Western New England University
College of Engineering
ECE Department
Microwave Engineering
EE 414
Spring 2024
Design Project #6
Due: May 09, 2024

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References: ______________________________

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Design Project #6

Task	Score	Max
1		100
2		200
3		100
4		100
5		100
6		100
7		100
8		200
9		200
Total		1200

Design a transition between a 50 Ω microstrip transmission line and a 50 Ω coaxial transmission line (SMA connector). The transition should be well matched at 5 GHz ($|S_{11}| \le -25$ dB). Assume that the microstrip transmission lines are to be realized using a 1.27 mm thick Duroid 6010 substrate ($\varepsilon_r = 10.7$, $\tan\delta = 0.0023$, $\sigma_c = 5.8\times10^{+7}$ S/m, and $t = 18\ \mu\text{m}$). In addition, assume that the coaxial transmission line is an SMA connector. An SMA connector employs Teflon ($\varepsilon_r = 2.1$) as the dielectric, an inner radius of 0.635 mm ($r_i = 0.635$ mm), and an outer radius of 2.032 mm ($r_o = 2.032$ mm).

1. Employing HFSS, simulate the junction formed by connecting a 50 Ω microstrip transmission line and a 50 Ω coaxial transmission line (SMA connector). Employ a frequency range of 3 GHz to 7 GHz (25 MHz step size). In addition, assume that the maximum number of passes is 35 and the maximum delta S is 0.001
   - Determine a value for S_{11} and S_{21} at a frequency of 5 GHz.
   - Plot S_{11} on a Smith Chart.
   - Plot $|S_{11}|$, in dB, over the range of -40 dB to 0 dB.
   - Plot $|S_{21}|$, in dB, over the range of -2 dB to 0 dB.

2. Using the results from Task (1), design an impedance matching network employing a shunt stub to match a 50 Ω microstrip transmission line to the 50 Ω coaxial transmission line.

3. Convert the matching network employing ideal transmission lines to microstrip transmission lines. In addition, employ a transmission line at each port with an electrical length of 45°. Determine a value for the width, spacing (if appropriate), and length of each transmission line. Add the MTEE_ADS Element (Libra Microstrip T-Junction) element and the MLEF Element (Microstrip Line Open-End Effect). This version will be called MStrip V1.

4. Using ADS, simulate MStrip V1. Employ a frequency range of 3 GHz to 7 GHz (25 MHz step size).
   - Determine a value for S_{11} and S_{21} at a frequency of 5 GHz.
   - Plot S_{11} on a Smith Chart.
   - Plot $|S_{11}|$, in dB, over the range of -40 dB to 0 dB.
   - Plot $|S_{21}|$, in dB, over the range of -2 dB to 0 dB.

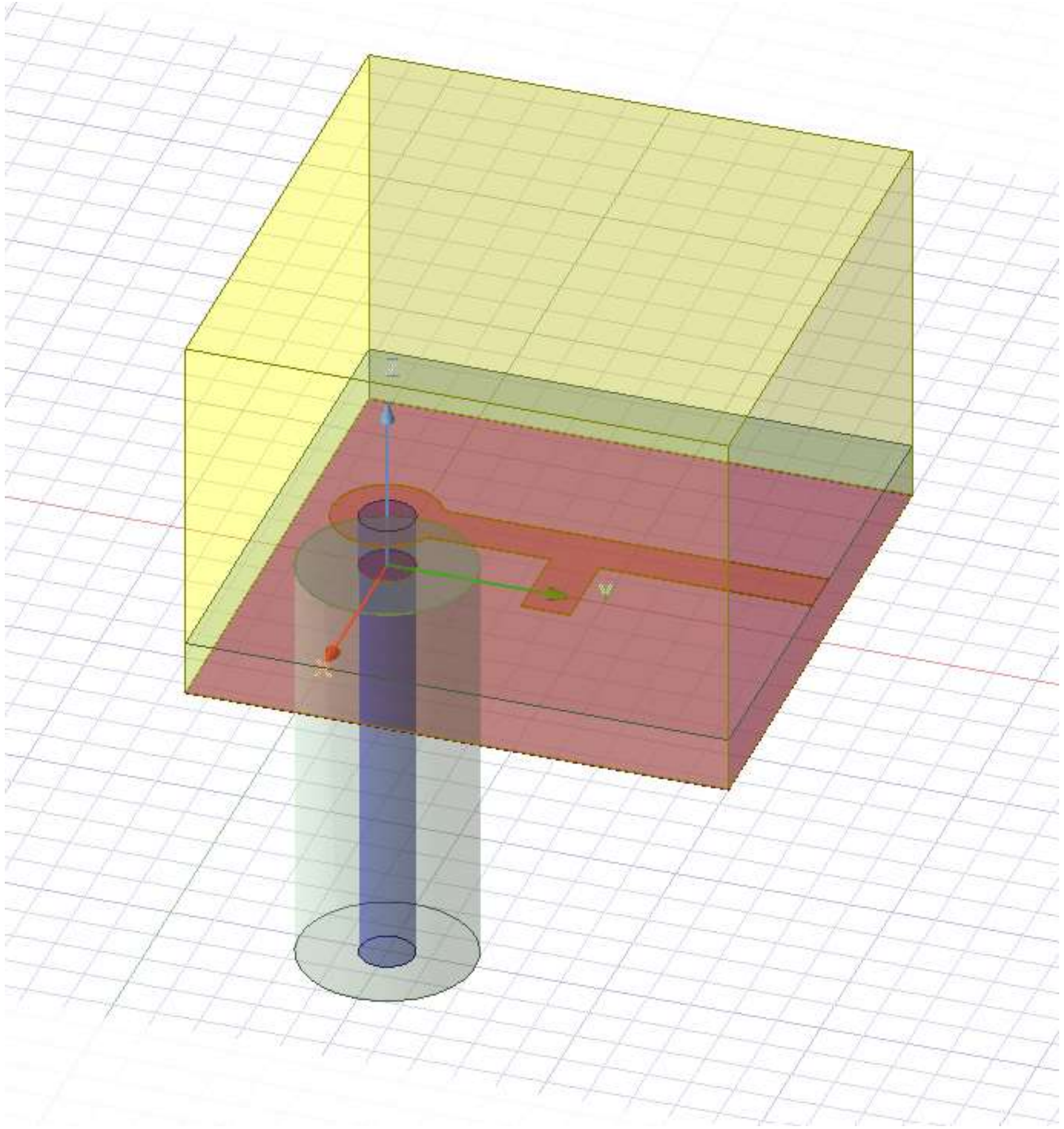
5. Tune MStrip V1. Determine a value for the width, spacing, and length of each transmission line. Note, set the length of d_{p1} to a very small value. This version will be called MStrip V2.
   - Determine a value for S_{11} and S_{21} at a frequency of 5 GHz.
   - Plot S_{11} on a Smith Chart.
   - Plot $|S_{11}|$, in dB, over the range of -40 dB to 0 dB.
   - Plot $|S_{21}|$, in dB, over the range of -2 dB to 0 dB.

6. Set d_{p1} back to its original value. This version will be called MStrip V3. Using ADS, simulate MStrip V3. Employ a frequency range of 3 GHz to 7 GHz (25 MHz step size)
   - Determine a value for S_{11} and S_{21} at a frequency of 5 GHz.
   - Plot S_{11} on a Smith Chart.
   - Plot $|S_{11}|$, in dB, over the range of -40 dB to 0 dB.
   - Plot $|S_{21}|$, in dB, over the range of -2 dB to 0 dB.

7. Using HFSS, simulate the matched transition from a 50 Ω microstrip transmission line to a 50 Ω coaxial transmission line (V3). Employ a frequency range of 3 GHz to 7 GHz (25 MHz step size). De-embed the Port 1 such that length between the stub and the reference plane for Port 1 is d_{p1}.
   - Determine a value for S_{11} and S_{21} at a frequency of 5 GHz.
   - Plot S_{11} on a Smith Chart.
   - Plot $|S_{11}|$, in dB, over the range of -40 dB to 0 dB.
   - Plot $|S_{21}|$, in dB, over the range of -2 dB to 0 dB.

8. Summarize the results for the ideal transmission line matching network, the ADS matching network (V3), and the HFSS matching network (V3).
   - On the same graph, plot $|S_{11}|$ in dB, for the three cases. Employ a frequency range of 3 GHz to 7 GHz and a range of -40 dB to 0 dB for $|S_{11}|$.
   - On the same graph, plot $|S_{21}|$ in dB, for the three cases. Employ a frequency range of 3 GHz to 7 GHz and a range of -2 dB to 0 dB for $|S_{21}|$.

