Operation Manual

Team 12

Development of Hammer Blow Test to Simulate Pyrotechnic Shock

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Table of Contents

Table of Figures

Table of Tables

Acknowledgements

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ABSTRACT

In order to ensure safety and a properly functioning system, thorough tests need to be done on every operational part. This is especially true for systems that encounter and make use of pyrotechnic shock. Many advanced systems use controlled explosive devices to accomplish tasks. Examples include rocket separation, pilot ejection, and air bag deployment. During these events it is critical that the components involved with the explosion and those surrounding it, especially the electronics, maintain functionality. This project aims to improve upon the pyrotechnic shock testing system that currently exists at Harris Corporation. A hammer blow impact test device has been built by a previous design team, but the resulting data lacked consistency and repeatability which provided little insight. The goal of this year's team is to capitalize off of the work of the previous design team while also implementing the necessary design changes in order to produce a repeatable pyroshock test that can be used to gain further understanding of the variables involved with pyroshock testing. To accomplish this several design changes were proposed and analyzed. The appropriate design changes that should be implemented consist of: a bearing hinge at the hammer pivot point, decoupling the frame and plate using a suspension system, stabilizing the entire device via anchoring, and making use of an electromagnetic release mechanism. So far the device has been anchored and the pivot has been replaced. The next steps in the project include trying to obtain repeatable results while also looking into electromagnetic release mechanisms and decoupling of the strike plate. Once repeatable results are obtainable, tests will be run in order to determine how variables affect SRS curve results.

1. Functional Analysis

There are two major aspects to this project, and each is necessary to gather the desired data. The first, the Data Acquisition System (DAQ) is crucial for proper data collection and will be described more in depth later in this manual. The second is the physical hammer blow test. The device was originally built last year and minor changes for repeatability improvement have been made this year, but the basic operation stays the same. The procedure for running a test is listed below.

1. With the assumption that the apparatus is assembled and anchored down, tighten all connections, especially those associated with the strike plate using the torque wrench.
2. Attach the accelerometer to the back side of the strike plate (opposite of where the hammer swings), and screw into one of the nine threaded holes depending on desired test location. Ensure secure attachment. Accelerometer will protrude out to front side of plate.
3. On front side of apparatus, adjust hammer arm to match desired strike location by loosening pivot and sliding left or right. Tightened at desired location.
4. Attach hammer block on hammer arm. Slide to desired height and tighten. Attach hammer sphere to hammer block. Tighten and ensure impact will not hit accelerometer directly. Strike location should be slightly off axis from accelerometer position to protect that equipment.
5. Set up DAQ and LabView (see below).
6. One person should be running LabView and another should be dropping the hammer. The hammer should be dropped from a desired height simultaneously as the LabView program is running.
7. Process collected data to create SRS curves (raw collected data → excel → MATlab).

It is important to note that all attachment points should be tightened after each test run, especially after the hammer drops from the top height. Loose screws can heavily affect the data in terms of both repeatability and desired results. The current strike plate can be used to test various different locations. The strike location is almost limitless because of its ability to be adjusted both vertically and horizontally. The accelerometer is limited to nine different locations drilled to follow the grid system of the plate already.

2. Project Specification

Table 1 shows crucial components and their respective dimensions. Data sheets for the data acquisition equipment are in the Appendix.

Table 1- Dimensions and Specifications of Components

Component	**Dimensions/Specifications**
Frame	34"x 34"x 26", T-slotted Al6061
Strike plate	31.63"x 31.63"x 0.19", Al6061
Hammer Block	3"x 4"x 3", Al6061
Hammer spheres, various sizes	1-7/8", 1-3/8", 1", 3/4", Stainless steel
DAQ	NI USB-6211, 16-bit
Accelerometer	Dytran Model 3086A4T
Signal Conditioner	PCB Piezotronics Model 482A21
Current Source Power Unit	Dytran Model 4110C

3. Product Assembly

Figure 1 shows the CAD assembly of the test device. Figure 2 displays a partially exploded view. It can be seen that that the hammer sphere attaches to the hammer block which attaches to the hammer arm. With a pivot attached to the top inner frame bar, the hammer arm connects to the frame. The strike plate is attached to the frame using four L-brackets at the corners of the plate. For viewing purposes, only some of the frame is exploded, but all bars of the frame are separate bars that attach in the same way.

