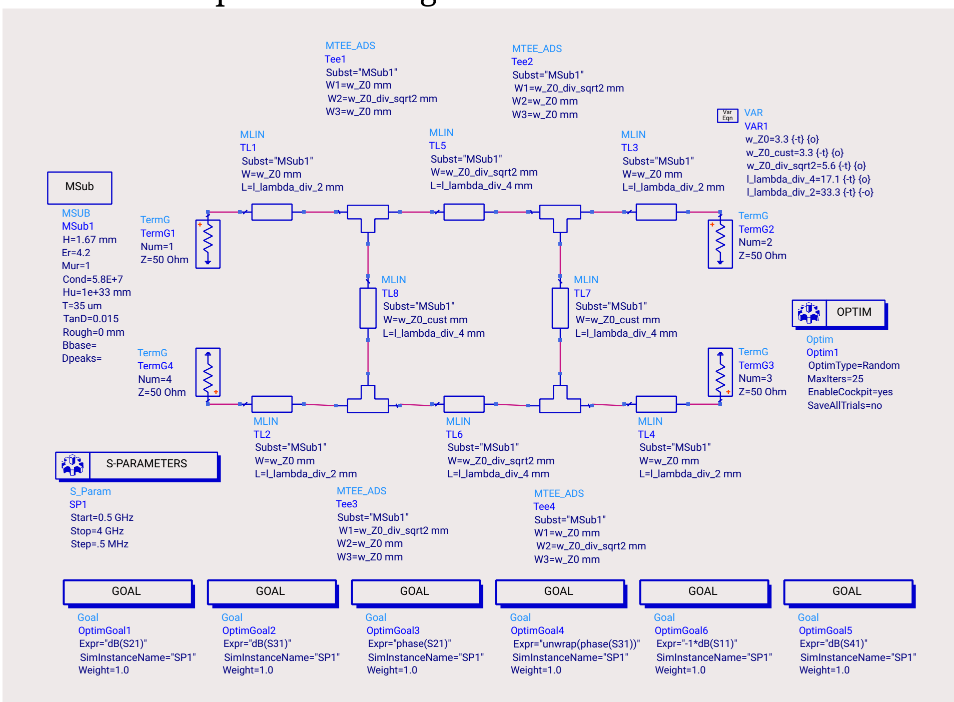
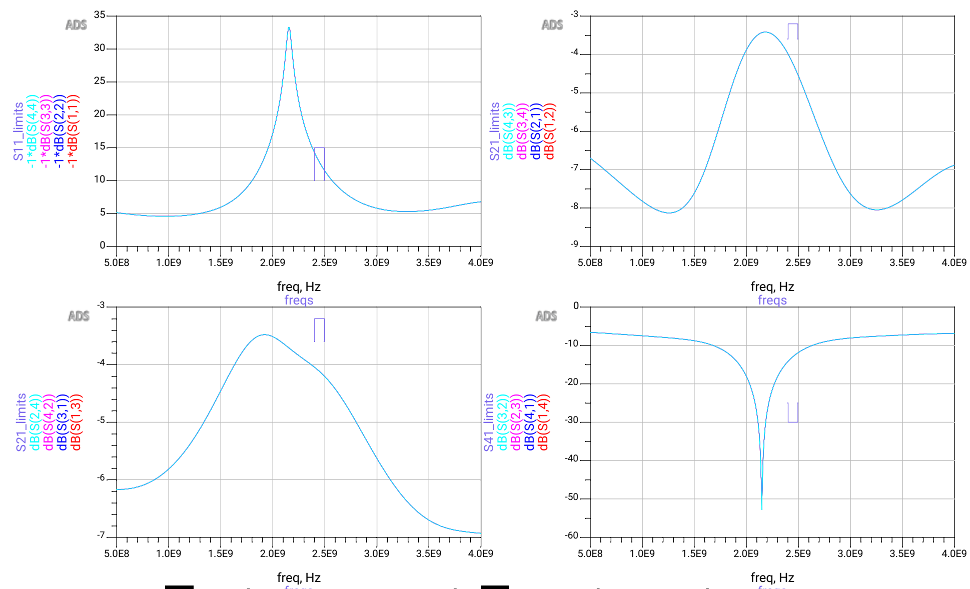
Design Status Report
EENG530 Final Project Group 3
Names: Jacob Hulvey, Jack Mullen, Dawit Yerdea

