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Twentieth Transducer Workshop
Sponsored by
Vehicular Instrumentation/ Transducer Committee of the Range Commander's Council
DAYTON, OHIO
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Tutorial:

COMPREHENSIVE REVIEW OF HIGH IMPEDANCE AND LOW IMPEDANCE PIEZOELECTRIC TRANSDUCERS

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Twentieth Transducer Workshop 2002

Agenda

Overview of common Piezoelectric Materials

Basic Transducer Design Criteria

Review of Important Specifications

Transducer constructions and extended capabilities

break

The measurement system components

Practical considerations - making a good measurement

Piezoelectric Materials and Their Characteristics

Natural Crystals

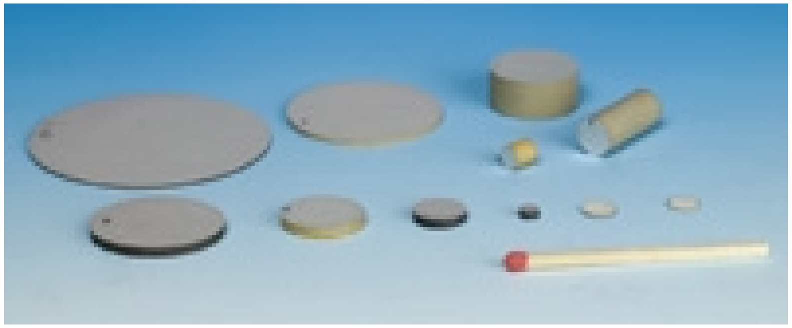
Quartz

Tourmaline

Piezoelectric Materials and Their Characteristics

Piezoceramics

Man Made - Engineered Solutions



Significant Material Properties (Compression)

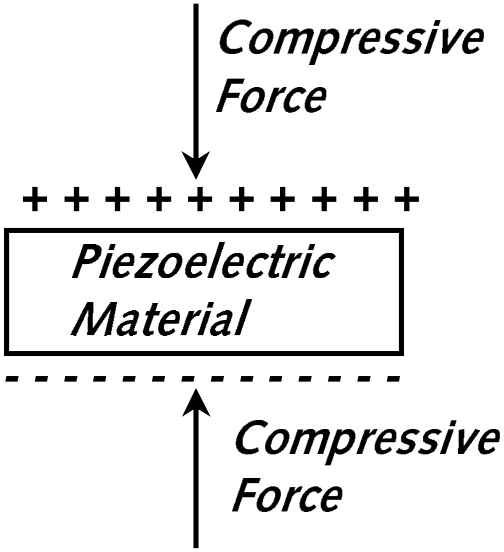
Piezoelectric Material	Charge Coefficient	Elastic Constant	Relative Dielectric Constant	Curie Temperature	Temperature coefficient of sensitivity
Quartz	2.31 pC/N	86.7 GN/m^2	4.54	573 °C	-0.03 %/°C
Tourmaline	1.93 pC/N	91.8 GN/m^2	7.00	600–800 °C*	-0.02 %/°C
PZT	330 pC/N	66.6 GN/m^2	1500	350 °C**	0.13 %/°C

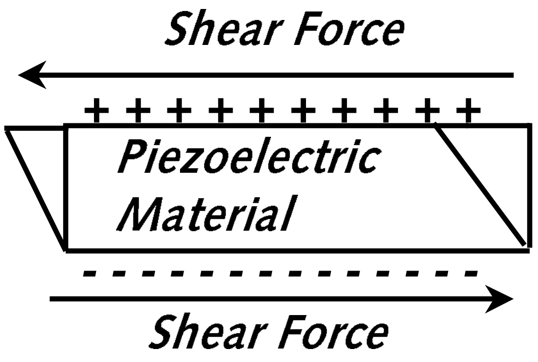
* Varies significantly

** Higher rated options available with lower charge coefficients

Piezoelectric Materials and Their Characteristics

Basic construction principles used in most designs





Basic design equations for a simple accelerometer

$F = m\ a$ = Force

$k = A\ E\ /\ l$ = Spring constant

$f_n = (k\ /\ m)^{1/2}$ = Natural frequency

$C = E_0\ k\ A\ /\ t$ = Capacitance

$V = Q\ /\ C$ = Voltage

m = seismic mass

a = 1 *g* = incremental acceleration

E = Modulus of Elasticity

l = spring length

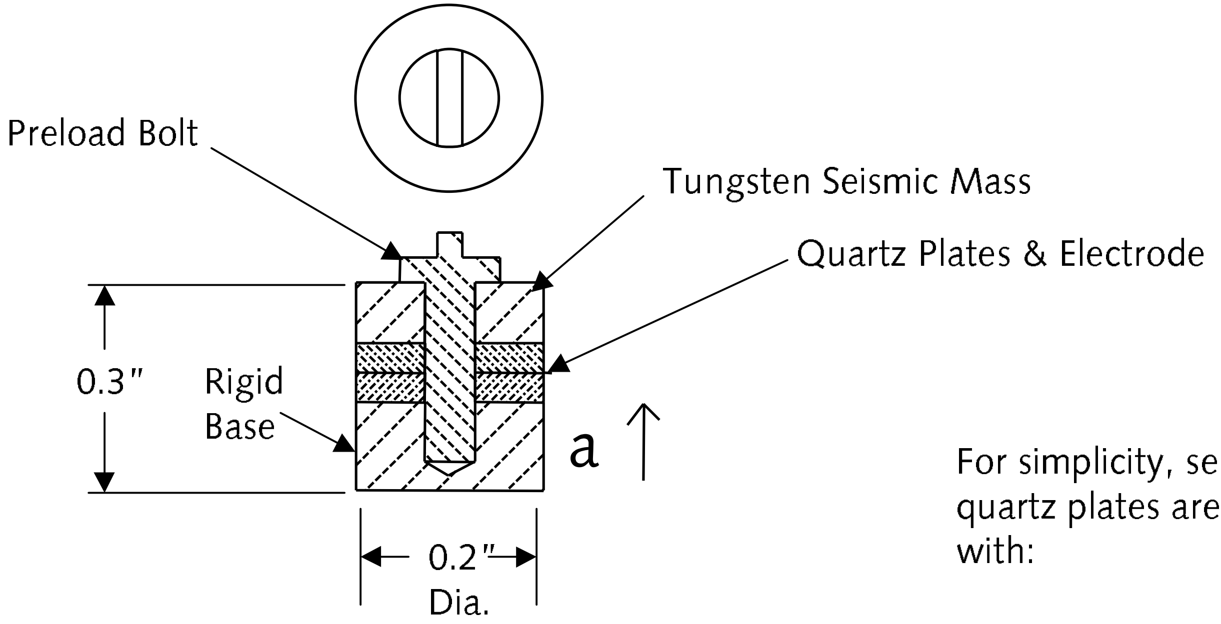
E_0 = 0.225 pf / in = Permeability constant

k = 4.54 = Dielectric constant for quartz

t = plate thickness

Q = charge

Simple Accelerometer Design Calculations (Approximation)



For simplicity, seismic mass and quartz plates are washer shaped with:

ID = 0.080 in & OD = 0.200 in

Mass thickness = 0.100 in
Plate thickness = 0.040 in

Simple Accelerometer Design Calculations (Approximation)

Seismic mass = $m = \rho V = \rho\, t\, \pi\, (OD^2 - ID^2) / 4 = 0.614\ (0.100)\ \pi\ (0.200^2 - 0.080^2) / 4$

$m = 0.0016$ lb $= 0.735$ grams

Knowing mass, compute charge per plate:

$Q_Q = d_{33}\, F = \mathbf{d_{33}}\, m\, a = \mathbf{2.31}\ (0.735 * 10^{-3})\ g$; $Q_Q / g = 0.0017$ pC/g **Quartz**

$Q_T = d_{33}\, F = \mathbf{d_{33}}\, m\, a = \mathbf{1.93}\ (0.735 * 10^{-3})\ g$; $Q_T / g = 0.0014$ pC/g **Tourmaline**

$Q_C = d_{33}\, F = \mathbf{d_{33}}\, m\, a = \mathbf{330}\ (0.735 * 10^{-3})\ g$; $Q_C / g = 0.243$ pC/g **PZT**

Simple Accelerometer Design Calculations (Approximation)

$$\text{Element capacitance} = C = E_0\, k\, A / t = 0.225\, k\, \pi\, (OD^2 - ID^2) / 4 / t$$
$$= 0.225\, k\, \pi\, (0.200^2 - 0.080^2) / 4 / 0.040$$
$$= 0.148\, k$$

$C_Q = 0.148\, k = 0.148\, (\mathbf{4.54}) = 0.670$ pf **Quartz**

$C_T = 0.148\, k = 0.148\, (\mathbf{7.00}) = 1.036$ pf **Tourmaline**

$C_C = 0.148\, k = 0.148\, (\mathbf{1500}) = 222.0$ pf **PZT**

Simple Accelerometer Design Calculations (Approximation)

Voltage produced = $V = Q / C$

$V_Q = Q_Q / C_Q = 0.0017 \text{ pC}/g \ / \ 0.670 \text{ pf} = 2.5 \text{ mV} / g$ **Quartz**

$V_T = Q_T / C_T = 0.0014 \text{ pC}/g \ / \ 1.036 \text{pf} = 1.4 \text{ mV} / g$ **Tourmaline**

$V_C = Q_C / C_C = 0.243 \text{ pC}/g \ / \ 222.0 \text{ pf} = 1.1 \text{ mV} / g$ **PZT**

Note: Since two plates present double charge and double capacitance, the per plate model is representative. Two plates allow appropriate polarity orientation where positive plate sides are connected to a common pick up.

Simple Accelerometer Design Calculations (Approximation)

Material	Charge Sensitivity (pC/*g*)	Capacitance (pF)	Voltage Sensitivity (mV/*g*)
Quartz	0.0017	0.670	2.5
Tourmaline	0.0014	1.036	1.4
PZT	0.243	222.0	1.1

Simple Accelerometer Design Calculations (Approximation)

Summary: A charge sensitivity is established proportional to the amount of mass

The P/E element exhibits an inherent capacitance dependent on its shape

A voltage is developed dependent on the charge and total * capacitance

These fundamental electrical principles are common throughout all piezoelectric sensor designs

* The voltage sensitivity is a function of total capacitance. When its magnitude is in the order of a few picofarads, stray capacitance (such as that resulting from close wires, close housings, etc.) becomes a significant contributor to the voltage sensitivity. Miniature crystal based designs require careful attention to wire routings, etc.

Simple Accelerometer Design Calculations (Approximation)

Mechanical Considerations

$k = A\ E / l$

Components supporting the mass are the predominate system ‘springs' and the spring mass system will respond to mechanical stimuli in a frequency dependent manner.

$f_n = (k / m)^{1/2}$

The stiff piezoelectric plates are the major contributor to the spring characteristics where the stiffness of the preload bolt's active area is relatively small.

$$k_T = k_B + k_Q$$

Simple Accelerometer Design Calculations (Approximation)

$k = A\ E\ /\ l$

Preload bolt active length 0.080" & 0.080 " Dia
Quartz Plate total thickness 0.080" with 0.080 ID & 0.200 OD

$k_b = \pi\ d^2\ E\ /\ 4\ l = \pi\ (0.00203^2)\ (131\ {*}10^9)\ /\ 4\ (0.00203)$
$k_b = 0.21\ \mathrm{GN/m}$

$k_Q = \pi\ (OD^2 - ID^2)\ E\ /\ 4\ l$
$= \pi\ (0.00508^2 - 0.00203^2)\ (86.7\ {*}10^9)\ /\ 4\ (0.00203)$
$= 0.73\ \mathrm{GN/m}$

$k_{ToT} = k_b + k_Q = 0.21\ {*}10^9 + 0.73\ {*}10^9$
$k_{ToT} = 0.94\ {*}\ 10^9\ \mathrm{GN/m}$

$f_n = (k\ /\ m)^{1/2}$

$f_n = [\ 0.94\ {*}10^9\ /\ (0.000735)\ (9.81)\ ]^{1/2}\ /\ 2\ \pi \approx$ **57,300 Hz**

Simple Accelerometer Design Calculations (Approximation)

$k = A\ E\ /\ l$

Preload bolt active length 0.080" & 0.080 " Dia
Quartz Plate total thickness 0.080" with 0.080 ID & 0.200 OD

$k_b = \pi\ d^2\ E\ /\ 4\ l = \pi\ (0.00203^2)\ (131\ {*}10^9)\ /\ 4\ (0.00203)$
$k_b = 0.21$ GN/m

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$k_{ToT} = k_b + k_Q = 0.21\ {*}10^9 + 0.73\ {*}10^9$
$k_{ToT} = 0.94\ {*}\ 10^9$ GN/m

$k_T = 0.98\ {*}10^9$ GN/m
$k_{PZT} = 0.77\ {*}10^9$ GN/m

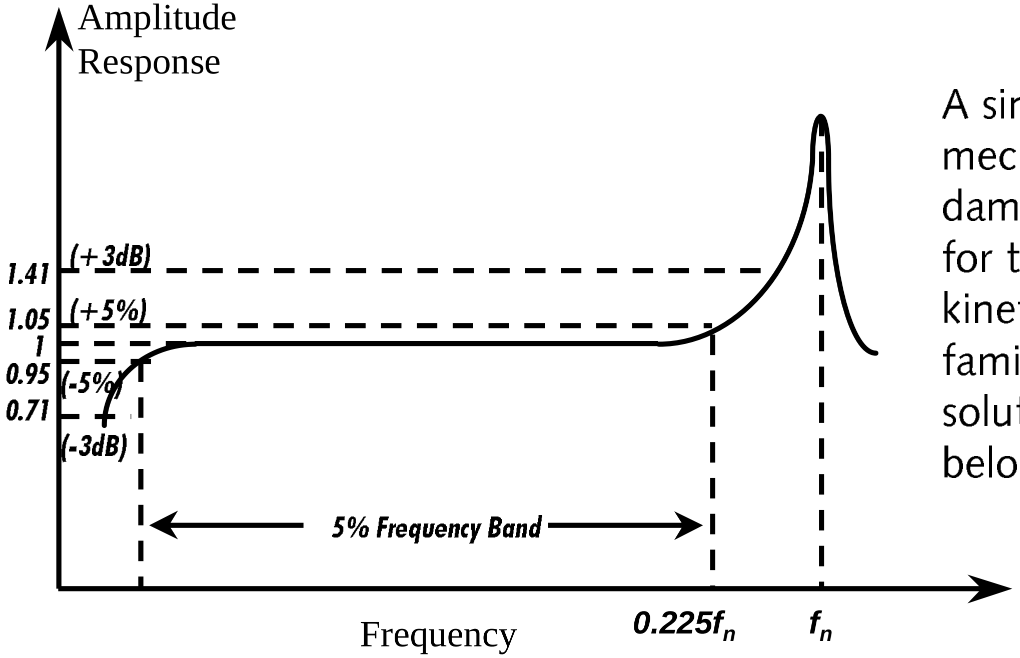
$f_n = (k\ /\ m)^{1/2}$

$f_n = [\ 0.94\ {*}10^9\ /\ (0.000735)\ (9.81)\ ]^{1/2}\ /\ 2\ \pi\ \approx$ **57,300 Hz**

Tourmaline f_n = 58,600 Hz

PZT f_n = 51,900 Hz

Simple Accelerometer Design Calculations (Approximation)



A single degree of freedom, second order mechanical system with negligible damping provides a mathematical model for the piezoelectric sensor. Summing kinetic and potential forces yields the familiar relationship m ÿ + k y = 0. A solution can be obtained as presented below:

$$\frac{a_o}{a_b} \cong \frac{1}{\sqrt{\left[1-\left(\frac{f}{f_n}\right)^2\right]^2+\left(\frac{1}{Q^2}\right)\left(\frac{f}{f_n}\right)^2}}$$

Major Transducer Specifications

Sensitivity

Amplitude Range

Resolution

Temperature Range

Frequency Response

Calibration

Undesired Sensitivity (thermal, transverse, moment, acceleration compensation, …)

Often Unspecified but Important

Major Transducer Specifications

Sensitivity

Amplitude Range

- Transducer sensitivity is a function of the piezoelectric material, the orientation or 'cut' of the crystal, construction, and either internal or external electronics. Most common output signals are defined in terms of V/lb, V/psi or V/*g* for force, pressure and acceleration sensors respectively.

- Mechanically, the durable constructions are 'over-designed' to accommodate non operational abuse such as mishandling, over-torque, etc. therefore the range limiting constraints are usually a function of the supporting electronics.

- Basic guide: Internal Electronics +/- 5 Volts
  External Electronics +/- 10 Volts

Major Transducer Specifications

Resolution

Temperature Range

- Also largely a function of the electronics.

