PORTABLE VIBRATION CALIBRATOR
Model 4000

INDEX

INDEX CONTINUED

1.0 Introduction

1.1. General Description

The Model 4000 Portable Vibration Calibrator (PVC) provides a field tested method for on-the-spot dynamic verification of accuracy. Accelerometers, velocity pickups and non-contact displacement transducers are accommodated. Optional fixtures and hardware needed to facilitate mounting most transducers, to the vibrating shaker head, are available upon request.

The PVC incorporates built-in sine wave oscillator, power amplifier, electrodynamic shaker, NIST traceable reference accelerometer, digital display, batteries, and external power supply/charger. The PVC is a completely self contained unit that operates on battery or AC power.

The built in reference accelerometer is attached permanently to the shaker armature. This maximizes the accuracy between the reference accelerometer and the test transducer. The PVC is designed to provide long term reliable performances over the frequency range of 20 HZ to 10 kHz. The PVC can be used for a variety of applications that include:

- Verification and Calibration of vibration transducers and related test systems.
- Verification of connector and cabling integrity.
- Verification of speed indicator measuring systems.

1.2 Caution

- *Loads of up to 750 grams (26.5 ounces) can be mounted directly to the shaker head. Larger loads may be applied to the shaker head, however, if prolonged testing of a heavy load is planned, we recommend that you use an external transducer suspension system. Under these conditions*

the vibration waveform should be viewed on the oscilloscope to aid in positioning the test transducer and shaker head to reduce distortion that can occur with very large weights.

- *The PVC should always be operated on a stable flat surface*

- *The PVC is designed for field test applications but care must be exercised in order to maintain the integrity of the shaker head assembly.*

1.3 Transportation

When transporting the PVC, care should be taken to ensure that sudden impacts are minimized. Any motion of the shaker head that might put abnormal vertical displacement or side loading should be minimized.

