VIT UNIVERSITY
(Estd. u/s 3 of UGC Act 1956)

Photonics and Microwave Division

Design and Simulation of "Maximum Gain Amplifier" using AWR Microwave office

Prof. D. Kannadassan,
Photonic and Microwave Division
School of Electronics Engineering
VIT University, Vellore - India
Email: dkannadassan@vit.ac.in

Example

Design an amplifier for maximum gain at 4.0 GHz using single-stub matching sections. Calculate and plot the input return loss and the gain from 3 to 5 GHz. The GaAs FET has the following S parameters ($Z_0 = 50\,\Omega$):

f (GHz)	S_{11}	S_{21}	S_{12}	S_{22}
3.0	$0.80\angle -89^\circ$	$2.86\angle 99^\circ$	$0.03\angle 56^\circ$	$0.76\angle -41^\circ$
4.0	$0.72\angle -116^\circ$	$2.60\angle 76^\circ$	$0.03\angle 57^\circ$	$0.73\angle -54^\circ$
5.0	$0.66\angle -142^\circ$	$2.39\angle 54^\circ$	$0.03\angle 62^\circ$	$0.72\angle -68^\circ$

Step-1

$$\Delta = S_{11}S_{22} - S_{12}S_{21} = 0.488\angle -162^\circ,$$

$$K = \frac{1 - |S_{11}|^2 - |S_{22}|^2 + |\Delta|^2}{2|S_{12}S_{21}|} = 1.195.$$

Shows that transistor is "***Un-conditionally stable***"

Thanks to "Prof. David Pozar"

Step-2

$$\Gamma_S = \frac{B_1 \pm \sqrt{B_1^2 - 4|C_1|^2}}{2C_1} = 0.872\angle 123^\circ$$

$$\Gamma_L = \frac{B_2 \pm \sqrt{B_2^2 - 4|C_2|^2}}{2C_2} = 0.876\angle 61^\circ.$$

Step-3

$$G_S = \frac{1}{1 - |\Gamma_S|^2} = 4.17 = 6.20 \text{ dB},$$

$$G_0 = |S_{21}|^2 = 6.76 = 8.30 \text{ dB},$$

$$G_L = \frac{1 - |\Gamma_L|^2}{|1 - S_{22}\Gamma_L|^2} = 1.67 = 2.22 \text{ dB}.$$

$$G_T = \frac{1 - |\Gamma_s|^2}{|1 - \Gamma_{IN}\Gamma_s|^2} |S_{21}|^2 \frac{1 - |\Gamma_L|^2}{|1 - S_{22}\Gamma_L|^2}$$

$$G_{T_{max}} = 6.20 + 8.30 + 2.22 = 16.7 \text{ dB}.$$

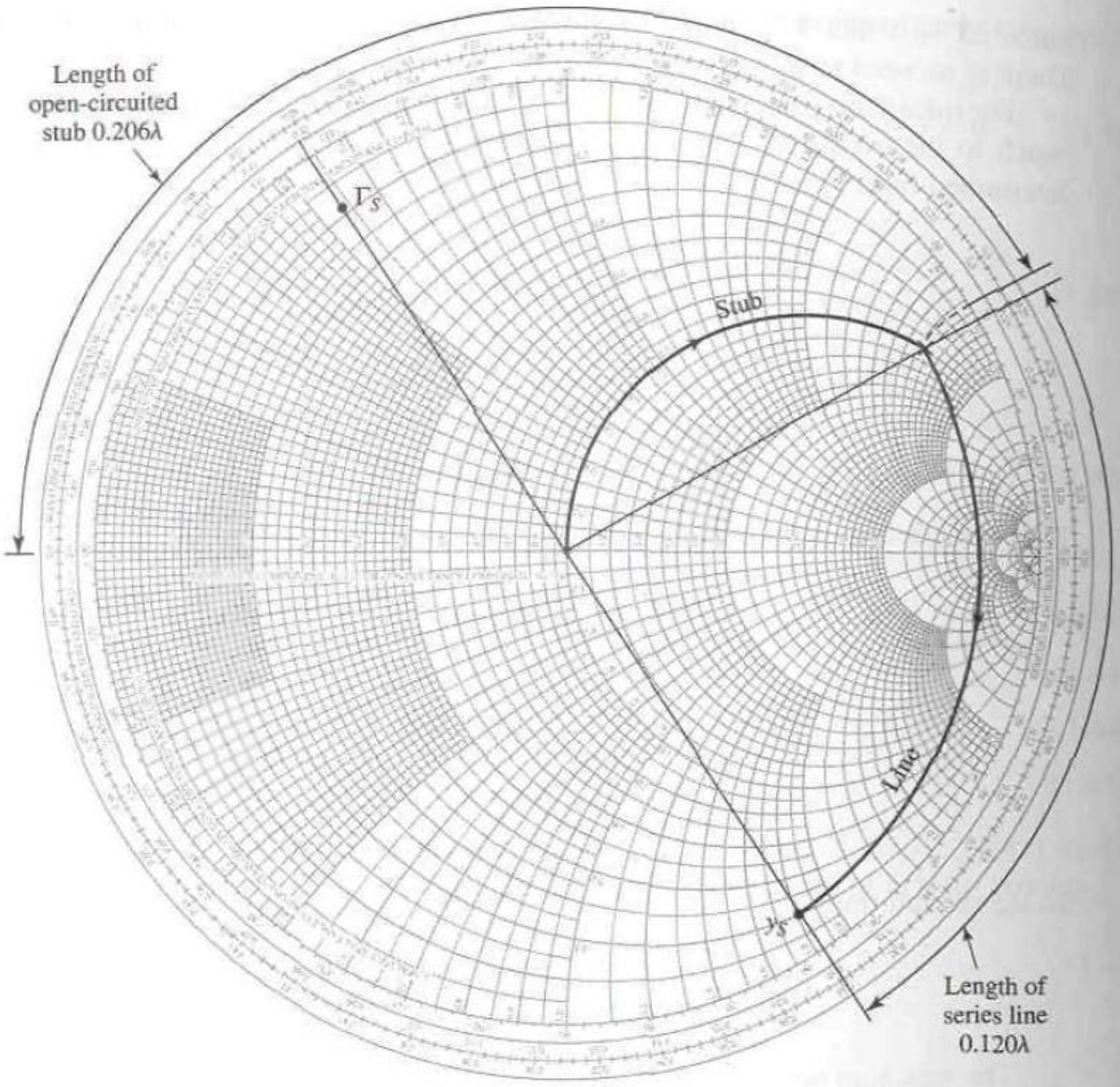
Step-4: For that calculated Γ_S, Γ_L values (in the stable region), we have to determine the matching circuit.

