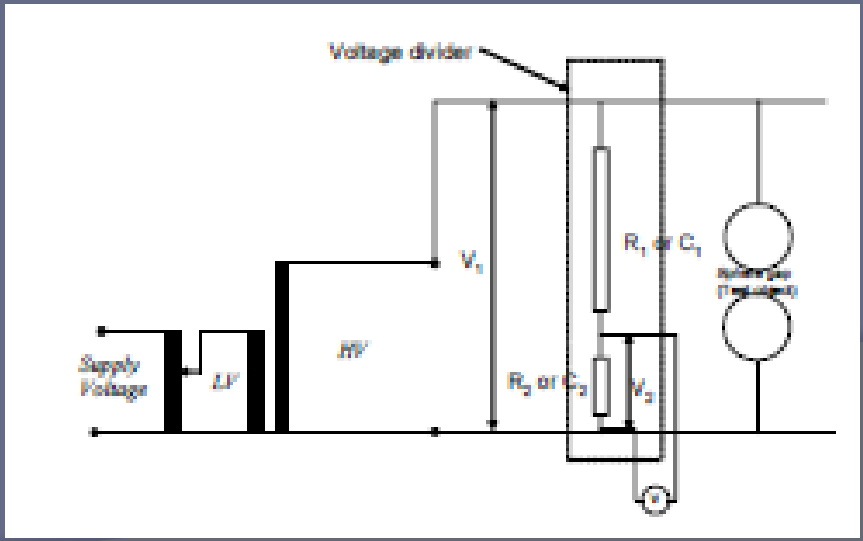
MEASUREMENT OF HV AND HC

Dr.-Ing. Getachew Biru

H.V Test Device

Typical AC test transformer and its connections

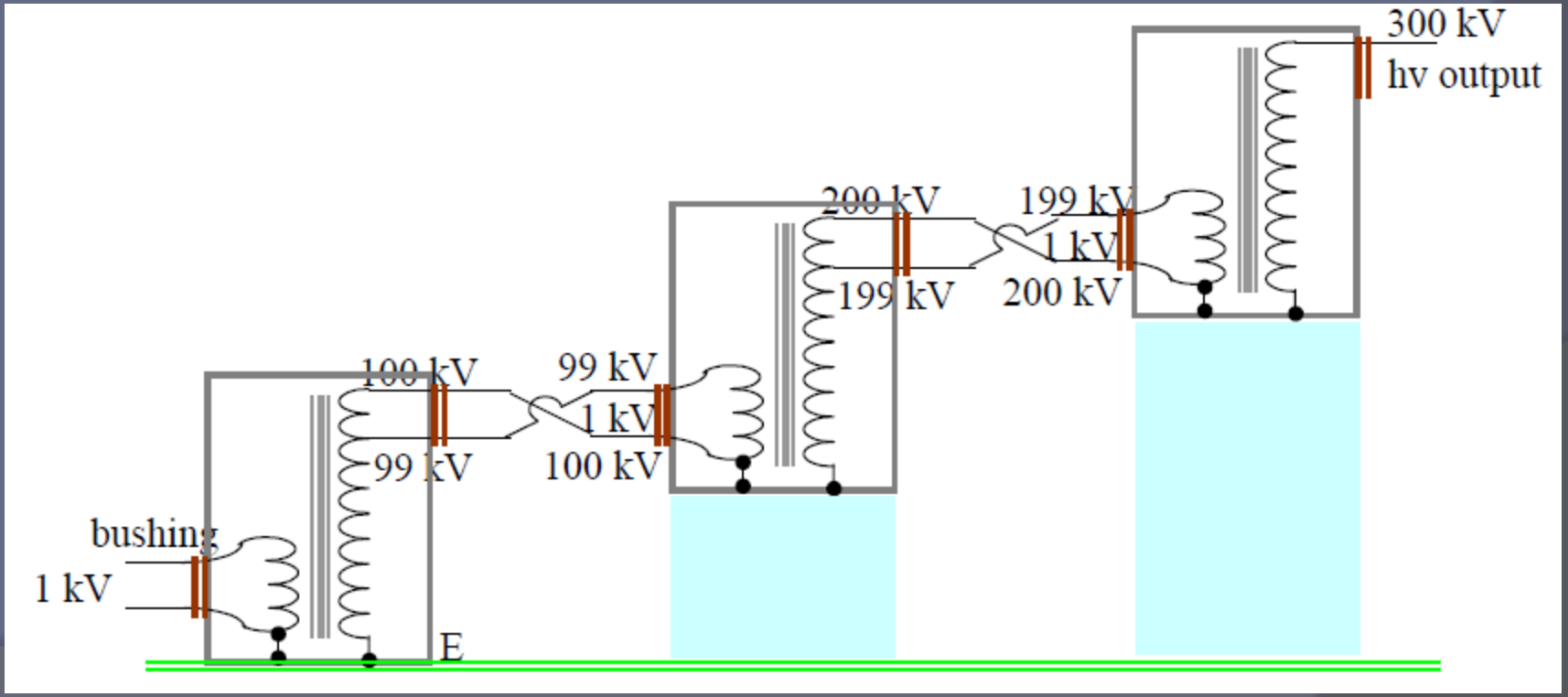
- Since flashover usually takes place at the peak of the AC wave, it is necessary to measure the peak and not the rms voltage (the voltage may deviate from a pure sinusoid).



