HPL resistivity *measurement* in Pavia

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How do we (Pavia) measure HPL Resistivity ?

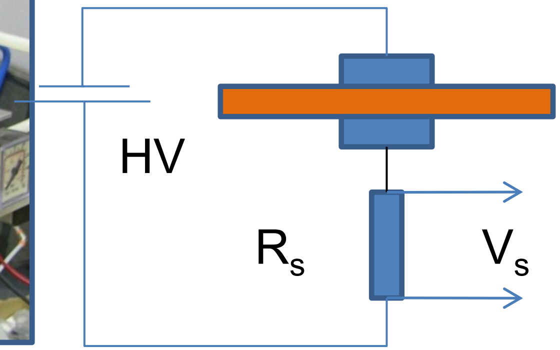
With:

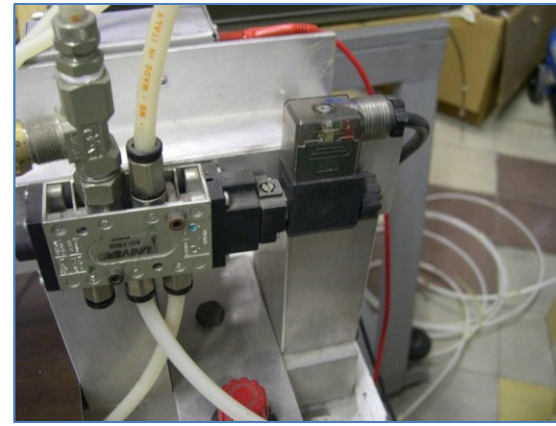
1) A “Portable” instrument: wet measurements on 30 cm x 30 cm (max) samples

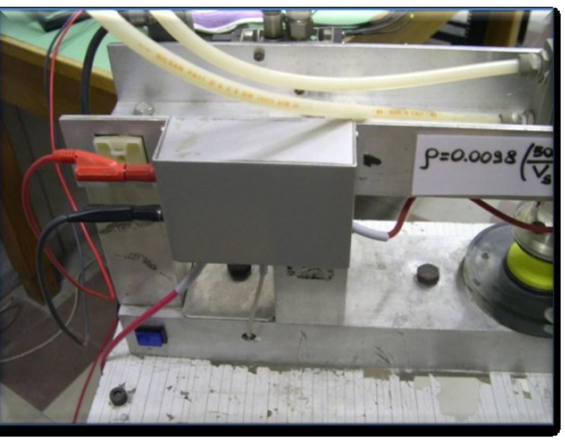
1) A “Fixed ” instrument: dry measurements on an entire panel (9 measurements in 9 different positions across the panel)

