R. T. Howe

- FALL 2001 MT II POSTER
- SAMPLE MIDTERM II
- INFO ON REVIEW SESSION, OH, ETC.

Lecture 30

- Last time:
  - Wrap-up of Chapter 8
- Today :
  - Frequency response of the CE and CS (?) current amplifiers
  - Unity-gain frequency ω_T

NOT ON MIDTERM II

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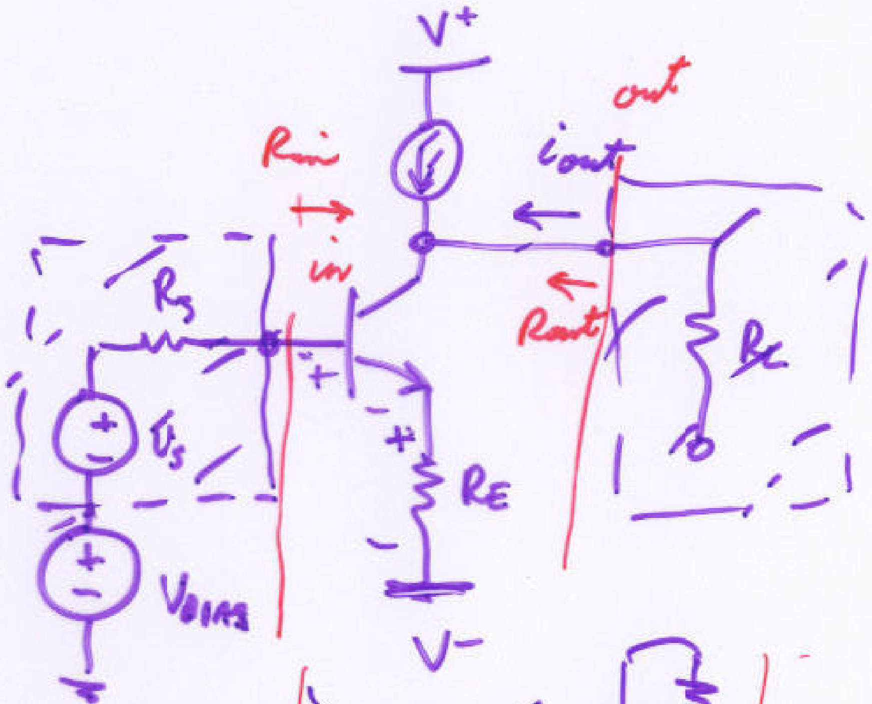
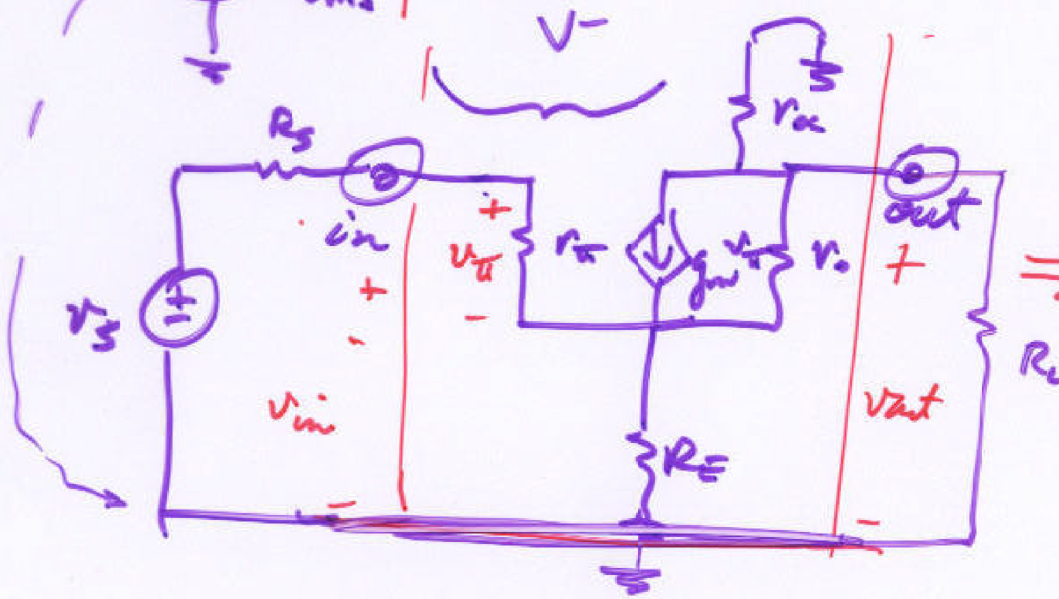
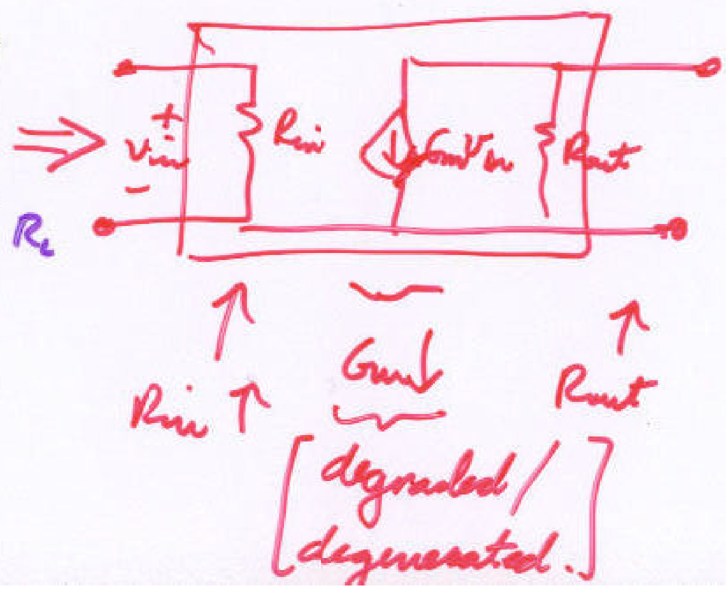


