Elektronik I

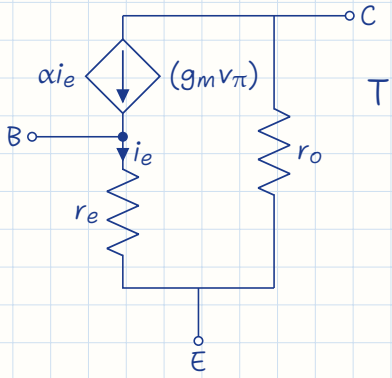
Notes – BJT küçük işaret modelleri ve ortak emetörlü yükselteç

Original notes: Notes.pdf

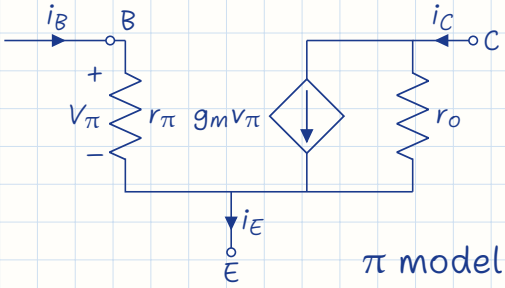
UYARI Bu belge, el yazısı ders notlarından Claude (Anthropic) yardımıyla dijitale aktarılmıştır. Yardımcı kaynak olarak hazırlanmıştır; hata veya eksik içerebilir. Lütfen orijinal notları ve ders kaynaklarını esas alın.

NOTICE *This document was transcribed from handwritten lecture notes with the help of Claude (Anthropic). It is meant as a supplementary resource and may contain errors or omissions. Always check against the original notes and official course material.*

orig. p. 1



T Model



π model

$$r_o \to \frac{V_A}{I_C} \qquad g_m \to \frac{I_C}{V_T}$$

$$r_e = \frac{V_T}{I_E} = 1/g_m$$

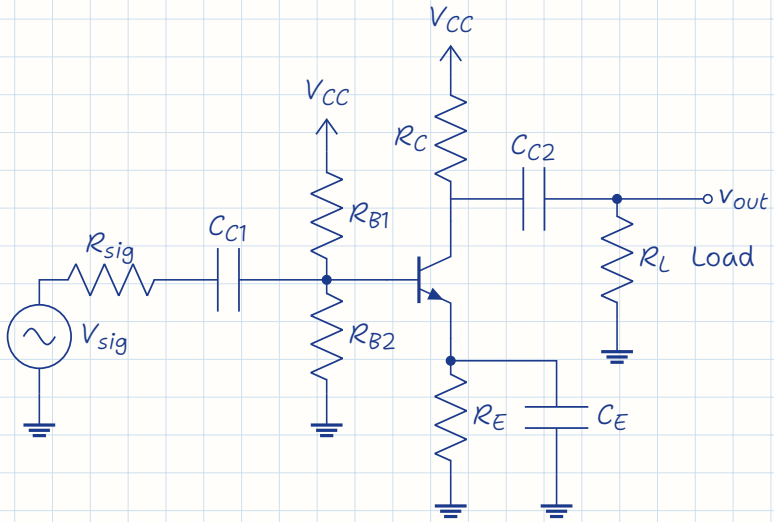
$$\boxed{r_\pi = (\beta + 1)\, r_e}$$

$$i_B = \frac{V_\pi}{r_\pi} \qquad i_B = \frac{i_C}{\beta}$$

$$i_B + i_C = i_E \qquad i_E = \frac{\beta + 1}{\beta} \cdot i_C$$

$$(\beta + 1)\, i_B = i_E$$

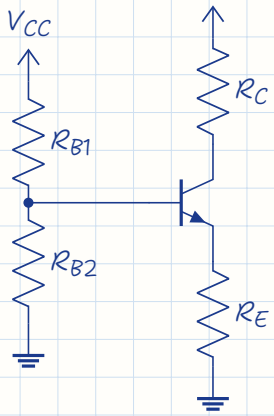
$$r_\pi \underbrace{i_B}_{\frac{i_E}{\beta+1}} = i_E \cdot r_e \qquad r_\pi = r_e\,(\beta + 1)$$

