DR. GYURCSEK ISTVÁN

Classic Electrical Measurements 4

Potentiometers and Comparators

Sources and additional materials (recommended)

- *S. Tumanski:Principles of electrical measurement, CRC Press 2006. ISBN 0-7503-1038-3*
- *Máté J.: Méréstechnika 1. PTE PMMIK, ERFP-DD2001-HU-B-01*
- *http://gyurcsekportal.hu/mik.html*

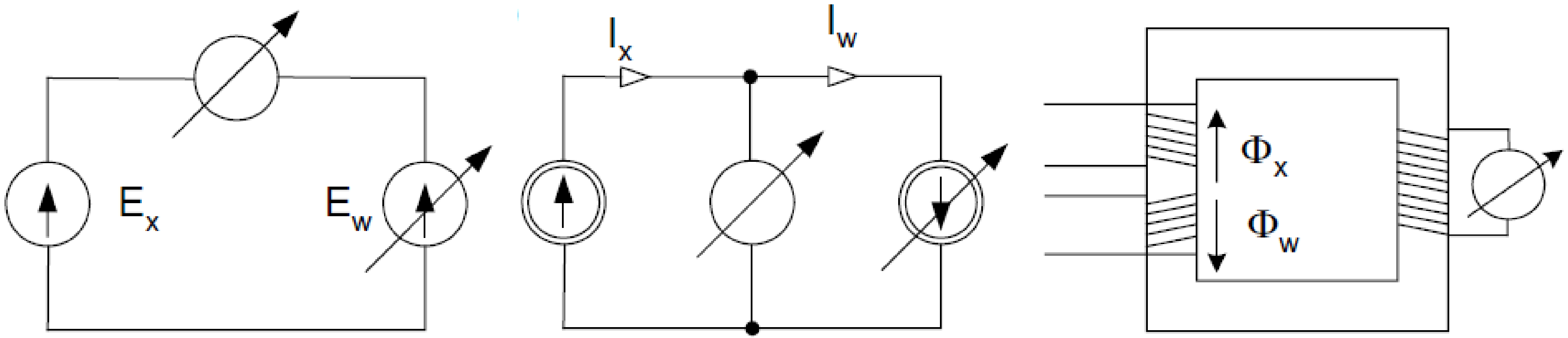
Progress in Content

- **Principle of Compensation**
- DC Compensators
- AC Compensators
- Practical Examples

Electric Compensation Principle

- Neutralization of two voltages (currents, magnetic fluxes, etc.)
- Balance conditions

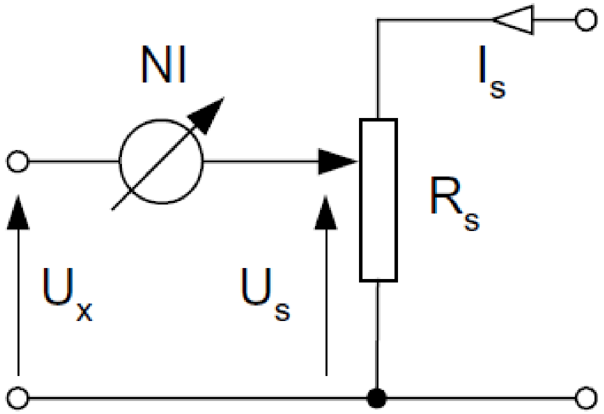
$E_X = E_W$ $\quad$ $I_X = I_W$ $\quad$ $\Phi_X = \Phi_W$



Compensation 2

Potentiometers (manual balancing)

- ❑ Compensation of two voltages
- ❑ For years - most accurate DEV for determ. U (directly) and I, R (indirectly)
- ❑ Nowadays - substituted by DVM (compensation principle used internal)



