HIGH PASS FILTER WITH 50 DB ATTENUATION AT 2.3 GHZ AND CUTOFF AT 2.4 GHZ

Course:RF and Microwave Passive Circuits

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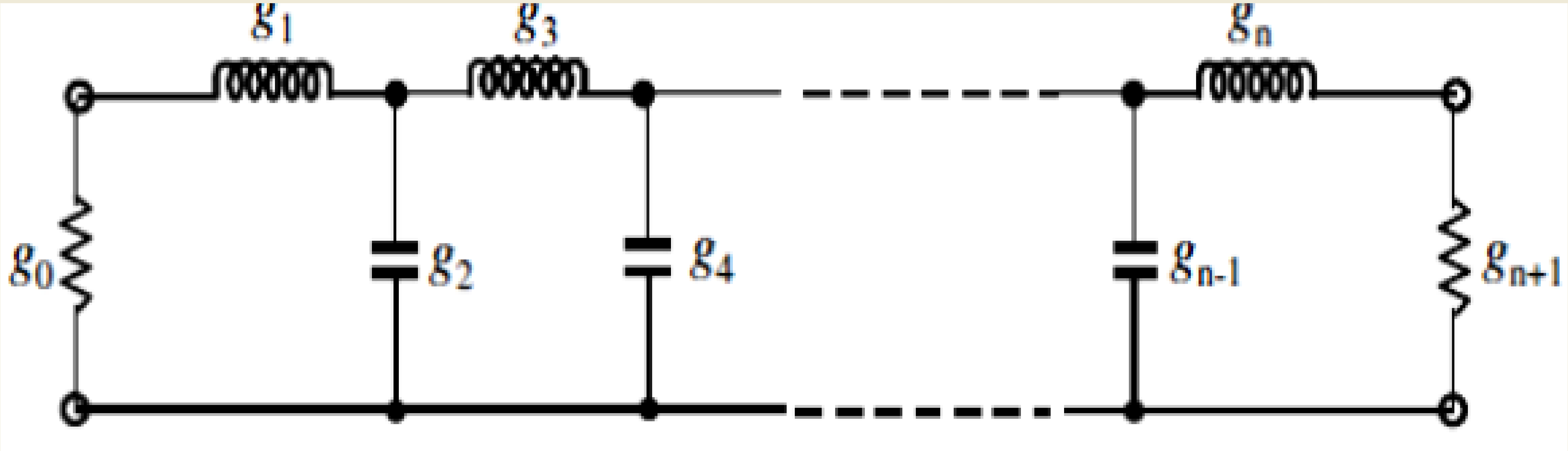
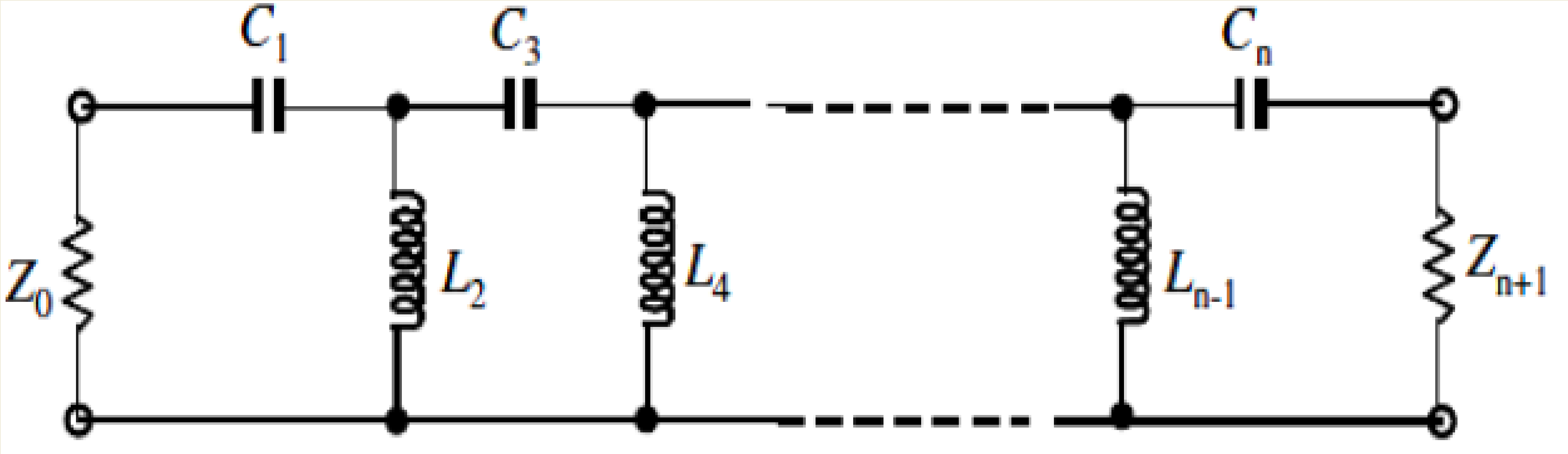
Aim: To design a high pass filter with 50db attenuation at 2.3GHZ and cutoff at 2.4GHZ.

