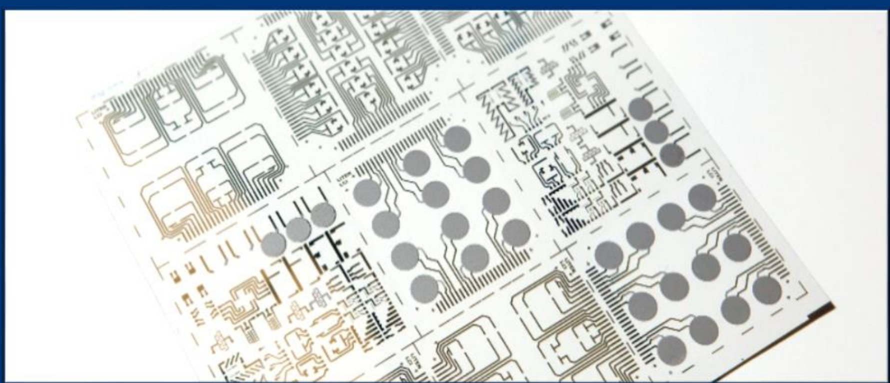
PIEZOTECH BY ARKEMA

TDS PVDF SHOCK GAUGES

Piezoelectric Sensors



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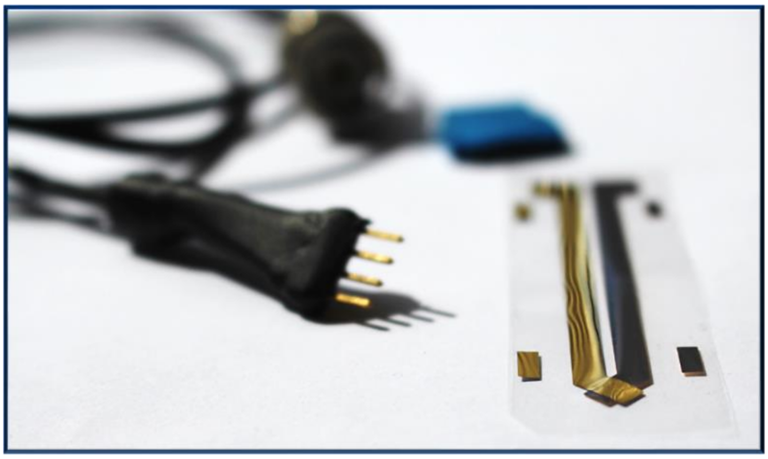
I. PVDF shock sensors

Polyvinylidene fluoride sensors (PVDF) are the sensors of choice for a wide range of measurement applications because they have unique characteristics:

- **Rapid response** (Nanosecond)
- **Large stress range** (kPa to GPa)
- **Large signal to noise ratio**
- **Sensitivity** (4 μC/cm² for 10 GPa)
- **Very thin** (25 μm)
- **Simple circuitry**



Piezotech® is the sole source for PVDF sensors suitable for shock physics research. The important features available only with Piezotech® sensors include:

- **Reproducibility**: The sensors are all made from a high quality biaxially stretched polymer material, poled by a patented process to provide a stable and consistent polarization. Evaporated gold over chromium electrodes allow precise active area measurement.

- **Calibration**: These are the only PVDF sensors that are supported by extensive shock calibration data. These data range from a few kPa to over 25 GPa.

- **Technical support**: The Piezotech staff has significant experience in all aspects of PVDF fabrication and use. We stand ready to support your experimental efforts. We provide the guidance you need to apply the transducer to your experimentation.

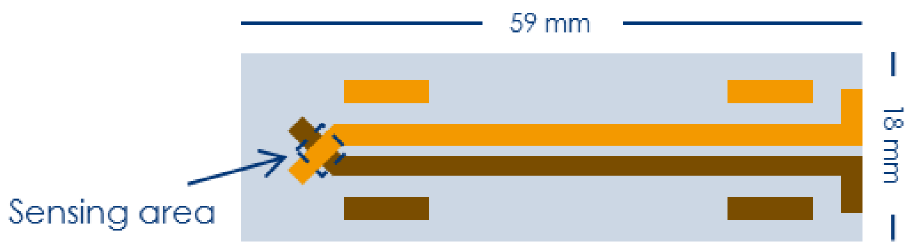
II. Standard PVDF sensor specifications

Description	Model
Basic PVDF Sensor with parallel lead	S_25
S_25 with connector mounted	S_25C
S_25C with laminated polyester protection on both sides*	S_25CP
S_25CP electrically shielded	S_25CPB
BNC Cable (1 m)	

