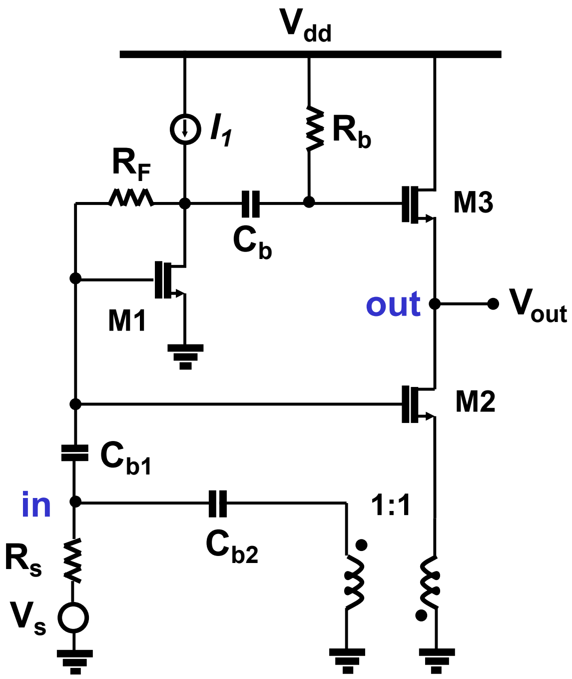
RF Circuit Design **Prof. Salvatore Levantino**

Available time: 90 minutes Jun. 26, 2018

Final Test

Problem #1

Assume the FETs' threshold voltage V_t = 0.4V, $\mu_n C_{ox}/2$ = 0.2mA/V^2, and $(W/L)_1$ = 125. Let V_{dd} = 1.2V, I_1 = 1mA, R_S = 50Ω. Let C_b = 1pF, R_b = 10kΩ (*Consider R_B only to determine the bias point and assume it to be very large otherwise*). Let the bypass capacitances: C_{b1} = C_{b2} = 100pF. *Assume the transformer to be real at DC and ideal at any other frequency.*



a) Derive the expressions of the **input impedance** at port "in" and the **voltage gain (V_{out}/V_{in})** and set the **value of $(W/L)_2$** to ensure input matching at 2.4GHz.

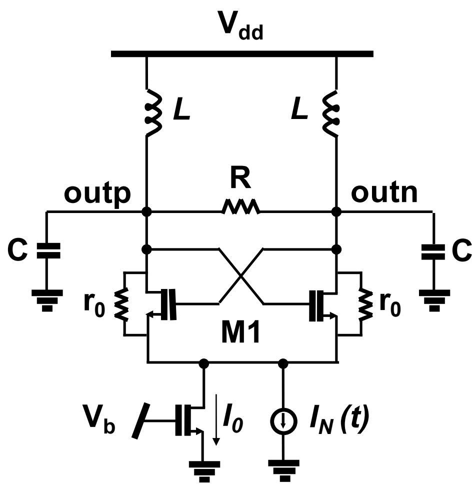
b) Set the **values of $(W/L)_3$ and R_F** to have gain (V_{out}/V_{in}) equal to +20dB and to cancel the thermal noise of **M1** at "out".

c) Recalculate the value of **$(W/L)_3$ and R_F** to have gain equal to +20dB and to cancel the thermal noise of **M2** at "out".

Sol.:
a) $Z_{in} = 1/(g_{m1}+2g_{m2})$, thus matching: $g_{m2}=1/(4R_S)$. Gain is $V_{out}/V_{in} = 1 - g_{m1}R_F - 2g_{m2}/g_{m3}$;
b) M1 noise gets cancelled if $v_{out} = v_1[1- R_{eq}/(R_{eq} + R_F)g_{m2}/g_{m3}] = 0$, where $R_{eq}=2R_S/3$; thus, $g_{m3} = 1/(2R_S+3R_F)$. Under that condition, $V_{out}/V_{in} = -2R_F/R_S$, thus R_F = 250Ω.

Problem #2

Consider the oscillator in figure and let V_{dd} = 1V, R = 1kΩ, L = 2nH, C = 2pF, I_0 = 1mA. The r_0 of M1 FETs is 1kΩ. Neglect the r_0 of the tail FET.



a) Calculate the **g_m of the FETs M_1** for a gain margin of the oscillation startup equal to 2.

b) Calculate the **differential oscillation amplitude** at *outp*, *outn* in **two cases**: (i) with $I_N(t)$ = 0 and (ii) with $I_N(t)$ = 0.5mA·cos($2\omega_0 t$), where ω_0 is the angular frequency of oscillation.

Sol.:
a) Startup: $2\cdot(2/g_m) = (2r_0)||R$, g_m = 6mS;
b) (i) $A_0 = (2/\pi)I_0\cdot(2r_0)||R$ = 425mV, (ii) $A_0 = [(2/\pi)I_0+I_{Np}/\pi]\cdot(2r_0)||R$ = 531mV].