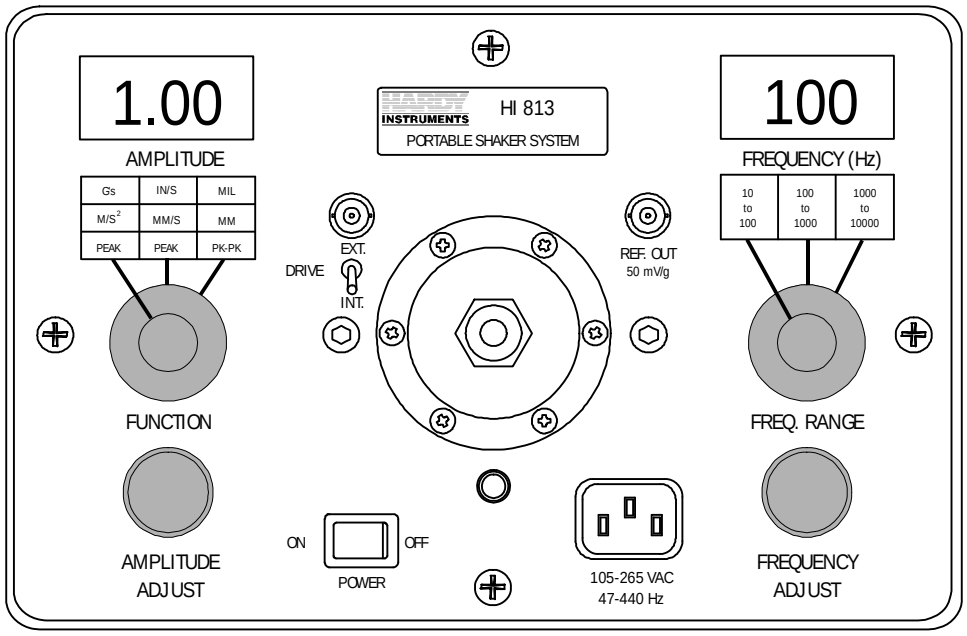
PORTABLE SHAKER SYSTEM
MODEL HI-813

OPERATION AND INSTALLATION MANUAL



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CHAPTER 1 - OVERVIEW

A Brief Description of Chapter 1

This manual provides the user and service personnel with a description of the specifications, installation, setup, configuration, operation, communication, maintenance, and troubleshooting procedures for the Hardy Instruments HI-813 Portable Shaker System (PSS). The HI-813 is a field test instrument to verify the accuracy of accelerometers, velocity pickups and non contact displacement transducers. The Instrument comes with the fixtures and hardware needed to mount most transducers to the vibrating shaking head. All accessories are stored in the removable lid of the PSS.

About Hardy Manuals

Every Hardy Installation and Operation manual is organized into easily referenced chapters, that are almost always the same:

- **Chapter 1** - Provides an introduction to the instrument and an **Overview** of the equipment and its capabilities.
- **Chapter 2** - Provides a complete list of **Specifications.**
- **Chapter 3** - Contains information needed to **Install** the HI-813 TTS. (both standard and optional equipment)
- **Chapter 4** - Provides all **Calibration** instructions.
- **Chapter 5** - Pertains to the **Operating Procedures** of the HI-813 TTS.

Hardy Instruments hopes that this manual meets your needs for information and operation. All corrections or suggestions for improvements of this manual are welcome and can be sent to the Technical Publications Department or Customer Support Department at Hardy Instruments Inc.

Description

The HI-813 is designed to test all three types of transducers:

- Accelerometers
- Velocity Transducers
- Eddy Current Displacement Probes

The standard instrument is completely self contained and consists of:

- Sine Oscillator
- Power Amplifier
- Electrodynamic Shaker
- Traceable Reference Accelerometer
- Digital Display
- Batteries and built-in battery charger.

A built-in reference accelerometer is permanently attached to the shaker and armature so as to maximize accuracy between the reference accelerometer and the Transducer Under Test (TUT). The PSS provides long term reliable performance over the frequency range of 30 Hz to 10 kHz.

The PSS is used for a number of applications including:

- Verification and calibration of vibration transducers and associated test systems.
- Verification of connector and cabling integrity.
- Verification of speed indicator measuring systems.

Loads of up to 750 grams (26.5 ounces) can be mounted directly on the shaker head (reference accelerometer). For larger loads we recommend that an external transducer suspension system be used. Under these conditions the vibration waveform should be viewed on an oscilloscope to aid in positioning the test transducer and shaker head to reduce distortion that might occur with very large weights.

NOTE: *Reference Accelerometer and shaker head are used interchangeably and mean the same thing.*

Traceability

The moving part of the vibrator contains the reference accelerometer and along with the electronics is factory calibrated with traceability to the National Institute of Standards and Technology (NIST). We recommend the built-in standard be re-calibrated once each year. The manual provides a simple calibration check which can be performed more frequently. For a more detailed check, contact your local Hardy representative for more information.

The HI-803 provides +- 3% indicated value (IV) +- 1 digit amplitude accuracy over the following ranges:

MEASUREMENT	**FREQUENCY RANGE**
ACCELERATION: g's, 0 - PEAK	30 Hz to 3 kHz
VELOCITY: ips, 0 - Peak	30 Hz to 400 Hz
DISPLACEMENT: Mils, Peak - Peak	30 Hz to 150 Hz

The ability to provide performance at high frequency ranges in velocity and displacement are limited by several factors. The major factor is the amount of force available from the electrodynamic vibrator. Other factors include:

- Mechanical coupling of the test transducer and fixturing.
- Lateral forces of the test transducer and fixturing.
- Weight of the test transducer and fixturing.

- Reaction of the shaker mechanism to resonance.

Accuracies of +- 6% IV in the acceleration mode can be obtained over the extended range of 10 kHz provided proper care is given when mounting the test transducer to the shaker head.

The Microcomputer

The microcomputer manages the operation of the PSS by interpreting external commands entered from the frequency control buttons, monitoring operating parameters, measuring the built-in reference accelerometer and the transducer under test, performing calculations and driving the displays. A significant benefit in having a microcomputer is its ability to run self tests to insure the PSS is functioning properly.