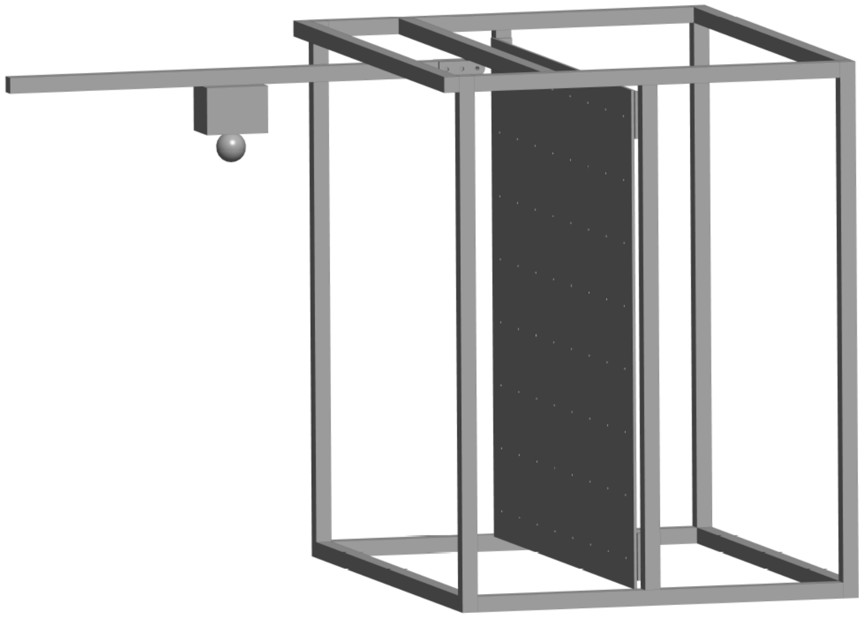


Fig. 1- CAD assembly of test device

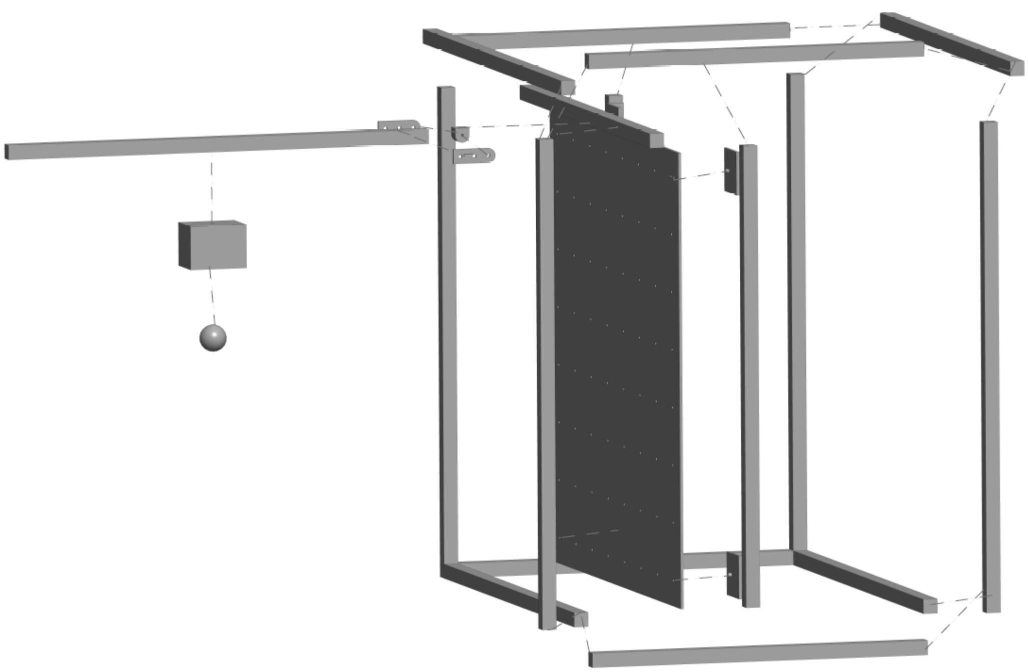


Fig. 2- Partial Exploded View of Test Device

4. Operation Instructions

The operating procedure for the running the physical test device was listed earlier. It is necessary to further explain the data acquisition system for users to be successful in running tests.

Data Acquisition Operation

The data acquisition system consists of various items in order to collect and record proper data. A list of this equipment is written below. Figure 3 explains the correctly ordered setup of this equipment, which is essential to proper data collection.

1. Accelerometer and attached cable with BNC connector
2. ICP signal conditioner/line filter and power cable
3. Current limiting power supply
4. Two BNC cables (1 needs stripped wires showing positive and negative ends to connect to DAQ)
5. USB DAQ
6. National Instruments LabView software installed on a computer

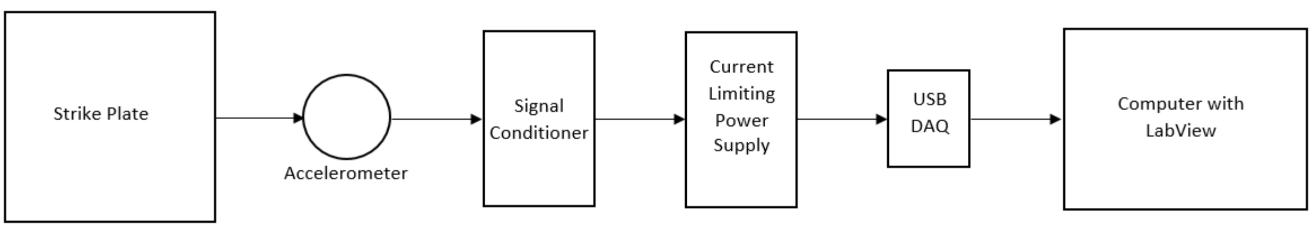


Fig. 3 - Flowchart of DAQ Hardware Setup

The next step is to build the LabView program, to read the signal output by the accelerometer. In this case, the output being read is in the form of voltage. This works well with LabView due to the easy to use DAQ Assistant. This feature allows a new user to quickly and easily setup a voltage based data acquisition system.

1. From the block diagram window, open the functions palette (right click white background)
2. Go to Express →Input →DAQ Assistant and drag the DAQ Assistant icon onto the block diagram and wait for it to automatically launch a wizard-style walkthrough (Figure 4).
3. Open the Acquire Signals drop down list.
4. Open the Analog Input drop down list and select Voltage (Figure 5).

   a. This screen shows the supported DAQ cards installed and their associated channels. Check the DAQ Connector box and select the appropriate Card and Channel and press Next (Figure 6).

5. The next window is the Configuration window (Figure 7).
   a. Here is where you set the Signal input Range, Scaling, Timing Settings, and Terminal Configuration.
6. For this project, these settings have the following Values.
   a. Max: 10, Min: -10, Scaled Units: Volts, Terminal Configuration: "Let NI-DAQ Choose", Custom Scaling: No Scale, Acquisition Mode: N Samples, Samples to Read: 50000, Rate (Hz): 50000.