There are several ways to design the “matching circuit”, Single stub matching is widely used for amplifier design because of the effectiveness.

More over “open circuited stub” are highly preferred for its many advantages.

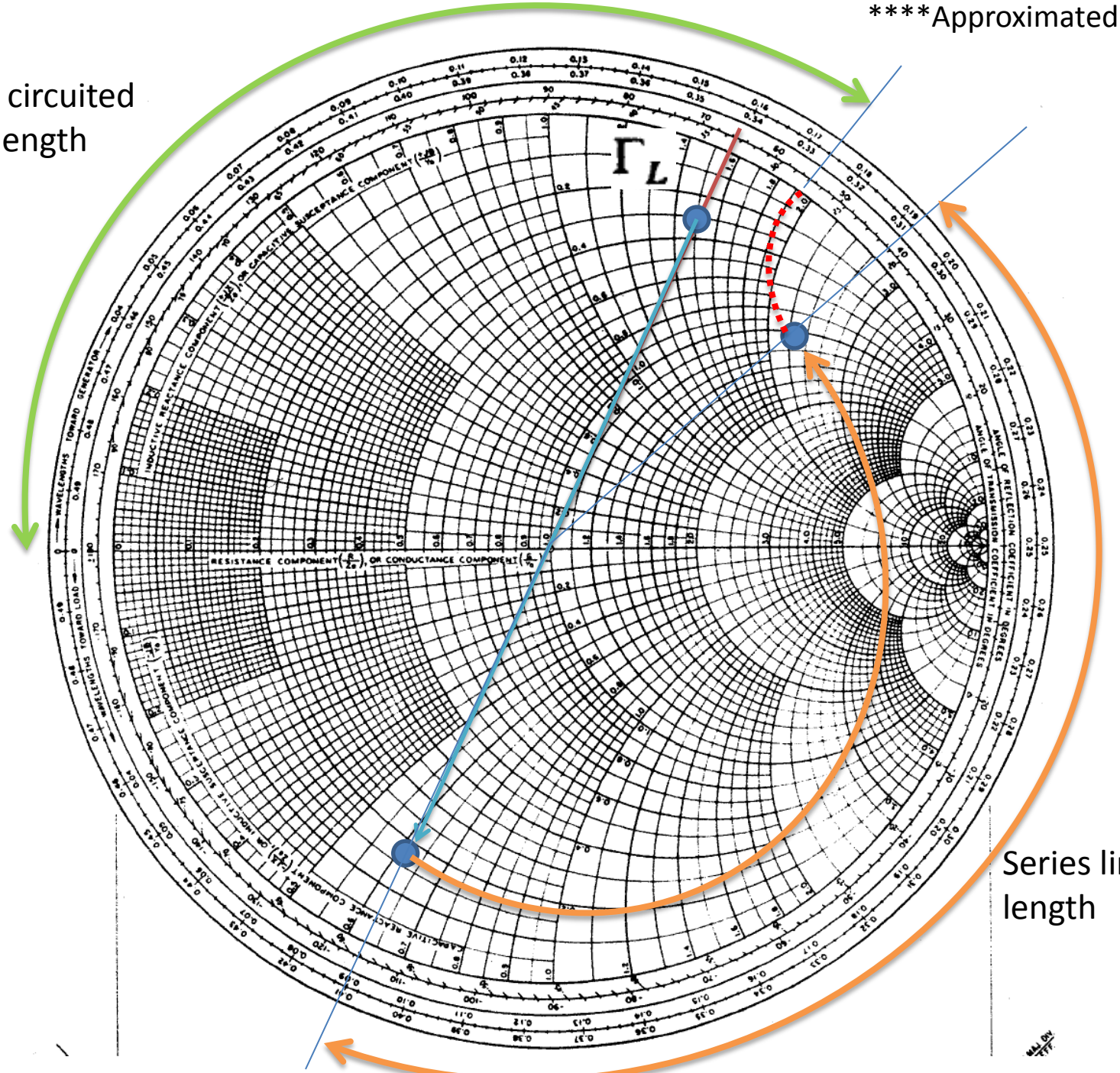
$$\Gamma_S = \frac{B_1 \pm \sqrt{B_1^2 - 4|C_1|^2}}{2C_1} = 0.872\angle 123^\circ$$