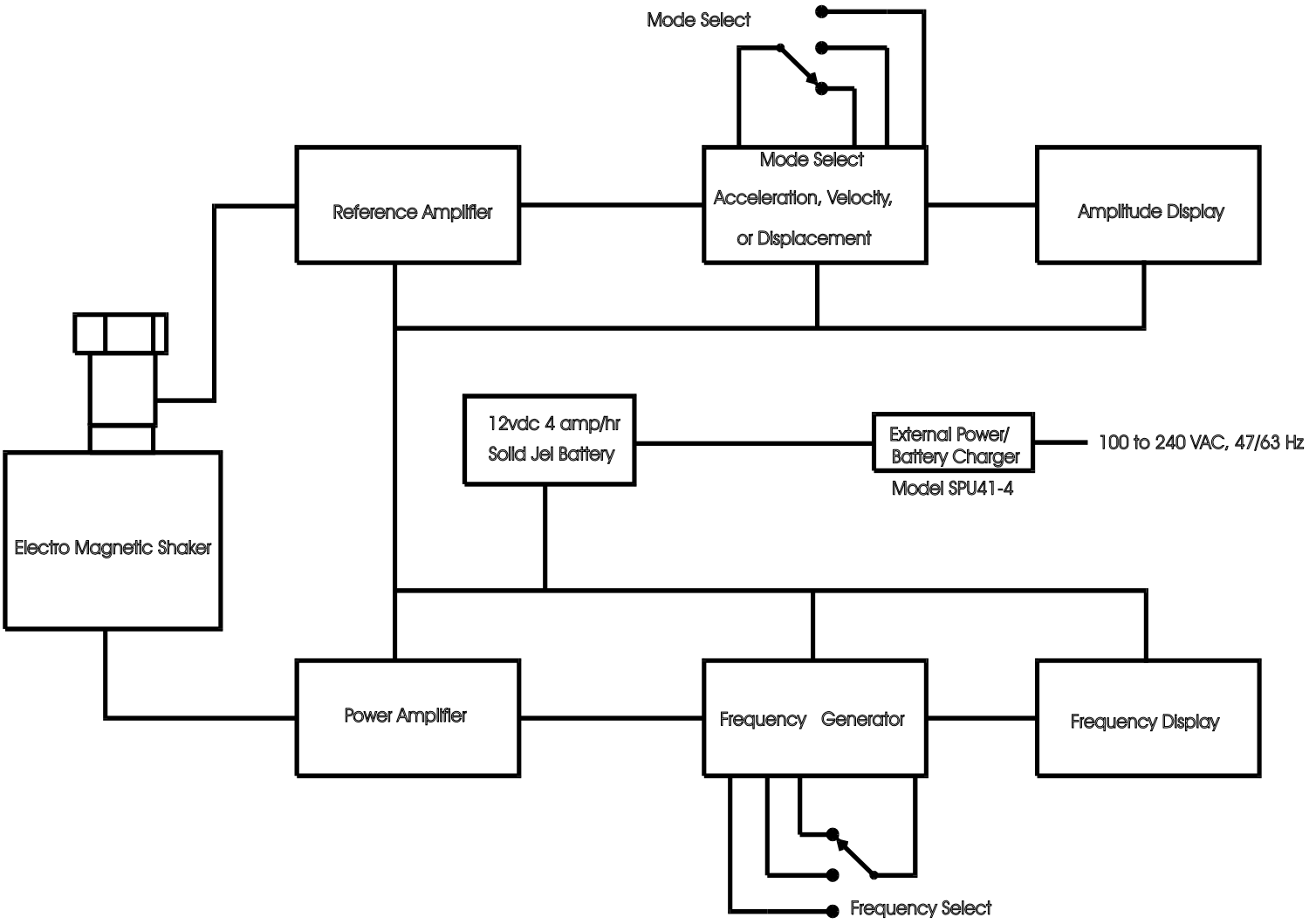
1.4 Shipping

When transporting the PVC VIA commercial carrier, care should be taken to insure that sudden impacts will be minimized. Any motion of the shaker head, that might exert abnormal vertical displacement or side loading, can damage the flexure system. The original shipping box is packed with sufficient foam to provide a good cushion for normal transportation environments.

Ship units to: Gilchrist Technology Inc.
1004 Turrentine Ave.
Gilchrist, TX. 77617
Call 409-286-5988 for a “Return Authorization”

2.0 Basics

2.1 Block Diagram



FUNCTIONAL BLOCK DIAGRAM

2.2 Accuracy

The main section of the 4000 PVC is the electrodynamic vibrator, which provides the vibration required to test transducers. The moving part of the vibrator contains the reference accelerometer which, combined with its electronics, is factory calibrated and traceable to the National Institute of Standards and Technology (NIST). The PVC performance record indicates

that the built-in standard be re-calibrated once yearly depending on the frequency of use and the amount of care given the unit. A simple calibration check is outlined that can be performed frequently. A more detailed check can be provided by GTI or through any standards or instrument lab with vibration testing capabilities.

The Model 4000 provides ± 3% indicated value (IV) ± 1 digit amplitude accuracy over the following ranges:

Measurement	Amplitude	Frequency Range
Acceleration (G)	0 - peak	20 Hz to 3 kHz
Velocity (ips)	0 - peak	20 Hz to 400 Hz
Displacement (Mils)	peak - peak	20 Hz to 150 Hz

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

Accuracy's of ± 6% in the acceleration mode can be obtained over the extended range of 20 Hz to 10 kHz provided proper care is given when mounting the test transducer to the shaker head. Refer to Transducer Mounting section (5.0 and 6.0) for suggestions on mounting precautions. At frequencies below 20Hz, the force is reduced to the point where the element cannot keep up with the change in the magnetic field. Severe distortion may result. Frequencies below 20 Hz are for reference only and carry no accuracy statement.

2.3 Shaker Resonance

The primary resonance in the Model 4000 PVC is the total mass of the shaker head (including the transducer mounted on the shaker) 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. This limits the low frequency operation, but is helped by increasing the mass.

The PVC has a high weight ratio for an instrument its size due to the electrodynamics vibrator sub-assembly and the lead acid battery.

The electrodynamic vibrator operates much like a very large loud speaker coil, with the cone replaced by a flexure system.
A high strength moving coil is accurately located in the annular gap by means of a flexible suspension system. This allows vertical motion yet exhibit a high lateral stiffness. This enables the coil to produce axial motion of the lightweight moving shaker head, without undue restraint on suspension systems, particularly at low frequencies where the excursion is at maximum.

