LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1000571-v1 Advanced LIGO UK 28 September 2010

Transmon Coil Drive Unit Test Plan

R. M. Cutler, University of Birmingham

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

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

TRANSMON COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit………………Transmon_15……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

Drive Card ID……Transmon_15………………
Monitor Card ID…Mon143………..…..………..

Contents

1. Description

The Transmon, or Transmission Monitor Coil Driver Unit is used to control the position of the Transmission Monitor suspension in the Advanced LIGO Gravity wave experiment. It is functionally identical to the Triple Top Drive Board.

It controls the current in the coil which provides the magnetic force which controls the position of the Transmission Monitor suspension. It works in conjunction with the OSEM coil and position sensor units. One Transmon coil drive unit controls four OSEMs.

The Transmon 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 Transmon Coil Drive Unit also passes the amplified signals from the Photodiodes, which detect the position of the suspension, back to the control electronics without processing them in any way.

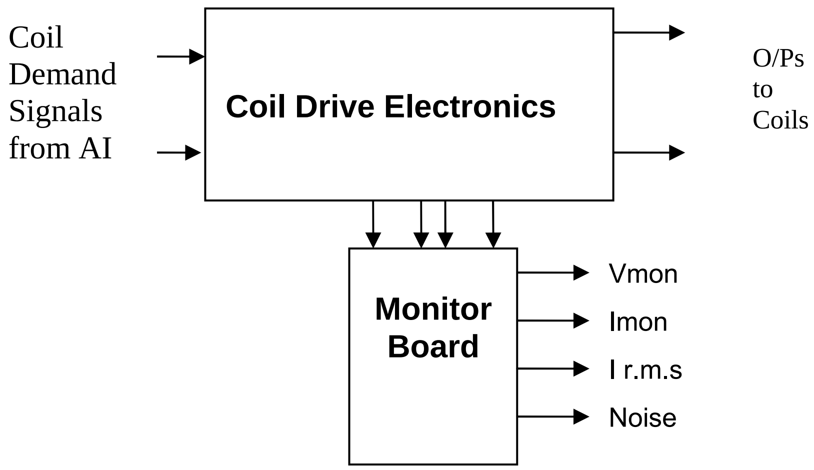


FIG. 1 Transmon Driver Unit Block Diagram

Each Transmon 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……………….Transmon_15……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

2. Test Equipment

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

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

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	
DVM	TENMA	72-7730	

Unit……………….Transmon_15…………………….Serial No ……………………………….
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

Unit………………Transmon_15……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

4. Continuity Checks

Use a multi-meter to check the connections below.

Photodiode outputs

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

LED Monitors

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

Power Supply to Satellite box

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

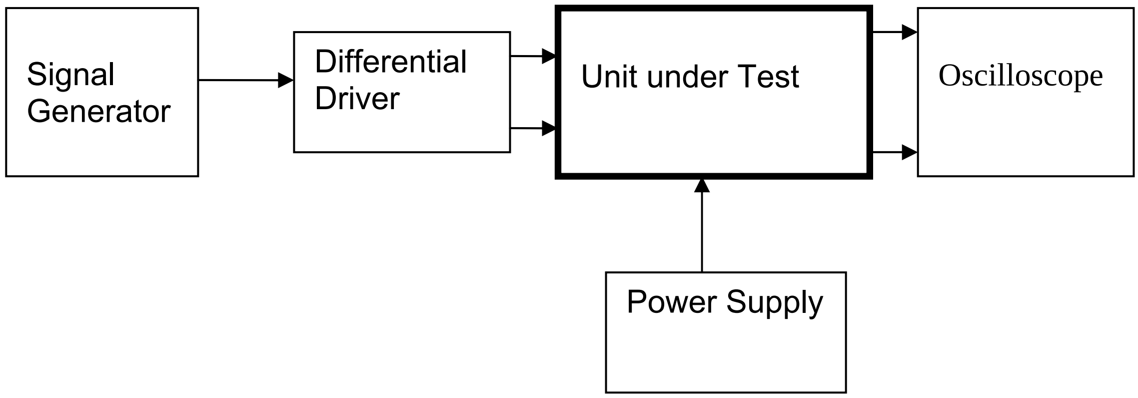
Unit……………….Transmon_15……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

Isolation Checks

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

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

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……………….Transmon_15…………………….Serial No ……………………………….
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

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)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

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

Unit……………….Transmon_15……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

7. Relay Operation

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

Filter

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

TEST SWITCHES

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

Unit……………….Transmon_15…………………….Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

8. Current Monitor tests

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

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

Remove all links W4 and W5.

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

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

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 2v peak appears across each resistor.

Connect a true r.m.s meter across the channel 4 resistor, and carefully adjust the signal generator to give an r.m.s reading of 1.5 volts.

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

Channel	Monitor Connector	Parameter	Theoretical Value (+/- .1v)	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	1.01V r.m.s	1.02	√
	Pin 1	RMS Current	1.01V dc	1.02	√
2	Pin 5	Current Monitor	1.01V r.m.s	1.02	√
	Pin 4	RMS Current	1.01V dc	1.02	√
3	Pin 8	Current Monitor	1.01V r.m.s	1.02	√
	Pin 7	RMS Current	1.01V dc	1.02	√
4	Pin 11	Current Monitor	1.01V r.m.s	1.02	√
	Pin 10	RMS Current	1.01V dc	1.02	√

Unit……………..Transmon_15……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

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 at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

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

10. Noise Monitor Tests

See Monitor re-test report.

Unit……………..Transmon_15…………………..Serial No ………………………………
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Date……………..2/12/10..………………

12. Corner frequency tests

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

Use the Dynamic Signal Analyser and signal generator.

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

Channel 1

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

Channel 2

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.1		
10Hz	-30.4		
100Hz	-42.8		
1KHz	-43.2		

Channel 3

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.1		
10Hz	-30.4		
100Hz	-42.8		
1KHz	-43.2		

Channel 4

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

0.1 Hz measurements with the signal generator and oscilloscope

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

Unit………………Transmon_15……………………Serial No ………………………………
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12. Distortion

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

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

13. Full Load Test

Apply the DC source to the input to the differential amplifier. Connect the 39 Ohm 5 watt loads to the outputs.
Increase the input voltage to 10v with respect to 0v, and monitor the temperatures of the drive amplifiers. If their temperature increases above 100°C, flag a problem!
Leave running for 10 minutes, then record the temperatures of drive amplifiers, and the differential output voltages from the amplifier (TP9 and TP13).

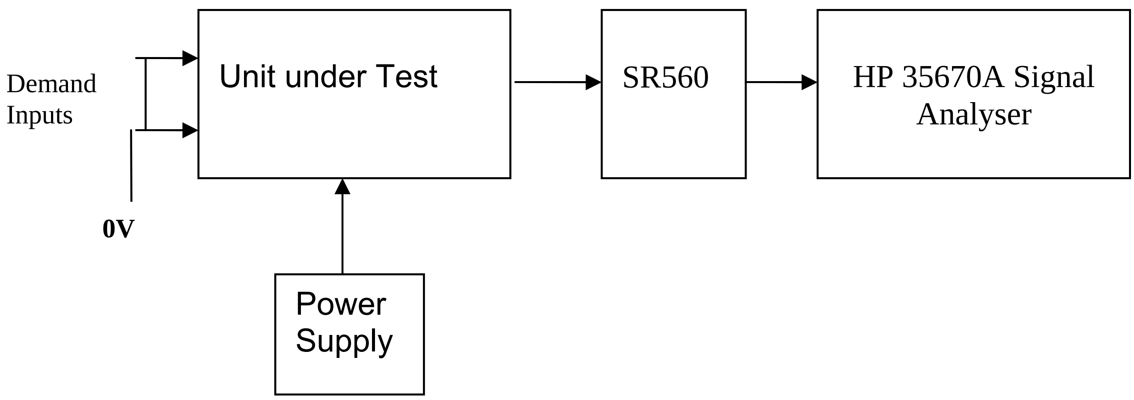
The output voltages should be recorded.

Output	Voltage	> 24v?	DRIVER	Temperature	<60°C?
CH1 Positive	24.4	√	CH1 IC1	36.0	√
CH1 Negative			CH1 IC5	37.9	√
CH2 Positive	24.4	√	CH2 IC1	38.9	√
CH2 Negative			CH2 IC5	37.0	√
CH3 Positive	24.4	√	CH3 IC1	36.2	√
CH3 Negative			CH3 IC5	37.2	√
CH4 Positive	24.4	√	CH4 IC1	36.0	√
CH4 Negative			CH4 IC5	37.7	√

Unit……………..Transmon_15……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

14. Noise Tests

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



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-161.15dB	-99.5	-159.5
Ch2	-161.15dB	-101.9	-161.9
Ch3	-161.15dB	-102.1	-162.1
Ch4	-161.15dB	-100.9	-160.9

Notes:
Specified noise output current at 10 Hz = 73 pA/√Hz
Total output resistance = 120 Ohms
Amplifier noise voltage should therefore = 8.76nV/√Hz or -161.15 dB

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

Unit……………….Transmon_15……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10...………………

15. Full Current Tests

High power dummy loads are needed for this test.

With the dummy loads removed, measure and record the value of each resistor. Nominal 39 Ohm power resistors should be used.

Plug in the dummy load.

Remove the filter links.

Drive the unit with a 10v peak sine wave on each channel, which should measure 7.07 volts on a true r.m.s meter.

Measure the voltage across each load resistor and record it. Calculate the current through each resistor, and compare with the specification. If a true r.m.s meter is used to make the measurement, compare with the r.m.s specification

Channel	R =	V=	Therefore I =	Spec (peak)	Spec (r.m.s)	Pass?
1	39.3	5.53	140.7mA	>200mA	>141.4mA	√
2	39.4	5.55	140.9mA	>200mA	>141.4mA	√
3	39.3	5.53	140.7mA	>200mA	>141.4mA	√
4	39.4	5.55	140.9mA	>200mA	>141.4mA	√

(The measured output is slightly low due to not being able to adjust the input voltage to the correct level of 7.07V)

Unit……………Transmon_15………………………Serial No ………………………………
Test Engineer……RMC..………
Date………..……7/12/10…..……

16. Final Assembly Checks

1. Remove the lid of the box. √

2. Unplug all external connections. √

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

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

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

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

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

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

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

UoB box ID	Transmon 15
Driver board ID	Transmon 15
Driver board Drawing No/Issue No	D1001650_v2
Driver board Serial Number	Transmon 15
Monitor board ID	MON143
Monitor board Drawing No/Issue No	D070480_5_K
Monitor board Serial Number	MON143

10. Check the security of any modification wires. √

11. Visually inspect. √

12. Put the lid on and fasten all screws,

    Check all external screws for tightness.

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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

TRANSMON COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit………………Transmon_1……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

Drive Card ID……Transmon_1………………
Monitor Card ID…Mon199……..…….………..

Contents

1. Description

The Transmon, or Transmission Monitor Coil Driver Unit is used to control the position of the Transmission Monitor suspension in the Advanced LIGO Gravity wave experiment. It is functionally identical to the Triple Top Drive Board.

It controls the current in the coil which provides the magnetic force which controls the position of the Transmission Monitor suspension. It works in conjunction with the OSEM coil and position sensor units. One Transmon coil drive unit controls four OSEMs.

The Transmon 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 Transmon Coil Drive Unit also passes the amplified signals from the Photodiodes, which detect the position of the suspension, back to the control electronics without processing them in any way.

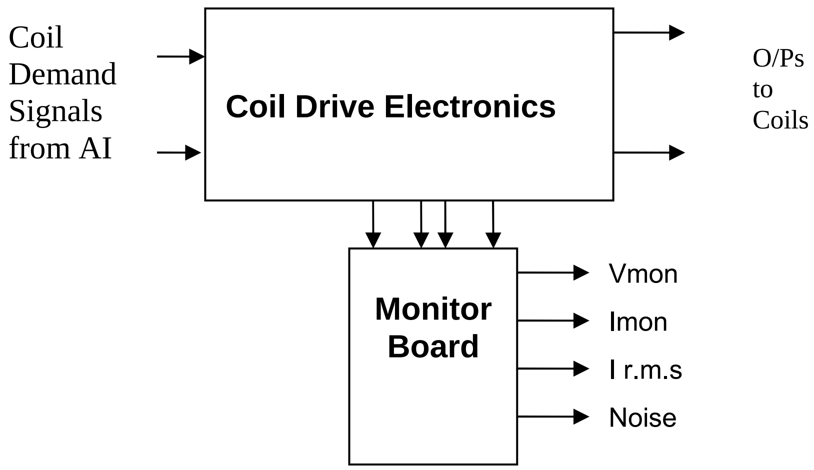


FIG. 1 Transmon Driver Unit Block Diagram

Each Transmon 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……………….Transmon_1……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

2. Test Equipment

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

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

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	
DVM	TENMA	72-7730	

Unit……………..Transmon_1……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

Unit……………….Transmon_1…………………….Serial No ……………………………….
Test Engineer…..Xen……………………
Date……………..23/11/10………………

4. Continuity Checks

Use a multi-meter to check the connections below.

Photodiode outputs

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

LED Monitors

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

Power Supply to Satellite box

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

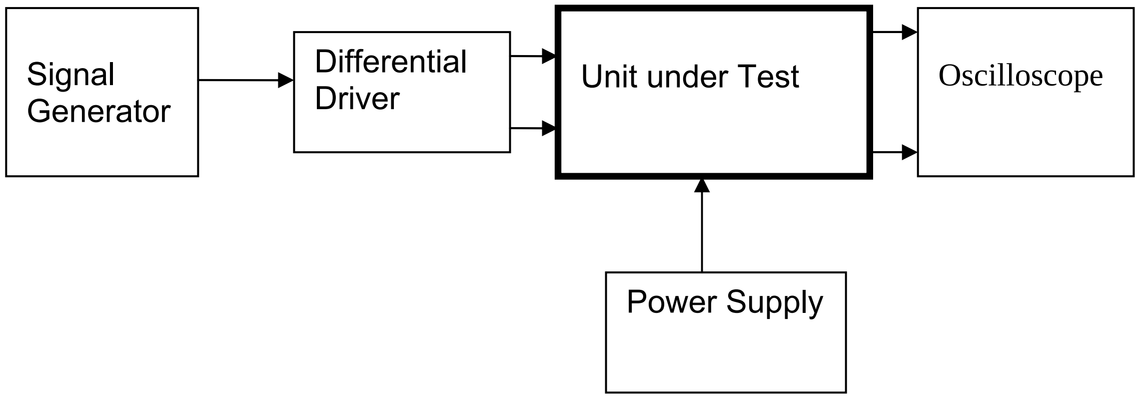
Unit……………….Transmon_1……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

Isolation Checks

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

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

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………………Transmon_1……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

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)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

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

Unit……………..Transmon_1……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

7. Relay Operation

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

Filter

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

TEST SWITCHES

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

Unit……………….Transmon_1…………………….Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

8. Current Monitor tests

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

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

Remove all links W4 and W5.

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

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

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 2v peak appears across each resistor.

Connect a true r.m.s meter across the channel 4 resistor, and carefully adjust the signal generator to give an r.m.s reading of 1.5 volts.

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

Channel	Monitor Connector	Parameter	Theoretical Value (+/- .1v)	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	1.01V r.m.s	1.02	√
	Pin 1	RMS Current	1.01V dc	1.02	√
2	Pin 5	Current Monitor	1.01V r.m.s	1.02	√
	Pin 4	RMS Current	1.01V dc	1.02	√
3	Pin 8	Current Monitor	1.01V r.m.s	1.02	√
	Pin 7	RMS Current	1.01V dc	1.02	√
4	Pin 11	Current Monitor	1.01V r.m.s	1.02	√
	Pin 10	RMS Current	1.01V dc	1.02	√

Unit……………….Transmon_1…………………….Serial No ……………………………….
Test Engineer…..Xen…………………….
Date……………..23/11/10………………

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 at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

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

10. Noise Monitor Tests

See Monitor re-test report.

Unit……………….Transmon_1…………………….Serial No ……………………………….
Test Engineer…..Xen…………………….
Date……………..23/11/10………………

12. Corner frequency tests

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

Use the Dynamic Signal Analyser and signal generator.

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

Channel 1

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

Channel 2

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

Channel 3

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

Channel 4

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

0.1 Hz measurements with the signal generator and oscilloscope

Frequency	Output	Expected O/P	Pass/Fail
Ch1	4.9		
Ch2	4.9		
Ch3	4.9		
Ch4	4.9		

Unit……………….Transmon_1…………………….Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

12. Distortion

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

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

13. Full Load Test

Apply the DC source to the input to the differential amplifier. Connect the 39 Ohm 5 watt loads to the outputs.
Increase the input voltage to 10v with respect to 0v, and monitor the temperatures of the drive amplifiers. If their temperature increases above 100°C, flag a problem!
Leave running for 10 minutes, then record the temperatures of drive amplifiers, and the differential output voltages from the amplifier (TP9 and TP13).

The output voltages should be recorded.

Output	Voltage	> 24v?	DRIVER	Temperature	<60°C?
CH1 Positive	24.4	√	CH1 IC1	40.4	√
CH1 Negative			CH1 IC5	41.6	√
CH2 Positive	24.4	√	CH2 IC1	39.4	√
CH2 Negative			CH2 IC5	39.4	√
CH3 Positive	24.4	√	CH3 IC1	40.1	√
CH3 Negative			CH3 IC5	43.3	√
CH4 Positive	24.4	√	CH4 IC1	40.6	√
CH4 Negative			CH4 IC5	39.2	√

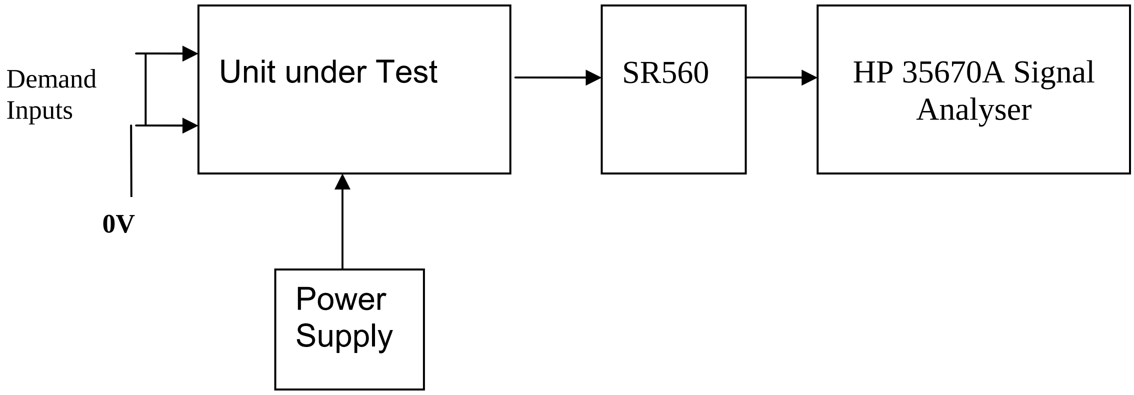
Unit……………..Transmon_1……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

14. Noise Tests

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

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

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



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-161.15dB	-100.0	-160.0
Ch2	-161.15dB	-100.6	-160.6
Ch3	-161.15dB	-101.1	-161.1
Ch4	-161.15dB	-100.6	-160.6

Notes:
Specified noise output current at 10 Hz = 73 pA/√Hz
Total output resistance = 120 Ohms
Amplifier noise voltage should therefore = 8.76nV/√Hz or -161.15 dB

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

Unit………………Transmon_1……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

15. Full Current Tests

High power dummy loads are needed for this test.

With the dummy loads removed, measure and record the value of each resistor. Nominal 39 Ohm power resistors should be used.

Plug in the dummy load.

Remove the filter links.

Drive the unit with a 10v peak sine wave on each channel, which should measure 7.07 volts on a true r.m.s meter.

Measure the voltage across each load resistor and record it. Calculate the current through each resistor, and compare with the specification. If a true r.m.s meter is used to make the measurement, compare with the r.m.s specification

Channel	R =	V=	Therefore I =	Spec (peak)	Spec (r.m.s)	Pass?
1	39.3	5.54	141.0mA	>200mA	>141.4mA	√
2	39.4	5.55	140.9mA	>200mA	>141.4mA	√
3	39.3	5.54	141.0mA	>200mA	>141.4mA	√
4	39.4	5.55	140.9mA	>200mA	>141.4mA	√

(The measured output is slightly low due to not being able to adjust the input voltage to the correct level of 7.07V)

Unit…………………Transmon1…………Serial No ………………………………
Test Engineer…………………RMC
Date………………..…………29/11/10

16. Final Assembly Checks

1. Remove the lid of the box.√

2. Unplug all external connections. √

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

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

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

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

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

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

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

UoB box ID	TRANSMON1
Driver board ID	TRANSMON1
Driver board Drawing No/Issue No	D1001650_V2
Driver board Serial Number	TRANSMON1
Monitor board ID	MON199
Monitor board Drawing No/Issue No	D070480_5_K
Monitor board Serial Number	MON199

10. Check the security of any modification wires. √

11. Visually inspect. √

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

    Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1000571-v1 Advanced LIGO UK 28 September 2010

Transmon Coil Drive Unit Test Plan

R. M. Cutler, University of Birmingham

Distribution of this document:
Inform aligo_sus

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

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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

TRANSMON COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit………………Transmon_2……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

Drive Card ID……Transmon_2………………
Monitor Card ID…Mon89……..………………..

Contents

1. Description

The Transmon, or Transmission Monitor Coil Driver Unit is used to control the position of the Transmission Monitor suspension in the Advanced LIGO Gravity wave experiment. It is functionally identical to the Triple Top Drive Board.

