Operations Manual

Pyrotechnic Shock Test Development

Team Number 15

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1 Functional Analysis

This testing apparatus was designed to deliver an impact to a large metal plate. In doing so, this impact is absorbed by a test article attached to the large metal plate, and the acceleration of the test article is measured by an accelerometer connected to a DAQ system. To perform a test a procedure must be followed. A simplified version is provided here and a detailed version is given under the Operating Instructions section. Here, it is assumed the apparatus is already assembled.

1. Locate impact location for test.
2. Attach sacrificial plate (assuming accelerometer is already threaded onto plate)
3. Locate test article location for test
4. Attach test article.
5. Adjust hammer pivot location to be centered on sacrificial plate.
6. Select hammer head for test
7. Attach hammer head to corresponding hammer weight.
8. Attach both hammer weights to hammer arm
    a. Hammer weight with attached head faces metal plate.
9. Adjust hammer head location to align with center of sacrificial plate
10. Relocate quick release frame mount to align with hammer arm.
11. Raise hammer and lock in place with quick release pin.
12. One person must operate test apparatus, one person must operate DAQ system.
13. The data acquisition and hammer release via pin must occur simultaneously.

Once the data is confirmed to be accurate and usable, further processing is done using Matlab in order to obtain the desired output, an SRS curve. This curve can then be tailored to a desired response by changing the parameters of the test setup.

2 Product Specifications

Some components of this team’s design are specifically selected, or manufactured. Detailed below are those items as well as the reasons and justifications for their selection.

- Test article is low carbon steel, 6” x 6” x 0.5”
  - Doesn’t sustain any impact. Chosen to achieve weight requirement posed by sponsor.
- Fixture plate is 6061 aluminum, 31.63” x 31.63” x 0.19”
  - suggested by sponsor, same material they use
  - works well for vibration/shock testing; not too rigid yet still retains strength
- Sacrificial plate is 6061 aluminum, 6” x 6” x 0.19”
  - sustains impact well and matches fixture material to minimize the effect of different materials in transfer of energy
  - Cheap and available in correct size. OTS pieces.
- Hammer Heads are spherical stainless steel, 1-7/8”, 1-3/8”, 1”, 3/4”
  - Forces any work hardening of material to occur on sacrificial plate
  - Best approximation to generating half-sine input (sponsor suggestion)

After an extensive search and communication with our sponsor and members of the FCAAP staff we were able to select an accelerometer for use in our system. We opted for a Dytran shock accelerometer model 3086A4T, a Dytran current limiting power source model 4110C, and a PCB signal conditioner model 482A21. The accelerometer and power source were suggestions as the power supply is specific to the accelerometer and the signal conditioner is a unit found on hand at FCAAP. This signal conditioner will help clean up the signal out of the accelerometer to limit noise. The specifics on these instruments can be found in the appendix.

3 Operating Instructions

3.1 Testing Operation

With the frame completely assembled the first step to begin testing operations is to determine which of our 4 variables is being tested and set up the apparatus accordingly. The five testing variables are test article location, hammer impact location, hammer tip size, plate boundary conditions, and modal tuning bands. These variables will be changed one at a time in order to visualize the effect of each change, while keeping all other variables constant. Each of the four different hammer head sizes will utilize its own sacrificial plate, as these plates will plastically deform through testing to match the curvature of the hammer tip size. This is done to make sure a solid contact surface is accomplished and eliminate possible deviation between tests. The constant position for the test article and impact location will be when both are centered on the fixture plate. Thus unless one of these variables are being tested the test article and sacrificial plate will always be mounted in the center of their respective sides of the fixture plate.
For tests changing the test article location:

1. Mount correct sacrificial plate in impact location on the front of the fixture plate
    a. For all test changing test article location, the impact location is the center of the plate
2. Mount hammer weight at correct height on hammer arm
    a. Mount hammer head to hammer weight
    b. Leave hammer arm down until ready to test
3. Mount test article in test location on the back of the fixture plate
    a. Mount accelerometer to the center of test article
4. Once data acquisition team is ready for test raise hammer arm and lock in place with pin
5. Clear test area of any obstructions
    a. Alert everyone present you are about to test
    b. Don safety equipment (hearing protection, eye protection)
6. Inform data acquisition team you are ready to release hammer
7. Release hammer on data acquisition team’s signal
8. Collect data
9. Repeat tests as necessary to collect sufficient data