$$i_{OUT} = \cancel{I_{OUT}} + i_{out}$$

set $V_{OUT} = 0\,V$





Two-Port Model for CE_{deg} (cont.)

- Find $G_m = \dfrac{g_m}{1 + g_m R_E} = \dfrac{i_{out}}{v_t}\Big|_{R_S = 0,\ R_L = 0}$

1 + LOOP GAIN

$R_{in} \cong r_\pi (1 + g_m R_E)$; $R_{out} = r_{oc} \,\|\, r_o (1 + g_m R_E)$

- Voltage Gain:

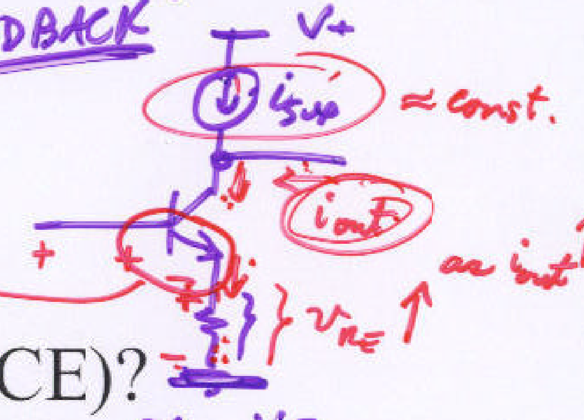
LOADED / OVERALL: R_S, R_L ATTACHED

UNLOADED / OPEN CKT.: $R_S = 0$, $R_L = \infty$.

