Elektronik I

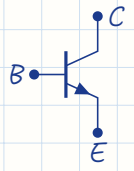
24.05 dersi – BJT küçük işaret modelleri ve ortak emetörlü yükselteç

Orijinal not: Elektronik-1-24-05.pdf

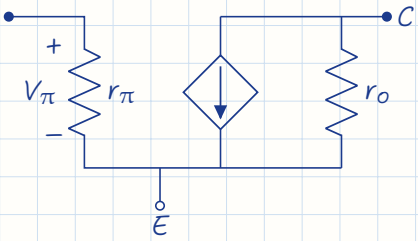
UYARI Bu belge, el yazısı ders notlarından Claude (Anthropic) yardımıyla dijitale aktarılmıştır. Yardımcı kaynak olarak hazırlanmıştır; hata veya eksik içerebilir. Lütfen orijinal notları ve ders kaynaklarını esas alın.

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.*

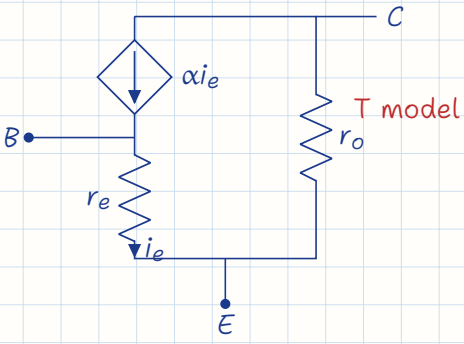
Small signal Models



π model



orj. s. 1



$v_i \ll V_T \cong 0{,}025\ \text{V}$

Small signal model

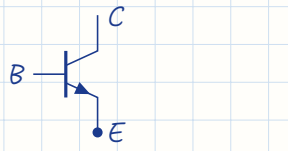
$r_o \rightarrow$ output resistance of BJT $= \dfrac{V_A}{I_C}$

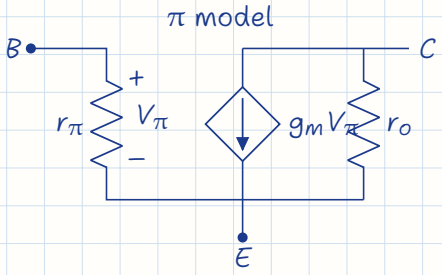
$g_m \rightarrow$ transconductance $= \dfrac{I_C}{V_T}$

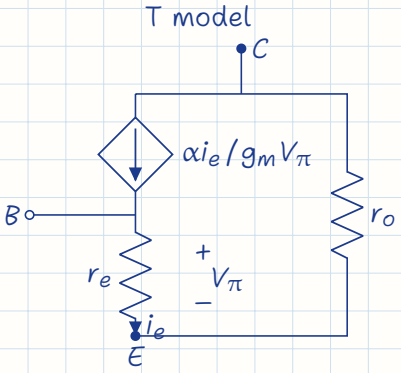
$r_e \rightarrow$ emitter resistance $= \dfrac{V_T}{I_E} \cong 1/g_m$

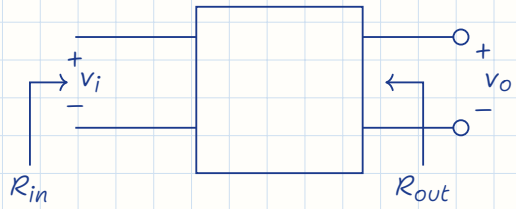
$r_\pi \rightarrow$ base resistance $= (\beta + 1) \cdot r_e$

