ELECTRODYNAMIC SHAKER USER MANUAL

MODEL K2007E01

Mini SmartShaker™
with
Integrated Power Amplifier

Helping you test, model and modify the behavior of structures.

MODEL K2007E01
Mini SmartShaker™ with Integrated Power Amplifier

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Product Support

For answers to questions about usage of The Modal Shop's Electrodynamic Shaker Model K2007E01, consult this manual. For additional product support, contact The Modal Shop at 800-860-4867 or 513-351-9919, 8 a.m. to 6 p.m. EST. If it is more convenient, fax your questions or comments to The Modal Shop at 513-458-2172 or email questions to techsupport@modalshop.com.

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1. INTRODUCTION

1.1 General Description

The K2007E01 Mini SmartShaker™ with Integrated Power Amplifier is an electrodynamic exciter designed for general purpose vibration testing of small components and sub-assemblies up to 9 kHz. It can also be used as excitation for modal testing of small structures.

A new generation of ultra compact precision power amplifier is integrated in its base. The revolutionary SmartShaker™ design eliminates the need for a separate, cumbersome, power amplifier.

The compact size of the K2007E01 exciter makes the shaker assembly ideally suited for applications such as production screening, reliability acceptance testing, and engineering evaluation.

The armature suspension and guidance system's use of composite materials provides a high degree of lateral and rotational restraint while maintaining maximum compliance in the axis of motion to permit full 0.5" peak to peak stroke.

The K2007E01 shaker body structure and trunnion assembly are designed to allow a variety of operating positions. The K2007E01 is typically used in the vertical orientation and can be rotated up to 90° for horizontal applications. The exciter is delivered with a variety of 10-32 nylon stingers which provide electrical isolation from and flexible attachments to test articles.

1.2 Technical Specifications

The following are the performance and physical characteristics of the K2007E01 SmartShaker™.

Shaker Performance

	Parameter	**Specification**
1.2.1	Rated output force:	
	Sine force	7 lbf pk (31 N pk)
	Random force	5 lbf rms (22 N pk)
	Shock force	15 lbf pk (67 N pk), 11 ms pulse
1.2.2	Displacement (max)	0.5" pk-pk (13 mm pk-pk), continuous
1.2.3	Velocity (max)	95 inches per second pk (2 m/s)
1.2.4	Acceleration (max), no load	70 g pk (628 m/s^2), driven 120 g pk (1177 m/s^2), resonance 190 g pk (1863 m/s^2), shock pulse
1.2.5	Frequency range	DC-9 kHz, bare table

1.2.6 Physical characteristics:

Moving element weight	0.1 pounds (0.045 kg)
Fundamental resonance	≥ 7.5 kHz
Rated armature current	8 A, max.
Specimen mounting	Internally-threaded, Aluminum insert (10-32 std.)
Armature guidance and suspension system	Upper guidance provided by four internally damped lateral flexures with foreshortening compensation. Lower guidance is provided by radial ball bearings.
Axial suspension stiffness	15 lb/in (2.63 N/mm), nominal
Stray magnetic field	<30 gauss @ 1" (25.4 mm) above table
Shaker weight	7 pounds (3.10 kg) including trunnion
Shaker dimensions	5.3" H x 6.75" W x 3.5" D (135 x 171 x 89 mm)
Shaker cooling	Natural convection (forced air cooling recommended for continuous operation above 4.5 pounds force).

1.2.7 Environmental Conditions:

Ambient Temperature	40° F to 100° F (4° C to 38° C) @ 85% RH max.
Force Derating (> 100° F / 38° C)	Reduce 1% per 1° F (0.56° C) Ambient air temperature >100°F (38° C)

1.2.8 Included Accessories:

- Trunnion
- EasyTurn™ handles
- 2110G06 Stinger pack, qty of 3
- User Manual
- Mini screw driver

Amplifier Performance

	Parameter	Specification
1.2.9	Efficiency	92%
1.2.10	Input Voltage	1 VAC RMS, max
1.2.11	Input Power	8 – 22 VDC (supplied with a DC universal power supply, 100-240V~, 60W, +19 VDC – 3.15A output)
1.2.12	Output Power	55 W (based on supplied universal power supply, 92% efficiency)
1.2.13	Distortion, typical	<0.02% (THD + noise at 1kHz, 1W)
1.2.14	Cooling	Convection
1.2.15	LED indicators	3, bi-color (red, green, or red+green)
	Discrete Gain Stages	Muted; 10, 18, 24 dB (nominal)
	Warning Indication	Clipping and over temperature
	Shutdown Protection	Over temperature and over current
1.2.16	Included Accessories	universal DC power supply with power cord (see 1.2.11 above)

2. INSTALLATION AND OPERATION

2.1 General

Installation of the K2007E01 SmartShaker™ involves unpacking, preparing the equipment, and readying it for operation. This must be preceded by selection of an appropriate site and preparation of same. Before proceeding with the actual installation of the shaker, ensure that the site conforms to the needs of the equipment, and meets all the requirements for its proper operation.