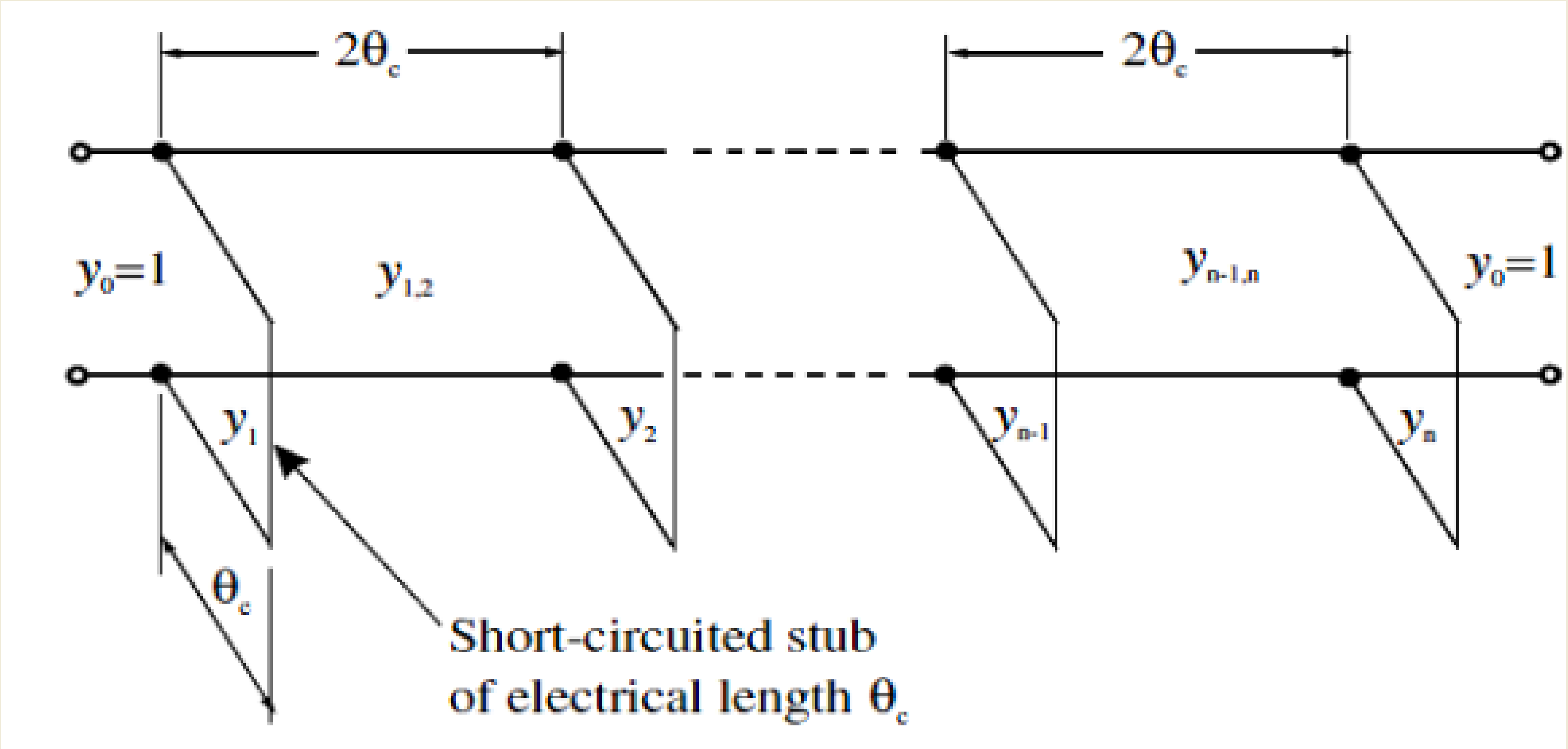


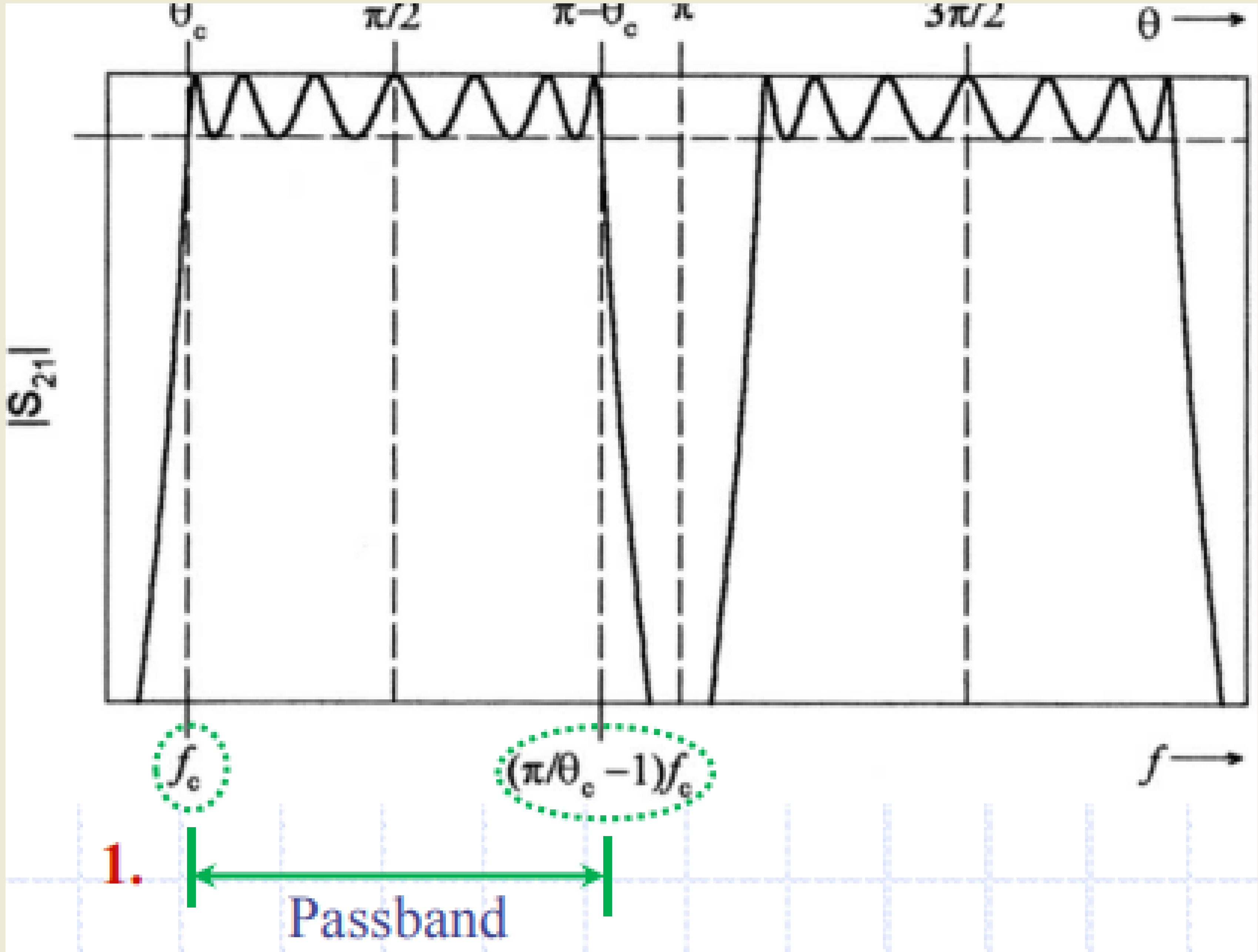
Low Pass filter prototype



High Pass filter transformed from low pass prototype

Basic transmission line structure of Optimum distributed high pass filter:





To design high pass filter, the cut off frequency fc=2.4 GHz is selected and a 0.1dB Ripple in pass band up to 10.4 GHz is taken

$$(\pi / \Theta_c) - 1 = 10.4/f_c$$

from this we get $\Theta_c = 33.75°$. For given terminating impedance Zo the associated impedance values can be determined by these equations:

Shorting stub: $$Z_i = Z_0/Y_i$$

Connecting line: $$Z_{i,i+1} = Z_0/Y_{i,i+1}$$

For i=1, 2……6

Zc=Zo = 50Ω and εr (dielectric constant) = 4.4, W= width, h= height of dielectric which is taken as 1.6mm.

