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OPERATING GUIDE

MODEL 1022V

MINIATURE LOW MASS LIVM™ FORCE SENSOR

This manual includes:

1) Specifications, Model Series 1022V
2) Outline/Installation drawing 1022V
3) Paper, “Low Impedance Voltage Mode (LIVM) Theory and Operation”

*__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 systems designated **IEPE**.

SPECIFICATIONS MODEL 1022V MINIATURE LIVM DYNAMIC FORCE SENSOR

SPECIFICATION	VALUE	UNITS
SENSITIVITY	100±5%	mV/Lb
RANGE	±50	Lbs
DISCHARGE TIME CONSTANT	100	Sec
STIFFNESS	26.2	Lb/µIn
MOUNTED RESONANT FREQUENCY, UNLOADED	50	kHz
LINEARITY [1]	±1	%F.S.
NOISE RESOLUTION	0.0004	LbF, rms
STRAIN SENSITIVITY	0.006	Lb/µε
F.S.OUTPUT VOLTAGE, NOM.	5	Volts
MAX SHOCK, UNLOADED	5,000	G's
MAX. VIBRATION, UNLOADED	± 2500	G's
COEFFICIENT OF THERMAL SENSITIVITY	.05	%/°F
TEMPERATURE RANGE	-100 to +250	°F
ENVIRONMENTAL SEAL	WELDED/EPOXY	
SUPPLY CURRENT / VOLTAGE RANGE [2]	2 to 20 / +18 to +30	mA / VDC
OUTPUT IMPEDANCE	150	Ohms
MATERIAL, HOUSING	TITANIUM	
WEIGHT	4.5	Grams
HEIGHT X DIAMETER	0.49 X 0.40	Inches

MOUNTING PROVISION 10-32 TAPPED HOLE AT TOP AND BOTTOM

ELECTRICAL CONNECTOR, MOUNTED AT END OF 5 FT INTEGRAL CABLE 10-32 Coaxial

ACCESSORIES SUPPLIED: (2) MOD 6200 Be Cu MOUNTING STUD

[1] Percent of full scale or of any lesser range, zero based best fit straight-line method.
[2] Power this instrument **only** with constant current type power units. **Do not** connect to a source of voltage without current limiting. This **will destroy** the integral IC amplifier.

OPERATING INSTRUCTIONS MODEL 1022V
LIVM MINIATURE DYNAMIC FORCE SENSOR

INTRODUCTION

The Dytran Model 1022V force sensor is designed to measure dynamic forces over a ±50g dynamic range scale over a very wide frequency range, quasi static to 50 kHz. Specifically, this sensor is designed to measure the driving forces from a vibration exciter into a specimen for modal analysis studies. Its miniature size and low mass (4.5 grams) means that very small specimens may be excited with little or no resultant effect of the mass of the force measuring sensor on the process.

Thin x-cut quartz crystals held under very high preload, provide voltage outputs exactly analogous to dynamic force inputs. The output polarity is positive-going for compression and negative-going for tension.

An integral IC unity gain amplifier, built within the instrument, converts the very high impedance voltage generated by the quartz crystals to a low impedance voltage output signal with excellent noise immunity. This instrument, thus, is able to drive long cables, virtually unaffected by cable capacitance and by triboelectric noise generated by moving cables.

The integral IC amplifier is powered by simple current source power units or from power sources now built into many data collection instruments. These power sources are labeled LIVM which is the Dytran designation for this type of instrumentation.

Model 1022V features tapped 10-32 mounting holes at the top and bottom surfaces to facilitate mounting of the sensor. These holes accept the Model 6200 mounting studs (supplied) which are designed to mount into threaded holes in the driving rods.

DESCRIPTION

Refer to figure 1 below for a representative cross section of Model 1022V force sensor. The cable extends transversely from a boss built into in the housing. The cable is coaxial, 5 ft. long with a 10-32 male coaxial connector at the end.