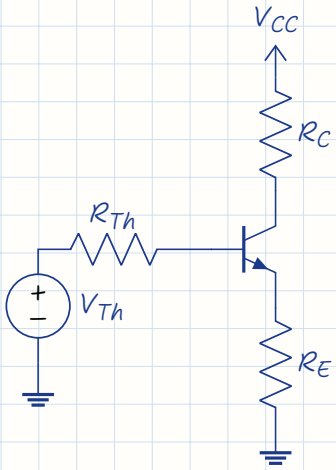


C_{C1}, C_{C2}, C_E high values

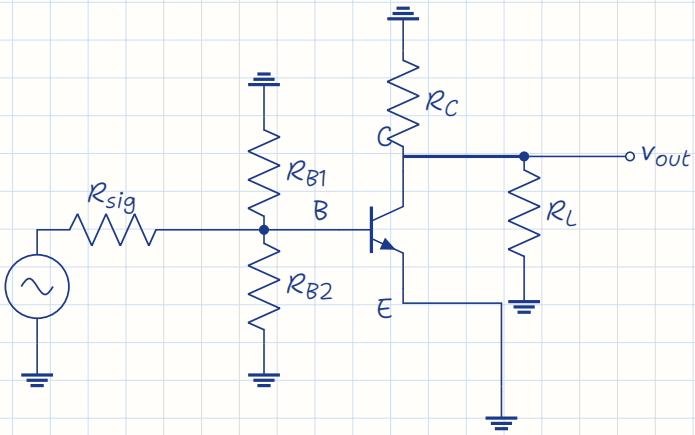
$$A_v = \frac{v_o}{v_i} = ?$$

in DC

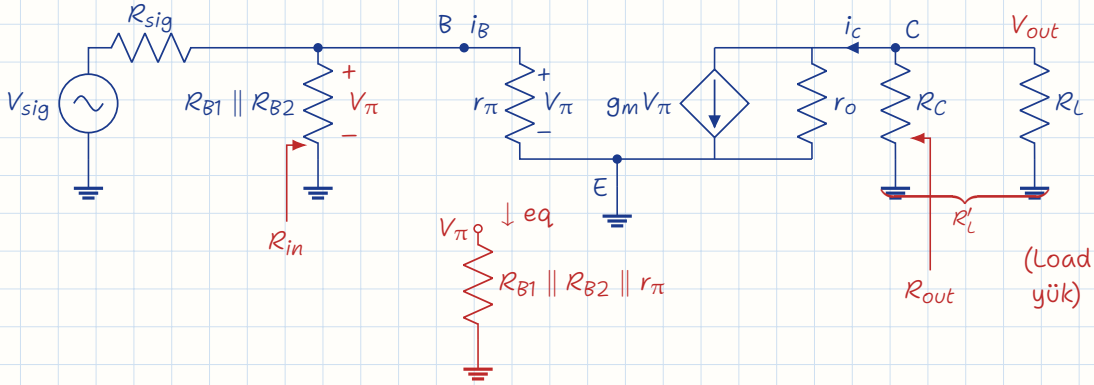




AC



Small signal circuit

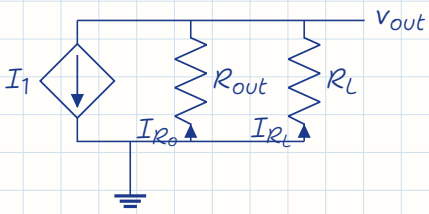


$$R_{in} = R_{B1} \parallel R_{B2} \parallel r_\pi$$

orig. p. 2

$R_{out} = R_C \parallel r_o$

$$A_v = \frac{v_{out}}{v_{in}} = \frac{v_{out}}{v_{sig}} =$$



I_1 sabit

$R_o \downarrow$ $\quad I_{R_o} + I_{R_L} = I_1$ ($I_{R_o} \uparrow$, $I_{R_L} \downarrow$)