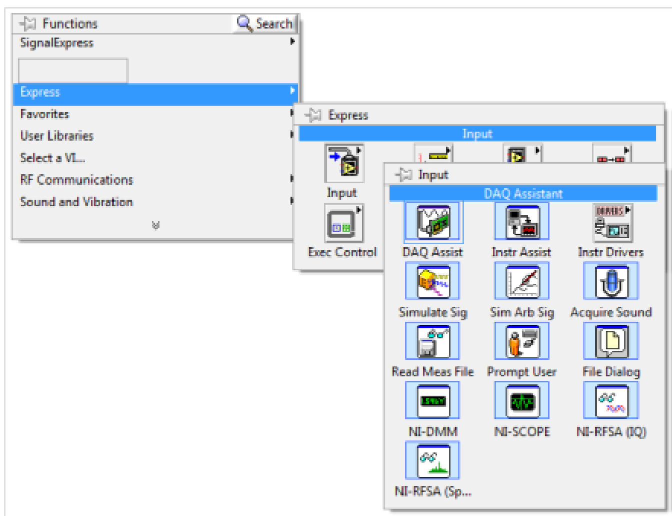


Fig. 4 - Adding a DAQ Assistant

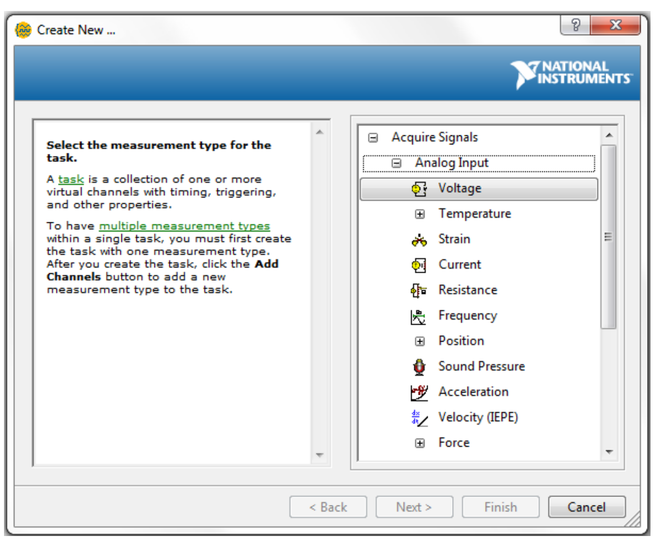


Fig. 5 - Selecting the Signal

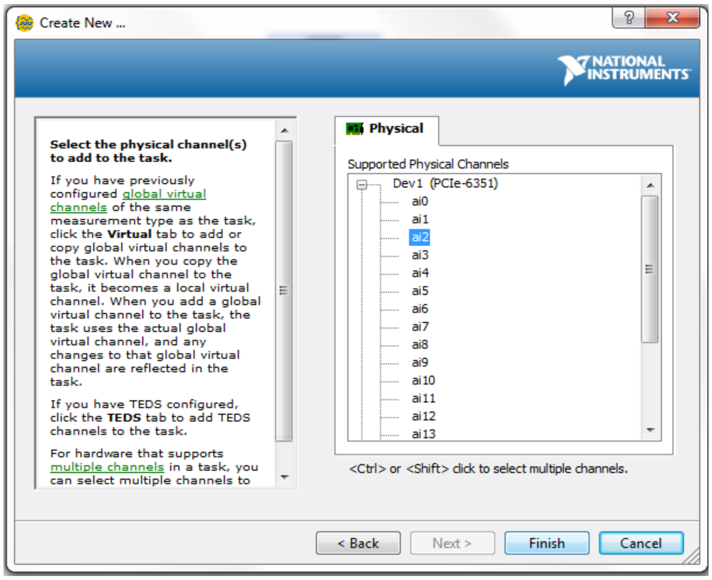


Fig. 6 - Selecting an input channel

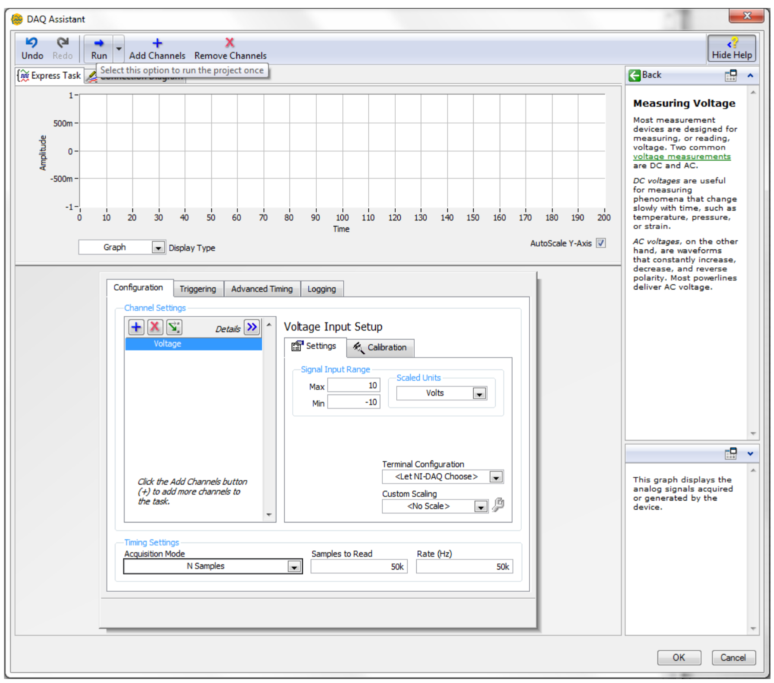


Fig. 7- Channel specific configuration page

Further development was done within LabView in order to output the data to both an on-screen graph, as well as a text file for further processing. Figure 8 shows the full block diagram and Figure 9 displays the interface screen of the program.

