dc Analysis

Consider $V_{BE} = 0.7V$,

We can obtain transistor input characteristic as:

$V_{BB} = I_B R_B + V_{BE}$ So,

$I_B = \frac{V_{BB} - V_{BE}}{R_B}$ IV Input Characteristic Curve Equation

As for the output characteristics,

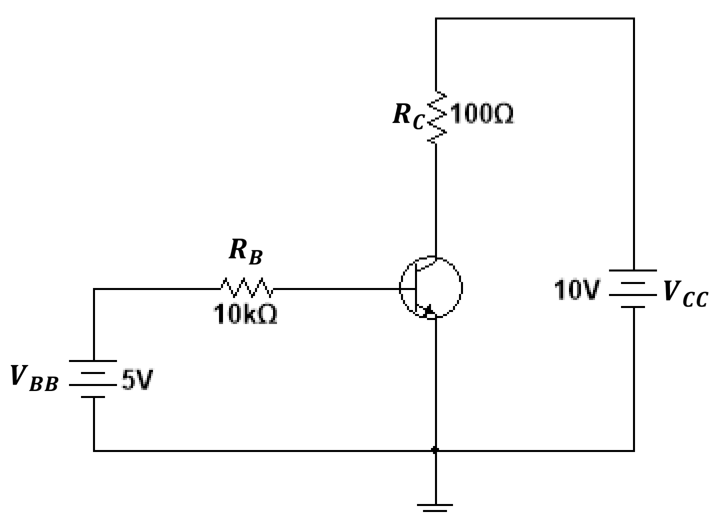
$$V_{CC} = I_C R_C + V_{CE}$$

$I_C = \frac{V_{CC} - V_{CE}}{R_C}$ Output characteristic equation

As for the voltage between base and collector:

$$V_{CB} = V_{CE} - V_{BE}$$

Example: Determine I_B, I_C , V_{CE} and V_{CB} in the circuit below. Transistor has $\beta_{dc} = 150$.



$$I_B = \frac{V_{BB} - V_{BE}}{R_B} = \frac{5 - 0.7V}{10k\Omega} = 430\ \mu A$$

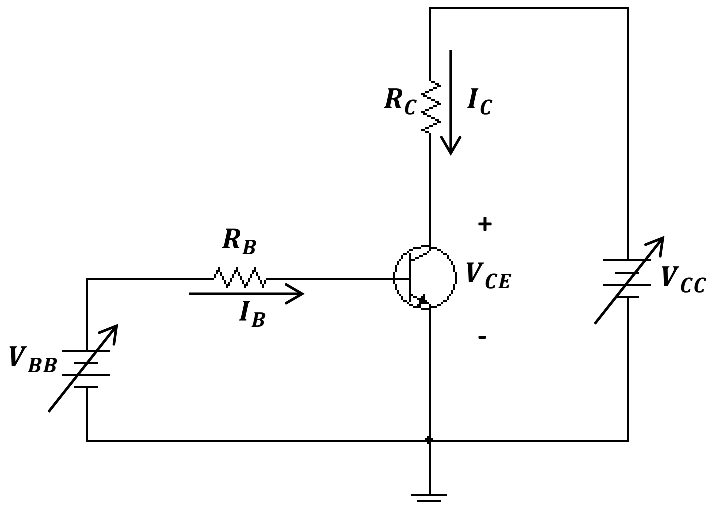
$$I_C = \beta_{dc} I_B = (150)(430\ \mu A) = 64.5\ mA$$

$$V_{CE} = V_{CC} - I_C R_C = 10V - (64.5mA)(100\Omega)$$

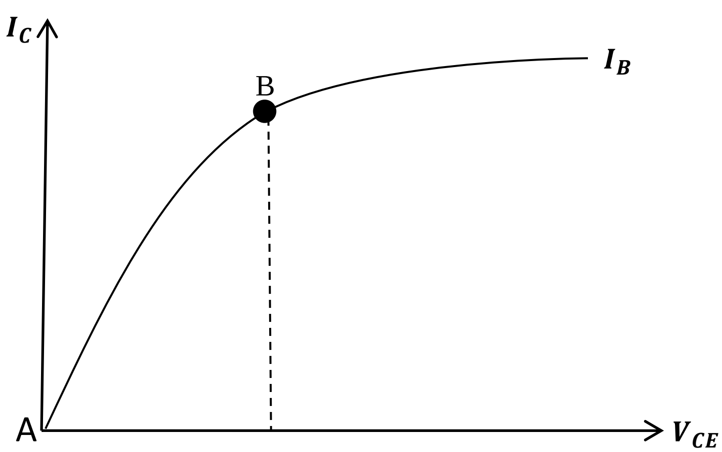
$$= 10V - 6.45V = 3.55V$$

$$V_{CB} = V_{CE} - V_{BE} = 3.55V - 0.7V = 2.85V$$

Collector Curves:

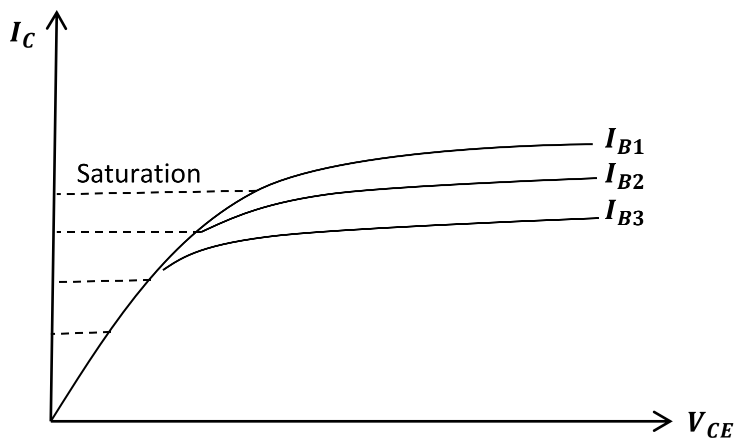


- Notice that both V_{BB} and V_{CC} are adjustable.



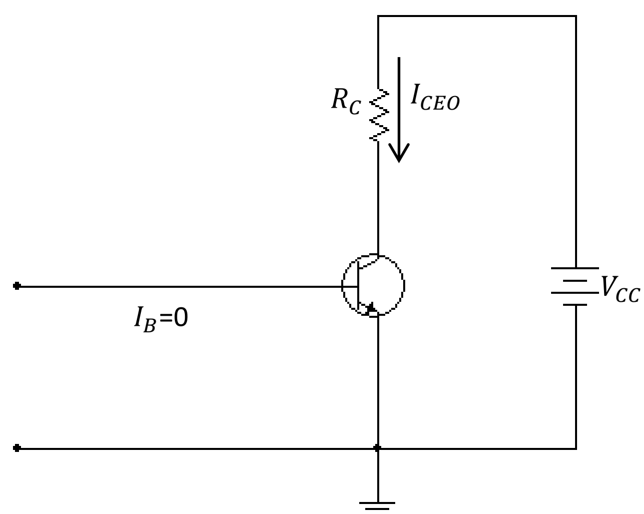
- If V_{BB} is set to produce a specific value of I_B and V_{CC} is zero, the $I_C = 0$ and $V_{CE} = 0$.
- As V_{CC} is gradually increased, V_{CE} will increase and so will I_C (from point A to point B).

- When V_{CE} reaches approximately 0.7V, the BC junction becomes reverse biased and I_C reaches its full value (almost constant) determined by the relationship $I_C = \beta_{dc} I_B$ as continues to increase.
- Actually I_C increases slightly as V_{CE} increases due to widening the BC depletion layer which results in fewer holes for recombination in the base region.



Cut off and Saturation

- When $I_B = 0$, the transistor is cutoff. There is only very small amount of collector leakage current I_{CEO} , due mainly to thermally produced carriers.

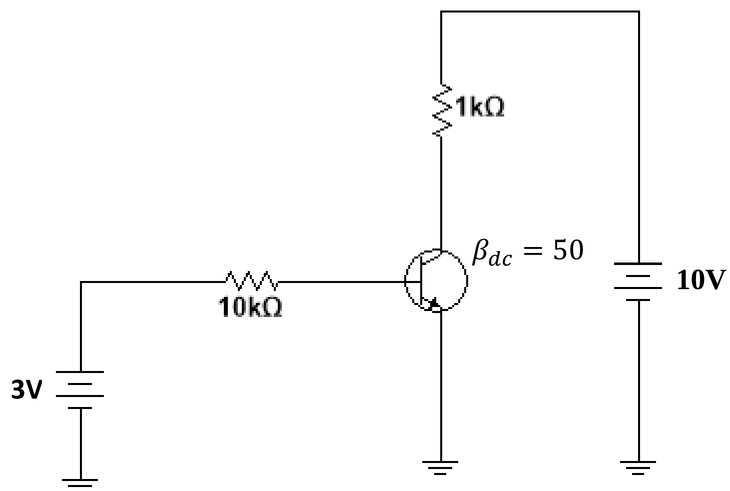


- In cutoff, both BE and BC junctions are reverse-biased.
- As for saturation, when I_B is increased, I_C also increases, V_{CE} decreases (more voltage drop across R_C)

$$V_{CC} = I_C R_C + V_{CE}$$

- When V_{CE} reaches a value called $V_{CE(sat)}$, BC becomes forward-biased and I_C can increase no further even with continued increase in I_B. At this point of saturation, $I_C = \beta_{dc} I_B$ is no longer valid.

  Example: Determine whether or not the transistor in figure below is in saturation. Assume $V_{CE}(sat)$ is small enough to neglect.



$$I_{C(sat)} = \frac{V_{CC} - V_{CE(sat)}}{R_C} = \frac{10V}{1k\Omega} = 10mA$$

Now, let's see if I_B is large enough to produce $I_{C(sat)}$.

$$I_B = \frac{V_{BB} - 0.7V}{R_B} = \frac{3V - 0.7V}{10k\Omega} = \frac{2.3V}{10k\Omega}$$

$$= 0.23mA$$

$$I_C = \beta_{dc} I_B = (50)(0.23mA) = 11.5mA$$

This shows that with the specified β_{dc} , this base current is capable of producing an I_C greater than $I_{C(sat)}$, therefore the transistor is saturated, and the $I_C = 11.5mA$ is never reached.