Piezoelectric shaker operating guide
Models F7, F7-1, D60L, D60H, D125L

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Wilcoxon Sensing Technologies is requesting all users of the D60-series* and D125-series* piezoelectric vibration exciters (shakers) to verify they are being operated in a mode with the case electrically grounded.
Due to the high voltages used for the electrical drive signal, the case MUST BE grounded to a proper electrical safety ground connection.

For users operating either the D60-series* or D125-series* properly connected to an electrical safety ground, no action is required.

Users who operate either the D60-series* or the D125-series* in such a manner that the case is not connected to an appropriate electrical safety ground should CEASE OPERATION IMMEDIATELY and CONTACT WILCOXON SENSING TECHNOLOGIES directly.

For users operating either the D60-series* or D125-series* ELECTRICALLY FLOATING or NOT PROPERLY CONNECTED to an electrical safety ground, IMMEDIATELY DISCONTINUE USE OR OPERATION and contact Wilcoxon Sensing Technologies IMMEDIATELY at:
1-800-946-2696 or 1-301-330-8811, request CUSTOMER SERVICE.

***** Models that are identified as being in the D60-series are:
D60-1, D60-1S, D60H, D60H-B, D60-M6, D60-M6B, D60-M8, D60L, D60L-1, D125H, D125L, D125L-10, and D125L-10, MOD.

WARNING: OPERATION OF THE SHAKER IS SAFE WHEN THE INSTRUCTIONS IN THIS MANUAL ARE READ THOROUGHLY BEFORE CONNECTING TO THE POWER AMPLIFIER. PARTICULAR ATTENTION MUST BE PAID TO THE SAFETY SECTION OF THIS MANUAL.

WARNING: TO PREVENT FIRE OR SHOCK HAZARD, DO NOT EXPOSE THIS EQUIPMENT TO RAIN OR MOISTURE.

WARNING: LETHAL VOLTAGES ARE PRESENT IN THE WILCOXON AMPLIFIER AND MATCHING NETWORKS.

Safety section

The piezoelectric shakers can be safely operated when the instructions in this manual are carefully followed.
This section summarizes the safety considerations. Reminders, in the form described below, will appear in the detailed instructions to assure operator awareness of these safety considerations. Qualified personnel should operate and maintain this power amplifier only after becoming thoroughly familiar with this manual.

WARNING: This symbol is used in the instruction manual where operator safety must be considered. The instruction manual should be consulted and read carefully.

CAUTION: This symbol is used when caution is needed to prevent damage to equipment. It is used where careful attention to certain procedures described in the instruction manual is needed. This symbol is also used to emphasize procedures other than normal operating procedures.

Safety summary

1. Make sure that the power amplifier is properly grounded to a good earth ground.
2. Make sure that any piezoelectric shaker being driven is properly grounded to a good earth ground.
3. Disconnect the power cord at its source before connecting or removing any cables.
4. To reduce the risk of electric shock, do not remove the power amplifier cover. No user-serviceable parts are inside. Refer all servicing issues to Wilcoxon Sensing Technologies.
5. Do not attempt to operate a power amplifier without the protective covers secured.
6. All cables must be connected between the power amplifier, matching network and shaker before electrical power is connected. Inspect for frayed or cut cables prior to operation.
7. Wear hearing protection when driving piezoelectric shakers at high levels and high frequencies.
8. Do not expose this equipment to rain or moisture.
9. Lethal high voltage may be present at any of the equipment connectors.
10. The Wilcoxon Model D125L Piezoelectric Shaker requires pressurization (minimum 1800 PSI) from a source of dry, inert gas. The shaker must be electrically connected to the matching network and power amplifier, or the shaker terminals should be shorted together, prior to pressurization or de-pressurization. Pressure must be applied or released slowly (1 minute) to prevent excessive voltages at the shaker connecting terminals. Use extreme caution when handling pressurized cylinders.
11. Use common sense and avoid haste!

