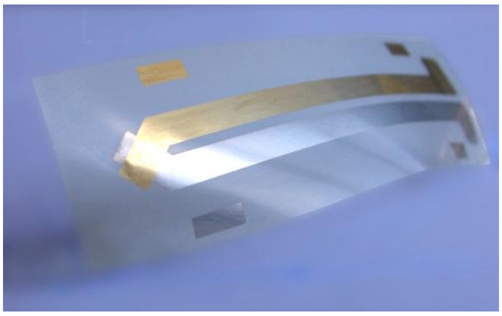
S25 PVDF SENSOR
Mono-dimensionnal schock pressure measurement

- How to use it -



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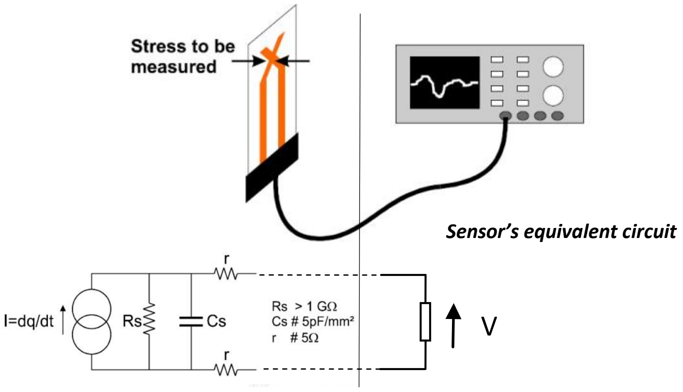
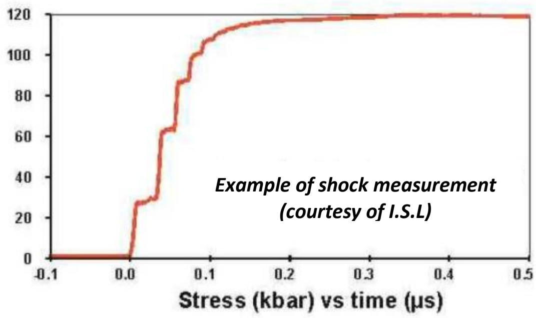
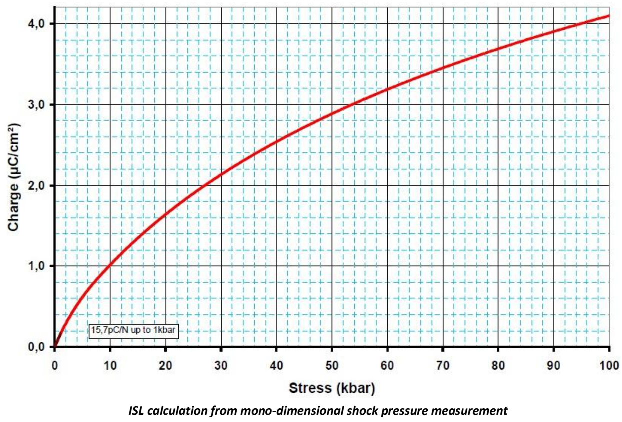
Piezoelectric sensors deliver electrical charge under stress





Charge measurement → *is converted into pressure*

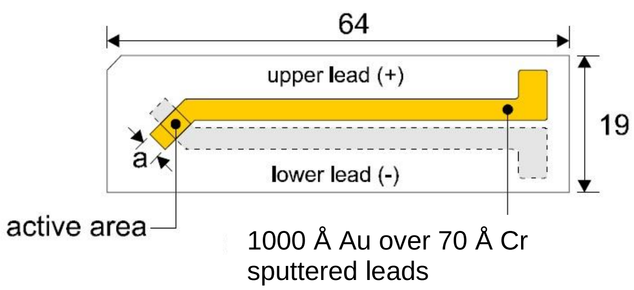


According to calibration data

ISL S25 shock sensors are the sensors of choice for a wide range of measurement applications because they have unique characteristics: rapid response (nanoseconds), large stress range (kPa to GPa), large signal to noise ratio, high sensitivity (4µC/cm² for 10 GPa), they are very thin (~25µm) and need simple circuitry.