H.V Test Device

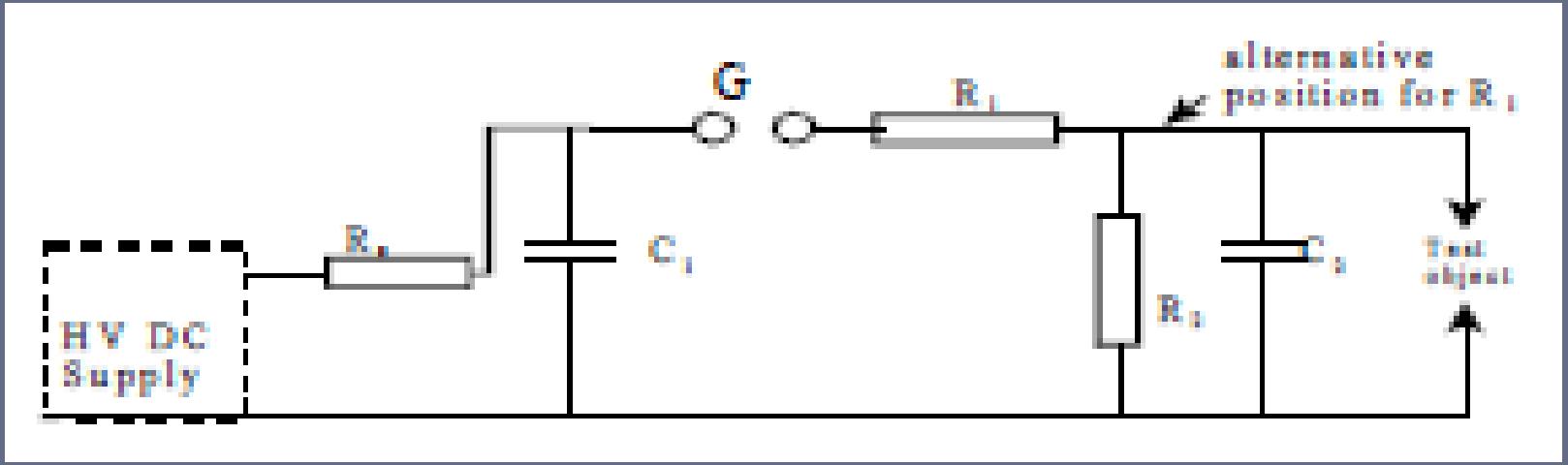
Cascaded Transformer

Aa typical cascade arrangement of transformers used to obtain up to 300 kV is shown.



H.V Test Device

The Impulse generator



Measurement of HV and Currents

INTRODUCTION

- The high voltage equipments have large stray capacitances with respect to the grounded structures and hence large voltage gradients are set up.
- A person handling these equipments and the measuring devices must be protected against these over voltages.
- Electromagnetic fields create problems in the measurements of impulse voltages and currents and should be minimized.

Measurement of HV and Currents

SPHERE GAP

- In the measuring device, two metal spheres are used, separated by a gas-gap.
- Sphere gap is by now considered as one of the standard methods for the measurement of peak value of d.c., a.c. and impulse voltages.
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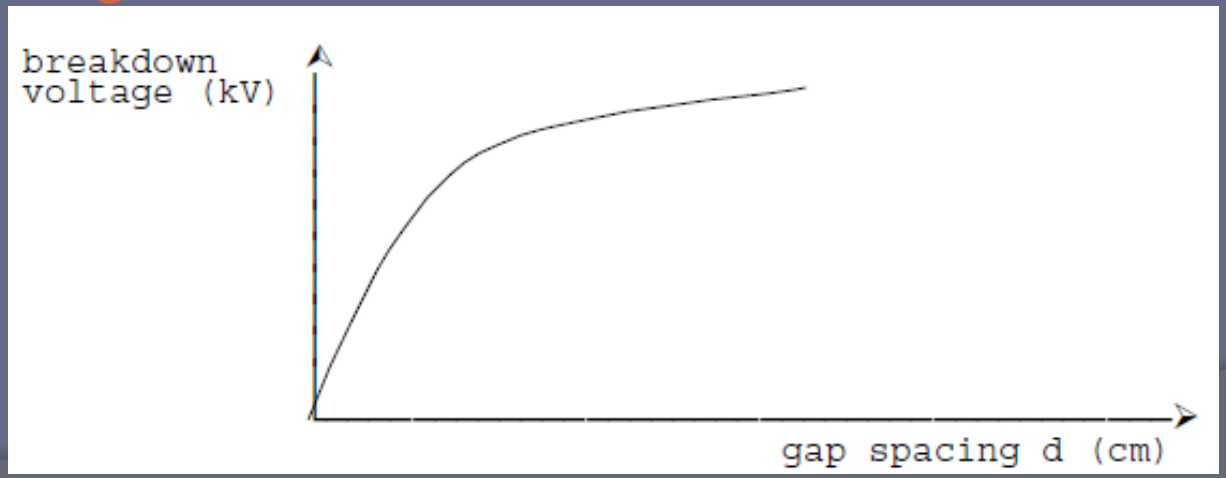
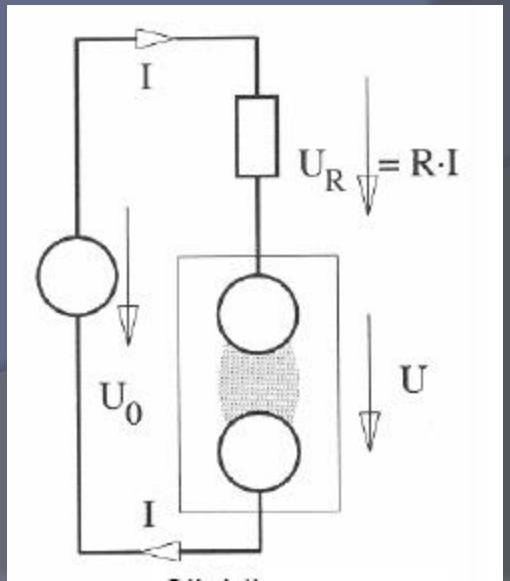




