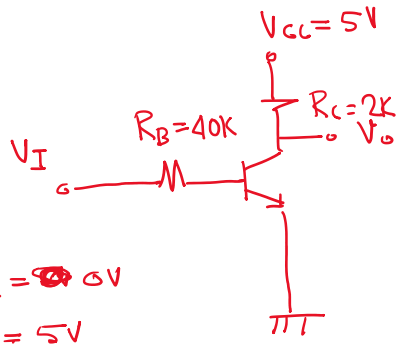
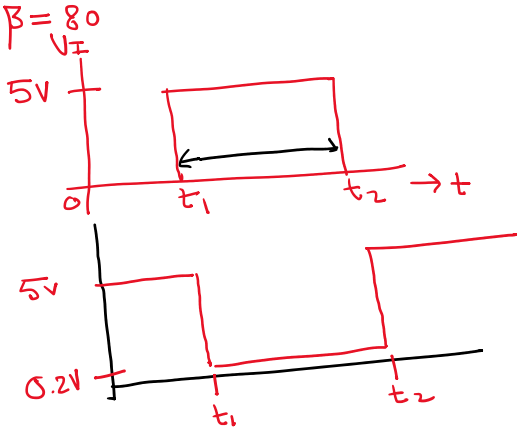
BJT Switching

Cut-off & Saturation

Cutoff → OFF
& triode region → ON
} MOSFET Switching





or $0<t<t_1$: $V_I = 0V$

$t_1<t<t_2$: $V=5V$

$0<t<t_1$, $V_I=0V$

Check EBJ, $V_P - V_N = 0-0 < 0.7V$

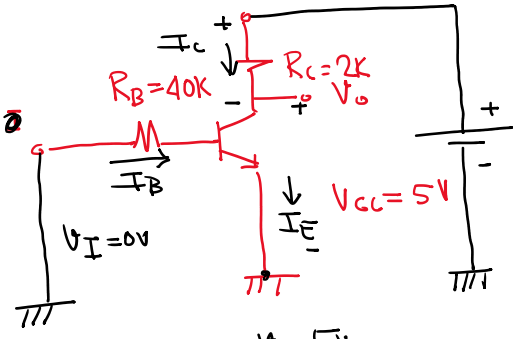
R.B

Cut-off Region.

$I_B = I_C = I_E = 0$

$V_o = V_{CE} = V_{CC} - I_C R_C$ ($I_C R_C = 0$)

$V_o = V_{CE} = V_{CC} = 5V$



$V_I = 0 \rightarrow V_o = 5V$

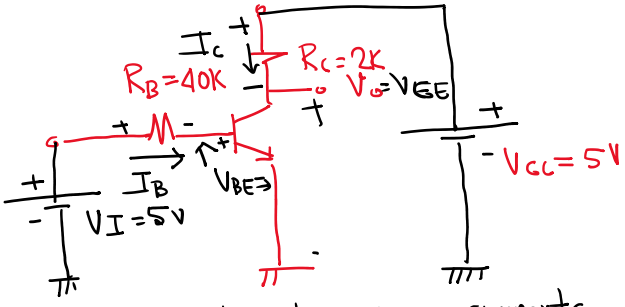
Low → High.

$t_1<t<t_2$: $V=5V$

Check EBJ: F.B

$V_P - V_N = 5-0 > 0.7V$

- Saturation
- ~~Cut-off~~ Active



Assume Saturation : ☐ No α/β to determine currents

☐ $V_{CE(Sat)} = 0.2V$,

☐ $\beta_f = \left(\frac{I_C}{I_B}\right)_{sat} < \beta$ [for Justification]