$$\Gamma_L = \frac{B_2 \pm \sqrt{B_2^2 - 4|C_2|^2}}{2C_2} = 0.876\angle 61^\circ.$$

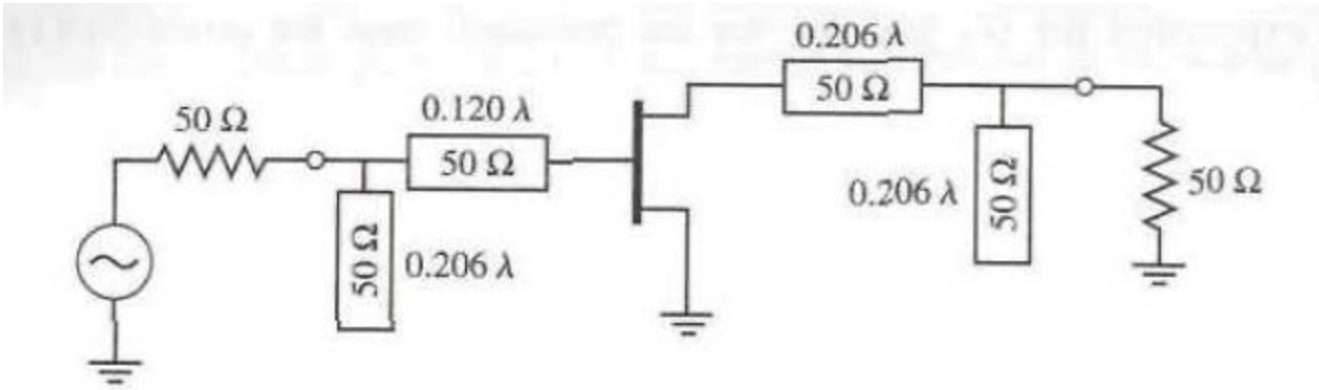

Length of
open-circuited
stub 0.206λ
Γ_S
Stub
Line
y_S
Length of
series line
0.120λ