- Internal electronics require miniature components and tradeoffs are required. Critical elements include: MOSFET, JFET, chip resistors, hybrids,… Typically a better noise floor is achieved when fundamental charge is processed through an efficient charge amplification technique.

- Frequency span plays a role in the noise characteristic and special consideration to filtering can adapt to critical requirements.

- External electronics avoid direct exposure to the temperature extremes presented to the sensor. A drastic increase in temperature range is realized when the the electronics are remote to the application.

Major Transducer Specifications

Frequency Response

Calibration

- By design: Force and pressure sensors have an extremely wide frequency response as required to achieve acceptable reproduction of fast events (fast rise time – very high resonant frequency). The components representing a contribution to the dynamic system mass must be extremely small (thin diaphragms, small flanges,…). On the other hand, accelerometers contain a substantial seismic mass in order to obtain significant sensitivity. These sensors often require a measurement of sensitivity throughout the usable frequency range to assure the construction is correct.

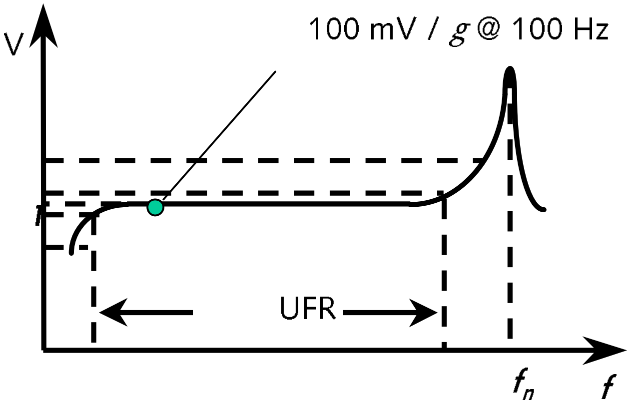
- Therefore: Amplitude linearity plots often accompany force & pressure sensors
  Frequency sweeps are typically supplied with an accelerometer calibration

- A sensitivity value is stated at prescribed input levels & defined environmental conditions

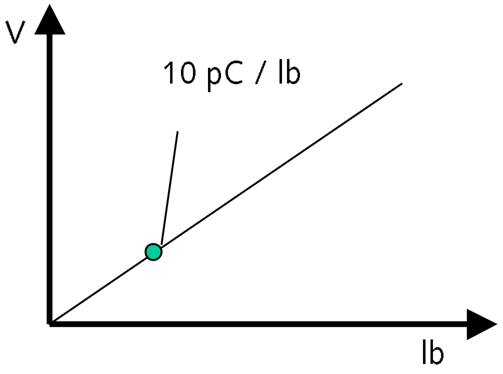
Major Transducer Specifications

Frequency Response

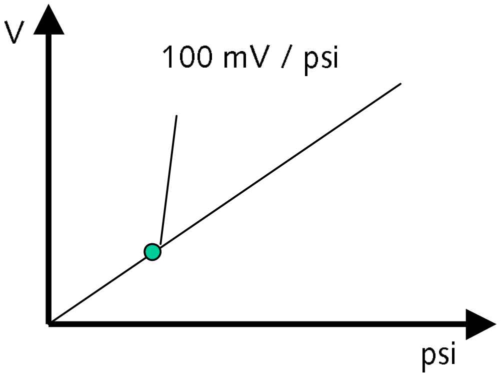
Calibration



Accelerometer



Force



Pressure

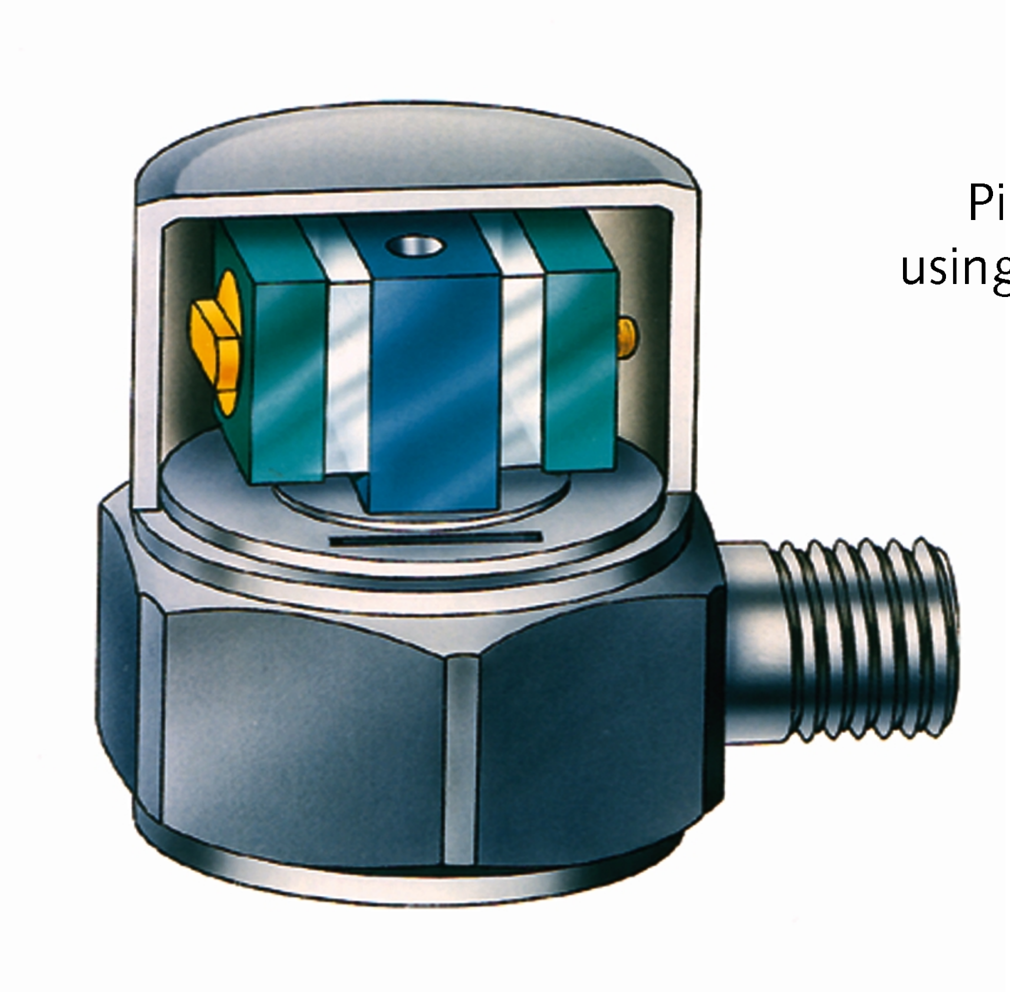
Major Transducer Specifications

Undesired Sensitivity (thermal, transverse, moment, acceleration compensation, acoustic, magnetic …)

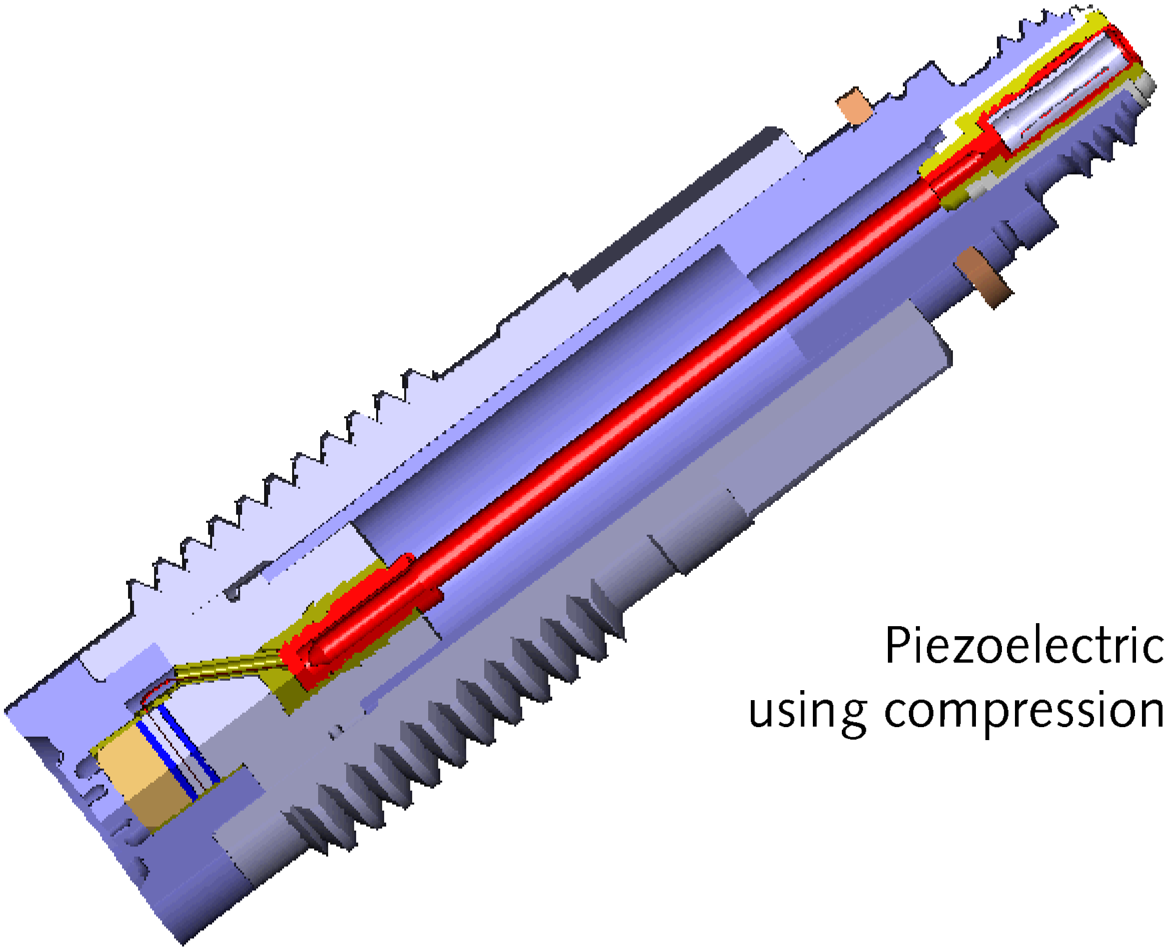
Often Unspecified but Important

- These two categories approach the specifics of an application. A general specification may actually be misleading. If unordinary situations exist, a detailed discussion between an application engineer and the educated user is necessary to avoid corrupt data.

- Some parameters have a defined specification, for instance transverse sensitivity, but let's consider thermal transient effects: This is usually not stated in the specifications and has only a secondary relationship to the specified Temperature Coefficient of Sensitivity. The desire is to define the rate of error resulting from a rapid thermal change. Does the change occur due to a varying base temperature or is radiant or convective energy the source of undesired input/output?



Piezoelectric Accelerometer using shear construction principle



Piezoelectric Pressure Sensor
using compression construction principle

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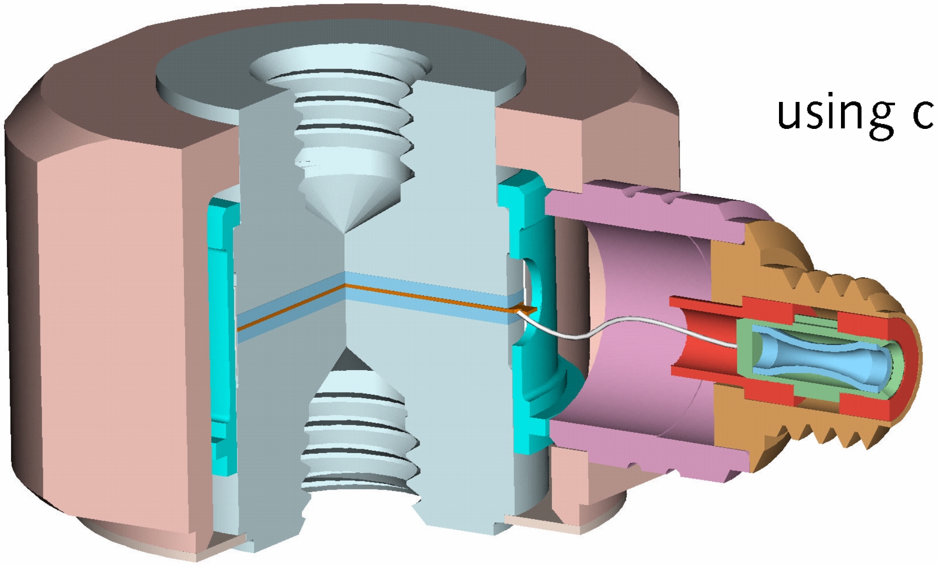

Piezoelectric Force Sensor
using compression construction principle

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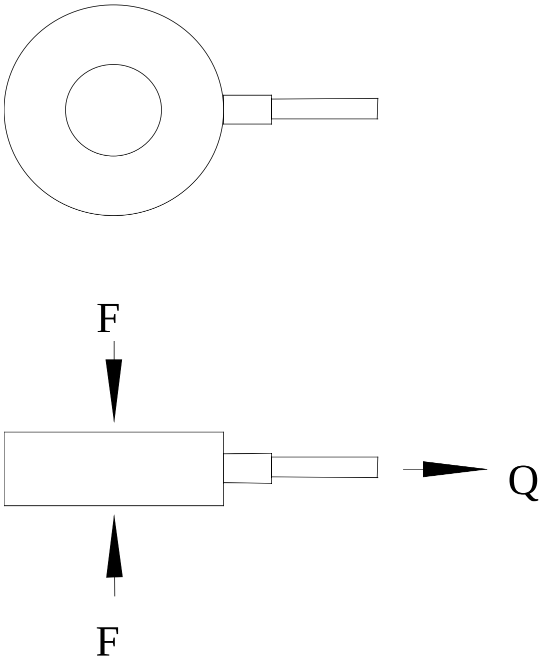
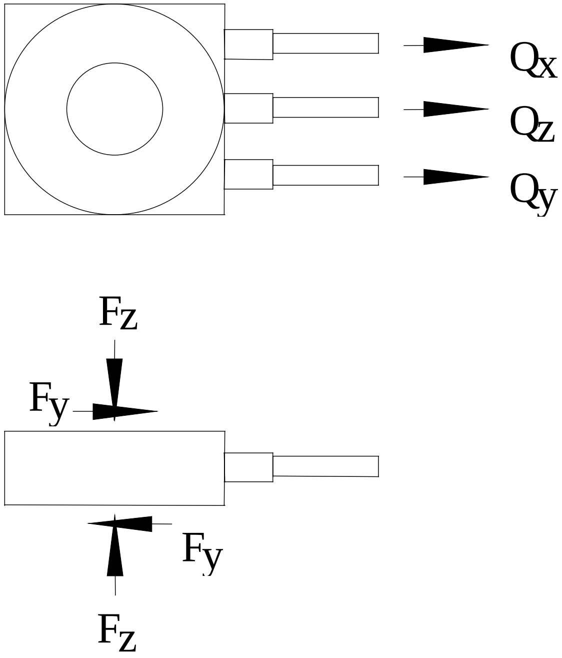
Multi-component Piezoelectric Force Sensor using compression & shear construction principle

Multi-component Piezoelectric Force Sensor using compression & shear construction principle



Single-Axis Load Washer



Three-Axis Load Washer
(Multi-Component)

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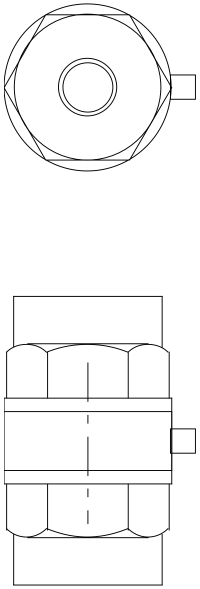
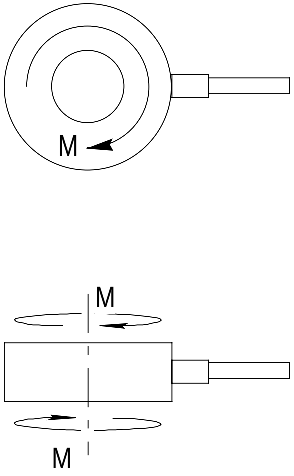
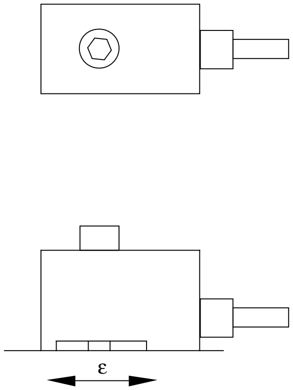
Piezoelectric Force
Advanced Configurations & Creative Solutions

