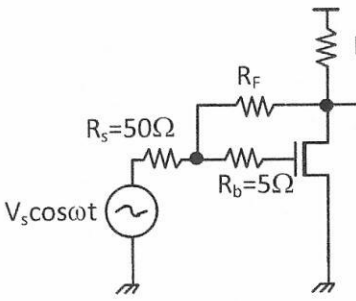
ECE5220 RFIC Midterm, 03/19/2012 **Name:** Solution **Grade:**

1. In the amplifier shown below, DC characteristic of the NMOS is set by square-law characteristic, i.e.

$$I_{DS} = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{TH})^2.$$

Assume that Rs << 1/ωCgs, **all resistors are noisy** and NMOS has drain thermal noise current. The drain thermal noise coefficient is γ.



$g_m = \mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{th}) = 540\cdot\mu\cdot\frac{334}{0.18}\times 0.2 = 200\ mS$

$I_{DS} = \frac{1}{2}\cdot g_m (V_{GS}-V_{th}) = 20\ mA$

1) Determine feedback resistance, R_F, to match input and output impedance to R_s and R_L, respectively (5pt).

$$Z_{in} = \frac{R_F + R_L}{1+g_m R_L} \simeq \frac{R_F}{g_m R_L} = R_s \rightarrow R_F = g_m \cdot R_L \cdot R_S = 5200\ \Omega$$

$$Z_{out} = \frac{R_F + R_S}{1+g_m R_S} \simeq \frac{R_F}{g_m R_S} = 50\ \Omega = R_L$$

2) Express output noise voltages due to R_s, R_F, R_b, R_L and drain current (I_{DS}), respectively, under matched condition (20pt). **You don't need to calculate them numerically**.

$$(V_{on})\text{ due to } R_S = \overline{V_{RS}}\cdot\frac{1}{2}\frac{R_F}{R_S} = \sqrt{4KTR_S\Delta f}\left(\frac{1}{2}\frac{R_F}{R_S}\right)$$

$$(V_{on})\text{ due to } R_F = \overline{V_{RF}}\cdot\frac{R_L}{Z_o + R_L} = \overline{V_{RF}}\frac{1}{2} = \sqrt{4KTR_F\Delta f}\left(\frac{1}{2}\right)$$

$$(V_{on})\text{ due to } R_b = \overline{V_{Rb}}\cdot g_m\frac{1}{2}R_L = \overline{V_{Rb}}\frac{1}{2}\frac{R_F}{R_S} = \sqrt{4KTR_b\Delta f}\left(\frac{1}{2}\frac{R_F}{R_S}\right)$$

$$(V_{on})\text{ due to } R_L = \overline{V_{RL}}\cdot\frac{1}{2} = \sqrt{4KTR_L\Delta f}\left(\frac{1}{2}\right)$$

$$(V_{on})\text{ due to } I_{DS} = \overline{i_{no}}\cdot\frac{1}{2}R_L = \sqrt{4KT\gamma g_m\Delta f}\left(\frac{1}{2}R_L\right)$$