LIGO Laboratory / LIGO Scientific Collaboration

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# Quad Monitor Board Test Plan

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This is an internal working note
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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

# QUAD MONITOR BOARD TEST PLAN

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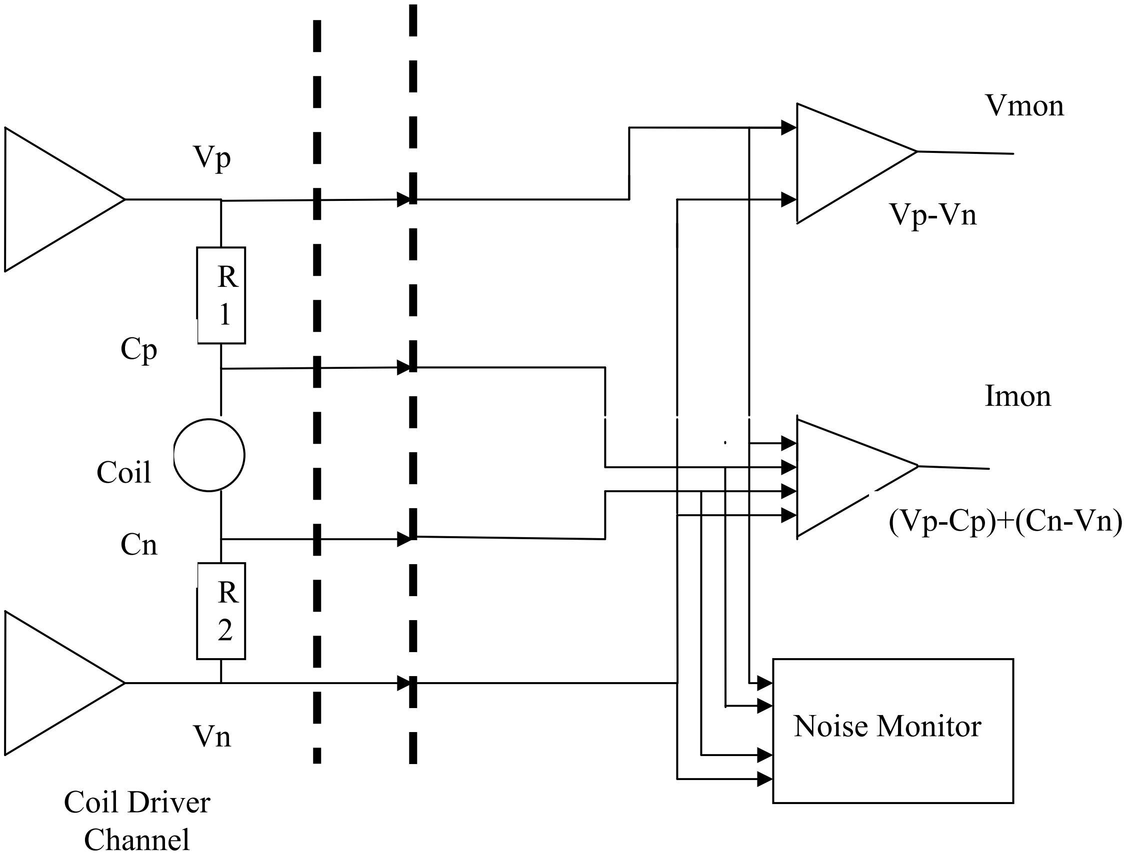
## 1. BLOCK DIAGRAM




**1. Block diagram of one channel of the monitor board.**
**Each board houses four such channels.**

## 2. TEST EQUIPMENT

Variable +/- 15v power supply
Precise DVM
Oscilloscope
Signal generator

The Coil Drive Simulator test equipment output is similar to the Coil Driver Channel shown above, except that the Coil is replaced by two 3.9K resistors in series.
Other resistors may be connected in parallel with this as required during the tests which follow.

## 3. DESCRIPTION

The function of the Monitor Board is to monitor the outputs from a drive board. It has four identical channels, one per drive board channel. Similar Monitor Boards are used to monitor the UIM Driver, the Top Driver and the PUM drivers.

