Operating Instructions, Installation Information, and Calibration Certificates:

Linear and Angular Servo Accelerometers

JEWELL INSTRUMENTS, LLC

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WARRANTY

Jewell Instruments warrants their products for a period of one year to date of shipment to original purchaser and guarantees to be free from defects in material and workmanship. The liability of Seller under this warranty is limited to replacing or repairing any instrument or component thereof which is returned by Buyer, at his expense, during such period and which has not been subjected to misuse, neglect, improper installation, repair, alteration, or accident. Seller shall have the right to final determinations as to the existence and cause of defect. This warranty is in lieu of any other warranty, expressed, implied or statutory; and no agreement extending or modifying it will be binding upon Seller unless in writing and signed by a duly authorized officer.

RECEIVING INSPECTION

Every Jewell Instrument is carefully inspected and is in perfect working order at time of shipment. Each instrument should be checked at soon as it is received. If the unit is damaged in any way or fails to operate properly, a claim should immediately be filed with the transportation company.

FACTORY SERVICE

Whenever a Jewell Instrument requires service, the nearest Jewell representative should be contacted. If it is determined that the unit does require factory service, call the repair department at 603-669-6400 at which time a Return Material Authorization (RMA) number will be assigned. The following information is necessary to obtain an RMA number:

- Model Number
- Serial Number
- Quantity
- Symptoms of the problem with the unit to be repaired
- If under warranty: Original Purchase Order number or Jewell Sales Order number

Repairs will not be accepted without the RMA number. Address all inquiries on operation or application to your nearest Sales Representative (a listing is available on the Where to Buy section of our website at www.jewellinstruments.com) or to:

Jewell Instruments
C/O Sensors and Controls Sales Dept.
850 Perimeter Rd
Manchester, NH 03103

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INTRODUCTION

The AS Series of angular accelerometers and the LS Series of linear accelerometers are solid-state, DC, closed-loop, force-balanced accelerometers with accuracy, stability and reliability several orders of magnitude greater than open-loop types. They are ideally suited to the precise requirements of inertial guidance and control systems.

These are pendulous devices, balanced for angular acceleration and unbalanced for linear acceleration. They operate on a torque balance principle from the equation:

TORQUE = MOMENT OF INERTIA X ACCELERATION

It follows that angular acceleration applied to an accelerometer and acting on a rotatable bearing-mounted balanced mass will develop a torque about the axis of rotation. Similarly, linear acceleration applied and acting on unbalanced mass will develop a torque. By arranging the mass so that any resultant motion develops an electrical signal which is properly amplified and supplied to an electrical torque generator acting on the mass, equilibrium is produced between the two torquers.

The electrical torque generator, a coil in a magnetic field, develops a torque proportional to the coil current. The net result is a current proportional to the acceleration, accompanied by an infinitesimal displacement of the pendulous mass. By permitting the current to pass through a stable resistor, a voltage proportional to acceleration is developed.

The advantage of such a system is that that two main sources of inaccuracy in the open-loop accelerometer, the mechanical spring and the displacement-to-voltage transducer, are eliminated. Thus, problems of non-linear springs, mechanical hysteresis, temperature coefficient of modulus of elasticity, spring deflection due to temperature or fatigue, are non-existent with these torque balance devices. Problems inherent to open loop accelerometers, such as non-linearity in the acceleration-to-position pickoff, temperature coefficient of scale factor, and zero shift with temperature, are eliminated.

A DISCUSSION OF TERMS AND OPERATIONAL PARAMETERS

Specific information about your accelerometer appears on the individual SERVO ACCELEROMETER DATA SHEET, which is included in this document. Explanations of the terms appearing on the data sheet are as follows:

POWER SUPPLY VOLTAGE(S)
If the (S) is not crossed out, an entry such as + 15 volts describes the required-dual (or balanced) power supply. To eliminate misinterpretation, such a supply will measure 30 volts between the plus terminal of the plus supply and the minus terminal of the minus supply. If the (S) is crossed out with an entry made such as 28 volts, this describes a single power supply.

POWER SUPPLY CURRENT
The entry made here is the maximum of either of the dual supplies, or is that of a single supply at the power supply noted, with the accelerometer in its normal altitude with zero applied acceleration.

NATURAL FREQUENCY
This is the frequency at which the phase of the output signal lags the phase of the applied acceleration by 90°.

DAMPING RATIO
This is a measure of the amount of damping. Critical damping is that condition of damping in which the response at the natural frequency is -6 Db. Damping ratio is the ratio of actual damping to critical damping. Thus the damping ratio corresponding to the critical damping would be 1.0.

RANGE
This describes the plus and minus input acceleration limits for linear output. For an angular accelerometer RADIANS/SEC^2 will appear instead of g.

SCALE FACTOR
The number entered bears no plus or minus sign, and the sign is carried by the entry under RANGE. Thus multiplying RANGE by SCALE FACTOR will give the plus and minus full range voltage limits. In the case of a typical telemetry-type unit with a single power supply there will be a ZERO OFFSET entry of + 2.5 volts, which must be added to the voltage limits calculated above.

CROSS AXIS-SENSITIVITY
Ideally, input acceleration vectors perpendicular to the true sensitive axis should not introduce acceleration vector components in line with the sensitive axis, and thus cause equivalent voltage signal outputs. CROSS AXIS SENSITIVITY is defined as accelerometer output per g of input acceleration perpendicular to the sensitive axis and parallel to the mounting base. The approximate magnitude of the CROSS AXIS SENSITIVITY can be determined by placing the accelerometer with (1) its sensitive axis, and (2) a side of the accelerometer, both perpendicular to the gravity vector. After making allowance for ZERO OFFSET, the accelerometer output will then approximate the stated CROSS AXIS SENSITIVITY.

NOISE
Generally random, and the value is entered as a read on an averaging type unfiltered, high-impedance ac voltmeter.

