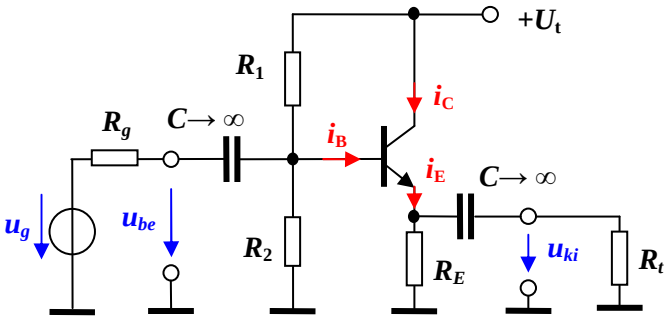
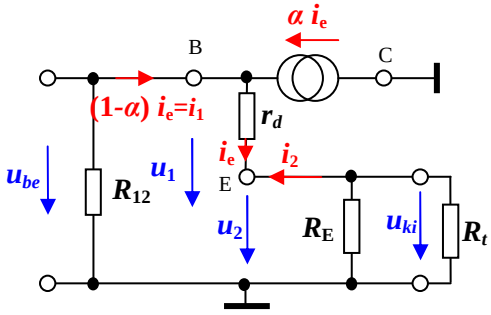
1. **Ismertesse a földelt kollektoros alapkapcsolás kisjelű paramétereit (előjelesen): $A_u$, feszültségerősítés; $A_i$, áramerősítés; $R_{be}$, bemeneti ellenállás; $R_{ki}$, kimeneti ellenállás!**

**Megoldás**:




A kisjelű helyettesítő kép:




**A fokozat feszültség erősítése:**

$$A_u = \frac{u_{ki}}{u_{be}} = \frac{u_2}{u_1} = \frac{R_E \times R_t}{r_d + R_E \times R_t} < 1$$

**A fokozat áram erősítése:**

$$A_i = \frac{i_2}{i_1} = \frac{-i_e}{(1-\alpha) i_e} = -\frac{1}{1-\alpha} = -(1+\beta)$$

**A fokozat bemenő ellenállása:**

$$R_{be} = \frac{u_1}{i_1} = \frac{u_{be}}{(1-\alpha) i_e} = (1+\beta)(r_d + R_E \times R_t)$$

**Mert:** $u_{be} = i_e (r_d + R_E \times R_t)$ **és** $\dfrac{u_{be}}{(1-\alpha) i_e} = \dfrac{r_d + R_E \times R_t}{1-\alpha} = (1+\beta)(r_d + R_E \times R_t)$

$$\frac{1}{1-\alpha} = 1+\beta$$

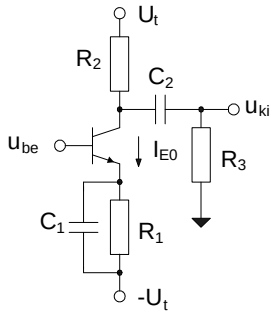
**A fokozat kimenő ellenállása:**

$$R_{ki} = \frac{u_2}{i_2} = r_d + \frac{R_g \times R_1 \times R_2}{(1+\beta)}$$

**Mert:**

$$R_{ki} = \frac{u_2}{i_2} = \frac{-i_e r_d - (1-\alpha) i_e (R_g \times R_1 \times R_2)}{-i_e} = r_d + (1-\alpha)(R_g \times R_1 \times R_2)$$

**2. Határozza meg az alábbi kapcsolás kivezérelhetőségét!**




$U_t = 15\,\text{V}, \quad U_m = 1\,\text{V}, \quad A = 1, \quad I_{E0} = 4\,\text{mA}$

a.) $U_{ki}^{+} = ?, \quad C_1 \to \infty, \quad C_2 \to \infty$

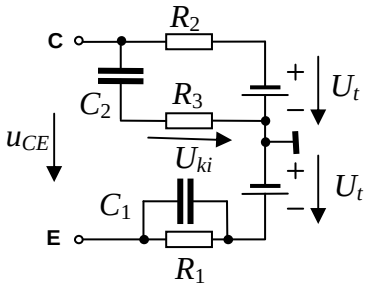
b.) $U_{ki}^{-} = ?, \quad C_1 \to \infty, \quad C_2 \to \infty$

c.) $U_{ki}^{+} = ?, \quad C_1 \to \infty, \quad C_2$ helyett rövidzár van a kapcsolásban

d.) $U_{ki}^{+} = ?, \quad C_1 = 0, \quad C_2 \to \infty$

$R_1 = 2{,}5\,\text{k}\Omega, \quad R_2 = 2{,}5\,\text{k}\Omega, \quad R_3 = 2{,}5\,\text{k}\Omega,$