2.4 CAUTION

ALWAYS USE A WRENCH TO HOLD THE SHAKER HEAD WHEN CHANGING THE TEST SPECIMEN

The end user is encouraged to take every precaution to ensure that the PVC is not misused. Overloading the unit for extended periods at high amplitudes is strongly discouraged. Following these precautions will help prolong the life of the vibrator sub-assembly.

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 PVC is being used to test a large load, the amplitude limit must not be reached. The following limits apply:

2.5 Shaker Loads

* The maximum displacement is 0.1 inches p-p
* The maximum velocity is 10 ins/second peak.
* The maximum acceleration is 10 G's peak.

When relatively light loads are being tested at lower frequencies, care should be taken to avoid repetitive contact with the limit stops. Continual hitting of the limits will result in damage to the moving elements and an increase in distortion.

2.6 Load/Amplitude Table

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

Table A 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

If the 4000 is used to test heavier loads for extended periods of time, some form of external support, such as an elastic suspensions or slip tables, should be used. Failure to support these excessive loads may result in damage to the moving coil and flexure.

Care must be taken when testing high aspect ratio loads, which exhibit a low stiffness. Severe rocking modes can produce high lateral loads on the moving coil and flexure, resulting in damage.

When fitting test transducers and fixtures onto the shaker head, aim to keep the center of gravity directly above, and in line with the center axis, of the ¼ - 28 threaded hole. This is a safeguard against side loading the shaker.

3.0 Theory of Operation

The Model 4000 Portable Vibration Calibrator (PVC) electrical system is comprised of several different mechanisms.

1. Digital Voltmeter
2. Digital Frequency Indicator
3. Power Amplifier
4. Reference Accelerometer
5. Electrodynamic Vibrator
6. Signal Generator

Also included are batteries and an external charger discussed in the Battery Discussion section (4.0) in the manual.

The 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 front panel AMPLITUDE control. The frequency is also controlled by the front panel FREQUENCY control.

The power amplifier is especially designed to provide the current required to drive the coil of the electrodynamic shaker

The reference accelerometer measures the level of vibration at the shaker head. The reference accelerometer incorporates a piezo-electric ceramic crystal, which has an output proportional to vibration. This signal is conditioned, buffered and sent to the BNC connector on the front panel. The sensitivity at the BNC is factory calibrated to 50 mV-p/g-p. A calibration “standard” is maintained by GTI that is used to calibrate the PVC and maintain NIST tractability.

The electrodynamic vibrator functions by the interaction between the magnetic field in the air gap and the oscillating current flowing in the moving coil. This current generates a force at right angles 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.

A digital voltmeter and frequency indicator are especially designed for the PVC that continuously reads vibration level and frequency on the front panel digital displays.

The vibration levels can be read in English or Metric units set by a front panel switch. Frequency is read in Hz.

4.0 Battery Discussion

The Model 4000 can be operated from AC line power or from its internal rechargeable batteries. When the external power supply is connected, it becomes the primary power source operating the unit as well as charging the battery.

Battery power is supplied by a sealed lead acid 12 VDC rechargeable battery. The battery is designed for continuous charging without damage. Keeping the battery with full charge means the PVC will be ready when you are. Under normal operation the PVC will operate in excess of 4 hours with a fully charged battery.

Charge life is directly dependent on the power used. When testing requires high forces to drive the test transducer, the charge life will be shortened.

4.1 Warning

A COMPLETE DISCHARGE WILL MOST LIKELY CAUSE BATTERY FAILURE.

When the “Bat” battery indication is seen on the display, switch over to AC power. If the warning is given again TURN THE UNIT OFF!!

Under normal conditions the battery will obtain a full charge with 2-4 hours of charge time. If deep discharge occurs, 2 or more days may be required to reach full charge (if at all). If you need to use the unit now, just

remember that you must put into the shaker 1.5 times what you take out. For every hour of discharge you must charge the unit for 1.5 hours.

4.2 SPECIAL HANDLING/STORAGE:
The internal battery should provide long-term service under normal operating conditions. They are securely mounted so that no damage can occur from shipping or normal transportation. No special handling should be required. GTI does not recommend that the battery be removed for shipping or storage for periods less than three (3) months. However, it is recommended that the unit be kept “on charge” when in storage.