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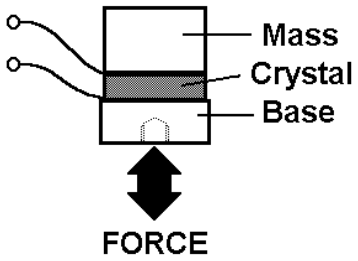
1.0 Theory of operation

The word "piezoelectricity" is derived from the Greek word "piezein" meaning "press" combined with the word electricity. Webster's dictionary[1] defines it as, "electricity or electric polarity due to pressure esp. in a crystalline substance (as quartz)." The piezoelectric effect is the production of electric current from the application of pressure to a crystalline substance.

Piezoelectricity was discovered at the Sorbonne in 1880 by Pierre and Jacques Curie. Pierre, who 18 years later collaborated with his wife in the discovery of radium, was 21 years old and Jacques was 24 when the brothers first demonstrated the piezoelectric effect. In her biography of Pierre, Marie Curie pointed out that the youthful discovery was not an accident but the product of extensive theoretical and experimental study of the symmetry of crystalline matter. Crystallographic and mathematical relations governing piezoelectricity were developed in the few years following the discovery. Crystals studied in this early period included quartz, tourmaline and Rochelle salt. The Curie brothers discovered the reverse of the piezoelectric effect in 1881. The reverse effect is that crystals would deform from the application of an electric field. It is this reverse effect that is employed in piezoelectric shakers.



Since the piezoelectric effect is bi-directional, it means that piezoelectric elements can be used to transform mechanical energy to electrical energy or vice versa. This energy transforming property means that piezoelectric elements are transducers. Piezoelectric shakers are a specific type of transducer, one where an electrical signal is transformed into mechanical displacement. The displacement of the piezoelectric material is in the order of microns of motion. Consequently, piezoelectric force generators (shakers) develop little useful acceleration in the low frequencies. Piezoelectric generators can be used successfully for vibration excitation at frequencies above 1,000Hz.

2.0 Product description

Piezoelectric shakers and tables are designed for use in the vibration test and analysis field. They utilize the properties of piezoelectric crystals for high level sonic and ultrasonic structural excitation. Conventional large electromagnetic shakers are limited to a frequency range of only several kHz while piezoelectric shakers and tables allow operation past 20 kHz. The largest piezoelectric shaker table, model D125L, surpasses

[1] Merriam-Webster's Collegiate® Dictionary, Tenth Edition, 1995

the capabilities of a 3,000 pound (13,000 Newton) electromagnetic shaker at frequencies above 4 kHz. Piezoelectric shakers can be mounted on top of large electromagnetic shakers to provide both low and high frequency capabilities in one set-up. The model F7 shaker is specifically designed to be mounted within the central core of either the Wilcoxon F4 or F10 electrodynamic shaker.

Piezoelectric shakers consist of three main components: the head or table, the compliant piezoelectric stack and the reaction mass. Below the fundamental resonance frequency of this system, the output for a given input voltage is displacement controlled. For example, if the displacement is 1 micron per 1,000 volts input, then a 1,000 volt, peak, sine wave will produce an acceleration of 4g, peak, at 1 kHz or 100g, peak at 5 kHz. The acceleration of the table is proportional to the square of the frequency times displacement.

Above the fundamental resonance frequency the output is force controlled. The force generated by the piezoelectric shakers can be up to 2,000 Newton, peak (800 Vrms) by the F7 model, 50 Newton, peak (800 Vrms) by the F7-1 model, 3,000 Newton, peak (1,500 Vrms input), by the D60 models and 13,000 Newton, peak (1,500 Vrms input), for the D125L model.

The output of the shaker with a typical test specimen attached to the shaker or table is dependent on the mechanical impedance of the specimen. At anti-resonances (maximum impedance) the displacement of the table is at a minimum, but the specified force is delivered, provided that the impedance of the base mass is sufficiently high. At the resonances (minimum impedance) the shaker or table acceleration must be limited to the maximum specified levels for the individual shakers or tables. The blocked force output curves refer to the force developed against a mass of infinite impedance. The graphs on the product data sheets for the shakers show typical frequency response and may vary between shakers. Matching of shakers to a common first resonance frequency is available on special order. Wide fluctuations in force output are present at very high frequencies; however, these shakers can be used as a source of structural excitation above 60,000 Hz.