90 Degree Branchline Hybrid Coupler:

- We have started tuning/optimizing the implemented microstrip lines but are struggling to meet the required specifications over the full bandwidth.
- Schematic with optimizer and goals:



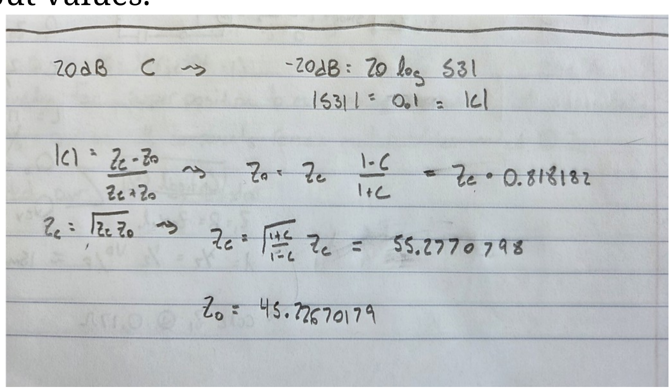
- Responses with Goals:



Eqn freqs=[2.401G,2.401G,2.495G,2.495G] Eqn S21_limits=[-3.6,-3.2,-3.2,-3.6]
Eqn S41_limits=[-25,-30,-30,-25] Eqn S11_limits=[10,15,15,10]

90 Degree 20dB coupled-line Coupler:

- We are currently calculating even and odd impedance values and implementing these values within the linecalc tool to achieve the desired effect.
- From here, the plan is to continue tuning dimensional values with the optimization tool to achieve the most ideal effect.
- We are currently a little bit hung up on getting the ideal response from the linecalc output values.



