

Automated Drift Chamber-Low Voltage Test Stand

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Abstract

At CEBAF's (Continuous Electron Beam Acceleration Facility) Hall B CLAS (CEBAF Large Acceptance Spectrometer), drift chambers (DC) are used to track the trajectories of charged particles. The drift chamber signals, received by a Signal Translator Board (STB), populated with SIPs (Single Inline Packets), are amplified and transmitted to the Data Acquisition system.

The only symptom of STB/SIP failure is a measured drop in current of the channels of the distribution box, which powers the STBs. Manual testing of the distribution box channels is a time consuming process and one that can only be undertaken when Hall B is open. Therefore, we created an automated system to monitor the current draw from each channel of the distribution box of the Drift Chamber-Low Voltage (DC-LV) system. This automated monitoring system comprises two essential parts; the hardware (the circuitry monitoring equipment) and the software (a LabView program and GUI {Graphical User Interface}) for monitoring the system in Hall B Counting House.

1.1 Introduction

The drift chambers consist of wires of both negative and positive potential. When the electrons of the ionized gas, a product of a charged particle's passage through the DC, reaches the central sense wire of positive potential, it generates an electric signal. These wires feed into the STB that houses 48 Single Inline Packages (SIPs), of Region 3, that amplify the particle's signal. These SIPs require 5V to function, which is provided by the low voltage power supply via a negative voltage regulator. When a SIP fails, the signal transmitted through the sense wire is not amplified to the level needed by the data acquisition (DAQ) system.

Monitoring the STBs for current fluctuations, provides advanced warning of faulty SIPs. Manual testing is a time-consuming process and can only be conducted when the Hall is open. By using a National Instruments Field Point Module (FP AI-111) in conjunction with a network module (FP-1600), we created a system, which will continuously monitor the current. The monitored data is transmitted to a GUI installed in Hall B Counting House.

2.1 Acknowledgement of Limitation of Devices

The DC-LV power supply delivers 7.5VDC to the negative bar, which provides the SIPs via a negative voltage regulator with a fixed 5V. The pair of STBs (axial and stereo) has an effective passive resistance of roughly 5Ω . This equates to 1A through the system [2]. The Field Point module, which we intend to read channel current through, cannot read current values greater than 20mA.

3.1 Test Setup of Prototype Circuit

We placed a 1Ω resistor in parallel with the FP module, which has a 100Ω internal resistor. The AI-111 has 16 channels [3]. Therefore, the schematic of Test Setup (Fig. 3-1A) was duplicated 16 times so that the entire AI-111 would be in use (Fig. 3-1B.)