It controls the current in the coil which provides the magnetic force which controls the position of the Transmission Monitor suspension. It works in conjunction with the OSEM coil and position sensor units. One Transmon coil drive unit controls four OSEMs.

The Transmon 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 Transmon Coil Drive Unit also passes the amplified signals from the Photodiodes, which detect the position of the suspension, back to the control electronics without processing them in any way.

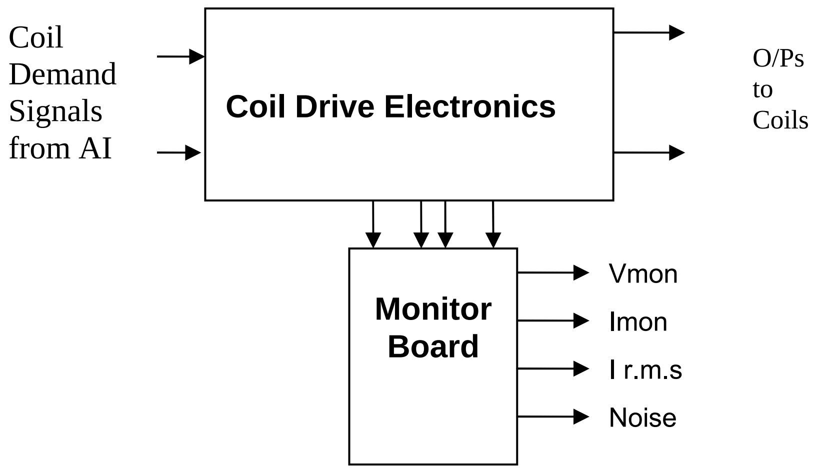


FIG. 1 Transmon Driver Unit Block Diagram

Each Transmon 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……………….Transmon_2……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

2. Test Equipment

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

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

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	
DVM	TENMA	72-7730	

Unit……………….Transmon_2……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

Unit……………….Transmon_2…………………….Serial No ……………………………….
Test Engineer…..Xen……………………
Date……………..23/11/10………………

4. Continuity Checks

Use a multi-meter to check the connections below.

Photodiode outputs

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

LED Monitors

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

Power Supply to Satellite box

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

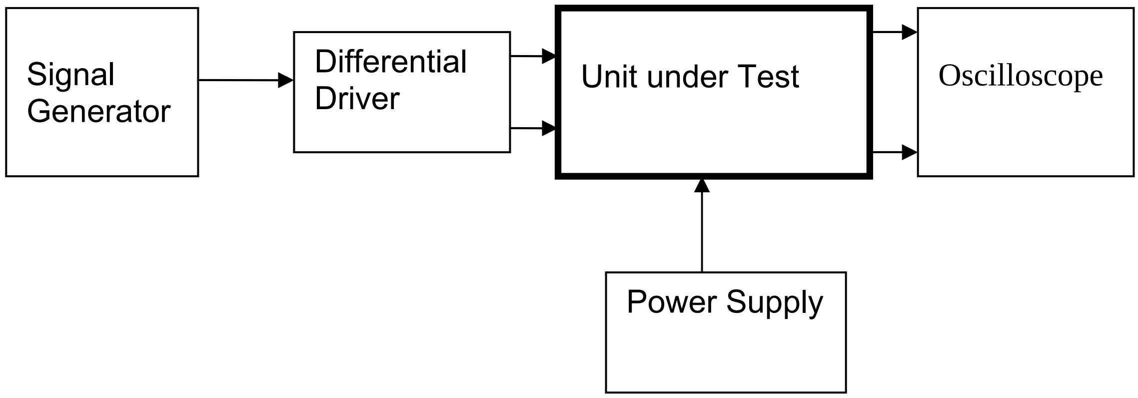
Unit………………Transmon_2……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

Isolation Checks

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

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

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………………Transmon_2……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

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)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

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

Unit……………..Transmon_2……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

7. Relay Operation

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

Filter

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

TEST SWITCHES

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

Unit……………..Transmon_2……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

8. Current Monitor tests

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

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

Remove all links W4 and W5.

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

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

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 2v peak appears across each resistor.

Connect a true r.m.s meter across the channel 4 resistor, and carefully adjust the signal generator to give an r.m.s reading of 1.5 volts.

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

Channel	Monitor Connector	Parameter	Theoretical Value (+/- .1v)	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	1.01V r.m.s	1.02	√
	Pin 1	RMS Current	1.01V dc	1.02	√
2	Pin 5	Current Monitor	1.01V r.m.s	1.02	√
	Pin 4	RMS Current	1.01V dc	1.02	√
3	Pin 8	Current Monitor	1.01V r.m.s	1.02	√
	Pin 7	RMS Current	1.01V dc	1.02	√
4	Pin 11	Current Monitor	1.01V r.m.s	1.02	√
	Pin 10	RMS Current	1.01V dc	1.02	√

Unit……………..Transmon_2……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

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 at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

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

10. Noise Monitor Tests

See Monitor re-test report.

Unit……………….Transmon_2…………………….Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

12. Corner frequency tests

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

Use the Dynamic Signal Analyser and signal generator.

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

Channel 1

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

Channel 2

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

Channel 3

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

Channel 4

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

0.1 Hz measurements with the signal generator and oscilloscope

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

Unit……………..Transmon_2……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

12. Distortion

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

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

13. Full Load Test

Apply the DC source to the input to the differential amplifier. Connect the 39 Ohm 5 watt loads to the outputs.
Increase the input voltage to 10v with respect to 0v, and monitor the temperatures of the drive amplifiers. If their temperature increases above 100°C, flag a problem!
Leave running for 10 minutes, then record the temperatures of drive amplifiers, and the differential output voltages from the amplifier (TP9 and TP13).

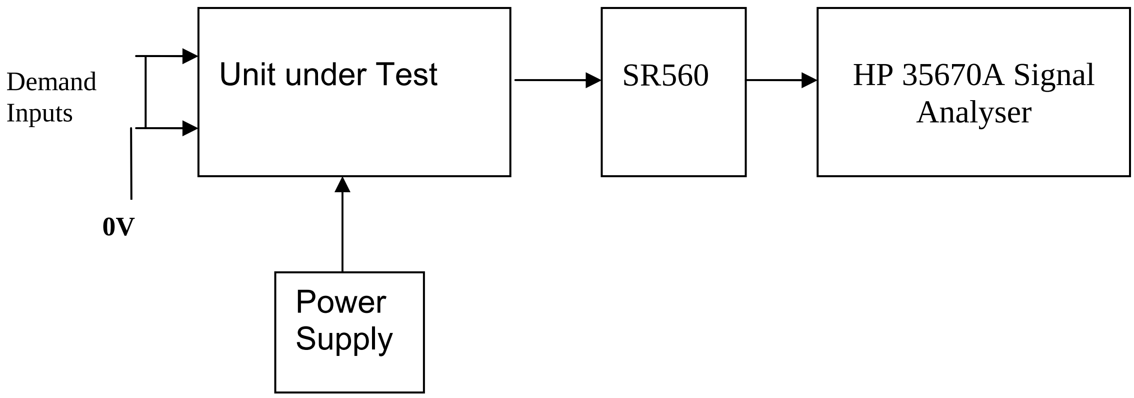
The output voltages should be recorded.

Output	**Voltage**	**> 24v?**	**DRIVER**	**Temperature**	**<60°C?**
CH1 Positive	24.4	√	**CH1 IC1**	34.8	√
CH1 Negative			**CH1 IC5**	39.4	√
CH2 Positive	24.4	√	**CH2 IC1**	37.7	√
CH2 Negative			**CH2 IC5**	40.1	√
CH3 Positive	24.4	√	**CH3 IC1**	38.4	√
CH3 Negative			**CH3 IC5**	43.6	√
CH4 Positive	24.4	√	**CH4 IC1**	37.7	√
CH4 Negative			**CH4 IC5**	38.7	√

Unit……………..Transmon_2…………………..Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

14. Noise Tests

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



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-161.15dB	-101.0	-161.0
Ch2	-161.15dB	-99.0	-159.0
Ch3	-161.15dB	-102.3	-162.3
Ch4	-161.15dB	-102.1	-162.1

Notes:
Specified noise output current at 10 Hz = 73 pA/√Hz
Total output resistance = 120 Ohms
Amplifier noise voltage should therefore = 8.76nV/√Hz or -161.15 dB

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

Unit..................Transmon_2........................Serial No ....
Test Engineer.....Xen........................
Date.................23/11/10..................

15. Full Current Tests

High power dummy loads are needed for this test.

With the dummy loads removed, measure and record the value of each resistor. Nominal 39 Ohm power resistors should be used.

Plug in the dummy load.

Remove the filter links.

Drive the unit with a 10v peak sine wave on each channel, which should measure 7.07 volts on a true r.m.s meter.

Measure the voltage across each load resistor and record it. Calculate the current through each resistor, and compare with the specification. If a true r.m.s meter is used to make the measurement, compare with the r.m.s specification

Channel	R =	V=	Therefore I =	Spec (peak)	Spec (r.m.s)	Pass?
1	39.3	5.54	141.0mA	>200mA	>141.4mA	√
2	39.4	5.55	140.9mA	>200mA	>141.4mA	√
3	39.3	5.53	140.7mA	>200mA	>141.4mA	√
4	39.4	5.54	140.6mA	>200mA	>141.4mA	√

(The measured output is slightly low due to not being able to adjust the input voltage to the correct level of 7.07V)

Unit……………………….Transmon 2………Serial No ………………………………
Test Engineer………………RMC
Date……………….………29/11/10

16. Final Assembly Checks

1. Remove the lid of the box. √

2. Unplug all external connections. √

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

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

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

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

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

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

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

UoB box ID	TRANSMON2
Driver board ID	TRANSMON2
Driver board Drawing No/Issue No	D1001650_V2
Driver board Serial Number	TRANSMON2
Monitor board ID	MON89
Monitor board Drawing No/Issue No	D070480_5_K
Monitor board Serial Number	MON89

10. Check the security of any modification wires. √

11. Visually inspect. √

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

    Check all external screws for tightness. √

LIGO-T1000571-v1 Advanced LIGO UK 28 September 2010

Transmon Coil Drive Unit Test Plan

R. M. Cutler, University of Birmingham

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

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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

TRANSMON COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit………………Transmon_3……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

Drive Card ID……Transmon_3………………
Monitor Card ID…Mon139…………..………..

Contents

1. Description

The Transmon, or Transmission Monitor Coil Driver Unit is used to control the position of the Transmission Monitor suspension in the Advanced LIGO Gravity wave experiment. It is functionally identical to the Triple Top Drive Board.

It controls the current in the coil which provides the magnetic force which controls the position of the Transmission Monitor suspension. It works in conjunction with the OSEM coil and position sensor units. One Transmon coil drive unit controls four OSEMs.

The Transmon 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 Transmon Coil Drive Unit also passes the amplified signals from the Photodiodes, which detect the position of the suspension, back to the control electronics without processing them in any way.

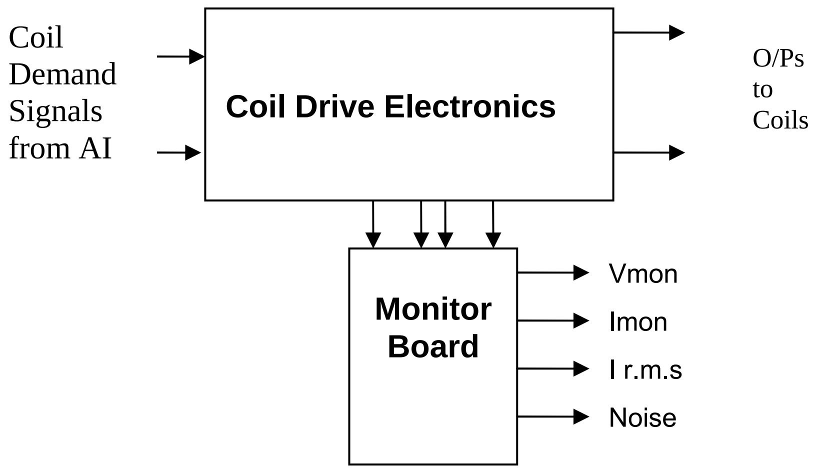


FIG. 1 Transmon Driver Unit Block Diagram

Each Transmon 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……………….Transmon_3……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

2. Test Equipment

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

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

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	
DVM	TENMA	72-7730	

Unit………………Transmon_3……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

Unit………………Transmon_3……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

4. Continuity Checks

Use a multi-meter to check the connections below.

Photodiode outputs

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

LED Monitors

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

Power Supply to Satellite box

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

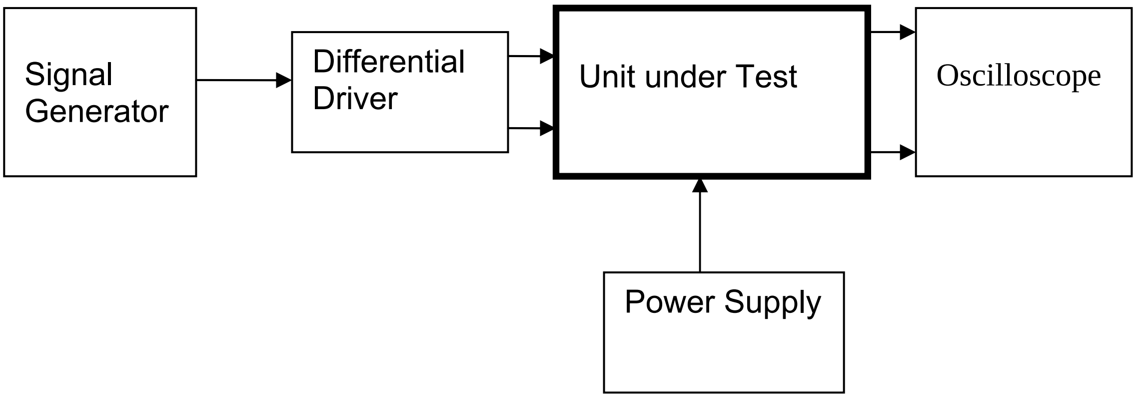
Unit……………..Transmon_3……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

Isolation Checks

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

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

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……………….Transmon_3……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

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)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

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

Unit……………….Transmon_3…………………….Serial No ……………………………….
Test Engineer…..Xen…………………….
Date……………..23/11/10………………

7. Relay Operation

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

Filter

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

TEST SWITCHES

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

Unit..................Transmon_3........................Serial No ....
Test Engineer.....Xen........................
Date................23/11/10..................

8. Current Monitor tests

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

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

Remove all links W4 and W5.

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

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

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 2v peak appears across each resistor.

Connect a true r.m.s meter across the channel 4 resistor, and carefully adjust the signal generator to give an r.m.s reading of 1.5 volts.

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

Channel	Monitor Connector	Parameter	Theoretical Value (+/- .1v)	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	1.01V r.m.s	1.02	√
	Pin 1	RMS Current	1.01V dc	1.02	√
2	Pin 5	Current Monitor	1.01V r.m.s	1.02	√
	Pin 4	RMS Current	1.01V dc	1.03	√
3	Pin 8	Current Monitor	1.01V r.m.s	1.02	√
	Pin 7	RMS Current	1.01V dc	1.02	√
4	Pin 11	Current Monitor	1.01V r.m.s	1.02	√
	Pin 10	RMS Current	1.01V dc	1.02	√

Unit……………..Transmon_3……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..23/11/10………………

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 at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

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

10. Noise Monitor Tests

See Monitor re-test report.

Unit.................Transmon_3.......................Serial No ....
Test Engineer.....Xen.......................
Date................23/11/10.................

12. Corner frequency tests

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

Use the Dynamic Signal Analyser and signal generator.

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

Channel 1

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

Channel 2

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

Channel 3

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.4		
10Hz	-30.0		
100Hz	-42.8		
1KHz	-43.2		

Channel 4

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

0.1 Hz measurements with the signal generator and oscilloscope

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

Unit……………..Transmon_3……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

12. Distortion

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

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

13. Full Load Test

Apply the DC source to the input to the differential amplifier. Connect the 39 Ohm 5 watt loads to the outputs.
Increase the input voltage to 10v with respect to 0v, and monitor the temperatures of the drive amplifiers. If their temperature increases above 100°C, flag a problem!
Leave running for 10 minutes, then record the temperatures of drive amplifiers, and the differential output voltages from the amplifier (TP9 and TP13).

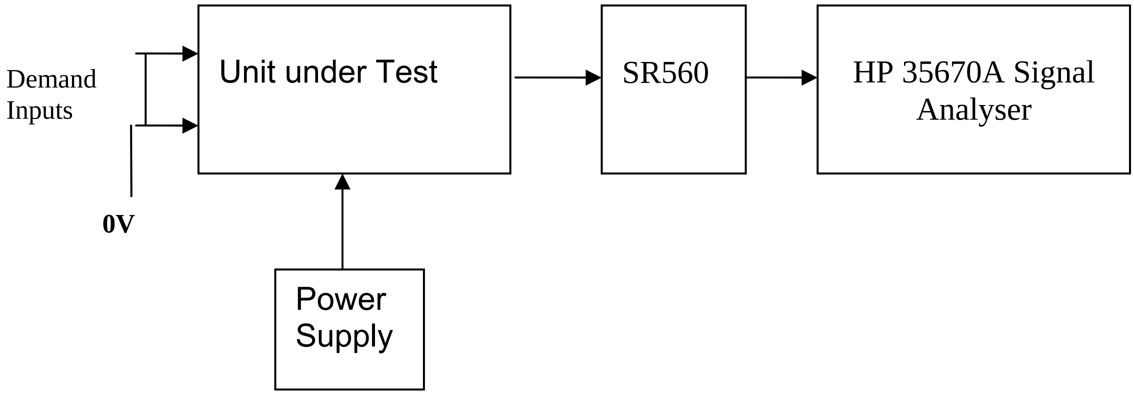
The output voltages should be recorded.

Output	**Voltage**	**> 24v?**	**DRIVER**	**Temperature**	**<60°C?**
CH1 Positive	24.4	√	**CH1 IC1**	37.5	√
CH1 Negative			**CH1 IC5**	38.4	√
CH2 Positive	24.4	√	**CH2 IC1**	41.4	√
CH2 Negative			**CH2 IC5**	39.7	√
CH3 Positive	24.4	√	**CH3 IC1**	39.9	√
CH3 Negative			**CH3 IC5**	43.1	√
CH4 Positive	24.4	√	**CH4 IC1**	39.2	√
CH4 Negative			**CH4 IC5**	40.9	√

Unit……………..Transmon_3……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

14. Noise Tests

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



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-161.15dB	-101.5	-161.5
Ch2	-161.15dB	-101.6	-161.6
Ch3	-161.15dB	-101.1	-161.1
Ch4	-161.15dB	-100.3	-160.3

Notes:
Specified noise output current at 10 Hz = 73 pA/√Hz
Total output resistance = 120 Ohms
Amplifier noise voltage should therefore = 8.76nV/√Hz or -161.15 dB

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

Unit..................Transmon_3........................Serial No ....
Test Engineer.....Xen........................
Date.................24/11/10..................

15. Full Current Tests

High power dummy loads are needed for this test.

With the dummy loads removed, measure and record the value of each resistor. Nominal 39 Ohm power resistors should be used.

Plug in the dummy load.

Remove the filter links.

Drive the unit with a 10v peak sine wave on each channel, which should measure 7.07 volts on a true r.m.s meter.

Measure the voltage across each load resistor and record it. Calculate the current through each resistor, and compare with the specification. If a true r.m.s meter is used to make the measurement, compare with the r.m.s specification

Channel	R =	V=	Therefore I =	Spec (peak)	Spec (r.m.s)	Pass?
1	39.3	5.54	141.0mA	>200mA	>141.4mA	√
2	39.4	5.56	141.1mA	>200mA	>141.4mA	√
3	39.3	5.55	141.2mA	>200mA	>141.4mA	√
4	39.4	5.54	140.6mA	>200mA	>141.4mA	√

(The measured output is slightly low due to not being able to adjust the input voltage to the correct level of 7.07V)

Unit……………………….Transmon3……………Serial No ………………………………
Test Engineer………………RMC…
Date………………….………29/11/10………..

16. Final Assembly Checks

1. Remove the lid of the box. √

2. Unplug all external connections. √

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

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

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

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

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

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

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

UoB box ID	TRANSMON3
Driver board ID	TRANSMON3
Driver board Drawing No/Issue No	D1001650_V2
Driver board Serial Number	TRANSMON3
Monitor board ID	MON139
Monitor board Drawing No/Issue No	D070480_5_K
Monitor board Serial Number	MON139

10. Check the security of any modification wires. √

11. Visually inspect. √

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

Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1000571-v1	Advanced LIGO UK	28 September 2010

Transmon Coil Drive Unit Test Plan

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

TRANSMON COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit………………Transmon_4……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

Drive Card ID……Transmon_4………………
Monitor Card ID…Mon138……………….……..

Contents

1. Description

The Transmon, or Transmission Monitor Coil Driver Unit is used to control the position of the Transmission Monitor suspension in the Advanced LIGO Gravity wave experiment. It is functionally identical to the Triple Top Drive Board.

It controls the current in the coil which provides the magnetic force which controls the position of the Transmission Monitor suspension. It works in conjunction with the OSEM coil and position sensor units. One Transmon coil drive unit controls four OSEMs.

The Transmon 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 Transmon Coil Drive Unit also passes the amplified signals from the Photodiodes, which detect the position of the suspension, back to the control electronics without processing them in any way.