S25 sensors are suitable for mono-dimensional compression stress measurement. They are based on piezoelectric properties of PVDF after polarization. ISL/Bauer polarization process permits to achieve controlled level of response and unique reproducibility of the sensors.

Sensors are made of a very thin (25µm) bi-axially stretched PVDF film polarized over a defined area which is defined by the leads crossing. This area is called “active area”. It corresponds to the measurement area.



For special applications, sensors can be mechanically protected and electrically insulated with PE, which can also be metalized to realize electrical shielding.

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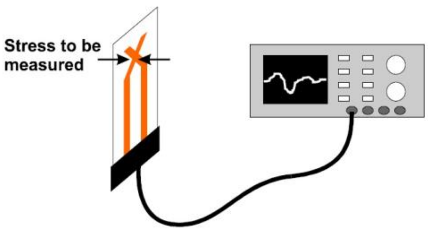
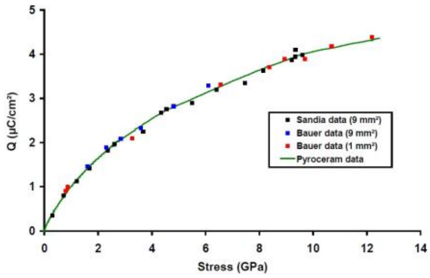
Principle

Piezoelectric material delivers electrical charges under mechanical stress. Pressure can be related to measured charges according to calibration data.





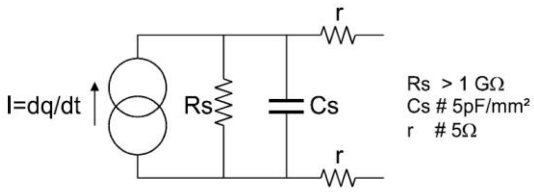
Stress / Gauge => Charges

Charges / Calibration => Pressure

The aim is to measure charges delivered by the gauge.

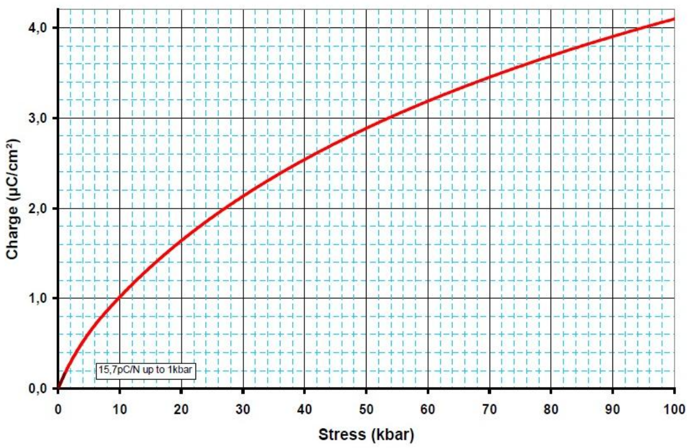
Equivalent circuit

As other piezoelectric components, equivalent circuit can be simplified and be presented as a current (charge) generator:



Calibration curve

At low pressures (<1000 bars), electrical charge delivered is linearly proportional to applied stress. The sensors sensibility is constant and equal to 15.7 pC/N. For higher pressure ranges, though sensibility remains high, it cannot be considered as constant anymore. Calibration data will then show the pressure reached. Maximum pressure that can be measured is about 30 GPa.



