Elektronik I

31.05 dersi – Common-Base ve Common-Collector yükselteçler, MOSFET temelleri

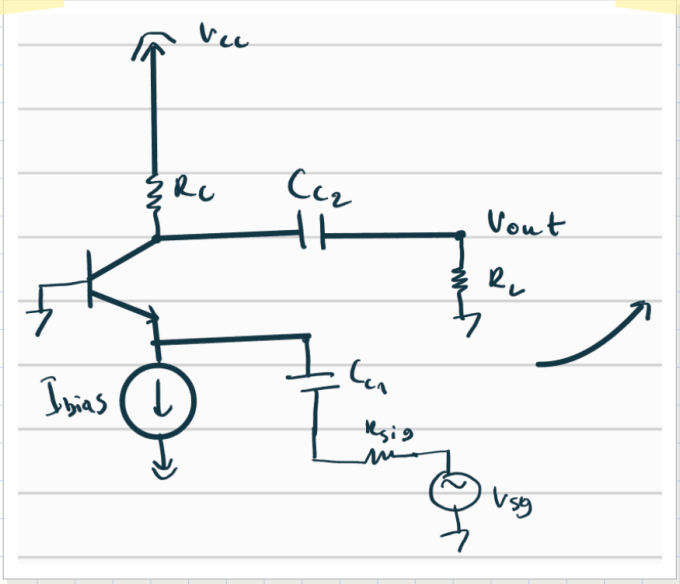
Orijinal not: 3105-elektronik-1.pdf

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.

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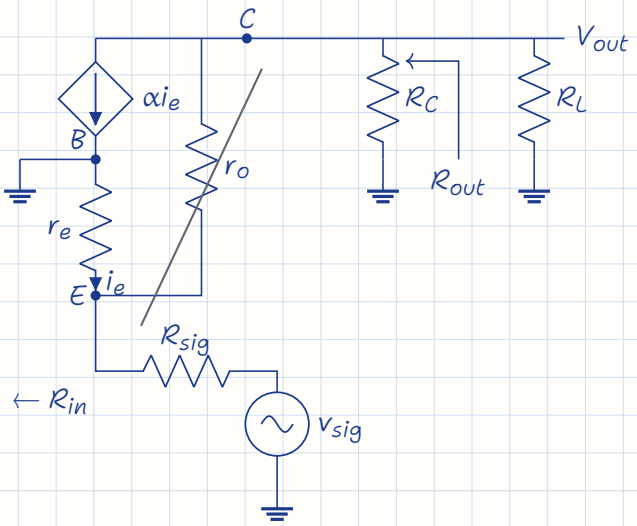
Common-Base Amplifier

orj. s. 1



orijinal çizim, s. 1

T model



$$R_{in} = r_e$$
$$R_{out} = R_C$$

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

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

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

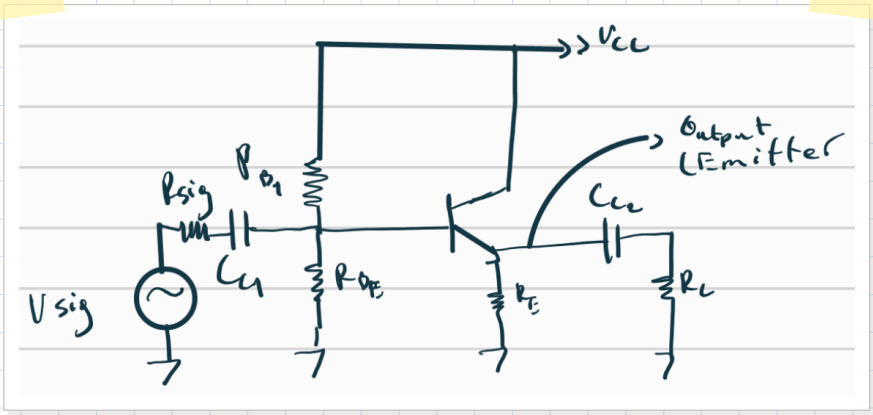
$\Rightarrow$ if $R_{sig} \ll r_e$ ignore R_{sig}

$\Rightarrow g_m (R_C \parallel R_L)$ $\left[r_e = \frac{1}{g_m}\right]$

orj. s. 2

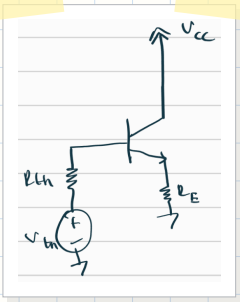
- Small input Resistance (opposite C-E)
  ↗ normalde yüksek giriş direnci isteriz sinyalin zayıflamaması için
- Moderate – High Output Resistance (C-E)
- High gain (C-E)