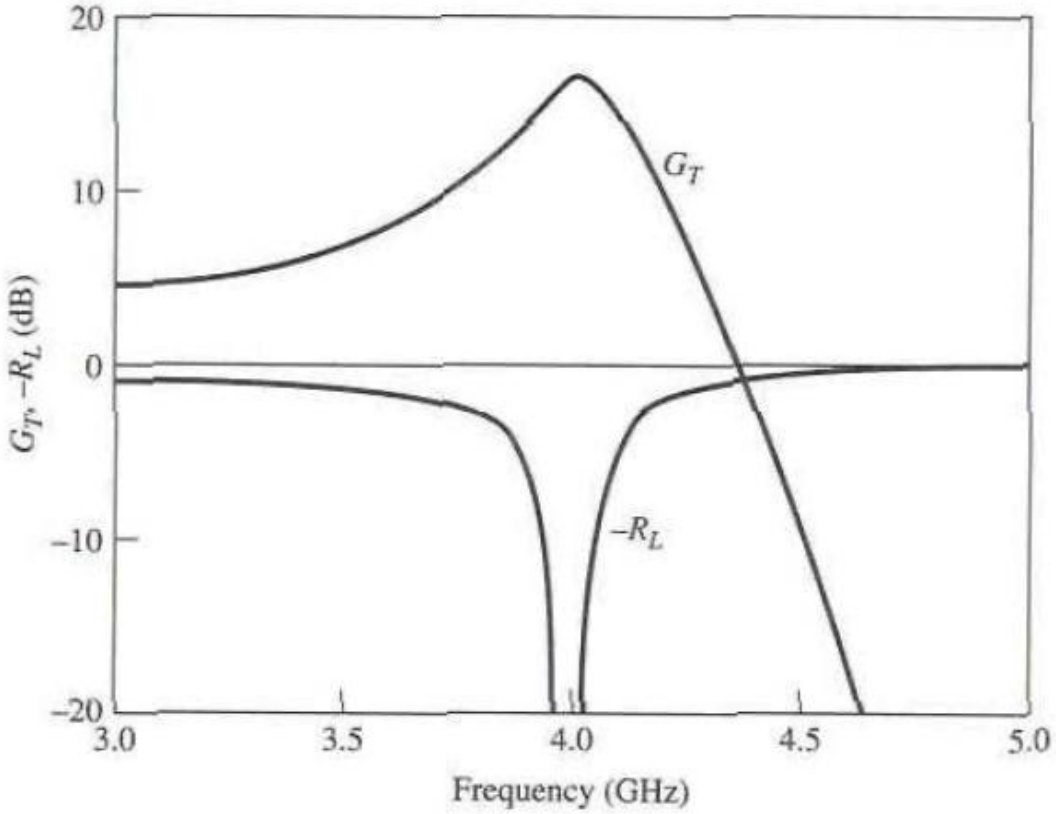
****Approximated calculations

Open circuited
Stub length



Series line
length