For tests changing the hammer impact location:

1. Mount test article to the back of the fixture plate
    a. For tests changing the impact location the correct test article location is the center of the fixture plate
    b. Mount accelerometer to the center of the test article
2. Mount correct sacrificial plate in impact location on the front of the fixture plate
3. Slide hammer arm laterally to correct position
4. Mount hammer weight at correct height on the hammer arm
    a. Mount hammer head to hammer weight
    b. Leave hammer arm down until ready to test
5. Repeat steps 4-9 from test article location instructions

For tests changing the hammer tip size:

1. Mount sacrificial plate for the selected hammer head to the front of the fixture plate

    a. Correct location is the center of the fixture plate
    b. Each different hammer head size has its own sacrificial plate that must be changed between tests changing the hammer head size as they plastically deform to the curvature of the hammer tip
2. Mount test article to the back of the fixture plate
    a. Correct location is the center of the fixture plate
    b. Mount accelerometer to the center of the test article
3. Mount hammer weight at correct height on hammer arm
    a. Mount hammer head corresponding to the test, and matching the sacrificial plate used, to the hammer weight
    b. Leave hammer down until ready to test
4. Repeat steps 4-9 from test article location instructions

For tests changing the plate boundary conditions

1. Determine plate condition to be tested, damped or rigid fixture mount
2. Remove fixture plate from mounts
    a. If testing damped insert high impact springs between fixture plate and mounting brackets
    b. Reattach fixture plate
    c. If testing rigid fixture mount remove springs if necessary
        i. If no springs in place it is unnecessary to remove the plate as it is rigidly fixed
    d. Reattach fixture plate
3. Mount correct sacrificial plate to the front of the fixture plate
    a. Center of the fixture plate
4. Mount test article to the back of the plate
    a. Center of the fixture plate
    b. Mount accelerometer to the center of the test article
5. Mount hammer weight at correct height on hammer arm
    a. Mount hammer head to hammer weight
    b. Leave hammer arm down until ready to test
6. Repeat steps 4-9 from test article location instructions

For tests utilizing modal tuning bands:

1. Mount the sacrificial plate to the front of the fixture plate
    a. Centered on the fixture plate
2. Mount test article to the back of the fixture plate
    a. Centered on the fixture plate
    b. Mount the accelerometer to the center of the test article
3. Determine length and number of tuning bands are necessary
    a. Determine which modes you are trying to connect
    b. Determine their locations on the plate
4. Attach necessary modal tuning bands
5. Repeat steps 4-9 from test article location instructions

3.2 Data Acquisition Operation

The data acquisition system used in this project involves an ICP accelerometer, ICP signal conditioner, current limiting power supply, a BNC connector box connected to a PCIe 16-bit analog to digital converter card on a desktop PC equipped with National Instruments LabView software.
A list of peripheral equipment that requires setup is given below:

1. Accelerometer and attached cable with BNC connector
2. ICP signal conditioner/line filter and power cable
3. Current limiting power supply
4. 2x BNC Cables
5. BNC connector box
6. Connector box to DAQ Card cable
7. DAQ Card (should be installed in PC and properly configured prior)
8. National Instruments LabView software installed on PC with DAQ card.

Once all of this equipment is inspected and accounted for, the data acquisition setup can continue. Figure 1 depicts a properly setup data acquisition system. It is important to note the order of connection. Connecting the components in any other order may result in flawed data and/or damage to components.