Measurement of HV and Currents

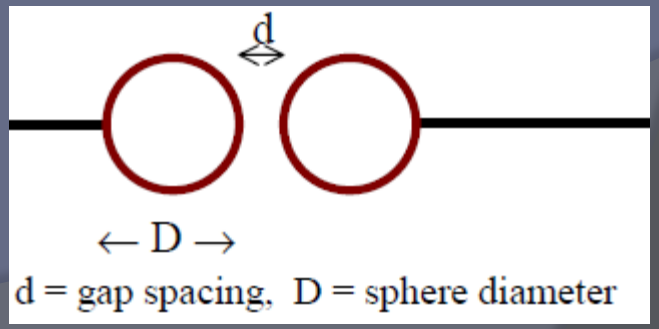
SPHERE GAP

- The breakdown voltage at normal atmospheric condition between the electrodes separated by a distance d in cm.

$$V = A \cdot d + B \cdot \sqrt{d}$$

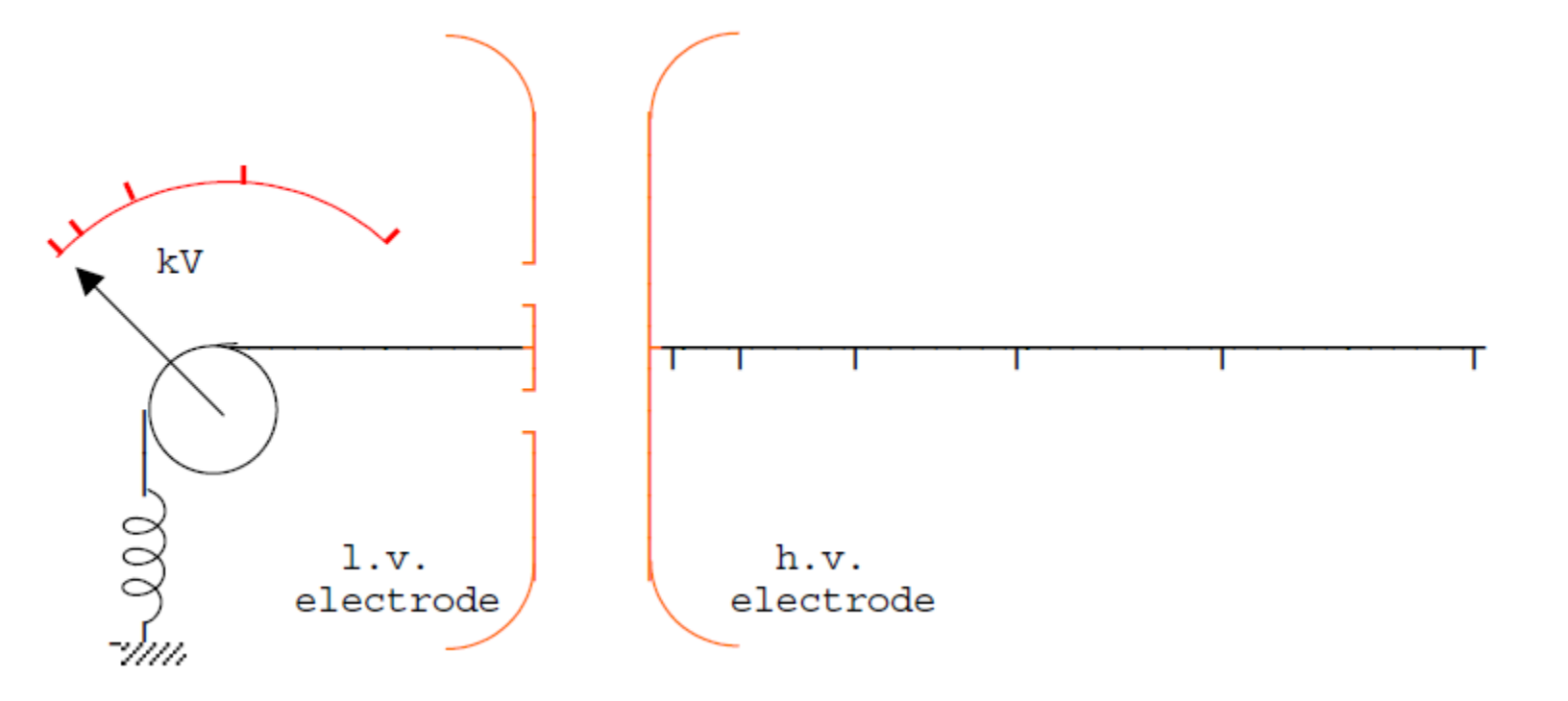
- $V_b = 24.4\ d + 6.29\sqrt{d}$ kV
- For air, under normal conditions, A = 24.4 kV/cm and B = $(6.29\ \text{kV/cm})^{1/2}$.

