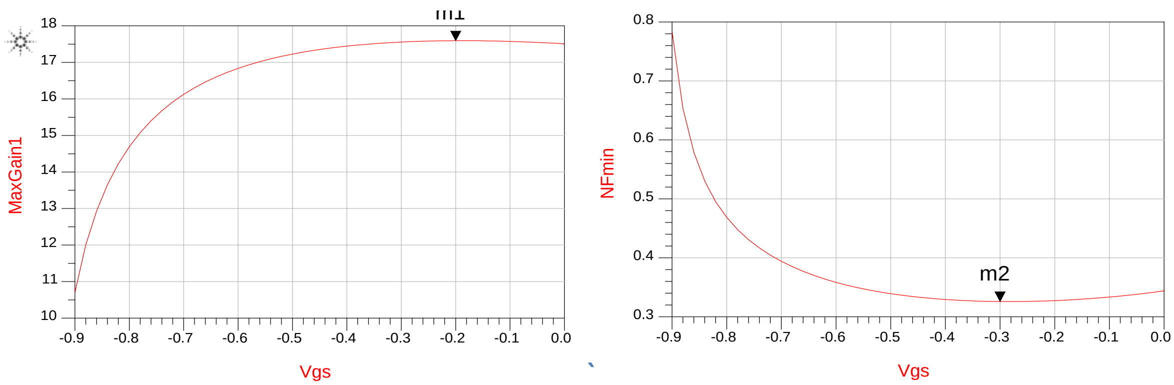
Solution to Assignment #2

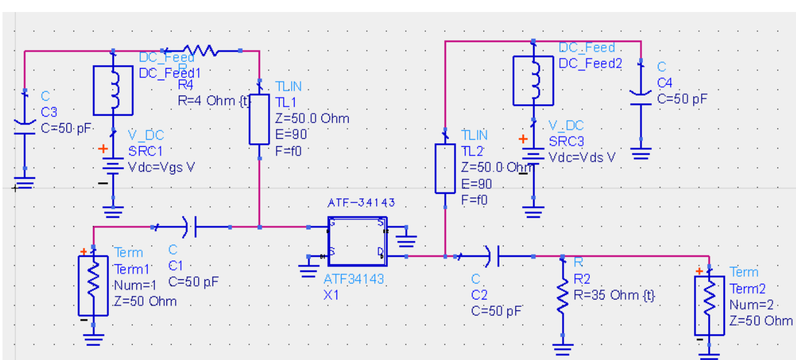
Note: The solution provided here is just a design example to demosntrate the design process. There is no unique answer to this assignment.

To find the optimal biasing point, Vds=4V is selected as recommended by datasheet. Vgs should be selected based on the required Ids which controls noise and gain performance. The transistor is a HEMT, which means the DC bias is negative. According to the data sheet (or DC simulation in ADS) the pinch-off voltage is ~-0.5V, which means the gate has to be biased between -0.5V and 0V for amplifier design. Figure 1 shows how to select Vgs for Cases I and II separately. According to the figure, Vgs=-0.2V and -0.3V are selected for Case 1 and 2, respectively. Figure 2(a)shows the schematic of the transistor, including the biasing and stability networks for Case II (Case I would be very similar). The transmission lines are 90° at the operating frequency. DC blocks are chosen to be 50pF which provide sufficiently small impedance at RF frequency (e.g., 1.5Ω at 2GHz).

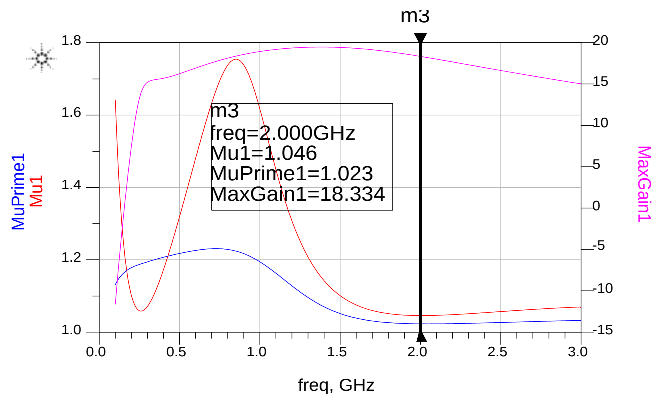


(a) (b)

