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OPERATING GUIDE

MODEL 4103C

3-CHANNEL BATTERY POWERED UNITY GAIN

CURRENT SOURCE WITH BNC SENSOR AND OUTPUT JACKS

FOR POWERING LIVM tm* SENSORS

THIS MANUAL INCLUDES:

1) **SPECIFICATIONS, MODEL 4103C**
2) **OPERATING GUIDE MODEL 4103C**
3) **OUTLINE/INSTALLATION DRAWING 127-4103C**
4) **PAPER: "LOW IMPEDANCE VOLTAGE MODE (LIVM) THEORY AND OPERATION"**

NOTE:
Model 4103C is a three channel unity gain constant current LIVM type power unit. Model 4103C features BNC input (Sensor) jack and Output jacks.

***NOTE: LIVM** is Dytran's trademark for its line of **L**ow **I**mpedance **V**oltage **M**ode sensors with built-in amplifiers operating from constant current sources over two wires. **LIVM** instruments are compatible with most other manufacturers' comparable systems.

SPECIFICATIONS

MODEL 4103C 3-CHANNEL CURRENT SOURCE POWER UNIT, BATTERY POWERED

SPECIFICATION	VALUE	UNITS
COMMON SPECIFICATIONS, EACH CHANNEL		
SENSOR SUPPLY CURRENT, FIXED,	2.0	mA
COMPLIANCE VOLTAGE	+18	VDC
VOLTAGE GAIN	UNITY	
COUPLING TIME CONSTANT INTO 10 MEGOHM LOAD	10	SEC
COUPLING TIME CONSTANT INTO 1 MEGOHM LOAD	5	SEC
LOW FREQUENCY -3db FREQ., 10 MEGOHM LOAD	0.016	Hz
LOW FREQUENCY -3db FREQ., 1 MEGOHM LOAD	.032	Hz
HIGH FREQUENCY RESPONSE	DETERMINED BY SENSOR, CABLE LENGTH AND SIGNAL LEVEL	
COUPLING CAPACITOR, NOM.	10	µF
PULLDOWN RESISTOR	1.0	MEGOHMS
MONITOR VOLTMETER RANGE, F.S.	20	VDC
ELECTRICAL NOISE, WIDEBAND	60	µV, RMS
SENSOR CONNECTOR	BNC	JACK
OUTPUT CONNECTOR	BNC	JACK
GENERAL SPECIFICATIONS		
POWER SOURCE ⚠1	9 VOLT BATTERIES	2
BATTERY LIFE, TYP.	40	HOURS
SIZE (H x W x D)	2.5 x 5.2 x 3.3	INCHES
WEIGHT	12	OUNCES

⚠1 Any type of transistor radio 9-Volt battery may be use to power the 4103C. However, longest battery life will be obtained by use of high grade alkaline type batteries.

OPERATING INSTRUCTIONS MODEL 4103C POWER UNIT

INTRODUCTION

The Dytran Model 4103C Current Source power unit is a battery operated 3-channel, portable LIVM power unit designed to operate Low Impedance Voltage Mode (LIVM) sensors which contain integral amplifiers.

NOTE: The word SENSOR may refer to accelerometers, pressure sensors, hammers and force transducers, etc. The words SENSOR and TRANSDUCER are used interchangeably in this guide.

LIVM sensors require a source of constant current, usually in the range of 2 to 20 mA at a supply (compliance) voltage range of +18 to +30 VDC.

Model 4103C supplies fixed constant current (called sensor drive current) to up to three sensors, of 2 mA at a +18 Volt compliance voltage level.

Power to operate the sensors is supplied by two 9 Volt transistor radio type dry cell batteries, operating in series, to produce +18 Volts DC.

A low current voltmeter located on the front panel of the 4103C constantly monitors the voltage appearing at the 'Sensor' jack of any of the three sensors selected for monitoring by a front panel rotary switch. This DC voltage is the quiescent bias voltage of the sensor and measuring this voltage is very useful in testing for faulty operation of cables and sensors.

A momentary pushbutton switch located just below the meter checks the battery voltage without disturbing the test in progress.

Both 'Sensor' and 'Output' jacks are BNC.