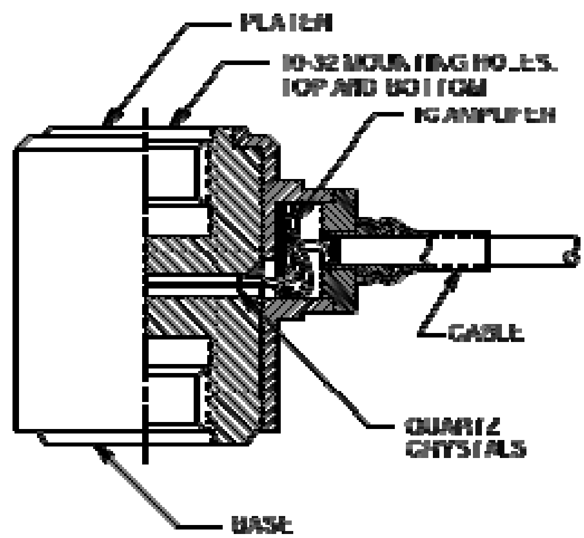

Figure 1
CROSS SECTION, MODEL 1022V

Referring to Figure 1, the upper female -threaded member (called the platen) distributes the force evenly across the quartz crystals while sealing the instrument against moisture and other contaminants. The very thin quartz crystals comprise a relatively small portion of the length of the sensor which results in a very high stiffness, (high rigidity) thus, high natural frequency. The overall stiffness of this instrument is almost comparable to a solid piece of titanium of similar dimension.

Refer to the Outline/Installation drawing, 127-1022V, supplied with this manual, for a dimensioned outline of Model 1022V.

THEORY OF OPERATION

Figure 2 (below) schematically illustrates a typical Sensor/ Cable/Power Unit measurement system. The readout instrument is connected directly to the power unit output signal jack at the right hand side of Figure 2.

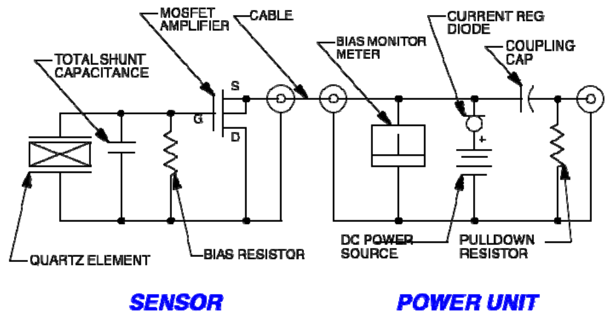

FIGURE 2
SYSTEM SCHEMATIC DIAGRAM

The input force compresses the crystals and, alternately, relaxes the preload, producing an analogous electrostatic charge, Q. The total shunt capacitance (see figure 2) converts this charge to a voltage V. This process is governed by the electrostatic equation:

$$V = \frac{Q}{C} \qquad \text{Eq. 1}$$

where: Q = total electrostatic charge,
C = total shunt capacitance across crystals,
V = resultant voltage across crystals

This voltage V, from the crystals, is connected across the gate of the unity gain MOSFET input IC amplifier where its impedance level is decreased approx. 10 orders of magnitude, i.e., from 1 Terraohm to 150 Ohms.

During normal operation, the source terminal of the IC amplifier in Model 1022V is supplied with constant current (in the range of 2 to 20 mA) from the LIVM power unit using a single 2-wire cable to connect sensor to power unit. The dynamic force signal from the sensor appears superimposed upon the DC bias level of the internal amplifier. This bias voltage (about +10 Volts DC) is blocked by the circuitry in the power unit and the dynamic (AC) voltage signal is passed along to the readout instrument via the Output jack.

Power inputs for the many types of power units available are 115VAC power mains, batteries and +28 VDC aircraft power, among others.

SIGNAL POLARITY

Compressive forces on this sensor (see Figure 1) produce positive-going output signal voltages while tension produces negative-going output signals.