2.2 Site Selection and Preparation

The location in which the shaker is to be installed should be one basically free of all airborne particles of foreign matter, but especially those that are of a ferromagnetic or other metallic nature. Consideration should be given to the vibration which will be introduced by the shaker to the mounting surface. The location should be chosen such that other equipment in the area (for example; a computer on the same table) will not be adversely affected.

A signal source is required for shaker operation. The K2007E01 SmartShaker™ can be driven directly from a function generator, an FFT analyzer with source output, vibration controller, or compatible equivalents.

As for the shaker itself, the physical location of its installation is restricted only by the lengths of the various interconnecting cables.

2.3 Unpacking and Handling

At the time of arrival of the shaker, check the equipment against the accessory list in section 1.2.8 and 1.2.16 to make sure that the shipment is complete. Inspect all packages for shipping damage and check for loose, broken, and/or damaged components.

In the event of shipping damage, notify the agent of the delivering carrier and obtain a full report of the irregularity. Have this signed by the agent before accepting the shipment.

2.4 Installation Procedure

The installation of the shaker is a simple process which only requires attention to a few details and can be accomplished as follows:

2.4.1. Place and position the shaker in the appropriately chosen site (see subsection 2.2).

2.4.2. Trunnion Mounting: A level mounting surface is desirable and the shaker trunnion should be firmly mounted to prevent the shaker from bouncing or "wandering" during operation. The EasyTurn™ handles are 1/4-20 UNC threads. Other attaching bolts may be used but make certain they protrude at least 3/8 and no more than 5/8 inch into the side of the shaker body.

2.4.3. Loosen the trunnion by rotating the EasyTurn™ handles and rotate the shaker to the desired operating position. Tighten the handle to lock the shaker into position. Note that with the SmartShaker's Integrated Power Amplifier the unit can only rotate in one direction from its vertical position.

2.4.5. The shaker power cable should be connected to the power amplifier. There are two short wires in the power cable that are pre-connected at the factory to the amplifier's red and black terminals. The two connections are the drive for the armature coil and should be connected to the Integrated Power Amplifier all the time to assure the proper motion of the shaker armature. The Integrated Power Amplifier's output signal delivered to the shaker may be monitored with a voltmeter or equivalent at the mini binding post if desired.

2.4.6. With an appropriate signal source connected to the BNC input of the Integrated Power Amplifier the shaker is now ready for operation.

2.5 Preoperational Procedure

Before actual use of the K2007E01 SmartShaker™ in a test application, it is recommended that a system vibration response signature be obtained. This procedure utilizes all of the system components; K2007E01 SmartShaker™, signal source and feedback accelerometer to observe the vibration waveform on an oscilloscope and verify proper shaker operation. Perform the following test:

2.5.1. Interconnect the SmartShaker™ to the signal source as detailed in the installation procedure.

2.5.2. Mount an accelerometer (see subsection 2.6 for correct load attachment procedure) to the shaker armature and connect its output to an appropriate signal conditioning amplifier.

2.5.3. Connect the output of the signal conditioning amplifier to an oscilloscope and adjust signal level resolution for about 1.5-2.5 inches on the display.

2.5.4. With the system connected as described, adjust the sinewave signal source to obtain about 2g response acceleration at approximately 100 Hz. Then, without changing the gain level, scan the frequency up and down (10 Hz to 10kHz) and observe the acceleration waveform on the oscilloscope. Make note of changes in waveform distortion at specific frequencies.

It is necessary to be able to differentiate between normal and abnormal waveform distortion in order to identify potential problems or deterioration in shaker performance. Some waveform distortion is normal such as the distortion which is seen at submultiples of the armature fundamental axial resonances. This distortion occurs when a small amount of harmonic distortion generated in the signal source and the system power amplifier are amplified by the major armature and accelerometer resonances.

A serious departure from the normal pattern of waveform distortion could indicate armature or suspension system misalignment or damage. It is highly recommended that a record be made of the armature fundamental resonance frequency and the waveform distortion when the shaker is received. This record can be used at a later date to differentiate between normal and abnormal distortion. A periodic check with this record will minimize troubleshooting time and can be used as a preventive maintenance check.