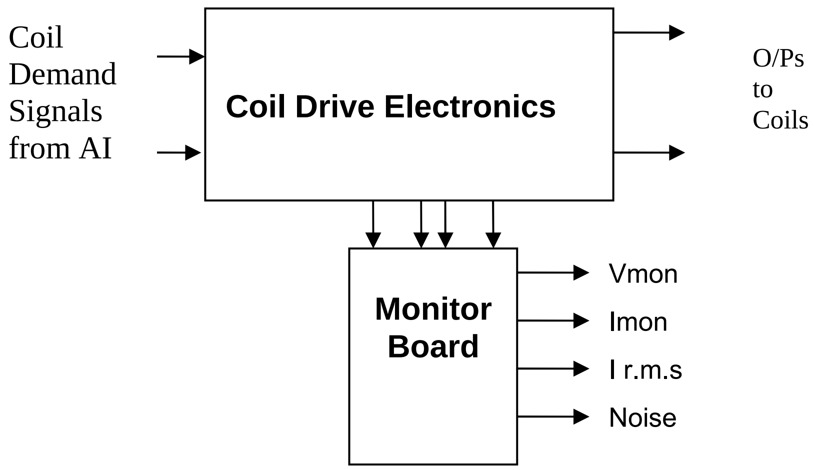


FIG. 1 Transmon Driver Unit Block Diagram

Each Transmon 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……………..Transmon_4……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

2. Test Equipment

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

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

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	
DVM	TENMA	72-7730	

Unit……………..Transmon_4……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

Unit………………Transmon_4……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

4. Continuity Checks

Use a multi-meter to check the connections below.

Photodiode outputs

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

LED Monitors

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

Power Supply to Satellite box

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

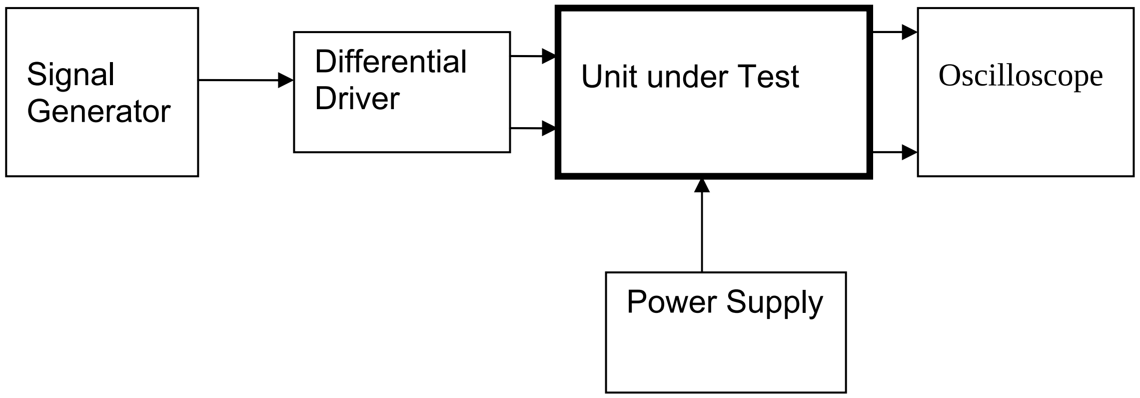
Unit………………Transmon_4……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

Isolation Checks

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

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

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.................Transmon_4.......................Serial No ....
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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)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

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

Unit…………….…Transmon_4……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

7. Relay Operation

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

Filter

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

TEST SWITCHES

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

Unit………………Transmon_4……………………Serial No ………………………………
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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.

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

Remove all links W4 and W5.

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

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

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 2v peak appears across each resistor.

Connect a true r.m.s meter across the channel 4 resistor, and carefully adjust the signal generator to give an r.m.s reading of 1.5 volts.

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

Channel	Monitor Connector	Parameter	Theoretical Value (+/- .1v)	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	1.01V r.m.s	1.02	√
	Pin 1	RMS Current	1.01V dc	1.02	√
2	Pin 5	Current Monitor	1.01V r.m.s	1.02	√
	Pin 4	RMS Current	1.01V dc	1.02	√
3	Pin 8	Current Monitor	1.01V r.m.s	1.02	√
	Pin 7	RMS Current	1.01V dc	1.02	√
4	Pin 11	Current Monitor	1.01V r.m.s	1.02	√
	Pin 10	RMS Current	1.01V dc	1.02	√

Unit.................Transmon_4.......................Serial No ....
Test Engineer.....Xen.......................
Date................24/11/10.................

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 at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

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

10. Noise Monitor Tests

See Monitor re-test report.

Unit.................Transmon_4......................Serial No ....
Test Engineer.....Xen......................
Date................24/11/10.................

12. Corner frequency tests

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

Use the Dynamic Signal Analyser and signal generator.

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

Channel 1

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

Channel 2

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

Channel 3

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

Channel 4

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.1		
10Hz	-30.4		
100Hz	-42.8		
1KHz	-43.2		

0.1 Hz measurements with the signal generator and oscilloscope

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

Unit……………….Transmon_4…………………….Serial No ………………………………
Test Engineer…..Xen……………………
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12. Distortion

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

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

13. Full Load Test

Apply the DC source to the input to the differential amplifier. Connect the 39 Ohm 5 watt loads to the outputs.
Increase the input voltage to 10v with respect to 0v, and monitor the temperatures of the drive amplifiers. If their temperature increases above 100°C, flag a problem!
Leave running for 10 minutes, then record the temperatures of drive amplifiers, and the differential output voltages from the amplifier (TP9 and TP13).

The output voltages should be recorded.

Output	Voltage	> 24v?	DRIVER	Temperature	<60°C?
CH1 Positive	24.4	√	**CH1 IC1**	35.5	√
CH1 Negative			**CH1 IC5**	40.1	√
CH2 Positive	24.4	√	**CH2 IC1**	37.9	√
CH2 Negative			**CH2 IC5**	39.4	√
CH3 Positive	24.4	√	**CH3 IC1**	36.5	√
CH3 Negative			**CH3 IC5**	37.7	√
CH4 Positive	24.4	√	**CH4 IC1**	39.7	√
CH4 Negative			**CH4 IC5**	40.1	√

Unit……………….Transmon_4……………………Serial No ………………………………
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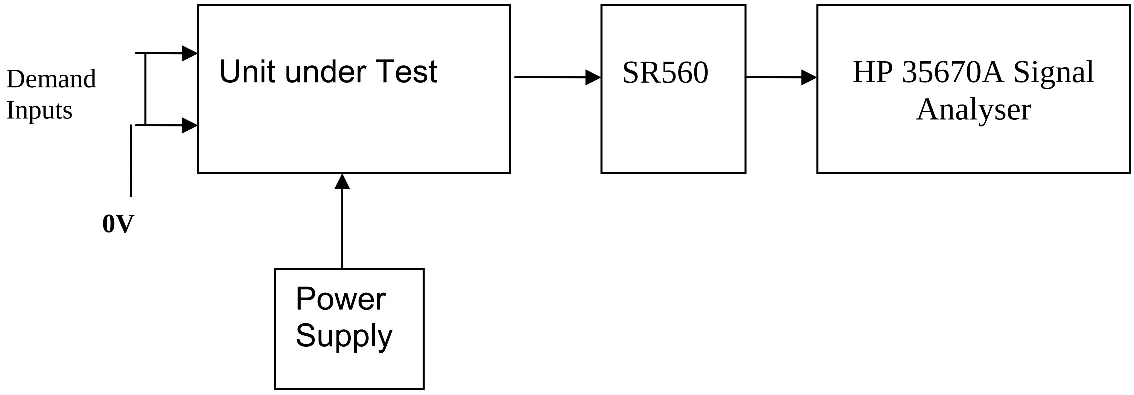
14. Noise Tests

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

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

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



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-161.15dB	-102.6	-162.6
Ch2	-161.15dB	-101.6	-161.6
Ch3	-161.15dB	-99.5	-159.5
Ch4	-161.15dB	-102.7	-162.7

Notes:
Specified noise output current at 10 Hz = 73 pA/√Hz
Total output resistance = 120 Ohms
Amplifier noise voltage should therefore = 8.76nV/√Hz or -161.15 dB

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

Unit……………..Transmon_4……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

15. Full Current Tests

High power dummy loads are needed for this test.

With the dummy loads removed, measure and record the value of each resistor. Nominal 39 Ohm power resistors should be used.

Plug in the dummy load.

Remove the filter links.

Drive the unit with a 10v peak sine wave on each channel, which should measure 7.07 volts on a true r.m.s meter.

Measure the voltage across each load resistor and record it. Calculate the current through each resistor, and compare with the specification. If a true r.m.s meter is used to make the measurement, compare with the r.m.s specification

Channel	**R =**	**V=**	**Therefore I =**	**Spec (peak)**	**Spec (r.m.s)**	**Pass?**
1	39.3	5.53	140.7mA	>200mA	>141.4mA	√
2	39.4	5.54	140.6mA	>200mA	>141.4mA	√
3	39.3	5.54	141.0mA	>200mA	>141.4mA	√
4	39.4	5.54	140.6mA	>200mA	>141.4mA	√

(The measured output is slightly low due to not being able to adjust the input voltage to the correct level of 7.07V)

Unit……………………Transmon4………………Serial No ………………………………
Test Engineer………………RMC
Date……………….………..29/11/10

16. Final Assembly Checks

1. Remove the lid of the box. √

2. Unplug all external connections. √

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

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

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

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

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

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

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

UoB box ID	TRANSMON4
Driver board ID	TRANSMON4
Driver board Drawing No/Issue No	D1001650_V2
Driver board Serial Number	TRANSMON4
Monitor board ID	MON138
Monitor board Drawing No/Issue No	D070480_5_K
Monitor board Serial Number	MON138

10. Check the security of any modification wires. √

11. Visually inspect. √

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

    Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1000571-v1	Advanced LIGO UK	28 September 2010

Transmon Coil Drive Unit Test Plan

R. M. Cutler, University of Birmingham

Distribution of this document:
Inform aligo_sus

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

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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

TRANSMON COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit………………Transmon_5……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10……………..

Drive Card ID……Transmon_5……………..
Monitor Card ID…Mon168………….………..

Contents

1. Description

The Transmon, or Transmission Monitor Coil Driver Unit is used to control the position of the Transmission Monitor suspension in the Advanced LIGO Gravity wave experiment. It is functionally identical to the Triple Top Drive Board.

It controls the current in the coil which provides the magnetic force which controls the position of the Transmission Monitor suspension. It works in conjunction with the OSEM coil and position sensor units. One Transmon coil drive unit controls four OSEMs.

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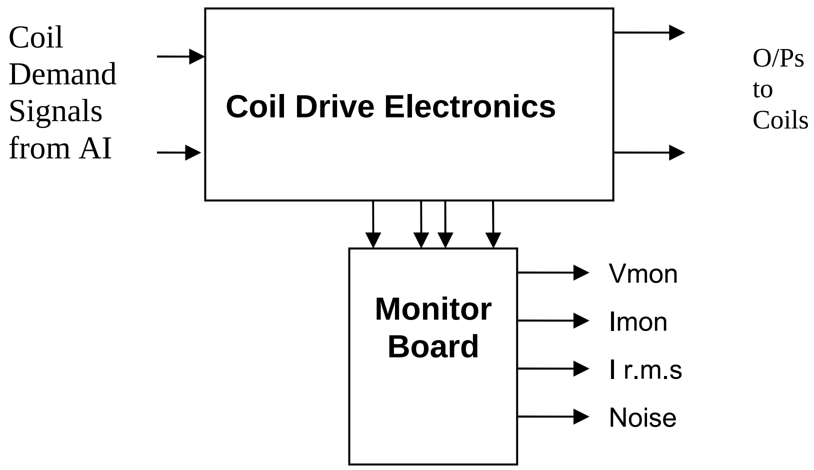

FIG. 1 Transmon Driver Unit Block Diagram

Each Transmon 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……………….Transmon_5……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

2. Test Equipment

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

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

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	
DVM	TENMA	72-7730	

Unit……………….Transmon_5…………………….Serial No ………………………………
Test Engineer…..Xen…………………….
Date……………..24/11/10………………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

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4. Continuity Checks

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1	PD1P	Photodiode A+	1	√
2	PD2P	Photodiode B+	2	√
3	PD3P	Photodiode C+	3	√
4	PD4P	Photodiode D+	4	√
5	0V	√		
6	PD1N	Photodiode A-	14	√
7	PD2N	Photodiode B-	15	√
8	PD3N	Photodiode C-	16	√
9	PD4N	Photodiode D-	17	√

LED Monitors

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

Power Supply to Satellite box

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

Unit……………..Transmon_5……………………Serial No ………………………………
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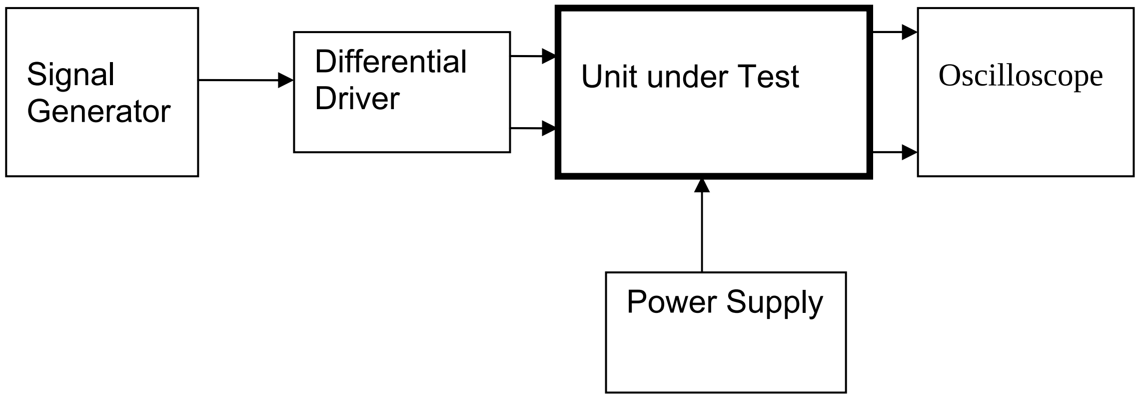
Isolation Checks

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

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

5. TEST SET UP



Note:
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Connections:

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Drive Input pins 1, 2, 3, 4 = positive input
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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……………….Transmon_5……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

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)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

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

Unit……………..Transmon_5……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

7. Relay Operation

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

Filter

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

TEST SWITCHES

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

Unit……………..Transmon_5……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

8. Current Monitor tests

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

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

Remove all links W4 and W5.

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

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

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 2v peak appears across each resistor.

Connect a true r.m.s meter across the channel 4 resistor, and carefully adjust the signal generator to give an r.m.s reading of 1.5 volts.

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

Channel	Monitor Connector	Parameter	Theoretical Value (+/- .1v)	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	1.01V r.m.s	1.02	√
	Pin 1	RMS Current	1.01V dc	1.02	√
2	Pin 5	Current Monitor	1.01V r.m.s	1.02	√
	Pin 4	RMS Current	1.01V dc	1.02	√
3	Pin 8	Current Monitor	1.01V r.m.s	1.02	√
	Pin 7	RMS Current	1.01V dc	1.02	√
4	Pin 11	Current Monitor	1.01V r.m.s	1.02	√
	Pin 10	RMS Current	1.01V dc	1.02	√

Unit……………..Transmon_5……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

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 at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

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

10. Noise Monitor Tests

See Monitor re-test report.

Unit………………Transmon_5……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

12. Corner frequency tests

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

Use the Dynamic Signal Analyser and signal generator.

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

Channel 1

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

Channel 2

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

Channel 3

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

Channel 4

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

0.1 Hz measurements with the signal generator and oscilloscope

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

Unit………………Transmon_5……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

12. Distortion

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

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

13. Full Load Test

Apply the DC source to the input to the differential amplifier. Connect the 39 Ohm 5 watt loads to the outputs.
Increase the input voltage to 10v with respect to 0v, and monitor the temperatures of the drive amplifiers. If their temperature increases above 100°C, flag a problem!
Leave running for 10 minutes, then record the temperatures of drive amplifiers, and the differential output voltages from the amplifier (TP9 and TP13).

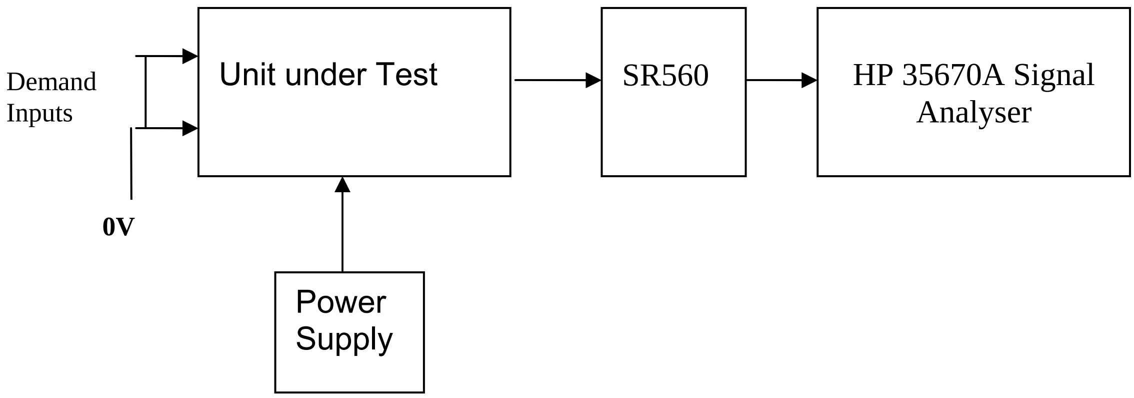
The output voltages should be recorded.

Output	Voltage	> 24v?	DRIVER	Temperature	<60°C?
CH1 Positive	24.4	√	CH1 IC1	39.9	√
CH1 Negative			CH1 IC5	41.4	√
CH2 Positive	24.4	√	CH2 IC1	40.9	√
CH2 Negative			CH2 IC5	42.6	√
CH3 Positive	24.4	√	CH3 IC1	41.1	√
CH3 Negative			CH3 IC5	40.1	√
CH4 Positive	24.4	√	CH4 IC1	39.4	√
CH4 Negative			CH4 IC5	38.7	√

Unit.................Transmon_5.......................Serial No ....
Test Engineer.....Xen.......................
Date................24/11/10.................

14. Noise Tests

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



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-161.15dB	-100.6	-160.6
Ch2	-161.15dB	-102.3	-162.3
Ch3	-161.15dB	-102.7	-162.7
Ch4	-161.15dB	-102.7	-162.7

Notes:
Specified noise output current at 10 Hz = 73 pA/√Hz
Total output resistance = 120 Ohms
Amplifier noise voltage should therefore = 8.76nV/√Hz or -161.15 dB

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

Unit.................Transmon_5.......................Serial No ....
Test Engineer.....Xen.......................
Date................24/11/10.................

15. Full Current Tests

High power dummy loads are needed for this test.

With the dummy loads removed, measure and record the value of each resistor. Nominal 39 Ohm power resistors should be used.

Plug in the dummy load.

Remove the filter links.

Drive the unit with a 10v peak sine wave on each channel, which should measure 7.07 volts on a true r.m.s meter.

Measure the voltage across each load resistor and record it. Calculate the current through each resistor, and compare with the specification. If a true r.m.s meter is used to make the measurement, compare with the r.m.s specification

Channel	R =	V=	Therefore I =	Spec (peak)	Spec (r.m.s)	Pass?
1	39.3	5.55	141.2mA	>200mA	>141.4mA	√
2	39.4	5.56	141.1mA	>200mA	>141.4mA	√
3	39.3	5.54	141.0mA	>200mA	>141.4mA	√
4	39.4	5.55	140.9mA	>200mA	>141.4mA	√

(The measured output is slightly low due to not being able to adjust the input voltage to the correct level of 7.07V)

Unit.................Transmon5.......................Serial No ....
Test Engineer...........RMC..............
Date.....................29/11/10..............

16. Final Assembly Checks

1. Remove the lid of the box.√

2. Unplug all external connections. √

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

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

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

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

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

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

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

UoB box ID	Transmon5
Driver board ID	Transmon5
Driver board Drawing No/Issue No	D1001650_V2
Driver board Serial Number	Transmon5
Monitor board ID	MON168
Monitor board Drawing No/Issue No	D070480_5_K
Monitor board Serial Number	MON168

10. Check the security of any modification wires. . √

11. Visually inspect. . √

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

Check all external screws for tightness. .√

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1000571-v1 Advanced LIGO UK 28 September 2010

Transmon Coil Drive Unit Test Plan

R. M. Cutler, University of Birmingham

Distribution of this document:
Inform aligo_sus

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

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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

TRANSMON COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit………………Transmon_6……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..25/11/10………………

Drive Card ID……Transmon_6………………
Monitor Card ID…Mon169…………….……….

Contents

1. Description

The Transmon, or Transmission Monitor Coil Driver Unit is used to control the position of the Transmission Monitor suspension in the Advanced LIGO Gravity wave experiment. It is functionally identical to the Triple Top Drive Board.

It controls the current in the coil which provides the magnetic force which controls the position of the Transmission Monitor suspension. It works in conjunction with the OSEM coil and position sensor units. One Transmon coil drive unit controls four OSEMs.

The Transmon 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 Transmon Coil Drive Unit also passes the amplified signals from the Photodiodes, which detect the position of the suspension, back to the control electronics without processing them in any way.