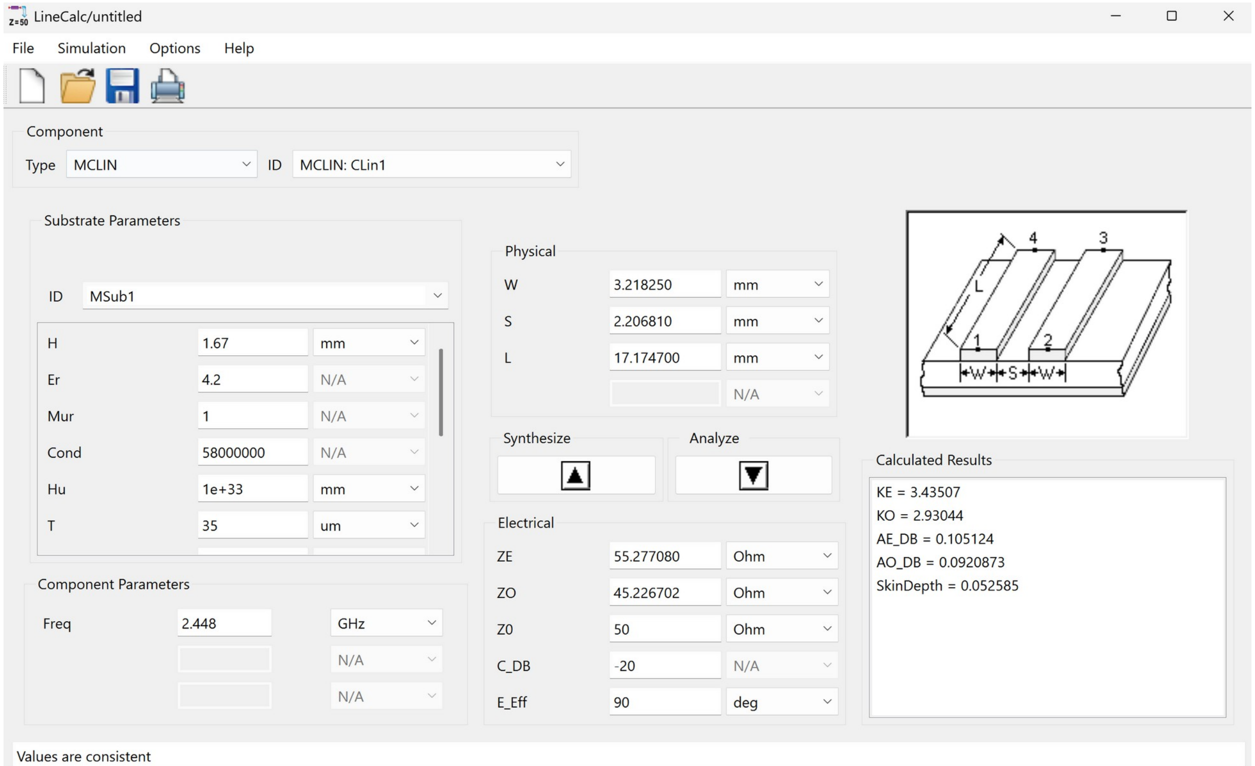
20dB C ⇝ $-20dB = 20 \log S31$

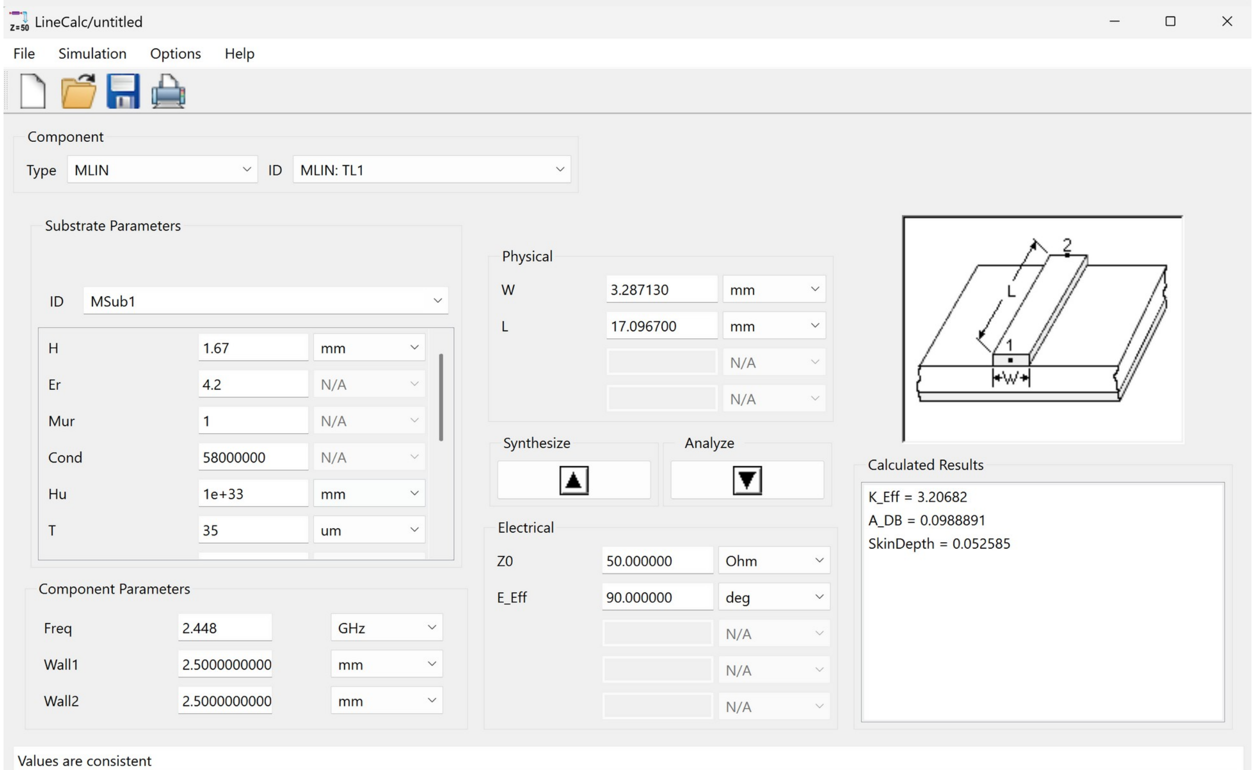
$|S31| = 0.1 = |C|$

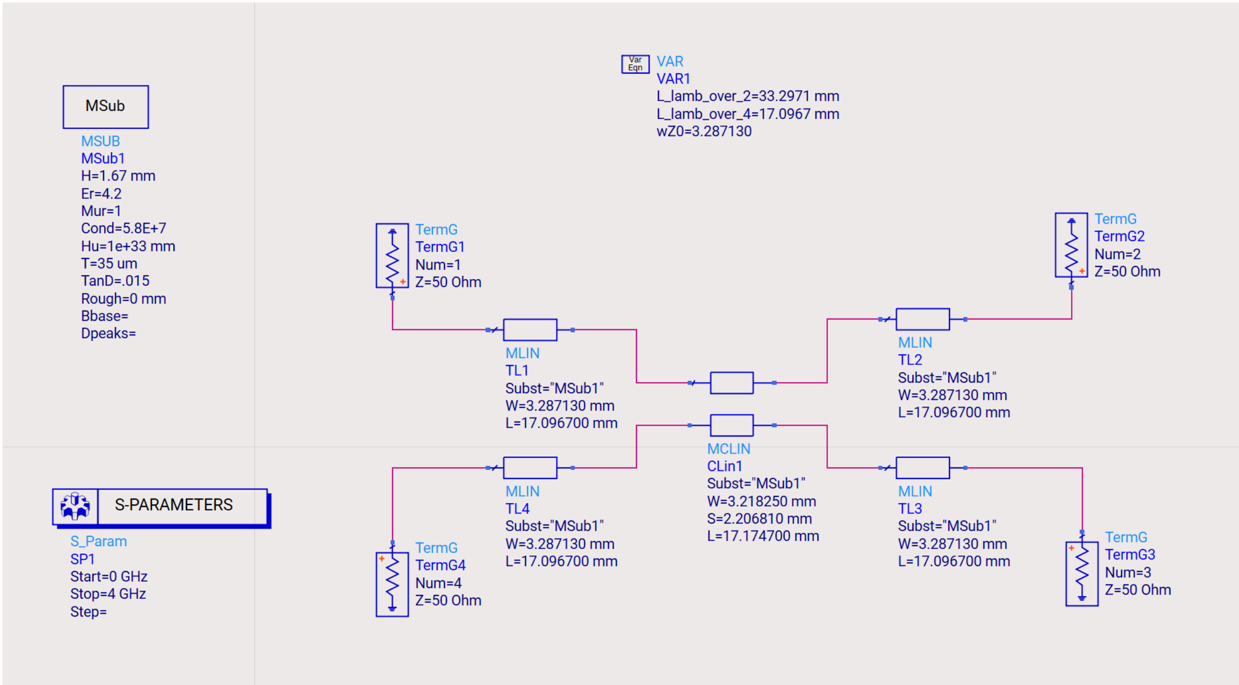
$|C| = \frac{Z_e - Z_o}{Z_e + Z_o}$ ⇝ $Z_o = Z_e \frac{1-C}{1+C} = Z_e \cdot 0.818182$

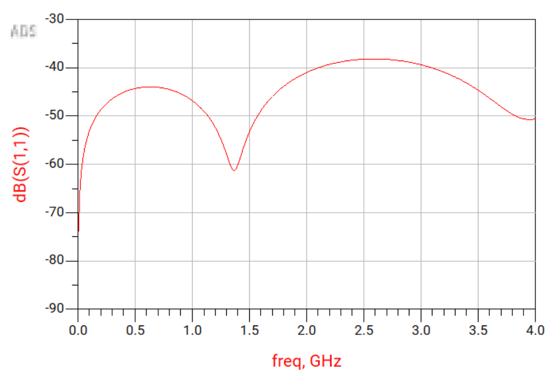
$Z_c = \sqrt{Z_e Z_o}$ ⇝ $Z_e = \sqrt{\frac{1+C}{1-C}}\, Z_c = 55.2770798$