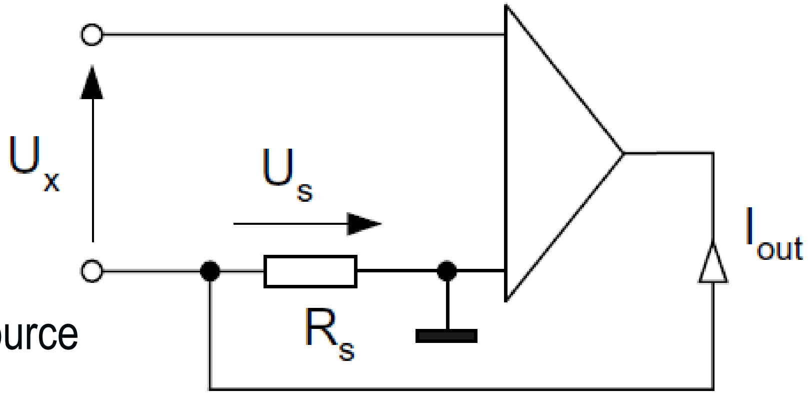
$$U_X = U_s = a \cdot R_S \cdot I_S$$

$$a = (0 \ldots 1)$$

- ❑ Accurate measurement!
- ❑ Truly non-invasive way
- ❑ No energy from the tested source
- ❑ Infinite input impedance

Electronic feedback (automatic balancing)

$$U_X = U_s = I_{out} \cdot R_S$$



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- ❑ **DC Compensators**
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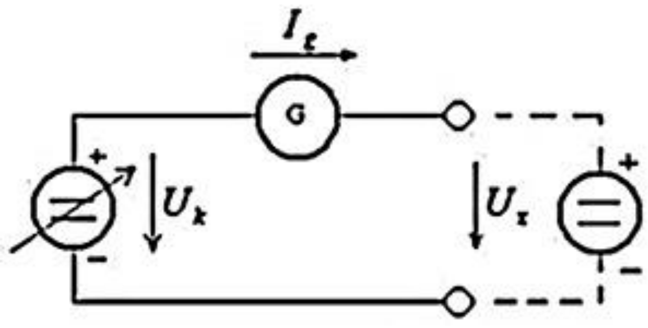
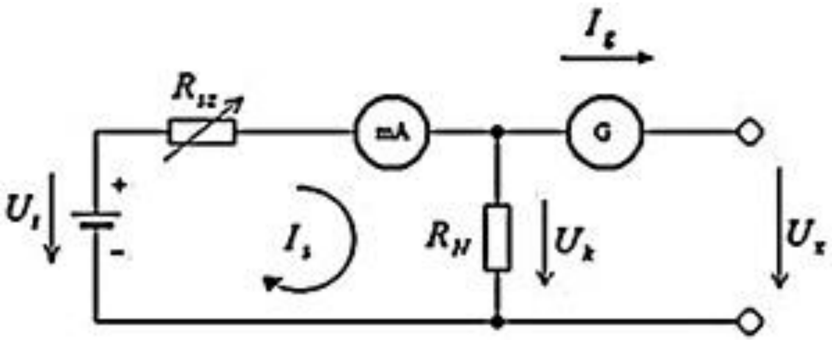
Principle of operation