DESCRIPTION

(Refer to Fig 1)

Model 4103C utilizes three 2 mA current regulating JFET diodes to supply the sensor drive current to up to 3 sensors. The metering circuit draws only 25μA at midscale (its normal operating level). With this low current drain, the battery life, starting out with a fresh pair of alkaline batteries, will be about 80 hours.

Figure 1 is a schematic diagram of one channel of Model 4103C. The voltmeter normally monitors the sensor bias voltage which is nominally about +10 Volts DC. Consult the specification sheet for your particular sensor to verify the actual bias voltage since some Dytran sensors have various other bias voltages.

The 'BATT TEST' switch momentarily connects the meter directly across the battery terminals when depressed, to allow the user to check the actual battery voltage during operation. This procedure will not disturb the test in progress.

The dynamic signal from the sensor is superimposed upon the bias voltage and appears at the "Sensor' jack. This signal is de-coupled from the DC bias by the 10μf coupling capacitor and connected to the 'Output' jack.

It can be seen, by examination of Fig. 1, that the dynamic signal may also be read by coupling to the 'Sensor' jack as well. However, if this is attempted, a means of dealing with the +10 Volt DC offset must be considered.

This type of connection can be useful when it is desirable to direct couple the readout to the sensor rather than to AC couple. More on this topic later.

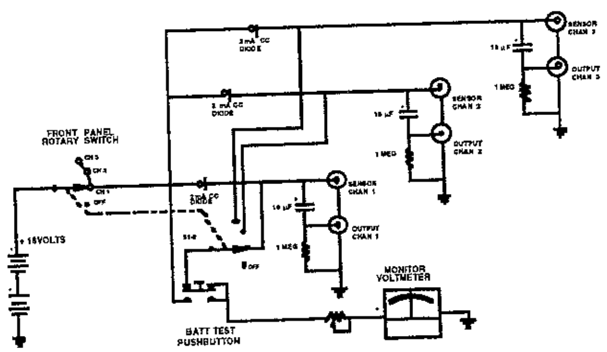


FIGURE 1 SCHEMATIC DIAGRAM, 4103C

OPERATION

To operate the 4103C with an LIVM sensor, connect the sensor cable to the BNC 'Sensor' jack on the channel one of the 4103C using the appropriate cable and or adaptor. (Refer to Figure 2.)

Connect the 'Output' jack for channel one to the input of the readout instrument (oscilloscope, voltmeter, recorder, etc.) using a Model 6020 coaxial cable. The BNC output jack on the 4103C eliminates the need for cable adaptors for the readout connection.

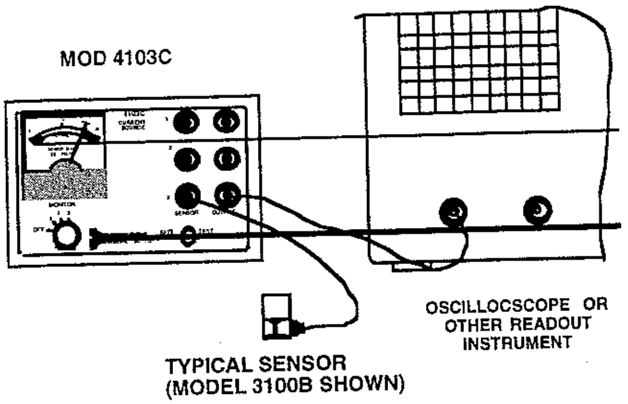


FIGURE 2 SYSTEM INTERCONNECT

Move the rotary channel select switch on the front panel to the channel 1 position which turns the power on and selects channel 1 for monitoring on the front panel voltmeter. Wait a few seconds for the coupling capacitor(s) to fully charge. The meter may indicate a slow drift while the capacitor is charging.

When conditions stabilize, observe the front panel meter. Normal operation of the of the sensor is indicated by a mid-scale reading on this meter. The normal mode of operation for most sensors is in the "Normal' area of the meter scale.

