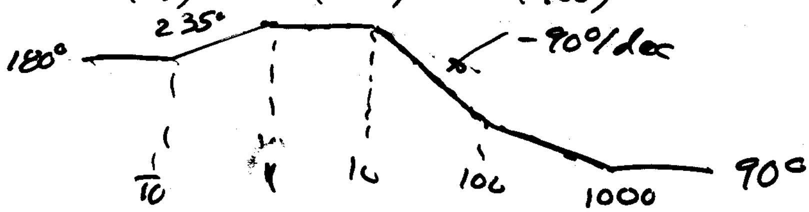
What homework will Quiz #2 be on? (Allen asked this question.)
Op amps (ideal) and frequency. (Q2 & Q3 of Fall 2002)

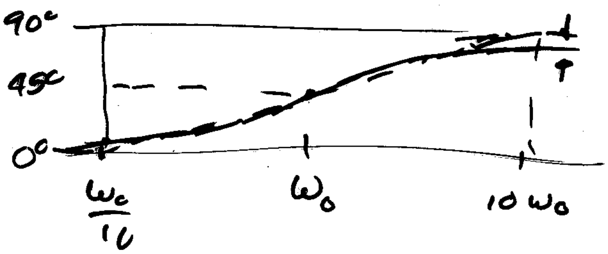
Question:

$$\frac{-10(s+1)}{(s+10)(s+100)} \nearrow \frac{-10\left(\frac{s}{1}+1\right)}{10(100)\left(\frac{s}{10}+1\right)\left(\frac{s}{100}+1\right)}$$

$$20\log_{10}\frac{1}{100} + 20\log_{10}\sqrt{1+\left(\frac{\omega}{1}\right)^2} - 20\log_{10}\sqrt{1+\left(\frac{\omega}{10}\right)^2} - 20\log_{10}\sqrt{1+\left(\frac{\omega}{100}\right)^2}$$

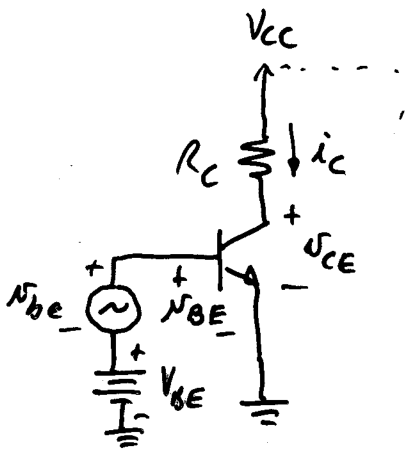
$$\pm 180^\circ + \tan^{-1}\left(\frac{\omega}{1}\right) - \tan^{-1}\left(\frac{\omega}{10}\right) - \tan^{-1}\left(\frac{\omega}{100}\right)$$

