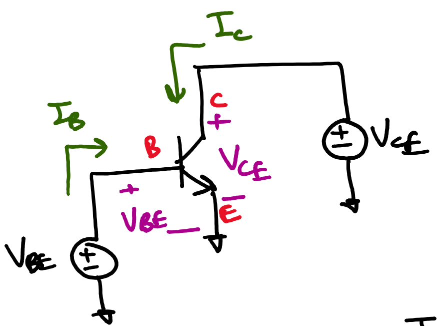
ECE 310 - Lecture 29

Wednesday, April 4, 2018 10:33 AM

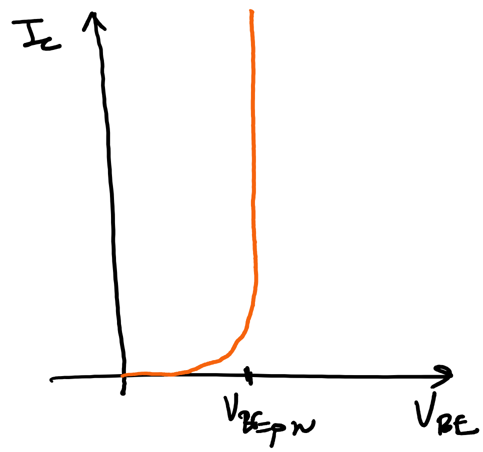


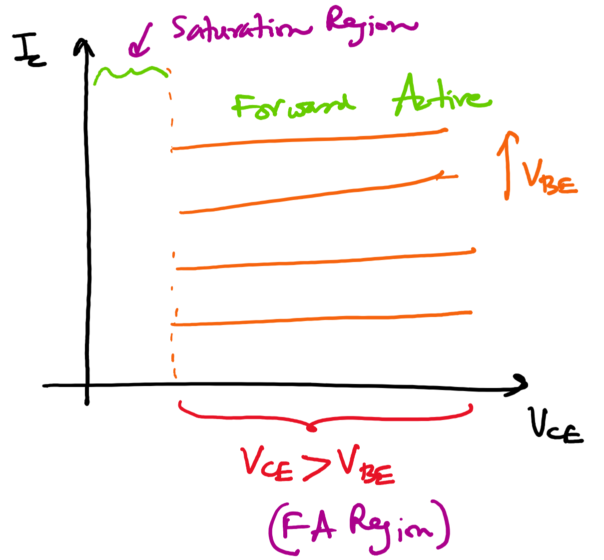
Nominally:

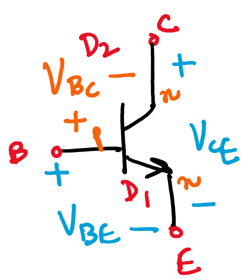
$V_{BE} > V_{BE,on}$ FWD BIAS

$V_{BC} < 0$ REV BIAS

} Forward Active Regime (FA)







$V_{CE} > V_{BE} \Rightarrow V_{BC} = V_{BE} - V_{CE} < 0$ D_2 is REV Bias

But if $V_{CE} < V_{BE} \Rightarrow V_{BC} > 0$

for $V_{BC} > 0$ Diode D_2 starts getting fwd biased

for $V_{BC} \gg 0$, say 200mV

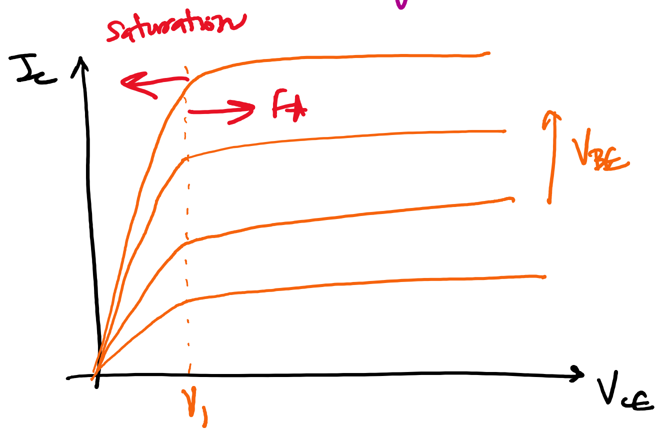
↳ $D_2 \Rightarrow$ BC junction starts carrying significant current

↳ A large number of holes must be supplied to the base terminal $\Rightarrow$ $I_B \uparrow$ while $I_C \leftrightarrow$

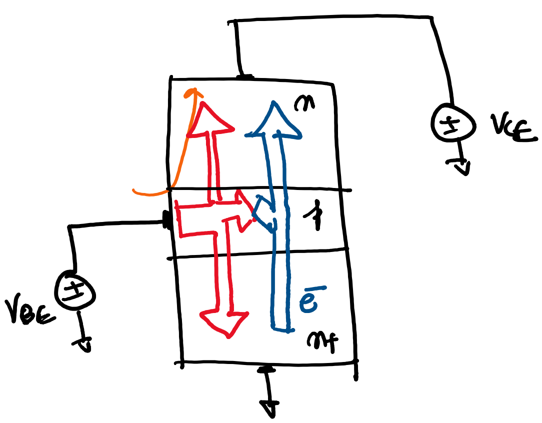
$\beta = \frac{I_C}{I_B} \downarrow$

↳ Saturation (not the MOSFET one) leads to a sharp rise in the current ⇒ thus a rapid fall in β in base current ⇒ thus a rapid fall in β

