EHB 456E – ANTENNAS

2019-2020 Fall

Term Project Report

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Deadline:

14.01.2020

1. Antenna Requirements

Antenna Parameters

Frequency Bandwidth:

Frequency bandwidth is the range of frequencies in which the antenna performs good to fit some specified standards. For instance, antenna's return loss is required to be less than -10 dB in its frequency bandwidth for wireless communication.

Return Loss:

It is a measurement that gives the efficiency for power transfer from transmission line to an antenna.

Radiation Pattern:

It represents an antenna's radiated power direction.

Antenna Gain:

It describes how much power is transmitted in the direction of peak radiation to that of an isotropic source.

Radiation Efficiency:

It is defined as the ratio of power radiated to the input power.

Polarization:

It is defined the polarization of the wave transmitted or radiated by the antenna.

Group Delay:

Pulse signal's distortion degree. If it passes 1 ns, phases become nonlinear in far field. Because of that, phase distortion happens; thus, this distortion can be cause critical problems for wideband applications.

Input Impedance:

It is the ratio of voltage to current at input of the antenna.

Usage

Microstrip antenna is one of the most popular antenna. It is small, low cost, low profile and easy to produce. Thus, it is used in GPS systems, mobile communication, mobile radio, biomedical radiators, intruder alarms etc.

Reference Solution

Used article as an idea:

Ul, Z. and Ullah, Z. (2017). Design of a Microstrip Patch Antenna with High Bandwidth and High Gain for UWB and Different Wireless Applications. *International Journal of Advanced Computer Science and Applications*, 8(10), pp.379-382.

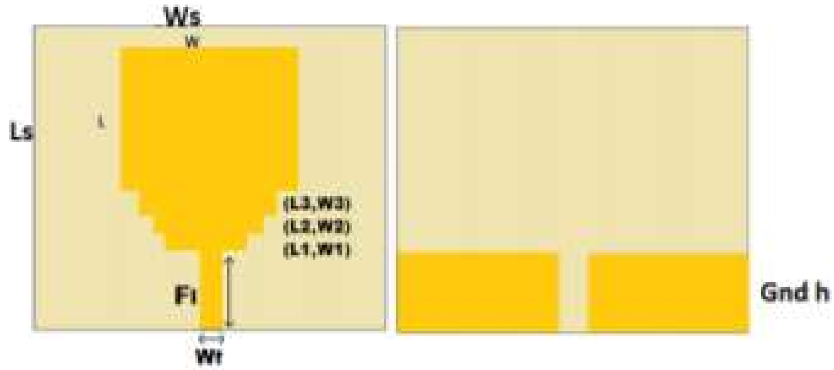

Figure 1. Proposed antenna in this reference article (Top view – Bottom view)

Parameter	Value(mm)	Parameter	Value(mm)
Sub. height	1.6	L1	3.2
Ls	40 (FR4)	L2	2.4
Ws	43	L3	1.2
Gnd h	11	W1	1. 6
Wf	3	W2	3.6
Fl	11.9	W3	6
Er	4.4	Ls	43 (other materials)

Table 1. Dimensions of proposed antenna in this reference article

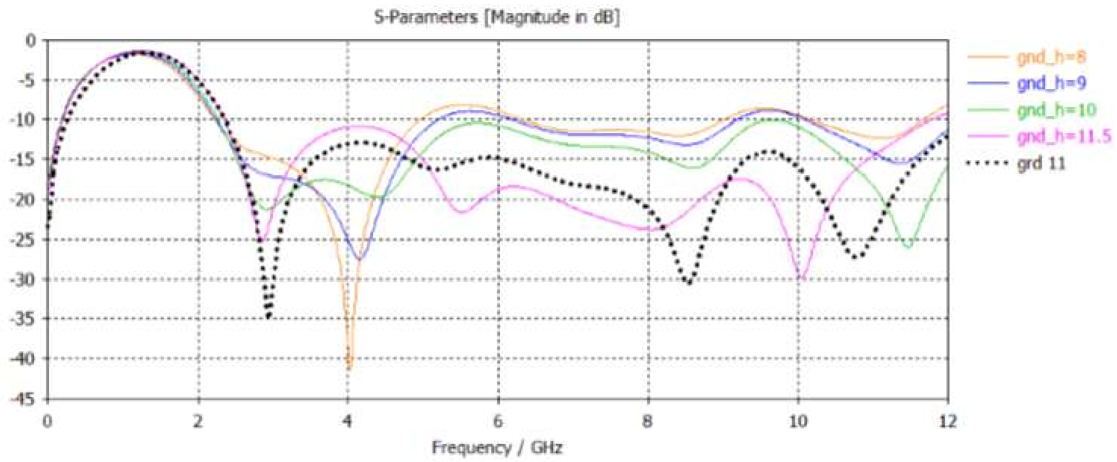

Figure 2. S parameter of proposed antenna in this reference article

2. Modelling and Simulation

Modelling Parameters:

Model structure which is used in this project:

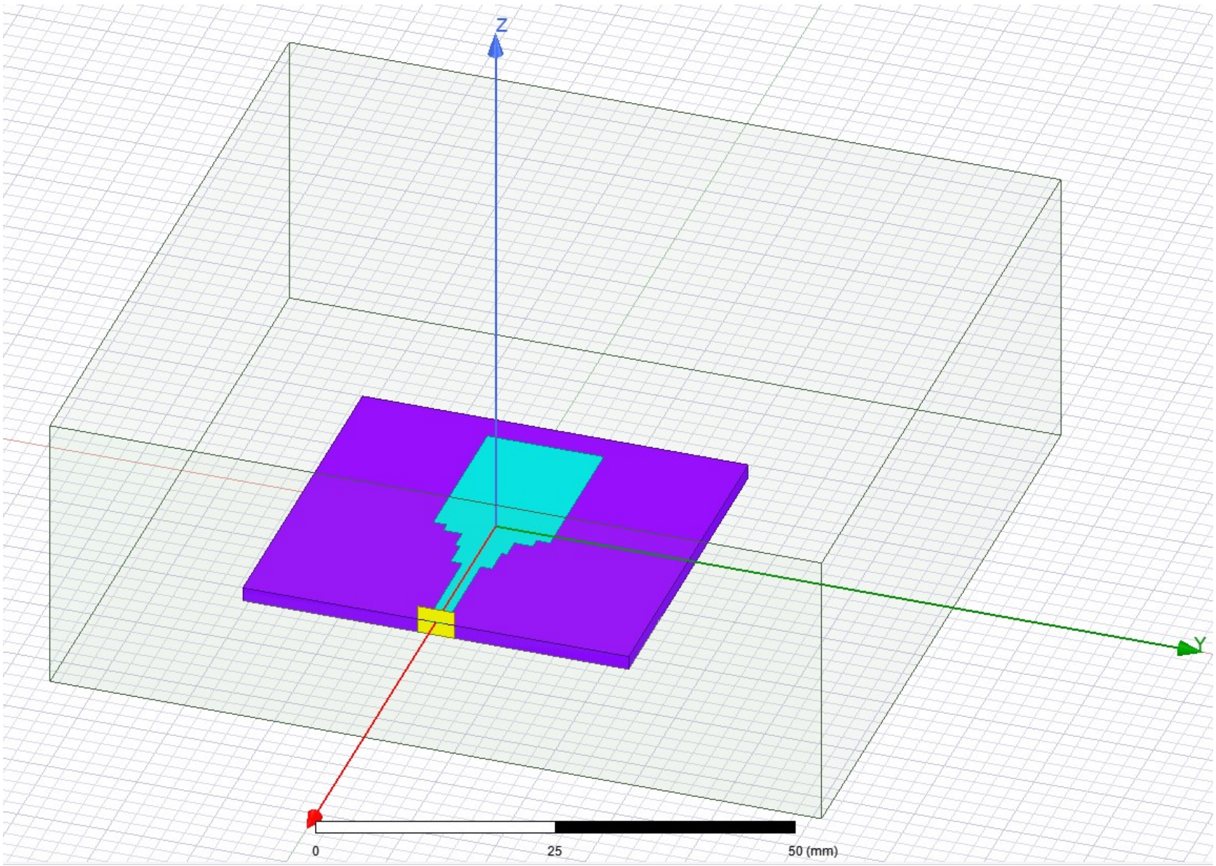

Figure 3. Antenna model with radiation box

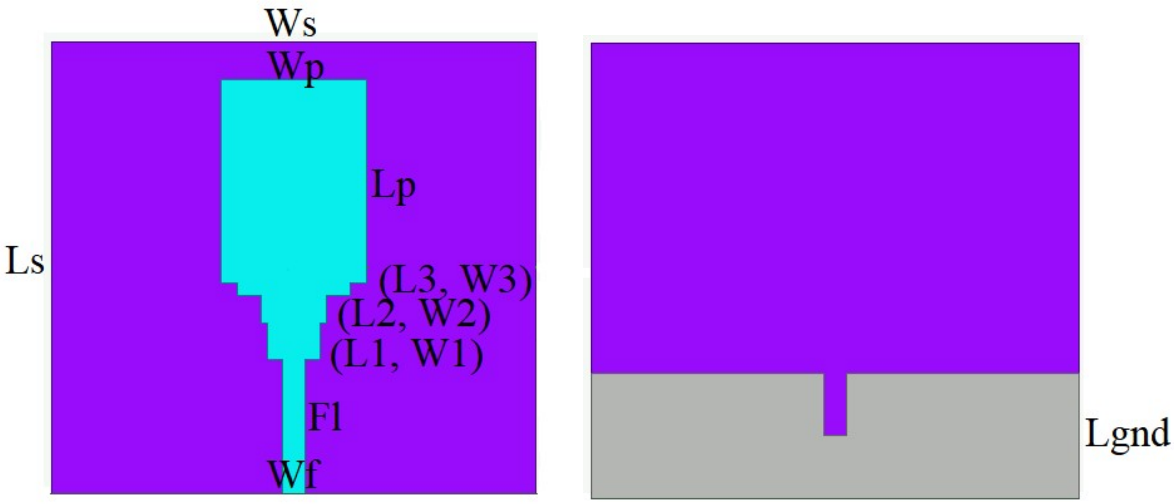

Figure 4. Model structure (Top view – Bottom view)

Dimensions for proposed antenna in this project:

Name	Val...	Unit	Evaluated V...
Wp	13	mm	13mm
Lp	18	mm	18mm
W3	10	mm	10mm
L3	1.2	mm	1.2mm
L2	2.4	mm	2.4mm
W2	5.8	mm	5.8mm
L1	3.2	mm	3.2mm
W1	4.6	mm	4.6mm
Wf	2.05	mm	2.05mm
Fl	11.9	mm	11.9mm
Ws	43	mm	43mm
Lgnd	11	mm	11mm
h	1.6	mm	1.6mm
Ls	40	mm	40mm

Wp: Big patch width.

Lp: Big patch length.

W3: Third patch width.

L3: Third patch length.

L2: Second patch length.

W2: Second patch width.

L1: First patch length.

W1: First patch width.

Wf: Feed line width.

Fl: Feed line length.

Ws: Substrate width.

Lgnd: Ground length.

h: Thickness of substrate.

Ls: Substrate length.

Table 2. Dimensions of proposed antenna in this project

By increasing W3, group delay is hold below 1 ns. This keeps phases stabile in far field.

If Wp is increased, frequency bandwidth (BW) decreases.

If Lp is increased, BW increases.

By adjusting Wp and Lp, BW is calibrated to be desired range.

By increasing Wf, input impedance is increased to 50 Ω.

Feeding:

Transmission line and wave port are used to feed the antenna. Wave port is selected bigger than transmission line to get expected input impedance.

Materials and Boundaries:

For substrate, FR4_epoxy is used. (h = 1.6 mm, Er = 4.4)

For patch and ground, perfect E is used.

For radiation box, vacuum is used.