d	< 0.5 D,	accuracy = ± 3 %
0.75 D > d	> 0.5 D,	accuracy = ± 5 %



Measurement of HV and Currents

Electrostatic Voltmeter



Measurement of HV and Currents

Electrostatic Voltmeter

- Whenever a voltage is applied to a parallel plate electrode arrangement, an electric field is set up between the plates.
- It is possible to have uniform electric field between the plates with suitable arrangement of the plates.
- If A is the area of the plate and E is the electric field intensity between the plates ε the permittivity of the medium between the plates, the energy density of the electric field between the plates is given as,

$$W_d = \frac{1}{2} \varepsilon E^2$$

Measurement of HV and Currents

Electrostatic Voltmeter

- Consider a differential volume between the plates and parallel to the plates with area *A* and thickness *dx*, the energy content in this differential volume *Adx* is:

$$dW = W_d A dx = \frac{1}{2} \varepsilon E^2 A dx$$

- Now force *F* between the plates is defined as the derivative of stored electric energy along the field direction *i.e.,*

$$F = \frac{dW}{dx} = \frac{1}{2} \varepsilon E^2 A$$

Measurement of HV and Currents

Electrostatic Voltmeter

- Now $E = V/d$ where V is the voltage to be measured and d the distance of separation between the plates.
- Therefore, the expression for force

$$F = \frac{1}{2}\varepsilon\frac{V^2 A}{d^2}$$

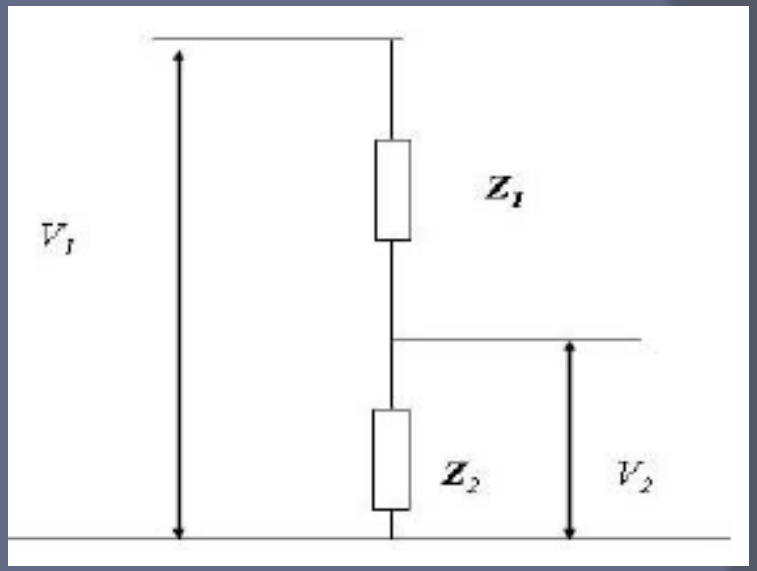
- Electrostatic voltmeters measure the force based on the above equations and are arranged such that one of the plates is rigidly fixed whereas the other is allowed to move.
- As the force is proportional to square of *V*rms, the meter can be used both for a.c. and d.c. voltage measurement.

