EECS 290C: Advanced circuit design for wireless
Homework # 3

Q1. This homework is focused on designing a 2.5GHz LNA with the focus is mainly on NF. We will be using the LNA topology shown. For the T28 technology provided for this class:

a. **Designing the LNA input Gm stage**: Based on lecture notes, use Spectre to properly select the LNA core device size MNA (minimum channel length), inductor degeneration Ls, Device Vgs (hence bias current), and Lg, at 2.5GHz to achieve the following:
    I. $Z_{s\text{-}opt}$ to 50Ω, so NF of this LNA is close to NF_{min}
    II. |S11|<-10dB, so simultaneous power and noise match
    III. Current consumption is flexible but try not to exceed 12mA if possible

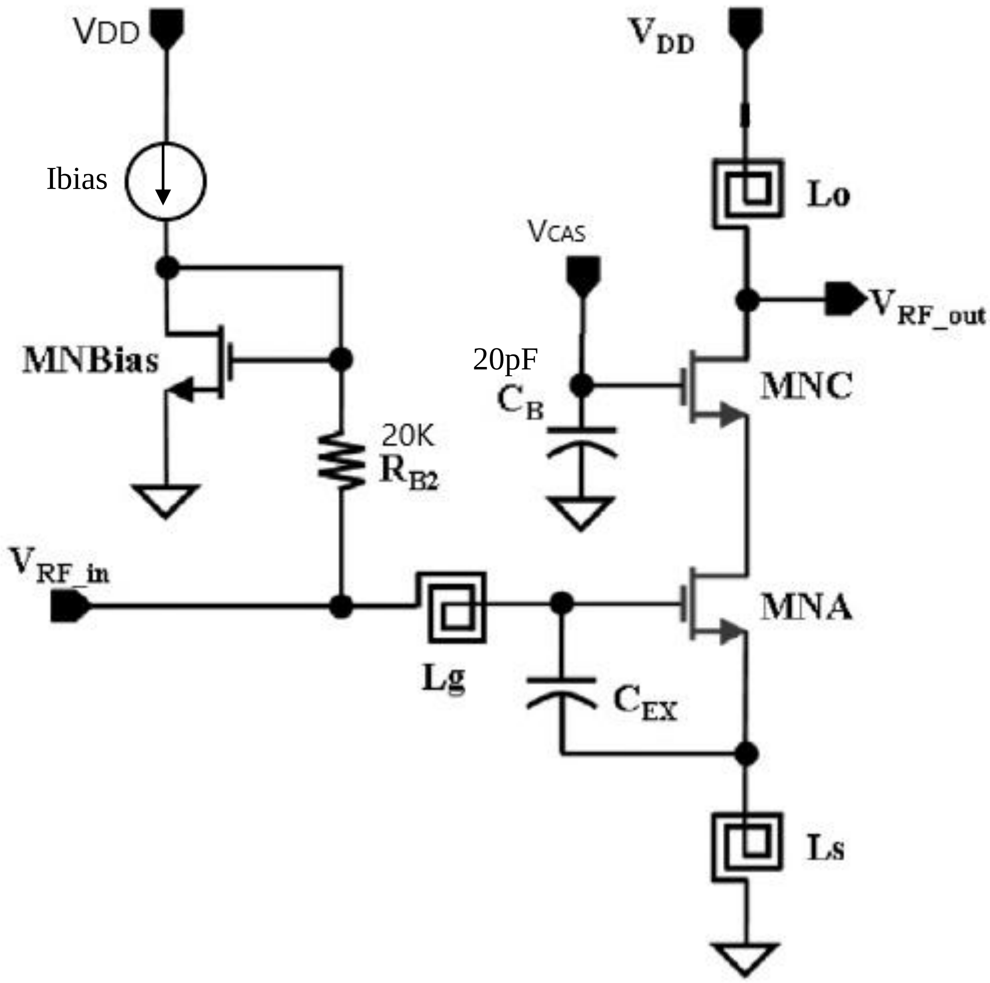
   Use C_{EX} if needed. Assume ideal inductor at this stage (will change later). Use SpectreRF to plot the NF and NF_{min} @ 2.5GHz. Assume device V_{DS} of 0.5V (by setting DC voltage of RF output port connected to drain of MNA). See how good your design is so far by comparing how close NF and NF_{min} are to each other.

b. Size bias device MNBias current mirror ratio as well as Ibias to get the LNA core bias current simulated in (a) above.

c. Change the Q of the all inductors to 10 at 2.5GHz. Assume all the inductor Q is due to wire series resistance with no substrate loss. Re-plot the NF_{min} of the device. See the shift in NF_{min} value.

d. **Designing the LNA output stage**: Plug your input device into the cascode LNA topology below (use Vdd of 1.2V). Adjust V_{CAS} DC voltage to get MNA V_{DS} of 0.5V DC. Properly size cascode device MNC so as it does not degrade the LNA NF (you can sweep its size to see impact). Design the LNA inductive load to get LNA S21 of >15dB. Use on-chip inductor (Lo) with Q of 10. Design the output L-match to match the LNA output to 50-ohms with |S22|<-10dB.

e. **Verifying LNA Design**: Simulate the complete LNA NF using SpectureRF with LNA input and outputs are terminated by 50Ω ports.
    I. Plot the NF and NF_{min} on the same plot and see how far your LNA is from the optimum value. If they are far apart, adjust LNA components to close the gap.
    II. Plot the LNA s-parameters over frequency 2GHz to 3GHz with markers at 2.4GHz and 2.5GHz WiFi band.
    III. Plot the LNA in-band IP1dB. Also plot the IIP3 for two in-band tones with 10MHz spacing (in this design, linearity was the focus, so you get what you get kind of thing). Check if your P1dB is input (bias current) or output (Vdd/headroom) limited.



LNA cascode topology