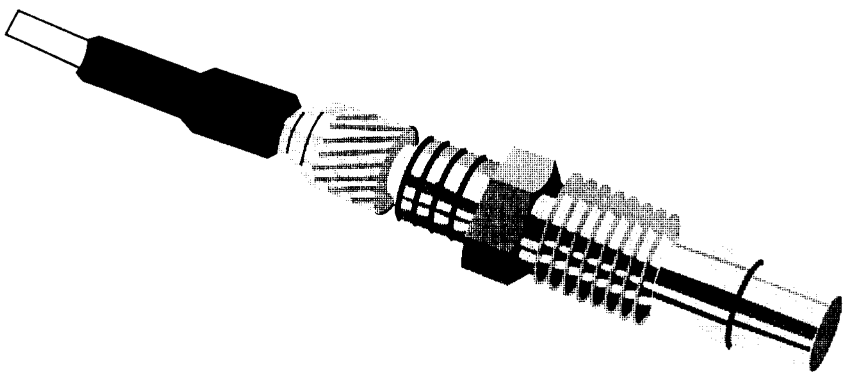
DPX101

High-Frequency Pressure Sensor



OMEGA®

An OMEGA Technologies Company

Operator's Manual

M1639/0493

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INTRODUCTION

The Model DPX101 Sensors are designed to measure transient (dynamic) pressure phenomena such as repetitive (cyclical) perturbations at frequencies from fractions of an Hz to 250 kHz and single pressure pulses from several microseconds to several seconds duration.

The six models in this series are ranged to produce 5 Volts out for inputs of 100, 250, 500, 1000, 5000 and 10,000 PSI respectively.

These instruments feature a very rigid quartz element coupled to a micro-miniature MOSFET input IC amplifier operating as a source follower (unity voltage gain). This amplifier converts the high impedance signal generated by the quartz element to a low impedance, fixed sensitivity voltage output signal which can be connected directly to readouts such as oscilloscopes, recorders, etc., without need for amplifiers, isolators, etc.

UNPACKING THE SENSOR

Remove the packing list and verify that you have received all equipment. If you have questions about the shipment, please call the OMEGA Customer Service Department at (800) 622-2378 or (203) 359-1660.

Upon receipt of shipment, inspect the container and equipment for any signs of damage. Note any evidence of rough handling in transit. Immediately report any damage to the shipping agent.

DESCRIPTION

Figure 1 is a cross-section drawing of the DPX101 sensor.

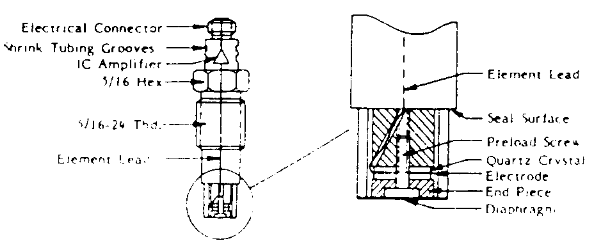


FIGURE 1 - Cross-section DPX101 Series

The self generating quartz element consisting of heavily preloaded synthetic quartz discs, produces an analogous electrical charge when stressed by pressure acting upon the thin steel diaphragm. This charge, ($\triangle q$) instantaneously charges shunt capacitor C, to voltage $\triangle v$ in accordance with the following relationship:

$$\triangle v = \frac{\triangle Q}{C} \qquad \textbf{EQ. 1}$$

where:

$\triangle v$ = instantaneous voltage, Volts

$\triangle q$ = instantaneous charge, pC

C = total shunt capacitance, pF

Refer to Figure 2.

Figure 2 is a simplified schematic of the DPX101 Sensor including simplified current source power unit.

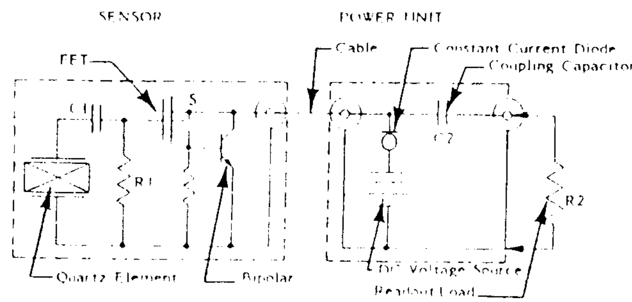


FIGURE 2 - Simplified Schematic Diagram

Since the FET amplifier is a unity gain source follower, voltage v also appears at the sensor source terminal. The bias voltage at this terminal is nominally +11V, thus the voltage at the output is:

$$V = \triangle v = 11, \quad \text{Volts} \qquad \textbf{EQ.2}$$

The electrolytic capacitor in the power unit serves to return the output signal to a zero-based level, i.e., it "removes" the +11V bias.

