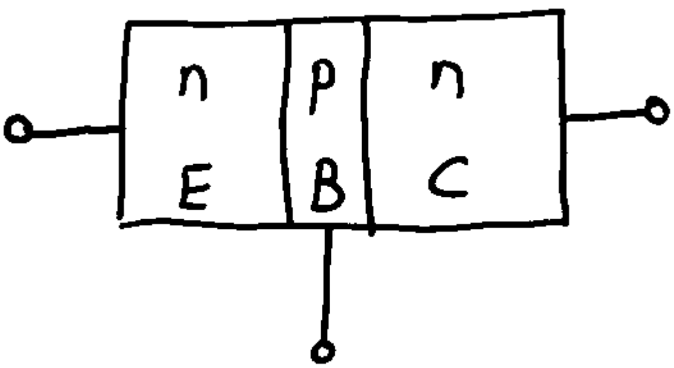
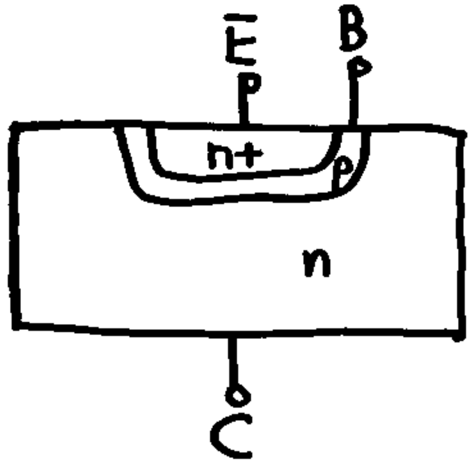
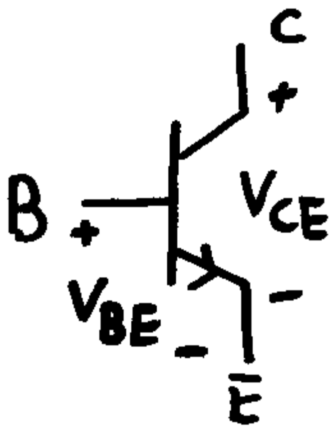
BJTs : Bipolar Junction Transistors





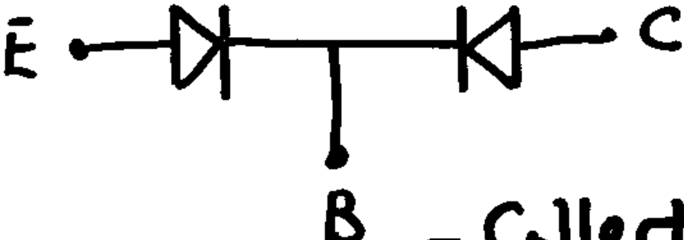
Three terminal device:



Emitter "emits" electrons

Collector "collects" electrons

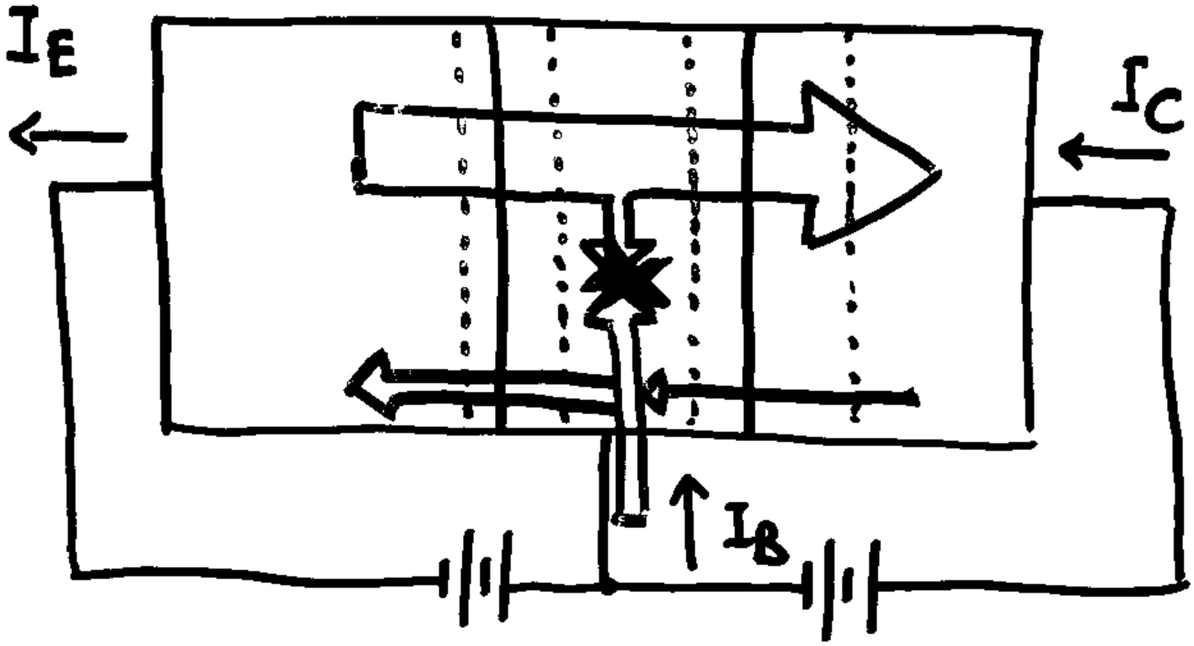
Is it back-to-back diodes?