**Megoldás**:




a.), b.) $C_1 \to \infty, \quad C_2 \to \infty$

$$U_t^* = 2U_t = 30\ V$$
$$R_e = R_1 + R_2 = 5\ k\Omega$$
$$R_v = R_2 \times R_3 = 1.25\ k\Omega$$
$$U_{CE0} = U_t^* - I_{C0}R_e = 30 - 4*5 = 10\ V$$
$$U_{ce}^{+} = U_{CE0} - U_m = 10 - 1 = 9\ V$$
$$U_{ce}^{-} = I_{C0}R_v = 4*1.25 = 5\ V$$

a.) $U_{ki}^{+} = ?, \quad C_1 \to \infty, \quad C_2 \to \infty$ $\qquad \boxed{U_{ki}^{+} = U_{ce}^{+} = 9\ V}$

b.) $U_{ki}^{-} = ?, \quad C_1 \to \infty, \quad C_2 \to \infty$ $\qquad \boxed{U_{ki}^{-} = U_{ce}^{-} = 5\ V}$

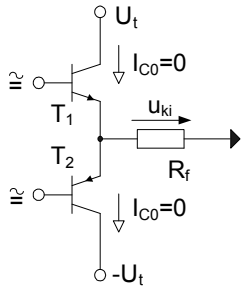
c.) $U_{ki}^{+} = ?, \quad C_1 \to \infty, \quad C_2$ helyett rövidzár van a kapcsolásban

$$U_t^* = U_t \frac{R_3}{R_2 + R_3} + U_t = 1.5U_t = 22.5\ \ V$$
$$R_e = R_1 + R_2 \times R_3 = 3.75\ k\Omega$$
$$R_v = R_2 \times R_3 = 1.25\ k\Omega$$
$$U_{CE0} = U_t^* - I_{C0}R_e = 22.5 - 4*3.75 = 7.5\ V$$
$$U_{ce}^{+} = U_{CE0} - U_m = 7.5 - 1 = 6.5\ V \qquad \boxed{U_{ki}^{+} = U_{ce}^{+} = 6.5\ V}$$

d.) $U_{ki}^{+} = ?, \quad C_1 = 0, \quad C_2 \to \infty$

$$U_t^* = U_t + U_t = 2U_t = 30\ \ V$$
$$R_e = R_1 + R_2 = 5\ k\Omega$$
$$R_v = R_1 + R_2 \times R_3 = 3.75\ k\Omega$$
$$U_{CE0} = U_t^* - I_{C0}R_e = 30 - 4*5 = 10\ V$$
$$U_{ce}^{+} = U_{CE0} - U_m = 10 - 1 = 9\ V \qquad \boxed{U_{ki}^{+} = U_{ce}^{+} \frac{R_2 \times R_3}{R_1 + R_2 \times R_3} = 9\frac{1.25}{3.75} = 3\ V}$$

**3. Határozza meg az alábbi teljesítményfokozat paramétereit („B" osztályú elrendezés, szinuszos kimeneti jel)!**




$U_t = 18$ V; $U_m = 1$ V; $R_f = 8{,}5\ \Omega$; $\alpha = A = 1$, $i_E = i_C$

a) $P_{f\max} = ?$

b) $P_{T\max} = ?$

c) $P_{D\max}$ (1 tr.) = ?

d) $\eta_{T\max} = ?$

**Megoldás**:

a) $P_{f\max} = ?$

$$I_{c\max} = \frac{U_t - U_m}{R_f} = \frac{18-1}{8.5} = 2 \ \ A$$

$$P_{f\max} = \frac{1}{2} I_{c\max}^2 R_f = \frac{1}{2} 4 * 8.5 = 17 \ \ W$$

b) $P_{T\max} = ?$

$$P_T = 2U_t \bar{i} = 2U_t \frac{1}{T} \int_{-T/4}^{+T/4} I_c \cos\left(2\pi \frac{t}{T}\right) dt = 2U_t \frac{I_c}{\pi}$$

$$P_{T\max} = \frac{2}{\pi} U_t I_{c\max} = \frac{2}{\pi} 18 * 2 = 22.92 \ \ W$$

c) $P_{D\max}$ (1 tr.) = ?

$$P_{D2} = P_T - P_f = \frac{2}{\pi} U_t I_c - \frac{1}{2} I_c^2 R_f = -\frac{R_f}{2} I_c \left( I_c - \frac{4U_t}{\pi R_f} \right) \quad \rightarrow \quad I_{cM} = \frac{2}{\pi} \frac{U_t}{R_f} = 1.35 \ \ A$$

