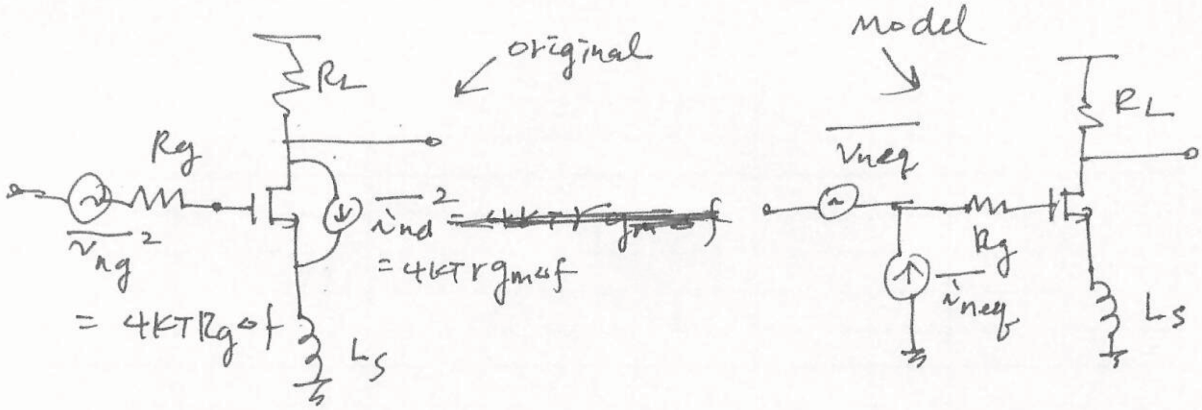


I) Equivalent input noise generators.

① Computing $\overline{v_{neq}}$ ⇒ short input to ground.

From original circuit, output noise ~~voltage~~ current is

$$\overline{i_{on}} = \overline{v_{ng}} \cdot \frac{g_m}{1+g_m \cdot sL_s} + \overline{i_{nd}} \, \frac{\frac{1}{g_m}}{\frac{1}{g_m}+sL_s}$$

$$= \frac{1}{1+g_m \cdot sL_s}\left(\overline{v_{ng}} \cdot g_m + \overline{i_{nd}}\right) \quad \text{— (A)}$$

From model, output noise current is

$$\overline{i_{on}} = \overline{v_{neq}} \, \frac{g_m}{1+g_m \cdot sL_s} \quad \text{— (B)}$$

⇒ From (A) and (B),

$$\overline{v_{neq}} = \overline{v_{ng}} + \frac{\overline{i_{nd}}}{g_m}$$

2 Computing $\overline{i_{neq}}$ ⇒ open input node.

From original circuit, output noise current is

$$\overline{i_{on}} = \overline{i_{nd}} \quad \text{— A}$$

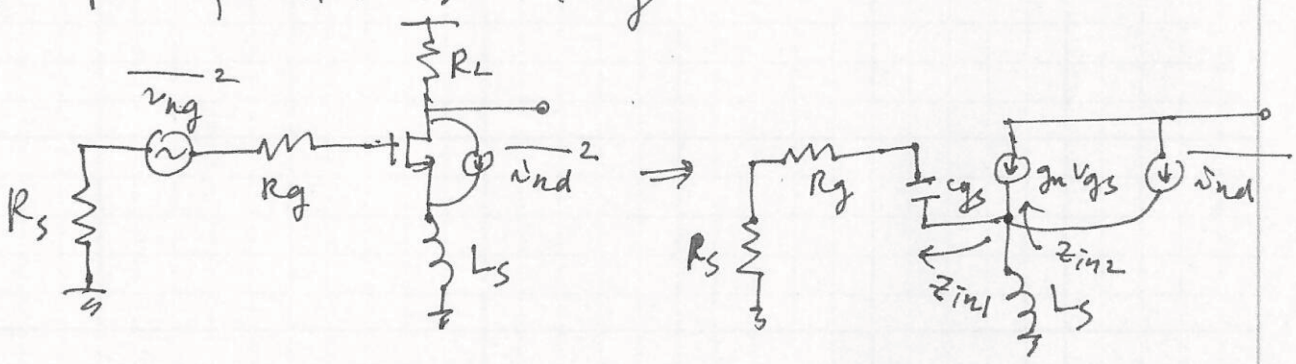
From model, output noise current is

$$\overline{i_{on}} = \overline{i_{neq}} \cdot \frac{1}{sC_{gs}} \cdot g_m \quad \text{— B}$$