The current regulating diode in the power unit supplies a fixed current to the sensor amplifier and because of its very high dynamic impedance allows the amplifier to operate at very close to unity gain.

USER PRECAUTIONS

If the sensor is to be used in a thermally active environment such as in blast or explosive pressure measurements, it may be necessary to thermally shield the diaphragm with an insulating or ablative coating to avoid excessive thermally induced transient output voltages, and to protect the diaphragm against damage from particle impingement that could abraid the diaphragm.

Black vinyl electrician's tape, available at most hardware stores, can be an excellent protective insulator in many cases.

Ablative coatings such as many of the RTV and other silicone rubber coatings can also be useful in these cases.

INSTALLATION

Installing Without The DPX-NPT Adapter *(sold separately)*:

The mating port for the DPX101 pressure sensor should be as shown in Figure 3 *(page 4)*. Prepare the port as follows:

1. Ream #2 (.221" diameter) through
2. Counterbore .250" diameter x .560" deep
3. Counterdrill .272" diameter x .500" deep
4. Bottom tap 5/16-24UNF-2B x .440 minimum depth
5. Inspect finished ports for chips and burrs before attempting installation.

Pay close attention to concentricities and smoothness of steel surfaces.

The DPX101 is provided with a brass seal. Install this seal in front of the sensor as shown in Figure 3. Install the sensor using 30 in.-lb. of mounting torque applied on the 5/16 hex surface using a torque wrench and a hex socket.

Installing With The DPX-NPT Adapter *(sold separately)*:

Using the DPX-NPT adapter, versus installing as described above, will give you the best repeatability of calibration. Another advantage of using the NPT adapter is that it is much easier to prepare a precise mounting surface in the adapter than in most actual installation surfaces.

1. Install the brass seal into the DPX-NPT adapter.
2. Torque sensor into DPX-NPT as close as possible to the torque listed on the calibration sheet.
3. Use teflon tape when installing the sensor/adapter assembly into the mating NPT threaded port.
4. Check for leaks by increasing pressure slowly and looking for fluid or gas leaks, until operating pressures are exceeded.

ELECTRICAL CONNECTIONS

Connect the constant current power unit to the sensor using a Model ACC-CB2 Cable (sold separately).

As shown in Figure 4, connect sensor to power unit at sensor jack.

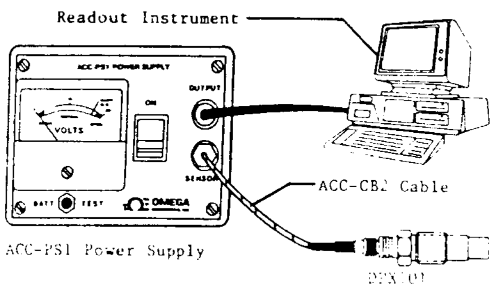


FIGURE 4 - Electrical Connections

Secure cables (hand tight, no pliers). Secure cable at sensor and with shrink tubing over tower provided if desired to protect connections in dirty or wet field installations.

Now connect output of power supply to the readout instrument. (Output cables are available from OMEGA Engineering).

Energize power unit; wait several seconds for coupling capacitors to fully charge (the output voltage will slowly "drift" while coupling capacitors charge) and proceed with measurement.

CALIBRATION

The DPX101 Series Pressure Sensors are calibrated at the factory using dynamic calibration methods, hydraulically. The actual calibration values are given on individual calibration sheets supplied with each sensor.

Because of the relatively short discharge time constants on most models, field calibration by quasi-static means is very difficult.

Should recalibration be necessary, consult the factory for details on the low cost calibration service available.

FREQUENCY RESPONSE

The DPX101 Series Pressure Sensors are "DYNAMIC" pressure transducers, i.e., they respond to changes in pressure at the diaphragm and can accurately measure pressure events as fast as several microseconds and as slow as several seconds.

They *cannot*, however, measure static pressure levels for longer than several seconds.