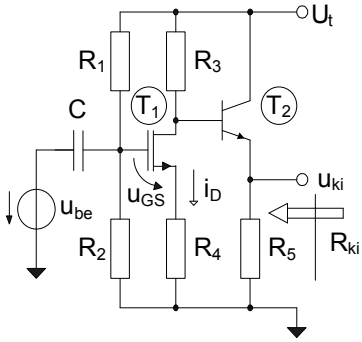
$$P_{D\max 2} = \frac{2}{\pi} U_t I_{cM} - \frac{1}{2} I_{cM}^2 R_f = \frac{1}{2} I_{cM}^2 R_f = \frac{1}{2} 1.35^2 8.5 = 7.74 \ \ W$$

$$P_{D\max(1tr)} = \frac{P_{D\max 2}}{2} = 3.87 \ \ W$$

d) $\eta_{T\max} = ?$

$$\eta_{T\max} = \frac{P_{f\max}}{P_{T\max}} = \frac{17}{22.92} = 0.742 = 74.2 \ \ \%$$

**4. Határozza meg az alábbi kapcsolás munkapontját és kisjelű paramétereit!**




$T_1$ n-csatornás növekményes MOS FET, $i_D = I_{D00}\left(\frac{u_{GS}-U_P}{U_P}\right)^2$

$U_P$ = 2 V; $I_{D00}$ = 4 mA;
$T_2$ n-p-n tranzisztor, $U_{BE0}$ = 0,6 V, $B_2 = \beta_2 \to \infty$
$U_t$ =12 V; $R_1$ = 100 kΩ; $R_2$= 100 kΩ; $R_3$ = 3 kΩ; $R_4$ = 3 kΩ; $R_5$ = 5,1 kΩ
a) A $T_1$ és $T_2$ tranzisztor alapkapcsolásának típusa?
b) $I_{D0}$ = ?; c) $I_{E0}$ = ?; d) $A_u$= ?, ha S = 2 mS, $r_d$ = 15,78 Ω.

**Megoldás**:

a) A $T_1$ és $T_2$ tranzisztor alapkapcsolásának típusa?

$T_1$: Földelt Source-os
$T_2$: Földelt Kollektoros

b) $I_{D0}$ = ?;

$$U_{G0} = U_t \frac{R_2}{R_1+R_2} = \frac{U_t}{2} = 6\ V \qquad U_{G0} = u_{GS} + i_D R_4 \rightarrow \quad 6 = u_{GS} + 3i_D$$

$$i_D = I_{D00}\left(\frac{u_{GS}-U_P}{U_P}\right)^2 = (u_{GS}-2)^2 = i_D$$

Az áramra megoldva:

$$i_D = (4-3i_d)^2$$

$$9i_D^2 - 25i_D + 16 = 0$$

$$i_D = I_{D0} = \frac{25-\sqrt{625-36*16}}{18} = 1\ mA$$

$$U_{GS0} = 6 - 3I_{D0} = 3\ V > U_P$$

A feszültségre megoldva:

$$\frac{6-u_{GS}}{3} = (u_{GS}-2)^2$$

$$3u_{GS}^2 - 11u_{GS} + 6 = 0$$

$$u_{GS} = U_{GS0} = \frac{11+\sqrt{121-72}}{6} = 3\ V > U_P$$

$$I_{D0} = \frac{6-U_{GS0}}{3} = 1\ mA$$

c) $I_{E0}$ = ?;

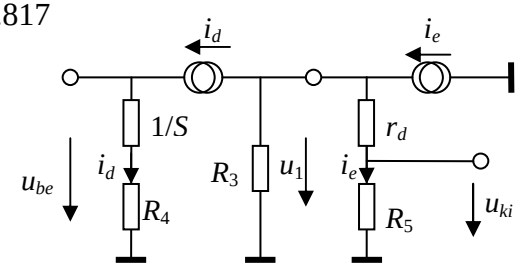
$$U_t = I_{D0}R_3 + u_{BE} + i_E R_5 \quad \rightarrow \quad I_{E0} = \frac{U_t - U_{BE0} - I_{D0}R_3}{R_5} = \frac{12-0.6-3}{5.1} = 1.647\ mA$$

d) $A_u$= ?, ha S = 2 mS, $r_d$ = 15,78 Ω.