Depress the 'Batt Test' pushbutton switch and observe the battery voltage. The meter should read to the right of the 'Batt OK' line at the right hand end of the meter scale if the batteries are fresh. When the battery test function yields a reading well below the Batt OK line, it is time to replace the batteries. While the sensor will continue to function even with low batteries, clipping of the signal may occur on the top (positive) side of the dynamic signal if the sensor signal plus the sensor bias approaches the battery voltage.

Consult the paper included with this guide, 'Low Impedance Voltage Mode (LIVM) Theory and Operation' for further inputs in the use of the monitor voltmeter as a trouble shooting tool.

The system is now ready to operate. Connect two more sensors if desired and follow the same procedure as for channel 1.

NOTE: To prolong battery life, remember to switch power off when the system is not in use.

COUPLING TIME CONSTANT AND LOW FREQUENCY RESPONSE

The low frequency capability of a piezoelectric measurement system may be limited by several factors about which the average user of such systems may not be aware.

The specifications each sensor will delineate the discharge time constant which controls the basic low frequency response of that sensor. However, the power unit and the readout may also play a part in this specification and may, in many cases, be the limiting factor rather than the sensor itself.

The low frequency response of any AC coupled system is limited by the coupling time constant (TC) of the composite measurement system. The coupling capacitor and the 1 megohm 'pulldown' resistor in each channel of the 4103B, in parallel with the DC input resistance of the readout instrument constitute a first order high pass filter.

The TC of this filter is the product of the 10μF capacitor and the parallel combination of the 1 megohm pulldown resistor and the input resistance of the readout instrument.

The relationship between the coupling TC and the lower -3db frequency is:

$$f_{-3db} = \frac{0.16}{TC} \qquad \text{Eq 1}$$

where:

TC is the product of R and C, in Seconds

If the readout instrument is of the order of 10 megohms, it may be ignored. The TC is then 10μF x 1 megohms = 10 seconds. The lower -3db frequency is then:

$$f_{-3db} = \frac{0.16}{10} = 0.016\ \text{Hz} \qquad \text{Eq 2}$$

If the readout instrument input resistance is 1 megohm, the parallel combination of the pulldown resistor and the input resistance is 500k ohms. The TC is then 10mF x 500,000 or 1 second. The lower -3db frequency is then:

$$f_{-3db} = \frac{0.16}{10} = .16\ \text{Hz.} \qquad \text{Eq 3}$$

The importance of this illustration is to show that the sensor itself may not be the deciding factor in low frequency response and to stress the importance of the input impedance of the readout instrument on the low frequency response of AC coupled sensor systems.

OPTIONAL DIRECT COUPLED CONNECTION FOR QUASI-STATIC MEASUREMENTS

For some types of measurements such as when using dead weight testers to calibrate pressure sensors or when making long term measurements with force sensors with long TC's, it is desirable to direct couple to the sensor instead of AC coupling as through the 'Output' jack of the 4103C.

To avoid the low frequency limitations as described in the previous section, it is possible, with some precautions, to use the 'Sensor' jack to measure the sensor signal , direct coupled instead of AC coupled through the 'Output' jack.

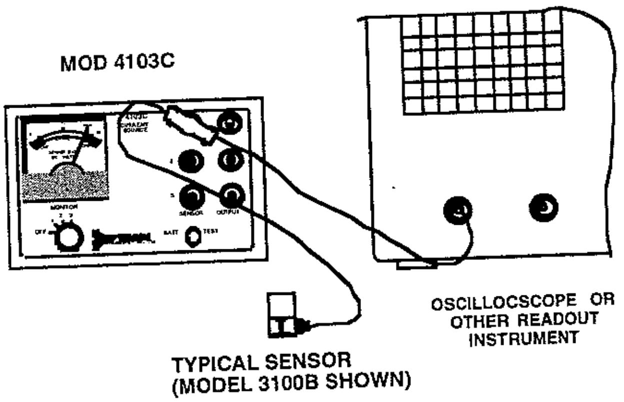


FIGURE 3 OPTIONAL DIRECT COUPLED CONNECTION

To do this, a BNC 'T' is connected to the 'Sensor' jack with one arm of the T connected to the sensor and the other arm connected to the readout. (Refer to Figure 3 above). The problem with this arrangement is that the readout must have the capability of 'nulling out' the approximate +10 Volt DC offset created by the sensor bias. Most readout instruments will not have this capability.