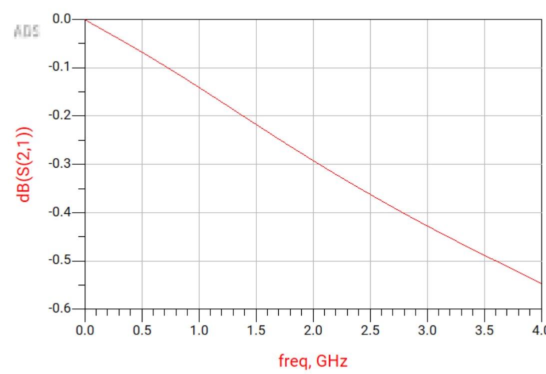
$Z_o = 45.22670179$

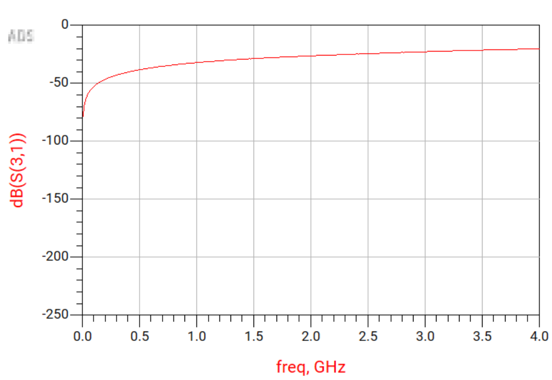

LineCalc/untitled
File
Simulation
Options
Help
Component
Type
MCLIN
ID
MCLIN: CLin1
Substrate Parameters
ID
MSub1
H
1.67
mm
Er
4.2
N/A
Mur
1
N/A
Cond
58000000
N/A
Hu
1e+33
mm
T
35
um
Component Parameters
Freq
2.448
GHz
N/A
N/A
Physical
W
3.218250
mm
S
2.206810
mm
L
17.174700
mm
N/A
Synthesize
Analyze
Electrical
ZE
55.277080
Ohm
ZO
45.226702
Ohm
Z0
50
Ohm
C_DB
-20
N/A
E_Eff
90
deg
4
3
L
1
2
W
S
W
Calculated Results
KE = 3.43507
KO = 2.93044
AE_DB = 0.105124
AO_DB = 0.0920873
SkinDepth = 0.052585
Values are consistent

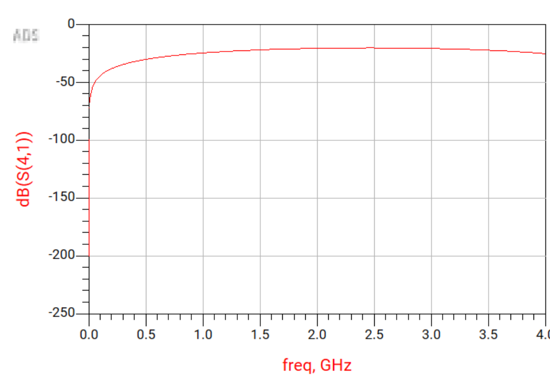

LineCalc/untitled
File
Simulation
Options
Help
Component
Type
MLIN
ID
MLIN: TL1
Substrate Parameters
ID
MSub1
H
1.67
mm
Er
4.2
N/A
Mur
1
N/A
Cond
58000000
N/A
Hu
1e+33
mm
T
35
um
Component Parameters
Freq
2.448
GHz
Wall1
2.5000000000
mm
Wall2
2.5000000000
mm
Physical
W
3.287130
mm
L
17.096700
mm
N/A
N/A
Synthesize
Analyze
Electrical
Z0
50.000000
Ohm
E_Eff
90.000000
deg
N/A
N/A
N/A
2
L
1
W
Calculated Results
K_Eff = 3.20682
A_DB = 0.0988891
SkinDepth = 0.052585
Values are consistent