Simulation:

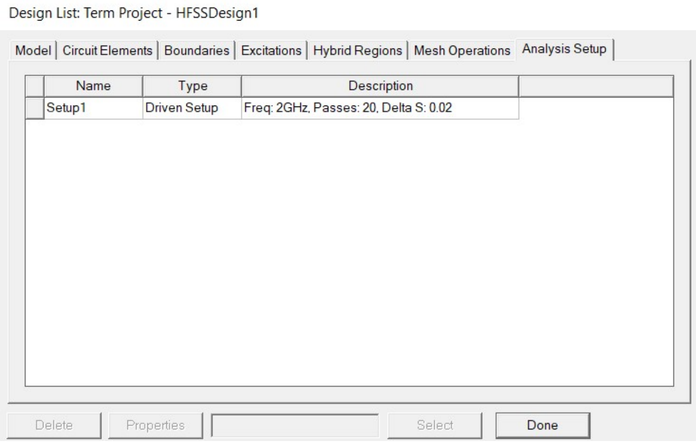

Figure 5. Analysis setup

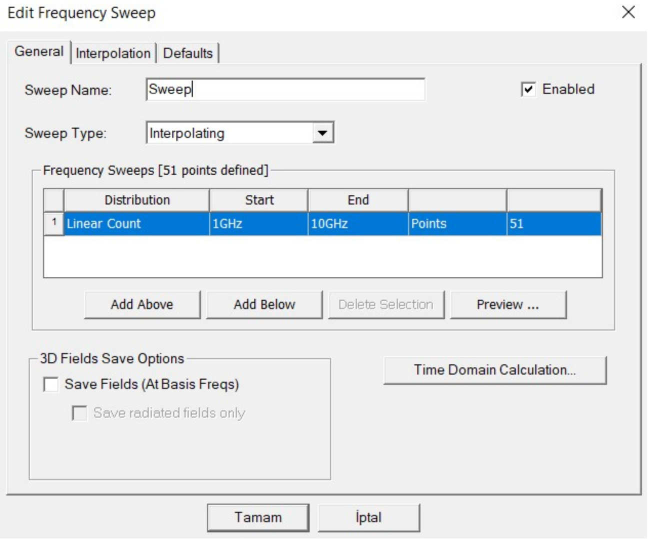

Figure 6. Analysis setup in details

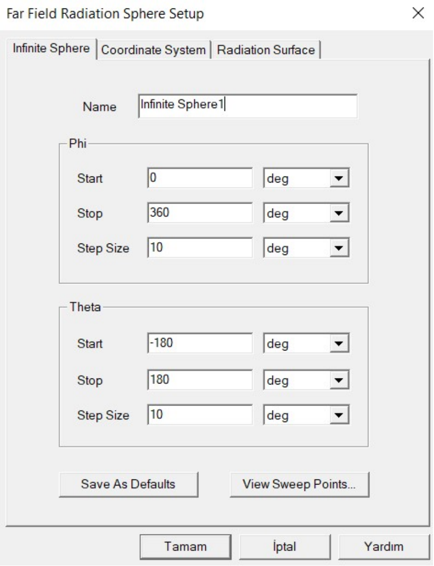

Figure 7. Far field radiation sphere setup

3. Simulation Results

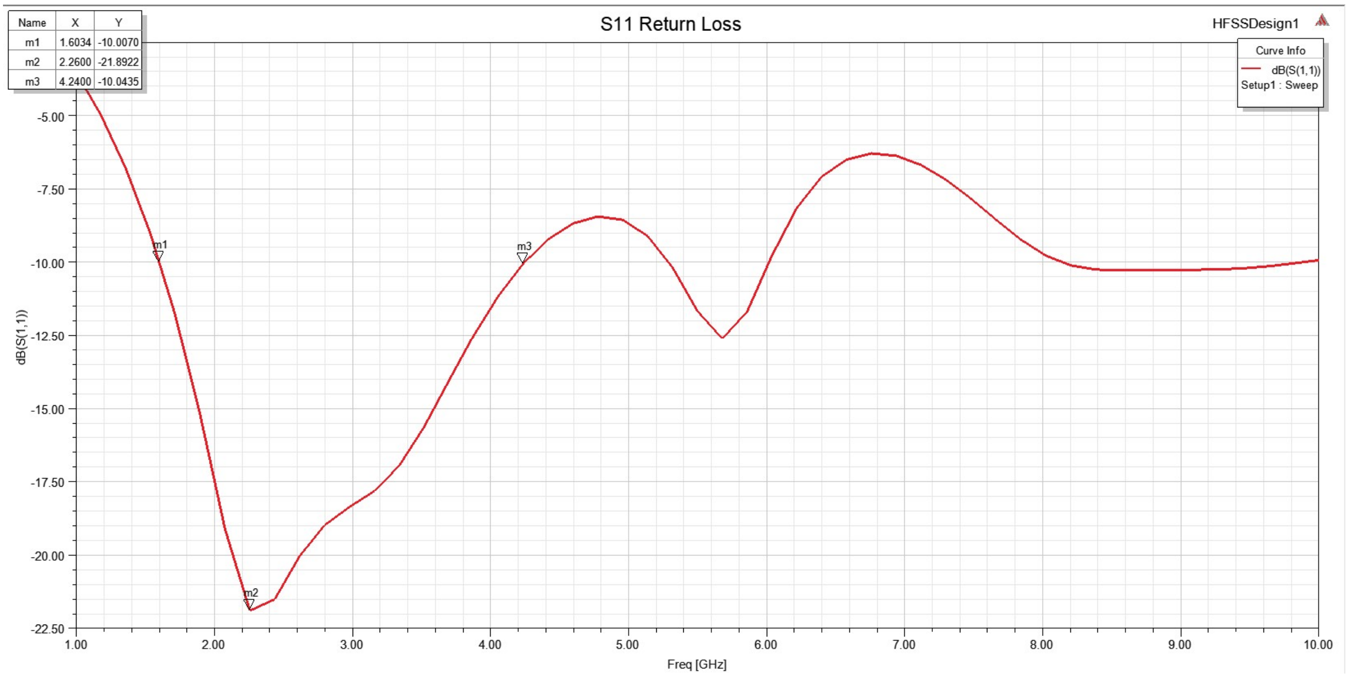

Figure 8. S Parameter and frequency bandwidth (BW = m3-m2 = 2.636 GHz)