A better solution is to use a power unit which has a direct coupling option such as the Dytran Model 4115. This line powered current source features a summing amplifier which sums the sensor signal with a variable DC voltage and which nulls the sensor bias precisely to zero with no coupling capacitors, i.e., direct coupled to the output jack. With this power unit, the only limiting factor in the low frequency or quasi-static response of the measurement system is the discharge TC of the sensor itself.

HIGH FREQUENCY RESPONSE

The high frequency response of any piezoelectric system is determined by a number of factors. These are:

1) The response characteristics of the sensor itself,

2) the length and type of cable between the sensor and the power unit,

3) the length and type of cable from the sensor to the readout, (in unbuffered units such as the 4103B),

4) the amplitude of the sensor signal, and,

5) the level of drive current to the sensor.

With the 4103C, the user has no choice of drive current settings since the sensor drive current is fixed at approximately 2 mA.

This amount of current should be sufficient to drive most sensors (except for some of the high frequency pressure sensors) to their full frequency range driving 100 ft. of combined input and output cable.

Experimentation is the only sure way to determine the effect of these various parameters on the high frequency response of the measurement system.

CHANGING THE BATTERIES

When the 'BATT TEST' switch is depressed (or when the sensor is disconnected), the meter will indicate the battery voltage. When this reading drops below the 'BATT OK' mark on the meter dial, it is time to replace the batteries.

NOTE: Under some circumstances, it is possible to continue to use the 4103C even with low batteries as in emergencies. If the measurement level is low and there is no danger of clipping the signal in the positive direction, then it is OK to use the system. As an example, if the battery voltage drops to 14 Volts and the sensor bias is +10.5 Volts, the available signal swing is 14 - 10.5 = 3.5 Volts. If 3.5 Volts is adequate range for the measurement, the measurement will be valid.

To change the batteries, proceed as follows:

NOTE: Refer to Outline/Installation Drawing 127-4103C for this section)

1) Remove the two screws at the bottom of the unit and separate the two halves of the case. Remove the bottom half of the case.

2) Carefully unsnap the connectors from the battery terminals using care not to overstress the wires to the terminals.

3) Remove the batteries from the battery clips and replace both with a good brand of 9V dry cell such as Duracell © MN1604. Eveready Energizer © alkaline no. 522 or equivalent. Before installing the batteries, make sure that they will fit into the clips. Some brands of battery may be oversize and these should not be used since there may not be adequate room for them in the 4103C.

4) Re attach the battery terminals and re assemble the unit and outer case. Use caution not to overtighten the front panel retaining screws to avoid stripping the plastic threads in the case.