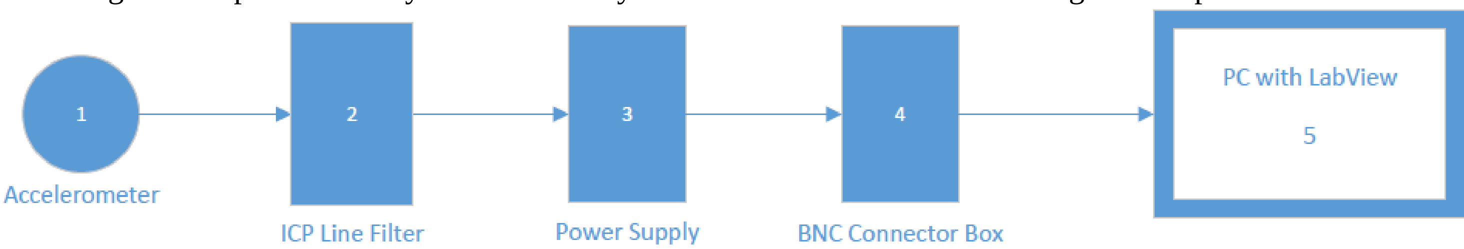


Figure 1 - Flowchart of DAQ Hardware setup order

After a properly connected peripheral system is completed, the next step is to build your LabView Virtual Instrument, or 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 DAQAssistant. This feature allows a novice 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.
3. Open the Acquire Signals drop down list.
4. Open the Analog Input drop down list.
5. Select Voltage (Figure 3)
    a. This screen shows the supported DAQ cards installed and their associated channels.

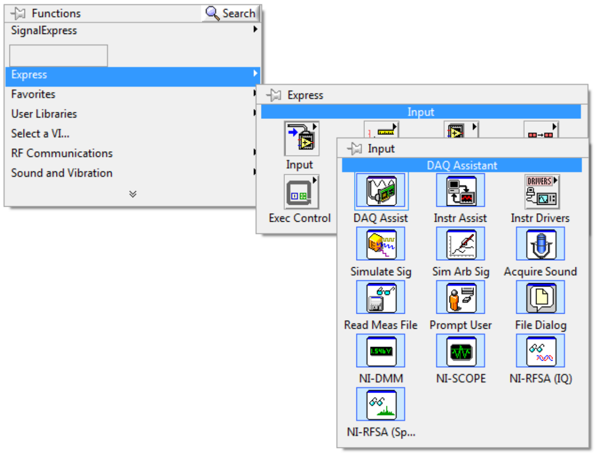


Figure 2 - Adding a DAQ Assistant to

   b. Check the DAQ Connector box and select the appropriate Card and Channel and press Next. (Figure 4)
6. The next window is the Configuration window (Figure 5)
   a. Here is where you set the Signal input Range, Scaling, Timing Settings, and Terminal Configuration.
7. 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.

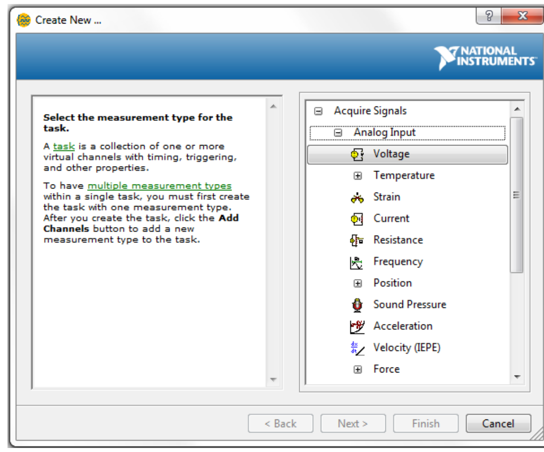


Figure 3 - Selecting the Signal

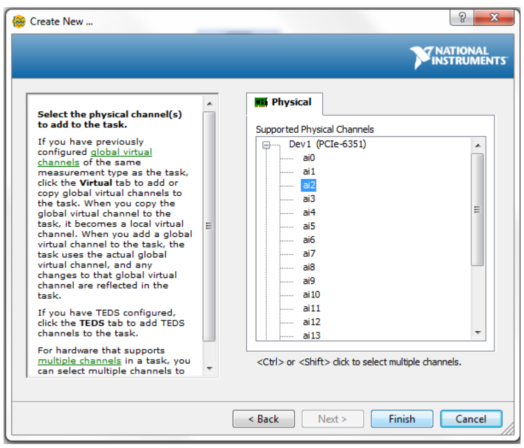


Figure 4 - Selecting an input channel

A quick test can be performed in this window as well by selecting Display Type: Graph, and Clicking on "Run".(Figure 5)

