.

EE1101: Circuits and Network Analysis

Lecture 13: BJT and MOSFET Circuits

August 26, 2025

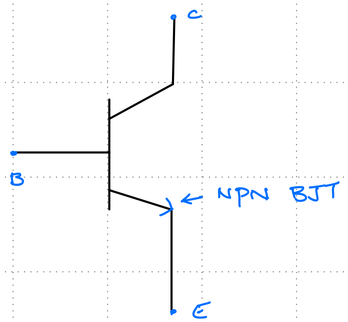
Topics :

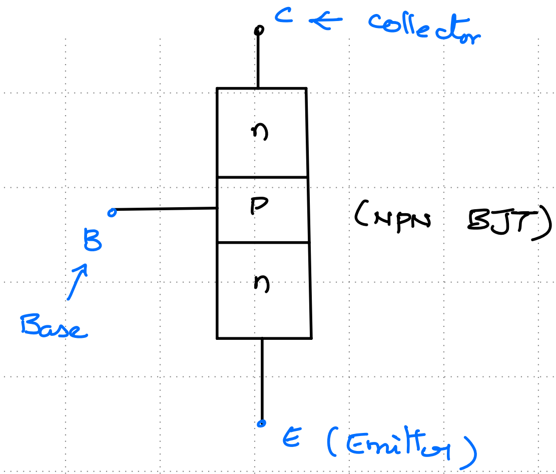
1. Bipolar Junction Transistor (BJT)

2. Metal Oxide Semiconductor Field Effect Transistor (MOSFET)

BJT from a Circuit Perspective

Circuit Symbol:





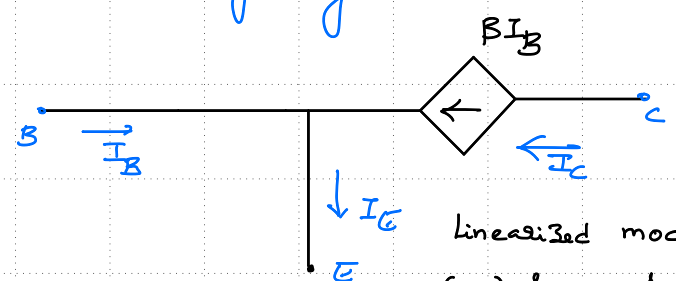
Control Part: B − E

Main Ckt: C − E

Cut-off mode → OFF State : $V_{BE} < 0.7\,V$ (typically) (range is 0.5 − 2V)

ON State : $V_{CE} < V_{CE,sat}$ (typically 0.2V) & $V_{BE} > 0.7\,V$ (typically)
(saturation mode)

Amplifier (Active mode) : $V_{BE} > 0.7V$ & $V_{CE} > V_{CE,sat}$ ⇒



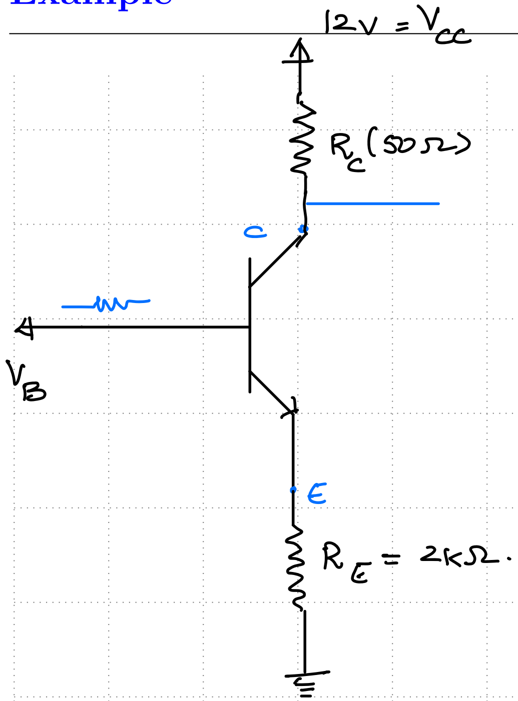
Linearized model (or) small signal Equivalent.

