05 v dc	0.9983	√
4	Pin 11	Current Monitor	0.95 v to 1.05 v r.m.s	0.9978	√
	Pin 10	RMS Current	0.95 v to 1.05 v dc	0.9995	√

Unit………………UIM17P……………Serial No ……… UIM17P
Test Engineer ………XEN
Date …………………15/9/9

9. 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 TP7 and TP11 at 100 Hz.
Adjust the signal generator to give a voltage to 3v r.m.s 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	1.0020	0.95v to 1.05v	√
2	Pins 3,11	Pin 6	1.0021	0.95v to 1.05v	√
3	Pins 5,13	Pin 9	1.0024	0.95v to 1.05v	√
4	Pins 7, 15	Pin 12	1.0021	0.95v to 1.05v	√

Measurements may be used using a 25 way break out box, or a 25 way connector on the V, I and r.m.s connector.

10. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct. There are two possible ways of performing this test depending on available equipment. Either 8.1 or 8.2 should be conducted (it is not necessary to do both).

10.1 Using a Signal Generator

Apply a signal to the input, amplitude 1v peak, Frequency 100Hz via the differential driver, to the Drive Input.

.

Switch out all the filter stages. Measure and record the peak differential output between the outputs of each channel, using two oscilloscope channels in differential mode.

	Coil Drive output pins	Pk/pk Output	Specification	Pass/Fail
Ch1	1 and 9		4.8v to 5v	
Ch2	3 and 11		4.8v to 5v	
Ch3	5 and 13		4.8v to 5v	
Ch4	7 and 15		4.8v to 5v	

Switch in each filter in turn and measure and record the peak output at 1Hz, 10 Hz, and 1 KHz.

1Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				3.3v to 3.7v	
Ch2	3 and 11				3.3v to 3.7v	
Ch3	5 and 13				3.3v to 3.7v	
Ch4	7 and 15				3.3v to 3.7v	

10Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.48 to 0.75v	
Ch2	3 and 11				0.48 to 0.75v	
Ch3	5 and 13				0.48 to 0.75v	
Ch4	7 and 15				0.48 to 0.75v	

1 KHz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.4v to 0.5v	
Ch2	3 and 11				0.4v to 0.5v	
Ch3	5 and 13				0.4v to 0.5v	
Ch4	7 and 15				0.4v to 0.5v	

Unit………………UIM17P……………Serial No ……… UIM17P
Test Engineer ………XEN
Date …………………15/9/9

10.2. Using the Dynamic Signal Analyser

With all filters switched in, measure the frequency response of each channel in turn between 0.1 Hz and 1KHz. If a fast turn around is required, limit the measurement to the frequency range to between 1 Hz and 1KHz. Measure the gain at the spot frequencies below and record them.

Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.4	6.6 to 8.7	√
1Hz	-0.9	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 2

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.5	6.6 to 8.7	√
1Hz	-0.8	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 3

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.3	6.6 to 8.7	√
1Hz	-0.7	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 4

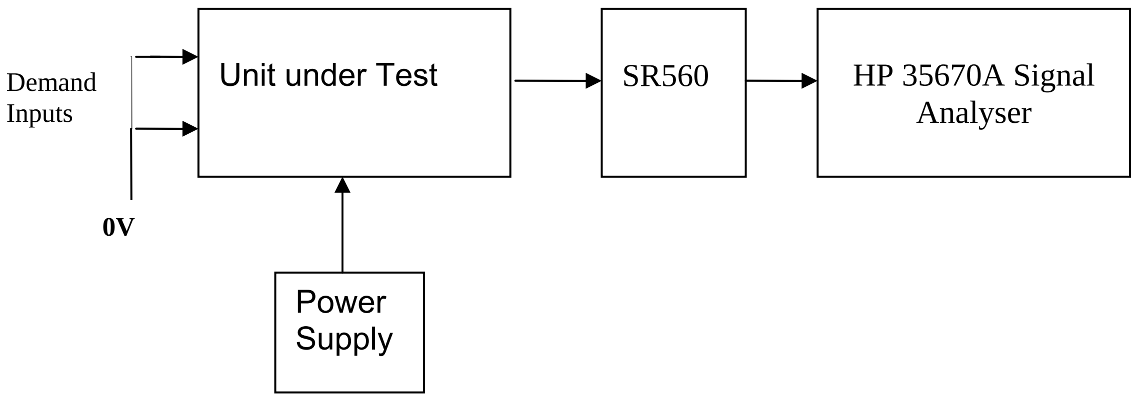
Frequency	Gain (dB)	Expected Gain	Pass/Fail
0.1 Hz	8.5	6.6 to 8.7	√
1Hz	-0.9	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Unit..................UIM17P...............Serial No UIM17P
Test Engineer ....RMC
Date 28/9.9

11. Noise Tests

Ensure the filter links W2, W3, W4 and W5 are present on each channel.

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, and readings should be made when the ambient noise is low. 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	-152.6	-95.7	-155.7
Ch2	-152.6	-94.8	-154.8
Ch3	-152.6	-93.5	-153.5
Ch4	-152.6	-95.5	-155.5

All channels are within specification

The specification at 10 Hz is a noise current of 3 pA per root Hz. The total load resistance is 7.8k. The permitted noise voltage from the amplifiers is therefore 23.4 nA/ /√Hz or -152.6 dB. The SR560 is set to a gain of 1000 (60dB) so 60dB needs to be subtracted from the reading.