$$v_{out} = -R'_L \cdot V_\pi g_m$$

$$v_\pi = \left(\frac{R_{B1} \parallel R_{B2} \parallel r_\pi}{r_\pi \parallel R_{B1} \parallel R_{B2} + R_{sig}} \right) v_{sig}$$

$$\frac{v_{out} = -g_m R'_L \cdot \left(\frac{R_{B1} \parallel R_{B2} \parallel r_\pi}{r_\pi \parallel R_{B1} \parallel R_{B2} + R_{sig}} \right) \cancel{v_{sig}}}{v_{in} = \cancel{v_{sig}}}$$

$$A_v = -g_m R'_L \left(\frac{R_{B1} \parallel R_{B2} \parallel r_\pi}{r_\pi \parallel R_{B1} \parallel R_{B2} + R_{sig}} \right)$$

if $R_{sig} \approx 0 \implies A_v = -g_m R'_L$

Properties

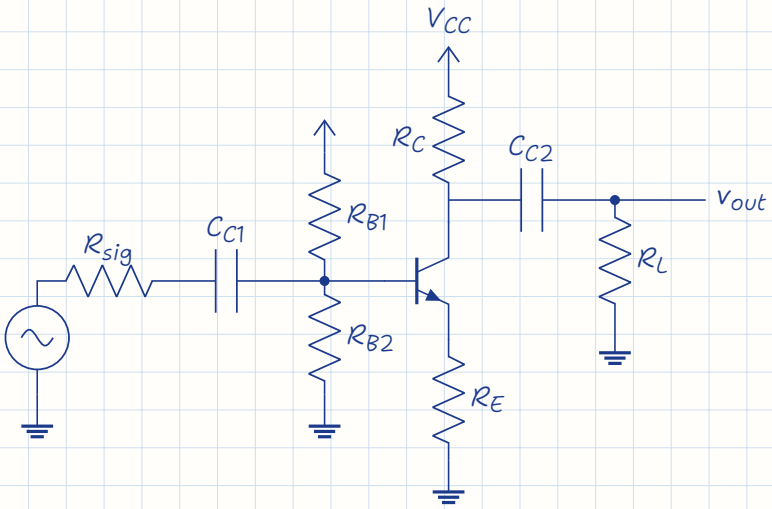
High voltage gain

→ Moderate Input Resistance ⇒ $R_{B1} \parallel R_{B2} \parallel r_\pi$

→ " High output Res → $R_C \parallel r_o$

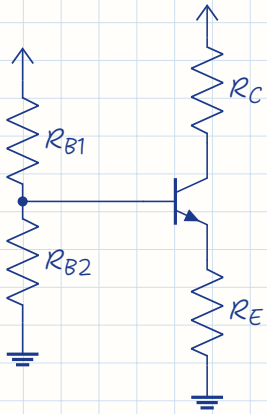
R_{in} büyük olsun isteriz ki singal zayıflamasın girişte voltaj düşümünü en aza indirgemek için