MSub
MSUB
MSub1
H=1.67 mm
Er=4.2
Mur=1
Cond=5.8E+7
Hu=1e+33 mm
T=35 um
TanD=.015
Rough=0 mm
Bbase=
Dpeaks=
VAR
VAR1
L_lamb_over_2=33.2971 mm
L_lamb_over_4=17.0967 mm
wZ0=3.287130
TermG
TermG1
Num=1
Z=50 Ohm
TermG
TermG2
Num=2
Z=50 Ohm
MLIN
TL1
Subst="MSub1"
W=3.287130 mm
L=17.096700 mm
MLIN
TL2
Subst="MSub1"
W=3.287130 mm
L=17.096700 mm
MCLIN
CLin1
Subst="MSub1"
W=3.218250 mm
S=2.206810 mm
L=17.174700 mm
S-PARAMETERS
S_Param
SP1
Start=0 GHz
Stop=4 GHz
Step=
MLIN
TL4
Subst="MSub1"
W=3.287130 mm
L=17.096700 mm
MLIN
TL3
Subst="MSub1"
W=3.287130 mm
L=17.096700 mm
TermG
TermG4
Num=4
Z=50 Ohm
TermG
TermG3
Num=3
Z=50 Ohm


dB(S(1,1))
freq, GHz


dB(S(2,1))
freq, GHz


dB(S(3,1))
freq, GHz


dB(S(4,1))
freq, GHz

Chebyshev Bandpass Filter:

- We are currently trying to convert an ideal bandpass filter to a stepped impedance or open stub bandpass filter.
- We have found a Chebyshev table with passband ripple of $0.1\,dB$ (see below). We are going to use this level of passband ripple because the filter will not work as well when we round to $0.1\,mm$ increments due to manufacturing limitation.

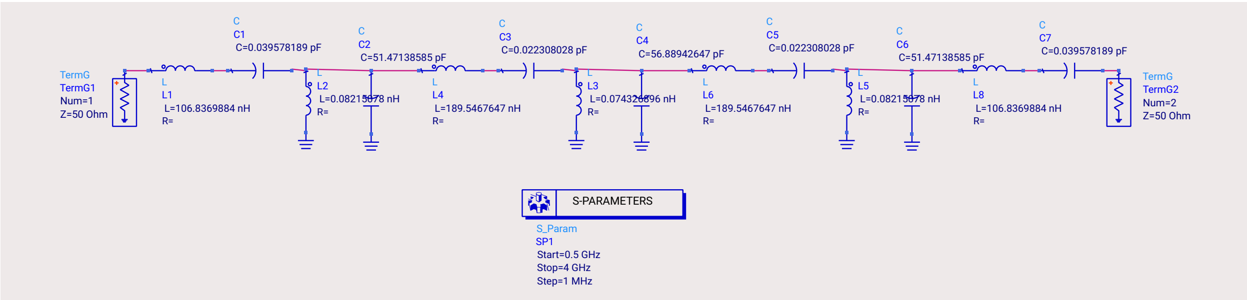
n	R_S/R_L	C_1	L_2	C_3	L_4	C_5	L_6	C_7
5	1.000	1.301	1.556	2.241	1.556	1.301		
	0.900	1.285	1.433	2.380	1.488	1.488		
	0.800	1.300	1.282	2.582	1.382	1.738		
	0.700	1.358	1.117	2.868	1.244	2.062		
	0.600	1.470	0.947	3.269	1.085	2.484		
	0.500	1.654	0.778	3.845	0.913	3.055		
	0.400	1.954	0.612	4.720	0.733	3.886		
	0.300	2.477	0.451	6.196	0.550	5.237		
	0.200	3.546	0.295	9.127	0.366	7.889		
	0.100	6.787	0.115	17.957	0.182	15.745		
	∞	1.561	1.807	1.766	1.417	0.651		
6	1.355	0.942	2.080	1.659	2.247	1.534	1.277	
	1.429	0.735	2.249	1.454	2.544	1.405	1.029	
	1.667	0.542	2.600	1.183	3.064	1.185	2.174	
	2.000	0.414	3.068	0.958	3.712	0.979	2.794	
	2.500	0.310	3.765	0.749	4.651	0.778	3.645	
	3.333	0.220	4.927	0.551	6.195	0.580	4.996	
	5.000	0.139	7.250	0.361	9.261	0.384	7.618	
	10.000	0.067	14.220	0.178	18.427	0.190	15.350	
	∞	1.534	1.884	1.831	1.749	1.394	0.638	
7	1.000	1.262	1.520	2.239	1.680	2.239	1.520	1.262
	0.900	1.242	1.395	2.361	1.578	2.397	1.459	1.447
	0.800	1.255	1.245	2.548	1.443	2.624	1.362	1.697
	0.700	1.310	1.083	2.819	1.283	2.942	1.233	2.021
	0.600	1.417	0.917	3.205	1.209	3.384	1.081	2.444
	0.500	1.595	0.753	3.764	0.928	4.015	0.914	3.018
	0.400	1.885	0.593	4.618	0.742	4.970	0.738	3.855
	0.300	2.392	0.437	6.054	0.556	6.569	0.557	5.217
	0.200	3.428	0.286	8.937	0.369	9.770	0.372	7.890
	0.100	6.570	0.141	17.603	0.184	19.376	0.180	15.813
	∞	1.575	1.858	1.921	1.827	1.734	1.379	0.631
n	R_S/R_L	L_1	C_2	L_3	C_4	L_5	C_6	L_7