1) *"Portable" Instrument:*

a) Piston regulated by an electro-valve

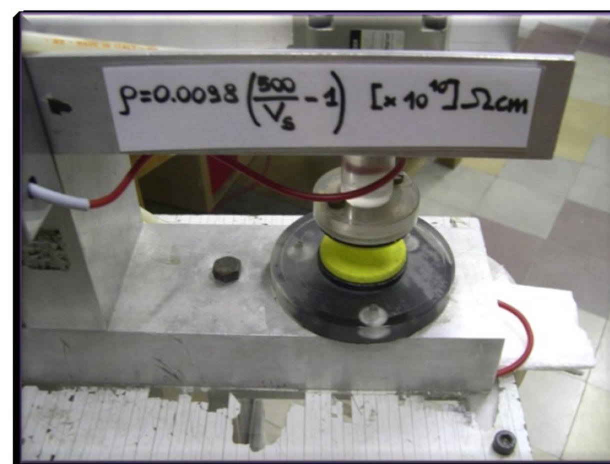




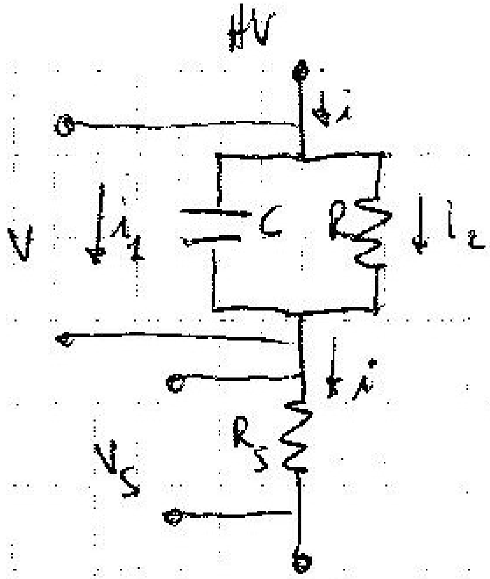


$$\rho = \left(\frac{HV}{V_s} - 1\right) \times f(g) \times f(H,T)$$

b) We measure the voltage V_s across a resistor R_s in series to the piston



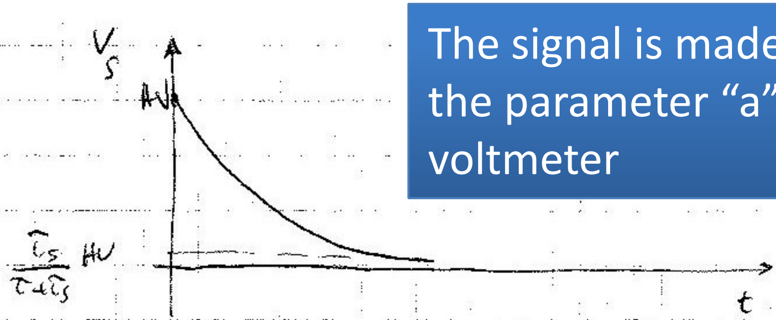
A model for the measurement.



$$\begin{cases} i = i_1 + i_2 \\ V_S = i R_S \\ V = \frac{1}{C}\int i_1 \, dt = i_2 R \end{cases} \qquad \begin{cases} \tau = RC \\ \tau_S = R_S C \end{cases}$$

$$i_2 = \frac{V}{R}$$

$$\boxed{V_S = HV - V(t) = HV - \frac{\tau}{\tau+\tau_S} HV \left(1 - e^{-at}\right) = \frac{\tau_S}{\tau+\tau_S} HV + \frac{\tau}{\tau+\tau_S} HV e^{-at}} \qquad a = \frac{1}{\tau} + \frac{1}{\tau_S}$$



The signal is made by a transient part (dielectric polarization) ruled by the parameter "a" and a steady part which is what we read in the voltmeter

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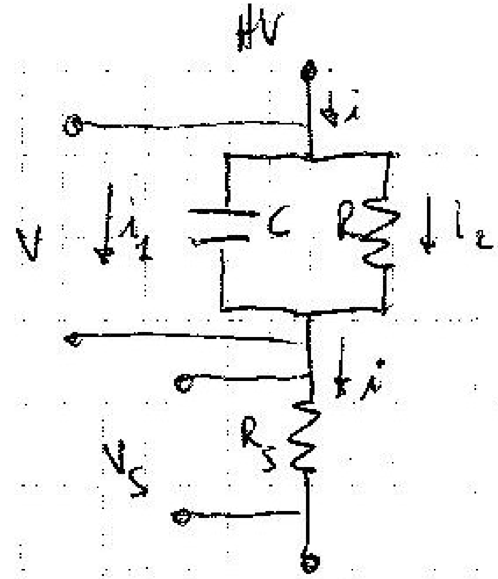

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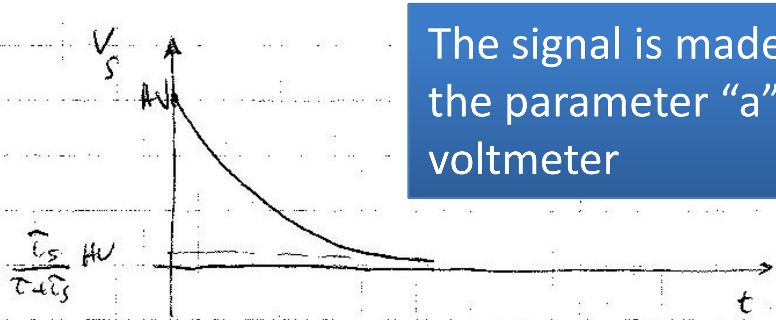
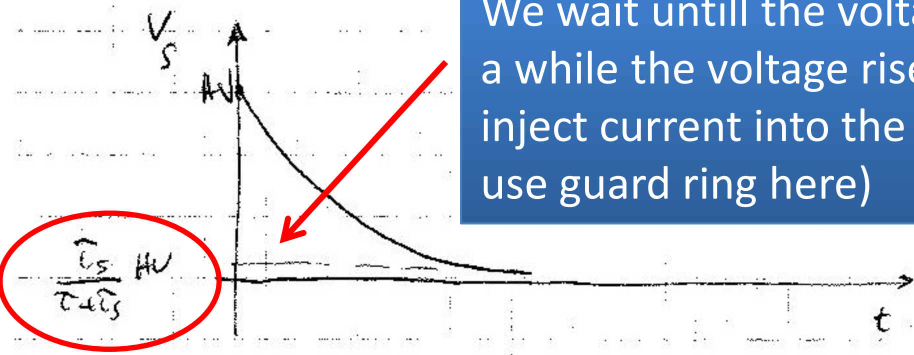
$$a = \frac{1}{\tau} + \frac{1}{\tau_S}$$



The signal is made by a transient part (dielectric polarization) ruled by the parameter “a” and a steady part which is what we read in the voltmeter

$$\boxed{V_s = HV - V(t) = HV - \frac{\tau}{\tau+\tau_s} HV \left(1 - e^{-\alpha t}\right) = \frac{\tau_s}{\tau+\tau_s} HV + \frac{\tau}{\tau+\tau_s} HV e^{-\alpha t}}$$

