

# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

**-LIGO-**

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<b>BSC Suspension Test Stand Electronics and Controls Quick Start Guide</b>		
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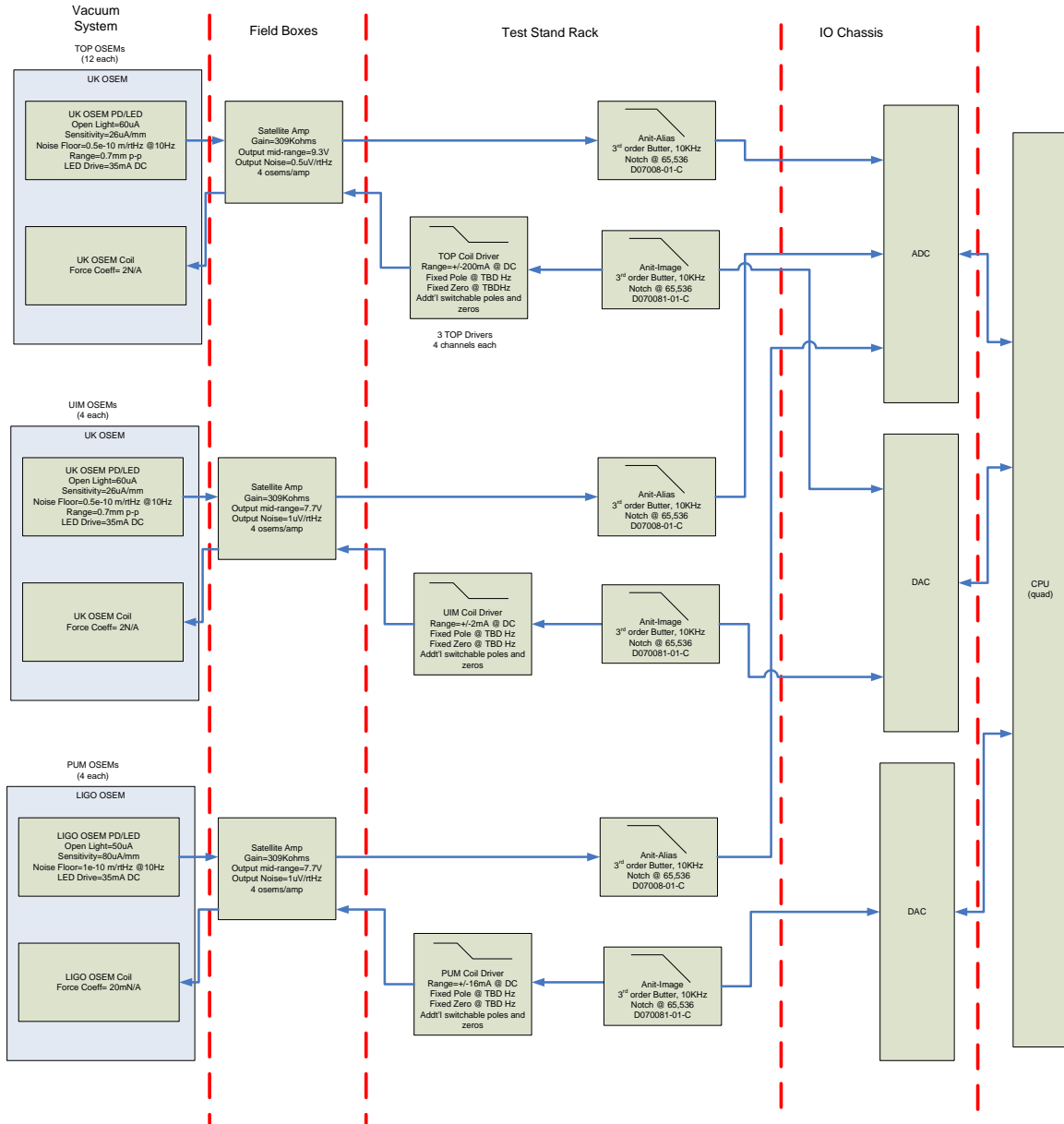
www: <http://www.ligo.caltech.edu/>

# 1 Introduction

This quick start guide is meant to as a quick reference and guide to the BSC Suspension Test Stand electronics hardware and software. The test stand will be used at each of the AdL sites, LLO and LHO, to aid in the installation and checkout of each of the quadruple suspension systems. The test stand is built to run as a standalone, self-contained unit and does not require any connection to the outside world to operate. All equipment is located in one rack that can be moved, either by rolling or craning, to the location where the suspension to be tested is located. Additionally, the test stand only includes those electronics that are needed for local damping and suspension parameter measurements. For example, the low noise output monitors that are essential for proper operation of the suspensions in AdL are not included in the test stand electronics since low noise operation of the quad suspension can not be achieved and is not required during initial assembly and checkout of a quadruple suspension. The software and the rack also have allotted for future inclusion of the Electro-static driver hardware which may be installed if the test stands are used to checkout and test full quadruple suspensions installed in the AdL vacuum system. Detailed descriptions and documentation for each of the individual modules can be found in the schematics and test procedures for those components.

The figure below is a basic block and signal flow diagram for the installed system.

## BSC SUS Test Stand Signal Flow



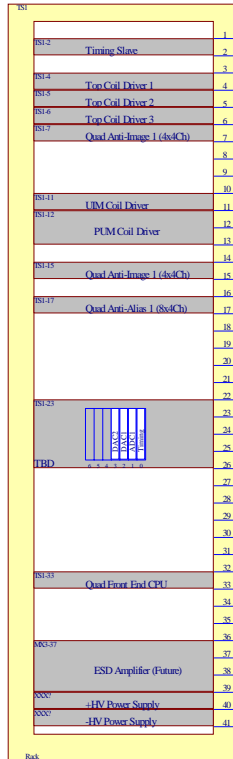
Each of the components is described in the sections below.