5.0 Transducer Mounting

The care given when mounting a test transducer to the shaker head often has a direct influence on the accuracy of the calibration. In fact, improper mounting can lead to erroneous readings and may cause damage to the test transducer and/or the PVC.

Helpful suggestions.

1. Ensure that the adjoining surfaces of the shaker head and the fixture or test transducer to be mated are free from dirt, paint, epoxy, scratches, etc.
2. Ensure that all mating threads match and contain no burrs or mechanical distortion. Clean the threads with a tap (or die) when they appear to be worn.
3. After cleaning the threads coat them with a light oil.
4. Using the correct fixture or threaded adapter, mount the test transducer onto the shaker head using a light oil on all mating parts and threads especially if testing is to be performed at frequencies above 500 Hz.
5. For measurements involving frequencies above 1 kHz both surfaces should be flat and parallel within 1 Mil and have a 32 millionth of an inch surface smoothness.
6. Tightening. Unless you are going to excite the transducer to very high frequencies, finger tight will probably do. If you must torque the transducer or mounting screw**, be sure to hold the shaker head with a wrench.** Damage to the suspension system can occur when twisting forces are applied.

7. When fitting test fixtures and test transducers onto the shaker head, aim to keep the center of gravity directly above and in line with the center axis of the ¼ - 28 threaded hole. This will help avoid side loading the shaker moving element.

CAUTION

When tightening or removing a test transducer, hold the shaker head with the wrench to prevent a circumference torque from being applied to the shaker suspension system. The Model 4000 is more vulnerable to "twisting" damage than any other abuse. When applying torque, do not exceed twenty inch pounds.

6.0 Test Transducer Mounting Fixtures

S4A-1	Non-contact displacement sensor holder, with micrometer and target.
S4A-2	4140 Steel target, non-contact displacement sensor calibration
S4A-3	Universal transducer adapter, circular plate for custom mounting holes to be drilled and tapped by user.
S4A-4	Screw adapter kit. Includes #6, #8, #10, and ¼-28 all to ¼-28

7.0 OPERATION

Introductory Information About Operation

The Model 4000 PVC is designed so that operation is intuitive for the operator. It performs very accurate measurements for testing transducers in the field.

The operator can set the PVC to display data in English or Metric units.

Caution

IF YOU HEAR THE TONE OF THE UNIT CHANGE WHEN YOU INCREASE THE AMPLITUDE, YOU ARE OVERDRIVING THE SHAKER.

DO NOT DRIVE THE DISPLACEMENT AMPLITUDE SO HIGH THAT THE ELEMENT "BANGS" THE STOPS.
DON'T FORGET TO TURN THE PVC OFF. PLUG IN THE CHARGER WHEN YOU ARE FINISHED.

The batteries are sealed lead acid, and like to be charged when at rest. It is advisable to keep the unit on charge when not in use.

7.1 Test Transducer and Mounting Fixture Weight Guide Examples:

Transducer Type	Weight	Fixture No.	Weight
CEC Instruments 4-123-0001 Velocity	121 gm	S4A-3	23.5 gm
Endevco 2217E Accelerometer	32 gm	10-32 Adapt	N/A
WILCOXON MODEL 793	110 gm	Direct	N/A

.

7.2 Putting the 4000 to Wor*k*

1. Set the Amplitude Function switch according to the type of transducer You are checking.

Type of Sensor	**Setting**	**Reading Units**
Accelerometer	ACC	g peak
Velocity	VEL	ips peak
Displacement	DISP	Mils pk to pk

Make sure the Amplitude Adjustment control is turned to minimum before turning the Power switch on. This is to prevent unnecessary jolting of the shaker head and the test transducer.

2. Set the Frequency Range switch to the lowest position, 10 to 100 Hz As a general rule, it is best to start applying vibration to the test transducer in the 60 Hz to 100 Hz range.

3. Be certain the Internal/External Drive switch is in the Internal position. Turn the Power switch On.

    a. If the level is too high, turn the Amplitude Adjust down.
    b. Turn the Frequency Adjust control to read 100 Hz.
    c. Turn the Amplitude Adjust control to set the desired vibration level. (As indicated on Amplitude display).

4. Verify that the level indicated on the PVC is the same as the

Level being read on the monitor or analyzer that the test transducer is connected to.
5. Always plug the PVC into AC power when available; always keep on charge when not being used. You cannot overcharge the batteries, but they can be damaged by too much discharging.