Piezoelectric shakers present a capacitive (reactive) load to power amplifiers, therefore the electrical impedance decreases with increasing frequency. A large power amplifier is required to drive a shaker at maximum voltage to its maximum frequency. Smaller amplifiers may be used to drive the shaker at maximum output at lower frequencies. Optimum operation over a range of frequencies requires the proper impedance matching network between the power amplifier and piezoelectric shaker.

2.1 Piezoelectric reaction shakers

Piezoelectric reaction shakers are compact, lightweight shakers that utilize the expansion/contraction properties of piezoelectric crystals for sonic and ultrasonic structural excitation. These portable reaction-type shakers generate large dynamic forces to very high frequencies for structural excitation in vibration research and testing. The reactive principle of operation combined with a lightweight and compact configuration allows these generators to be stud-mounted in any position, directly to structures, without external support or critical shaft alignment problems. The F7 piezoelectric vibration generator is designed to mate with the F4 electromagnetic vibration generator to extend the frequency range down to low frequencies (see the specification sheet for model F4/F7 for details).

A transducer base is located on the model F7 and has a transducer containing a force gage and an accelerometer. These transducers are built into the attachment point of the F7 and measure the force applied to the structure (force gage) and the resulting vibratory motion (accelerometer). The transducer signals can be fed into either the read-out equipment or into signal conditioners. During the design of this base, particular attention was given to yield a minimum mass below the force gage.

Applications for these instruments include such areas as biomedical research, production testing, mechanical impedance studies, high frequency vibration research and other areas where structural excitation over a wide frequency range is required.

2.1.1 Model F7 piezoelectric shaker

The model F7 piezoelectric shaker is a compact, lightweight shaker that produces large dynamic forces to high frequencies for structural excitation. The model F7 piezoelectric shaker is supplied with an impedance head that contains a force transducer and internal high impedance accelerometer to monitor the force applied to the test structure and the resultant motion.

The Wilcoxon model N7FS matching network is designed for use with the model F7 piezoelectric shaker.

The impedance head transducer base consists of a cylindrical titanium housing containing a piezoelectric accelerometer and a piezoelectric force gauge. The transducer base is mounted concentrically within the model F7 piezoelectric shaker.

When applying a sinusoidal force to a structure with a shaker equipped with an impedance head, one can calculate the mechanical impedance of the structure from

values of the applied force (force gauge output) and the resulting motion at the point of force application (accelerometer output).

2.1.2 Model F7-1 piezoelectric shaker

The model F7-1 piezoelectric shaker is a compact, lightweight shaker that produces large dynamic forces to very high frequencies for structural excitation. The model F7-1 shaker is, typically, used without an impedance head and produces higher frequencies than the model F7 piezoelectric shaker.

The Wilcoxon model N8HFS matching network is specifically designed for the model F7-1 piezoelectric shaker.

The model F7-1 piezoelectric shaker has a mounting base with one tapped hole, 1/4-28 UNF in the center of the base, and four equally spaced tapped holes, 10-32 UNF, on a one-inch circle.

2.2 Piezoelectric shaker tables

Piezoelectric shaker tables are designed for use in the vibration test and analysis field. They utilize the properties of piezoelectric crystals for high level sonic and ultrasonic structural excitation. They produce more force than the piezoelectric reaction shakers and are not, generally, supplied with an attached impedance head for measuring the force or acceleration imparted to a test specimen. Piezoelectric shaker tables consist of three main components: the table, the compliant piezoelectric stack and the base mass. Below the fundamental resonance frequency of this system, the output for a given input voltage is displacement controlled. Above the fundamental resonance frequency the output is force controlled.

The output of the shaker with a typical test specimen attached to the table is dependent on the mechanical impedance of the specimen. At anti-resonances (maximum impedance) the displacement of the table is at a minimum, but the specified force is delivered, provided that the impedance of the base mass is sufficiently high. At the resonances (minimum impedance) the table acceleration must be limited to the specified levels.

2.2.1 Model D60H piezoelectric shaker table

The model D60H piezoelectric shaker table is designed as base-mounted shaker table for vibration testing at frequencies up to 50,000 Hz. It is useful for structural excitation

for modal analysis and device testing. The model D60H is not supplied with an impedance head.

The Wilcoxon model N8FS matching network is designed for use with the model D60H piezoelectric shaker table.

