# Lecture 6 - Transistors

Resistors, capacitors, diodes are passive devices
- Apply a voltage, get a current
- Always some power dissipation

Most applications require active components
- Generate or amplify a signal
- Really, transfer power from a supply to a signal

Basic active building block: transistor

Three terminals:

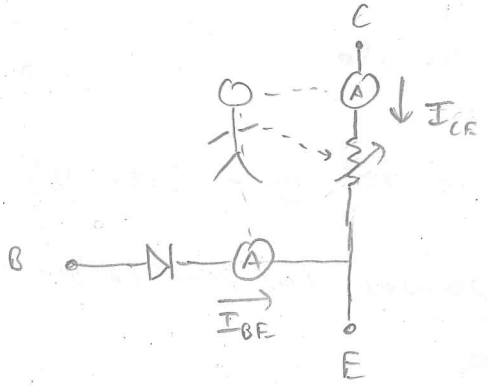

Simple explanation of what it does:

Current amplifier: $I_{CE} = \beta I_{BE}$

($I_{CE}$: current from collector to emitter)

$\beta \sim 100$ typically

Picture: transistor man adjusts potentiometer to keep $I_{CE} = \beta I_{BE}$




- All he can control is pot setting.

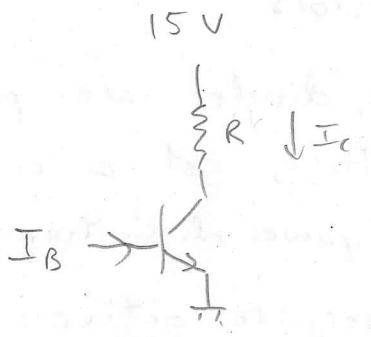
If $V_C \leq V_E$, pot is at minimum resistance, current at maximum.

Say transistor is saturated

Start saturating if $V_C - V_E < \sim 1$ V

Completely saturated if $V_C - V_E < \sim 0.2$ V

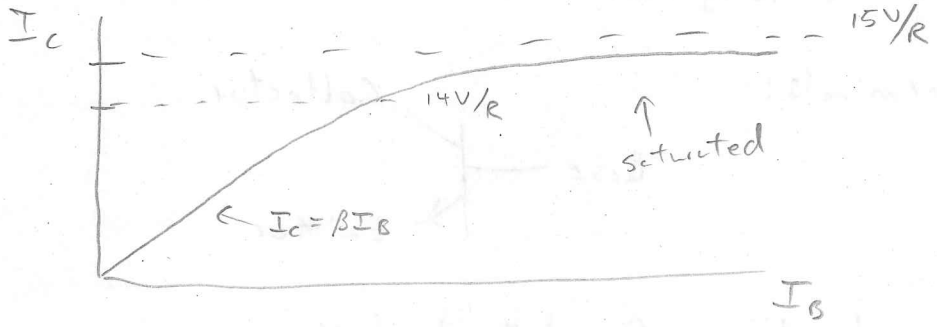
So in typical circuit:




Have $V_c = 15V - I_C R$

Starts to saturate at $I_C R = 14V$

Get




So you can't just count on $I_c = \beta I_B$

Some more details:

1) Looks like diode from B to E (arrow in symbol)
   Get diode drop $V_B \simeq V_E + 0.6V$

2) Value of $\beta$ varies from device to device
   & with temperature
   Better to use external components to set gain: see lab

3) Limits on $I_c, I_B, V_{CE}$ & total power (or device breaks)

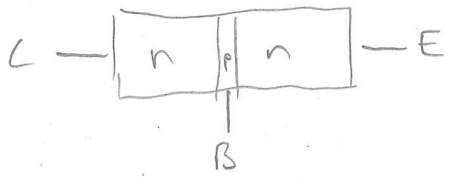
   2N3904 $I_C < 200mA$
   $I_B < 100mA$
   $V_{CE} < 40V$
   $P < 500mW$

Important to consider when designing circuit!

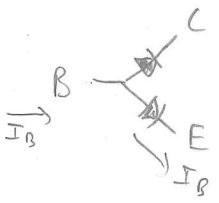
Physics:

Recall diode = pn junction

Transistor = two junctions




So B-C & B-E really are diodes




Wouldn't expect any current C→E

If $V_C > V_E$, get current B→E only

⇒ electrons from E→B

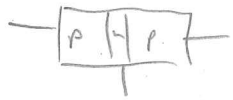
But, base region is very thin

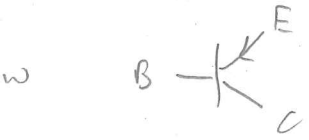
Electrons that enter through E see positive = attractive potential in C region. ~99% get diverted into C rather than exiting via B

⇒ current from C to E, $I_{CE} \approx 100\, I_{BE}$

Actually two types of transistor

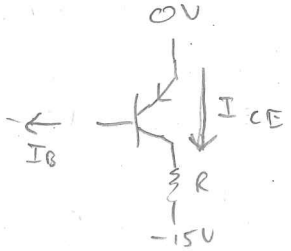
npn as described

pnp: 


Draw 


Very similar, but currents reversed: $I_{E\to C} = \beta I_{E\to B}$

Need $V_E > V_C$




To remember:

npn: needs positive base

pnp: needs negative base

for current gain in normal operation