Practice









orj. s. 2

Voltage Gain

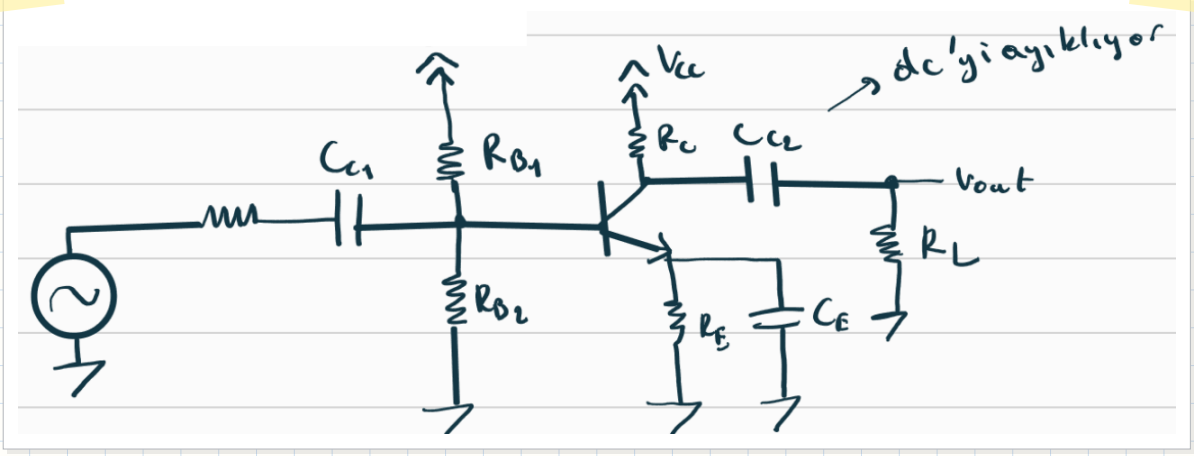
$$A_V = \frac{v_o}{v_i}$$

R_{in} → Input resistance
R_{out} → Output

Amplifier Topologies

- Common Emitter
- Common Emitter with R_E
- Common Base
- Common Collector (Emitter-Fol.)

