CHAPTER 17 – FREQUENCY RESPONSE

Quiz 7 – Diff. Amps

LOW FREQUENCY ANALYSIS

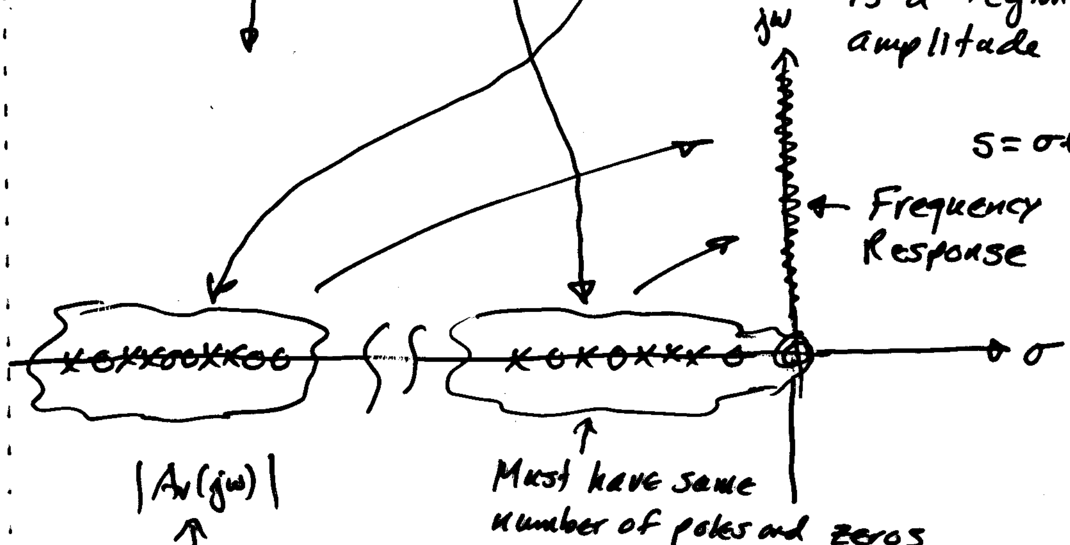
General amplifier response –

$$A_v(s) = \frac{a_0 + a_1 s + a_2 s^2 + \cdots + a_m s^m}{b_0 + b_1 s + b_2 s^2 + \cdots + b_n s^n} \qquad m \le n$$

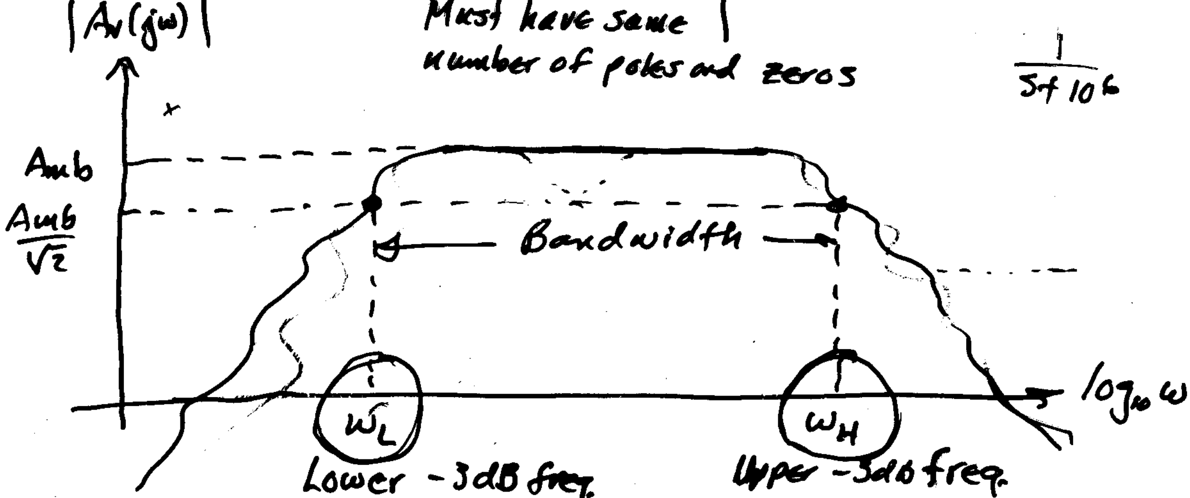
$$= A_{mb} F_L(s) F_H(s)$$

Good only when there is a region of constant amplitude (wideband)

$s = \sigma + j\omega$



$\frac{1}{5\pi 10^6}$

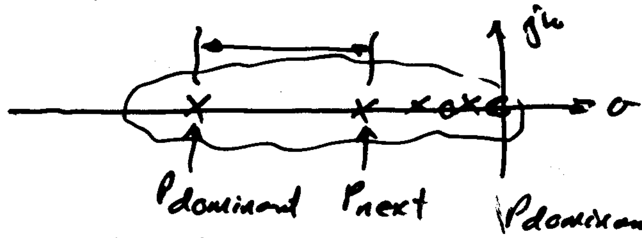


How do we find ω_L?

