COMMON SOURCE AMPLIFIER

31 JANUARY 2006

COMMON SOURCE CONFIGURATION.

- Writing the nodal equations

$$(V_{in} - V_g)\frac{1}{R_s} = V_{gs}C_{gs} + (V_g - V_o)sC_{gd} \quad (1)$$

$$(V_g - V_o)sC_{gd} = V_o(g_{ds} + G_L + sC_L) + g_m V_{gs} \quad (2)$$

Solving the two equations we get the tranfer function

$$\frac{V_o}{V_{in}} = \frac{-g_m}{g_{ds} + G_L} \frac{1 - \frac{sC_{gd}}{g_m}}{(s^2 \frac{C_{gs}C_{gd} + C_{gd}C_L + C_{gs}C_L}{G_s(g_{ds}+G_L)} + s(\frac{C_{gs}}{G_s} + \frac{C_{gd}(g_m+g_{ds}+G_L)}{G_s(g_{ds}+G_L)} + \frac{C_L}{g_{ds}+G_L}) + 1)} \quad (3)$$

- Consider the case if $C_{gd} = 0$

  The transfer function is then cascade of 2 first order transfer functions with the two poles p_1 and p_2 given by

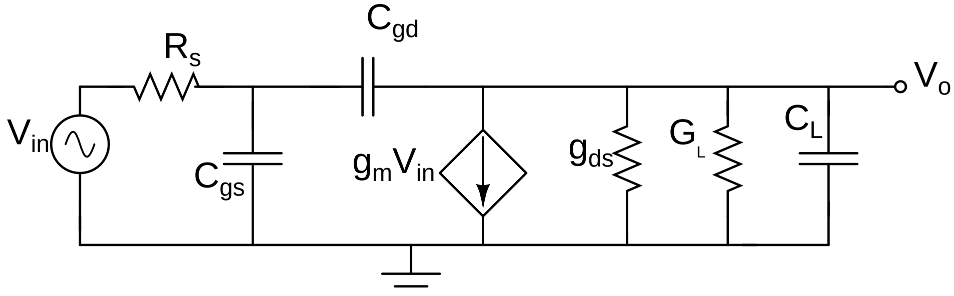

Figure 1: SMALL SIGNAL EQUIVALENT CIRCUIT

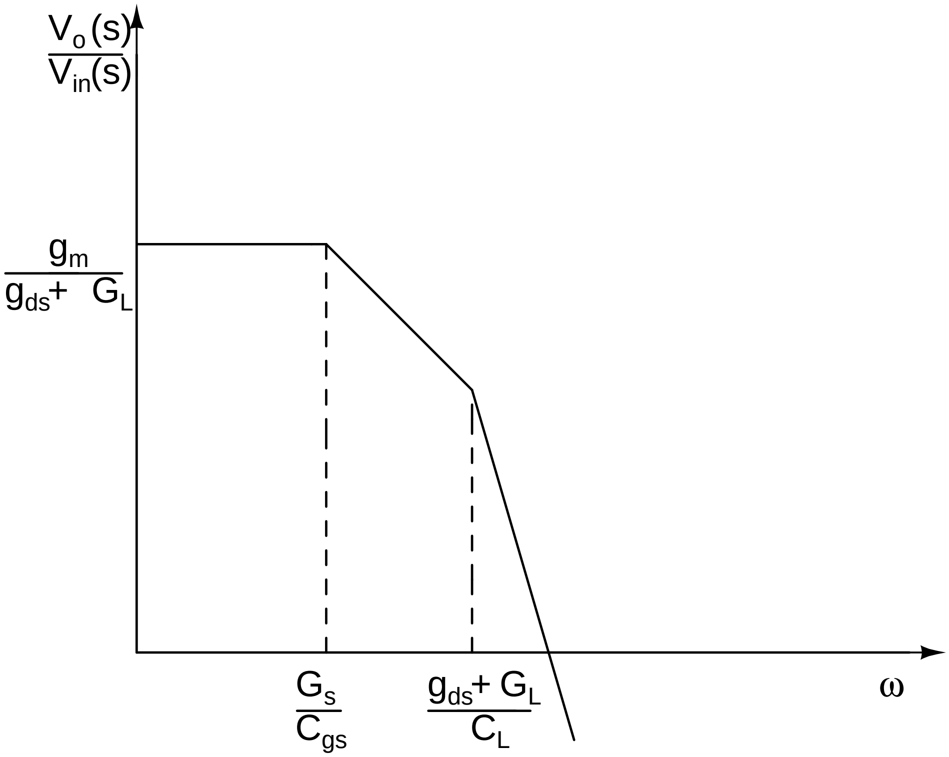

Figure 2: BODE PLOT OF GAIN

$$
\begin{aligned}
P_1 &= -\frac{1}{R_s C_{gs}} && (4) \\
p_2 &= -\frac{g_{ds} + G_L}{C_L} && (5)
\end{aligned}
$$

- Consider the case when $C_{gs} = C_L = 0$

  Due to MILLER EFFECT , the input capacitance is $C_{gd}(1 + \frac{g_m}{g_{ds}+G_L})$. Therefore

$$p_1 = \frac{1}{R_s C_{gd}(1 + \frac{g_m}{g_{ds}+G_L})} \quad (6)$$

- The poles of the actual tranfer function can be found by assuming that they are far apart.