When $\left(\frac{W}{H}\right) < 1$

$$\varepsilon_e = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[\frac{1}{\sqrt{1+12\left(\frac{H}{W}\right)}} + 0.4\left(1-\frac{W}{H}\right)^2\right]$$

$$Z_o = \frac{60}{\sqrt{\varepsilon_e}}\ln\left(8\frac{H}{W} + 0.25\frac{W}{H}\right)$$

When $\left(\frac{W}{H}\right) > 1$

$$\varepsilon_e = \frac{\varepsilon_r+1}{2} + \left[\frac{\varepsilon_r-1}{2\sqrt{1+12\left(\frac{H}{W}\right)}}\right]$$

$$Z_o = \frac{120\pi}{\sqrt{\varepsilon_e}\left[\frac{W}{H}+1.393+\frac{2}{3}\ln\left(\frac{W}{H}+1.444\right)\right]}$$

The guided wavelength is given by:

$$\lambda_g = \frac{300}{f(GHz)\sqrt{\varepsilon_{re}}}$$

εe =εre is the effective dielectric constant

Element values of high pass filter with 0.1db ripple:

n	θ_c	y_1 y_n	$y_{1,2}$ $y_{n-1,n}$	y_2 y_{n-1}	$y_{2,3}$ $y_{n-2,n-1}$	y_3 y_{n-2}	$y_{3,4}$
2	25°	0.15436	1.13482				
	30°	0.22070	1.11597				
	35°	0.30755	1.08967				
3	25°	0.19690	1.12075	0.18176			
	30°	0.28620	1.09220	0.30726			
	35°	0.40104	1.05378	0.48294			
4	25°	0.22441	1.11113	0.23732	1.10361		
	30°	0.32300	1.07842	0.39443	1.06488		
	35°	0.44670	1.03622	0.60527	1.01536		
5	25°	0.24068	1.10540	0.27110	1.09317	0.29659	
	30°	0.34252	1.07119	0.43985	1.05095	0.48284	
	35°	0.46895	1.02790	0.66089	0.99884	0.72424	
6	25°	0.25038	1.10199	0.29073	1.08725	0.33031	1.08302
	30°	0.35346	1.06720	0.46383	1.04395	0.52615	1.03794
	35°	0.48096	1.02354	0.68833	0.99126	0.77546	0.98381