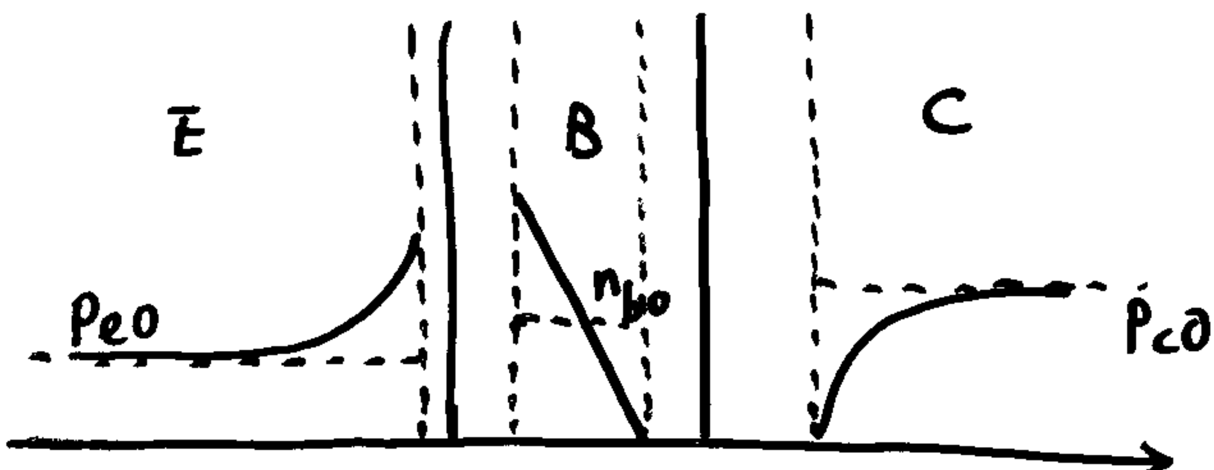


BJT has very narrow base region

- Collector voltage can influence current flow through base

Common-base Configuration





Minority carrier concentration

E doping is high $10^{19}/cm^3$

B " moderate $10^{17}/cm^3$

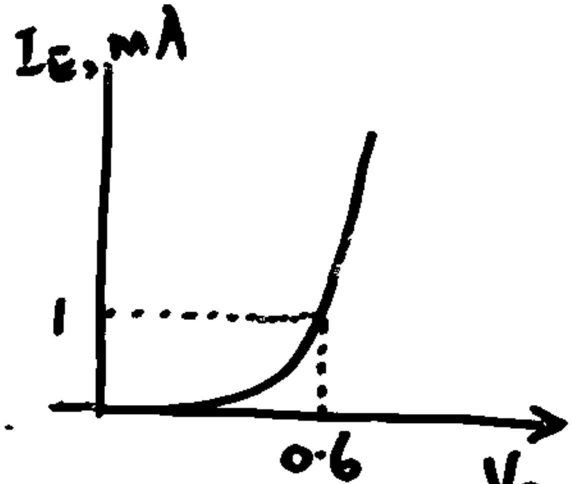
C " lower $10^{15}/cm^3$

Forward Active Operation

BE = Forward Biased
BC = Reverse Biased

1. Electrons injected from E → B
2. Narrow base – electrons can diffuse through base
3. Some electrons "recombine" with holes in base. Holes are supplied with I_B
4. BC junction R.B. ⇒ large electric field @ junction
5. Electrons get swept across BC junction and "collected"