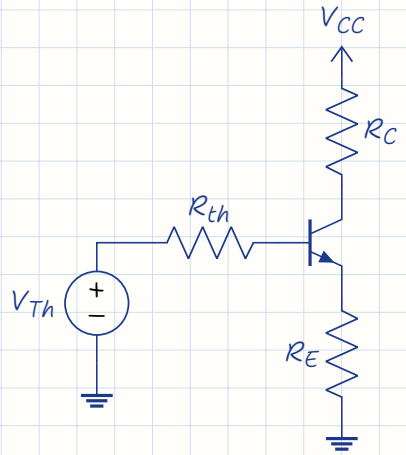
Common Emitter amplifier



orijinal çizim, s. 2

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

C are open circuit at DC

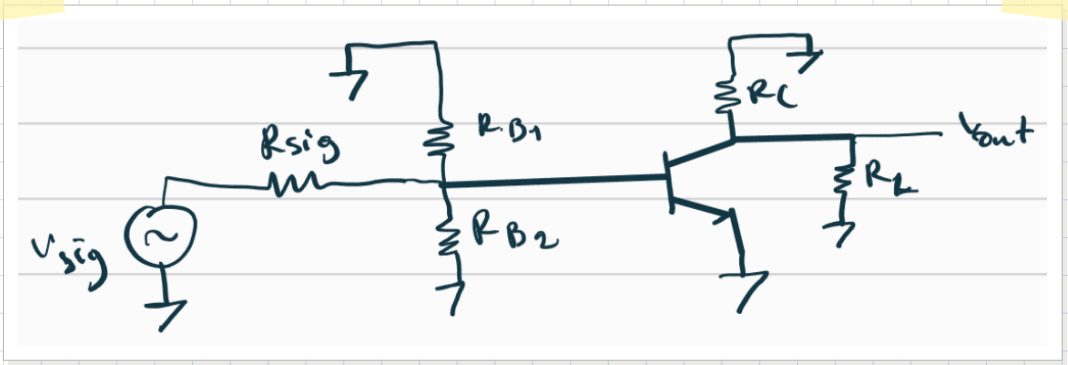


g_m, r_e, r_π, r_o

@ AC

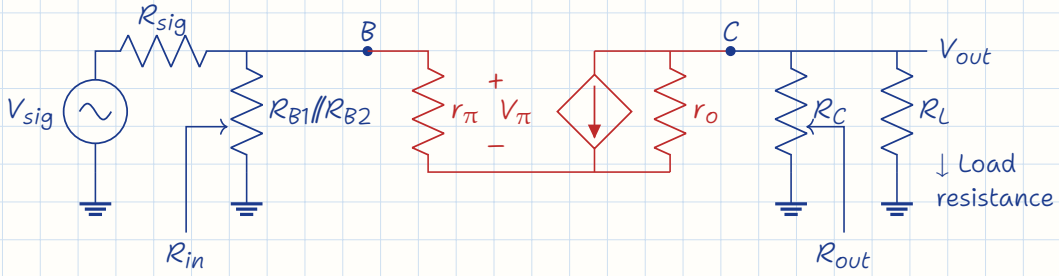
orj. s. 3

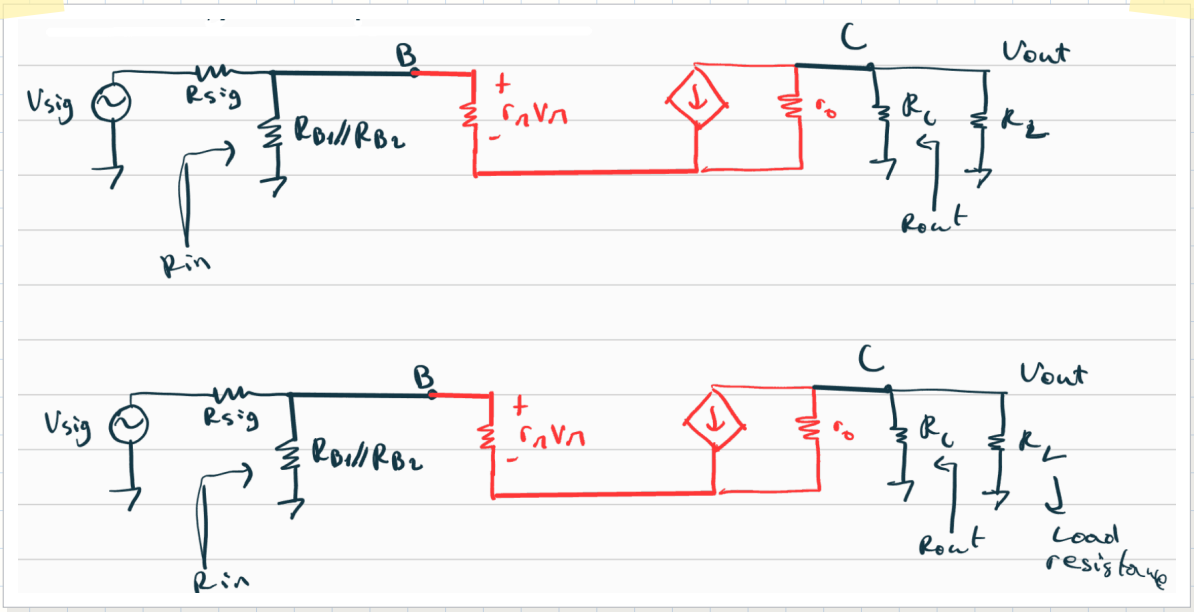
- Now all caps are short circuit
- DC voltage sources are short circuit
- DC current sources are "open circuit"