## 2 Electronics Hardware

### 2.1 System Wiring Diagram and Rack layout

The system wiring diagram can be found in the LIGO DCC or at: <http://www.ligo.caltech.edu/~jay/drawings/D080273-00-C.pdf>

The figure below shows the rack layout for the system.



## 2.2 UK Satellite Amplifier

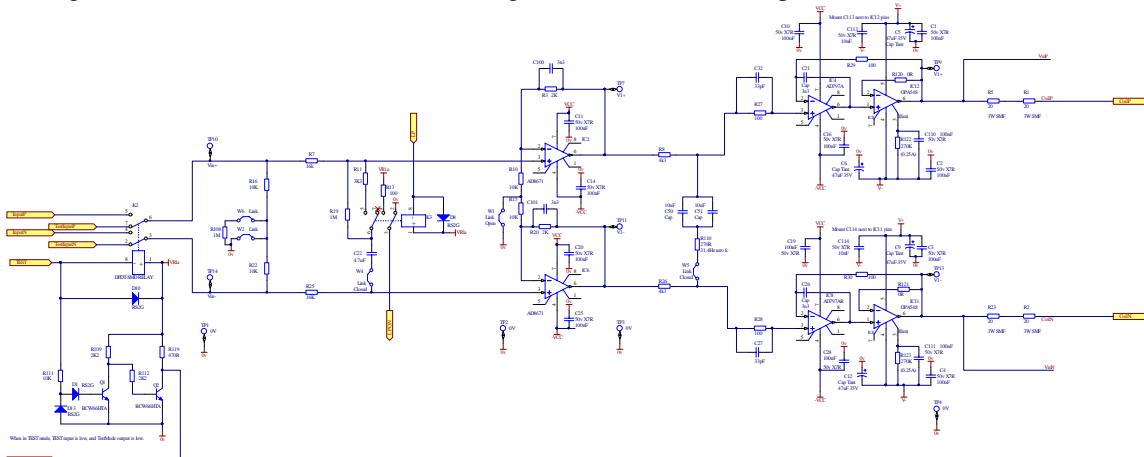
The satellite amplifier provides two main functions in the system:

- Constant 35 mA bias current for the OSEM LEDs.
- Gain stage for the OSEM photodiode. The gain of the stage is 309 Kohms.

The coil driver signals from the coil driver to the OSEM coils only pass through the satellite amplifier. As can be seen from the figure above, the satellite amplifiers are located in the field near the quadruple suspension. Note that the design requires that the vacuum flange, or similar connector be included in the cabling from the satellite amplifier to the osem. This is because the vacuum flange actually mirrors the connector pins as they are passed through the flange. If the flange is not installed in the test setup, then an adapter cables that mirrors the pins must be used.

## 2.3 UK TOP Coil Driver

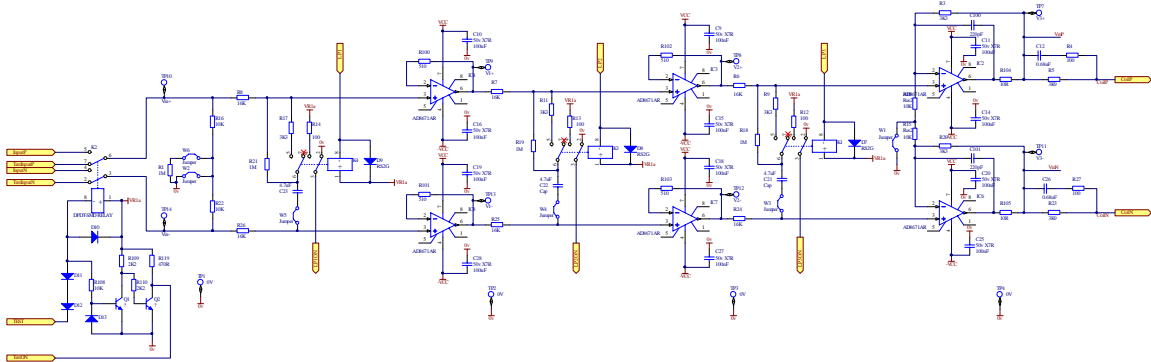
The figure below shows the schematic for a single channel of the UK Top Coil Driver module.



The nominal response of the circuit is TBD the final design of the TOP coil driver.