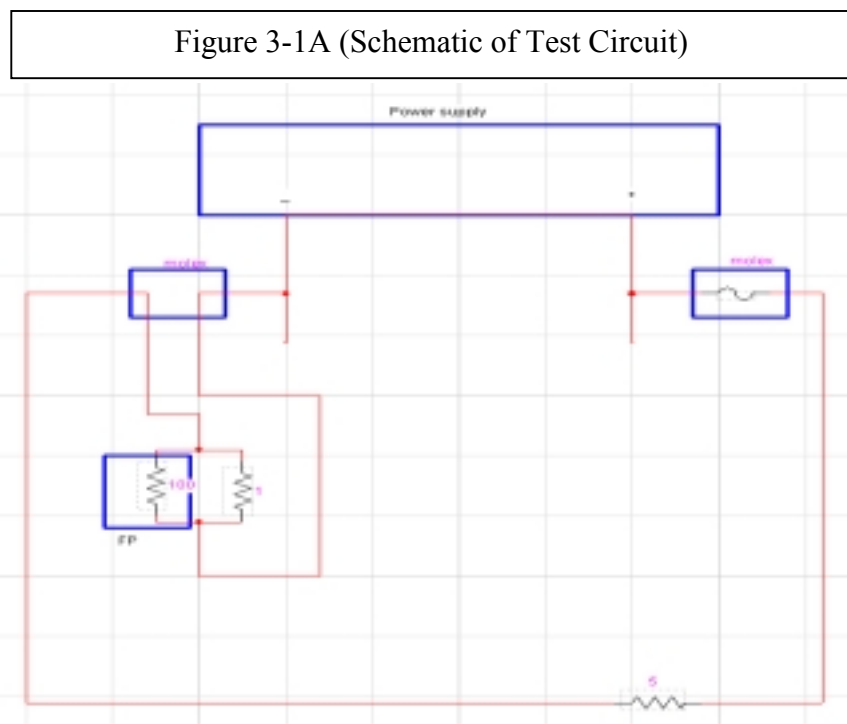
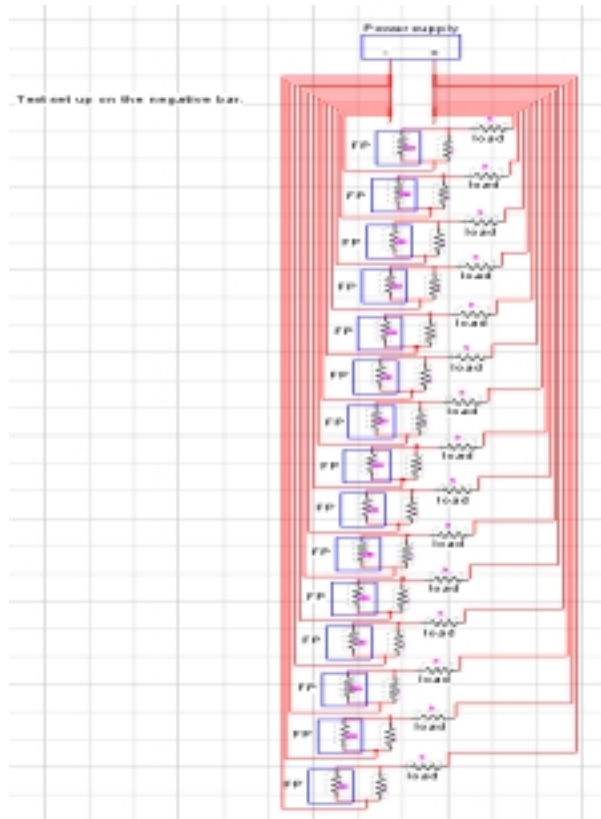
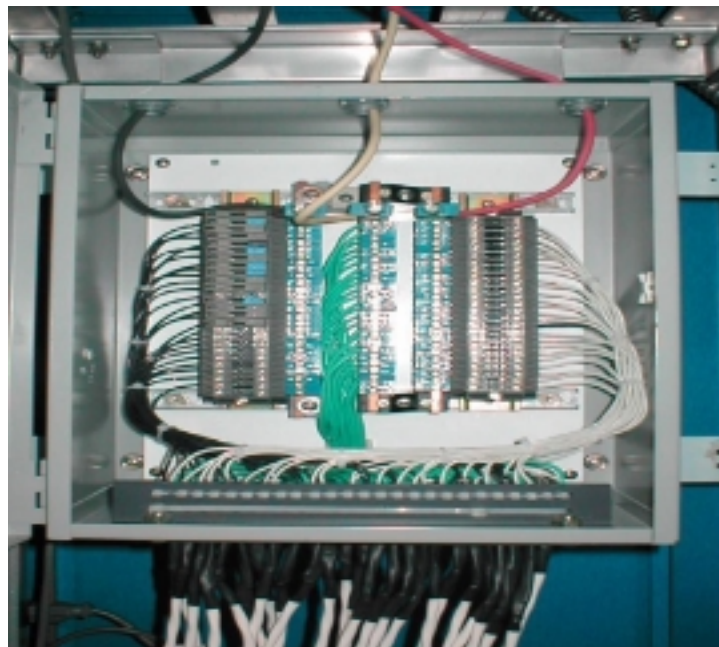


Figure 3-1B (Replication of Test Circuit)



As is diagramed in the Fig. 3-1A(Schematic of Test Circuit), each circuit has a load representing the STBs ($5\ \Omega$), the $100\ \Omega$ resistor in the FP and a $1\ \Omega$ shunt resistor. The shunt resistor was attached to the power bar. The white cables, at the bottom of Figure 3-2, running from the power bars to the Molex connectors connected to the load.

Figure 3-2 (Distribution Box)