Unit………………UIM17P……………Serial No ……… UIM17P
Test Engineer ………XEN
Date …………………15/9/9

12. Distortion

No filters. Increase input voltage to 10v peak, f = 1KHz. Dummy 39 Ohm loads. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit..................UIM17P...............Serial No UIM17P
Test Engineer ....RMC
Date 28/9/09

13. Final Assembly Tests

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 all the LEDs are nicely centred. √

7. Check that links W3, W4 and W5 are in place. √

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

UoB box ID	UIM17P
Driver board ID	UIM17P
Driver board Drawing No/Issue No	D070481-4-K
Driver board Serial Number	UIM17P
Monitor board ID	MON17P
Monitor board Drawing No/Issue No	D070480-4-K
Monitor board Serial Number	UIM MON17P

9. Check the security of any modification wires. None

10. Visually inspect. √

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

    Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T0900236-v3 Advanced LIGO UK 16 September 2009

UIM18P Drive Unit Test Results

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.

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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

UIM DRIVE
COMPLETED UNIT TEST PLAN

Unit…………………UIM18P………Serial No ………….. UIM18P
Test Engineer …….XEN
Date ………………16/9/9

Drive Card ID………….. UIM18P
Monitor Card ID ……….. MON18P

Contents

1. Description

2. Test Equipment

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4. Continuity Checks

5. Test Set Up

6. Power

7. Relay operation

8. Current Monitor Tests

9. Voltage Monitor Tests

10. Corner Frequency Tests

11. Noise Tests

12. Distortion

13. Final Assembly Tests

1. Description

The UIM Driver Unit will be used to control the 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 UIM mirror in a Quad assembly. It works in conjunction with the OSEM coil and position sensor units. One UIM unit controls four OSEMs.

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

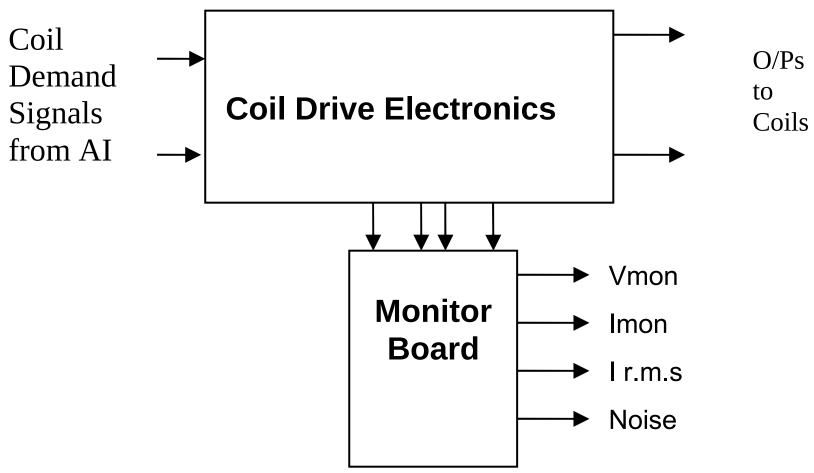


FIG. 1 UIM Driver Unit Block Diagram

Each UIM 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…………………UIM18P………Serial No …………… UIM18P
Test Engineer …….XEN
Date ………………16/9/9

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
DVM	FLUKE	115	
V/I Calibrator	Time Electronics	1044	
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-Tech	ISR622	
PSU x 2	Farnell	L30-2	

Unit…………………UIM18P………Serial No …………… UIM18P
Test Engineer …….XEN
Date ………………16/9/9

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment:

Good

Links:

Check that links W3, W4 and W5 are present on each channel of the Drive board. If not, connect them.

Unit…………………UIM18P………Serial No …………… UIM18P
Test Engineer …….XEN
Date ………………16/9/9

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	√

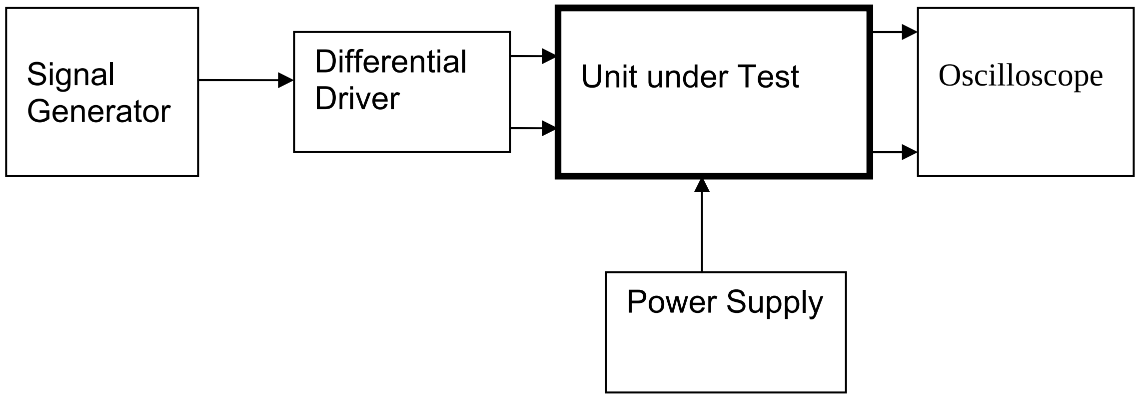
LED Monitors

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	√

5. 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…………………UIM18P………Serial No …………… UIM18P
Test Engineer …….XEN
Date ………………16/9/9

6. 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)
500mA	400mA

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…………………UIM18P………Serial No …………… UIM18P
Test Engineer …….XEN
Date ………………16/9/9

7. Relay Operation

Connect the test unit to the Binary IO inputs.

Operate switches and check that LEDs are on when the relays are switched on, and off when they are switched off:

Relay	LED Operation					
	Filter 1		Filter 2		Filter 2	
	ON	OFF	ON	OFF	ON	OFF
Ch1	√	√	√	√	√	√
Ch2	√	√	√	√	√	√
Ch3	√	√	√	√	√	√
Ch4	√	√	√	√	√	√

This indicates that the relays are operating, and that the talk back contacts work OK.

