3) Calculate noise factor (F) under the impedance matched condition (10pt).

$$F = 1 + \frac{4kTR_F\Delta f\left(\frac{1}{2}\right)^2 + 4kTR_b\Delta f\left(\frac{1}{2}\frac{R_F}{R_S}\right)^2 + 4kTR_L\Delta f\left(\frac{1}{2}\right)^2 + 4kT\gamma g_m \Delta f\left(\frac{1}{2}\cdots\right.}{4kTR_S\Delta f\left(\frac{1}{2}\frac{R_F}{R_S}\right)^2}$$

$$= 1 + \frac{R_S}{R_F} + \frac{R_b}{R_S} + \frac{R_L}{R_S}\left(\frac{R_S}{R_F}\right)^2 + \frac{\gamma g_m}{R_S}\left(\frac{R_S}{R_F}\right)^2 \cdot R_L^2$$

$$= 1 + \frac{R_S}{R_F} + \frac{R_b}{R_S} + \frac{R_L}{R_S}\left(\frac{R_S}{R_F}\right)^2 + \gamma\frac{R_S}{R_F}$$

$$= 1 + 0.1 + 0.1 + (0.1)^2 + 3\times 0.1 = 1.51 \rightarrow 1.79\,dB$$

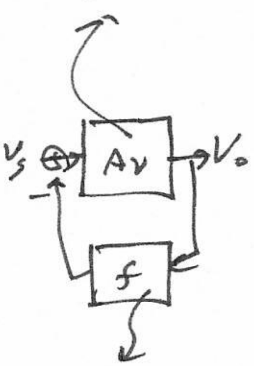
4) Calculate THD without feedback ($R_F=\infty$). Assume that V_s=40 mV_p (10pt).

$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}\left(V_{GS}-V_{th}+V_s\cos\omega t\right)^2$$

$$= I_{DC} + \underbrace{\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{th})}_{=g_m=\alpha_1} V_s\cos\omega t + \underbrace{\frac{1}{2}\mu_n C_{ox}\frac{W}{L}}_{=\alpha_2} V_s^2\cos^2\omega t$$

$$\therefore THD = HD_2 = \frac{1}{2}\frac{\alpha_2}{\alpha_1}V_s = \frac{V_s}{4(V_{GS}-V_{th})} = \frac{40\,mV_p}{4\times 0.2} = 0.05 = 5\,\%$$

$A_v = g_m R_L$



$f = R_S/R_F$

5) With R_F, determine feedback factor and loop gain (10pt).

- feedback factor, $f = \frac{R_S}{R_F+R_S} \simeq \frac{R_S}{R_F} = 0.1$
- loop gain $= (g_m\cdot R_L)\cdot f = \frac{R_F}{R_S}\cdot\frac{R_S}{R_F} = 1$

6) Calculate THD with feedback. Also assume that V_s=40 mV_p (~~10~~ 15pt).

when applying feedback,

$$\alpha_1 \rightarrow \frac{\alpha_1}{1+\text{loop gain}}$$

$$\alpha_2 \rightarrow \frac{\alpha_2}{(1+\text{loop gain})^3}$$

$\Rightarrow (HD_2)_{\text{with feedback}}$

$$= (HD_2)_{\text{without feedback}} \times \frac{1}{(1+\text{loop gain})^2}$$

$$= 0.05 \times \frac{1}{4} = 0.0125 \rightarrow 1.25\,\%$$