Measurement

Voltage dividers

- In this equation $Z_2 << Z_1$, resulting in V_2 being a scaled version of V_1. The nature of Z_1 and Z_2 depends on the type of voltage to be measured, as is shown in Table

$$V_2 = \frac{Z_2}{Z_1 + Z_2} V_1$$

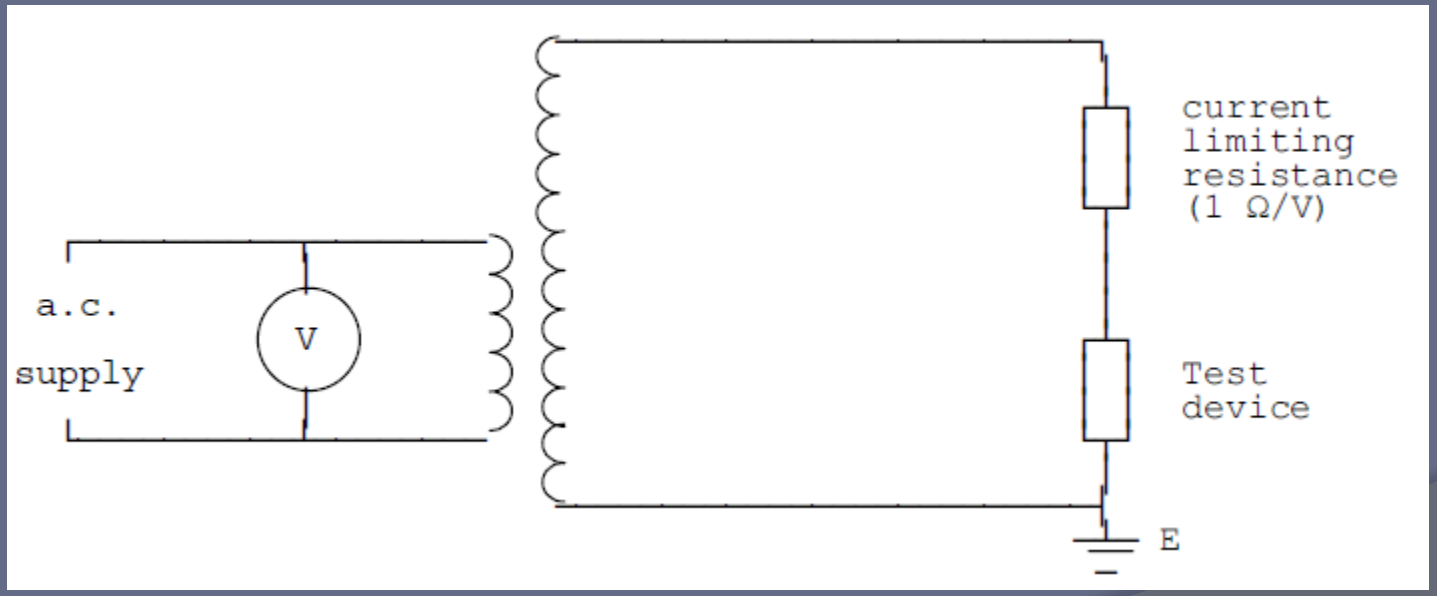


Type of voltage	Nature of the impedances
DC	Resistors
AC	Resistors or Capacitors
Impulse	Resistors or Capacitors

