Western New England University
College of Engineering
ECE Department
Microwave Engineering
EE 414
Spring 2024
Design Project #5
Due: May 06, 2024

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References: _____

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Design Project #5

	Score	Max
Coupler Design		100
MATLAB Simulation		100
MStrip V1 Design		100
MStrip V1 Simulation		200
MStrip V2 Simulation		100
Summary Graphs		200
Presentation		100
Total		800

1. Design a 10 dB single section coupled line directional coupler. The network impedance is 50 Ω ($Z_0 = 50\,\Omega$), and the center frequency is 5 GHz. Determine the even-mode and odd-mode impedances, Z_{0e} and Z_{0_o}, respectively.

2. Simulate the coupler network using MATLAB. Employ ideal transmission lines and a frequency range of 3 GHz to 7 GHz. In addition, employ a transmission line at each port with an electrical length of 60°.
   - Determine a value for S_{11}, S_{21}, S_{31}, and S_{41} at 5 GHz.

3. Convert the coupler network employing ideal transmission lines to microstrip transmission lines. 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, employ a transmission line at each port with an electrical length of 60°. Determine a value for the width, spacing, and length of each transmission line. This version will be called MStrip V1.

4. Simulate the coupler using ADS (V1).
   - Determine a value for S_{11}, S_{21}, S_{31}, and S_{41} at 5 GHz.

5. Add the microstrip "Optimally Chamfered Bend 90-Degree" element (MSOBND_MDS) to the model in Task (4). This version will be called MStrip V2.