### Inputs

The inputs of the monitor Board are connected to the two amplifier outputs and the coil feeds. The Driver Board and the monitor Board are both mounted in a Drive unit.
The signals which are monitored on each channel are: the positive and negative output voltages from the drive amplifiers, and the positive and negative output voltages developed across the coil.

These four signals are used to measure the amplifier output voltage, the current through the coil and the output noise on each of the drive amplifier channels.

### Output Voltage

The Amplifier Output Voltage is measured in IC9, by subtracting the Positive Amplifier output from the Negative Amplifier Output. The output is scaled by a factor of 3, so, for example, inputs of +15v and -15v, the sum of which is 30v, would give an output of 30v/3 = 10v.

### Coil Current

The coil current is calculated by IC8, by measuring the sum of the voltages across the two output resistors (R1 and R2 on the block diagram.) The amplifier performs the following calculation:

{(Pos Voltage Output) – (Negative Voltage Output)} -
{(Pos Coil Voltage) - (Negative Coil Voltage)}

The voltage across the coil is subtracted from the voltage across the Amplifier output. This gives the voltage across the output resistors, which is proportional the coil current.
The test equipment has 3.9K resistors for R1 and R2. The coil is simulated by two 3.9K resistors in series. Each resistor will therefore drop a quarter of the sum of the two outputs. The summing amplifier has a gain of 1/3, so for +/-15v in the output will be 5v.
IC10 is an r.m.s. converter chip, which calculates the true r.m.s. output current. It is followed by an amplifier. The overall scaling factor of the r.m.s. converter and amplifier circuits is 1/3.

### Noise Measurement

As the noise level amounts to a few pico amps, it is extremely difficult to measure directly. Instead, the noise voltage across the amplifier outputs is monitored. This enables the coil noise current to be estimated. Four amplifier stages each coupled with a high pass filter are used, followed by a two stage low pass filter.

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# 4. Inspection

**Workmanship**

| | |
|---|---|
| **General Comments** | **OK?** |
| | |
| **Visual overall check** | **OK?** |
| **Solder joint** | **OK?** |
| **Placement** | **OK?** |

**Modifications**

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## NOTES

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## 5. Power

Measure output voltages from the regulators as follows:
Increase input voltages from zero up to +/-3v.
Determine that polarities are correct.
If they are correct, increase the voltages until rated input voltages are reached (+/-16.5v)

Record regulator the regulator output voltages:

| **Regulator** | **Output voltage** | **Pass/Fail (Nominal +/-0.5v)** |
|---|---|---|
| +15v (TP4) | | |
| -15v (TP6) | | |

If output voltages are satisfactory, proceed to next section.

Record the regulator noise levels, check for stability, and record the powe supply current.

| **Regulator** | **Stable?** | **Output Noise level pk/pk** | **Current (Amps)** |
|---|---|---|---|
| +15v (TP4) | | | |
| -15v (TP6) | | | |

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## 6. Circuit operation

Test the operation of each channel. The Coil Driver Simulator board will normally be used for these tests.

### 6.1.1 NOISE AMPLIFIER

#### 6.1.1.1 INPUT BUFFER GAINS

Test that the gain of each of the input buffers, IC1 and IC6 is 25.

**Pass band Gain**
Set frequency to 20 Hz
Set Amplitude 100mV peak (Signal generator indicates 100mV pk/pk)
Ground reference = Power 0v

**Positive input:**

| | Input (TP8) (mV peak) | Output -IC1/6 (V peak) | Expected value (V peak) | Pass/Fail |
|---|---|---|---|---|
| **Ch1** | | | 2.4V to 2.6V | |
| **Ch2** | | | 2.4V to 2.6V | |
| **Ch3** | | | 2.4V to 2.6V | |
| **Ch4** | | | 2.4V to 2.6V | |