H.V Measurement

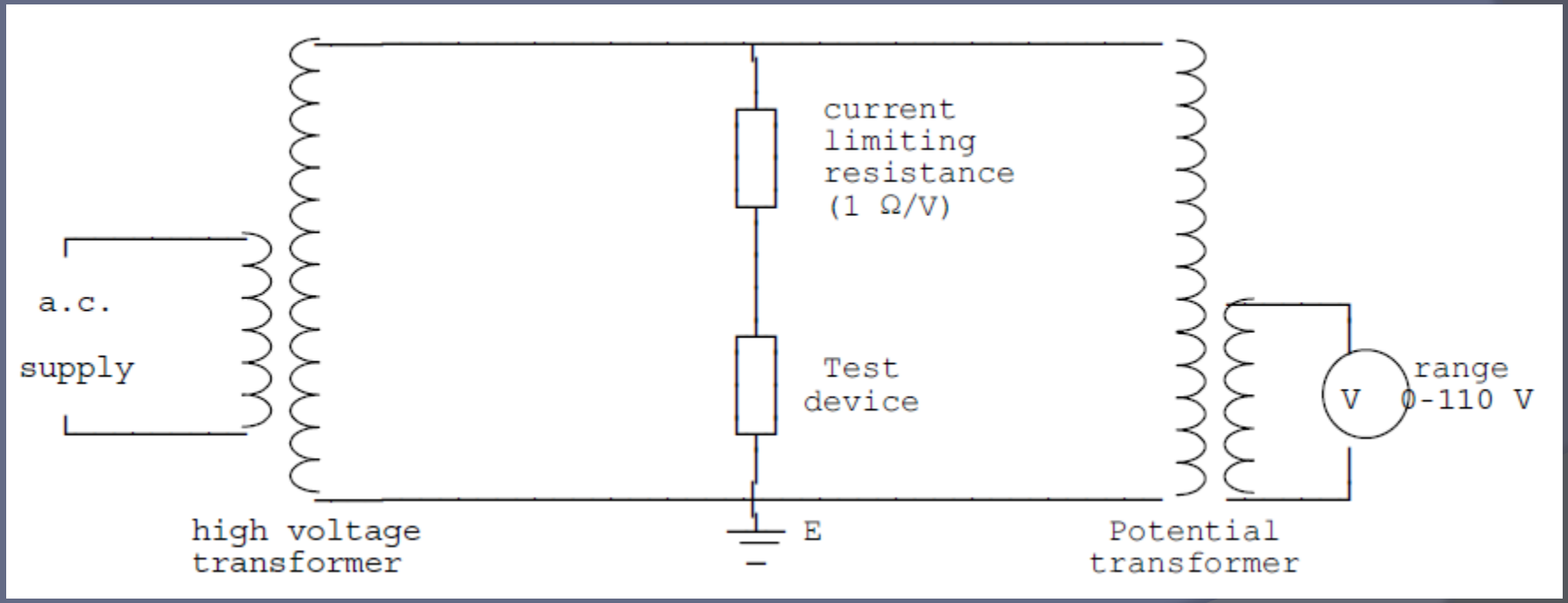
Transformer ratio method

- The voltage on the low voltage side of the high-tension transformer is measured.



H.V Measurement

With PT

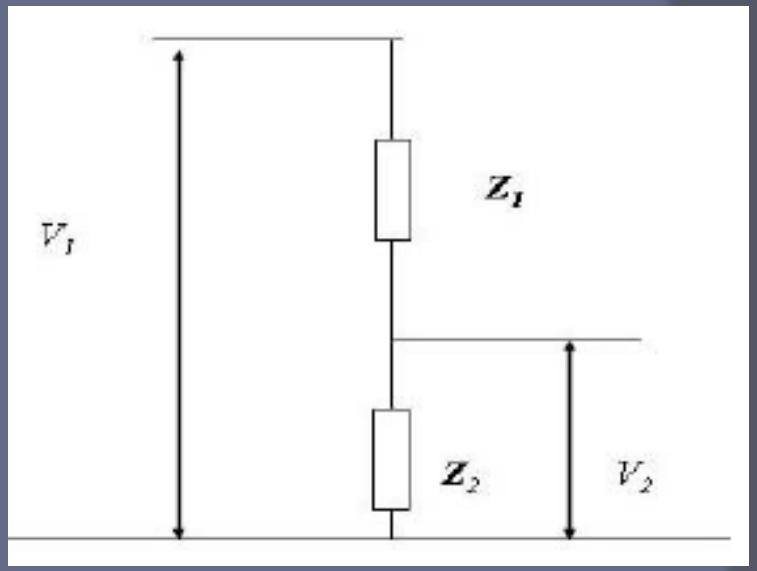


Measurement

Potential divider method

- In this equation $Z_2 << Z_1$, resulting in V_2 being a scaled version of V_1. The nature of Z_1 and Z_2 depends on the type of voltage to be measured, as is shown in Table