7.4 Standard Checks for Transducers

Linearity and Frequency Response checks should be performed periodically. Linearity is a check to determine if the output sensitivity (mV/Unit of vibration, i.e., mV/g) remains constant from a minimum operating level to higher operating levels. This check is usually made at 100 Hz. The transducer manufacturer usually specifies this frequency on the transducer's original calibration certificate. If in doubt, use 100 Hz.

Frequency Response is a check to determine 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.

The following Typical Transducer Checkout table 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 operating procedure in the Basic Operation section. Substitute the frequencies and levels given in the tables.

Be certain to turn down the Amplitude control before switching the Frequency Range switch to avoid jolting the shaker.

7.4 TYPICAL TRANSDUCER CALIBRATION CHECKOUT

7.4.1 Accelerometers
Linearity Check – Frequency
100 Hz

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

Frequency Response Check – Ref. Level 1 g

Reference Level (Hz) 100 200 500 1k 2k 4k
Actual Level

7.4.2 Velocity Pickups

Linearity Check – Frequency 100 Hz

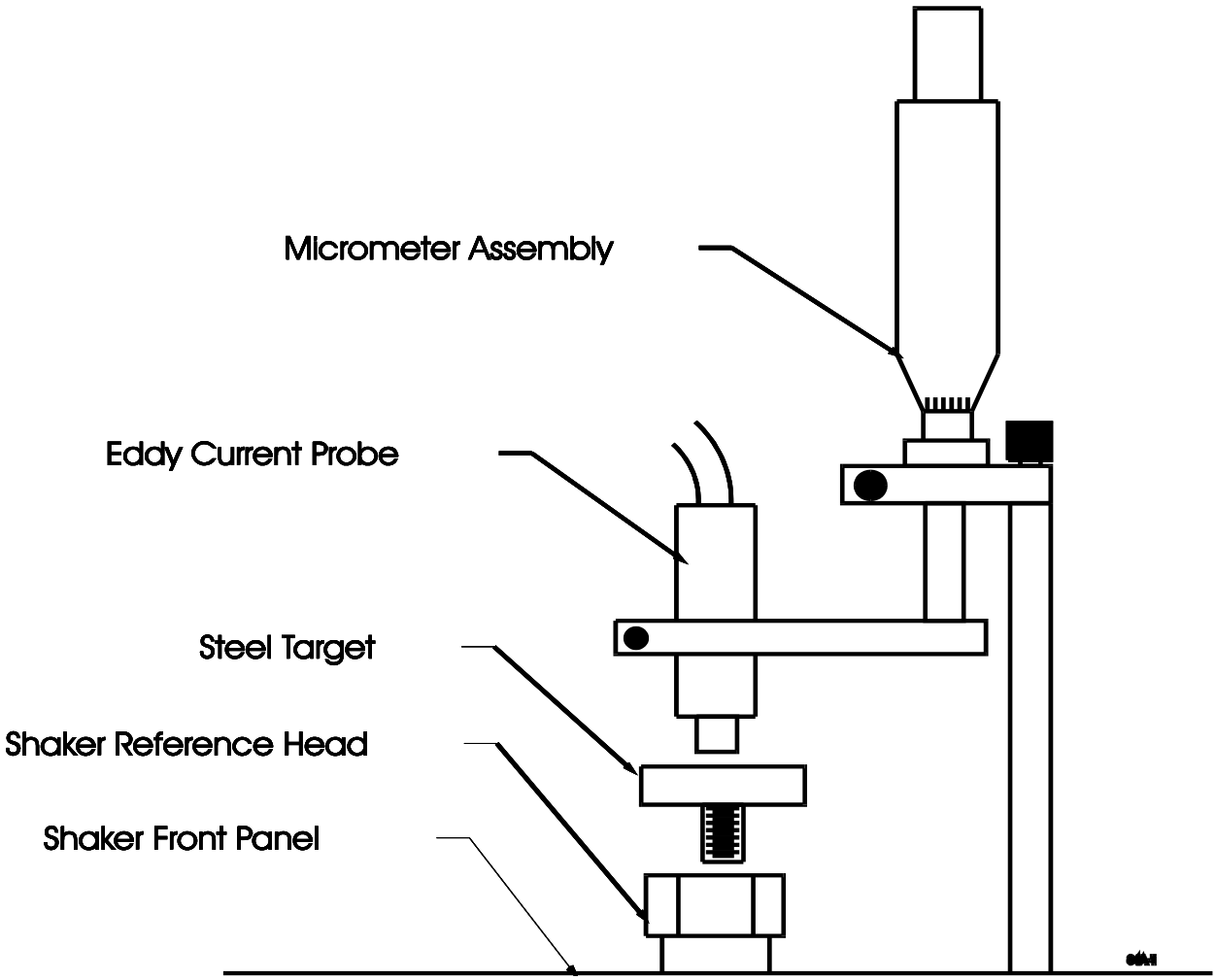
Reference Level 0.2 ips 0.4 ips 0.6 ips 0.8 ips 1.0 ips
Actual Level

