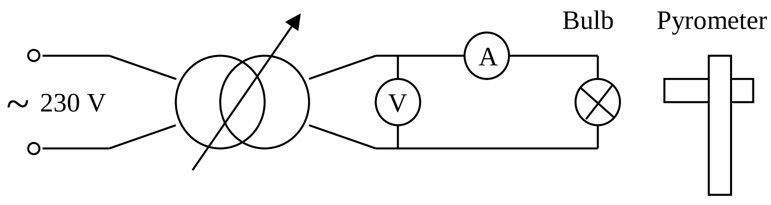
# Contactless temperature measurement

**Assignment:**

1. Measure with a pyrometer the dependence of the brightness temperature $T_L = f\,(U)$ of the given tungsten bulb and omit this dependence.
2. Compare the actual corrected temperature $T' = f\,(U)$ with the theoretical temperature $T_{theory} = f\,(U)$.
3. Calculate the energy temperature $T_e = f\,(U)$ and the chromaticity temperature $T_c = f\,(U)$ and plot them graphically.
4. Calculate the waveform of the spectral density dependence of the radiation intensity for the wavelength.

   $\lambda = 0.65\mu$ m, $E_\lambda = f\,(T)$ and plot it graphically.
5. Evaluate the dependence of the temperature coefficient of resistance $\alpha = f\,(T)$. Plot this graphically.

**Wiring diagram:**




**Instruments used:**

1. Light bulb
2. Pyrometer
3. Regulated voltage source
4. Ammeter
5. Voltmeter
6. Connecting wires

**Theoretical analysis:**

Any substance heated to a temperature higher than the ambient temperature emits a radiant flux into its surroundings.

The dependence of spectral density on temperature is given by Planck's law:

$$M(\lambda,T)=\frac{c_1}{\lambda^5\cdot\left(e^{\frac{c_2}{\lambda.T}}-1\right)} \qquad (\mathrm{W\cdot m^{-3}};\ \mathrm{m},\ \mathrm{K})$$

where $c_1 = 3.73.10^{-16}$ W-m$^2$

where $c_2 = 1{,}438.10^{-2}$ m-K

The energy temperature is the temperature of an absolutely black body at which its spectral radiant flux equals the spectral radiant flux of the body under consideration:

$$T=\frac{T_e}{\sqrt[4]{\varepsilon_r}} \qquad \varepsilon_r = 1-e^{-\beta.T},$$ for tungsten $\beta$ = 1.47 (K, K)

Where $T_e$ ...energy temperature

T ... the actual temperature of the real body

$\varepsilon_r$ ... total emissivity

Chromaticity temperature:

$$\frac{1}{T}=\frac{1}{T_c}-\frac{\ln\frac{\varepsilon(\lambda_1 T)}{\varepsilon(\lambda_2 T)}}{c_2.\left(\frac{1}{\lambda_2}-\frac{1}{\lambda_1}\right)} \qquad (\mathrm{K};\ \mathrm{K},\ \mathrm{m})$$

Where $\varepsilon_1$ = 0.42 for $\lambda_1$ = 0.7 mμ

$\varepsilon_2$ = 0.48 for $\lambda_2$ = 0.4 mμ

$T_c$ ... chromaticity temperature

T ... the actual temperature of the real body

Brightness temperature:

$$T=\frac{c_2}{\frac{c_2}{T_L}+[\ln\varepsilon(\lambda,T)].\lambda} \qquad (\mathrm{K};\ \mathrm{K})$$

Where $\varepsilon(\lambda, T)$ = 0.43 ... spectral emissivity for $\lambda$ = 650 nm

T...the actual temperature of the real body

$T_L$ ... brightness temperature

Theoretical temperature:

$$T_{theore} = T_{220} \cdot \left(U / 220\right)^{0.4} \qquad \text{(K; K, V)}$$

Where $T_{theore}$ ... the theoretical filament temperature of the bulb at voltage U

$T_{220}$ ... filament temperature of the bulb at 220 V (for vacuum bulbs $T_{220}$ = 2450 K)

Corrected actual temperature:

$$\frac{1}{T} - \frac{1}{T'} = \frac{\lambda \cdot a \cdot t}{c_2} \qquad \text{(K; K, m, mm)}$$

Where T ... corrected actual temperature of the body

T′ ... the temperature indicated by the pyrometer

λ ... wavelength of radiation

a ... absorption coefficient (for glass a = 0.05)

t ... absorption wall thickness (0,03 mm)

Filament resistance increases with temperature:

$$R = R_o \cdot \left(1 + \alpha \cdot \Delta\vartheta\right) \qquad (\Omega;\ \Omega,\ K^{-1},\ K)$$

**Measurement procedure:**

1. Connect the devices according to the diagram.
3. Vary the voltage from 0-240 V in 20 V steps and for each value read the current and measure the brightness temperature $T_{(L)}$ of the bulb filament with a pyrometer.
4. From the measured brightness temperature, calculate the actual temperature, then the actual corrected temperature, the chromaticity temperature and the energy temperature for each voltage value.
5. For each voltage value, we further calculate the theoretical temperature, filament resistance and resistance coefficient, and for a wavelength of 650 nm we calculate the spectral density of the intensity of the radiation.
6. From the measured and calculated values we make a table and graphs
7. Finally, we evaluate the measured values and the measurement methods used, especially with regard to the accuracy of the measured results.