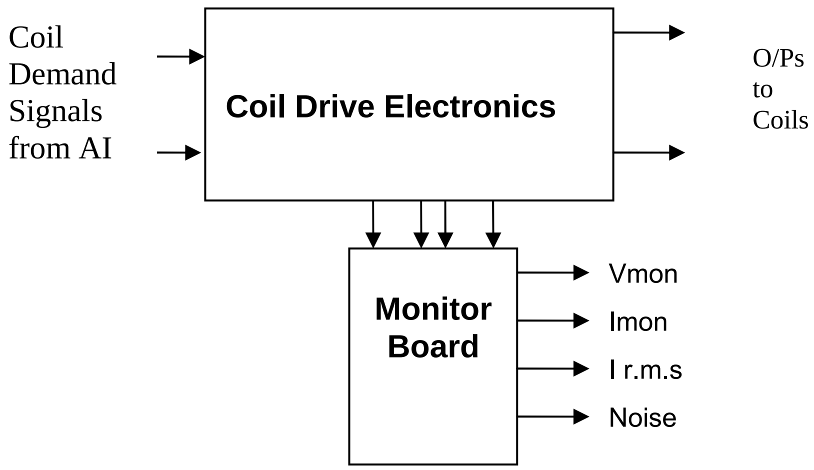


FIG. 1 Transmon Driver Unit Block Diagram

Each Transmon 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……………..Transmon_6……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..25/11/10………………

2. Test Equipment

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

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

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	
DVM	TENMA	72-7730	

Unit………………Transmon_6……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

Unit……………..Transmon_6…………………..Serial No ……………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

4. Continuity Checks

Use a multi-meter to check the connections below.

Photodiode outputs

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

LED Monitors

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

Power Supply to Satellite box

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

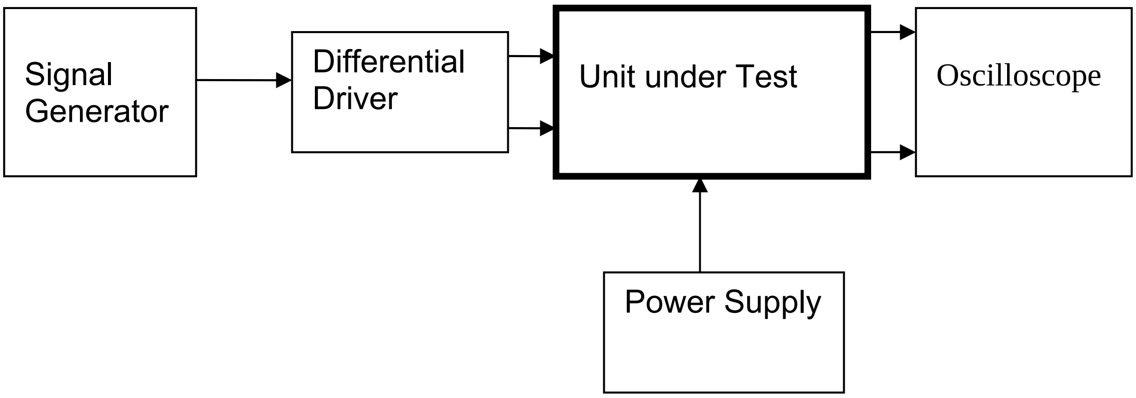
Unit………………Transmon_6……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

Isolation Checks

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

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

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………………Transmon_6……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

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)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

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

Unit……………..Transmon_6……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

7. Relay Operation

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

Filter

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

TEST SWITCHES

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

Unit……………..Transmon_6……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

8. Current Monitor tests

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

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

Remove all links W4 and W5.

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

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

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 2v peak appears across each resistor.

Connect a true r.m.s meter across the channel 4 resistor, and carefully adjust the signal generator to give an r.m.s reading of 1.5 volts.

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

Channel	Monitor Connector	Parameter	Theoretical Value (+/- .1v)	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	1.01V r.m.s	1.02	√
	Pin 1	RMS Current	1.01V dc	1.03	√
2	Pin 5	Current Monitor	1.01V r.m.s	1.02	√
	Pin 4	RMS Current	1.01V dc	1.02	√
3	Pin 8	Current Monitor	1.01V r.m.s	1.02	√
	Pin 7	RMS Current	1.01V dc	1.03	√
4	Pin 11	Current Monitor	1.01V r.m.s	1.02	√
	Pin 10	RMS Current	1.01V dc	1.02	√

Unit……………..Transmon_6……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..24/11/10………………

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 at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

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

10. Noise Monitor Tests

See Monitor re-test report.

Unit……………..Transmon_6…………………..Serial No ……………………………..
Test Engineer…..Xen……………………
Date……………..25/11/10……………..

12. Corner frequency tests

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

Use the Dynamic Signal Analyser and signal generator.

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

Channel 1

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

Channel 2

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

Channel 3

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

Channel 4

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

0.1 Hz measurements with the signal generator and oscilloscope

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

Unit……………..Transmon_6……………………Serial No ……………………………
Test Engineer…..Xen……………………
Date……………..25/11/10………………

12. Distortion

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

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

13. Full Load Test

Apply the DC source to the input to the differential amplifier. Connect the 39 Ohm 5 watt loads to the outputs.
Increase the input voltage to 10v with respect to 0v, and monitor the temperatures of the drive amplifiers. If their temperature increases above 100°C, flag a problem!
Leave running for 10 minutes, then record the temperatures of drive amplifiers, and the differential output voltages from the amplifier (TP9 and TP13).

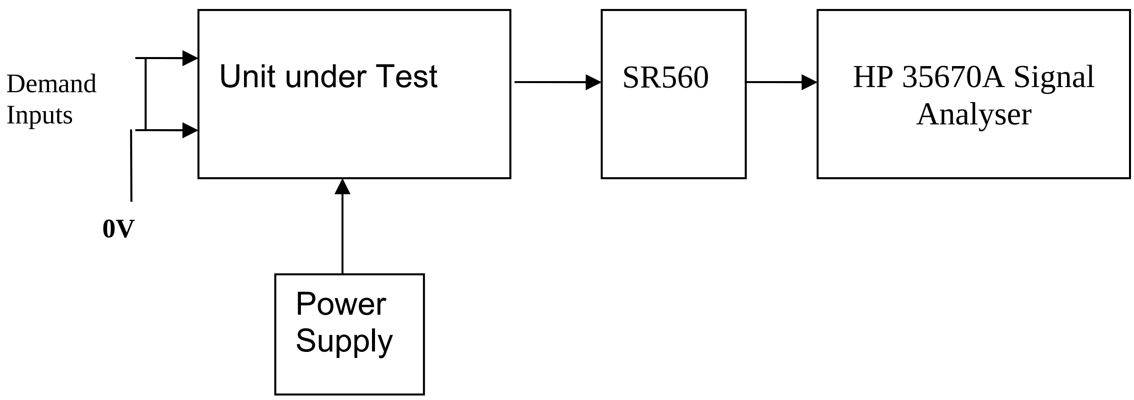
The output voltages should be recorded.

Output	Voltage	> 24v?	DRIVER	Temperature	<60°C?
CH1 Positive	24.4	√	CH1 IC1	37.2	√
CH1 Negative			CH1 IC5	42.1	√
CH2 Positive	24.4	√	CH2 IC1	40.4	√
CH2 Negative			CH2 IC5	43.6	√
CH3 Positive	24.4	√	CH3 IC1	40.6	√
CH3 Negative			CH3 IC5	41.6	√
CH4 Positive	24.4	√	CH4 IC1	39.7	√
CH4 Negative			CH4 IC5	42.1	√

Unit………………Transmon_6……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..25/11/10………………

14. Noise Tests

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



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-161.15dB	-102.1	-162.1
Ch2	-161.15dB	-100.9	-160.9
Ch3	-161.15dB	-99.7	-159.7
Ch4	-161.15dB	-100.6	-160.6

Notes:
Specified noise output current at 10 Hz = 73 pA/√Hz
Total output resistance = 120 Ohms
Amplifier noise voltage should therefore = 8.76nV/√Hz or -161.15 dB

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

Unit……………..Transmon_6……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..25/11/10………………

15. Full Current Tests

High power dummy loads are needed for this test.

With the dummy loads removed, measure and record the value of each resistor. Nominal 39 Ohm power resistors should be used.

Plug in the dummy load.

Remove the filter links.

Drive the unit with a 10v peak sine wave on each channel, which should measure 7.07 volts on a true r.m.s meter.

Measure the voltage across each load resistor and record it. Calculate the current through each resistor, and compare with the specification. If a true r.m.s meter is used to make the measurement, compare with the r.m.s specification

Channel	**R =**	**V=**	**Therefore I =**	**Spec (peak)**	**Spec (r.m.s)**	**Pass?**
1	39.3	5.54	141.0mA	>200mA	>141.4mA	√
2	39.4	5.55	140.9mA	>200mA	>141.4mA	√
3	39.3	5.53	140.7mA	>200mA	>141.4mA	√
4	39.4	5.54	140.6mA	>200mA	>141.4mA	√

(The measured output is slightly low due to not being able to adjust the input voltage to the correct level of 7.07V)

Unit……………………….Tansmon6………Serial No ………………………………
Test Engineer………………RMC
Date………………….………29/11/10

16. Final Assembly Checks

1. Remove the lid of the box. √

2. Unplug all external connections. .√

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

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

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

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

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

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

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

UoB box ID	Transmon6
Driver board ID	Transmon6
Driver board Drawing No/Issue No	D1001650_v2
Driver board Serial Number	Transmon6
Monitor board ID	MON169
Monitor board Drawing No/Issue No	D070480_5_K
Monitor board Serial Number	MON169

10. Check the security of any modification wires. √

11. Visually inspect. √

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

Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1000571-v1	Advanced LIGO UK	28 September 2010

Transmon Coil Drive Unit Test Plan

R. M. Cutler, University of Birmingham

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

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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

TRANSMON COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit………………Transmon_7……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..16/11/10……………….

Drive Card ID……Transmon_7………………
Monitor Card ID…Mon148……………..……..

Contents

1. Description

The Transmon, or Transmission Monitor Coil Driver Unit is used to control the position of the Transmission Monitor suspension in the Advanced LIGO Gravity wave experiment. It is functionally identical to the Triple Top Drive Board.

It controls the current in the coil which provides the magnetic force which controls the position of the Transmission Monitor suspension. It works in conjunction with the OSEM coil and position sensor units. One Transmon coil drive unit controls four OSEMs.

The Transmon 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 Transmon Coil Drive Unit also passes the amplified signals from the Photodiodes, which detect the position of the suspension, back to the control electronics without processing them in any way.

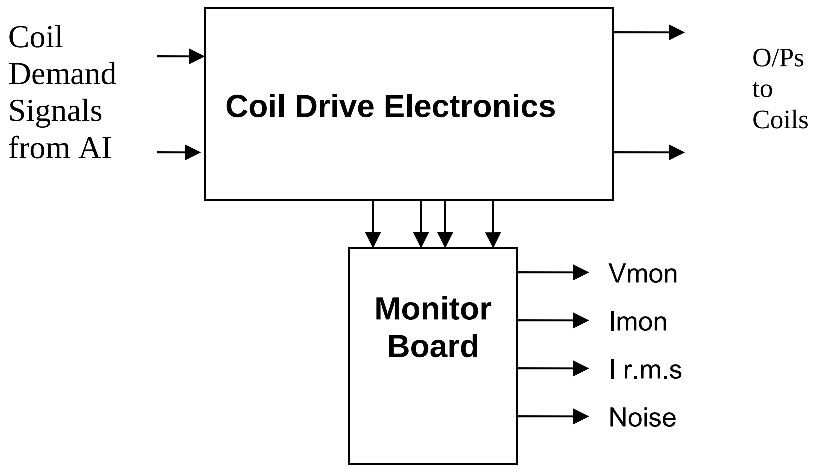


FIG. 1 Transmon Driver Unit Block Diagram

Each Transmon 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……………..Transmon_7……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..16/11/10………………

2. Test Equipment

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

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

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	
DVM	TENMA	72-7730	

Unit………………Transmon_7……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..16/11/10………………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

Unit……………….Transmon_7…………………….Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..16/11/10………………

4. Continuity Checks

Use a multi-meter to check the connections below.

Photodiode outputs

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

LED Monitors

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

Power Supply to Satellite box

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

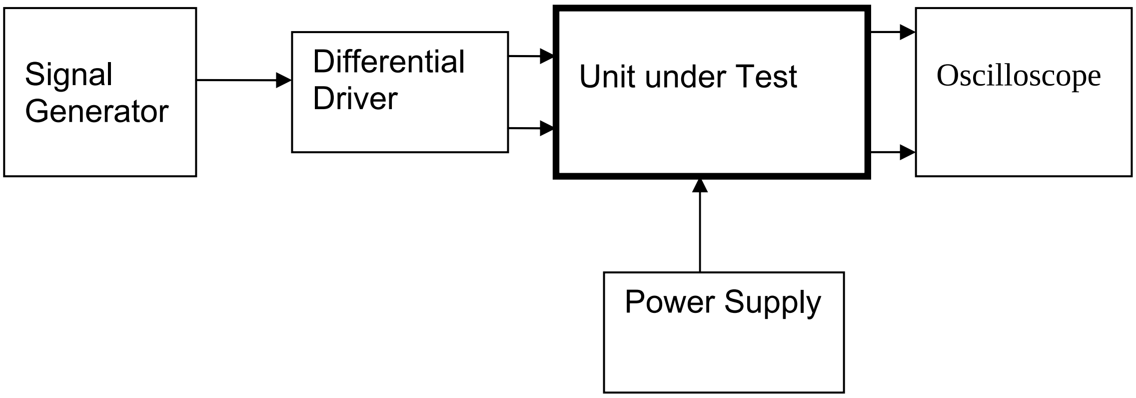
Unit……………….Transmon_7……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..16/11/10………………

Isolation Checks

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

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

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………………Transmon_7……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..16/11/10………………

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)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

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

Unit.................Transmon_7......................Serial No ....
Test Engineer.....Xen.......................
Date................16/11/10.................

7. Relay Operation

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

Filter

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

TEST SWITCHES

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

Unit……………..Transmon_7……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..16/11/10………………

8. Current Monitor tests

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

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

Remove all links W4 and W5.

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

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

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 2v peak appears across each resistor.

Connect a true r.m.s meter across the channel 4 resistor, and carefully adjust the signal generator to give an r.m.s reading of 1.5 volts.

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

Channel	Monitor Connector	Parameter	Theoretical Value (+/- .1v)	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	1.01V r.m.s	1.02	√
	Pin 1	RMS Current	1.01V dc	1.02	√
2	Pin 5	Current Monitor	1.01V r.m.s	1.02	√
	Pin 4	RMS Current	1.01V dc	1.02	√
3	Pin 8	Current Monitor	1.01V r.m.s	1.02	√
	Pin 7	RMS Current	1.01V dc	1.02	√
4	Pin 11	Current Monitor	1.01V r.m.s	1.02	√
	Pin 10	RMS Current	1.01V dc	1.02	√

Unit.................Transmon_7.......................Serial No ....
Test Engineer.....Xen.......................
Date................16/11/10.................

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 at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

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

10. Noise Monitor Tests

See Monitor re-test report.

Unit………………Transmon_7……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..16/11/10………………

12. Corner frequency tests

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

Use the Dynamic Signal Analyser and signal generator.

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

Channel 1

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

Channel 2

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.0		
10Hz	-30.6		
100Hz	-42.8		
1KHz	-43.3		

Channel 3

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

Channel 4

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.2		
10Hz	-30.5		
100Hz	-42.8		
1KHz	-43.2		

0.1 Hz measurements with the signal generator and oscilloscope

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

Unit……………..Transmon_7……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..16/11/10………………

12. Distortion

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

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

13. Full Load Test

Apply the DC source to the input to the differential amplifier. Connect the 39 Ohm 5 watt loads to the outputs.
Increase the input voltage to 10v with respect to 0v, and monitor the temperatures of the drive amplifiers. If their temperature increases above 100°C, flag a problem!
Leave running for 10 minutes, then record the temperatures of drive amplifiers, and the differential output voltages from the amplifier (TP9 and TP13).

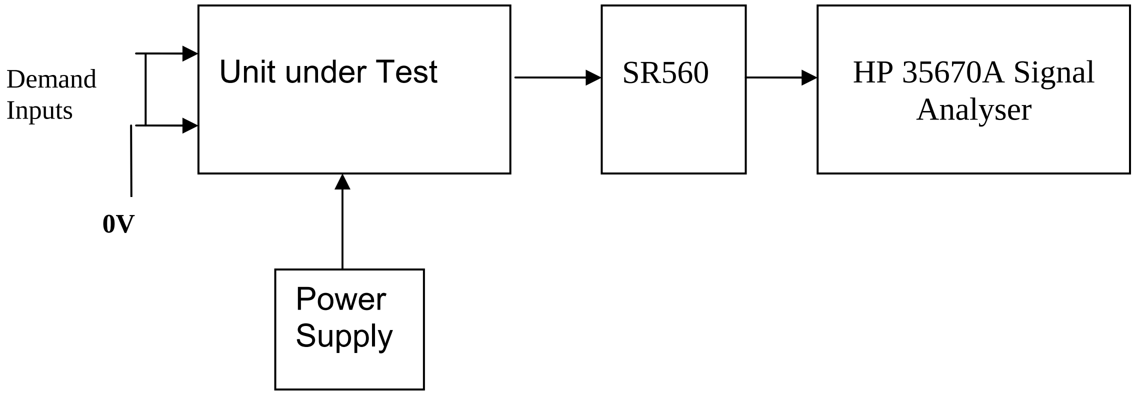
The output voltages should be recorded.

Output	**Voltage**	**> 24v?**	**DRIVER**	**Temperature**	**<60°C?**
CH1 Positive	24.4	√	**CH1 IC1**	38.7	√
CH1 Negative			**CH1 IC5**	40.4	√
CH2 Positive	24.4	√	**CH2 IC1**	41.4	√
CH2 Negative			**CH2 IC5**	40.6	√
CH3 Positive	24.4	√	**CH3 IC1**	38.4	√
CH3 Negative			**CH3 IC5**	42.3	√
CH4 Positive	24.4	√	**CH4 IC1**	39.4	√
CH4 Negative			**CH4 IC5**	42.6	√

Unit……………..Transmon_7…………………..Serial No ……………………………..
Test Engineer…..Xen……………………
Date……………..16/11/10………………

14. Noise Tests

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



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-161.15dB	-100.6	-160.6
Ch2	-161.15dB	-101.2	-161.2
Ch3	-161.15dB	-100.8	-160.8
Ch4	-161.15dB	-101.1	-161.1

Notes:
Specified noise output current at 10 Hz = 73 pA/√Hz
Total output resistance = 120 Ohms
Amplifier noise voltage should therefore = 8.76nV/√Hz or -161.15 dB

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

Unit……………..Transmon_7……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..16/11/10………………

15. Full Current Tests

High power dummy loads are needed for this test.

With the dummy loads removed, measure and record the value of each resistor. Nominal 39 Ohm power resistors should be used.

Plug in the dummy load.

Remove the filter links.

Drive the unit with a 10v peak sine wave on each channel, which should measure 7.07 volts on a true r.m.s meter.

Measure the voltage across each load resistor and record it. Calculate the current through each resistor, and compare with the specification. If a true r.m.s meter is used to make the measurement, compare with the r.m.s specification

Channel	R =	V=	Therefore I =	Spec (peak)	Spec (r.m.s)	Pass?
1	39.3	5.55	141.2mA	>200mA	>141.4mA	√
2	39.4	5.56	141.1mA	>200mA	>141.4mA	√
3	39.3	5.55	141.2mA	>200mA	>141.4mA	√
4	39.4	5.55	140.9mA	>200mA	>141.4mA	√

(The measured output is slightly low due to not being able to adjust the input voltage to the correct level of 7.07V)

Unit……………………Transmon7………………Serial No ………………………………
Test Engineer……………RMC
Date…………………..29/11/10

16. Final Assembly Checks

1. Remove the lid of the box. √

2. Unplug all external connections. √

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

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

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

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

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

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

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

UoB box ID	Transmon7
Driver board ID	Transmon7
Driver board Drawing No/Issue No	D1001650_v2
Driver board Serial Number	Transmon7
Monitor board ID	MON148
Monitor board Drawing No/Issue No	D070480_5_K
Monitor board Serial Number	MON148

10. Check the security of any modification wires. √

11. Visually inspect. √

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

Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1000571-v1	Advanced LIGO UK	28 September 2010

Transmon Coil Drive Unit Test Plan

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

TRANSMON COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit……………….Transmon_8……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..16/11/10....……………

Drive Card ID……Transmon_8……………..
Monitor Card ID…Mon162…………………..

Contents

1. Description

The Transmon, or Transmission Monitor Coil Driver Unit is used to control the position of the Transmission Monitor suspension in the Advanced LIGO Gravity wave experiment. It is functionally identical to the Triple Top Drive Board.

It controls the current in the coil which provides the magnetic force which controls the position of the Transmission Monitor suspension. It works in conjunction with the OSEM coil and position sensor units. One Transmon coil drive unit controls four OSEMs.

The Transmon 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 Transmon Coil Drive Unit also passes the amplified signals from the Photodiodes, which detect the position of the suspension, back to the control electronics without processing them in any way.