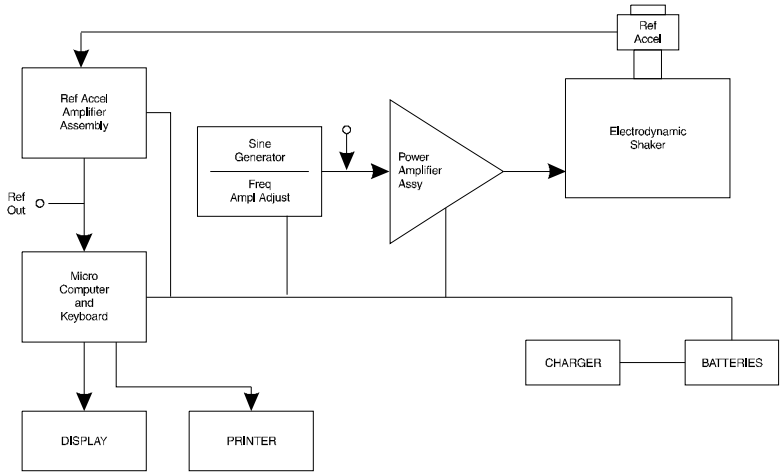

FIG. 1-1 BLOCK DIAGRAM HI-813

Typical Applications

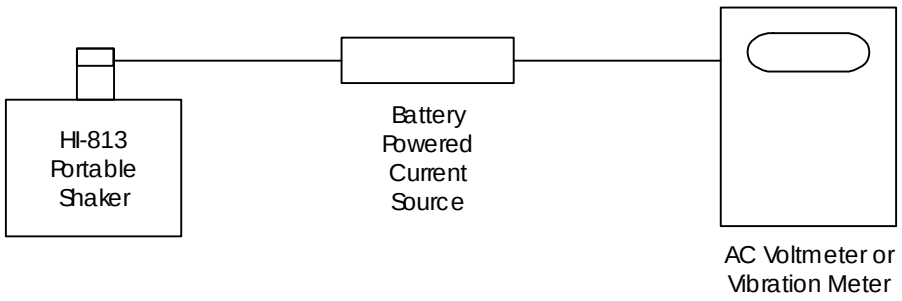

FIG. 1-2 CHECKING ACCLEROMETERS WITH BUILT-IN AMPLIFIERS

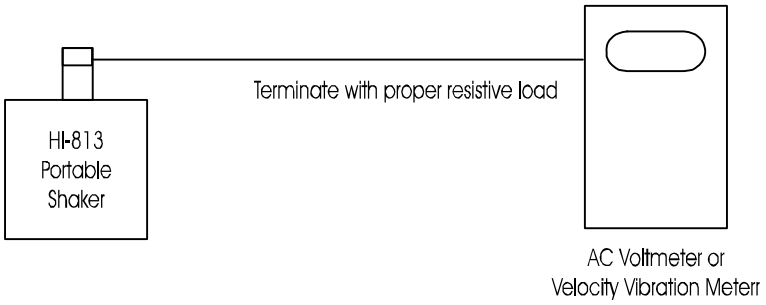

FIG. 1-3 CHECKING VELOCITY TRANSDUCERS THAT ARE SELF POWERED

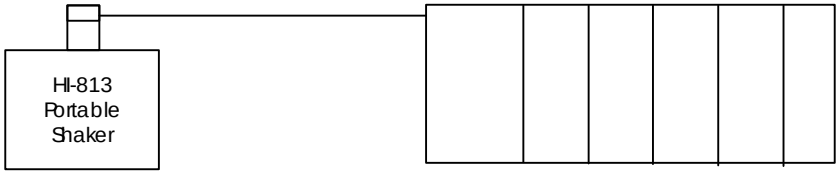

FIG. 1-4 CHECKING ALARM SET POINTS ON VIBRATION MONITORING SYSTEMS

FIG. 1-5 CHECKING THE CALIBRATION OF TRANSDUCERS AND PORTABLE DATA COLLECTORS

Test Transducer Operational Characteristics Guide

C = Charge Amplifier
V = Voltage Amplifier
S = Self Generating

Test Transducer	Sensitivity	C/V/S	Current
Hardy Instruments			
DI-111 Accelerometer	100mV/g	V	2mA

CHAPTER 2 - SPECIFICATIONS

Electrodynamic Vibrator	• Rated Sine Vector Force	4.0 lbs (17.6 N)
	• Max. Displacement (pk to pk)	0.1 inch (2.54 mm)
	• 1st major resonance of table	12,000 Hz (nominal)
	• Frequency Range (minimum load)	25 Hz to 10,000 Hz
	• Rated Load	26.4 ozs (750 grams)
	• Coil Resistance	0.96 ohms (nominal)
	• Magnetic Field	Permanent Magnet
	• Sensor Attachment	1/4-28 UNF Threads
	• Vibrator Cooling	Convection Cooling
Amplitude Readout Accuracy		
Acceleration	• 30 Hz to 1000 Hz	+- 0.3dB +- 1 digit
	• 1 KHz to 10 kHz	+- 1dB +- 1 digit
Velocity	• 30 Hz to 500 Hz	+- 0.3 dB +- 1 digit
Displacement	• 30 Hz to 100 Hz	+- 0.3% dB +- 1 digit
Frequency Accuracy		
Display Resolution	Within 1 Hz	
Output Frequency Display	+- 1% IV or less, + 1 digit	
Operator Interface		
Digital Displays	Two (2)	
Vernier Controls	Two (2) Adjustable/lock	
Internal Functions		
Displayed Functions	Reference level in g, ips & disp., frequency dependent	
Amplitude Display Units	English or Metric	
Frequency Display Units	Hz	
Power Requirements		
AC Power	100-240 VAC, 47-63 Hz	
Maximum Input Power	50-60 watts	

HI 813 PORTABLE SHAKER SYSTEM

Battery Size (2)	10 VDC, 2.5 amp. hour
Battery Type	Sealed solid gel lead acid
Battery Charger	Built-in, automatic

Dynamic Specifications vs. Load

Frequency Range	0-100 grams	100-250 grams	250-500 grams	500-700 grams
25 - 100 Hz	10 g	4g	2g	1g
l00 - 1000 Hz	7g	4g	2g	1g
1 - 2 kHz	3g	1.5g	1g	n/a
1 - 10 kHz	3g	1.5g	n/a	n/a

Waveform Distortion	30 Hz to 2 kHz, <5% T.H.D. with 100 gram load up to 80% rated shaker output.

Environmental Specifications

Operating Temperature Range	0-50^{o} C (32-122^{o} F)
Altitude	Not Affected
Humidity	95-98% non condensing
Long Term Stability	3% per year maximum

Physical Dimensions

Aluminum Case	11”L x 7”W x 10”H (28mmH x 18mmW x 25.4mmH)
Weight	19 lbs. (8.62 kg)

Approvals

CE	CE Marked

CHAPTER 3 - INSTALLATION

A Brief Description of Chapter 3

Chapter 3 covers unpacking, cabling, interconnecting, configuration and installing the HI-813 PSS and Optional Equipment. Users and service personnel should be familiar with the procedures contained in this chapter, before installing or operating the HI-813 PSS. Hardy Instruments appreciates your business. Should you experience any problems installing this equipment, contact your local or Hardy Instruments Inc., Customer Support for assistance.

Unpacking

Step 1. Before signing the packing slip, inspect the packing for damage of any kind.

Step 2. Report any damage to the carrier company immediately.

Step 3. Check to see that everything in the package matches the bill of lading. You should normally have:

- One Assembled HI-813 PSS Unit
- Power Cord (Prt. #6006-0008)
- Special Spanner Wrench (Prt. #0228-0072-01)
- Operation and Installation Manual

Step 4. Write down the Model and Serial number of the instrument. Store this information in a convenient location for reference when contacting The Hardy Customer Support Department for parts or service.

Accessories

Stud	• 1/4-28 to 1/4-28 Stud - - - - - - - 0228-0070-01 • 11/4-28 to 10-32 UNF Stud - - - - 0228-0070-02
Accelerometer Adapter, Circular Plate	Fits many common sensors with flange style bases. Prt. # 0228-0071-01 Mounting Screw - Prt. #2824-0135
Power Cord	115 VAC - 6006-0008
Wrench	Spanner - 0228-0072-01
Manual	Operation and Installation- - - - - - - - - - - - - - 0296-0024-01

Options

DI 223 Non-Contact Displacement Eddy Current Probe Fixture Kit	Mounting Kit with Micrometer and Bracket Assembly with target standard. (Prt. #0251-0019-01) Used for Linearization check.

NOTE: *There should be no weight on the vibration generator during shipping. The unit must be free of any brackets before transportation.*

DI 224 Non-Contact Displacement Eddy Current Probe Fixture Kit — Bracket Kit (Prt. #0251-0011-01) with target standard. Used for Frequency Response Checks.

NOTE: *For purchasing information contact your local Hardy Instruments Representative.*

Installation Procedures

Triaxial Accelerometer Installation

Installation of the Mounting Bracket and Cables

Step 1. **ALWAYS** use the Spanner Wrench (Prt. #0228-0072-01) to prevent damage to the Reference Accelerometer when installing the mounting bracket or a test accelerometer. (See Fig. 3-1)

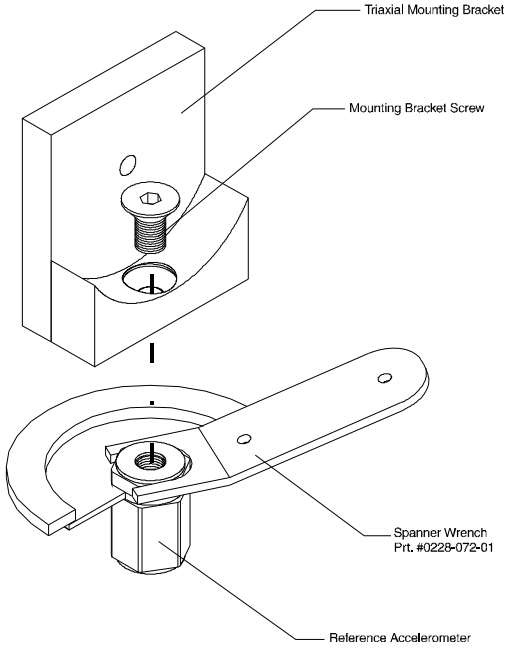

FIG. 3-1 INSTALLATION OF MOUNTING BRACKET FOR AXIS A & B

Step 2. While holding the reference accelerometer steady with the spanner wrench, place the mounting bracket (Prt. #0205-0043-01) over the top of the reference accelerometer.

WARNING **ALWAYS USE THE SPANNER WRENCH WHEN INSTALLING, REMOVING OR ADJUSTING THE TRANSDUCERS OR MOUNTING BRACKET ON THE REFERENCE ACCELEROMETER.**

Step 3. While still holding the spanner wrench in place, use the allen wrench provided with the bracket kit to screw the mounting bracket socket head screw into the reference accelerometer. (See Fig. 3-1) Tighten the screw so that the bracket is snug

against the reference accelerometer. If you want, use a torque wrench and torque to 18 inch pounds. Do not over torque the mounting screw. Overtightening the mounting screw can cause bad readings.