## 2.4 UK UIM Coil Driver

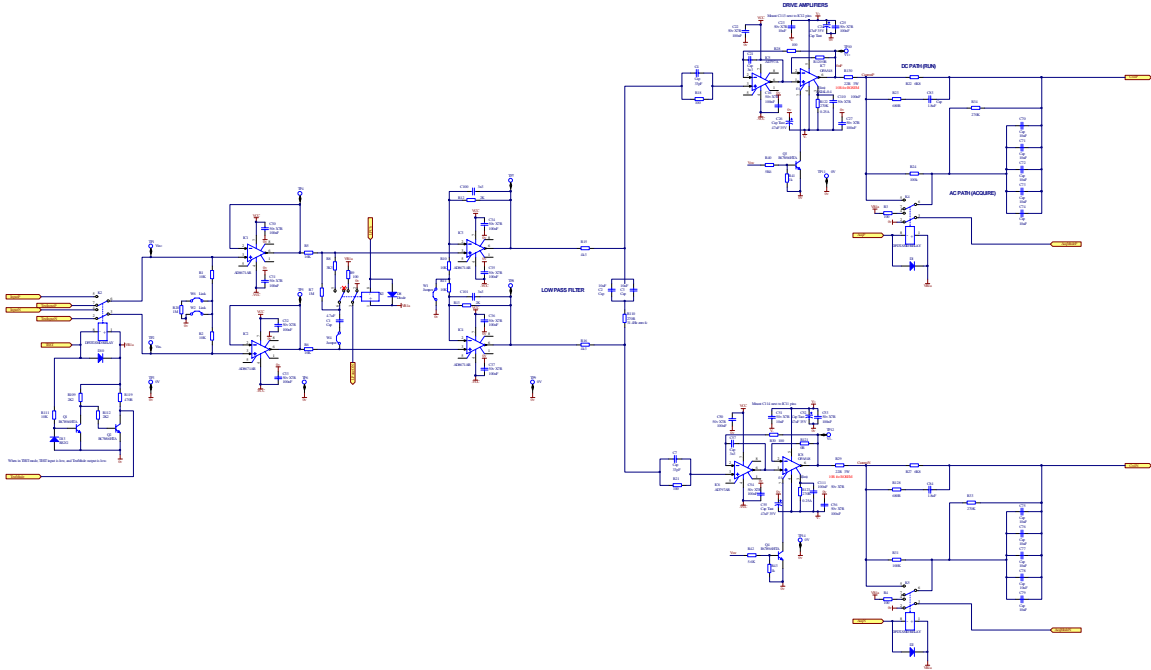
The figure below shows the schematic for a single channel of the UK UIM Coil Driver module.



The nominal response of the circuit is TBD the final design of the UIM coil driver.

## 2.5 UK PUM Coil Driver

The figure below shows the schematic for a single channel of the UK PUM Coil Driver module.

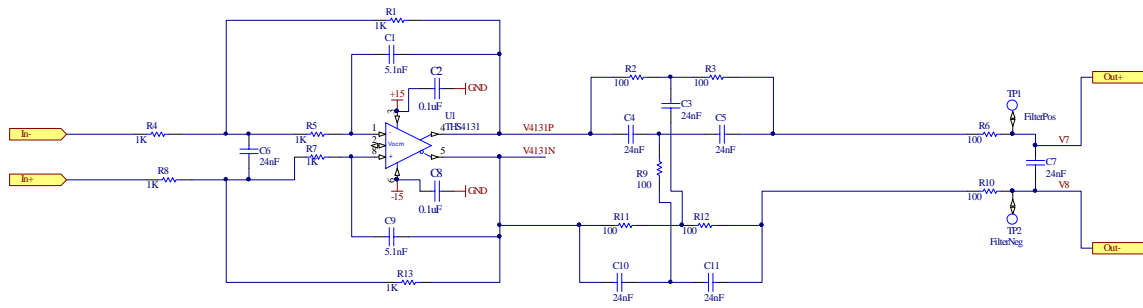


The nominal response of the circuit is TBD the final design of the PUM coil driver.

## 2.6 Anti-Alias and Anti-Image Chassis

The anti-alias and anti-image filters used for the LASTI Noise prototype are the standard 3<sup>rd</sup> order, 10KHz Butterworth low pass filters with a notch at 65536 Hz. The fundamental sample frequency for the system is 65536 SPS and the data is software decimated to 16384 SPS for the controls. The figure below shows the schematic for a single channel of the anti-alias/anti-image filter.