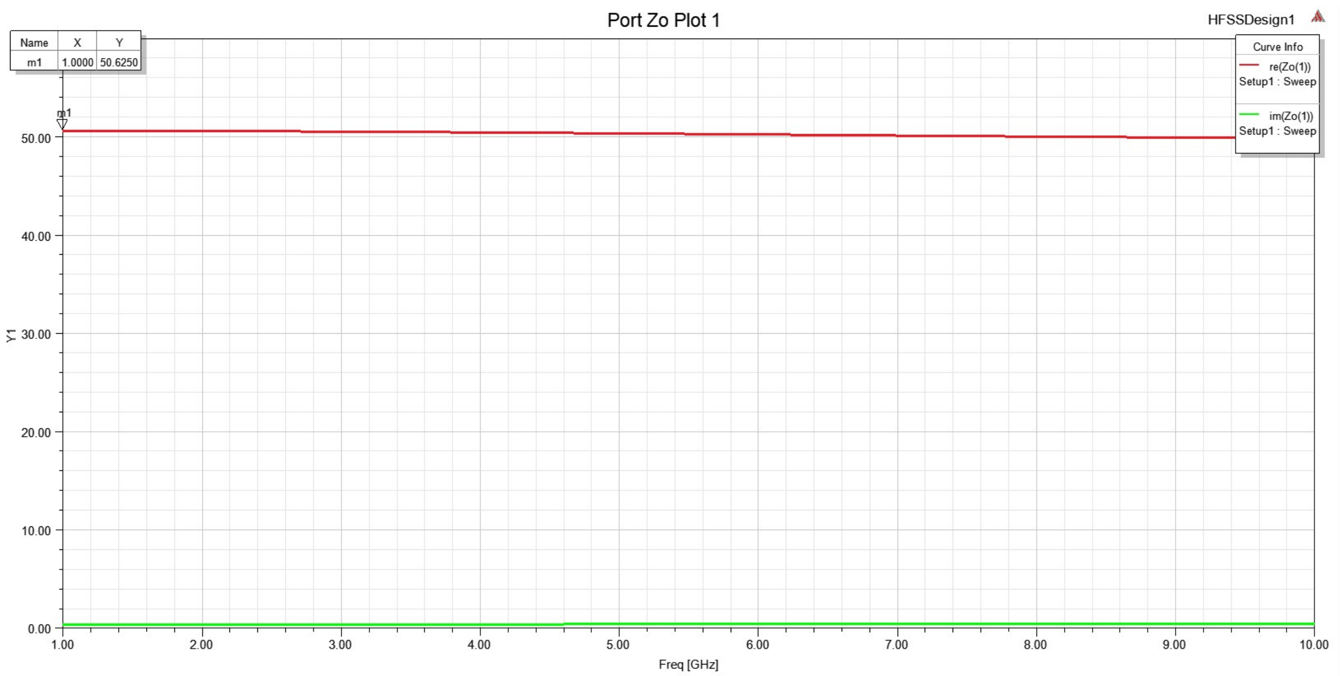

Figure 9. Input impedance (50.6250 ohm)

