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OPERATING GUIDE

MODEL 2013B

HIGH INTENSITY LIVM* MICROPHONE

INCLUDED WITH THIS MANUAL:
1) Specifications, Model 2013B
2) Outline/Installation dwgs. 127-2013B & 127-2013-GI
3) Paper. "Low Impedance Voltage Mode (LIVM) Theory and Operation".

* **LIVM** is Dytran's trademark for its line of **L**ow **I**mpedance **V**oltage **M**ode sensors which operate from constant current over two wires.

DYTRAN INSTRUMENTS, INC. USA

SPECIFICATIONS, MODEL 2013B HIGH SENSITIVITY MICROPHONE

SPECIFICATION	VALUE	UNITS
PHYSICAL		
WEIGHT, INCLUDES ADAPTOR & HOLLOW CLAMP NUT	35	GRAMS
SIZE (BODY DIA x HEIGHT)	.618 x 1.47	INCHES
MOUNTING PROVISION	HOLLOW CLAMP NUT	3/4-16 THD.
CONNECTOR, COAXIAL, AXIALLY MOUNTED	10-32, UNF-2A	
BODY/CONNECTOR MATERIAL	TITANIUM	300 SERIES
DIAPHRAGM MATERIAL	TITANIUM	316L
PERFORMANCE		
SENSITIVITY, NOM. [1]	2.00	V/Psi
RANGE F.S. FOR 5 VOLTS RMS OUT	2.5 (185)	Psi (db)
ABSOLUTE MAXIMUM PRESSURE	20 (196)	Psi (db)
EQUIVALENT ELECTRICAL NOISE (RESOLUTION)	2.5×10^{-5} (74)	Psi (db)
MOUNTED RESONANT FREQUENCY, NOM.	50	kHz
FREQUENCY RESPONSE, ±5%	5	kHz
MINIMUM RISE TIME OF INPUT PULSE OR STEP	5	µSec
DISCHARGE TIME CONSTANT, MIN.	0.4	Sec
LOWER -3db FREQUENCY	0.4	Hz
LOWER -5% FREQUENCY	1.2	Hz
NON-LINEARITY (ZERO BASED BEST FIT ST. LINE METHOD) [2]	1.0	% F.S., MAX.
ACCELERATION SENSITIVITY, AXIAL DIRECTION	.001	Psi/G
ENVIRONMENTAL		
MAXIMUM VIBRATION	± 300	G's, RMS
MAXIMUM SHOCK	500	G's, PEAK
TEMPERATURE RANGE	-60 TO +300	°F
MAXIMUM DIAPHRAGM FLASH TEMPERATURE, SHORT DURATION	3000	°F
THERMAL COEFFICIENT OF SENSITIVITY	0.03	%/°F
SEAL	HERMETIC	WELDED/GLASS TO METAL
ELECTRICAL		
EXCITATION (COMPLIANCE) VOLTAGE RANGE [3]	+20 to +30	VDC
EXCITATION CURRENT RANGE [3]	2 to 20	mA
OUTPUT IMPEDANCE, NOM.	150	OHMS
OUTPUT BIAS VOLTAGE, NOM.	11.5	VDC
OUTPUT SIGNAL POLARITY FOR INCREASING PRESSURE	POSITIVE GOING	

SUPPLIED ACCESSORIES:

ONE MODEL 6230 HOLLOW CLAMP NUT
TWO (2) MODEL 6607B BRASS SEALS

NOTES:

[1] 0 db REFERENCE: .0002 DYNES PER CM^2
[2] PERCENT FULL SCALE, ZERO-BASED BEST FIT STRAIGHT LINE METHOD.
[3] FROM CONSTANT CURRENT TYPE POWER UNIT ONLY. THIS SENSOR MUST NOT BE CONNECTED TO A DC POWER SOURCE WITHOUT CURRENT LIMITING, 20 mA MAXIMUM.
[4] A CALIBRATION CERTIFICATE TRACEABLE TO NIST IS SUPPLIED WITH EACH INSTRUMENT.