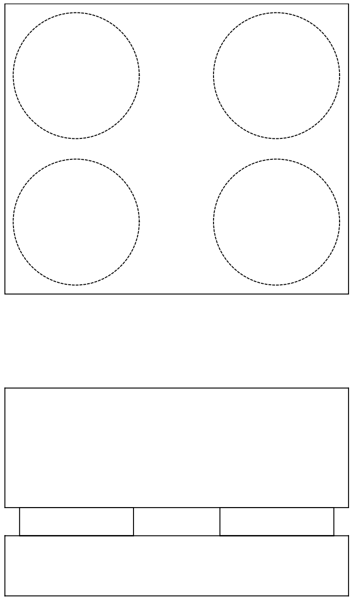

Force Link



Torque transducer



Strain transducer


Dynamometer

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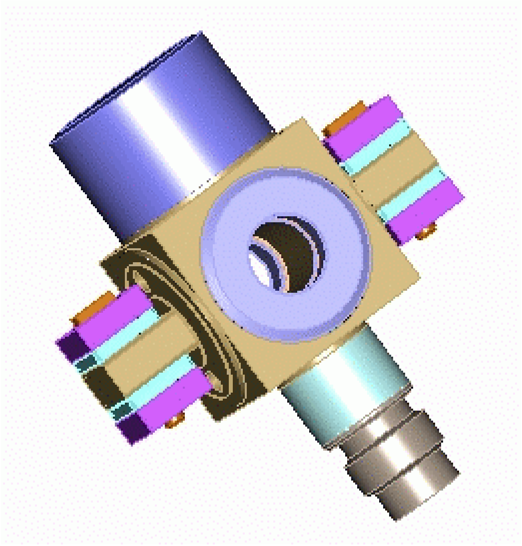
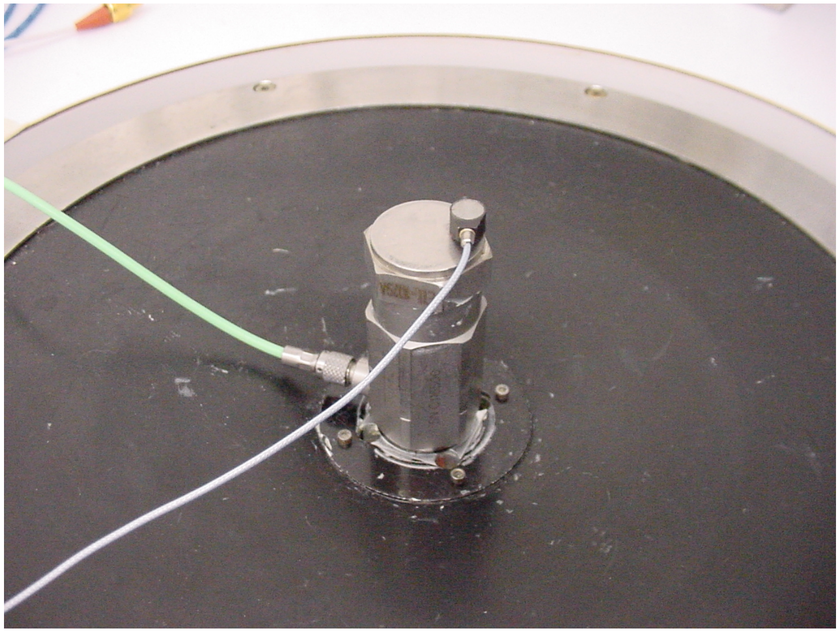
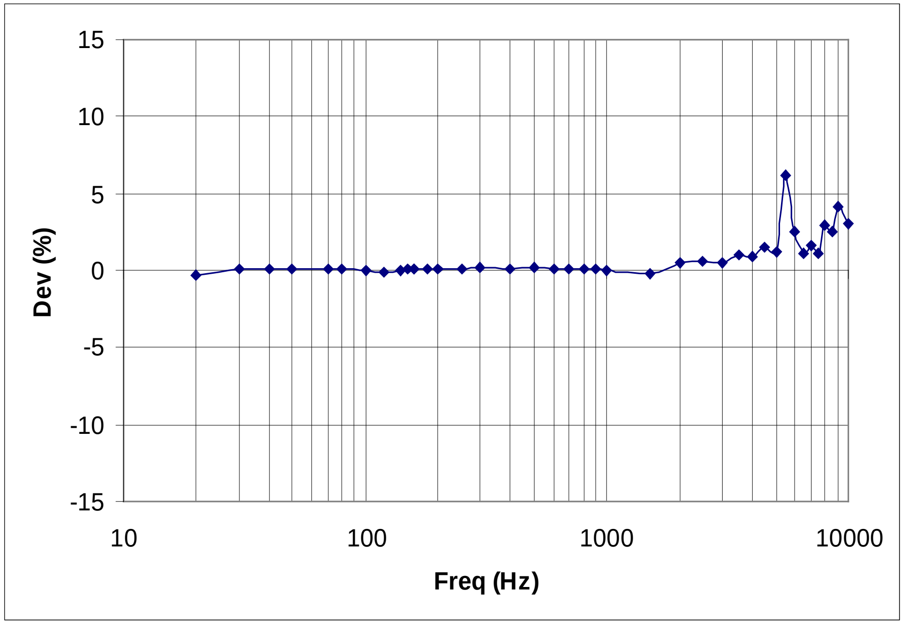
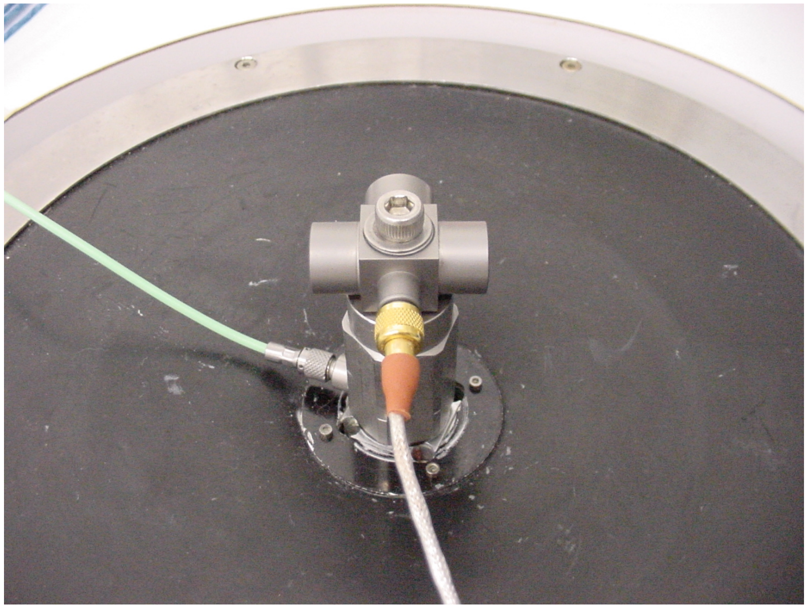
Piezoelectric Acceleration
Advanced Configurations & Creative Solutions

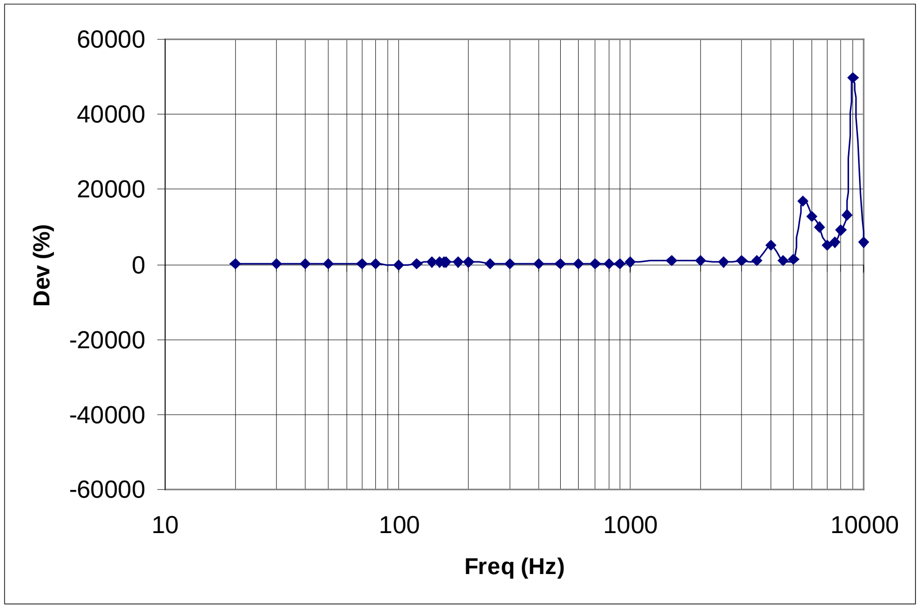


Rotational acceleration can be measured using well matched, symmetric, seismic systems with inverted polarity

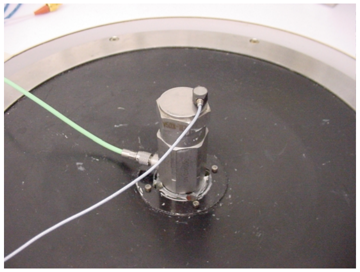


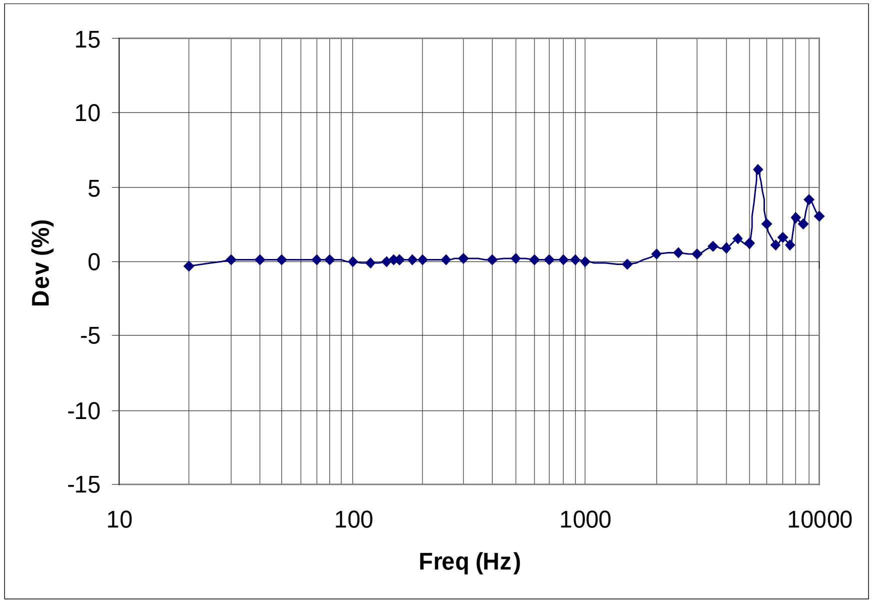

15
10
5
0
-5
-10
-15
Dev (%)
10
100
1000
10000
Freq (Hz)



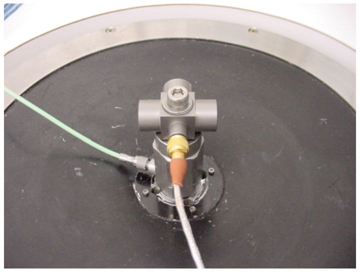


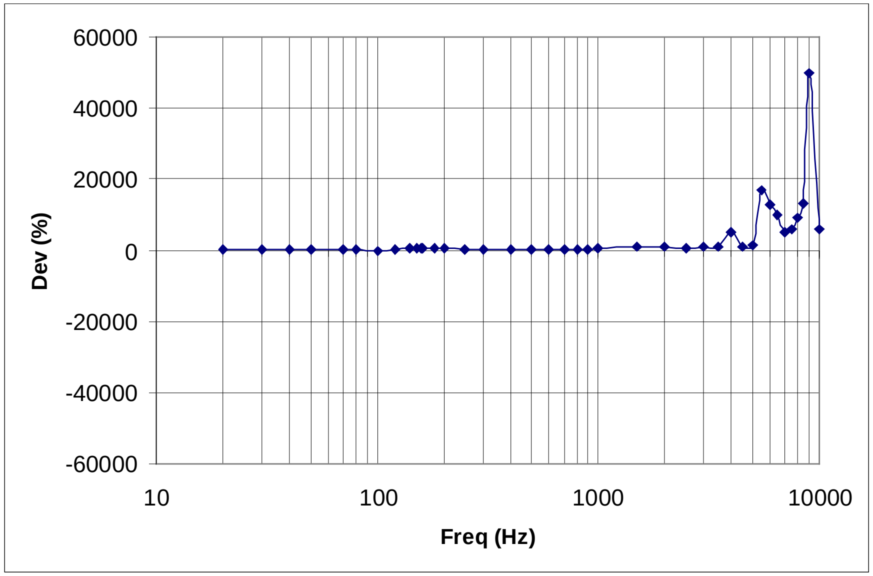
60000
40000
20000
0
-20000
-40000
-60000
Dev (%)
10
100
1000
10000
Freq (Hz)





Rotational Sensitivity due
to asymmetric mounting





Rotational Acceleration due
to shaker error

Twentieth Transducer Workshop-2002

Typical equipment and description of high and low impedance piezoelectric components

- Terminology
- Why do transducers get returned to the factory?
- Description of the typical hardware used in piezoelectric systems
- Several Piezoelectric transducer combinations (electrical diagram)
- Several Piezoelectric transducer system combinations (block diagram and pictures). Low impedance and high impedance systems
- Low and high impedance signal conditioning
- Troubleshooting a low impedance connection

Terminology

Piezotron/Isotron/ICP/etc. - Describes a piezoelectric transducer with the electronic built inside a housing. None of the high impedance connections are in direct contact with the atmosphere

Constant Current Excitation - The current necessary to power a piezoelectric system using an internal or in-line amplifier

Time constant - Classical definition: The time in seconds required by a capacitor to charge to 63.3% of its final value

Insulation Resistance - The electric resistance measured between the signal lead and connector ground on a charge mode transducer and/or cable

Coupler/Power supply - A device capable of supplying a constant current and a DC voltage to a piezoelectric transducer that incorporate either built-in electronics, an in-line charge or in-line voltage amplifier

Bias voltage (Turn on voltage) the DC Voltage measured at the output of a Piezotron/Isotron/ICP/etc. connection, or in-line voltage amplifier connection

Terminology

Charge Mode Sensor - Describes a piezoelectric transducer without internal electronics and with the high impedance connection present at the connector

Charge Amplifier- An electric device utilizing a capacitive feedback capable of converting the charge generated by a piezoelectric sensor into a low impedance voltage output. They are available with adjustable or fixed gain.

Insulation Resistance - The electric resistance measured between the signal lead and connector ground on a charge mode transducer and/or cable

Polarity - The positive or negative response of the transducer when a mechanical event is applied

Clipping - The truncation of the output signal forced by the transducer itself or the coupler/charge amplifier/readout

Noise - The presence of an electrical signal without applying any mechanical event

Triboelectric noise- The electrical noise generated by the friction between the shield and internal insulator resulting from the motion of a coaxial cable.

Why do transducers go back to the factory for repair?

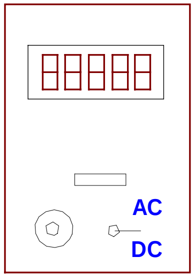
- Misapplication
- To be recalibrated
- Physically damaged
- They do not work properly
- Open circuit prior and during operation
- Short circuit
- They turn on but no output at the readout
- Too noisy
- They do not supply data as expected
- They lost insulation- high impedance
- Poor low frequency response- Low impedance
- Their new calibration does not match the factory's
- The off ground is grounded
- Discontinuity in the data acquired
- Data shows an undershoot
- Non linear, saturated, clipping, excess ringing and more………………..

Description of the typical hardware used in piezoelectric systems (see separate slide)

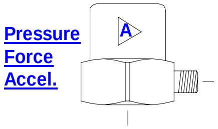
- Piezotron/Isotron/ICP/etc. can describe an accelerometer, pressure or force sensor
- The coupler/signal conditioning/power supply should have the following features:
  - a) Capable of providing a constant current between 2-20 mA and voltage 18-28 VDC
  - b) It can be battery operated or line operated (115-230 Volts AC)
  - c) Preferable with an DC-AC coupling. If DC, it also must have a pot to adjust for the offset
  - d) Preferable with a meter or LED to check the level of the battery, cable status (short/open)
  - e) Low noise
  - f) Preferable with gain capability
- Cabling- Output RG 58, input low noise cable and standard input
- In line voltage amplifier
- In line charge amplifier
- Digital Voltmeter- AC - DC capable
- Lab. type charge amplifier. Preferable with TC adjustment, adjustable gain, dual mode
- Readout- Oscilloscope, DVM, spectrum analyzer, computer with data acquisition…..