LINEARITY
As entered here, this defines the maximum plus or minus voltage deviation from a straight-line plot, divided by the total voltage between rated voltage limits, times 100. For the usual + 5 volt instrument, if the maximum deviation is + 0.005 volts, the % linearity will be:

$$\frac{+\,0.005}{+\,5-(-5)} \times 100 = +\,0.05\%$$

As entered, the + sign is omitted.

OUTPUT IMPEDANCE
This defines the DC resistance of either the internally-installed or specified external load resistor across which rated force-balance current develops the rated output-signal-voltage.

ZERO OFFSET
This is defined as the voltage-signal-output with no intentional acceleration components along the sensitive axis and is caused by either a small residual spring force, or an INTERNAL 1g BIAS that does not balance the effect of 1g gravity precisely. The resultant offset voltage adds to the output signal for one direction of applied acceleration and subtracts for the other. This generally is limited to +0.1% of full scale; that is, +0.010 volts for a +5 volt instrument. Note that an output observed when an unbiased unit is oriented with its mounting base horizontal is not necessarily equal to the ZERO OFFSET because there may also be an output due to HORIZONTAL AXIS ALIGNMENT which will add or subtract from the ZERO OFFSET.

HORIZONTAL AXIS ALIGNMENT
This defines the non-coincidence of the true sensitive axis with a designated geometrical element of the accelerometer. If for example, a finite angle exists between the true sensitive axis and the designated element (most often the plan of the mounting base), acceleration applied parallel to the base will provide an acceleration component along the sensitive axis proportional to the cosine of the angle. Generally this is not of significance for small angles, since the cosine of an angle as large as 1° is equal to .9998 (a .02% reduction). However, if the accelerometer is intended to measure horizontal acceleration in a 1g gravity field perpendicular to the sensitive axis, it is desirable that the true sensitive axis be exactly parallel to the mounting base. If it is not, a component of gravity proportional to the sine of the angle will constantly be applied along the true sensitive axis, yielding a significant error. Except when specifically designed or adjusted to be less, the HORIZONTAL AXIS ALIGNMENT, the angle between the true sensitive axis and the plane of the mounting base, is a maximum of +0.5 degree, or in g units represents +.00873g. The value entered in volts is the value of the output signal equivalent to the existing angle and is proportionally larger for low g-range accelerometers than high g-range accelerometers. Note that the value entered is not the value observed when an unbiased unit is placed on true horizontal surface. The value observed is a combination of ZERO OFFSET voltage and the component due to axis tilt, and in the case of an unbiased low-g instrument, can be completely eliminated at installation by shimming the mount base appropriately.

SENSITIVE AXIS ATTITUDE FOR ZERO OFFSET OUTPUT
This is the attitude for which that value entered under ZERO OFFSET is obtained. For example, a telemetry output instrument will generally have +2.5 volts entered under ZERO OFFSET. If such an instrument is also equipped with an INTERNAL 1g BIAS, the entry under SENSITIVE AXIS ATTITUDE will be _____HOR_____VERT, CONNECTOR _____UP_____DOWN. A standard BALANCE POWER SUPPLY instrument with an INTERNAL 1g BIAS might typically have an entry under ZERO OFFSET of +0.002 volts. The entry under SENSITIVE AXIS ATTITUDE will be

_____HOR_____VERT, CONNECTOR _____UP_____DOWN. Any instrument without an INTERNAL 1g BIAS will have the entry _____HOR_____VERT, CONNECTOR _____UP _____DOWN.

LINEAR ACCELERATION APPLIED IN DIRECTION OF SENSITIVE AXIS ARROW AWAY FROM CONNECTOR CAUSES OUTPUT VOLTAGE TO BECOME MORE___________.

Standard units display a double-ended sensitive axis arrow and have the external connectors located close to an end (rather than centered on face). In almost all units, the sensitive axis is perpendicular to the face of the housing of smallest areas (the ends). Thus acceleration is applied along the sensitive axis in a direction either toward or away from an end of the unit close to the external connector (or pins).

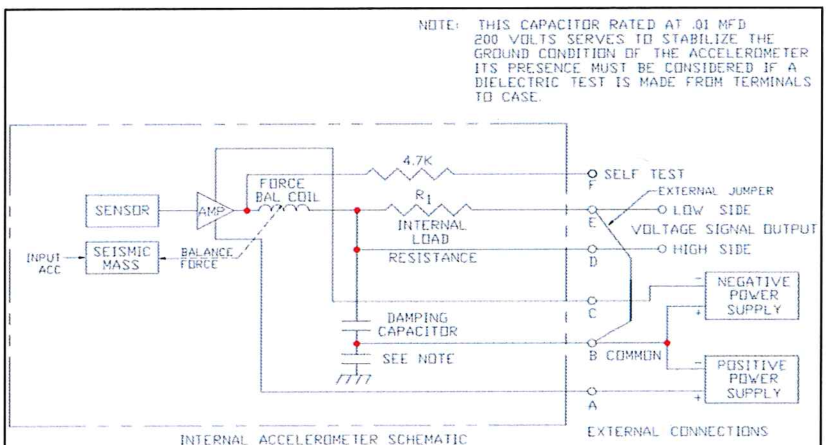
The entry will be either NEGATIVE or POSITIVE. For most standard units with or without INTERNAL 1g BIAS, and for most telemetry units with or without INTERNAL 1g BIAS, the entry will be POSITIVE. This means that is the ZERO OFFFSET entry is zero volts, the output will become positive at the signal terminal (terminal D for most instruments). For a telemetry unit with a ZERO OFFSET entry of +2.5 volts, the output will rise toward +4.8 volts.

ANGULAR ACCELERATION APPLIED CLOCKWISE AS VIEWED LOOKING AT THE SENSITIVE AXIS PLATE CAUSES OUTPUT VOLTAGE TO BECOME MORE_________.