This section is an attempt to outline the advantages as well as the limitation of these sensors.

If a steady state (static) pressure is applied to the diaphragm of the sensor, the output voltage will respond instantly to the initial input step (assuming it is applied instantly), then will immediately begin to discharge toward the bias voltage level at a rate determined by the discharge time constant (TC) built into each sensor. Consult the calibration certificate for the actual value for each sensor. It will vary from model to model.

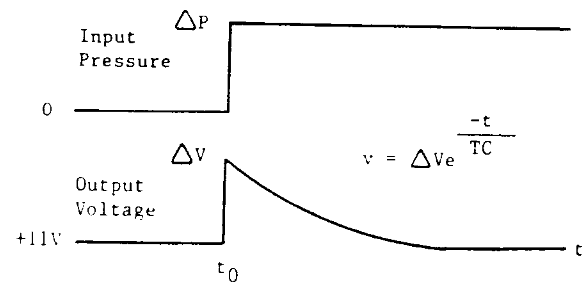


FIGURE 5 - Response to Steady State Input

Figure 5 is a representation of the response of the DPX101 to a step function application of steady state pressure.

The output voltage response follows the classical exponential decay formula:

$$v = \Delta V e^{\frac{-t}{TC}} \qquad \textbf{EQ. 3}$$

where:

v	=	instantaneous output voltage response,	Volts
ΔV	=	initial voltage response to step pressure input,	Volts
TC	=	discharge time constant of sensor,	Seconds
e	=	base of natural logarithm	
t	=	time,	Seconds

It is this factor that determines the Low Frequency response of the sensor and which limits the ability to measure static pressures.

To find the frequency at which the sensor low frequency response is down (attenuated) by 3db, solve for it by use of the following equation:

$$f_{-3db} = \frac{.16}{TC} \qquad \textbf{EQ.4}$$

where:

f_{-3db}	=	frequency at which sensor response is 3db down,	Hz
TC	=	discharge time constant of sensor,	Seconds

Refer to Figure 6.

Figure 6 illustrates the typical frequency response characteristics of the DPX101 Series pressure sensors.

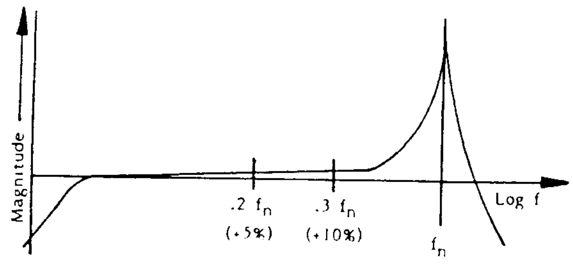


FIGURE 6 - Typical Frequency Response Characteristics

Since the piezo element responds like a typical underdamped spring-mass system, the output will show a slight rising characteristic with increasing input frequency, then close to resonance the output will show a marked increase as shown in Figure 6.

The upper +3db frequency will be approximately $0.5f_n$. For the DPX101 the resonant or natural frequency is nominally 500 kHz making the +3db frequency approximately 170 kHz ($.5\ f_n$).

These guidelines loosely define the useable frequency range of your piezo measurement system.

Consult the factory for help with specific measurement problems not covered by this manual.

GUIDELINES

Here are some guidelines to help you get maximum life and use from your sensor investment.

- Do not, under any circumstances, connect power to sensor by use of a DC voltage supply (battery or other voltage supply) without current limiting protection, 20 mA MAXIMUM. To do so will instantly destroy the built-in amplifier and void the warranty.
- Do not exceed the maximum rated temperature of +250°F. This can also destroy the internal amplifier.
- Observe mounting torque carefully. Overtorquing could strip threads, warp sensor body, damage mounting ports, sensor mounting surfaces and/or seals and permanently change calibration factor of sensor. Too little torque can result in errors in scale factors and leakage.
- Check seal seats carefully for burrs, chips, nicks and other imperfections that could damage surfaces of sensor or port and preclude a pressure seal.
- Bleed air out of hydraulic installations by torquing sensor in place, hand tight, and slowly increasing pressure until leaking oil contains no bubbles. In some cases, trapped air ahead of the diaphragm can give erroneous results especially with fast transient measurements.
- Consider frequency limiting effects of long passages ahead of the diaphragm due to "pipe organ" effect. Consult factory for guidelines on this effect.
- Protect cables and connections with shrink tubing in dirty, wet or vibrating installations.

