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MICROSTRIP ANTENNA FOR AUTOMOBILE COMMUNICATION SYSTEMS

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ABSTRACT

Microstrip antennas have been one of the most innovative topics in antenna theory and design in recent years, and are increasingly finding application in a wide range of modern microwave systems. In this paper a brief overview of the of microstrip antennas, design and analyses of the microstrip antenna using ANSYS HFSS is given for automobile communication system such as V2V communication and radar system etc. It was noted that the difference in the gain of the single patch and in the array was increased as the number of patch increased in the array. Microstrip antenna of co-axial feed gives an impedance bandwidth of 5.4 and 1.642773 of gain whereas microstrip antenna (PRMSA) of the array gives an impedance bandwidth of 3.68 and 5.341208 of gain. Also the other antenna parameters such as radiation pattern, scattering factor, and VSWR are calculated and discussed.

1. INTRODUCTION

In high-performance aircraft, spacecraft, satellite, automobile and missile applications, where size, weight, cost, performance, ease of installation, and aerodynamic profile are constraints, low-profile antennas may be required. Presently there are many other government and commercial applications, such as mobile radio and wireless communications that have similar specifications. To meet these requirements, microstrip antennas can be used. Though, bandwidth and gain are sometimes low and not sufficient in most of applications. Alteration of shape and using special materials could be useful to solve such backlashes of this type of antennas.

These antennas are low profile, conformable to planar and non-planar surfaces, simple and inexpensive to manufacture using modern printed-circuit technology, mechanically robust when mounted on rigid surfaces, compatible with MMIC designs, and when the particular patch shape and mode are selected, they are very versatile in terms of resonant frequency, polarization, pattern, and impedance.

Basically a microstrip antenna consists of a planar radiating design of desired geometrical shape on one side of a dielectric substrate material and a ground plane on the other. Generally preferred microstrip radiating geometries are rectangular and circular.

2. MICROSTRIP ANTENNA FEEDING METHOD

There are different types of feeding mechanisms are available and some vital among them are Microstrip feed, Co-axial feed, Aperture coupling feed and Proximity coupling feed.

2.1 Co-axial feed

The co-axial feeding is used in design 1 microstrip antenna.

Co-axial feeding is a feeding method in which the inner conductor of the coaxial is attached to the radiation patch of the antenna while the outer conductor is connected to the ground plane.

2.2 Proximity-Coupled Feed

The proximity-coupled feed is used in design 2 proposed microstrip antenna.

In proximity-coupled feed method, two dielectric substrates are placed in such way that the feed line is between the two substrates and the radiating patch is on top of the upper substrate.

3. ANTENNA DESIGNS

The microstrip patch is designed so its pattern maximum is normal to the patch (broadside radiator). For a rectangular patch, the length L of the element is usually $\lambda0/3<L<\lambda0/2$. The strip (patch) and the ground plane are separated by a dielectric sheet (referred to as the substrate).

The dielectric constant of substrate is usually in the range of $2.2 \leq Ir \leq 12$. The ones that are most desirable for good antenna performance are thick substrates whose dielectric constant is in the lower end of the range because they provide better efficiency, larger bandwidth, loosely bound field for radiation into space, but at the expense of larger element size.

The first step of this process is to design an antenna suitable for the network/communication requirements such as the required bandwidth to maintain a tolerable bit error rate (BER) or throughput.

It includes single element design (e.g., dimensions, material, and geometry), and array design (e.g., configuration, inter-element spacing, and number of elements).

The Proximity-coupled Rectangular Microstrip Antenna (PRMSA) is fabricated with 'patches' of a metal and a substrate material of dielectric constant (2.2).

Figure 1 and Figure 2 shows the 3D view of the Rectangular Microstrip Antenna.

Design 1

It is a simple co-axial feed design, which contains single rectangular patch.

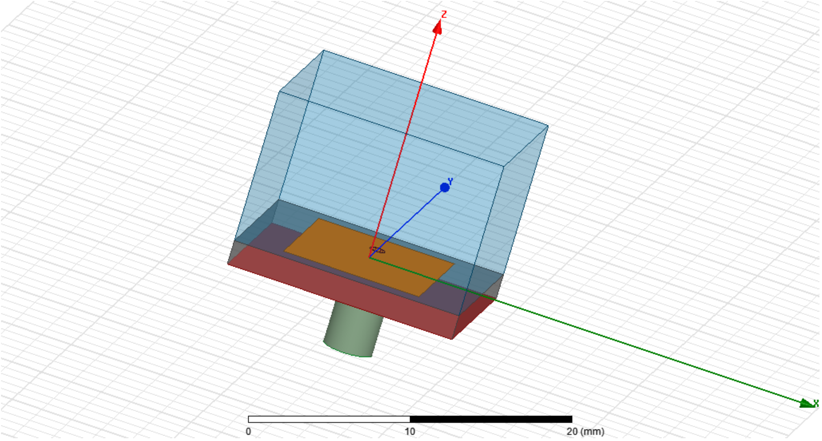

Figure 1 Geometry of co-axial

The Co-axial feed has been designed for 7.4 GHz. The physical dimension of rectangular radiating patch and substrate are approximately determined as;