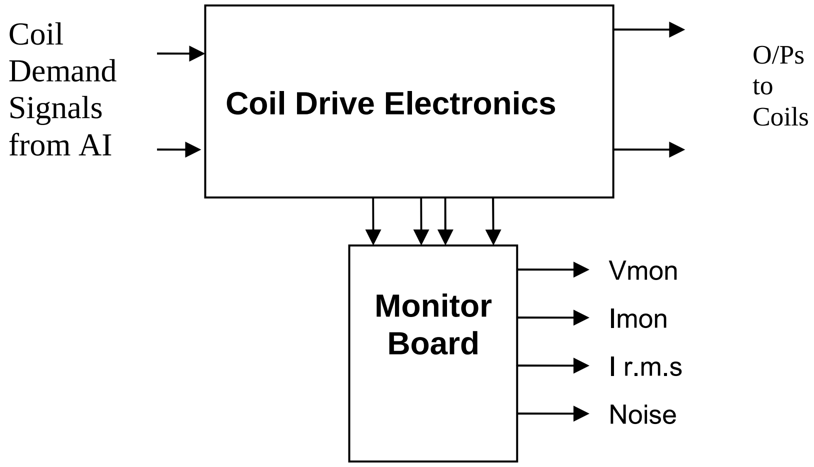


FIG. 1 Transmon Driver Unit Block Diagram

Each Transmon 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……………… Transmon_8……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..16/11/10....……………

2. Test Equipment

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

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

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	
DVM	TENMA	72-7730	

Unit……………….Transmon_8……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..16/11/10….……………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

Unit………………Transmon_8……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..16/11/10....……………

4. Continuity Checks

Use a multi-meter to check the connections below.

Photodiode outputs

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

LED Monitors

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

Power Supply to Satellite box

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

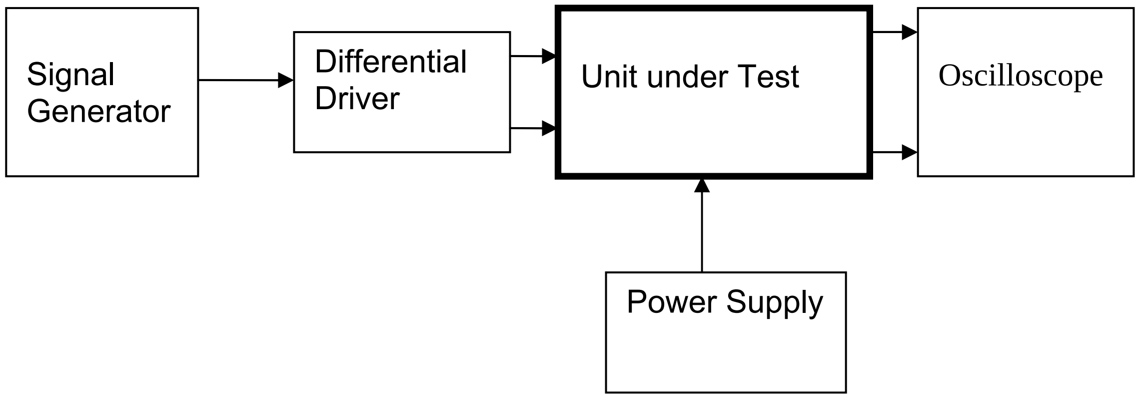
Unit……………….Transmon_8……………………..Serial No ……………………………….
Test Engineer…..Xen……………………
Date……………..16/11/10....……………

Isolation Checks

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

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

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……………….Transmon_8……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..16/11/10....……………

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)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

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

Unit……………….Transmon_8…………………….Serial No ……………………………….
Test Engineer…..Xen……………………
Date……………..16/11/10....……………

7. Relay Operation

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

Filter

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

TEST SWITCHES

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

Unit………………Transmon_8……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..16/11/10....……………

8. Current Monitor tests

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

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

Remove all links W4 and W5.

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

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

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 2v peak appears across each resistor.

Connect a true r.m.s meter across the channel 4 resistor, and carefully adjust the signal generator to give an r.m.s reading of 1.5 volts.

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

Channel	Monitor Connector	Parameter	Theoretical Value (+/- .1v)	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	1.01V r.m.s	1.02	√
	Pin 1	RMS Current	1.01V dc	1.02	√
2	Pin 5	Current Monitor	1.01V r.m.s	1.02	√
	Pin 4	RMS Current	1.01V dc	1.02	√
3	Pin 8	Current Monitor	1.01V r.m.s	1.02	√
	Pin 7	RMS Current	1.01V dc	1.02	√
4	Pin 11	Current Monitor	1.01V r.m.s	1.02	√
	Pin 10	RMS Current	1.01V dc	1.02	√

Unit……………….Transmon_8……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..16/11/10....……………

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 at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

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

10. Noise Monitor Tests

See Monitor re-test report.

Unit……………..Transmon_8…………………..Serial No ……………………………..
Test Engineer…..Xen……………………
Date……………..16/11/10.....…………..

12. Corner frequency tests

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

Use the Dynamic Signal Analyser and signal generator.

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

Channel 1

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.2		
10Hz	-30.4		
100Hz	-42.8		
1KHz	-43.2		

Channel 2

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.1		
10Hz	-30.4		
100Hz	-42.8		
1KHz	-43.3		

Channel 3

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.1		
10Hz	-30.4		
100Hz	-42.8		
1KHz	-43.2		

Channel 4

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.1		
10Hz	-30.5		
100Hz	-42.8		
1KHz	-43.3		

0.1 Hz measurements with the signal generator and oscilloscope

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

Unit………………Transmon_8……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..16/11/10....……………

12. Distortion

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

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

13. Full Load Test

Apply the DC source to the input to the differential amplifier. Connect the 39 Ohm 5 watt loads to the outputs.
Increase the input voltage to 10v with respect to 0v, and monitor the temperatures of the drive amplifiers. If their temperature increases above 100°C, flag a problem!
Leave running for 10 minutes, then record the temperatures of drive amplifiers, and the differential output voltages from the amplifier (TP9 and TP13).

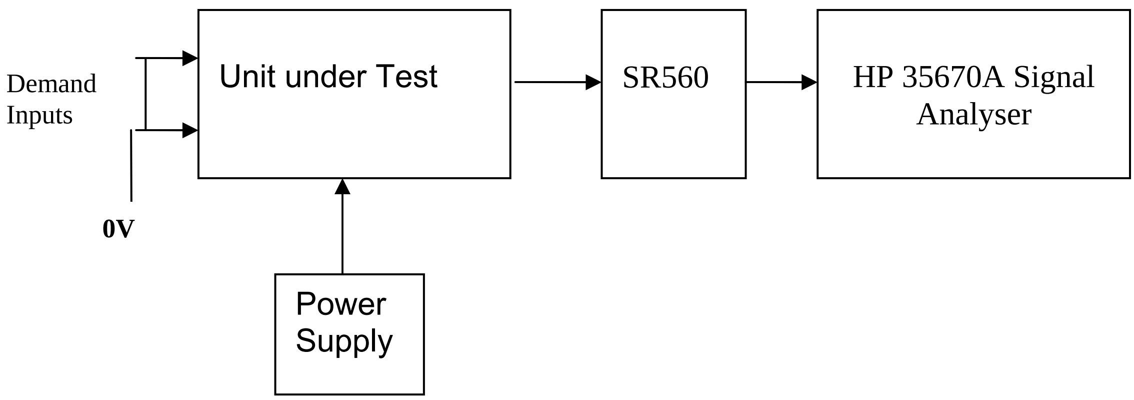
The output voltages should be recorded.

Output	Voltage	> 24v?	DRIVER	Temperature	<60°C?
CH1 Positive	24.4	√	**CH1 IC1**	40.9	√
CH1 Negative			**CH1 IC5**	46.5	√
CH2 Positive	24.4	√	**CH2 IC1**	43.1	√
CH2 Negative			**CH2 IC5**	47.7	√
CH3 Positive	24.4	√	**CH3 IC1**	43.3	√
CH3 Negative			**CH3 IC5**	45.0	√
CH4 Positive	24.4	√	**CH4 IC1**	41.4	√
CH4 Negative			**CH4 IC5**	41.8	√

Unit……………..Transmon_8……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..16/11/10....……………

14. Noise Tests

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



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-161.15dB	-100.7	-160.7
Ch2	-161.15dB	-98.8	-158.8
Ch3	-161.15dB	-101.2	-162.2
Ch4	-161.15dB	-102.0	-162.0

Notes:
Specified noise output current at 10 Hz = 73 pA/√Hz
Total output resistance = 120 Ohms
Amplifier noise voltage should therefore = 8.76nV/√Hz or -161.15 dB

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

Unit……………..Transmon_8……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..16/11/10....……………

15. Full Current Tests

High power dummy loads are needed for this test.

With the dummy loads removed, measure and record the value of each resistor. Nominal 39 Ohm power resistors should be used.

Plug in the dummy load.

Remove the filter links.

Drive the unit with a 10v peak sine wave on each channel, which should measure 7.07 volts on a true r.m.s meter.

Measure the voltage across each load resistor and record it. Calculate the current through each resistor, and compare with the specification. If a true r.m.s meter is used to make the measurement, compare with the r.m.s specification

Channel	**R =**	**V=**	**Therefore I =**	**Spec (peak)**	**Spec (r.m.s)**	**Pass?**
1	39.3	5.53	140.7mA	>200mA	>141.4mA	√
2	39.4	5.55	140.9mA	>200mA	>141.4mA	√
3	39.3	5.54	141.0mA	>200mA	>141.4mA	√
4	39.4	5.54	140.6mA	>200mA	>141.4mA	√

(The measured output is slightly low due to not being able to adjust the input voltage to the correct level of 7.07V)

Unit…………………Transmon8……………Serial No ………………………………
Test Engineer…………RMC……
Date……………….……30/11/10……………

16. Final Assembly Checks

1. Remove the lid of the box.√

2. Unplug all external connections. √

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

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

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

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

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

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

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

UoB box ID	Transmon8
Driver board ID	Transmon8
Driver board Drawing No/Issue No	D1001650_V2
Driver board Serial Number	Transmon8
Monitor board ID	MON162
Monitor board Drawing No/Issue No	D070480_5_K
Monitor board Serial Number	MON162

10. Check the security of any modification wires. √

11. Visually inspect. √

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

    Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1000571-v1 **Advanced LIGO UK** 28 September 2010

Transmon Coil Drive Unit Test Plan

R. M. Cutler, University of Birmingham

Distribution of this document:
Inform aligo_sus

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

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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

TRANSMON COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit………………Transmon_9……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..30/11/10……………..

Drive Card ID……Transmon_9……………..
Monitor Card ID…Mon167……………………..

Contents

1. Description

The Transmon, or Transmission Monitor Coil Driver Unit is used to control the position of the Transmission Monitor suspension in the Advanced LIGO Gravity wave experiment. It is functionally identical to the Triple Top Drive Board.

It controls the current in the coil which provides the magnetic force which controls the position of the Transmission Monitor suspension. It works in conjunction with the OSEM coil and position sensor units. One Transmon coil drive unit controls four OSEMs.

The Transmon 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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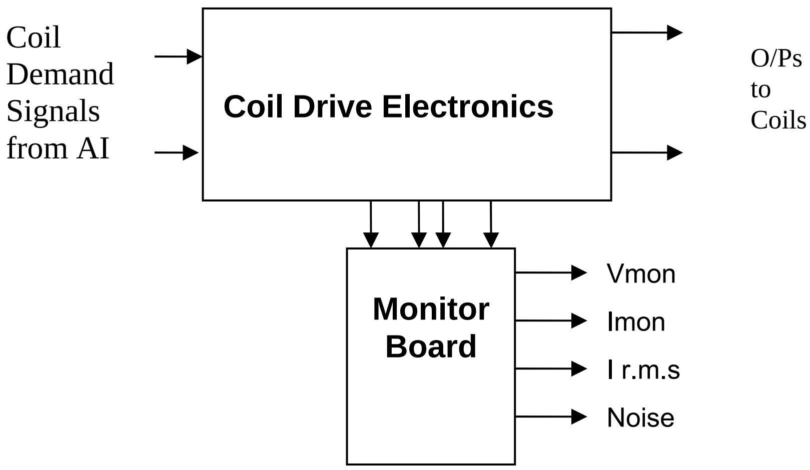

FIG. 1 Transmon Driver Unit Block Diagram

Each Transmon 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………………Transmon_9……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..30/11/10………………

2. Test Equipment

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

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

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	
DVM	TENMA	72-7730	

Unit……………….Transmon_9…………………….Serial No ……………………………….
Test Engineer…..Xen…………………….
Date……………..30/11/10………………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

Unit……………….Transmon_9…………………….Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..30/11/10………………

4. Continuity Checks

Use a multi-meter to check the connections below.

Photodiode outputs

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

LED Monitors

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

Power Supply to Satellite box

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

Unit………………Transmon_9……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..30/11/10………………

Isolation Checks

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

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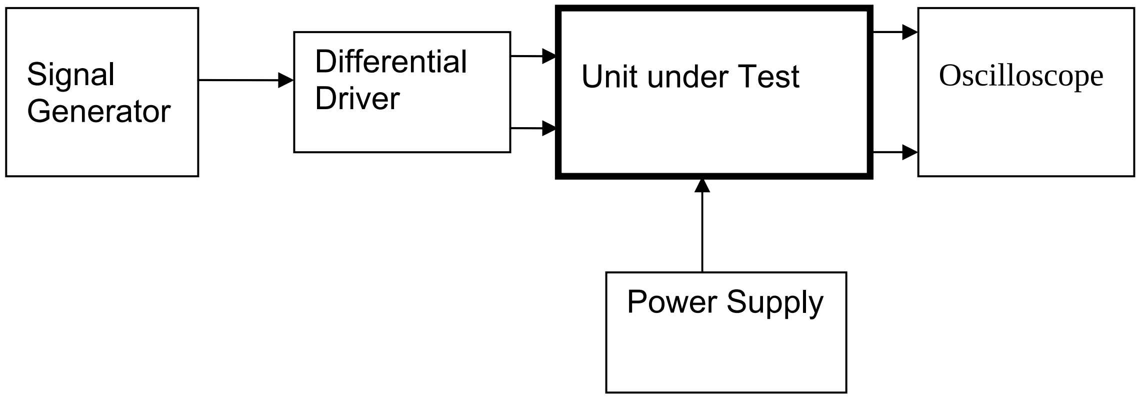
IC12 Channel 3	OL	√
IC11 Channel 4	OL	√
IC12 Channel 4	OL	√

5. TEST SET UP



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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……………..Transmon_9……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..30/11/10………………

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)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

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

Unit………………Transmon_9……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..30/11/10………………

7. Relay Operation

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

Filter

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

TEST SWITCHES

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

Unit………………Transmon_9……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..30/11/10………………

8. Current Monitor tests

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

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

Remove all links W4 and W5.

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

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

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 2v peak appears across each resistor.

Connect a true r.m.s meter across the channel 4 resistor, and carefully adjust the signal generator to give an r.m.s reading of 1.5 volts.

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

Channel	Monitor Connector	Parameter	Theoretical Value (+/- .1v)	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	1.01V r.m.s	1.02	√
	Pin 1	RMS Current	1.01V dc	1.02	√
2	Pin 5	Current Monitor	1.01V r.m.s	1.02	√
	Pin 4	RMS Current	1.01V dc	1.02	√
3	Pin 8	Current Monitor	1.01V r.m.s	1.02	√
	Pin 7	RMS Current	1.01V dc	1.02	√
4	Pin 11	Current Monitor	1.01V r.m.s	1.02	√
	Pin 10	RMS Current	1.01V dc	1.02	√

Unit……………..Transmon_9……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..30/11/10………………

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 at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

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

10. Noise Monitor Tests

See Monitor re-test report.

Unit……………..Transmon_9…………………..Serial No ……………………………..
Test Engineer…..Xen……………………
Date……………..30/11/10……………..

12. Corner frequency tests

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

Use the Dynamic Signal Analyser and signal generator.

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

Channel 1

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

Channel 2

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

Channel 3

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

Channel 4

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

0.1 Hz measurements with the signal generator and oscilloscope

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

Unit……………..Transmon_9……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..30/11/10………………

12. Distortion

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

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

13. Full Load Test

Apply the DC source to the input to the differential amplifier. Connect the 39 Ohm 5 watt loads to the outputs.
Increase the input voltage to 10v with respect to 0v, and monitor the temperatures of the drive amplifiers. If their temperature increases above 100°C, flag a problem!
Leave running for 10 minutes, then record the temperatures of drive amplifiers, and the differential output voltages from the amplifier (TP9 and TP13).

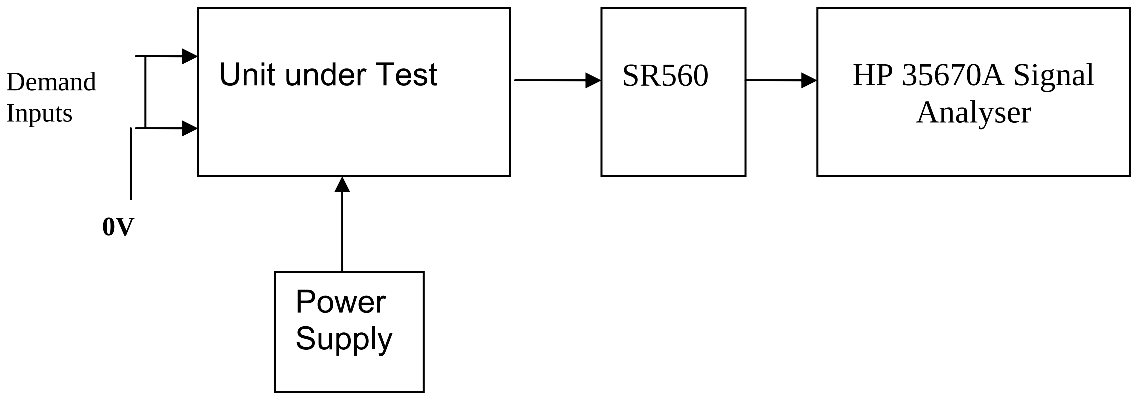
The output voltages should be recorded.

Output	Voltage	> 24v?	DRIVER	Temperature	<60°C?
CH1 Positive	24.4	√	CH1 IC1	34.5	√
CH1 Negative			CH1 IC5	39.9	√
CH2 Positive	24.4	√	CH2 IC1	37.2	√
CH2 Negative			CH2 IC5	40.6	√
CH3 Positive	24.4	√	CH3 IC1	37.7	√
CH3 Negative			CH3 IC5	40.4	√
CH4 Positive	24.4	√	CH4 IC1	36.7	√
CH4 Negative			CH4 IC5	39.4	√

Unit.................Transmon_9.......................Serial No ....
Test Engineer.....Xen.......................
Date................30/11/10.................

14. Noise Tests

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



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-161.15dB	-98.9	-158.9
Ch2	-161.15dB	-100.2	-160.2
Ch3	-161.15dB	-99.9	-159.9
Ch4	-161.15dB	-101.7	-161.7

Notes:
Specified noise output current at 10 Hz = 73 pA/√Hz
Total output resistance = 120 Ohms
Amplifier noise voltage should therefore = 8.76nV/√Hz or -161.15 dB

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

Unit………………Transmon_9……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..30/11/10………………

15. Full Current Tests

High power dummy loads are needed for this test.

With the dummy loads removed, measure and record the value of each resistor. Nominal 39 Ohm power resistors should be used.

Plug in the dummy load.

Remove the filter links.

Drive the unit with a 10v peak sine wave on each channel, which should measure 7.07 volts on a true r.m.s meter.

Measure the voltage across each load resistor and record it. Calculate the current through each resistor, and compare with the specification. If a true r.m.s meter is used to make the measurement, compare with the r.m.s specification

Channel	R =	V=	Therefore I =	Spec (peak)	Spec (r.m.s)	Pass?
1	39.3	5.54	141.0mA	>200mA	>141.4mA	√
2	39.4	5.54	140.6mA	>200mA	>141.4mA	√
3	39.3	5.53	140.7mA	>200mA	>141.4mA	√
4	39.4	5.54	140.6mA	>200mA	>141.4mA	√

(The measured output is slightly low due to not being able to adjust the input voltage to the correct level of 7.07V)

Unit…………………Transmon_5…………………Serial No ………………………………
Test Engineer…………RMC……………
Date……………….…7/12/10...…………

16. Final Assembly Checks

1. Remove the lid of the box.√

2. Unplug all external connections. √

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

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

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

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

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

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

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

UoB box ID	Transmon 9
Driver board ID	Transmon 9
Driver board Drawing No/Issue No	D1001650_v2
Driver board Serial Number	Transmon 9
Monitor board ID	MON167
Monitor board Drawing No/Issue No	D070480_5_K
Monitor board Serial Number	MON167

10. Check the security of any modification wires. √

11. Visually inspect. √

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

Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1000571-v1 Advanced LIGO UK 28 September 2010

Transmon Coil Drive Unit Test Plan

R. M. Cutler, University of Birmingham

Distribution of this document:
Inform aligo_sus

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

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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

TRANSMON COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit………………Transmon_10……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..30/11/10………………

Drive Card ID……Transmon_10…………
Monitor Card ID…Mon166…..…………..

Contents

1. Description

The Transmon, or Transmission Monitor Coil Driver Unit is used to control the position of the Transmission Monitor suspension in the Advanced LIGO Gravity wave experiment. It is functionally identical to the Triple Top Drive Board.

It controls the current in the coil which provides the magnetic force which controls the position of the Transmission Monitor suspension. It works in conjunction with the OSEM coil and position sensor units. One Transmon coil drive unit controls four OSEMs.

The Transmon 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 Transmon Coil Drive Unit also passes the amplified signals from the Photodiodes, which detect the position of the suspension, back to the control electronics without processing them in any way.

