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OPERATING GUIDE

MODEL SERIES 1212V IEPE FORCE SENSOR

This manual includes:

1) Specifications, Model Series 1212V
2) Outline/Installation drawing 1212V

NOTE: IEPE is an acronym for Integrated Electronics Piezoelectric types of low impedance voltage mode sensors with built-in amplifiers operating from constant current sources over two wires. **IEPE** instruments are compatible with other comparable systems labeled **LIVM**™.

OPERATING INSTRUCTIONS MODEL SERIES 1212V
IEPE DYNAMIC FORCE SENSORS

INTRODUCTION

The series 1212V low profile ring style force sensors are designed to measure dynamic forces over a range of 500 Lbs to 5,000 Lbs full scale and over a wide frequency range.

Thin x-cut quartz crystals held under very high compressive preload, provide a voltage output analogous to dynamic force inputs when stressed by input force. 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. Additionally, these built-in electronics also eliminate the need for an external charge amplifier and converter.

Model series 1212V features a 10 foot integral cable that terminates into a BNC connector. The amplifier is located within the housing.

DESCRIPTION

Refer to Figure 1 below for a cross section of Model Series 1212V force sensors.

The internal amplifier is mounted within the hollow radial housing and the integral cable is located at the end of this housing.

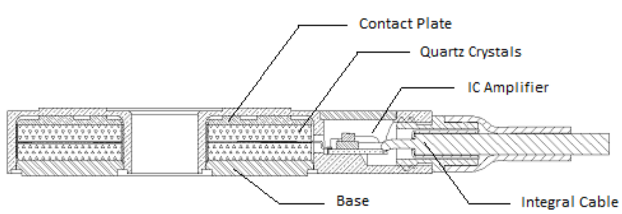

Figure 1
CROSS SECTION, MODEL 1212V

Model series 1212V is recommended for use where radial space is not a problem, such as in some drop-shock testers or when instrumenting shafts or pushrods where there is space around the machine for the electrical connector to exit radially.

Refer to the Outline/Installation drawing, 127-1212V1, supplied with this manual, for a dimensioned outline of Model series 1212V.

THEORY OF OPERATION

Refer to Figure 2, below.

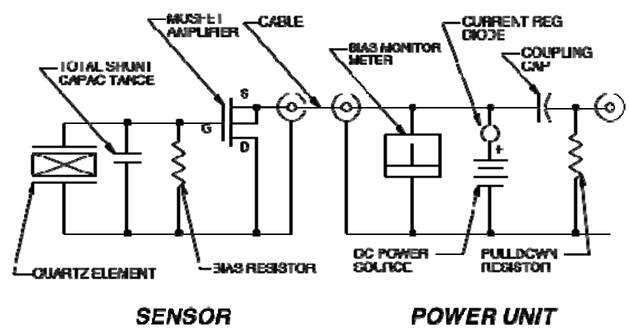

FIGURE 2
SYSTEM SCHEMATIC DIAGRAM

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

The input force stresses the crystals inside the sensor and produces 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, is connected across the gate of the MOSFET input IC amplifier where its impedance level is decreased by approximately 10 orders of magnitude, i.e., from 1 Terraohm to 100 Ohms.

The source terminal of the IC amplifier in the 1212V is supplied with constant current (from 2 to 20 mA) from the power unit, and the force signal 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 signal is passed along to the readout instrument via the Output jack.

SIGNAL POLARITY

Compressive forces on these sensors (see Figure 1) will 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 sensitivity of each sensor is given on a calibration certificate supplied with each sensor. Consult the chart on the specification sheet supplied with this guide for available nominal sensitivities and ranges for each model.

INSTALLATION

Refer to Outline/Installation drawing 127-1212V, supplied with this guide.

To mount model 1212V, it is necessary to prepare a flat smooth mounting surface that is 11/16” minimum in diameter. This surface should be flat to .001 TIR for best results. Make sure that the sensor is mounted by the base and not by the top surface. Use Outline/Installation drawing 127-1212V to determine which is the proper mounting surface.

Before installing the sensor into a force joint, inspect the mating surfaces for any foreign particles which may become lodged between these surfaces and clean if necessary. It is important that the mating surfaces meet squarely and intimately with no particles of foreign matter of any kind included between them. Foreign particles included between mating surfaces could damage the sensor and/or modify the sensitivity of the sensor.

When you are satisfied that the surfaces are square and clean, place a thin layer of silicone grease on the mating surfaces and thread the force sensor in place, torquing 25 to 30 lb-in. of torque to secure.

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. 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

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 or to verify normal operation.

LOADING CONSIDERATIONS

When applying loads to the force sensor, it is important to note that the load is distributed evenly across the force sensitive face of the force sensor.

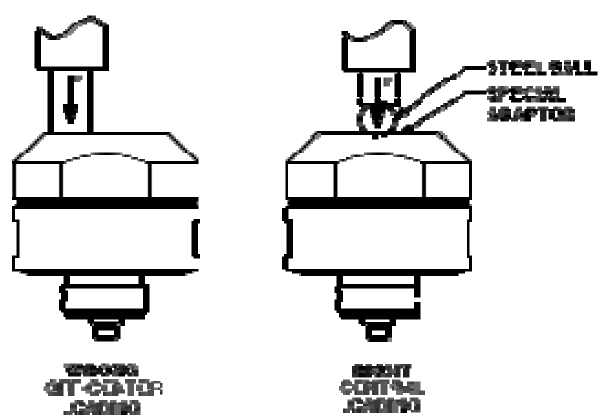

FIGURE 3
ILLUSTRATING OFF-CENTER LOADING

Figure 3 is intended to illustrate the proper way to apply loads to the sensor. Due to the various potential applications, the figure should only illustrate, in the most basic sense, the proper and improper ways to apply loads.