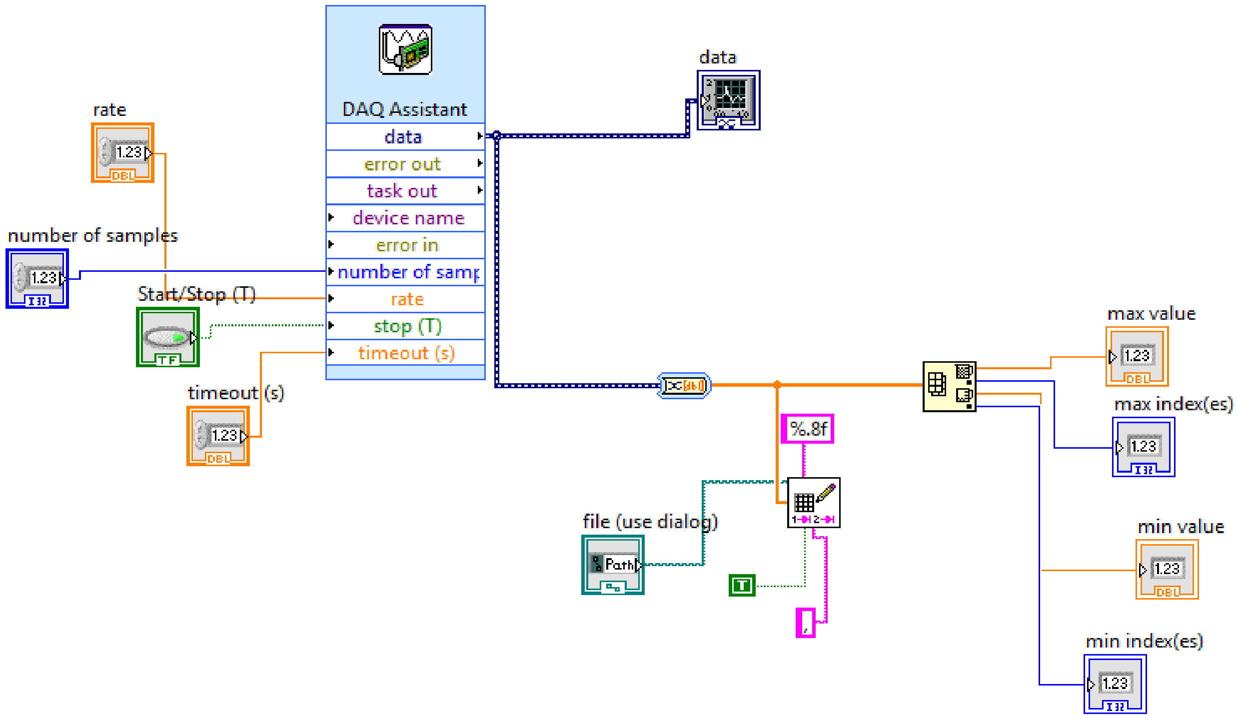


Fig. 8 - Block diagram of LabView Program

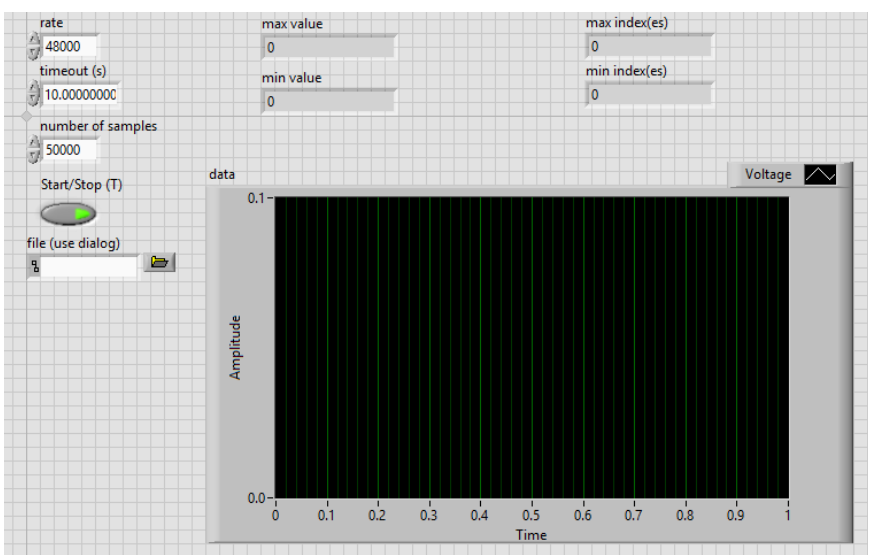


Fig. 9 - LabView user interface

The LabView blocks are created by right-clicking the various tools in the in the Data Acquisition Assistant and making control blocks. Figure 10 shows an example of creating a control block from the Data Acquisition Assistant. Outputting to a file was done by first outputting the data to an array, then transposing this array into columns, and passing this array to a text file that will be given a name through the dialogue box on the interface. The data can also be obtained by right-clicking the data in the user interface and exporting directly to Microsoft Excel.

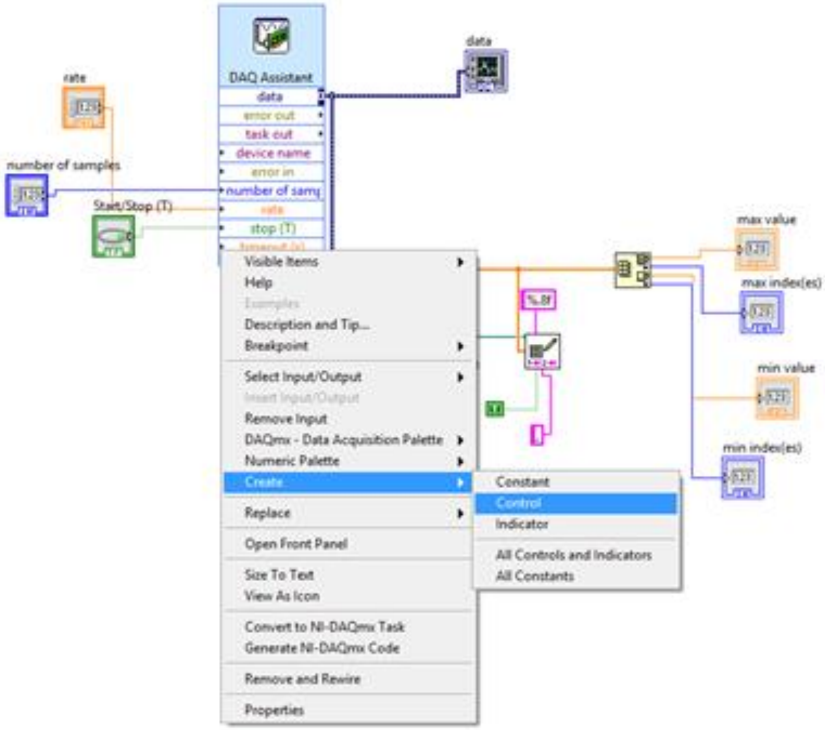


Fig. 10 - Creating a control block in LabView

After exporting the raw data (time and voltage) to Excel, a conversion factor must be used before importing that data into MATlab. All voltages should be multiplied by 1919.386. From there, the MATlab codes, provided by last year's team and written by Tom Irvine, can be used to generate SRS curves. Figure 11 shows the running code with the proper answers to the given prompts. It is important that Q=10, but the prompts about plot formatting is based on what the user desires.

```
>> SRS_new

 srs.m   ver 4.2   July 1, 2013
 by Tom Irvine   Email: tom@vibrationdata.com

 This program calculates the shock response spectrum
 of an acceleration time history, which is pre-loaded into Matlab.
 The time history must have two columns: time(sec) & acceleration

 Select units
  1=English: accel(G),       vel(in/sec),  disp(in)
  2=metric : accel(G),        vel(m/sec),  disp(mm)
  3=metric : accel(m/sec^2),  vel(m/sec),  disp(mm)
 1
 Select file input method
   1=external ASCII file
   2=file preloaded into Matlab
   3=Excel file
3

 Time Step
 dtmin  =    2e-05 sec
 dt     = 2.08e-05 sec
 dtmax  =  2.1e-05 sec

 Sample Rate
 srmin  = 4.762e+04 samples/sec
 sr     = 4.808e+04 samples/sec
 srmax  =    5e+04 samples/sec


 Warning:  time step is not constant.  Continue calculation? 1=yes 2=no
 1
 Enter the starting frequency (Hz)  50
 Enter damping format:  1= damping ratio   2= Q  2

 Enter the amplification factor (typically Q=10) 10

 Include residual?
  1=yes  2=no
 1
```

```
Calculating response.....

Absolute Peak is       6180 G at     4271.5 Hz

Select output option
1=plot only   2=plot & output text file  1


Plotting output.....
select plot type:  1=positive & negative   2=maximax
2
Matlab matrices:
     SRS_pn  - Acceleration SRS positive & negative
     SRS_max - Acceleration SRS maximax

Plot pseudo velocity?
1=yes   2=no  2

Plot relative displacement?
1=yes   2=no  2

Plot std dev response spectrum?
1=yes   2=no  2
```

Fig. 11- MATlab Program to Generate SRS Curves

5. Troubleshooting

With so many variables affecting the data and various pieces of equipment needed to collect said data, issues are bound to arise. Table 2 lists some problems that may occur and possible solutions to rectify them.