OPERATING GUIDE
MODEL 2013B HIGH INTENSITY MICROPHONE

INTRODUCTION

Model 2013B is a piezoelectric microphone designed to measure high intensity sound pressure levels to 179 db. This instrument utilizes piezoceramic crystals to generate a signal in response to sound pressure acting on the .618 diameter diaphragm.

The signal generated by the ceramic element is fed to the input of a very low noise miniature charge amplifier within the housing of the 2013B. This amplifier changes the impedance level of the signal to about 150 Ohms and amplifies it to produce a sensitivity of 2 Volts/Psi.

An accelerometer, built as an integral part of the piezo element, nulls out acceleration effects from the mass of diaphragm and end piece and lowers the acceleration sensitivity to less than .001 Psi/g of acceleration in the sensitive axis.

Model 2013B is a hermetically sealed instrument with all joints welded. The electrical connector, a glass-to-metal hermetic design, is a 10-32 coaxial type.

DESCRIPTION

(Refer to Outline/Installation drawing 127-2013B for a physical description of Model 2013B)

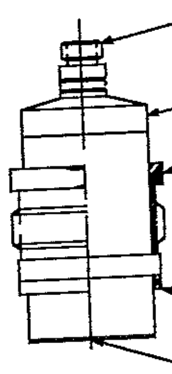


FIGURE 1. MODEL 2013B

2013B is cylindrical in shape with a diaphragm diameter of .618 in. A raised collar is used to secure the instrument into its mounting port. A hollow clamp nut which slides over the top portion of the body threads into the mounting port and bears against the top of the raised collar, holding the 2013B firmly in place. A seal (provided), seals the installation against leaks. There are several installation choices provided, one of which provides ground isolation should this be important. More about this detail in the next section, "Installation".

Model 2013B is a Low Impedance Voltage Mode (LIVM) design. What this means is that this instrument operates from a constant current type power unit. Within the power unit, a DC power supply applies power to a constant current diode (or comparable circuit) that is connected to the sensor via two wires. The power to the sensor amplifier and the dynamic signal from the sensor are carried on these two wires. In the power unit, the signal is separated from the DC power and is sent to an output jack.

An advantage to this type of system is that the signal can be transported great distances without appreciable degradation. The actual sensitivity of each sensor is provided on a calibration certificate supplied with each instrument.

INSTALLATION

NORMAL INSTALLATION (NOT GROUND ISOLATED)

To install Model 2013B, it is necessary to first decide whether a ground isolated installation is needed. If it is not, refer to outline/installation drawing **127-2013B**. This installation uses one Model 6607B brass seal below the raised body collar bearing against the shoulder on the mounting surface. The hollow clamp nut, (Model 6230) bears against the collar and squeezes the collar and seal against the seal shoulder retaining the sensor. A moderate amount of torque (5-10 Lb-inches) will seal the installation.

GROUND ISOLATED INSTALLATION

If ground isolation is required, i.e., if it is required that the body of the sensor (signal/power ground) be insulated from the mounting surface, refer to outline/installation drawing **127-2013B-GI**.

For this type of installation, two Model 6607D (Delrin) seals are required, one below the raised collar and one above. Also, the body of the 2013B in the area of the hollow clamp nut, is wrapped with Kapton® tape (.003 thick) to insulate the body from the hollow clamp nut. The body of the sensor will be totally electrically isolated from the mounting surface with this installation.

Remember though, that the diaphragm of the sensor is still a part of the sensor and as such, is at sensor ground potential.

MOUNTING PORT PREPARATION

The mounting port must be prepared in accordance with instructions on either of the installation drawings provided. These instructions are listed as "PORT PREPARATION INSTRUCTIONS" on these drawings.