   - Determine a value for S_{11}, S_{21}, S_{31}, and S_{41} at 5 GHz.

6. Summarize the results.
   - On the same graph, plot $|S_{11}|$ in dB, the simulated using MATALB , MStrip V1, and MStrip V2. Employ a range of -40 dB to 0 dB.
   - On the same graph, plot $|S_{21}|$ in dB, the simulated using MATALB , MStrip V1, and MStrip V2. Employ a range of -0.8 dB to 0 dB.
   - On the same graph, plot $|S_{31}|$ in dB, the simulated using MATALB , MStrip V1, and MStrip V2. Employ a range of -12.5 dB to -8.75 dB.
   - On the same graph, plot $|S_{41}|$ in dB, the simulated using MATALB , MStrip V1, and MStrip V2. Employ a range of -40 dB to 0 dB.

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

Table 1 Summary of the simulated values for the coupling and directivity at 5 GHz.

	Coupling (dB)	Directivity (dB)
MATLAB Simulation		
MStrip V1		
MStrip V2		

Design Project 5

Single section coupled line Directional Coupler

By : Nittala Satya Surya Lakshmi Vasuki Siva Srinivas

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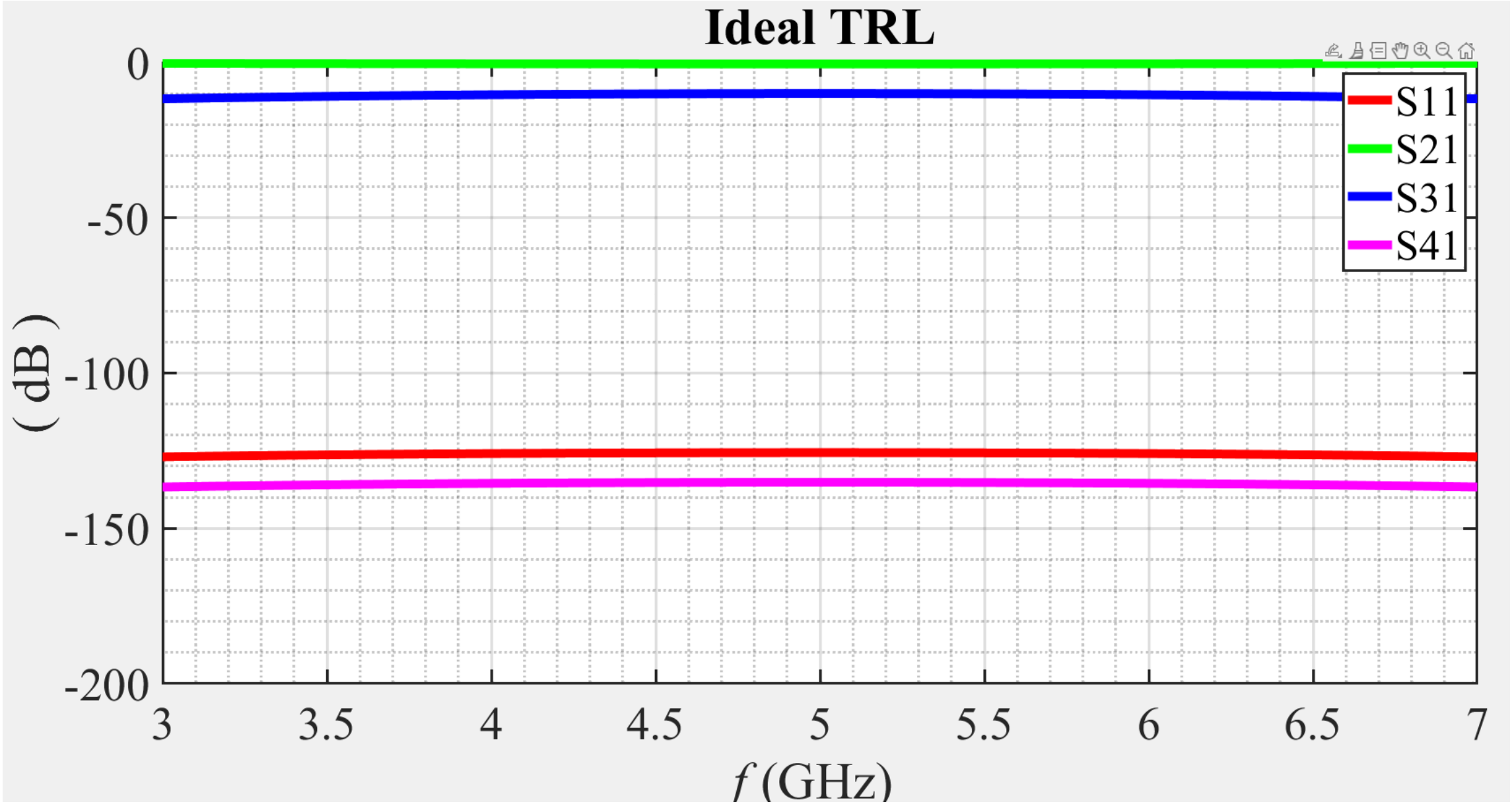
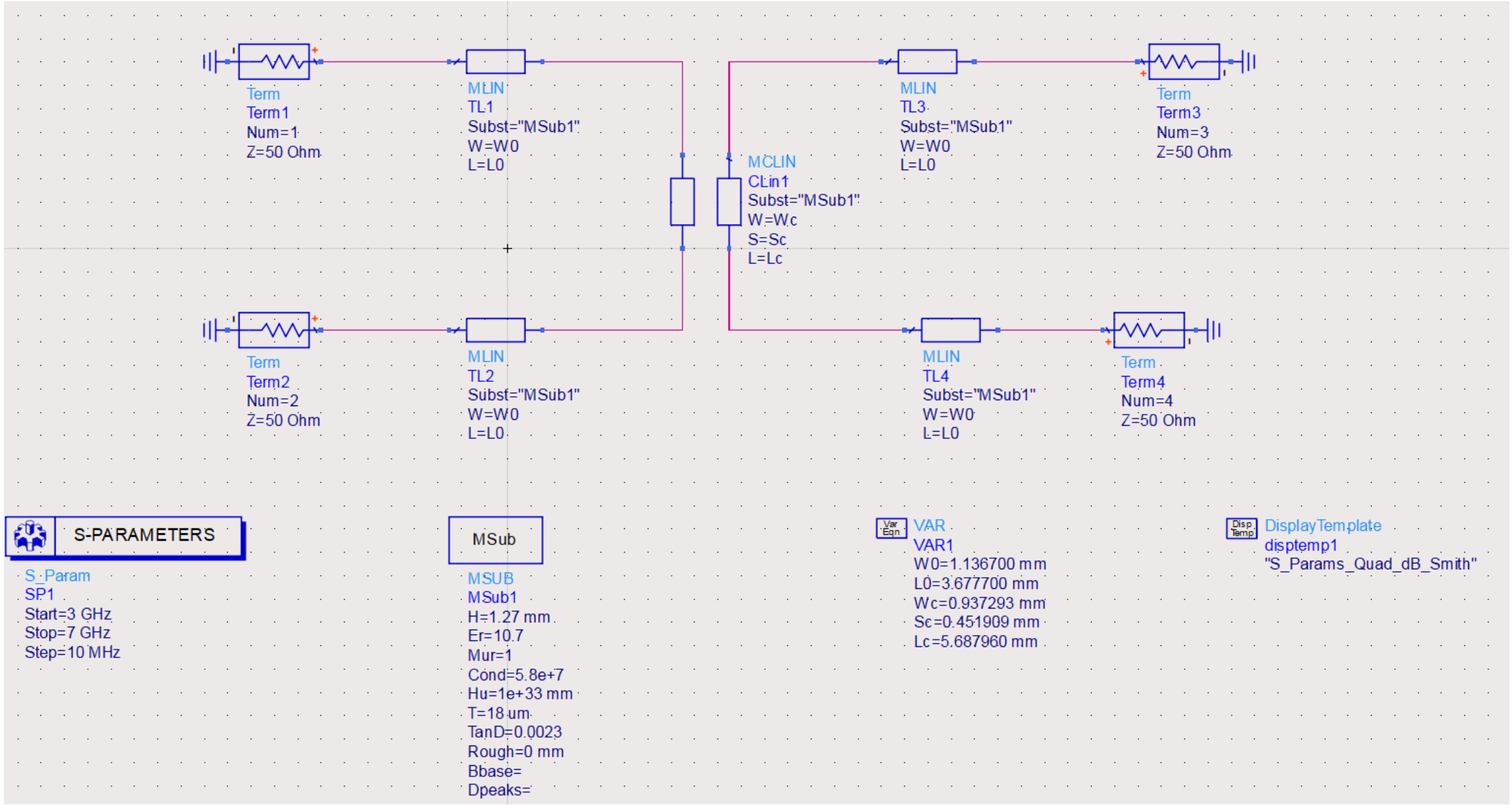
	MATLAB	MStrip_V1	MStrip_V2	
Z_{0e}	69.3713	69.3713	69.3713	Ω
Z_{0o}	36.0380	36.0380	36.0380	Ω
θ_e	90	90	90	°
θ_o	90	90	90	°
θ_P	60	60	60	°
Return Loss	125.6185	28.9896	23.9538	dB
Insertion Loss	457.5735	558.4755	496.1234	mdB
Coupling	10.0000	10.1729	10.5519	dB
Isolation	135.1609	19.4677	24.4622	dB
Directivity	125.1609	9.2948	13.9104	dB