$I_C = \beta I_B$ ← Current gain

$I_E = (1+\beta) I_B$

To operate as a switch : avoid Amplifier mode
→ Pick V_{BE} high enough
→ if max (V_{BE}) is fixed, adjust the ckt design.

Example



$\beta = 99$: Compute V_B such that BJT operates in ON state

Bec the seq is OFF — Amp — ON

↓

use the Eq ckt & find V_B when $V_{CE} \approx 0.2\,V$: $V_{B,ON}$

↓

any V_B above $V_{B,ON}$ will the drive the ckt in to one state.

① $V_C = V_{CC} - I_C R_C$

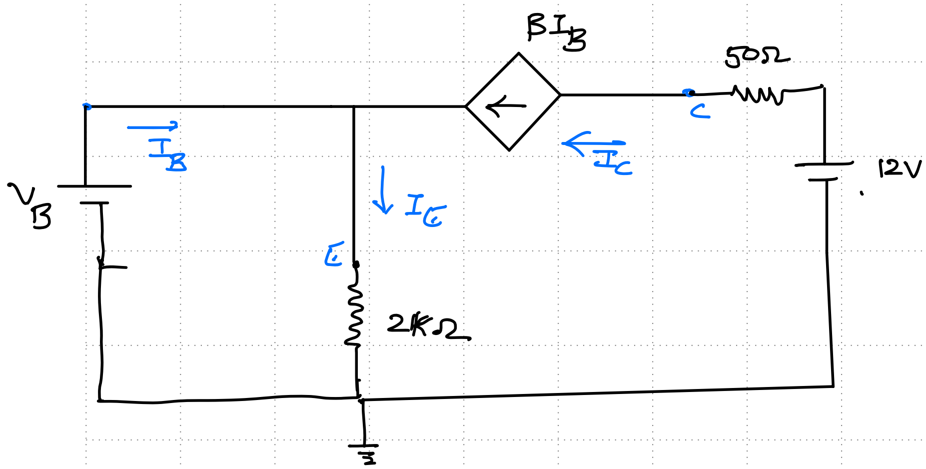
$= V_{CC} - \beta I_B R_C$

② How to compute $I_B \rightarrow$?

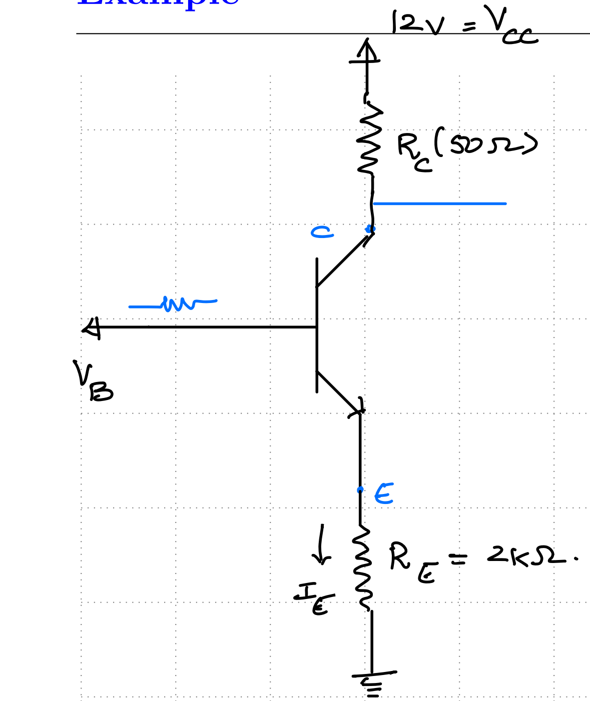
by KVL in loop 1: $\underbrace{I_B(1+\beta)}_{I_E} R_E = V_B$.