If it is necessary that the diaphragm be flush with the wall of the chamber or test surface, it will be necessary to weld a boss to surfaces thinner than .750 or counterbore surfaces thicker than .750 to attain flush diaphragm installations. Refer to the outline installation drawings.

RECESSED (LONG PASSAGE) INSTALLATIONS

In some installations, it is desirable to recess the diaphragm. In these cases, adjust the depth of the port to attain the desired recess. (See figure 2)

Remember that as the recess gets deeper, the ability to detect high frequencies diminishes due to passage resonance effects. The passage has its own resonant frequency, dependent upon the depth of the recess (passage length) and the speed of sound in the medium under test.

The resonant frequency of the passage is governed by the following equation:

$$f_R = v/4l \quad \text{where:} \qquad \text{(Eq 1)}$$

f_R = resonant frequency of the passage, (Hz)
v = velocity of sound in the medium (in/Sec) (Velocity of sound in air @20° C is 13,200 in/Sec)
l = passage length, measured from the face of the diaphragm to the end of the passage (inches)

As a general rule, the frequency response of your system will be flat to about ± 5% to about 1/3 of the passage resonant frequency as determined by equation 1, above. The shortest rise time (in response to a zero time step function input) is roughly 1/3 of the period of this frequency.

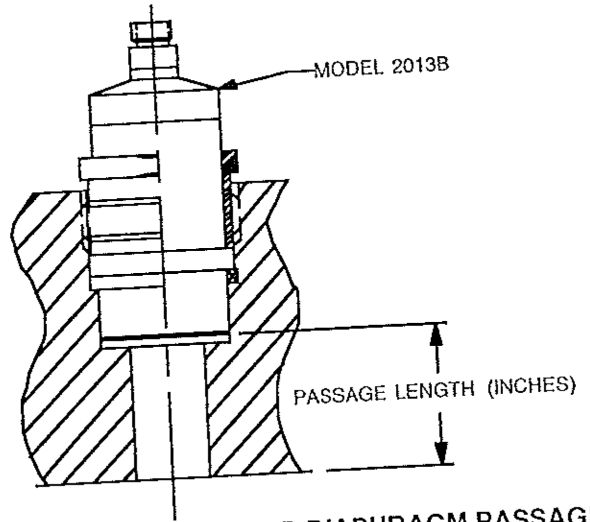


FIGURE 2 RECESSED DIAPHRAGM PASSAGE LENGTH

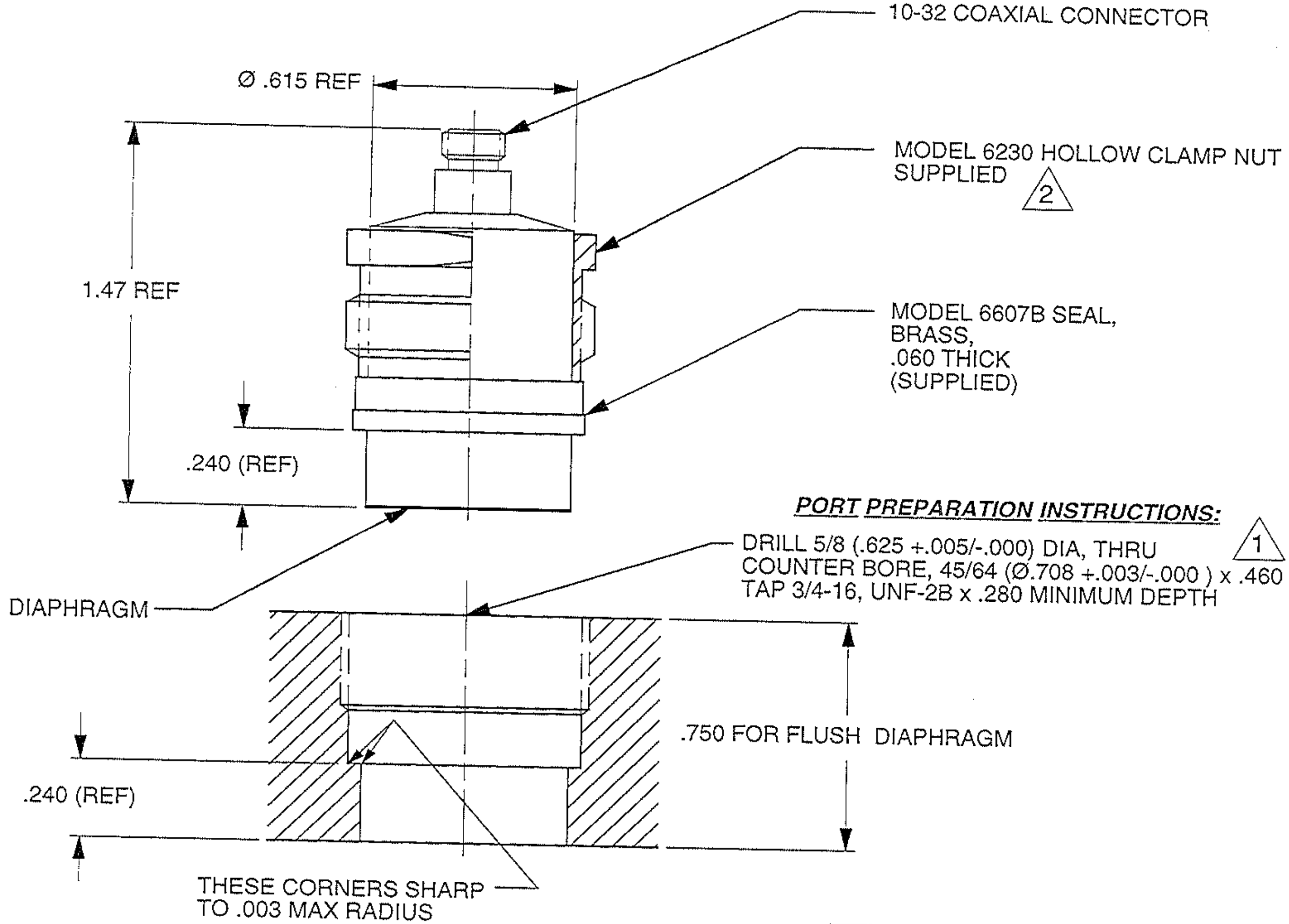
Using the sound velocity in air @20° C and equation 1, we construct the table shown as figure 3, which relates passage length to resonant frequency and shortest rise time for several passage lengths.

Remember that the values shown in the table, figure 3, are calculated for air @20° C. To calculate values for your particular measurement, substitute into equation 1, the velocity of sound for your medium.

Remember also, that these values will be approximations and are not to be relied upon for absolute accuracy.

RECESS L (inches)	NATURAL FREQUENCY (Hz)	APPROX. SHORTEST RISE TIME (μSec)
.001	3.3 MHz	0.1
.002	1.6 M Hz	0.2
.003	1.1 M Hz	0.3
.005	660 KHz	0.5
.01	330 KHz	1
.05	66 KHz	5
.10	33 KHz	10
.20	16.5 KHz	20
.50	6.6 KHz	50
1.00	3.3 KHz	100
2.00	1.66 KHz	200

FIGURE 3 RESONANT FREQUENCY AND RISE TIME VS. PASSAGE LENGTH



PORT PREPARATION INSTRUCTIONS: △1

DRILL 5/8 (.625 +.005/-.000) DIA, THRU
COUNTER BORE, 45/64 (Ø.708 +.003/-.000) x .460 DEEP △1
TAP 3/4-16, UNF-2B x .280 MINIMUM DEPTH

ODY/DIAPHRAGM MATERIAL, TITANIUM LLOY.

EIGHT, LESS CLAMP NUT-35 GRAMS

TORQUE ON 6230 CLAMP NUT: 20 LB-IN.

