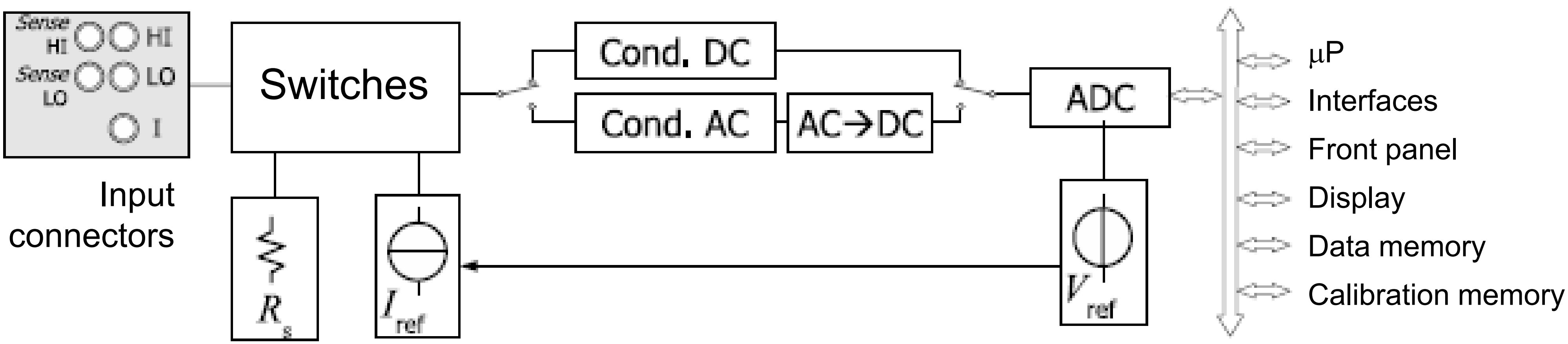
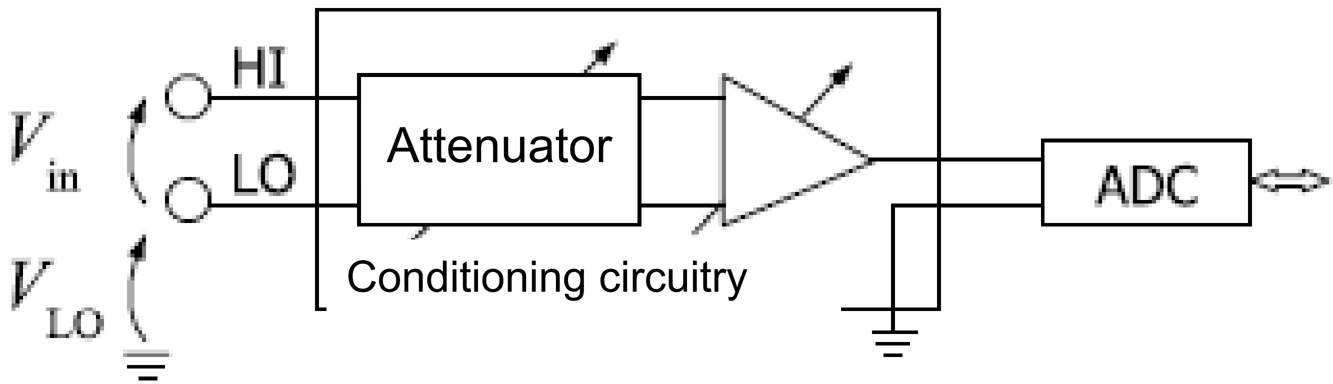
Digital Multi Meter
(DMM)