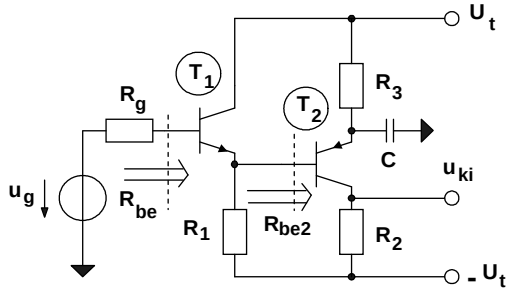
$$A_{ü1} = \frac{u_1}{u_{be}} = -\frac{R_3}{1/S + R_4} = -\frac{SR_3}{1+SR_4} = -\frac{6}{7} = -0.817$$

$$A_{ü2} = \frac{u_{ki}}{u_1} = \frac{R_5}{r_d + R_5} = \frac{5.1}{5.11578} = 0.997$$

$$A_u = A_{ü1}A_{ü2} = -0.816$$



## 5. Határozza meg az alábbi kapcsolás kisjelű paramétereit!




$T_1$ n-p-n tranzisztor, $U_{BE0}$ = 0,6 V, $B_1 = \beta_1 = 99$
$I_{E01}$ = 1 mA
$T_2$ p-n-p tranzisztor, $U_{EB0}$ = 0,6 V, $B_2 = \beta_2 \to \infty$
$I_{E02}$ = 2 mA
$U_t$ =12 V; $R_1$ = 11,3 kΩ; $R_2$= 4 kΩ; $R_3$ = 6,05 kΩ;
$R_g$ = 10 kΩ
a) A $T_1$ és $T_2$ tranzisztor alapkapcsolásának típusa?
b) $R_{be}$ = ?

c) $A_u = \frac{u_{ki}}{u_g}$ = ? ha $C \to \infty$, d) $A_u = \frac{u_{ki}}{u_g}$ = ? ha $C$ = 0,

**Megoldás**:

a) A $T_1$ és $T_2$ tranzisztor alapkapcsolásának típusa?

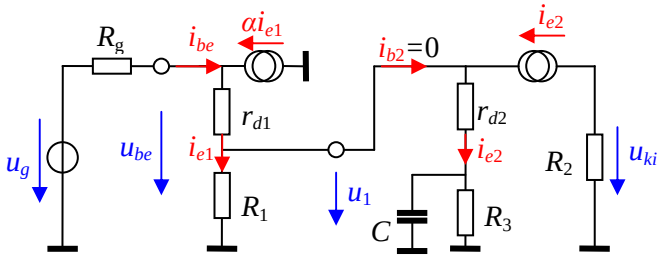
$T_1$: Földelt Kollektoros
$T_2$: Földelt Emitteres

b) $R_{be}$ = ?

$$R_{be} = \frac{u_{be}}{i_{be}} = \frac{(r_{d1} + R_1) i_{e1}}{(1-\alpha_1) i_{e1}} =$$

$$= \frac{(r_{d1} + R_1)}{(1-\alpha_1)} = (1+\beta)(r_{d1} + R_1)$$

$$r_{d1} = \frac{26mV}{I_{E01}} = 26\ \Omega$$




$$R_{be} = (1+\beta)(r_{d1} + R_1) = 1132.6\ k\Omega$$

c) $A_u = \frac{u_{ki}}{u_g}$ = ? ha $C \to \infty$

$$L_{be} = \frac{u_{be}}{u_g} = \frac{R_{be}}{R_g + R_{be}} = \frac{1132.6}{1142.6} \cong 1, \qquad R_{be2} = \frac{u_1}{i_{b2}} = \infty$$

$$A_{ü1} = \frac{u_1}{u_{be}} = \frac{R_1}{r_{d1} + R_1} = \frac{11.3}{11.326} \cong 1$$

$$A_{ü2} = \frac{u_{ki}}{u_1} = \frac{-R_2 i_{e2}}{r_{d2} i_{e2}} = -\frac{R_2}{r_{d2}} = -\frac{4}{0.013} = -307.7 \qquad r_{d2} = \frac{26mV}{I_{E02}} = 13\ \Omega$$

$$A_u = \frac{u_{ki}}{u_g} = L_{be} A_{ü1} A_{ü2} = \text{-}307.7$$

d) $A_u = \frac{u_{ki}}{u_g}$ = ? ha $C$ = 0,

$$A_{ü2} = \frac{u_{ki}}{u_1} = \frac{-R_2 i_{e2}}{(r_{d2} + R_3) i_{e2}} = -\frac{R_2}{(r_{d2} + R_3)} = -\frac{4}{6.063} = -0.66$$

$$A_u = \frac{u_{ki}}{u_g} = L_{be} A_{ü1} A_{ü2} = \text{-}0.66$$