EXCEPT AS OTHERWISE NOTED
ALL DIMENSIONS IN INCHES TOLERANCE: .XXX = ± .XX= ±
SURFACE FINISH EXCEPT AS NOTED √
BREAK EDGES TO DEBURR RADIUS OR CHAMFER
△1 THESE DIAS ⊙ TO .002 T.I.R.
FILLETS - MAX RAD.

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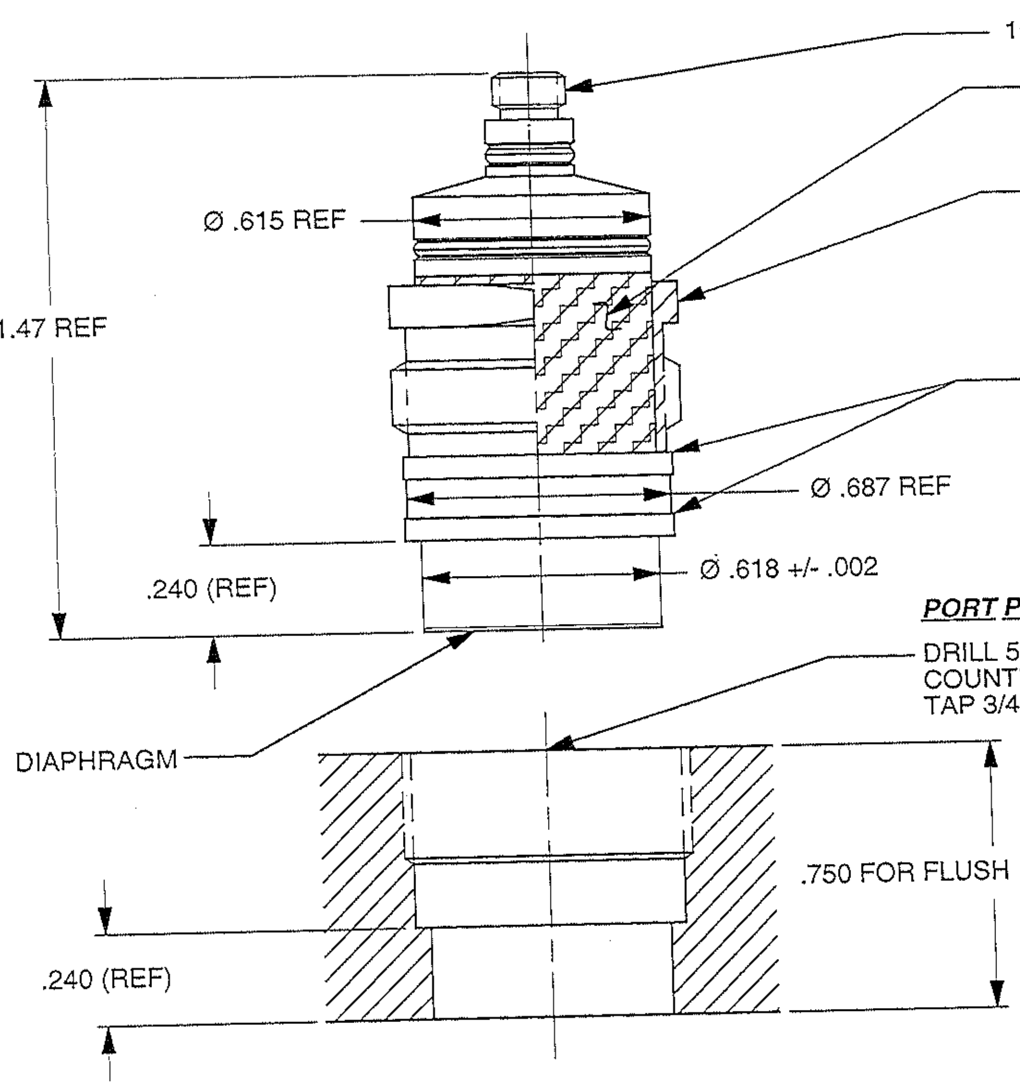
CHATSWORTH, CA.