Figure 1. Vgs selection for (a) Case I, and (b) Case II



(a) Schematic



(b) Stability analysis

Figure 2. Case II biasing and stability circuitry

freq	MaxGain1	SmGamma1	SmGamma2
3.000 GHz	15.520	0.853 / 140.525	0.761 / 158.614

(a)

freq	MaxGain1	SmGamma1	SmGamma2
2.000 GHz	18.342	0.884 / 102.033	0.786 / 150.315

(b)

Figure 3. G_{Tmax}, Γ_{MS} and Γ_{ML} for (a) Case I, and (b) Case II.

Design for Case I

Step 1. Plot $G_A = G_{Tmax} - 1dB$ circle as well as various constant-noise circles. Find the noise circle that is tangent to the G_A circle.

Step 2. Choose Γ_S as the intersection of the two circles. This ensures $G_A = G_{Tmax} - 1dB$ while achieving the best possible NF. According to Figure 4,

$$\Gamma_S = 0.575\measuredangle 141.1°$$

Step 3. Calculate $\Gamma_L = \Gamma_{out}^* = \left(S_{22} + \frac{S_{12}S_{21}\Gamma_S}{1-S_{11}\Gamma_S}\right)^* = 0.590\measuredangle 165.8°$

Step 4. Design input matching network from 50Ω to Γ_S or from Γ_S^* to 50Ω (why?).

Likewise, design output matching network from 50Ω to Γ_L or from Γ_L^* to 50Ω.