### 3rd order Butterworth, 10KHz, notch at 65536Hz



## 2.7 ADC and DAC Modules

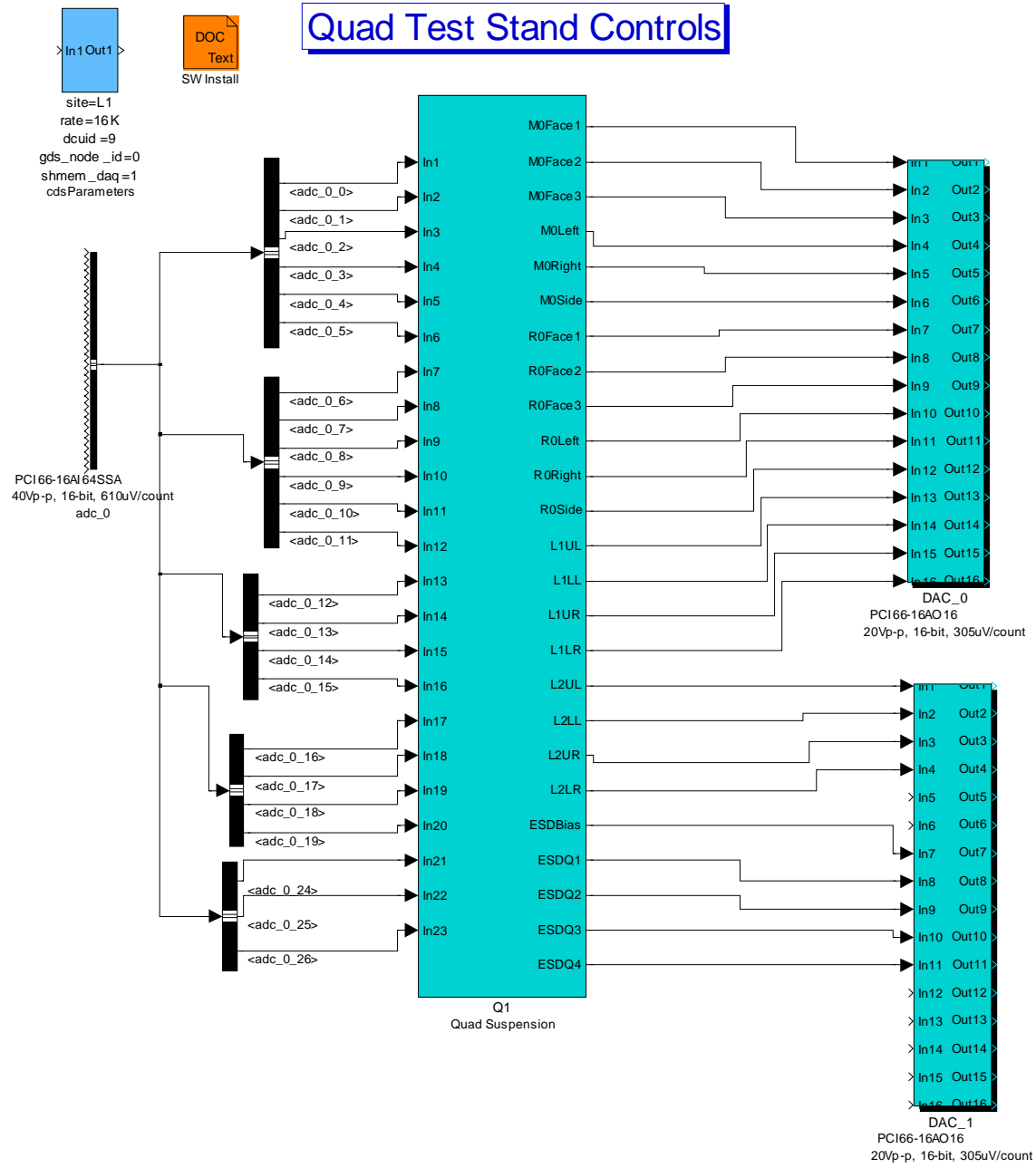
The ADCs and DACs used in the controls for the BSC SUS Test Stand are the same ADC and DAC modules used in a variety of control systems at LASTI and elsewhere in LIGO. They are both manufactured by General Standards Corporation. The user manuals can be found at:

- ADC- [http://www.generalstandards.com/user-manuals/pmc66\\_16ai64ssa\\_c\\_man\\_082006.pdf](http://www.generalstandards.com/user-manuals/pmc66_16ai64ssa_c_man_082006.pdf)
- DAC- [http://www.generalstandards.com/user-manuals/pmc66\\_16ao16\\_man\\_090406.pdf](http://www.generalstandards.com/user-manuals/pmc66_16ao16_man_090406.pdf)