SCALE 2X	REV	DATE	ECN
DATE 1/24/03	PART NO. MODEL 2013B		
DRAWN N.C. / CHECKED R.A.	MAT'L		
APPROVED 1-10-05	NEXT ASSEMBLY	USED ON	
TITLE OUTLINE/INSTALLATION DRAWING MODEL 2013B, NORMAL INSTALLATION		DWG NO. 127-2013B	SHEET 1 OF 1



PORT PREPARATION INSTRUCTIONS:

DRILL 5/8 (.625 +.005/-.000) DIA, THRU
COUNTER BORE, FLAT BOTTOM, 45/64 (.708 DIA) x .460 DEEP
TAP 3/4-16, UNF-2B x .280 MINIMUM DEPTH

WEIGHT, LESS CLAMP NUT-35 GRAMS

2 TORQUE ON 6230 CLAMP NUT: 20 LB-IN.

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SCALE 2X		REV	DATE	ECN	
DATE 12/20/04		PART NO. MODEL 2013B			
DRAWN N.C	CHECKED N.C	MAT'L			
APPROVED 12-20-04		NEXT ASSEMBLY		USED ON	
TITLE OUTLINE/INSTALLATION DRAWING MODEL 2013B, GROUND ISOLATED MOUNT				DWG NO. 127-2013B-GI	SHEET 1 OF 1

DYTRAN INSTRUMENTS, INC.

LOW IMPEDANCE VOLTAGE MODE (LIVM) THEORY AND OPERATION

LIVM: WHAT IS IT?

LIVM is Dytran's trademark for our version of Low Impedance Voltage Mode piezoelectric instruments, i.e., piezoelectric instruments with integral impedance-converting amplifiers operating from constant current over two wires.

LIVM instruments produced at Dytran include force, pressure and acceleration sensors. Each class of sensor is produced in many variations for a wide variety of applications.

Also falling under the class of LIVM instruments are in-line charge amplifiers utilizing the same two-wire mode of operation as the LIVM sensors.

Operating principles for all LIVM sensors and in-line amplifiers are similar in that all utilize the two wire constant current operating principle. The amplifier built into the sensors is either a MOSFET input unity gain voltage amplifier or an MOS or JFET input charge amplifier.

Both types of amplifier serve to convert the very high impedance of the piezoelectric crystals to a much lower impedance voltage signal which has the capability of driving long cables with little signal degradation.

THEORY OF OPERATION

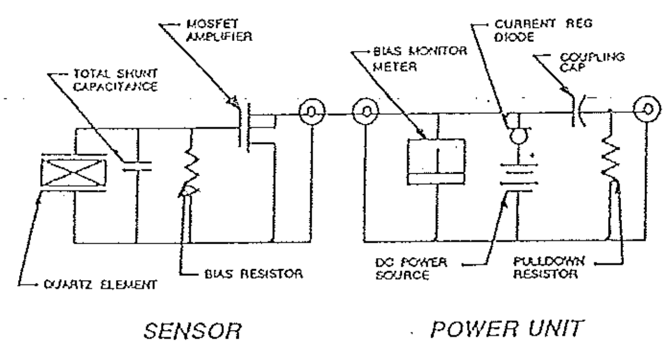

FIGURE I THE VOLTAGE MODE LIVM SYSTEM

Figure I is a simplified schematic of a basic LIVM system including the sensor with integral electronics, the cable and the power unit. The sensor amplifier in this case is the unity gain voltage follower. This is the type of amplifier used in most LIVM sensors and almost exclusively used with quartz sensors.

The sensing element (force, pressure or acceleration) usually made from quartz, is connected directly to the gate of a MOSFET input integrated circuit (IC) amplifier. The amplifier is operated as a source follower and as such has unity voltage gain.