2.6 Load Attachment

The K2007E01 SmartShaker™ specimen mounting surface is a replaceable aluminum insert with internal threads (#10-32 standard, other thread available upon request) for load attachment. The best dynamic performance is obtained with the specimen firmly attached to the mounting surface. The load attachment screw should be long enough to reach into the load mounting insert at least (1/4 inch) but no more than (1/2 inch). It is highly recommended that a reaction wrench (1/2 inch) be used to hold the insert firmly in place while tightening the mounting screw. This will allow maximum torque to be applied without damaging the shaker suspension.

Caution! Do not apply more than 4 inch-pounds of torque to the shaker mounting insert without using a reaction wrench.

Looseness or excessive compliance in any of the mechanical connections between the armature insert and the load will cause erratic, uncontrolled test levels and spurious frequency components. Difficulties caused by such looseness can be detected by connecting an oscilloscope to the accelerometer output. Serious departure from a sinusoidal response and, more particularly, the addition of high frequency nonharmonic noise components superimposed on the waveform are nearly always an indication of decoupling between the shaker armature and fixture or fixture and specimen.

Care must be exercised in locating the load over the armature table. The fixture height should be minimized to keep the center of gravity (CG) of the test load as close to the mounting surface as possible. Driving a complicated fixture/specimen assembly causes coupled modes of vibration which can only be reduced by rigorous attention to symmetry and careful alignment of the load over the thrust axis of the armature. Load attachment is a specialized problem which must be solved for each load configuration. The relative motion of the table and fixture with the specimen in place can be checked by a series of measurements taken with lightweight piezoelectric accelerometers.

Maximum Load Mounting Screw Torque Values

Size	Thread	Torque (in/lb)	Torque (N.m)
Standard Mounting Hole:			
No. 10	32 UNF	38	4.3
(3/8” minimum thread engagement in load mounting insert)			
Alternate Mounting Hole Options:			
M4	0.70 mm	23	2.6
No. 6	32 UNC	13	1.4
No. 8	32 UNC	23	2.6
¼ in.	28 UNF	90	10.2

2.6.1 Vertical Orientation

For vertical operation, the shaker should be positioned as close to true vertical as possible. This is especially important if the loads are greater than 0.25 lbs or if they have a high center of gravity. Off center loads will exert torque on the armature suspension that can cause the armature coil to contact the shaker magnetic pole causing damage to the armature. Damage can be caused by dynamic loading due to relatively small static imbalances and the user should be cautioned to look for any significant non-axial motion of the load and armature and to correct the situation immediately.

This type of damage is caused by a combination of the relative size of the off center load and the associated acceleration. The following can be used as a guide to approximate maximum off-center loads that can be tolerated by the K2007E01 armature suspension.

$$X \leq 0.08/W.g$$

X = Armature axial center line to load CG offset distance in inches
W = Load weight in pounds
g = peak axial acceleration expected in g's

Caution! This equation should serve as a guide only and is not applicable under lateral resonant conditions.

The shaker flexure system support capabilities (axial suspension stiffness) should be considered before attaching a specimen and fixture to the mounting surface. The K2007E01 armature suspension has been offset to allow full relative displacement with the armature displaced into the shaker approximately 0.025 inch from its nominal unloaded position. This is equivalent to approx. 0.25 pounds of weight with the shaker in the vertical position.

In order to obtain the full shaker stroke capability (0.5" pk-pk or ± 0.25") with load greater than 0.25 pounds, the weight of the fixture and specimen must be externally supported. DC offset current to the armature coil may also be used to center the armature but the shaker AC performance will be reduced accordingly.

If less than the full shaker stroke capability is required for a test, a static deflection of the armature is permissible as long as the sum of the required vector displacement and the static deflection is less than 0.25" from the neutral position.