$$U_x = U_k \rightarrow I_g = 0$$

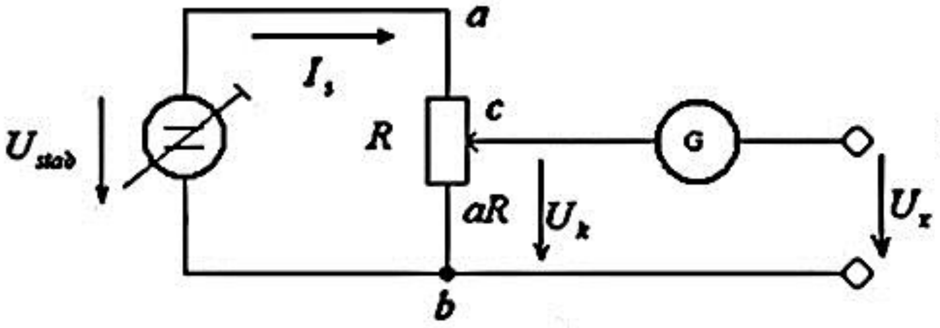
Adjustable auxiliar PWR



$$U_x = U_k = I_s R_N$$

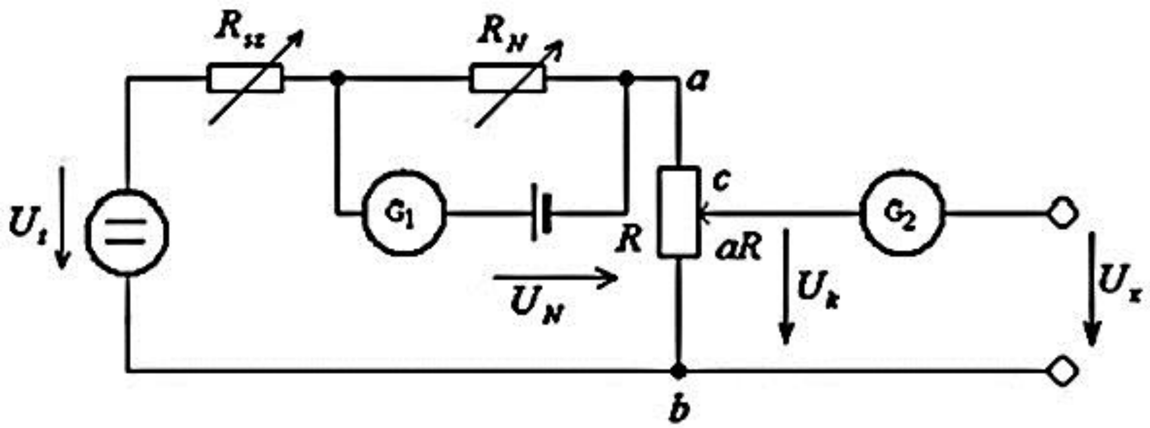
DC Compensators 2

Constant auxiliar PWR



$$I_s = \frac{U_{stab}}{R} = konst.$$

Constant auxiliar PWR (modified)



- Comp.1 - balance G_1 *(U_N – Weston norm. source)*

$$R_N = \frac{U_N}{I_s} = \frac{1{,}01865V}{1mA} = 1018{,}65\Omega$$

- Comp.2 - balance G_2

$$U_x = U_k, U_k = I_s aR = \frac{U_N}{R_N} aR \rightarrow U_x = \frac{U_N}{R_N} aR$$

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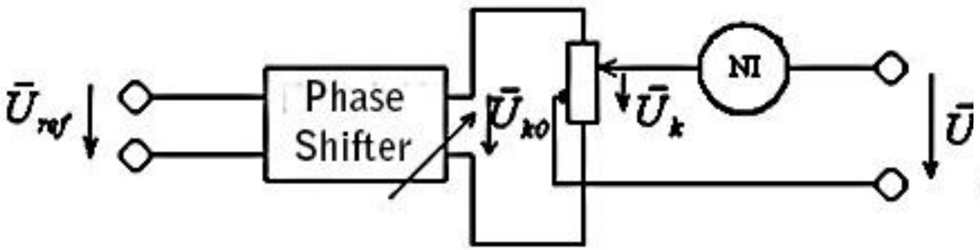
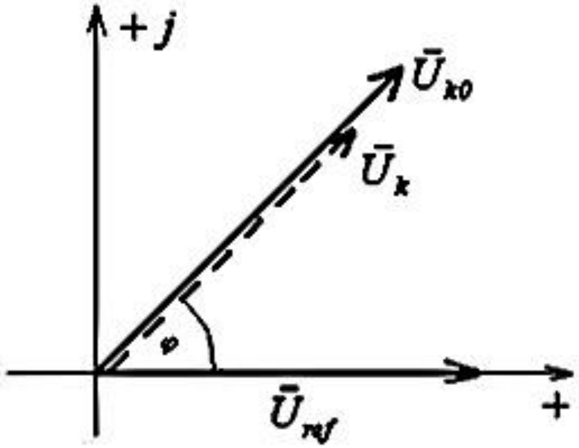
AC Compensators 1

- Two params → magnitude, phase *(and frequency!)*
  - *Magnitude condition*
  - *Phase condition*
- General periodic signal → balance only for base harmonic (selective NI necessary)