Common Emitter Amp. with R_E



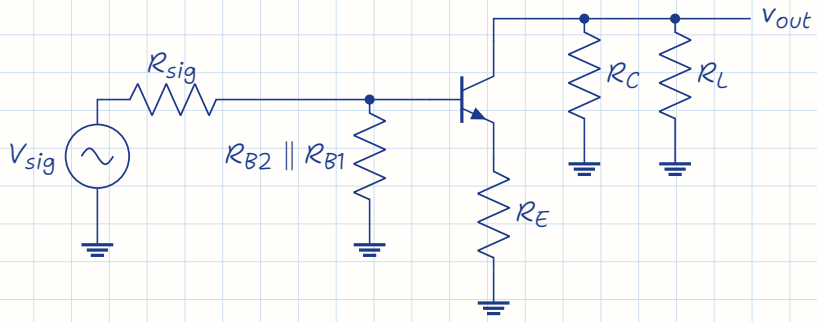
AC

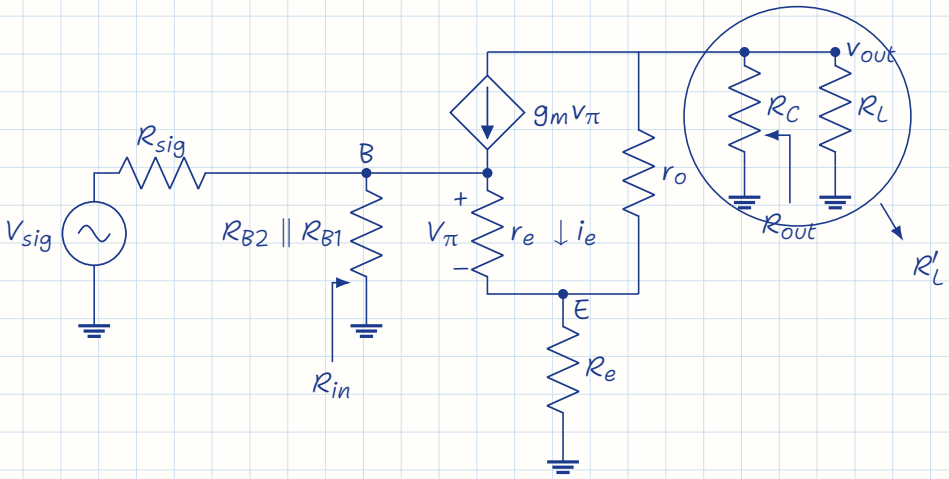
DC



orig. p. 3

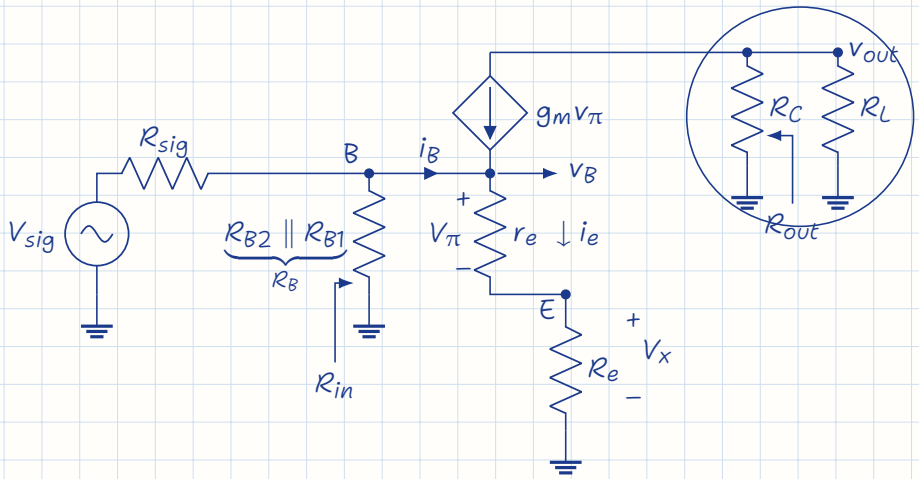
AC





$$R_{in} = R_{B2} \parallel R_{B1} \parallel ((\beta + 1)(R_e + r_e))$$
$$R_{out} = R_C \parallel (r_o + R_e)$$

$V_A = \infty,\ r_o = \infty$



$$i_B = (\beta + 1)\, i_e$$ [1]

akım kay. → açık d.
voltaj kay. → kısa d.

