

Direct Analysis of ω_H for MOSFET Example

17R-5A

$$\left(\frac{1}{R_S} + \frac{1}{R_G} + sC_{gs} + sC_{gd}\right)V_{gs} - sC_{gd}V_o = \frac{V_i}{R_S} \quad (1)$$

$$sC_{gd}(V_o - V_{gs}) + g_m V_{gs} + \frac{V_o}{R_D} + \frac{V_o}{R_3} = 0 \quad (2)$$

$$(10^{-3} + 0.004 \times 10^{-3} + 512 \text{ pF})V_{gs} - 52 \text{ pF}V_o = 10^{-3}V_i \quad (3)$$

$$(1.23 \times 10^{-3} - 52 \text{ pF})V_{gs} + (0.233 \times 10^{-3} + 0.01 \times 10^{-3} + 52 \text{ pF})V_o = 0 \quad (4)$$

$$(10^{-3} + 512 \text{ pF})V_{gs} - 52 \text{ pF}V_o = 10^{-3}V_i$$

$$V_{gs} = - \frac{0.233 \times 10^{-3} + 52 \text{ pF}}{1.23 \times 10^{-3} - 52 \text{ pF}} V_o$$

$$- \left[(10^{-3} + 512 \text{ pF}) \left(\frac{0.233 \times 10^{-3} + 52 \text{ pF}}{1.23 \times 10^{-3} - 52 \text{ pF}} \right) + 52 \text{ pF} \right] V_o = 10^{-3}V_i$$

$$\frac{V_o}{V_i} \left[(10^{-3} + 512 \text{ pF}) (0.233 \times 10^{-3} + 52 \text{ pF}) + 52 \text{ pF} (1.23 \times 10^{-3} - 52 \text{ pF}) \right] = -10^{-3} (1.23 \times 10^{-3} - 52 \text{ pF})$$

$$\frac{V_o}{V_i} = \frac{-10^{-3} (1.23 \times 10^{-3} - 52 \text{ pF})}{0.233 \times 10^{-6} + s \left[12 \text{ pF} \times 0.233 \times 10^{-3} + 2 \text{ pF} \times 10^3 \right] + s^2 29 \text{ pF}^2 + 2 \text{ pF} \times 1.23 \times 10^{-3} = s^2 4 \text{ pF}^2}$$

$$= \frac{-10^{-3} (1.23 \times 10^{-3} - 52 \text{ pF})}{0.233 \times 10^{-6} + s \left[12 (0.233) + 2 + 2(1.23) \right] \times 10^{-15} + s^2 \left[20 \times 10^{-24} \right]}$$

$$= \frac{-10^{-3} (1.23 \times 10^{-3} - 52 \text{ pF})}{20 \times 10^{-24} \left[1.165 \times 10^{16} + \frac{7.256 \times 10^{-15}}{20 \times 10^{-24}} s + s^2 \right]}$$

$\downarrow 3.628 \times 10^8$

$$= \frac{-10^{-3} (1.23 \times 10^{-3} - 52 \times 10^{-12})}{20 \times 10^{-24} \left[s^2 + 3.628 \times 10^8 s + 1.165 \times 10^{16} \right]}$$

Roots of $s^2 + 3.628 s + 1.165$ are

$$P_1, P_2 = - \frac{3.628}{2} \pm \frac{1}{2} \sqrt{(3.628)^2 - 4(1.165)} = -1.814 \pm 1.458$$

$$P_1, P_2 = -0.356 \times 10^8 \text{ and } -3.272 \times 10^8$$

$$z_1 = + \frac{1.23 \times 10^{-3}}{2 \times 10^{-12}} = 6.15 \times 10^8$$

$$\omega_H \approx 0.356 \times 10^8 \text{ rads/sec} \rightarrow \underline{\underline{5.67 \text{ MHz}}}$$