In the illustration chosen in Figure 3, the force sensor is being loaded dynamically by a hydraulic or pneumatic ram. It is important that the force be evenly distributed, centrally, to the force sensor.

TENSILE LOADING

Figure 4 illustrates one proper way to load the 1212V in tension. Again, the forces must travel through the center of the sensor as shown.

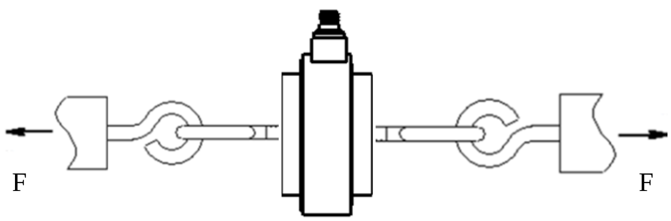

FIGURE 4
PROPER TENSILE LOADING

The arrangement shown in Figure 4 ensures that the load is applied centrally onto the sensor without bending moments and transverse loading.

An important point to keep in mind when making tensile measurements, due to limits in the design of the internal preload structure of the sensors, the **maximum tensile force is limited** to **the preload force of the force link used**. If this level is exceeded, the signal may clip and the preload of the force link may suddenly release. This could create a dangerous situation for personnel and equipment if this is not fully understood.

Remember that the maximum force is the combination of both static and dynamic tensile forces. For example, if the force link is preloaded to 500 lbf and the sensor is supporting a static load of 300 Lbs., the **maximum** dynamic range possible is **200 Lbs**.

QUASI-STATIC CONSIDERATIONS

The discharge time constant of Model series 1212V is long enough to allow near static measurements to be performed. However, it is important to consider other coupling time constants within the measurement system which could affect any quasi-static measurements.

As previously stated, the integral IC amplifier in the IEPE sensor is powered by a single coaxial cable. This cable supplies anywhere from 2 to 20 mA of current from the power unit. (Refer to Figure 5), below.

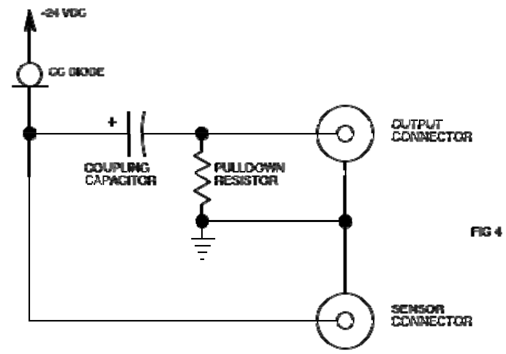

FIGURE 5
POWER UNIT DECOUPLING CONSIDERATIONS

The voltage produced by a dynamic force acting upon the crystals is superimposed upon the fixed bias voltage of the internal IC.

Most power units are AC coupled, i.e., the bias voltage is “blocked” by a capacitor (usually 10 uF) within the power unit as shown in Figure 5. This effectively returns the signal level to zero volts.

The 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 making the system unsuitable for quasi-static measurements. In most Dytran power units, a “pull down:” resistor (usually 1 Megohm) is placed across the output jack of the power unit (Refer to Figure 5) to reduce the amount of DC offset which would result from leakage from the 10 uF capacitor used in the output decoupling circuit. This further exacerbates the problem by raising the low frequency cut-off frequency higher still.

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

$$TC = RC = 500{,}000 \times 10uF = 5 \text{ Seconds}$$

The low frequency cutoff is:

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

The first 10% of the RC discharge curve is relatively linear so in order to make a measurement with 1% accuracy, the total elapsed time of the measurement of a static event must be less that 1% of the discharge TC.

With a discharge TC of 5 seconds, we can calculate the time to take a 1% reading.

$$T = 1\% \times 5 = 0.5 \text{ Seconds.}$$

This result states that we have a maximum time of 0.5 seconds to take the reading after the application of the static force. This of course, is very difficult to do without the use of a digital storage oscilloscope. A better solution 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 6). 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.

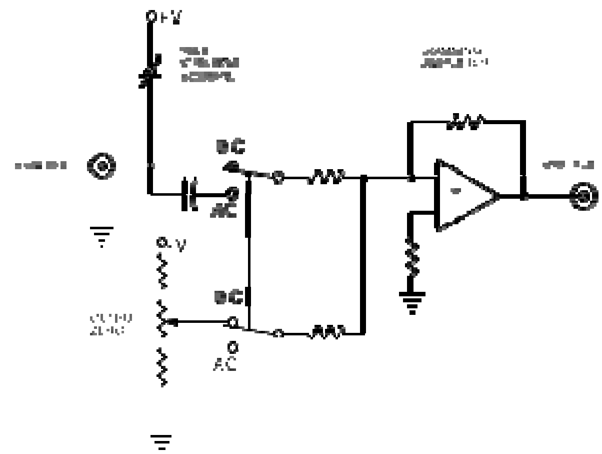

FIGURE 6
SIMPLIFIED SCHEMATIC, 4115B

CALIBRATION

Since the Model 1212V sensors are dynamic sensors, i.e., sensors designed to measure dynamic (rapidly changing) forces, it makes sense to calibrate them dynamically.

These sensors are calibrated at the factory by placing a traceable force on them, then rapidly removing it and capturing the resultant step function on a digital storage oscilloscope. This is a very accurate and repeatable method for calibration of these sensors. 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 Series 1212V 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 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.