1.) Direct analysis
2.) Approximation methods

a.) Dominant pole

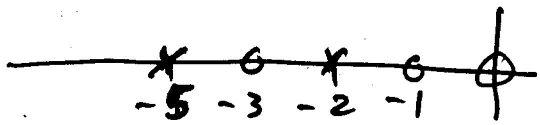
$\omega_L \approx \omega_p$ (dominant) if $|\omega_p(\text{dominant})| \geq 4$ (next smallest pole)

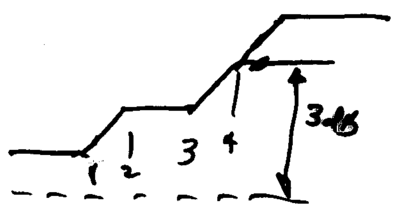


$|P_{dominant}| \geq 4\,|P_{next}|$

b.) No dominant pole -

$$\omega_L \approx \sqrt{\sum_n p_n^2 - 2\sum_j z_j^2}$$





$$\omega_L \approx \sqrt{25+4-2[9+1]} \approx \sqrt{19} \approx 3$$

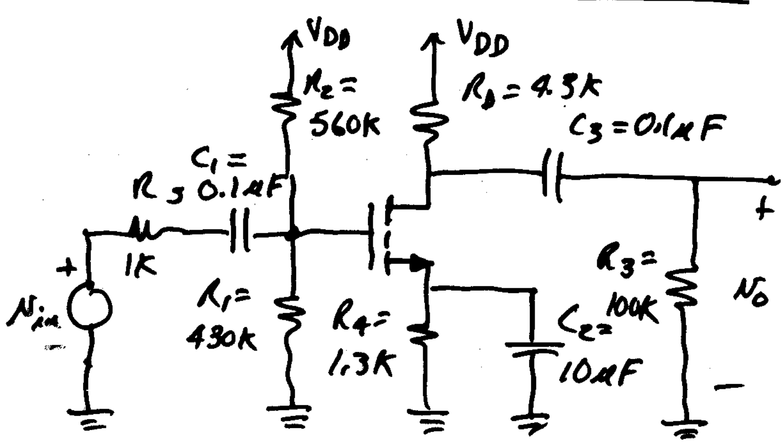
c.) Bode plot

3.) Short-circuit time constant

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

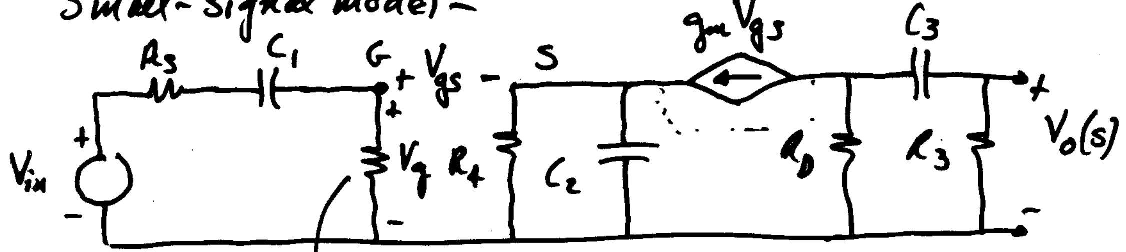
R_{is} is the Thev. eq. R seen by C_i with all other capacitors shorted.

<u>MOSFET Low Frequency Example</u>



Find ω_L if $g_m = 1.23\,mS$ & $r_o = \infty$

Small-signal model –



$R_G = R_1 || R_2 = 243K$

1.) Direct analysis – no approximations except $r_o = \infty$.

$$\frac{V_o}{V_{in}} = \left(\frac{V_o}{V_{gs}}\right)\left(\frac{V_{gs}}{V_g}\right)\left(\frac{V_g}{V_{in}}\right) \qquad Z_c(s) = \frac{1}{sC}$$

$$V_o = -g_m\left(\frac{R_D \, V_{gs}}{R_D + R_3 + \frac{1}{sC_3}}\right)R_3 = \frac{-g_m R_D R_3}{R_D + R_3 + \frac{1}{sC_3}} V_{gs} \qquad z_3 = 0$$

$$\frac{V_o}{V_{gs}} = \left(\underbrace{\frac{-g_m R_D R_3}{R_D + R_3}}_{C_3 = \infty}\right)\left(\frac{s}{s + \frac{1}{C_3(R_D + R_3)}}\right) \qquad p_3 = \frac{-1}{C_3(R_D + R_3)}$$

$$V_{gs} = V_g - V_s = V_g - g_m V_{gs}\left(\frac{R_4 \frac{1}{sC_2}}{R_4 + \frac{1}{sC_2}}\right)$$

$$V_{gs}\left[1 + \frac{g_m R_4}{sR_4C_2 + 1}\right] = V_g \rightarrow \frac{V_{gs}}{V_g} = \frac{sC_2R_4 + 1}{sC_2R_4 + 1 + g_m R_4}$$

$$\frac{V_{gs}}{V_g} = \frac{s + \frac{1}{R_4C_2}}{s + \frac{1 + g_m R_4}{R_4 C_2}} \qquad z_2 = -\frac{1}{R_4C_2} \qquad p_2 = -\frac{1 + g_m R_4}{R_4 C_2}$$

$$\frac{V_g}{V_{in}} = \frac{R_G}{R_G + R_s + \frac{1}{sC_1}} = \left(\underbrace{\frac{R_G}{R_G + R_s}}_{C_1 = \infty}\right)\left(\frac{s}{s + \frac{1}{C_1(R_G + R_s)}}\right) \qquad z_1 = 0 \qquad p_1 = -\frac{1}{C_1(R_G + R_s)}$$

$$\frac{V_o(s)}{V_{in}(s)} = \left(\frac{-g_m R_D R_3}{R_D + R_3}\right)\left(\frac{R_G}{R_G + R_s}\right)\left[\frac{s}{s + p_1} \cdot \frac{s + z_2}{s + p_2} \cdot \frac{s}{s + p_3}\right]$$

$z_1 = 0$, $z_2 = -76.9$ rads/sec, $z_3 = 0$, $p_1 = -41$ rads/sec, $p_2 = -200$ rads/s, $p_3 = -95.9$ rad/s