Table 2- Problems and Possible Solutions for Shock Simulation

Problem	**Possible Solutions**
Noisy Data	Ensure DAQ is properly grounded and all connections are secure.
	Ensure the accelerometer is tightened down.
	Check that all screws and nuts are tightened.
Hammer Impact Not Consistent	Make sure pivot is not too tight.
DAQ Not Being Recognized by the Computer	Make sure proper drivers are installed
	Make sure the professional version of LabView is being used.

6. Regular Maintenance

Regular maintenance of the test device should include tightening of all attachments after each test run. This is to ensure not only repeatable data, but also safety. Also, it is important to check the data acquisition equipment to make sure all is running correctly. Other than that and general inspection of the strike plate for fractures or crack, the test apparatus does not require too much maintenance.

7. Spare Parts

Figure 12 shows the table of spare parts from the team last year and an image of said parts. All of those things are still part of the inventory, and most of them will not be used. Specific to this year, the test article mounting plate has now become a spare part as well since it is no longer being used and the accelerometer is being mounted directly to the strike plate.

Table 1 - Spare Parts Inventory

Description	QTY	Notes
Long Stiffening Bands	3	8 holes, 4" spacing
Short Stiffening Bands	4	4 holes, 4" spacing
Sacrificial Plates	4	Specific to Hammer Tip Size
Bushings	6	70 Durometer
T-Slot Brackets	12	
Short Hex Bolts	25	Size: 1/4-20 x 7/8"
Long Hex Bolts	13	Size: 1/4-20 x 1-1/2"
Lock Nuts	13	Size: 1/4-20
Washers	90	Size: 1/4"
Nuts	90	Size: 1/4-20
T-Slot Hardware	5 Bags	Nuts and Bolts
Lanyard	1	Length: 15ft
Long Threaded Rod	1	Size: 3/8-16 x 8"
Short Threaded Rod	1	Size: 1/4-20 x 1-1/2"
T-Slotted Aluminum	1	Size: 1" x 6' Solid
Angled Steel	1	Size: 3" x 3" x 1'

Figure 6 - Spare Parts

Fig. 12- Table and Image of Spare Parts from Team 15 Last Year

References

1. DeMartino, Charles, Chad Harrell, Chase Mitchell, and Nathan Crisler. *Operations Manual.* Senior Design Team 15. Web. 3 April. 2015. <http://eng.fsu.edu/me/senior_design/2015/team15/Operations_Manual_Final.pdf>.

1. DeMartino, Charles, Chad Harrell, Chase Mitchell, and Nathan Crisler. *Impact Testing and Pyrotechnic Shock Modeling Final Report.* Senior Design Team 15. Web. 10 April. 2015. <http://eng.fsu.edu/me/senior_design/2015/team15/Final_Report_Team15.pdf>.

2. Wells, Robert. “University Capstone: Development of Hammer Blow Test Device to Simulate Pyrotechnic Shock (Second Year Project).” 14 Aug. 2015.

Appendix

National Instruments DAQ USB-6211

Detailed Specifications

Specifications listed below are typical at 25 °C unless otherwise noted. Refer to the *NI USB-621x User Manual* for more information about USB-621*x* devices.

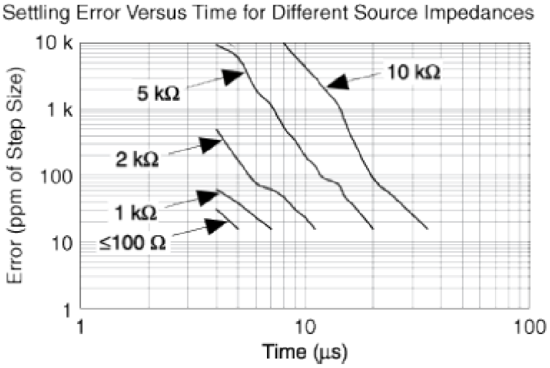
Caution The input/output ports of this device are not protected for electromagnetic interference due to functional reasons. As a result, this device may experience reduced measurement accuracy or other temporary performance degradation when connected cables are routed in an environment with radiated or conducted radio frequency electromagnetic interference.

To ensure that this device functions within specifications in its operational electromagnetic environment and to limit radiated emissions, care should be taken in the selection, design, and installation of measurement probes and cables.

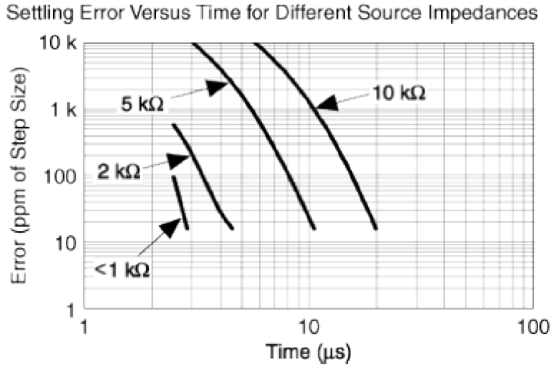
Analog Input	
Number of channels	
USB-6210/6211/6212/6215/6216	8 differential or 16 single ended
USB-6218	16 differential or 32 single ended
ADC resolution	16 bits
DNL	No missing codes guaranteed
INL	Refer to the AI Absolute Accuracy Tables
Sampling rate	
Maximum	
USB-6210/6211/6215/6218	250 kS/s single channel, 250 kS/s multichannel (aggregate)
USB-6212/6216	400 kS/s single channel, 400 kS/s multichannel (aggregate)
Minimum	0 S/s
Timing accuracy	50 ppm of sample rate
Timing resolution	50 ns
Input coupling	DC
Input range	±10 V, ±5 V, ±1 V, ±0.2 V
Maximum working voltage for analog inputs (signal + common mode)	±10.4 V of AI GND
CMRR (DC to 60 Hz)	100 dB
Input impedance	
Device on	
AI+ to AI GND	>10 GΩ in parallel with 100 pF
AI- to AI GND	>10 GΩ in parallel with 100 pF

