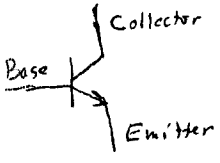
Real devices

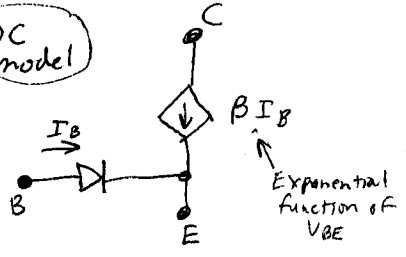
- There is resistance in parallel with the current source. (We will still ignore this for now).
- There may be something between the input (Gate or base) to the source (or emitter) which may load the input.
- The controlled source is nonlinear

  G_m is a function of current.

Bipolar Junction transistors



DC model



If $I_B = I_S\left(e^{\frac{V_{BE}}{nV_T}} - 1\right)$

solve for V_{BE} ...

$$\log I_B \approx \log I_S + \frac{V_{BE}}{nV_T}$$

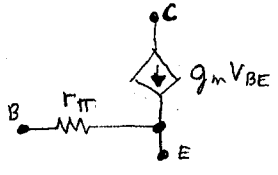
$$\frac{V_{BE}}{nV_T} = \log I_B - \log I_S$$

$$V_{BE} = nV_T(\log I_B - \log I_S)$$

($\log I_B$: $I_B \uparrow 10^{-6}$; $\log I_S$: $I_S \uparrow 10^{-15}$)

$$\approx .6\ V.$$

"small signal" model

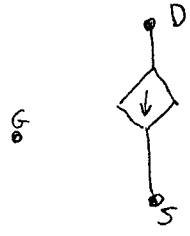


$$r_\pi = \frac{.026}{I_B}$$

$$g_m = \frac{I_C}{.026}$$

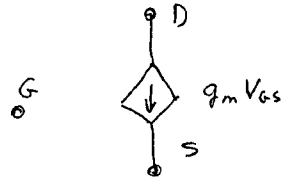
Field Effect Transistors

Dc model:



$$I = K(V_{GS} - V_{TH})^2$$

"Small signal" model



$$g_m = 2\sqrt{KI_D}$$

K = "process transconductance" $\frac{amps}{volts^2}$

V_{TH} = "Threshold Voltage" — determined by process

K — determined by size and process

$$K = \frac{1}{2}K'\frac{W}{L}$$

K' is determined by process (actually by the thickness of the insulator)