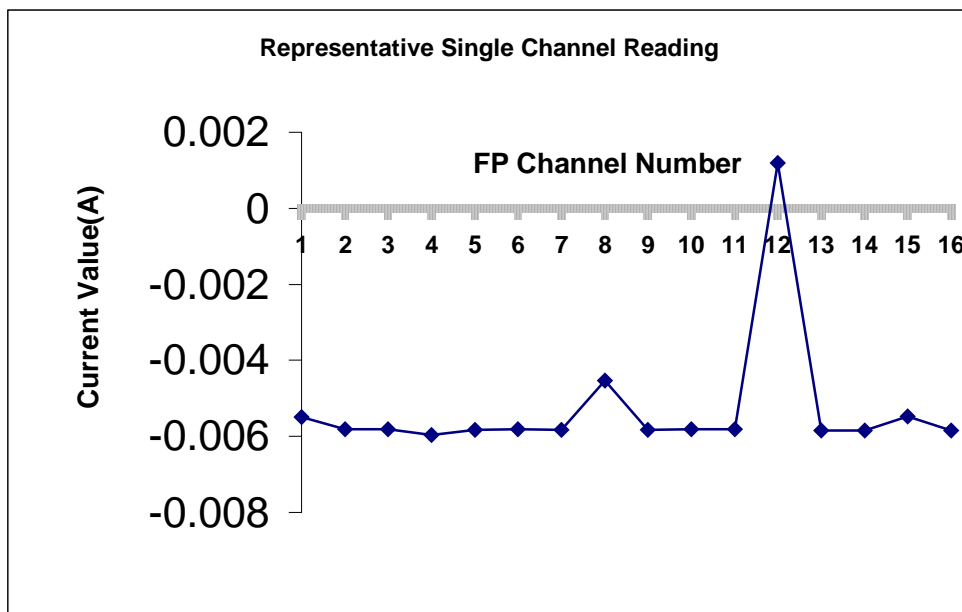


4.1 Channel by Channel Diagnostic Test of Systems

This test read the current values through all sixteen channels and checked the status of the systems on which we would run our tests. The test was run with a single circuit in place on the bus bar. After a reading was taken for Channel 1 of the bus bar, that probe was removed (along with the fuse on the positive node) and the Channel 2 probe was placed in with its corresponding probe.

Graph 4-1 displays a representative run of a single channel connected to the power bar. The rise at channel 12 was found to occur in every test; later tests skipped channel 12 on the power bar, on the basis that something within the power box was awry. The jump on Channel 8 was due to a bad solder joint.

Graph 4-1

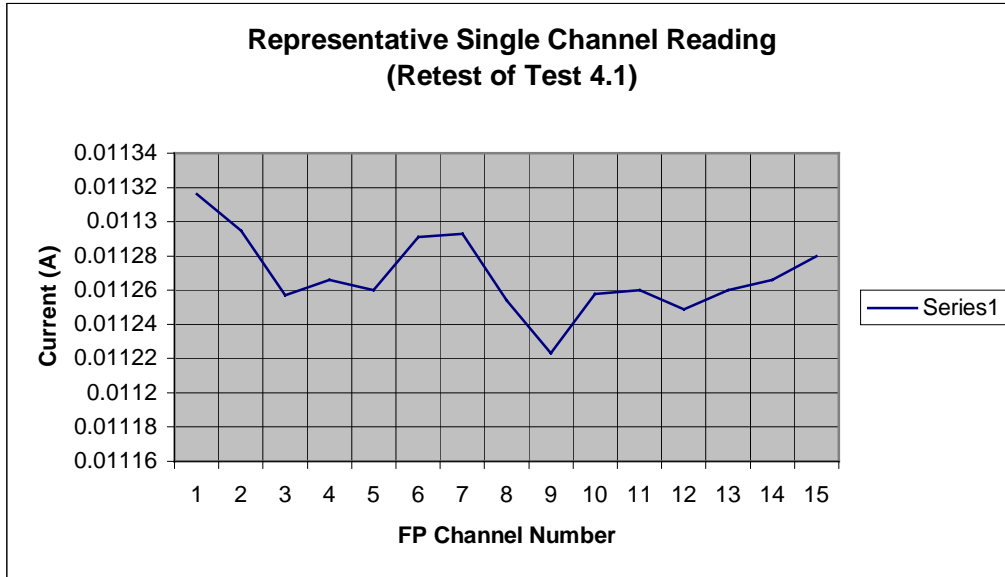


We expected the shunt resistor to displace 1/100 of the current to the Field Point module, roughly 10 mA. The standard current read from this graph, and the others, was roughly 5.5 mA; roughly one-half of the predicted value.

4.2 Test of Circuitry after Corrections

The circuits were inspected and channel 16 was dropped from the test setup as it presented a safety hazard and the previous test was repeated. Graph 4-2 is a re-examination of the Diagnostic Check of Exterior Systems.

Graph 4-2

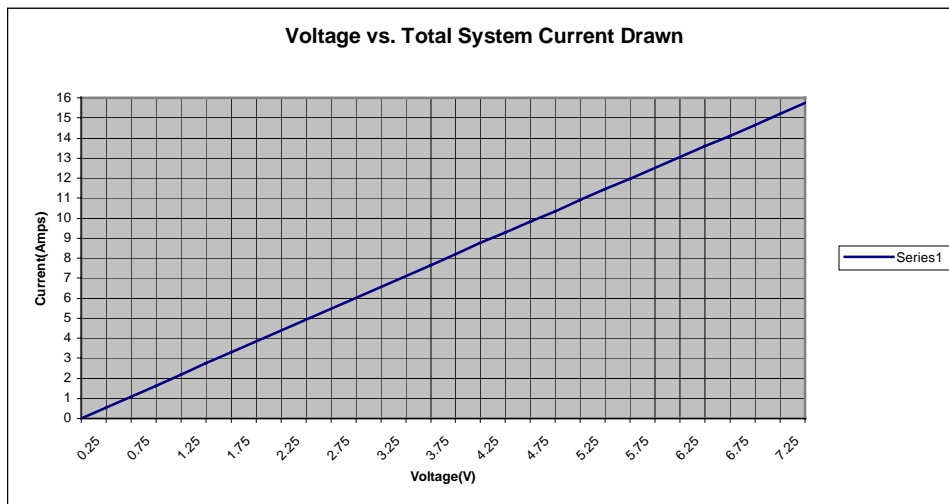


There are still fluctuations, but these are restricted to a range of .01122A to .0113A. These results are in agreement with the calculated values.