9. Present the results from the design project into a well-organized presentation.



Design Project 6

By: Nittala Satya Surya Lakshmi Vasuki Siva Srinivas

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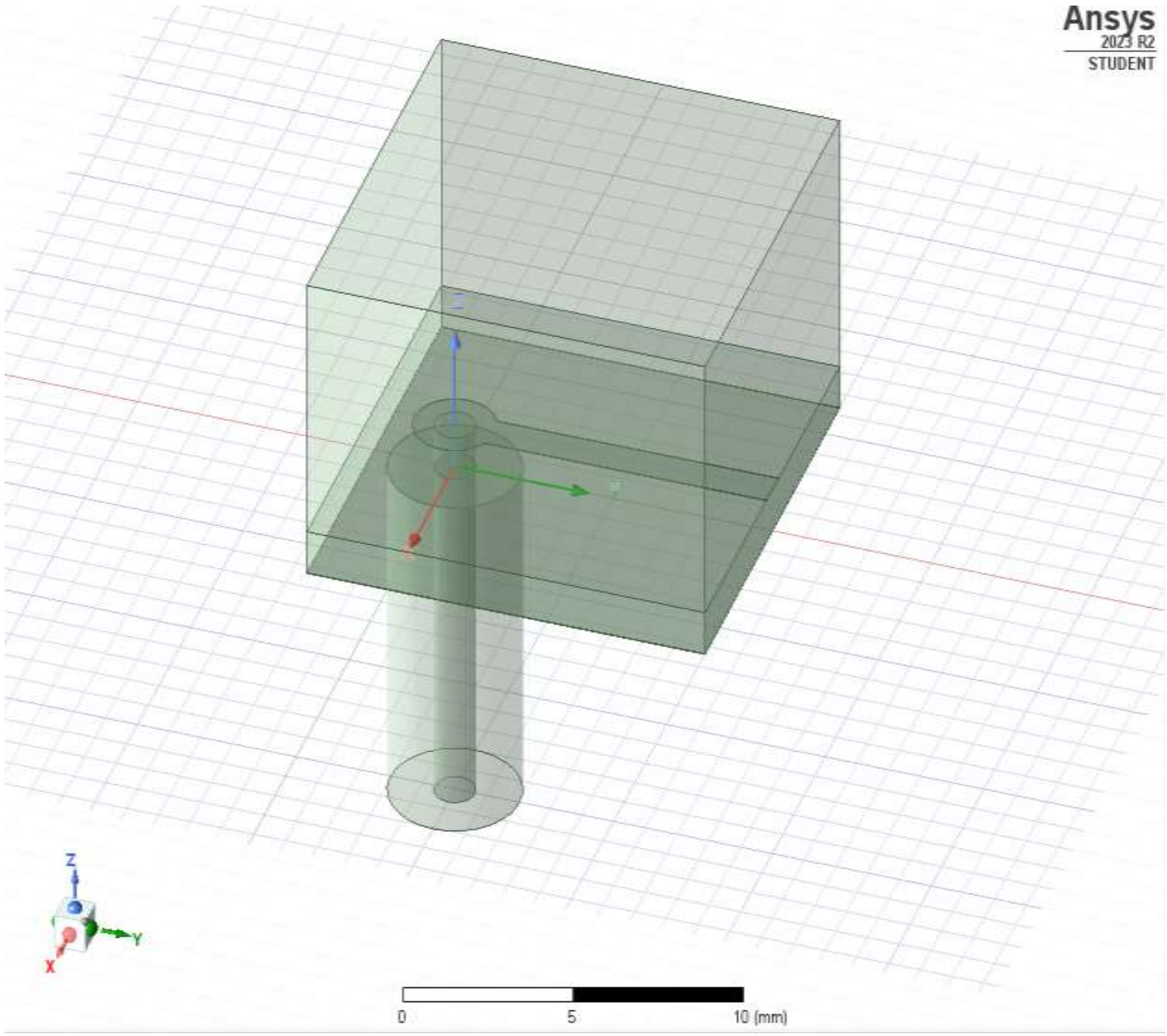
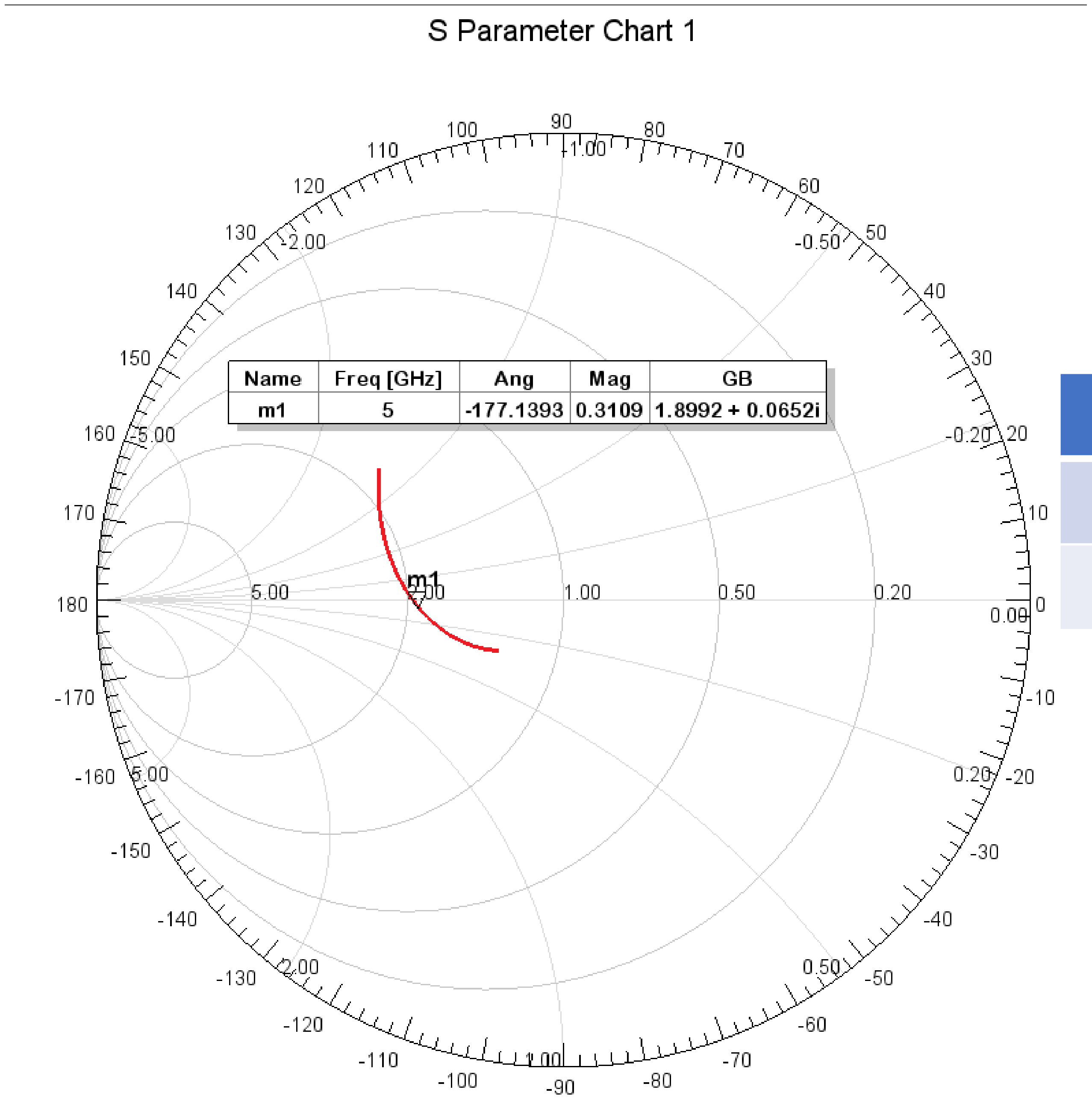
HFSS V0