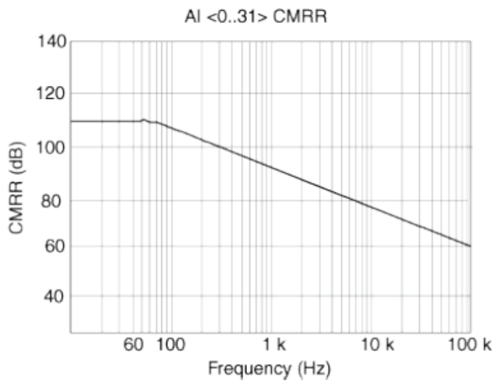
Device off	
AI+ to AI GND	1200 Ω
AI- to AI GND	1200 Ω
Input bias current	±100 pA
Crosstalk (at 100 kHz)	
Adjacent channels	-75 dB
Non-adjacent channels	-90 dB
Small signal bandwidth (-3 dB)	
USB-6210/6211/6215/6218	450 kHz
USB-6212/6216	1.5 MHz
Input FIFO size	4,095 samples
Scan list memory	4,095 entries
Data transfers	USB Signal Stream, programmed I/O
Overvoltage protection (AI <0..31>, AI SENSE)	
Device on	±30 V for up to two AI pins
Device off	±20 V for up to two AI pins
Input current during overvoltage condition	±20 mA max/AI pin
Settling Time for Multichannel Measurements	
Accuracy, full scale step, all ranges	
USB-6210/6211/6215/6218	
±90 ppm of step (±6 LSB)	4 µs convert interval
±30 ppm of step (±2 LSB)	5 µs convert interval
±15 ppm of step (±1 LSB)	7 µs convert interval
USB-6212/6216	
±90 ppm of step (±6 LSB)	2.5 µs convert interval
±30 ppm of step (±2 LSB)	3.5 µs convert interval
±15 ppm of step (±1 LSB)	5.5 µs convert interval
Typical Performance Graphs	

USB-6210/6211/6215/6218
Settling Error Versus Time for Different Source Impedances



USB-6212/6216
Settling Error Versus Time for Different Source Impedances

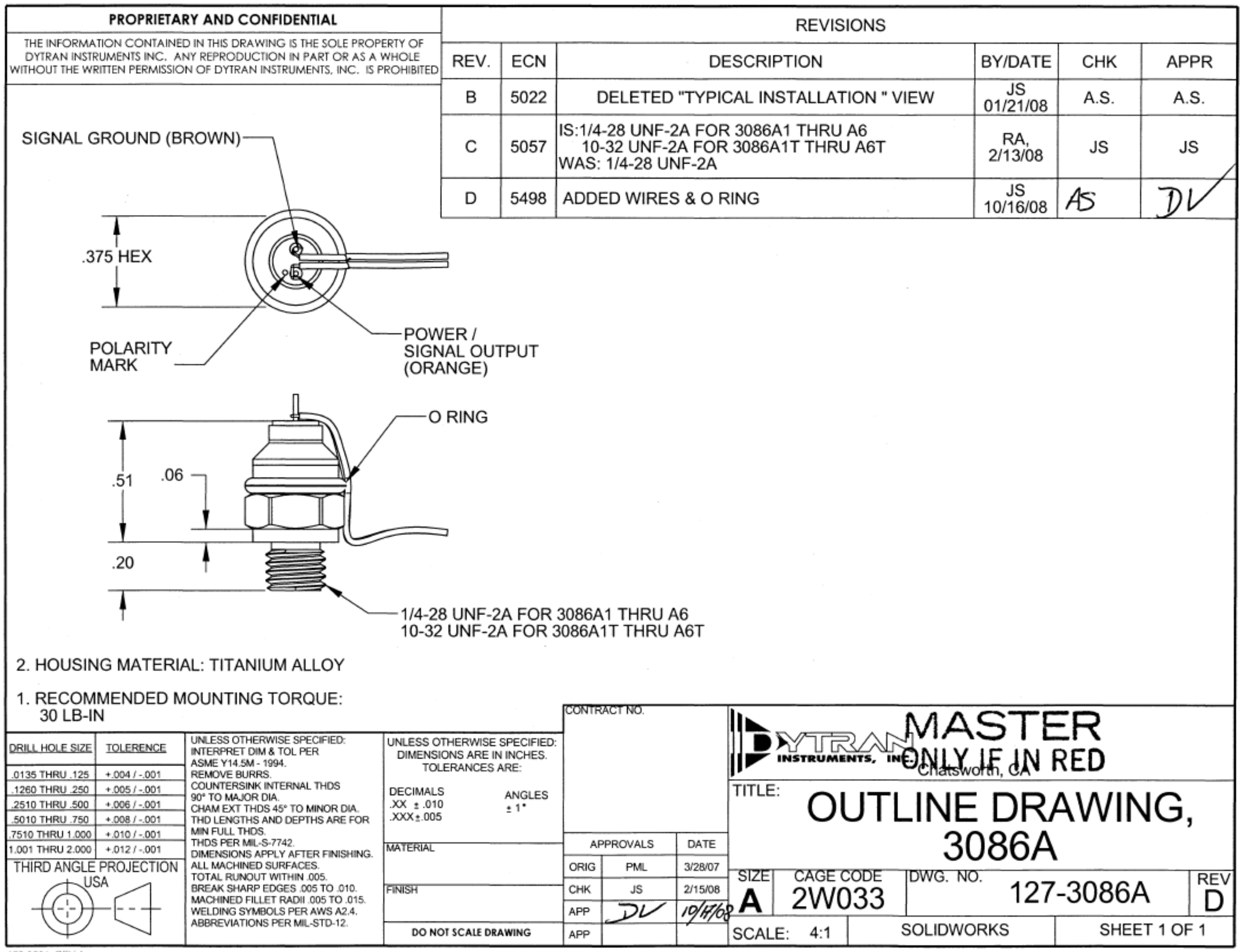




Analog Output	
Number of channels	
USB-6210	0
USB-6211/6212/6215/6216/6218	2
DAC resolution	16 bits
DNL	±1 LSB
Monotonicity	16 bit guaranteed
Maximum update rate	
1 channel	250 kS/s
2 channels	250 kS/s per channel
Timing accuracy	50 ppm of sample rate
Timing resolution	50 ns
Output range	±10 V
Output coupling	DC
Output impedance	0.2 Ω
Output current drive	±2 mA
Overdrive protection	±30 V
Overdrive current	2.4 mA
Power-on state	±20 mV
Power-on glitch	±1 V for 200 ms
Output FIFO size	8,191 samples shared among channels used
Data transfers	USB Signal Stream, programmed I/O
AO waveform modes: ▪ Non-periodic waveform ▪ Periodic waveform regeneration mode from onboard FIFO ▪ Periodic waveform regeneration from host buffer including dynamic update	
Settling time, full scale step 15 ppm (1 LSB)	32 μs
Slew rate	5 V/μs
Glitch energy	
Magnitude	100 mV
Duration	2.6 μs