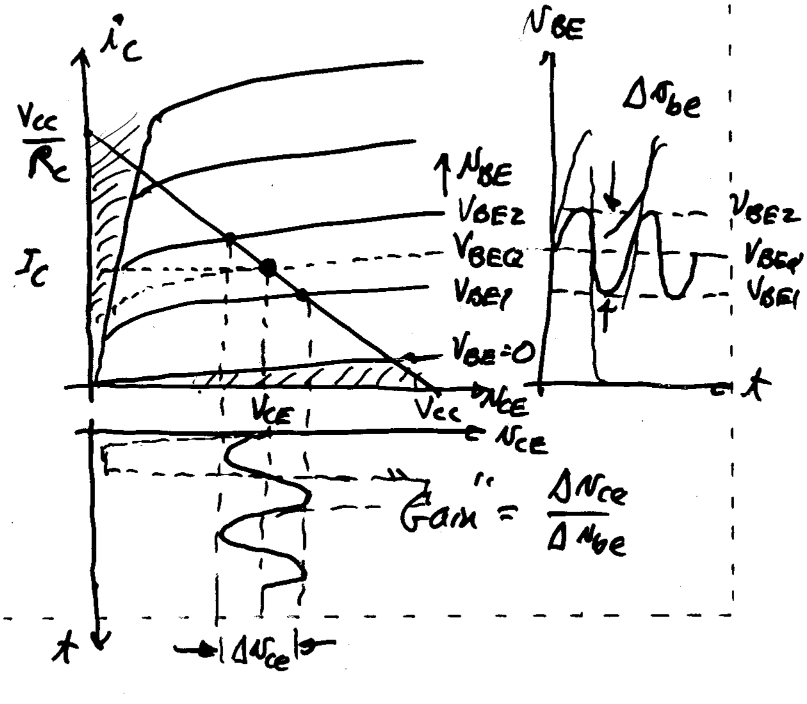




TRANSISTOR AMPLIFIERS

1.) BJT





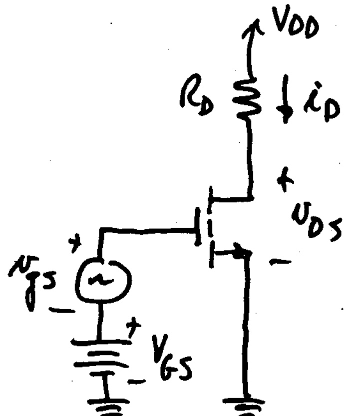
Mathematically,

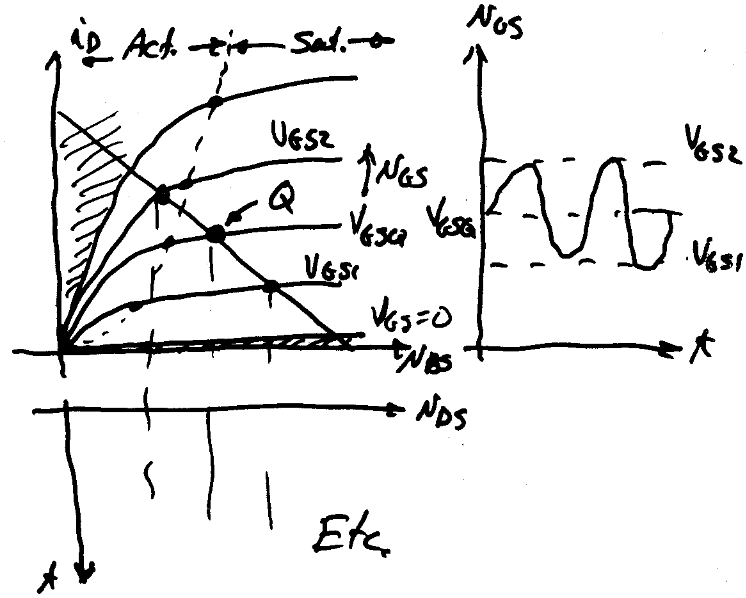
$$v_{CE} = V_{CC} - i_C R_C = V_{CC} - R_C I_S \exp\left(\frac{v_{BE}}{V_t}\right) - \text{[crossed out]}$$

$$\left.\frac{\partial v_{CE}}{\partial v_{BE}}\right|_{v_{BE}=V_{BEQ}} = -\frac{R_C I_S}{V_t}\exp\left(\frac{v_{BE}}{V_t}\right)\Bigg|_{V_{BEQ}} = -\frac{R_C}{V_t}\overbrace{I_S \exp\left(\frac{V_{BEQ}}{V_t}\right)}^{I_{CQ}}$$

$$\text{"Gain"} = \left.\frac{\partial v_{CE}}{\partial v_{BE}}\right|_Q = -\frac{R_C I_{CQ}}{V_t} \rightarrow \frac{-10k\Omega\,(1mA)}{25mV} = -400\ V/V$$