Ideal Transmission Lines

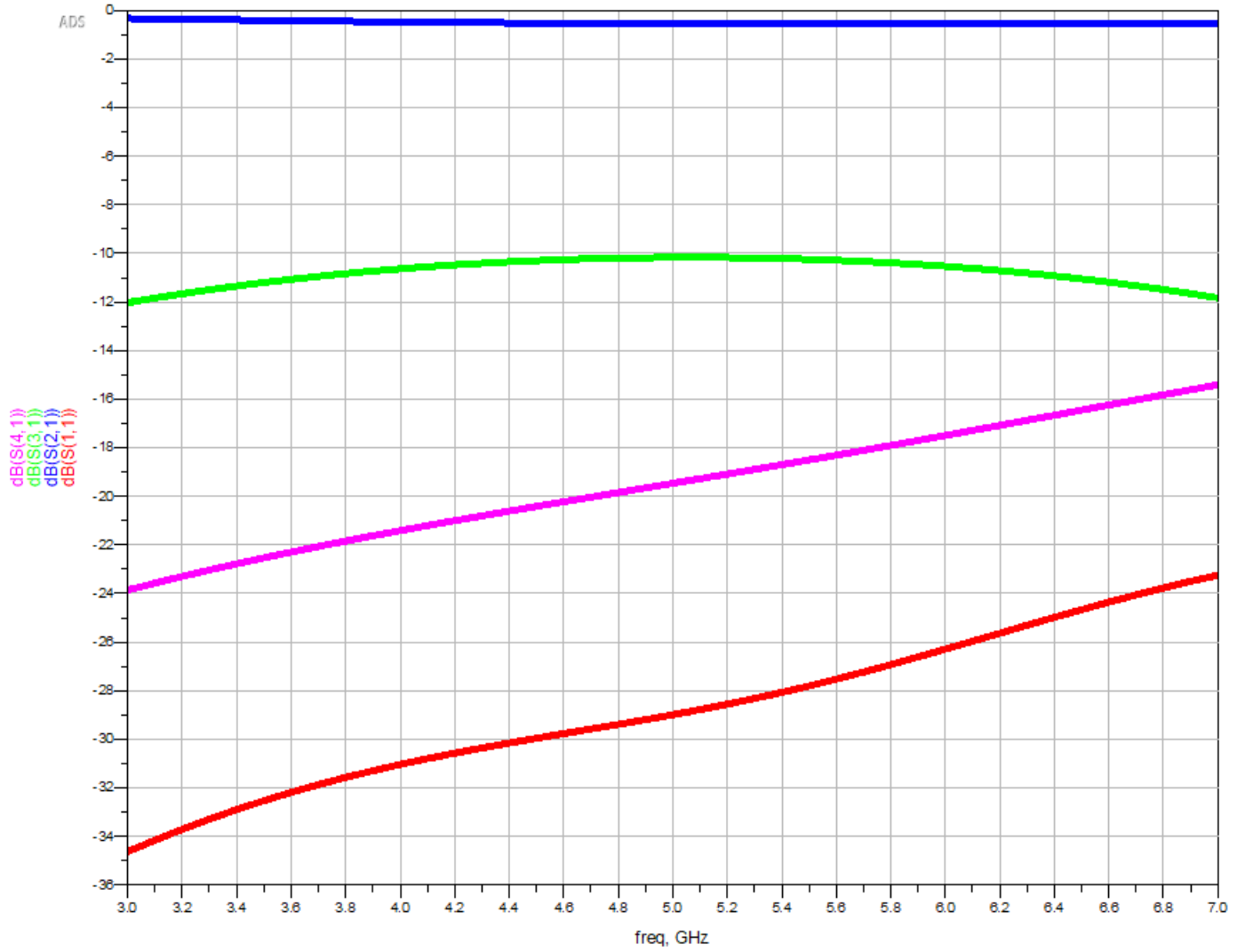


Mstrip_V1

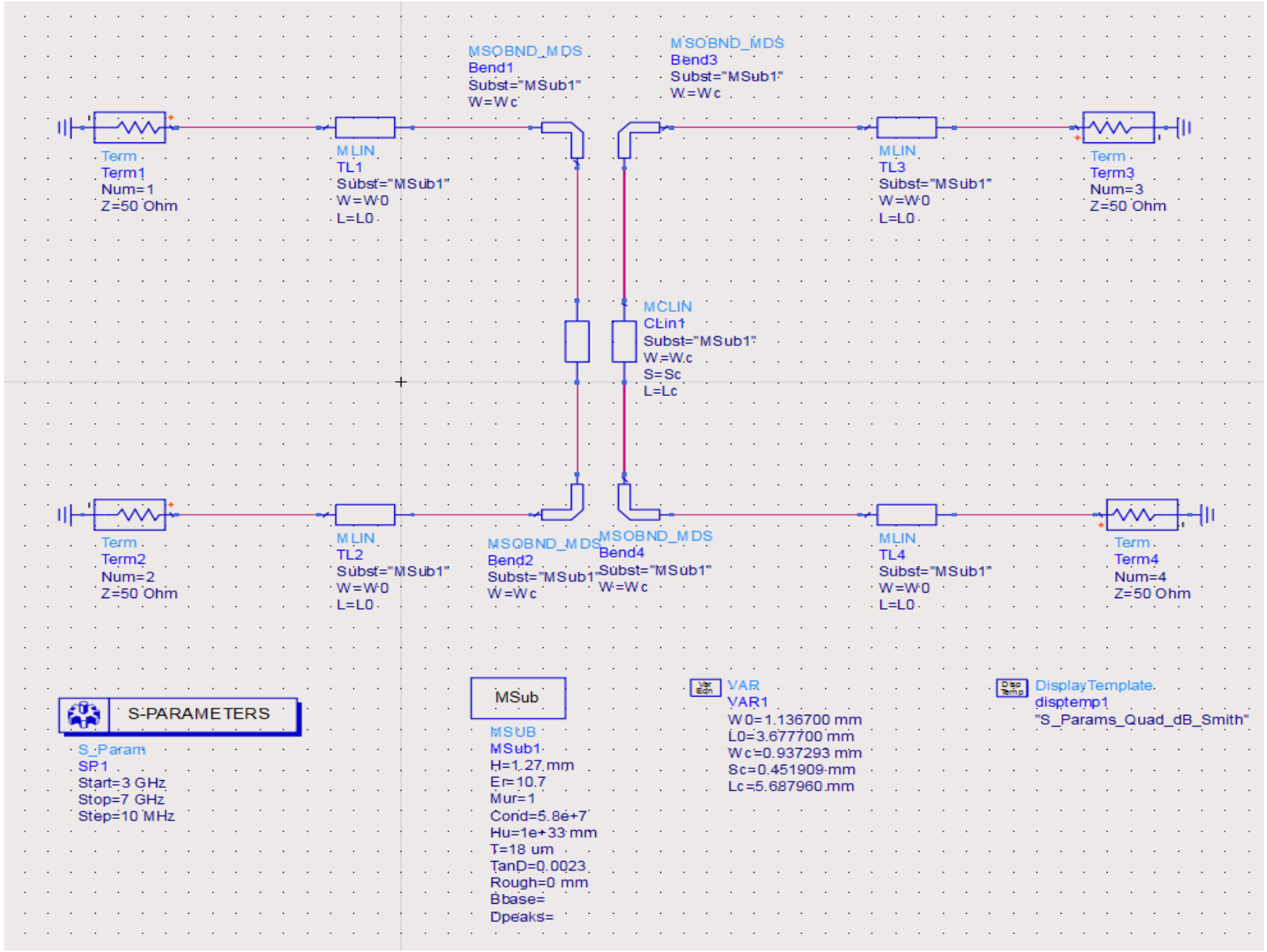

Term
Term1
Num=1
Z=50 Ohm
MLIN
TL1
Subst="MSub1"
W=W0
L=L0
MCLIN
CLin1
Subst="MSub1"
W=Wc
S=Sc
L=Lc
MLIN
TL3
Subst="MSub1"
W=W0
L=L0
Term
Term3
Num=3
Z=50 Ohm
Term
Term2
Num=2
Z=50 Ohm
MLIN
TL2
Subst="MSub1"
W=W0
L=L0
MLIN
TL4
Subst="MSub1"
W=W0
L=L0
Term
Term4
Num=4
Z=50 Ohm
S-PARAMETERS
S_Param
SP1
Start=3 GHz
Stop=7 GHz
Step=10 MHz
MSub
MSUB
MSub1
H=1.27 mm
Er=10.7
Mur=1
Cond=5.8e+7
Hu=1e+33 mm
T=18 um
TanD=0.0023
Rough=0 mm
Bbase=
Dpeaks=
VAR
VAR1
W0=1.136700 mm
L0=3.677700 mm
Wc=0.937293 mm
Sc=0.451909 mm
Lc=5.687960 mm
DisplayTemplate
disptemp1
"S_Params_Quad_dB_Smith"