ISL calculation for mono-dimensional shock pressure measurements

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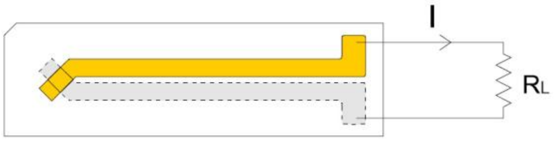
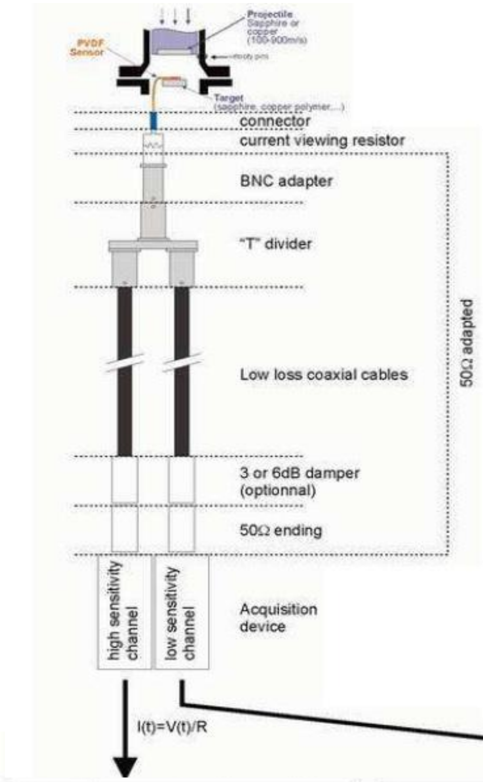
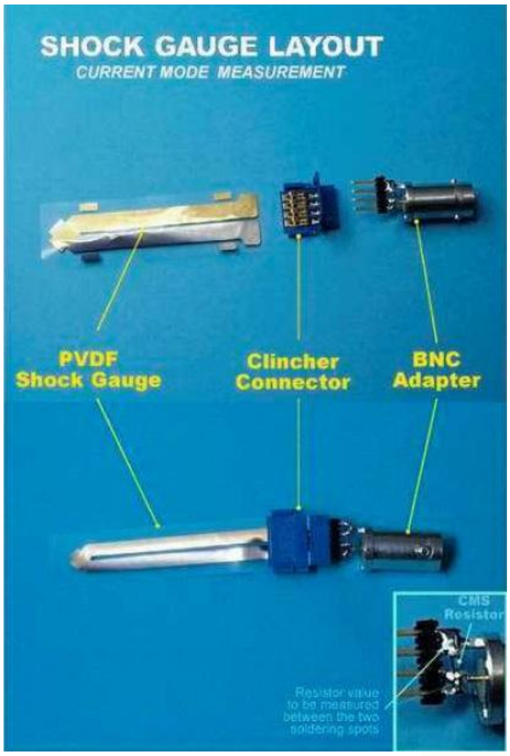
Measurement methods

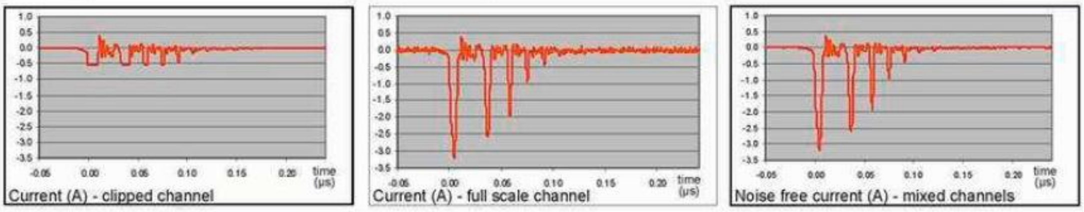
Current mode : RC <t (rising time)

The gauge is directly connected to a low value current viewing resistor (CVR).

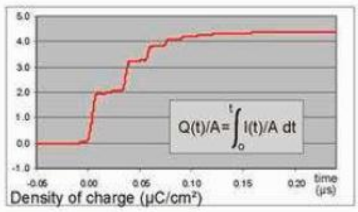


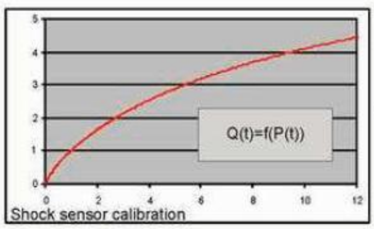


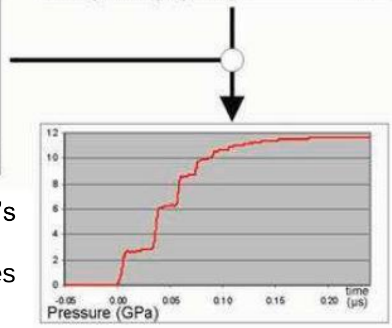




Current is measured on two channels (I(t)=V(t)/R).
Data are transferred to a computer to perform software aided mathematical operation.
Offset is reduced and both channels are first mixed together to get a noise free current.