Given a quadratic equation $ax^2 + bx + c = 0$, given the roots $x_1 and x_2$ are real and far apart $x_1 >> x_2$ then $x_1 = -\frac{b}{a}$ and $x_2 = -\frac{c}{b}$.

So to find the poles of the transfer function

$$\frac{V_o}{V_{in}} = \frac{-g_m}{g_{ds} + G_L} \frac{1 - \frac{sC_{gd}}{g_m}}{(s^2 \frac{C_{gs}C_{gd} + C_{gd}C_L + C_{gs}C_L}{G_s(g_{ds} + G_L)} + s(\frac{C_{gs}}{G_s} + \frac{C_{gd}(g_m + g_{ds} + G_L)}{G_s(g_{ds} + G_L)} + \frac{C_L}{g_{ds} + G_L}) + 1)} \tag{7}$$

we assume that they are far apart therefore, The high frequency pole p_1 and The low frequency pole p_2 are

$$p_1 = -\frac{(\frac{C_{gs}}{G_s} + \frac{C_{gd}(g_m + g_{ds} + G_L)}{G_s(g_{ds} + G_L)} + \frac{C_L}{g_{ds} + G_L})}{(\frac{C_{gs}C_{gd} + C_{gd}C_L + C_{gs}C_L}{G_s(g_{ds} + G_L)})} \tag{8}$$

$$p_2 = \frac{1}{(\frac{C_{gs}}{G_s} + \frac{C_{gd}(g_m + g_{ds} + G_L)}{G_s(g_{ds} + G_L)} + \frac{C_L}{g_{ds} + G_L})} \tag{9}$$

☛ If $C_{gd} >> C_{gs}, C_L$

$$p_1 = -\frac{g_m + g_{ds} + G_L}{C_{gs} + C_L} \tag{10}$$

$$p_2 = -\frac{1}{R_s[C_{gd}(1 + \frac{g_m}{g_{ds} + G_L}) + C_{gs}]} \tag{11}$$

☛ As C_{gd} increases pole splitting occurs.

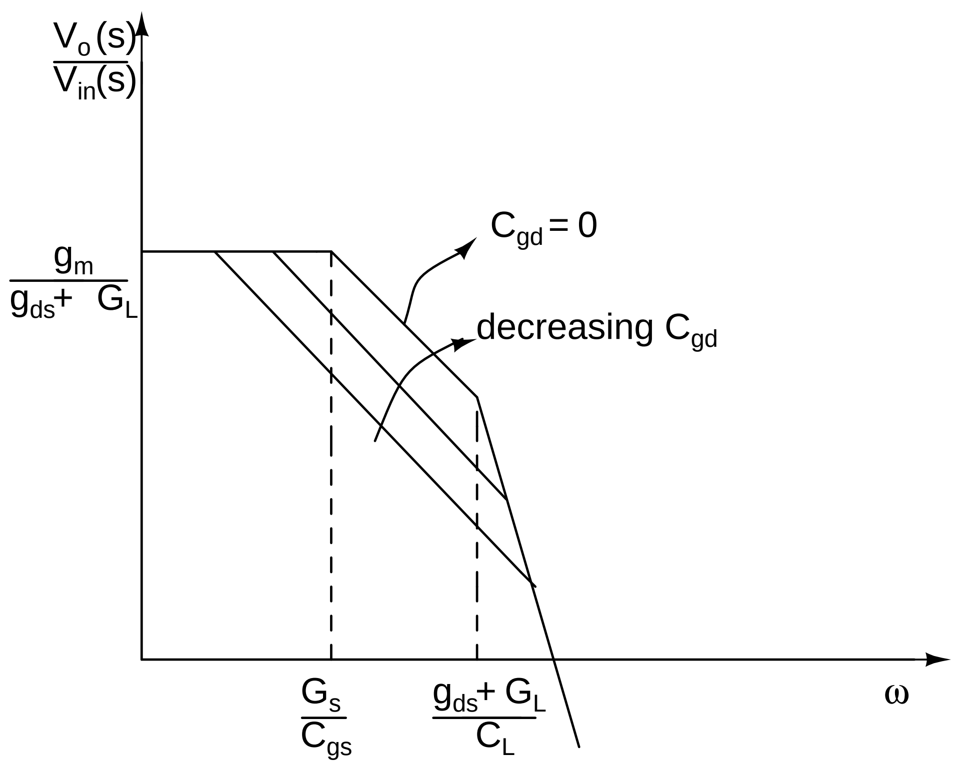

Figure 3: BODE PLOT OF GAIN