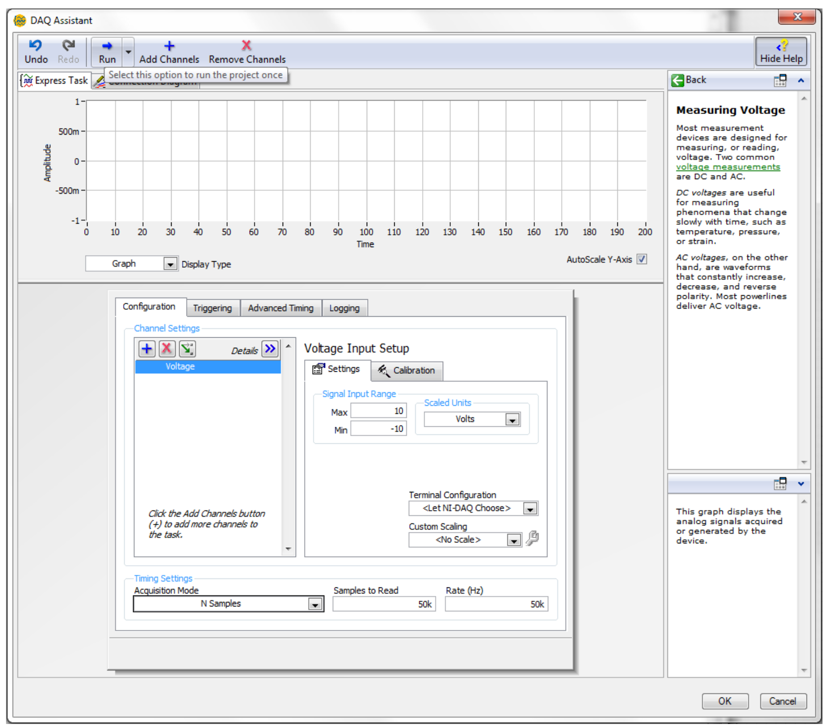


Figure 5 - Channel specific configuration page

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 6 shows the full block diagram and interface screen of the actual LabView virtual instrument.