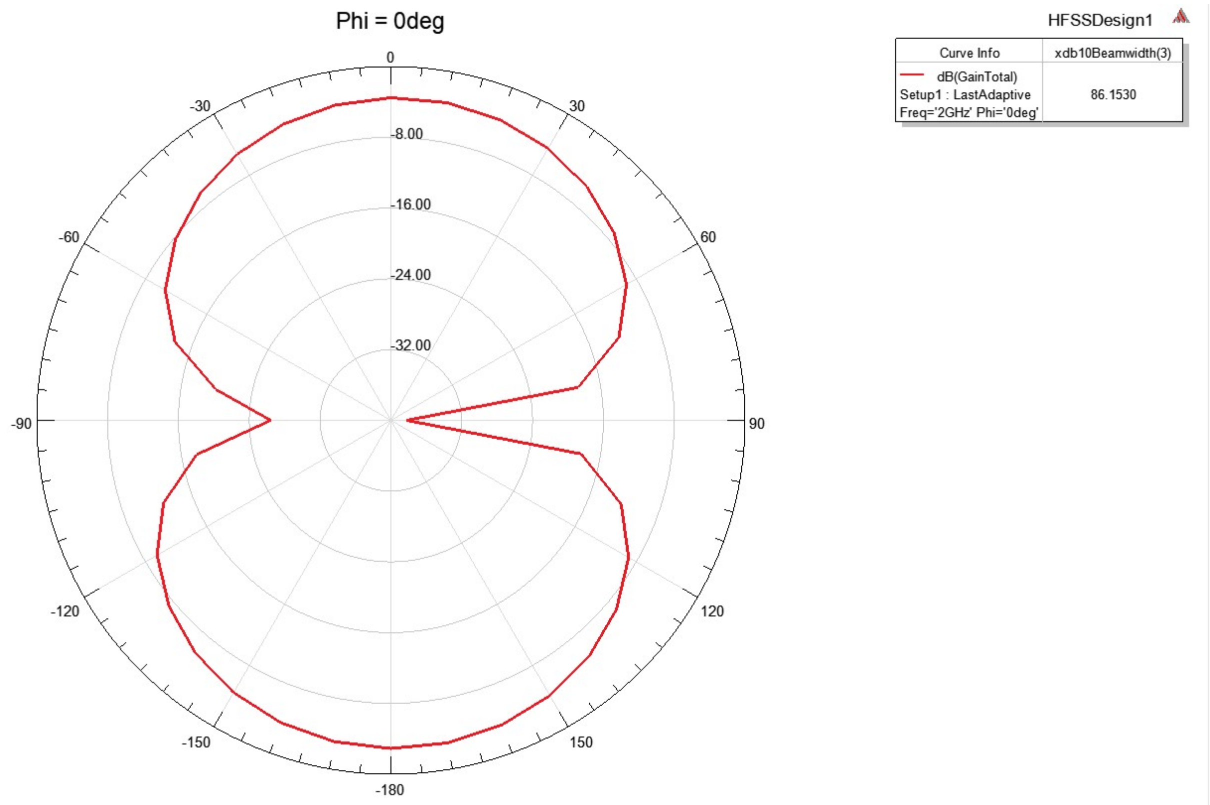

Figure 10. Gain plot at Phi = 0 degree

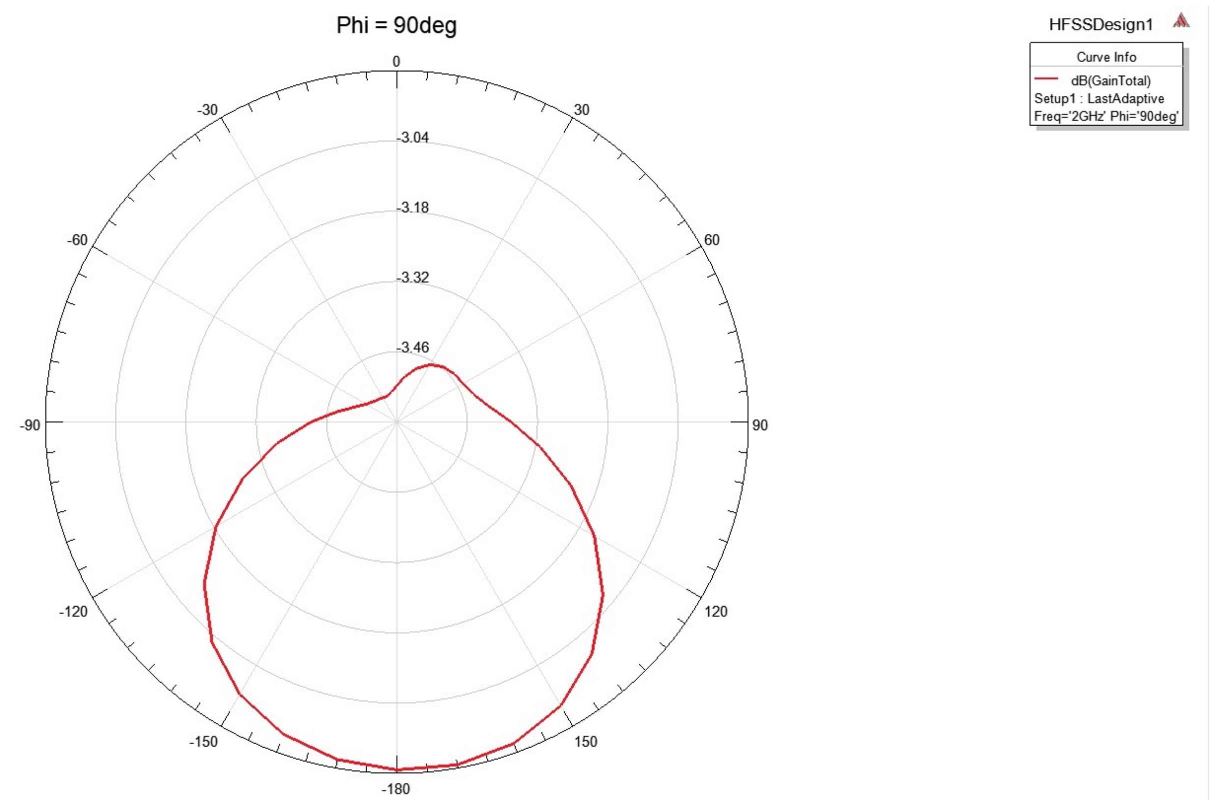

Figure 11. Gain plot at Phi = 90 degree

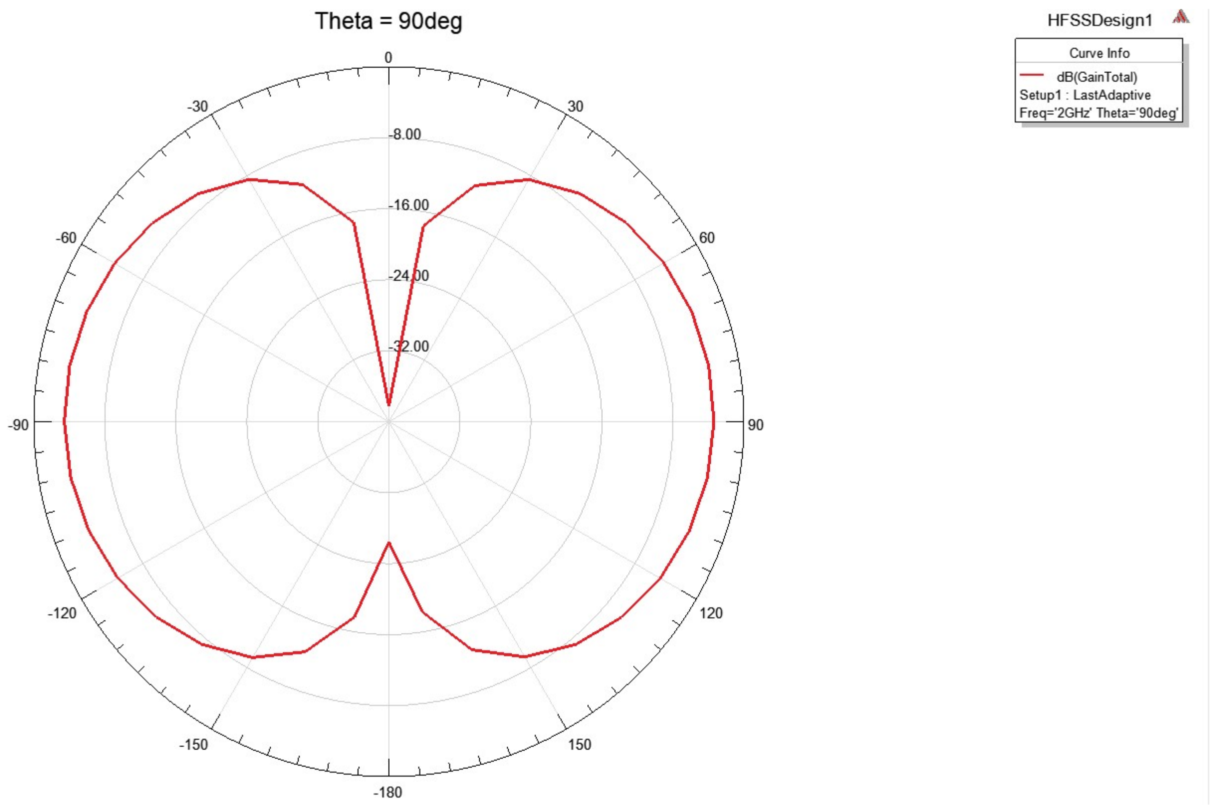

Figure 12. Gain plot at Theta = 90 degree

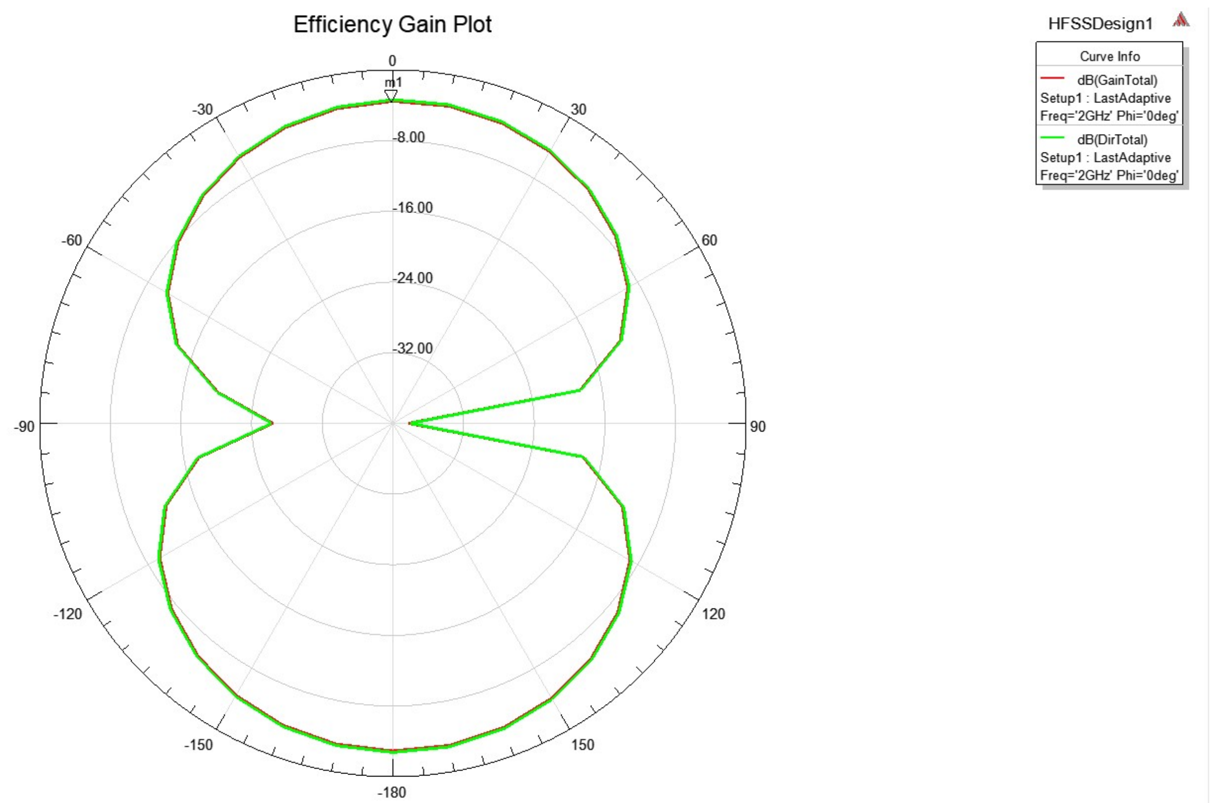

Figure 13.1. Gain and Directivity plot at Phi = 0 degree

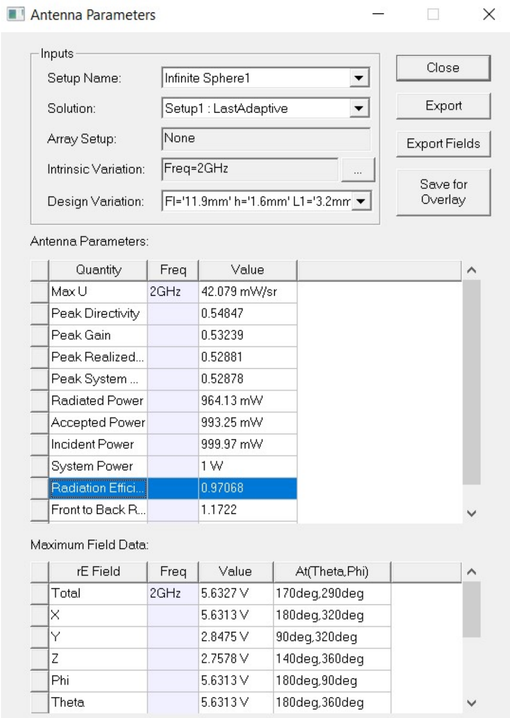

Figure 13.2. Antenna parameters

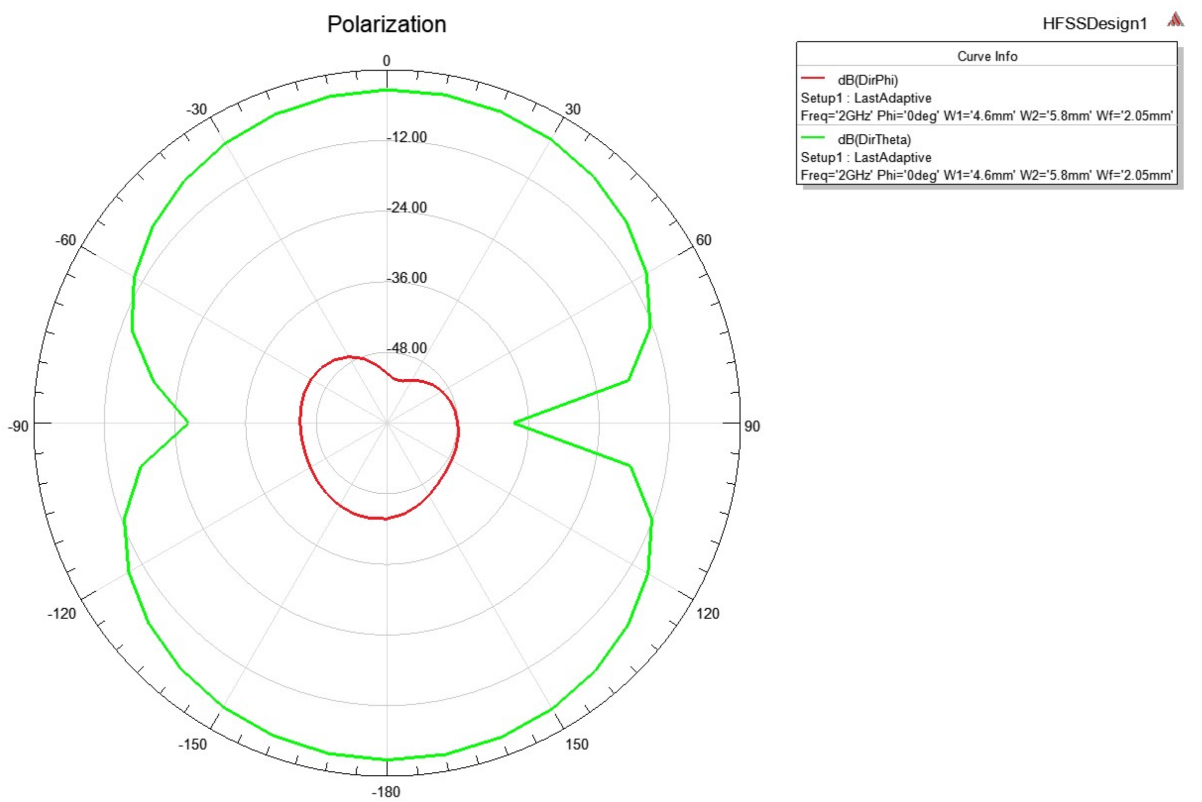

Figure 14. Directivity plot for Phi and Theta to decide polarization

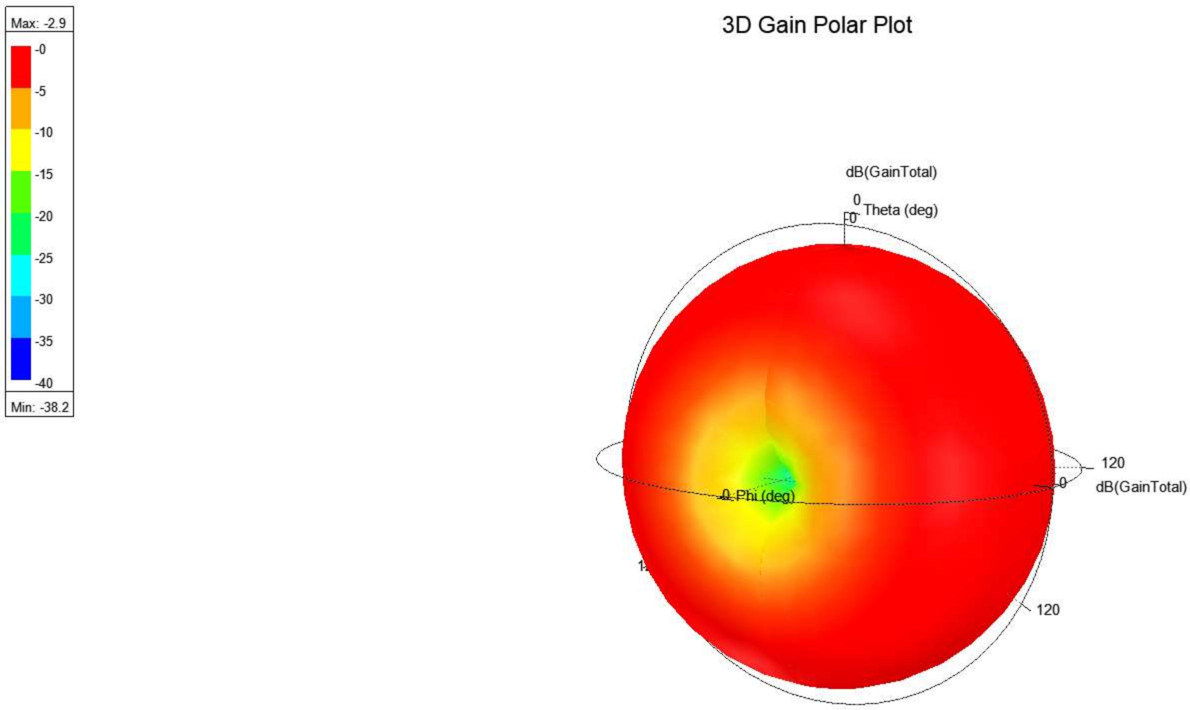

Figure 15. 3D Gain polar plot

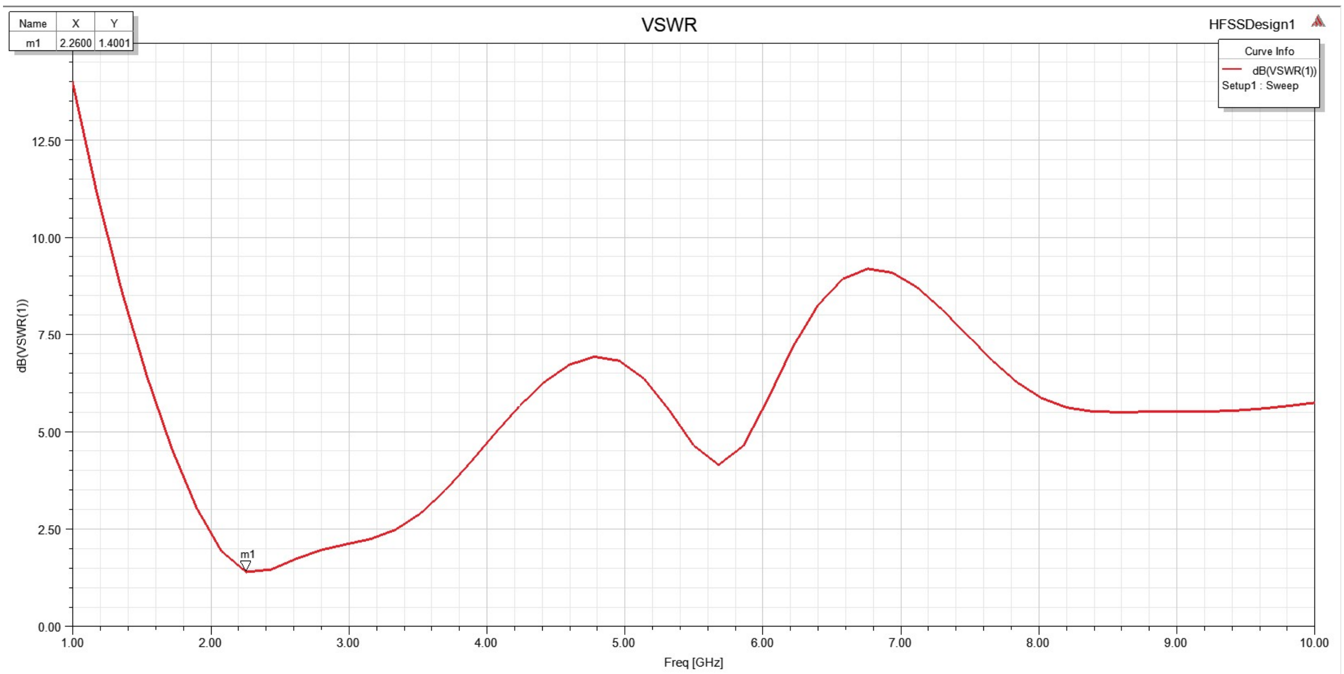

Figure 16. VSWR plot

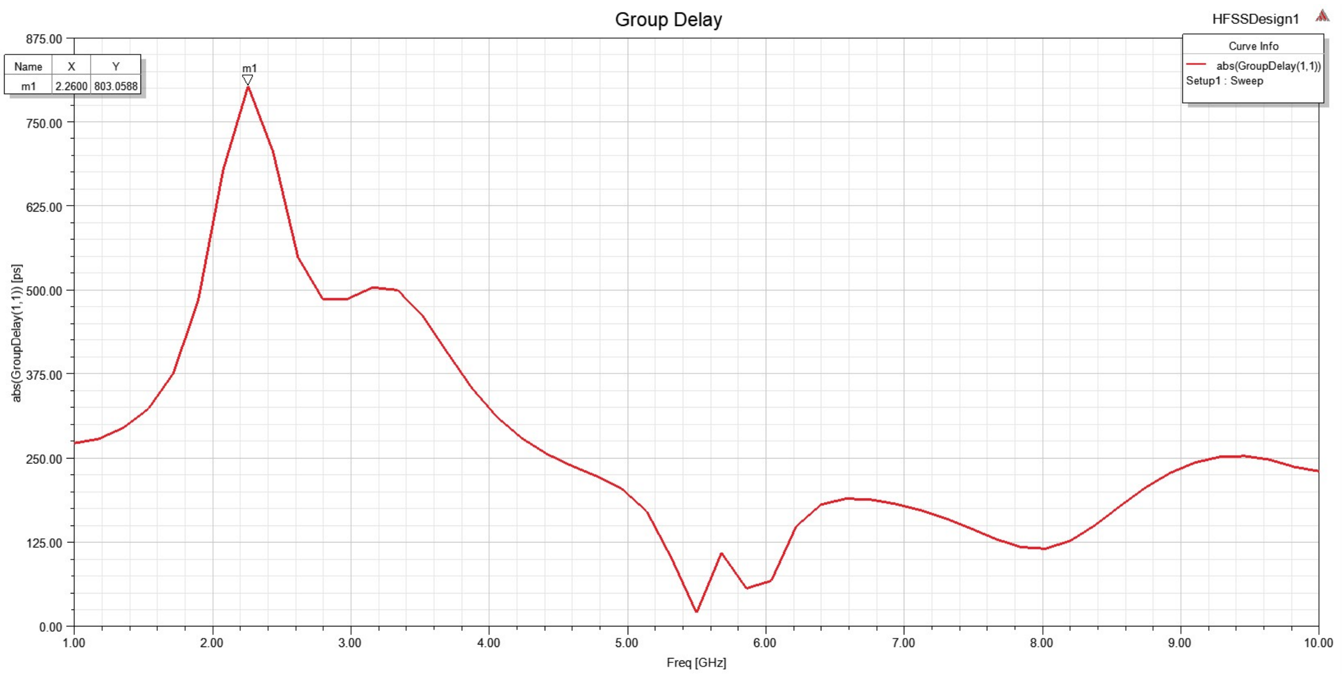

Figure 17. Group delay plot