- U_{k0} → shifted phase to U_{ref}
- U_k → potentiometer adjusted





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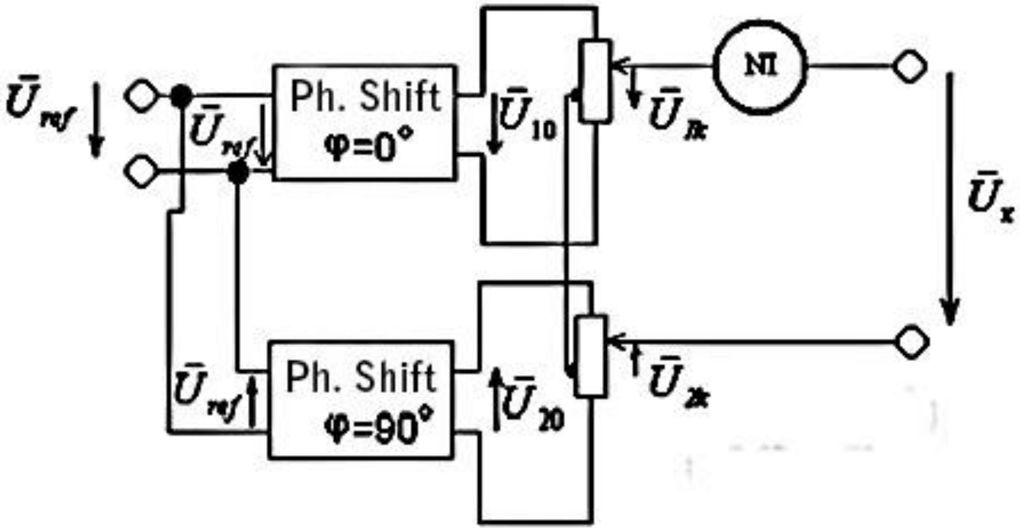
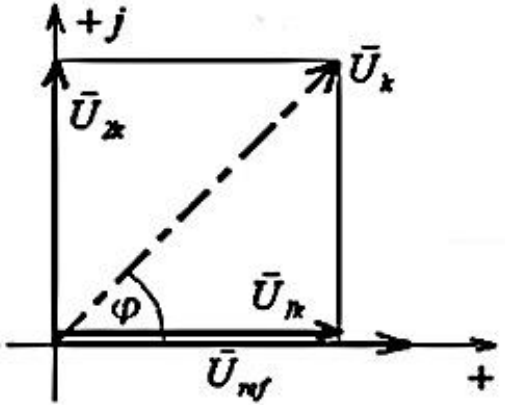
AC Compensators 2





$$\overline{U_x} = \overline{U_k} = \overline{U_{1k}} + \overline{U_{2k}}$$

$$\overline{U}_{10} = \overline{U}_{ref}\ ,\ \overline{U}_{20} = \overline{U}_{ref} \cdot e^{j90°} \qquad U_x = \sqrt{U_{1k}^2 + U_{2k}^2}\ , \varphi = tan^{-1}\left(\frac{U_{2k}}{U_{1k}}\right)$$

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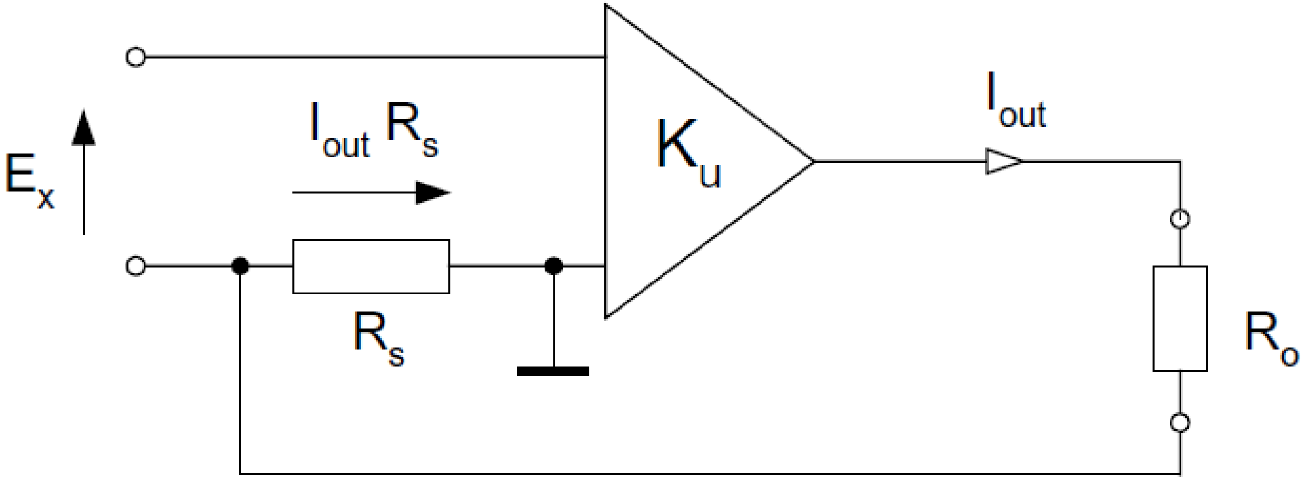
Compensation Example 1 – Voltage to Current Transducer