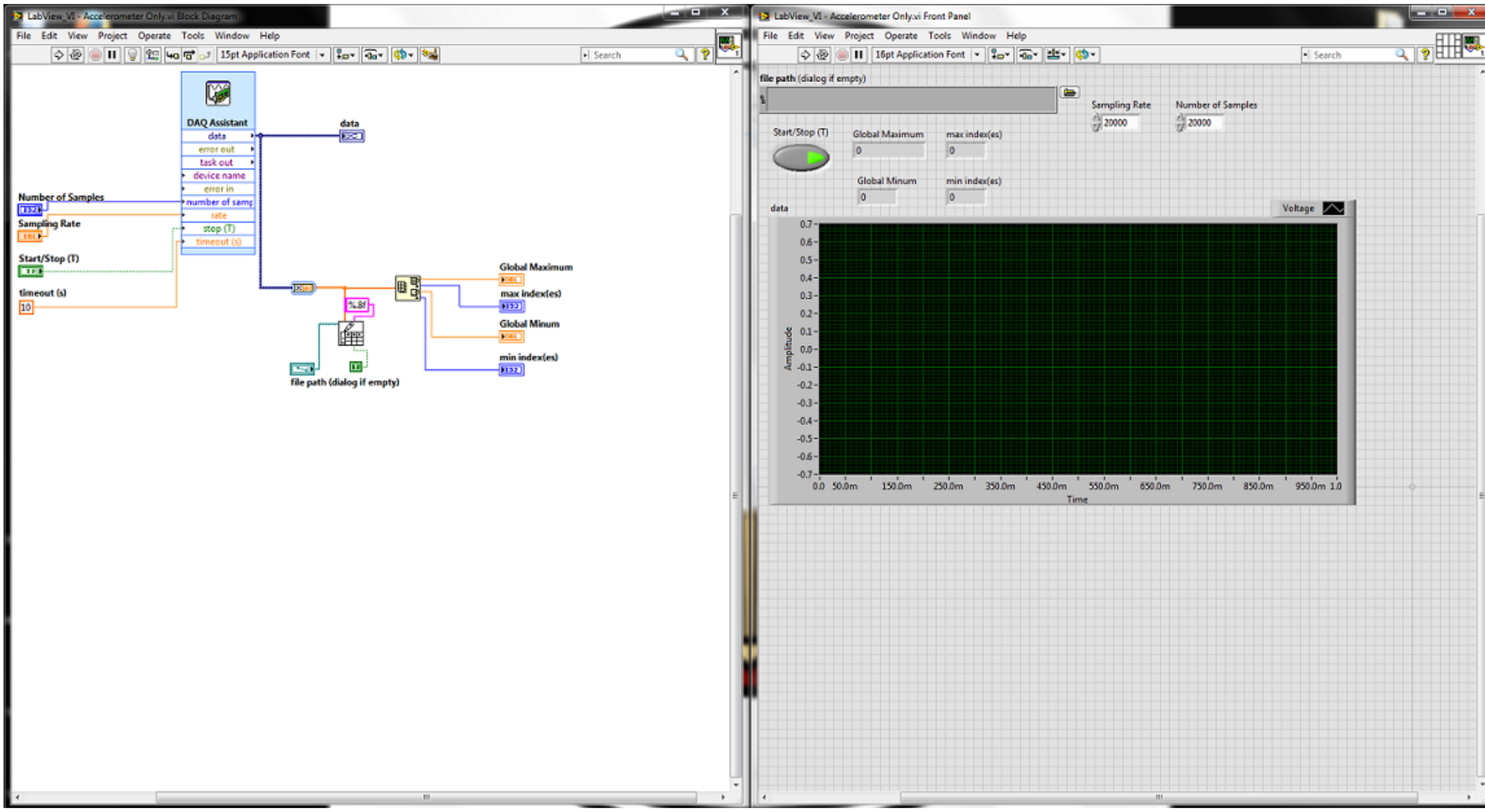


Figure 5 - Block diagram and user interface of actual LabView setup

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. Each individual test for new data will be given a unique name. The standard naming convention for these files is #HT_#SL_#AL_UD_#LSB_#SSB.txt

- #HT - designated hammer tip
- #SL - designated strike location
- #AL - designated article location
- UD – un-damped fixture plate connections (can also be D for damped)
- #LSB - number of long stiffening brackets (if 0 exclude)
- #SSB - number of short stiffening brackets (if 0 exclude)

4 Troubleshooting

The list shown below details any problems the team has encountered or can foresee others encountering in recreating this project. The solid bullets indicate the issues and the open bullets indicate possible solutions.

- Strike location not consistent
    - Check location of pivot joint is centered
    - Check location of vertical hammer head alignment
- Vertical bars holding fixture plate moving
    - Add bracing bars
    - Ensure joint fasteners are tightened.
- Frame moving/jumping during testing
    - Add weights to frame or fix frame to ground
- Captured data not starting or ending at zero (0)
    - Check power supply knob is set to “OFF”.
    - Check order of power supply and signal conditioner/line filter.

4.1 Regular Maintenance

The regular maintenance of our testing apparatus is very simple. There are a few key requirements to ensure proper working order that results in consistent and usable data.

- Different sacrificial plate per each hammer head
    - Each individual hammer head has a different radius, thus causing a different indentation on the sacrificial plate. In order to keep the results of each test consistent, these plates must match up to each individual hammer head.
- Hammer arm pivot joint
    - The hammer arm pivot joint used in this setup has a tendency to self-tighten. If a noticeable difference in friction occurs, this joint should be examined and the fasteners tightened or loosened accordingly.