Currents & Gains



$$I_E \doteq I_S e^{V_{BE}/V_T}$$

Essentially a diode

$V_{BE} \sim 0.6-0.7\,V$

$$I_C = \alpha I_E$$

→ Base transport factor
How much current goes through base

α: Common-base current gain

$$I_B \propto I_S e^{V_{BE}/V_T}$$

$$I_C = \beta I_B$$

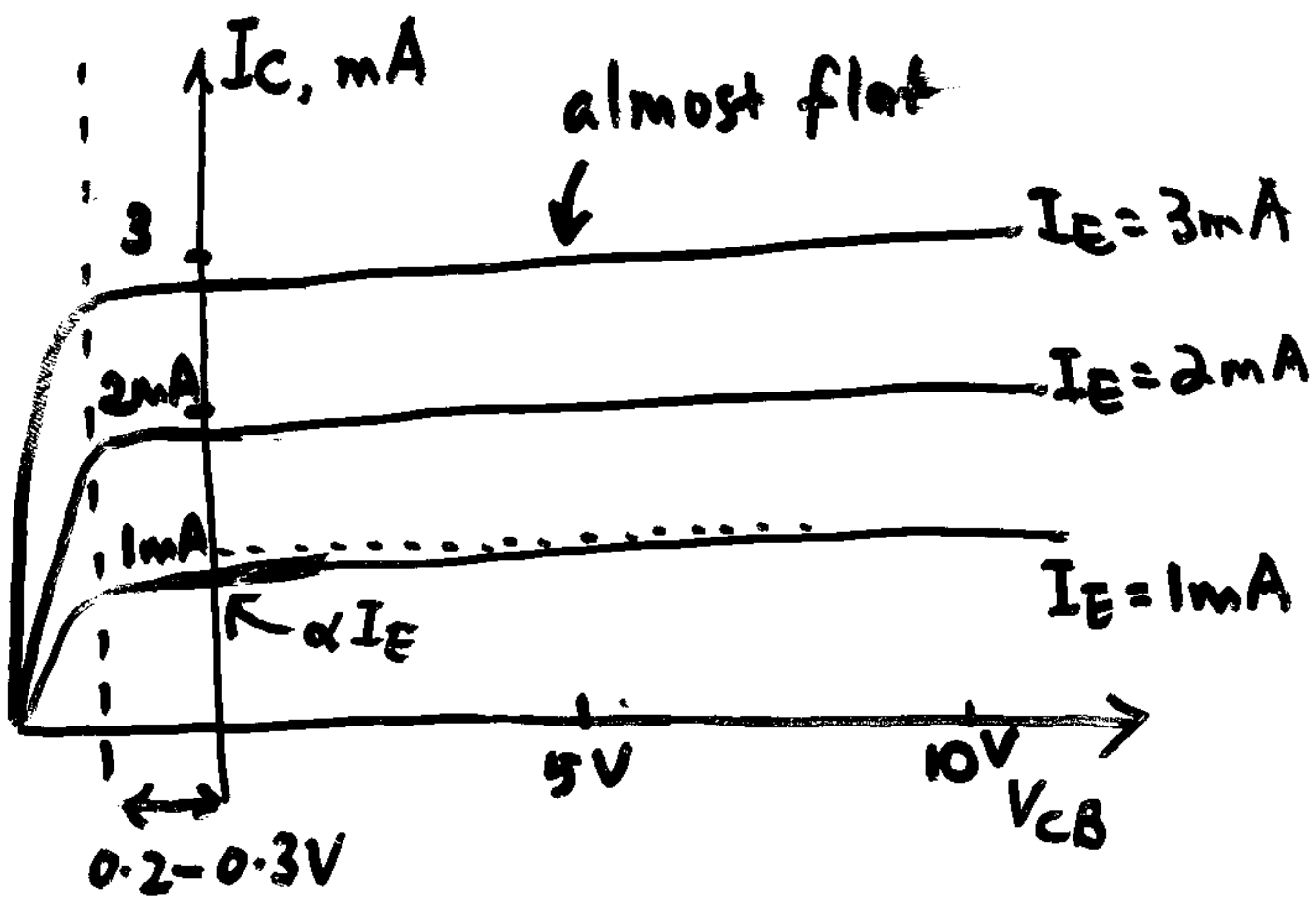
β: Common-Emitter current gain

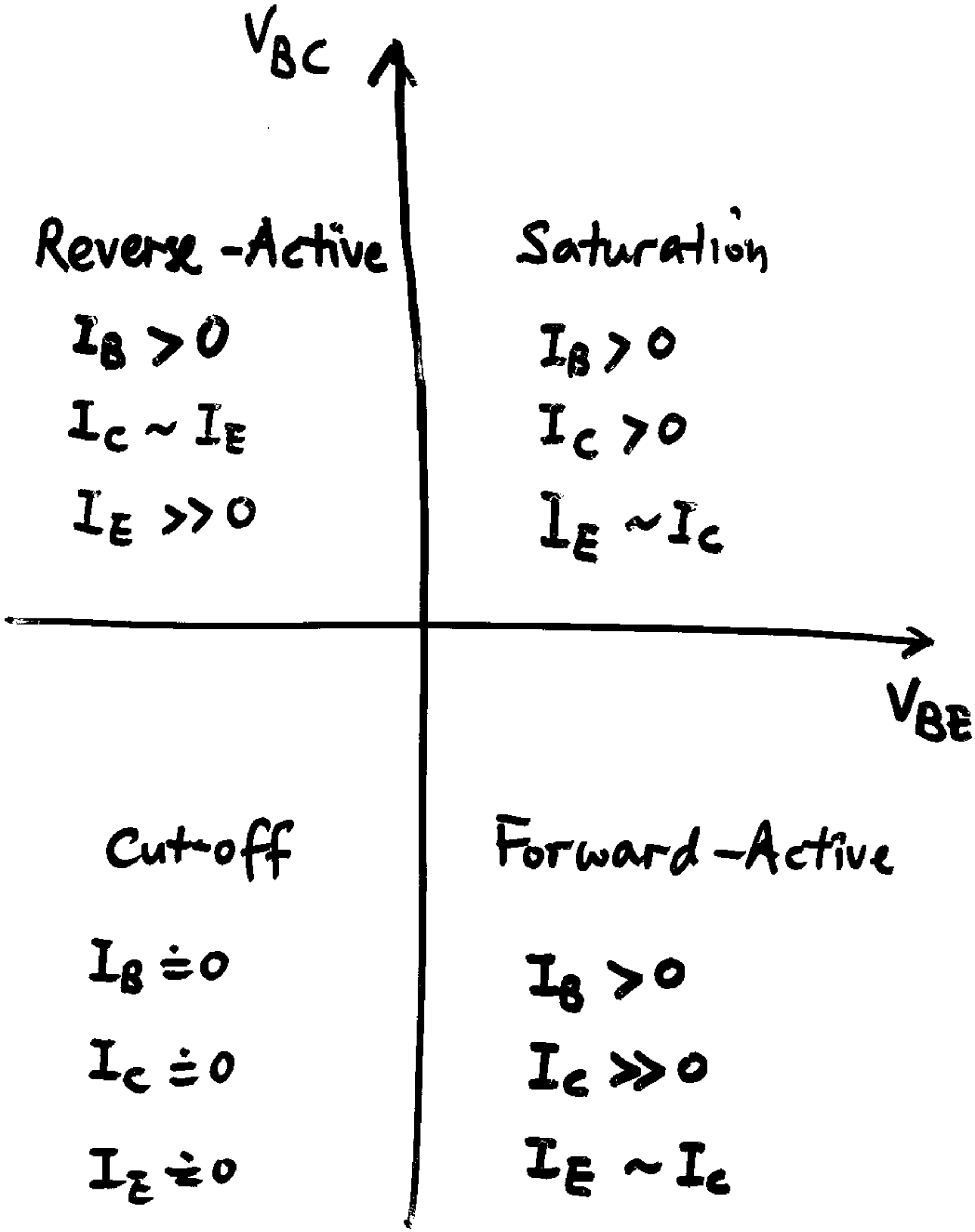
$$I_E = I_C + I_B$$
$$= (\beta + 1) I_B$$
$$I_C = \frac{\beta}{\beta+1} I_E = \alpha I_E$$