Common-Collector Amplifier (Emitter-Follower)



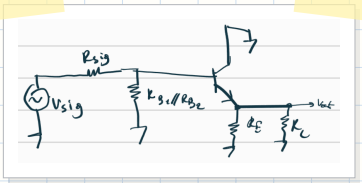
orijinal çizim, s. 2

DC



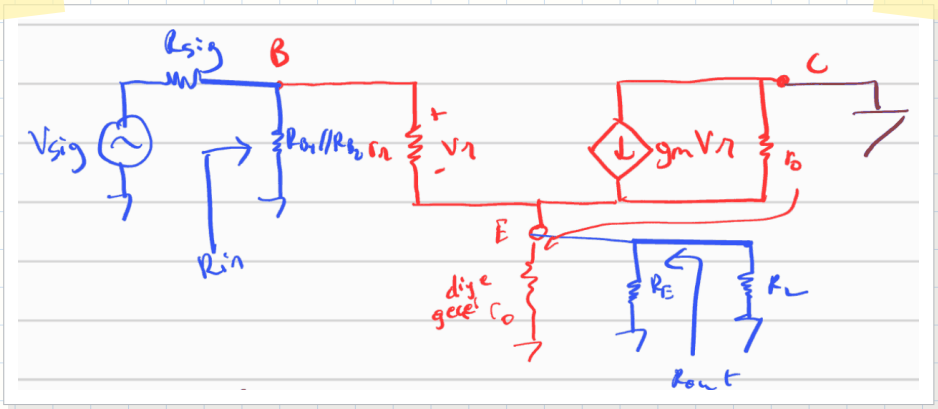
orijinal çizim, s. 2

AC ?A ≠ ∞



orijinal çizim, s. 2

orj. s. 3



orijinal çizim, s. 3

$$R_{in} = ? \quad (R_{B1} /\!/ R_{B2}) /\!/ (r_\pi + (\beta + 1)(R_E /\!/ R_L /\!/ r_o))$$

$$R_{out} = ? \quad r_o /\!/ R_E /\!/ \left(\frac{(R_{sig} /\!/ R_{B1} /\!/ R_{B2}) + r_\pi}{\beta + 1} \right)$$

$$\frac{V_{out}}{V_{sig}} = \frac{V_\pi (g_m + 1/r_\pi) R'_L}{V_\pi + V_\pi (g_m + 1/r_\pi) R'_L} \quad \Rightarrow \quad \begin{matrix} R_{sig} = 0 \text{ (Assumption)} \\ V_{sig} = V_\pi + V_\pi (g_m + 1/r_\pi) R'_L \end{matrix}$$

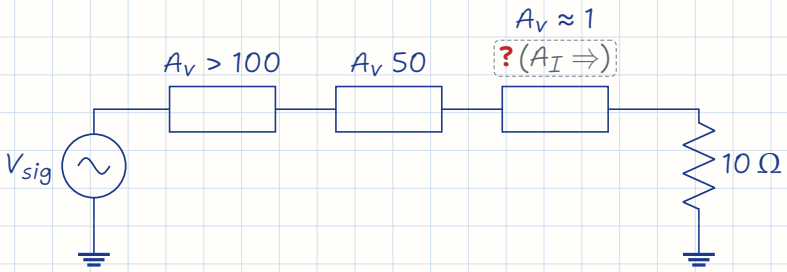
$$A_v = \frac{V_{out}}{V_{sig}} = \frac{(g_m + 1/r_\pi) R'_L}{1 + (g_m + 1/r_\pi) R'_L}$$

Her zaman

- Voltage gain < 1 (0,6 ~ 0,??)
- High current output gain
- Input High Resistance
- Low Output resistance