TYPICAL HARDWARE USED IN A PIEZOELECTRIC SENSING SYSTEM

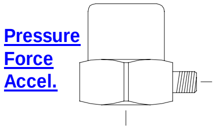
Digital Voltmeter



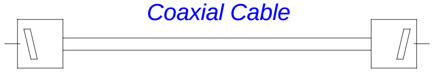
PiezoelectricTransducer With Internal Electronic



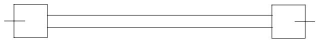
Charge Mode Piezoelectric Transducer



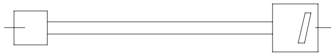
Standard Output Coaxial Cable



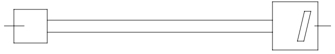
Low Noise Input Coaxial Cable



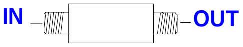
Low Noise Input Coaxial Cable



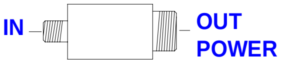
Standard Input Coaxial Cable



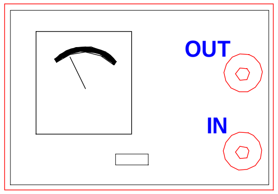
In Line voltage Amplifier



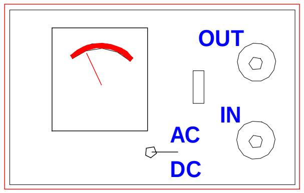
In Line Charge Amplifier



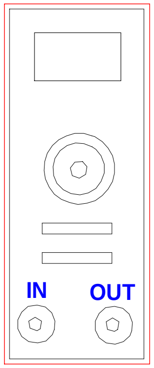
AC Mode Coupler (Battery Operated)



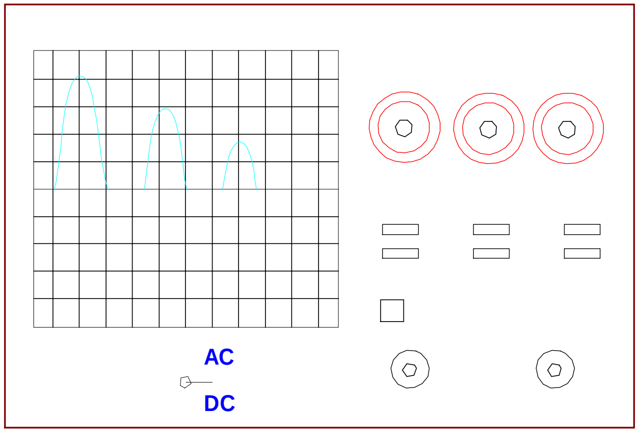
AC/DC Mode Coupler (Line Operated)

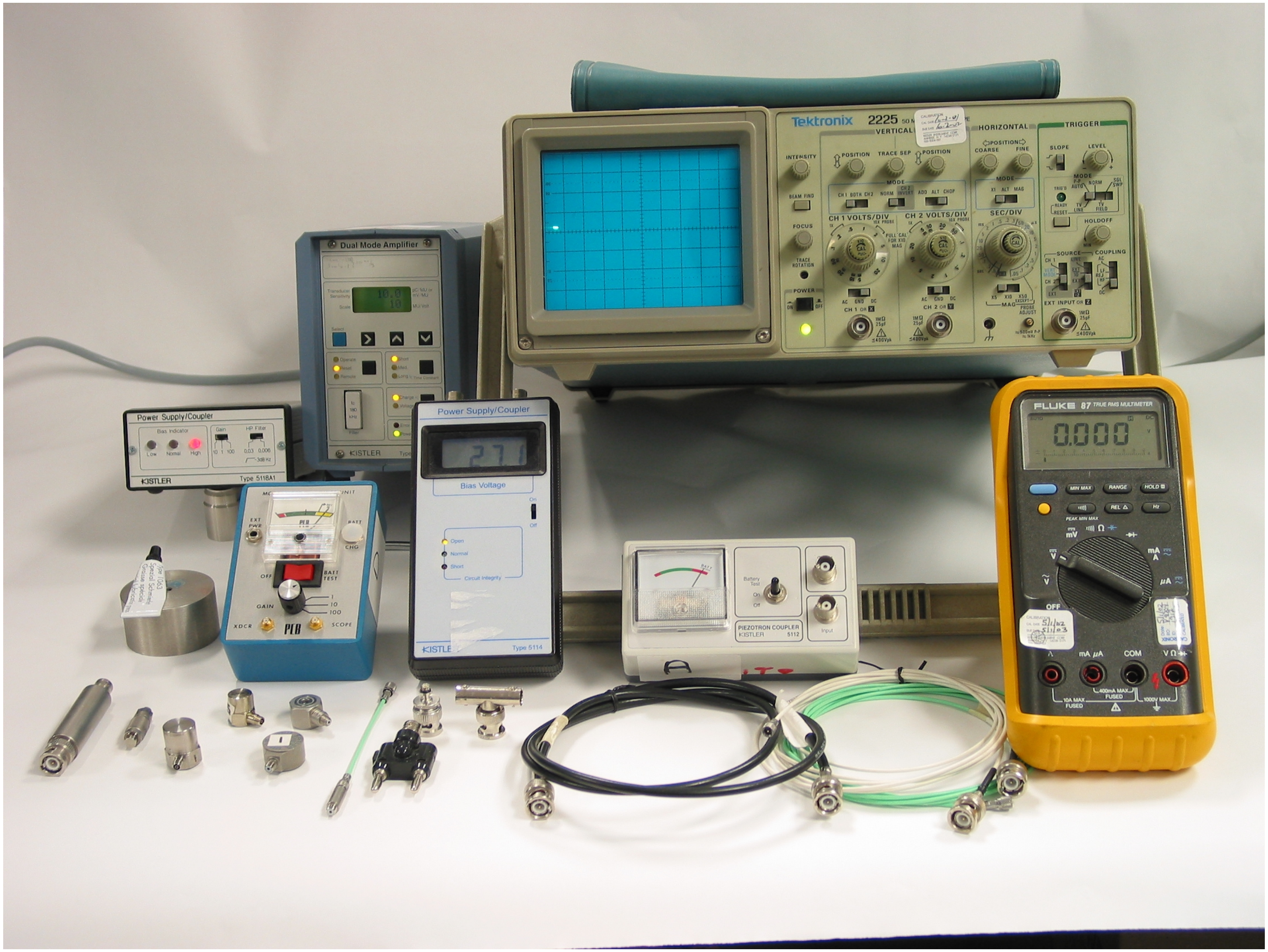


Charge Mode Amplifier



Readout





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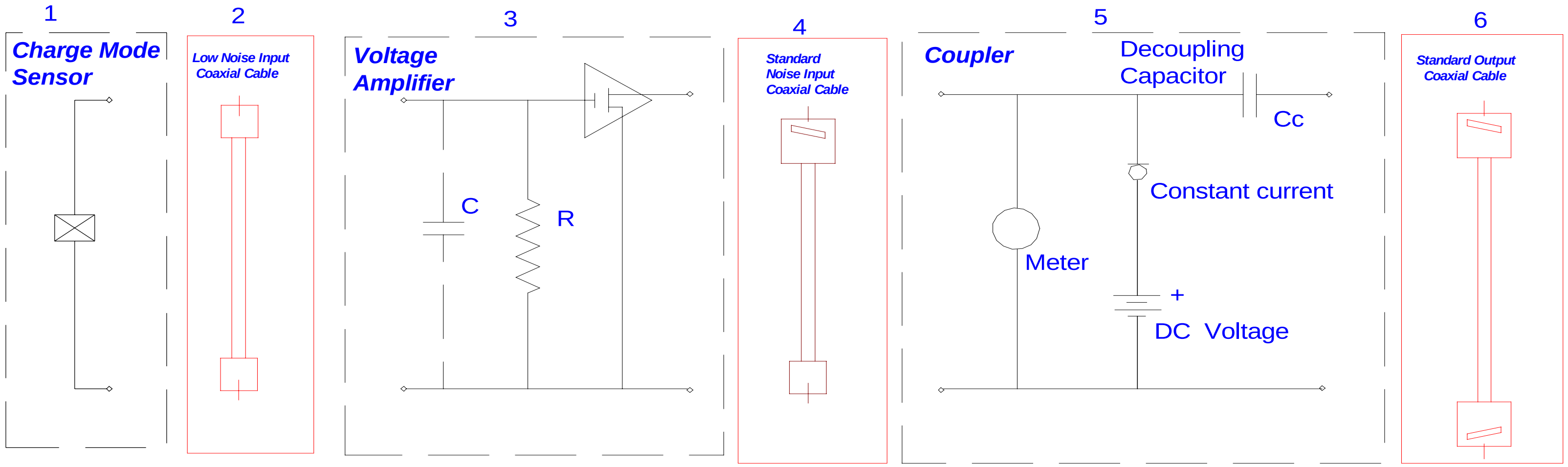
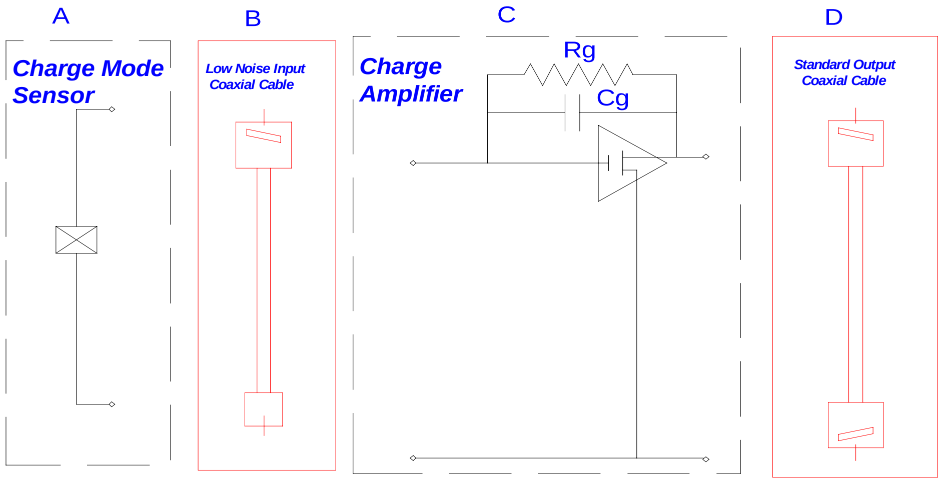
Several Piezoelectric Transducers Combinations





COMBINATIONS

☐1+3 +4 +5+6 = PIEZOTRON / ICP CONNECT.

☐A+C +4+5+6 = PIEZOTRON / ICP CONNECT.

1+2+3+4+5+6= TYPYCAL INLINE VOLTAGE CONNECT.

A+B+C+D = CHARGE MODE CONNECT.

A+B+C +5+6 =TYPICAL INLINE CHARGE CONNECT.

☐ = Built inside transducer

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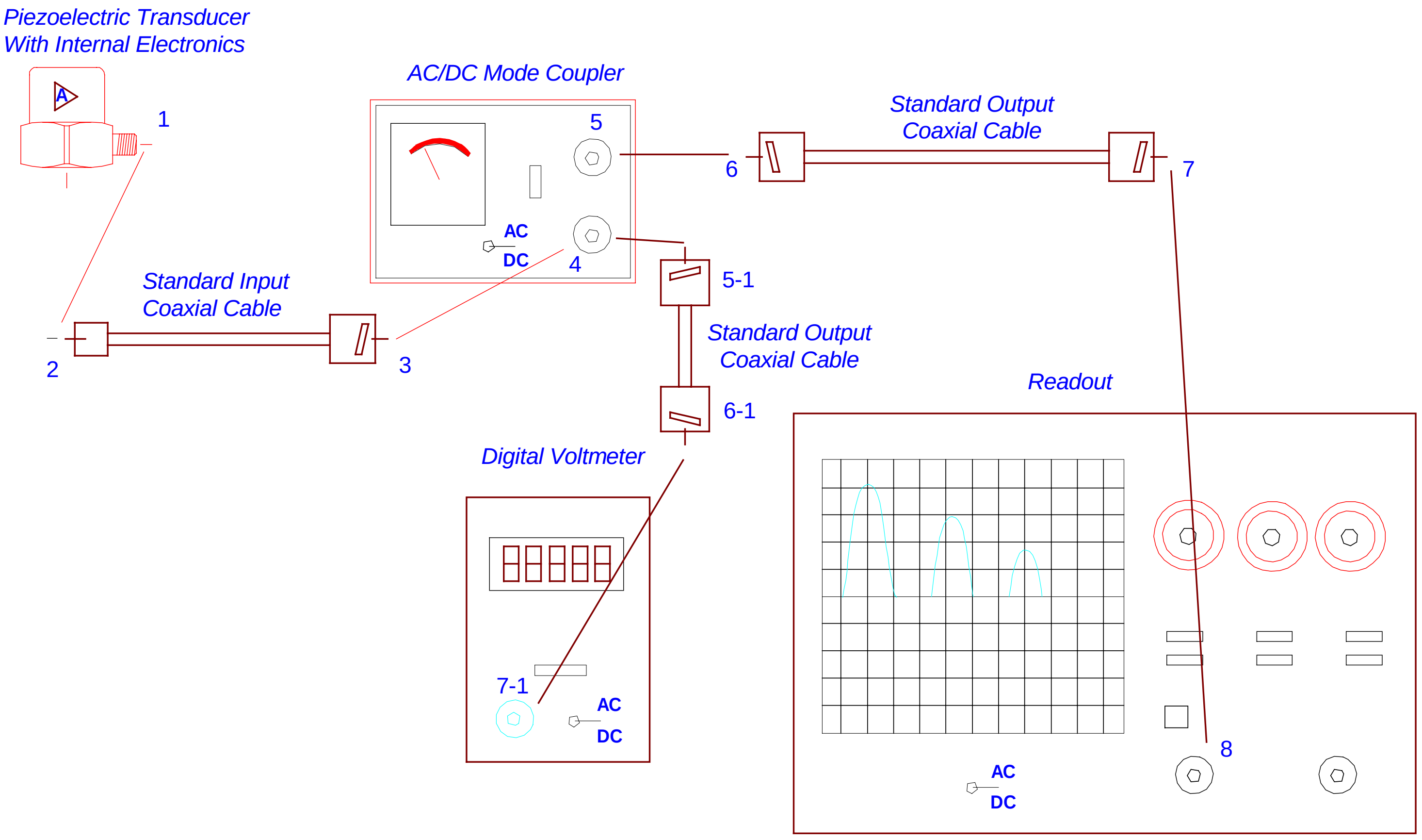
TYPICAL LOW IMPEDANCE CONNECTION (Internal Electronic)



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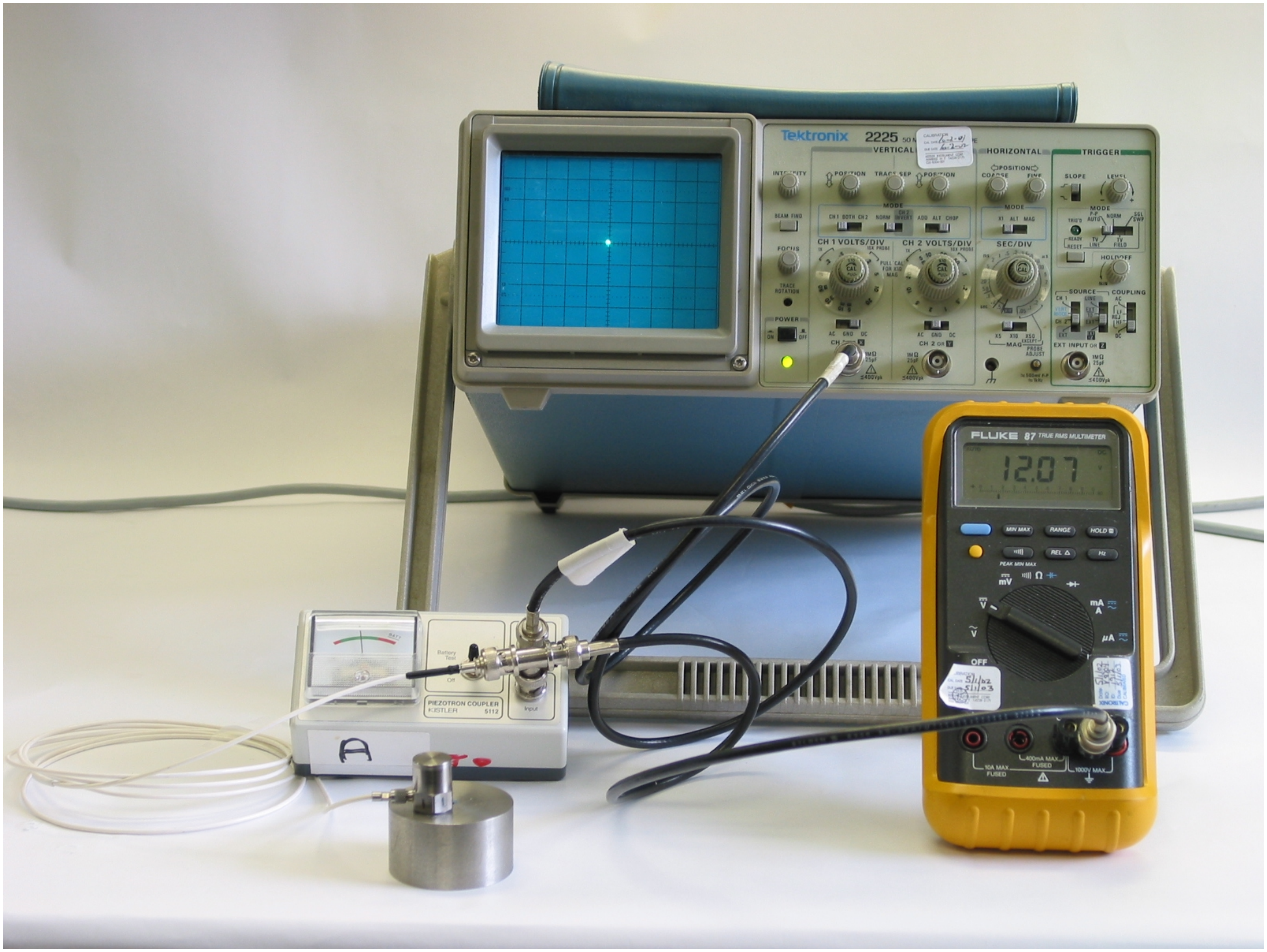