The angular acceleration axis is perpendicular to the surface bearing the curved double end arrow and passes through the center of the arc. For most standard units, the entry will be POSITIVE.

HOW TO USE THE ACCELEROMETER

In the most common configuration, a dual power source is used, and a VOLTAGE OUTPUT SIGNAL is available. In this configuration, the force balance current flows through a low-temperature-coefficient internal resister R_1, which returns the current to the midpoint of the dual power supply. This operating mode is shown in Figure 1.



ACTUAL FULL SCALE FACTOR AVAILABLE DEPENDS ON LOAD RESISTANCE THE RECEIVING CIRCUIT IMPOSES LET R_E REPRESENT THIS RESISTANCE. MULTIPLY RATED SCALE FACTOR BY:

$$\frac{R_E}{R_1 + R_E}$$

FIGURE 1 VOLTAGE SIGNAL OUTPUT WITH INTERNAL LOAD

Note that the return path for R_1 is made externally.

Figure 1A differs from Figure 1 only in showing the protective resistor and the bias circuit. This diagram covers accelerometers furnished with an INTERNAL 1g BIAS, as well as other bias that might be required for units to be used with the sensitive axis inclined at any angle from the horizontal or when zero output is desired other than zero g input.

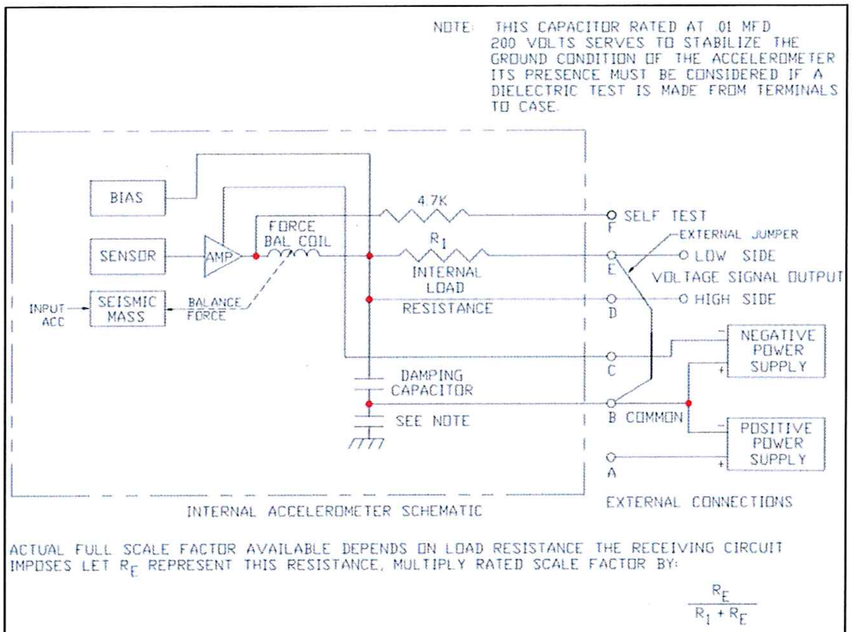


FIGURE 1A. VOLTAGE SIGNAL OUTPUT WITH INTERNAL LOAD -BIAS OPTION

The ability to complete the current path externally permits two additional operating modes. In one, an alternative load resistor may be substituted. As an example, suppose that the internal resistor is 5,000 ohms, and that the normal full-range-voltage available across this resistor is +5 volts. If the resistance of the external circuit is 5,000 ohms, it will in effect shunt the internal load so that it is equal to 2,500 ohms, and the full-range-output-voltage will then be reduced to +2.5 volts. However, if it is more suitable, the 5,000 ohm (resistive) circuit may replace the internal resistor, and this is illustrated in Figure 2.

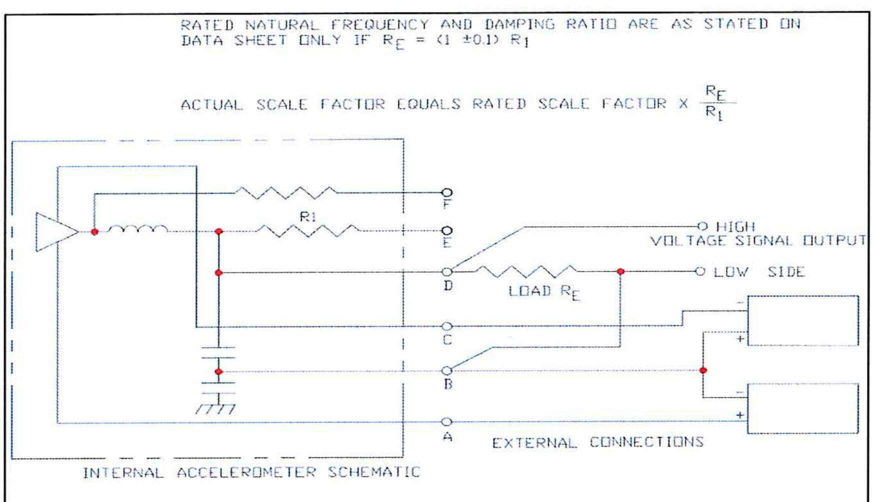


FIGURE 2 VOLTAGE SIGNAL OUTPUT WITH INTERNAL LOAD

In the second mode, CURRENT ANALOG operation may be selected instead of VOLTAGE ANALOG operation. The proper connections are illustrated in Figure 3. The full-range current of 1 milliamp ere in most cases is available to flow through the external circuit if it is of relatively low resistance (resistance of 20% or less of the internal resistance of the accelerometer). Note that the INTERNAL RESISTANCE is recorded on the accelerometers individual data sheet. Rate full-range-current is recorded on the individual data sheet.

