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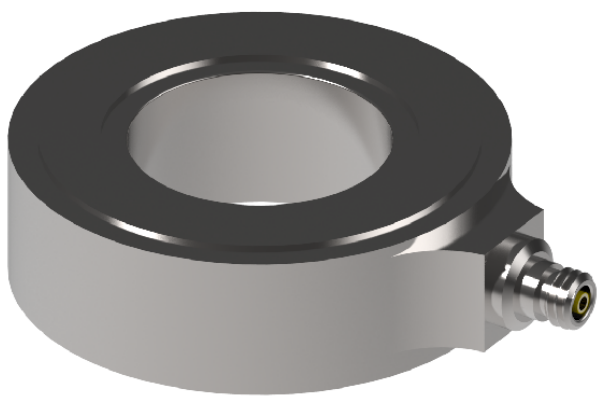
OPERATING GUIDE

MODEL SERIES 1210V IEPE FORCE SENSOR



This manual includes:

1) Specifications, Model Series 1210V
2) Outline/Installation drawing 1210V

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 1210V
IEPE DYNAMIC FORCE SENSORS

INTRODUCTION

The series 1210V force sensors are designed to measure dynamic forces over a wide dynamic range, e.g., from 5,000 Lbs full scale to 100,000 Lbs full scale over a very wide frequency range, quasi static to 50 kHz.

These sensors are available in seven full scale compression ranges: 5,000 to 100,000 Lbs input for 5 Volts output. Refer to the chart of ranges and sensitivities in the specification sheet provided with this guide.

Thin x-cut quartz crystal 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. These instruments thus are able to drive long cables, unaffected by cable capacitance and by triboelectric noise generated by moving cables.

The integral IC amplifier is powered by simple current source power units. Connections from power unit to force sensor may be made using inexpensive two-wire cable in lieu of coaxial cable if desired.

Model series 1210V features a radially, mounted connector which is mounted to a connector housing protruding radially from the side the unit. The amplifier is housed within this housing.

DESCRIPTION

Refer to figure 1 below for a cross section of Model Series 1210V force sensors.

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

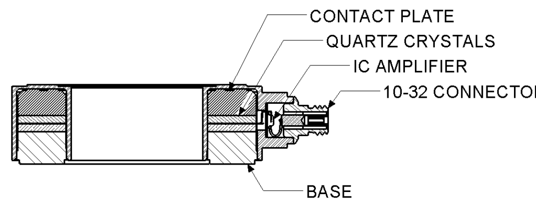


Figure 1
CROSS SECTION, MODEL 1210V

Model series 1210V 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, 127-1210V, supplied with this manual, for a dimensioned outline of Model series 1210V.

THEORY OF OPERATION

Refer to Figure 2, below.

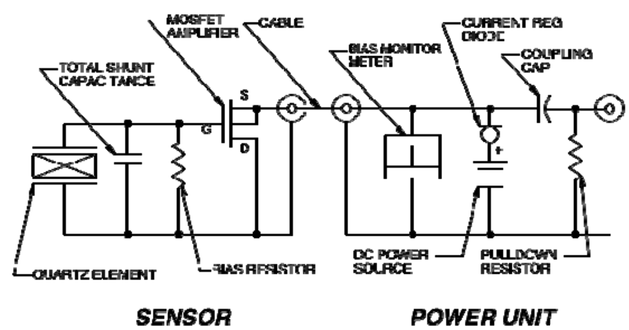


FIGURE 2
SYSTEM SCHEMATIC DIAGRAM

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 (squeezes) the crystals 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:

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

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 approx. 10 orders of magnitude, i.e., from 1 Terraohm to 100 Ohms.

The source terminal of the IC amplifier in the 1210V is supplied with constant current (from 2 to 20 mA) from the power unit over a single 2-wire cable (coax, twisted pair, etc.) 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.

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

SIGNAL POLARITY

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

INSTALLATION

Refer to outline/installation drawing 127-1210V, supplied with this guide.

To mount model 1210V, it is necessary to prepare a flat smooth mounting surface of 5/8" minimum diameter. The surface should be flat to .0005 TIR for best results.

When planning the installation, make sure that there is radial clearance available to allow connection of the cable to the 10-32 connector at the end of the amplifier housing. Make sure that that sensor is mounted by the base and not by the top surface. Use the outline/installation drawing 127-1210V to determine which is the proper mounting surface.

Before installing 1210V into a force joint, inspect the mating surfaces for 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 one of the surfaces and thread the force sensor place, torquing it in place with 25 to 30 Lb-inches of torque to secure.

Connect the sensor 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. Tighten the cable 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. In the higher range units, (1210V1 to V3) the extra-long discharge time constant (2000 Sec.) 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

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.