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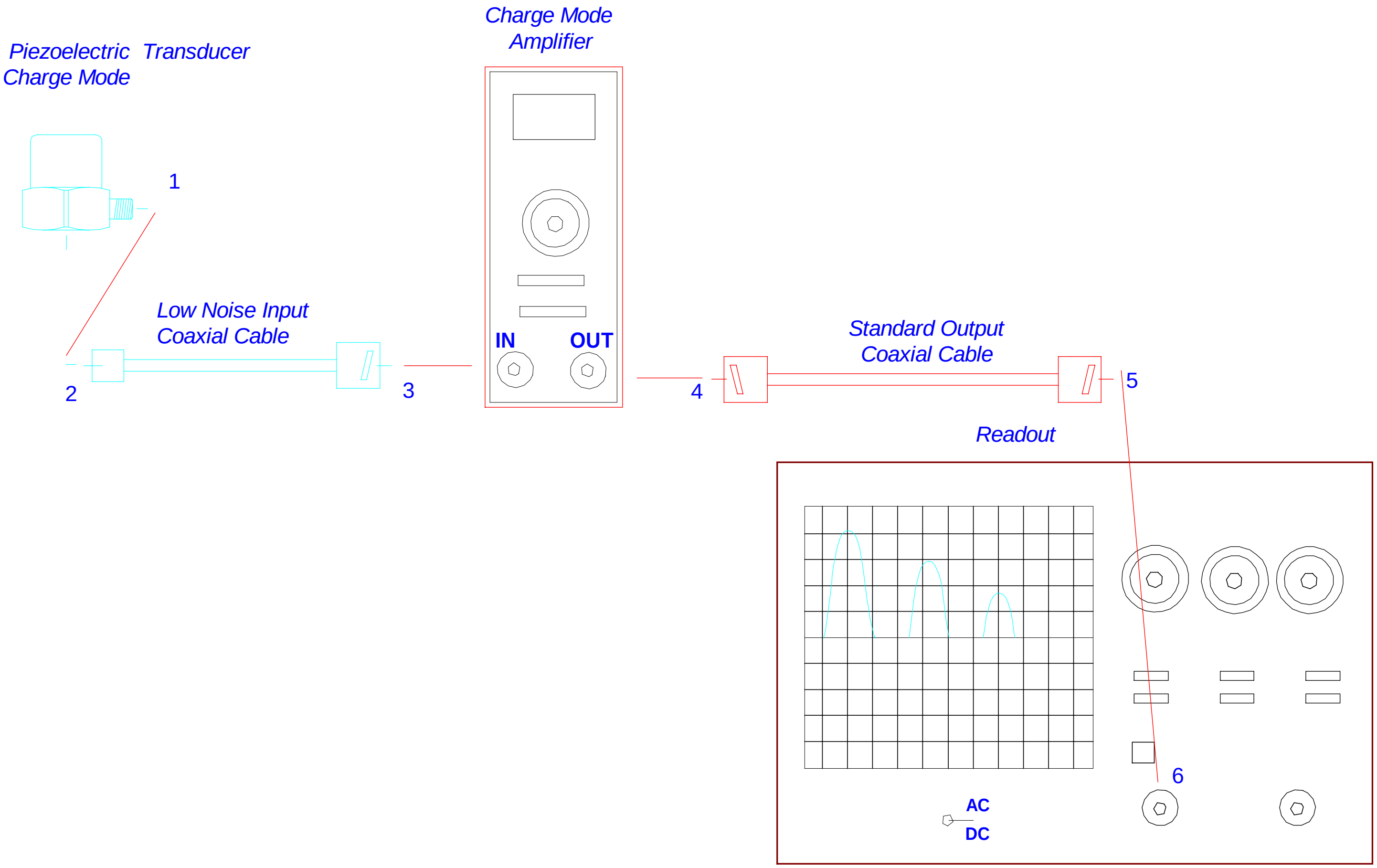
TYPICAL CHARGE MODE CONNECTION (No Internal Electronic)



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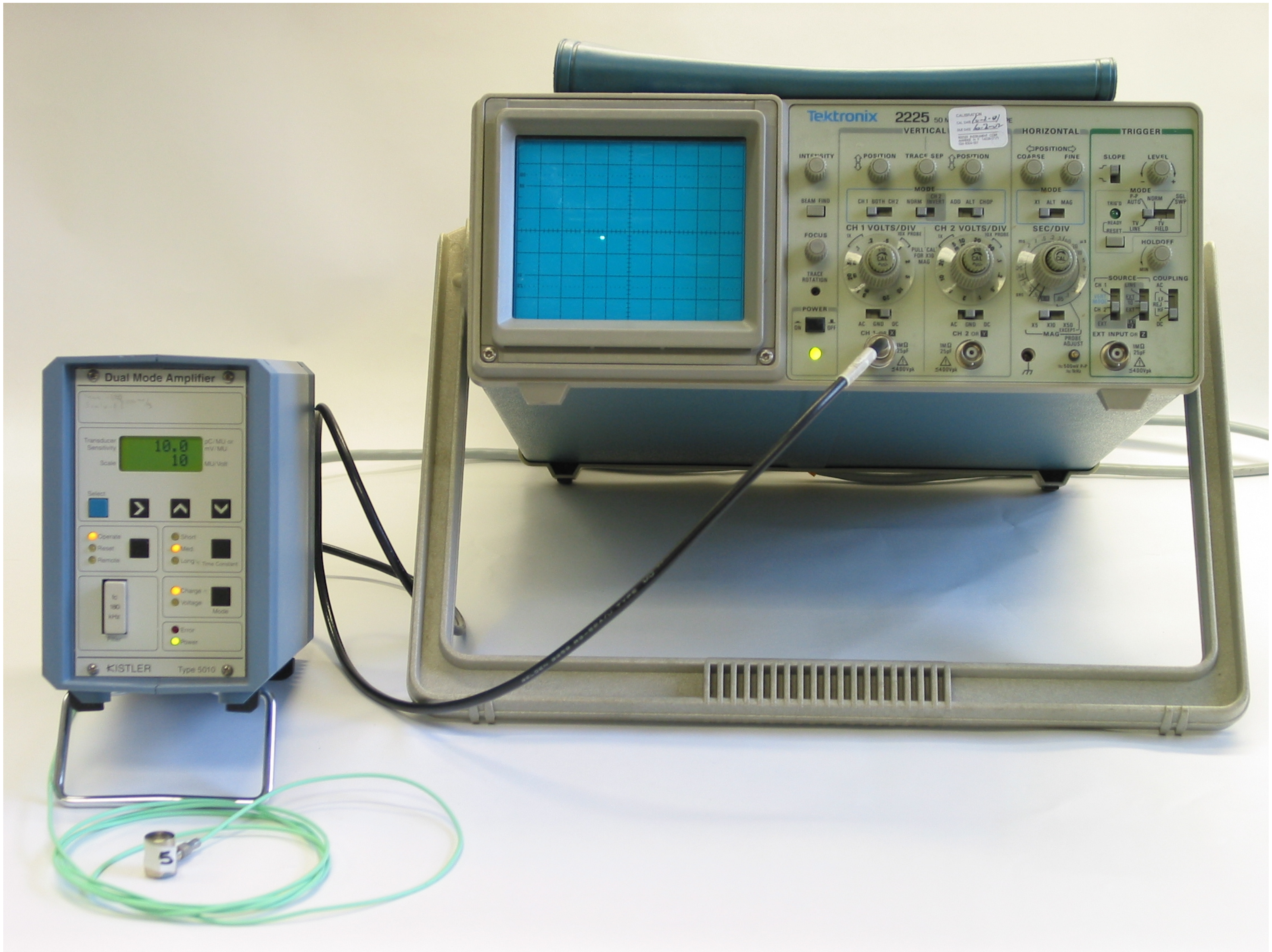

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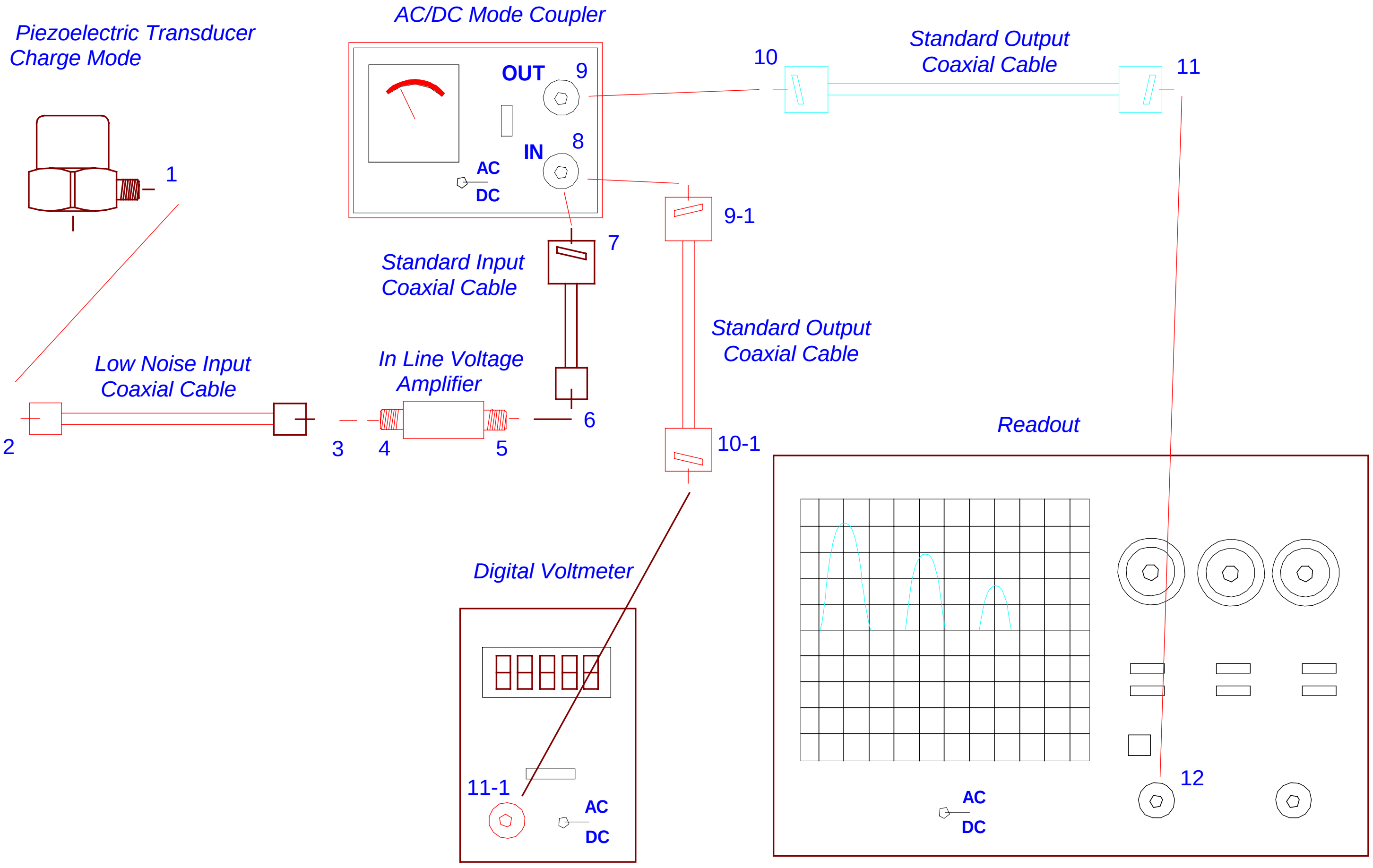
TYPICAL IN LINE VOLTAGE CONNECTION (In-line Voltage Amplifier)



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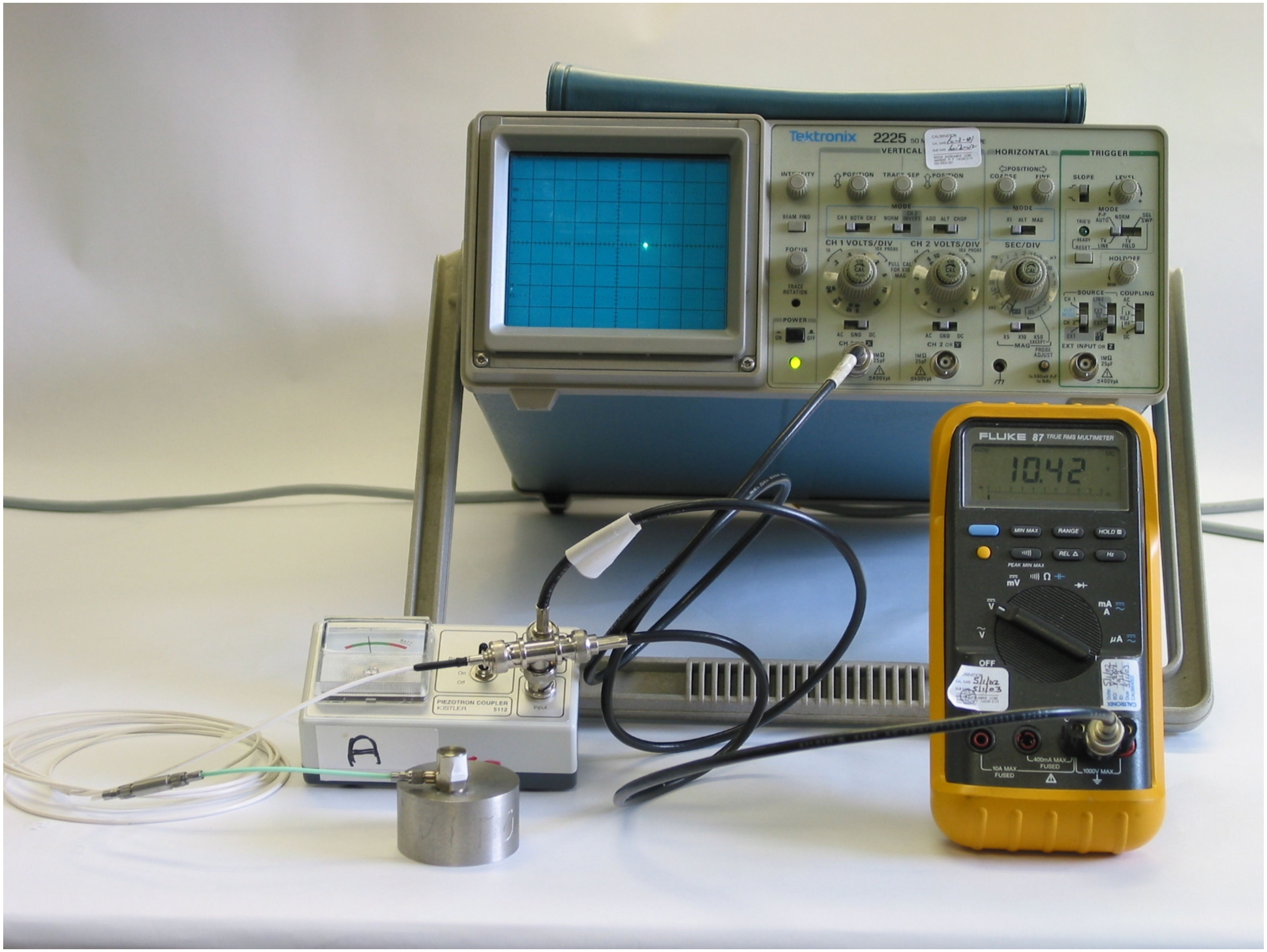