$$V_2 = \frac{Z_2}{Z_1 + Z_2} V_1$$

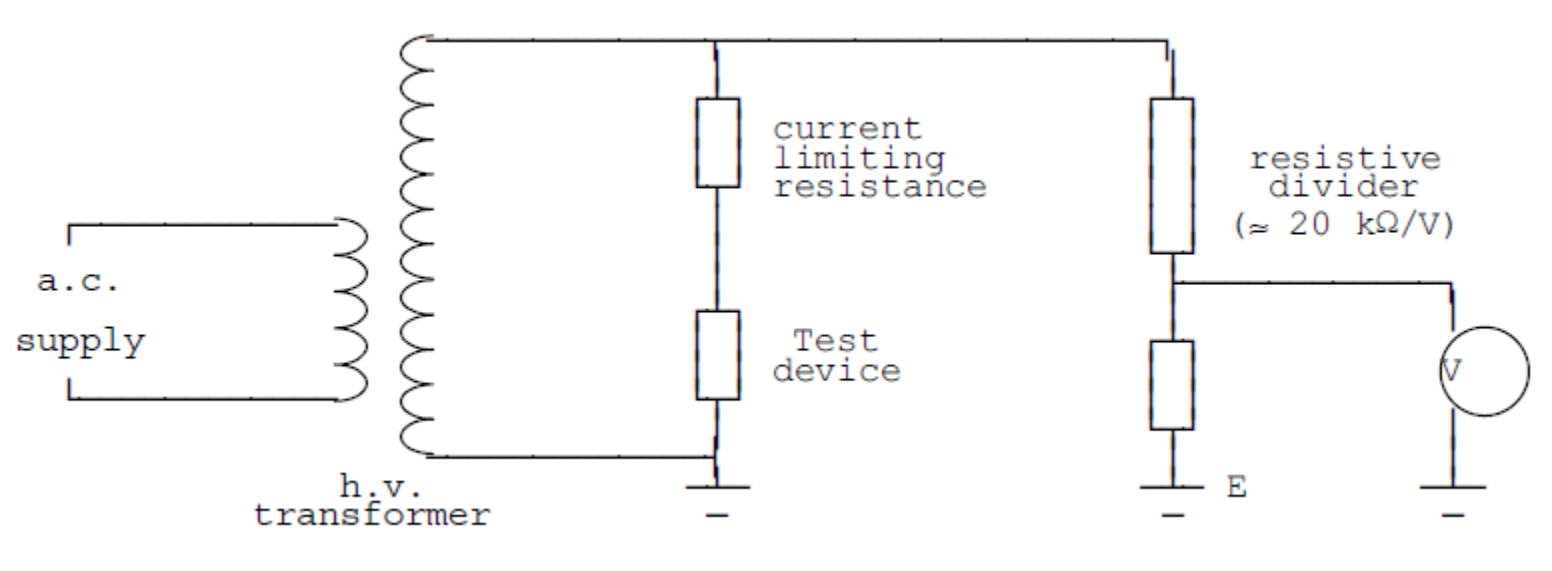


Type of voltage	Nature of the impedances
DC	Resistors
AC	Resistors or Capacitors
Impulse	Resistors or Capacitors

Measurement

Potential divider method

$$V_2 = \frac{R_2}{R_1 + R_2} V_1$$

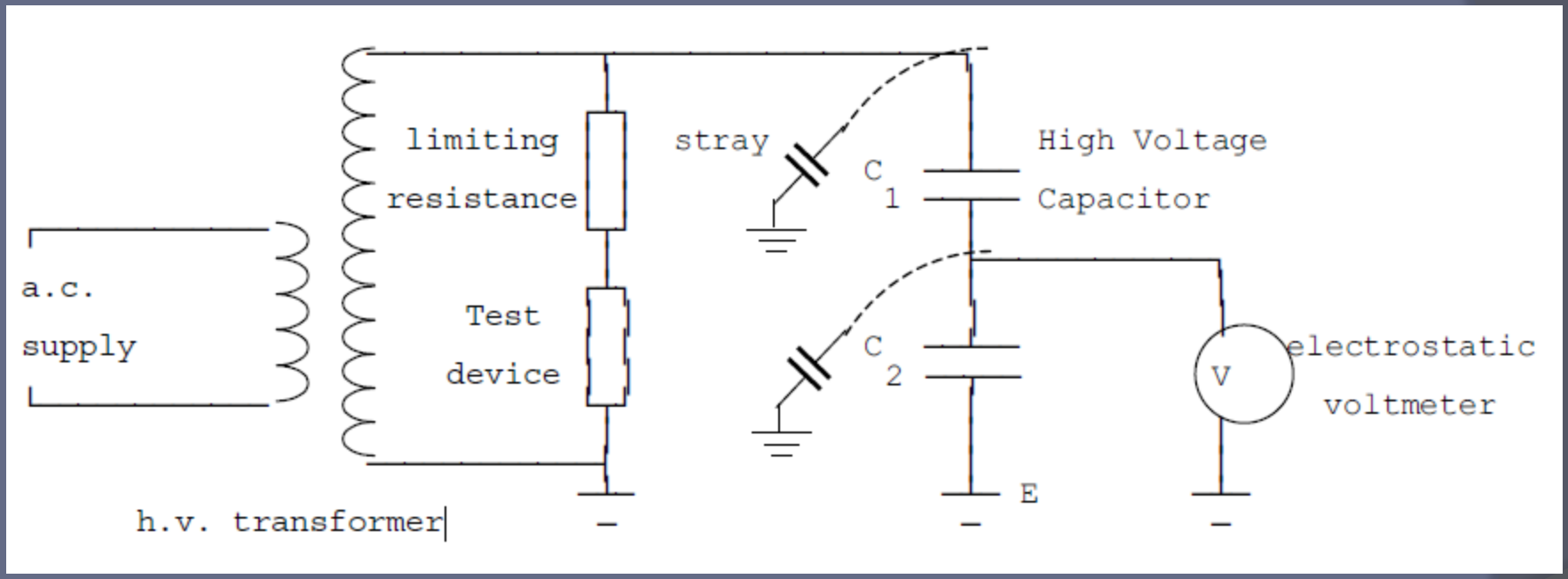


In this method, a high resistance potential divider is connected across the high-voltage winding, and a definite fraction of the total voltage is measured by means of a low voltage voltmeter.