DI-103 Installation for A & B Axes

Step 4. Position the TUT for the A position. (See Fig. 3-2)

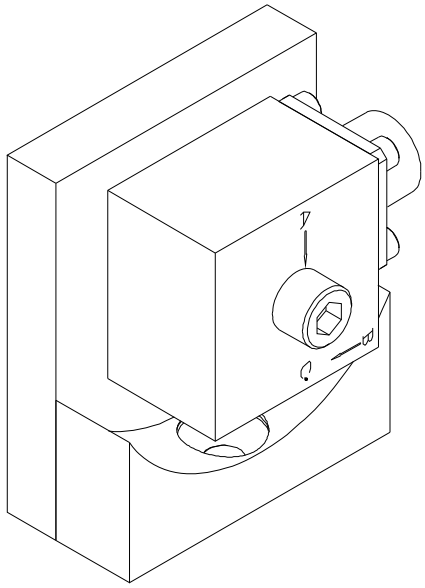

FIG. 3-2 DI-103 A-AXIS POSITION WITH A ARROW POINTING DOWN

Step 5. Screw the socket head bolt into the mounting bracket. Use a torque wrench and tighten the bolt that fastens the transducer to the bracket to 18 inch pounds. Do not overtighten.

Step 6. Perform the tests for Axis A. This information can be found in the documentation that comes with the transducer you are testing. We use the DI-103 as an example. Make sure to refer to the test documentation for the transducer you are currently using. This information may differ from manufacturer to manufacturer. If you have more than one transducer to test, complete the test for the A Axis for all the transducers before moving on to Axis B or Axis C. This will save a lot of time.

Step 7. When all the tests are complete, use the allen wrench and loosen the socket head bolt until you can rotate the transducer to the Axis B position. (See Fig. 3-3)

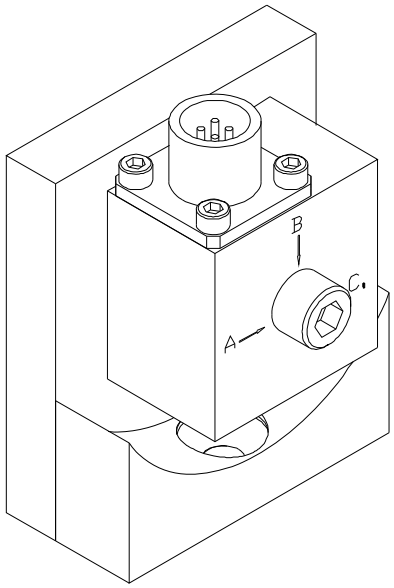

FIG. 3-3 DI-103 B-AXIS POSITION WITH B ARROW POINTING DOWN

Step 8. Screw the socket head bolt into the mounting bracket. Use a torque wrench and tighten the bolt that fastens the transducer to the bracket to 18 inch pounds. Do not overtighten.

Step 9. Perform the tests for Axis B. This information can be found in the documentation that comes with the transducer you are testing. We use the DI-103 as an example. Make sure to refer to the test documentation for the transducer you are currently testing. This information may differ from manufacturer to manufacturer. If you have more than one transducer to test, complete the test for the B Axis for all the transducers before moving on to Axis C. This will save a lot of time.

Step 10. When all the tests are complete, use the allen wrench and loosen the socket head bolt until you can remove the accelerometer from the bracket.

Step 11. Use the allen wrench provided and remove the mounting bracket socket head screw. Take the mounting bracket off the reference accelerometer and store it in secure location. Do not store the bracket in the kit bag provided, because it might damage the reference accelerometer when closing the lid.

DI-103 Installation for the C-Axis Tests

Step 12. Slide the spacer (Prt. #0205-0049-01) over the socket head bolt that fastens the Transducer Under Test (TUT) to the reference accelerometer. (See fig. 3-4)

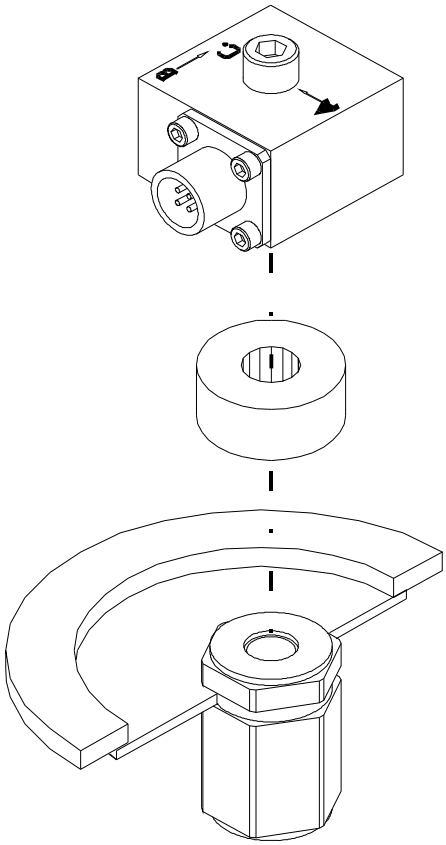

FIG. 3-4 DI-103 INSTALLATION FOR C AXIS TEST

Step 13. Use the spanner wrench to hold the reference accelerometer. (See Fig. 3-1)

Step 14. Use a torque wrench to tighten the socket head bolt to the reference accelerometer. Tighten to 18 inch pounds. (See Fig. 3-14

NOTE: *You can position the TUT in any of 1 of four directions.*

Step 15. Perform the tests for Axis C. This information can be found in the documentation that comes with the transducer you are testing. We use the DI-103 as an example. Make sure to refer to the test documentation for the transducer you are currently testing. This information may differ from manufacturer to manufacturer. If you have more than one transducer to test, complete the test for the C Axis for all the transducers. This will save a lot of time.

Step 16. When all the tests are complete, use the allen wrench and loosen the socket head bolt until you can remove the accelerometer.

DI-103A Installation for A & B- Axes Tests

Step 1. **ALWAYS** use the Spanner Wrench (Prt. #0228-0072-01) to prevent damage to the Reference Accelerometer when installing the mounting bracket or a test accelerometer. (See Fig. 3-1)

WARNING

ALWAYS USE THE SPANNER WRENCH WHEN INSTALLING, REMOVING OR ADJUSTING THE TRANSDUCERS OR MOUNTING BRACKET ON THE REFERENCE ACCELEROMETER.

Step 2. While still holding the spanner wrench in place, use the allen wrench provided with the bracket kit to screw the mounting bracket socket head screw into the reference accelerometer. (See Fig. 3-1) Tighten the screw so that the bracket is snug against the reference accelerometer. If you want, use a torque wrench and torque to 18 inch pounds. Do not over torque the mounting screw. Overtightening the mounting screw can cause bad readings.

Step 3. Position the TUT for the A position. (See Fig. 3-15

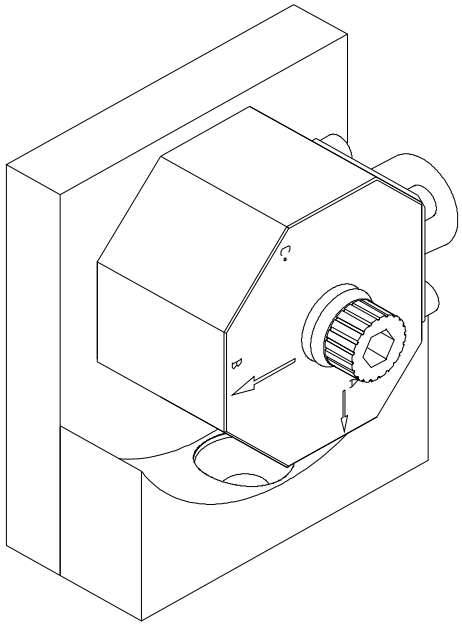

FIG. 3-5 DI-103A A-AXIS POSITION WITH A ARROW POINTING DOWN

Step 4. Screw the socket head bolt into the mounting bracket. Use a torque wrench and tighten the bolt that fastens the transducer to the bracket to 18 inch pounds. Do not overtighten.

Step 5. Perform the tests for Axis A. This information can be found in the documentation that comes with the transducer you are testing. We use the DI-103 as an example. Make sure to refer to the test documentation for the transducer you are currently using. This information may differ from manufacturer to manufacturer. If you have more than one transducer to test, com-

plete the test for the A Axis for all the transducers before moving on to Axis B or Axis C. This will save a lot of time.