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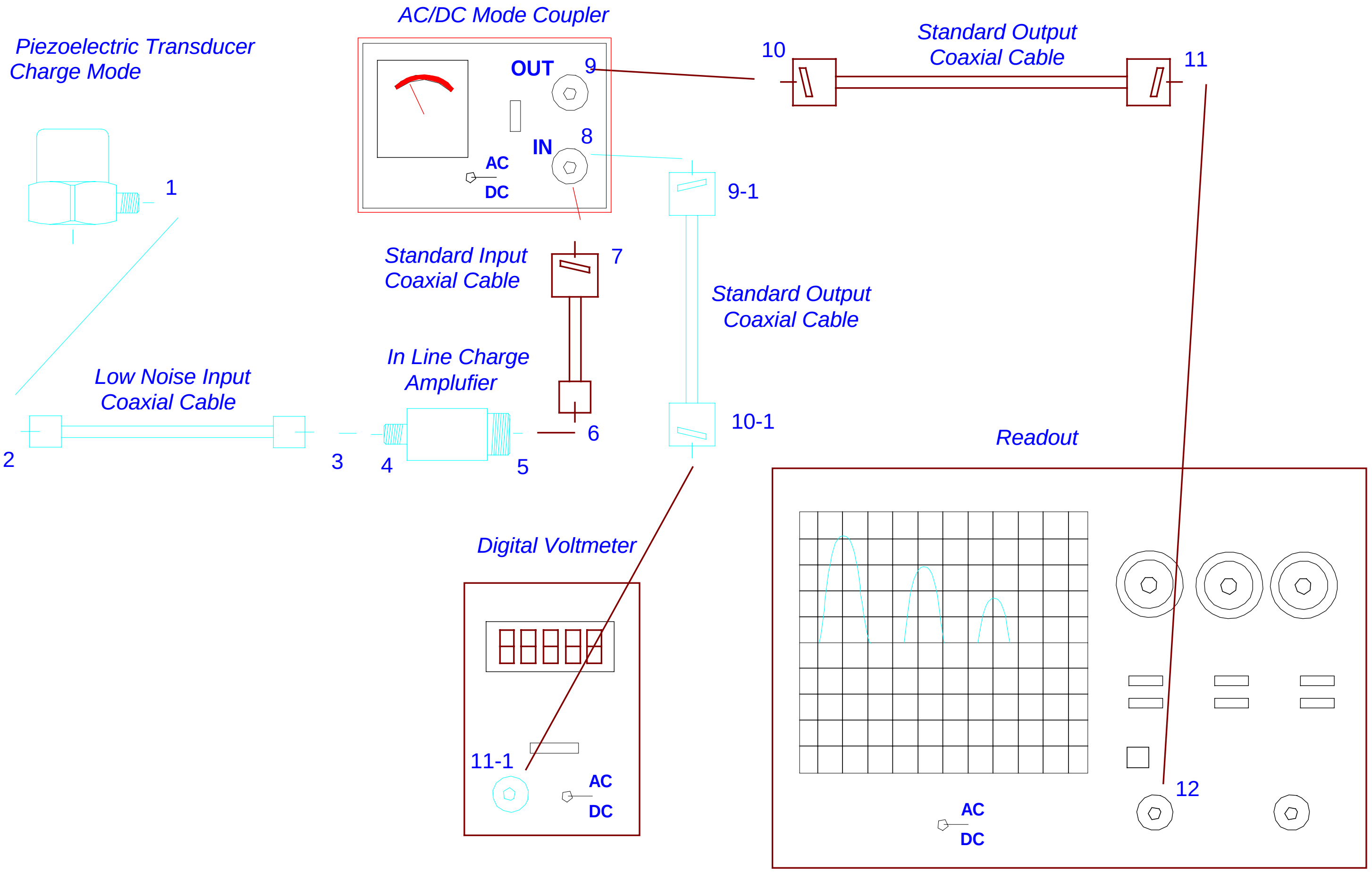
TYPICAL IN LINE CHARGE CONNECTION (In-line Charge Amplifier)



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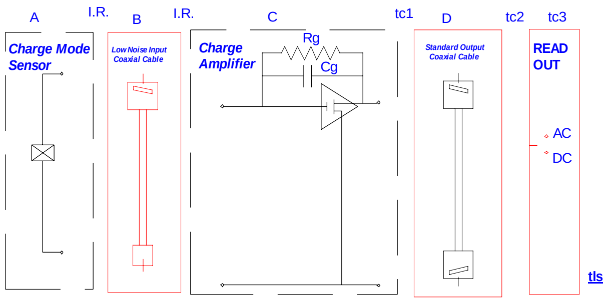
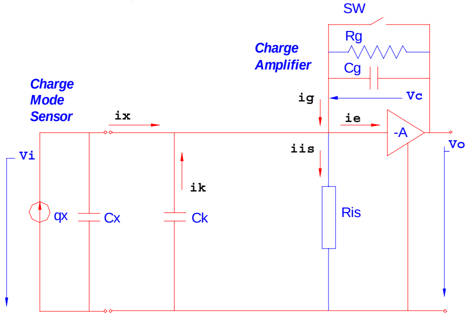
Piezoelectric Transducer - Low and High Impedance
More On Charge Amplifier





Cx = Transducer capacitance
Ck = Cable capacitance
Cg = Feedback capacitor (range)
A = Open loop gain of op. amp.
Rg = Time constant or insul. res. of range capacitor
Ris = Insul. res. of input ckt.(cable and trasducer)
Vo = Output voltage

An ideal charge ampl. is immune from the input capacitance in the front circuit. (transducer and cable). The voltage ouptut is a function of the charge sensitivity and feedback capacitor (range)

Vo = -qx/Cg

In our simplified model above we assume a high but finite open loop gain Vi, but neglect the effects of the Ris, ie, and Rg

.

The open loop output voltage is Vo = - A x Vi while the voltage across Cg is: Vc = Vo - Vi = Vo + Vo/A = (1+ 1/A). Vo

At the above node neglecting iis and ie we can write ix + ig + ik = 0 where ix = dqx/dt, ig = Cg . dVc/dt and ik = -Ck. dVi/dt

Cx is ignored in the case of the quartz material because it is much smaller than the cable capacitance itself

Plugging the proper current variables from above in ix + ig + ik = 0 we obtain

dqx/dt + Cg . dVc/dt + (-Ck. dVi/dt) ; dqx/dt + (1+ 1/A).Cg. dVo/dt + 1/A.Ck. dVo/dt = 0

by integrating and solving by Vo we obtain

$$Vo = \frac{-qx}{Cg} \cdot \frac{1}{1 + \frac{1}{A} + \frac{1}{A} \cdot \frac{Ck}{Cg}}$$

for A = 100,000 and Ck/Cg = 100 the overall error is less than 0.1 %

File/xducer8a

Troubleshooting a typical ICP/Piezotron/Isotron connection (see separate slide)

Check the status of the power supply.

•First thing to do is to check the magnitude of the battery voltage used in the battery operated power supply

•If the power supply has a digital readout, then you would read directly the battery voltage

•Some couplers have light emitting diodes indicating the system status and consequently are incapable of measuring the battery voltage

•If you are interested in measuring the exact voltage of the battery, use a DC voltmeter and connect it to the input of the power supply while keeping the sensor disconnected from the circuit

Check the status of the system.

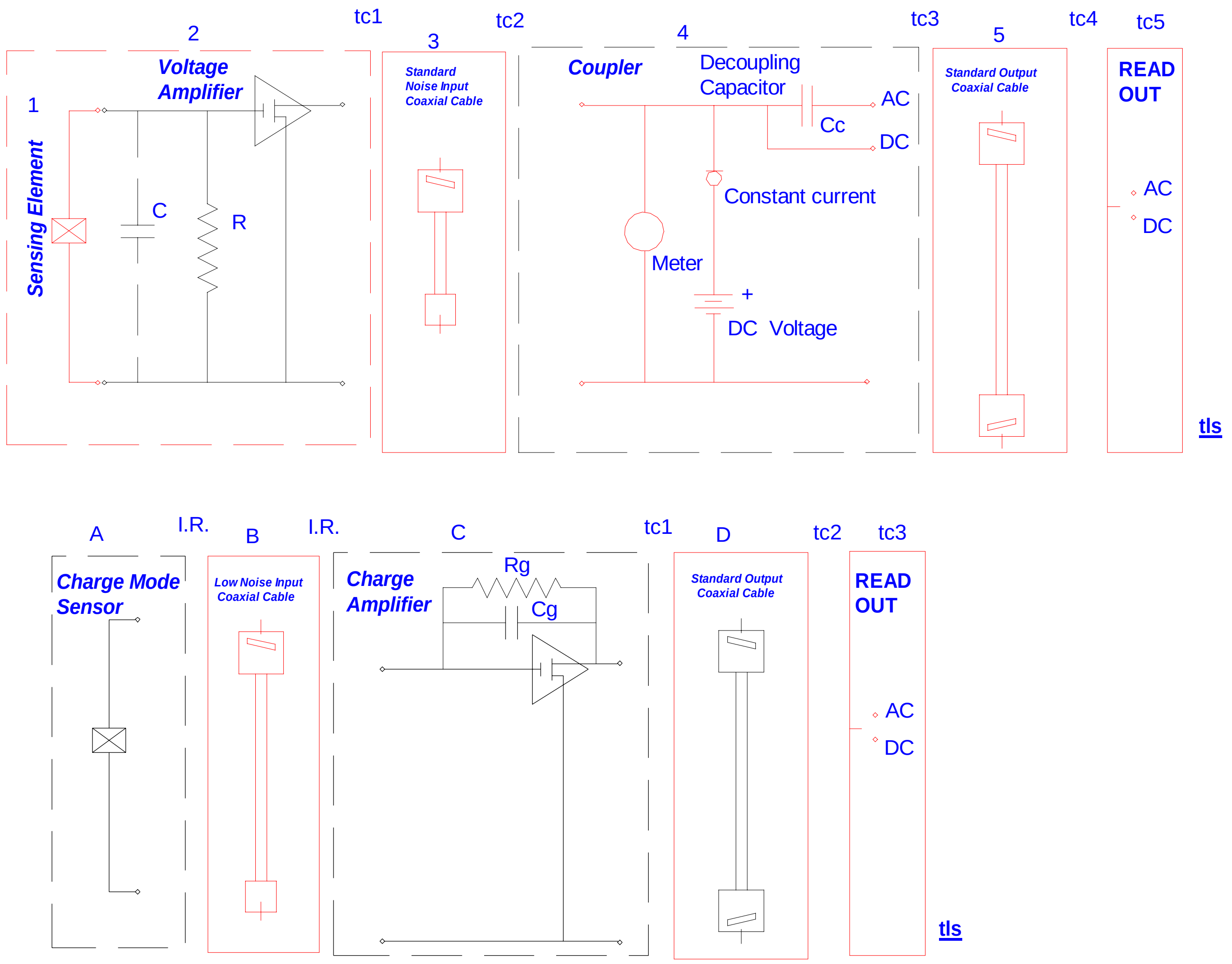
Case1 - The sensor turns on but no output is present at the readout

•The problem is due to either a short circuit in the output cable, in the output of the signal conditioning or in the input of the read out

•A short circuit exists inside the transducer in the high impedance area. In any case this situation cannot be rectified by the customer and the unit must be returned to the factory for evaluation and possible repair.

•To test the output cable: connect it to the input of the signal conditioning

Piezoelectric Transducer - Low and High Impedance



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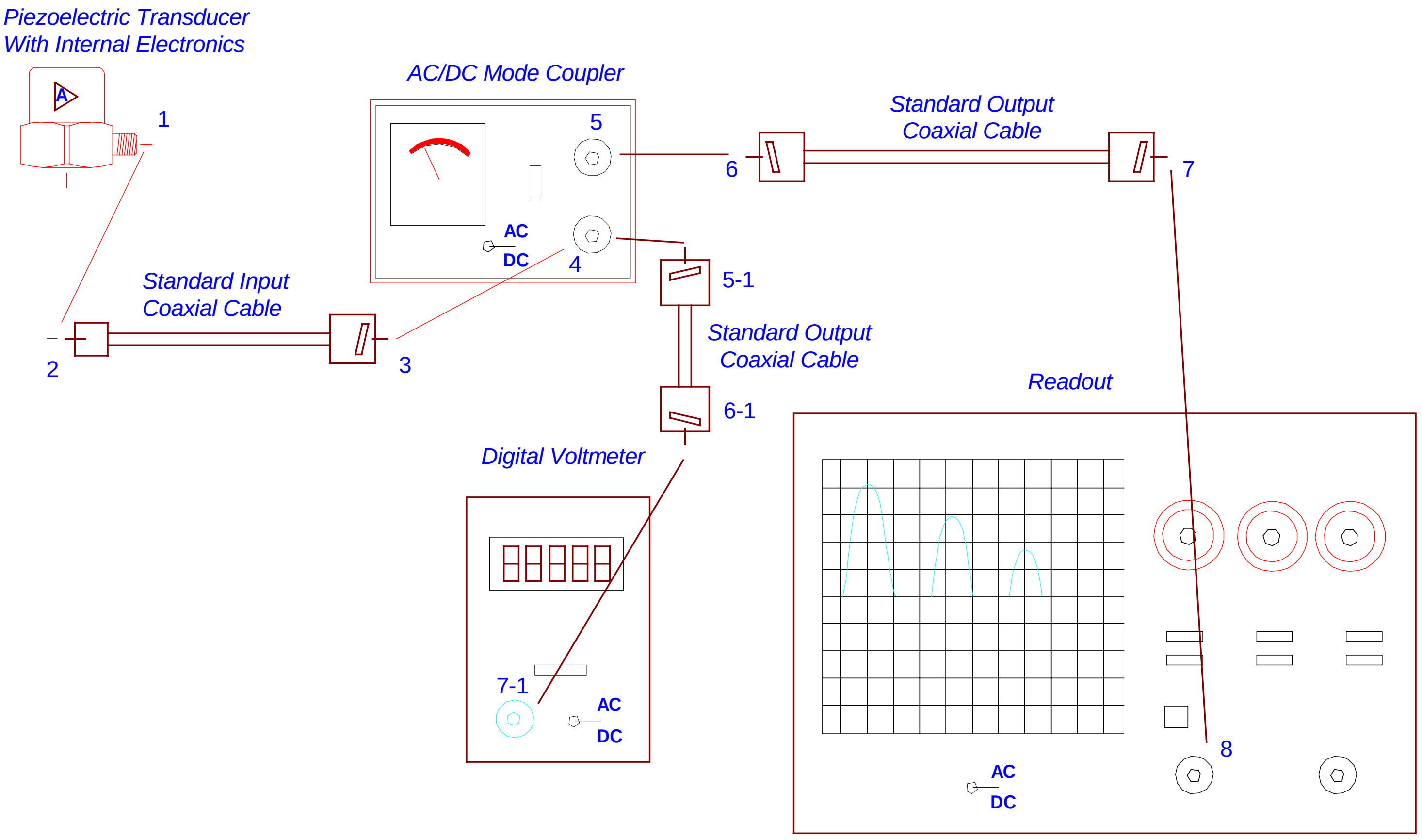
TYPICAL LOW IMPEDANCE CONNECTION (Internal Electronic)