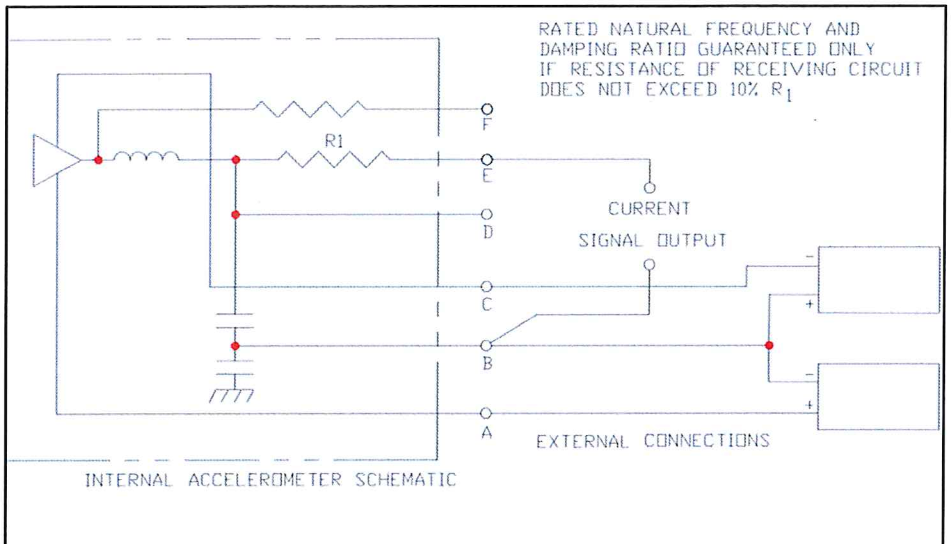


FIGURE 3 CURRENT SIGNAL OUTPUT

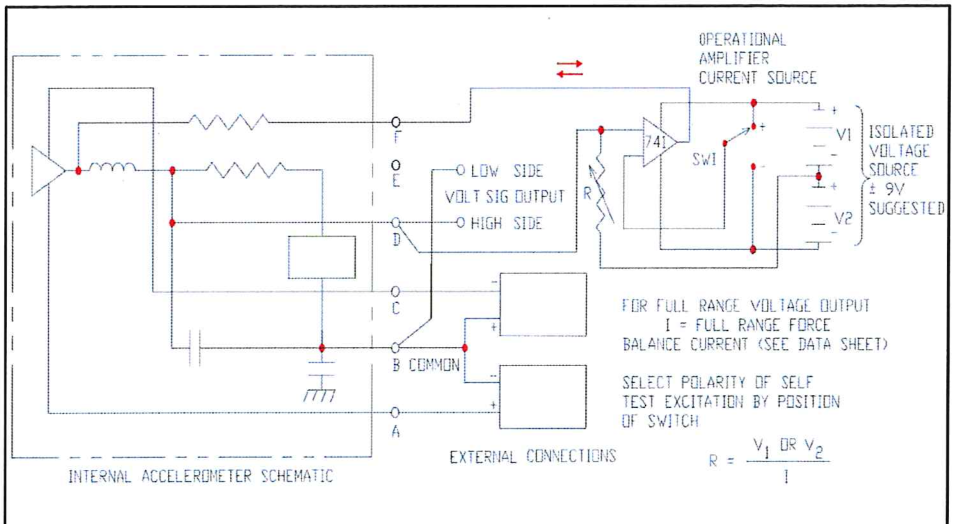


FIGURE 4 DC SELF TEST

The isolated current source shown has a high-impedance, 10 megohms or higher. If the accelerometer is working properly, servo-action will cause it to develop a current in the force-balance coil equal and opposite to the injected current. The net effect is that this current will be forced through the internal load resistor just as if it were being developed by an applied acceleration. Rated current injected will result in rated signal-voltage-output. Once the self-test source has been set up to produce this response, any failure to achieve rated signal-voltage-output is an indication that the accelerometer is not operating properly.

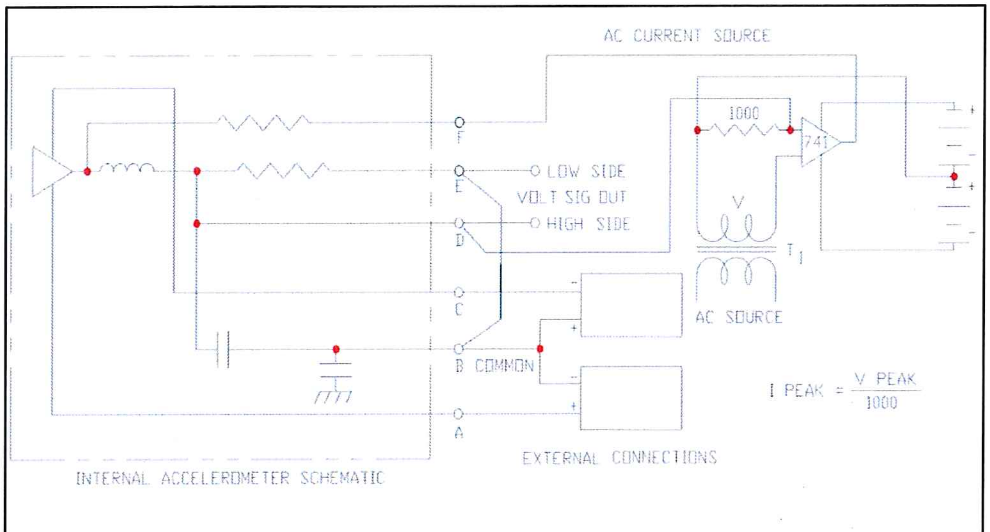


FIGURE 5 AC SELF TEST

The AC self-test circuit of Figure 5 is an AC version of the DC operational amplifier current source shown in Figure 4. It may be used to examine the frequency response or to produce a simulated AC input to the system receiving the accelerometer output. Only 1 volt is required in the secondary of T1 for 1 mA peak AC self-test current. Since the secondary of T1 is lightly loaded by the non-inverting input to the amplifier, it is possible to attain even very low frequency excitation despite the low efficiency of a transformer at low frequencies.