Step 6. When all the tests are complete, use the allen wrench and loosen the socket head bolt until you can rotate the transducer to the Axis B position. (See Fig. 3-18)

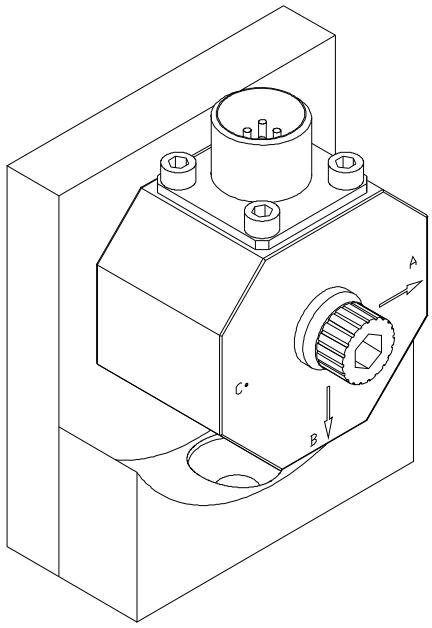

FIG. 3-6 DI-103A B-AXIS POSITION WITH B ARROW POINTING DOWN

Step 7. Screw the socket head bolt into the mounting bracket. Use a torque wrench and tighten the bolt that fastens the transducer to the bracket to 18 inch pounds. Do not overtighten.

Step 8. Perform the tests for Axis B. This information can be found in the documentation that comes with the transducer you are testing. We use the DI-103 as an example. Make sure to refer to the test documentation for the transducer you are currently testing. This information may differ from manufacturer to manufacturer. If you have more than one transducer to test, complete the test for the B Axis for all the transducers before moving on to Axis C. This will save a lot of time.

Step 9. When all the tests are complete, use the allen wrench and loosen the socket head bolt until you can remove the accelerometer from the bracket.

Step 10. Use the allen wrench provided and remove the mounting bracket socket head screw. Take the mounting bracket off the reference accelerometer and store it in secure location. Do not store the bracket in the kit bag provided, because it might damage the reference accelerometer when closing the lid.

DI-103A Installation for the C-Axis Tests

Step 11. Slide the spacer (Prt. #0205-0049-01) over the socket head bolt that fastens the Transducer Under Test (TUT) to the reference accelerometer. (See fig. 3-19)

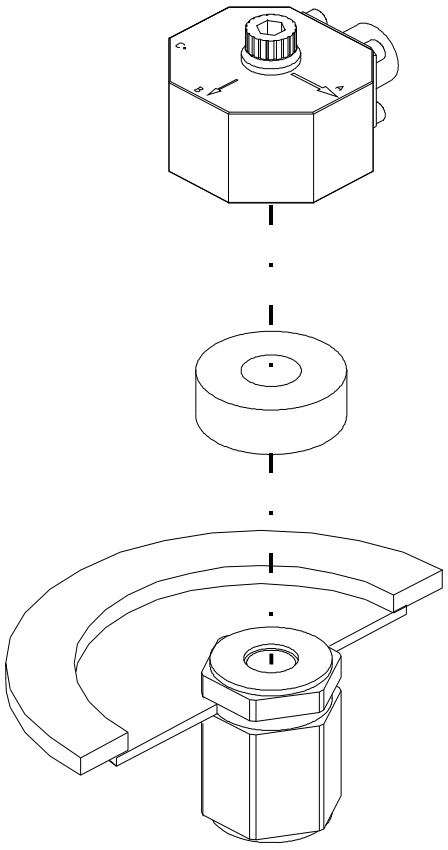

FIG. 3-7 DI-103A INSTALLATION FOR C-AXIS TEST

Step 12. Use the spanner wrench to hold the reference accelerometer. (See Fig. 3-11)

Step 13. Use a torque wrench to tighten the socket head bolt to the reference accelerometer. Tighten to 18 inch pounds. (See Fig. 3-19)

NOTE: *You can position the TUT in any of 1 of four directions.*

Step 14. Perform the tests for Axis C. This information can be found in the documentation that comes with the transducer you are testing. We use the DI-103A as an example. Make sure to refer to the test documentation for the transducer you are currently testing. This information may differ from manufacturer to manufacturer. If you have more than one transducer to test, complete the test for the C Axis for all the transducers. This will save a lot of time.

Step 15. When all the tests are complete, use the allen wrench and loosen the socket head bolt until you can remove the accelerometer.

Non-Contact Displacement Probe Bracket Assembly Installation

DI-223 Bracket Assembly

Step 1. On the top cover of the HI-813 on both sides of the shaker head you will see two screws. Use an allen wrench and remove the two screws. (See Fig. 3-8)

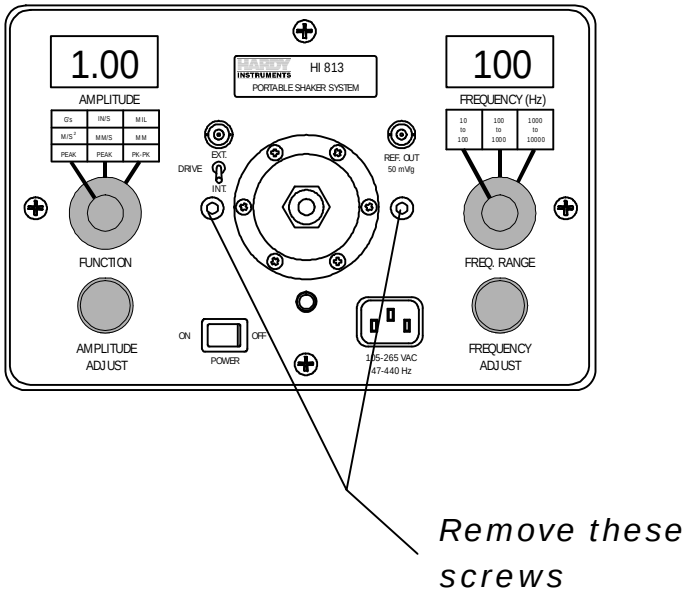

FIG. 3-8 DI-223 BRACKET INSTALLATION/REMOVE SCREWS

Step 2. Place the bracket over the threaded holes and use the thumb screws to fasten the bracket to the top panel. (See Fig. 3-9)

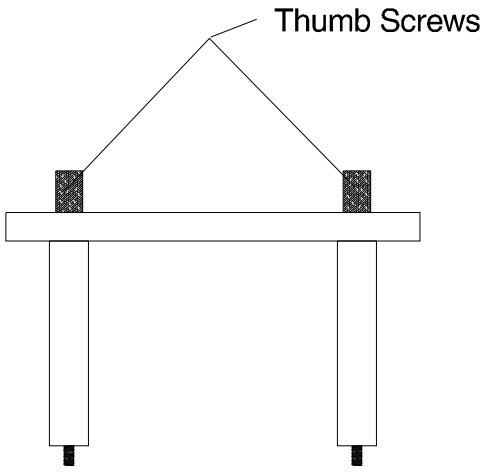

FIG. 3-9 DI-223 BRACKET/THUMB SCREWS

Step 3. Attach the Eddy Current Probe to the bracket.
Step 4. Attach the target standard to the shaker head.

DI-224 Bracket Assembly

Step 1. On the top cover of the HI-813 on both sides of the shaker head you will see two screws. Use an allen wrench and remove the two screws. (See Fig. 3-8)

Step 2. Place the bracket over the threaded holes and use the thumb screws to fasten the bracket to the top panel. (See Fig. 3-10)

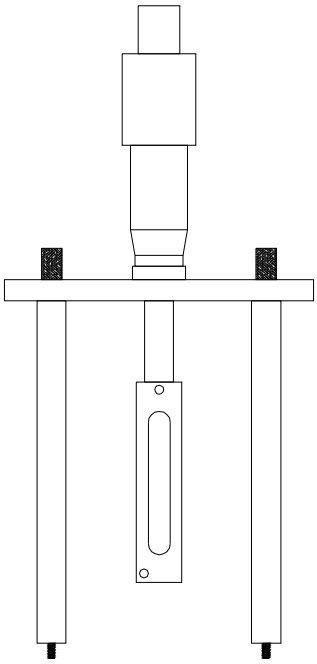

FIG. 3-10 BRACKET WITH MICROMETER

Step 3. Place the Eddy Current Probe in the holder.

Step 4. Attach the target standard to the shaker head.