Requirement $I_{out} = f(E_X)$

Solution $E_X = I_{out} \cdot R_S$

Advantages

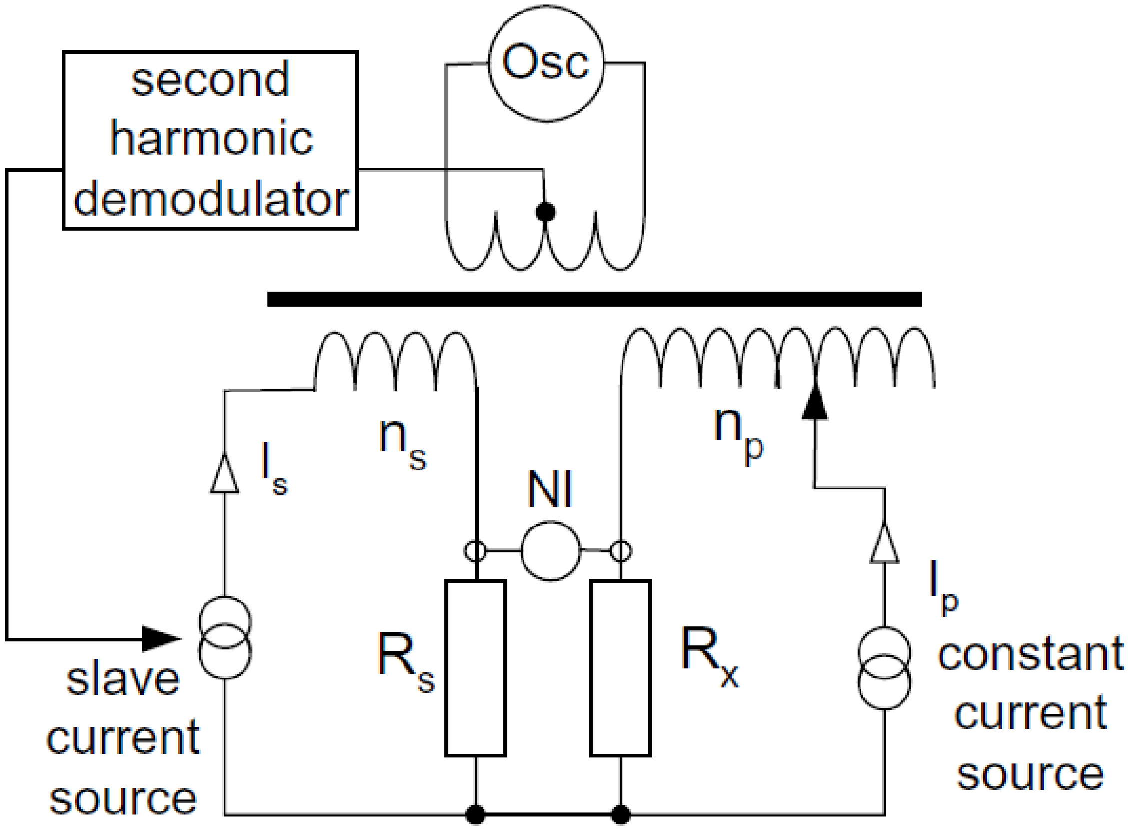
- ❑ Very large input resistance
- ❑ Excellent accuracy (depends only on standard R_S)



Compensation Example 2 – Direct Current Comparator (DCC)

Hall quantum resistance device (NIST1458 2003 - *National Institute of Standards and Technology*)

- ❑ Nobel Prize 1985
- ❑ Reconstruction of resistance standard
- ❑ Most precise method
- ❑ Excellent accuracy (no error in count of turns)
- ❑ Transformer's precondition
  - high permeability ring cores
  - with perfect symmetry
  - shielding, etc.