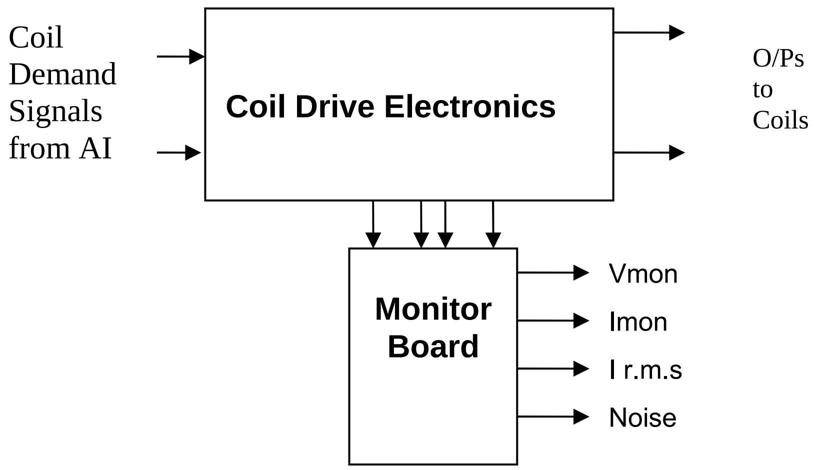


FIG. 1 Transmon Driver Unit Block Diagram

Each Transmon 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..................Transmon_10........................Serial No ....
Test Engineer.....Xen........................
Date.................30/11/10..................

2. Test Equipment

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

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

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	
DVM	TENMA	72-7730	

Unit………………Transmon_10……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..30/11/10………………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

Unit……………….Transmon_10…………………….Serial No ……………………………….
Test Engineer…..Xen……………………
Date……………..30/11/10………………

4. Continuity Checks

Use a multi-meter to check the connections below.

Photodiode outputs

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

LED Monitors

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

Power Supply to Satellite box

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

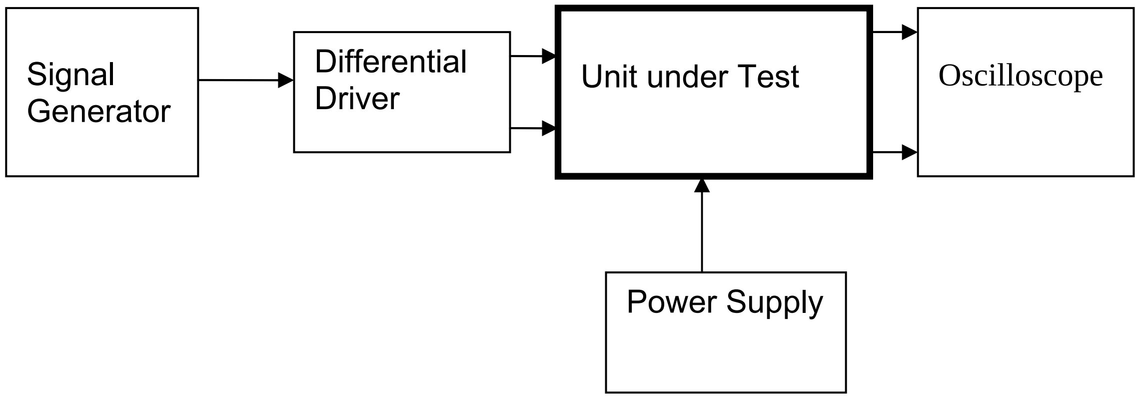
Unit……………….Transmon_10……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..30/11/10………………

Isolation Checks

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

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

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……………….Transmon_10…………………….Serial No ……………………………….
Test Engineer…..Xen……………………
Date……………..30/11/10………………

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)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

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

Unit……………..Transmon_10……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..30/11/10………………

7. Relay Operation

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

Filter

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

TEST SWITCHES

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

Unit……………….Transmon_10……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..30/11/10………………

8. Current Monitor tests

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

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

Remove all links W4 and W5.

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

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

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 2v peak appears across each resistor.

Connect a true r.m.s meter across the channel 4 resistor, and carefully adjust the signal generator to give an r.m.s reading of 1.5 volts.

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

Channel	Monitor Connector	Parameter	Theoretical Value (+/- .1v)	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	1.01V r.m.s	1.02	√
	Pin 1	RMS Current	1.01V dc	1.02	√
2	Pin 5	Current Monitor	1.01V r.m.s	1.02	√
	Pin 4	RMS Current	1.01V dc	1.02	√
3	Pin 8	Current Monitor	1.01V r.m.s	1.02	√
	Pin 7	RMS Current	1.01V dc	1.02	√
4	Pin 11	Current Monitor	1.01V r.m.s	1.02	√
	Pin 10	RMS Current	1.01V dc	1.02	√

Unit……………..Transmon_10……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..30/11/10………………

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 at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

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

10. Noise Monitor Tests

See Monitor re-test report.

Unit………………Transmon_10……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..30/11/10………………

12. Corner frequency tests

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

Use the Dynamic Signal Analyser and signal generator.

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

Channel 1

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.03		
10Hz	-30.6		
100Hz	-42.8		
1KHz	-43.2		

Channel 2

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	0.9		
10Hz	-30.6		
100Hz	-42.9		
1KHz	-43.3		

Channel 3

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.2		
10Hz	-30.4		
100Hz	-42.8		
1KHz	-43.2		

Channel 4

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

0.1 Hz measurements with the signal generator and oscilloscope

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

Unit……………..Transmon_10……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..30/11/10………………

12. Distortion

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

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

13. Full Load Test

Apply the DC source to the input to the differential amplifier. Connect the 39 Ohm 5 watt loads to the outputs.
Increase the input voltage to 10v with respect to 0v, and monitor the temperatures of the drive amplifiers. If their temperature increases above 100°C, flag a problem!
Leave running for 10 minutes, then record the temperatures of drive amplifiers, and the differential output voltages from the amplifier (TP9 and TP13).

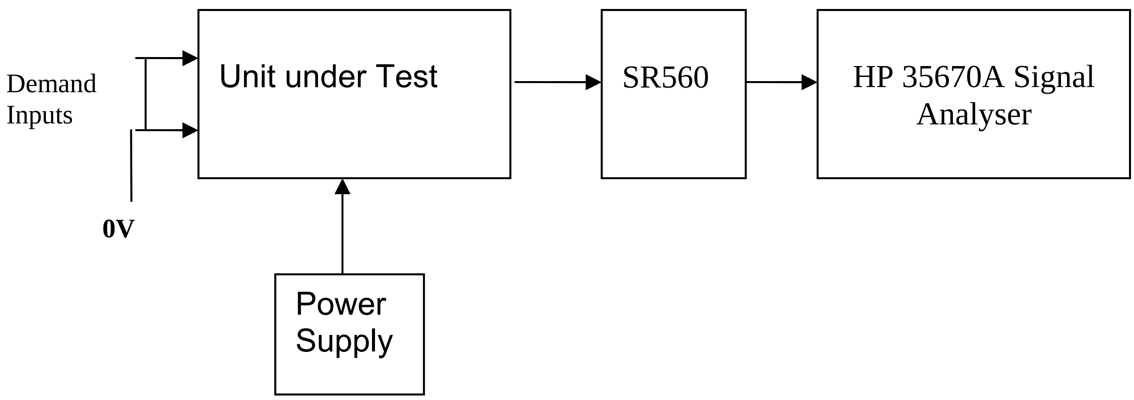
The output voltages should be recorded.

Output	Voltage	> 24v?	DRIVER	Temperature	<60°C?
CH1 Positive	24.4	√	CH1 IC1	37.2	√
CH1 Negative			CH1 IC5	39.2	√
CH2 Positive	24.4	√	CH2 IC1	39.4	√
CH2 Negative			CH2 IC5	42.1	√
CH3 Positive	24.4	√	CH3 IC1	38.2	√
CH3 Negative			CH3 IC5	41.4	√
CH4 Positive	24.4	√	CH4 IC1	38.4	√
CH4 Negative			CH4 IC5	41.6	√

Unit……………..Transmon_10……………………Serial No ……………………………..
Test Engineer…..Xen……………………
Date……………..30/11/10………………

14. Noise Tests

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



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-161.15dB	-99.8	-159.8
Ch2	-161.15dB	-100.2	-160.2
Ch3	-161.15dB	-102.0	-162.0
Ch4	-161.15dB	-100.4	-160.4

Notes:
Specified noise output current at 10 Hz = 73 pA/√Hz
Total output resistance = 120 Ohms
Amplifier noise voltage should therefore = 8.76nV/√Hz or -161.15 dB

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

Unit………………Transmon_10……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..30/11/10………………

15. Full Current Tests

High power dummy loads are needed for this test.

With the dummy loads removed, measure and record the value of each resistor. Nominal 39 Ohm power resistors should be used.

Plug in the dummy load.

Remove the filter links.

Drive the unit with a 10v peak sine wave on each channel, which should measure 7.07 volts on a true r.m.s meter.

Measure the voltage across each load resistor and record it. Calculate the current through each resistor, and compare with the specification. If a true r.m.s meter is used to make the measurement, compare with the r.m.s specification

Channel	R =	V=	Therefore I =	Spec (peak)	Spec (r.m.s)	Pass?
1	39.3	5.55	141.2mA	>200mA	>141.4mA	√
2	39.4	5.57	141.4mA	>200mA	>141.4mA	√
3	39.3	5.54	141.0mA	>200mA	>141.4mA	√
4	39.4	5.55	140.9mA	>200mA	>141.4mA	√

(The measured output is slightly low due to not being able to adjust the input voltage to the correct level of 7.07V)

Unit…………………Transmon10……Serial No ………………………………
Test Engineer…………RMC………
Date……………….…7/12/10...……

16. Final Assembly Checks

1. Remove the lid of the box.√

2. Unplug all external connections. √

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

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

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

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

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

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

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

UoB box ID	Transmon10
Driver board ID	Transmon10
Driver board Drawing No/Issue No	D1001650v2
Driver board Serial Number	Transmon10
Monitor board ID	Mon166
Monitor board Drawing No/Issue No	D070480_5_K
Monitor board Serial Number	Mon166

10. Check the security of any modification wires. √

11. Visually inspect. √

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

Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1000571-v1 Advanced LIGO UK 28 September 2010

Transmon Coil Drive Unit Test Plan

R. M. Cutler, University of Birmingham

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

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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

TRANSMON COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit……………….Transmon_11……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

Drive Card ID……Transmon_11………………
Monitor Card ID…Mon236………………..………..

Contents

1. Description

The Transmon, or Transmission Monitor Coil Driver Unit is used to control the position of the Transmission Monitor suspension in the Advanced LIGO Gravity wave experiment. It is functionally identical to the Triple Top Drive Board.

It controls the current in the coil which provides the magnetic force which controls the position of the Transmission Monitor suspension. It works in conjunction with the OSEM coil and position sensor units. One Transmon coil drive unit controls four OSEMs.

The Transmon 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 Transmon Coil Drive Unit also passes the amplified signals from the Photodiodes, which detect the position of the suspension, back to the control electronics without processing them in any way.

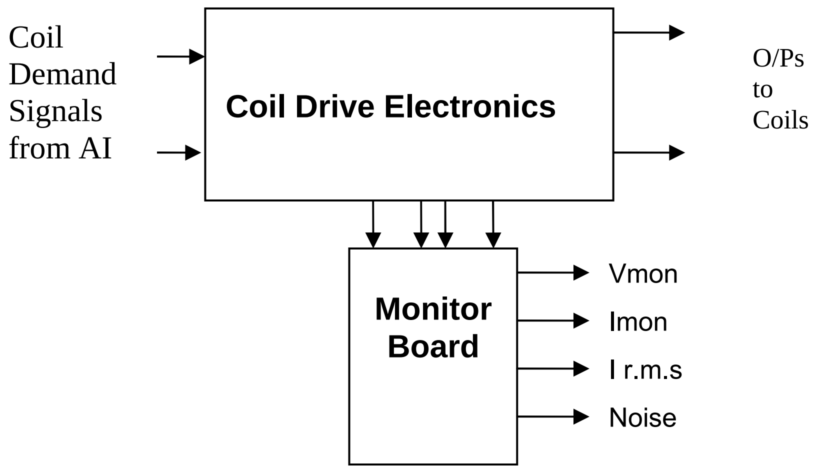


FIG. 1 Transmon Driver Unit Block Diagram

Each Transmon 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……………….Transmon_11……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

2. Test Equipment

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

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

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	
DVM	TENMA	72-7730	

Unit……………….Transmon_11…………………….Serial No ……………………………….
Test Engineer…..Xen…………………….
Date……………..30/11/10………………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

One of the screw locks on the Test In 16-way D-type connector on the drive board has been reinforced with a nut and some Loctite 290 as the thread in the connector is warped.

Unit……………….Transmon_11…………………….Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..30/11/10………………

4. Continuity Checks

Use a multi-meter to check the connections below.

Photodiode outputs

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

LED Monitors

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

Power Supply to Satellite box

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

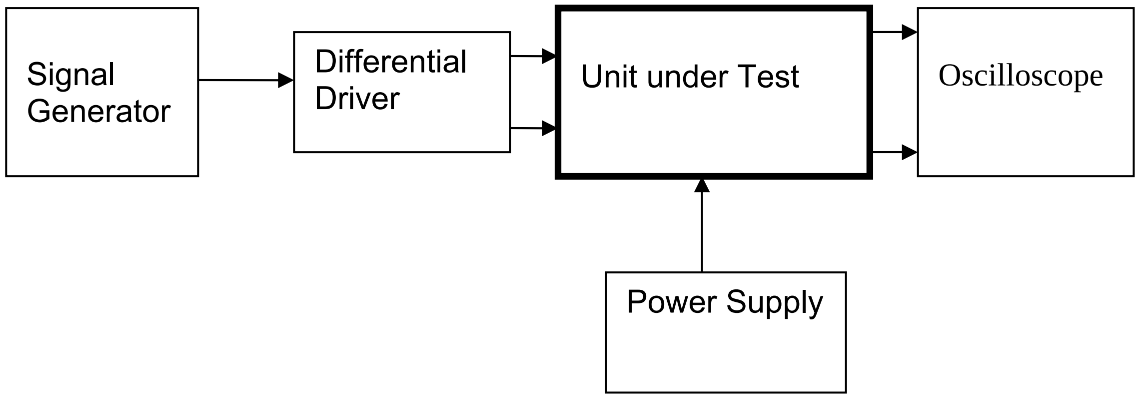
Unit………………Transmon_11……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..30/11/10………………

Isolation Checks

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

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

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……………..Transmon_11……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..30/11/10………………

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)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

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

Unit………………Transmon_11……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..30/11/10………………

7. Relay Operation

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

Filter

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

TEST SWITCHES

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

Unit……………….Transmon_11…………………….Serial No ……………………………….
Test Engineer…..Xen……………………
Date……………..30/11/10………………

8. Current Monitor tests

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

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

Remove all links W4 and W5.

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

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

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 2v peak appears across each resistor.

Connect a true r.m.s meter across the channel 4 resistor, and carefully adjust the signal generator to give an r.m.s reading of 1.5 volts.

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

Channel	**Monitor Connector**	**Parameter**	**Theoretical Value (+/- .1v)**	**Measured Value**	**Pass/ Fail**
1	Pin 2	Current Monitor	1.01V r.m.s	1.02	√
	Pin 1	RMS Current	1.01V dc	1.02	√
2	Pin 5	Current Monitor	1.01V r.m.s	1.02	√
	Pin 4	RMS Current	1.01V dc	1.02	√
3	Pin 8	Current Monitor	1.01V r.m.s	1.02	√
	Pin 7	RMS Current	1.01V dc	1.02	√
4	Pin 11	Current Monitor	1.01V r.m.s	1.02	√
	Pin 10	RMS Current	1.01V dc	1.02	√

Unit……………..Transmon_11……………………Serial No ……………………………
Test Engineer…..Xen……………………
Date……………..30/11/10………………

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 at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

Channel	Coil Drive Output pins	Voltage Monitor socket Pin	Monitor output?	Expected value	OK?
1	Pins 1,9	Pin 3	3.32	3.2v to 3.4v	√
2	Pins 3,11	Pin 6	3.33	3.2v to 3.4v	√
3	Pins 5,13	Pin 9	3.33	3.2v to 3.4v	√
4	Pins 7, 15	Pin 12	3.32	3.2v to 3.4v	√

10. Noise Monitor Tests

See Monitor re-test report.

Unit………………Transmon_11……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..30/11/10………………

12. Corner frequency tests

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

Use the Dynamic Signal Analyser and signal generator.

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

Channel 1

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

Channel 2

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

Channel 3

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.4		
10Hz	-30.1		
100Hz	-42.8		
1KHz	-43.2		

Channel 4

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

0.1 Hz measurements with the signal generator and oscilloscope

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

Unit………………Transmon_11……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

12. Distortion

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

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

13. Full Load Test

Apply the DC source to the input to the differential amplifier. Connect the 39 Ohm 5 watt loads to the outputs.
Increase the input voltage to 10v with respect to 0v, and monitor the temperatures of the drive amplifiers. If their temperature increases above 100°C, flag a problem!
Leave running for 10 minutes, then record the temperatures of drive amplifiers, and the differential output voltages from the amplifier (TP9 and TP13).

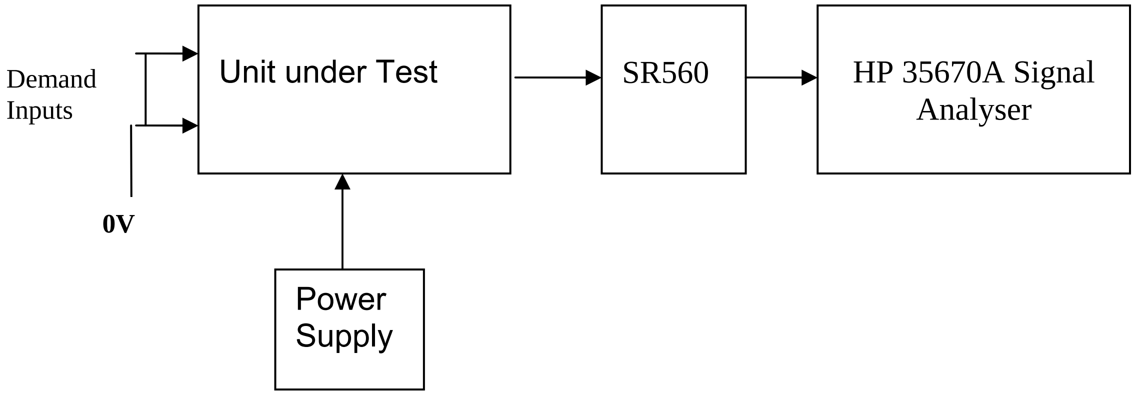
The output voltages should be recorded.

Output	**Voltage**	**> 24v?**	**DRIVER**	**Temperature**	**<60°C?**
CH1 Positive	24.4	√	**CH1 IC1**	-38.2	√
CH1 Negative			**CH1 IC5**	41.6	√
CH2 Positive	24.4	√	**CH2 IC1**	41.4	√
CH2 Negative			**CH2 IC5**	41.8	√
CH3 Positive	24.4	√	**CH3 IC1**	41.6	√
CH3 Negative			**CH3 IC5**	42.3	√
CH4 Positive	24.4	√	**CH4 IC1**	39.9	√
CH4 Negative			**CH4 IC5**	41.4	√

Unit..................Transmon_11.......................Serial No ....
Test Engineer.....Xen.......................
Date...............1/12/10...................

14. Noise Tests

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



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-161.15dB	-99.2	-159.2
Ch2	-161.15dB	-101.3	-161.3
Ch3	-161.15dB	-99.4	-159.4
Ch4	-161.15dB	-99.5	-159.5

Notes:
Specified noise output current at 10 Hz = 73 pA/√Hz
Total output resistance = 120 Ohms
Amplifier noise voltage should therefore = 8.76nV/√Hz or -161.15 dB

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

Unit……………..Transmon_11……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10………………..

15. Full Current Tests

High power dummy loads are needed for this test.

With the dummy loads removed, measure and record the value of each resistor. Nominal 39 Ohm power resistors should be used.

Plug in the dummy load.

Remove the filter links.

Drive the unit with a 10v peak sine wave on each channel, which should measure 7.07 volts on a true r.m.s meter.

Measure the voltage across each load resistor and record it. Calculate the current through each resistor, and compare with the specification. If a true r.m.s meter is used to make the measurement, compare with the r.m.s specification

Channel	R =	V=	Therefore I =	Spec (peak)	Spec (r.m.s)	Pass?
1	39.3	5.55	141.2mA	>200mA	>141.4mA	√
2	39.4	5.55	140.9mA	>200mA	>141.4mA	√
3	39.3	5.54	141.0mA	>200mA	>141.4mA	√
4	39.4	5.55	140.9mA	>200mA	>141.4mA	√

(The measured output is slightly low due to not being able to adjust the input voltage to the correct level of 7.07V)

Unit…………………Transmon 11…………Serial No ………………………………
Test Engineer…………RMC………
Date………………..…7/12/10………………

16. Final Assembly Checks

1. Remove the lid of the box. √

2. Unplug all external connections. √

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

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

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

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

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

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

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

UoB box ID	Transmon11
Driver board ID	Transmon11
Driver board Drawing No/Issue No	D1001650_V2
Driver board Serial Number	Transmon11
Monitor board ID	MON236
Monitor board Drawing No/Issue No	D070840_5_K
Monitor board Serial Number	MON236

10. Check the security of any modification wires. √

11. Visually inspect. √

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

    Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1000571-v1 Advanced LIGO UK 28 September 2010

Transmon Coil Drive Unit Test Plan

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

TRANSMON COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit………………Transmon_12……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

Drive Card ID……Transmon_12………………
Monitor Card ID…Mon211………..…..………..

Contents

1. Description

The Transmon, or Transmission Monitor Coil Driver Unit is used to control the position of the Transmission Monitor suspension in the Advanced LIGO Gravity wave experiment. It is functionally identical to the Triple Top Drive Board.

It controls the current in the coil which provides the magnetic force which controls the position of the Transmission Monitor suspension. It works in conjunction with the OSEM coil and position sensor units. One Transmon coil drive unit controls four OSEMs.