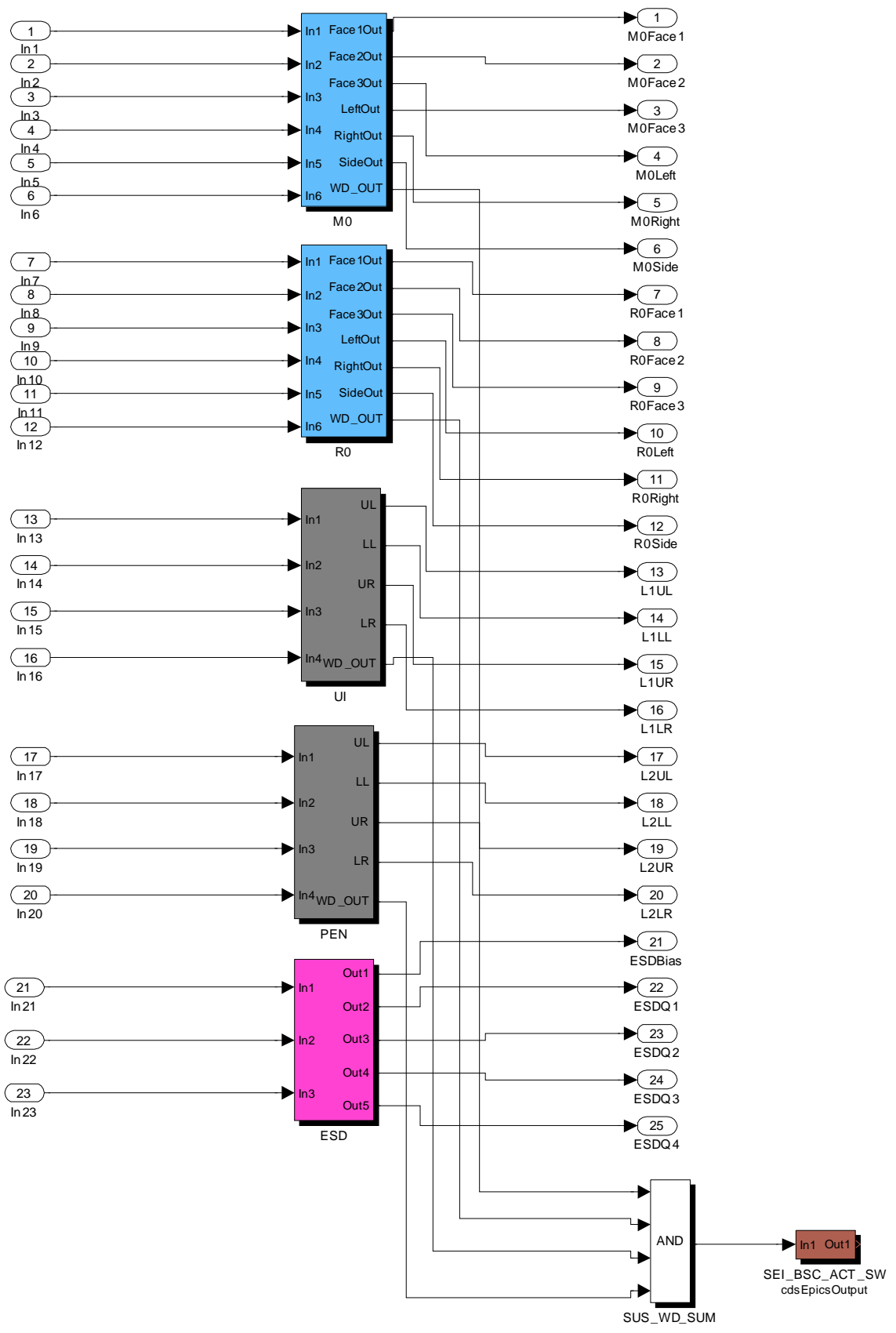
## 3 Control Software

### 3.1 Simulink Diagram

The control software for the BSC SUS Test Stand was generated using Simulink and the real-time and Linux compilers used for all CDS control systems. The top level Simulink diagram for the system is shown in the figure below.



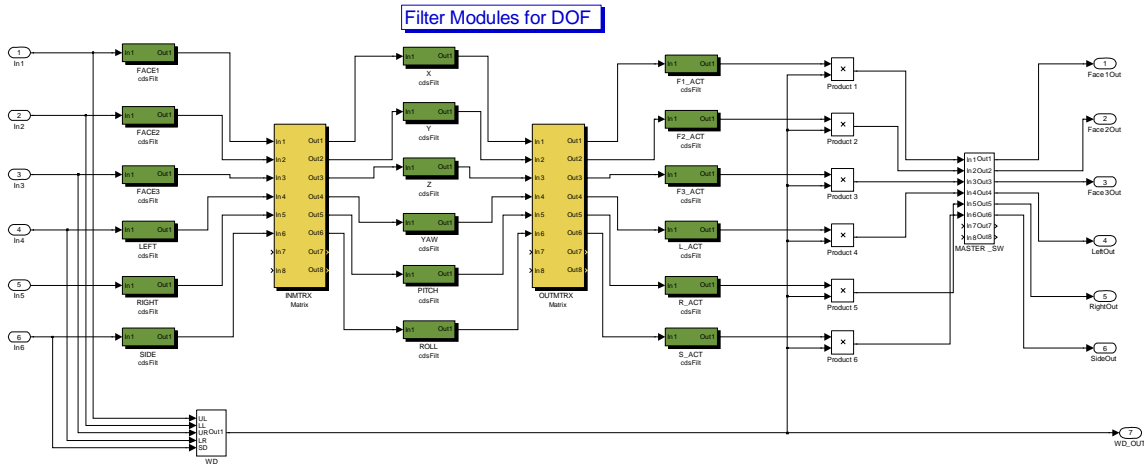
The figure below shows the inside of the Q1 subsystem block.





As can be seen from the figure, the OSEM channels for each stage feed subsystem blocks for the corresponding stages. Note that each subsystem stage also provides a watchdog output that is summed and used as an interlock for the BSC seismic controls.

The figure below shows the control diagram for the M0 stage. The control diagrams for the other stages are similar.



## 3.2 Code Generation and Operating the Front End

### 3.2.1 Code Generation

All code for the front end is generated by compiling user generated simulink diagrams like those shown above. Use of the code generator is described in LIGO document T080135-00-C, "AdvLigo CDS Realtime Code Generator (RCG) Application Developer's Guide".

### 3.2.2 Operating the Front End

The Test Stand has been designed and built to be a standalone self-contained unit that does not require the user to be an expert in the operation of real-time linux control and data acquisition systems. Normal starting and stopping of the front end and configuration of the DAQ system is controlled via scripts. These scripts are in the /cvs/cds/llo/scripts directory.

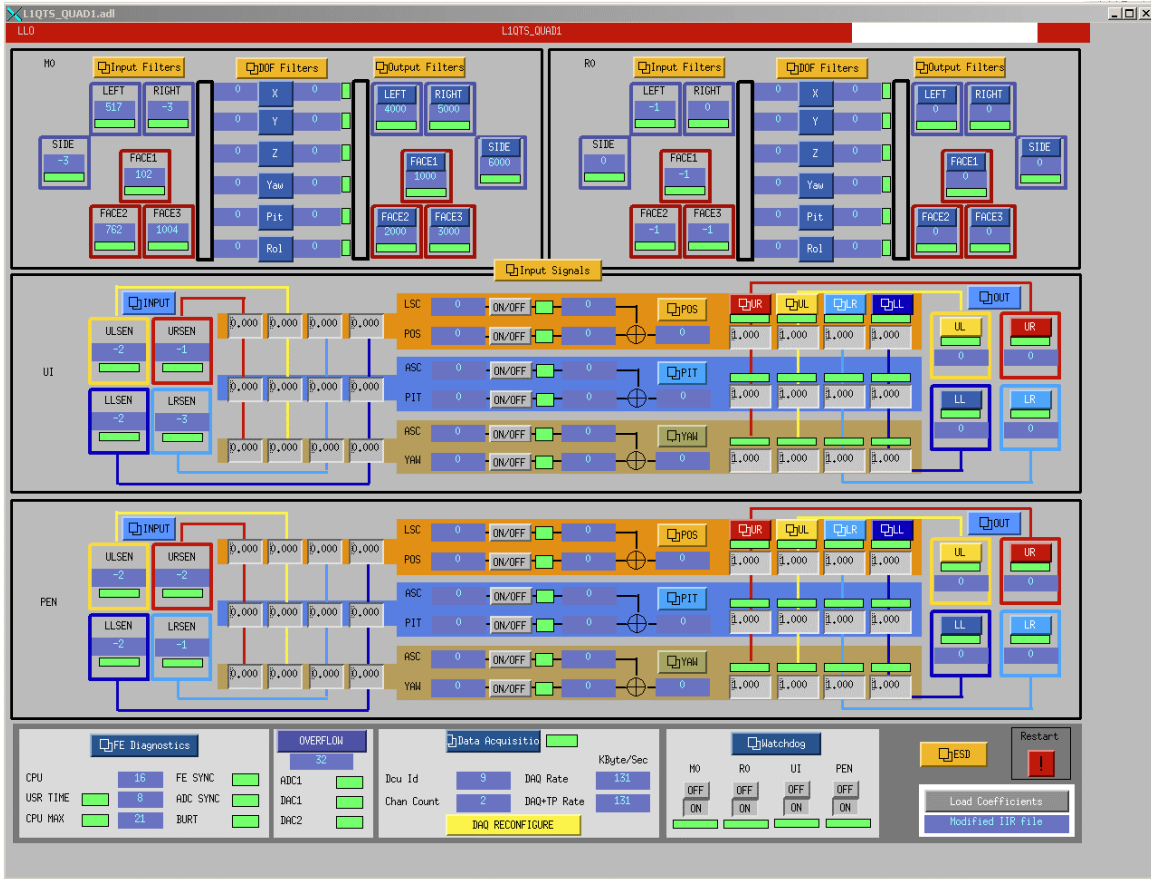
"startqts" is used to start or restart the front end as necessary.