**Negative Input:**

| | Input (TP9) (mV peak) | Output - IC6/6 (V peak) | Expected value (V peak) | Pass/Fail |
|---|---|---|---|---|
| **Ch1** | | | 2.4V to 2.6V | |
| **Ch2** | | | 2.4V to 2.6V | |
| **Ch3** | | | 2.4V to 2.6V | |
| **Ch4** | | | 2.4V to 2.6V | |

#### 6.1.1.2 GAIN AT THE CORNER FREQUENCY

Set frequency to 5 Hz:
Amplitude= 100mV pk/pk
Ground reference = Power 0v

**Positive input:**

| | Input - TP8 mV peak | Output - IC1/6 V peak | Expected value (V peak) | Pass/Fail |
|---|---|---|---|---|
| **Ch1** | | | **1.6v to 1.9v** | |
| **Ch2** | | | **1.6v to 1.9v** | |
| **Ch3** | | | **1.6v to 1.9v** | |
| **Ch4** | | | **1.6v to 1.9v** | |

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**Negative Input:**

| | Input - TP9 mV peak | Output - IC6/6 V peak | Expected value V peak | Pass/Fail |
|---|---|---|---|---|
| **Ch1** | | | **1.6v to 1.9v** | |
| **Ch2** | | | **1.6v to 1.9v** | |
| **Ch3** | | | **1.6v to 1.9v** | |
| **Ch4** | | | **1.6v to 1.9v** | |

### 6.1.1.3 Summing Amplifier

**Pass band Gain**
Set frequency to 20 Hz
Set Amplitude 100mV pk/pk (sig gen o/p = 100mV peak)
Apply input between TP8 and TP9

| | Input - TP8 toTP9 (mV peak) | Output TP5 V peak | Expected value (V Peak) | Pass/Fail |
|---|---|---|---|---|
| **Ch1** | | | **4.8v to 5.2v** | |
| **Ch2** | | | **4.8v to 5.2v** | |
| **Ch3** | | | **4.8v to 5.2v** | |
| **Ch4** | | | **4.8v to 5.2v** | |

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**Gains of Successive Stages:**
Make measurements at 100 Hz, then at 5 Hz starting by setting the TP5 voltage to 1V peak for each frequency.

| | 100Hz | | | | 5Hz | | | |
|---|---|---|---|---|---|---|---|---|
| | Ch1 mV | Ch2 mV | Ch3 mV | Ch4 mV | Ch1 mV | Ch2 mV | Ch3 mV | Ch4 mV |
| TP5 | | | | | | | | |
| TP4 | | | | | | | | |
| TP6 | | | | | | | | |
| TP7 | | | | | | | | |

Calculate the ratios of successive outputs from the table above. Check that successive outputs have a ratio of x2 ± 0.1 at 100Hz, and 1.4 ± 0.1 at the 5 Hz the corner frequency.

| | 100Hz | | | | 5Hz | | | | P/F |
|---|---|---|---|---|---|---|---|---|---|
| | Ch1 | Ch2 | Ch3 | Ch4 | Ch1 | Ch2 | Ch3 | Ch4 | |
| TP4/TP5 | | | | | | | | | |
| TP6/TP4 | | | | | | | | | |
| TP7/TP6 | | | | | | | | | |

**Low Pass Output Stage**
Set signal generator to give 10V peak on **TP7**. Measure and record the output at 500Hz and 5Khz **TP10**, and compare with the specifications at those frequencies.

| | | 500Hz (V peak) | Spec @ 500hz | OK? | 5 KHz (V peak) | Spec @ 5KHz | OK? |
|---|---|---|---|---|---|---|---|
| Ch1 | TP10 | | 9.7 to 10v | | | 4 to 5.5v | |
| Ch2 | TP10 | | 9.7 to 10v | | | 4 to 5.5v | |
| Ch3 | TP10 | | 9.7 to 10v | | | 4 to 5.5v | |
| Ch4 | TP10 | | 9.7 to 10v | | | 4 to 5.5v | |