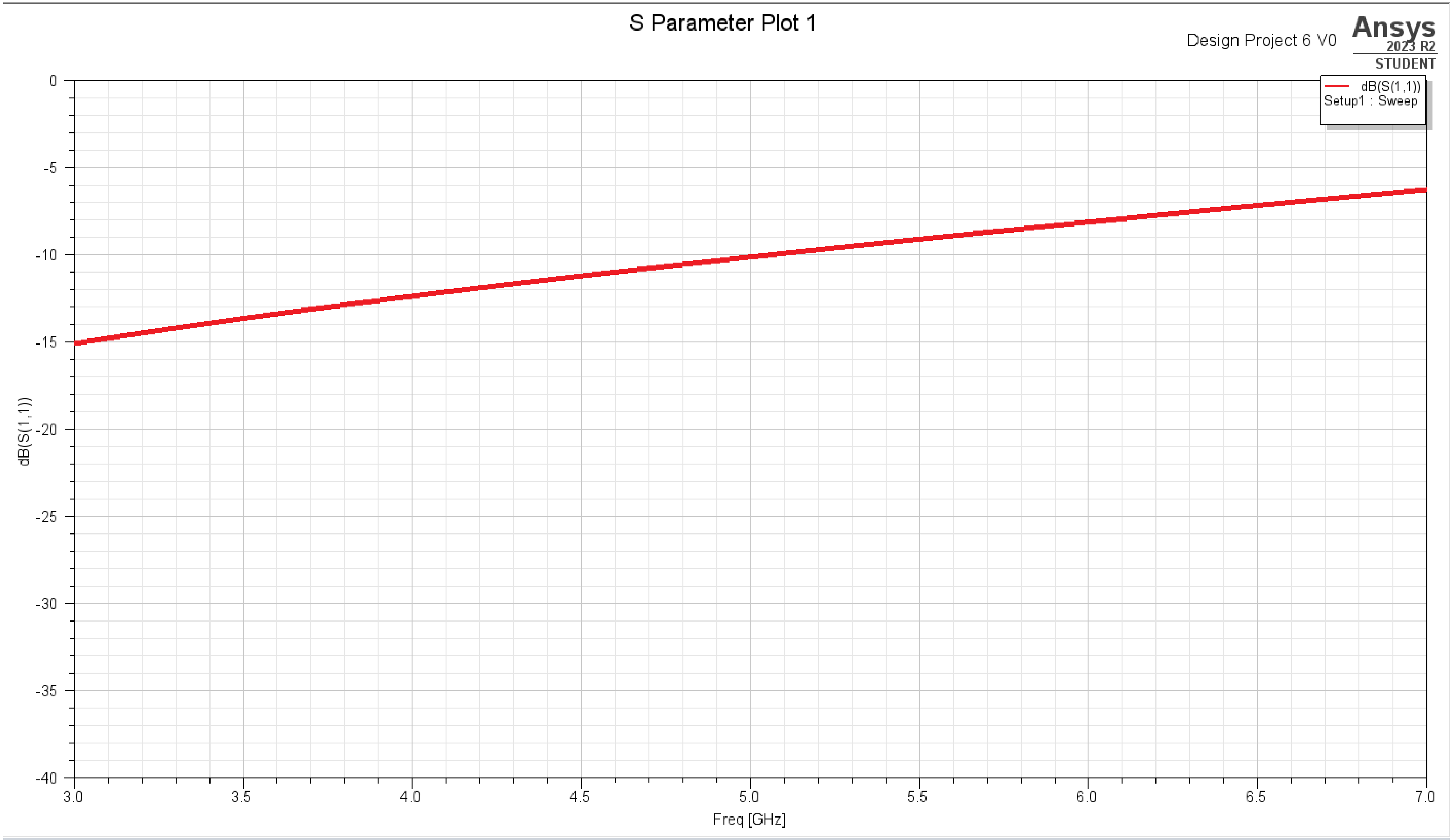
Boundaries

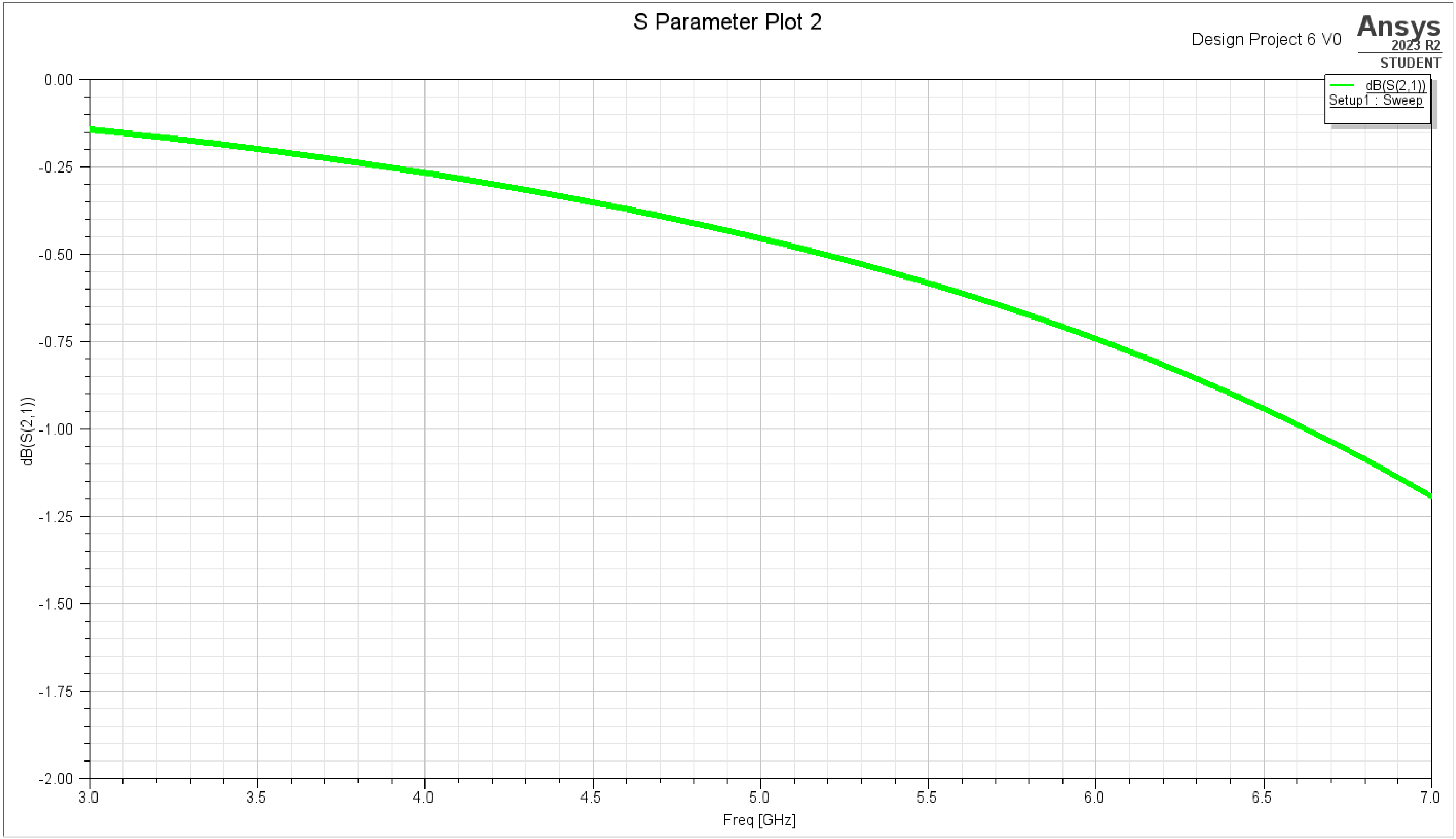
Properties

Name	Value	Unit	Evaluated V...	Type
h	1.27	mm	1.27mm	Design
W	1.13555	mm	1.13555mm	Design
A	12.7	mm	12.7mm	Design
B	7*h		8.89mm	Design
ds	2.54	mm	2.54mm	Design
Lm	10	mm	10mm	Design
C	ds+Lm		12.54mm	Design
ri	0.635	mm	0.635mm	Design
LC	10	mm	10mm	Design
ro	2.032	mm	2.032mm	Design
rp	2*ri		1.27mm	Design
d0	ro		2.032mm	Design
t	18	um	18um	Design
dp1	Lm-d0		7.968mm	Design

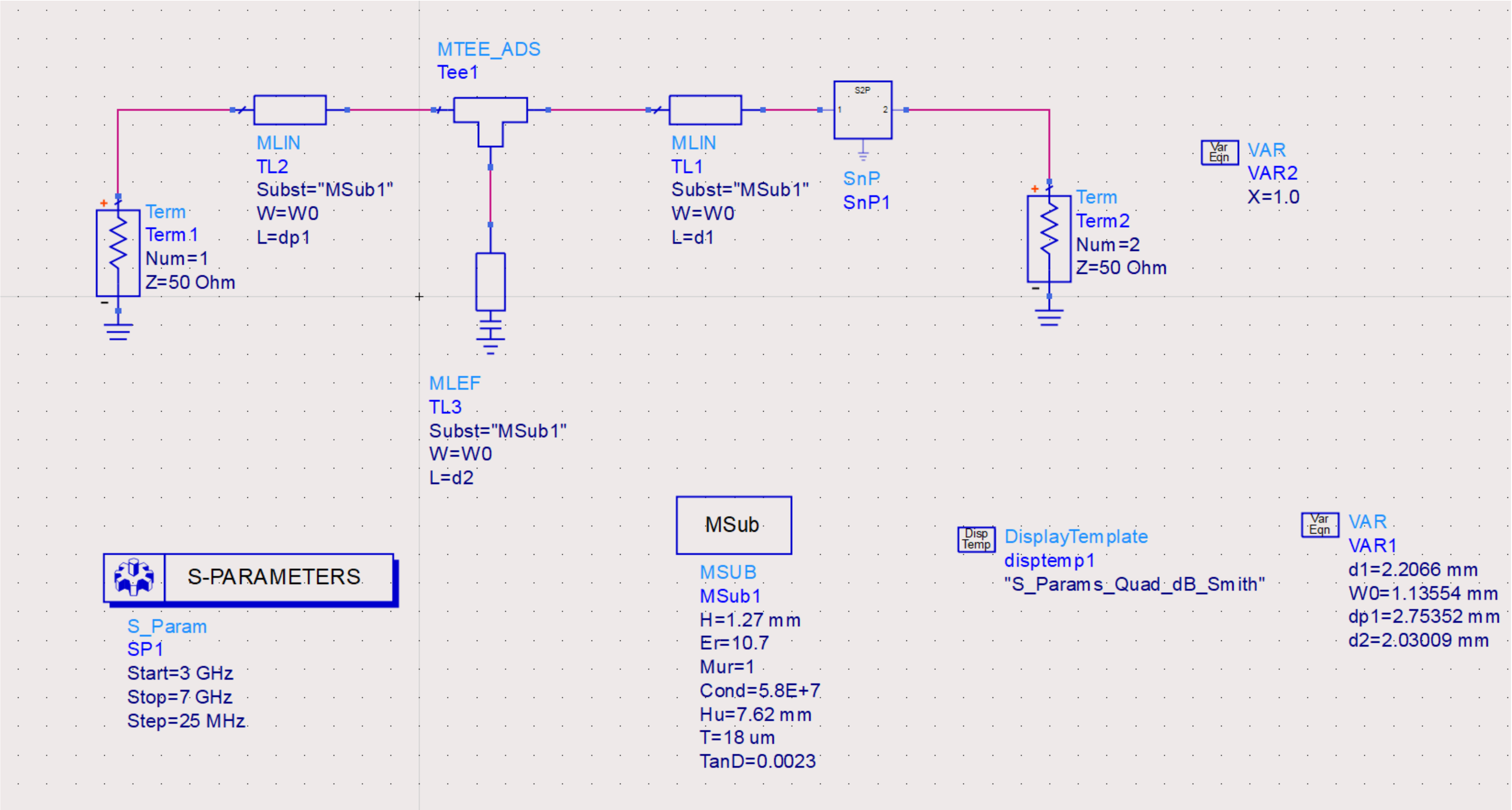


	Values	dB
S_{11}	0.311<-177.139°	-10.148
S_{21}	0.949<-51.545°	-0.456


S Parameter Plot 1
Design Project 6 V0
Ansys
2023 R2
STUDENT
dB(S(1,1))
Setup1 : Sweep
0
-5
-10
-15
-20
-25
-30
-35
-40
dB(S(1,1))
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
Freq [GHz]

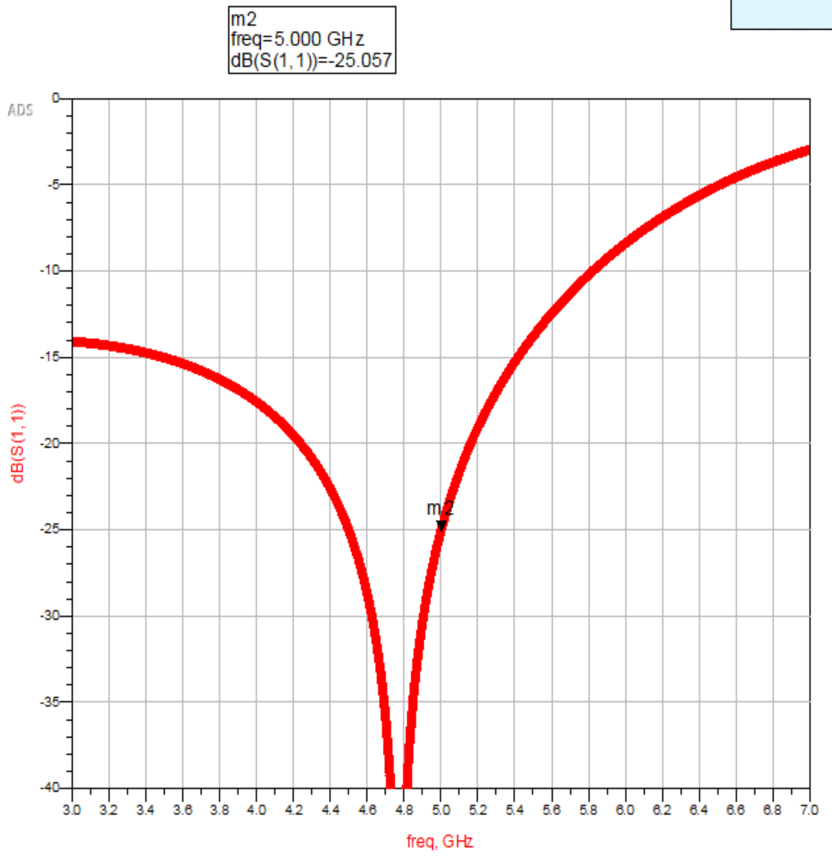

S Parameter Plot 2
Design Project 6 V0
Ansys
2023 R2
STUDENT
dB(S(2,1))
Setup1 : Sweep
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
-1.75
-2.00
dB(S(2,1))
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
Freq [GHz]