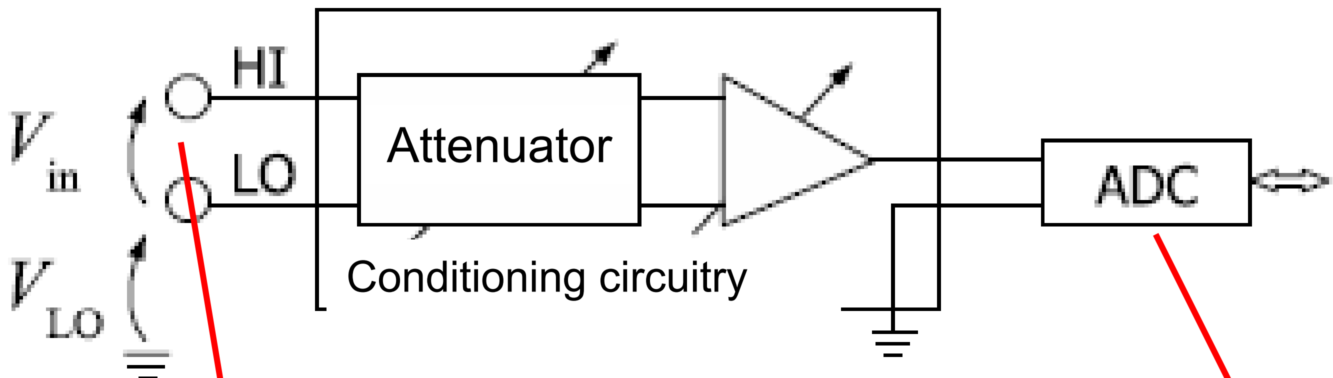
DMM – Block scheme



DMM – DCV section



DMM – DCV section



Measurement range up to 1 kV

Multi-range capability

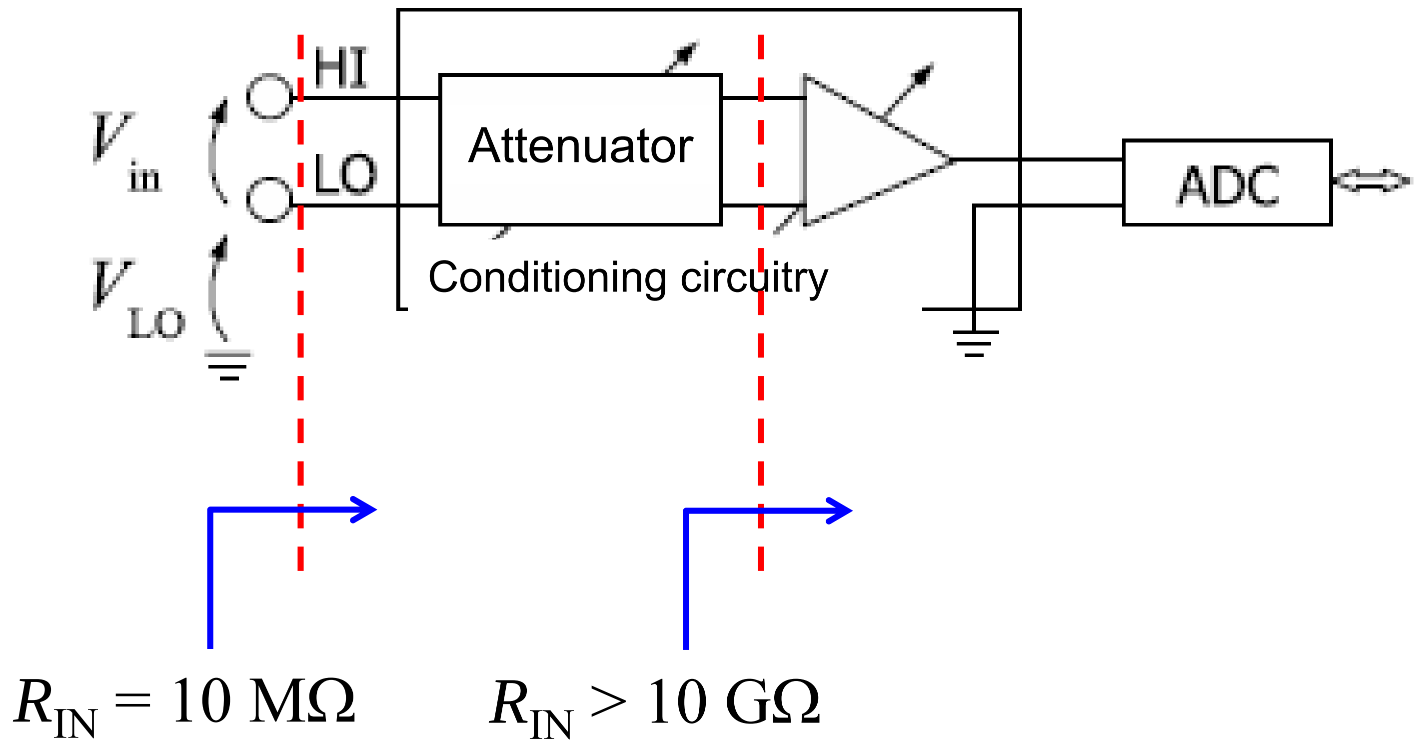
Example:

± 50 mV, ± 500 mV, ± 5 V, ± 50 V, ± 500 V, ± 1000 V

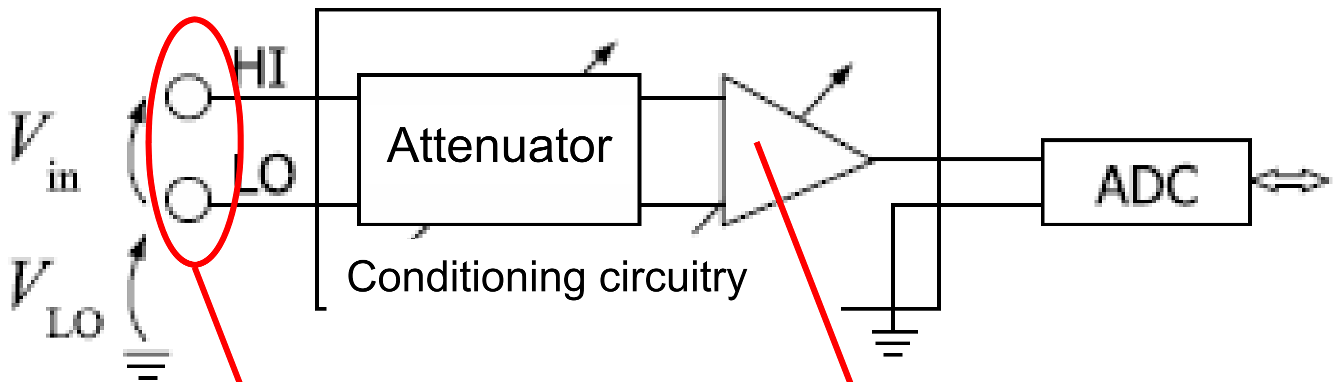
Bipolar measurement range not greater than 10 V

Example: ± 5 V

DMM – DCV section



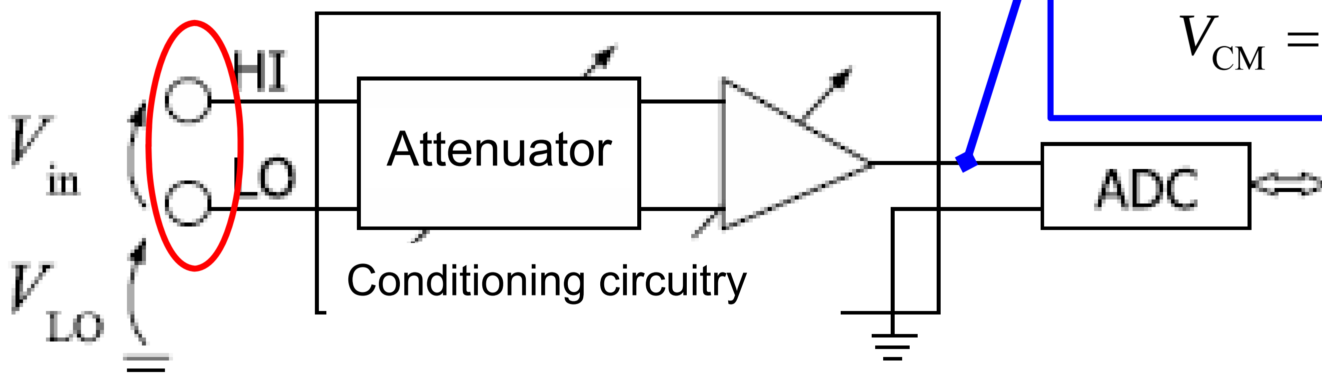
DMM – DCV section



Differential amplifier

Measurement of voltages not referred to ground (low sensitivity to the voltage V_{LO})