CHAPTER 4 - CALIBRATION

A Brief Description of Chapter 4

Chapter 4 pertains to the setup and calibration of the HI-813 PSS. This chapter lists the equipment necessary, test equipment setup and Calibration test in order to perform a calibration of the PSS. Do not attempt this calibration without proper test equipment. A list is provided of the test equipment required. It is important that all test equipment have a current calibration. All users and service personnel should be familiar with this section before attempting an installation or repair of this instrument.

Required Test Equipment

- Reference Standard Accelerometer and Data Sheet
- Power Supply
- 2 RMS voltmeters and other display equipment (scope) with an aggregate accuracy of one (1.0) percent or better.

Detailed Calibration Process

Step 1. Remove the certification sticker on the left side of the chassis when looking down on the top panel. An access port is exposed.

Step 2. Turn the Amplitude lock knob counter clockwise to unlock the Amplitude knob.

Step 3. Turn the Amplitude knob counter clockwise until it stops. This sets the Amplitude to its minimum value.

Step 4. Attach the External Standard Reference Accelerometer to the shaker head. See Chapter 3 for installation instructions. Make sure you have the Standard Reference Accelerometer Data Sheet to check the readings at various frequency settings.

Step 5. Turn the Power Switch on.

Step 6. Turn the Frequency Lock knob counter clockwise to unlock the frequency knob.

Step 7. Turn the Frequency Range knob until the hash mark points to the 10-100 Hz range.

Step 8. Turn the Frequency Knob to 100 Hz.

Step 9. On the right side of the Amplitude display you will see two horizontal hash marks and a little switch beside the marks. This switch selects English Units or Metric Units. Up=English Down=Metric. Adjust for the units you want to use for this test.

Step 10. Connect a cable from the External Reference Accelerometer to a current source and connect the current source to a meter or scope. (See Fig. 4-1)

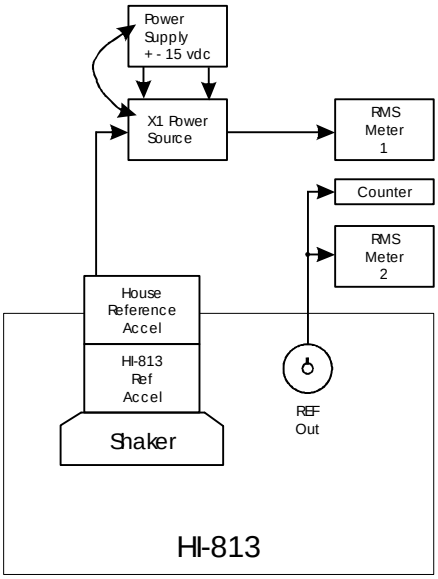

FIG. 4-1 CALIBRATION SETUP DIAGRAM

Step 11. Check to see what the External Reference Accelerometer is reading in mV RMS. Check the Manufacturer's data sheet to see what the mV RMS reading should be for 1 g.

Step 12. Adjust the amplitude knob until you match that reading. For example the Dytran3100B when set to 0.063 mV RMS should read 1 g.

Step 13. Now connect a cable from the REF OUT to a second meter and check the output mV RMS reading. 1 g should read 35.4 mV RMS. If it does not, go to step 14. If the mV RMS reading is 35.4 the system is calibrated. Begin testing.

Step 14. Remove the four screws that fasten the top panel to the chassis. Gently lift the top panel off the chassis. If you look straight down into the chassis you will see a printed circuit board with a blue potentiometer mounted towards the front of the chassis. Use a small screw driver and adjust the potentiometer until you get the correct output voltage of 35.4 mV RMS. Once you get the correct output voltage the amplitude should read 1.0 g.

Step 15. Replace the top panel.

Step 16. The frequency should already be set at 100 Hz.

Step 17. Set the function switch to acceleration (g's or M/Sec/Sec).

Step 18. There are three pots accessed via the port on the left side of the instrument positioned from right to left: R-27-Accelerometer, R-25 - Velocity, R-23-Displacement Remember the certification sticker you removed which revealed the access port. (See Fig. 4-2)

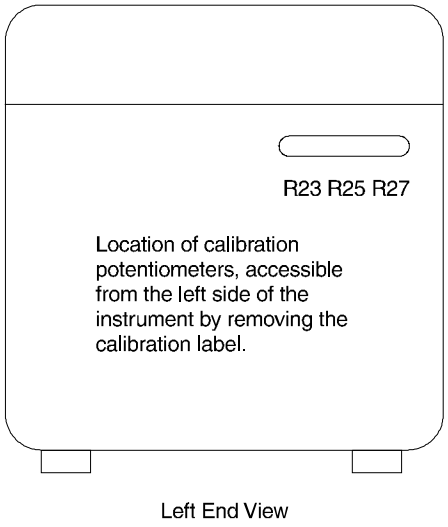

FIG. 4-2 ACCESS PORT TO POTS R27, R25, R23

Step 19. On your reference accelerometer data sheet you will see a table. Use the table for 100 Hz.

- If the value on the Amplitude display is the same or within +- 1% of the g's reading in the table you are set to test.
- If the value on the Amplitude is not the same or within +- 1% of the g's reading in the reference accelerometer table, use a small screwdriver and adjust the R-27 pot until the reading is within tolerance. For example the g's value in our example should be 2.56 g's or between 2.48 - 2.64 g's.

Step 20. Set the function switch to velocity (IN/S or MM/S).

Step 21. On your reference accelerometer data sheet you will see a table. Use the row for 100 Hz.

- If the value on the Amplitude display is the same or within +- 1% of the in/sec reading in the table you are set to test.
- If the value on the Amplitude display is not the same or within +- 1% of the in/secs reading in the reference accelerometer table, use a small screwdriver and adjust the R-25 pot until the reading is within tolerance.

Step 22. Set the function switch to velocity (IN/S or MM/S).

Step 23. On your reference accelerometer data sheet you will see a table. Use the row for 100 Hz.

- If the value on the Amplitude display is the same or within +- 1% of the Mils reading in the table you are set to test.
- If the value on the Amplitude display is not the same or within +- 1% of the Mils reading in the reference accelerometer table, use a small screwdriver and adjust the R-23 pot until the reading is within tolerance.

Step 24. The calibration is complete.

Quick Calibration Check Procedures

The HI-813 PSS can be functionally checked for measurement accuracy by comparing readings on the display for Acceleration, Velocity and Displacement at crossover frequencies. These three readings are derived from the reference accelerometer signal output.

Crossover Frequency	Readings to Compare
61.44 Hz	1g = 1 ips
44.3 Hz	5g = 50 Mils pk-to-pk
29.3 Hz	5 ips = 50 Mils pk-to-pk

Frequency Checks

Frequencies for Acceleration, Velocity and Displacement

Step 1. Set the frequency for 30 Hz. Check your data sheet for the g's, in/sec, Mils values at that frequency to make sure they match or are within +- 1%.

Step 2. Repeat Step 1 for 50, 70, and 100 Hz

Frequencies for Acceleration and Velocity

Step 3. Set the frequency for 200 Hz. Check your data sheet for the g's, in/sec values at that frequency to make sure they match or are within +- 1%.

Step 4. Repeat Step 3 for 300 and 500 Hz.

Frequencies for Acceleration

Step 5. Set the frequency for 1000 Hz. Check your data sheet for the g values at that frequency to make sure they match or are within +- 1%.

Step 6. Repeat Step 5 for 2000, 3000, 6000 and 10,000 Hz.

CHAPTER 5 - OPERATING PROCEDURES

A Brief Description of Chapter 5

All information contained in Chapter 5 pertains to the operation of the HI-813 PSS. The Operating Procedures include checking for Linearization and Frequency Responses of transducers, Cable and Connector Checks, Non-Contact Displacement Eddy Current Probe calibration and sensor frequency response check and discusses some Electronic and Mechanical Technology necessary for the successful use of this instrument. It is very important that the user be familiar with this chapter before operating the HI-813 PSS.

Mechanical Information

There are two (2) primary resonances in the HI-813 PSS which is common in all shakers of this design. The first is the spring/mass resonance of the shaker head acting against the spring support system. This resonance is not apparent in the output of the shaker system and only affects the amount of drive current required to drive the moving element and shaker head. The spring/mass resonance is eliminated through internal compensation.

The second is mechanical resonance which appears in the shaker output and is not internally compensated. Mechanical resonances occurs between 10 kHz and 11 kHz and is activated at the 5 kHz sub-harmonics. Mechanical resonance appears as distortion of the output signal and may be a significant part of the signal. Because this signal appears in both the measuring system and the transducer under test, the comparative accuracy remains quite good.