$$\boxed{\alpha = \frac{\beta}{\beta+1}}$$

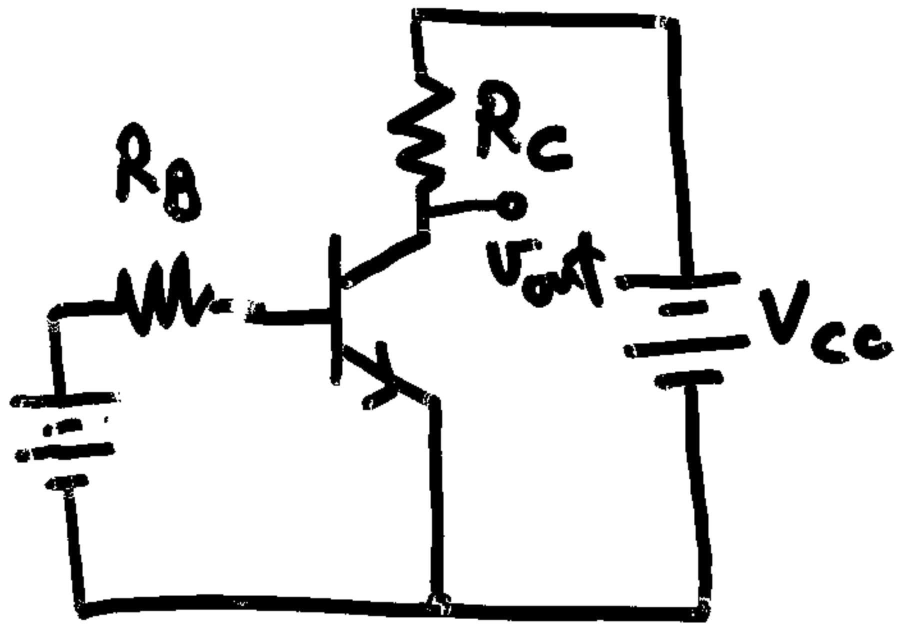
$$I_E = I_C + I_B$$
$$I_B = (1-\alpha) I_E$$
$$I_C = \frac{\alpha}{1-\alpha} I_B = \beta I_B$$

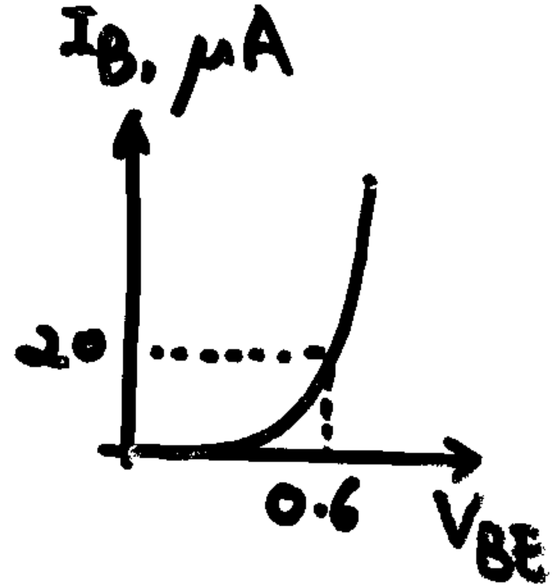
$$\boxed{\beta = \frac{\alpha}{1-\alpha}}$$