DMM – DCV section



$$V_{out} = A_D \cdot V_{in} + A_{CM} \cdot V_{CM}$$

$$V_{in} = V_{HI} - V_{LO}$$

$$V_{CM} = \frac{V_{HI} + V_{LO}}{2}$$

Common-Mode Rejection Ratio

$$CMRR = 20 \cdot \log_{10}\left(\frac{A_D}{A_{CM}}\right)$$

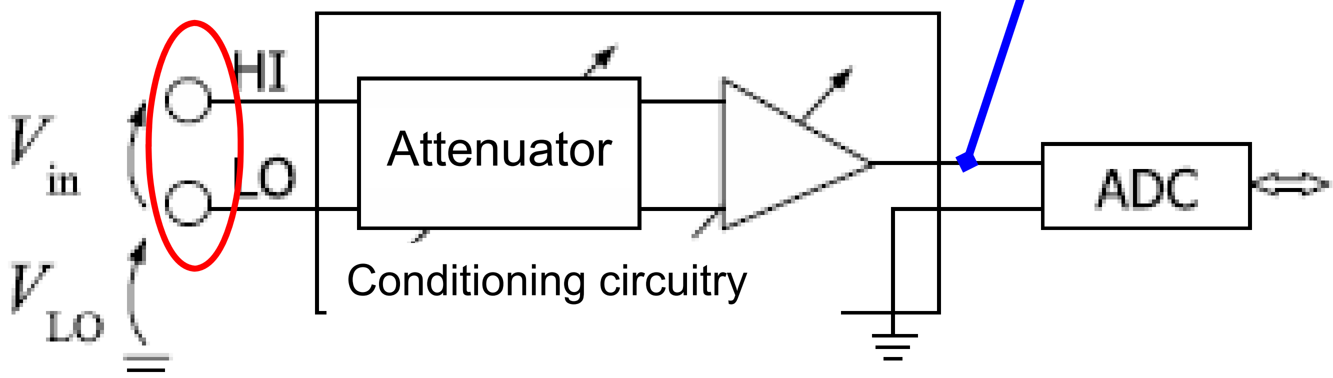
A_D: Differential gain

A_{CM}: Common-mode gain

Ideal amplifier A_{CM} = 0 ⇨ $CMRR$ = ∞

DMM – DCV section

$$V_{out} = A_D \cdot V_{in} + A_{CM} \cdot V_{CM}$$



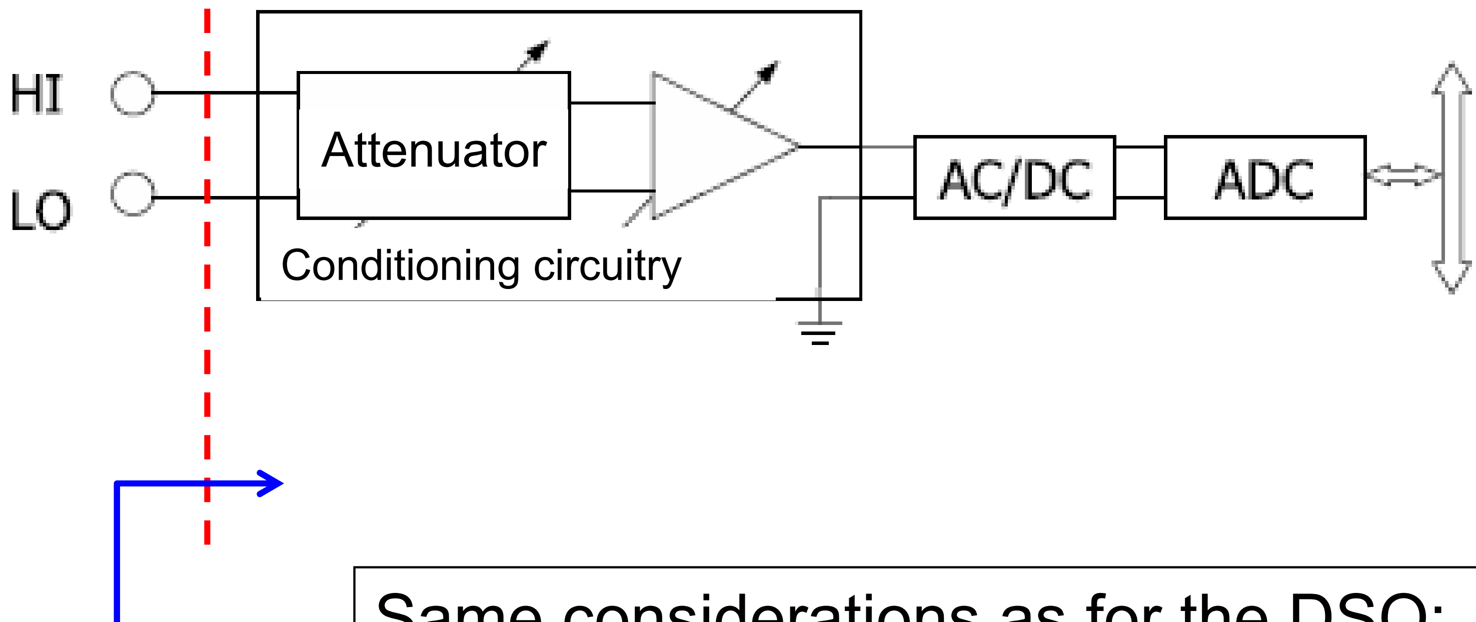
$$CMRR = 20 \cdot \log_{10}\left(\frac{A_D}{A_{CM}}\right)$$