Current is then integrated versus time and divided by the sensor's area to get the density of charge that has been delivered.
Pressure is computed according to the calibration curve that relates density of charge to pressure.

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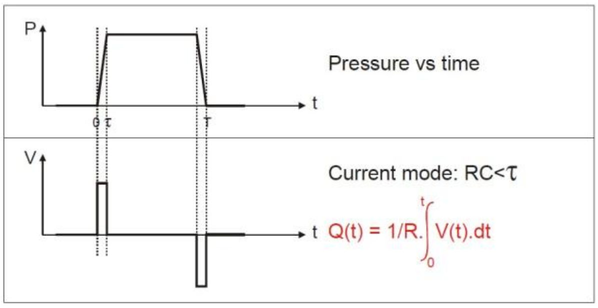
This method is highly recommended for fast phenomenon measurement.
Voltage is measured. Its value is proportional to the current passing through the resistance which is the derivative of the generated charges.

$$Q(t)=\int_0^t I(t).dt$$

Avec :

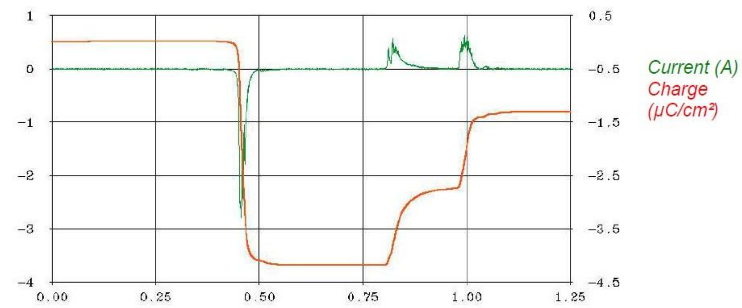
$$I(t) = V(t)/R$$

$$Q(t)=\frac{1}{R}\int_0^t V(t).dt$$



Numerical integration of this signal will give electrical charges delivered by the sensors. Digital data acquisition devices with high sampling rates are particularly adapted to the signal processing. If possible, it is recommended to measure the signal on two channels with different sensitivities.

Relatively to the calibration data, the pressure can then be computed.



Example of shock recording *(courtesy of ISL)*

For several applications, a 50Ω cable can be used and connected to the 50Ω input of the acquisition device. For short rising time a low resistance CVR should be used (1Ω or even less) in order to reduce RC time constant. CVR is to be mounted as close to the sensor's connector as possible. Measurement components have to be carefully chosen. Impedances have to be adapted and the inductances minimized.The level of current that is reached is proportional to the gauge area, to the rising time of the pressure and to the pressure level.

For shock wave measurement with rising time shorter than time of transit in the sensor (tilt = 0) first short circuit (CVR ~1Ω) current peak can be estimated at 0.75 A/mm²/GPa.
For slower phenomenon current can be estimated as:

example:

	50 kbar in 500 ns.
on the calibration curve, we get:	50 kbar = 5 GPa => 2.8 µC/cm²
with a 9mm² gauge:	Q = 0.25 µC
	I = dQ/dt # $0.25/500.10^{-9}$ = 0.5 A

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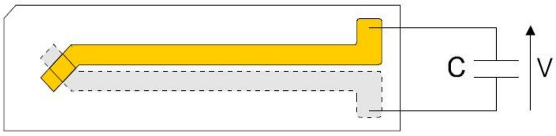
The expected voltage to be measured is then V = R.I