Unit…………………UIM18P………Serial No …………… UIM18P
Test Engineer …….XEN
Date ………………16/9/9

8. Current Monitor tests

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

Connect the 39 ohm dummy loads to the coil drive output. Connect the differential driver to the input, fed by the signal generator. Set the signal generator to 4v at 100 Hz.

Switch out the filters.
Use the true r.m.s meter to measure the r.m.s voltage between test points TP7 and TP11 on the drive board. Adjust the signal generator unit the until this voltage is 3v r.m.s.

Connect a scope probe to each end of one of the load resistors. Set up the scope to differentially observe the voltage across the load resistor. Check that it is a sine wave.

Measure and record the output from each current monitors, and each of the RMS circuits. Set the meter to r.m.s for the “current monitor” readings (ac signal), and to dc when measuring the r.m.s outputs (dc signal).

The theoretical output is 0.995v.

Ch.	Monitor Connector	Parameter	Theoretical Value	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	0.95v to 1.05 v r.m.s	0.9961	√
	Pin 1	RMS Current	0.95 v to 1.05 v dc	0.9986	√
2	Pin 5	Current Monitor	0.95 v to 1.05 v r.m.s	0.9972	√
	Pin 4	RMS Current	0.95 v to 1.05 v dc	1.0021	√
3	Pin 8	Current Monitor	0.95 v to 1.05 v r.m.s	0.9960	√
	Pin 7	RMS Current	0.95 v to 1.05 v dc	0.9981	√
4	Pin 11	Current Monitor	0.95 v to 1.05 v r.m.s	0.9947	√
	Pin 10	RMS Current	0.95 v to 1.05 v dc	0.9956	√

Unit…………………UIM18P………Serial No …………… UIM18P
Test Engineer …….XEN
Date ………………16/9/9

9. 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 TP7 and TP11 at 100 Hz.
Adjust the signal generator to give a voltage to 3v r.m.s 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	1.0018	0.95v to 1.05v	√
2	Pins 3,11	Pin 6	1.0010	0.95v to 1.05v	√
3	Pins 5,13	Pin 9	1.0010	0.95v to 1.05v	√
4	Pins 7, 15	Pin 12	1.0022	0.95v to 1.05v	√

Measurements may be used using a 25 way break out box, or a 25 way connector on the V, I and r.m.s connector.

10. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct. There are two possible ways of performing this test depending on available equipment. Either 8.1 or 8.2 should be conducted (it is not necessary to do both).

10.1 Using a Signal Generator

Apply a signal to the input, amplitude 1v peak, Frequency 100Hz via the differential driver, to the Drive Input.

.

Switch out all the filter stages. Measure and record the peak differential output between the outputs of each channel, using two oscilloscope channels in differential mode.

	Coil Drive output pins	Pk/pk Output	Specification	Pass/Fail
Ch1	1 and 9		4.8v to 5v	
Ch2	3 and 11		4.8v to 5v	
Ch3	5 and 13		4.8v to 5v	
Ch4	7 and 15		4.8v to 5v	

Switch in each filter in turn and measure and record the peak output at 1Hz, 10 Hz, and 1 KHz.

1Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				3.3v to 3.7v	
Ch2	3 and 11				3.3v to 3.7v	
Ch3	5 and 13				3.3v to 3.7v	
Ch4	7 and 15				3.3v to 3.7v	

10Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.48 to 0.75v	
Ch2	3 and 11				0.48 to 0.75v	
Ch3	5 and 13				0.48 to 0.75v	
Ch4	7 and 15				0.48 to 0.75v	

1 KHz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.4v to 0.5v	
Ch2	3 and 11				0.4v to 0.5v	
Ch3	5 and 13				0.4v to 0.5v	
Ch4	7 and 15				0.4v to 0.5v	

Unit…………………UIM18P………Serial No …………… UIM18P
Test Engineer …….XEN
Date ………………16/9/9

10.2. Using the Dynamic Signal Analyser

With all filters switched in, measure the frequency response of each channel in turn between 0.1 Hz and 1KHz. If a fast turn around is required, limit the measurement to the frequency range to between 1 Hz and 1KHz. Measure the gain at the spot frequencies below and record them.

Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.3	**6.6 to 8.7**	√
1Hz	-0.7	**-0.2 to -2**	√
10Hz	-44	**-41 to -52**	√
100Hz	-53	**-51 to -58**	√
1KHz	-53	**-51 to -58**	√

Channel 2

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.5	**6.6 to 8.7**	√
1Hz	-1.0	**-0.2 to -2**	√
10Hz	-44	**-41 to -52**	√
100Hz	-53	**-51 to -58**	√
1KHz	-53	**-51 to -58**	√

Channel 3

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.2	**6.6 to 8.7**	√
1Hz	-1.0	**-0.2 to -2**	√
10Hz	-44	**-41 to -52**	√
100Hz	-53	**-51 to -58**	√
1KHz	-53	**-51 to -58**	√

Channel 4

Frequency	Gain (dB)	Expected Gain	Pass/Fail
0.1 Hz	8.4	**6.6 to 8.7**	√
1Hz	-1.0	**-0.2 to -2**	√
10Hz	-44	**-41 to -52**	√
100Hz	-53	**-51 to -58**	√
1KHz	-53	**-51 to -58**	√