Calibration (AI and AO)	
Recommended warm-up time	15 minutes
Calibration interval	1 year

Dytran Accelerometer Model 3086A4T



SPECIFICATIONS, SERIES 3086A/AT
LIVM HIGH SHOCK ACCELEROMETERS

SPECIFICATIONS BY MODEL

MODEL	RANGE F.S. (g)	MAXIMUM SHOCK (g)	SENSITIVITY (NOM)[1] (mV/g)	ELECTRICAL NOISE (g)	NATURAL FREQUENCY (kHz)	ISOLATION CUP RESONANCE (kHz)
3086A1/A1T	70,000	100,000	0.05	1.40	100	45
3086A2/A2T	50,000	100,000	0.1	0.7	100	45
3086A3/A3T	20,000	100,000	0.25	0.28	100	45
3086A4/A4T	10,000	50,000	0.5	0.14	100	45
3086A5/A5T	5000	50,000	1.0	0.07	100	45
3086A6/A6T	2500	50,000	2.0	0.035	100	45

COMMON SPECIFICATIONS

SPECIFICATION	VALUE	UNITS
DISCHARGE TIME CONSTANT	.8 to 2.0	SECOND
LOW FREQUENCY -3db POINT, NOM.	.16	Hz
LOW FREQUENCY -5% POINT	.50	Hz
FREQUENCY RESPONSE, ±10%	.35 to 10000	Hz
LINEARITY [2]	±1	% F.S.
TRANSVERSE SENSITIVITY, MAXIMUM	3.0	%
OUTPUT IMPEDANCE, NOM.	100	OHMS
OUTPUT VOLTAGE BIAS	+7.5 to +9.5	VDC
SUPPLY CURRENT RANGE [3]	2 to 20	mA
COMPLIANCE (SUPPLY) VOLTAGE RANGE [4]	+18 to +20	VDC
OPERATING TEMPERATURE RANGE	-60 to +250	°F
SIZE (HEX x HEIGHT) [4]	3/8 x .64	INCHES
WEIGHT	3.5	GRAMS
CONNECTOR, TOP MOUNTED	SOLDER PINS	
MATERIAL, HOUSING/CONNECTOR	TITANIUM ALLOY	
MOUNTING PROVISION, 3086A/3086AT	1/4-28 INTEGRAL STUD/10-32 MOUNTING STUD	
ENVIRONMENTAL SEAL	HERMETIC	
ISOLATION, CASE TO MOUNTING SURFACE, MIN	10	MΩ

RECOMMENDED CABLE: DYTRAN PART NO. 128-6869AXX (XX DENOTES LENGTH IN FEET)

[1] Measured by impacting against calibrated force sensor. NIST traceable.
[2] Percent of full scale or any lesser designated full scale range, zero-based best fit straight line method.
[3] Power only with Dytran or Dytran approved current source type power unit. Do not supply power without current limiting. You will destroy the integral electronics. This will void the warranty.
[4] Height measured from mounting surface to top of connector. Integral mounting studs are .20 in. long.

REV H ECN10559 11/19/13 2

PCB Piezotronics Signal Conditioner Model 482A21

Model Number 482A21	SENSOR SIGNAL CONDITIONER	Revision: K ECN #: 43617

Performance	ENGLISH	SI	
Channels	1	1	
Voltage Gain(± 1 %)	1:1	1:1	
Low Frequency Response(-5 %)	<0.1 Hz	<0.1 Hz	[3][4]
High Frequency Response(-5 %)	>1000 kHz	>1000 kHz	
Fault/Bias Monitor/Meter	26 V FS	26 V FS	
Environmental			
Temperature Range	32 to 120 °F	0 to 50 °C	
Electrical			
Power Required(Standard)	DC power	DC power	
Excitation Voltage(To Sensor)	25 to 27 VDC	25 to 27 VDC	
DC Offset(Maximum)	<20 mV	<20 mV	
DC Power	+32 to 38 VDC	+32 to 38 VDC	[1]
DC Power	0.12 Amps	0.12 Amps	[1]
Constant Current Excitation(To Sensor)	2 to 20 mA	2 to 20 mA	[2]
Discharge Time Constant(0 to +50%)	10 sec	10 sec	[3][4]
Spectral Noise(1 Hz)	0.71 µV/√Hz	-123 dB	[5]
Spectral Noise(10 Hz)	0.09 µV/√Hz	-142 dB	[5]
Spectral Noise(100 Hz)	0.05 µV/√Hz	-147 dB	[5]
Spectral Noise(1 kHz)	0.04 µV/√Hz	-149 dB	[5]
Spectral Noise(10 kHz)	0.03 µV/√Hz	-150 dB	[5]
Broadband Electrical Noise(1 to 10,000 Hz)	3.25 µV	-110 dB	[5]
Physical			
Electrical Connector(Input, sensor)	BNC Jack	BNC Jack	
Electrical Connector(Output)	BNC Jack	BNC Jack	
Electrical Connector(DC Power Input)	DIN Jack	DIN Jack	
Size (Height x Width x Length)	6.3 in x 2.4 in x 11 in	16 cm x 6.1 cm x 28 cm	
Weight	1.51 lb	685 gm	

CE [6]

All specifications are at room temperature unless otherwise specified.
In the interest of constant product improvement, we reserve the right to change specifications without notice.
ICP® is a registered trademark of PCB Group, Inc.

OPTIONAL VERSIONS

Optional versions have identical specifications and accessories as listed for the standard model except where noted below. More than one option may be used.

NOTES:

[1]Provided by supplied external DC power supply.
[2]User adjustable, factory set at 4 mA (± 0.5 mA). One control adjusts all channels.
[3]With ≥ 1M ohm input impedance of readout device.
[4]Un-buffered output, read out device input impedance affects discharge time constant and low frequency response of unit.
[5]Typical.
[6]See PCB Declaration of Conformance PS024 for details.