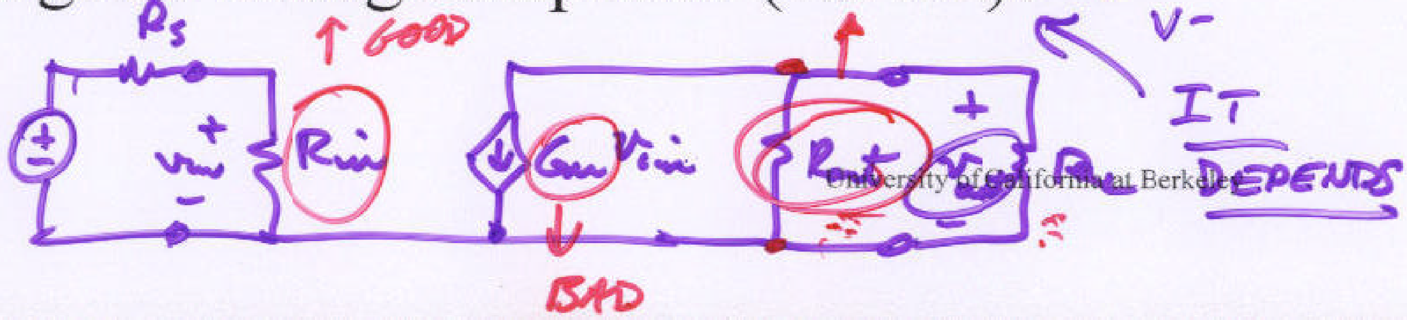
TOTAL

$v_{BE} = v_{IN} - v_{RE}$

FEEDBACK



- Is it a good voltage amplifier (vs. CE)?



$G_m = \frac{g_m}{1 + g_m R_E} \approx \frac{1}{R_E}$ ← GET A STABLE R_E

← WHY CE_{deg}?

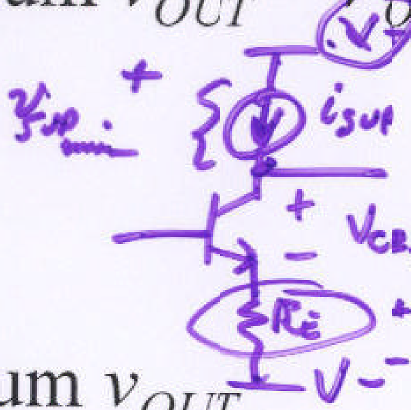
$G_{m_{CE}} = g_m = \frac{I_C}{V_{th}}$

$g_m = \frac{q I_C}{kT}$

T dependence (usually) bad.

Output "Swing"

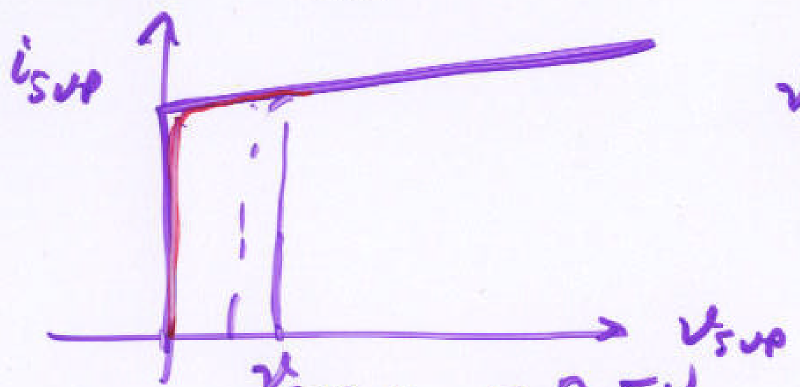
- Maximum $v_{OUT} = V_{OUT} + v_{out} = v_{out}$
- Minimum v_{OUT}



$v_{OUT}|_{min} = V^- + 0.05 + 0.1 = V^- + 0.15V.$

$V_{CE_{sat}} \approx 0.1V$

$V_{RE} = 0.05V.$ (LAST TIME)