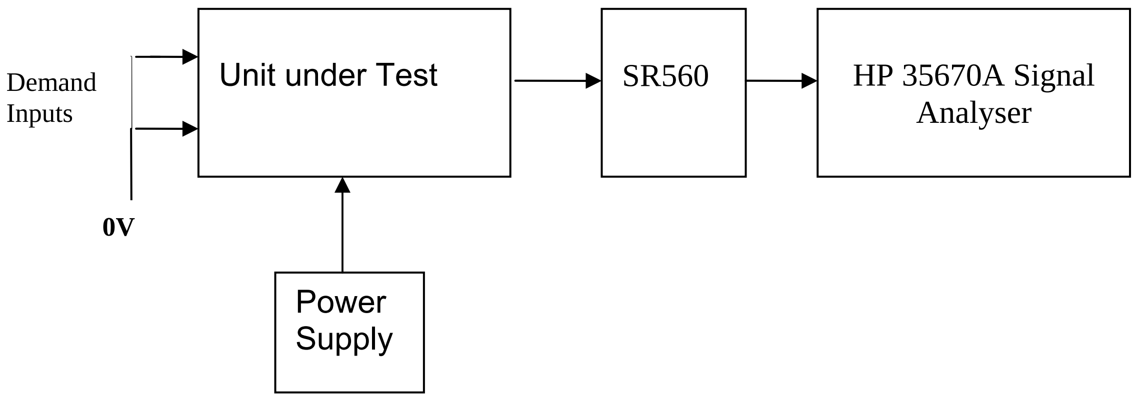
Unit…………………UIM18P………Serial No …………… UIM18P
Test Engineer …….RMC
Date ………………28/8/9

11. Noise Tests

Ensure the filter links W2, W3, W4 and W5 are present on each channel.

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, and readings should be made when the ambient noise is low. 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	-152.6	-93.8	-153.8
Ch2	-152.6	-96.5	-156.5
Ch3	-152.6	-91.6	-151.6
Ch4	-152.6	-94.4	-154.4

Channel 3 is 1 dB out of specification.

The specification at 10 Hz is a noise current of 3 pA per root Hz. The total load resistance is 7.8k. The permitted noise voltage from the amplifiers is therefore 23.4 nA/ /√Hz or -152.6 dB. The SR560 is set to a gain of 1000 (60dB) so 60dB needs to be subtracted from the reading.

Unit…………………UIM18P………Serial No …………… UIM18P
Test Engineer …….XEN
Date ………………16/9/9

12. Distortion

No filters. Increase input voltage to 10v peak, f = 1KHz. Dummy 39 Ohm loads. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit…………………UIM18P………Serial No …………… UIM18P
Test Engineer ………RMC
Date …………………28/9/9

13. Final Assembly Tests

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 all the LEDs are nicely centred. √

7. Check that links W3, W4 and W5 are in place. √

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

UoB box ID	
Driver board ID	
Driver board Drawing No/Issue No	
Driver board Serial Number	
Monitor board ID	
Monitor board Drawing No/Issue No	
Monitor board Serial Number	

9. Check the security of any modification wires. None

10. Visually inspect. √

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

    Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T0900236-v3 Advanced LIGO UK 16 September 2009

UIM19P Drive Unit Test Results

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.

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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

UIM DRIVE
COMPLETED UNIT TEST PLAN

Unit……………………….UIM19P……..Serial No …… UIM19P
Test Engineer ………XEN
Date …………………16/9/9

Drive Card ID…………… UIM19P
Monitor Card ID ……….. MON19P

Contents

1. Description

2. Test Equipment

3. Inspection

4. Continuity Checks

5. Test Set Up

6. Power

7. Relay operation

8. Current Monitor Tests

9. Voltage Monitor Tests

10. Corner Frequency Tests

11. Noise Tests

12. Distortion

13. Final Assembly Tests

1. Description

The UIM Driver Unit will be used to control the 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 UIM mirror in a Quad assembly. It works in conjunction with the OSEM coil and position sensor units. One UIM unit controls four OSEMs.

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

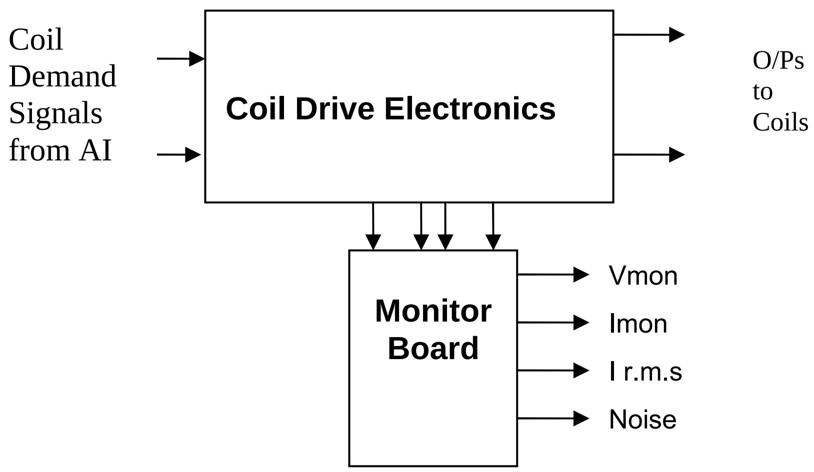


FIG. 1 UIM Driver Unit Block Diagram

Each UIM 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.........................UIM19P.........Serial No UIM19P
Test Engineer ....XEN
Date 16/9/9

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
DVM	FLUKE	115	
V/I Calibrator	Time Electronics	1044	
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-Tech	ISR622	
PSU x 2	Farnell	L30-2	

Unit………………………UIM19P………Serial No …… UIM19P
Test Engineer ………XEN
Date …………………16/9/9

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment:

Good

Links:

Check that links W3, W4 and W5 are present on each channel of the Drive board. If not, connect them.

