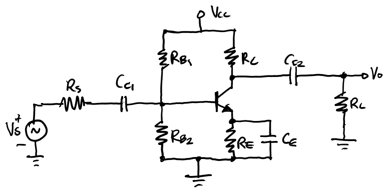
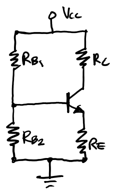
Common Emitter Amplifier

October 12, 2017 3:49 PM

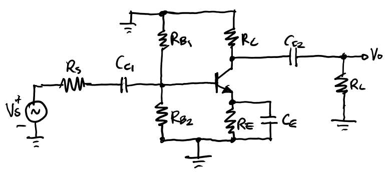
Typical Common Emitter (CE) Amplifier:



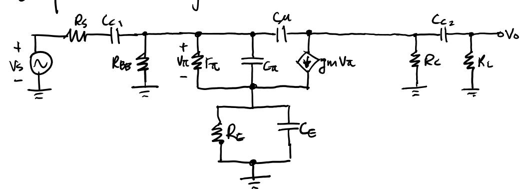
DC circuit



AC circuit

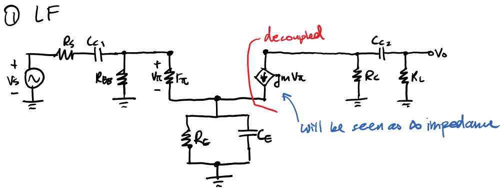


→ Complete Small Signal Models

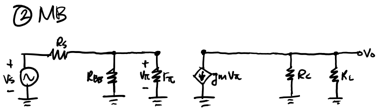


S.S model can be split into ① Low frequency (LF)
② Midband (MB)
③ High frequency (HF)

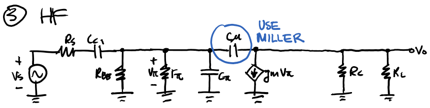
① LF



② MB



③ HF



①

First, we shall find the zeroes:

C_{c1} and C_{c2} are coupling capacitors and thus have zeroes at zero:

$$\omega_{Lz1} = 0, \quad \omega_{Lz2} = 0$$

Third zero is at where admittance of emitter network = 0

$$Y_E = \frac{1}{R_E} + sC_E = 0$$

$$\rightarrow s = -\frac{1}{R_E C_E}$$

Thus, we have the third pole:

$$\omega_{Lz3} = \frac{1}{R_E C_E}$$

Now we need to find the poles

The output stage is decoupled from the rest, pole associated with C_{c2} is

$$\tau_{SC}^{C_{c2}} = (R_C + R_L) C_{c2}$$

$$\omega_{Lp1} = \frac{1}{(R_C + R_L) C_{c2}}$$

For the left side, we do SCTC tests

For C_{c1}, we short C_{E} (R_E is neglected)

$$\tau_{SC}^{C_{c1}} = (R_s + R_{BB} \| r_\pi) \cdot C_{c1}$$

For C_E, we short C_{c1}, (Impedance of the base is DEMAGINIFIED by $1+\beta$)

This is shown by replacing C_E with a test voltage source, calculating the test current. The impedance seen by C_E is

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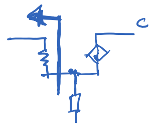


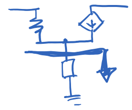
$$\tau_{SC}^{C_E} = \left(R_E \parallel \underbrace{\left(\frac{1}{1+\beta}\right)}_{\text{DEMAGNIFICATION}}(r_\pi + R_{BB} \parallel R_s)\right) \cdot C_E$$

We want C_E to be an open circuit when C_{C1} conducts, hence...

OCTC test on C_{C1} (opening C_E):

$$\tau_{OC}^{C_{C1}} = \left[R_s + R_{BB} \parallel (r_\pi + \underbrace{(1+\beta)}_{\text{MAGNIFICATION}} R_E)\right] \cdot C_{C1}$$

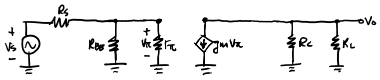
(For resistances seen from the base)



Thus $\omega_{Lp2} = \frac{1}{\tau_{SC}^{C_{C1}}}$, $\omega_{Lp3} = \frac{1}{\tau_{OC}^{C_{C1}}}$

Finally, $$F_L(s) = \underbrace{\left(\frac{s}{s + \left(\frac{1}{\tau_{OC}^{C_{C1}}}\right)}\right)}_{C_{C1}} \underbrace{\left(\frac{s}{s + \left(\frac{1}{\tau_{SC}^{C_{C2}}}\right)}\right)}_{C_{C2}} \underbrace{\left(\frac{s + \frac{1}{R_E C_E}}{s + \left(\frac{1}{\tau_{SC}^{C_E}}\right)}\right)}_{C_E}$$

②



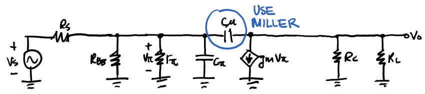
The midband gain is straightforward:

$$V_\pi = V_s \cdot \left(\frac{R_{BB} \parallel r_\pi}{R_{BB} \parallel r_\pi + R_s}\right)$$

$$V_o = -g_m (R_C \parallel R_L) V_\pi$$

$$A_m = \frac{V_o}{V_s} = -g_m \left(\frac{R_{BB} \parallel r_\pi}{R_{BB} \parallel r_\pi + R_s}\right)(R_C \parallel R_L)$$

③



High frequency response is just like what we've done before

1. Use miller
2. decouple output
3. Find poles (all zeroes are at ∞ (negligible)) via SCTC, OCTC tests.

(Refer to previous notes)

$$F_H(s) = \left(\frac{\omega_{Hp1}}{s + \omega_{Hp1}}\right)\left(\frac{\omega_{Hp2}}{s + \omega_{Hp2}}\right)$$