$v_{OUT}|_{max} = V^+ - v_{SUP_{min}}$

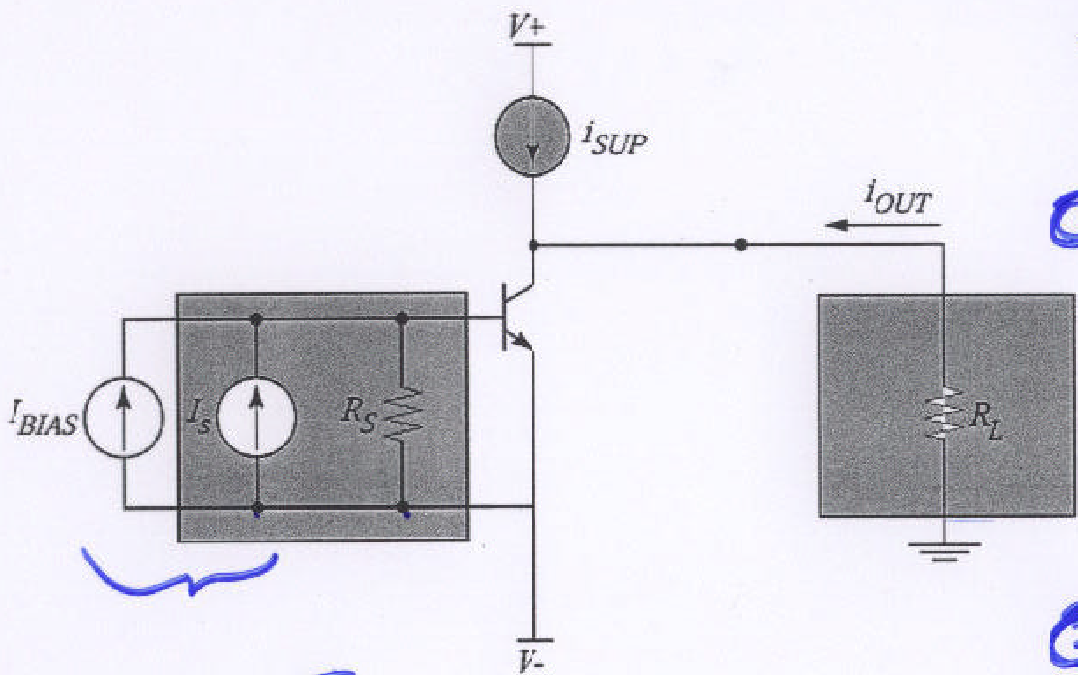
$v_{SUP_{min}} = 0.5V$

CHAPTER 10

CE Amplifier with Current Input

→ REVIEW OF PHASORS ...

USE THEM



START :

1. "CLASSIC EXAMPLES"
   f_T ... TRANSITION FREQUENCIES.
   o ARTIFICIAL ... SIMPLE.
2. LOOK AT CS, CD, CG, CE ...

$$I_{BIAS} = \frac{I_c}{\beta_F}$$

CHAPTERS

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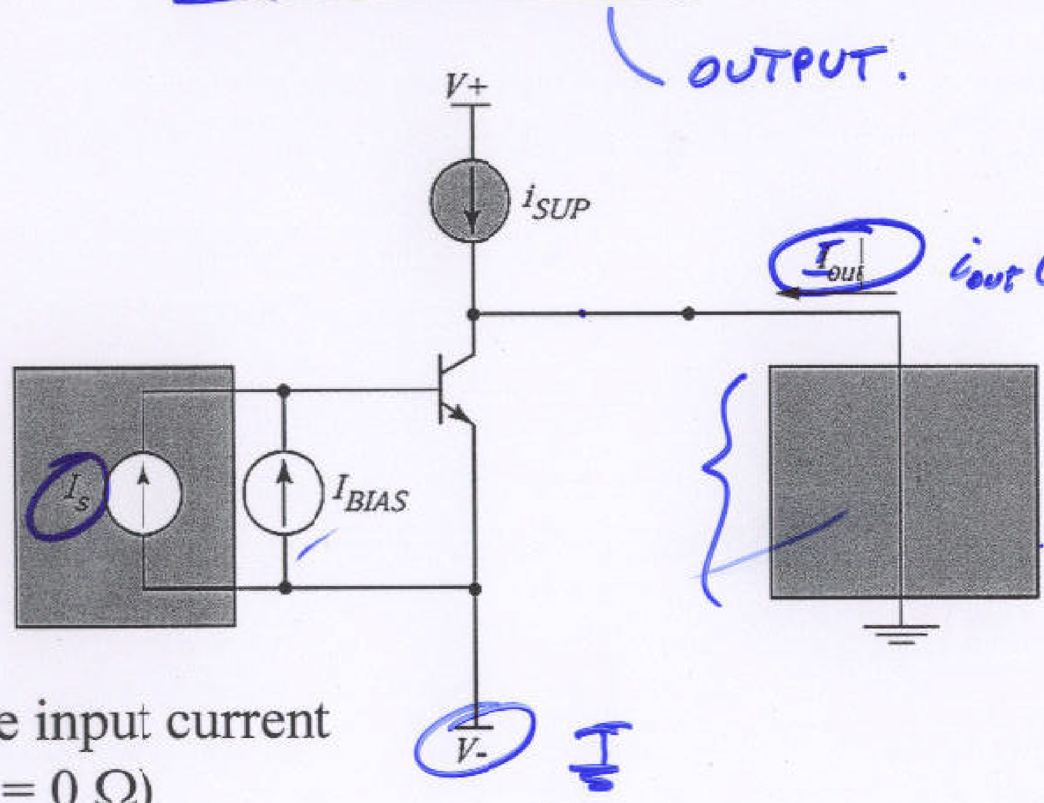
CHAP. 10