Consult the paper, “Low Impedance Voltage Mode (IEPE) Theory and Operation” included with this manual, for a more in-depth description of this feature.

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.

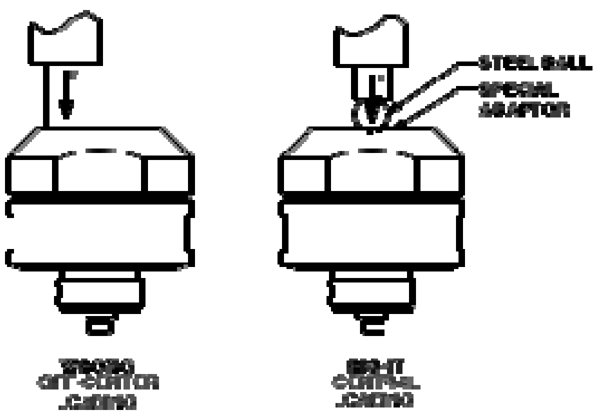


FIGURE 3
ILLUSTRATING OFF-CENTER LOADING

Figure 3 is intended to illustrate the proper way to apply loads to the 1210V. Obviously we cannot address the many different applications but merely want to illustrate, in the most basic sense, the proper and improper ways to apply loads to these instruments for the purpose of heading off measurement problems which may be incurred by improper use.

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 1210V in tension. Again, the forces must travel through the center of the sensor.

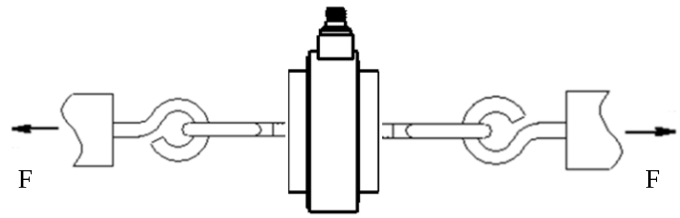


FIGURE 4
PROPER TENSILE LOADING

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

One important point to keep in mind when making tensile measurements is that, due to limits in the design of the internal preload structure of these sensors, the **maximum tensile force is limited** to **the preload force of the force link used**. If this level is exceeded, the signal may be clipping and the preload of the force link will be suddenly released. This could engender dangerous situations for personnel and equipment if this eventuality 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 the Model series 1210V, especially for the higher ranges, is long enough to allow near static measurements to be performed. However, it is important to consider other coupling time constants in the measurement system which could effect 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.

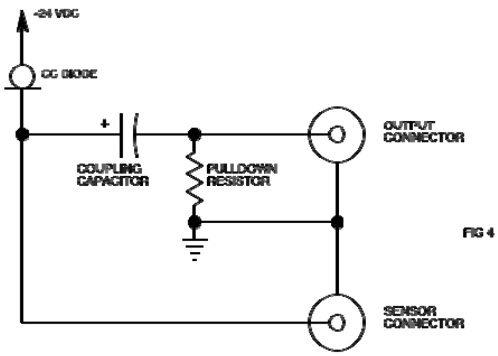


FIGURE 5
POWER UNIT DECOUPLING CONSIDERATIONS

The voltage produced by 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 “pulldown:” resistor (usually 1 Megohm) is placed across the output jack of the power unit (Refer to Fig. 5) to reduce the amount of DC offset which would result from leakage from the 10 uF tanalytic capacitor used in the output decoupling circuit. This further exacerbates the problem raising the low frequency cutoff frequency still higher.

As an example, lets 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 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 we may say that 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 may calculate the time to take a 1% reading.

T = 1% x 5 = 0.50 Seconds.

This result states that we have a maximum 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.

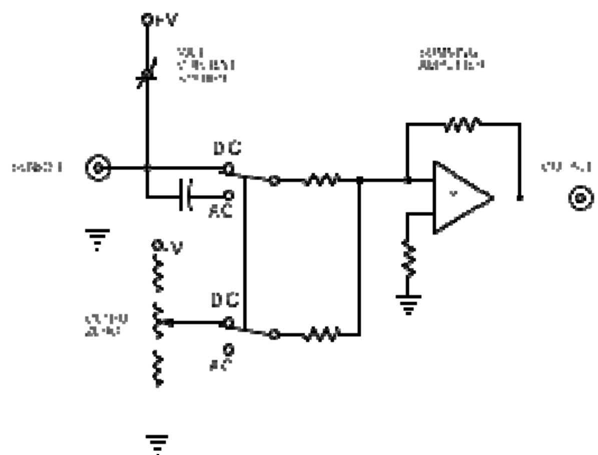


FIGURE 6
SIMPLIFIED SCHEMATIC, 4115B

CALIBRATION

Since the Model 1210V 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 1210V 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.