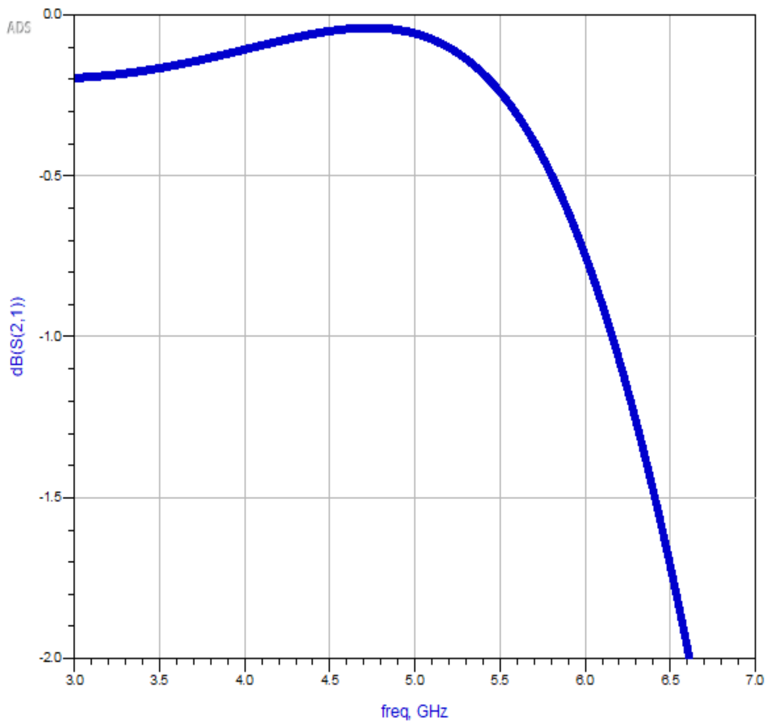
MStrip_V1

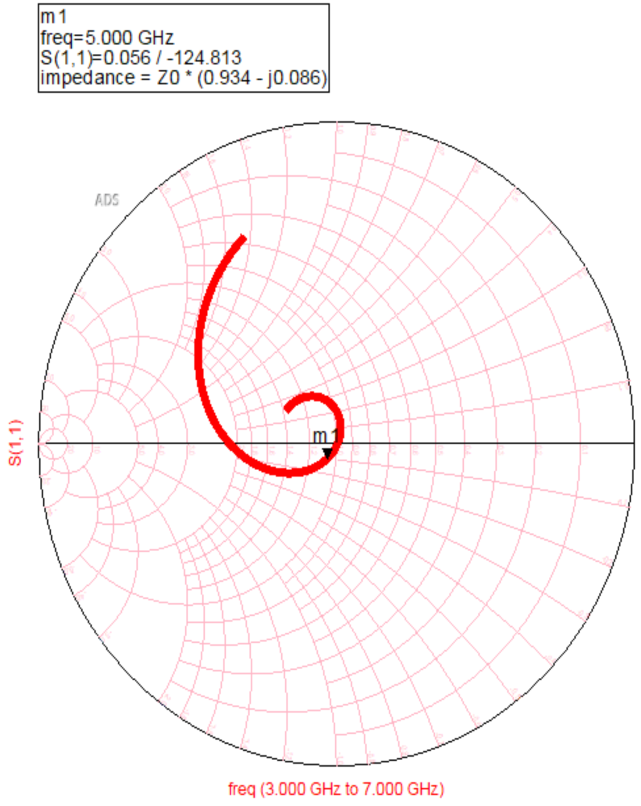

MTEE_ADS
Tee1
S2P
1
2
MLIN
TL2
Subst="MSub1"
W=W0
L=dp1
MLIN
TL1
Subst="MSub1"
W=W0
L=d1
SnP
SnP1
Var Eqn
VAR
VAR2
X=1.0
Term
Term1
Num=1
Z=50 Ohm
Term
Term2
Num=2
Z=50 Ohm
MLEF
TL3
Subst="MSub1"
W=W0
L=d2
S-PARAMETERS
S_Param
SP1
Start=3 GHz
Stop=7 GHz
Step=25 MHz
MSub
MSUB
MSub1
H=1.27 mm
Er=10.7
Mur=1
Cond=5.8E+7
Hu=7.62 mm
T=18 um
TanD=0.0023
Disp Temp
DisplayTemplate
disptemp1
"S_Params_Quad_dB_Smith"
Var Eqn
VAR
VAR1
d1=2.2066 mm
W0=1.13554 mm
dp1=2.75352 mm
d2=2.03009 mm