Unit……………………….UIM19P………Serial No …… UIM19P
Test Engineer ………XEN
Date …………………16/9/9

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	√

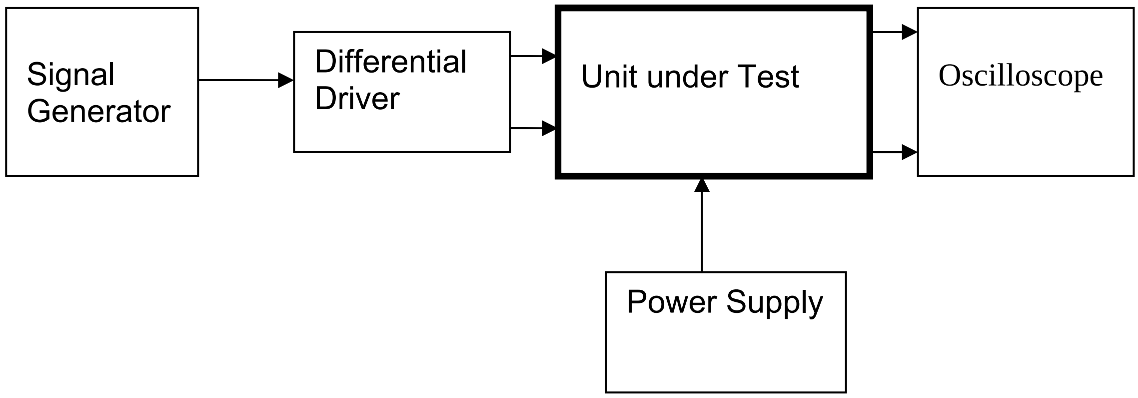
LED Monitors

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	√

5. 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……………………….UIM19P………Serial No …… UIM19P
Test Engineer ………XEN
Date …………………16/9/9

6. 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)
500mA	400mA

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……………………….UIM19P………Serial No …… UIM19P
Test Engineer ………XEN
Date …………………16/9/9

7. Relay Operation

Connect the test unit to the Binary IO inputs.

Operate switches and check that LEDs are on when the relays are switched on, and off when they are switched off:

Relay	**LED Operation**					
	Filter 1		**Filter 2**		**Filter 2**	
	ON	**OFF**	**ON**	**OFF**	**ON**	**OFF**
Ch1	√	√	√	√	√	√
Ch2	√	√	√	√	√	√
Ch3	√	√	√	√	√	√
Ch4	√	√	√	√	√	√

This indicates that the relays are operating, and that the talk back contacts work OK.

Unit……………………….UIM19P………Serial No …… UIM19P
Test Engineer ………XEN
Date …………………16/9/9

8. Current Monitor tests

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

Connect the 39 ohm dummy loads to the coil drive output. Connect the differential driver to the input, fed by the signal generator. Set the signal generator to 4v at 100 Hz.

Switch out the filters.
Use the true r.m.s meter to measure the r.m.s voltage between test points TP7 and TP11 on the drive board. Adjust the signal generator unit the until this voltage is 3v r.m.s.

Connect a scope probe to each end of one of the load resistors. Set up the scope to differentially observe the voltage across the load resistor. Check that it is a sine wave.

Measure and record the output from each current monitors, and each of the RMS circuits. Set the meter to r.m.s for the "current monitor" readings (ac signal), and to dc when measuring the r.m.s outputs (dc signal).

The theoretical output is 0.995v.

Ch.	Monitor Connector	Parameter	Theoretical Value	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	0.95v to 1.05 v r.m.s	0.9970	√
	Pin 1	RMS Current	0.95 v to 1.05 v dc	1.0051	√
2	Pin 5	Current Monitor	0.95 v to 1.05 v r.m.s	0.9977	√
	Pin 4	RMS Current	0.95 v to 1.05 v dc	0.9974	√
3	Pin 8	Current Monitor	0.95 v to 1.05 v r.m.s	0.9976	√
	Pin 7	RMS Current	0.95 v to 1.05 v dc	0.9998	√
4	Pin 11	Current Monitor	0.95 v to 1.05 v r.m.s	0.9968	√
	Pin 10	RMS Current	0.95 v to 1.05 v dc	1.0000	√

Unit……………………….UIM19P………Serial No …… UIM19P
Test Engineer ………XEN
Date …………………16/9/9

9. 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 TP7 and TP11 at 100 Hz.
Adjust the signal generator to give a voltage to 3v r.m.s 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	1.0012	0.95v to 1.05v	√
2	Pins 3,11	Pin 6	1.0013	0.95v to 1.05v	√
3	Pins 5,13	Pin 9	1.0022	0.95v to 1.05v	√
4	Pins 7, 15	Pin 12	1.0007	0.95v to 1.05v	√

Measurements may be used using a 25 way break out box, or a 25 way connector on the V, I and r.m.s connector.

10. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct. There are two possible ways of performing this test depending on available equipment. Either 8.1 or 8.2 should be conducted (it is not necessary to do both).

10.1 Using a Signal Generator

Apply a signal to the input, amplitude 1v peak, Frequency 100Hz via the differential driver, to the Drive Input.

.

Switch out all the filter stages. Measure and record the peak differential output between the outputs of each channel, using two oscilloscope channels in differential mode.

	Coil Drive output pins	Pk/pk Output	Specification	Pass/Fail
Ch1	1 and 9		4.8v to 5v	
Ch2	3 and 11		4.8v to 5v	
Ch3	5 and 13		4.8v to 5v	
Ch4	7 and 15		4.8v to 5v	

Switch in each filter in turn and measure and record the peak output at 1Hz, 10 Hz, and 1 KHz.

1Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				3.3v to 3.7v	
Ch2	3 and 11				3.3v to 3.7v	
Ch3	5 and 13				3.3v to 3.7v	
Ch4	7 and 15				3.3v to 3.7v	

10Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.48 to 0.75v	
Ch2	3 and 11				0.48 to 0.75v	
Ch3	5 and 13				0.48 to 0.75v	
Ch4	7 and 15				0.48 to 0.75v	

1 KHz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.4v to 0.5v	
Ch2	3 and 11				0.4v to 0.5v	
Ch3	5 and 13				0.4v to 0.5v	
Ch4	7 and 15				0.4v to 0.5v	

Unit……………………….UIM19P………Serial No …… UIM19P
Test Engineer ………XEN
Date …………………16/9/9

10.2. Using the Dynamic Signal Analyser

With all filters switched in, measure the frequency response of each channel in turn between 0.1 Hz and 1KHz. If a fast turn around is required, limit the measurement to the frequency range to between 1 Hz and 1KHz. Measure the gain at the spot frequencies below and record them.

Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.4	6.6 to 8.7	√
1Hz	-0.7	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 2

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.4	6.6 to 8.7	√
1Hz	-0.7	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 3

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.2	6.6 to 8.7	√
1Hz	-0.8	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 4

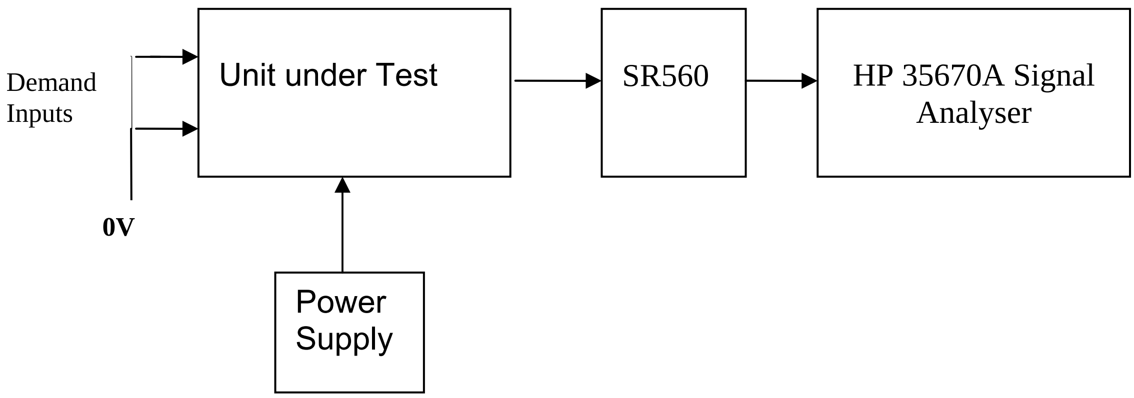
Frequency	Gain (dB)	Expected Gain	Pass/Fail
0.1 Hz	8.2	6.6 to 8.7	√
1Hz	-0.7	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Unit……………………….UIM19P………Serial No …… UIM19P
Test Engineer ………RMC
Date …………………28/9/9

11. Noise Tests

Ensure the filter links W2, W3, W4 and W5 are present on each channel.

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, and readings should be made when the ambient noise is low. 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	-152.6	-94.1	-154.1
Ch2	-152.6	-93.2	-153.2
Ch3	-152.6	-92.9	-152.9
Ch4	-152.6	-94.0	-154.0

All channels are within specification

The specification at 10 Hz is a noise current of 3 pA per root Hz. The total load resistance is 7.8k. The permitted noise voltage from the amplifiers is therefore 23.4 nA/ /√Hz or -152.6 dB. The SR560 is set to a gain of 1000 (60dB) so 60dB needs to be subtracted from the reading.

Unit……………………….UIM19P………Serial No …… UIM19P
Test Engineer ………XEN
Date …………………16/9/9

12. Distortion

No filters. Increase input voltage to 10v peak, f = 1KHz. Dummy 39 Ohm loads. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit…………………………UIM19P………Serial No …… UIM19P
Test Engineer ………RMC
Date …………………5/10/9

13. Final Assembly Tests

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 all the LEDs are nicely centred. √

7. Check that links W3, W4 and W5 are in place. √

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

UoB box ID	UIM19P
Driver board ID	UIM19P
Driver board Drawing No/Issue No	D070481-4-K
Driver board Serial Number	UIM19P
Monitor board ID	MON19P
Monitor board Drawing No/Issue No	D070480-4-K
Monitor board Serial Number	UIM MON19P

9. Check the security of any modification wires.

10. Visually inspect. √

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

Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T0900236-v3 Advanced LIGO UK 16 September 2009

UIM20P Drive Unit Test Results

R. M. Cutler, University of Birmingham

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of the Advanced LIGO Project, prepared by members of the UK team.

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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

UIM DRIVE
COMPLETED UNIT TEST PLAN

Unit...............UIM20P..........................Serial No UIM20P
Test Engineer ....XEN
Date 16/9/9

Drive Card ID...............UIM20P
Monitor Card ID ……….. MON20P

Contents

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13. Final Assembly Tests

1. Description

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

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

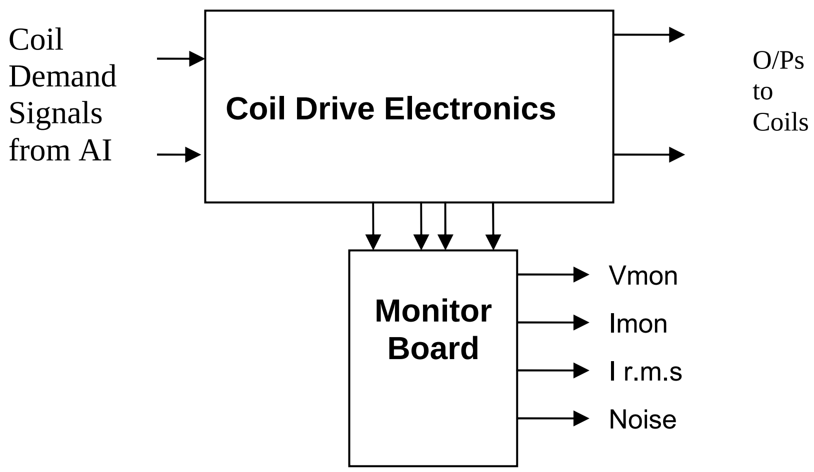


FIG. 1 UIM Driver Unit Block Diagram

Each UIM 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……………UIM20P………………………Serial No …………UIM20P
Test Engineer ………XEN
Date …………………16/9/9