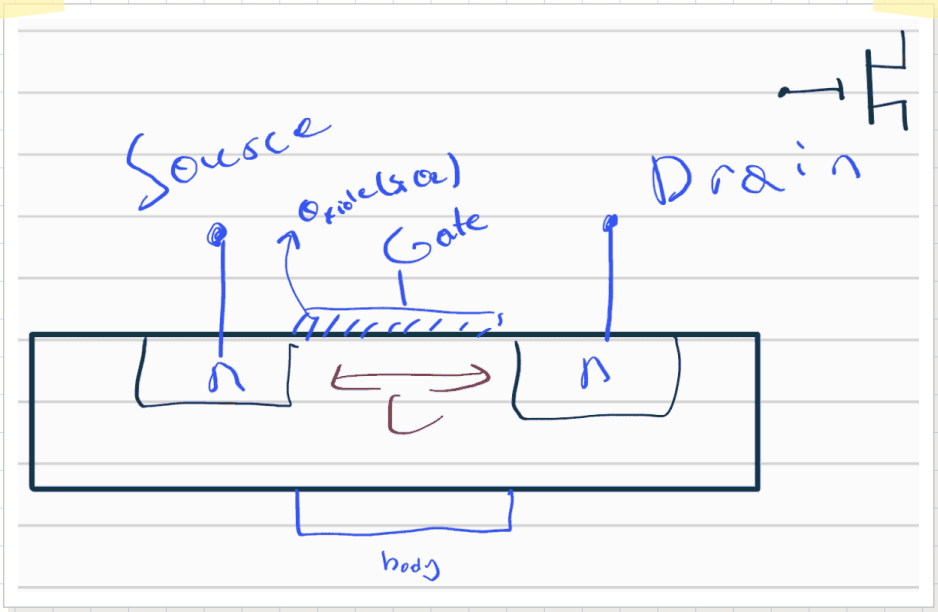
You can use as
Voltage buffer

- Use it at the last stage of ripple stage amplifier



Mosfet

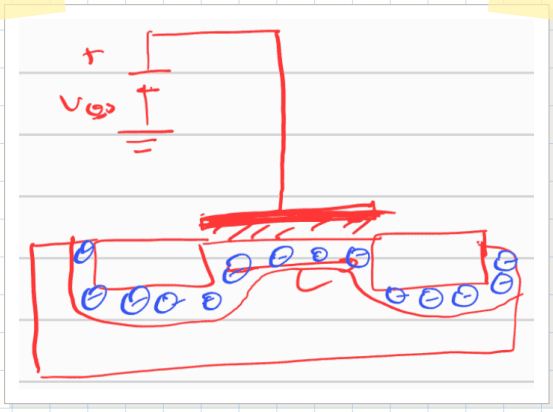
orj. s. 4



orijinal çizim, s. 4

Drain is positive

5.1.3 Creating a channel for current Flow



orijinal çizim, s. 4

⋮

Threshold Voltage (V_T) – is the min value of v_{GS}

field effect!

orj. s. 5

effective / overdrive voltage

$$v_{OV} = v_{GS} - V_t$$

oxide capacitance (C_{ox})

$$C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}} \text{ in } F/m^2 \qquad C = \frac{\varepsilon A}{d}$$

$$|Q| = C_{ox}(WL)\,v_{OV} \text{ in } C$$

Applying a small v_{DS}

$$i_D = (C_{ox} W v_{OV})\left(\frac{\mu_n v_{DS}}{L}\right) A \qquad \text{? kontrol et}$$

⋮

Small v_{DS}

$$\text{(eq 5.7)} \quad i_D = \left[(\mu_n C_{ox})\frac{W}{L} v_{OV}\right] v_{DS} \text{ in A}$$

$$\text{(eq 5.8a)} \quad r_{DS} = \frac{v_{DS}}{i_D} = \frac{1}{(\mu_n C_{ox})\left(\frac{W}{L}\right)} \cdots$$

Operation as v_{DS} increased

$$v_{GD} = v_{GS} - v_{DS}$$

→ v ...

orj. s. 6



orijinal çizim, s. 6

★ Saturation Current formula

$$I_D = \frac{1}{2}\underbrace{\overbrace{\mu_n C_{ox}}^{k'_n}\frac{W}{L}}_{k_n}(V_{GS} - V_t)^2$$

$$I_D = \mu_n C_{ox}\frac{W}{L}\left((V_{GS} - V_t) - \frac{1}{2}V_{DS}\right)V_{DS}$$

Cutoff	Triode	Saturation
$v_{GS} < V_t$	$v_{GS} \geq V_T$ $v_{DS} < V_{OV}$	$v_{GS} \geq V_T$ $v_{DS} \geq V_{OV}$