4.3 Test of total Current Flow as a Function of Voltage

The power supply for the DC-LV system allows analog control of voltage and reads total current drawn. The values for this test were read from the Power Supply display and *not* the Field Point.

Graph 4-3



For this test, voltage was decreased in $\frac{1}{4}V$ steps and current readings were taken. Graph 4-3 data displayed a linear slope which confirmed the circuit was working properly i.e. current decreased proportionally to voltage.

4.4 Cumulative Test of all Variables

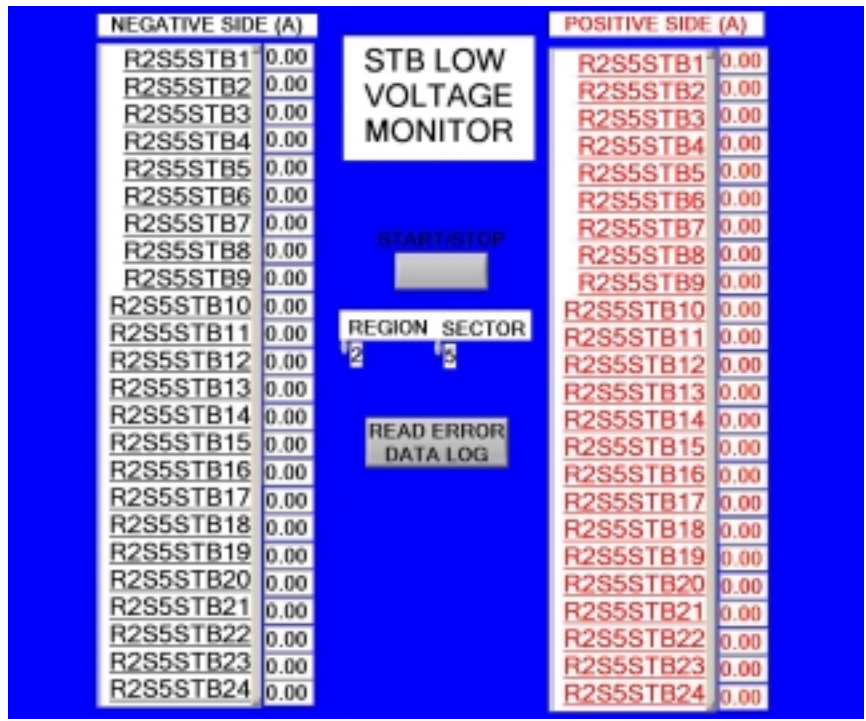
Three points of data were collected during this test: the total voltage supplied, the total current through the system, and 15 individual channel read-outs from the individual circuits.

This procedure collected data from both the positive and negative bus bar. Analysis of the graphs (Graph 4-4A, 4-4B in the Appendix) shows that current drop is approximately equal to .0006A for each $\frac{1}{4}V$ decrease in total supplied voltage.

5.1 Programming and GUI

Hall B shift takers are concerned with total current; values of the FP module are only 1/100 of this. Our software translates this data using NI's "Lab View" program. Lab View is a graphically based programming platform designed to create GUIs (graphical user interface) and interface with NI hardware. The front panel (the GUI) consists of both the input and return of all 24 channels that are monitored.