SENSITIVITY

The voltage sensitivity of each sensor is fixed at time of manufacture and cannot be changed. The exact calibrated sensitivity of the sensor is given on a calibration certificate supplied with each sensor. Nominal sensitivity is 100 mV/Lb force.

INSTALLATION

Refer to outline/installation drawing 127-1022V, supplied with this guide and to Fig. 3 below.

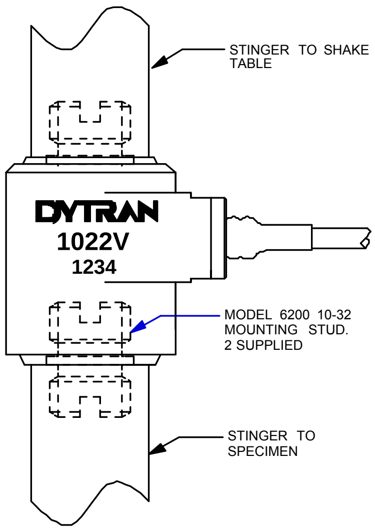

FIGURE 3
TYPICAL INSTALLATION

Model 1022V is designed to be mounted to a stinger (or rod), one side of which attaches to the driving exciter and the other end of which drives the specimen under test. To mount model 1022V, it is necessary to prepare a flat smooth mounting surface of a Ø.280 nominal diameter rod (or stinger) at each end of the sensor. The surfaces should be flat to .0005 TIR for best results.

To mount the sensor, drill and tap a thru hole to accept the 10-32 thread on the mating end of both rods to secure the 1022V to its mounting surfaces.

When you are satisfied that the mating surfaces of the input and output rods are square and clean, place a thin layer of silicone grease on the mating surfaces. Thread the two model 6200 10-32 mounting studs supplied, into top and bottom surfaces of the sensor. Thread the force sensor into each of the rods, torquing it in place with 3 to 7 Lb-inches of torque to secure.

Connect the sensor cable to the power unit using Series 6010AXX cable (10-32 to 10-32) or Series 6011AXX (10-32 to BNC plug), depending on the connector called for by the power unit. (“xx” is the cable length in feet). Tighten the cable connector lock ring snugly by hand. Do not use a pliers or vise grips on these cable lock rings.

OPERATION

After connecting the cable from the sensor to the power unit, wait several seconds for the internal coupling capacitors to fully charge and for the sensor bias voltage to stabilize. Model 1022V has a relatively long 100 Second discharge time constant (TC) for excellent low frequency response. This extra-long TC will require a longer wait to completely stabilize the output voltage level. The instrument may be used before complete stabilization of the sensor bias voltage since the DC bias is blocked within the power unit.

BIAS MONITOR METER ON DYTRAN POWER UNITS

Most Dytran power units feature self test bias monitoring voltmeters on the front panel to check for normal system operation. This meter will indicate in the mid-scale area (Normal) when the sensor and cable are functioning normally. If the cable is open or disconnected, the meter will read full scale (Open) and if the cable or sensor is shorted, the meter will indicate to the left of the scale limit (Short).

This feature presents the user with a very handy trouble shooting tool when looking for system problems. Consult the paper, “Low Impedance Voltage Mode (LIVM) Theory and Operation” included with

this manual, for a more in-depth description of this feature.
Within the sensor, the voltage produced by dynamic forces acting upon the crystals is superimposed upon the fixed bias voltage of the internal IC amplifier.

Refer to Fig. 4, a schematic of a typical LIVM Dytran power unit. Typical Dytran power units are AC coupled, i.e., the DC bias voltage from the sensor is "blocked" by a capacitor (usually 10 uF) within the power unit as shown in Figure 4. This effectively returns the DC signal level to zero volts.