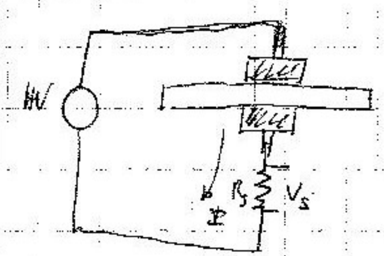


We wait untill the voltage becomes steady and we use that value (after a while the voltage rises again due to the adjacent cells that start to inject current into the system or to discharge the capacitor – we do not use guard ring here)

http://www.pv.infn.it/~vitulo/DSCN1707.MOV

$$\frac{\tau_s}{\tau+\tau_s} HV = V_s \qquad \frac{R_s C}{RC+R_s C} HV = V_s \qquad \frac{HV}{V_s} R_s = R + R_s$$

$$(*) \quad \boxed{R = \left(\frac{HV}{V_s} - 1\right) R_s} = \rho \frac{\ell}{S}$$



$$V_s = I R_s$$

$$I = \frac{HV}{R+R_s} \qquad V_s = \frac{HV}{R+R_s} \cdot R_s$$

$$R V_s + R_s V_s = HV R_s \Rightarrow R V_s = (HV - V_s) R_s \Rightarrow R = \frac{HV - V_s}{V_s} \cdot R_s$$

$$\Rightarrow (*) \quad \boxed{R = \left(\frac{HV}{V_s} - 1\right) \cdot R_s} \quad !$$

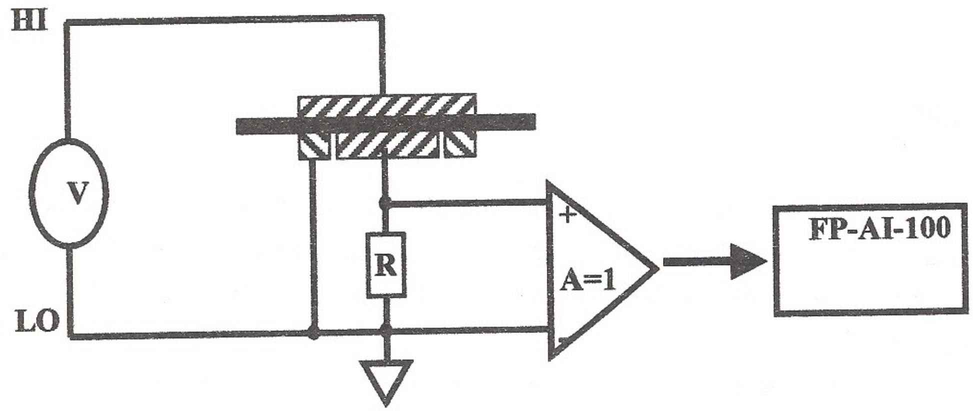
1) *<u>"Fixed" Instrument:</u>*

Automatic Resistivity System.

a) 9 points of measure on the panel

b) Electrodes made by conductive rubber (dry measurement)

9 x



Calibration:

Typically the resistivity is measured using a water soaked pad mounted on a piston. Our system uses a dry pad with safety ring and therefore a calibration is required to scale the values obtained to those of a water pad.
The calibration is performed on a small sample of HPL, whose resistivity is measured both with wet and with dry pad.
The ratio

$$A = \frac{< V_{H_2 0} >}{< V_i >} \times 1.17$$

is then calculated and used in the automated software to correct the results.
The factor 1.17 accounts for the different geometry of the two pads.

1) Measure of $<V_{H20}>$

Using the wet piston system, the voltage drop across the HPL is measured several times and the average is calculated.

2) Measure of $<V_i>$

A LABView software allows to measure the voltage drop on each of the nine dry pistons V_i.
The measure has to be performed using the same HPL sample used for the wet system under piston *i*, and using other eight spare HPL plates for the other pistons.
After one measurement the sample is moved to another piston until all of them are measured.
The average $<Vi>$ is used to calculate **A**. Furthermore the ratio $\sigma[V_i]/<V_i>$ provides an idea of the error in the measurement of a full plate: tipically such ratio is comprised between 10% and 15%.

Temperature

For our purposes the range of values is 1-6x10^{10} Ωcm.
Resistivity is usually done at T=20 °C, so if a measure has to be performed at T_{amb}, a formula can be used to correct it:

$$\frac{\rho_{20}}{\rho_{T\,amb}} = e^{\alpha(T_{amb}-20)}$$

Where **α** is a function of the percentual humidity H%.

The software automatically measures and saves T_{amb}, however it is recommended to measure the temperature on the plate, since typically the HPL has a higher termical capacitance.
The difference between ambience and plate can be inserted in the formula through the **DTc** value. DTc= T_{amb}-T_{plate}

The value of α can be obtained from a table