The source terminal of the IC is supplied with constant current over the range of 2 to 20 mA at a compliance (supply) voltage of 18 to 30 volts DC. The power unit can take many configurations from simple battery powered 2 mA supplies with constant current diode to line powered adjustable current power units able to supply 2 to 20 mA of constant current from a variable magnitude constant current circuit.

In either case, the constant current device (current diode or constant current circuit) acts as the source impedance for the IC built into the sensor or the in-line charge amplifier.

Under quiescent conditions, the IC will bias itself at approximately +10 volts DC at the input (source) terminal of the sensor. This bias voltage is monitored with most Dytran power units and this feature serves as a handy trouble shooting tool serving as an indicator for normal or abnormal operation of sensor, cable and power unit. (More on this topic in a following section, "The fault monitor as a trouble shooting tool)".

The sensor signal, produced by the measurand acting upon the piezo element, is superimposed upon the +10 Volt DC bias and appears at the "Sensor" jack of the power unit. At this point, the DC bias portion of the signal is blocked by a coupling capacitor and the AC portion containing the sensor information, is coupled to the "Output" jack. This jack is connected directly to the readout instrument(s), (oscilloscope, spectrum analyzer, frequency counter, etc. The very low output impedance of the sensor (about 100 Ohms) makes the effect of most readout instruments negligible.

Be aware that the coupling capacitor in the power unit (usually 10 mF) and the impedance of the readout load constitute a high pass filter which may set the low frequency response of the system. In most accelerometer applications, the 10 mF coupling capacitor provides ample time constant to allow vibration measurements down to fractions of a Hz.

Dytran also manufactures a DC coupled power unit for LIVM sensors which utilizes an active variable voltage amplifier circuit to buck out the bias voltage of the sensor IC. This unit, the Model 4115, supplies constant current to the sensor and direct couples the sensor to the output jack eliminating the coupling capacitor. This allows the user to take full advantage of the long time constant built into the sensor and precludes the effect or readout load on the low frequency response of the system. This unit is especially useful for very long term (quasi-static) measurements with force and pressure sensors.

OPERATION, GENERAL

Special note: LIVM sensors depend on the power unit to supply a fixed amount of current to the sensor IC. These circuits will absorb any amount of current supplied until the exceed their power rating and burn up. For this reason, never apply power to an LIVM sensor without this current limiting protection. This precludes the connection to batteries, Ac and DC power units and many types of resistance measuring instruments. Never measure the continuity of an LIVM sensor with any type of Ohmmeter. This type of measurement is redundant and may lead to destruction of the sensor IC. To determine if the IC is burned out, use the Monitor meter on the front panel of most Dytran LIVM power units. This topic is covered in the following section, "The fault monitor meter as a trouble shooting tool."

After installing the sensor in accordance with instructions in the Operating Guide (manual) supplied with each instrument, connect the sensor to the power unit "Sensor" jack. This jack is, in most power units, a BNC coaxial connector. You should have been supplied with the proper cable to connect the sensor to the power unit.

It is important to carefully support the cable, especially in situations where there is movement between the sensor and the surroundings. This practice will prolong cable life and will diminish the effects of triboelectric (cable generated) noise on the signal.

THE FAULT MONITOR METER AS A TROUBLE SHOOTING TOOL

Most Dytran LIVM power units incorporate a DC voltmeter on the front panel which measures the DC bias voltage at the sensor terminal. Measuring this voltage supplies information about the health of the sensor, cable and power unit which can be very useful in searching for problems in the measurement system. The three conditions it can identify are: 1) normal operation, 2) shorted cable or power unit or non operating power unit and 3) open sensor, or cable. We will examine each condition here.

NOTE: The fault monitor meter may be the led style (shown on left in Fig 2) or the D'Arsonval panel meter style, shown on the right, Fig 2, depending on the power unit model.