2.6.2 Horizontal Orientation

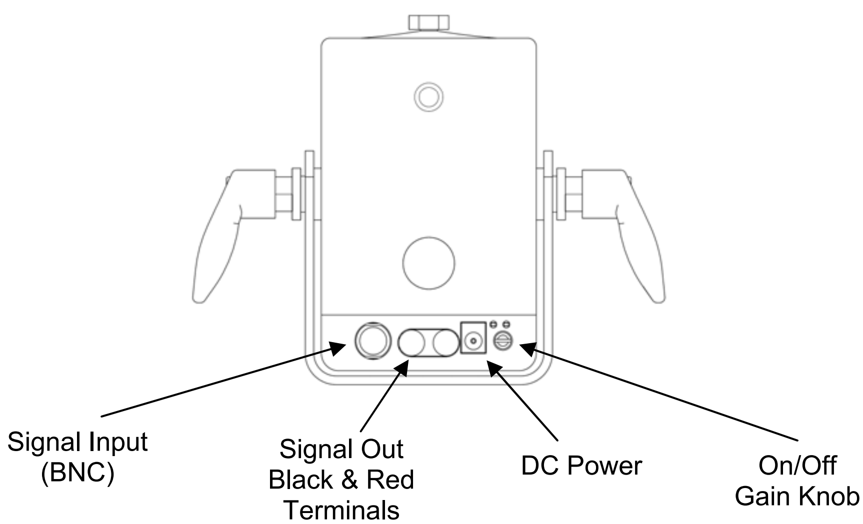
For horizontal operation, all of the concerns relative to vertical operation remain valid with an additional load carrying constraint. In addition to the axial off-center loading limitations, horizontal operation requires that the armature suspension counteract the torque applied by an over-hung test article due to its weight. If especially heavy or high center of gravity loads must be tested, additional load support should be used (slip table, linear bearings, "bungee" cords, etc.).

The following equation can be used as a guide to approximate maximum off-center loads (lateral) that can be tolerated by the K2007E01 armature suspension.

$X \leq (8/W) - 2$ **X** = Armature mounting surface to load CG distance in inches
W = Load weight in pounds

2.7 Operation

Refer to the figure below that shows the unit's connector configuration. Connect the DC power supply and the drive signal to the unit's DC power input and BNC signal input respectively. Then turn on the K2007E01 SmartShaker™ by pressing the On/Off Gain knob one time.



Note that on the opposite side of the amplifier, there are 3 LEDs on the bottom. When the amplifier first powers up, the gain LEDs indicate "off-line" by blinking. By pressing the On/Off Gain knob, the unit turns on (unmute) and the blinking green LED's become solid green as indicate on table 1.

To adjust gain up, turn the On/Off Gain knob in clockwise direction using a small screwdriver or fingernail. To adjust the gain down, turn the On/Off Gain knob in the counter clockwise direction. There are 3 possible gain settings indicated by the LED as seen on table 1.

To mute the amplifier, press the On/Off Gain knob anytime and the level indicator LEDs will blink, indicating "off-line." The outermost LED (left) stays green to indicate DC power is applied. Any interruption of power will cause amplifier to be "off-line" when the power is regained. Press On/Off Gain knob to return the amplifier to the last gain setting used.

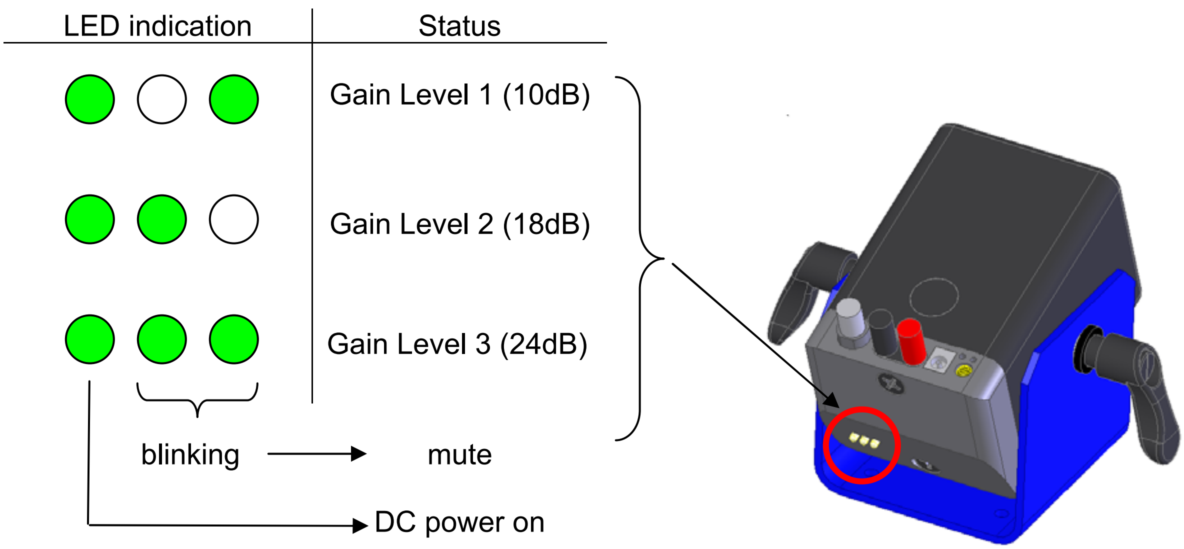
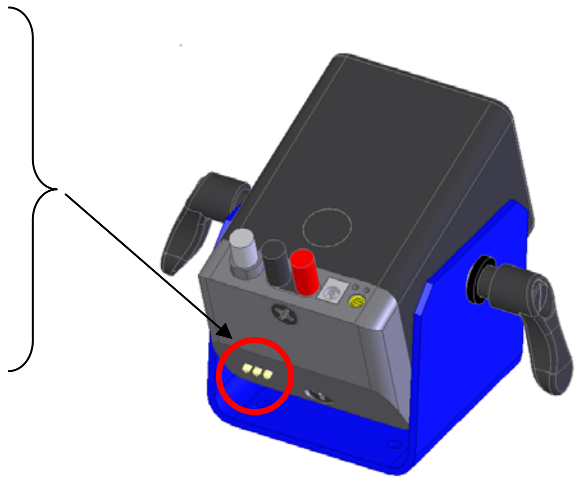