Operation for $v_{DS} \gg V_{OV}$

⋮

The p Channel MOSFET

$$V_{SG} \geq |V_{tp}| \rightarrow V_{tp} < 0$$
$$V_{SG} < |V_t| \rightarrow \text{Cutoff}$$

orj. s. 7

$V_{SG} \geq \lvert V_T \rvert \Rightarrow$ $V_{SD} \geq V_{OV} \Rightarrow$	Saturation
$V_{SG} \geq \lvert V_t \rvert$ $V_{SD} < V_{OV}$	Triode

$$\text{(NMOS)} \quad I_{D1} = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{OV})^2$$
$$\text{(PMOS)} \quad I_{D2} = \frac{1}{2}\mu_p C_{ox}\frac{W}{L}(V_{OV})^2$$

if $\frac{W}{L}$, C_{ox}, V_{OV} are equal $\Rightarrow I_{D1} > I_{D2}$ because

$$\underset{\substack{\uparrow \\ \text{electron} \\ \text{mobility}}}{\mu_n} > \mu_p$$

Quick Recap

The i_D–v_{GS} Characteristics:

In sat

Örnek (Ex 5.3)

$I_D = 0{,}4$ mA

$V_D = 0{,}5$ V

$\mu_n C_{ox} = 100\ \mu A/V^2$ $\quad L = 1\ \mu m,\ W = 32\ \mu m$

$$0{,}4\text{ mA} = \frac{1}{2}\,0{,}1\text{ mA}\left(\frac{\cancel{32}^{16}}{1}\right)(V_{ov})^2$$

$$V_{ov} = 0{,}5 \leftarrow (V_{ov})^2 = 0{,}25 \rightarrow V_{ov} = +0{,}5$$

orj. s. 8

$$V_{GS} = 0{,}5 + \overset{\frown}{0{,}7}^{V_T} \qquad V_S = -1{,}2$$

$R_S =$

⋮

Örnek (Ex 5.5)

$V_{GS} \geq V_t$ $\qquad$ $V_{DS} \geq V_{ov}$

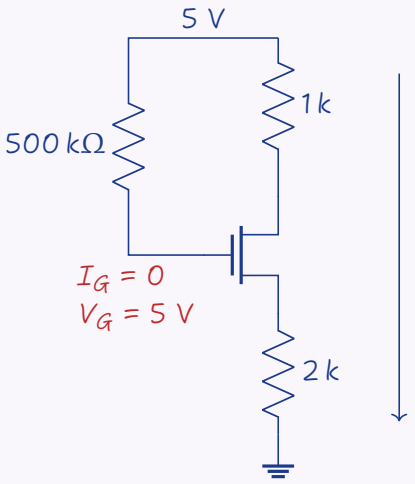
$5 - 0 \geq 1$ V ✓ $\qquad$ $0{,}1 \geq 4$ V ? × Triode

$$I_D = \mu_n C_{ox} \frac{W}{L}\left(V_{ov} - \frac{1}{2}V_{DS}\right) V_{DS} \qquad r_{DS} = \frac{V_{DS}}{I_D}$$

$$\hookrightarrow 1\ \text{mA/V}^2\,(4 - 0{,}05)\,0{,}1$$

$I_D = 0{,}395$ mA $\qquad$ $\frac{V_{DS}}{I_D} = 253\ \Omega$

Örnek



$\mu_n C_{ox} \frac{W}{L} = 0{,}25\ \text{mA/V}^2$

$V_{tn} = 2$ V

$\lambda = 0$ $\qquad$ $V_A =$?0 V

$I_D,\ V_G,\ V_S,\ V_D$ = ?

orj. s. 9

$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_t)^2$$

$$I_D = \frac{1}{2}\,0{,}25\ \text{mA/V}^2\,(5 - V_S - 2)^2$$

$$I_D = \frac{1}{2}\,0{,}25\ \text{mA/V}^2\,(3 - V_S)^2$$

$$I_D = \frac{1}{2}\,\frac{0{,}25\ \text{mA}}{\text{V}^2}\,(3 - 2I_D)^2$$

$$I_D = \frac{1}{2}\,\frac{0{,}25\ \text{mA}}{\text{V}^2}\left(9 + 4I_D^2 - 6I_D\right) \quad [1]$$

$$8I_D = 9 + 4I_D^2 - 6I_D$$

$$4I_D^2 - 14I_D + 9 = 0$$

[1] Claude notu: muhtemelen $(3 - 2I_D)^2 = 9 + 4I_D^2 - 12I_D$ olmalı; bu durumda denklem $4I_D^2 - 20I_D + 9 = 0$ olur.