Frequency Response Check – Ref. Level 0.2 ips

Reference Level (Hz) 30 50 70 100 200 400
Actual Level

7.4.3 Cable and Connector Checks for Looseness

Following the performance checks for transducers and their measurement systems, one should check for cable and connector integrity. Run the PVC at a high frequency and at a moderate-to-high vibration level, check for possible signal interruptions that would occur if looseness was present. Looseness may not be detected at low frequencies, but can become very detectable at higher frequencies.



Model S4A-1 Probe Attachment

7.4.4 Non-contact Displacement Sensor Calibration

Non-contact Displacement Sensors, also referred to as proximity probes, eddy current probes or simply displacement probes, can be checked for accuracy, linearity, and frequency response. Proximity probe systems require the use of the S4A-1.

7.4.5 Non-contact Displacement Sensor Frequency Response Check

1. Install steel target into the shaker on the shaker head.

2. Install the micrometer fixture on the PVC using the threaded holes as shown above.

3. Install the displacement probe in the bar fixture. A 3/8 – 24 threaded probe will mount directly while ¼ - 28 threaded probes require a bushing). Set the gap between the probe tip and the 4140 target electrically to 40 or 45 Mils, -8 or –9 Vdc, using a DC voltmeter, and lock the probe in place with its locking nut.

4. Set the Amplitude Function switch to Displacement and turn the AMPLITUDE adjustment to minimum level.

5. Set the Frequency Range switch to 10 to 100 Hz position.

6. Be certain the External/Internal Drive switch is locked in the Internal position. Turn the Power switch On and set the test frequency to 100 Hz using the Frequency Adjust control.

7. Set the vibration level to 5 Mils pk to pk, using the Amplitude Adjust control. Check the non-contact displacement sensor system output using an AC voltmeter or a vibration monitoring system indicator for the correct level ± 5%. If the displacement system output sensitivity is 200 mV/Mil the AC voltmeter should read approximately 353.5 mV rms (70.7mV x 5). An oscilloscope should read approximately 1 V pk to pk (200 mV x 5).

8. Make corresponding measurement checks at other frequencies in the 30 Hz to 100 Hz range. Then turn the vibration level to minimum. Set the Frequency Range switch to 100 to 1000 Hz and turn the Frequency Adjust control to minimum.

9. Turn the Power On and set the vibration level to 5 Mils again and continue making corresponding measurement checks in the 100 Hz to 150 Hz range.

10. Turn the vibration level to minimize, and turn the Power Off when calibration checks are complete. Remove the displacement sensor and then store the proximity probe fixture and the target.

7.4.6 Non-contact Displacement Sensor Linearity Check

1. Install the probe target on the shaker head.
2. Install micrometer attachment to the shaker front panel.
3. Install the non-contact displacement sensor (eddy probe) in the appropriate adapter sleeve. Ensure that at least one complete thread is visible below the sleeve and lock the probe in place with the set screw.

4. Mount the entire Model 4000 Dial Micrometer Calibration attachment on the PVC using the threaded holes in the front panel and the thumbscrews on the adapter.

5. Power up the probe driver and connect a digital voltmeter to the output.

6. Set the micrometer to the number of Mils corresponding to the center of the linear range for the probe being tested.

7. Loosen the setscrew holding the probe in the adapter.

8. Move the probe toward the target until the DC voltage, measured at the driver output, corresponds to the recommended gap voltage for the transducer under test (7.5 to 12 VDC typical).