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### 6.1.2 VOLTAGE MONITOR

Set the signal generator to give 3V peak at 30 Hz between TP8 and TP9.
Measure the output on TP12.

| | Input -TP8, TP9 (Volts peak) | Output -TP12 (Volts peak) | Expected value (Volts peak) | Pass/Fail |
|---|---|---|---|---|
| **Ch1** | | | **1.9 to 2.1v** | |
| **Ch2** | | | **1.9 to 2.1v** | |
| **Ch3** | | | **1.9 to 2.1v** | |
| **Ch4** | | | **1.9 to 2.1v** | |

### 6.1.3 CURRENT MONITOR

**Current monitoring is done by measuring the voltage dropped across two resistors carrying the output current. The current monitor circuit has a gain of 1/3.**

**The circuit is tested by applying selected voltages across the current monitor inputs, and observing the current monitor output.**

Connect the Monitor Test Unit to the 16 way header on the monitor board, and power it up.
Connect the signal generator to its input.

Set
Frequency to 100Hz
The input voltage between TP8 and TP9 to 3v Peak
Ground reference = Power 0V

Select the following four settings in turn:
(1) Open circuit – representing zero current - zero output expected
(2) Half – giving 3 volts of current monitor signal and 1 volt out.
(3) Quarter – giving 4.5 volts of current monitor signal and 1.5 volts out
(4) Short circuit - giving 6 volts of monitor signal and 2 volts out

| Test | TP11 Expected V | TP11 Ch1 (V) | TP11 Ch2 (V) | TP11 Ch3 (V) | TP11 Ch4 (V) | Pass/ Fail (V) |
|---|---|---|---|---|---|---|
| **(1) 0v in** | **0v +/- 0.1v** | | | | | |
| **(2) 3v in** | **1v +/- 0.1v** | | | | | |
| **(3) 4.5vin** | **1.5v +/- 0.1v** | | | | | |
| **(4) 6v in** | **2v +/- 0.1v** | | | | | |

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**6.1.4 RMS CIRCUIT**
**The r.m.s circuit monitors the r.m.s current flowing in the coil. A square wave of the same peak amplitude as a sine wave should give an output √2 times as high.**
**Sine Wave Test**
Set frequency to 30 Hz
Without the resistance box,

| I/p sine wave amplitude (between TP8 and TP9) | r.m.s dc output (TP13) | Expected value (volts DC) | Pass/ Fail |
|---|---|---|---|
| 3V Peak | | | |
| Ch1 | | 0.707 (0.69 to 0.71) | |
| Ch2 | | 0.707 (0.69 to 0.71) | |
| Ch3 | | 0.707 (0.69 to 0.71) | |
| Ch4 | | 0.707 (0.69 to 0.71) | |
| 1.5V peak | | | |
| Ch1 | | 0.35v (0.33 to 0.37) | |
| Ch2 | | 0.35v (0.33 to 0.37) | |
| Ch3 | | 0.35v (0.33 to 0.37) | |
| Ch4 | | 0.35v (0.33 to 0.37) | |

**Square Wave Test**
Compare the output for a sine wave input just measured with the output for a square wave input. Set input level to a 3v peak and the frequency to 30 Hz.

| 3v peak Square Wave | | Expected value (volts dc) | Pass/ Fail |
|---|---|---|---|
| Ch1, TP13 | | 1v (0.9 to 1.1v) | |
| Ch2, TP13 | | 1v (0.9 to 1.1v) | |
| Ch3, TP13 | | 1v (0.9 to 1.1v) | |
| Ch4, TP13 | | 1v (0.9 to 1.1v) | |

**DC input**
Apply a 3v dc input between TP8 and TP9.

| 3v DC | | Expected value (volts dc) | Pass/ Fail |
|---|---|---|---|
| Ch1, TP13 | | 1v (0.9 to 1.1v) | |
| Ch2, TP13 | | 1v (0.9 to 1.1v) | |
| Ch3, TP13 | | 1v (0.9 to 1.1v) | |
| Ch4, TP13 | | 1v (0.9 to 1.1v) | |