2.) MOSFET





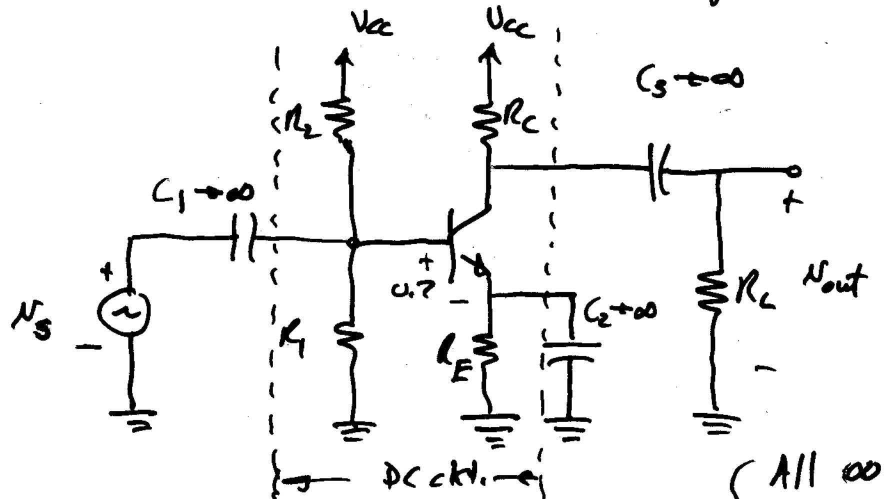
$$v_{DS} = V_{DD} - i_D R_D = V_{DD} - R_D\frac{K_n}{2}\left(v_{GS} - V_{TN}\right)^2$$

$$\left.\frac{\partial v_{DS}}{\partial v_{GS}}\right|_Q = -R_D K_n\left(V_{GSQ} - V_{TN}\right) = -R_D K_n\sqrt{\frac{2I_{DQ}}{K_n}} = -R_D\sqrt{2K_n I_D}$$

$$= -10k\sqrt{2\left(.250\frac{mA}{V^2}\right)1mA} = -7.07\ V/V$$

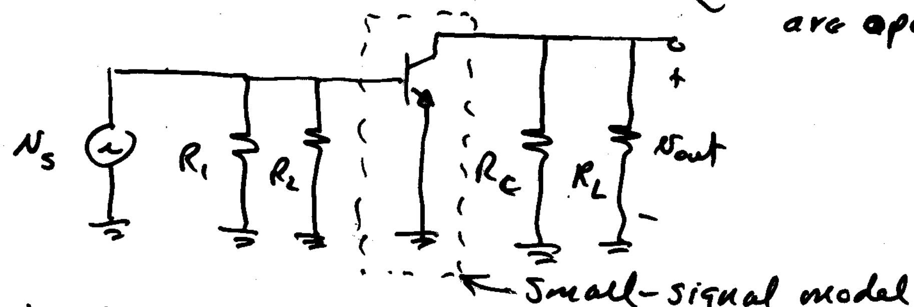
3.) Coupling and By pass Capacitors

How do you separate the ac and dc signals?



⇓ Ac circuit

- All ∞ caps are shorted
- All dc voltages are "
- All dc current sources are opened



4.) Diode Small-Signal Model → ac model, s.s. model

Large signal: $i_D = I_S \left[\exp\left(\frac{v_D}{V_t}\right) - 1 \right]$

$$i_D = i_d + I_D = I_S \left[\exp\left(\frac{v_d + V_D}{V_t} \right) - 1 \right]$$

$$i_d + I_D = I_S \exp\left(\frac{v_d}{V_t}\right) \exp\left(\frac{V_D}{V_t}\right) - 1$$

Expand $\exp\left(\frac{v_d}{V_t}\right)$ with a Maclaurin's series

$$i_d + I_D = I_S \left\{ \exp\left(\frac{V_D}{V_t}\right) \left[1 + \frac{v_d}{V_t} + \frac{1}{2}\left(\frac{v_d}{V_t}\right)^2 + \cdots \right] - 1 \right\}$$

$$i_d + I_D \approx I_S \left[\exp\left(\frac{V_D}{V_t}\right)\right]\left[1 + \frac{v_d}{V_t}\right] - I_S = I_S \left[\exp\left(\frac{V_D}{V_t}\right) - 1\right] + \left[I_S \exp\left(\frac{V_D}{V_t}\right)\right]\left(\frac{v_d}{V_t}\right)$$

$$\therefore\ i_d + I_D = I_D + \left[I_S \exp(V_D/V_t)\right](v_d/V_t) \rightarrow i_d = \left(\frac{I_D + I_S}{V_t}\right) v_d = g_m v_d$$