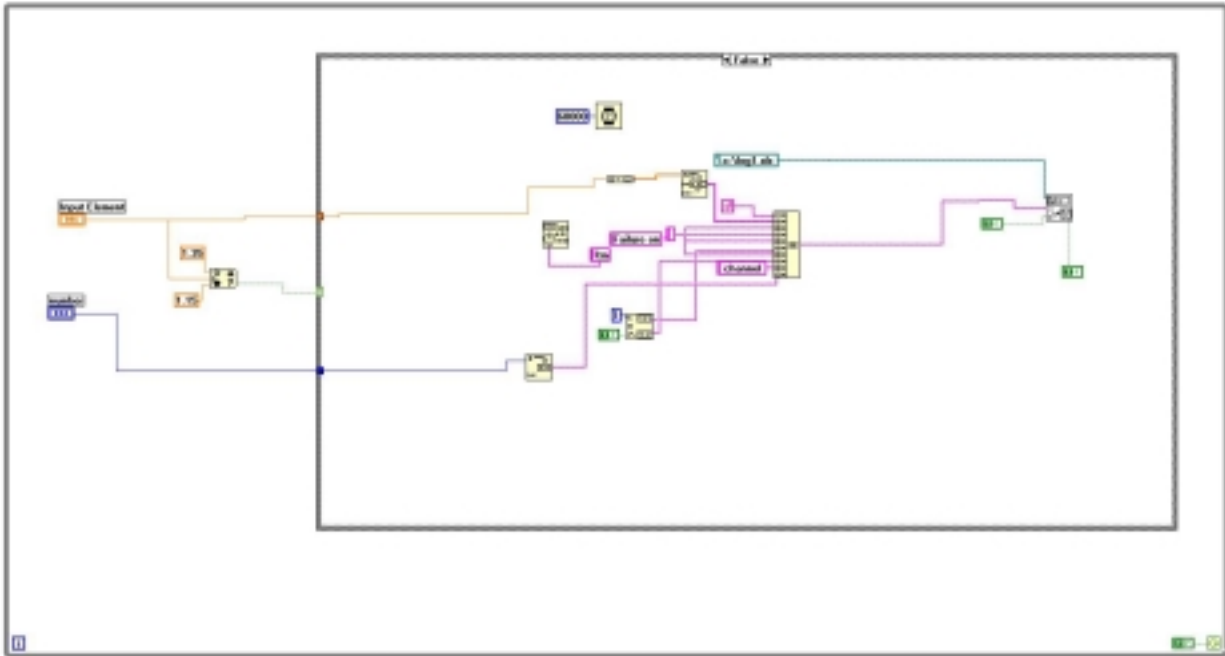
Figure 5-1 (Front Panel)



The program (the back panel) uses FP specific VIs to interface with the FP AI-111 by creating connections, finding specific channels, reading and displaying what is needed, and ending the data transfer. LabView uses the program "Field Point Explorer" to create a network connection with the AI-111. The back panel has several sub-VIs

which were created: a sub-VI, **Log**, for data logging total current flow to Microsoft Excel, another sub-VI, **Labs**, for recalling STB names upon user demand and another sub-VI, **Region 1**, for creating a front panel for Region 1.

Figure 5-2 (**Log** subVI)



Log gathers the data, including channel name, into the VI and determines if it is within 8% for the expected current value. If the data is beyond that range for a given channel, **Log** sends, or creates if needed, Excel file “log1.xls”: the name of that channel, the date, the time, and on which side of the distribution box the error occurred.

The front panel has a button that opens the Excel-based data log. Data logging is stopped when button is clicked. Also in the mainVI, **FP Reader**, a simple error handler is placed at the end of the program to finish the process.

The subVI, **Labs**, which imports STB names, brings in information when the user inputs which region and sector in which they are working. Using case loops, which determine whether the inputs correspond to a database STB title, the subVI recalls the titles of the STB requested. There are three regions and six sectors hence, there are three region loops and six sector loops within this subVI. If both a specific region and sector loop read “true” then Lab View accesses a notepad document which has the STB names specific to that region/sector and then displays them on the front panel. If the user inputs Region 1 on the front panel, **Labs** opens a front panel specific to Region 1. This front panel is similar to the **FP Reader**, in that it opens its own connection to the AI-111. Also has sector specific names which are displayed when the user inputs the sector.

6.1 Prototype Chassis

The test results were used to design a prototype chassis. Forty-eight resistors were installed in this chassis to allow for use in Region 3.

Figure 6-1 (Back Panel)