*The polyester thickness is 55 µm for each side

Sensing areas available:

- 1x1 mm
- 5x5 mm



Material:	Biaxially stretched 25 µm PVDF
Poling – Calibration:	Crossed lead strip sensing area. Remnant polarization = 9.2 ± µC/cm², by the patented method
Leads:	Evapored (1500 Å of Au over 100 Å of Cr)

III. Piezoelectric Polyvinylidene Fluoride (PVDF) films

III.1 Piezoelectric and Pyroelectric effects

When certain materials are subjected to mechanical stress, electrical charges proportional to the stress appear on their surface. When an electric potential difference is applied to these materials, mechanical deformation occurs. This effect is known as piezoelectricity. When the temperature of the material is changed, an electric potential appears between the terminals, this is called the pyroelectric effect.

III.2 Piezoelectric Films

Piezoelectricity can be obtained by orienting the molecular dipoles of polar polymers such as PVDF in the same direction by subjecting films to an intense electric filed, this is the polarization. The polarized electrets are thermodynamically stable up to about 90 °C.

PVDF is particularly suitable for the manufacture of such polarized films because of its molecular structure (polar material), its purity – which makes it possible to produce thin and regular films – and its ability to solidify in the crystalline form for polarization.

III.3 Properties of PVDF Piezoelectric films

- Flexibility (possibility of application on curved surfaces)
- High mechanical strength
- Dimensional stability
- High and stable piezoelectric coefficients over time up to approximately 90 °C
- Characteristic chemical inertness of PVDF
- Continuous polarization for great lengths spooled onto drums

III.4 Examples of Applications

- Pressure pick-ups
  - Distribution of pressure on surface
  - Localization of impacts
  - Accelerometers
  - Keyboards

- Robotics
  - Artificial sensitive skin
  - Pressure sensors

- Acoustic components
  - Microphones
  - Ultrasonic detectors
  - Hydrophones
  - Sonars

- Optical devices
  - Laser diameter measurement
  - Variable mirrors

- Electrical components
  - Switches

- Miniature electric fan

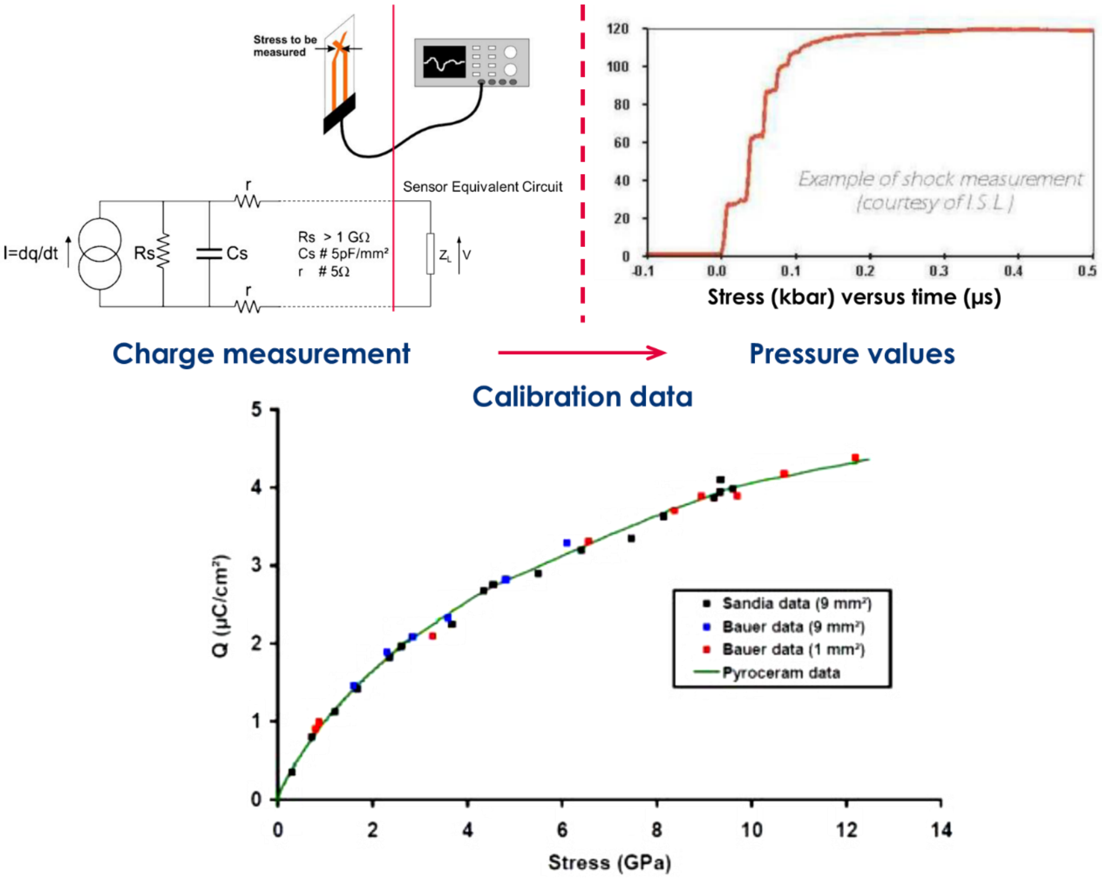
- Security devices
  - Intruder alarms
  - IER alarms
  - Vibration sensors