For a real amplifier A_{CM} > 0, then the DMM provides an indication $L_{CM} \neq 0$ event though V_{IN} = 0

Example: $CMRR$ = 100 dB; V_{HI} = 100 V; V_{LO} = 99 V; A_d = 1

$$\Rightarrow \quad V_{out,V_{in}} = 1\text{ V}; \quad V_{out,V_{CM}} = V_{CM} \cdot 10^{\left(-\frac{CMRR}{20}\right)} = 0.995\text{ mV}$$

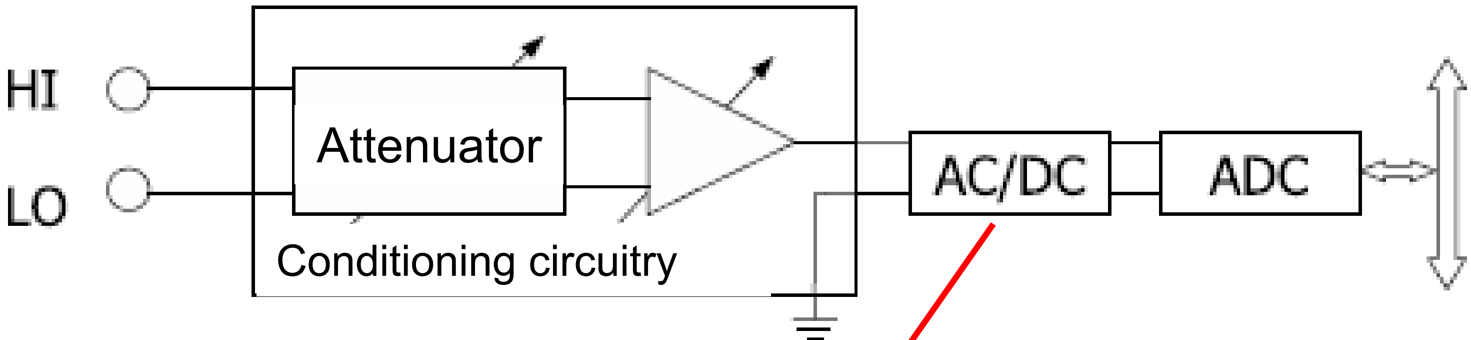
DMM – ACV section



$$Z_{IN} = R_{IN} // C_{IN}$$

Same considerations as for the DSO:
load effect dependent on the frequency of the input signal