Table 1: LEDs - normal operation indication.

The LEDs may turn orange/red to indicate a clipping and over temperature warning or to indicate a system shutdown due to over temperature, over current, or under voltage (see Table 2).

LED indication	Status
red O O	clipping or over temperature warning*
green O red	DC-power under voltage shutdown*
green red O	over temperature shutdown*
green red red	over current shutdown**



* a blank (O) LED indicates the LED is either green or off, depending on the status prior to the warning/shutdown condition.

** this condition is rare; typically when an over current condition happens, it drives the DC power supply to shut itself off for approximately 200ms, which results in a reset of the amplifier. The unit boots up “off line” with one or two green LEDs blinking (according to the previous gain settings) and no RED LED indication.

Table 2: LEDs – warning and shutdown indication.

The K2007E01 Shaker is designed to provide a force output proportional to the input drive from a signal source and faithfully reproduce the waveform within the specified level and frequency bandwidth limits. It is important to note that the shaker/amplifier system, whether operated by a manual or closed-loop control system, will react directly to an input either intentional or accidental. Great care must be taken to avoid damage to the armature coil or suspension system. Damage can be caused by transients in the supply waveform or by exceeding the displacement and/or acceleration limits. To prevent such potential damage please observe the following cautions during operation:

> **Caution!** If the shaker is being controlled manually through the frequency range, approach the armature fundamental resonance frequency slowly while monitoring the acceleration level. Shaker armature resonances have a very large amplification factor and can force the acceleration level to exceed the shaker's acceleration limit.
>
> **Caution!** Always reduce the input signal to zero or mute the system before switching the oscillator or control system to a different range. Failure to do that could result in a transient which would exceed the shaker's acceleration or displacement limits.
>
> **Caution!** Make sure that the maximum displacement is not exceeded at the low frequency end of the range. Exceeding the displacement will cause the armature

assembly to strike the mechanical stop with an impact that could exceed the acceleration limit or break the armature coil bond.

Caution! Observe that proper cooling air flow is maintained since overheating and possible armature damage can occur.

3. PRINCIPLES OF OPERATION

3.1 Description

The K2007E01 SmartShaker™ incorporates a single-ended magnet structure to provide the high level magnetic field which surrounds the armature drive coil assembly. The armature assembly is suspended and centered in the magnetic gap by composite material flexures and a linear bearing assembly. The flexures are attached to the shaker body through foreshortening flexures which maintain the linear motion over the entire stroke.

The armature assembly consists of a cylindrical copper coil bonded to an aluminum armature table assembly to minimize the overall weight and maximize the structural stiffness. The armature coil is positioned around the center pole of the magnet assembly and is suspended in the air gap in the magnetic structure. The flexures provide axial support for the armature assembly as well as lateral and rotational restraint.

3.2 Theory of Operation

A shaker (vibration exciter) transforms electrical current into mechanical force for the purpose of vibration testing. A shaker is similar to a loudspeaker. It consists of a magnet structure and a moving coil. Force is generated in the moving coil by interaction between current flowing in the coil and the magnetic field in which the coil is placed. An alternating current in the coil will produce an alternating force and resultant motion at the same frequency in the coil.