4.2 Spare Parts

Figure 6 shows the spare parts and wear and tear items. Table 1 lists out all the items shown in the figure.

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

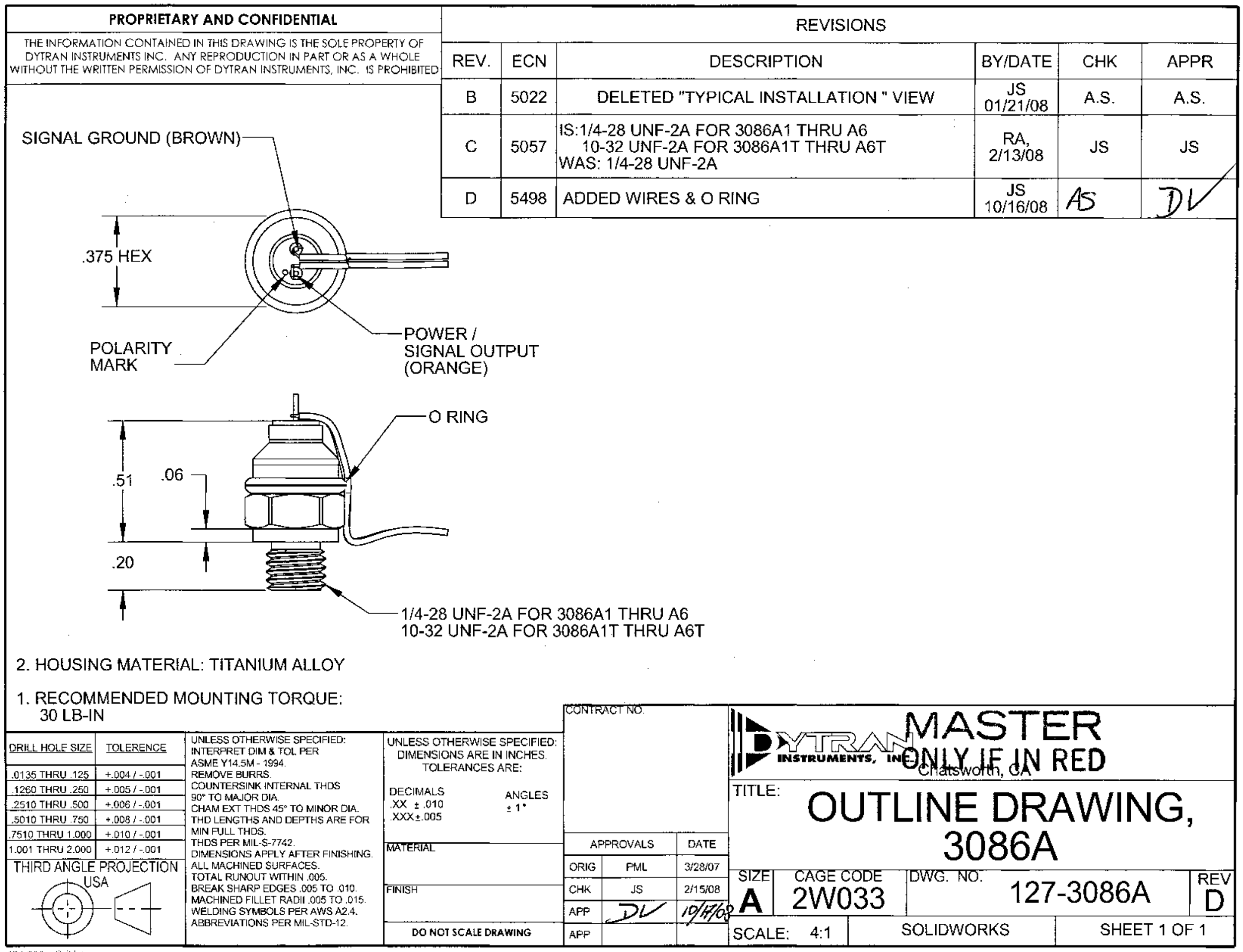
5 References

[1] Wells, Robert. "University Capstone Development of Hammer Blow Test Device to Simulate Pyrotechnic Shock 2 Year Project." 6 Jan. 2015. Web. 7 Jan. 2015.