Mstrip_V1

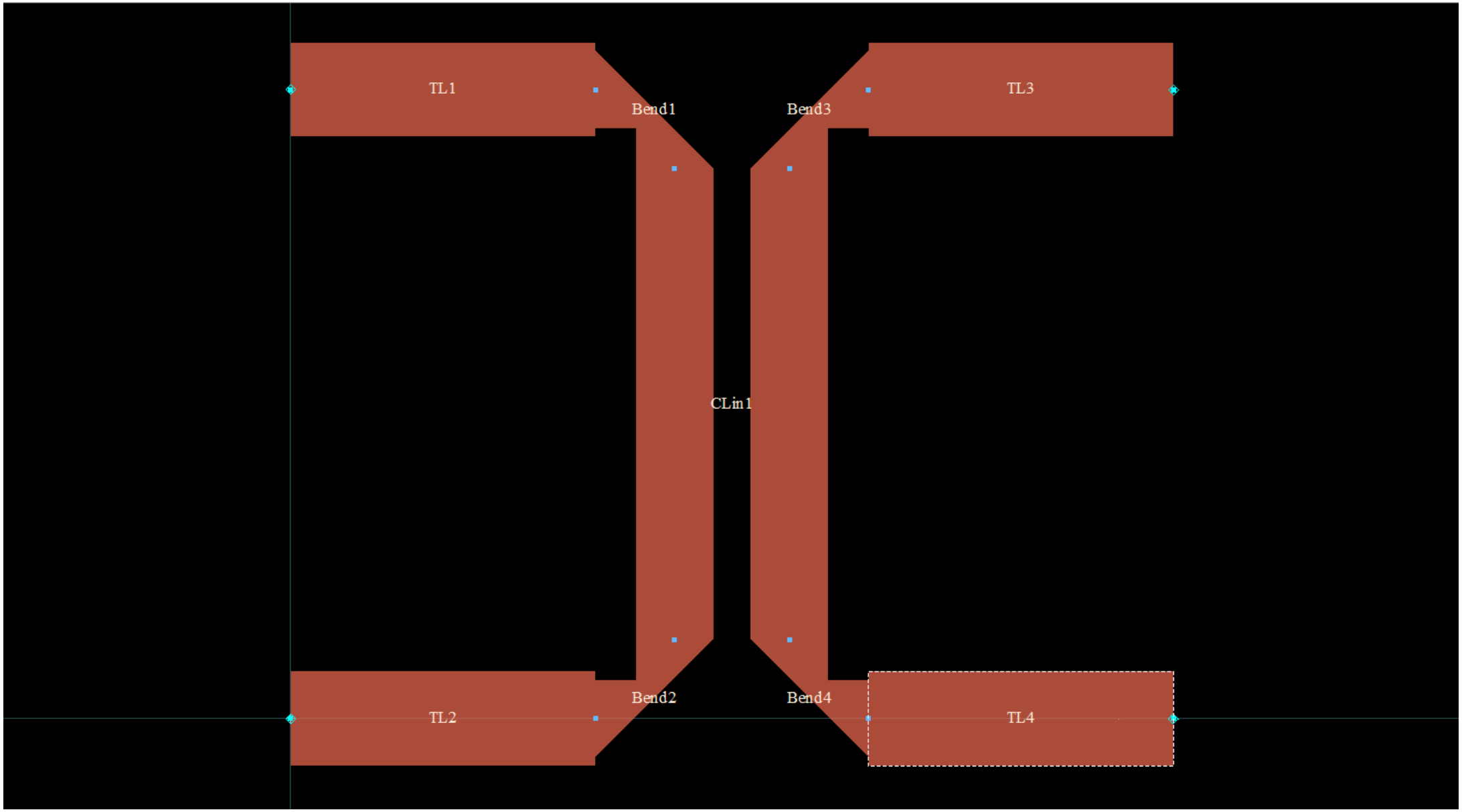
S-Parameters vs. Frequency



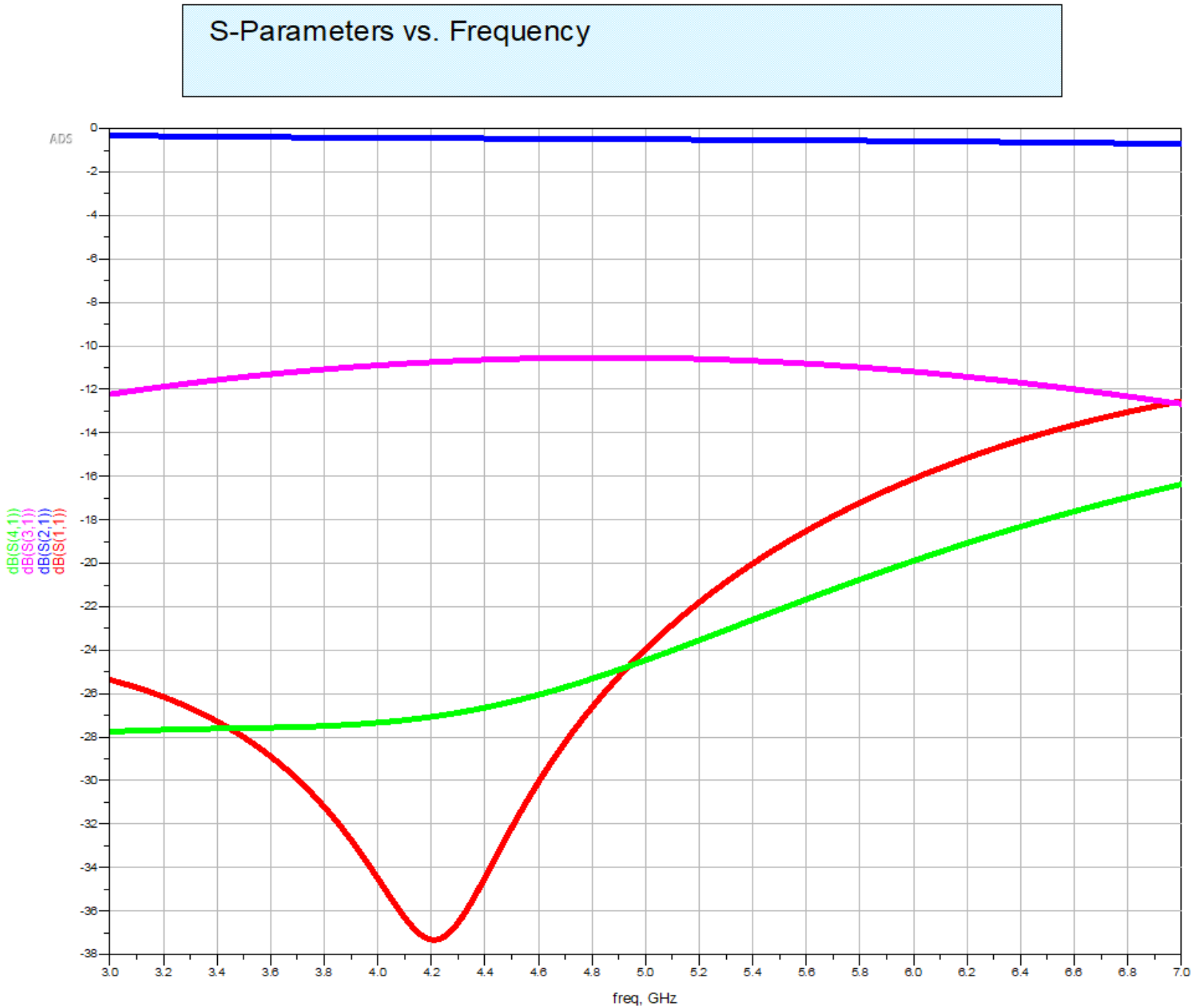
Mstrip_V2


MSOBND_MDS
Bend1
Subst="MSub1"
W=Wc
MSOBND_MDS
Bend3
Subst="MSub1"
W=Wc
Term
Term1
Num=1
Z=50 Ohm
MLIN
TL1
Subst="MSub1"
W=W0
L=L0
MLIN
TL3
Subst="MSub1"
W=W0
L=L0
Term
Term3
Num=3
Z=50 Ohm
MCLIN
CLin1
Subst="MSub1"
W=Wc
S=Sc
L=Lc
Term
Term2
Num=2
Z=50 Ohm
MLIN
TL2
Subst="MSub1"
W=W0
L=L0
MSOBND_MDS
Bend2
Subst="MSub1"
W=Wc
MSOBND_MDS
Bend4
Subst="MSub1"
W=Wc
MLIN
TL4
Subst="MSub1"
W=W0
L=L0
Term
Term4
Num=4
Z=50 Ohm
S-PARAMETERS
S_Param
SP1
Start=3 GHz
Stop=7 GHz
Step=10 MHz
MSub
MSUB
MSub1
H=1.27 mm
Er=10.7
Mur=1
Cond=5.8e+7
Hu=1e+33 mm
T=18 um
TanD=0.0023
Rough=0 mm
Bbase=
Dpeaks=
VAR
VAR1