The moving coil and the force-transmitting structure is called the armature. The armature is supported in the magnet structure or body by springs or flexures. This suspension allows movement of the armature normal to its mounting surface.

The magnet structure is designed to provide extremely high flux densities in the coil gap and yet have low leakage flux density at the table. The high flux density provides a high ratio of force to current.

The force generated in the armature coil is always defined by the following equation:

$$F = K_1 \, BL \, i \, (2.54)^2$$

F = the force generated in the armature coil
K_1 = a physical constant (0.885×10^{-7} in English system of units)
B = the magnetic flux density (gauss) in the gap
L = the length of conductor (in inches) in the gap (coil circumference x number of coil turns)

i = the armature current

Thus the force-current ratio is constant for a particular shaker.

Whenever a conductor is moving in a magnetic field at the same time that current is flowing through the conductor, there is an interchange of power between the electric circuit and the mechanical system associated with the motion of the conductor. This is true in the case of a shaker. Neglecting the voltage drop across the electrical impedance of the armature coil due to the flow of current through it, a voltage will be generated in the coil that is directly proportional to the velocity of the coil.

$$E_B = K_2 \, BL \, v \, (2.54)^2$$

E_B = the back-voltage generated in the coil
K_2 = a physical constant (10^{-8} in English system of units)
B = the magnetic flux density (gauss) in the gap
L = the length of conductor (in inches) in the gap
v = the velocity of the armature coil (inches/sec)

3.3 Formulae

To effectively utilize the K2007E01 SmartShaker™ for specific vibration testing applications it is useful to review the formulae which describe the physical principles of shaker operations. Some of these formulae define the payload capabilities of the shaker while others describe the physical relationship between the operational parameters of Acceleration, Velocity and Displacement.

3.3.1 Defining shaker payload capabilities:

F = M • A
(F = W • g)

F = vector force, (*lbf*)
M= total moving mass (mass of shaker armature + mass of specimen + mass of the fixture), *pounds*
A = vector acceleration, *gravity units (g is a unitless multiple of gravity)*

Example:

Find the force required for a sinewave test of 5g pk to be performed on a specimen of 0.2 pounds and a fixture of 0.1 pounds.

F = M • A (F = W • g)
F = (specimen mass + fixture mass + armature mass) • A
F = (0.2 + 0.1 + 0.077) lbs • 5g pk
F = 0.377 lbs • 5g pk
➔ F = 1.89 lbf pk

Caution! Although this calculation determines the force required, the maximum displacement and velocity must also be determined before proceeding with the test.

3.3.2 Describing the relationships between Acceleration, Velocity & Displacement:

$$V = \pi f D$$
$$V = 61.44 g/f$$
$$g = 0.0511 f^2 D$$
$$g = 0.0162 V f$$

V = velocity in *inches/second pk*
D = displacement in *inches pk-pk*
f = frequency in *Hertz*
g = acceleration in *gravity units*

All of the relationships for sinewave testing can be derived from the formulae shown.

3.3.3 Defining the Random acceleration levels:

$$g\ rms = [\Delta f\ (g^2/Hz)]^{1/2}$$

Δf = bandwidth (f_2-f_1), in Hz
g^2/Hz = acceleration spectral density
g rms = root mean square accel.

This formula will provide the total root mean square (rms) acceleration level for a flat random spectrum. For shaped spectra, a more lengthy calculation is required.

4. MAINTENANCE

4.1 General

The K2007E01 SmartShaker™ is designed to provide trouble-free service for long periods of time when operated within the performance limits set forth in subsection 1.2 and in an environment which is free of excessive dust, metallic particles and other potentially harmful materials.

The only maintenance that should be performed on a routine basis, outside of replacement of worn or damaged components, is the cleaning of the air filter. Inspection of the shaker moving element (flexures, armature and wiring) can be performed if operational problems are suspected. The following procedures will aid in performing these inspection and routine maintenance functions:

Caution! Disconnect the shaker from the amplifier during maintenance procedures.

4.2 Cleaning Air Filter

If the shaker is operated in a relatively dust-free environment, the air filters (located both at the top of the shaker and inside the two cooling inlets near the bottom) should not need cleaning for a period of approximately 500 hours of operation. If cleaning is deemed necessary, please proceed as follows:

- Using a small vacuum cleaner, adjusted for the minimum suction, gently vacuum the filter at the top of the shaker until it appears clean. Gradually increase the vacuum as required to obtain satisfactory results being careful not to damage the filter membrane.

- Similarly clean the filters located in the two cooling inlets located near the bottom on either side of the shaker.