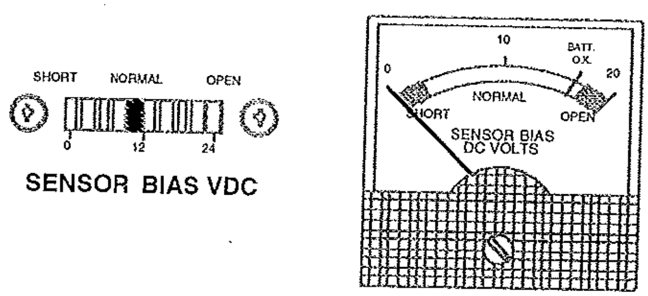

FIGURE 2 TYPICAL FAULT MONITOR METERS

NORMAL OPERATION

Under normal operating conditions, the Monitor meter will indicate mid scale or approximately +10 volts DC when the sensor is connected. Many of the meter faces have a "Normal" area delineated to indicate that the sensor IC is functioning and the cable from sensor to power unit is not open or shorted. It is still possible that certain failure modes of the sensors can provide "Normal" indications but these modes are very rare. In most cases, if the meter reads in the normal area, the system is ready to receive data

As a further quick check on normal operation, with some sensors such as pressure and force sensors, pressing on the diaphragm or force sensitive surface with the hand can cause the monitor meter pointer to deflect showing that the sensor is "alive". With some higher sensitivity accelerometers, shaking them back and forth in the sensitive axis can deflect the monitor meter enough to show that the sensor is functioning.

OPEN SENSOR OR CABLE (FULL SCALE METER READING)

If the sensor amplifier is blown or the cable connecting sensor to power unit is open, the monitor meter will read full scale (in the "Open" area) since the current source in the power unit has no load. To see if the problem is in the sensor, disconnect the sensor from its cable, (leaving the other end of the cable attached to the power unit), and short across the cable end with a metallic object while observing the meter. If the meter does not go to zero ("Short" indication) while the cable end is shorted, the cable is bad (open) replace the cable and try again for the "normal" indication.

If it the meter reads zero when the short is applied, the cable is OK but the sensor is open. If another sensor is available, try it to verify the finding.

SHORTED SENSOR OR CABLE ("SHORT" METER READING)

If the fault monitor meter reads in the "short" (zero volts) region after connecting the sensor, this means that a short has brought the voltage output of the constant current circuit to zero volts.

This condition cannot destroy the power unit since the current will be limited to from 2 to 20 mA, depending upon the specific power unit. Sometimes, shards of metal will scrape off the cable connector threads (with the 10-32 connectors) and will short across the cable contacts. To remove these shards, tap the ends of the cable connectors gently against a rigid surface to dislodge them. Cleaning the connector end with a stiff bristled brush may also dislodge any metal shavings.

If the short is still indicated, then the problem is with the cable or the power unit itself. Disconnecting the cable from the power unit and getting a full scale reading means that the power unit is OK and the problem is a shorted cable. Replace the cable.

MAINTENANCE AND REPAIR

Because of their small size and sealed construction, field maintenance of LIVM sensors is limited to cleaning of connectors and maintenance of mounting surfaces.

Clean connectors with a cloth or paper wipe dipped in solvents such as alcohol, Freon, etc. For hermetically sealed units, acetone may be used also. Acetone is not recommended for non-sealed units.

Clean epoxy from the mounting surfaces of accelerometers with acetone or such other solvent which will dissolve epoxies.

If the problem you are having is poor low frequency response and the sensor is not hermetically sealed, baking in a 250 degree F oven for an hour will often get rid of moisture which may have shortened the discharge time constant.

If you cannot solve the problem, call the factory for assistance in trouble shooting the system or for instructions in returning the unit for evaluation and/or possible repair.

If the instruments to be returned, you will be issued a Returned Material Authorization (RMA) number by the Service Department which helps speed the instrument through the evaluation process. Do not return an instrument without first contacting the factory.