"killqts" is used to stop the front end

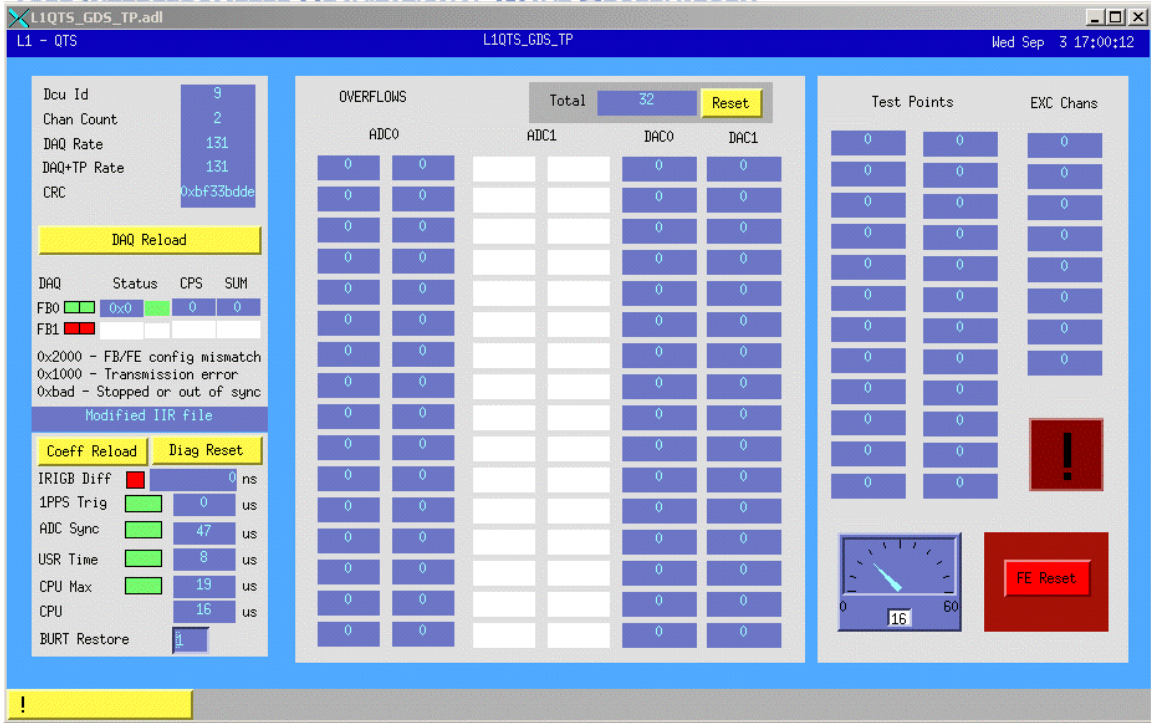
"daqconfig" is used to start the GUI used to set and remove DAQ signals in the data stored by the system.