[2] Wells, Robert. "Conference Call with Robert Wells." Telephone interview. 14 Jan. 2015.

[3] DeMartino, Charles, Nathan Crisler, Chad Harrell, and Chase Mitchell. *Interim Design Report* (2014): 6-13. *Senior Design Team 15*. 6 Dec. 2014. Web. <http://eng.fsu.edu/me/senior_design/2015/team15/Team_members.html>.

6 Appendix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REVISIONS
REV. ECN DESCRIPTION BY/DATE CHK APPR
B 5022 DELETED "TYPICAL INSTALLATION " VIEW JS 01/21/08 A.S. A.S.
C 5057 IS:1/4-28 UNF-2A FOR 3086A1 THRU A6 10-32 UNF-2A FOR 3086A1T THRU A6T WAS: 1/4-28 UNF-2A RA, 2/13/08 JS JS
D 5498 ADDED WIRES & O RING JS 10/16/08 AS DV
SIGNAL GROUND (BROWN)
.375 HEX
POLARITY MARK
POWER / SIGNAL OUTPUT (ORANGE)
O RING
.51
.06
.20
1/4-28 UNF-2A FOR 3086A1 THRU A6
10-32 UNF-2A FOR 3086A1T THRU A6T
2. HOUSING MATERIAL: TITANIUM ALLOY
1. RECOMMENDED MOUNTING TORQUE: 30 LB-IN
DRILL HOLE SIZE TOLERENCE
.0135 THRU .125 +.004 / -.001
.1260 THRU .250 +.005 / -.001
.2510 THRU .500 +.006 / -.001
.5010 THRU .750 +.008 / -.001
.7510 THRU 1.000 +.010 / -.001
1.001 THRU 2.000 +.012 / -.001
THIRD ANGLE PROJECTION USA
UNLESS OTHERWISE SPECIFIED: INTERPRET DIM & TOL PER ASME Y14.5M - 1994. REMOVE BURRS. COUNTERSINK INTERNAL THDS 90° TO MAJOR DIA. CHAM EXT THDS 45° TO MINOR DIA. THD LENGTHS AND DEPTHS ARE FOR MIN FULL THDS. THDS PER MIL-S-7742. DIMENSIONS APPLY AFTER FINISHING. ALL MACHINED SURFACES. TOTAL RUNOUT WITHIN .005. BREAK SHARP EDGES .005 TO .010. MACHINED FILLET RADII .005 TO .015. WELDING SYMBOLS PER AWS A2.4. ABBREVIATIONS PER MIL-STD-12.
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES. TOLERANCES ARE:
DECIMALS .XX ± .010 .XXX ± .005
ANGLES ± 1°
MATERIAL
FINISH
DO NOT SCALE DRAWING
CONTRACT NO.
APPROVALS DATE
ORIG PML 3/28/07
CHK JS 2/15/08
APP DV 10/17/08
APP
DYTRAN INSTRUMENTS, INC. Chatsworth, CA
MASTER ONLY IF IN RED
TITLE: OUTLINE DRAWING, 3086A
SIZE A
CAGE CODE 2W033
DWG. NO. 127-3086A
REV D
SCALE: 4:1
SOLIDWORKS
SHEET 1 OF 1

