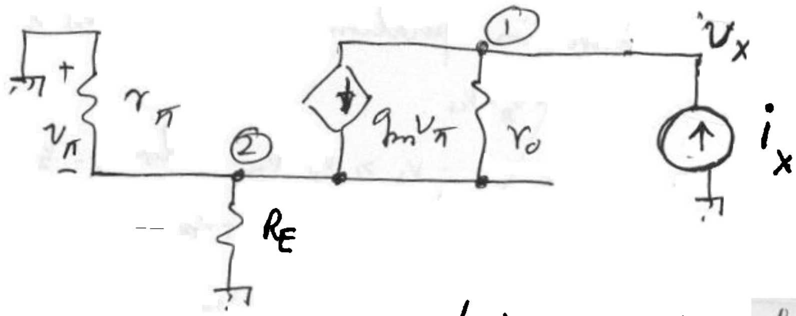
Ch 1 / ELEC 312 lecture note pack

Q 1:



For nodal analysis use a dummy i-source

The NAM:

Let $g \to \frac{1}{r}$ for all

$$\begin{array}{cc} ① & ② \end{array}$$

$$\begin{bmatrix} g_o & -g_o \\ -g_o & g_E + g_\pi + g_o \end{bmatrix} \begin{bmatrix} v_① \\ v_② \end{bmatrix} = \begin{bmatrix} i_x - g_m v_\pi \\ g_m v_\pi \end{bmatrix}$$

But $v_\pi = 0 - v_② = -v_②$.

$$\begin{array}{cc} ① & ② \end{array}$$

$$\begin{bmatrix} g_o & -g_o \\ -g_o & g_E + g_\pi + g_o \end{bmatrix} \begin{bmatrix} v_① \\ v_② \end{bmatrix} = \begin{bmatrix} i_x - g_m(-v_②) \\ g_m(-v_②) \end{bmatrix}$$

Move '$g_m v_②$' term from RHS to LHS

$v_{(2)}$ goes to column ②

$$\begin{bmatrix} g_o & -g_m - g_o \\ -g_o & g_E + g_\pi + g_o + g_m \end{bmatrix} \begin{bmatrix} v_① \\ v_② \end{bmatrix} = \begin{bmatrix} i_x \\ 0 \end{bmatrix}$$

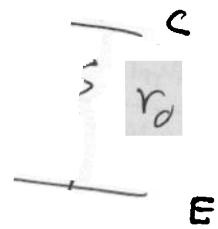
Solve for $v_x \to v_①$:

$$v_① = \frac{\begin{vmatrix} i_x & -g_m - g_o \\ 0 & g_E + g_\pi + g_o + g_m \end{vmatrix}}{\begin{vmatrix} g_o & -g_m - g_o \\ -g_o & g_E + g_\pi + g_o + g_m \end{vmatrix}}$$

Then find $v_① / i_x \to R_{out}$

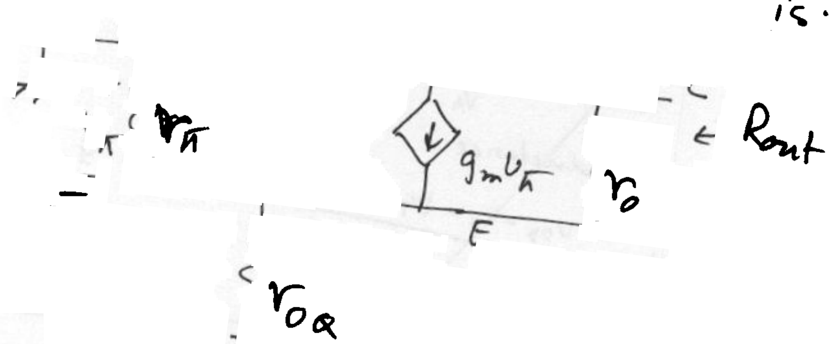
Q2

For the BJT with $v_{be} = V_B + V_{EE}$ a dc value the ac equivalent circuit becomes



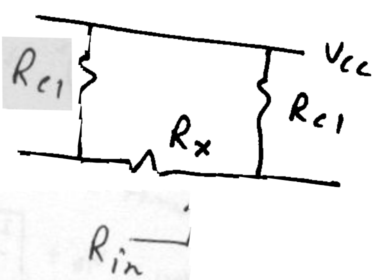
$g_m v_\pi \to 0$, open circuit current source is.