## 3.3 Operator Screens

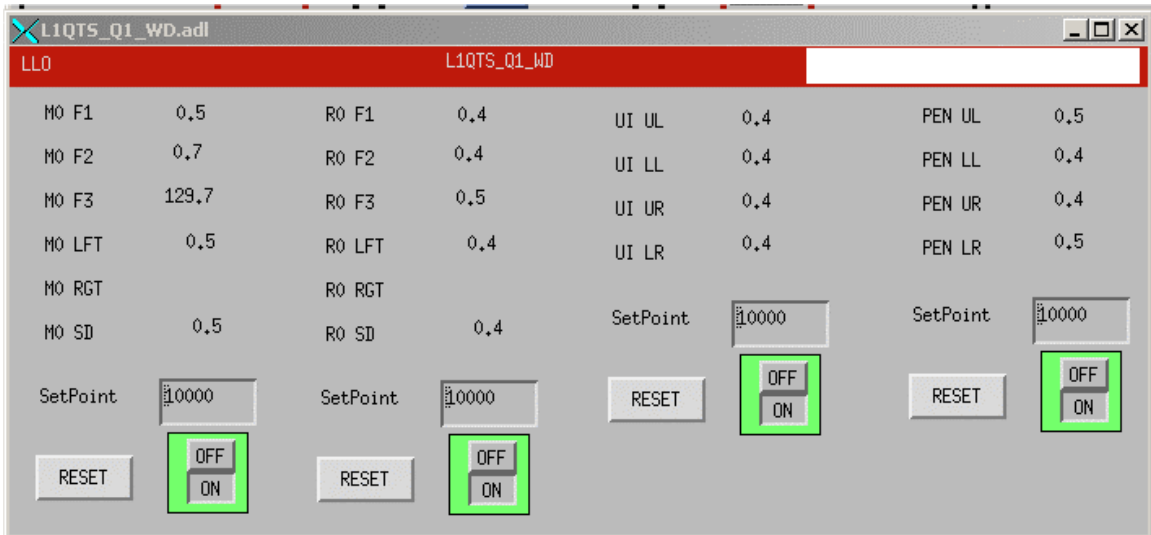
MEDM is used to create and display data on operator screens. The operator screens for the test stand can be found in the directory /cvs/cds/llo/medm/11/qts on the control computer. In order to start medm login into the test stand computer as user controls and type "medm" at the command prompt. The main control screen for the test stand is named L1QTS\_QUAD1.adl and is shown in the figure below. From this screen the user can see an overview of the controls and reach all other operator screens.



In addition to all of the filter module and matrix screens needed for controls, there are several other very useful screens that are shown and described below. The first screen, "LIQTS\_GDS\_TP.adl" can be reached by clicking on the FE Diagnostics button in the bottom left corner of the main control screen. A picture of this screen is shown in the figure below. On this screen, the operator can check the status of the frameBuilder, the CPU computation time, monitor ADC and DAC overflows and monitor which test points have been set. Another important feature of this screen is the BURT Restore field in the bottom left corner of this screen. In order for the front end to begin execution a "1" must be entered into this field by the operator. If a "1" is not entered into this field the front end code will not begin execution.

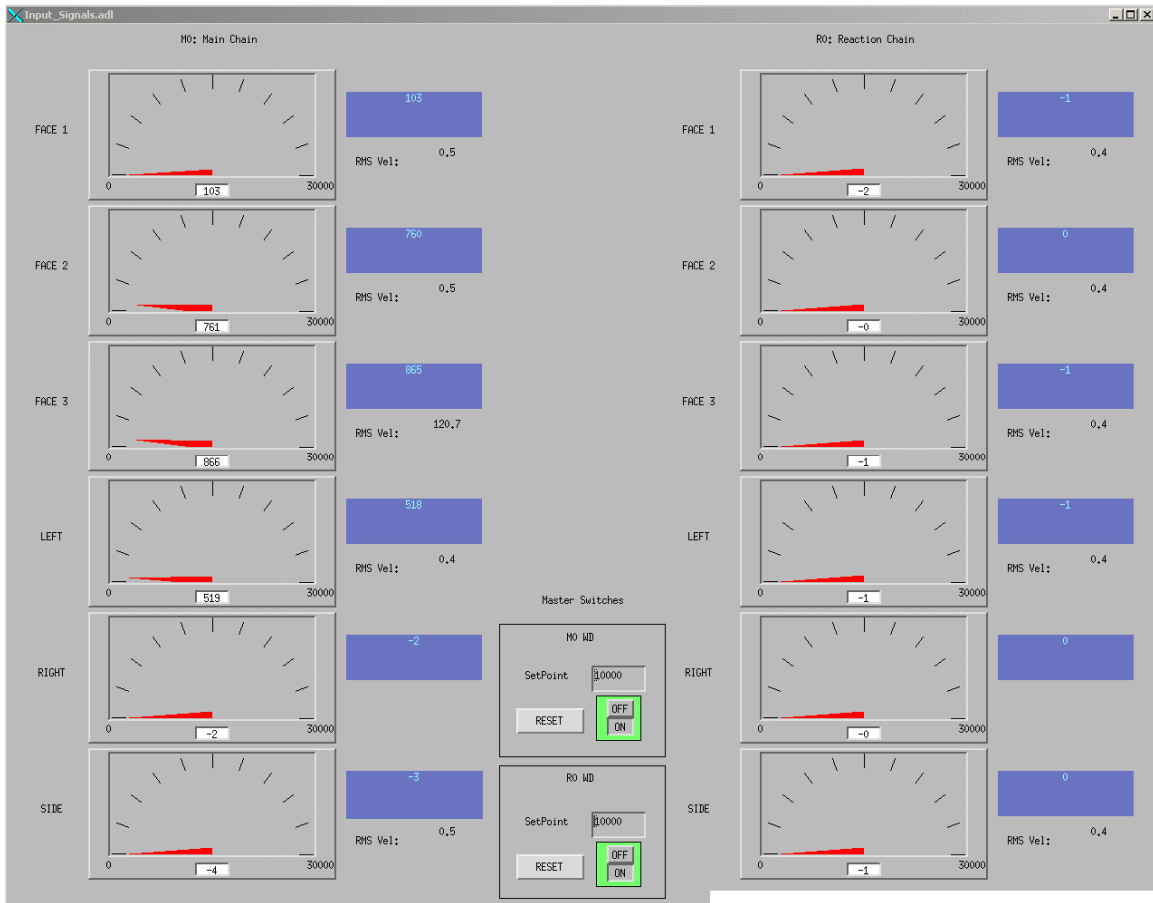


The next very useful screen is the watchdog screen shown in the figure below. This screen can be accessed by clicking on the Watchdog button in the bottom right portion of the main control screen.



