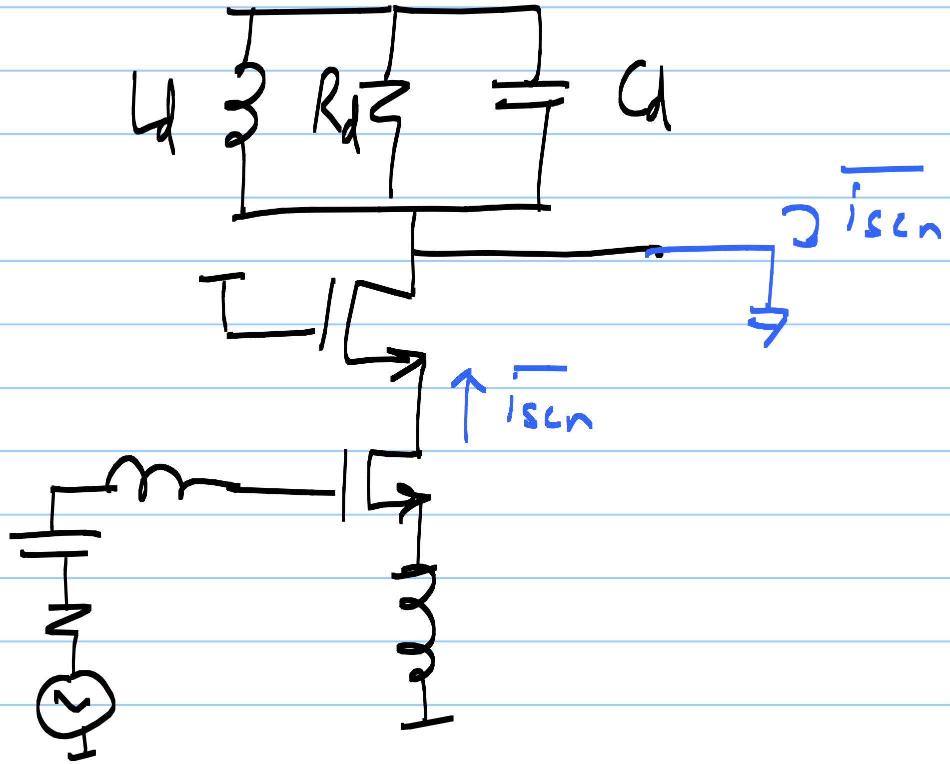
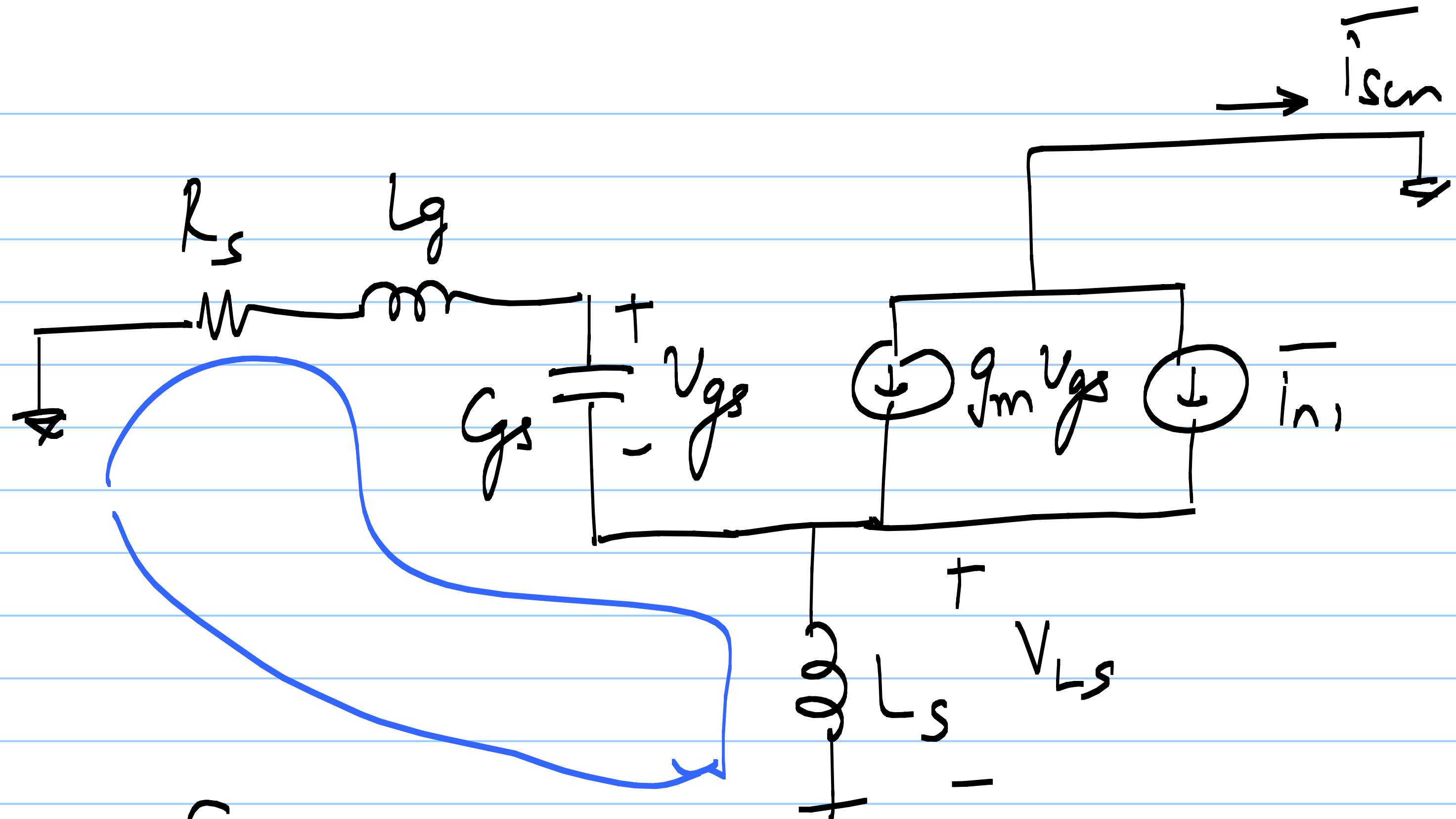
18/2/20