If it is desired only to check the operation of a control system, a simpler method is possible, illustrated in Figure 6.

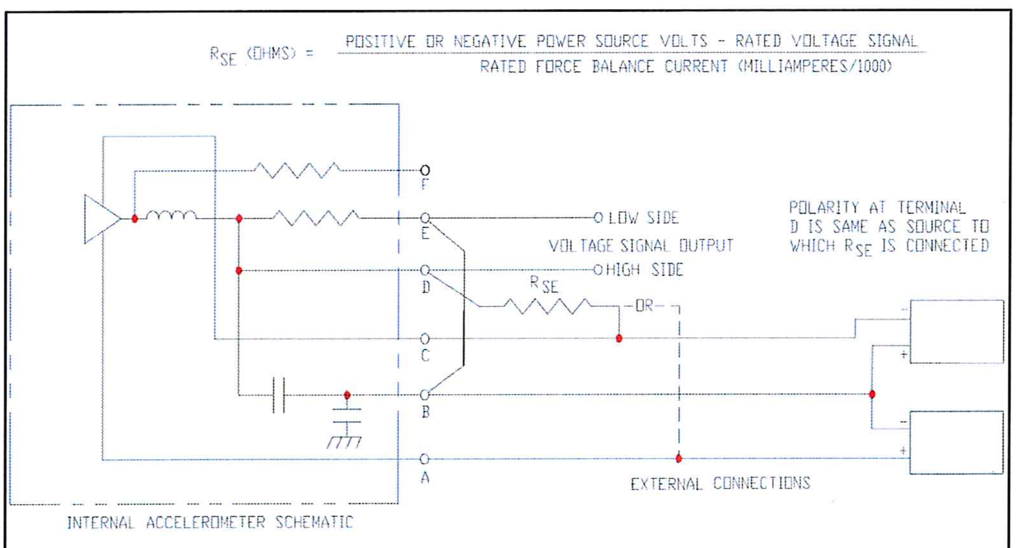


FIGURE 6 ALTERNATE SELF TEST

This method provides a signal to the control system but note that it does not always verify proper operation of the accelerometer. Accomplishing self-test from a non-isolated source by a method that DOES verify proper operation of the accelerometer is a very desirable feature. While not possible in standard units, such a feature can be furnished on special request as follows: during manufacture the torque coil and load resistance will be interchanged. That is, the amplifier will connect first to the load resistance and then return to power supply common through the torquer coil. Voltage signal is taken from the amplifier end of the of the load resistor. A current source can then be applied to the load resistance end of the torquer coil and the other end of the source connected to common. It is also possible to derive the current source from the plus or minus power terminal without needing any external voltage source.

Figure 7 illustrates operation of the accelerometer from a single power source. Note that in this configuration the power source cannot have a terminal common to the signal return.

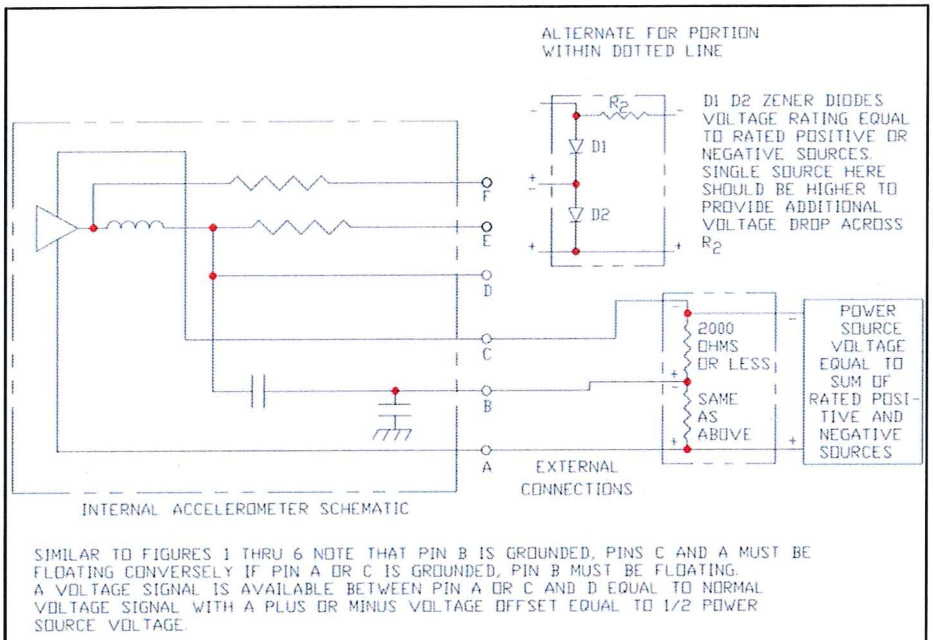


FIGURE 7 OPERATION FROM SINGLE POWER SOURCE

Another configuration, often termed TELEMETRY OUTPUT, may be utilized to permit operation from a grounded single power supply. Internal connections are illustrated in Figure 8. For the type of self-test described in Figure 6, terminal F of the TELEMETRY OUTPUT configuration is equivalent to terminal D for the BALANCED POWER SUPPLY configuration.