Length of the elements is given by:

$$\theta_c = \beta * l$$

where β is phase constant

Y1 Calculation:

$$Y1 = 0.35346 + ((0.48096-0.35346)/5)*3.75$$
$$= 0.449396$$

Z1 Calculation:

$$Z1 = 50/Y1$$
$$= 50/0.449396$$
$$= 111.32$$

Parameters	Connecting line	Short Circuit Stub
Admittance values (mho)	Y1,2= 1.03472	Y1=0.44936
	Y2,3=1.00483	Y2=0.63258
	Y3,4=0.99746	Y3=0.71545
	Y4,5=1.00483	Y4=0.71545
	Y5,6= 1.03472	Y5=0.63258
		Y6=0.44936
Impedance values (ohm)	Z1,2= 48.336	Z1= 111.325
	Z2,3= 49.856	Z2= 79.128
	Z3,4= 50.147	Z3= 70.159
	Z4,5= 49.856	Z4= 70.159
	Z5,6= 48.336	Z5= 79.128
		Z6= 111.325

Values Used

Frequency : 2.4 GHz

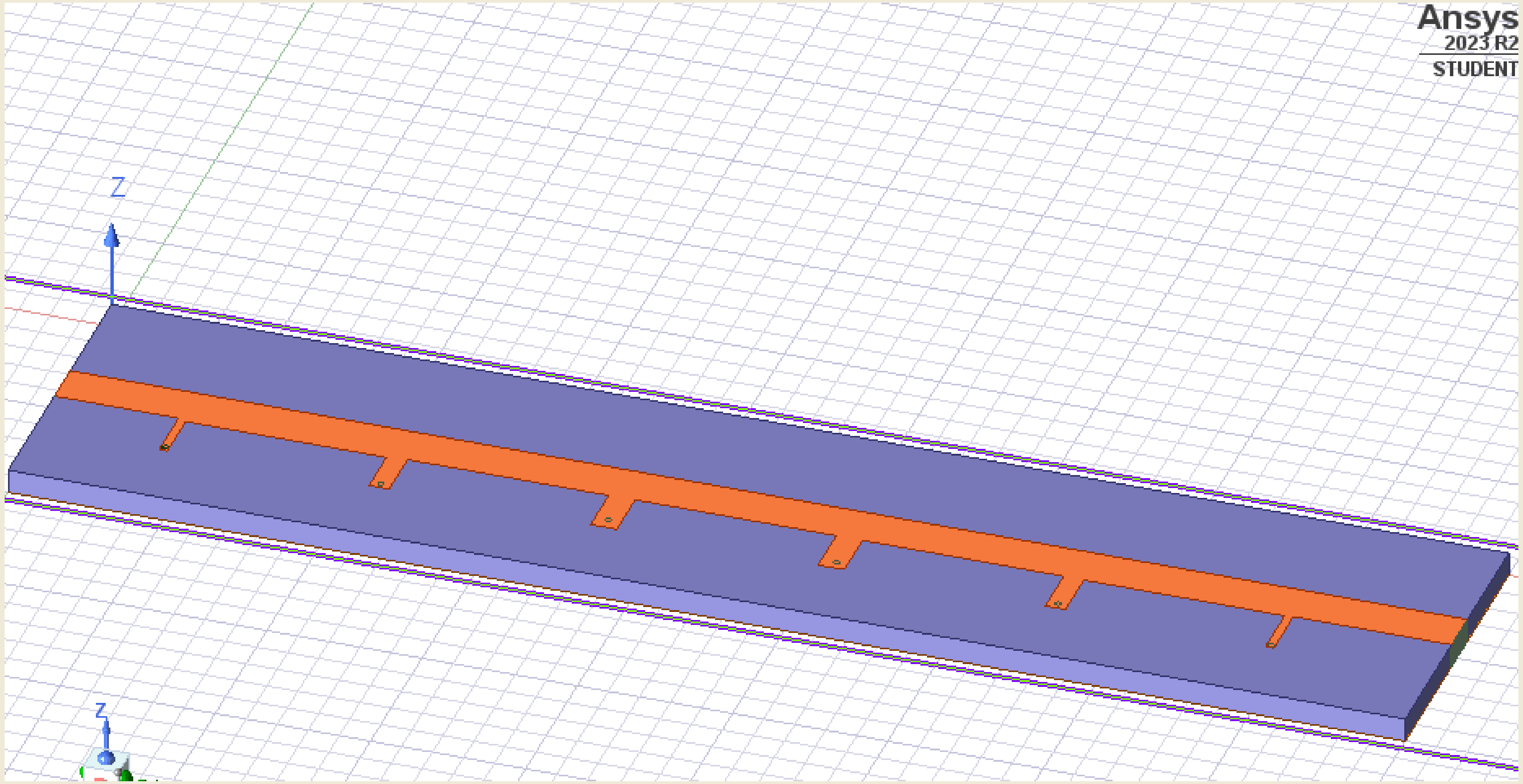
Dielectric Constant (εr): 4.4 FR4 Epoxy

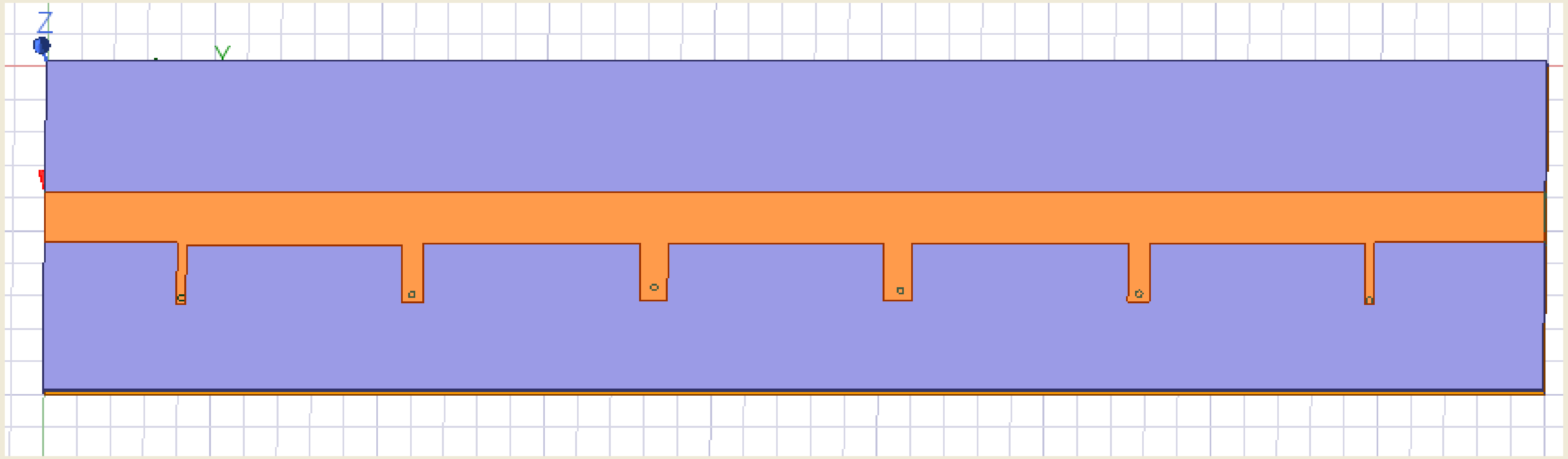