Lec 14





$$V_{L_s} = \left[s C_{gs} \cdot v_{gs} - \overline{i_{scn}} \right] \cdot s L_s$$

$$\overline{i_{scn}} + g_m v_{gs} + \overline{i_{n1}} = 0 \Rightarrow v_{gs} = -\frac{(\overline{i_{scn}} + \overline{i_{n1}})}{g_m}$$

$$V_{L_s} = s^2 L_s C_{gs} v_{gs} + s L_s \left(g_m v_{gs} + i_{n1} \right)$$

$$0 = s C_{gs} v_{gs} \left(R_s + sL_g + \frac{1}{sC_{gs}} \right) + V_{L_s}$$

$$0 = s C_{gs} v_{gs} \left(R_s + sL_g + \frac{1}{sC_{gs}} \right) + s^2 L_s C_{gs} v_{gs} + sL_s \left(g_m v_{gs} + \overline{i_{n,}} \right)$$

$$0 = v_{gs} \left[\cancel{s^2 C_{gs} (L_s + L_g)} \cancel{+1} + s C_{gs} R_s + sL_s g_m \right] + s L_s \overline{i_{n,}}$$

$$v_{gs} = \frac{-s L_s \overline{i_{n,}}}{sL_s g_m + s C_{gs} R_s} = \frac{-L_s \overline{i_{n,}}}{g_m L_s + C_{gs} R_s}$$

$$v_{gs} = \frac{-\left(\overline{i_{scn}} + \overline{i_{n1}}\right)}{g_m}$$

$$\frac{L_s \cdot \overline{i_{n1}}}{g_m L_s + C_{gs} R_s} = \frac{\overline{i_{scn}}}{g_m} + \frac{\overline{i_{n1}}}{g_m}$$

