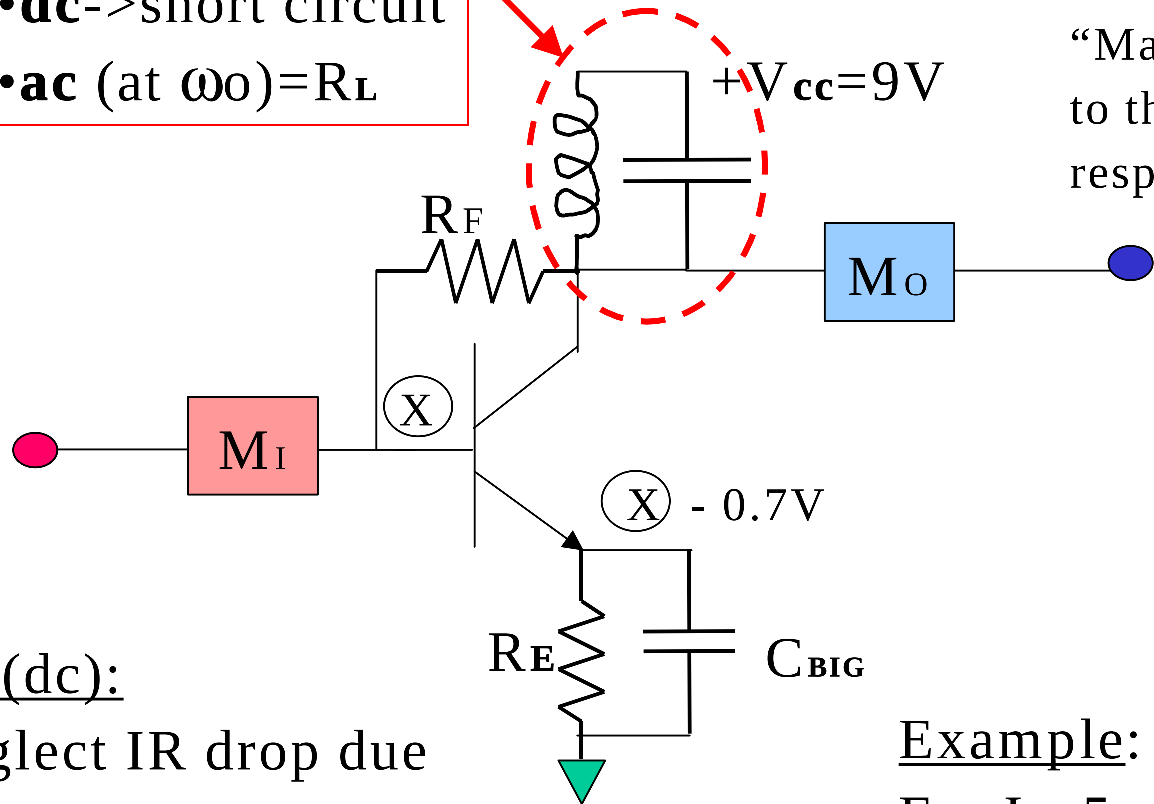
Low Noise Amplifier (LNA) Analysis and Design--Part I (dc & ac)

- A Shunt-Shunt Feedback configuration has been (pre-) selected:
  - Feedback allows improved input impedance match and
  - Lack of extra bias resistors can improve noise performance (TBD)
- Biasing is done by means of setting single R_E
- Noise Performance will be discussed later in the quarter:
  - Typically, noise of total receiver is dominated by first stage (therefore it is a really good idea to use LNA)

“tuned” load:

- **dc**->short circuit
- **ac** (at ω_o)=R_L



M_I and M_O are “Matching Networks” to the Input and Output respectively

Biasing (dc):

- Neglect IR drop due to Rf
- Hence V_X=+V_{cc}
- Assume $I_C \sim I_E$ (β>>1)
- Resulting bias is: ⇨ $I_C \sim (9V-0.7V)/R_E$

Example:

For I_c=5mA

R_E=8.3V/5mA=1.66KΩ

About Bipolar Junction Transistor (BJT) and moving to ac parameters

- Given dc bias point (I_c) we linearize about that point:
  - $g_m = qI_C/kT$
  - $r_\pi = \beta/g_m$
  - $C_\pi = C_{JE}(V_{BE}) + g_m \tau_F$
  - $C_\mu = C_{JC}(V_{BC})$
- Equivalent circuit and typical numbers are given next...

