Amplifier Freq. Response (cont.)

High Freq. Response (1.) $\omega_H \approx \omega_p$(dominant) if $\omega_p \le \frac{1}{4}$ (next longer pole)

2.) $$\omega_H = \frac{1}{\sqrt{\sum_n \frac{1}{\omega_{pn}^2} - 2\sum_n \frac{1}{\omega_{zn}^2}}}$$

17.2 Finding poles/zeros

1.) Direct analysis

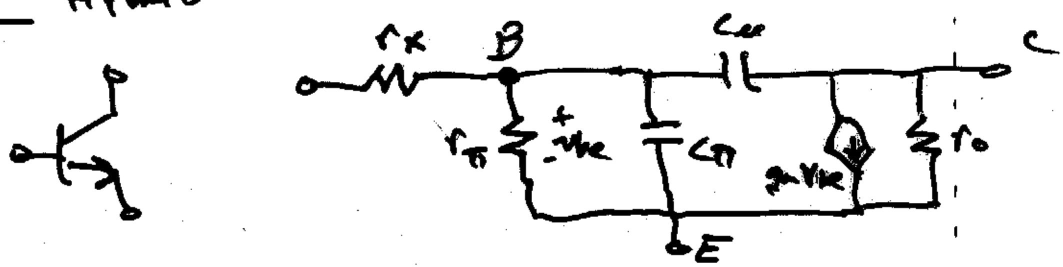
2.) Approximate methods

17.3 Short-circuit time constant method

$$\omega_L \approx \sum_{i=1}^{n} \frac{1}{R_{is} C_i}$$

17.4/17.5 Transistor models at high freqs

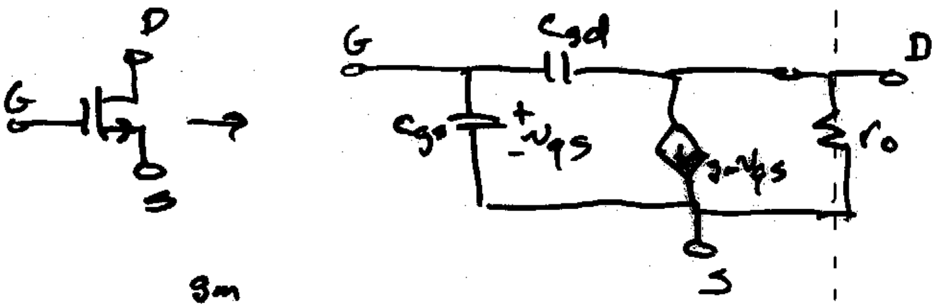
1) BJT Hybrid-PI



$$C_\mu = \frac{C_{\mu o}}{\sqrt{1 + \frac{V_{CB}}{\Phi_{jc}}}} \qquad C_\pi = g_m \tau_F$$

U.G.B.W. $$\omega_T = \frac{g_m}{C_\mu + C_\pi}$$

2) MOSFET



$$\underline{\omega_T} = \frac{g_m}{C_{gs} + C_{gd}}$$

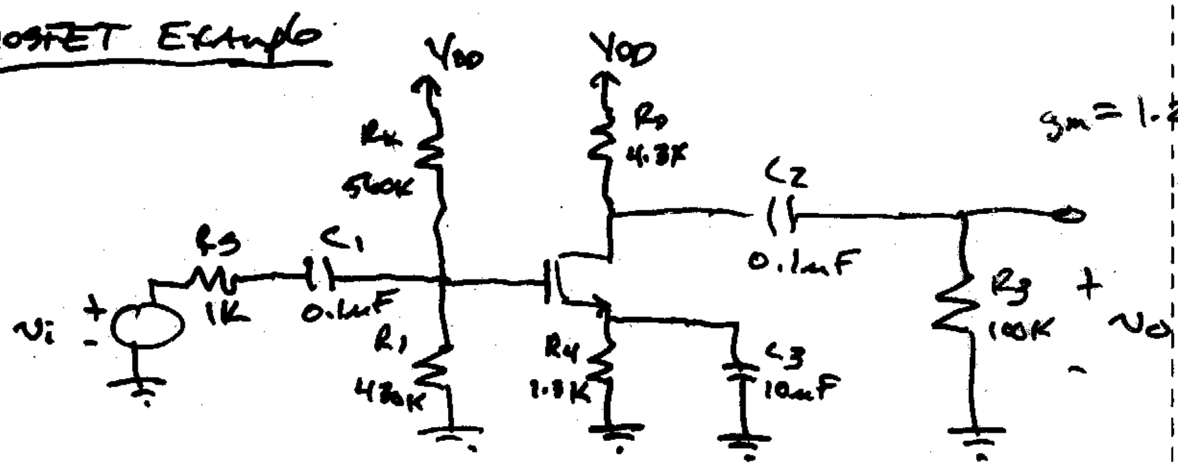
17.6 High Freq Analysis: Goal Find ω_H

1.) Direct analysis
2.) Approximate 2nd order poly. approximation (polynomial)