- Medical instrumentation
  - Catheter
  - Pedobarography
  - Osteogenesis
  - Lithotrophy
  - Medical echography
  - Blood pressure detector

IV. Piezoelectric Sensors

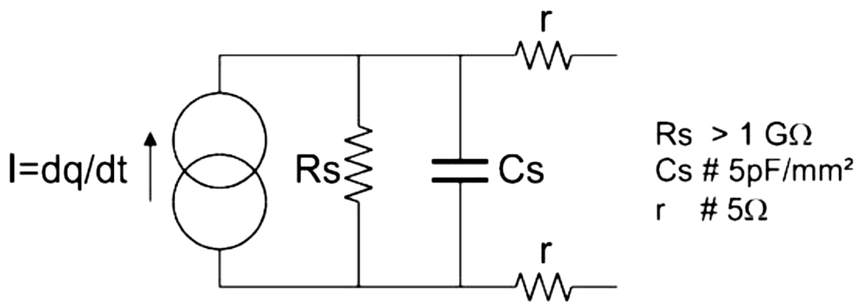
IV.1 Principle

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



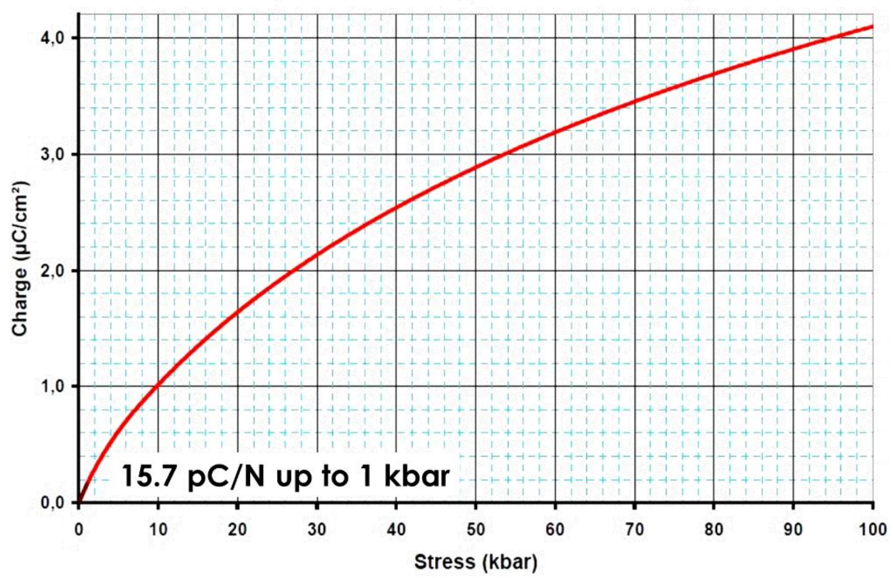
IV.2 Equivalent Circuit

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



IV.3 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.



IV.4 Measurement Methods

IV.4.1 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 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.

