

# LIGO Laboratory / LIGO Scientific Collaboration

**LIGO-T0900235-v1**

**Advanced LIGO UK**

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Response to the Pre-Production TOP Unit Evaluation Report,  
T0900170

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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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# **RESPONSE TO THE TOP UNIT EVALUATION REPORT T0900170-V1**

## **INTRODUCTION**

The relevant comments from the Caltech Evaluation Report, T0900170-V1, are listed here, followed by the University of Birmingham responses. This document should be read in conjunction with T0900170-V1.

### **Response to the Evaluation Report**

#### **Comment 1**

##### **2.1.2 Circuit Boards**

The footprint used for the diodes is not correct and should probably be corrected prior to production as the spacing between the pads is much too large for the component used.

##### **Response to Comment 1**

These footprints will be changed from SMC to SMB, which will then be correct for the type of diode used.

#### **Comment 2**

##### **2.1.2 Circuit Boards**

The only circuit board issues observed were jumpers used to correct a design mistake. The circuit board artwork should be corrected to eliminate the need for these jumpers prior to production.

##### **Response to Comment 2**

The layout of the monitor board will be revised. These jumpers will be replaced by tracks on the production units.

#### **Comment 3**

##### **2.2 Serviceability**

Although a complete bill of materials was not provided, a check of the availability of the capacitors used in the critical portions of the circuit showed that they may not be readily available in the US. If this is the case, then an adequate number of spares need to be provided with the production units. The same can be said of any other components used in the designs. This possibility will need to be evaluated when a complete set of documentation is supplied.

##### **Response to Comment 3**

The best solution may be to ensure that suitable components with the same footprint are available on both sides of the Atlantic. Where this is not possible, an agreed number of spares will need to be provided. It is also likely that in all cases the same components should be available in the USA as in the UK through Farnell or a similar distributor, though the delivery times may be longer.

#### **Comment 4**

**2.3 Adequacy of Documentation** A complete set of schematics was provided with the pre-production units. Test plans and test results were also supplied with the unit. No bill of materials, quick start guide or other documentation was provided. Prior to production all materials listed in Electronics Requirements document (T060067) and LIGO document T000053-04-D, "Universal Suspension Subsystem Design Requirements Document" will need to be evaluated.

#### **Response to Comment 4**

The documentation listed above will be supplied. The quick start guide will be included in the User's guide.

Documentation required by T060067:- no documentation is listed in T060067

Documentation required by T000053-04-D:-

All designs require the following:

(A) Test Plan for the module or subsystem being designed. This test plan should fully test the function of the circuit or system and should include, but not be limited to transfer functions, channel-to-channel crosstalk, nominal currents and voltages, list of necessary test equipment and test fixtures. In addition to the "standard" functional tests, the plan should include tests for out of band noise and oscillations. An excellent example of a test plan for a module can be found in LIGO T040189-00, "Common Mode Servo Board Test Procedure".

(B) Test Report and Electronics Travellers for each component supplied

(C) Functional description and block diagrams. For more complex components or subsystems, a complete user manual including a troubleshooting guide and maintenance manual should be supplied.

(D) Bill of Materials

(E) Schematics for board and system level

(A): Test Plans have been produced.

(B): A test report will be supplied with each unit. An example of the Electronics traveller format would be useful.

(C): Functional descriptions and block diagrams are included in the Test Plan and will be included in the Users' Guide.

(D): Bills of Materials will be supplied

(E): Schematics of all the Drive Unit circuits will be supplied.

#### **Comment 5**

##### **Section 2.3**

The only difficulty found with the test plans provided with the units was that in the transfer function measurements only the magnitude response of the unit is measured and recorded. Typically in AdL and LIGO systems both the magnitude and phase response of the devices is measured and recorded. In systems with multiple poles and zeros in the response the phase information has proved to be invaluable. It is strongly recommended that the test plans be revised to include tests of both magnitude and phase response.

#### **Response to Comment 5**

Phase responses were not thought necessary, as the magnitude transfer functions were thought to provide all the information needed.

As phase information has been found to be useful, will look at providing phase information for the production units in addition to magnitude information.

#### **Comment 6**

##### **Section 2.3**

Additionally, the complete Altium project and all files required for production of the units will need to be provided.

##### **Response to Comment 6**

Would it be possible to list the files you would like?

#### **Comment 7**

##### **3.2 Test Inputs**

One observation worthy of mentioning is that when link W2 is left open and the test input switch in the normally closed position, there is no bias return path for op amps IC2 and IC6. This leads to amplifier offsets and drifts that may not be acceptable in AdL. It is recommended that W2 be installed.

##### **Response to Comment 7**

In large, complex systems, noise from the ground connections is a common problem. LIGO is a very large, very complex system with an extremely tight noise specification. The Coil drive amplifiers are therefore designed as four terminal modules, isolated from ground. The link to ground has been added to allow the option of referring the units to ground if required.

It is recognised that if the test input is not connected to anything, the test inputs will be floating, and large offsets will occur. It is recommended that a dummy connector is always fitted to the test input when it is not being used, with all pins connected together. This effectively grounds the test inputs, preventing offsets.

#### **Comment 8**

##### **4.1.2 Monitor Noise**

One of the requirements for monitors on the Top driver is a noise monitor capable of “seeing” output referred noise voltage of the driver at 10Hz (hardest requirement) in the low noise mode of operation. In an effort to do this, the University of Birmingham has designed a noise monitor that is a high gain AC coupled differential amplifier tied to the voltage output legs of the driver. The output referred noise of the driver at 10Hz should be less than 8nV/vHz. This was tested, confirmed and described in the section above. Given the design of the noise monitor, the output noise of the monitor at 10Hz should be less than 1uV/vHz. Simulations conducted at Caltech on the circuit design suggest that the output noise should be approximately 2uV/vHz which is above the requirement by a factor of 2. The measured noise at 10Hz was 2.2, 2.5, 4 and 5.6uV/vHz for channels 1 through 4, respectively. In the test report received with the unit the output noise at the noise monitor output was -117.48, -118, -118 and -107 dBV/rtHz, for channels 1 through 4, respectively. This translates to 1.3, 1.25, 1.25 and 4.5uV/vHz. The measurement for channel 4 is in line with the measurement made at Caltech, but the other channels measurements made by the University of Birmingham are lower.

This discrepancy and the possibility that the circuit cannot meet the requirement should be resolved prior to production.

**Response to Comment 8**

The noise measurements made in Birmingham were made after 5 pm when the ambient EMC level was reduced. Care was taken to ensure that the readings were representative, and not biased towards an optimistic figure. It is agreed that channel 4 was noisy for some reason.

Maybe further measurements could be made both at Birmingham and in the USA. Perhaps the simulation could be repeated, and the noise level of the noise monitor itself could be measured. The differential nature of the noise measuring circuit needs to be carefully taken into account during simulation.