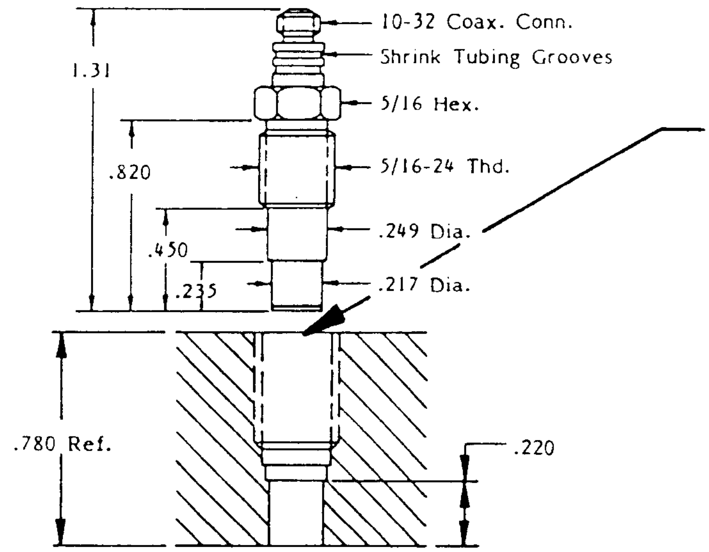
MAINTENANCE

Other than for an occasional cleaning of the electrical connector and mounting threads, no routine maintenance is possible or necessary.

DLX101 SPECIFICATIONS

Excitation:	2 mA nominal @ 18-30 Vdc, constant current
Rated Output:	5 Vdc nominal FS
Rise Time:	1.0 uSec
Resonant Frequency	500 kHz
High Frequency Range:	170 kHz (approx. 1/3 of resonant frequency)
Low Frequency Range: (-3 dB)	0.08 Hz (DPX101-250) 0.03 Hz (DPX101-500) 0.02 Hz (DPX 101-1K) 0.003 Hz (DPX101-5K)
Acceleration Sensitivity:	0.002 psi/g
Discharge Time Constant:	2 sec (DPX101-250) 5 sec (DPX101-500) 10 sec (DPX101-1K) 50 sec (DPX 101-5K)
Proof Pressure:	5000 psi (DPX 101-250) 10,000 psi (DPX101-500) 10,000 psi (DPX101-1K) 15,000 psi (DPX101-5K)
Overload Recovery:	10 uS for 2X range
Maximum Shock:	±10,000 g peak
Maximum Vibration:	±5,000 g
Amplitude Linearity:	± 1% FS (BSFL/0)
Temperature Range:	-100 to 250 deg F (-75 to 120 deg C)
Temperature Sensitivity Effect:	0.03% F.S./deg F
Output Impedence:	100 Ohms
Bias Voltage:	9V nominal
Noise Floor (wideband, RMS):	0.004 psi (DPX101-250) 0.007 psi (DPX101-500) 0.014 psi (DPX101-1K) 0.07 psi (DPX101-5K)
Weight:	0.5 oz. nominal
Material:	316L stainless steel diaphragm 17-4 stainless steel housing
Connector:	10-32 male termination (cable not included - order P/N ACC-CB2-10)

OUTLINE/INSTALLATION DETAIL



PORT PREPARATION:

Ream #2 (.221 dia.) Thru
C'Bore .250 dia x .560 Deep
C'Drill I (.272 dia.) x .500 Deep
Bottom Tap 5/16-24, .440 Deep
Use Model 6600 Seal and Torque To 30 In. Lbs.

FIGURE 3 - Flush Mount Installation

Recessed Diaphragm Installations

A pressure sensor mounted with a passage in front of the diaphragm as shown in Figure 7 (recessed mount), may exhibit impaired frequency response and rise time characteristics when compared to the original sensor specifications. These limitations may be due to the passage. The column of gas or liquid in the passage (cavity) ahead of the sensor diaphragm is in itself a second order system with its own resonant frequency. Since we are using this column to couple the event to the sensor, its frequency characteristics are important.