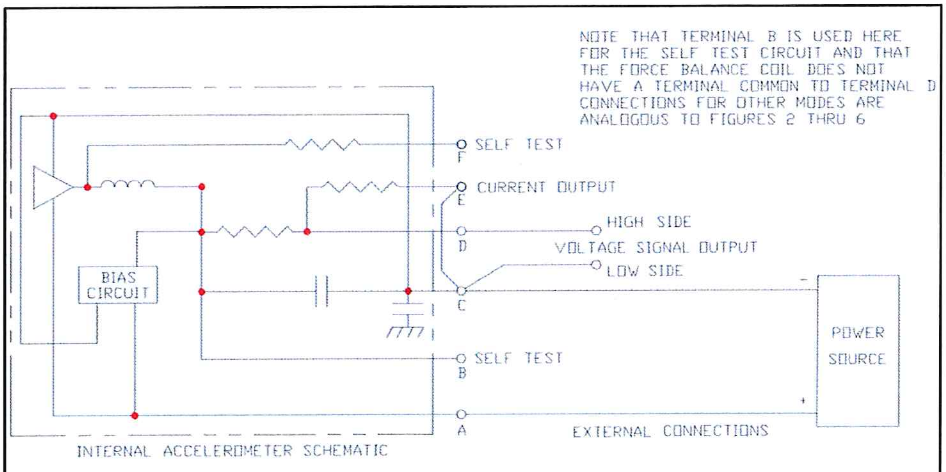


FIGURE 8 TELEMETRY OUTPUT

INSTALLATION

The accelerometer should be installed on a mounting surface known to be flat and in one plane. The simplest way of verifying qualitative operation of the accelerometer is to connect it in accordance with one of the diagrams and place it at rest n the position in which it is to be installed. For most accelerometers not furnished with an INTERNAL 1g BIAS the sensitive axis will be horizontal. The ZERO OFFSET output should appear in either the measuring or control system being fed by the accelerometer. Move the accelerometer back and forth by hand in a direction parallel to the sensitive axis. The readout system should display a periodic output. If the rated range of the accelerometer is ±1g or higher, hold the sensitive axis vertical and invert the unit. The readout system should display its equivalent of ±1g output. If the rated range is less than 1g, tilt the sensitive axis less than 90° both ways. The acceleration input in g's is equal to the sine of the angle of tilt.

If the accelerometer is furnished with an INTERNAL 1g BIAS, its normal attitude will be with the sensitive axis vertical. The ZERO OFFSET output should appear in the measuring or control system with the proper end up (as noted on the individual data sheet). If the rated range is ±1g or higher, a constant output equivalent to losing 1g will be displayed if the sensitive axis is rotated 90°. If the rated range is ±2g or higher and the sensitive axis is rotated an additional 90°, a constant output equivalent to losing 2g's will be displayed. Moving the accelerometer up and down by hand will cause the readout system to display a periodic output.

An angular accelerometer should have no output for any rest position. Periodic angular rotation applied by hand about the sensitive axis should result in a periodic output.

OPTIONS

Certain options are available depending on the specific accelerometer type. Some of these are:

- Low Output Impedance (buffered output)
- Plus and Minus output with single-ended power supply
- Low Pass Filter Output
- Non-Standard Power Supply Voltage
- RFI Filter
- Non-Isolated Self-Test
- Non-Standard Bias

In any case where the external terminal functions for an option different from those shown in these instructions, the correct information will be found on a special sheet stapled to the back cover.

LINEAR SERVO-ACCELEROMETER DATA SHEET

Date	______________	Tested By	______________
Model #	______________	Approved By	______________
Serial #	______________	Customer Insp	______________
Customer	______________	Gov't Insp	______________
Sales #	______________		
PO #	______________		

Connections – Drawing #	______________	
Power Supply Voltage(s)	______________	volts
Power Supply Current	______________	mA
Natural Frequency	______________	Hz
Damping Ratio	______________	
Range	______________	g
Scale Factor (open circuit)	______________	volts/g
Full Range Force Balance Current	______________	mA
Cross Axis Sensitivity	______________	volts/g
Noise	______________	volts rms
Linearity	______________	%
Output Impedance	______________	int.
	______________	ext.
Zero Offset	______________	volts
Horizontal Axis Alignment	______________	volts
Sensitive Axis Attitude for Zero	________ Hor. ________	Vert.
Offset Output	________ Up ________	Down

Linear acceleration applied in direction of sensitive axis arrow away from connector causes output voltage to become more ______________

Mounting Dimensions ______________

Case Integrity Leak Test ______________

ANGULAR SERVO-ACCELEROMETER DATA SHEET

Date	______	Tested By	______
Model #	______	Approved By	______
Serial #	______	Customer Insp	______
Customer	______	Gov't Insp	______
Sales #	______		
PO #	______		