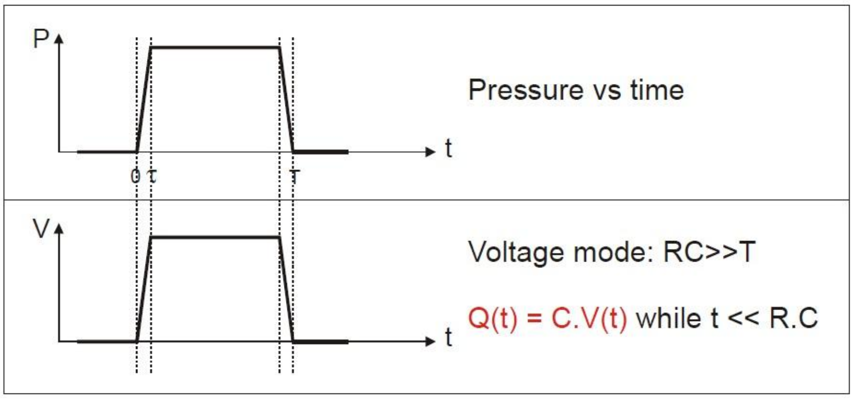
Sensor delivers a derivate signal. This can be an advantage when chronometric information is needed.

Voltage mode : RC >> T

The gauge is connected to an external capacitance. Measured voltage is directly proportional to charges delivered by the sensor.



$$Q(t) = C.V(t)$$



High impedance acquisition devices can be used. Total capacitor has to be considered (source capacitor, cable capacitor, device capacitor and optional additional capacitance).

example:	sensor:	Cs = 45pF Ri > 1GΩ
	cable:	C1 = 500pF R1> 100MΩ
	acq. device:	Ci = 10pF Ri = 1MΩ
	ext. capacitance:	Ca = 500pF
	then:	C # 1nF R # 1MΩ
Gain is:	$G = V/Q = 1/C = 1/10^{-9} = 1000$ V/µC	
or	G = 1V/nC	

If a 0.1 GPa pressure is expected, calibration data shows: Q # 0.157 µC/cm²
With a 9mm² sensor: Q # 14nC
=> V = 14V

Measurement is only valid as long as t<<R.C.
This method doesn't require specific instrumentation but capacitor value C has to be precisely determined. As electrical impedances are not adapted, it can only be used for slow signals. For fast signals, current mode should be used.

Charge mode

The gauge is directly connected to a charge amplifier. Its output voltage is proportional to charges delivered by the sensor. Charge amplifier characteristics define the high and low cut frequencies. This measurement mode is simple and can be easily used for dynamic low pressures. The accuracy and the minimum pressure that can be measured are given by the signal/noise ratio of the amplifier.

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HANDLING

The active area has to be perfectly clean. Any area exposed to air which hasn‘t just been cleaned is to be considered as dirty and needs to be cleaned. Any contact with fingers is to be avoided. Therefore, clips must be used to handle the gauge from the moment it is removed from its protecting sleeve until it is mounted. Eventual dust will be removed with a soft clean cloth. To clean gauges, only use pure alcohol (methanol or ethanol).

In many cases, gauge has to be glued. Materials in contact with the gauges must be neither conductive nor polar. If this is not the case, a Teflon protected gauge has to be used. Polar materials have to be eclectically shielded and connected to ground. The active area of the gauge has to be perfectly plane. Its existing deformation is normal, but it has to be removed by pressure during the mounting of the gauge.

Assembly can be made using epoxy or cyano-acrylate glues, under high pressure to reduce the thickness of glue. These glues are non polar, have a mechanical impedance close to PVDF and don‘t damage the gauge. If you don‘t use a pre-connected gauge, great care should be taken during electrical wiring in order to minimize resistance and inductance. Low temperature weld (<85 °C) or clincher connectors can be used.

Positive lead is marked with a “+” sign and sensor upper corner is cut on this lead side. Positive signal is measured on this lead when sensor is under compression.

PLEASE CONTACT US FOR MORE INFORMATION!