MStrip_V1

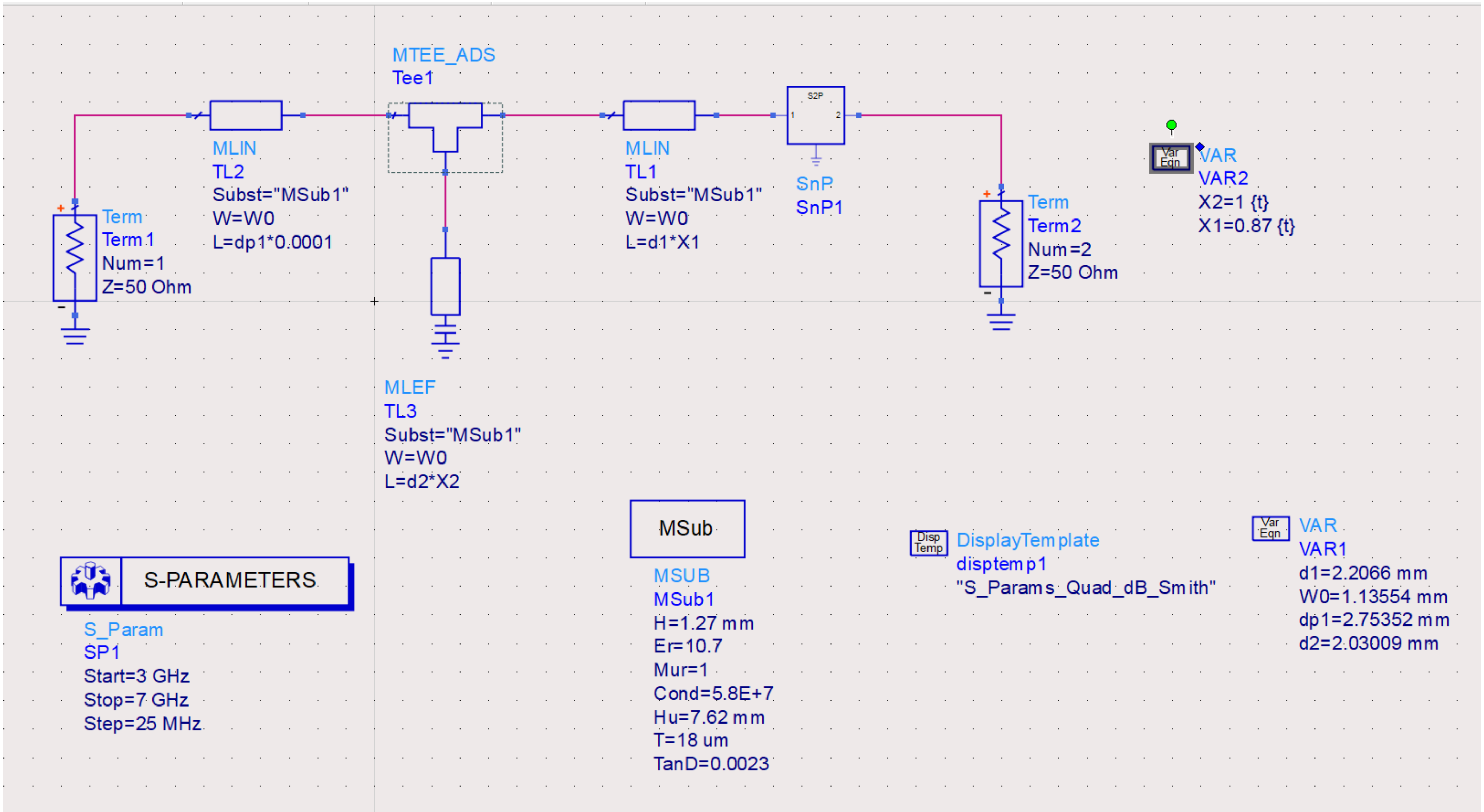
S-Parameters vs. Frequency







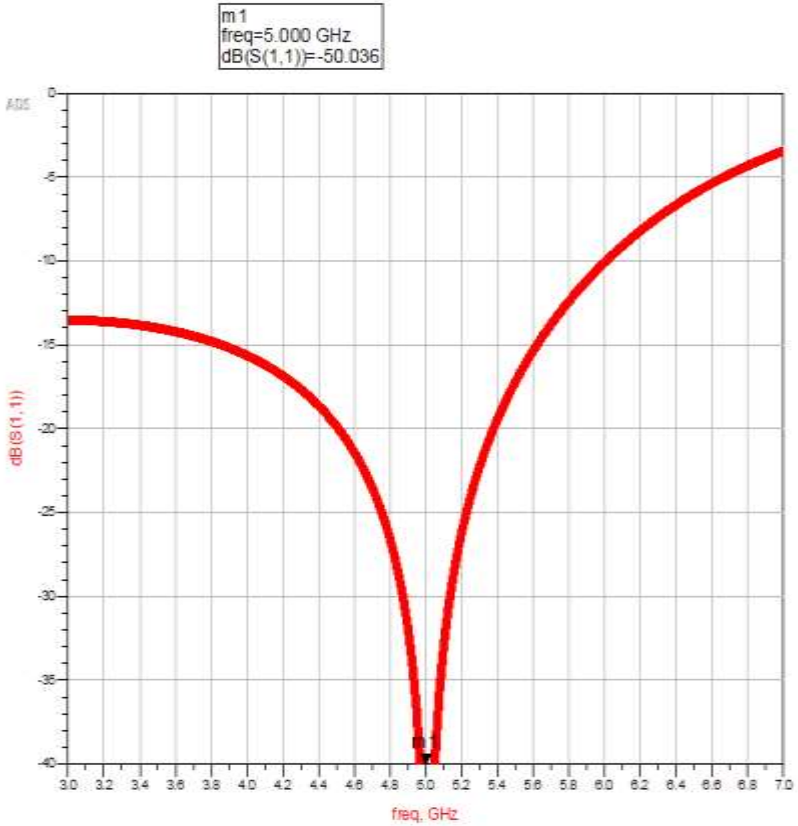
MStrip_V2

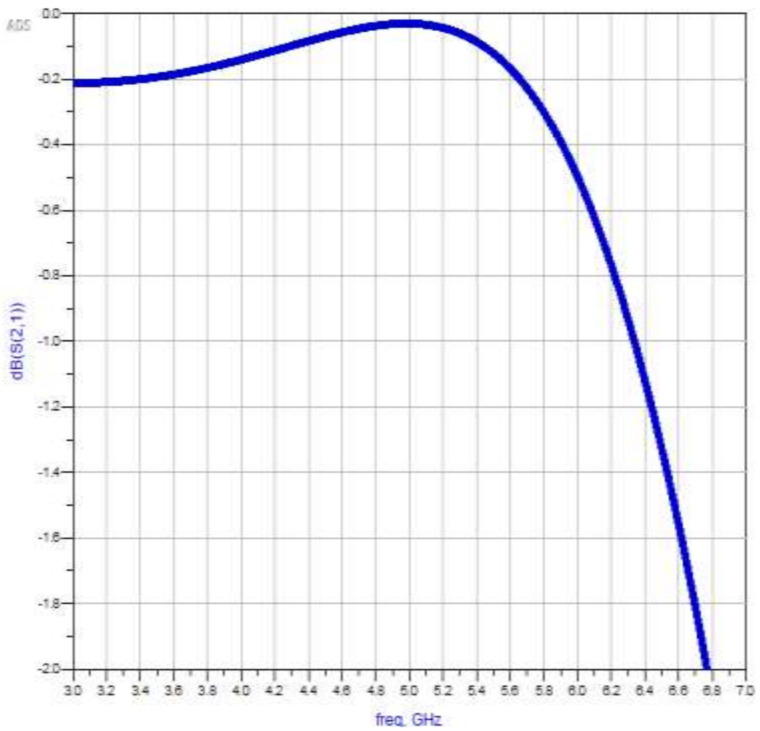


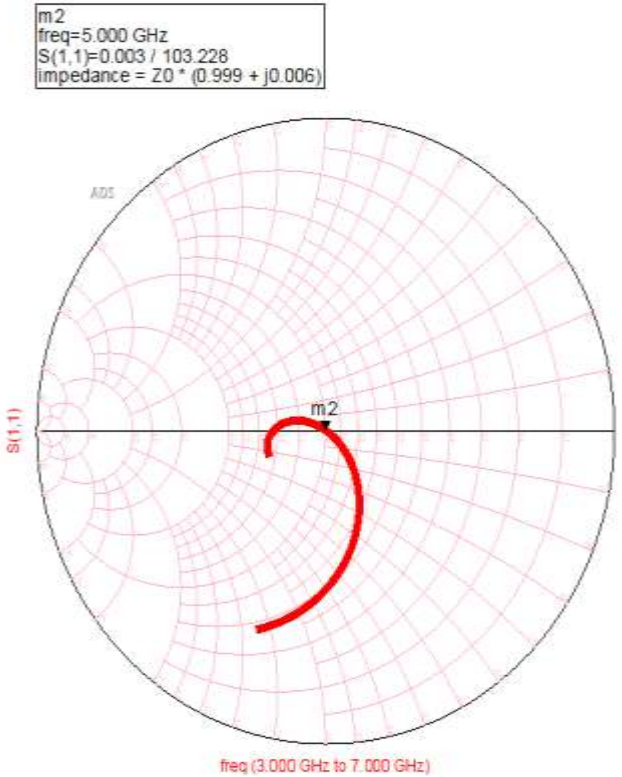
MTEE_ADS
Tee1
MLIN
TL2
Subst="MSub1"
W=W0
L=dp1*0.0001
MLIN
TL1
Subst="MSub1"
W=W0
L=d1*X1
S2P
1
2
SnP
SnP1
Var
Eqn
VAR
VAR2
X2=1 {t}
X1=0.87 {t}
Term
Term1
Num=1
Z=50 Ohm
Term
Term2
Num=2
Z=50 Ohm
MLEF
TL3
Subst="MSub1"
W=W0
L=d2*X2
S-PARAMETERS
S_Param
SP1
Start=3 GHz
Stop=7 GHz
Step=25 MHz
MSub
MSUB
MSub1
H=1.27 mm
Er=10.7
Mur=1
Cond=5.8E+7
Hu=7.62 mm
T=18 um
TanD=0.0023
Disp
Temp
DisplayTemplate
disptemp1
"S_Params_Quad_dB_Smith"
Var
Eqn
VAR
VAR1
d1=2.2066 mm
W0=1.13554 mm
dp1=2.75352 mm
d2=2.03009 mm