MAINTENANCE AND REPAIR

Refer to the Outline/Installation drawing 127-4103C

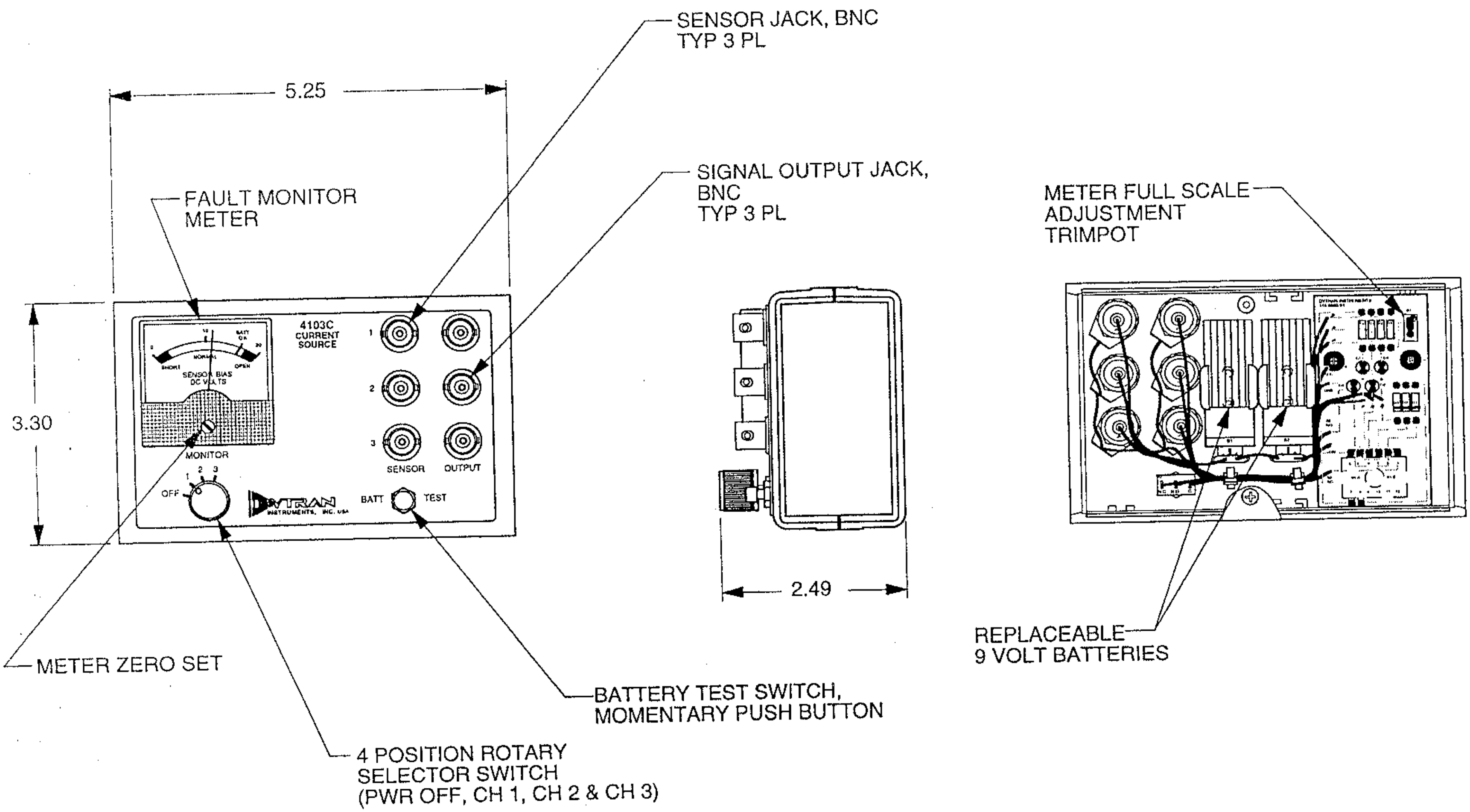
Aside from battery replacement, there is no routine maintenance required for the 4103C.

Should the meter require re-zeroing, place the unit on a level table, face up with the power off, and adjust the zero adjust screw located directly below the meter face.

It is not likely that the meter should need recalibration but should this become necessary, a potentiometer is located inside the unit mounted on the circuit board. This pot. sets the full scale reading of the meter. First measure the battery voltage with a DVM connected across the appropriate battery terminals (the batteries are in series), then set the meter scale to match by adjusting the potentiometer.

The connectors may be cleaned with a soft brush dipped in a solvent which is friendly to the atmosphere and to the plastic face of the meter and the outer case of the instrument. Avoid solvents such as methylene chloride and acetone which will attack the meter face and other plastic parts.

Should the 4103C develop a problem, contact the factory Customer Service Department for help in trouble shooting or for instructions in returning the unit to the factory for evaluation. At this time, a **R**eturned **M**aterial **A**uthorization (**RMA**) number will be assigned to help track the unit through the repair process., should it be necessary to return the unit to the factory.



2. VOLTAGE AT "BATT O.K." MARK IS 17 VDC.
1. WEIGHT - 340 GRAMS (12 OZ.)

DYTRAN INSTRUMENTS, INC.

MASTER ONLY IF IN RED

CHATSWORTH, CA.

SCALE 1/2X	REV -	DATE -	ECN -
DATE 7/7/98	PART NO.		
DRAWN N.C. / CHECKED N.C.	MAT'L		
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DYTRAN INSTRUMENTS, INC.

LOW IMPEDANCE VOLTAGE MODE (LIVM) THEORY AND OPERATION

LIVM: WHAT IS IT?