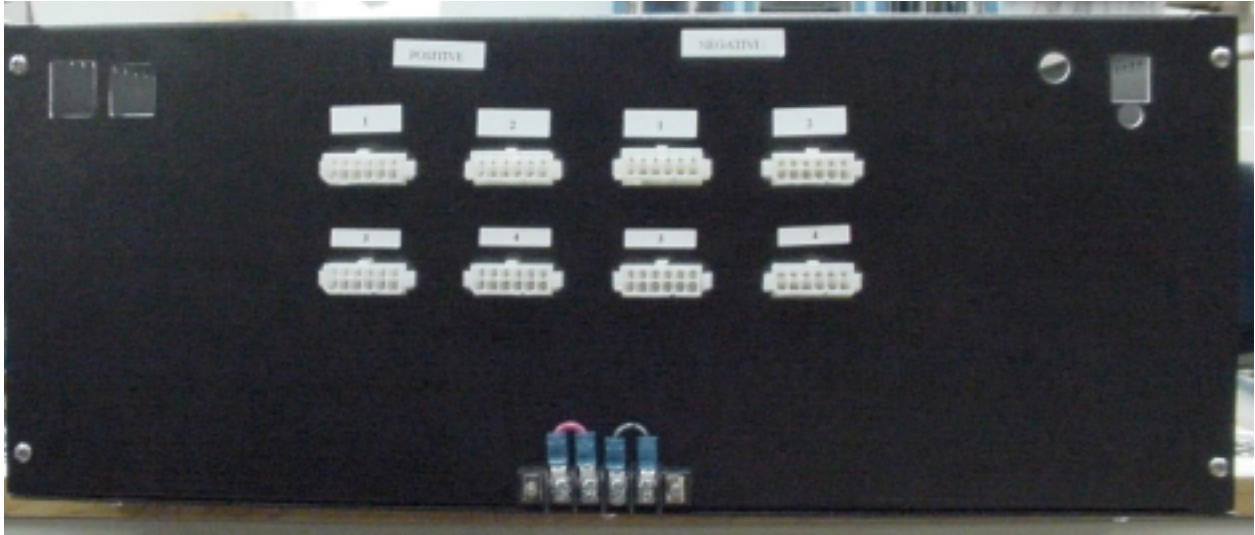


Figure 6-2 (Front Panel with 48 fuses)



Figure 6-3 (Mid-Chassis with FP-1600, AI-111)

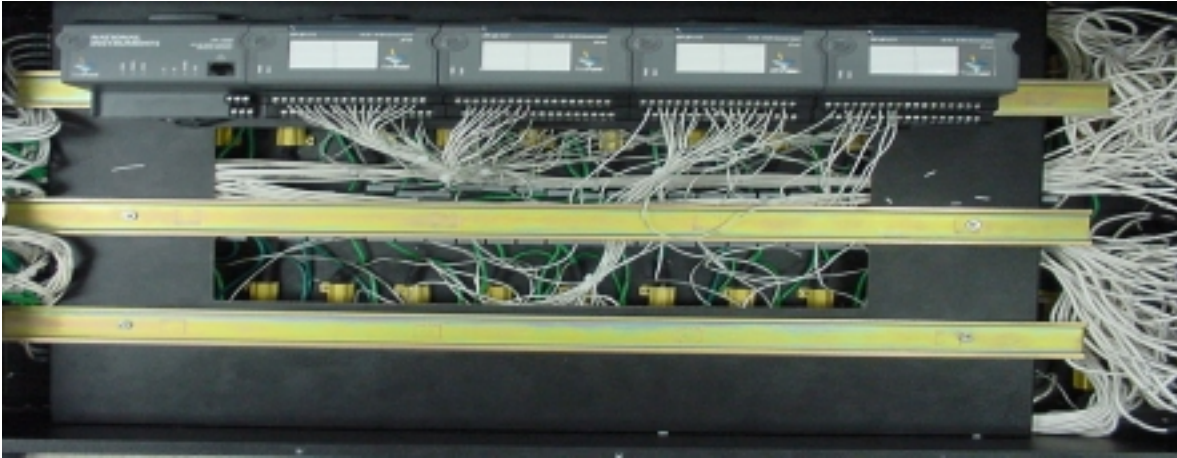
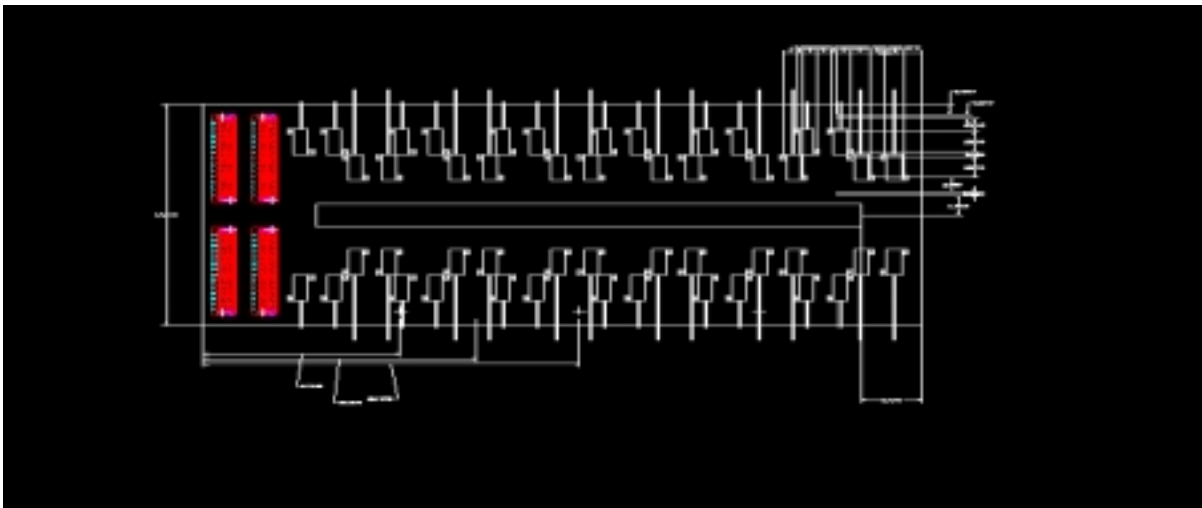


Figure 5-4 (Bottom Chassis with 48 shunt resistors)



