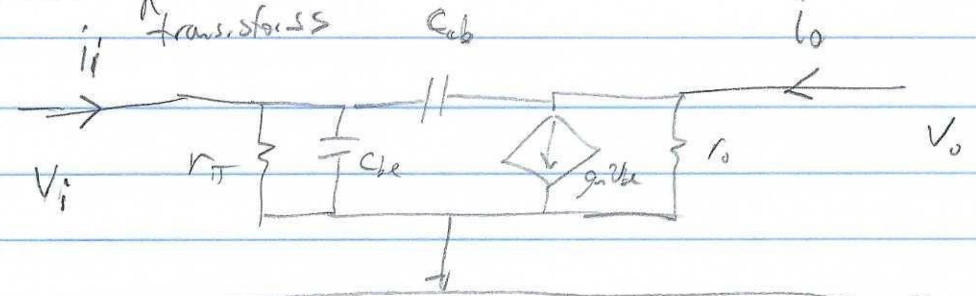
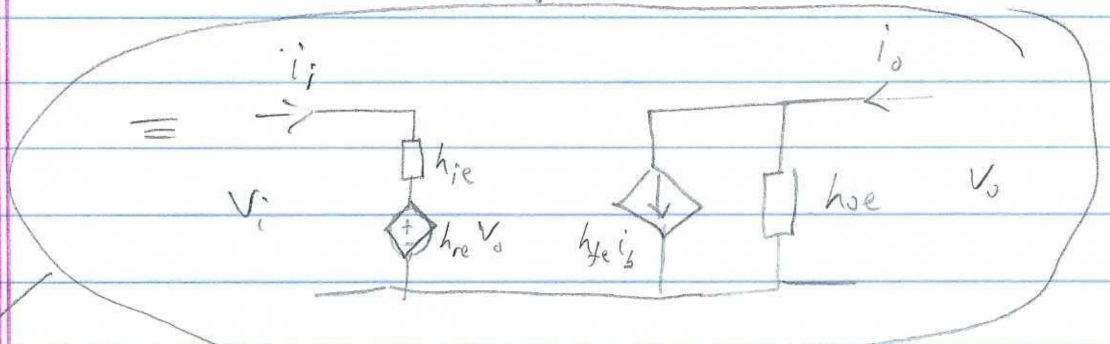
☆ Show data sheet for 5179

2-Port Parameters (H, Y, and S)

Recall model used so far transistors





Can also model w/ 2 port parameters (H, Y, S, ...)

H-Parameter Case:

$$\begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} h_i & h_r \\ h_f & h_o \end{bmatrix} \begin{bmatrix} I_1 \\ V_2 \end{bmatrix}$$

OR:

$$V_i = h_i I_i + h_r V_o$$
$$I_o = h_f I_i + h_o V_o$$

If CE Amp

$$V_i = h_{ie} I_i + h_{re} V_o$$
$$I_o = h_{fe} I_i + h_{oe} V_o$$

NOTE $h_{ie} = \left.\frac{V_i}{I_i}\right|_{V_o=0} \equiv Z_i\Big|_{V_o=0}$ $\quad h_{re} = \left.\frac{V_i}{V_o}\right|_{I_i=0}$ ⇒ Reverse Gain

Show data sheet & point out how to find g_m, C_{be}, etc.

$h_{fe} = \left.\frac{I_o}{I_i}\right|_{V_o=0} \equiv$ Short Ckt I gain $\quad h_{oe} = \left.\frac{I_o}{V_o}\right|_{I_i=0} = Y_o\Big|_{\text{Input Open}}$

Example

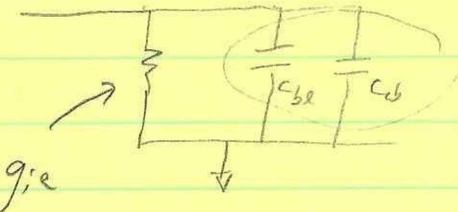
2N5179

Looking at data sheet, for $I_c = 1.5mA$, $V_{ce} = 6V$

$h_{ie} = g + jb$

$= 0.3m + j\,4m\ \mho$ at 100 MHz

This corresponds to



$\frac{1}{r_\pi} = g_{ie}$ $\qquad\qquad$ $\frac{1}{|X_c|} = |b_c|$

$\Rightarrow r_\pi = \frac{1}{.3m} = \underline{3.3K\Omega}$ $\qquad$ $\Rightarrow X_c = \frac{1}{4m} = 250\Omega$