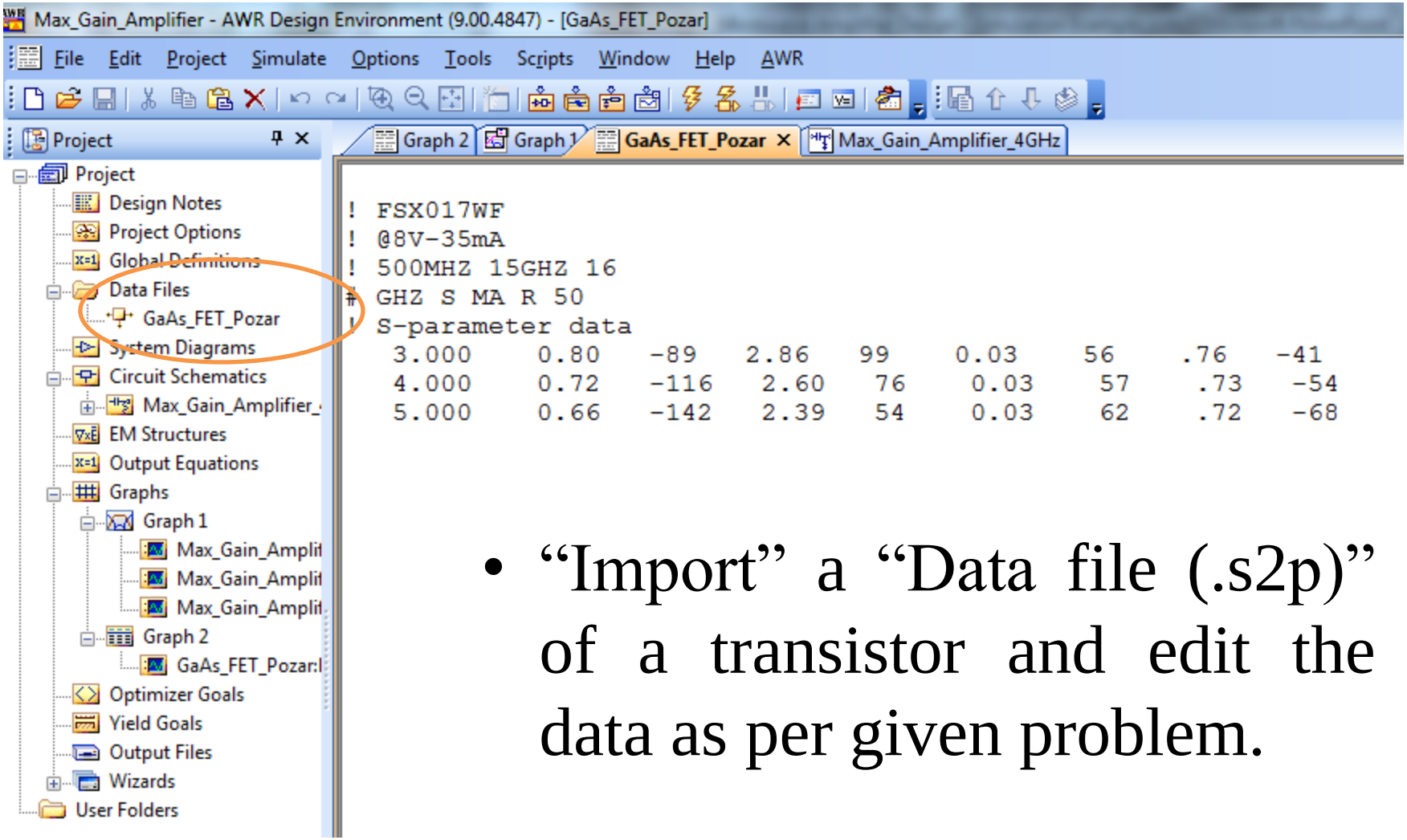




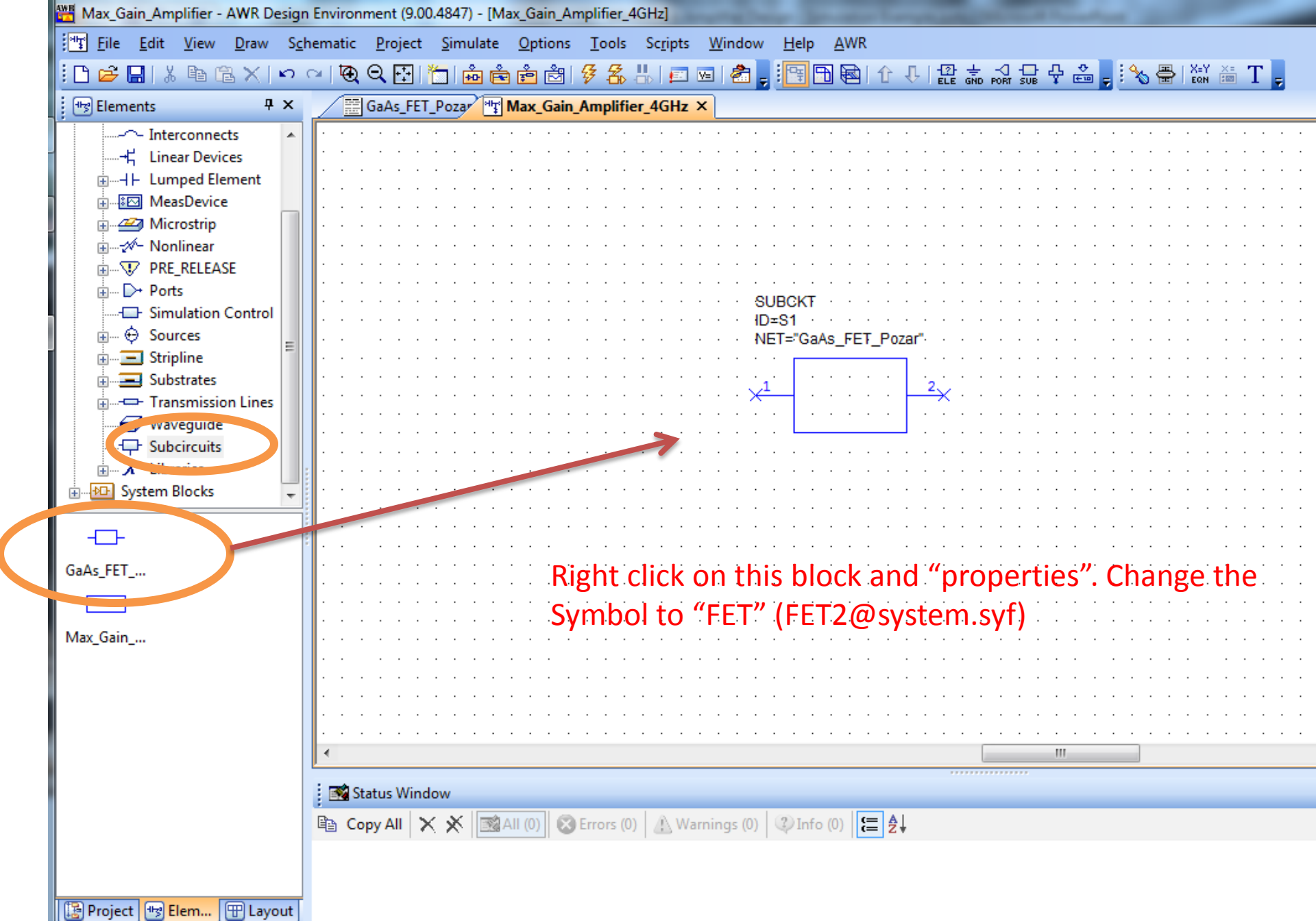
$0.120 \times 360^{o} = 43.2^{o}$