$\Rightarrow I_B = \dfrac{V_B}{R_E(1+\beta)}$.

for given values: $I_B = \dfrac{V_B}{2} \times 10^{-5}$



Example



To drive the ckt to ON state:

$$V_{CE} < 0.2V$$

$$V_C - V_E$$

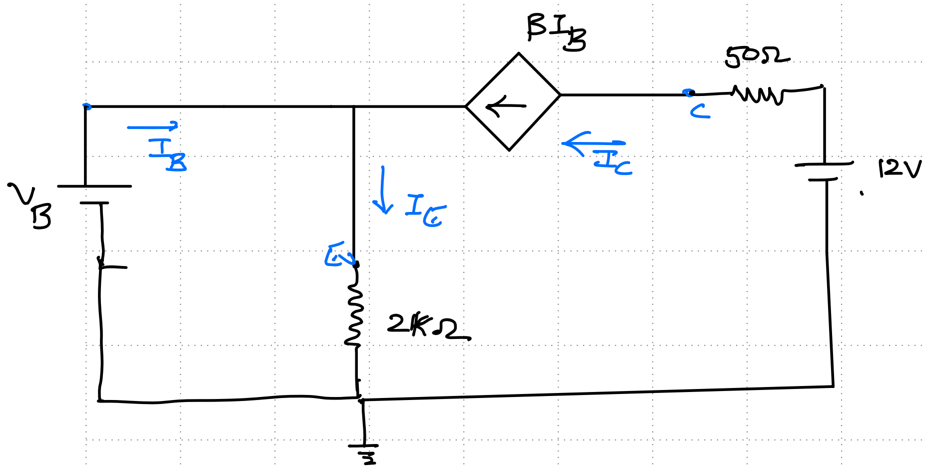
$$V_C - V_B < 0.2V$$

$$\left[V_{CC} - \frac{\beta V_B}{(1+\beta) R_E} R_C\right] - V_B = 0.2V \longrightarrow \text{Solve to get } V_B.$$

$$V_{B,ON} \approx V_B$$

$$V_{B,ON} \approx 11.5$$

$$V_{B,ON} > 11.5\ V.$$



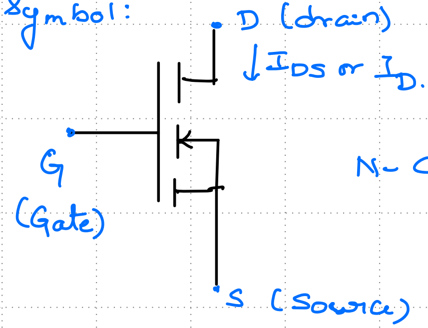
if R_c is changed to $2k\Omega$

$$V_{B,ON} = 5.92V.$$

$$V_B > 5.92V$$

MOSFET from a Circuit Perspective

Circuit Symbol:



N- Channel MOSFET

Control Part: G − S

Main Ckt: D − S

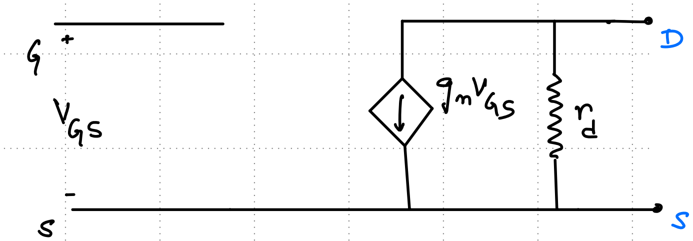
OFF State : $V_{GS} < V_t$

ON State : $V_{GS} > V_t$ and $V_{DS} < V_{GS} - V_t$

Amplifier : $V_{GS} > V_t$ and $V_{DS} > V_{GS} - V_t$

typical range of V_t is 0.6V to 2.5V.

$\Rightarrow$



Small signal Equivalent of a MOSFET.