$V_I - I_B R_B - V_{BE} = 0$

$\Rightarrow I_B = \frac{V_I - V_{BE}}{R_B}$

$= \frac{5-0.7}{40K} = 0.1075\,mA$

$V_o = V_{CE(sat)} = 0.2V$

$V_I = 5V \rightarrow V_o = 0.2V$

High → Low

KVL In output loop

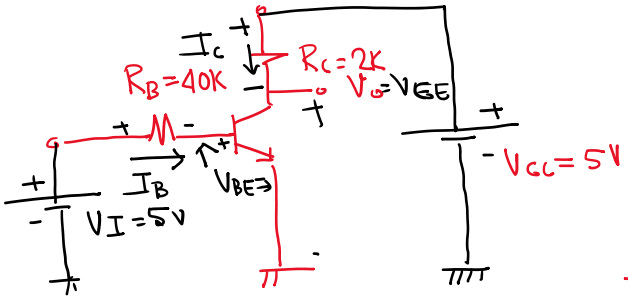
$= \frac{5-0.7}{40K} = 0.1075\ mA$

KVL In output loop

$+V_{CE}(sat) + I_C R_C = V_{CC} \Rightarrow V_{CE}(sat) = V_o = \frac{V_{CC} - V_{CE}}{R_C}$

$= \frac{5-0.2}{2} = 2.4\ mA$

$\beta_f = \frac{2.4}{0.1075} \simeq 22 < \beta\ (80)$



Assume, Active region
- α/β Allowed to determine currents
- Justification. $V_{CB} \rightarrow$ R.B or not

$V_{CE} > 0.3V \rightarrow$ Active
$< 0.3V \rightarrow$ Saturation.

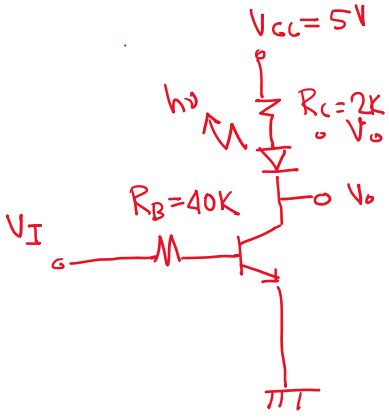
$I_B = 0.1075\ mA,$
$I_C = \beta I_B = 80 \times 0.1075\ mA = 8.6\ mA$

$+V_{CE} + I_C R_C = V_{CC} \Rightarrow V_{CE} = V_{CC} - I_C R_C$
$= 5 - 8.6 \times 2$
$= -12.2V < 0.3V$

V_{CE} Saturation.

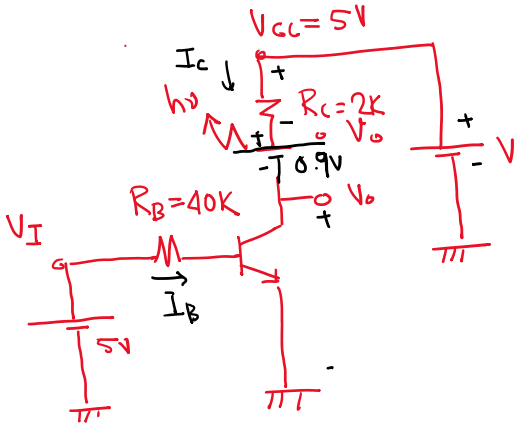
$V_{CE} = V_o = 0.2V$

$V_I - I_B R_B - V_{BE} = 0$
$\Rightarrow I_B = \frac{V_I - V_{BE}}{R_B}$
$= \frac{5-0.7}{40K} = 0.1075\ mA$



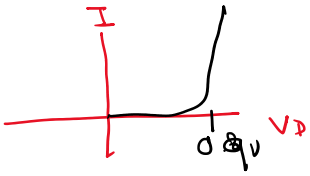
$V_I = 0,\ I_B = I_C = I_E = 0$
LED is OFF $\rightarrow$ R.B

$V_I = 5V$



$V_\gamma = 0.9V$

Assume saturation



$I_B = 0.1075$ mA

$+V_o + V_\gamma + I_C R_C = V_{CC}$

$$I_C = \frac{V_{CC} - V_o - V_\gamma}{R_C} = \frac{5 - 0.2 - 0.9}{2}$$

$= 1.95$ mA

$$\beta_f = \frac{1.95}{0.1075} = 18.13 < \beta\,(80)$$

Assume Active, $I_B = 0.1075$ mA, $I_C = \beta I_B = 8.6$ mA

$+V_{CE} + V_\gamma + I_C R_C = V_{CC} \Rightarrow V_{CE} = V_{CC} - V_\gamma - I_C R_C$

$= 5 - 0.9 - 8.6 \times 2$

$= -13.1V < 0.3V$

↳ Saturation region. $V_o = V_{CE} = 0.2V$