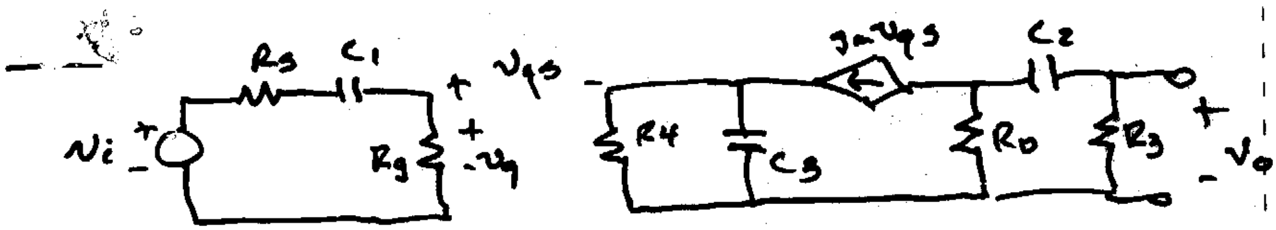
17.8 Open circuit Time-constant method

$$\omega_H \simeq \frac{1}{\sum_{i=1}^{m} R_{io} C_i}$$

MOSFET Example



$g_m = 1.23\,mS$



$R_g = R_1 \| R_2$
$= 243K$

1.) <u>Direct Analysis</u> – only approximation → r_o large

$$\frac{V_o}{V_i} = \left(\frac{V_o}{V_{gs}}\right)\left(\frac{V_{gs}}{V_g}\right)\left(\frac{V_g}{V_i}\right)$$

$$V_o = -g_m V_{gs}\left(\frac{R_D}{R_D + R_3 + \frac{1}{sC_2}}\right)R_3 = \frac{-g_m R_3 R_D}{R_D + R_3}\left(\frac{s}{s + \frac{1}{C_2(R_D + R_3)}}\right)V_{gs}$$

$$V_{gs} = V_g - V_s = V_g - g_m V_{gs}\left(\frac{R_4 \frac{1}{sC_3}}{R_4 + \frac{1}{sC_3}}\right) = V_g - \frac{g_m R_4}{sC_3 R_4 + 1} V_{gs}$$

$$V_{gs}\left[1 + \frac{g_m R_4}{sC_3 R_4 + 1}\right] = V_g \rightarrow \frac{V_{gs}}{V_g} = \frac{sC_3 R_4 + 1}{sC_3 R_4 + 1 + g_m R_4}$$

$$\left\{ \frac{V_{gs}}{V_g} = \frac{s + \frac{1}{C_3 R_4}}{s + \frac{1 + g_m R_4}{C_3 R_4}} \right.$$

$$V_g = \frac{R_G}{R_s + R_G + \frac{1}{sC_1}} v_i = \left(\frac{R_G}{R_s + R_G}\right)\left(\frac{s}{s + \frac{1}{C_1(R_s + R_G)}}\right)$$

$$\therefore \frac{V_o(s)}{V_i(s)} = \underbrace{\left[\left(\frac{-g_m R_3 R_D}{R_3 + R_D}\right)\left(\frac{R_G}{R_s + R_G}\right)\right]}_{A_{mid}} \underbrace{\frac{s^2\left(s + \frac{1}{R_4 C_3}\right)}{\underset{(\omega_{p1})}{\left[s + \frac{1}{C_1(R_s + R_G)}\right]}\left[s + \frac{1 + g_m R_4}{R_4 C_3}\right]\left[s + \frac{1}{C_2(R_D + R_3)}\right]}}_{F_L(s)}$$

example (cont)

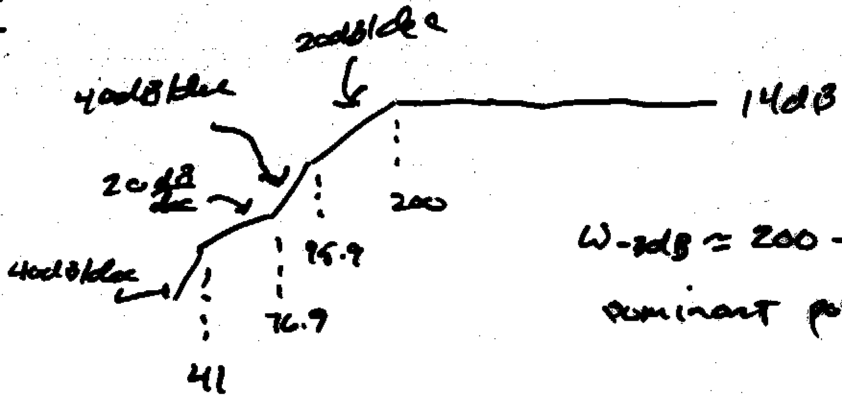
$$\omega_{p1} = \frac{-1}{0.1\mu F(244K)} = -41 \text{ rad/sec}$$

$$\omega_{p3} = \frac{-1}{(0.1\mu F)(104.3K)} = -95.9 \text{ rad/sec}$$

$$\omega_{p2} = -\left(\frac{1+(1.23)(1.3)}{(1.3K)(10\mu F)}\right) = -200 \text{ rad/sec}$$

$$\therefore f_L = \frac{1}{2\pi}\sqrt{200^2+95.9^2+41^2-2(76.9)^2} = \underline{\underline{31.5\,HZ}}$$

BODE PLOT



$\omega_{-3dB} \simeq 200 \rightarrow 31.5\,HZ$

dominant pole

2.) Find ω_L by short-ckt T.C. method

$R_{1s} = R_s + R_G = 244K$, $R_{2s} = R_D + R_3 = 104.3K$

$$R_{3s} = \frac{1}{g_m} \| R_4 = \frac{R_4}{1+g_m R_4} = \frac{1.3K}{1+(1.23)(1.3)} = 0.5K$$

$$\therefore \omega_L = \frac{1}{(244K)(0.1\mu F)} + \frac{1}{(104.3K)(0.1\mu F)} + \frac{1}{(0.5K)(10\mu F)}$$

$$\omega_L = 0.337\times10^3 = 337 \text{ rad/sec} \rightarrow 53.6\,HZ$$