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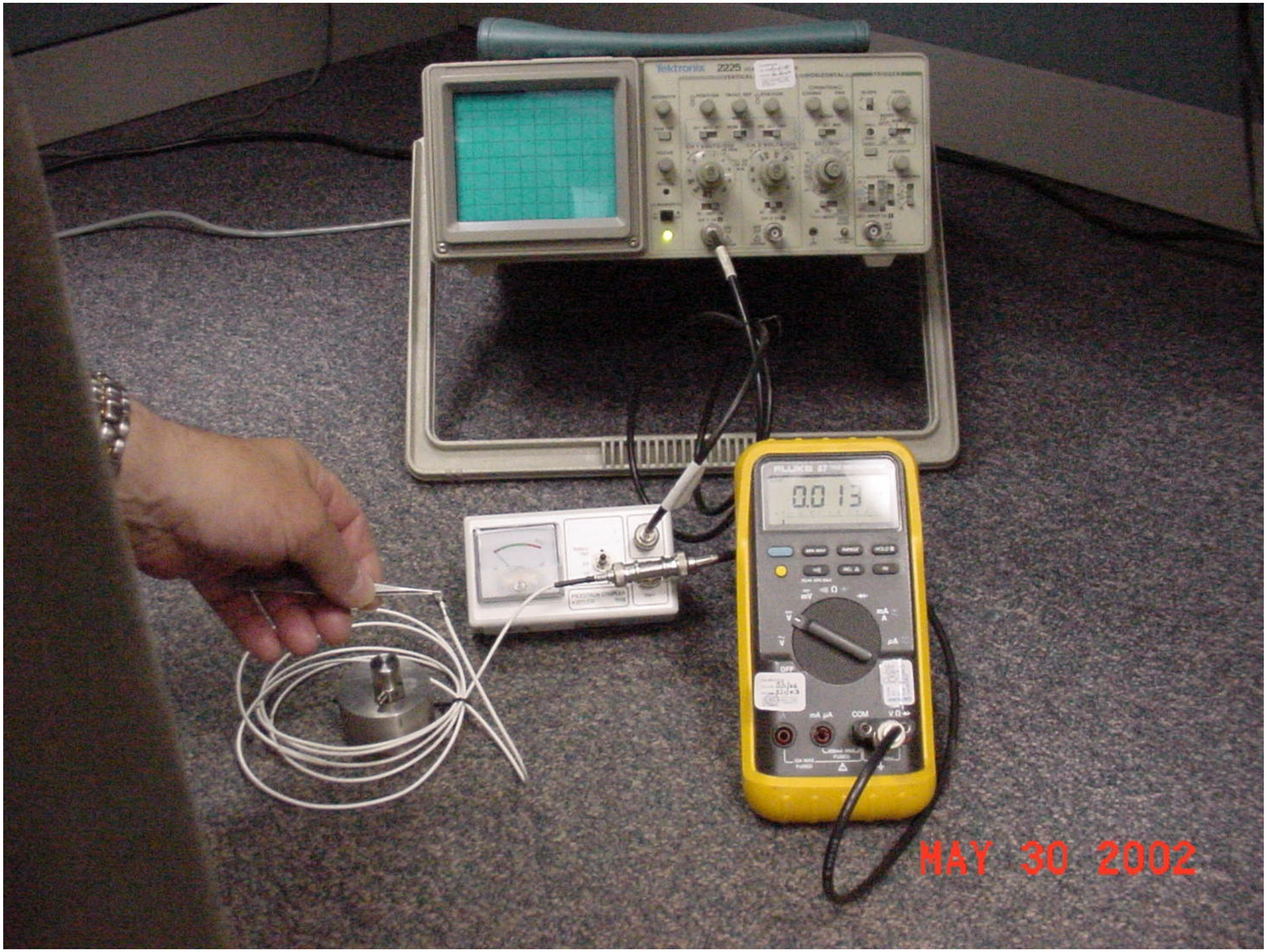
Troubleshooting a typical Isotron/ ICP/Piezotron connection (see separate slide)

Case 2 - The sensor does not turn on

- When this condition exists the problem is usually associated with the sensor itself or the coaxial input cable. Test the input cable. Ultimately the problem may be attributed to the power supply itself or the sensor. In this case systematically exclude one part and then the other. The output cable is never the cause of a bias that does not turn on!

- This is caused by an open circuit inside the transducer in the high impedance area. In any case this situation cannot be rectified by the customer and the unit must be returned to the factory for evaluation and possible repair.



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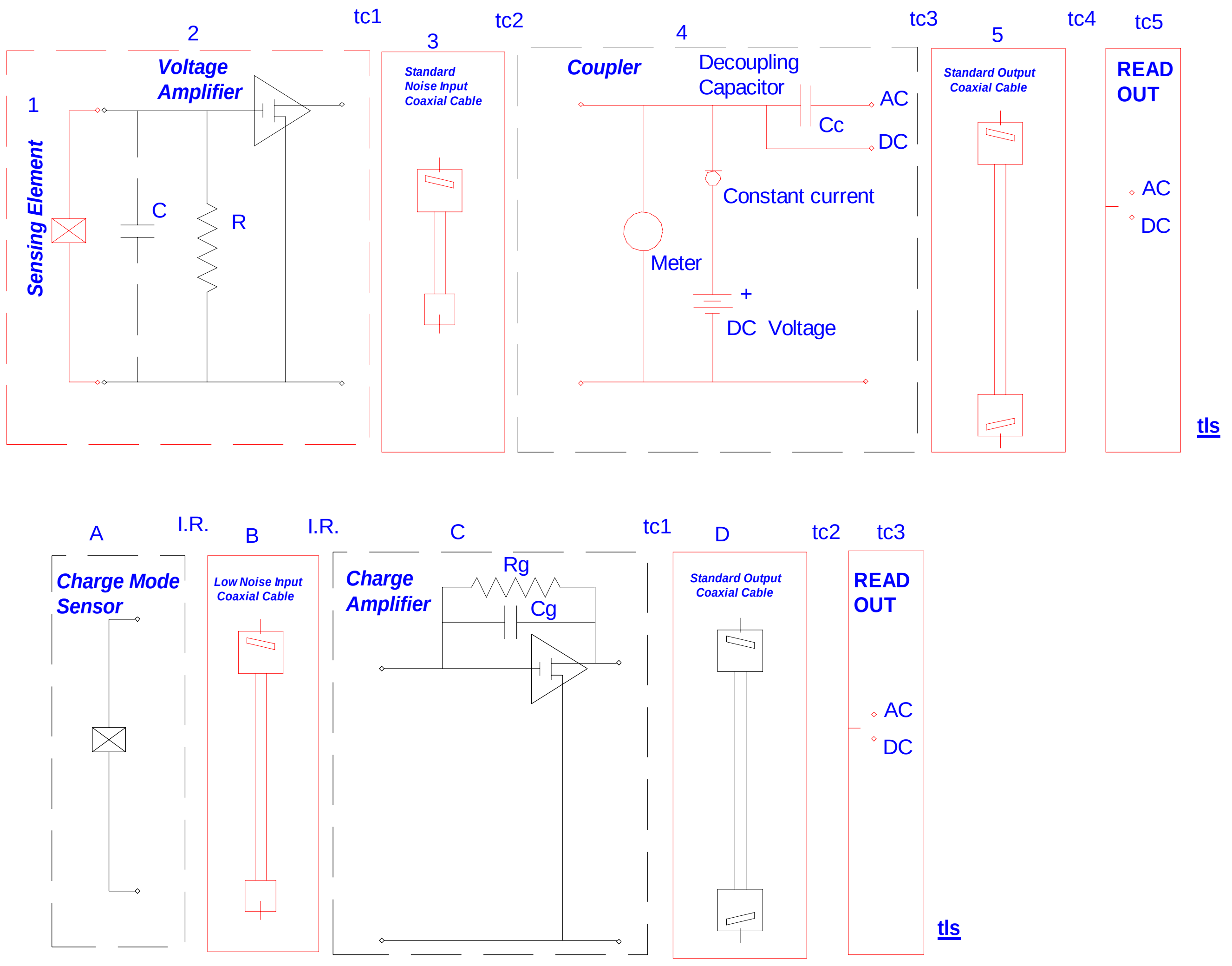
Twentieth Transducer Workshop-2002

Theoretical and practical review of the interaction of the system components

- Time Constant- sensor time constant, system time constant. Theory and practical application
- Coupler/power supply/signal conditioning in AC/DC mode
- Read out in AC or DC mode? Signal conditioning in AC or DC mode?
- Practical test for sensitivity and time constant of a low and high impedance piezoelectric transducer
- Troubleshooting a high impedance system connection
- Low and high impedance piezoelectric transducers. Which one to use?

Piezoelectric Transducer - Low and High Impedance



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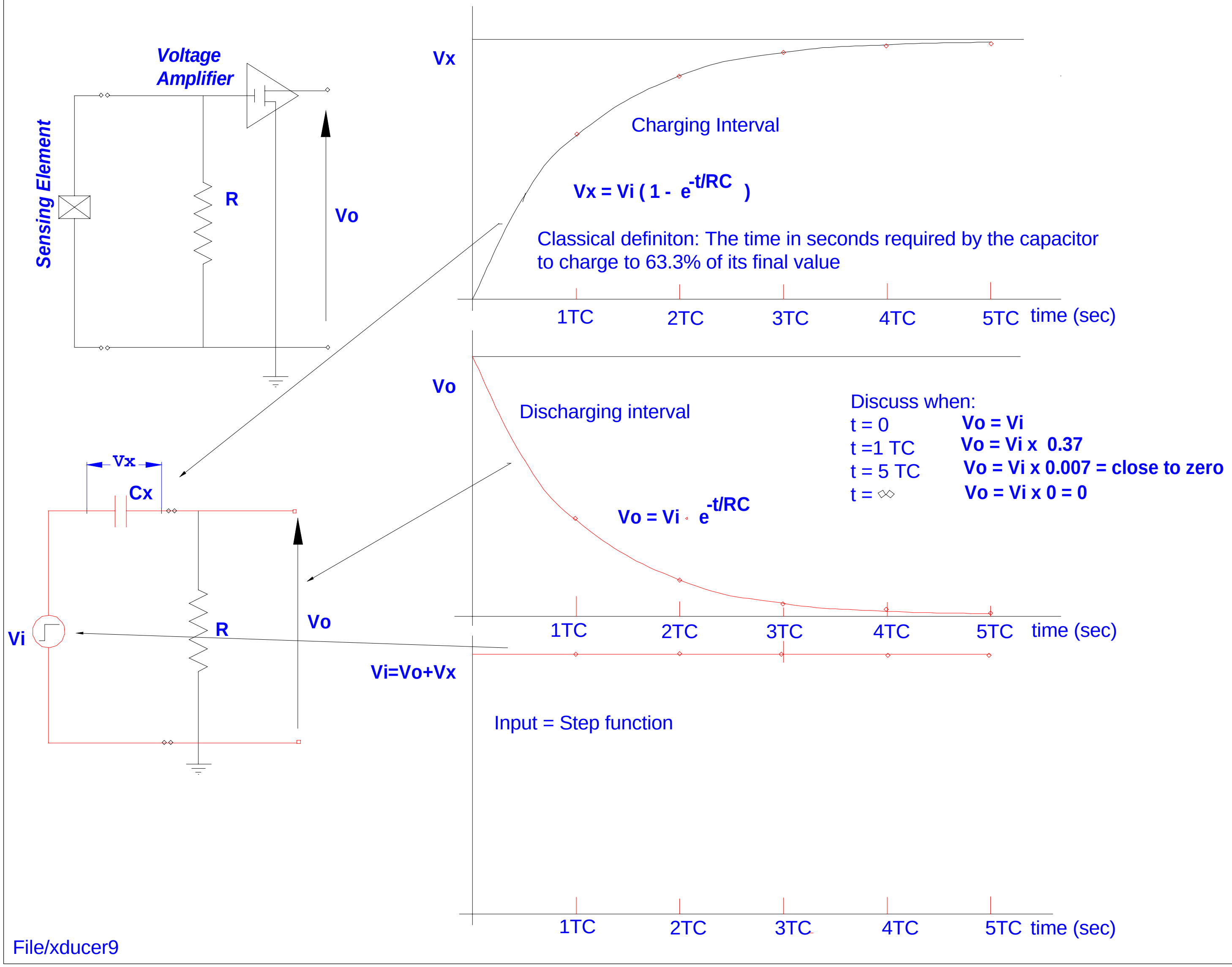
Piezoelectric Transducer - Low and High Impedance (Time Constant = TC=RC)



Charging Interval

$V_x = V_i\,(1 - e^{-t/RC})$

Classical definiton: The time in seconds required by the capacitor to charge to 63.3% of its final value

Discharging interval

$V_o = V_i \cdot e^{-t/RC}$

Discuss when:

t = 0	**Vo = Vi**
t =1 TC	**Vo = Vi x 0.37**
t = 5 TC	**Vo = Vi x 0.007 = close to zero**
t = ∞	**Vo = Vi x 0 = 0**

Vi=Vo+Vx

Input = Step function

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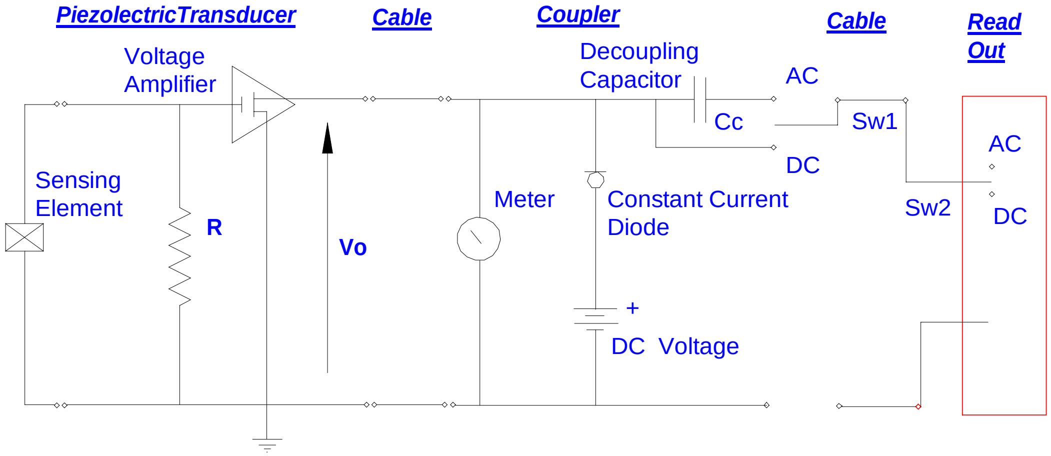
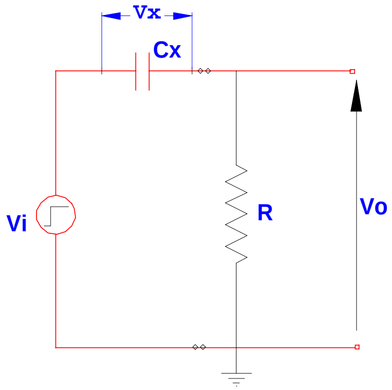
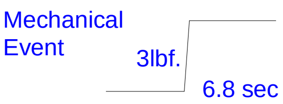
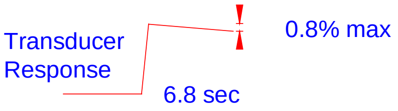
Piezoelectric Transducer - Low and High Impedance (Time Constant = TC=RC)





In order to make a correct measurement you must know with a good approximation the expected event profile (Amplitude and duration)
In our example we'd like to make a force measuremnt of 3 lbf., profile step function, duration 6.8 sec. with an acceptable max. error of 0.8% due to the TC decay





Let's choose a force transducer with a Sens=500mV/lb
to take this measurement. Further determine the proper:
1) TC needed by the sensor.
2)The coupler, read out and the way they should be coupled.