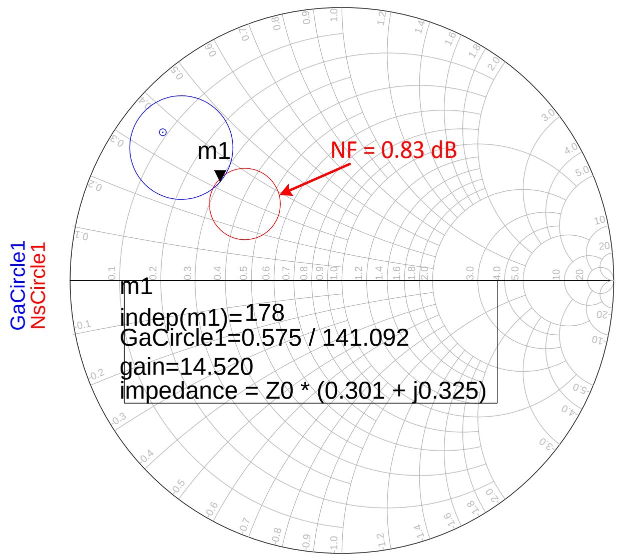


Figure 4

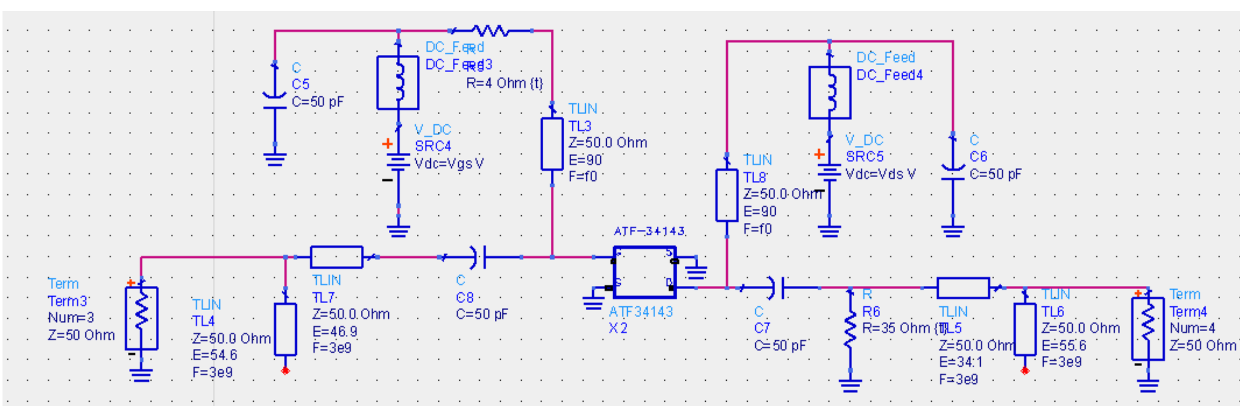


Figure 5

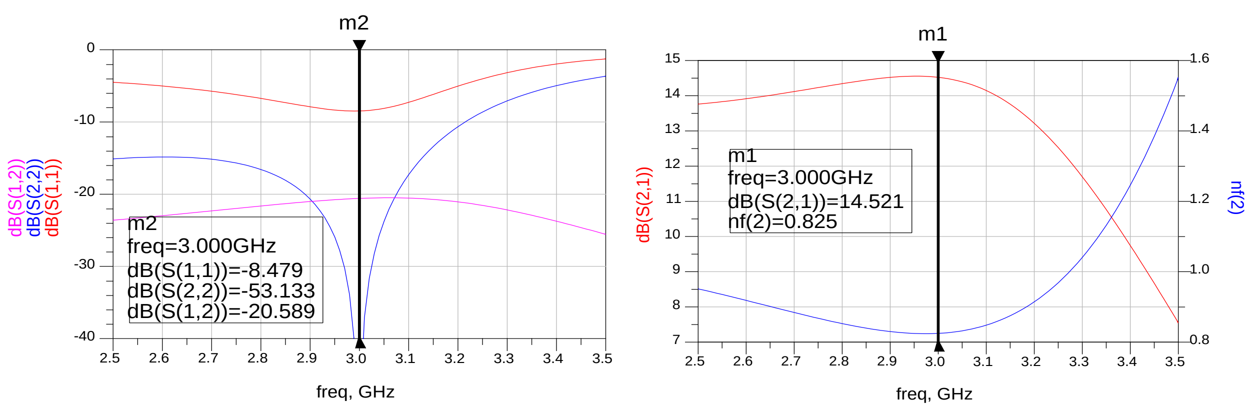


Figure 6

Design for Case II

Step 1. Plot $G_A = 16dB$ and $NF = 1dB$ circles.

Step 2. Choose Γ_S as the intersection of the two circles (or somewhere inside the overlapping area). This ensures $G_A > 16dB$ and $NF < 1dB$ (some margin has been considered to ensure the specifications are met). According to Figure 7,

$$\Gamma_S = 0.607\measuredangle 104.5°$$

Step 3. Calculate $\Gamma_L = \Gamma_{out}^* = \left(S_{22} + \frac{S_{12}S_{21}\Gamma_S}{1-S_{11}\Gamma_S}\right)^* = 0.578\measuredangle 157.5°$

Step 4. Design input matching network from 50Ω to Γ_S or from Γ_S^* to 50Ω.

Likewise, design output matching network from 50Ω to Γ_L or from Γ_L^* to 50Ω.

