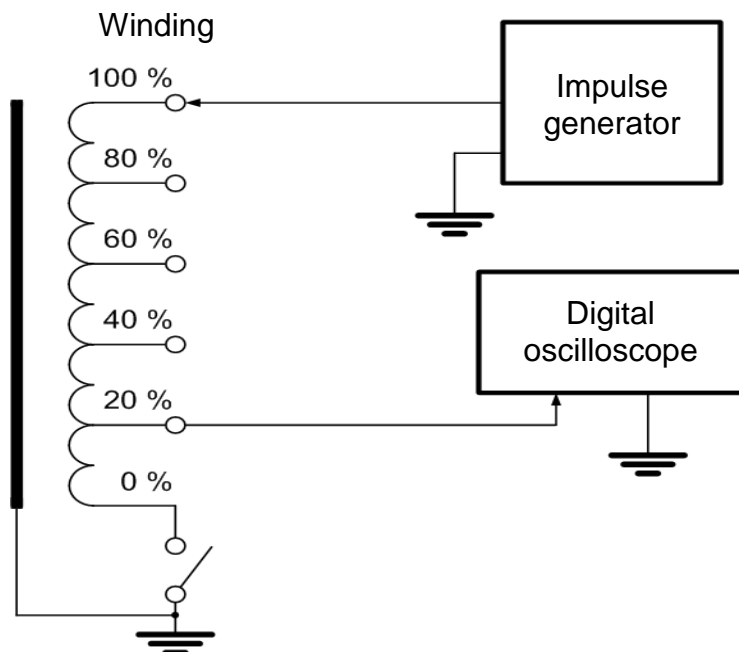# Task 10: Voltage Distribution Along Transformer Winding
(Laboratory F1-13, main lab)

Determine initial voltage distribution along physical model of transformer winding when the lightning impulse is applied to the input terminal of winding. This measurement should be performed for the case when the end terminal of winding is grounded and for the case when this terminal is open. Compare the measured voltage distribution with theoretical results and determine the winding factor γ.

Measurement procedure:

a) Connect the circuit according to the instruction.
b) Measure the voltage waveform on each winding terminals by digital scope. Read the voltage value from all recorded waveforms for the same time (the time of peak value of input impulse).
c) Evaluate the initial voltage distribution on winding from determined values on winding terminals.
d) Compare the measured initial voltage distribution with the theoretical initial voltage distribution and determine the winding factor γ.

Measurement circuit:

Theoretical calculation of initial voltage distribution:

An equivalent circuit of a transformer winding is composed of inductances and turn to ground capacities and interturn capacities. If the voltage impulse is applied to the winding input terminal, only capacitances are employed.

Initial voltage distribution **along the winding with grounded end** can be expressed as:

$$u_0 = \frac{\boldsymbol{sinh}\,\gamma(\mathrm{d}-\mathrm{x})}{\boldsymbol{sinh}\,\gamma\cdot\mathrm{d}}\,, \qquad\qquad \text{where } \gamma = \sqrt{\frac{C}{K}}$$

Initial voltage distribution **on the winding with open end** can be expressed as:

$$u_0 = \frac{\boldsymbol{cosh}\,\gamma(\mathrm{d}-\mathrm{x})}{\boldsymbol{cosh}\,\gamma\cdot\mathrm{d}}\,, \qquad\qquad \text{where } \gamma = \sqrt{\frac{C}{K}}$$

and for final voltage distribution: $u_k = u_0$

>   d ... length of the winding
>   x ... distance of determined point on the winding
>   C ... transverse capacitance of the winding
>   K ... longitudinal capacitance of the winding

Example of the initial voltage distribution on a winding for grounded end (on the left) and ungrounded end (on the right) for winding factor $\gamma = 0{,}01$ to 5