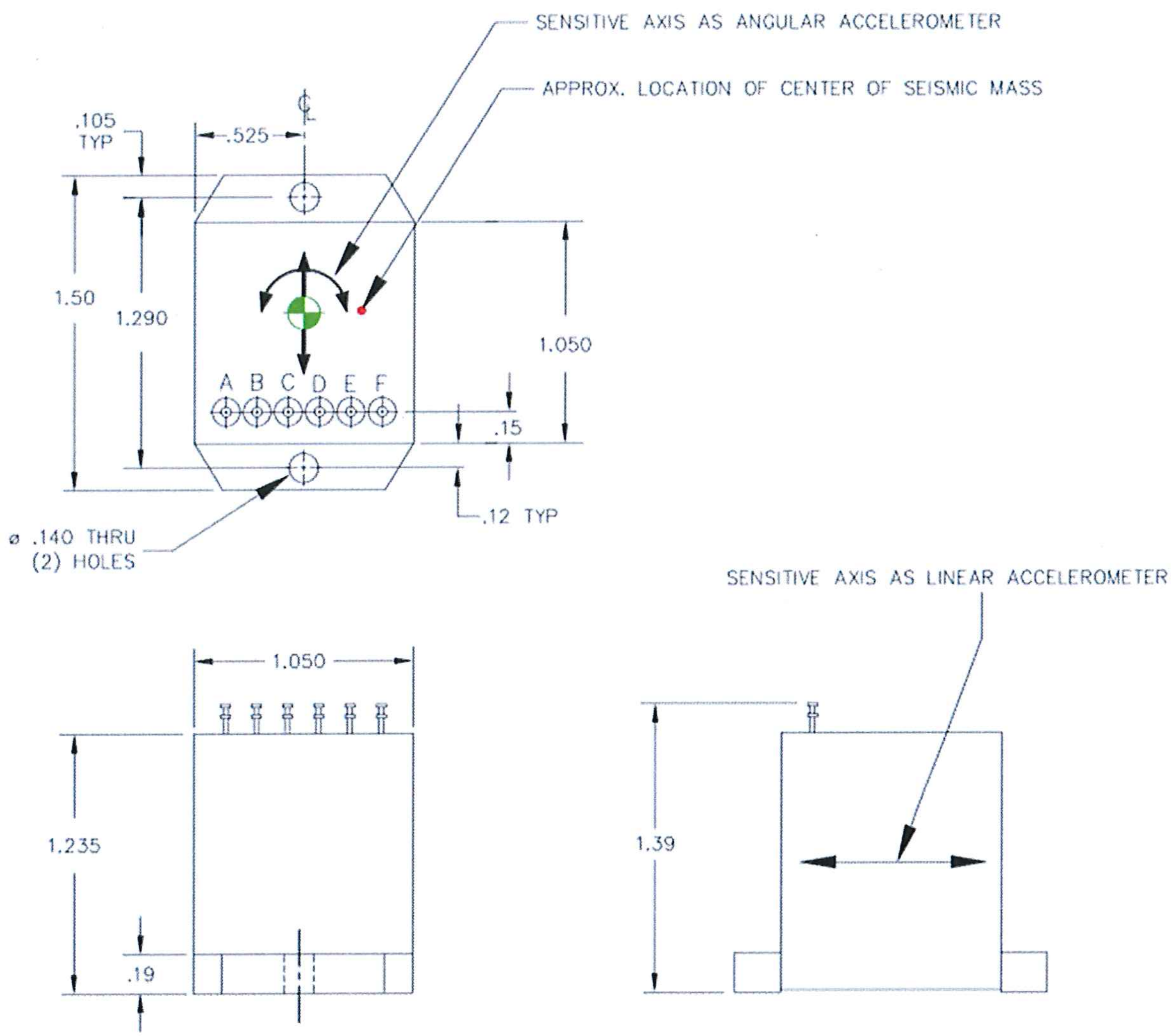
Connections – Drawing #	______	
Power Supply Voltage(s)	______	volts
Power Supply Current	______	mA
Natural Frequency	______	Hz
Damping Ratio	______	
Range	______	rad/sec^2
Scale Factor (open circuit)	______	V/rad/sec^2
Full Range Force Balance Current	______	mA
Cross Axis Sensitivity	______	volts/g
Noise	______	volts rms
Linearity	______	%
Output Impedance	______	int.
	______	ext.
Zero Offset	______	volts

Angular acceleration applied clockwise as viewed looking at the sensitive axis plate causes output voltage to become more ______

