Piezotech Processing's guides

- How to measure -

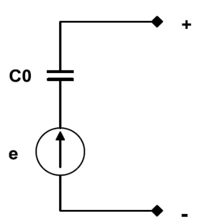
Charge sensors.

Concepts:

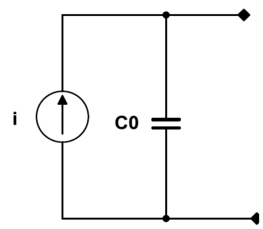
A charge sensor generates on its surface equal electric charges of opposite sign when it is stimulated by a mechanical force (piezoelectric effect) or a variation of temperature (pyro electric effect).

Equivalent diagrams:

A piezo- pyro- electric sensor can be modelled by one of the following equivalent diagrams:



Thevenin equivalent diagram: The electromotive force $e = Q/C_0$ is in series with a capacitor C_0.



Norton equivalent diagram: The current source $i = \frac{dQ}{dt}$ is in parallel with a capacitor C_0

Mode of operation:

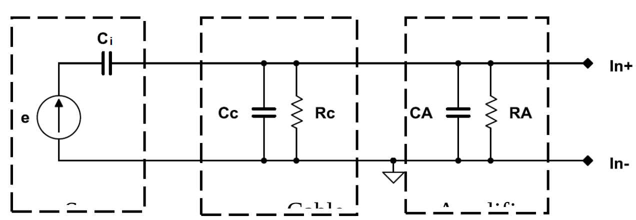
When using a piezo- pyro- electric sensor, the measured signal strongly depends on the conditions of experimentation. It is possible to measure a proportional signal, or to its derivate. The limit of these operation modes is given by the cut-off frequency of your instrumentation chain.

Signal conditioning

Direct connection:

By connecting your sensor directly to your amplifier, oscilloscope, or DAC (data acquisition card) it must be kept in mind that external impedances may have a critical influence on the signal you will measure. In order to determine the said influences, the involved impedances (from the sensor, cable and measuring instrument input) are modelled as follows:

Equivalent diagram of a direct connection of a sensor.



Further analysis of the diagram shows a high-pass filter behaviour,for which the cut-off frequency is given by:

$$f_c = \frac{1}{2\pi \cdot R_{eq} \cdot (C_{eq} + C_i)}$$

When $f \gg f_C$ the measured signal is directly proportional to the generated charges:

$$v_{IN(t)} = -\frac{q_{(t)}}{C_{eq} + C_t}$$

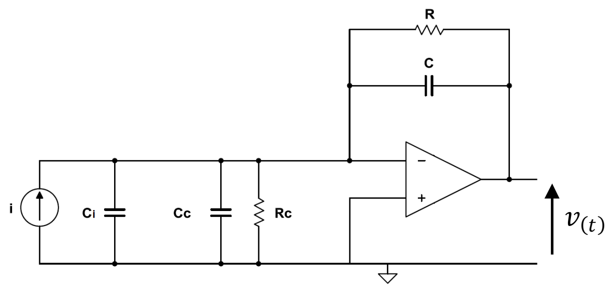
When $f \ll f_C$ the measured signal is proportional to the derivate:

$$v_{IN(t)} - R_{eq} \cdot \frac{dq_{(t)}}{dt}$$

Charge transducer:

In order to drastically limit the influence of external impedances, the use of a charge transducer is recommended. The operating principle is based on the use of an external capacitor C to store the generated charges. A charge transducer may be also be called a charge-voltage converter.

Practical implementation of a charge-voltage



transducer

As shown in the diagram, we consider the operational amplificator as ideal. The differential voltage between its inputs is null, so the current i generated by the sensor is driven to the feedback capacitor C. In order to prevent saturation of the output by parasitic influences, a parallel resistor R must be added to the feedback capacitor.

Such a circuit has a high-pass filter behaviour, for which the cut-off frequency is given by:

$$f_C = {}^{1}/_{2\pi RC}$$

When $f \gg f_C$, the measured signal is directly proportional to the generated charges:

$$v_{(t)} = -\frac{q_{(t)}}{C}$$

When $f \ll f_C$, the measured signal is proportional to the derivate:

$$v_{(t)} = -R \cdot \frac{dq_{(t)}}{dt}$$

Safety and Storage

Please refer to the safety datasheet

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