The Transmon 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 Transmon Coil Drive Unit also passes the amplified signals from the Photodiodes, which detect the position of the suspension, back to the control electronics without processing them in any way.

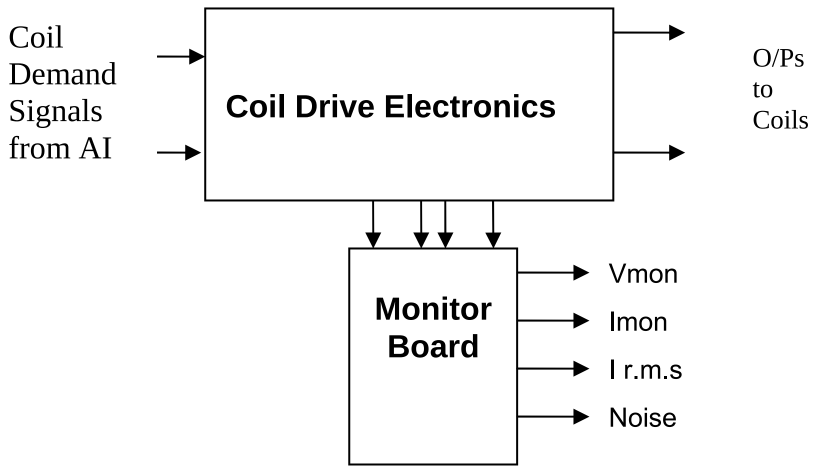


FIG. 1 Transmon Driver Unit Block Diagram

Each Transmon 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……………..Transmon_12……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

2. Test Equipment

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

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

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	
DVM	TENMA	72-7730	

Unit………………Transmon_12……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

Unit………………Transmon_12……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

4. Continuity Checks

Use a multi-meter to check the connections below.

Photodiode outputs

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

LED Monitors

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

Power Supply to Satellite box

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

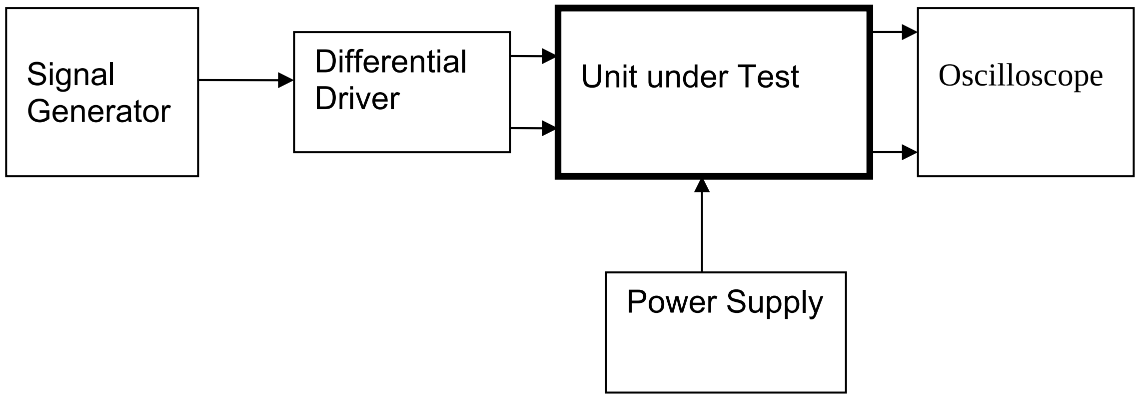
Unit……………….Transmon_12……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

Isolation Checks

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

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

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………………Transmon_12……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

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)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

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

Unit……………..Transmon_12……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

7. Relay Operation

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

Filter

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

TEST SWITCHES

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

Unit………………Transmon_12……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

8. Current Monitor tests

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

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

Remove all links W4 and W5.

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

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

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 2v peak appears across each resistor.

Connect a true r.m.s meter across the channel 4 resistor, and carefully adjust the signal generator to give an r.m.s reading of 1.5 volts.

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

Channel	Monitor Connector	Parameter	Theoretical Value (+/- .1v)	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	1.01V r.m.s	1.02	√
	Pin 1	RMS Current	1.01V dc	1.02	√
2	Pin 5	Current Monitor	1.01V r.m.s	1.02	√
	Pin 4	RMS Current	1.01V dc	1.02	√
3	Pin 8	Current Monitor	1.01V r.m.s	1.02	√
	Pin 7	RMS Current	1.01V dc	1.02	√
4	Pin 11	Current Monitor	1.01V r.m.s	1.02	√
	Pin 10	RMS Current	1.01V dc	1.02	√

Unit……………..Transmon_12……………………Serial No ……………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

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 at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

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

10. Noise Monitor Tests

See Monitor re-test report.

Unit……………..Transmon_12……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

12. Corner frequency tests

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

Use the Dynamic Signal Analyser and signal generator.

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

Channel 1

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.0		
10Hz	-30.6		
100Hz	-42.8		
1KHz	-43.2		

Channel 2

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

Channel 3

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.5		
10Hz	-30.0		
100Hz	-42.8		
1KHz	-43.2		

Channel 4

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

0.1 Hz measurements with the signal generator and oscilloscope

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

Unit………………Transmon_12……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

12. Distortion

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

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

13. Full Load Test

Apply the DC source to the input to the differential amplifier. Connect the 39 Ohm 5 watt loads to the outputs.
Increase the input voltage to 10v with respect to 0v, and monitor the temperatures of the drive amplifiers. If their temperature increases above 100°C, flag a problem!
Leave running for 10 minutes, then record the temperatures of drive amplifiers, and the differential output voltages from the amplifier (TP9 and TP13).

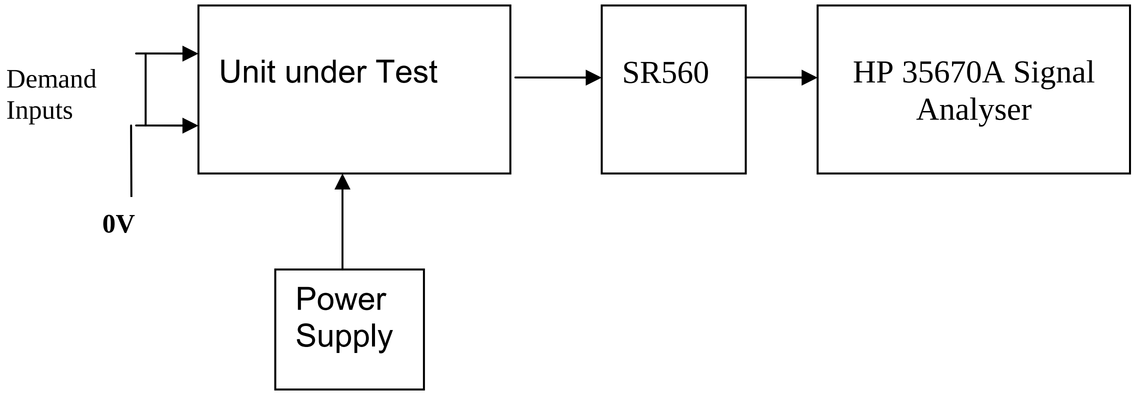
The output voltages should be recorded.

Output	Voltage	> 24v?	DRIVER	Temperature	<60°C?
CH1 Positive	24.4	√	**CH1 IC1**	37.7	√
CH1 Negative			**CH1 IC5**	40.9	√
CH2 Positive	24.4	√	**CH2 IC1**	37.9	√
CH2 Negative			**CH2 IC5**	39.9	√
CH3 Positive	24.4	√	**CH3 IC1**	37.0	√
CH3 Negative			**CH3 IC5**	37.0	√
CH4 Positive	24.4	√	**CH4 IC1**	37.2	√
CH4 Negative			**CH4 IC5**	38.7	√

Unit……………….Transmon_12…………………….Serial No ……………………………….
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

14. Noise Tests

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



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-161.15dB	-100.3	-160.3
Ch2	-161.15dB	-100.0	-160.0
Ch3	-161.15dB	-100.6	-160.6
Ch4	-161.15dB	-102.4	-162.4

Notes:
Specified noise output current at 10 Hz = 73 pA/√Hz
Total output resistance = 120 Ohms
Amplifier noise voltage should therefore = 8.76nV/√Hz or -161.15 dB

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

Unit……………..Transmon_12……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10...………………

15. Full Current Tests

High power dummy loads are needed for this test.

With the dummy loads removed, measure and record the value of each resistor. Nominal 39 Ohm power resistors should be used.

Plug in the dummy load.

Remove the filter links.

Drive the unit with a 10v peak sine wave on each channel, which should measure 7.07 volts on a true r.m.s meter.

Measure the voltage across each load resistor and record it. Calculate the current through each resistor, and compare with the specification. If a true r.m.s meter is used to make the measurement, compare with the r.m.s specification

Channel	**R =**	**V=**	**Therefore I =**	**Spec (peak)**	**Spec (r.m.s)**	**Pass?**
1	39.3	5.55	141.2mA	>200mA	>141.4mA	√
2	39.4	5.57	141.4mA	>200mA	>141.4mA	√
3	39.3	5.55	141.2mA	>200mA	>141.4mA	√
4	39.4	5.54	140.6mA	>200mA	>141.4mA	√

(The measured output is slightly low due to not being able to adjust the input voltage to the correct level of 7.07V)

Unit…………………Transmon_12…………Serial No ………………………………
Test Engineer…………RMC………
Date……………….…7/12/10……

16. Final Assembly Checks

1. Remove the lid of the box. √

2. Unplug all external connections. √

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

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

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

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

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

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

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

UoB box ID	Transmon_12
Driver board ID	Transmon_12
Driver board Drawing No/Issue No	D1001650_V2
Driver board Serial Number	Transmon_12
Monitor board ID	MON211
Monitor board Drawing No/Issue No	D070480_5_K
Monitor board Serial Number	MON211

10. Check the security of any modification wires. √

11. Visually inspect. √

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

    Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1000571-v1	Advanced LIGO UK	28 September 2010

Transmon Coil Drive Unit Test Plan

R. M. Cutler, University of Birmingham

Distribution of this document:
Inform aligo_sus

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

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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

TRANSMON COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit………………Transmon_13……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

Drive Card ID……Transmon_13………………
Monitor Card ID…Mon190………………..……..

Contents

1. Description

The Transmon, or Transmission Monitor Coil Driver Unit is used to control the position of the Transmission Monitor suspension in the Advanced LIGO Gravity wave experiment. It is functionally identical to the Triple Top Drive Board.

It controls the current in the coil which provides the magnetic force which controls the position of the Transmission Monitor suspension. It works in conjunction with the OSEM coil and position sensor units. One Transmon coil drive unit controls four OSEMs.

The Transmon 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 Transmon Coil Drive Unit also passes the amplified signals from the Photodiodes, which detect the position of the suspension, back to the control electronics without processing them in any way.

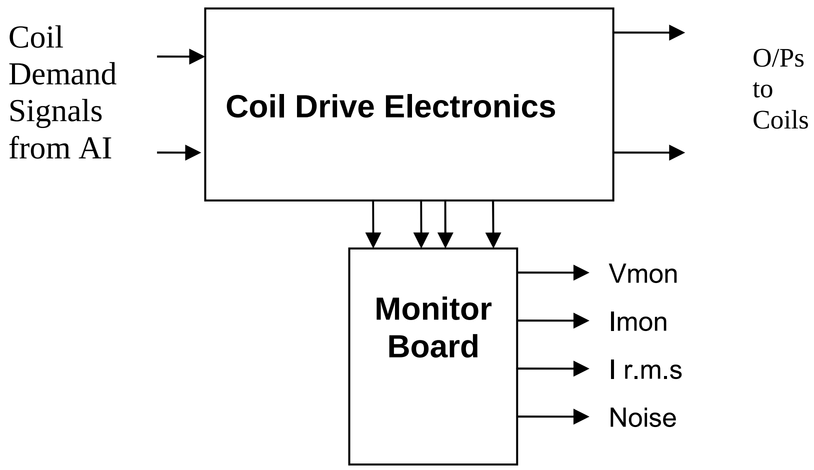


FIG. 1 Transmon Driver Unit Block Diagram

Each Transmon 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………………Transmon_13……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

2. Test Equipment

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

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

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	
DVM	TENMA	72-7730	

Unit………………Transmon_13……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

Unit……………….Transmon_13……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

4. Continuity Checks

Use a multi-meter to check the connections below.

Photodiode outputs

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

LED Monitors

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

Power Supply to Satellite box

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

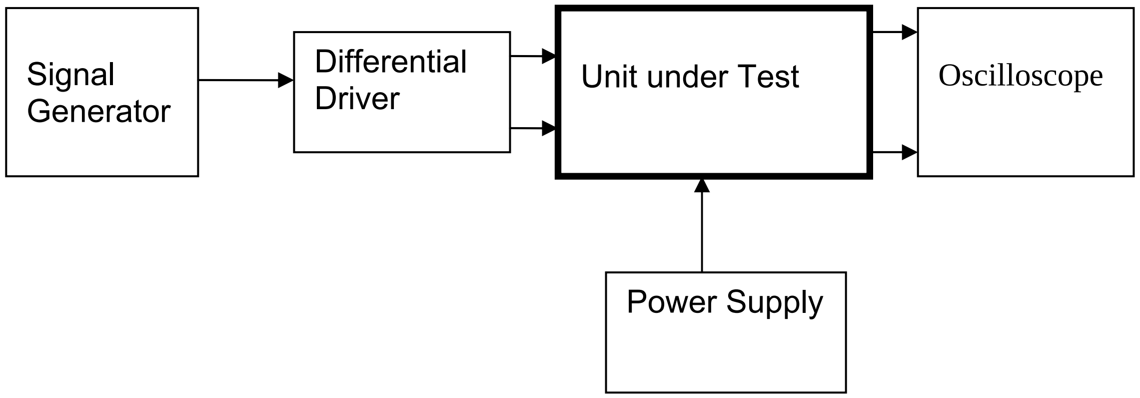
Unit………………Transmon_13……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

Isolation Checks

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

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

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……………….Transmon_13……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

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)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

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

Unit………………Transmon_13……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

7. Relay Operation

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

Filter

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

TEST SWITCHES

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

Unit……………….Transmon_13…………………….Serial No ……………………………….
Test Engineer…..Xen…………………….
Date……………..1/12/10..………………

8. Current Monitor tests

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

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

Remove all links W4 and W5.

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

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

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 2v peak appears across each resistor.

Connect a true r.m.s meter across the channel 4 resistor, and carefully adjust the signal generator to give an r.m.s reading of 1.5 volts.

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

Channel	Monitor Connector	Parameter	Theoretical Value (+/- .1v)	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	1.01V r.m.s	1.02	√
	Pin 1	RMS Current	1.01V dc	1.02	√
2	Pin 5	Current Monitor	1.01V r.m.s	1.02	√
	Pin 4	RMS Current	1.01V dc	1.02	√
3	Pin 8	Current Monitor	1.01V r.m.s	1.02	√
	Pin 7	RMS Current	1.01V dc	1.02	√
4	Pin 11	Current Monitor	1.01V r.m.s	1.02	√
	Pin 10	RMS Current	1.01V dc	1.02	√

Unit……………..Transmon_13…………………..Serial No ……………………………..
Test Engineer…..Xen……………………
Date……………..1/12/10...………………

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 at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

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

10. Noise Monitor Tests

See Monitor re-test report.

Unit……………..Transmon_13…………………..Serial No ……………………………
Test Engineer…..Xen……………………
Date……………..1/12/10………………

12. Corner frequency tests

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

Use the Dynamic Signal Analyser and signal generator.

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

Channel 1

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

Channel 2

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

Channel 3

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.0		
10Hz	-30.6		
100Hz	-42.8		
1KHz	-43.2		

Channel 4

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

0.1 Hz measurements with the signal generator and oscilloscope

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

Unit………………Transmon_13……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

12. Distortion

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

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

13. Full Load Test

Apply the DC source to the input to the differential amplifier. Connect the 39 Ohm 5 watt loads to the outputs.
Increase the input voltage to 10v with respect to 0v, and monitor the temperatures of the drive amplifiers. If their temperature increases above 100°C, flag a problem!
Leave running for 10 minutes, then record the temperatures of drive amplifiers, and the differential output voltages from the amplifier (TP9 and TP13).

The output voltages should be recorded.

Output	Voltage	> 24v?	DRIVER	Temperature	<60°C?
CH1 Positive	24.4	√	**CH1 IC1**	36.5	√
CH1 Negative			**CH1 IC5**	38.2	√
CH2 Positive	24.4	√	**CH2 IC1**	36.5	√
CH2 Negative			**CH2 IC5**	41.6	√
CH3 Positive	24.4	√	**CH3 IC1**	39.7	√
CH3 Negative			**CH3 IC5**	39.9	√
CH4 Positive	24.4	√	**CH4 IC1**	36.2	√
CH4 Negative			**CH4 IC5**	40.4	√

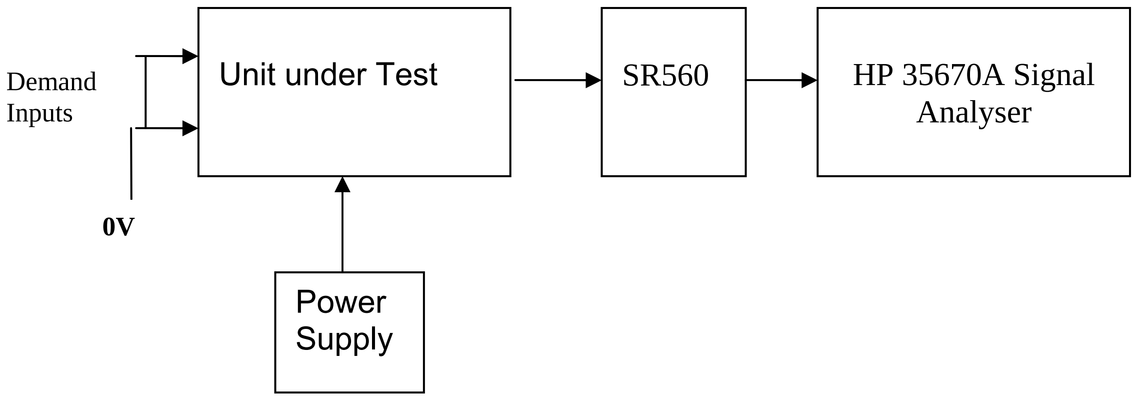
Unit.................Transmon_13.......................Serial No ....
Test Engineer.....Xen.......................
Date................1/12/10...................

14. Noise Tests

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

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

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



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-161.15dB	-100.6	-160.6
Ch2	-161.15dB	-102.7	-162.7
Ch3	-161.15dB	-100.3	-160.3
Ch4	-161.15dB	-101.9	-161.9

Notes:
Specified noise output current at 10 Hz = 73 pA/√Hz
Total output resistance = 120 Ohms
Amplifier noise voltage should therefore = 8.76nV/√Hz or -161.15 dB

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

Unit……………..Transmon_13…………………..Serial No ……………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

15. Full Current Tests

High power dummy loads are needed for this test.

With the dummy loads removed, measure and record the value of each resistor. Nominal 39 Ohm power resistors should be used.

Plug in the dummy load.

Remove the filter links.

Drive the unit with a 10v peak sine wave on each channel, which should measure 7.07 volts on a true r.m.s meter.

Measure the voltage across each load resistor and record it. Calculate the current through each resistor, and compare with the specification. If a true r.m.s meter is used to make the measurement, compare with the r.m.s specification

Channel	R =	V=	Therefore I =	Spec (peak)	Spec (r.m.s)	Pass?
1	39.3	5.54	141.0mA	>200mA	>141.4mA	√
2	39.4	5.55	140.9mA	>200mA	>141.4mA	√
3	39.3	5.55	141.2mA	>200mA	>141.4mA	√
4	39.4	5.54	141.0mA	>200mA	>141.4mA	√

(The measured output is slightly low due to not being able to adjust the input voltage to the correct level of 7.07V)

Unit……………..Transmon_13……………………Serial No ………………………………
Test Engineer………RMC...………
Date……………….7/12/10..………

16. Final Assembly Checks

1. Remove the lid of the box. √

2. Unplug all external connections. √

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

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

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

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

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

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

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

UoB box ID	Transmon_13
Driver board ID	Transmon_13
Driver board Drawing No/Issue No	D1001650_v2
Driver board Serial Number	Transmon_13
Monitor board ID	MON190
Monitor board Drawing No/Issue No	D070480_5_K
Monitor board Serial Number	MON190

10. Check the security of any modification wires. √

11. Visually inspect. √

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

Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1000571-v1	Advanced LIGO UK	28 September 2010

Transmon Coil Drive Unit Test Plan

R. M. Cutler, University of Birmingham

Distribution of this document:
Inform aligo_sus

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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

TRANSMON COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit……………….Transmon_14……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

Drive Card ID……Transmon_14………………
Monitor Card ID…Mon220……………….………..

Contents

1. Description

The Transmon, or Transmission Monitor Coil Driver Unit is used to control the position of the Transmission Monitor suspension in the Advanced LIGO Gravity wave experiment. It is functionally identical to the Triple Top Drive Board.

It controls the current in the coil which provides the magnetic force which controls the position of the Transmission Monitor suspension. It works in conjunction with the OSEM coil and position sensor units. One Transmon coil drive unit controls four OSEMs.

The Transmon 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 Transmon Coil Drive Unit also passes the amplified signals from the Photodiodes, which detect the position of the suspension, back to the control electronics without processing them in any way.