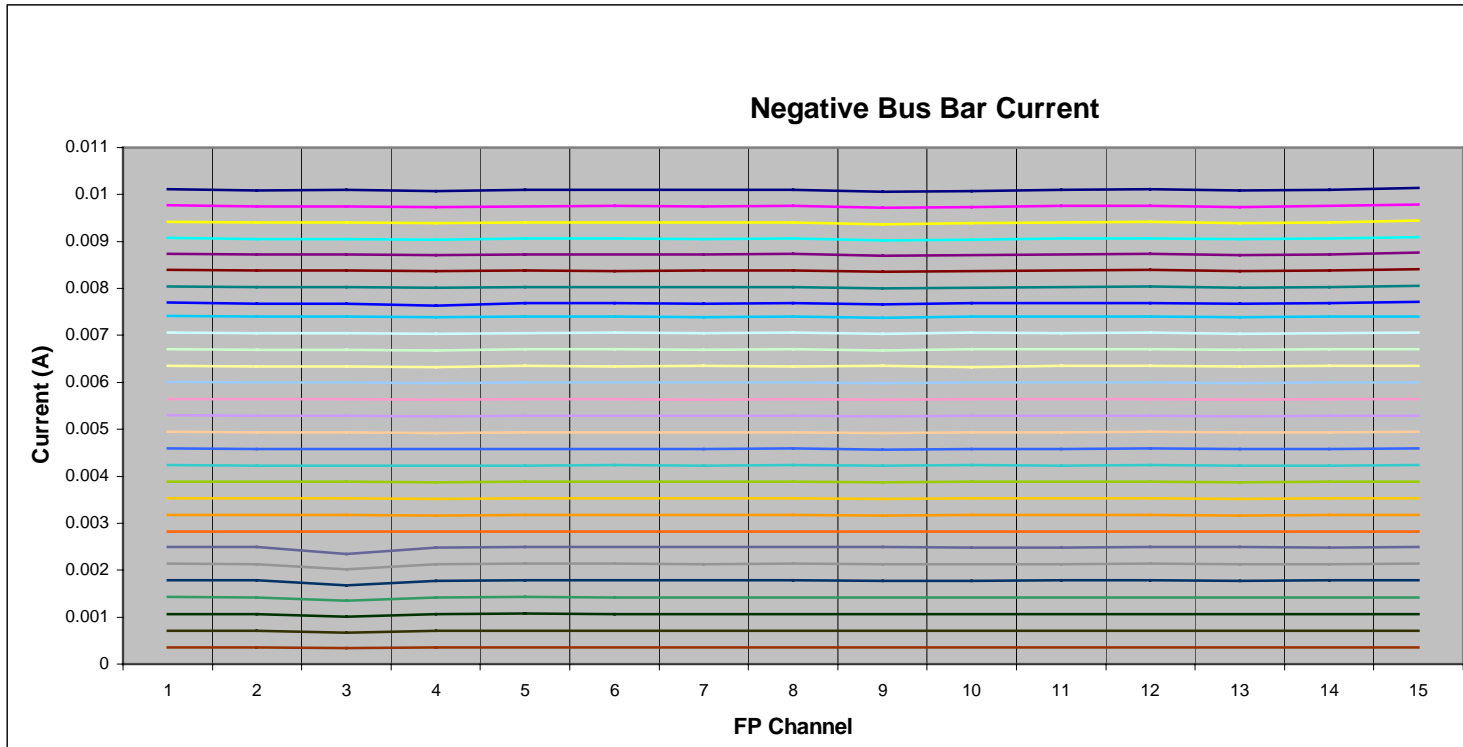
7.1 Conclusion

After thorough testing of the electrical circuitry, a prototype chassis was built. This device can be installed in the DC-LV system to monitor current running through individual channels upon demand. Data is read using a LabView-created GUI. The total system, comprised of hardware (the chassis) and software (the GUI and its programming), is capable of identifying problems within the DCLV system and alerting the user of the status of a channel.