SUPPLIED ACCESSORIES:

Model 017AXX Power Cord
Model 488B04/NC Power Convertor

Entered: AP	Engineer: CPH	Sales: ML	Approved: JWH	Spec Number:
Date: 1/28/2015	Date: 1/28/2015	Date: 1/28/2015	Date: 1/28/2015	**6528**

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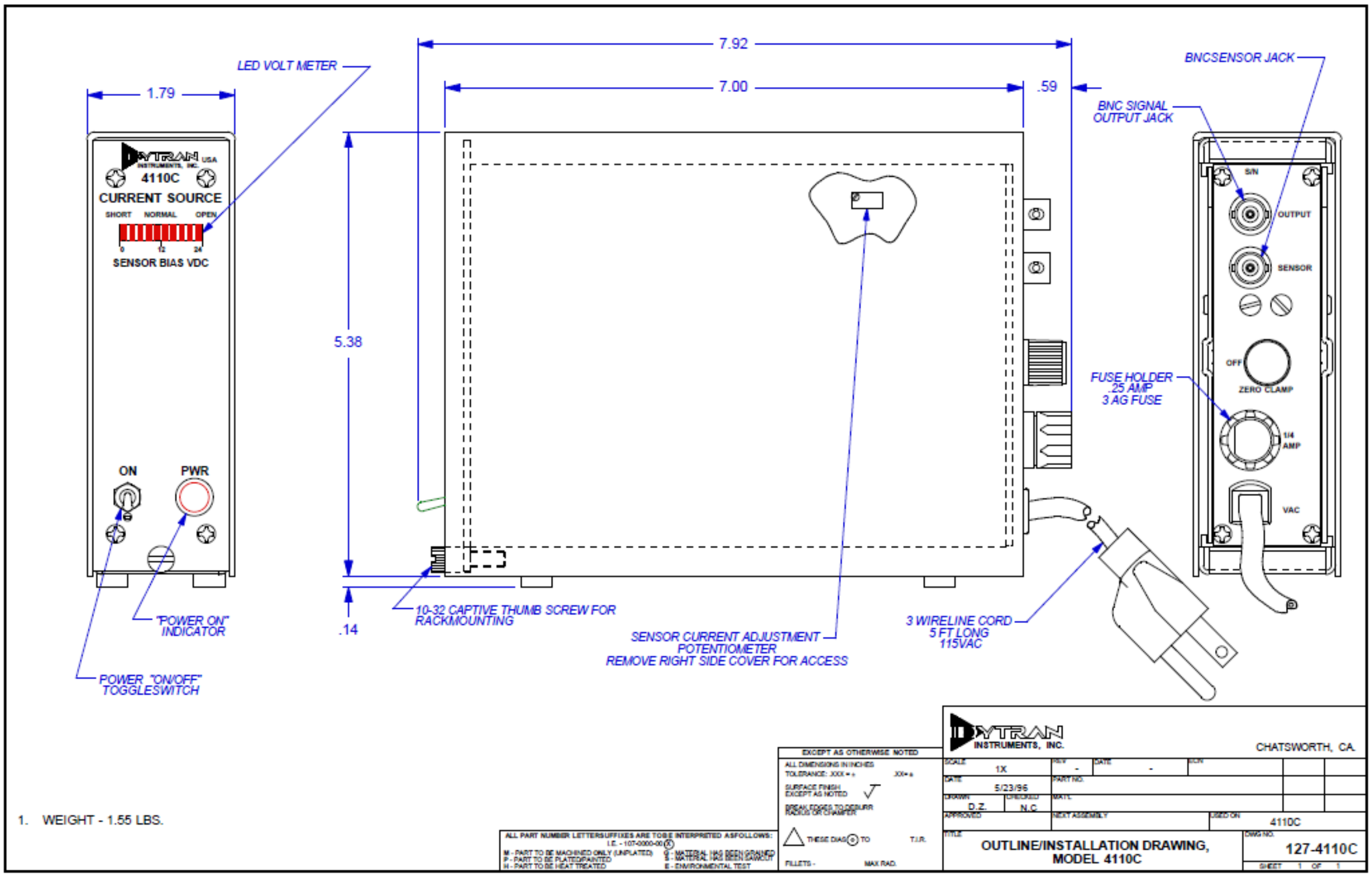
Dytran Current Source Power Unit Model 4110C



SPECIFICATIONS
MODELS 4110C SINGLE CHANNEL & 4114B 4-CHANNEL LIVM
LINE-POWERED CURRENT SOURCE POWER UNITS

SPECIFICATIONS		VALUE	UNITS
SENSOR DRIVE CURRENT ADJUSTMENT RANGE		2 to 20	mA
COMPLIANCE (SUPPLY) VOLTAGE		+24	VDC
VOLTAGE GAIN		1	UNITY
DE-COUPLING CAPACITOR		10	µF
PULLDOWN RESISTOR		1	MEGOHM
COUPLING TIME CONSTANT, NO LOAD		10	SECONDS
W/1 MEGOHM LOAD		1	SECONDS
LOWER -3db FREQUENCY, NO LOAD		.016	Hz
W/1 MEGOHM LOAD		.03	Hz
HIGH FREQUENCY RESPONSE:		DETERMINED BY SENSOR, CABLE LENGTH AND SENSOR DRIVE CURRENT.	
BACKGROUND ELECTRICAL NOISE, WIDEBAND		150	µV RMS
SENSOR CONNECTOR, REAR PANEL,	MODEL 4110C	BNC	JACK
	MODEL 4114B	10-32 (4)	JACK
OUTPUT CONNECTOR, REAR PANEL,	ALL MODELS	BNC	JACK
POWER CORD, 3-WIRE W/GND		6	FT
POWER REQUIRED: [1]			
MODEL 4110C		1.1	VA
MODEL 4114		4.4	VA
SIZE, H x W x D [2]	BOTH MODELS	5.5 x 1.6 x 8.0	IN
WEIGHT	BOTH MODELS	32/907	OZ/GRAMS

[1] 115 VAC, 50-60 Hz FOR STANDARD MODELS. EXPORT ["E"] VERSIONS REQUIRE 230 VAC, 50-60Hz.

[2] RACK MOUNTING: UP TO 10 UNITS MAY BE MOUNTED IN 19 IN. WIDE MODEL 4200 RACK ADAPTOR. UNIT IS SECURED IN RACK BY MEANS OF A CAPTIVATED 10-32 THUMB SCREW AT THE BOTTOM OF THE FRONT PANEL.