ECE 671 – Assignment #2

This assignment deals with the analysis and design of linear low noise amplifiers using a discrete microwave transistor. The ATF-34143 RF packaged transistor from Avago Technologies® is chosen for this assignment for illustration purpose. It is a low noise pseudomorphic high-electron-mobility transistor (PHEMT) housed in a surface mount plastic package with operating frequency spanning from 450 MHz through 10 GHz.

The ATF-34143 compact model is available in ADS. You should unarchive the .zap file first, and then add the transistor to your own workspace library via **DesignKits>Manage Libraries…** in the main ADS window. Choose **Add Library…** and then click "Yes" in the next dialog box. Search for the library folder (ATF_34143_lib) inside the unarchived workspace, named ATF_34143_wrk (all are the default names) and change the mode to "Read-only". You can now insert the transistor model in your schematic, following **Insert > Component > Component Library**, then selecting ATF34143 under "Read-Only Libraries".

Two design scenarios will be considered in this assignment:

- **Case I:** the transistor biased for operating as a linear high gain stage at 3 GHz
- **Case II:** the transistor biased for operating as a low-noise amplifier at 2GHz

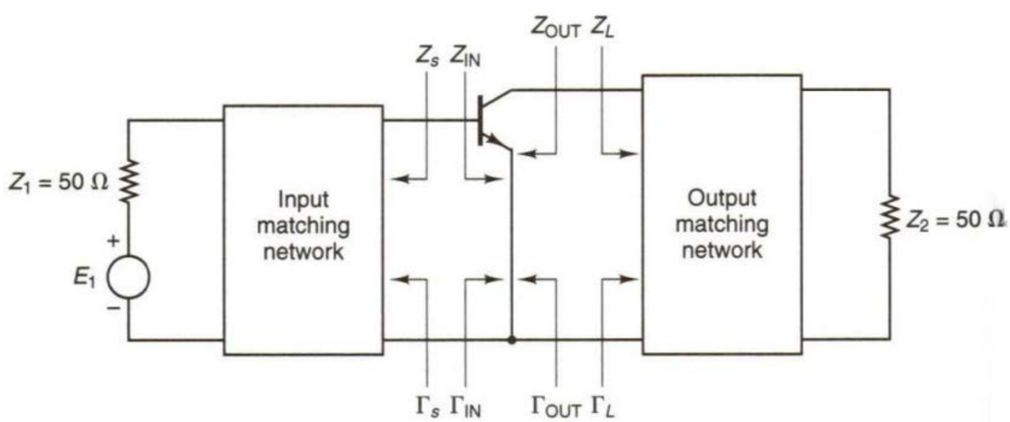

Figure 1: A generic schematic of an RF amplifier (biasing network is not shown).

Answer the following questions for the abovementioned Case I and II, separately.

1. Build the biasing network for the transistor using ideal transmission lines and lumped capacitors.
2. Determine the S-parameters of the transistor with the biasing network, at the design frequencies, using hand analysis and then confirm it using S-parameter simulation in ADS.

Hand Analysis

3. Assess the stability of the transistor at the design frequency.
4. If the transistor is conditionally stable at the design frequency, (unconditionally) stabilize the transistor by adding a shunt resistance to the output. Skip this part is the transistor is already unconditionally stable.

ADS Simulation

5. First, confirm your answers to questions 4 and 5 by S-parameter simulation in ADS.
6. To ensure, robust amplifier design, the stability of the transistor should typically be considered over a wide frequency range spanning from the low frequencies, where the stability is usually difficult to obtain due to the large intrinsic gain of the transistor. By modifying the stability network, stabilize the transistor from 100 MHz through 3 GHz.

   Hint: To stabilize the transistor at low frequencies (below 1 GHz), you can add a very small resistor at the end of the gate biasing line.