Some Precautions

1. The flexure system in the vibrator can be damaged if excessive twisting forces are applied to the shaker head.

2. Overloading the unit for extended periods at high amplitudes is not recommended.

3. As long as the displacement limits of the vibrator are not exceeded, the full power of the amplifier can be used to drive the shaker. If the PSS is being used to test a large load, the amplitude limit must not be reached. The following limits apply:

    - The maximum displacement at 10 Hz is 0.1 inches p-p

NOTE: *Not obtainable with the ruggedized suspension system.*

    - The maximum velocity at 29.3 Hz is 10 inches/second peak
    - The maximum acceleration at 61.44 Hz is 10 G peak.

4. When relatively light loads are being tested at frequencies below 30 Hz, care should be taken to avoid repetitive contact with the limit

stops; continual hitting of the limits results in damage to the moving elements in the PSS and an increase in distortion.

Usable Frequency Range vs. Weights

The recommended maximum loads that should be placed on the PSS are as shown below:

Table Frequency Range	0-100 grams	100-250 grams	250-500 grams	500-750 grams
10 - 100 Hz*	10 g	4 g	2 g	1 g
100-1000 Hz	7 g	4 g	2 g	1 g
1 - 2 kHz	3 g	1.5 g	1 g	n/a
1 - 10 kHz	3 g	1.5 g	n/a	n/a

NOTE: *30-100 Hz when the ruggedized suspension option is installed.*

5. If the PSS is used to test heavier loads for extended periods of time, some form of external support, such as elastic suspensions or slip tables, should be used. Failure to support these excessive loads may result in a permanent “set” in the suspension system and possible damage to the moving coil and flexures.
6. Care must be taken when testing high aspect ration loads which exhibit a low stiffness. Severe rocking modes can produce high lateral loads on the moving coil and flexures that will result in damage.
7. When fitting test transducers and fixtures onto the shaker head, keep the center of gravity in line with the center axis of the 1/4-28 threaded hole to prevent any side loading of the shaker.
8. Remember that the PSS is a precision instrument. Care should be taken to avoid sudden impacts which could exert two types of loads, alone or in combination on the shaker head: radial (perpendicular to the shaft) and axial (thrust along the shaft). Both types of loading can damage the flexure system. The original shipping box is specifically designed with carton liners to provide a good cushion for normal transportation.

Electrical Information

PSS Modules

Signal Generator

Produces a variable frequency sine wave which becomes the source of the driving signal to produce the vibration at the shaker head. The amplitude of this sine wave signal is controlled by the top panel Amplitude control. The frequency is controlled by the top panel Frequency control. (See Fig. 5-1)

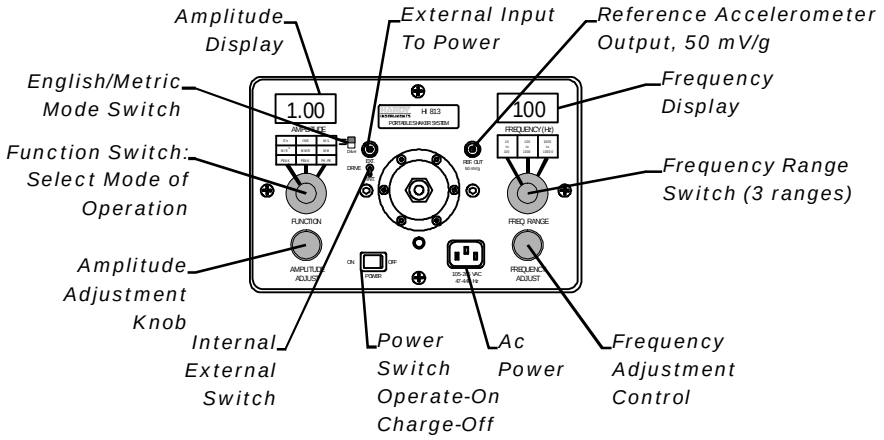

FIG. 5-1 HI-813 TOP PANEL FUNCTIONS

Power Amplifier

The power amplifier is specifically designed to provide the current required to drive the coil in the electrodynamic vibrator through an impedance matching circuit. The frequency and amplitude of the shaker are controlled by and are proportional to the frequency and amplitude of the oscillator signal applied to the amplifier input.

Electrodynamic Vibrator

Functions by means of the interaction between the magnetic field in the air gap and the oscillating current flowing in the moving coil. This current generates a force perpendicular to the lines of flux in the air gap and to the conductor carrying the current. This force is proportional to the product of the instantaneous current and the magnetic flux density.

Reference Accelerometer

The reference accelerometer is used to measure and set the level of vibration at the shaker head (which is the mechanical interface to the test transducer) for calibration. The reference accelerometer is an integral part of the shaker head. It's sensing element is a ferroelectric ceramic crystal that outputs a voltage proportional to compression and extraction forces imposed by a precise mass that is fixed to the crystal assembly. This signal is conditioned and factory calibrated to 50 mV/g. A calibration "standard" is maintained by Hardy Instruments that is used to calibrate the PSS and provide NIST traceability.

Digital Voltmeter and Frequency Indicator

The digital voltmeter and frequency indicator continuously read vibration level and frequency on the top panel displays.

English or Metric Units

The vibration levels can be read in English or Metric units by setting the English/Metric Mode Switch on the top panel. (See Fig. 5-1) Frequency can be read in Hz.

Battery Information

The HI-813 PSS can be operated when connected to an AC power source or the internal rechargeable batteries. No switching is necessary because the AC power line is always connected to a built-in battery

charger providing a charge whenever connected as long as the Power switch is off. (See Fig. 5-1)

Batteries

There are two (2) sealed solid gel 10 Volt DC rechargeable batteries. The batteries are designed for continuous charging without damage. Batteries should be kept fully charged. Under norm operating conditions the PSS will function more than 4 hours with fully charged batteries.

Charge Life

Charge life is directly dependent on the power used which is established by the test requirements. When testing requires high force be supplied to drive the transducer under test (due to heavy fixturing or transducer size and/or due to high test levels) the charge life will be shortened.

CAUTION **A COMPLETE DISCHARGE CAN CAUSE BATTERY FAILURE.**

Precautions

When the "Batt" battery indication appears on the Amplitude display, switch over to AC power. If the battery indication appears again, **turn the unit off!** The PSS must be connected to an AC power source with the power off to activate the battery charger right away.

Under normal conditions, batteries will obtain a full charge after (8) hours charge time. If deep discharge occurs, 2 or more days may be required to reach full charge (it at all).

Storage

Hardy Instruments does not recommend that the batteries be removed for shipping. You do not need to remove the batteries for storage periods =< three (3) months.

There are no special handling requirements.

NOTE: *Always turn the PSS off and connect the instrument to an AC power source to activate the charger when not in use.*

Check Procedures

Step 1. Mount the Transducer Under Test or fixture onto the shaker head. (See Chapter 3 - Installation for complete instructions.)

Step 2. Turn the Amplitude knob counter clockwise until the knob stops. This sets the amplitude to its minimum value.

Step 3. Turn the Frequency knob counter clockwise until the knob stops. This sets the frequency to its minimum value.

Step 4. Set the Amplitude Function knob to the type of transducer being checked:

• Accelerometer	ACC	g peak
• Velocity	VEL	ips peak (m/s)
• Displacement	DISP	Mils pk to pk (mm)

Step 5. Set the Internal/External Toggle Lock Switch to Internal by lifting up on the toggle switch and setting it in the Internal position. The toggle switch is designed so that if a user accidently hits the switch it won't change position.
Step 6. Turn the power on.
Step 7. Set the frequency between 60 - 100 Hz as read in the Frequency Display.
Step 8. Set the amplitude to the desired test vibration level as read in the Amplitude Display.
Step 9. Verify that the vibration level in the Amplitude display is the same as the level displayed in the monitor or analyzer that the test transducer is connected. Under normal circumstances the reading should be within +- 5% of full scale.
Step 10. Repeats steps 1-9 for every transducer you want to check.

Standard Checks for Transducers

Linearization

Linearization is a check to determine that the output sensitivity (mV/Unit of vibration e.g. mV/g), or actual reading is maintained from a minimum operating level to a higher operating level while not changing test frequency. This check is usually made at 100 Hz. The transducer manufacturer usually specifies this frequency on the transducers original calibration certificate. If in doubt, use 100 Hz.

Frequency Response

Frequency Response is a check to see that the output sensitivity (mV/Unit of vibration), or actual reading is maintained over a normal operating frequency range. The reference input vibration level is held at a constant level for the frequency response test.

