Elektronik I

Final notu – BJT ve MOSFET özeti, küçük işaret modelleri

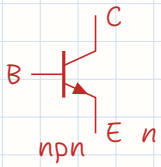
Original notes: Final-notu.pdf

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

BJT



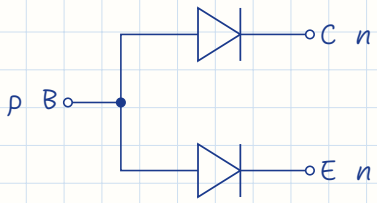
$$i_C = I_S e^{v_{BE}/V_T}$$

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

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

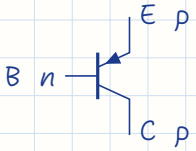
	Active	Sat	Cutoff
EBJ	Forward bias	Forward bias	Reverse bias
CBJ	Reverse bias	Forward bias	Reverse bias

In npn



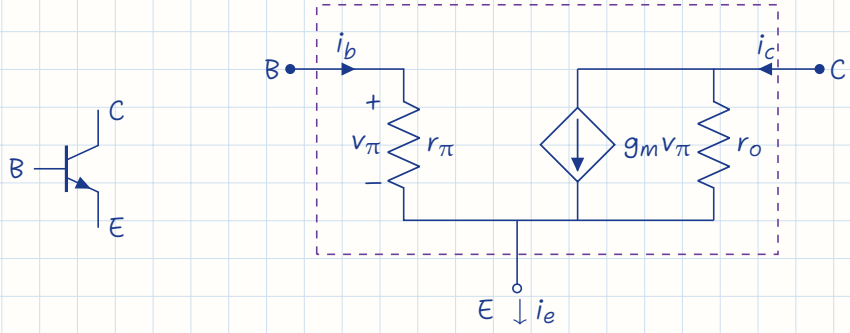
Active: $V_{BE} \geq 0{,}7$, $V_{BC} \leq 0{,}4\,V$
Cutoff: $V_{BE} < 0{,}7$, $V_{BC} \leq 0{,}4\,V$
Saturation: $V_{BE} \geq 0{,}7$, $V_{BC} > 0{,}4\,V$

In pnp



Active: $V_{EB} \geq 0{,}7$, $V_{CB} \leq 0{,}4\,V$
Cutoff: $V_{EB} < 0{,}7$, $V_{CB} \leq 0{,}4\,V$
Saturation: $V_{EB} \geq 0{,}7\,V$, $V_{CB} > 0{,}4\,V$

Small signal Models



$$i_b = \frac{v_\pi}{r_\pi}$$

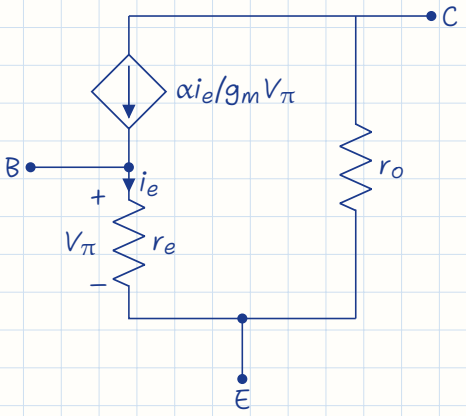
$r_o \rightarrow$ output resistance of bjt : $r_o = \dfrac{|V_A|}{I_C}$ $\quad (I_C \rightarrow DC)$

$g_m \rightarrow$ transcunductance : $g_m = \dfrac{I_C}{V_T}$

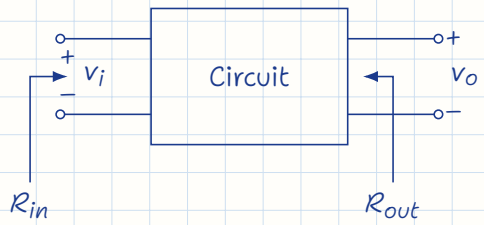
$r_\pi \rightarrow$ base resistance : $r_\pi = (\beta + 1)\, r_e$

$r_e \rightarrow$ emitter resistance : $r_e = \dfrac{V_T}{I_E} = \alpha \dfrac{V_T}{I_C} = \dfrac{1}{\cancel{\alpha}} \dfrac{1}{g_m}$

T model



$$r_o = \frac{|V_A|}{I_C}$$
$$g_m = \frac{I_C}{V_T}$$
$$r_\pi = (\beta + 1)\, r_e$$
$$r_e = \frac{V_T}{I_E} = \alpha \frac{V_T}{I_C} = \frac{1}{\cancel{\alpha}} \frac{1}{g_m}$$



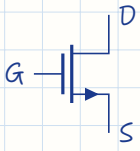
Voltage Gain

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

$R_{in} \rightarrow$ Input Resistance
$R_{out} \rightarrow$ Output Res.

Mosfet

NMOS



$V_{DS} < V_{GS} - V_t$
$V_{GS} \geq V_t$ } Triode
$V_{DS} \geq V_{GS} - V_t$ } Saturation

$v_{GS} < V_t$ } cut off

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

NMOS

Triode	$v_{GS} \geq V_t$	Saturation Region
$V_{GD} > V_t$		$V_{GD} \leq V_t$
$V_{DS} < V_{OV}$		$V_{DS} \geq V_{OV}$
$i_D = k'_n \left(\frac{W}{L}\right)\left(V_{OV} - \frac{1}{2}V_{DS}\right)V_{DS}$		$i_D = \frac{1}{2}k'_n \left(\frac{W}{L}\right)v_{OV}^2$

($k'_n = \mu_n C_{ox}$)

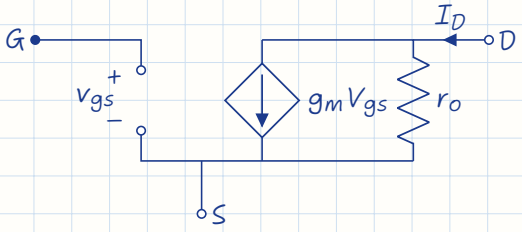
PMOS

PMOS

Triode Region	Saturation Region
$V_{DG} > \lvert V_t \rvert$	$V_{DG} \leq \lvert V_t \rvert$
$V_{SD} < \lvert V_{OV} \rvert$	$V_{SD} \geq \lvert V_{OV} \rvert$
$i_D = k'_p \left(\frac{W}{L}\right)\left(\lvert V_{OV} \rvert - \frac{1}{2}V_{SD}\right)V_{SD}$	$i_D = \frac{1}{2}k'_p \left(\frac{W}{L}\right)V_{OV}^2$

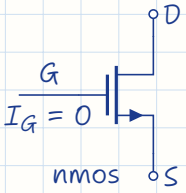
Mosfet small signal

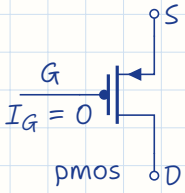
→ π model



$g_m = \frac{2I_D}{V_{OV}}$

$r_o = \frac{V_A}{I_D}$





T model