W0=1.136700 mm
L0=3.677700 mm
Wc=0.937293 mm
Sc=0.451909 mm
Lc=5.687960 mm
DisplayTemplate
disptemp1
"S_Params_Quad_dB_Smith"

Mstrip_V2 Layout



Mstrip_V2


S-Parameters vs. Frequency
ADS
dB(S(4,1))
dB(S(3,1))
dB(S(2,1))
dB(S(1,1))
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
-32
-34
-36
-38
3.0
3.2
3.4
3.6
3.8
4.0
4.2
4.4
4.6
4.8
5.0
5.2
5.4
5.6
5.8
6.0
6.2
6.4
6.6
6.8
7.0
freq, GHz

IDEAL TRANSMISSION LINES

	Values	dB
S11	0.0000 < -120.000°	-125.618
S21	0.949 < 150.000°	-0.458
S31	0.316 < -120.000°	- 10.000
S41	0.0000 < -30.0000°	- 135.161

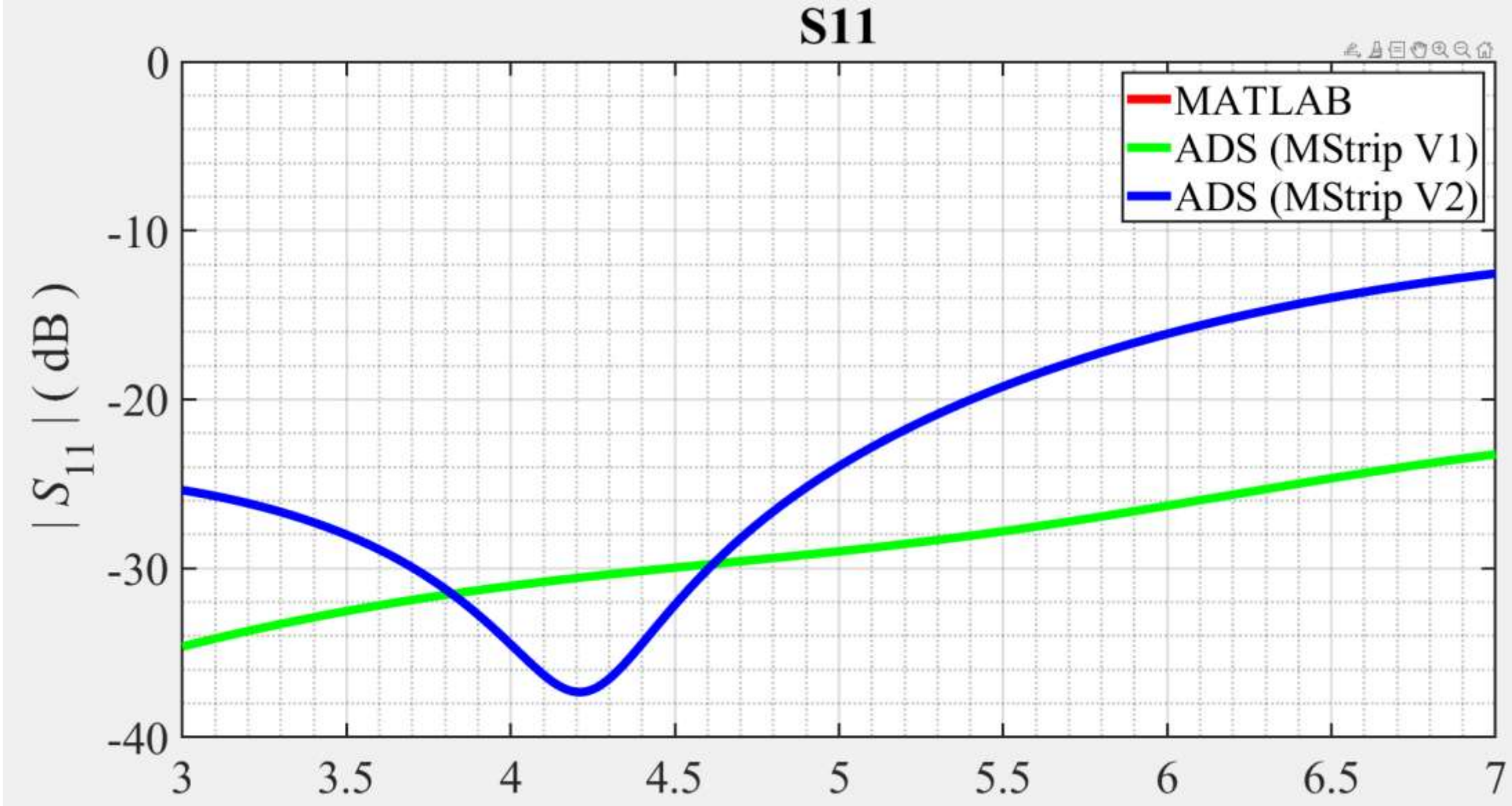
Mstrip_V2

	Values	dB
S11	0.063 < 33.794°	-23.954
S21	0.944 < 107.414°	-0.496
S31	0.297 < -161.759°	- 10.553
S41	0.060 < 36.255°	- 24.462