$A_i(j\omega) = \frac{I_{out}}{I_s}\Big|_{R_S \to \infty, R_L \to 0}$ ← phasors

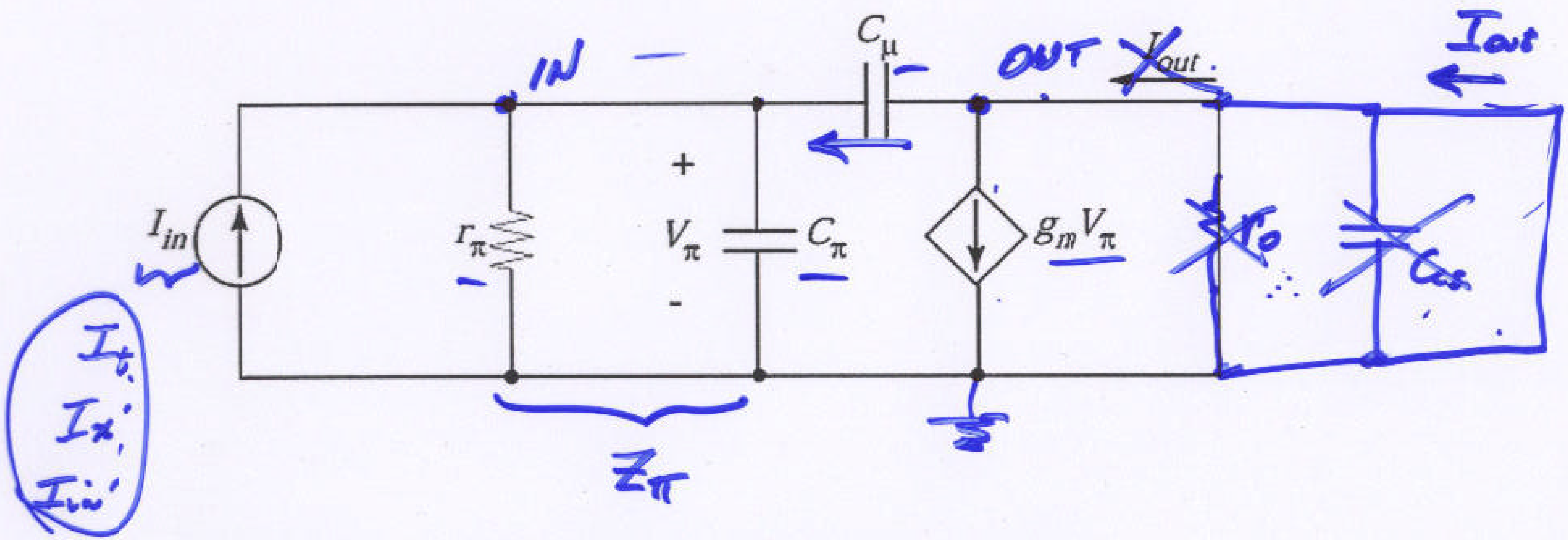
Short-Circuit Current Gain



Pure input current ($R_S = 0\ \Omega$)

Small-signal short circuit (could be a DC voltage source)

Small-Signal Model: $A_i = \frac{I_{out}}{I_{in}}$



Note that r_o, C_{cs} play no role (shorted out)

COMPLICATE ANALYSIS
NOT "FUNDAMENTAL"