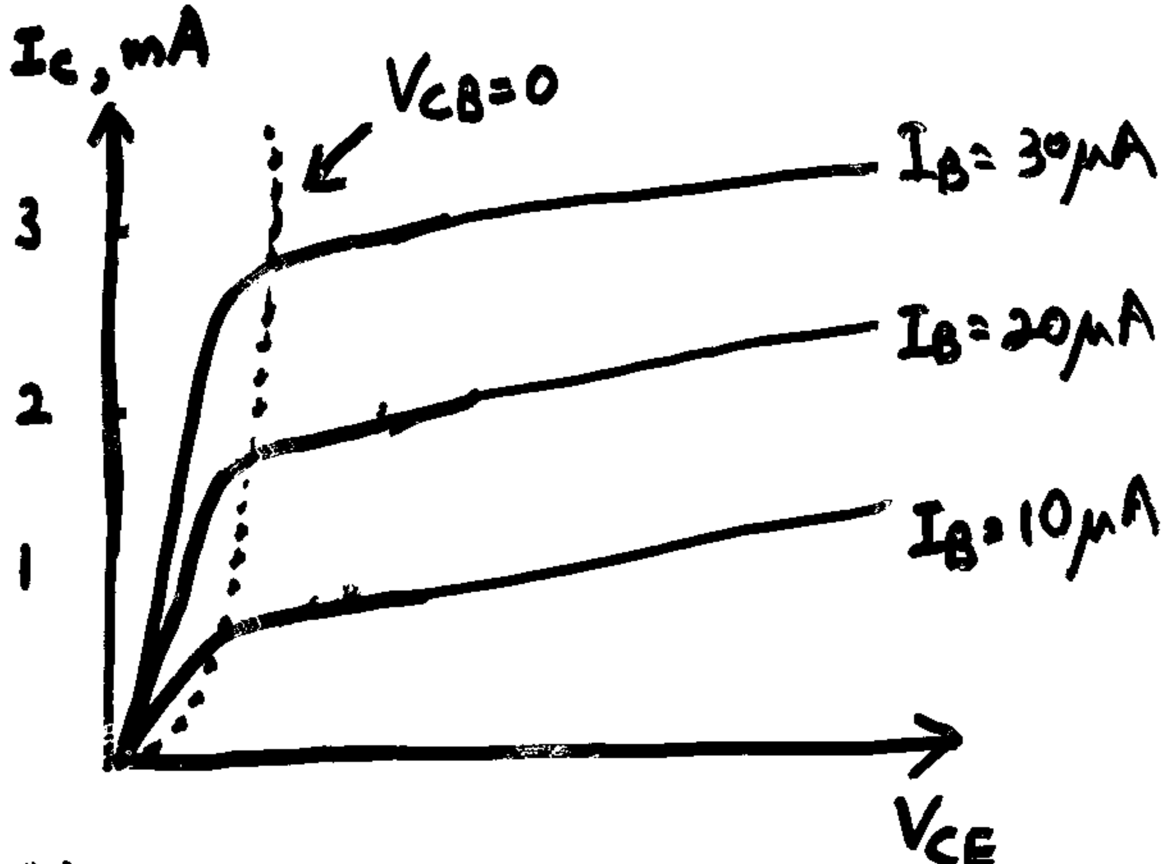



V_{BC}
Reverse-Active
$I_B > 0$
$I_C \sim I_E$
$I_E \gg 0$
Saturation
$I_B > 0$
$I_C > 0$
$I_E \sim I_C$
V_{BE}
Cut-off
$I_B \doteq 0$
$I_C \doteq 0$
$I_E \doteq 0$
Forward-Active
$I_B > 0$
$I_C \gg 0$
$I_E \sim I_C$