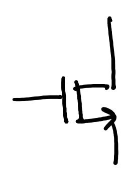
$g_m \propto \beta$

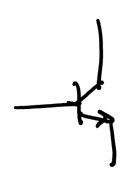


"Saturation" ⇒ because increasing the base current (I_B) in this region leads to little change in collector current



large base current in Saturation
↳ Effectively $\beta \downarrow$
also the speed of BJT degrades.

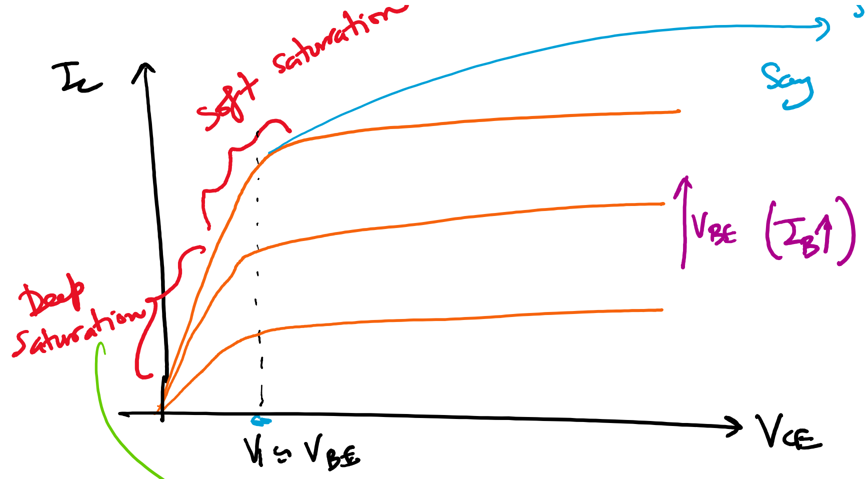




CUTOFF	$V_{GS} < V_{THN}$	$V_{BE} < V_{BE,on}$	CUTOFF
TRIODE	$V_{DS} < V_{DS,sat}$	$V_{CE} < V_{BE}$	SATURATION
SATURATION	$V_{DS} > V_{DS,sat}$	$V_{CE} > V_{BE}$	FORWARD ACTIVE

$I_C \uparrow$ at saturation → Soft saturation

Say $V_{BE} \simeq 200mV$ and

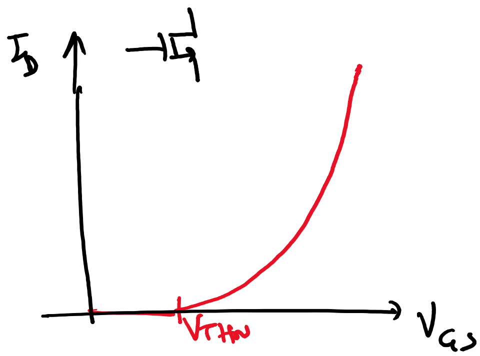


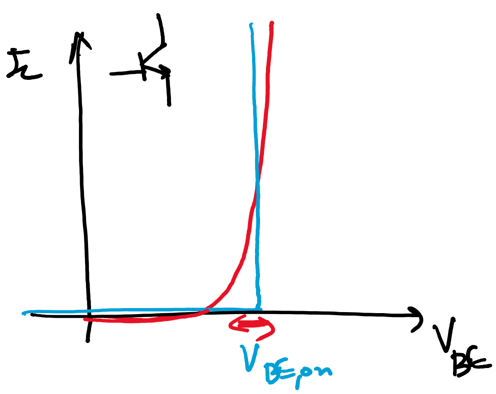
Soft saturation

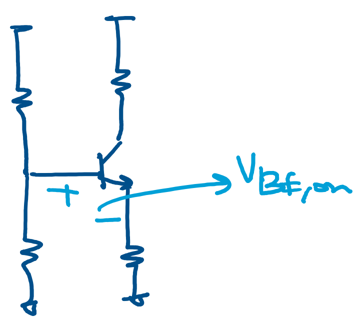
Say $V_{BE} \simeq 200mV$ and less amount of current flows

