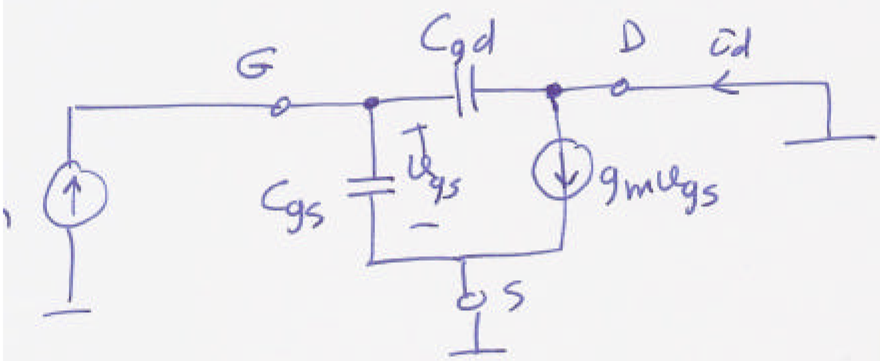
5-11.

f_T (the unity gain bandwidth)

The definition

The most common definition of $\omega_T = 2\pi$



Neglecting the effect of C_{gd} on i_d and shorting the drain to A-C-ground:

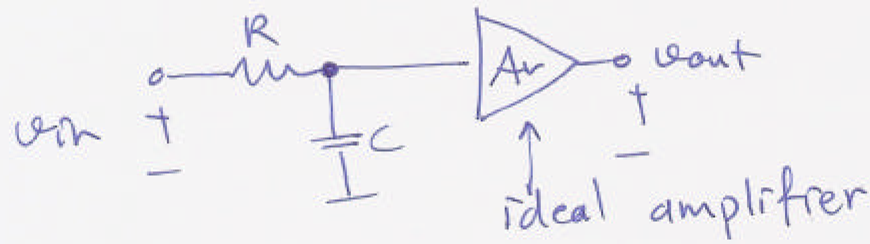
ω_T is the radian frequency at which the current gain of the amplifier is equal to unity (or more precisely at the frequency at which the extrapolated gain curve meets t unity gain line)!

$$\Rightarrow \left| \frac{i_d}{i_{in}} \right| = \frac{g_m}{\omega (C_{gs} + C_{gd})}$$

$$1 = \frac{g_m}{\omega_T (C_{gs} + C_{gd})} \Rightarrow$$

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

The other name for ω_T is the gain-bandwith product. Take the following example of an amplifier with single dominant pole.



$$G(\omega) = \frac{v_{out}(j\omega)}{v_{in}(j\omega)} = \frac{A_v}{1+j\omega RC}$$

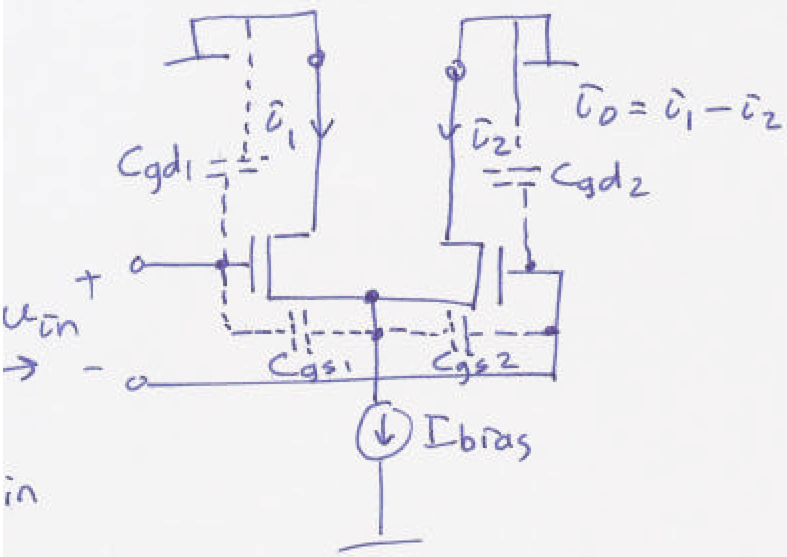
$$G(\omega_T) = 1 = \left(\frac{A_v^2}{1^2+\omega_T^2R^2C^2}\right)^{1/2}$$

$$\Rightarrow \omega_T = \frac{(A_v^2-1)^{1/2}}{RC} \approx \frac{A_v}{RC} \quad \text{for } A_v > 3$$

The 3dB bandwidth of the amplifier is $\omega_{3dB} = \frac{1}{RC}$ $\Rightarrow$

$$\text{gain-bandwidth product} = \frac{A_v}{RC} = \omega_T$$

f_t doubler



differential pair as f_T doubler

The gain g_m of the differential pair is the same as of the single transistor if i_o is taken as $i_1 - i_2$ since v_{gs} of each transistor is the half of v_{in}, but i_o is twice of i_1 and i_2. At the same time, C_{in} is half of the gate-to-source capacitance, therefore doubling f_t. Remember

$$w_t = \frac{g_m}{C_{in}} = \frac{2 \times g_m/2}{\frac{C_{gs}}{2} + \frac{C_{gd}}{2}} = \frac{2g_m}{C_{gs} + C_{gd}}$$