LIVM is Dytran's trademark for our version of **L**ow **I**mpedance **V**oltage **M**ode piezoelectric instruments, i.e., piezo instruments with integral-impedance-converting amplifiers operating from constant current supplies over two wires. **LIVM** instruments are fully compatible with the new **IEPE** designated instruments.

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

Also falling under the class of LIVM instruments are in-line charge amplifiers that utilize the same two-wire constant current operating mode as the LIVM sensors.

Operating principles for all LIVM sensors and in-line amplifiers are similar in that they all utilize the same two-wire constant current operating mode. The amplifiers built into the sensors are either MOSFET input unity gain voltage amplifiers or MOSFET or JFET input charge amplifiers.

All types of LIVM amplifiers serve to convert the very high impedance of the piezoelectric crystals to a much lower impedance voltage signal that has the capability of driving long cables with little or no signal degradation.

THEORY OF OPERATION

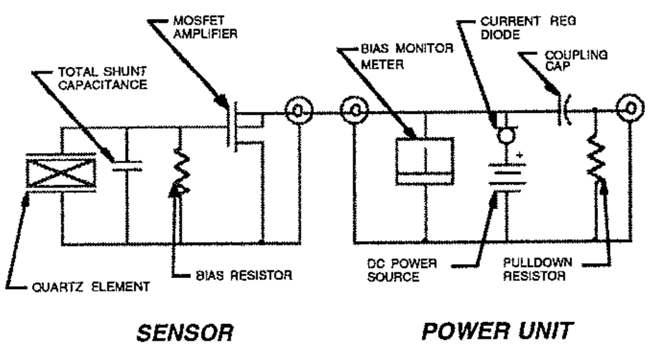

FIGURE 1: TYPICAL LIVM VOLTAGE MODE SYSTEM

Figure 1 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 element sensors.

The sensing element (force, pressure or acceleration), usually made with quartz crystals, is connected directly to the gate of a MOSFET input integrated circuit (IC) amplifier. This 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 may take the form of many different configurations from simple battery powered 2 mA units with constant current diode to line-powered adjustable current power units able to supply 2 to 20 mA of constant current from adjustable level constant current circuits.

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

Under quiescent conditions, most Dytran sensor amplifiers will bias themselves at approximately +11 volts DC at the input (source) terminal of the sensor. This sensor bias voltage is monitored and displayed, on most Dytran power units, and this feature serves as a handy trouble-shooting tool, serving as an indicator for normal or abnormal operation. (More on this topic in a following section, "The fault monitoring monitor as a trouble-shooting tool").

The sensor signal, produced by the measurand acting upon the piezo element, is superimposed upon the sensor bias voltage 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 (signal) portion is coupled directly to the "Output" jack of the power unit.

This jack may be connected directly to the input of readout instruments (oscilloscopes, spectrum analyzers, AC meters, frequency counters, etc.). The very low output impedance of the LIVM sensor (about 150 Ohms) makes the effect of most readout instruments on the signal, negligible.

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

Dytran also manufactures several DC-coupled power units for LIVM sensors that utilizes an active variable voltage level amplifier circuit to "buck out" the DC bias voltage of the sensor. One of these units, model 4115B, supplies constant current to the sensor and direct-couples the sensor to the output jack eliminating the coupling capacitor. This feature allows the user to take full advantage of the long time constant built into the sensor and precludes the effect of readout instrument load on the low frequency response of the system, The 4115B is especially useful for very long-term (quasi-static) measurements especially 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 IC circuits will absorb any amount of current supplied until they 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 of LIVM sensors directly to batteries, DC power units and many types of resistance measuring devices. 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. To determine if the IC is intact, use the monitor meter on the front panel of your Dytran power unit. This topic is covered in the following section, "The fault monitoring meter as a trouble-shooting tool".

After installing the sensor in accordance with instructions in the operating guide (manual) supplied with each sensor. connect the sensor to the power unit's "Sensor" jack . This jack, in most cases, is a BNC coaxial connector. You should have been supplied with the proper cable to connect the sensor to the power unit you have selected. If you were not, contact the factory for help.