Deep saturation

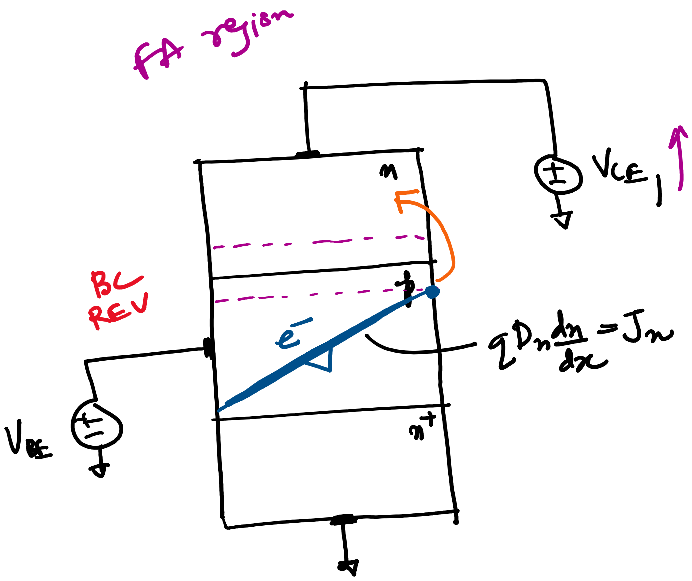
Say $V_{CE} \simeq 200mV$ and large amount of base current can flow $\Rightarrow \beta \downarrow$

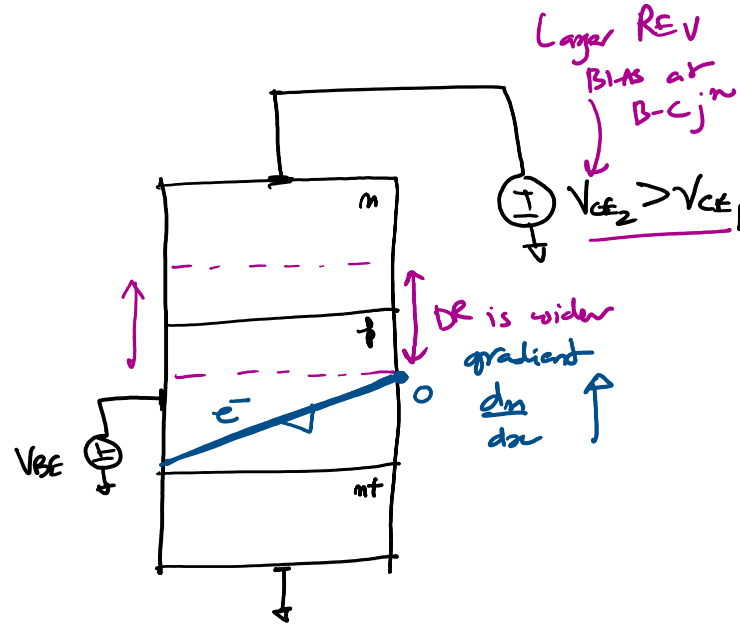






Early Effect





if V_{CE} ↑

↳ reverse bias at the BC junction ↑

↳ Depletion Region width at BC J^n ↑

↳ $\bar{e}$ profile, $n(x)$, gets more "slopy" $\left|\frac{dn}{dx}\right|$ ↑

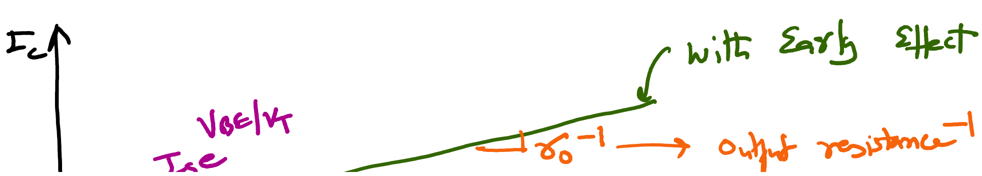
⇒ Also the effective Base width ↓

⇒ Collector Current, I_C ↑

$$I_C = I_S\left(e^{\frac{V_{BE}}{V_T}} - 1\right)\left(1 + \frac{V_{CE}}{V_A}\right)$$

EARLY VOLTAGE (V_A)

$$\simeq I_S e^{\frac{V_{BE}}{V_T}} \cdot \left(1 + \frac{V_{CE}}{V_A}\right)$$



$$I_C = \underbrace{I_S e^{V_{BE}/V_T}}_{I_{C0}} \left(1 + \frac{V_{CE}}{V_A}\right) = I_{C0}\left(1 + \frac{V_{CE}}{V_A}\right)$$

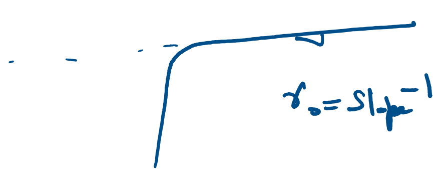
$$\frac{\partial I_C}{\partial V_{CE}} = \frac{I_{C0}}{V_A}$$

$$r_o = \left(\frac{\partial I_C}{\partial V_{CE}}\right)^{-1} = \frac{V_A}{I_{C0}}$$

$$r_o = \frac{V_A}{I_{C0}} \simeq \boxed{\frac{V_A}{I_C}}$$

In the Book $V_A \simeq 20V$

$V_A \to \infty \Rightarrow r_o \to \infty$



performance metric $\frac{g_m}{I_D}$

BJTs have higher $\frac{g_m}{I_D}$ than MOSFET

$I_D >$

BiCMOS $\Rightarrow$ NMOS, PMOS

BiCMOS ⇒ NMOS
PMOS
npn HBT
pnp HBT

90nm BiCMOS.