The setpoints on this screen are the operator adjustable trip levels for the watchdog logic. The reset button is used to reset any trips that have occurred and the on/off buttons are used to enable the outputs to the suspension coil drivers. The on/off buttons will not enable the outputs if a fault has not been reset, or one the osem monitors in the fields above exceeds the setpoint. In the event of a fault condition, the background color around the on/off buttons will turn from green to red.

The screen shown below is an input signal monitor screen that has been created to monitor the 12 osem levels in the TOP level of the main and reaction chains of the quad. This screen is very useful during assembly and osem adjust and can be reached by clicking the Input Signals button in the middle of the main control screen.



### 3.4 Data Display and Analysis

All of the standard data display and analysis tools used in LIGO and AdL can be used on the test stand. These tools include:

- Dataviewer—started by typing “dataviewer” at the command prompt
- Dtt—started by typing “diaggui” at the command prompt
- Foton—started by typing “foton” at the command prompt
- Awg—started by typing “awggui” at the command prompt

## 4 Documentation List

### 4.1 Schematics

BSC SUS Test Stand Wiring—D080273-00-C

AdL AA and AI Filter (3rd order 10KHz, 65536 notch for 65536 sample rate)—D070081-01-C

UK TOP Coil Driver—drawing number TBD

UK UIM Coil Driver—drawing number TBD

UK PUM Coil Driver—drawing number TBD

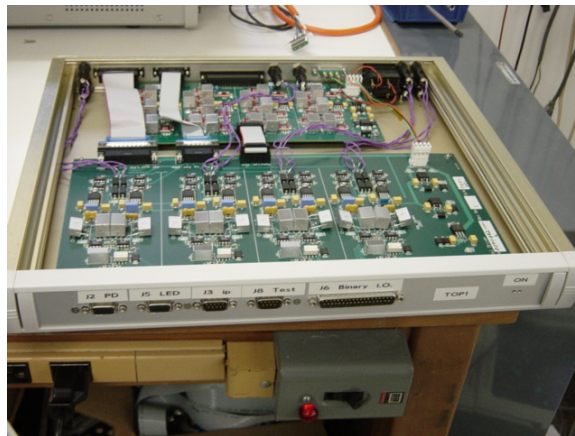
UK Satellite Amplifier—drawing number TBD

### 4.2 System and Chassis Photos

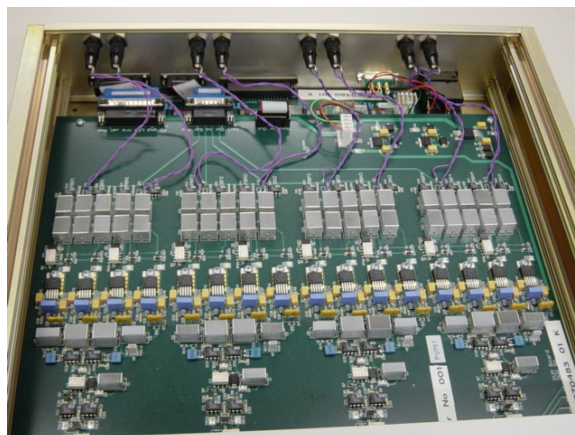
The picture below shows the prototype UK Satellite Amplifier removed from the box. It is assumed that the pre-production prototype is similar and this picture will be updated when the units are received.



The picture below shows the prototype TOP Coil Driver chassis with the top cover removed. It is assumed that the pre-production prototype is similar and this picture will be updated when the units are received.

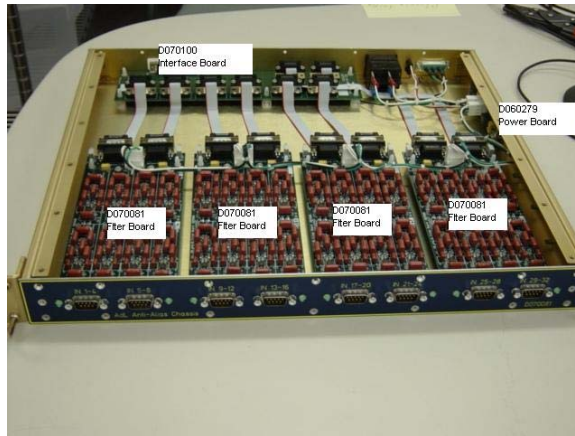


The picture below shows the prototype Penultimate Coil Driver Chassis with the top cover removed. It is assumed that the pre-production prototype is similar and this picture will be updated when the units are received.

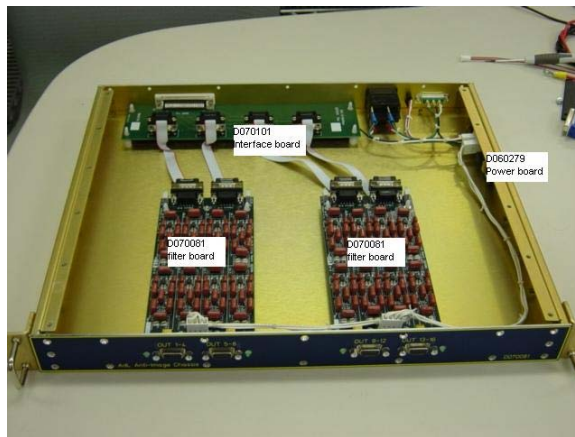


The picture below shows the Anti-Alias Chassis with the top cover removed.





The picture below shows the Anti-Image Chassis with the top cover removed.



The picture below shows the IO chassis (Blue-Box) with the cover removed and two PCIX boards installed.