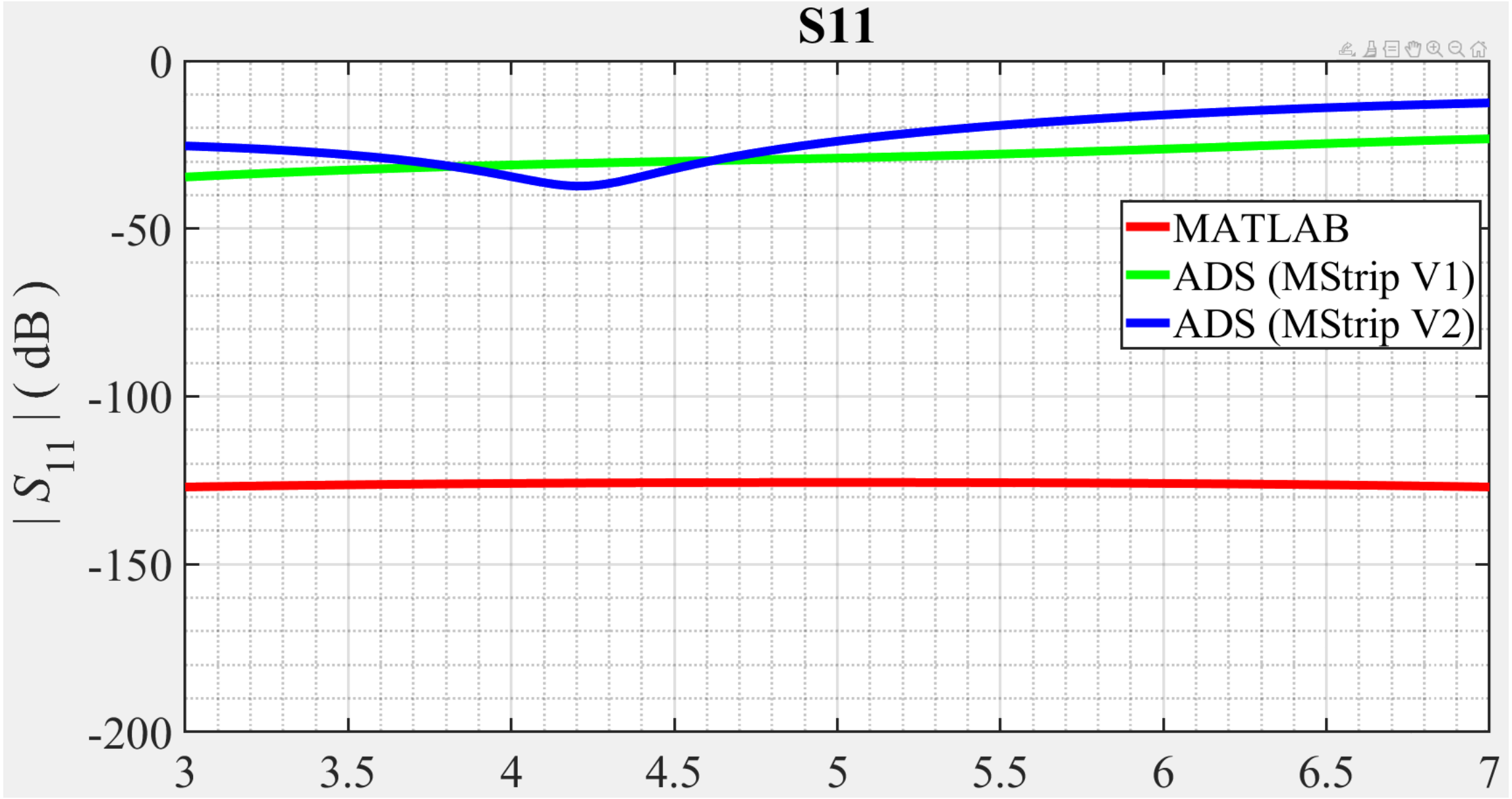
Mstrip_V1

	Values	dB
S11	0.036 < 149.745°	-28.990
S21	0.938 < 149.873°	-0.558
S31	0.310 < -120.081°	-10.173
S41	0.106 < 59.890°	-19.468

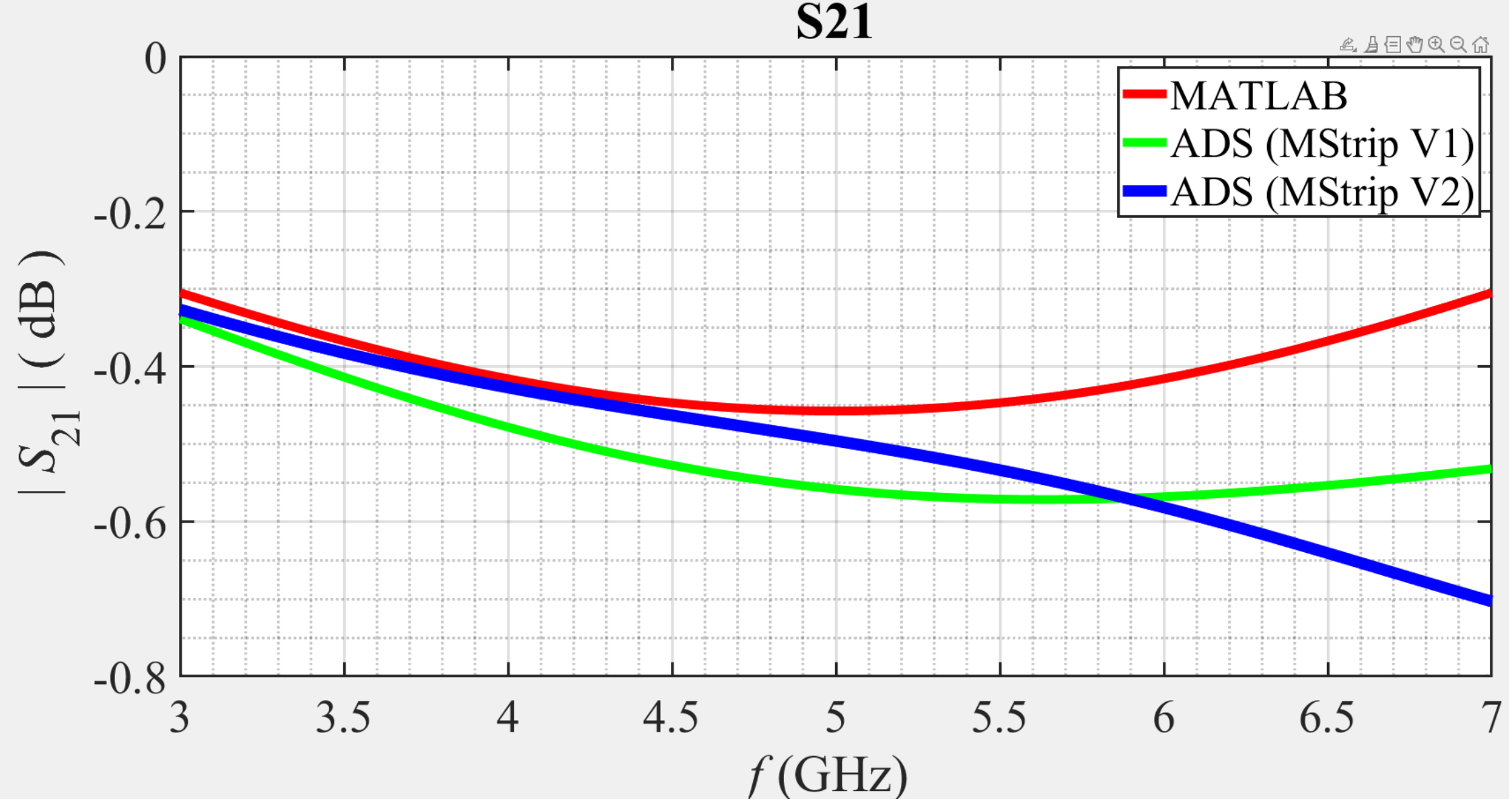
On the same graph, plot $|S_{11}|$ in dB, the simulated using MATALB , MStrip V1, and MStrip V2. Employ a range of -40 dB to 0 dB.