The standard model D60H piezoelectric shaker table has seven (7) bolt holes for mounting test specimens. The central hole is a 10-32 NF threaded hole 0.38 inches (9.6 mm) deep. Surrounding the central mounting hole are six (6) ¼-28 NF threaded holes 0.5 inches (12.7 mm) deep mounting holes equally spaced around a 1.614 inch (41 mm) diameter circle.

2.2.2 Model D60L piezoelectric shaker table

The model D60L piezoelectric shaker table is designed as base-mounted shaker table for vibration testing at frequencies up to 20,000 Hz. It is useful for structural excitation for modal analysis and device testing. The model D60L is not supplied with an impedance head.

The Wilcoxon model N8FS matching network is designed for use with the model D60L piezoelectric shaker table.

The standard model D60L piezoelectric shaker table has nine (9) bolt holes for mounting test specimens. There is no central hole on the standard shaker. There are six (6) ¼-28 NF threaded holes 0.5 inches (12.7 mm) deep mounting holes equally spaced around a 1.61 inch (40.9 mm) diameter circle. Set within this same circle are three (3) 10-32 NF threaded holes 0.48 inches (12.2 mm) deep mounting holes equally spaced around a 1.614 inch (41 mm) diameter circle.

2.2.3 Model D125L piezoelectric shaker table

The model D125L piezoelectric shaker table is designed as base-mounted shaker table for vibration testing at frequencies up to 20,000 Hz. It is useful for structural excitation for modal analysis and device testing. The model D125L is not supplied with an impedance head.

The Wilcoxon model N8FS matching network is designed for use with the model D125L piezoelectric shaker table.

The standard model D125L piezoelectric shaker table has ten (10) bolt holes for mounting test specimens. The central hole is a 3/8-16 NF threaded hole 0.75 inches (19

mm) deep. There are six (6) 3/8-16 NF threaded hole 0.75 inches (19 mm) deep mounting holes equally spaced around a 3.0 inch (76.2 mm) diameter circle. Set around this same circle are three (3) 10-32 NF threaded holes 0.48 inches (12.2 mm) deep mounting holes equally spaced around a 3.5 inch (89 mm) diameter circle.

A static source of inert gas (nitrogen is recommended) at 1,800 psi minimum (124 Bars) is required to pressurize the D125L for the static pre-load on the piezo-ceramic stack. The gas must be connected to the pressure fitting on the side of the shaker through a 1/4 “ high pressure hose and a 1 /4 “ x 37° flare swivel fitting (7/16-20 threaded coupling).

WARNING: When the D125L is being pressurized, lethal high voltage can be generated at the connection terminals of the D125L shaker. The shaker electrical leads should be shorted together during pressurization and de-pressurization to prevent a shock hazard.

2.3 System components

2.3.1 Model F7 piezoelectric shaker system

The model F7 piezoelectric shaker system comes complete with the Model F7 piezoelectric shaker, the Z7 impedance head, all input and output cables, a mounting stud, and a spanner wrench.

2.3.2 Model F7-1 piezoelectric shaker system

The model F7-1 piezoelectric shaker system comes complete with the model F7-1 piezoelectric shaker, all input cables, a mounting stud, and a spanner wrench.

2.3.3 Model D60H piezoelectric shaker table

The model D60H piezoelectric shaker table comes with an R7-7M-J59-12 input cable.

2.3.4 Model D60L piezoelectric shaker table

The model D60H piezoelectric shaker table comes with an R7-7M-J59-12 input cable.

2.3.5 Model D125L piezoelectric shaker table

The model D60H piezoelectric shaker table has an integral input cable with a special high-voltage BNC connector to mate with the N8FS. A high-pressure hose is supplied for pressurization of the crystal stack of the D125L.

2.4 Matching networks: theory and operation

CAUTION: If you attempt to operate a piezoelectric shaker without a matching network, you risk serious damage to the output stage of the power amplifier used to drive the piezoelectric shaker.