Dielectric Height : 1.6 mm

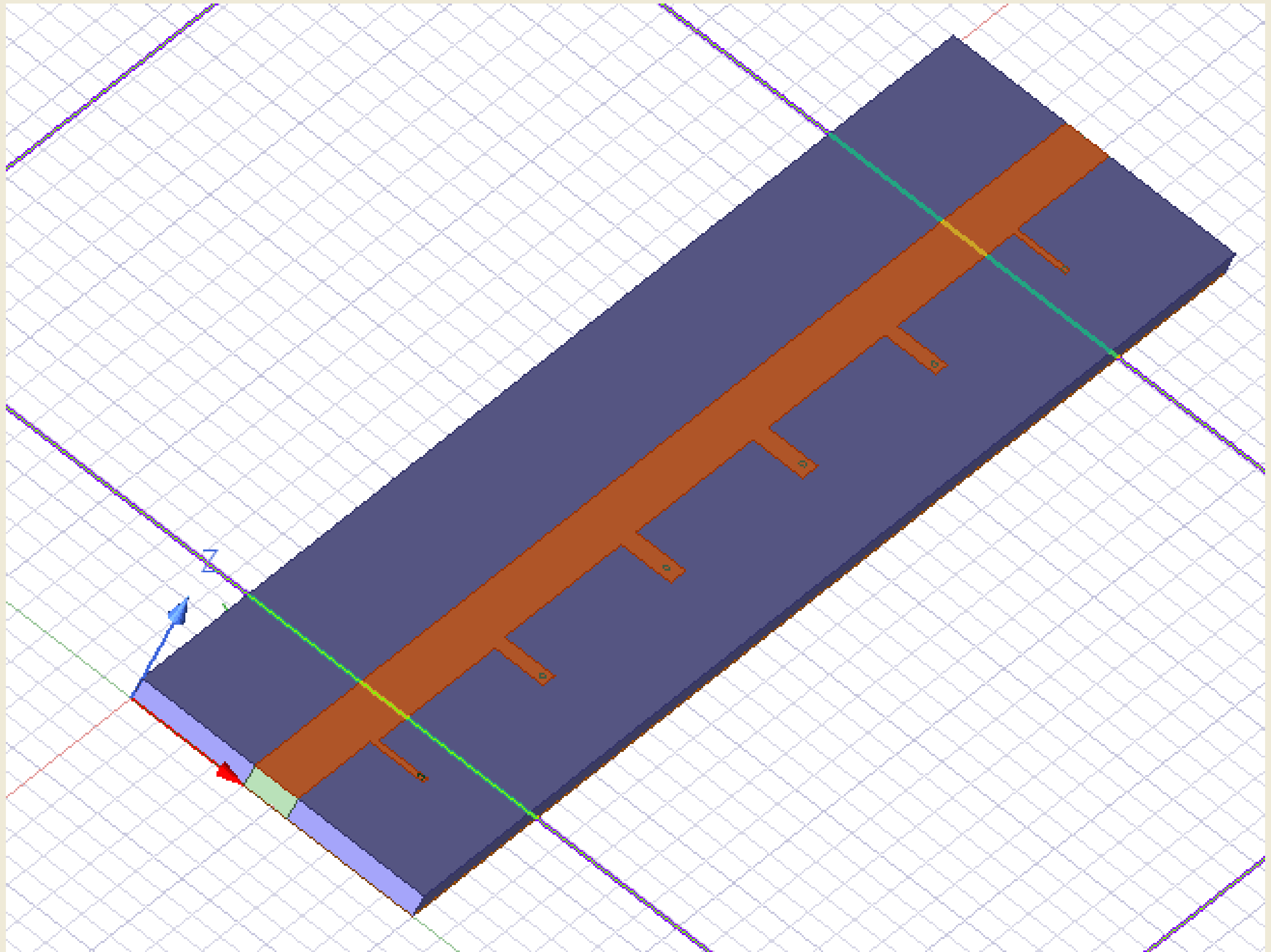
Electrical Length : 90 & 33.75

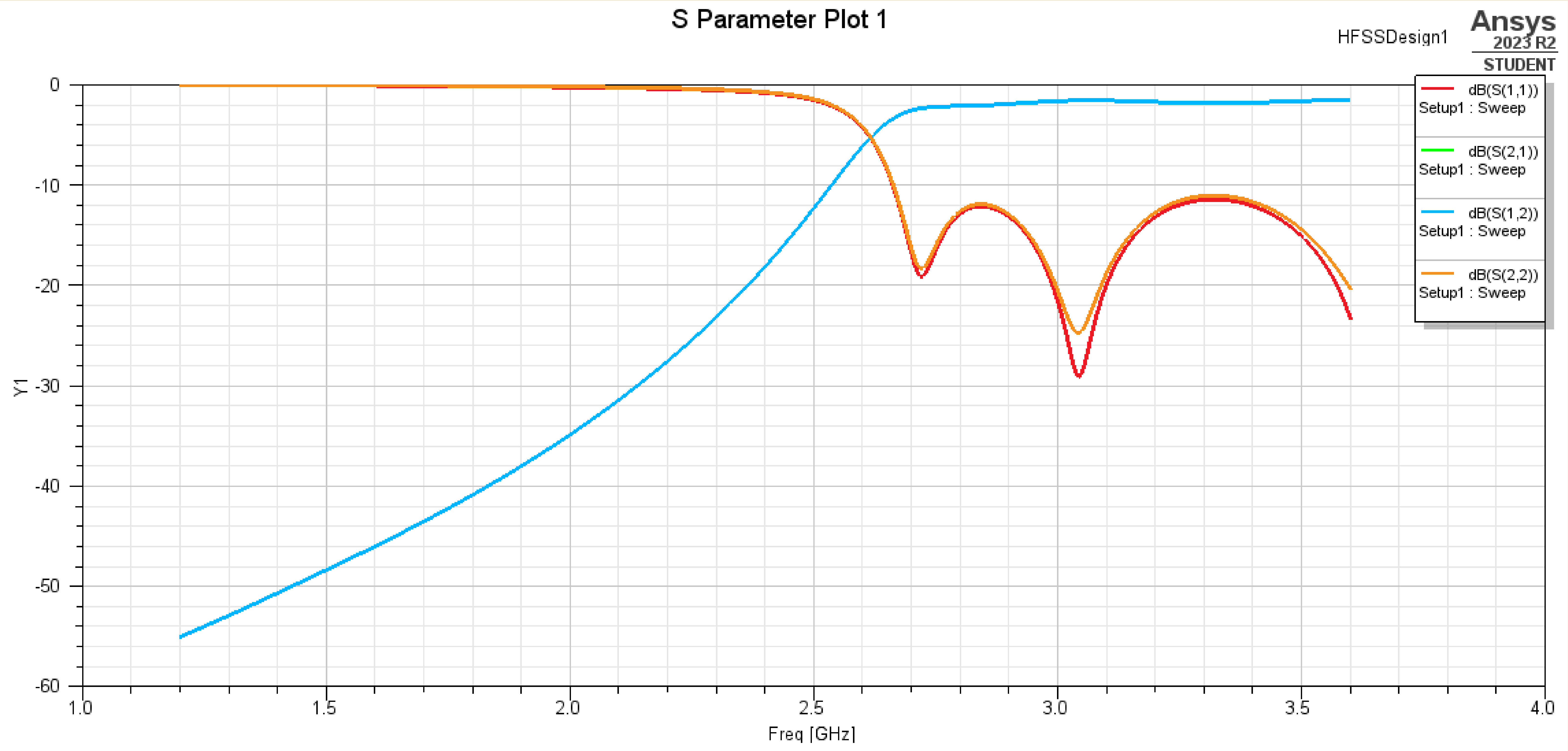
Values Used

Length of the element (mm)	l1,2= 12.937	l1= 6.822
	l2,3= 12.964	l2= 6.690
	l3,4= 12.970	l3= 6.636
	l4,5= 12.964	l4= 6.636
	l5,6= 12.937	l5= 6.690
		l6= 6.822
Width of the element (mm	w1,2= 3.296	w1= 0.535
	w2,3= 3.133	w2= 1.302
	w3,4= 3.103	w3= 1.684
	w4,5= 3.133	w4= 1.684
	w5,6= 3.296	w5= 1.302
		w6= 0.535


Ansys
2023 R2
STUDENT
Z
Z


Z
Y


Z


S Parameter Plot 1
HFSSDesign1
Ansys
2023 R2
STUDENT
dB(S(1,1))
Setup1 : Sweep
dB(S(2,1))
Setup1 : Sweep
dB(S(1,2))
Setup1 : Sweep
dB(S(2,2))
Setup1 : Sweep
Y1
0
-10
-20
-30
-40
-50
-60
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Freq [GHz]