Typical Transducer Sample Data Sheet

The Transducer Sample Data Sheet outlines typical test frequencies and vibration levels for checking accelerometers and velocity transducers. These should meet most general purpose requirements for verifying the functionality of transducers and measuring systems. Follow the Check Procedures but substitute the frequencies and levels given in the Manufacturer's Transducer Data Sheet.

CAUTION

TURN DOWN THE AMPLITUDE ADJUST CONTROL BEFORE SWITCHING THE FREQUENCY RANGE SWITCH TO AVOID SHOCK LOADING THE SHAKER ASSEMBLY.

Typical Transducer Calibration Sample Data Sheet - Accelerometer

Linerarity Check - Frequency [100] Hz

Reference Level	0.25 g	0.5 g	1.0 g	2.0 g	3.0 g
Actual Level					

TABLE 5-1: LINEARITY CHECK - ACCELEROMETER

Frequency Response Check - Ref. LOevel [1] Hz

Frequency Hz	100	200	500	1k	2k	3k
Actual Level						

TABLE 5-2: FREQUENCY CHECK - ACCELEROMETER

Typical Transducer Calibration Sample Data Sheet - Velocity Pickup

Linearity Check - Frequency [100] Hz

Reference Level	0.2 ips	0.4 ips	0.6 ips	0.8 ips	1.0 ips
Actual Level					

TABLE 5-3: LINEARITY CHECK - VELOCITY PICKUP

Frequency Response Check - Ref. Level [0.2] ips

Frequency Hz	30	50	70	100	200	400
Actual Level						

TABLE 5-4: FREQUENCY RESPONSE CHECK - VELOCITY PICKUP

Checking for Loose Cables or Connectors

Step 1. Mount the Transducer Under Test with the connectors and cables attached onto the shaker head. Be careful not to exceed the recommended weight loading on the shaker head.
Step 2. Connect the TUT to an analyzer or scope.
Step 3. Set the frequency to a high frequency.
Step 4. Set the Amplitude to a moderate to high amplitude.
Step 5. Check the reading on the analyzer or scope to see if it matches the readings in the two displays on the top panel of the PSS.
Step 6. Watch the analyzer display and see if the readings are interrupted or drop out for short periods of time.
Step 7. If you see the reading dropping out, with the shaker still on go around and wiggle each connector or cable until you determine which cable or connector is loose or broken and causing the interruption of the signal to the analyzer.
Step 8. Once the problem connector or cable has been located, tighten the connector or replace the broken cable immediately.

Non Contact Displacement (Eddy Current) Probe Checks

Non Contact Probes, also called proximity probes, eddy current probes or displacement probes, can be checked for linearity and frequency response. Frequency response checks can be made using the Model DI-224 Displacement Probe Fixture Kit. The Model DI-223 Displacement Probe Fixture Kit with Dial Micrometer can be used to make the linearization check.

Sensor Frequency Response Check

Step 1. Get the DI-224 Displacement Probe Fixture Kit. (Prt. #0251-0111-01)
Step 2. Switch the power off.

Step 3. Install the 4140 steel target that comes in the DI-224 kit by screwing the target onto the shaker head. Be sure to use the spanner wrench when installing the standard. Tighten finger tight.

Step 4. Use an allen wrench and remove the two (2) socket head cap screws located on both sides of the shaker head assembly. (See Fig. 5-2)

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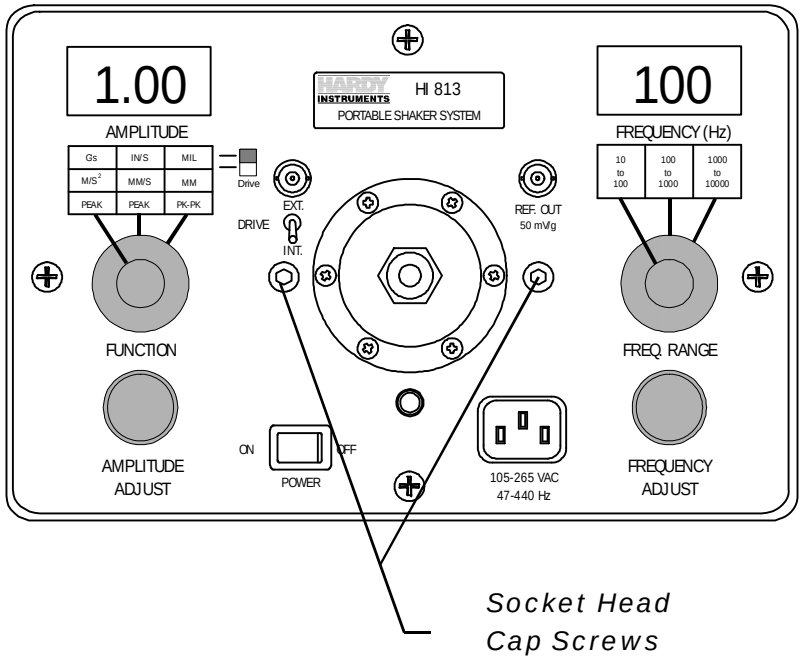

FIG. 5-2 REMOVE SOCKET HEAD CAP SCREWS

Step 5. Now place the fixture over the threaded holes and use the thumb screws to fasten the fixture to the top panel. Tighten so the thumb screws are finger tight.

Step 6. Insert the displacement probe onto the fixture. (3/8-24 threaded probes mount directly onto the fixture. 1/4-28 threaded probes use a threaded bushing)

Step 7. Use a voltmeter and set the gap between the probe tip and the 4140 target to, -8 or -9 VDC (40 to 45 Mils).

Step 8. Set the Amplitude Function switch to Displacement (Mils or mm).

Step 9. Rotate the Amplitude knob counter clockwise until it stops.

Step 10. Set the Frequency Range switch to “10 to 100 Hz”.

Step 11. Set the Internal/External Toggle Lock Switch to Internal by lifting up on the toggle switch and setting it in the Internal position. The toggle switch is designed so that if a user accidently hits the switch it won’t change position.

Step 12. Use the Amplitude knob and set the vibration level to 5 Mils pk to pk.

Step 13. Use an AC volt meter or vibration monitoring system to check and see if the output is at the correct level +- 5%. For exam-

ple, if the displacement system output sensitivity is 200 mV/Mil the ac voltmeter should read approximately 353.5 mV rms (70.7 mV x 5) while an oscilloscope should read approximately 1 V pk to pk (200 mV x 5)

Step 14. Continue checking at other frequencies in the 30 to 100 Hz range.
Step 15. Turn the amplitude counterclockwise to the minimum setting.
Step 16. Turn the power off.
Step 17. Set the Frequency Range Switch to "100 to 1000 Hz" range.
Step 18. Turn the frequency counterclockwise to the minimum setting.
Step 19. Turn the power on.
Step 20. Set the vibration level to 5 Mils again and continue making corresponding measurement checks in the 100 Hz to 150 Hz range.
Step 21. When the calibration checks are done, rotate the Amplitude knob counter clockwise until it stops.
Step 22. Turn the power off.
Step 23. Remove the displacement fixture and 4140 steel target. Remember to use the spanner wrench.

Sensor Linearization Check

Step 1. Get the DI-223 Displacement Probe Fixture Kit. (Prt. #0251-0119-01)
Step 2. Switch the power off.
Step 3. Install the 4140 steel target that comes in the DI-223 kit by screwing the target onto the shaker head. Be sure to use the spanner wrench when installing the standard. Tighten finger tight.
Step 4. Use an allen wrench and remove the two (2) socket head cap screws located on both sides of the shaker head assembly. (See Fig. 5-2)
Step 5. Now place the fixture over the threaded holes and use the thumb screws to fasten the fixture to the top panel. Tighten so the thumb screws are finger tight.
Step 6. Insert the displacement probe into the adapter sleeve.
Step 7. Tighten the set screw to secure the probe to the adapter sleeve. Tighten the set screw so that it is not snug. Do not overtighten the set screw.
Step 8. Connect the probe driver to the correct power supply.
Step 9. Connect a digital voltmeter to the output of the driver.
Step 10. Set the micrometer to the number of Mils corresponding to the center of the linear range for the eddy current probe under test.
Step 11. Loosen the set screw holding the probe in the adapter and move the probe toward the 4140 steel target until the DC voltage measured at the driver output corresponds to the recommended gap voltage for the transducer under test. (-7.5 to -8.5 VDC typical).
Step 12. Tighten the set screw.

Step 13. Adjust the micrometer to the specified minimum gap reading and record the voltage on the voltmeter.