$Vo = Vi \cdot e^{-t/RC}$ if Vi =1 500 mV then Vo is 0.8% lower than 1500mV/lb = 1488mV = Vo **$1488mV = 1500mV \cdot e^{-6.8\ sec/RC}$**

ln1488mV/1500mV = -6.8 sec/RC ln 0.992 = -6.8 sec/RC -0.008 = -6.8 sec/RC RC = 6.8/0.008 = 850 sec

For the coupler in order to avoid any decay due to its own TC should have a TC in the order of 120,000 sec if in AC mode. This is pratically impossible consequently it has to be coupled in DC mode

The same applies fot the readout which must be also in DC mode for the maximun voltage transfert

A charge amplifier with a charge mode piezoelectric transducer must follow the same rules as above as far as proper coupling and TC selection

View on a picture the output signal degradation due to the improper coupling (AC vs. DC)

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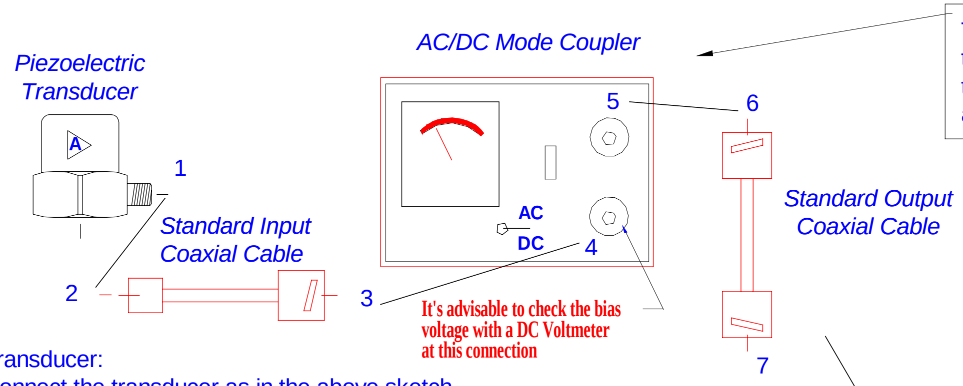
TYPICAL LOW IMPEDANCE SYSTEM VERIFICATION

This typical system is used to verify the transducer operation, the approximate time constant, the approximate sensitivity and the sensor polarity or phase



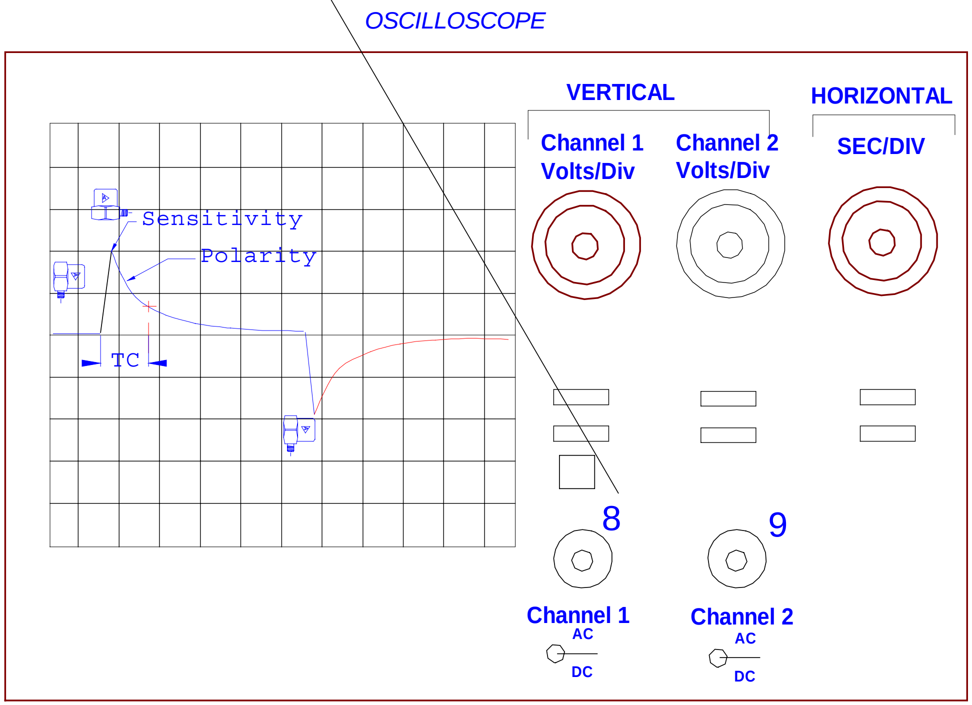
It's advisable to check the bias voltage with a DC Voltmeter at this connection

Transducer:
Connect the transducer as in the above sketch and keep it in a neutral position (green trace). Then rotate it upward so that the gravity acts on the seismic mass producing positive output voltage, (blue trace). Back to the neutral position generating a negative output voltage(red trace).The typical voltage outputs provide info.on the polarity, approximate sensitivity and TC of the sensor under test

Specification of the test transducer:
100 mV/g, TC = 1.2 sec(The sensor to be tested can be a force, pressure or an accelerometer)

Specificaton of the coupler:
In AC mode the TC must be greater than 12 sec if into a 1 Mohms load for an error of 10% . If you are in doubt set it in DC mode

Read out
Oscilloscope with storage capability or a digital voltmeter. Set the oscilloscope in DC mode, the horizontalscale 0.5/1 sec/div and the vertical scale to 20/50 mv/div.



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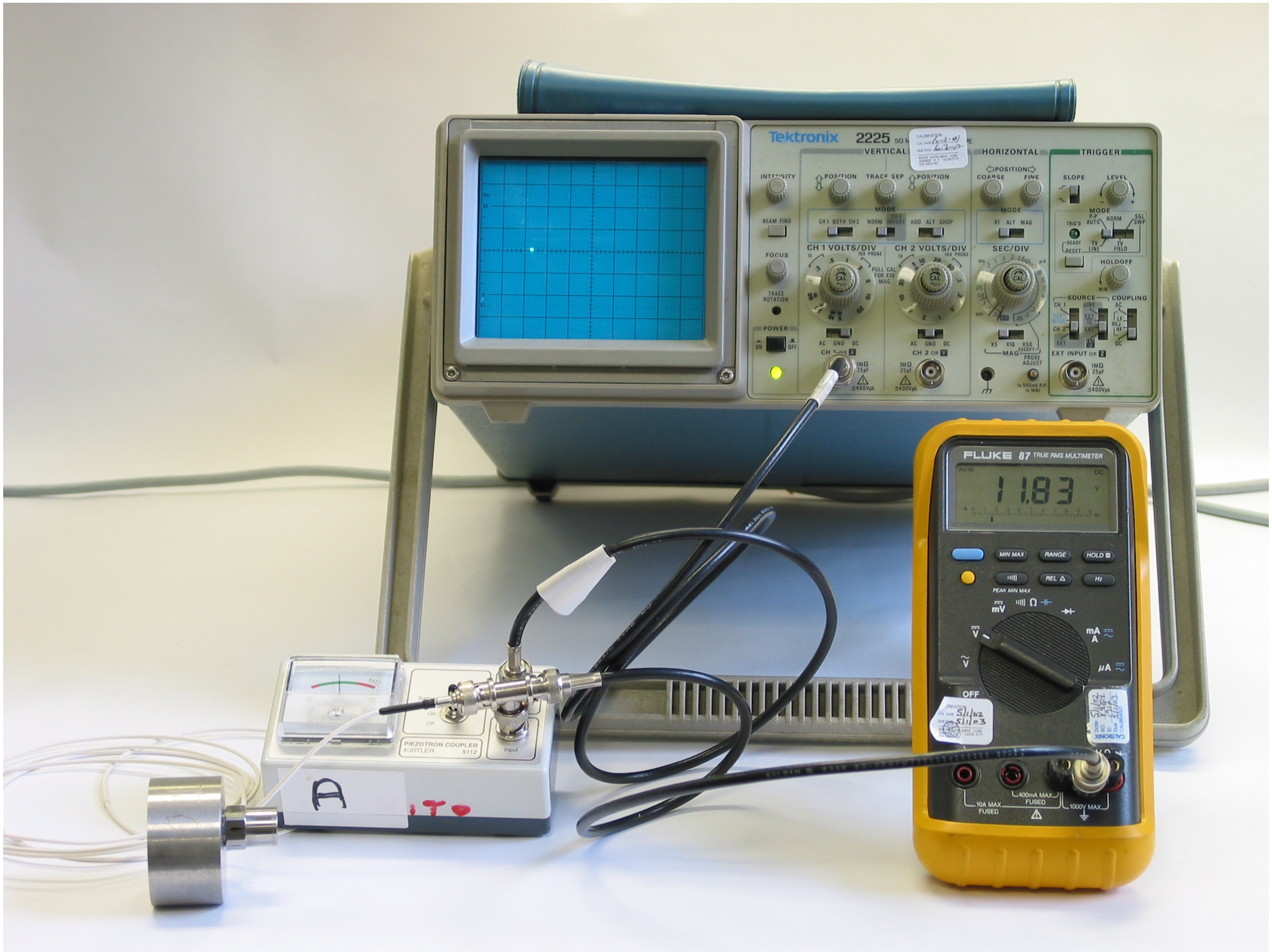

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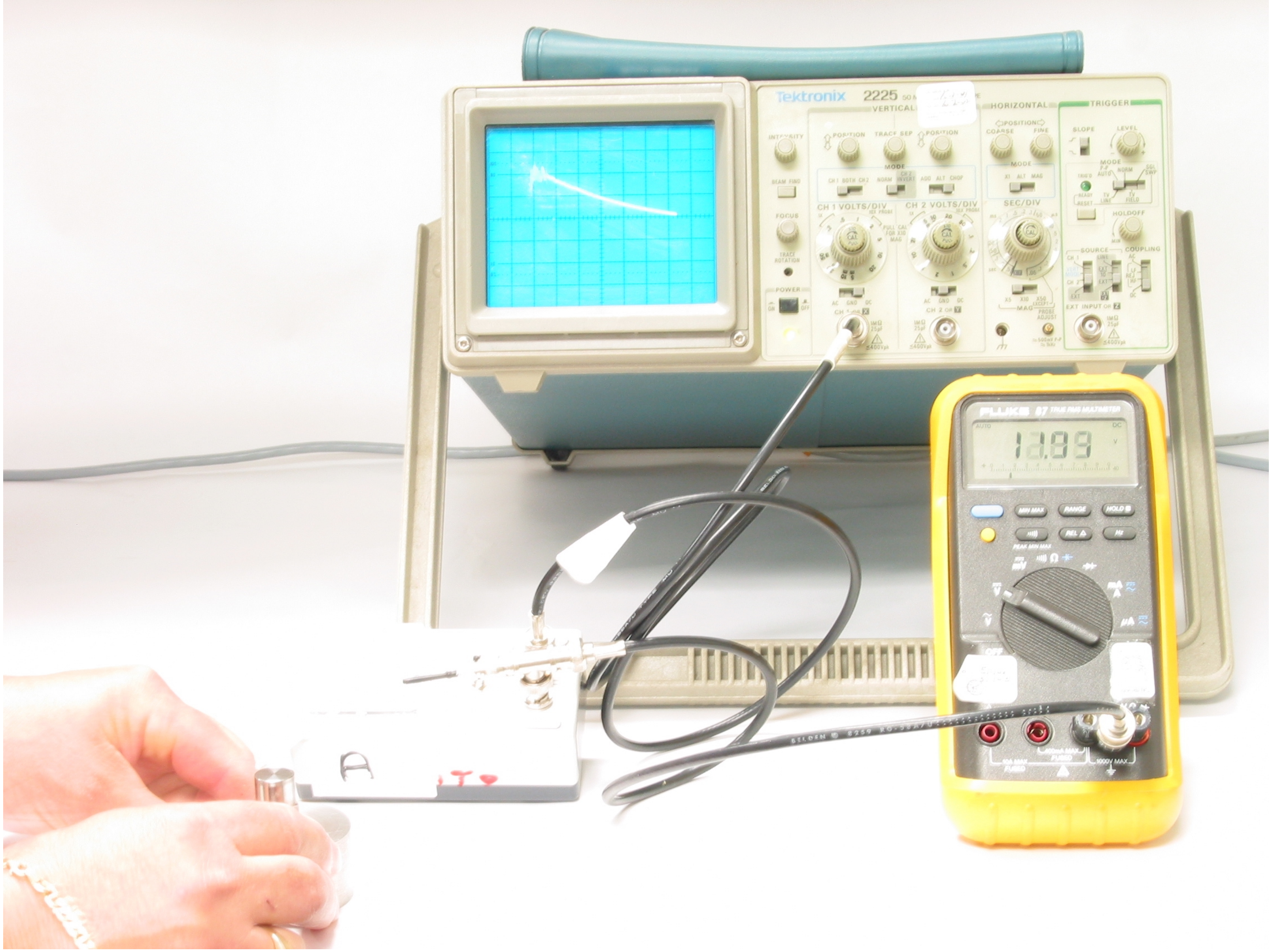

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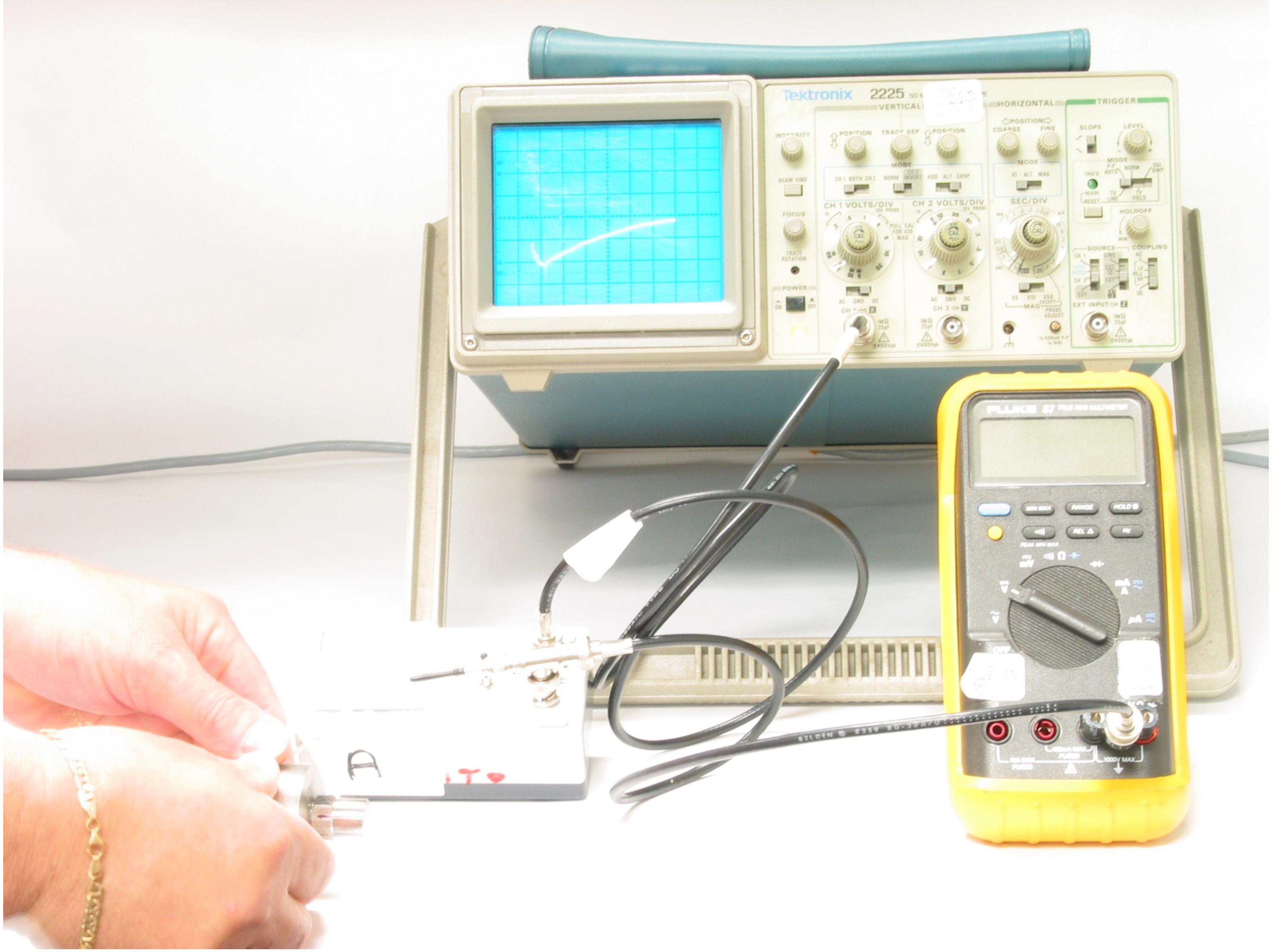

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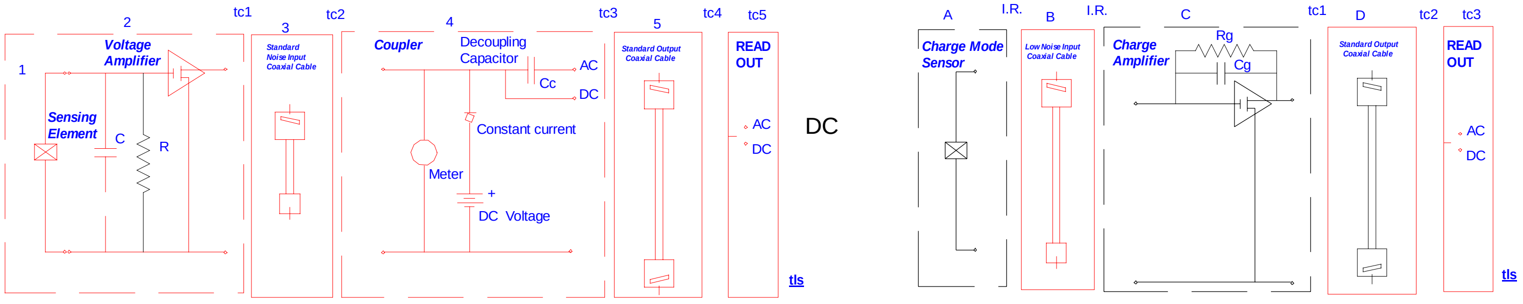
Piezoelectric Transducer - Low and High Impedance



Main Features

Low Impedance Systems

-Simple to operate
-Built in system test features
-Less sensitive to moisture
-Les sensitive to noise
-Less expensive to operate
 (cables and signal conditioning)
-Long cable capable

High Impedance Systems

-High Dynamic Range
-Adjustable Time Constant
-Adjustable Sensitivity
-Sensitiviy in multiples of 10
-Higher Temperature
-Ground button capable (Reset)
-Nuclear application

WHICH ONE TO USE?

Both systems are application dependent, it is up to the customer or the sales engineer to define the piezoelectric transducer for the correct application