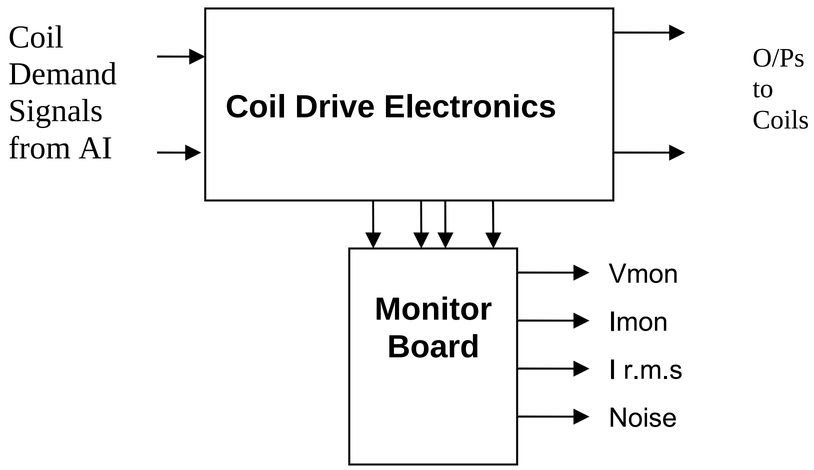


FIG. 1 Transmon Driver Unit Block Diagram

Each Transmon 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………………Transmon_14……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

2. Test Equipment

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

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

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	
DVM	TENMA	72-7730	

Unit………………Transmon_14……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

Unit……………….Transmon_14……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

4. Continuity Checks

Use a multi-meter to check the connections below.

Photodiode outputs

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

LED Monitors

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

Power Supply to Satellite box

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

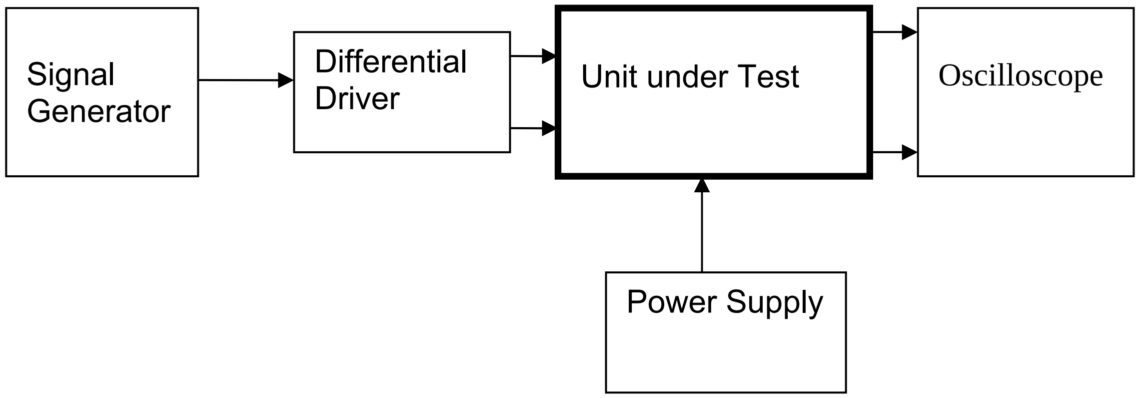
Unit………………Transmon_14……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

Isolation Checks

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

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

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..................Transmon_14........................Serial No ....
Test Engineer.....Xen........................
Date.................1/12/10...................

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)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

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

Unit……………..Transmon_14……………………Serial No ……………………………..
Test Engineer…..Xen……………………
Date……………..1/12/10..………………

7. Relay Operation

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

Filter

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

TEST SWITCHES

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

Unit……………….Transmon_14…………………….Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

8. Current Monitor tests

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

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

Remove all links W4 and W5.

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

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

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 2v peak appears across each resistor.

Connect a true r.m.s meter across the channel 4 resistor, and carefully adjust the signal generator to give an r.m.s reading of 1.5 volts.

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

Channel	Monitor Connector	Parameter	Theoretical Value (+/- .1v)	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	1.01V r.m.s	1.02	√
	Pin 1	RMS Current	1.01V dc	1.02	√
2	Pin 5	Current Monitor	1.01V r.m.s	1.02	√
	Pin 4	RMS Current	1.01V dc	1.02	√
3	Pin 8	Current Monitor	1.01V r.m.s	1.02	√
	Pin 7	RMS Current	1.01V dc	1.03	√
4	Pin 11	Current Monitor	1.01V r.m.s	1.02	√
	Pin 10	RMS Current	1.01V dc	1.02	√

Unit……………..Transmon_14……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

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 at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

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

10. Noise Monitor Tests

See Monitor re-test report.

Unit.................Transmon_14......................Serial No ....
Test Engineer.....Xen.......................
Date................2/12/10...................

12. Corner frequency tests

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

Use the Dynamic Signal Analyser and signal generator.

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

Channel 1

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.1		
10Hz	-30.4		
100Hz	-42.8		
1KHz	-43.2		

Channel 2

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	0.9		
10Hz	-30.7		
100Hz	-42.8		
1KHz	-43.2		

Channel 3

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.1		
10Hz	-30.5		
100Hz	-42.8		
1KHz	-43.2		

Channel 4

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.1		
10Hz	-30.4		
100Hz	-42.8		
1KHz	-43.3		

0.1 Hz measurements with the signal generator and oscilloscope

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

Unit……………….Transmon_14…………………….Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

12. Distortion

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

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

13. Full Load Test

Apply the DC source to the input to the differential amplifier. Connect the 39 Ohm 5 watt loads to the outputs.
Increase the input voltage to 10v with respect to 0v, and monitor the temperatures of the drive amplifiers. If their temperature increases above 100°C, flag a problem!
Leave running for 10 minutes, then record the temperatures of drive amplifiers, and the differential output voltages from the amplifier (TP9 and TP13).

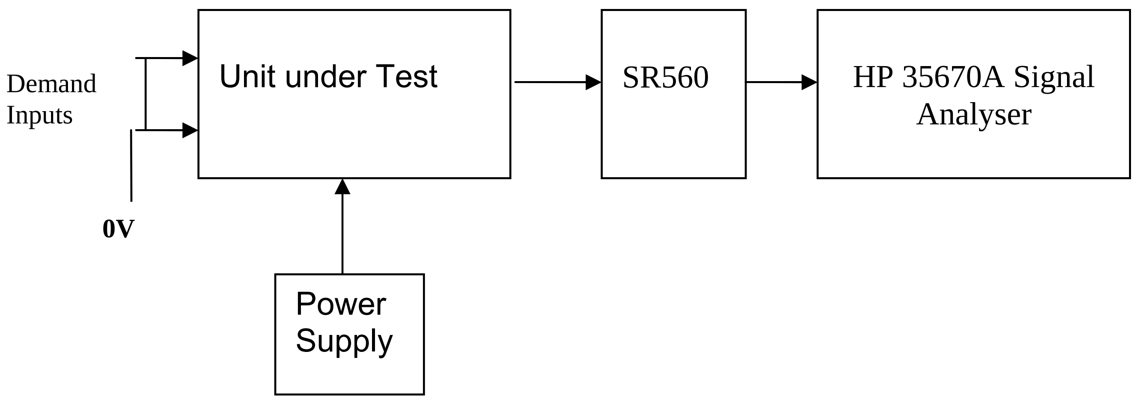
The output voltages should be recorded.

Output	Voltage	> 24v?	DRIVER	Temperature	<60°C?
CH1 Positive	24.4	√	CH1 IC1	37.2	√
CH1 Negative			CH1 IC5	40.9	√
CH2 Positive	24.4	√	CH2 IC1	39.4	√
CH2 Negative			CH2 IC5	40.4	√
CH3 Positive	24.4	√	CH3 IC1	38.9	√
CH3 Negative			CH3 IC5	41.4	√
CH4 Positive	24.4	√	CH4 IC1	37.2	√
CH4 Negative			CH4 IC5	40.9	√

Unit……………….Transmon_14……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

14. Noise Tests

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



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-161.15dB	-101.7	-161.7
Ch2	-161.15dB	-100.4	-160.4
Ch3	-161.15dB	-97.0	-157.0
Ch4	-161.15dB	-100.7	-160.7

Notes:
Specified noise output current at 10 Hz = 73 pA/√Hz
Total output resistance = 120 Ohms
Amplifier noise voltage should therefore = 8.76nV/√Hz or -161.15 dB

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

Unit………………Transmon_14……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

15. Full Current Tests

High power dummy loads are needed for this test.

With the dummy loads removed, measure and record the value of each resistor. Nominal 39 Ohm power resistors should be used.

Plug in the dummy load.

Remove the filter links.

Drive the unit with a 10v peak sine wave on each channel, which should measure 7.07 volts on a true r.m.s meter.

Measure the voltage across each load resistor and record it. Calculate the current through each resistor, and compare with the specification. If a true r.m.s meter is used to make the measurement, compare with the r.m.s specification

Channel	R =	V=	Therefore I =	Spec (peak)	Spec (r.m.s)	Pass?
1	39.3	5.55	141.2mA	>200mA	>141.4mA	√
2	39.4	5.55	140.9mA	>200mA	>141.4mA	√
3	39.3	5.54	141.0mA	>200mA	>141.4mA	√
4	39.4	5.54	140.6mA	>200mA	>141.4mA	√

(The measured output is slightly low due to not being able to adjust the input voltage to the correct level of 7.07V)

Unit………………Transmon 14………………Serial No ………………………………
Test Engineer………RMC………………
Date……………….7/12/10…………………

16. Final Assembly Checks

1. Remove the lid of the box.√

2. Unplug all external connections. √

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

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

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

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

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

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

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

UoB box ID	Transmon 14
Driver board ID	Transmon 14
Driver board Drawing No/Issue No	D1001650_V2
Driver board Serial Number	Transmon 14
Monitor board ID	MON220
Monitor board Drawing No/Issue No	D070480_5_K
Monitor board Serial Number	MON220

10. Check the security of any modification wires. √

11. Visually inspect. √

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

    Check all external screws for tightness. √

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1000571-v1 Advanced LIGO UK 28 September 2010

Transmon Coil Drive Unit Test Plan

R. M. Cutler, University of Birmingham

Distribution of this document:
Inform aligo_sus

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

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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

TRANSMON COIL DRIVER
COMPLETED UNIT TEST PLAN

Unit………………Transmon_16……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

Drive Card ID……Transmon_16……………
Monitor Card ID…Mon145…..……..………..

Contents

1. Description

The Transmon, or Transmission Monitor Coil Driver Unit is used to control the position of the Transmission Monitor suspension in the Advanced LIGO Gravity wave experiment. It is functionally identical to the Triple Top Drive Board.

It controls the current in the coil which provides the magnetic force which controls the position of the Transmission Monitor suspension. It works in conjunction with the OSEM coil and position sensor units. One Transmon coil drive unit controls four OSEMs.

The Transmon 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 Transmon Coil Drive Unit also passes the amplified signals from the Photodiodes, which detect the position of the suspension, back to the control electronics without processing them in any way.

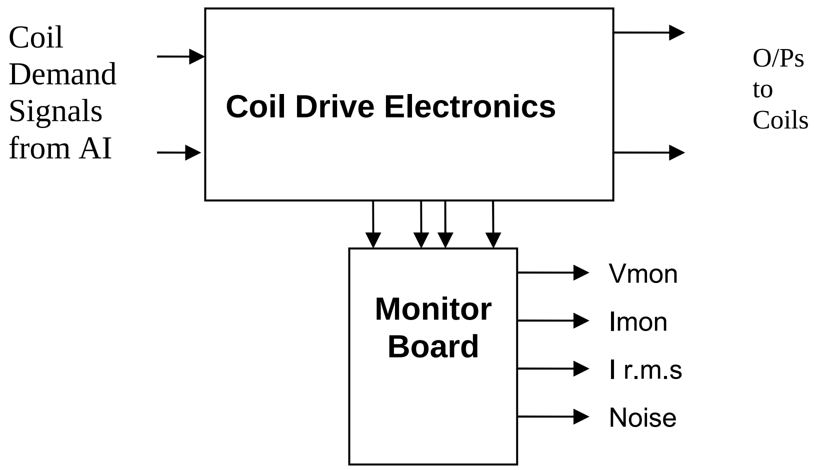


FIG. 1 Transmon Driver Unit Block Diagram

Each Transmon 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………………Transmon_16……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

2. Test Equipment

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

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

Unit (e.g. DVM)	Manufacturer	Model	Serial Number
Signal Generator	Agilent	33250A	
Oscilloscope	ISO-TECH	ISR622	
PSU*2	Farnell	L30-2	
DVM	Fluke	77III	
Signal analyzer	Agilent	35670A	
Pre-amplifier	Stanford Systems	SR560	
DVM	TENMA	72-7730	

Unit………………Transmon_16……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

3. Inspection

Remove the lid of the case.

Workmanship

Inspect the general workmanship standard and comment: √

Unit………………Transmon_16……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10...………………

4. Continuity Checks

Use a multi-meter to check the connections below.

Photodiode outputs

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

LED Monitors

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

Power Supply to Satellite box

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

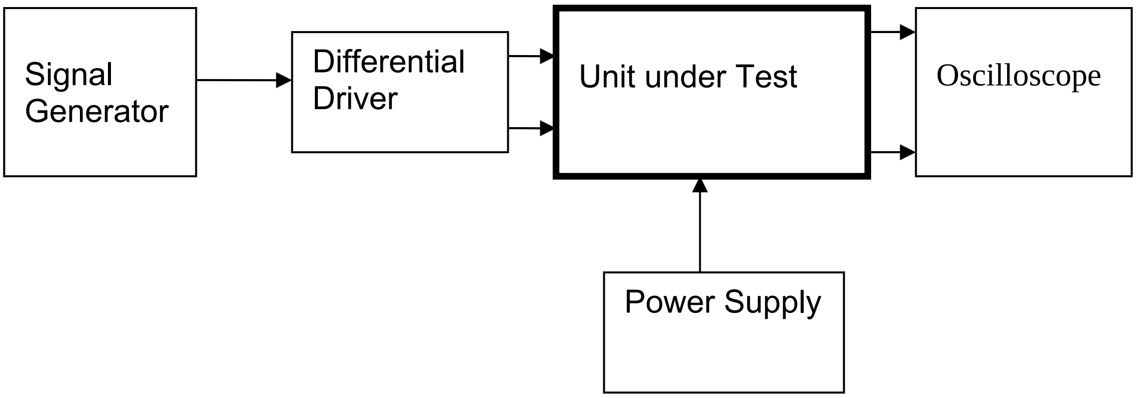
Unit……………….Transmon_16……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

Isolation Checks

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

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

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………………Transmon_16……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

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)
550mA	500mA

Check that all power LEDs are illuminated.

LEDs	Plus	Minus
Front Panel	√	√
Rear Panel	√	√

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

Unit……………..Transmon_16……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

7. Relay Operation

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

Filter

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

TEST SWITCHES

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

Unit……………….Transmon_16……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10...………………

8. Current Monitor tests

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

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

Remove all links W4 and W5.

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

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

Connect a scope probe to each end of one of the load resistors. Check that a sine wave of around 2v peak appears across each resistor.

Connect a true r.m.s meter across the channel 4 resistor, and carefully adjust the signal generator to give an r.m.s reading of 1.5 volts.

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

Channel	Monitor Connector	Parameter	Theoretical Value (+/- .1v)	Measured Value	Pass/ Fail
1	Pin 2	Current Monitor	1.01V r.m.s	1.02	√
	Pin 1	RMS Current	1.01V dc	1.01	√
2	Pin 5	Current Monitor	1.01V r.m.s	1.02	√
	Pin 4	RMS Current	1.01V dc	1.03	√
3	Pin 8	Current Monitor	1.01V r.m.s	1.02	√
	Pin 7	RMS Current	1.01V dc	1.02	√
4	Pin 11	Current Monitor	1.01V r.m.s	1.02	√
	Pin 10	RMS Current	1.01V dc	1.02	√

Unit……………..Transmon_16……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

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 at 100 Hz. Adjust the signal generator to give a voltage to 10v on the coil drive outputs.
Record the peak voltage on each Voltage Monitor pin, and check against the theoretical figure.

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

10. Noise Monitor Tests

See Monitor re-test report.

Unit……………Transmon_16…………………Serial No ……………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

12. Corner frequency tests

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

Use the Dynamic Signal Analyser and signal generator.

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

Channel 1

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.1		
10Hz	-30.4		
100Hz	-42.8		
1KHz	-43.2		

Channel 2

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.1		
10Hz	-30.5		
100Hz	-42.8		
1KHz	-43.2		

Channel 3

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	1.1		
10Hz	-30.4		
100Hz	-42.8		
1KHz	-43.2		

Channel 4

Frequency	Gain (dB)	Expected Gain	Pass/Fail
1Hz	0.9		
10Hz	-30.7		
100Hz	-42.9		
1KHz	-43.2		

0.1 Hz measurements with the signal generator and oscilloscope

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

Unit……………..Transmon_16……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

12. Distortion

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

	Distortion Free?
Ch1	√
Ch2	√
Ch3	√
Ch4	√

13. Full Load Test

Apply the DC source to the input to the differential amplifier. Connect the 39 Ohm 5 watt loads to the outputs.
Increase the input voltage to 10v with respect to 0v, and monitor the temperatures of the drive amplifiers. If their temperature increases above 100°C, flag a problem!
Leave running for 10 minutes, then record the temperatures of drive amplifiers, and the differential output voltages from the amplifier (TP9 and TP13).

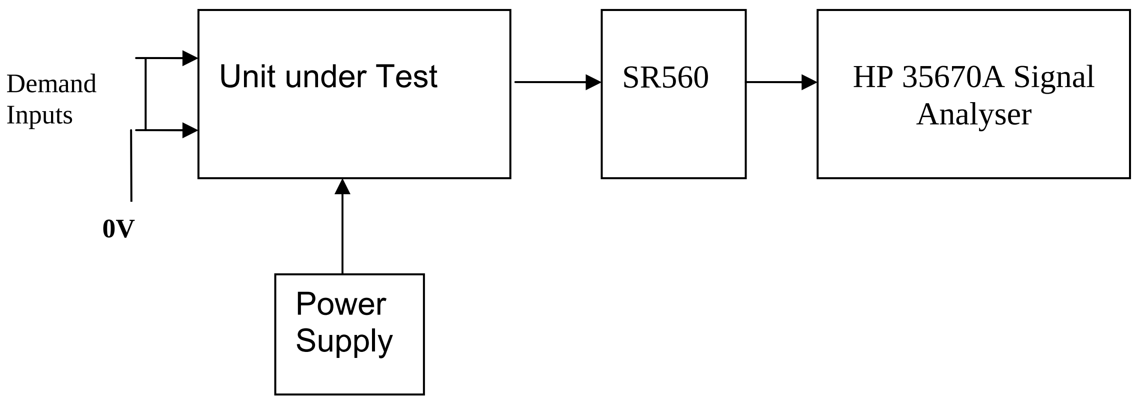
The output voltages should be recorded.

Output	Voltage	> 24v?	DRIVER	Temperature	<60°C?
CH1 Positive	24.4	√	CH1 IC1	38.2	√
CH1 Negative			CH1 IC5	39.9	√
CH2 Positive	24.4	√	CH2 IC1	37.7	√
CH2 Negative			CH2 IC5	40.4	√
CH3 Positive	24.4	√	CH3 IC1	36.0	√
CH3 Negative			CH3 IC5	38.4	√
CH4 Positive	24.4	√	CH4 IC1	38.7	√
CH4 Negative			CH4 IC5	41.1	√

Unit……………..Transmon_16…………………..Serial No ……………………………..
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

14. Noise Tests

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



	Spec in dB V/√Hz	Measured @ 10Hz	-60dB =
Ch1	-161.15dB	-99.8	-159.8
Ch2	-161.15dB	-102.2	-162.2
Ch3	-161.15dB	-101.1	-161.1
Ch4	-161.15dB	-102.4	-162.4

Notes:
Specified noise output current at 10 Hz = 73 pA/√Hz
Total output resistance = 120 Ohms
Amplifier noise voltage should therefore = 8.76nV/√Hz or -161.15 dB

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

Unit……………..Transmon_16……………………Serial No ………………………………
Test Engineer…..Xen……………………
Date……………..2/12/10..………………

15. Full Current Tests

High power dummy loads are needed for this test.

With the dummy loads removed, measure and record the value of each resistor. Nominal 39 Ohm power resistors should be used.

Plug in the dummy load.

Remove the filter links.

Drive the unit with a 10v peak sine wave on each channel, which should measure 7.07 volts on a true r.m.s meter.

Measure the voltage across each load resistor and record it. Calculate the current through each resistor, and compare with the specification. If a true r.m.s meter is used to make the measurement, compare with the r.m.s specification

Channel	R =	V=	Therefore I =	Spec (peak)	Spec (r.m.s)	Pass?
1	39.3	5.54	141.0mA	>200mA	>141.4mA	√
2	39.4	5.56	141.1mA	>200mA	>141.4mA	√
3	39.3	5.54	141.0mA	>200mA	>141.4mA	√
4	39.4	5.55	140.9mA	>200mA	>141.4mA	√

(The measured output is slightly low due to not being able to adjust the input voltage to the correct level of 7.07V)

Unit………………Transmon……………Serial No ………………………………
Test Engineer………RMC...……..
Date…………………..…7/12/10……

16. Final Assembly Checks

1. Remove the lid of the box. √

2. Unplug all external connections. √

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

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

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

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

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

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

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

UoB box ID	Transmon_16
Driver board ID	Transmon_16
Driver board Drawing No/Issue No	D1001650_v2
Driver board Serial Number	Transmon_16
Monitor board ID	MON145
Monitor board Drawing No/Issue No	D070480_5_K
Monitor board Serial Number	MON145

10. Check the security of any modification wires. √

11. Visually inspect. √

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

    Check all external screws for tightness. √