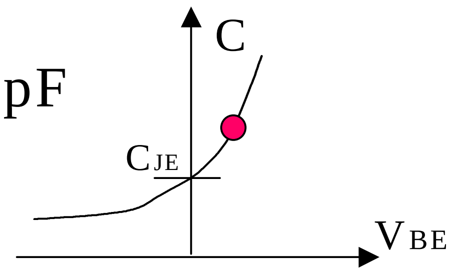
For I_C=5mA, β=80, τ_F=30ps (and other parameters per SPICE deck)

$g_m = qI_C/kT = 0.193\ 1/\Omega$ and $r_\pi = \beta/g_m = 414\Omega$

$C_\pi = C_{JE}(V_{BE}) + g_m\tau_F$

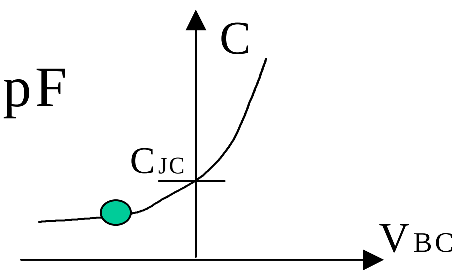
$= 1.3\text{pF}\ f(V) + 5.8\text{pF}$

$\sim 7.1\text{pF}$

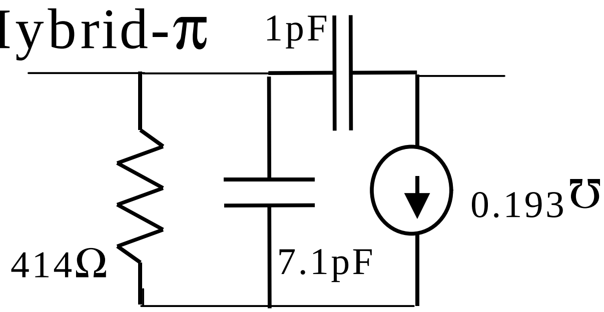


Parameter	Value
β	80
τ_F	30ps
C_{JE}	1.3pF
C_{JC}	1.0pF

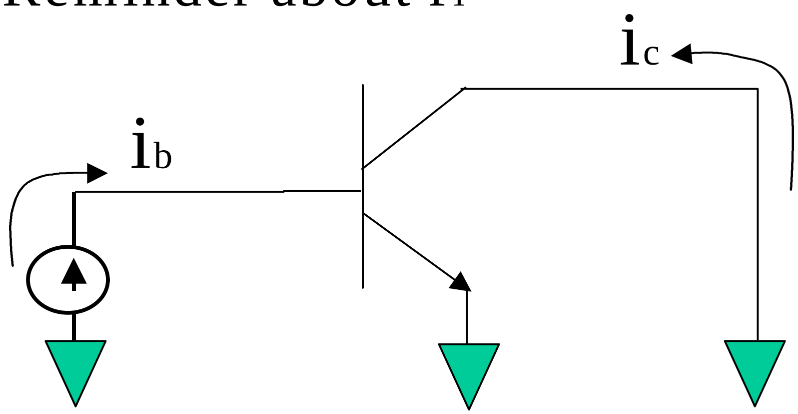
$C_\mu = C_{JC}(V_{BC}) \sim C_{JC} = 1\text{pF}$



Hybrid-π



Reminder about f_T



$$\frac{i_c(s)}{i_b(s)} = b(s)$$

$$at..w_T..b(s) = 1$$

(and reviewing EE113 notes…)

$$b(s) = \frac{b}{1 + s r_p \left(c_p + c_m\right)}$$

$$w_T = \frac{g_m}{c_p + c_m}$$

(from data sheet)

@20mA $\quad g_m$=0.772

$C_\pi + C_\mu = (0.772)/(2\pi\ 5x10\hat{}9)$ ← (I.e. f_T)

= 24.6pF

$C_\pi + C_\mu = C_{JE} + C_{JC} + g_m\ \tau_F$

(now check out the SPICE deck…that is, you can print out all small signal parameters and confirm the hand calculations)