While an electromagnetic shaker presents a low, relatively constant, largely resistive impedance, a piezoelectric shaker is essentially capacitive. This means that the impedance presented by the piezoshaker will decrease almost linearly with increasing frequency. However at the shaker systems' resonant frequency, the impedance is real and extremely low. The matching networks include series resistance to prevent damage to the power amplifiers at resonance. A piezoshaker creates a displacement proportional to the voltage input for frequencies below its resonance. Therefore in order to get maximum displacement and consequently maximum acceleration levels at low frequencies the voltage must be stepped up significantly.

Note: If a constant voltage (i.e. constant displacement) independent of frequency is generated, then the acceleration and force outputs will increase with the square (i.e. at 40dB per decade) of the frequency up to the resonance of the piezoshaker.

The impedance matching network normally consists of a step-up transformer, and an output tap switching arrangement. A variety of output voltages are then available to maximize the voltage delivered to the piezoshaker at different frequencies. Due to the capacitive nature of the piezoelectric shaker, the output impedance of the power amp, and the impedance transformation of the matching network's transformer the voltage at the piezoelectric shaker rolls off at 20dB per decade after the corner frequency (exactly like an RC filter). As the voltage switch setting on the matching network is switched from highest to lowest the bandwidth of the system will increase.

In general, the piezoshaker can be operated at their lower frequencies with the matching network switch in its highest voltage position. The relatively low load (high impedance) of the piezoshaker at low frequencies is not demanding and the power

amplifier can maintain the high voltage swing for maximum shaker output, however as the operating frequency increases, lower output voltage taps become more efficient. The greatest power requirements for the power amplifier will occur at the corner frequencies of the matching network and shaker system and at the resonant frequency of the shaker.

CAUTION: The piezoshakers can be damaged by internal heat build up when run at high levels for extended periods. This is due to the dielectric loss tangent of the piezoceramic material that generates heat. When driven at high power levels this heat buildup will raise the temperature of the piezoceramic to the Curie temperature were it will depolarize itself. Please contact Wilcoxon for assistance when extended high output testing will be performed.

CAUTION: Reduce power to minimum prior to changing switch settings.

The N7FS matching network connects to the power amplifier and provides selectable maximum voltage outputs of 100, 200, 300, 500, and 800 Vrms. The N7FS matching network is designed to power the model F7 piezoelectric shaker.

The N8FS matching network connects to the power amplifier and provides selectable voltage outputs of 300, 450, 800, 1150, and 1500 V rms. The N8FS matching network is designed to power the model D60L, D60H, or D125L piezoelectric shaker.

The N8HFS matching network connects to the power amplifier and provides a maximum voltage output of 360 Vrms. The N8HFS matching network is designed to power the model F7-1 piezoelectric shaker.

2.5 Optional accessories

Accessories available from Wilcoxon Sensing Technologies for these systems include power amplifiers, high-pressure supply hose, mounting hardware, and cables. Refer to the Wilcoxon catalog for product numbers and ordering information.

3.0 Initial system setup

While the piezoelectric shaker, itself, does not have any operating controls or settings, it functions as a part of a total system for vibration excitation. This system should be checked using the following steps for complete installation.

CAUTION: Complete all of these steps before operating the shaker system.

3.1 Checking components

After carefully unpacking the shakers and any accessories, inspect all external parts for visible damage to the shaker or connectors. If there is damage, file a claim with the carrier who transported the system. Retain the shipping containers and packing material for use in case reshipment is required.

CAUTION: Do not drop the shaker. The piezoelectric shaker operating element is a piezoelectric ceramic. The mechanical shock from dropping could fracture the ceramic. If space permits, it is recommended that a thick piece of protective material, such as foam rubber, be wrapped around the periphery to prevent accidents.

Ensure that you have all components of the purchased system.

3.2 Mounting instructions

The mounting surface of the Z7 impedance head must rest flush against the test structure to maintain transducer sensitivity. The F7-1 has no impedance head, but should contact the surface of the structure under test rigidly to insure adequate vibration energy transfer.

The D-series shakers tables have mounting hole patterns for attaching test structures to the table face. Placing a thin layer of grease between the shaker table face and the test object can help insure good mechanical energy transfer.

Do not dent shaker mounting surface when mounting to test structure.