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
DVM	FLUKE	115	
V/I Calibrator	Time Electronics	1044	
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-Tech	ISR622	
PSU x 2	Farnell	L30-2	

Unit……………UIM20P……………………….Serial No …………UIM20P
Test Engineer ………XEN
Date …………………16/9/9

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment:

Good

Links:

Check that links W3, W4 and W5 are present on each channel of the Drive board. If not, connect them.

Unit…………….UIM20P……………………….Serial No …………UIM20P
Test Engineer ………XEN
Date …………………16/9/9

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	√

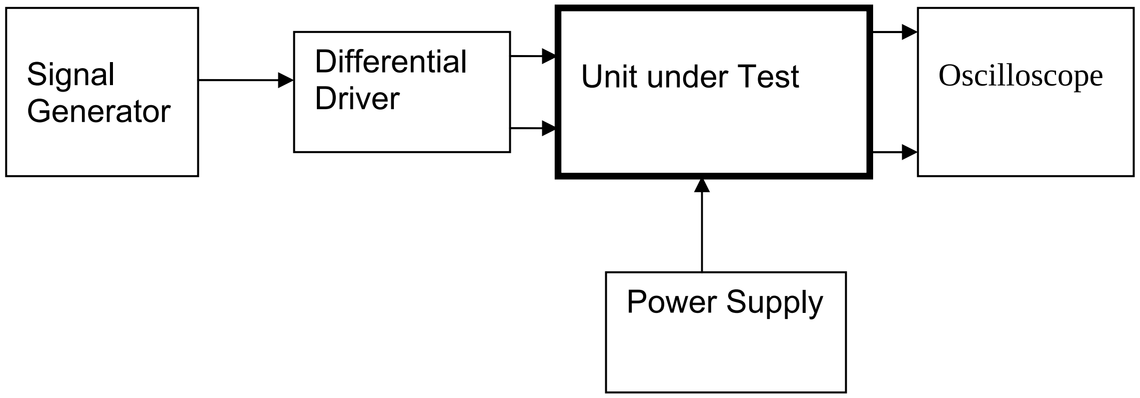
LED Monitors

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	√

5. 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……………UIM20P………………………Serial No …………UIM20P
Test Engineer ………XEN
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6. 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)
500mA	400mA

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……………UIM20P………………………Serial No …………UIM20P
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7. Relay Operation

Connect the test unit to the Binary IO inputs.

Operate switches and check that LEDs are on when the relays are switched on, and off when they are switched off:

Relay	LED Operation					
	Filter 1		Filter 2		Filter 2	
	ON	OFF	ON	OFF	ON	OFF
Ch1	√	√	√	√	√	√
Ch2	√	√	√	√	√	√
Ch3	√	√	√	√	√	√
Ch4	√	√	√	√	√	√

This indicates that the relays are operating, and that the talk back contacts work OK.

Unit……………UIM20P………………………Serial No ………..UIM20P
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8. Current Monitor tests

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

Connect the 39 ohm dummy loads to the coil drive output. Connect the differential driver to the input, fed by the signal generator. Set the signal generator to 4v at 100 Hz.

Switch out the filters.
Use the true r.m.s meter to measure the r.m.s voltage between test points TP7 and TP11 on the drive board. Adjust the signal generator unit the until this voltage is 3v r.m.s.

Connect a scope probe to each end of one of the load resistors. Set up the scope to differentially observe the voltage across the load resistor. Check that it is a sine wave.

Measure and record the output from each current monitors, and each of the RMS circuits. Set the meter to r.m.s for the “current monitor” readings (ac signal), and to dc when measuring the r.m.s outputs (dc signal).

The theoretical output is 0.995v.

Ch.	Monitor Connector	Parameter	Theoretical Value	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	0.95v to 1.05 v r.m.s	0.9972	√
	Pin 1	RMS Current	0.95 v to 1.05 v dc	0.9965	√
2	Pin 5	Current Monitor	0.95 v to 1.05 v r.m.s	0.9974	√
	Pin 4	RMS Current	0.95 v to 1.05 v dc	0.9981	√
3	Pin 8	Current Monitor	0.95 v to 1.05 v r.m.s	0.9979	√
	Pin 7	RMS Current	0.95 v to 1.05 v dc	0.9951	√
4	Pin 11	Current Monitor	0.95 v to 1.05 v r.m.s	0.9972	√
	Pin 10	RMS Current	0.95 v to 1.05 v dc	0.9970	√

Unit……………UIM20P………………………Serial No …………UIM20P
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9. 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 TP7 and TP11 at 100 Hz.
Adjust the signal generator to give a voltage to 3v r.m.s 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	1.0020	0.95v to 1.05v	√
2	Pins 3,11	Pin 6	1.0032	0.95v to 1.05v	√
3	Pins 5,13	Pin 9	1.0029	0.95v to 1.05v	√
4	Pins 7, 15	Pin 12	1.0025	0.95v to 1.05v	√

Measurements may be used using a 25 way break out box, or a 25 way connector on the V, I and r.m.s connector.

10. Corner frequency tests

The purpose of this test is to verify that the frequency response of each filter stage of each channel is correct. There are two possible ways of performing this test depending on available equipment. Either 8.1 or 8.2 should be conducted (it is not necessary to do both).