- If satisfactory results cannot be obtained in this manner the shaker housing will have to be removed and the filters cleaned by blowing through them with compresses air (see subsection 4.4 for cover removal procedure).

4.3 Inspecting Flexures, Armature and Wiring

Before disassembly of the shaker to locate a suspected operational problem, it is always a good idea to check the other system components such as: signal generator or accelerometer and signal conditioning instrumentation for malfunctions since, historically, the largest majority of field problems have been traced to electronic component malfunctions rather than shaker mechanical problems.

Although the shaker moving element and suspension (flexures, armature and wiring) should not require routine maintenance, an inspection to look for signs of wear, loose screws, etc., is recommended if the housing is to be removed to clean the air filters or if an internal malfunction is suspected. To perform the inspection, please follow the procedure below:

4.3.1. Disassemble the trunnion from the shaker body by removing the two trunnion EasyTurn™ handle screws normally used to lock the shaker in place. These screws also hold the shaker cover in place. The cover is snug fit to the shaker body to prevent rattling and must be carefully forced up by prying with a putty knife or similar instrument or grasping the shaker cover and shaking the body down/out of the cover using its momentum. In either case be sure to disconnect the drive cable first from the red/black terminals and feed drive cable into the shaker through the cable grommet before and during shaker cover removal to prevent damage to the internal connections (it may be necessary to cut the heat shrink applied to the cable). A small amount of lubricant (WD-40, Tri-flow, or equivalent non-aggressive lubricant) on the cable will allow it to slide through the grommet with less force.

Caution! Although the shaker cable is attached inside to the body by a strain relief, be careful not to pull the cover too far without feeding the cable back through the grommet in the housing.

4.3.2. Visually inspect the armature guidance system. Grasp the armature insert and slowly move it in and out to exercise the flexures and lower bearings. Look for signs of cracks in the flexure material, loose connections at the flexure fastening screws or excessive slop in the bearing fit.

4.3.3. Look for and remove any foreign matter inside the shaker.

4.3.4. If all is well, reassemble the shaker in the reverse order being careful to properly relocate the shaker cable so that it does not interfere. If a problem is found refer to subsection 4.4.

4.4 Shaker Disassembly and Repair

There are basically three user replaceable subassemblies to the shaker. These are the armature/flexure and guide bearing assemblies. The guide bearing assemblies can and should be adjusted or removed without removing the armature as described in subsection 4.4.1. To remove the armature/flexure assembly for inspection or replacement see subsection 4.4.2.

4.4.1 The guide bearing assemblies which can be seen at the open ends of the magnet structure are adjusted and/or replaced as follows:

1. Remove the housing as described in subsection 4.3.

2. Check for proper bearing fit by gently side-loading the armature. If the armature coil can be made to touch any part of the magnet structure or if any of the four wheels are not in contact with the armature they should be adjusted or replaced.

3. Determine which pair of guide wheels is most likely causing the problem (the pair which did not behave properly in step 2). Loosen the two screws which hold the mounting block (to which the wheels are attached) in place. Adjust the block so that there is a slight preload between the armature and the guide wheels and tighten the screws.

Caution! When making adjustments it is important to be sure that the armature coil remain centered in the gap of the magnet structure. Nonmetallic shims should be used for this purpose and the concentricity should be maintained within .002 inches.

4. Repeat steps 2 and 3 as required to obtain the proper fit. The silicone rubber O-ring "tires" take up the preload and should be inspected for wear along with the bearings themselves if correct adjustment cannot be attained. It is a good idea to remove only one guide wheel pair at a time for inspection.

5. Reassemble the shaker as described in subsection 4.4.1 steps 2 through 4.

4.4.2 The armature/flexure assembly can be removed and inspected or replaced as follows:

1. Remove the housing as described in subsection 4.3.

2. Visually inspect the armature guidance system. Grasp the armature insert and slowly move it in and out to exercise the upper flexures and lower bearings. Look for signs of cracks in the flexure material, loose or broken wiring connections, loose flexure fastening screws or excessive slop in the bearing fit (see subsection 4.4.1 for suspected bearing problems).

3. Remove the eight screws and associated nut plates which hold the flexures in place and the two screws on the cable clamps holding the armature leads.