DMM – ACV section



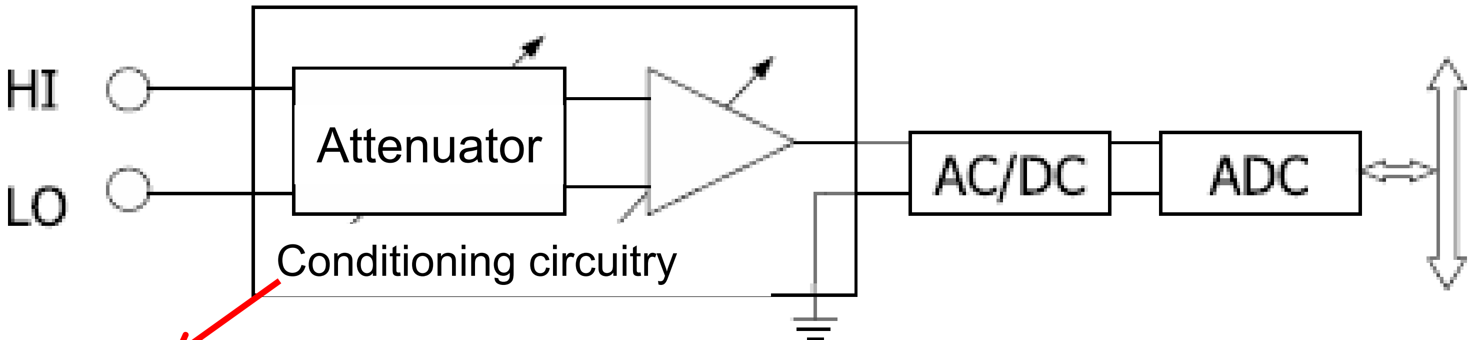
True rms AC/DC converter

- It converts the input signal into a DC voltage that is equal to the rms value of the input signal, **regardless of its waveform**

Influence quantity: crest factor of the input signal

- $$\frac{V_{pk}}{V_{rms}}$$

DMM – **ACV** section



Usually AC coupled

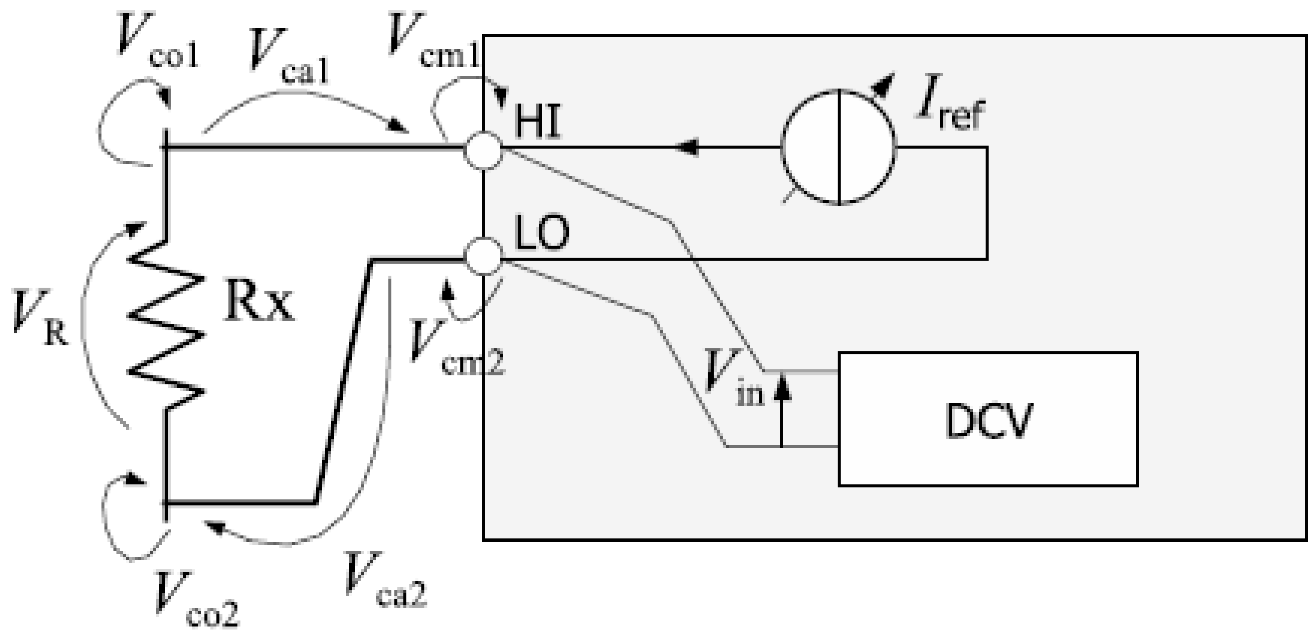
If $v_{in}(t) = V_{DC} + v_{AC}(t)$ → only the rms value of the AC component is measured

