ME 412: Active components

- powered devices that change behavior when powered.

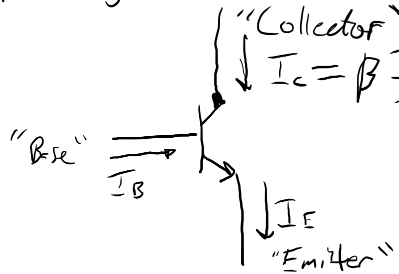
- A key example: the transistor:
  name is concatenation of
  "[Transfer Resistor]"
  - A type of controlled resistor.

Transistors function like valves: modulate current with an input.

Transistors are 3-pole devices:

bipolar junction transistor (BJT):

npn:



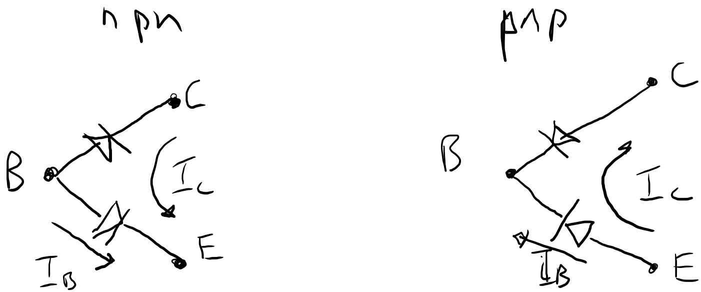
$I_C = \beta I_B$ β is typ. large, >100.

$I_E = I_C + I_B$

Rules of transistors: 2 types npn, pnp.

(reverse the polarities of these rules for pnp-type).

1. Collector must be "more positive" than the emitter
2. Base-Emitter & Base-collector junctions behave like diodes:



* Diodes are non-linear passive devices : AoE pg. 44.

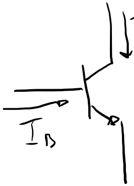
3. Any transistor has a maximal I_C, I_B, V_{CE}. IF these values are exceeded, the device is destroyed.

4. $I_C \sim I_B$ ("proportional to"), where $I_C = h_{CE} I_B = \beta I_B$

β typ. ≥ 100. * β is typically not a precise value, even for same part #'s.

- No design should rely on β's value

Re-state rule #4: Small base currents → large collector currents.

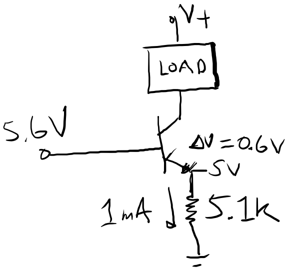


$I_C = \beta I_B$

$I_E = \underline{\underline{I_C}} + \underline{\underline{I_B}} = (1+\beta) I_B \simeq I_C.$

Devices w/ transistor:

* CURRENT SOURCE:



Ohm's law:

$V = IR$

$\Rightarrow I_E = \frac{5V}{5k\Omega} = 1mA.$

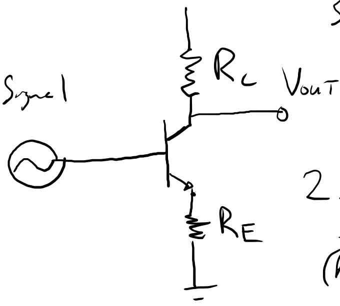
Thought Experiment: Suppose $V_+ = 20V$, load is variable resistor $50k\Omega$. (trim pot).

- What happens as we vary the value of R_{LOAD} from 0 to $50k\Omega$?
  - Does the behavior deviate from "Ideal Current Source" or not?

Ideal behavior breaks when $R_{LOAD} > \frac{14V}{1mA} \cong 14k\Omega$.

* EMITTER AMPLIFIER:

1. Apply Signal ΔV_B

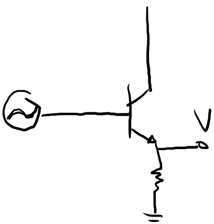


2. $\Delta V_B \rightsquigarrow \Delta V_E$;
$\Rightarrow \Delta I_E$: Small $R_E \Rightarrow$ lg. ΔI_E
(Recall Ohm: $\Delta I_E = \dfrac{\Delta V_E}{R_E}$)

3. $\Delta I_C \rightsquigarrow \Delta V_{OUT}$
(lg. $R_C \rightsquigarrow$ lg. ΔV_{OUT})

* Emitter-Follower:

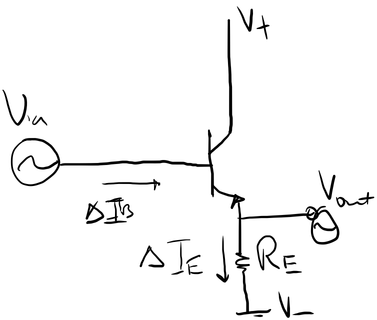
V_{in}



$V_{out} = V_{in} - 0.6V$

Why do we use this?
"Rose-colored lens" effect

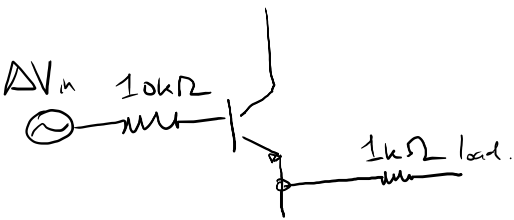
A closer look at the Emitter-Follower:



1. ΔV_{in}, ΔV_{out} are the same

2. ΔI_B, ΔI_E are <u>very</u> different.

Generalized Ohm: $\frac{\Delta V}{\Delta I} = $ "Z"



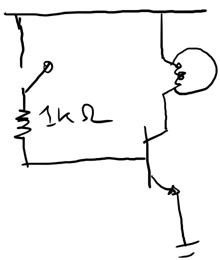
1. "Looking into" transistor from output side: Load "sees" ΔI_E from ΔV_{in}

$$R_{eff} = \frac{\Delta V_{in}}{\Delta I_E} = \frac{\Delta V_{in}}{\beta \Delta I_B} \sim \frac{R_B}{100}$$

2. Looking into the transistor from the base:
base "sees" the 1kΩ load as:

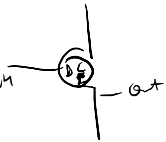
$$R_{eff} = \frac{\Delta V_E}{\Delta I_B} = \frac{\beta \Delta V_E}{\Delta I_E} = \beta R_{LOAD} \simeq 100\, R_{LOAD}$$

A Different transistor device: The switch. (How computers & logic work)

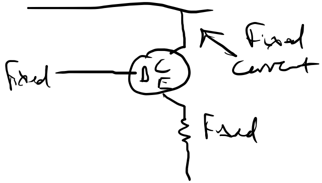


* Binary response: on or off.
  - purposely over-driven, $10 \times I_B$ to obtain req'd I_C
  - V_{CE} is kept low. (All power goes thru lamp).

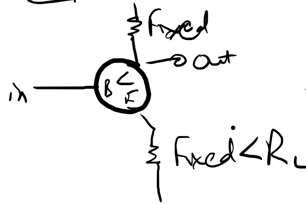
Follower:



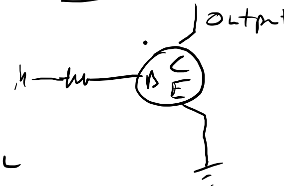
Current Source:



Amplifier:



Switch:



AoE pg. 98-102; Ebers-Moll: §2.10 & 2.11.

All lab work today: BJT.

FET. (More common).

Lab exercises