9. Retighten the setscrew.

10. Adjust the micrometer to the specified minimum gap reading and record the voltage on the voltmeter. Do not let the probe touch the target.

11. Increase the gap with the micrometer in either five or ten Mil steps and record the voltage at each step.

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

11. Upon completion of tests, remove and store the probe adapter and the target.

Optional Method

Perform the above linearity check except operate the PVC at 100 Hz with very low displacement level. This is to create a very low “delta gap” condition for the measurements. The delta gap sometimes results in a smoother calibration curve.

7.4.7 Using the Internal Reference Accelerometer

The internal reference accelerometer signal is available on the front panel, Ref Out connector. This can be used with volt meters, analyzers, oscilloscopes, and other measuring devices. The output impedance is 100 ohms and has a level of 50 mV/g peak. Dial this sensitivity into the instrument or analyzer being checked and its scale should then agree with the vibration level indicated on the PVC.

7.4.8 Mass Loading Compensation

There is a characteristic of most accelerometers where the rated output is affected by a combination of weight. The reference accelerometer, in the PVC, is subject to a characteristic called mass loading. If you regularly check heavy transducers (above 200 grams), and your testing requirements are such that you will be often testing at frequencies above 1 kHz, contact the factory for data that will allow you to compensate for mass loading. We will supply you correction values to be applied to readings. It is important that the serial number (S/N) of the PVC be supplied when requesting this information. In most applications, below 500 HZ, compensation is not required.

Fixture weight information is given in this manual to assist you in determining the combined weight of the test transducer, fixture and any mounting hardware that might be used.

8.0 MAINTAINANCE

The Model 4000 is designed for many years of trouble free service. Service of internal parts should be performed by factory personnel. If the unit is removed from the case, the NIST calibration is void. Certification can only preformed after re-assembly.

9.0 PRODUCT WARRANTY POLICY

There is no warranty on batteries expressed or implied.
The GTI Model 4000 is warranted against defects in materials and workmanship. This warranty applies to only those products manufactured by Gilchrist Technology Incorporated.

Gilchrist Technology Incorporated will repair or replace products, which prove to be defective during the warranty period, providing the failure or damage has not been caused by misuse, abnormal operating conditions, or alterations. The warranty period starts from the date of shipment, plus an added 30 days shipping time for products delivered outside the United States. If the malfunction or portion thereof is determined by Gilchrist Technology Inc, to have been caused by misuse, abnormal operating conditions, or is not within the scope of this warranty, an estimate of the cost to repair the product will be submitted to the purchaser for approval prior to beginning any repair work.

Liability under this warranty is limited to servicing and adjusting the equipment returned to the factory, with all transportation charges prepaid by the purchaser. No other warranty is expressed or implied. Gilchrist Technology Incorporated is not liable for consequential damages.

If a malfunction develops, notify Gilchrist Technology Incorporated. Provide details of the problem as well as the name, model and serial number of the product. Upon receipt of this information, service instructions or issuance of a return authorization number will be provided.

All products manufactured directly by Gilchrist Technology Incorporated will be warranted for a period of one year. Any related product will carry the manufactures warranty.

10.0.0 Shipping and Inspection Procedures.

- *When transporting the PVC VIA commercial carrier, care should be taken to insure that sudden impacts will be minimized. Any motion of the shaker head, that might exert abnormal vertical displacement or side loading, can damage the flexure system. The original shipping box is*

packed with sufficient foam to provide a good cushion for normal transportation environments.

GTI will not be held responsible for damage caused by shippers. This instrument is shipped fully assembled, packed in a manner designed to protect against all normal shipping hazards. Immediately upon receipt, inspect and note any apparent damage. Keep all forms and invoices. Test its operation, and if any shipping damage is apparent, file a claim with the carrier claim agent and send a copy to Gilchrist Technology Incorporated. Be sure to include instrument name, model number, and serial number on all correspondence. GTI will advise the buyer what should be done; arrangements for repair or replacement will be made accordingly.

11.0 Return Shipment Procedure

On receipt of return authorization, forward the instrumentation prepaid to the factory. Replace the instrument in the original shipping case, or surround with a minimum of four inches of shock absorbing packing material, and then pack in a container equal or greater in strength to a heavy weight cardboard or wooden box.