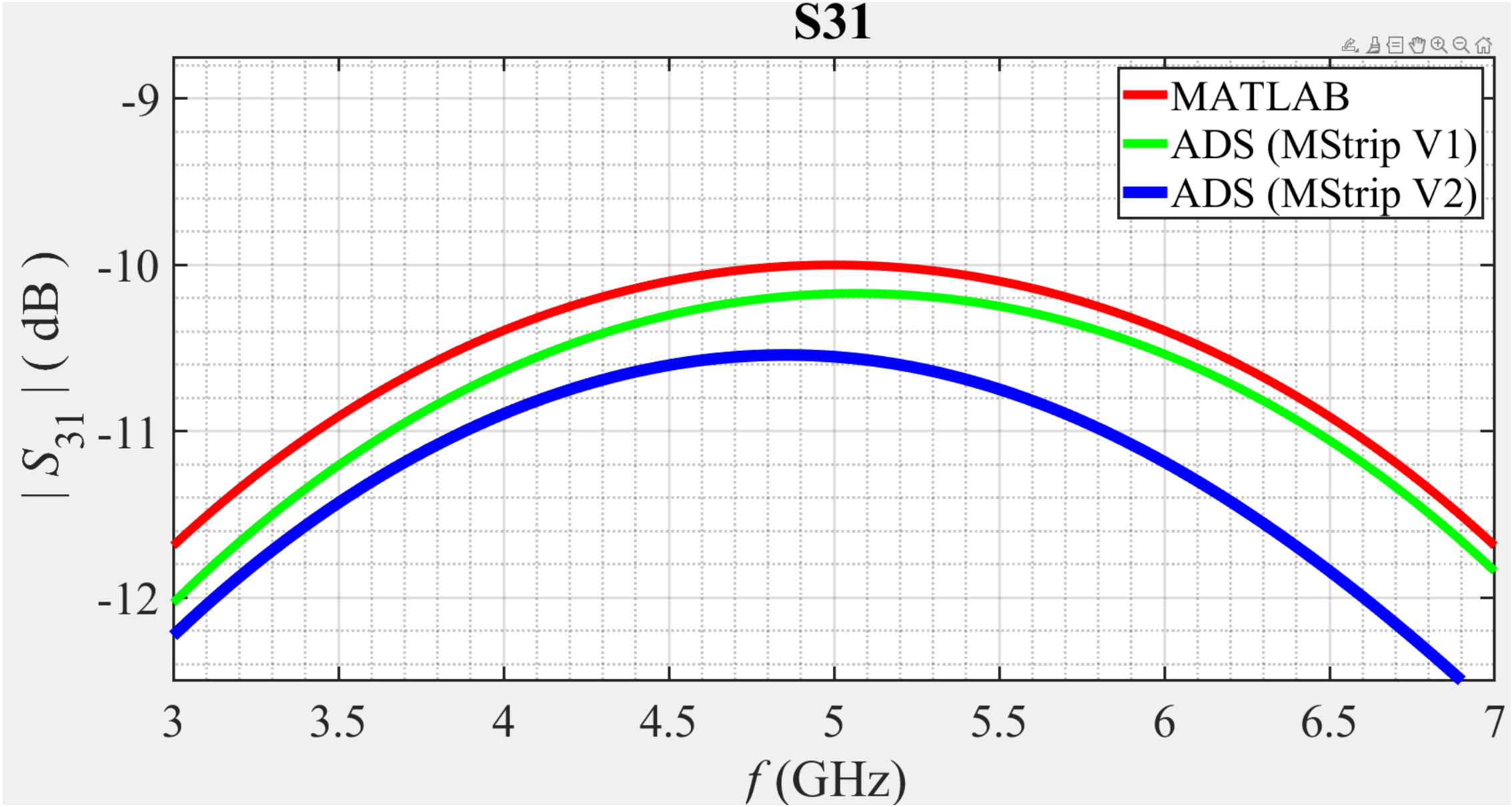
S11 plot of MATLAB, MStrip_V1 and MStrip_V2, range of 0 to -200dB