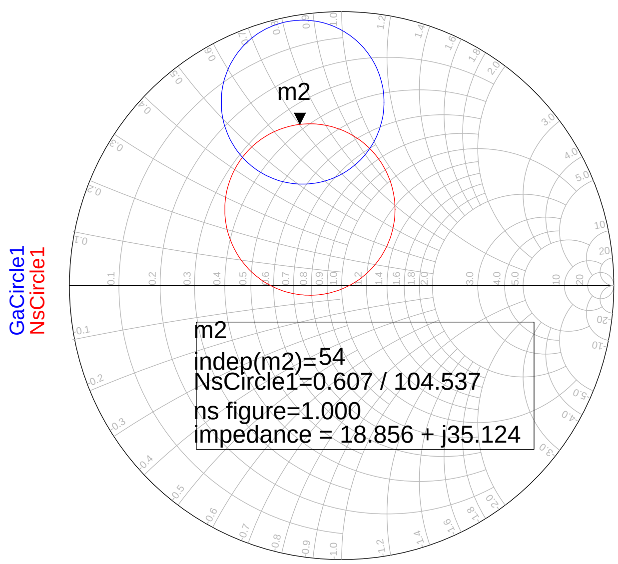


Figure 7

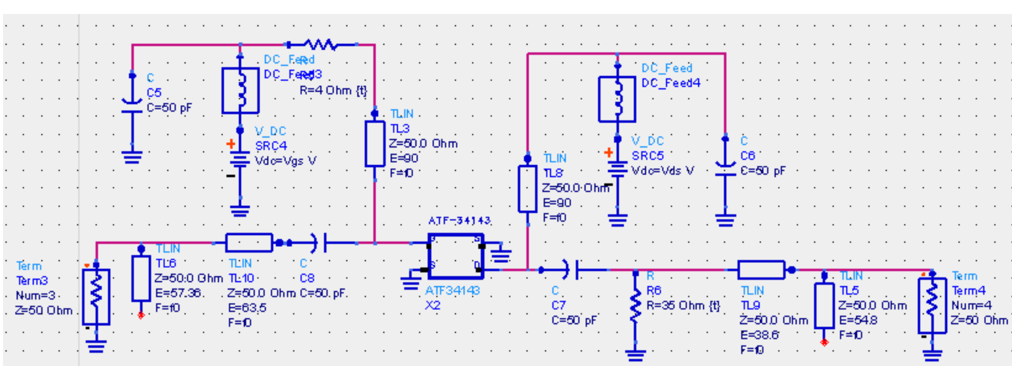


Figure 8

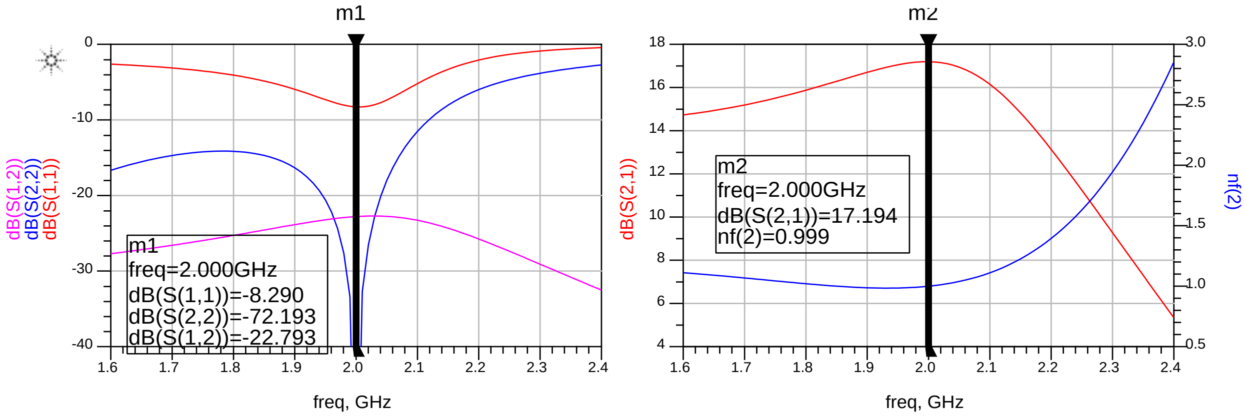

m1
0
-10
-20
-30
-40
dB(S(1,2))
dB(S(2,2))
dB(S(1,1))
m1
freq=2.000GHz
dB(S(1,1))=-8.290
dB(S(2,2))=-72.193
dB(S(1,2))=-22.793
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
freq, GHz
m2
18
16
14
12
10
8
6
4
dB(S(2,1))
m2
freq=2.000GHz
dB(S(2,1))=17.194
nf(2)=0.999
3.0
2.5
2.0
1.5
1.0
0.5
nf(2)
freq, GHz

Figure 9