$\Rightarrow C = \frac{1}{2\pi f X_c} = \underline{6.4pF}$

Check against formulas:

median guessed

24Ω

$$\boxed{r_\pi \approx h_{fe}\frac{1}{g_m}} \approx 130\left[\frac{(1.4)(.026)}{1.5mA}\right] = 3.2K \checkmark$$

$$\boxed{C_{be} \approx \frac{1}{2\pi f_T \frac{1}{g_m}}} = \frac{1}{2\pi(920MHz)(26\Omega)} = 8\ pF \quad \text{OK}$$

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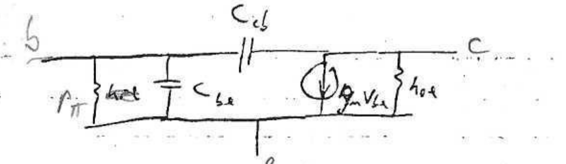
HF Transistor 2 Port Parameters

Recall simplified high freq (h parameter) BJT model used previously



PROB →

- Difficult to measure r, C directly due to parasitic L, C in connectors
- At very high frequencies, this model produces poor results ~~and more complex model is needed (Shockley-Spice model)~~

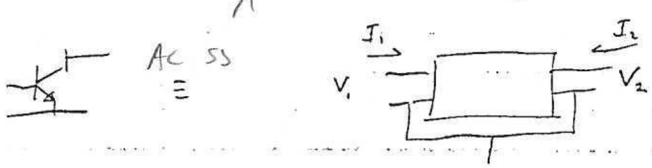
Additional problem

- ~~makes circuit analysis complex~~
- Difficult to measure transistor behavior at HF due to board / test equipment parasitics
- Difficult to map measurements to component values

Soln: Use Y param & S param 2-port models

Y Parameters

Treat Transistor (SS AC modeling) as black box ← Phasors!



Y

Characterize as

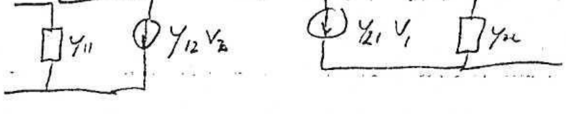
$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

Dependent Independent

$$I_1 = y_{11} V_1 + y_{12} V_2 \Rightarrow y_{11} = \frac{I_1}{V_1}\Big|_{V_2=0} \text{ input admittance}, \quad y_{12} = I_1/V_2\,\big|_{V_1=0} \text{ reverse transfer}$$

$$I_2 = y_{21} V_1 + y_{22} V_2 \Rightarrow y_{21} = I_2/V_1\,\big|_{V_2=0} \text{ forward adm}, \quad y_{22} = I_2/V_2\,\big|_{V_1=0}$$

Ckt model



Easier to measure because no open ckts required

Easier to work with because simpler model...

No mapping to components needed.
Just measure at freqs of interest.

Example: 2N5179 y parameters (Show Data Sheet)

$y_{ie} \equiv y_{11}$ Shows behavior of $r_\pi \parallel -jX_{c_{be}}$

$y_{oe} \equiv y_{22}$ Shows behavior of $\frac{1}{h_{oe}} \parallel -jX_{C_{cb}}$

$y_{fe} \equiv y_{21}$ Shows behavior of g_m & $-jX_{C_{cb}}$

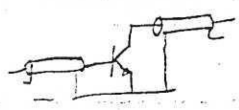
$y_{re} \equiv y_{12}$ Shows behavior of $-jX_{C_{cb}}$

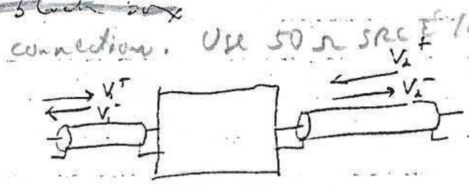
Comment on CE vs CB & Show transformations

Problem: Difficult to measure @ 1GHz or above [Hard to create short ckts; Stability problems]

Soln: S Parameters

~~Treat transistor as black box~~
Use 50 Ω TX line for connection. Use 50 Ω SRC & load





Describe as

$$\begin{bmatrix} V_1^- \\ V_2^- \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \begin{bmatrix} V_1^+ \\ V_2^+ \end{bmatrix}$$

$$V_1^- = S_{11} V_1^+ + S_{12} V_2^+$$

$$V_2^- = S_{21} V_1^+ + S_{22} V_2^-$$

$S_{11} = \left.\frac{V_1^-}{V_1^+}\right|_{V_2^+=0}$ = Input refl coeff w/ output terminated in 50 Ω (~ input Z)

S_{22} = Output " (~ output Z)

S_{21} = Fwd trans coeff (~ V Gain w/ 50 Ω I/O)

S_{12} = Reverse trans coeff (Reverse isolation in 50 Ω I/O)

(Show Data Sheet) Comment on CE vs CB