4. Conclusion

For figure 8: Center frequency is obtained at 2.260 Ghz. It is close to the design parameter 2 GHz. Frequency bandwidth is 2.636 GHz. In frequency bandwidth, return loss is below -10 dB which is required to make a good antenna. Thus, most of the power is transferred to the antenna.

For figure 9: Input impedance is nearly 50 ohm (exact value 50.6250 ohm). Hence, there is low mismatch.

For figure 10: It shows 2D gain plot while Phi is 0 degree. 3 dB beamwidth is 86.153. Besides, radiation is symmetrical.

For figure 11: It shows 2D gain plot while Phi is 90 degree. Besides, radiation is in one direction.

For figure 12: It shows 2D gain plot while Theta is 90 degree. Again, radiation is symmetrical.

For figure 13.1: It shows 2D gain and directivity plot while Phi is 0 degree. Both of them are nearly the same. Thus, antenna radiation efficiency is high. Radiation efficiency = 0.97068 (from figure 13.2)

For figure 14: It shows 2D directivity plot for both Theta and Phi while Phi is 0 degree. As one can see that Theta is dominant, so the antenna has linear polarization towards to Theta direction.

For figure 15: It shows 3D polar gain plot. Generally, microstrip antenna's gain is small and it is between 1.5 dB – 5 dB. In this plot, maximum gain is -2.9 dB. It is related to this antenna’s parameter sizes. Since they are so small compared to wave length at 2 GHz, gain is negative.

For figure 16: It shows VSWR (voltage standing wave ratio) plot. VSWR is a measure that numerically describes how well the antenna is impedance matched to transmission line it is connected to. The better matched antenna gives the lower VSWR value. At center frequency (2.260 GHz), VSWR is equal to 1.4. It shows that most of the power is radiated, not reflected. For frequency bandwidth, firstly, VSWR reduces while it reaches center frequency, then it increases.

For figure 17: It shows group delay plot. It’s peak point which is 803.058 ps is at center frequency. For different frequencies, it decreases even below to 803.058 ps. Group delay must be smaller than 1 ns to avoid phase distortions on far field. In short, this condition is met.

In brief, this antenna met several conditions while it has negative gain.