MStrip_V2

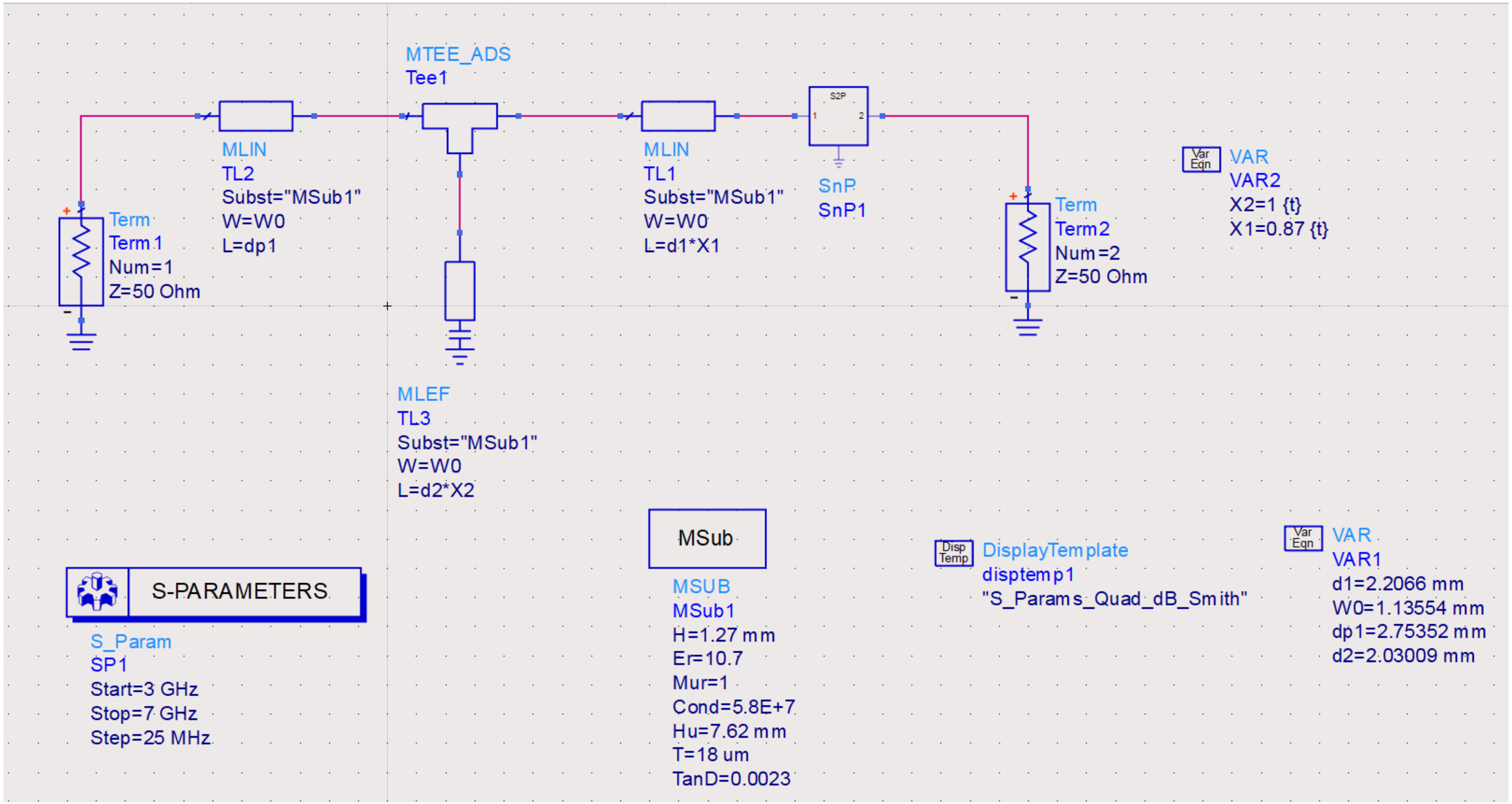
S-Parameters vs. Frequency







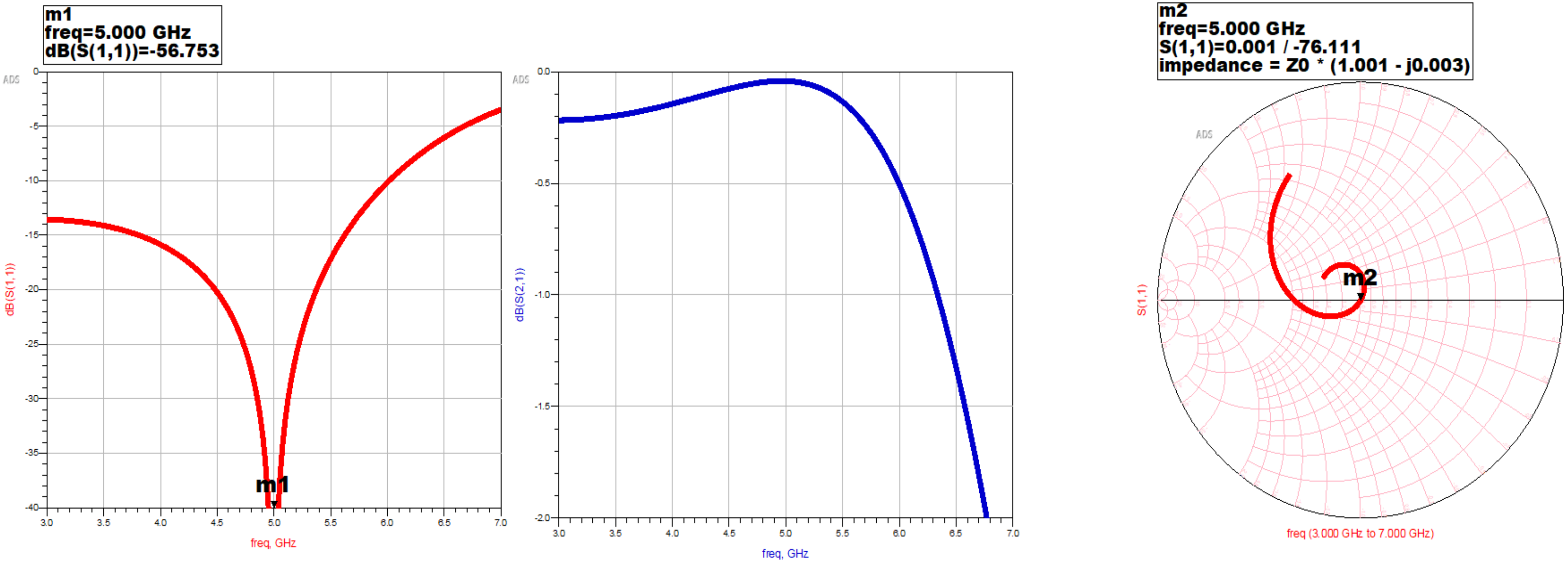
MStrip_V3



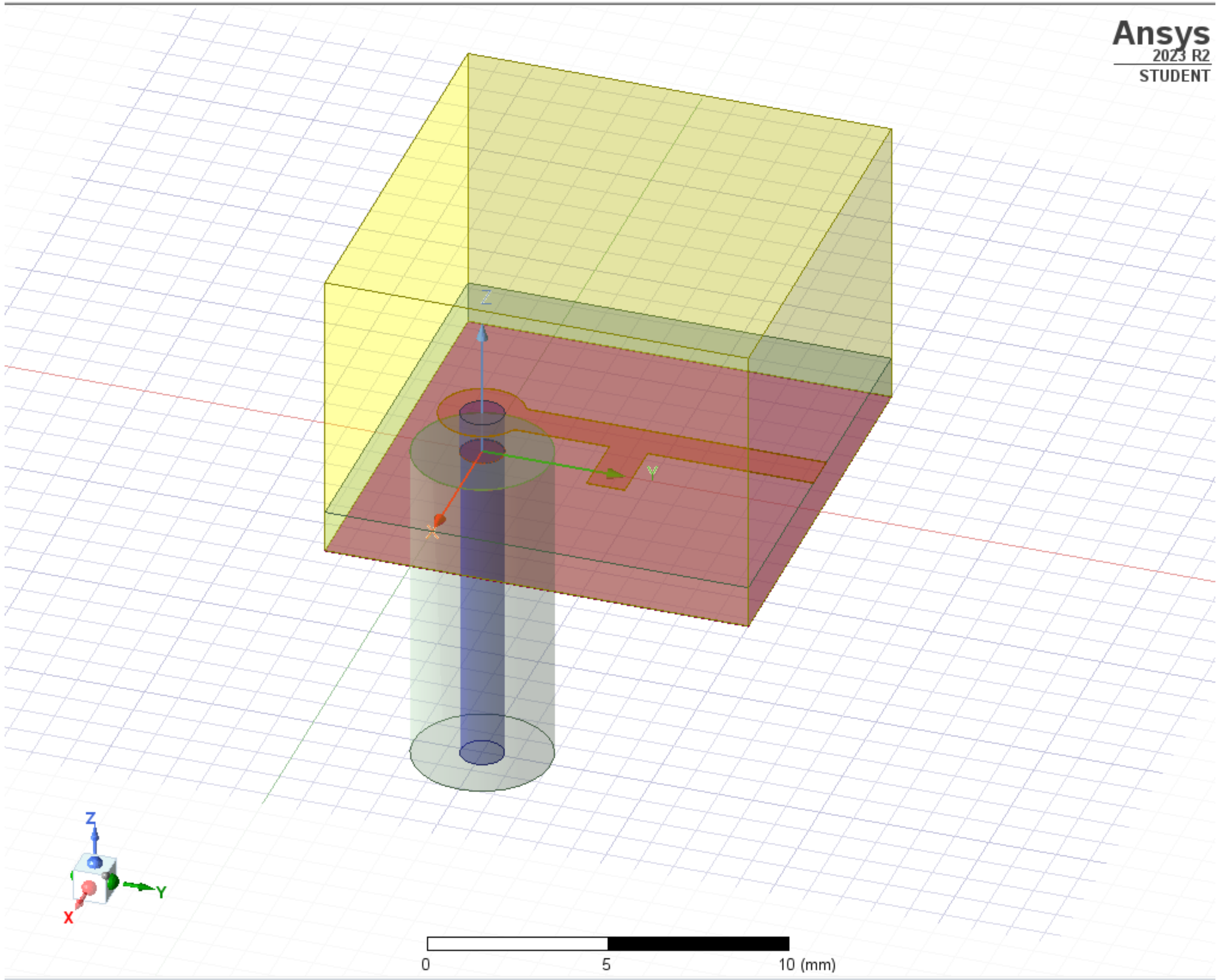
MTEE_ADS
Tee1
MLIN
TL2
Subst="MSub1"
W=W0
L=dp1
MLIN
TL1
Subst="MSub1"
W=W0
L=d1*X1
S2P
SnP
SnP1
Term
Term1
Num=1
Z=50 Ohm
Term
Term2
Num=2
Z=50 Ohm
VAR
VAR2
X2=1 {t}
X1=0.87 {t}
MLEF
TL3
Subst="MSub1"
W=W0
L=d2*X2
S-PARAMETERS
S_Param
SP1
Start=3 GHz
Stop=7 GHz
Step=25 MHz
MSub
MSUB
MSub1
H=1.27 mm
Er=10.7
Mur=1
Cond=5.8E+7
Hu=7.62 mm
T=18 um
TanD=0.0023
Disp Temp
DisplayTemplate
disptemp1
"S_Params_Quad_dB_Smith"
Var Eqn
VAR
VAR1
d1=2.2066 mm
W0=1.13554 mm
dp1=2.75352 mm
d2=2.03009 mm