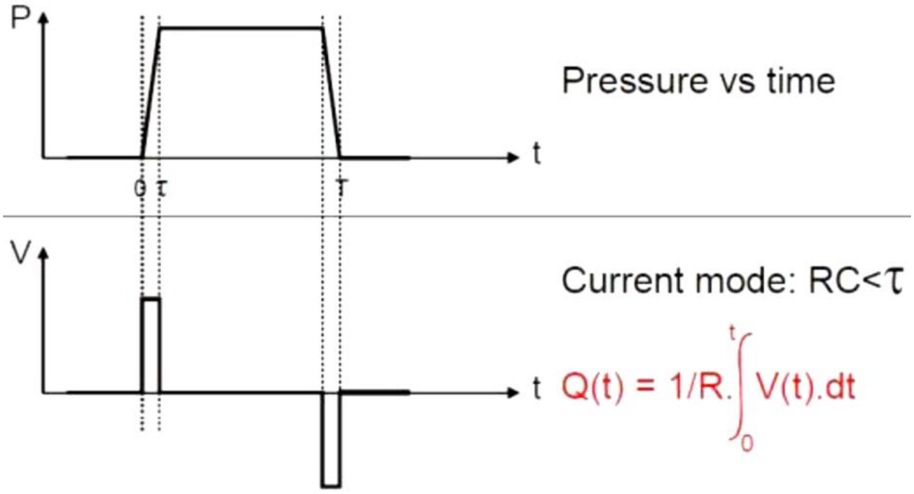
This method is highly recommended for fast phenomenon measurement.

Voltage is measured. Its value is proportional to the current passing through the resistance which is the derivative of the generated charges.

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

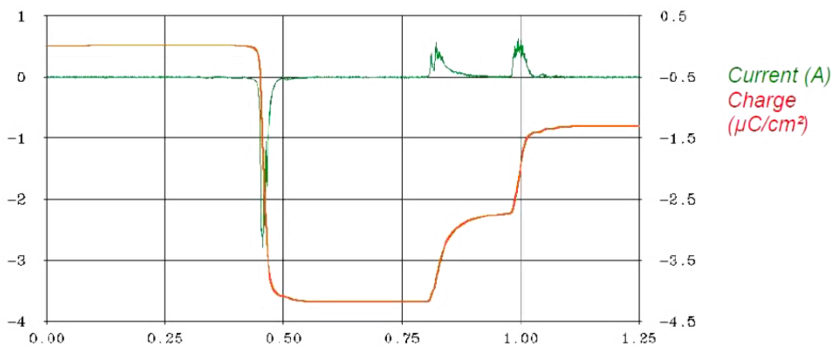
$$I(t) = {}^{V(t)}/_{R}$$

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



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 50 Ω cable can be used and connected to the 50 Ω input of the acquisition device. For short rising time, a low resistance CVR should be used (1 Ω 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.

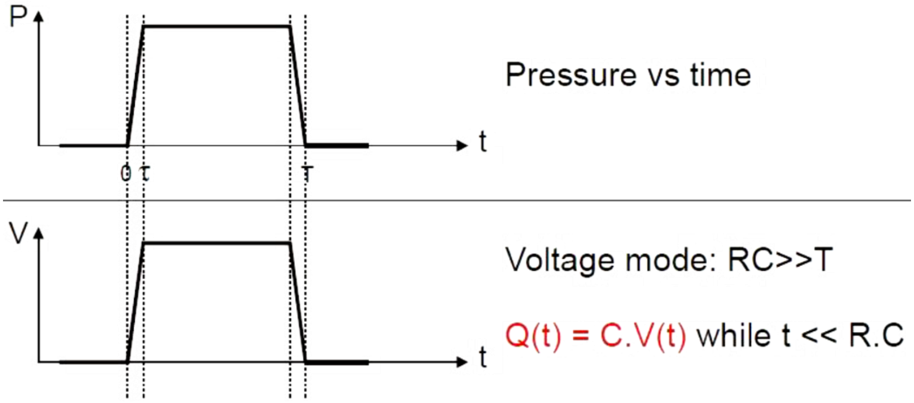
For shock wave measurement with rising time shorter than time of transit in the sensor (tilt = 0), first short circuit (CVR ~1Ω) current peak can be estimated at 0.75 A/mm²/GPa.

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

IV.4.2 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).

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.

IV.4.3 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.

V. Handling

The active area has to be perfectly clean. Any area exposed to air which has not just been cleaned is to be considered as dirty and needs to be cleaned. Any contact with fingers should 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 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 do not damage the gauge. If you do not 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.