⇒ From A and B

$$\overline{i_{neq}} = \overline{i_{nd}} \cdot \frac{sC_{gs}}{g_m} = \overline{i_{nd}} \frac{j\omega C_{gs}}{g_m}$$

2) Input referred noise voltage



From equivalent circuit shown in ~~left~~ right side,

$$Z_{in1} = \frac{1}{sC_{gs}} + R_g + R_s \approx \frac{1}{sC_{gs}} + R_s$$

$$Z_{in2} = \frac{\frac{1}{sC_{gs}} + R_s + R_g}{\frac{g_m}{sC_{gs}}} \approx \frac{1 + sC_{gs}R_s}{g_m}$$

⇒ Output noise current due to $\overline{i_{nd}}$ is

$$i_{no}\Big|_{\text{due to } \overline{i_{nd}}} = \frac{Z_{in2}}{Z_{in1} \,//\, sL_s + Z_{in2}} \cdot \overline{i_{nd}}$$

Therefore equivalent input noise voltage to create this noise current is

$$\overline{v_{neq}} \cdot \frac{\frac{g_m}{sC_{gs}}}{R_s + R_g + \frac{1}{sC_{gs}} + \left(1 + \frac{g_m}{sC_{gs}}\right)\cdot sL_s} = i_{no}\Big|_{\text{due to } \overline{i_{nd}}}$$

$$\Rightarrow \overline{v_{neq}} = \frac{\left(\frac{Z_{in2}}{Z_{in1} /\!/ sL_s + Z_{in2}} \cdot \overline{i_{nd}}\right)}{\left(\frac{\frac{g_m}{sC_{gs}}}{R_s + R_g + \frac{1}{sC_{gs}} + \left(1 + \frac{g_m}{sC_{gs}}\right)\cdot sL_s}\right)}$$

if, $|Z_{in1}| \gg \omega L_s$

$$= \frac{\frac{1 + sC_{gs}R_s}{g_m sL_s + 1 + sC_{gs}R_s}}{\frac{\frac{g_m}{sC_{gs}}}{R_s + \frac{g_m L_s}{C_{gs}} + \frac{1}{sC_{gs}}}} \cdot \overline{i_{nd}}$$

if $|1 + j\omega C_{gs} \cdot R_s| \gg g_m \cdot \omega L_s$

$$\simeq \frac{1}{g_m}\left(1 + sC_{gs}\left(R_s + \frac{g_m L_s}{C_{gs}}\right)\right)\overline{i_{nd}}$$

$\therefore$ Input referred noise voltage, $\overline{V_{n,in}}$

$$\overline{V_{n,in}} = \overline{V_{ng}} + \overline{V_{neq}}$$

$$\approx \overline{V_{ng}} + \overline{i_{nd}} \cdot \frac{1}{g_m}\left(1 + sC_{gs}\left(R_s + \frac{g_m L_s}{C_{gs}}\right)\right)$$

3) correlation admittance

$$Y_c = \frac{\overline{v_{neq}}^{*}\,\overline{i_{neq}}}{\overline{v_{neq}}^{2}}$$

$$\approx j\omega C_{gs}$$ ← same as without L_s (see leteurt note, page-65)

~~4)~~ Uncorrelate noise current

$$\overline{i_{nu}} = \overline{i_{neq}} - Y_c\,\overline{v_{neq}}$$

$$= -j\omega C_{gs}\,\overline{v_{ng}}$$ ← see lecture note, page-65

correlated noise current

$$\overline{i_{nc}} = \overline{i_{neq}} - \overline{i_{nu}}$$

4) Optimum admittance

$$Y_{opt} = \omega C_{gs}\sqrt{\frac{g_m R_g}{r}} - j\omega C_{gs}$$ ← see lecture note page-66

5) Fmin

$$F_{min} = 1 + 2\omega C_{gs}\sqrt{r\frac{R_g}{g_m}}$$ ← see lecture note page-67.

$\boxed{\text{Think about why these results are same as in the case of without source inductor}}$