Remember that $V_{rms} = \sqrt{V_{DC}^2 + V_{rms,AC}^2}$

CMRR for AC signal worse than the CMRR for DC signal

DMM – **OHM (2 wire)** section

Measurement based on the volt-ammeter method

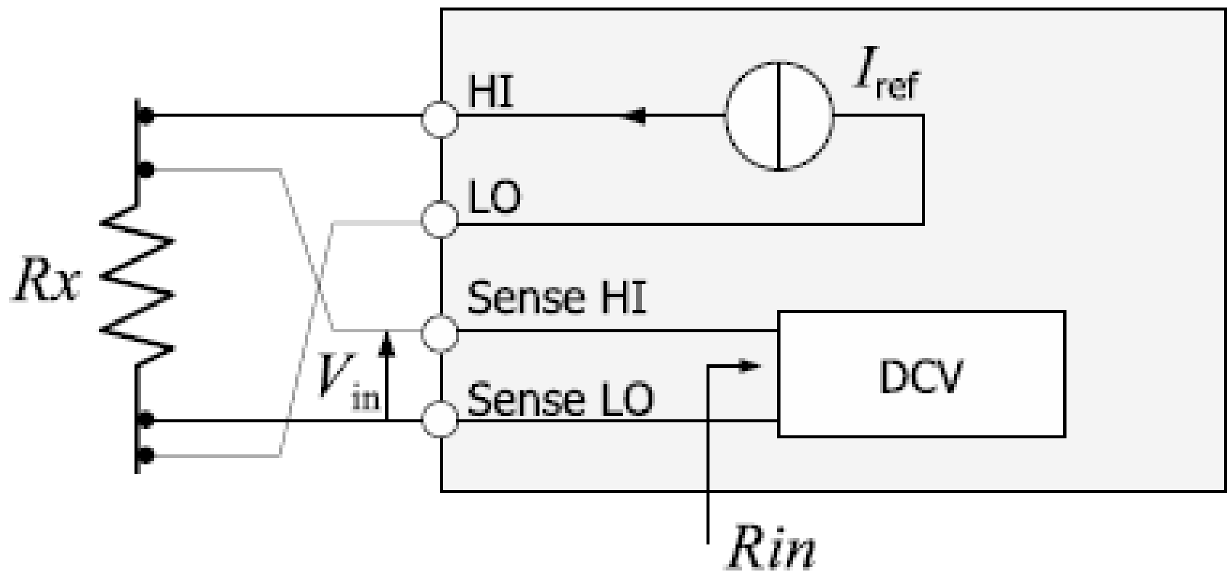


$$R_m = \frac{V_{in}}{I_{ref}} = R_x + R_{con} + R_{wire}$$

Systematic error due to cable and contact resistances

DMM – OHM (4 wire) section

Not always available



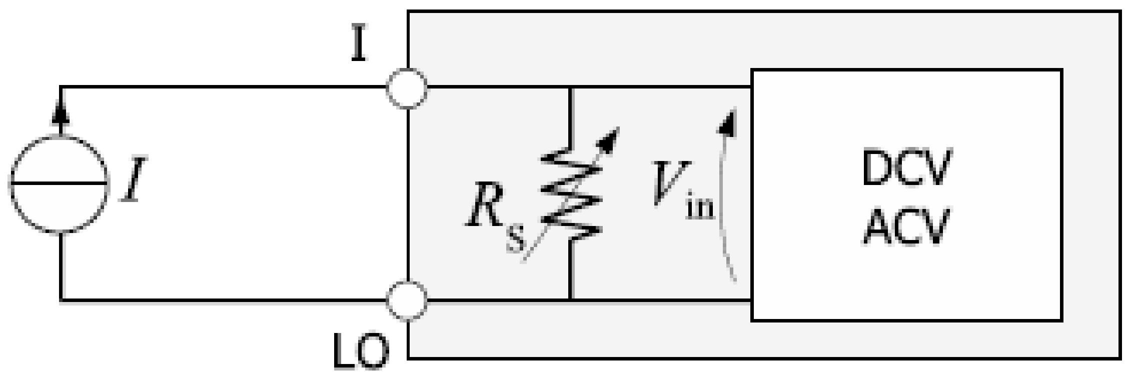
$$R_m = \frac{V_{in}}{I_{ref}}$$

$$\varepsilon_{R_m} = -\frac{R_x}{R_x + R_{in}}$$

Relative systematic error due to the input resistance of the DCV section

DMM – **DCI** and **ACI** sections

Current under measurement converted into voltage by means of internal shunts R_S



$$\boxed{I_m = \frac{V_{in}}{R_S}}$$