3.3 Connect the power amplifier

Wilcoxon Sensing Technologies power amplifiers are purchased and shipped separately from vibration generator products. Refer to the operating guide supplied with the power amplifier for connection instructions. If using a power amplifier other than one supplied by Wilcoxon, follow that manufacturer's recommended procedure for installation and operation.

3.4 Connect the matching network

Wilcoxon Sensing Technologies matching networks are purchased and shipped separately from vibration generator products. Refer to the operating guide supplied with the matching network for connection instructions.

3.5 Electrical connection instructions

3.5.1 Make sure that the AC line receptacle used for the power amplifier is properly grounded to a good earth ground.

WARNING: Do not operate the system without proper grounding.

3.5.2 Decrease power to minimum before changing the matching network switch positions.

3.5.3 Before making any changes in electrical connections, turn signal input level to a minimum and turn main power switch off on the power amplifier.

3.5.4 After the shaker system and its components are properly connected and mounted to the test specimen, the accelerometer and force gauge outputs in the impedance head should be connected to the proper signal conditioners and to the readout device.

CAUTION: Powering systems supplied by Wilcoxon Sensing Technologies are designed such that the maximum input voltage cannot be exceeded. Do not exceed the maximum input voltage to the piezoelectric shaker if another powering system is used.

3.5.5 The following table indicates the cable types and connections for the Wilcoxon Sensing Technologies power amplifiers, matching networks, and piezoelectric shakers. This table should be consulted for guidance as to cable and equipment connection.

Table 3.5 – Interconnecting cables

Piezoelectric shaker	Cable from power amplifier to matching network	Matching network	Cable from matching network to shaker
F7	R22-22-J9B-5	N7FS	R4-4M-J9-10
F7-1	R22-22-J9B-5	N8HFS	R4-4M-J9-10
D60L	R22-22-J9B-5	N8FS	R7-7M-J59-12*
D60H	R22-22-J9B-5	N8FS	R7-7M-J59-12*
D125L	R22-22-J9B-5	N8FS	Integral, high voltage BNC*

*** Note: The D-series shakers also have a screw terminal on the shaker for attaching an additional ground wire between the shaker and matching network for increased safety.**

3.6 Model Z7 impedance head connection

The Z7 impedance head is an integral part of the model F7 piezoelectric shaker. It contains a piezoelectric accelerometer and a piezoelectric force gauge. The output from these high impedance, charge-mode sensors is from two 10-32 coaxial (Microdot) connector jacks on the periphery of the transducer. They are marked “A” for acceleration, and “F” for force.

4.0 Operation

The vibration generating system is ready for operation only after it has been thoroughly checked for proper electrical connections. The user should have selected a suitable location for the system, preferably in a sound isolated room, since the shaker may generate a considerable amount of sonic output.

WARNING: It is recommended that the operating personnel use hearing protection.

The following steps are suggested for operation of the vibration generating system:
1. Make sure the oscillator amplitude control is set to a minimum or off.
2. Adjust the matching network selector switch to the lowest output amplitude setting.
3. (Optional, depending on your system configuration.) Turn on the vibration monitoring system consisting of the accelerometer and its associated output-measuring or display instruments.
4. Turn on the oscillator and set its frequency dial to the low end of the desired frequency range of the test sequence.

5. STAND CLEAR OF THE SHAKER DURING OPERATION.

WARNING: The D125L shaker face is pre-loaded by the high pressure nitrogen. NEVER place any portion of your body directly in line with the shaker face.

6. Set the amplifier power switch to ON.
7. Slowly increase the setting of the signal generator amplitude control until the shaker generates the desired vibration level or until clipping of the power amplifier output occurs.
8. (Optional, depending on your system configuration.) It is recommended to use a monitoring system to monitor the amplifier output to prevent overdriving the shaker.
9. Continue the test by changing the oscillator frequency dial and adjusting the amplitude control to attain the desired vibration levels.
10. When using a matching network, higher vibration levels can be obtained by turning the signal generator output amplitude control to minimum before turning the matching network selector switch to a higher output voltage setting when required.
11. Proceed as in steps 8 and 10 above.
12. When the test sequence is completed, turn down the signal generator output amplitude control then turn the matching network selector switch to the minimum output position.
13. Set the power amplifier power switch to OFF.