CAUTION **DO NOT LET THE PROBE TOUCH THE TARGET AS THIS IS A NONLINEAR AREA FOR THESE SENSORS.**

Step 14. Increase the gap by turning the micrometer counter clockwise in five or ten Mil increments and record the voltage at each increment.

Step 15. Divide the voltage difference at each increment by the number of Mils per increment. This value when converted to millivolts DC corresponds to the transducer sensitivity, typically 200 mV/Mil.

Step 16. If the calibration curve does not meet manufacturers specifications readjust the gap voltage at the center of the range and recheck. (See Fig. 5-3)

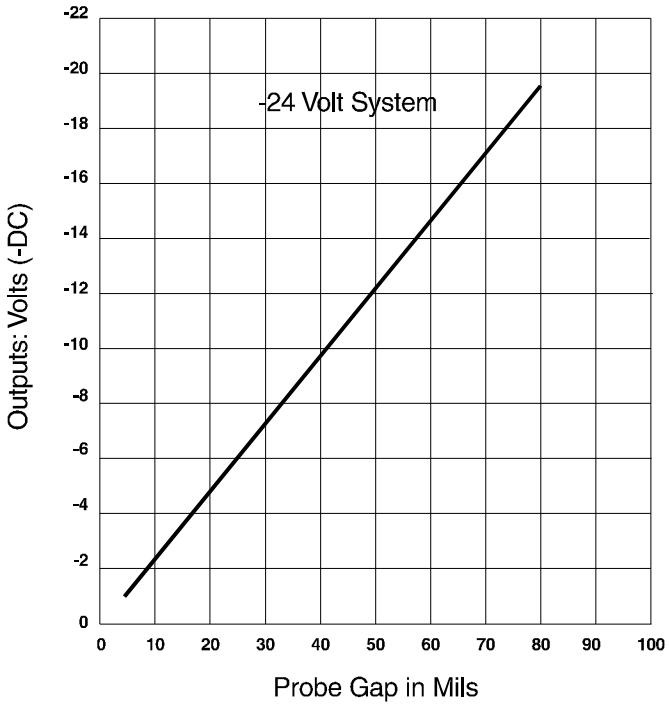

FIG. 5-3 DISPLACEMENT CALIBRATION - TYPICAL LINEARITY PLOT

NOTE: *Example plot of voltage reading vs. gap setting. 1 Volt = 5 Mils for 200 mV/Mil sensitivity. Metric: 8 mV/micrometer, each volt equals 125 micrometers. Zero volts is not necessarily contact because the gap is measured from the coil within the tip, not from the surface of the probe tip itself.*

Step 17. When you complete the tests remove the probe fixtures and the target and store them in a secure location.

Optional Linearization Procedure

Step 1. Go through the procedures for the standard linearization checks.

Step 2. Operate the PSS at 100 Hz and at a very low amplitude level to create a very low "delta gap" condition for the measurements.

Step 3. The delta gap sometimes results in a smoother calibration curve. (See Fig. 5-3)

Internal Reference Accelerometer Accuracy Check

The Internal Reference Accelerometer signal is available on the top panel, REF OUT connector, which can be used to check instruments or analyzers for accuracy. The output sensitivity of this signal is 50 mV/g.

Step 1. Set the analyzer or instrument being checked for an output sensitivity of 50 mV/g.

Step 2. This should agree with the vibration level displayed on the PSS.

Mass Loading Compensation

There is a characteristic of most accelerometers where the rated output is affected by a combination of heavy weights and high frequencies, i.e. mass loading. The reference accelerometer in the PSS is subject to this characteristic called mass loading. If you are going to regularly check heavy transducers (above 200 grams) and you testing requires frequent test at frequencies above 1 kHz, contact your local Hardy Representative for information that will allow you to compensate for mass loading. We can provide you the correction values to be applied to the readings. Make sure you provide the serial number of the PSS when requesting mass loading compensation information. Fixture weights are provided below for your convenience.

Test Transducer and Mounting Fixture Weight Guide

Transducer Type	Weight	Fixture #	Weight
CEC Instruments			
4-123-0001 Velocity	221 grms	0228-0071-02	65.5 grms
Endevco			
2217E Accelerometer	32 grms	10-32 Adaptor	n/a
Hardy Instruments			
DI-111 Accelerometer	110 grms	Direct	n/a

Mounting Hardware Weight (Typical for use with 0228-0071-02 Adapter)

Adapter Type	Weight
10-32 x 1 inch	4.2 grams
8-32 x 1 inch	2.8 grams
6-32 x 1 inch	1.8 grams
10-32 x 1/2 inch	2.7 grams
8-32 x 1/2 inch	1.8 grams
6-32 x 1/2 inch	1.1 grams
4-40 x 1/2 inch	0.6 grams

General Vibration Information

There is a specific relationship in the characteristics of vibration signals that holds true for sine waves.

rms value	=	0.707 x peak value
rms value	=	1.11 x average value
peak value	=	1.414 x rms value
peak value	=	1.57 x average value
average value	=	0.637 x peak value
average value	=	0.90 x rms value
peak-to-peak	=	peak value

Relationships of sinusoidal Velocity, Acceleration & Displacement

English Units

$V = 3.14\ fD$	D = inches pk-to-pk
$V = 61.44\ g/f$	V = inches per second
$g = 0.0511\ f^2\ D$	f = Hertz
$g = 0.0162\ Vf$	$g = 386.1$ in/sec^2
$D = 0.3183\ V/f$	
$D = 19.57\ g/f^2$	

Metric Units

$V = 3.14\ fD$	D = meters pk-to-pk
$V = 1.56\ g/f$	V = meters per second
$g = 2.013\ f^2\ D$	f = Hertz
$g = 0.641\ Vf$	$g = 9.80665$ m/sec^2
$D = 0.3183\ V/f$	
$D = 0.4968\ g/f^2$	

Crossover Frequencies for the PSS

At these crossover frequencies, like numbers are displayed on the PSS as shown in the examples. This characteristic makes these frequencies a good choice to make quick operational reference checks.

29.3 Hz - - - - - - - - - - - C x 0.01 = V
(0.05 inches pk-to-pk = 5 ips)

44.3 Hz - - - - - - - - - - - D x 0.01 = A
(0.05 inches pk-to-pk = 5 g)

61.44 Hz - - - - - - - - - - - V = g
(1 ips = 1 g)

HI-813
EC DECLARATION OF CONFORMITY

WE

Hardy Instruments, Inc.
3860 Calle Fortunada
San Diego, CA 92123-1825

Declare under sole responsibility that the

HI 813

Meets the intent of the following Directives:
Directive 89/336/EED for Electromagnetic Compatibility
Directive 73/23/EEC for Low Voltage (Safety)

Compliance was demonstrated to the following specifications as listed in the Office Journal of the European Communities:

EN 50081-1	**Generic Immunity**
EN 50082-1	**Generic Immunity**
IEC 1000-4-4	**Electrical fast transient / burst immunity**
IEC 1000-4-2	**Electrostatic Discharge Immunity**
IEC 1010-1	**Safety Cat 2 Class 2**

ISO 9001
REGISTERED

Certificate of Calibration and Conformance
EC Declaration of Conformity

Model: HI 813CE Portable Shaker
Serial Number: 1309
Calibration Date: January 21, 2002

This Portable Shaker was calibrated using the comparison method. the comparison method was made directly to our transfer standard accelerometer (Dytran Model # 310B, Serial Number 4242, ID TE# 0720), that is traceable to the National Institute of Standards and Technology (NIST) under test number 3623-130H.

We certify that the HI 813CE Portable Shaker mentioned above, was manufactured in accordance with IRIS INFRARED purchase order with all requirements specifications and drawings reference therein.

It is also certified that product provided meets specifications published by Hardy Instruments Inc., for the time period in which the product was made, as dictated by the product date code or serial number. All tests and verification results are on file and available for review upon request.

We, Hardy Instruments, Inc. Declare under our sole responsibility that the product HI 813CD Transducer Test Set, is in conformity with the following EEC Directives and harmonized standards:

Directive 89/336/EEC for Electromagnetic Compatibility and Directive 73/23/EEC for Low Voltage.

Compliance was demonstrated to the following specifications as listed in the Office Journal of the EC: EN 50081-1 and 50082-1, Generic Immunity; IEC 100-4-4, Electric Fast Transient/Burst Immunity; IEC 1000-4-2, Electrostatic Discharge Immunity and IEC1010-1, Safety Cat 2 Class 2.

Manolo Hernandez
Sr. Quality Engineer