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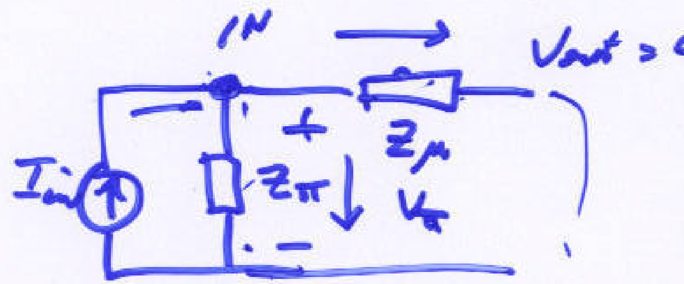
Phasor Analysis: Find A_i

- KCL at the output node: OUT

$$I_{out} = g_m V_\pi + (0 - V_\pi)/Z_\mu$$

KCL at the input node: IN

$$I_{in} = V_\pi / Z_\pi + (V_\pi - 0)/Z_\mu$$



Solve for V_π:

$$I_{in} = V_\pi \left(\frac{1}{Z_\pi} + \frac{1}{Z_\mu} \right)$$

$$V_\pi = \frac{I_{in}}{\frac{1}{Z_\pi} + \frac{1}{Z_\mu}} = (Z_\pi \parallel Z_\mu) I_{in}$$

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Phasor Analysis for A_i (cont.)

$$I_{out} = (g_m - j\omega C_\mu)V_\pi = \frac{g_m - j\omega C_\mu}{(1/Z_\pi) + j\omega C_\mu} I_{in}$$

Substituting for V_π

$$A_i(j\omega) = \frac{(g_m - j\omega C_\mu)}{(1/Z_\pi) + j\omega C_\mu} = \frac{g_m\left[1 - j\omega \frac{C_\mu}{g_m}\right]}{\frac{1}{r_\pi}(1 + j\omega r_\pi C_\pi) + j\omega C_\mu}$$

Substituting for $Z_\pi = r_\pi \,||\, (1/j\omega C_\pi) = \frac{r_\pi \left(\frac{1}{j\omega C_\pi}\right)}{r_\pi + \frac{1}{j\omega C_\pi}}$

$$= \frac{r_\pi}{1 + j\omega r_\pi C_\pi}$$

Short-Circuit Current Gain Transfer Function

Transfer function has one pole and one zero:

$$A_i(j\omega) = \frac{\beta_o(1 - j\omega[C_\mu / g_m])}{1 + j\omega[r_\pi(C_\pi + C_\mu)]}$$

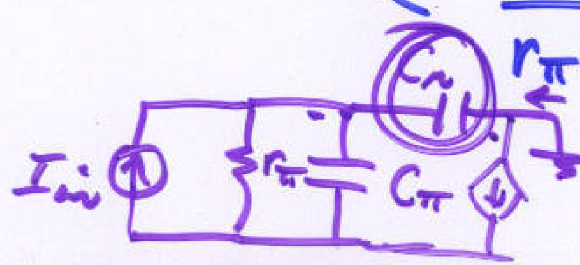
$$A_i(j\omega) = \frac{\beta_o(1 - j\omega / \omega_z)}{(1 + j\omega / \omega_p)}$$