MStrip_V3

S-Parameters vs. Frequency

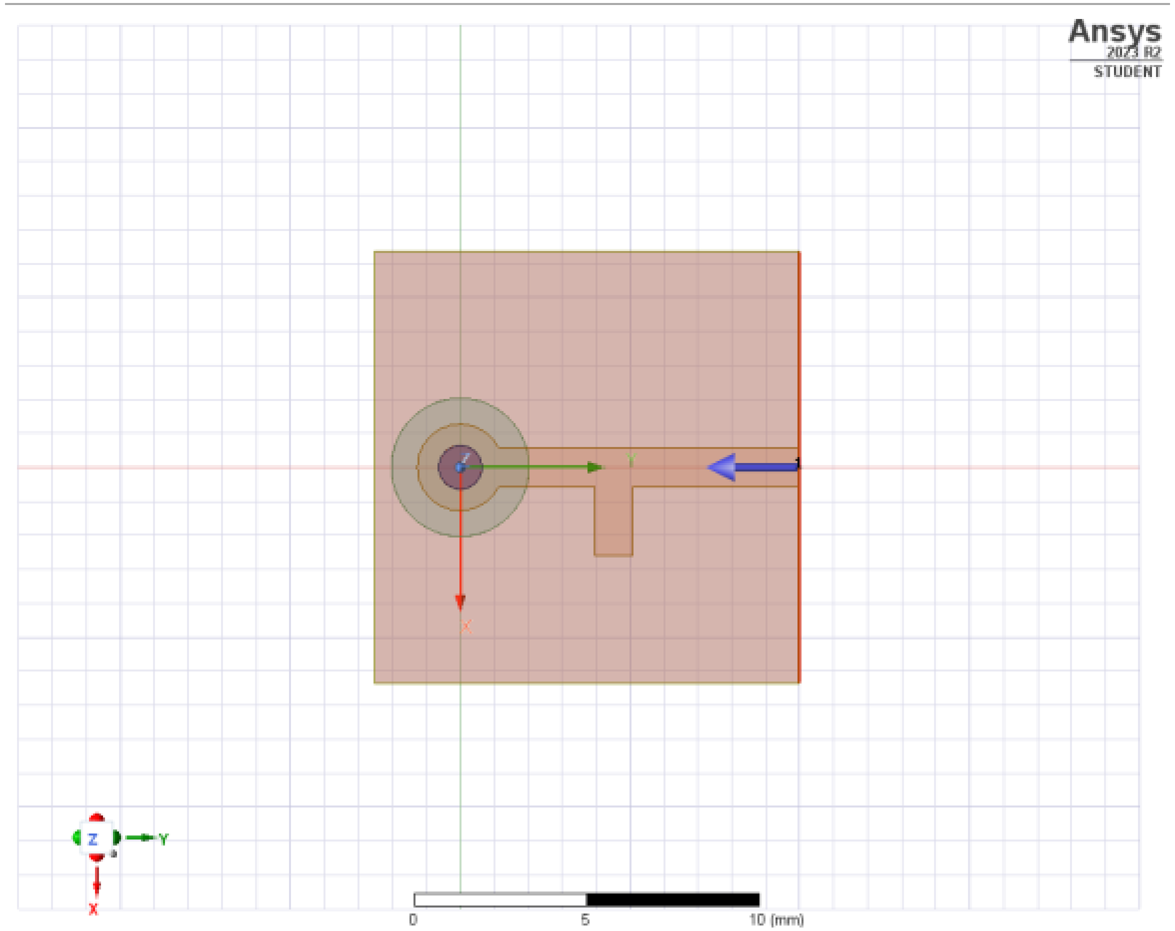


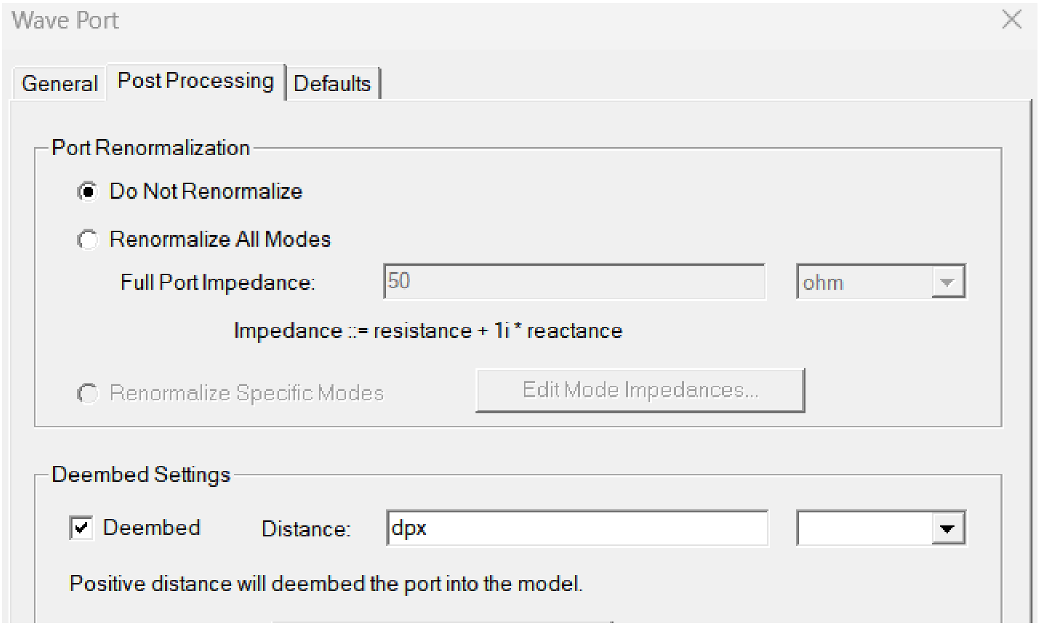
HFSS V3



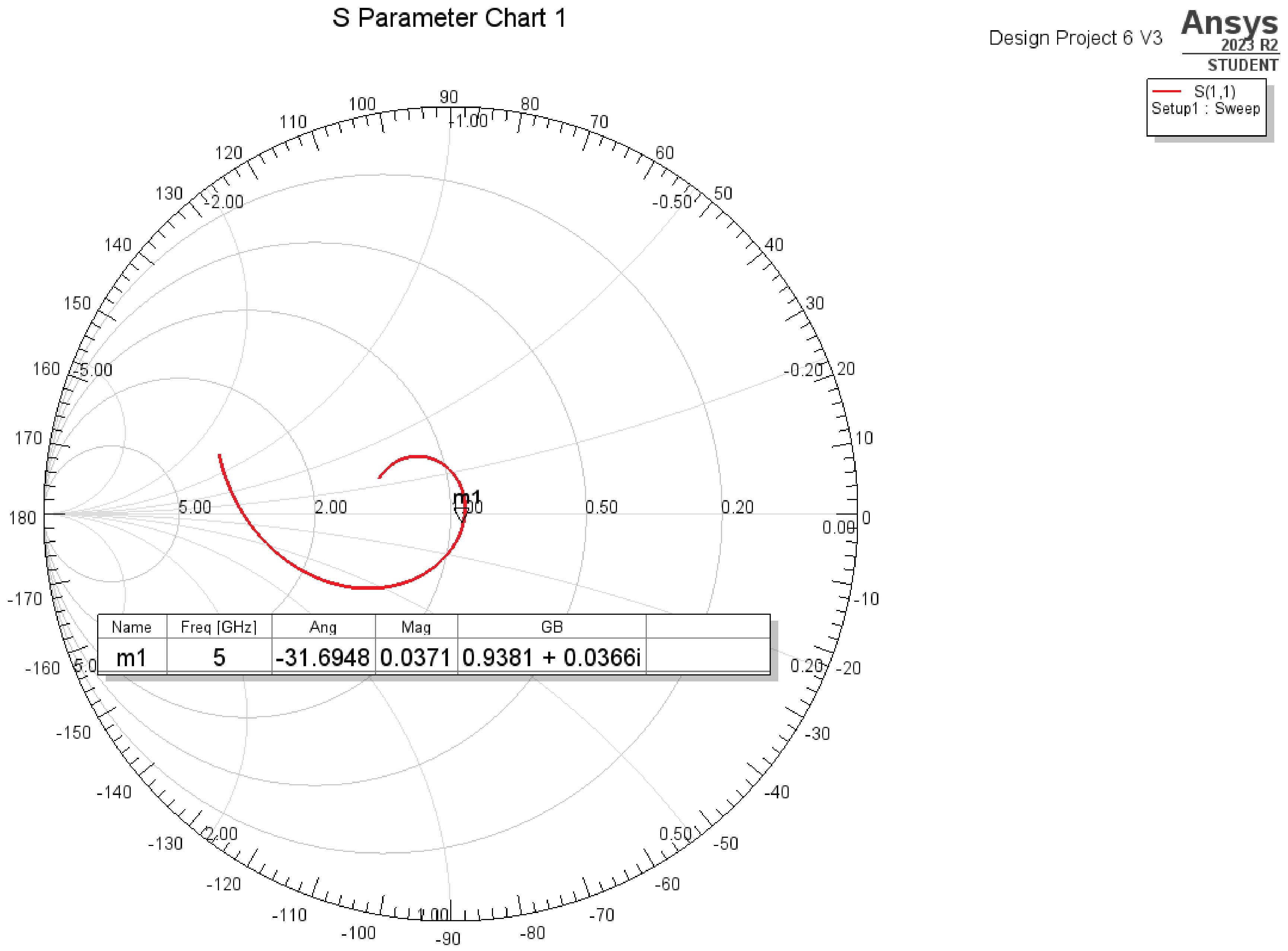
Properties

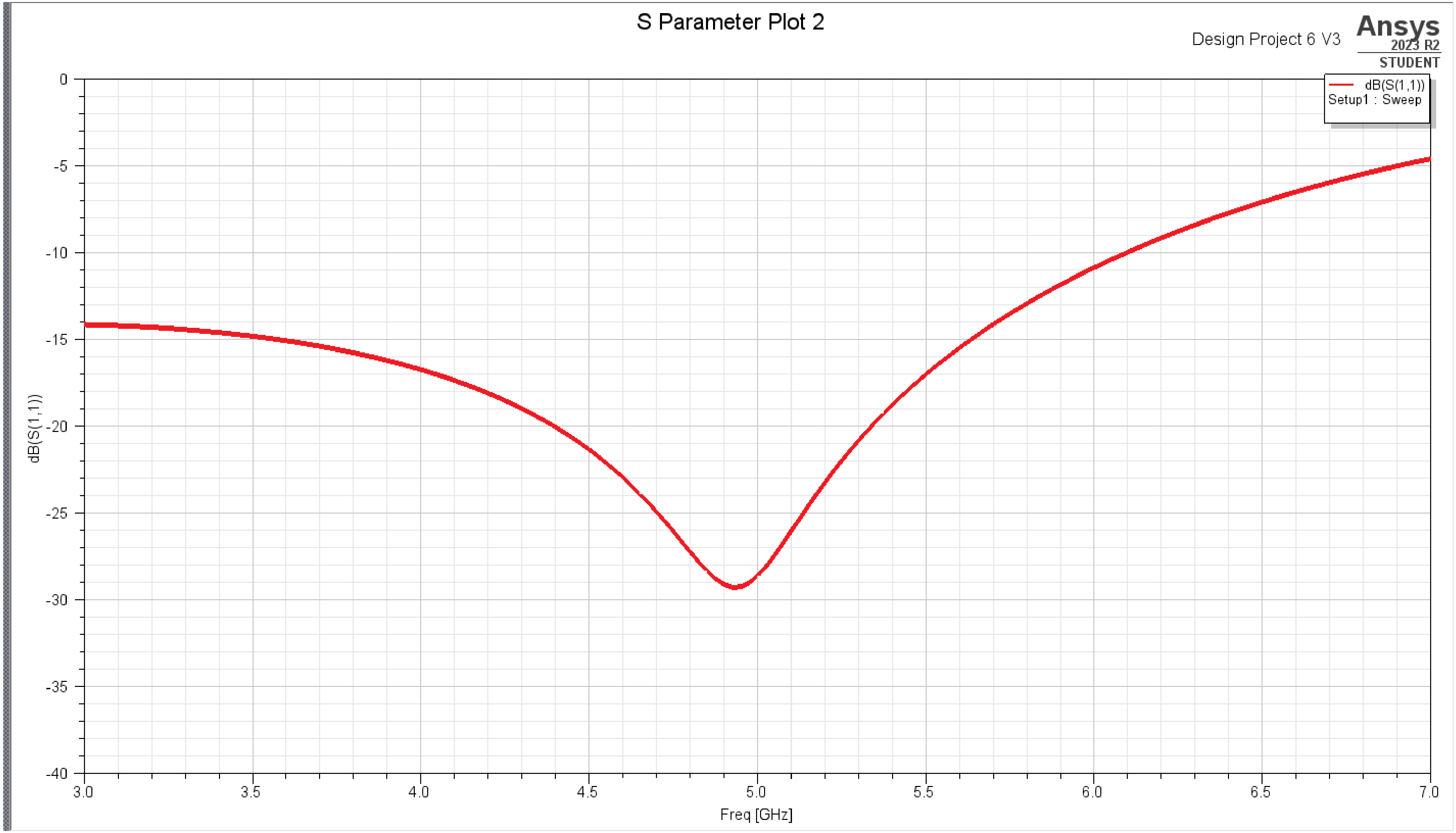
Name	Value	Unit	Evaluated V...	Type
h	1.27	mm	1.27mm	Design
W	1.13555	mm	1.13555mm	Design
A	12.7	mm	12.7mm	Design
B	7*h		8.89mm	Design
ds	2.54	mm	2.54mm	Design
Lm	10	mm	10mm	Design
C	ds+Lm		12.54mm	Design
ri	0.635	mm	0.635mm	Design
LC	10	mm	10mm	Design
ro	2.032	mm	2.032mm	Design
rp	2*ri		1.27mm	Design
d0	ro		2.032mm	Design
t	18	um	18um	Design
dp1	Lm-d0		7.968mm	Design
d1	2.2066	mm	2.2066mm	Design
d2	2.03009	mm	2.03009mm	Design
dpx	2.75828	mm	2.75828mm	Design
dp1_new	0.87*d1		1.919742mm	Design
d1_new	dp1_new		1.919742mm	Design

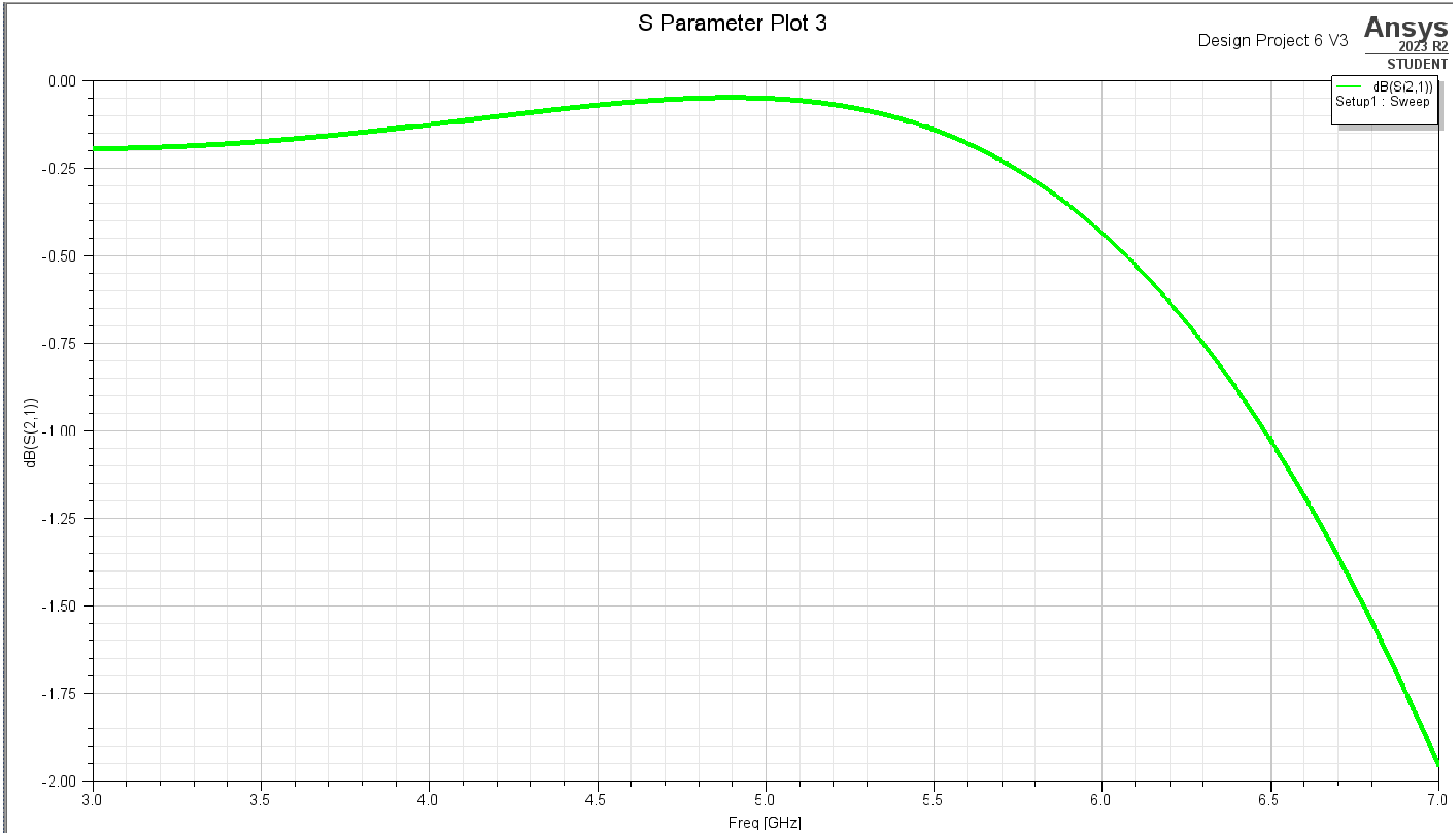




d1	2.2066	mm	2.2066mm	Design
d2	2.03009	mm	2.03009mm	Design
dpx	2.75828	mm	2.75828mm	Design
dp1_new	0.87*d1		1.919742mm	Design
d1_new	dp1_new		1.919742mm	Design