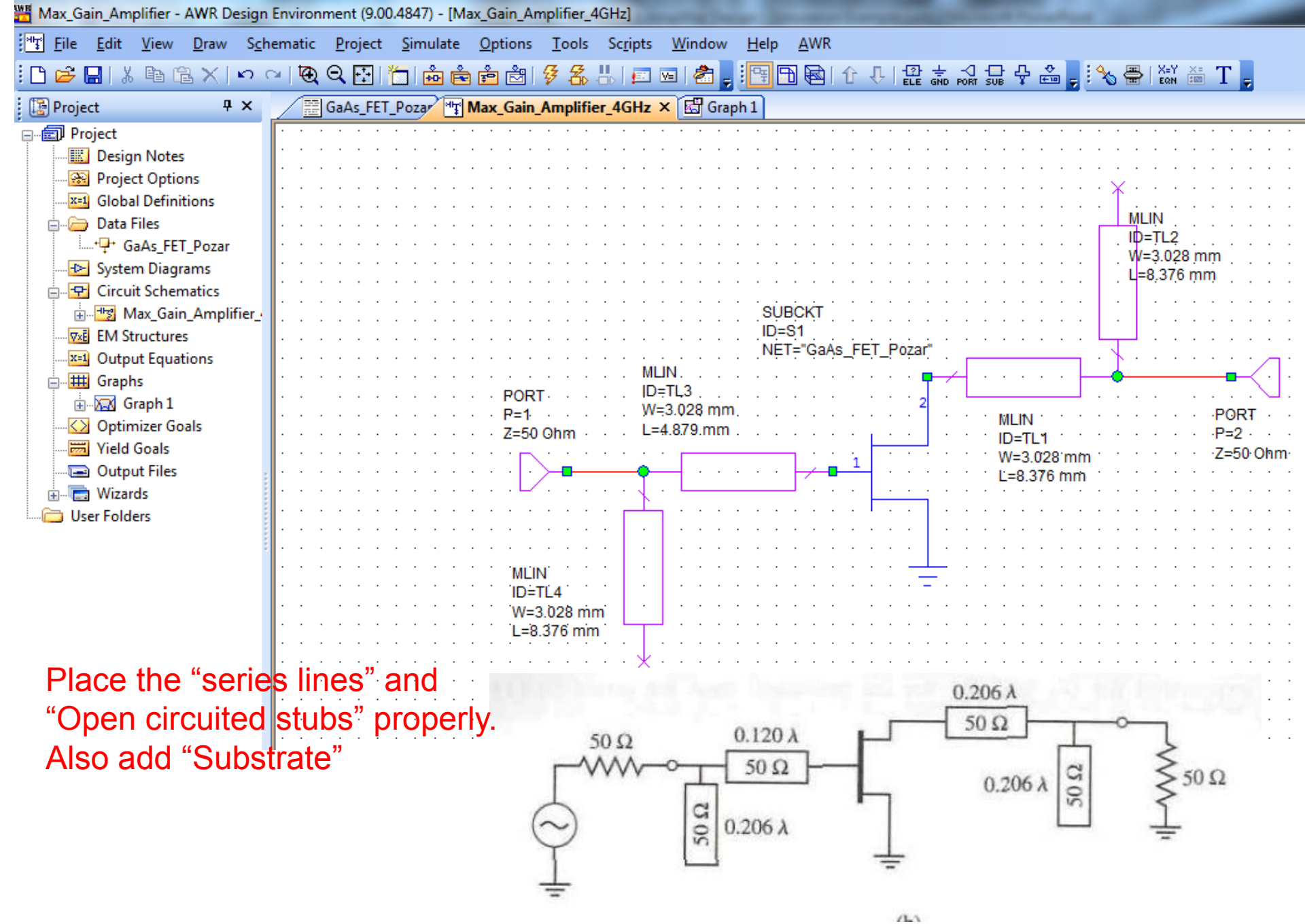
$0.206 \times 360^{o} = 74.16^{o}$

Simulation

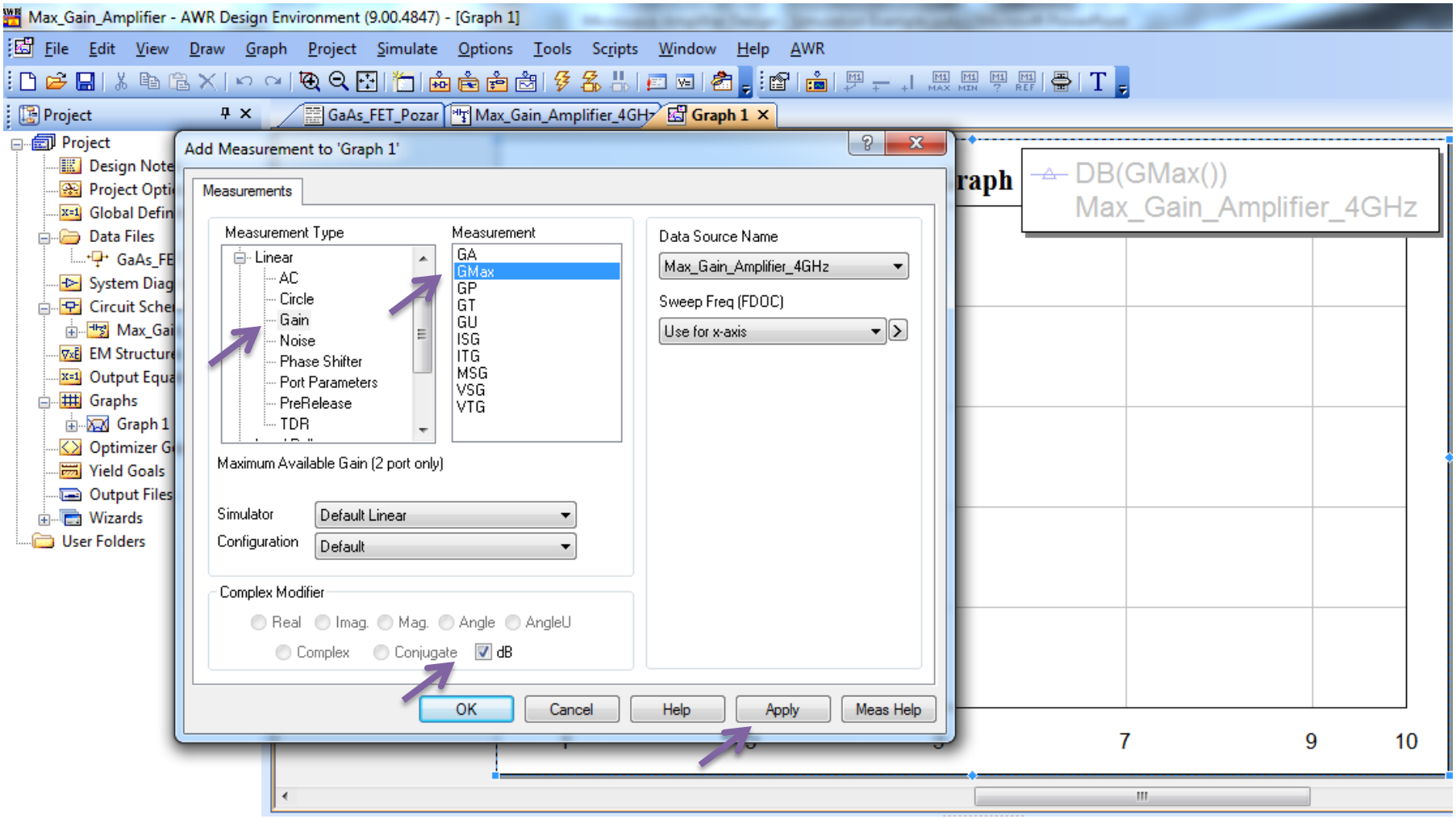