Mounting Dimensions ______

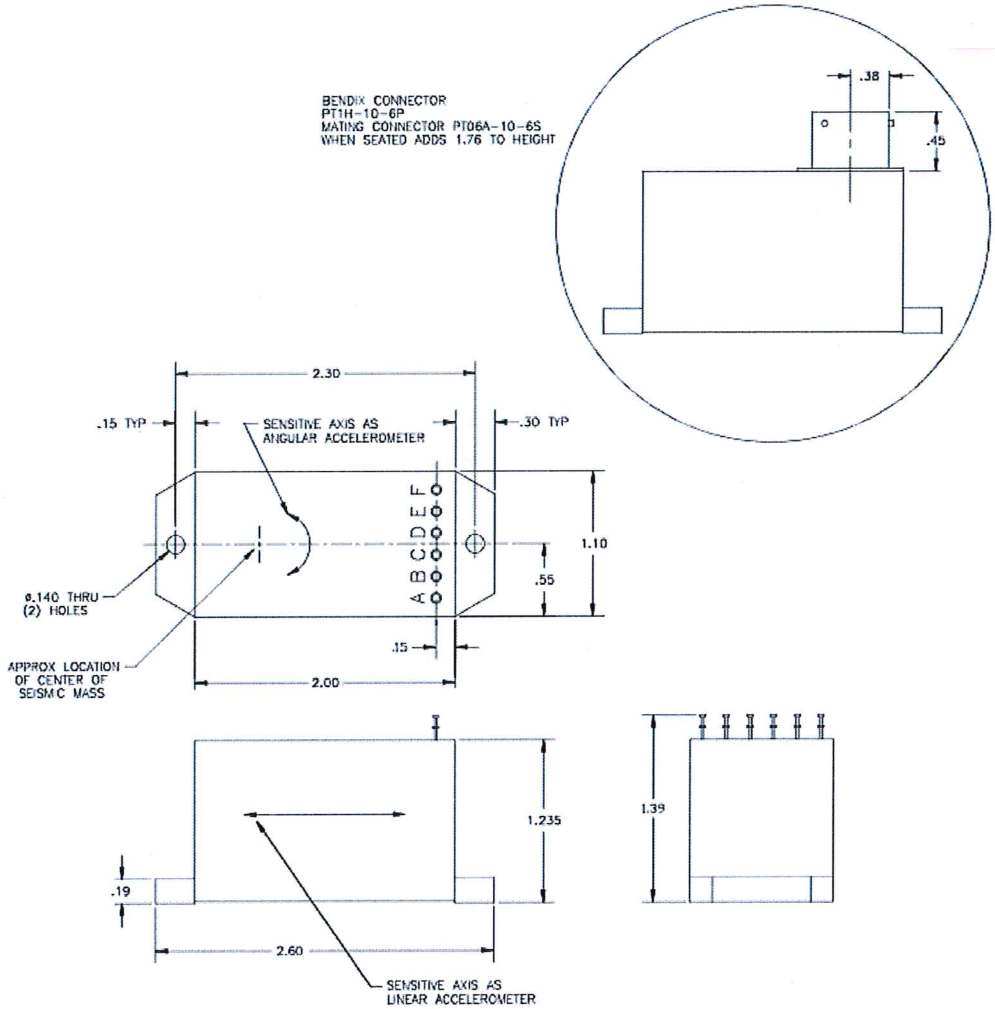
Case Integrity Leak Test ______

SM Series



UNIT WEIGHT = 2 OZ.
LSMP, ASMP OUTLINE

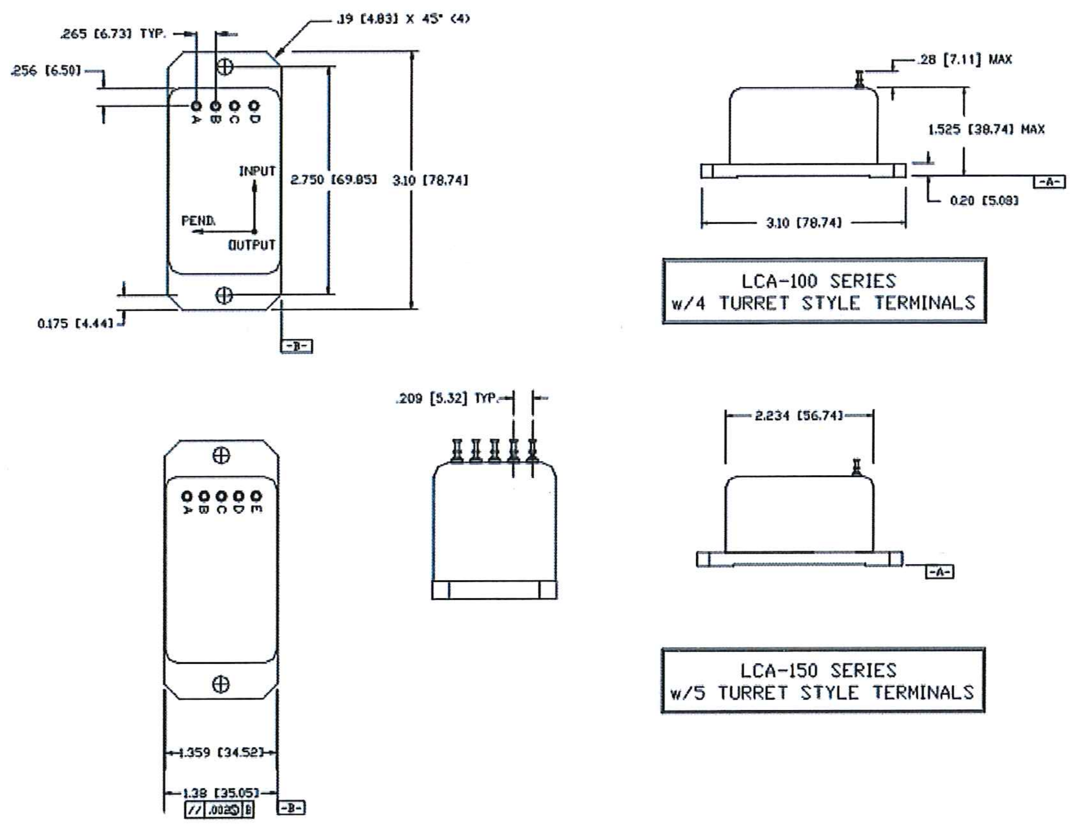
SB Series



UNIT WEIGHT = 3 OZ.

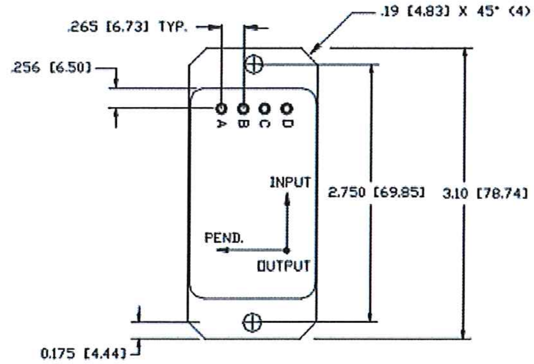
LCA Series

1 - DIMENSIONS ARE IN INCHES [mm]
2 - DATUM -A- AND -B- ARE DEFINED AS REFERENCE SURFACES

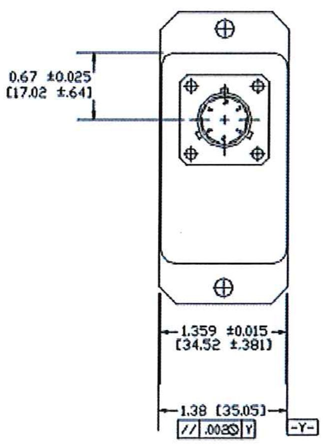


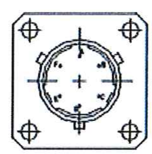
LCF Series

1 - DIMENSIONS ARE IN INCHES [mm]
2 - DATUM -X- AND -Y- ARE DEFINED AS REFERENCE SURFACES

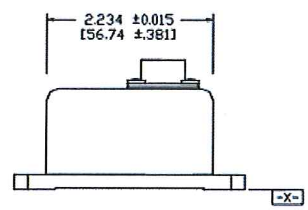


LCF-200 SERIES
w/TURRET STYLE TERMINALS





CONNECTOR - PT02H-10-6P
MATES WITH PT06A-10-6S(SR)



LCF-201 SERIES
w/6 PIN CONNECTOR

ASXC Series