orijinal çizim, s. 3

Small signal equivalent circuit



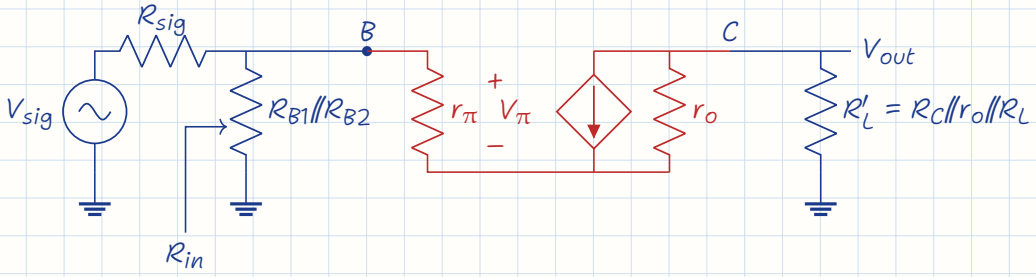


orijinal çizim, s. 3

$$A_v = \frac{v_{out}}{v_{in}}, \quad R_{in}, \quad R_{out}$$

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

orj. s. 4



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

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

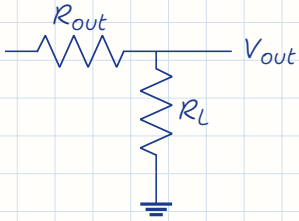
$$\frac{v_{out}}{v_{sig}} = -\left(\underbrace{\frac{R_{B1} \parallel R_{B2} \parallel r_\pi}{R_{sig} + (R_{B1} \parallel R_{B2} \parallel r_\pi)}}_{\text{Due to large } R_{sig}} \right) g_m \cdot R'_L$$

$$R_{sig} \approx 0 \Rightarrow = -g_m R'_L$$

→ High Voltage Gain $\cong -g_m R'_L$
→ Moderate Input Resistance → $R_{B1} \parallel R_{B2} \parallel r_\pi$

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

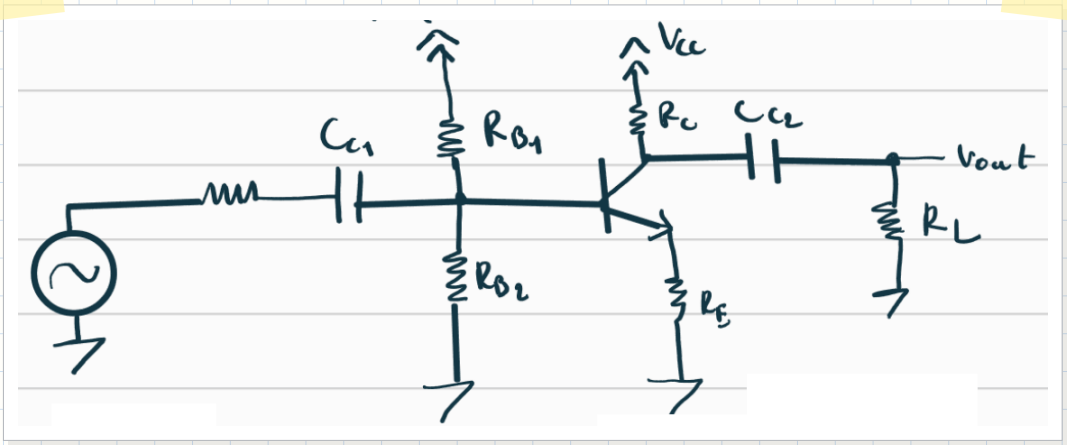
R_{in} büyük olsun isteriz



R_{out} küçük olmasını isteriz

Common Emitter amplifier with R_E

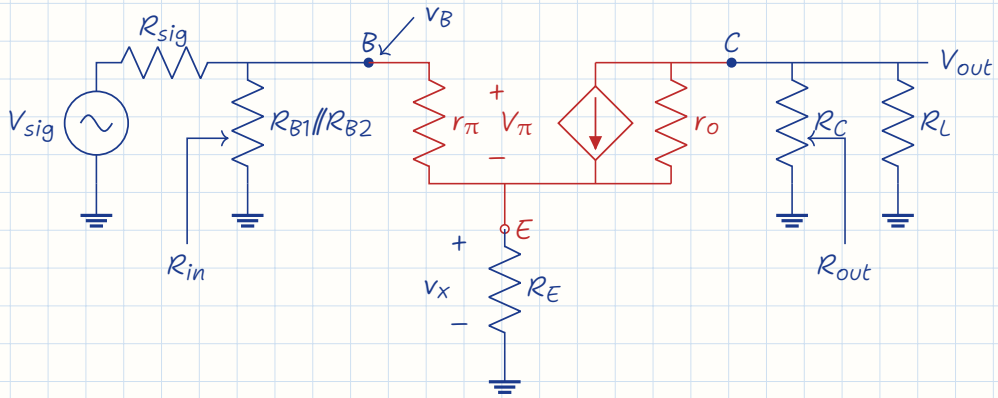
orj. s. 5



orijinal çizim, s. 5

Use t model

$R_B = R_{B1} \parallel R_{B2}$



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

$$R_{in} = R_B\left(r_\pi + R_E(\beta + 1)\right)$$
$$= R_B \parallel \left[(\beta + 1)(r_e + R_E)\right]$$
$$R_{out} \cong R_C$$
$$A_v = \frac{v_{out}}{v_{in}}$$