$$\overline{i_{scn}} = \left(\frac{g_m L_s}{g_m L_s + C_{gs} R_s} - 1\right) \overline{i_{n1}}$$

$$= -\frac{C_{gs} R_s}{g_m L_s + C_{gs} R_s} \cdot \overline{i_{n1}}$$

$$= \frac{-1}{1 + \frac{g_m L_s}{C_{gs} R_s}} \cdot \overline{i_{n1}}$$

$$\omega_T L_s = R_s \Rightarrow \frac{g_m}{C_{gs}} \cdot L_s = R_s$$

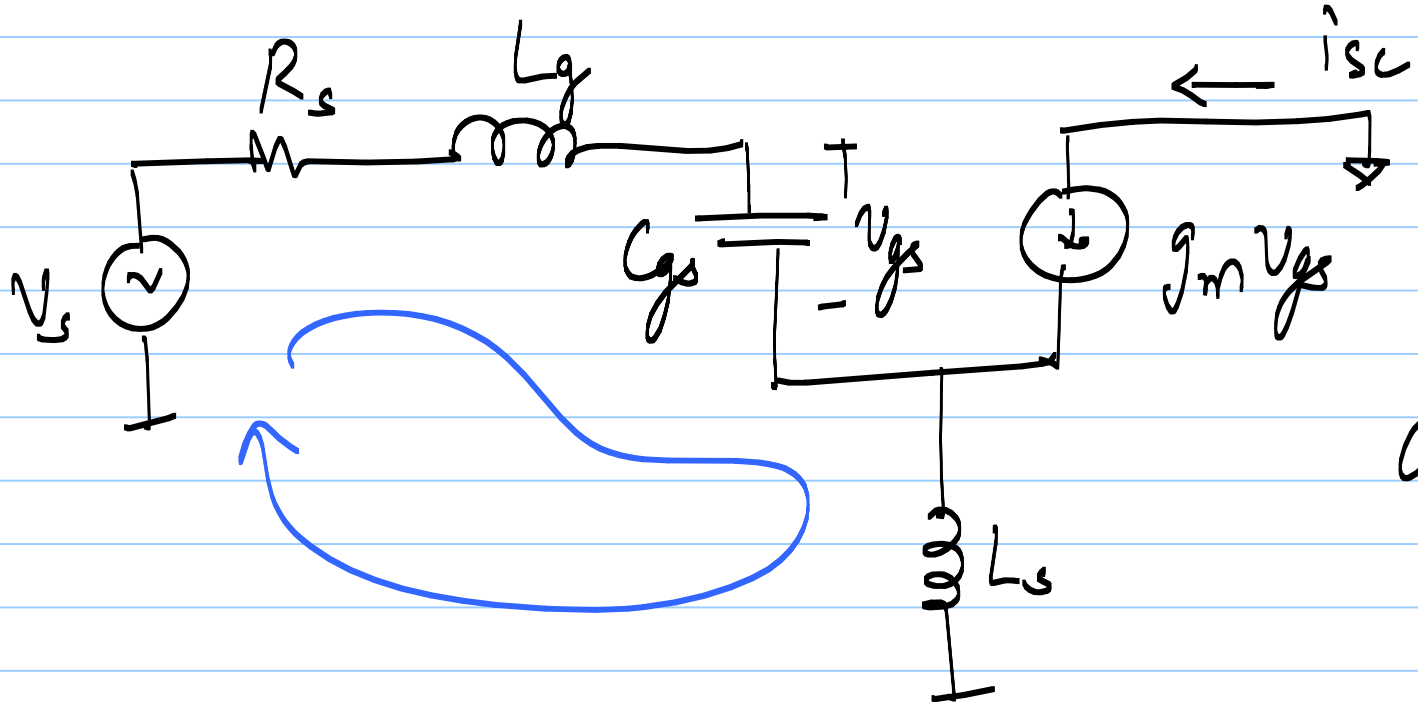
$$\frac{g_m L_s}{C_{gs} R_s} \simeq 1$$

$$\overline{i_{scn}} = -\frac{\overline{i_n}}{2}$$

$$\overline{i_{scn}^2} = \frac{\overline{i_n^2}}{4} = kT\gamma g_m \Delta f$$

$$\overline{i_{scn_{Rd}}^2} = \frac{4kT}{R_d} \Delta f$$

$$G_{m_{LNA}} = ?$$



$$G_m = \frac{i_{sc}}{v_s}$$

$$V_{L_s} = \left(i_{sc} + sC_{gs}v_{gs}\right)\cdot sL_s$$

$$v_s = sC_{gs}v_{gs}\left(R_s + sL_g + \frac{1}{sC_{gs}}\right) + V_{L_s}$$

$$= sC_{gs}v_{gs}\left(R_s + sL_g + \frac{1}{sC_{gs}}\right) + \left(sL_s i_{sc} + s^2 C_{gs}L_s v_{gs}\right)$$

$$v_s = v_{gs}\left(\cancel{s^2 C_{gs}(L_g+L_s)} \cancel{+1} + sC_{gs}R_s\right) + sL_s i_{sc}$$

$$v_s = v_{gs} \cdot sC_{gs}R_s + sL_s i_{sc}$$

$$g_m v_{gs} = i_{sc}$$

$$v_s = \left[\frac{sC_{gs}R_s}{g_m} + sL_s\right] i_{sc}$$

$$= \frac{sC_{gs}R_s + sL_s g_m}{g_m}\, i_{sc}$$