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

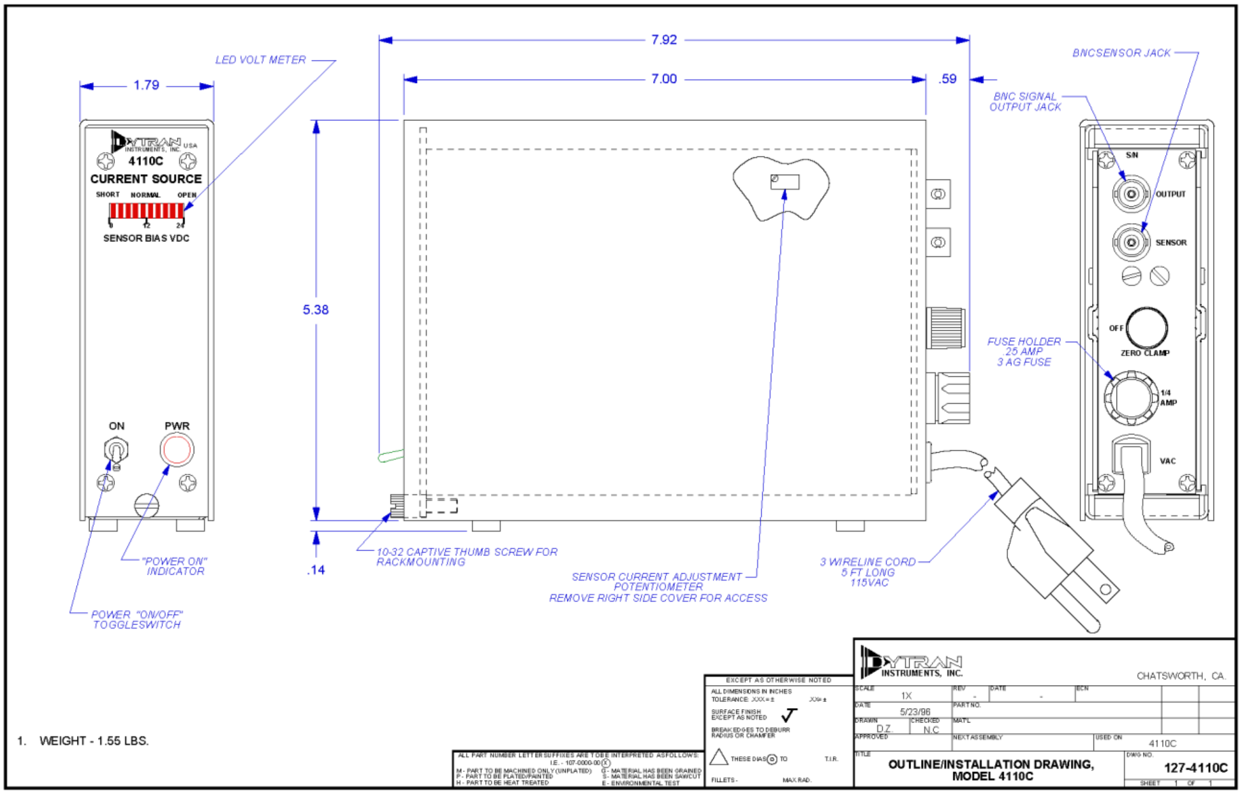
COMMON SPECIFICATIONS

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


LED VOLT METER
1.79
7.92
7.00
.59
BNCSENSOR JACK
BNC SIGNAL OUTPUT JACK
4110C
CURRENT SOURCE
SHORT NORMAL OPEN
SENSOR BIAS VDC
5.38
ON
PWR
S/N
OUTPUT
SENSOR
OFF
ZERO CLAMP
1/4 AMP
VAC
FUSE HOLDER .25 AMP 3 AG FUSE
"POWER ON" INDICATOR
.14
10-32 CAPTIVE THUMB SCREW FOR RACKMOUNTING
SENSOR CURRENT ADJUSTMENT POTENTIOMETER REMOVE RIGHT SIDE COVER FOR ACCESS
3 WIRELINE CORD 5 FT LONG 115VAC
POWER "ON/OFF" TOGGLESWITCH
1. WEIGHT - 1.55 LBS.
DYTRAN INSTRUMENTS, INC.
CHATSWORTH, CA.
SCALE 1X
DATE 5/23/96
DRAWN DZ
CHECKED NC
4110C
OUTLINE/INSTALLATION DRAWING, MODEL 4110C
127-4110C

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.

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	

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

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.
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