$$v_{out} = -g_m V_\pi (R_C \parallel R_L) \qquad V_\pi \stackrel{?}{=} V_{sig}$$

$$v_x = \left(g_m V_\pi + \frac{V_\pi}{r_\pi}\right) R_E$$
$$= \left(\frac{V_\pi}{r_e} + \frac{V_\pi}{r_\pi}\right) R_E \cong \frac{v_\pi}{r_e} \cdot R_E$$
$$v_b = v_\pi \left(1 + \frac{R_E}{r_e}\right)$$

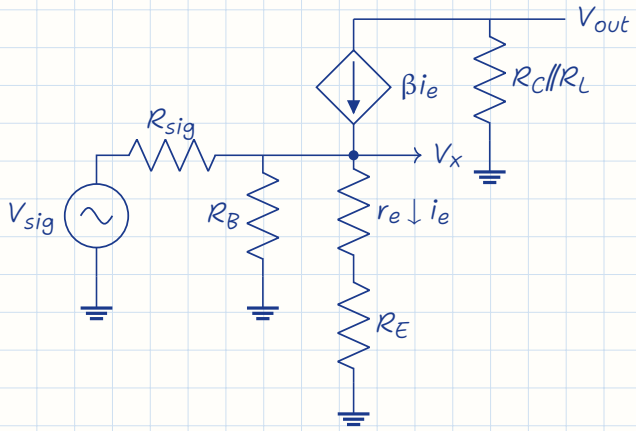
if $R_{sig} \approx 0$ $v_b = v_{sig}$

orj. s. 6

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

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

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

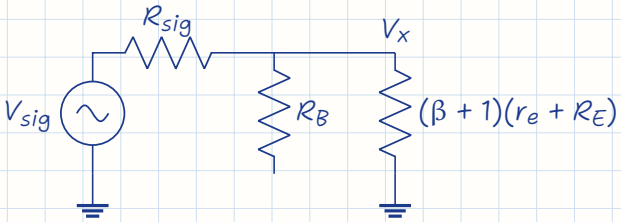


② → $v_x = i_e (R_E + r_e)$

? $V_{sig} \neq i_e (R_E + r_e)$

③

$$\frac{v_{out}}{V_{sig}} = \frac{-\alpha i_e (R_C \parallel R_L)}{i_e (R_E + r_e)}$$



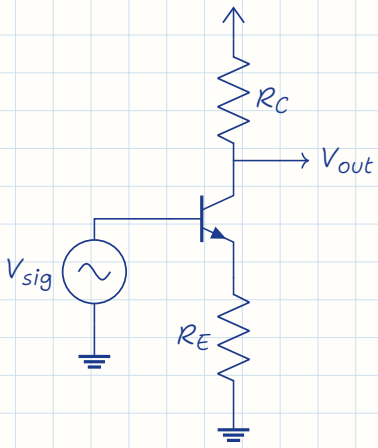
$$V_x = \frac{(\beta + 1)(r_e + R_E) \parallel R_B \cdot V_{sig}}{R_{sig} + \underbrace{(\beta + 1)(r_e + R_E) \parallel R_B}_{\downarrow T}}$$

$R_{signal} \ll T$

orj. s. 7

Validation

[1] Claude notu: $g_m = 1/r_e$ yerine konduğunda payda g_m kalmamalı, yani $-\frac{(R_C \parallel R_L)}{r_e(1 + R_E/r_e)}$ olmalı; son sonuç doğru.



$$A_v = -\frac{R_C}{R_E}$$

High input Imp
Low voltage gain
More output Imp
More stable
Independent of g_m
High bandwidth