10.1 Using a Signal Generator

Apply a signal to the input, amplitude 1v peak, Frequency 100Hz via the differential driver, to the Drive Input.

.

Switch out all the filter stages. Measure and record the peak differential output between the outputs of each channel, using two oscilloscope channels in differential mode.

	Coil Drive output pins	Pk/pk Output	Specification	Pass/Fail
Ch1	1 and 9		4.8v to 5v	
Ch2	3 and 11		4.8v to 5v	
Ch3	5 and 13		4.8v to 5v	
Ch4	7 and 15		4.8v to 5v	

Switch in each filter in turn and measure and record the peak output at 1Hz, 10 Hz, and 1 KHz.

1Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				3.3v to 3.7v	
Ch2	3 and 11				3.3v to 3.7v	
Ch3	5 and 13				3.3v to 3.7v	
Ch4	7 and 15				3.3v to 3.7v	

10Hz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.48 to 0.75v	
Ch2	3 and 11				0.48 to 0.75v	
Ch3	5 and 13				0.48 to 0.75v	
Ch4	7 and 15				0.48 to 0.75v	

1 KHz

	Coil Drive output pins	F1	F2	F3	Specification	Pass/Fail
Ch1	1 and 9				0.4v to 0.5v	
Ch2	3 and 11				0.4v to 0.5v	
Ch3	5 and 13				0.4v to 0.5v	
Ch4	7 and 15				0.4v to 0.5v	

Unit……………UIM20P………………………Serial No …………UIM20P
Test Engineer ………XEN
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10.2. Using the Dynamic Signal Analyser

With all filters switched in, measure the frequency response of each channel in turn between 0.1 Hz and 1KHz. If a fast turn around is required, limit the measurement to the frequency range to between 1 Hz and 1KHz. Measure the gain at the spot frequencies below and record them.

Connect the 39 ohm loads across each coil output to simulate the coils.

Channel 1

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.3	6.6 to 8.7	√
1Hz	-1.0	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 2

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.3	6.6 to 8.7	√
1Hz	-1.0	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 3

Frequency	Gain (dB)	Expected Gain (dB)	Pass/Fail
0.1 Hz	8.4	6.6 to 8.7	√
1Hz	-0.9	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Channel 4

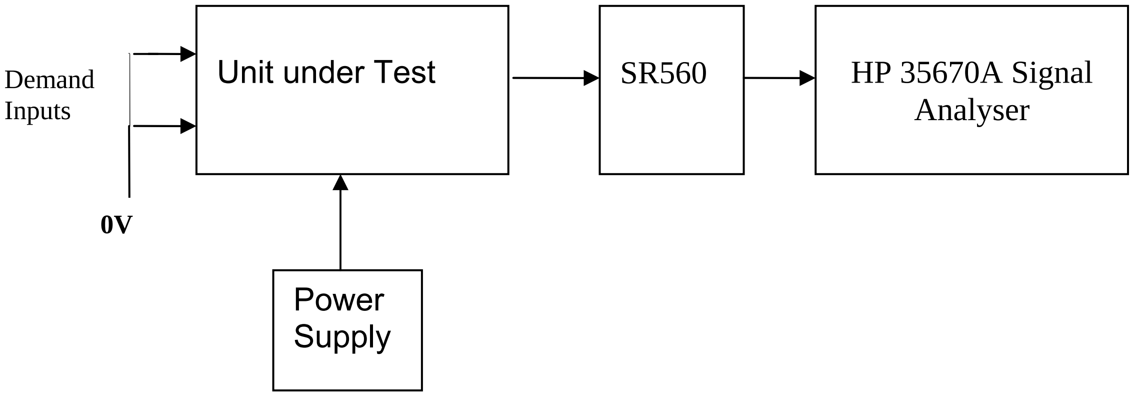
Frequency	Gain (dB)	Expected Gain	Pass/Fail
0.1 Hz	8.4	6.6 to 8.7	√
1Hz	-1.1	-0.2 to -2	√
10Hz	-44	-41 to -52	√
100Hz	-53	-51 to -58	√
1KHz	-53	-51 to -58	√

Unit...............UIM20P..........................Serial No UIM20P
Test Engineer ....RMC
Date 28/9/9

11. Noise Tests

Ensure the filter links W2, W3, W4 and W5 are present on each channel.

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, and readings should be made when the ambient noise is low. 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	-152.6	-94.5	-154.5
Ch2	-152.6	-94.7	-154.7
Ch3	-152.6	-94.9	-154.9
Ch4	-152.6	-93.4	-153.4

All channels are in specification.

The specification at 10 Hz is a noise current of 3 pA per root Hz. The total load resistance is 7.8k. The permitted noise voltage from the amplifiers is therefore 23.4 nA/ /√Hz or -152.6 dB. The SR560 is set to a gain of 1000 (60dB) so 60dB needs to be subtracted from the reading.

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12. Distortion

No filters. Increase input voltage to 10v peak, f = 1KHz. Dummy 39 Ohm loads. Check the differential voltage across each load for distortion with an analogue oscilloscope.

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

Unit...............UIM20P..........................Serial No UIM20P
Test Engineer ....RMC
Date 7/10/9

13. Final Assembly Tests

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 all the LEDs are nicely centred. √

7. Check that links W3, W4 and W5 are in place. √

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

UoB box ID	UIM20P
Driver board ID	UIM20P
Driver board Drawing No/Issue No	D070481-4-K
Driver board Serial Number	UIM20P
Monitor board ID	MON20P
Monitor board Drawing No/Issue No	D070481-4-K
Monitor board Serial Number	UIM MON20P

9. Check the security of any modification wires. None

10. Visually inspect. √

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

Check all external screws for tightness. √