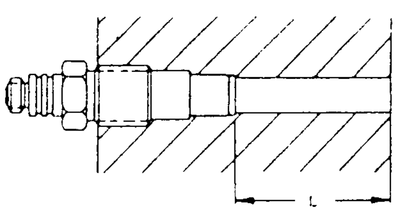


FIGURE 7 - The Recessed Mount

The following chart (Figure 8) displays the theoretical effect of various length cavities formed by the diaphragm recess. The formula used to calculate the chart values is the well-known pipe organ formula:

$$f = v / 4L \quad (Hz) \qquad \textbf{(Eq. 1)}$$

where: f is the resonant frequency of the passage
v is the velocity of sound in air (in/Sec)
L is the cavity length (inches)

NOTE: The value for sound velocity is for sea level and 20 C.

Recess L (In)	Natural Frequency (Hz)	Approx. Fastest Rise Time $1/2f_n$ (Sec)
.001	3.3 MHz	.1 uSec
.002	1.6 MHz	.2 uSec
.003	1.1 MHz	.3 uSec
.005	660 KHz	.5 uSec
.010	330 KHz	1 uSec
.050	66 KHz	5 uSec
.100	33 KHz	10 uSec
.200	16.5 KHz	20 uSec
.500	6.6 KHz	50 uSec
1.00	3.3 KHz	.1 MSec
2.00	1.66 KHz	.2 MSec

FIGURE 8 - Cavity Length vs. Frequency Response

As a general rule, the frequency response of your system will be valid to about 1/3 of the passage resonant frequency. The fastest rise time you can expect is roughly 1/3 of the period of this frequency. Remember, these are general guides only, not hard and fast rules. Remember also to correct the chart values for media other than air and for other pressures and temperatures.

MADE IN USA

WARRANTY

OMEGA warrants this unit to be free of defects in materials and workmanship and to give satisfactory service for a period of **13 months** from date of purchase. OMEGA Warranty adds an additional one (1) month grace period to the normal **one (1) year product warranty** to cover handling and shipping time. This ensures that our customers receive maximum coverage on each product. If the unit should malfunction, it must be returned to the factory for evaluation. Our Customer Service Department will issue an Authorized Return (AR) number immediately upon phone or written request. Upon examination by OMEGA, if the unit is found to be defective it will be repaired or replaced at no charge. However, this WARRANTY is VOID if the unit shows evidence of having been tampered with or shows evidence of being damaged as a result of excessive corrosion; or current, heat, moisture or vibration; improper specification; misapplication; misuse or other operating conditions outside of OMEGA's control. Components which wear or which are damaged by misuse are not warranted. These include contact points, fuses, and triacs.

We are glad to offer suggestions on the use of our various products. Nevertheless OMEGA only warrants that the parts manufactured by it will be as specified and free of defects.

OMEGA MAKES NO OTHER WARRANTIES OR REPRESENTATIONS OF ANY KIND WHATSOEVER, EXPRESSED OR IMPLIED, EXCEPT THAT OF TITLE AND ALL IMPLIED WARRANTIES INCLUDING ANY WARRANTY OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE HEREBY DISCLAIMED.

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Every precaution for accuracy has been taken in the preparation of this manual; however, OMEGA ENGINEERING, INC. neither assumes responsibility for any omissions or errors that may appear nor assumes liability for any damages that result from the use of the products in accordance with the information contained in the manual.

RETURN REQUESTS / INQUIRIES

Direct all warranty and repair requests/inquiries to the OMEGA ENGINEERING Customer Service Department. Call toll free in the USA and Canada: 1-800-622-2378, FAX: 203-359-7811; International: 203-359-1660, FAX: 203-359-7807.

BEFORE RETURNING ANY PRODUCT(S) TO OMEGA, YOU MUST OBTAIN AN AUTHORIZED RETURN (AR) NUMBER FROM OUR CUSTOMER SERVICE DEPARTMENT (IN ORDER TO AVOID PROCESSING DELAYS). The assigned AR number should then be marked on the outside of the return package and on any correspondence.

FOR **WARRANTY** RETURNS, please have the following information available BEFORE contacting OMEGA:

1. P.O. number under which the product was PURCHASED,
2. Model and serial number of the product under warranty, and
3. Repair instructions and/or specific problems you are having with the product.

FOR **NON-WARRANTY** REPAIRS OR **CALIBRATION**, consult OMEGA for current repair/calibration charges. Have the following information available BEFORE contacting OMEGA:

1. Your P.O. number to cover the COST of the of the repair/calibration,
2. Model and serial number of product, and
3. Repair instructions and/or specific problems you are having with the product.

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