$\beta_o = g_m r_\pi$

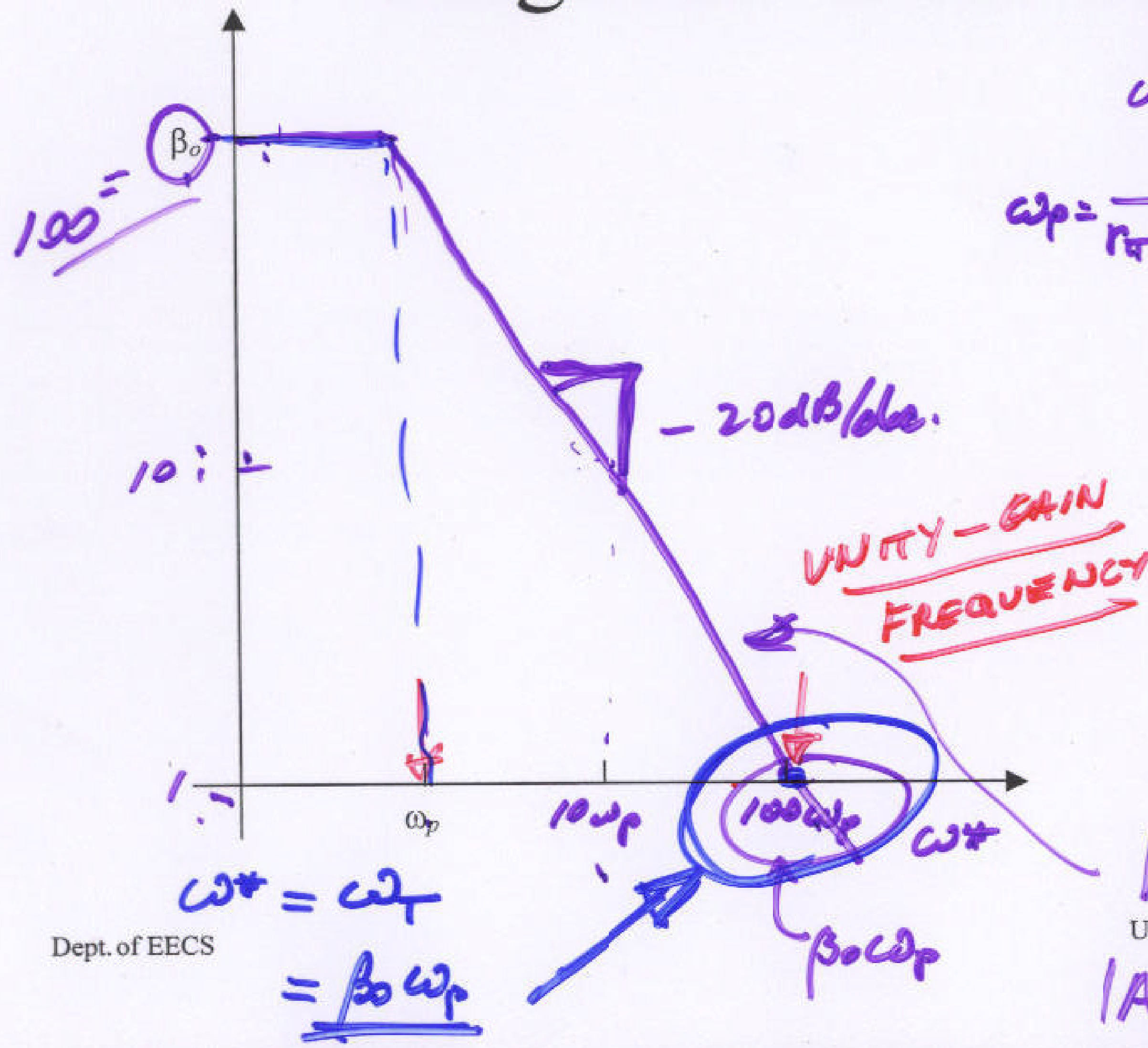
$\omega_z = \frac{g_m}{C_\mu}$

$\frac{1}{r_\pi(C_\pi + C_\mu)} = \omega_p$!

$|A_i(j\omega)| \big|_{\omega \to 0} = \beta_o$



Magnitude Bode Plot



$\omega^* = \omega_T = \beta_0 \omega_p$

$\omega_p \ll \omega_z$ ($\frac{1}{T\omega\omega}$)

$\omega_p = \frac{1}{r_\pi (C_\pi + C_\mu)} = \frac{1}{(\beta_0 / g_m)(C_\pi + C_\mu)}$

$\omega_p = \frac{g_m}{\beta_0 (C_\pi + C_\mu)}$

$\omega_z = \frac{g_m}{C_\mu}$

$A_i(j\omega) = \frac{\beta_0}{1 + j\omega/\omega_p}$

$|A_i(j\omega)| \approx \beta_0 \left(\frac{\omega_p}{\omega}\right)$

$|A_i(j\omega^*)| = 1 = \frac{\beta_0 \omega_p}{\omega^*}$