5.0 Warranty

Wilcoxon Sensing Technologies offers a Warranty service plan for all Wilcoxon-manufactured products. Under this plan Wilcoxon will repair or replace any part or component that is not operating in accordance with published specifications.

This warranty service plan does not include:

- Products improperly installed or calibrated.
- Products damaged, misused, or misapplied.
- Products not manufactured by Wilcoxon Sensing Technologies.
- Unauthorized repairs or alterations.
- Neglect or accidents.

To receive service, contact Wilcoxon for a return materials authorization (RMA) number. To assure delivery acceptance, write the RMA number clearly and in an obvious place on the outside of the package containing the part or component. The RMA number should be referenced on all paperwork. Shipment to Wilcoxon must be prepaid by the customer. After repair or replacement, Wilcoxon will return the part or component to the

customer prepaid by Wilcoxon. Alternatively, the customer may desire on-site work. In such cases, the customer may be required to pay travel and per diem for service personnel.

This service is offered to the customer at NO CHARGE for a period of two (2) years from shipment of the hardware from the factory. The period of this warranty service Plan may vary for specific models. At the end of this period the repair or replacement service shall be terminated. Renewals of this basic plan will be available on selected products. The products must be recertified or repaired to original specifications by Wilcoxon Sensing Technologies before the service agreement can be renewed. Wilcoxon's liability for incidental and consequential damages is expressly excluded. THIS WARRANTY SERVICE PLAN IS THE EXCLUSIVE REMEDY FOR CORRECTIONS OF IMPROPERLY PERFORMING PARTS AND COMPONENTS. NO WARRANTIES, EITHER EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR USE OR PURPOSE ARE GIVEN. If full payment on the goods is not received by Wilcoxon Sensing Technologies, this warranty service plan is null and void.

6.0 Technical assistance

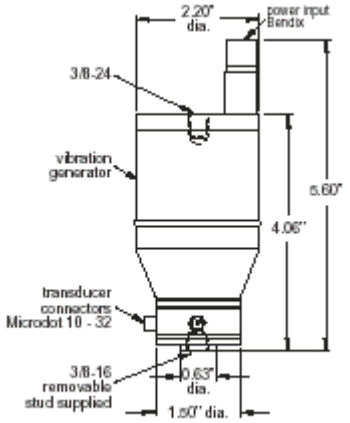
6.1 Technical assistance

For technical assistance, please contact Wilcoxon's Product Manager at 301-330-8811, fax to 301-330-8873, or email to info@wilcoxon.com.

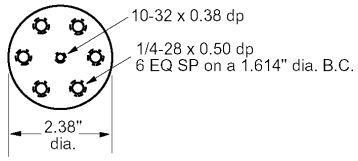
6.2 Customer service

For all customer service inquiries, please call 301-330-8811, fax to 301-330-8873, or email info@wilcoxon.com.

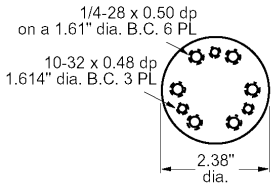
Appendix – Mechanical drawings



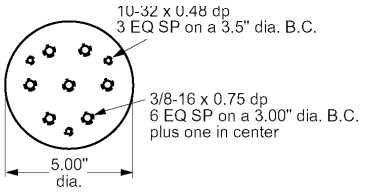
Model F7



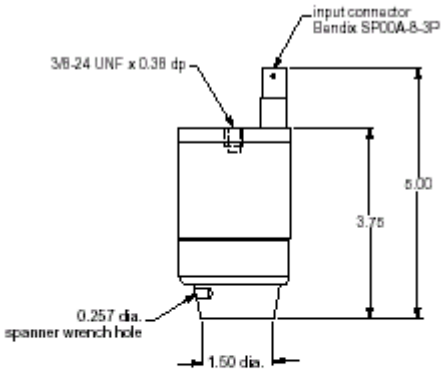
D60H bolt hole pattern

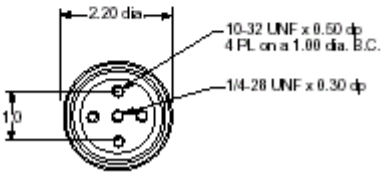


D60L bolt hole pattern



D125L bolt hole pattern





Model F7-1