So the ac equivalent to

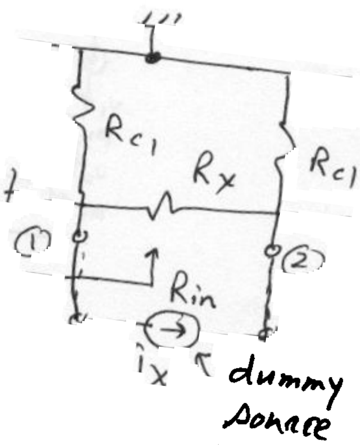


Proceed as — f — with $R_E \to r_{oa}$

Q4



→ ac equivalent



For the ac equivalent circuit

$$\begin{bmatrix} g_{c1} + g_x & -g_x \\ -g_x & g_{c1} + g_x \end{bmatrix} \begin{bmatrix} v_① \\ v_② \end{bmatrix} = \begin{bmatrix} -i_x \\ i_x \end{bmatrix}$$

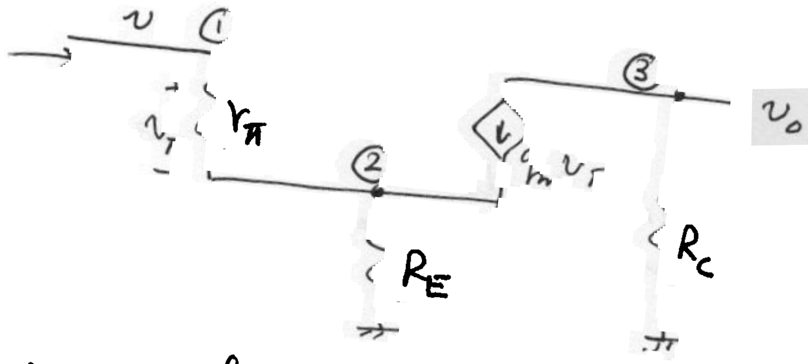
is the nodal admittance matrix (NAM)

Solve for $v_①$, $v_②$. Then

$$R_{in} = \frac{v_② - v_①}{i_x}$$

Q5

Let, i_s



The NAM is formed as below

$$\begin{array}{ccc} ① & ② & ③ \end{array}$$

$$\begin{bmatrix} g_\pi & -g_\pi & 0 \\ -g_\pi & g_\pi + g_E & 0 \\ 0 & 0 & g_c \end{bmatrix} \begin{bmatrix} v_{①} \\ v_{②} \\ v_{③} \end{bmatrix} = \begin{bmatrix} i_s \\ g_m v_\pi \\ -g_m v_\pi \end{bmatrix}$$

But $v_\pi = v_{①} - v_{②}$

$$\begin{bmatrix} g_\pi & -g_\pi & 0 \\ -g_\pi & g_\pi + g_E & 0 \\ 0 & 0 & g_c \end{bmatrix} \begin{bmatrix} v_{①} \\ v_{②} \\ v_{③} \end{bmatrix} = \begin{bmatrix} i_s \\ g_m [v_{①} - v_{②}] \\ -g_m [v_{①} - v_{②}] \end{bmatrix}$$

$$\begin{bmatrix} g_\pi & -g_\pi & 0 \\ -g_m - g_\pi & g_m + g_\pi + g_E & 0 \\ g_m & -g_m & g_c \end{bmatrix} \begin{bmatrix} v_{(1)} \\ v_{(2)} \\ v_{(3)} \end{bmatrix} = \begin{bmatrix} i_s \\ 0 \\ 0 \end{bmatrix}$$

$\frac{v_o}{v_i}$ is same as $\frac{v_{③}}{v_{①}}$

Q5 (Contd.)

$$v_{(3)} = \frac{1}{\Delta} \begin{vmatrix} g_\pi & -g_\pi & i_s \\ -g_m - g_\pi & g_m + g_\pi + g_E & 0 \\ g_m & -g_m & g_c \end{vmatrix}$$

Δ = determinant of the NAM

$$v_{(1)} = \frac{1}{\Delta} \begin{vmatrix} i_s & -g_\pi & 0 \\ 0 & g_m + g_\pi + g_E & 0 \\ 0 & -g_m & g_c \end{vmatrix}$$

You can find $v_{(3)} = -\, g_m g_E \, i_s$

$$v_{(1)} = g_c(g_m + g_\pi + g_E)\, i_s$$

Then $\dfrac{v_{(3)}}{v_{(1)}} = -\dfrac{R_c}{r_e + R_E + R_E \frac{r_e}{r_\pi}}$, using $\frac{1}{g_m} \approx r_e$

Q9: $y_{11} = G + jX$ $\quad G = Re(y_{11})$

$X = Im(y_{11})$

$G = 10^{-11}$ in all results $\quad$ So $R = \frac{1}{10^{-11}} = 10^{11}\ \Omega$

$X = 6.06 \times 10^{-6}$ @ $f = 100$

60.6×10^{-6} @ $f = 1000$

X increases by 10 as f increases by 10. Means a capacitive reactance.