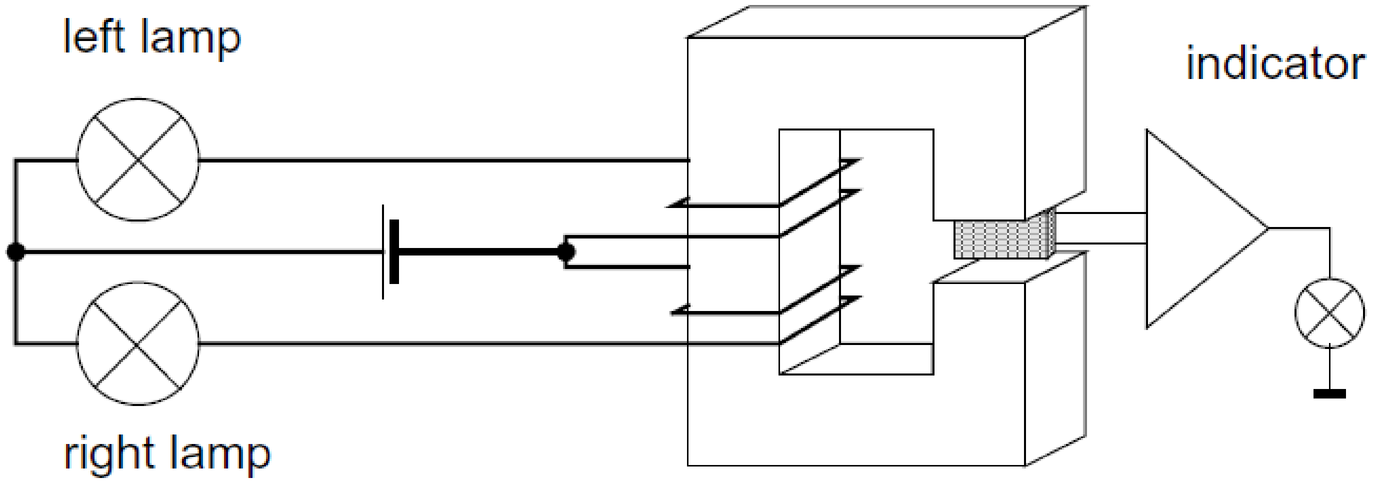
- ❑ Auto balace $n_S I_S = n_P I_P$
- ❑ Man. balance $R_S I_S = R_X I_P$

$$R_X = R_S \frac{n_P}{n_S}$$

Compensation Example 3 – DC Current Comparator (DCC)

Car lighting system tester

- ❑ Both bulbs work → same currents → magnetic flux = 0
- ❑ Bulb damage → unbalanced flux, → magnetic field sensor



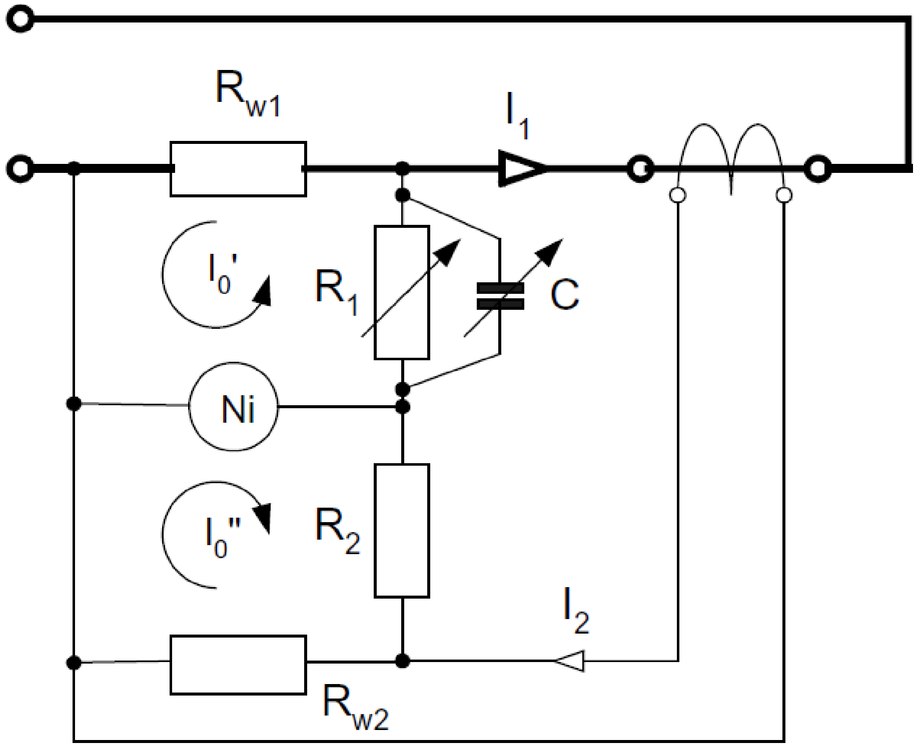
Compensation Example 4 – AC Current Comparator (ACC)