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

THE FAULT MONITOR METER AS A TROUBLE - SHOOTING TOOL

Most Dytran power units incorporate a dc voltmeter on the front panel that measures the DC bias voltage at the sensor terminal. Measuring this voltage supplies information about the "health" of the measurement system. The three conditions it can identify are 1) normal operation, 2) shorted cable or sensor or faulty power unit and 3) open sensor or cable connection. We will examine each possibility here.

NOTE: The fault monitor meter may be the LED style shown on the left, Fig. 2, or the D'Arsonval panel meter style shown on the right, Fig. 2.

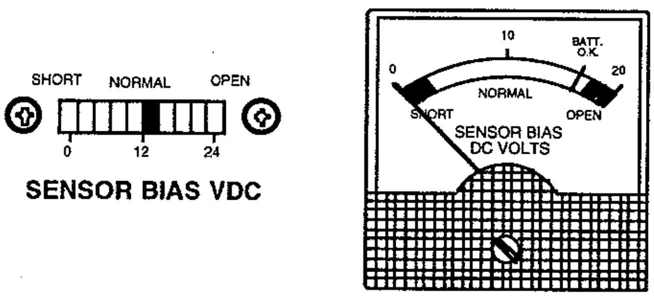

FIGURE 2 TYPICAL FAULT MONITOR METERS

NORMAL OPERATION

Under normal operating conditions, the monitor meter will indicate approx. mid-scale (+10 to +13 volts DC) when the sensor is connected. Many of the meter faces have a "Normal" area delineated to indicate that the sensor is functioning and the cable from sensor to power unit is neither open or shorted. It is possible that certain failure modes of the sensor can produce "Normal" indications but these modes are very rare. In most cases, if the meter reads in the "Normal" area, the system is viable.

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 a finger can cause the monitor meter pointer to deflect showing that the sensor is "alive". With some higher sensitivity accelerometers, shaking them by hand can deflect the monitor meter enough to show the sensor is functioning.

OPEN SENSOR OR CABLE (FULL SCALE METER READING)

If the sensor amplifier is burned out or the cable connecting sensor to power unit is open, the monitor meter will read in the "Open" area of the scale since the current source in the power unit has no load. To check if the problem is in the sensor, disconnect the sensor from its cable (leaving the other end connected to the power unit), and short across the open end of the cable with a metallic object while observing the meter. If the meter does not indicate zero ("short") while the sensor end of the cable is shorted, the cable is open. Replace the cable and try the sensor again, looking for the "Normal" indication.

If 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" area after connecting the sensor, this means that there is a short in the cable or sensor.

This condition cannot hurt the power unit since the maximum current is limited by the constant current circuit or diode in the power unit. Sometimes, shards of metal can scrape off of the cable connector of the 10-32 cables and these may short across the sensor connection. Check for this. Cleaning with a stiff-bristled brush will dislodge such metal shards.

If a short is still indicated, then the problem is with the cable or the power unit. Disconnect the cable from the power unit and observe the meter reading. If the meter reads full scale, the power unit is OK and the problem is a shorted cable or sensor. Replace the cable to verify.

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-hermetic units.

Clean epoxy from the mounting surfaces of accelerometers, if necessary, with acetone or other solvents that will dissolve and remove epoxies.

If the problem you are having is poor low frequency response and the sensor is not hermetically sealed, baking in a 250° oven for one hour will often get rid of moisture that may have shorted across the crystals and shortened the discharge time constant.

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

If the instrument is 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.

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WARRANTY

Dytran Instruments, Inc. warrants its products against defects in materials and workmanship for a period of one year after delivery. During the warranty period, Dytran, at its option, will either repair or replace products which prove to be defective.

WARRANTY LIMITS

1. Improper or inadequate maintenance by the buyer.
2. Unauthorized modification or misuse.
3. Improper installation by the buyer.

EXCLUSIVE REMEDIES

The remedies provided herein are the buyer's sole and exclusive remedies. Dytran shall not be liable for any direct, indirect, special, incidental or consequential tort or any other legal theory. Dytran warrants only the free recalibration of any sensor which deviates beyond its calibrated value within the warranty period.

Contact he factory for return instructions before sending any material for repair.