Measurement

Potential divider method

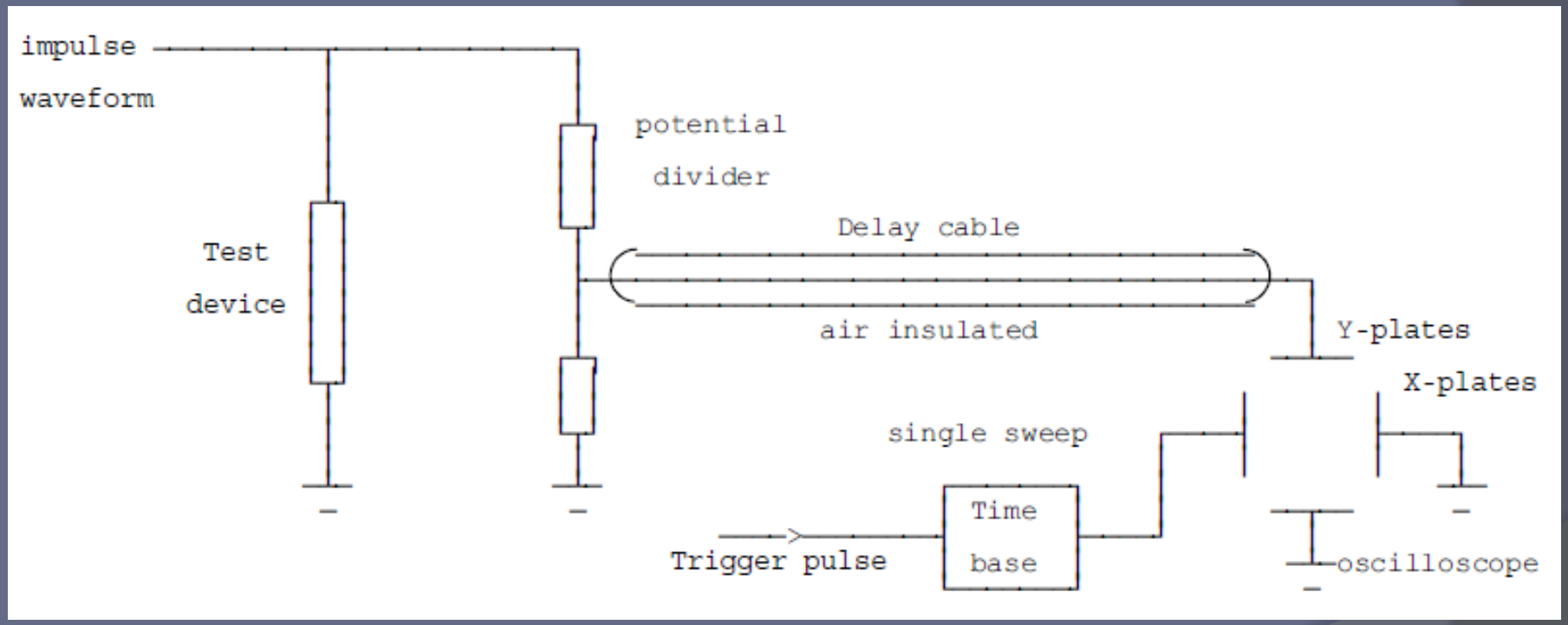
$$V_2 = \frac{C_1}{C_1 + C_2} V_1$$



For AC, instead of using a resistive potential divider, we could use a capacitive potential divider. In this two capacitances C1 and C2 are used in series, the electrostatic voltmeter being connected across the lower capacitor.

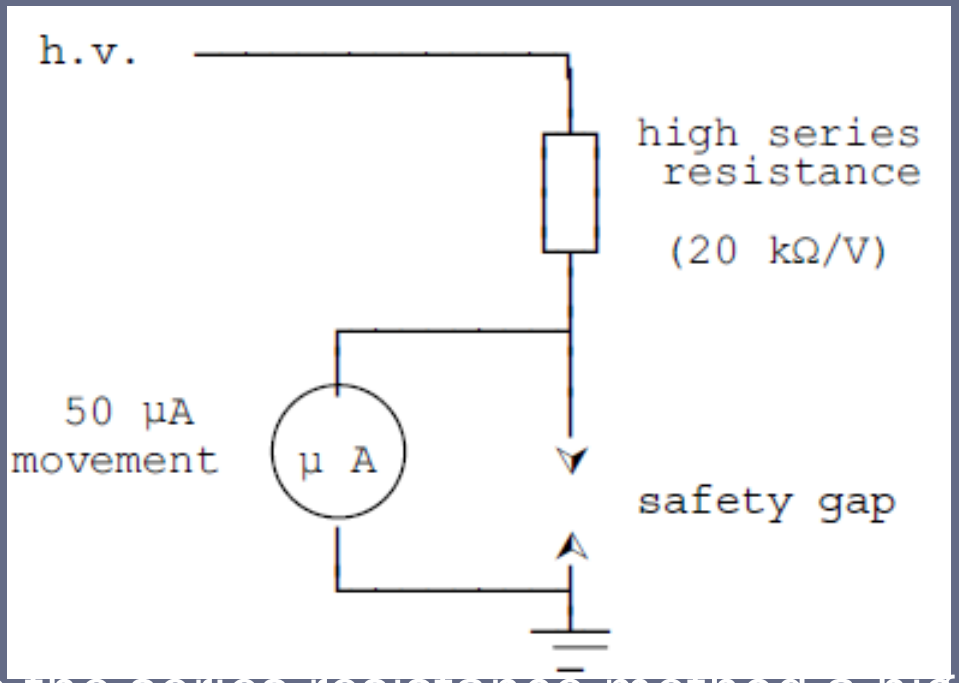
Measurement

Observation of wave shapes



H.V Measurement

Series resistance method of measurement



- In the series resistance method a high series resistance (specially designed to withstand high voltage) of 20 k Ω/V - is used.
- The method is applicable for both ac and dc.