$$G_m = \frac{i_{sc}}{v_s} = \frac{g_m}{g_m sL_s + sC_{gs}R_s} = \frac{\overbrace{\frac{g_m}{C_{gs}}}^{=\omega_T}\cdot\frac{1}{sR_s}}{\underbrace{1 + \frac{g_m L_s}{C_{gs}R_s}}_{=2}}$$

$$\left|G_m(\omega_0)\right| = \frac{1}{2R_s}\cdot\left|\frac{\omega_T}{\omega_0}\right|$$

$$-\omega_0^2 C_{gs}(L_s + L_g) + 1 = 0$$

$$\overline{v_{n,in}^2} = \frac{1}{|G_m(\omega_0)|^2} \cdot \left[\overline{i_{s,cM_1}^2} + \overline{i_{s,cR_d}^2} \right]$$

$$F = 1 + \frac{\overline{v_{n,in}^2}}{v_{nR_s}^2}$$

$$= 1 + \frac{4R_s^2 \cdot \left(\frac{\omega_0}{\omega_T}\right)^2 \left[kT\gamma g_{m_1} + \frac{4kT}{R_d} \right]}{4kTR_s}$$

$$= 1 + g_{m_1} R_s \gamma \left(\frac{\omega_0}{\omega_T}\right)^2 + 4\frac{R_s}{R_d}\left(\frac{\omega_0}{\omega_T}\right)^2$$

e.g. $\dfrac{\omega_0}{\omega_T} = \dfrac{1}{5}$; $\gamma = 2$; $R_s = 50\Omega$

$R_d = 200\Omega$; $g_m = 100mS$ (say)

$$|G_m(\omega_0)| = \frac{5}{2R_s} = \frac{5}{100} = 50mS$$

$$F = 1 + (0.1)(50) \times (1/5)^2 \times 2$$

$$+ \frac{4 \times 50}{200} (1/5)^2$$

$$= 1 + 0.4 + 0.04 = 1.44$$

$$NF = 10 \log_{10}(F) = 1.6dB$$

$Q_{in} \uparrow \Rightarrow \dfrac{1}{2 R_s C_{gs} \cdot \omega_0} \uparrow \Rightarrow C_{gs} \downarrow$

if ω_T & $\dfrac{\omega_T}{\omega_0}$ were kept constant,

$L_s = \text{constant}$

$\Rightarrow L_g \uparrow$