7. Find G_{Tmax}, Γ_{MS} and Γ_{ML}.
8. Design a linear RF amplifier for the following cases (50Ω input and output impedances). Implement the matching networks using single open-circuited shunt stub.
   a) For Case I, design for $G_T > G_{Tmax} - 1dB$.
   b) For Case II, design for $G_T > 15dB$ and $NF < 1.1dB$.
9. Plot the gain, input and output return loss, isolation and noise figure for both design cases over $0.8f_o$ to $1.2f_o$.

Few Notes:

- Please include the complete schematic of the circuits (for Case I and II) in your report.
- For noise analysis, activate the option ***Calculate noise*** in the ***S-Parameter*** component. You can find this option in Noise tab after you double click on ***S-parameter*** component.
- To compute the noise figure of the amplifier, use ***nf(2)*** in the data display window.
- The designs with the best input return loss (Case II) and best noise figure (Case I) will get a bonus mark.
- You can use the pre-defined functions in ADS, under ***Simulation-S_Param***, as shown in Figure 2.

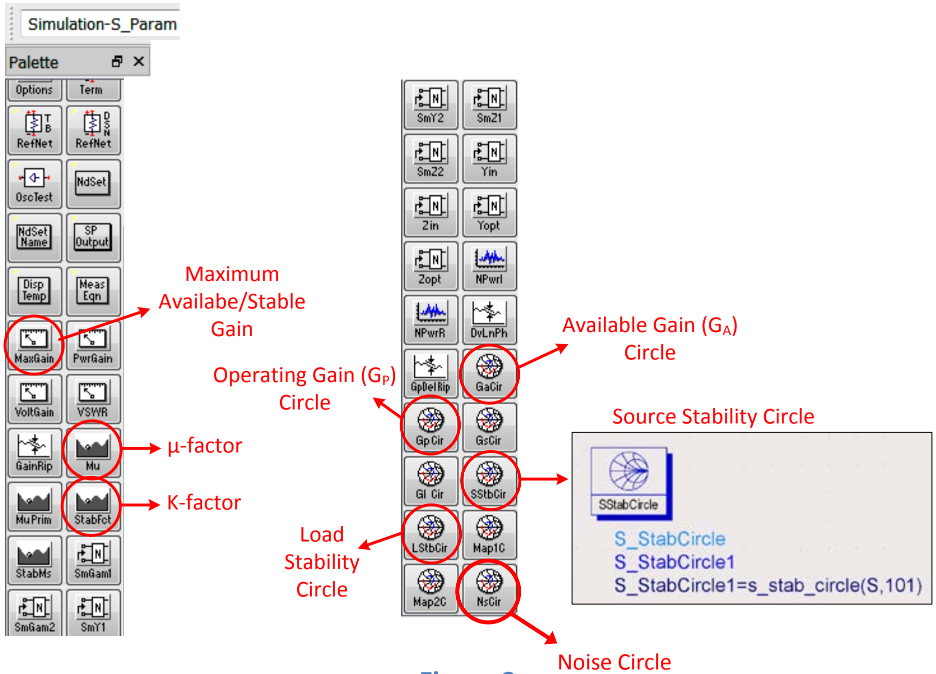
Simulation-S_Param
Palette
Options
Term
RefNet
RefNet
OscTest
NdSet
NdSet Name
SP Output
Disp Temp
Meas Eqn
MaxGain
PwrGain
VoltGain
VSWR
GainRip
Mu
MuPrim
StabFct
StabMs
SmGam1
SmGam2
SmY1
Maximum Availabe/Stable Gain
μ-factor
K-factor
SmY2
Sm21
Sm22
Yin
Zin
Yopt
Zopt
NPwrI
NPwrR
DvLnPh
GpDelRip
GaCir
Gp Cir
GsCir
Gl Cir
SStbCir
LStbCir
Map1C
Map2C
NsCir
Operating Gain (G_P) Circle
Load Stability Circle
Available Gain (G_A) Circle
Source Stability Circle
SStabCircle
S_StabCircle
S_StabCircle1
S_StabCircle1=s_stab_circle(S,101)
Noise Circle

Figure 2