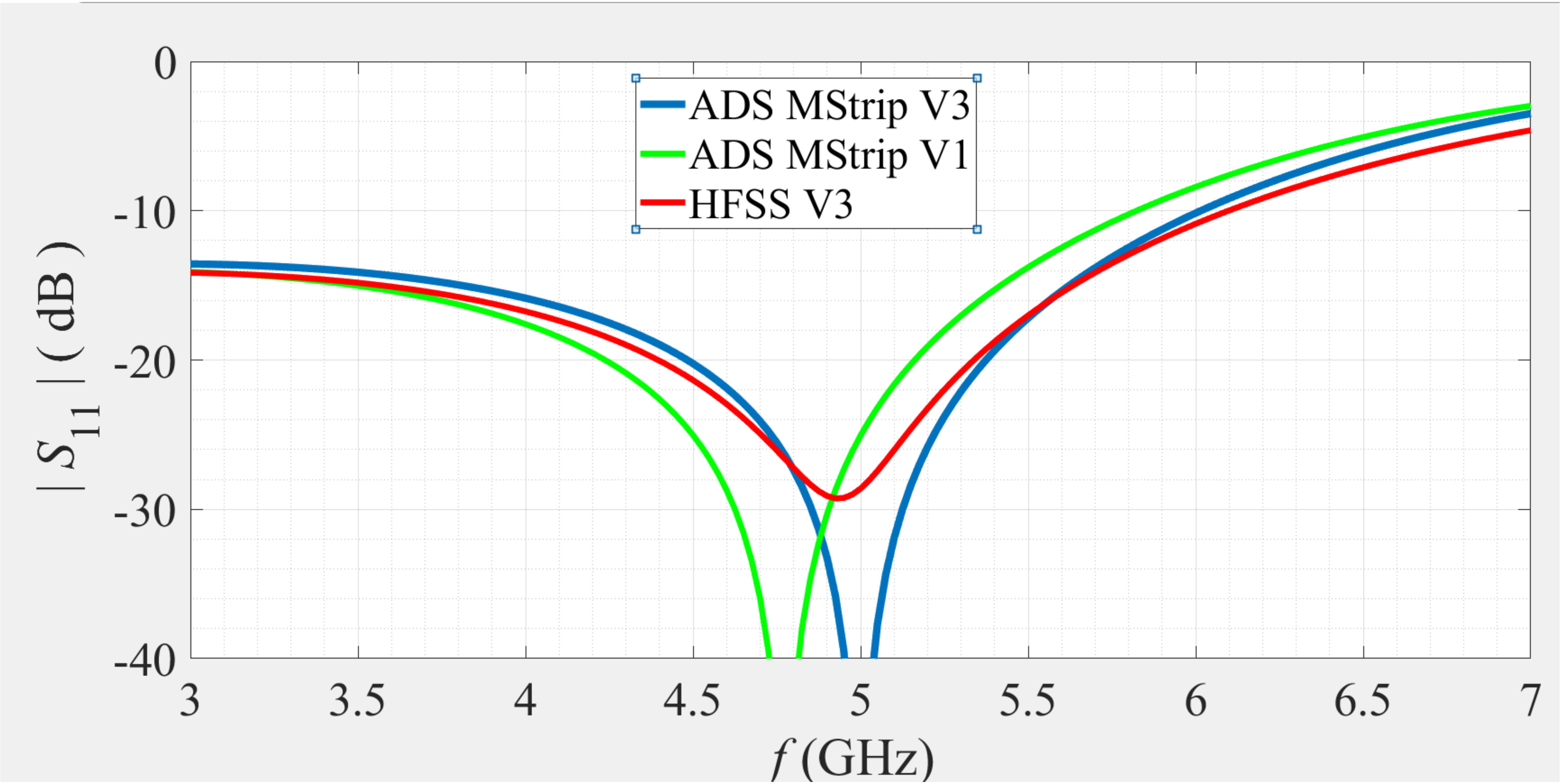

S Parameter Chart 1
Design Project 6 V3
Ansys
2023 R2
STUDENT
S(1,1)
Setup1 : Sweep
m1
Name
Freq [GHz]
Ang
Mag
GB
m1
5
-31.6948
0.0371
0.9381 + 0.0366i


S Parameter Plot 2
Design Project 6 V3
Ansys
2023 R2
STUDENT
dB(S(1,1))
Setup1 : Sweep
0
-5
-10
-15
-20
-25
-30
-35
-40
dB(S(1,1))
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
Freq [GHz]

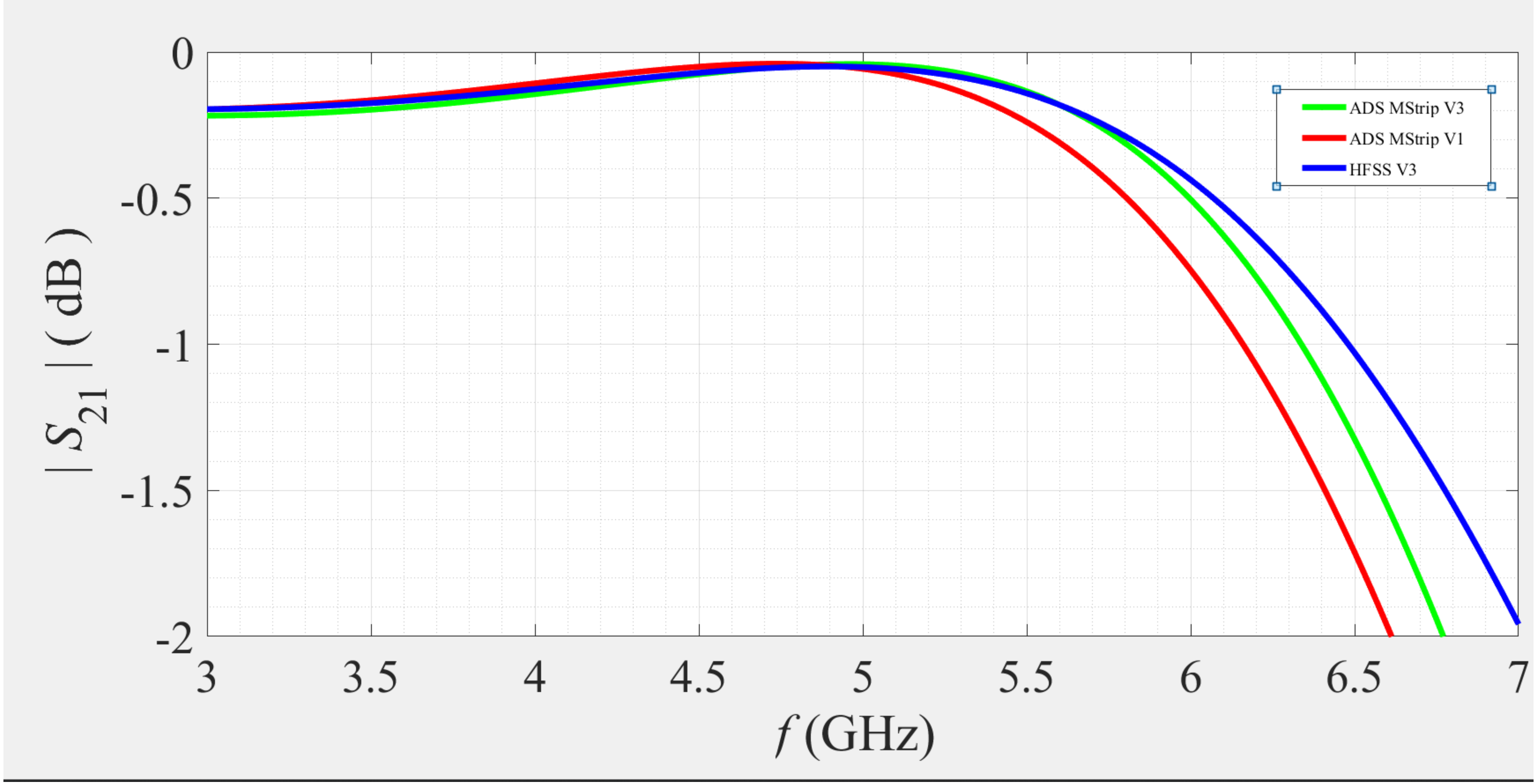

S Parameter Plot 3
Design Project 6 V3
Ansys
2023 R2
STUDENT
dB(S(2,1))
Setup1 : Sweep
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
-1.75
-2.00
dB(S(2,1))
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
Freq [GHz]

	S_{11}	dB	S_{21}	dB
M Strip(V1)	0.056<-124.813°	-25.055	0.993<-163.753°	-0.058
M Strip(V2)	0.003<+103.228°	-50.036	0.996<-113.469°	-0.031
M Strip(V3)	0.001<-76.111°	-56.753	0.995<-158.135°	-0.042
HFSS(V3)	0.0371<-31.7°	-28.6112	0.99407<+30.2°	-0.0516

On the same graph, plot $|S_{11}|$ in dB, for the three cases. Employ a frequency range of 3 GHz to 7 GHz and a range of -40 dB to 0 dB for $|S_{11}|$.



On the same graph, plot $|S_{21}|$ in dB, for the three cases. Employ a frequency range of 3 GHz to 7 GHz and a range of -2 dB to 0 dB for $|S_{21}|$.



Appendices

- MATLAB
- HFSS
- ADS

THE END