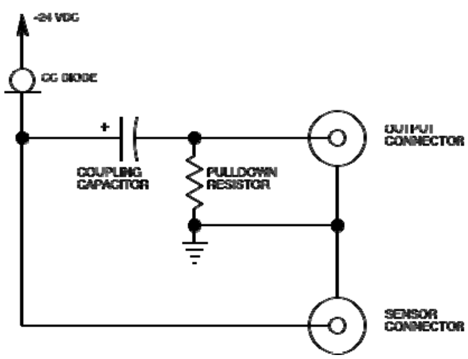

FIGURE 4
POWER UNIT DECOUPLING CONSIDERATIONS

A potential problem with this is that the readout instrument puts a resistive load at the output terminal of this coupling capacitor which forms a high pass filter. This filter limits the low frequency response of the power unit possibly making the system unsuitable for very low frequency measurements.

In most Dytran AC coupled power units, a "pulldown" resistor (R in Fig. 4) usually 1 Megohm, is placed across the output jack of the power unit to reduce the amount of DC offset which would result from leakage from the 10 uF tantalytic capacitor used in the output decoupling circuit. This further exacerbates the problem raising the low frequency cutoff frequency still higher.

As an example, let's assume your readout instrument has a 1 Megohm input resistance. This appears in parallel with the 1 Megohm pulldown resistor to place a 500 kΩ load across the 10uF capacitor. The coupling time constant (TC) is:

TC = RC = 500,000 x 10uF = 5 Seconds

The low frequency cutoff (-3db) is:

$$f_l = \frac{1}{2\pi RC} = \frac{.16}{5} = .032 \text{ Hz}$$

The low frequency -5% frequency is approx. 1/3 times the -3db frequency which means that we may take readings with 5% accuracy down to about 0.1 Hz. Another solution available to allow even lower frequency measurement is to use a power unit which does not use a de-coupling capacitor but rather a DC coupled voltage level shifting circuit.

The Dytran Model 4115B is such a power unit. (Refer to simplified schematic, Figure 5, below). In the Model 4115B, the input signal from the sensor is applied to a DC-coupled summing amplifier. A variable negative DC voltage is applied to the negative terminal of the summing amplifier. By adjusting this negative voltage to exactly the amplitude of the positive DC bias voltage from the sensor, the output of the 4115B may be set precisely to zero volts, and with the discharge time constant limited only by the TC of the sensor itself. Model 4115B is virtually unaffected by readout load input impedance.

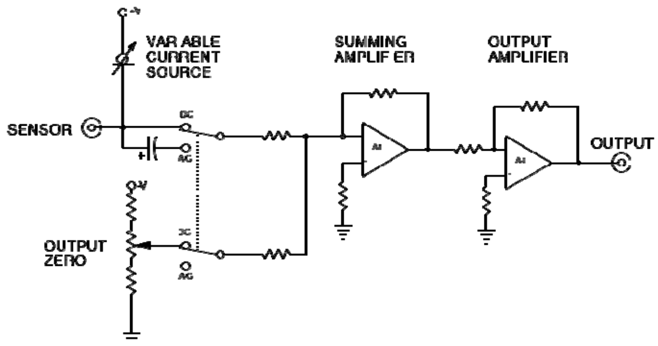

FIGURE 5
SIMPLIFIED SCHEMATIC, 4115B
DC-COUPLED POWER UNIT

CALIBRATION

Since the Model 1022V sensor is a dynamic sensor, i.e., a sensor designed to measure dynamic (rapidly changing) forces, it makes sense to calibrate it dynamically.

This sensor is calibrated at the factory by placing a traceable compressive force on it, then rapidly removing this force and capturing the resultant negative-going step function on a digital storage oscilloscope. This is a very accurate and repeatable method for calibration of this sensor.

It is recommended that these sensors be returned to the factory for periodic recalibration with frequency of calibration determined by the usage factor.

MAINTENANCE AND REPAIR

The sealed construction of Model 1022V precludes field maintenance. Should you experience a problem with your sensor, contact the factory to discuss the problem with one of our sales engineers. If the instrument must be returned to the factory, you will be issued a Returned Materials Authorization (**RMA**) number so we may better follow the instrument through the evaluation and repair process. Please do not return an instrument without first obtaining the RMA number. There is no charge for the evaluation and you will be notified of any charges before we proceed with a repair.