- Using the 7[th] order filter coefficients above we converted to real lumped element capacitance and inductance:

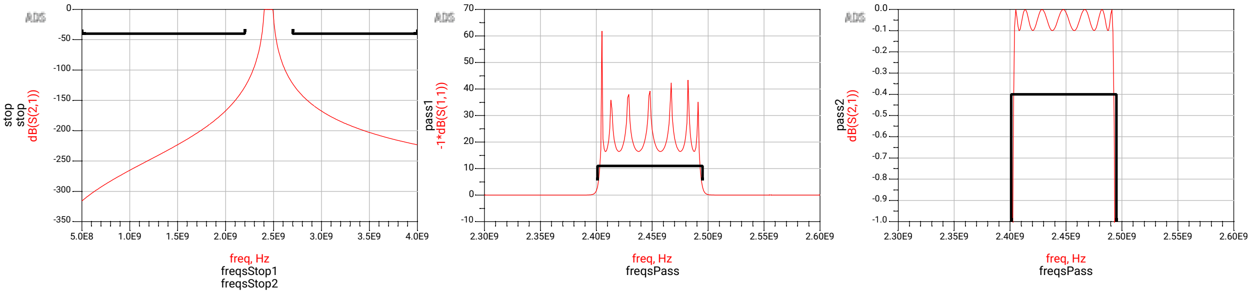
	Original Type	Original L and C	Lowpass	Lowpass Typ	Highpass	Highpass Typ	Bandpass Inducto	Bandpass Capacito	Bandpass Inductor nh	Bandpass Capcitor pl	Bandpass Type
1	series L	1.262	4.103E-09	series L	1.031E-12	series C	1.06837E-07	3.95782E-14	106.8369884	0.039578189	series L and C
2	shunt C	1.52	1.977E-12	shunt C	2.139E-09	shunt L	8.21508E-11	5.14714E-11	0.08215078	51.47138585	shunt L and C
3	series L	2.239	7.28E-09	series L	5.809E-13	series C	1.89547E-07	2.2308E-14	189.5467647	0.022308028	series L and C
4	shunt C	1.68	2.185E-12	shunt C	1.935E-09	shunt L	7.43269E-11	5.68894E-11	0.074326896	56.88942647	shunt L and C
5	series L	2.239	7.28E-09	series L	5.809E-13	series C	1.89547E-07	2.2308E-14	189.5467647	0.022308028	series L and C
6	shunt C	1.52	1.977E-12	shunt C	2.139E-09	shunt L	8.21508E-11	5.14714E-11	0.08215078	51.47138585	shunt L and C
7	series L	1.262	4.103E-09	series L	1.031E-12	series C	1.06837E-07	3.95782E-14	106.8369884	0.039578189	series L and C

Z0	50
N	7
omega_c	15378402494
f_c	2447548774
f_min	2401000000
f_max	2495000000
delta	0.038405772

- Then we implemented the values as lumped elements. Lumped Element Schematic:



- Lumped Element Simulation results and constraints:



- We are currently trying an open stub bandpass filter using the following testing schematic (values have not yet been updated):