$$R_{in} = R_B \parallel ((\beta + 1)(r_e + R_e))$$
$$R_{out} = R_C$$

$$A_v = \frac{v_{out}}{v_{in}} =$$
$$v_{out} = -g_m V_\pi (R_C \parallel R_L)$$

$$v_B = v_\pi + v_x$$
$$v_B = v_\pi + i_e R_e$$
$$v_B = v_\pi + \left((i_B + g_m v_\pi) R_e\right)$$

orig. p. 4

$R_{sig} = 0$
$v_{sig} = v_b$

$$v_B = v_\pi + i_B R_e + \frac{v_\pi \cancel{R_e}}{\cancel{R_e}}$$
$$= \boxed{?\ 2v_\pi}$$

$$i_B = \frac{V_\pi}{r_\pi}$$

$$\begin{aligned} v_x &= i_e R_e \\ &= (g_m v_\pi + i_B) R_e \\ &= \left(g_m v_\pi + \frac{V_\pi}{r_\pi}\right) R_e \\ &= \left(\frac{V_\pi}{r_e} + \frac{V_\pi}{r_\pi}\right) R_e \\ &= \boxed{\frac{v_\pi}{r_e} \cdot R_E} \end{aligned}$$

[1] Claude notu: muhtemelen $i_e = (\beta + 1)\, i_B$ olmalı.

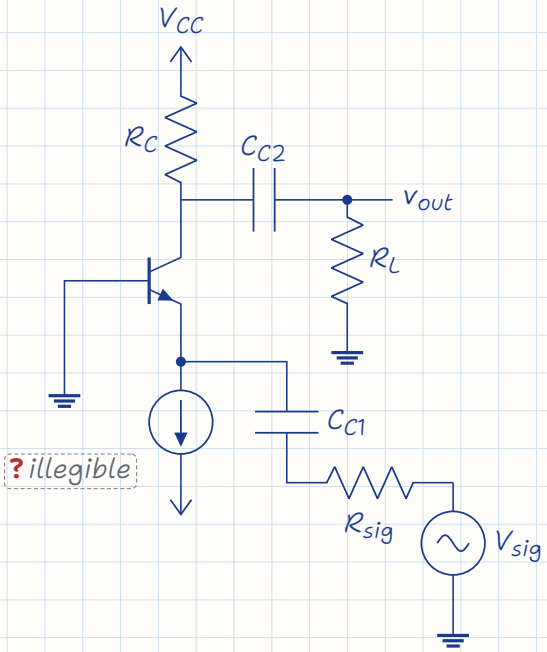
$$\frac{v_{out}}{v_{in}} = \frac{-g_m \cancel{v_\pi} (R_C \parallel R_L)}{\cancel{v_\pi}\left(1 + \frac{R_e}{r_e}\right)}$$

$$\frac{v_{out}}{v_{in}} = \frac{-g_m (R_C \parallel R_L)}{r_e\left(1 + \frac{R_E}{r_e}\right)}$$