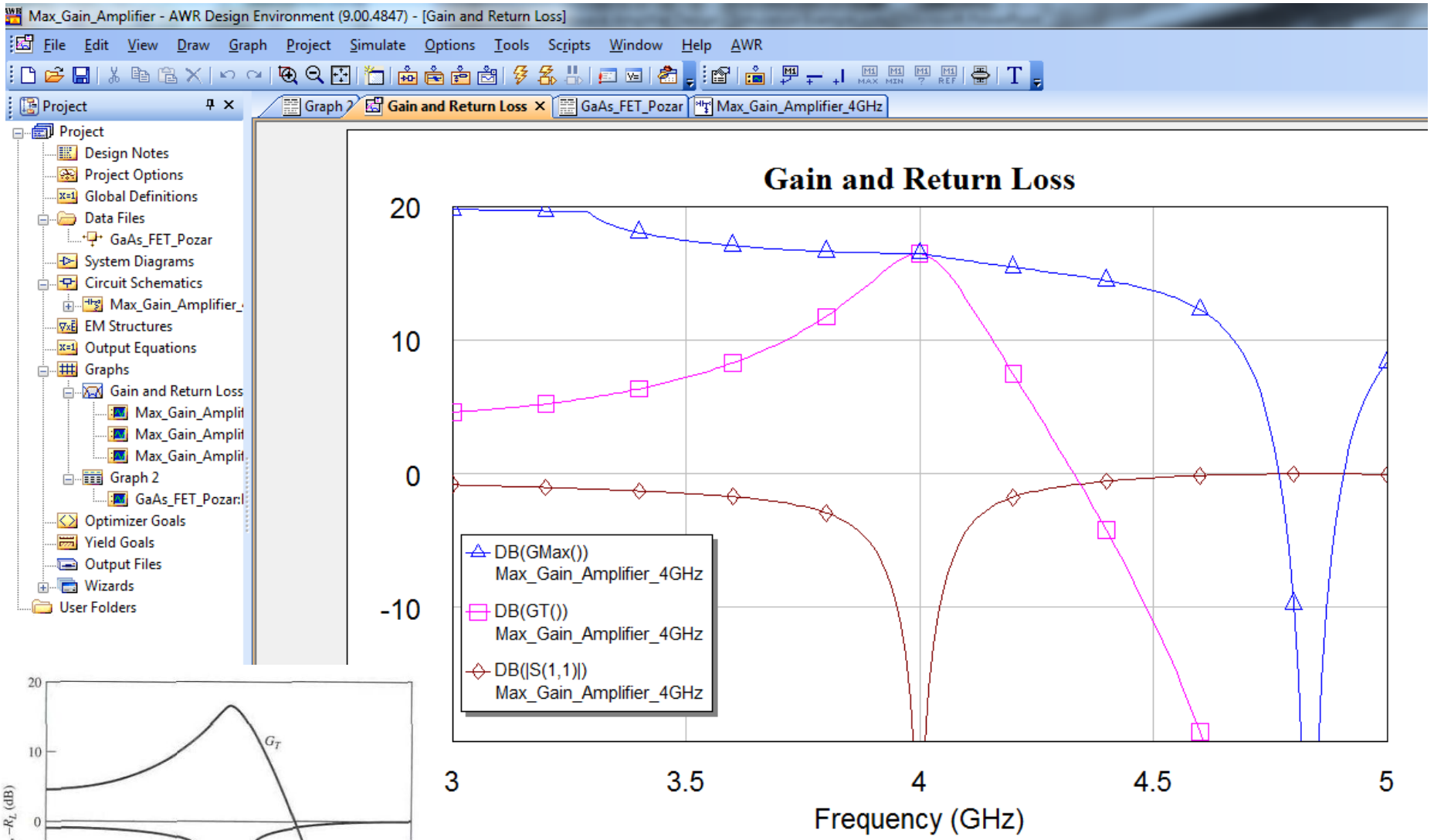
- "Import" a "Data file (.s2p)" of a transistor and edit the data as per given problem.