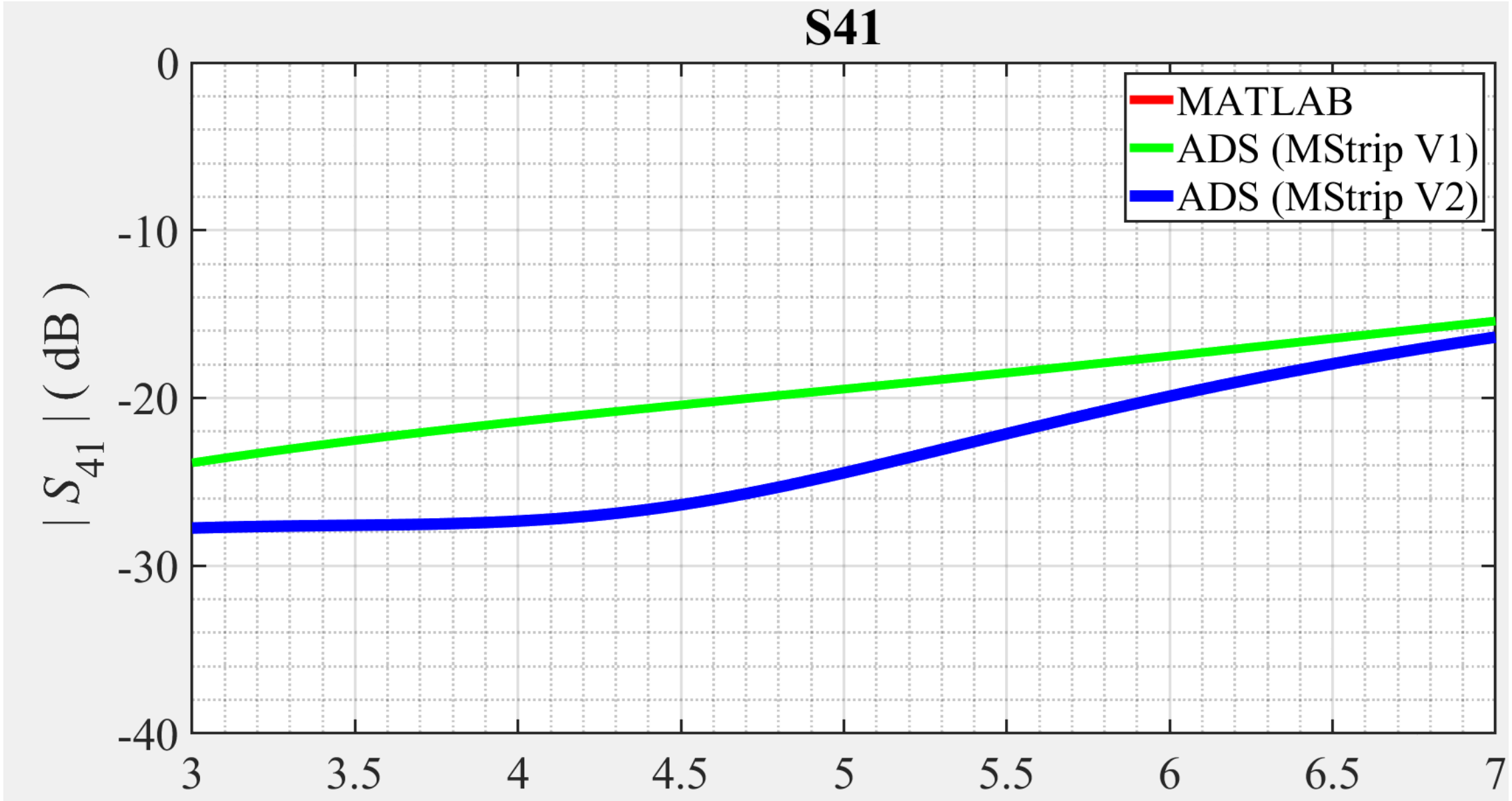
On the same graph, plot $|S_{21}|$ in dB, the simulated using MATALB , MStrip V1, and MStrip V2. Employ a range of -0.8 dB to 0 dB.



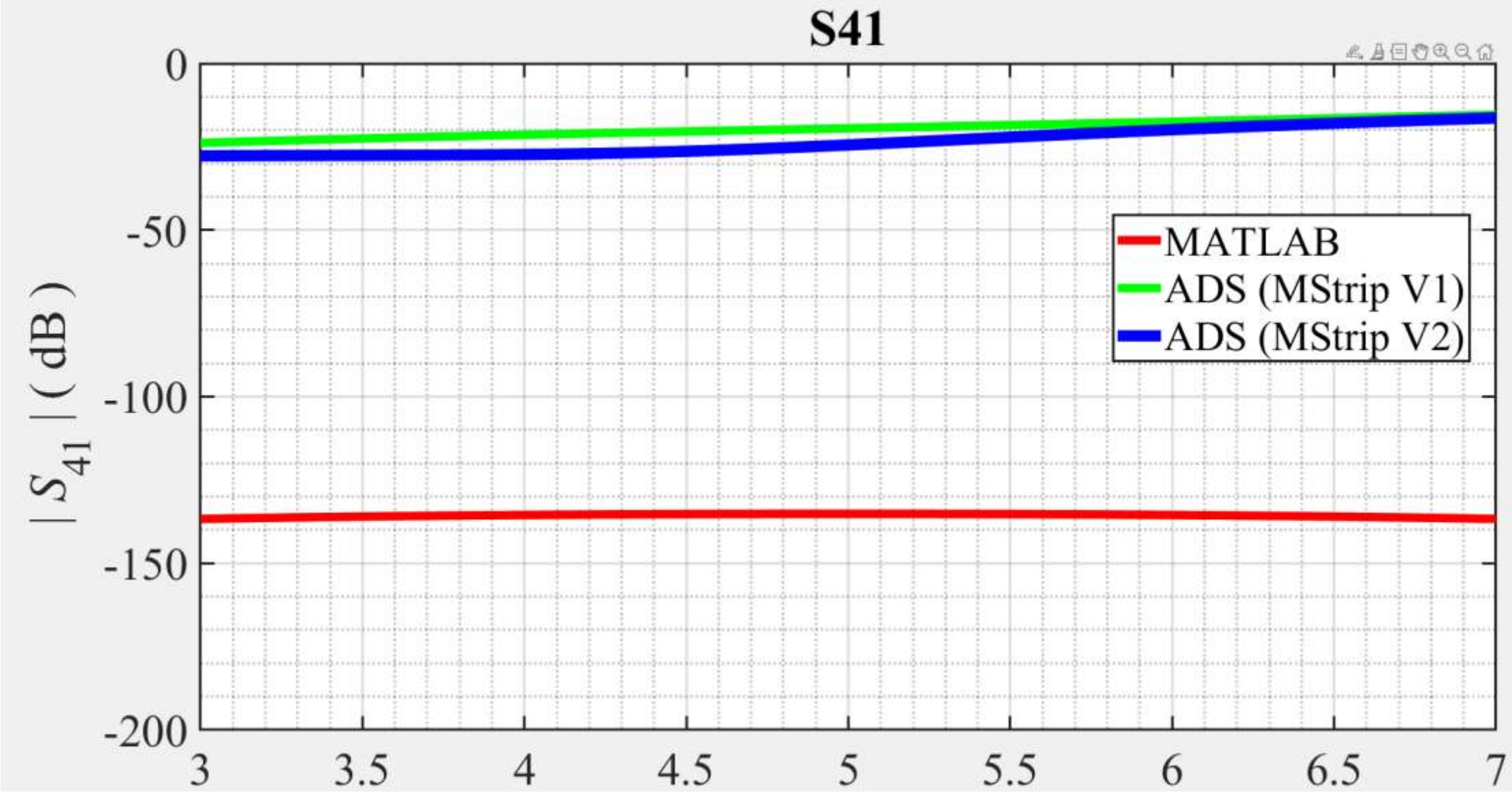
On the same graph, plot $|S_{31}|$ in dB, the simulated using MATALB , MStrip V1, and MStrip V2. Employ a range of -12.5 dB to -8.75 dB.



On the same graph, plot $|S_{41}|$ in dB, the simulated using MATALB , MStrip V1, and MStrip V2. Employ a range of -40 dB to 0 dB.



S11 plot of MATLAB, MStrip_V1 and MStrip_V2, range of 0 to -200dB



Appendices

- MATLAB
- ADS

The End