Testing current transformer *(áramváltó)*

- I_1 and I_2 are compared
  (as voltage drops on the standard R_{w1} and R_{w2}.)
- Balancing in two steps
  - Magnitude condition (R_1)
  - Phase condition (C)
- Balance → $I_o' = I_o''$ → (NI=0)

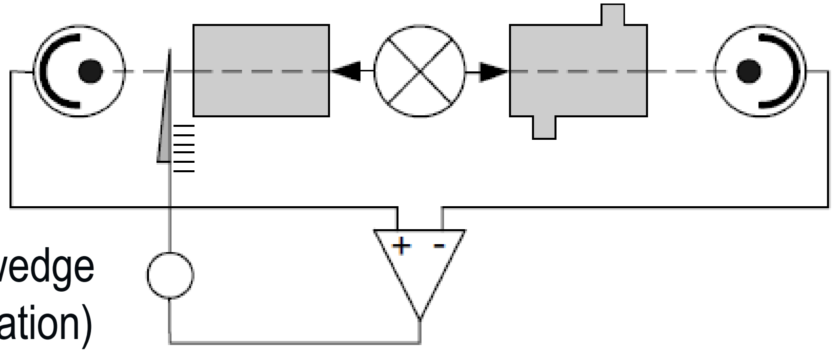
Test result

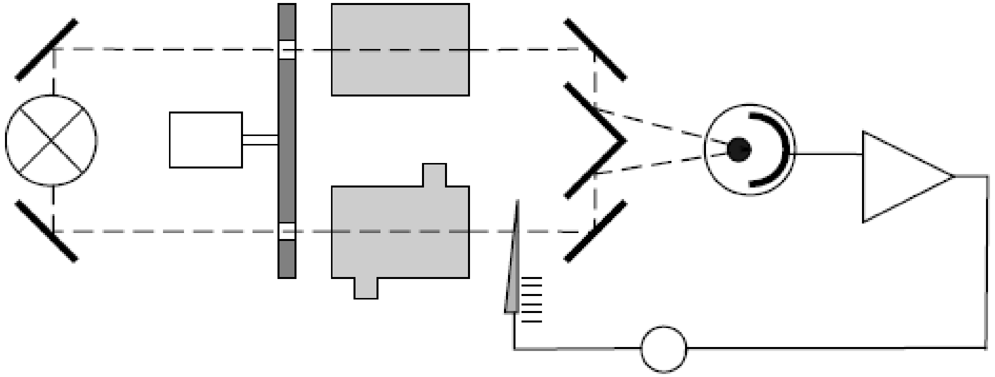
- Transformation ratio $$K_I = \frac{I_1}{I_2} = \frac{R_{W2}R_1}{R_{W1}R_2}$$
- Angle error $$\tan\gamma \cong \omega R_1 C$$



Compensation Example 4 – Light Comparator

- Light through two absorption cells
  - Cell.1 - standard liquid
  - Cell.2 . measured liquid
- Two photodetectors *(or one alternately)*
- Difference bw. lights → controls the movement of the wedge
  (→ absorption properties of tested liquid (i.e. concentration)





Questions