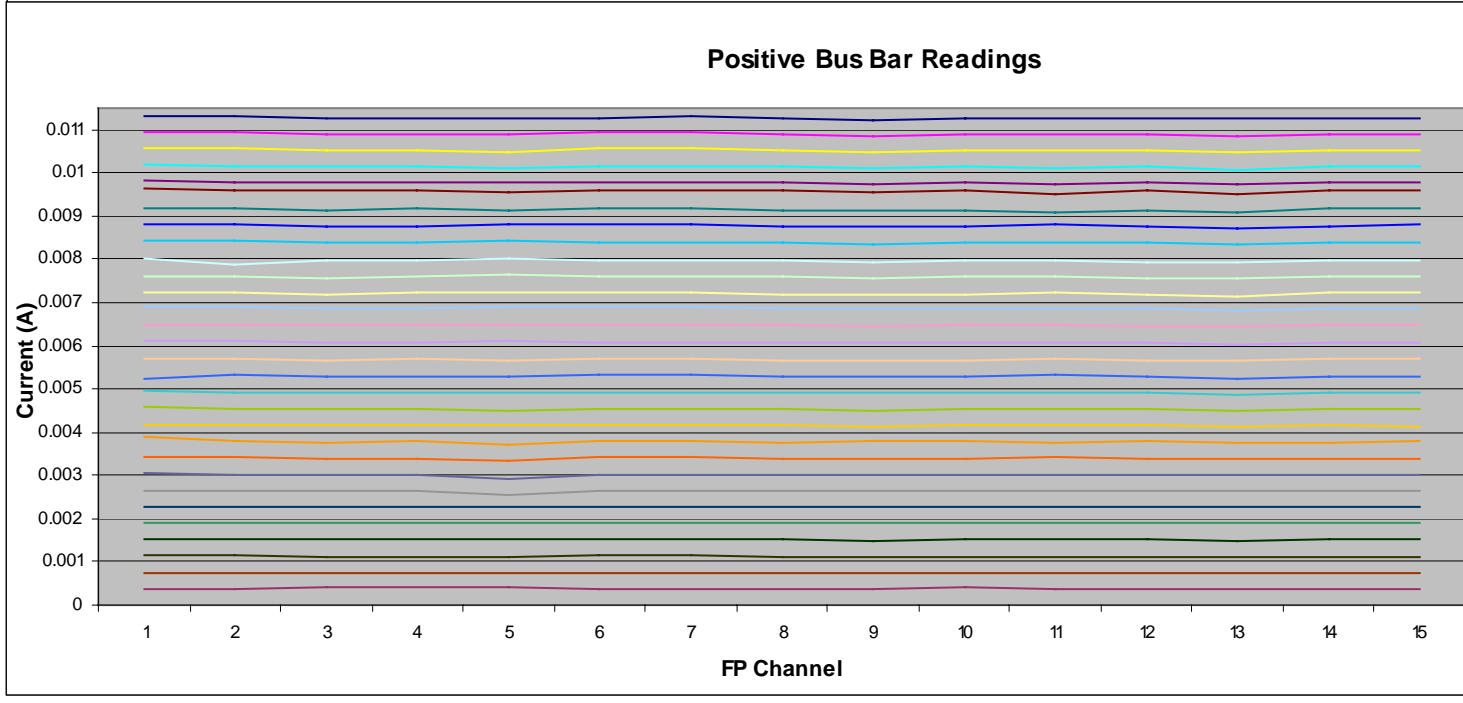
References

- [1] M.D. Mestayer et al. "The CLAS drift chamber system," *Nuclear Instruments and Methods in Physics Research A* 449 (2000) 81-111
- [2] Boston University. "Series and Parallel Circuits"
< <http://physics.bu.edu/py106/notes/Circuits.html> > 15 July 2002
- [3] "FP-AI-111: Operating Instructions." *National Instruments*. June 1999

Appendix (Figure 4-4A, 4-4B)



- 7.25V, 15.739A
- 7V, 15.195A
- 6.75V, 14.665A
- 6.5V, 14.121A
- 6.25V, 13.592A
- 6V, 13.048A
- 5.75V, 12.504A
- 5.5V, 11.974A
- 5.25V, 11.548A
- 5V, 10.914A
- 4.75V, 10.351
- 4.5V, 9.826A
- 4.25V, 9.282A
- 4V, 8.783A
- 3.75V, 8.194A
- 3.5V, 7.65A
- 3.25V, 7.093A
- 3V, 6.549A
- 2.75V, 6.005A
- 2.5V, 5.461A
- 2.25V, 4.917A
- 2V, 4.373A
- 1.75V, 3.827
- 1.5V, 3.285A
- 1.25V, 2.741
- 1V, 2.184A
- .75V, 1.64A
- .5V, 1.096A
- .25V, .53A



- 7.5V, 17.273A
- 7.25V, 16.789A
- 7V, 16.158A
- 6.75V, 15.572A
- 6.5V, 15A
- 6.25V, 14.372A
- 6V, 13.815A
- 5.75V, 13.243A
- 5.5V, 12.682A
- 5.25V, 12.099A
- 5V, 11.527A
- 4.75V, 10.97A
- 4.5V, 10.384A
- 4.25V, 9.812A
- 4V, 9.226A
- 3.75V, 8.669A
- 3.5V, 8.097A
- 3.25V, 7.511A
- 3V, 6.939A
- 2.75V, 6.354A
- 2.5V, 5.768A
- 2.25V, 5.196A
- 2V, 4.624A
- 1.75V, 4.052A
- 1.5V, 3.467A
- 1.25V, 2.895A
- 1V, 2.309A
- .75V, 1.737A
- .5V, 1.166A
- .25V, .58A