$$\cong -\frac{(R_C \parallel R_L)}{r_e + R_e}$$

$$A_v \cong -\frac{R_C \parallel R_L}{R_E + r_e}$$

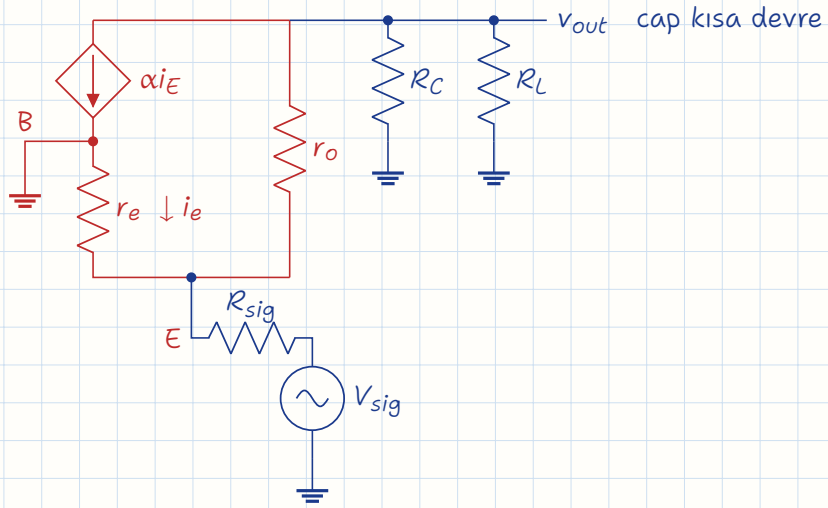
Common-Base Amplifier



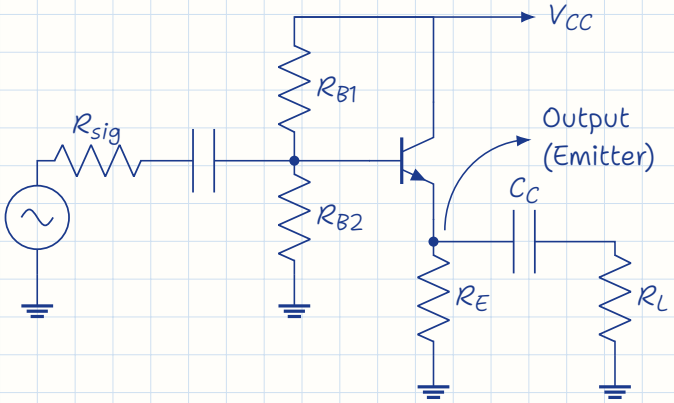
[2] Claude notu: muhtemelen paydaki r_e olmadan, yani $\frac{-g_m(R_C \parallel R_L)}{1 + R_E/r_e}$ olmalı; $g_m = 1/r_e$ ile bir sonraki satır elde edilir.

orig. p. 5

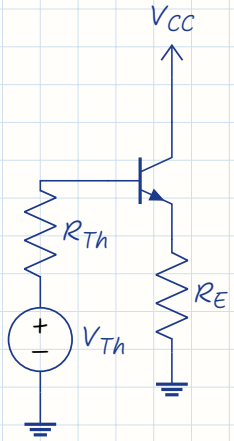
AC



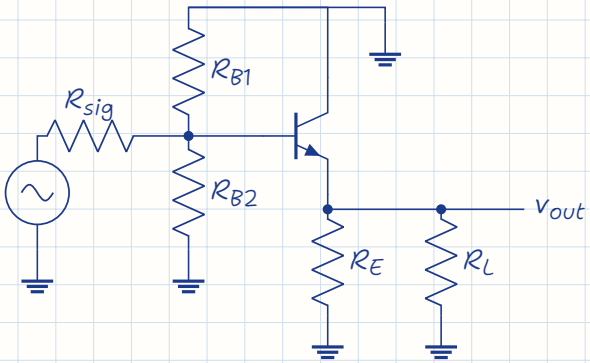
Common-Collector Amplifier (Emitter-Follower)

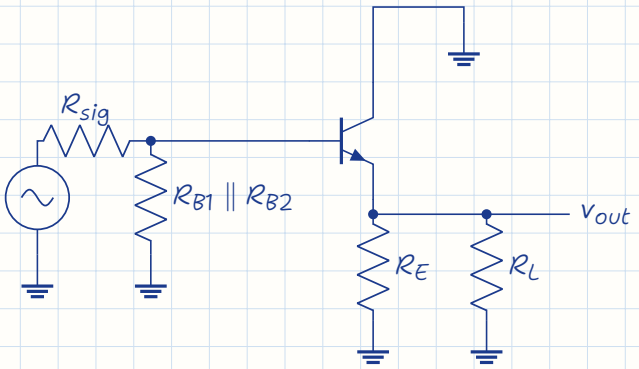


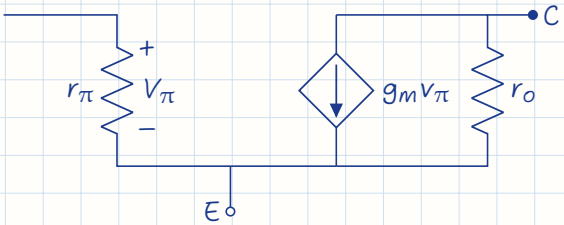
DC



AC







orig. p. 6

$V = IR$

$$\left(g_m v_\pi + \frac{v_\pi}{r_\pi}\right) R_L'$$

$$= R_L' \cdot V_\pi \left(g_m + \frac{1}{r_\pi}\right)$$