4. Gently pull the armature upward and out of the gap.

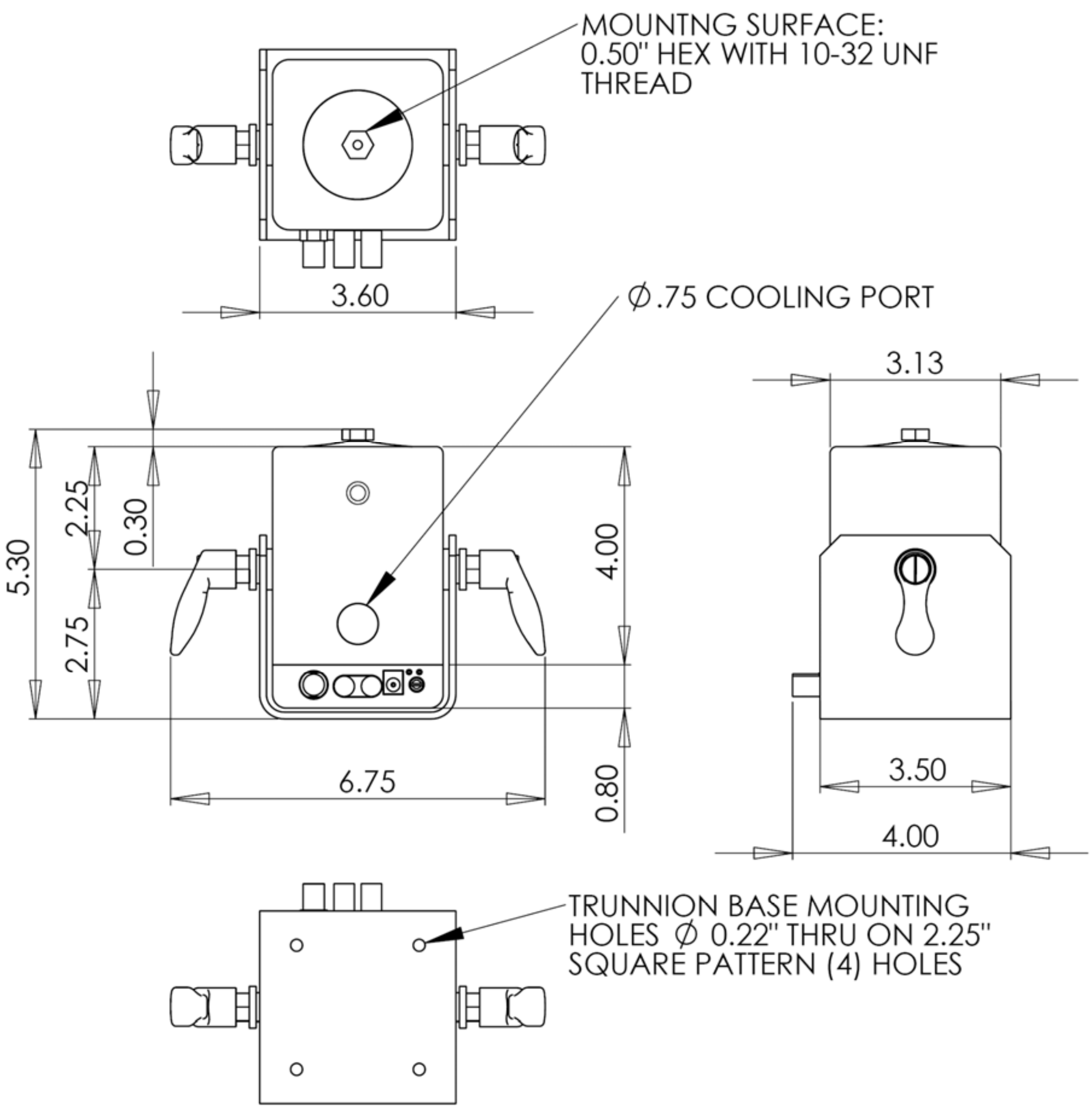
5. Slightly loosen the remaining two screws which hold the flexure foreshortening assembly in place.

6. Install the replacement armature/flexure assembly by pushing the coil gently into the magnetic gap and between the lower guide wheels. If there is excessive preload from the guide wheels they will have to be adjusted as described in subsection 4.4.1. Attach the cable clamps (loosely) and flexures to the foreshortening assembly using the screws and nut-plates removed in step 3.

7. Center the armature coil in the magnetic gap by moving the foreshortening assembly and then tighten it into place using the four screws loosened in step 5. It is important to be sure that the armature coil is centered in the gap of the magnetic structure. Nonmetallic shims should be used for this purpose and the concentricity should be maintained within .002 inches.

8. Proceed to subsection 4.4.1 step 2 for proper bearing fit.

5. OUTLINE DRAWING



PD-1375 revNR

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