Common-Emitter Configuration

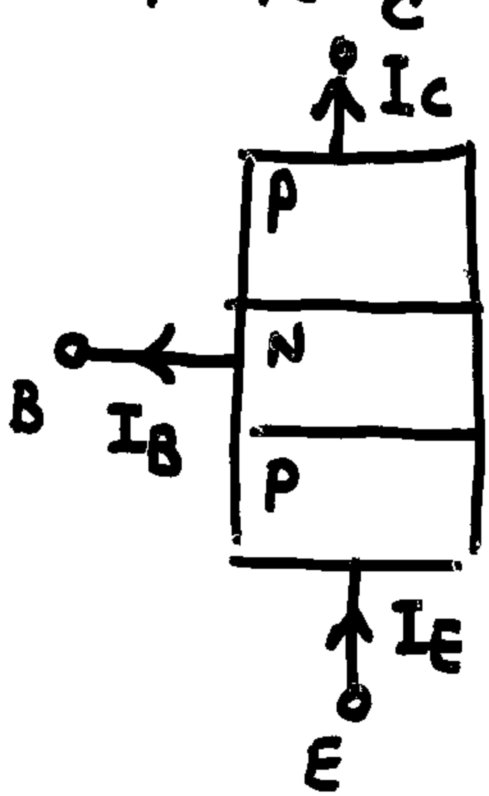


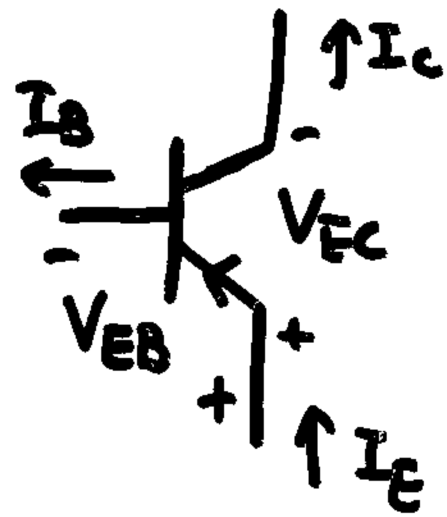


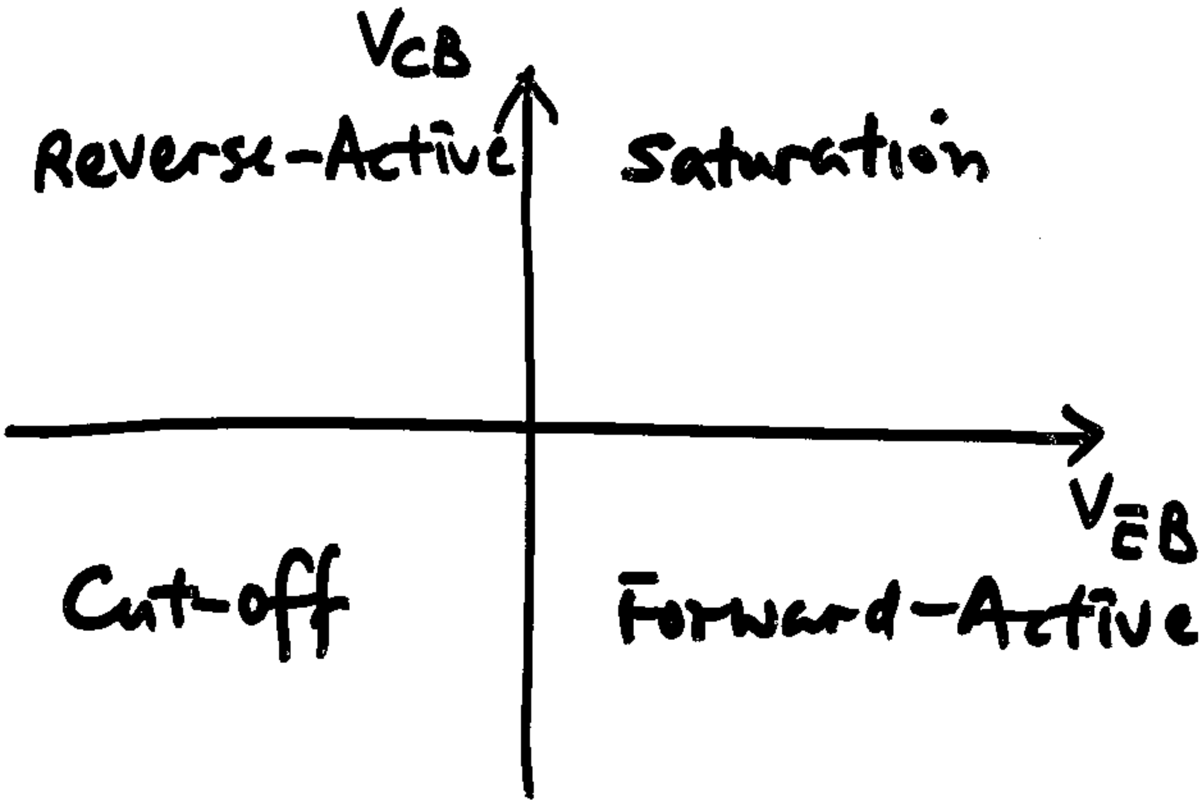


$V_{CE(SAT)} \simeq 0.2\,V$

PNPs


C
I_c
P
N
P
B
I_B
I_E
E


I_c
I_B
-
V_{EC}
-
V_{EB}
+
+
I_E


V_{CB}
Reverse-Active
Saturation
V_{EB}
Cut-off
Forward-Active

Identify the Regions