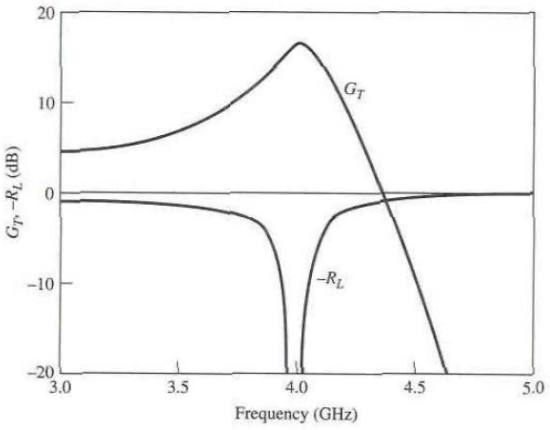

Max_Gain_Amplifier - AWR Design Environment (9.00.4847) - [Max_Gain_Amplifier_4GHz]
File Edit View Draw Schematic Project Simulate Options Tools Scripts Window Help AWR
Elements
Interconnects
Linear Devices
Lumped Element
MeasDevice
Microstrip
Nonlinear
PRE_RELEASE
Ports
Simulation Control
Sources
Stripline
Substrates
Transmission Lines
Waveguide
Subcircuits
System Blocks
GaAs_FET_...
Max_Gain_...
Project
Elem...
Layout
GaAs_FET_Pozar
Max_Gain_Amplifier_4GHz
SUBCKT
ID=S1
NET="GaAs_FET_Pozar"
1
2
Right click on this block and “properties”. Change the Symbol to “FET” (FET2@system.syf)
Status Window
Copy All
All (0)
Errors (0)
Warnings (0)
Info (0)



Place the “series lines” and “Open circuited stubs” properly. Also add “Substrate”


Max_Gain_Amplifier - AWR Design Environment (9.00.4847) - [Graph 1]
File Edit View Draw Graph Project Simulate Options Tools Scripts Window Help AWR
Project
GaAs_FET_Pozar
Max_Gain_Amplifier_4GHz
Graph 1
Project
Design Note
Project Opti
Global Defin
Data Files
GaAs_FE
System Diag
Circuit Sche
Max_Gai
EM Structure
Output Equa
Graphs
Graph 1
Optimizer G
Yield Goals
Output Files
Wizards
User Folders
Add Measurement to 'Graph 1'
Measurements
Measurement Type
Linear
AC
Circle
Gain
Noise
Phase Shifter
Port Parameters
PreRelease
TDR
Measurement
GA
GMax
GP
GT
GU
ISG
ITG
MSG
VSG
VTG
Maximum Available Gain (2 port only)
Data Source Name
Max_Gain_Amplifier_4GHz
Sweep Freq (FDOC)
Use for x-axis
Simulator
Default Linear
Configuration
Default
Complex Modifier
Real Imag. Mag. Angle AngleU
Complex Conjugate dB
OK
Cancel
Help
Apply
Meas Help
raph
DB(GMax())
Max_Gain_Amplifier_4GHz
7
9
10





Prof. Pozar's simulation

$G_{max} = G_T$, which proves that our "Maximum gain amplifier" design is correct.