So $X = f.C$ $\quad$ (like $y = mx$ graph)

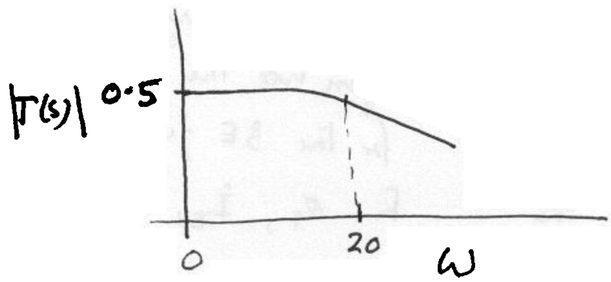
$C = X/f = \dfrac{6.06 \times 10^{-6}}{100}$ $\quad$ so on

Q 10

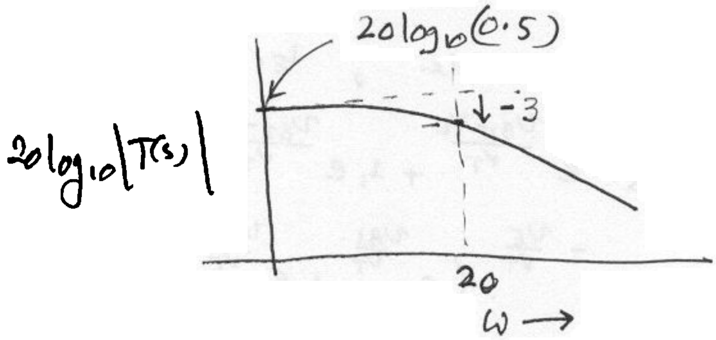
$$T(s) = \frac{10}{s+20}, \qquad |T(s)| = \frac{10}{\sqrt{\omega^2 + 20^2}}$$

T(s) has a pole at $\omega = 20$ rad/sec

at $W = 0$, $|T(s)| = 0.5$



Bode plot is $20\log_{10}|T(s)|$

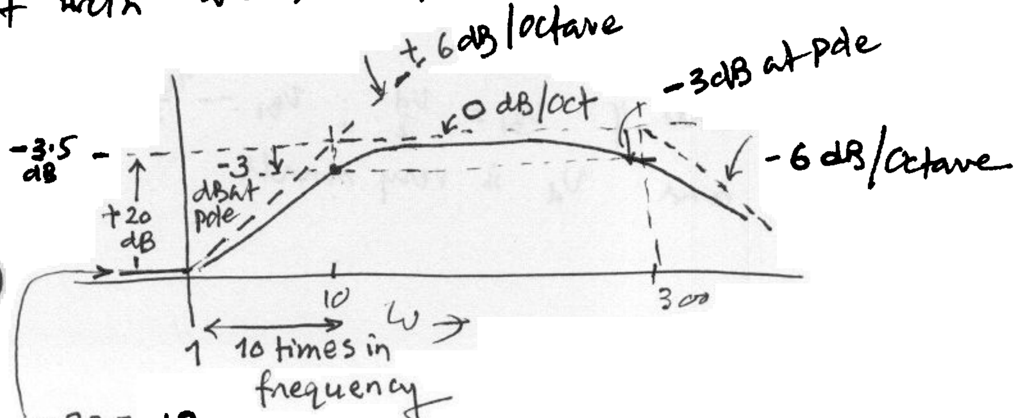


Q 11:

$$T(s) = 200\,\frac{s}{(s+10)(s+300)}$$; Has a zero at $\omega = 0$, poles at $\omega = 10, 300$

As $\log(0) \to -\infty$, it cannot be shown

So start with $\omega = 1$ rad/sec.



$|T(1)|$

$$\approx \frac{200}{10 \cdot 300}(1)$$

$$= \frac{1}{15}$$

$20\log_{10}|T(1)| = -23.5$ dB