Antenna Geometry Parameters

PATCH	Length of the patch (L)	Width of the patch (W)
Single patch	9.06 mm	11.96 mm

Substrate

Length of the substrate (X size)	15 mm
Width of the substrate (Y size)	15 mm
Thickness of the substrate (Z size)	1.588 mm
Dielectric constant	2.2 (RT DURIOD 5880)

Design 2

It is array proximity-coupled feed (PRMSA) design, which contains 1 centre patch and 4 side patches which are at uniform distance from the centre patch.

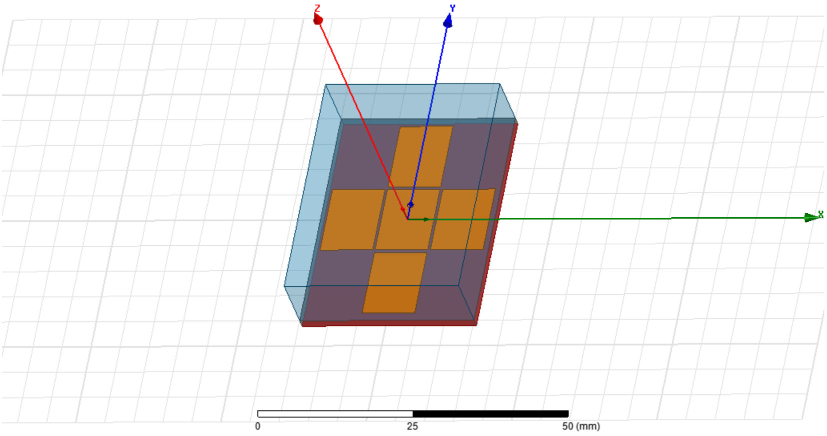

Figure 2: Geometry of PRMSA

The PRMSA has been designed for 7.6 GHz. L is the resonant dimension. The width W is usually chosen to be larger then L (to get higher bandwidth). The physical dimension of rectangular radiating patch and substrate are approximately determined as;

Antenna Geometry Parameters

(Patches)	Length of the patch, L	Width of the patch, W
Centre patch	9.06 mm	11.96 mm
Patch 1 (left)	9.06 mm	11.96 mm
Patch 2 (right)	9.06 mm	11.96 mm
Patch 3 (up)	9.06 mm	11.96 mm
Patch 4 (down)	9.06 mm	11.96 mm

Substrate

Length of the substrate (X size)	30 mm
Width of the substrate (Y size)	40 mm
Thickness of the substrate (Z size)	1.588 mm
Dielectric constant	2.2 (RT DURIOD 5880)

4. THEORY AND FORMULAS

4.1 Effective Dielectric Constant

The effective dielectric constant is defined as the dielectric constant of the uniform dielectric material has identical electrical characteristics, particularly propagation constant. The effective dielectric constant is also a function of frequency. As the frequency of operation increases, most of the electric field lines concentrate in the substrate.

For low frequencies the effective dielectric constant is essentially constant. At intermediate frequencies its values begin to monotonically increase and eventually approach the values of the dielectric constant of the substrate.

$$\varepsilon_r^{eff} = \frac{\varepsilon_r+1}{2} + \left(\frac{\varepsilon_r-1}{2}\right)\left[1+12\left(\frac{h}{W}\right)\right]^{-1/2}$$

4.2 Effective Length, Resonant Frequency, and Effective Width

The resonance frequency is controlled by the patch length L and the substrate permittivity.

$$f_{10} = \frac{c}{\sqrt{\varepsilon_r}}\left(\frac{1}{2L}\right) \qquad kL = \pi \quad \Longrightarrow \quad L = \lambda_d / 2 = \frac{\lambda_0 / 2}{\sqrt{\varepsilon_r}}$$

A higher substrate permittivity allows for a smaller antenna (miniaturization) - but lower bandwidth.

The calculation can be improved by adding a “fringing length extension” ΔL to each edge of the patch to get an “effective length” Le.

$$L_e = L + 2\Delta L$$

$$f_{10} = \frac{c}{2\sqrt{\varepsilon_r}}\left(\frac{1}{L_e}\right) \qquad \Delta L / h = 0.412\left[\frac{\left(\varepsilon_r^{eff}+0.3\right)\left(\frac{W}{h}+0.264\right)}{\left(\varepsilon_r^{eff}-0.258\right)\left(\frac{W}{h}+0.8\right)}\right]$$

Whereas ΔL= 0.5 h and W/L = 1.5.

5. EXPERIMENTAL RESULTS

5.1 Scattering parameter (s11)

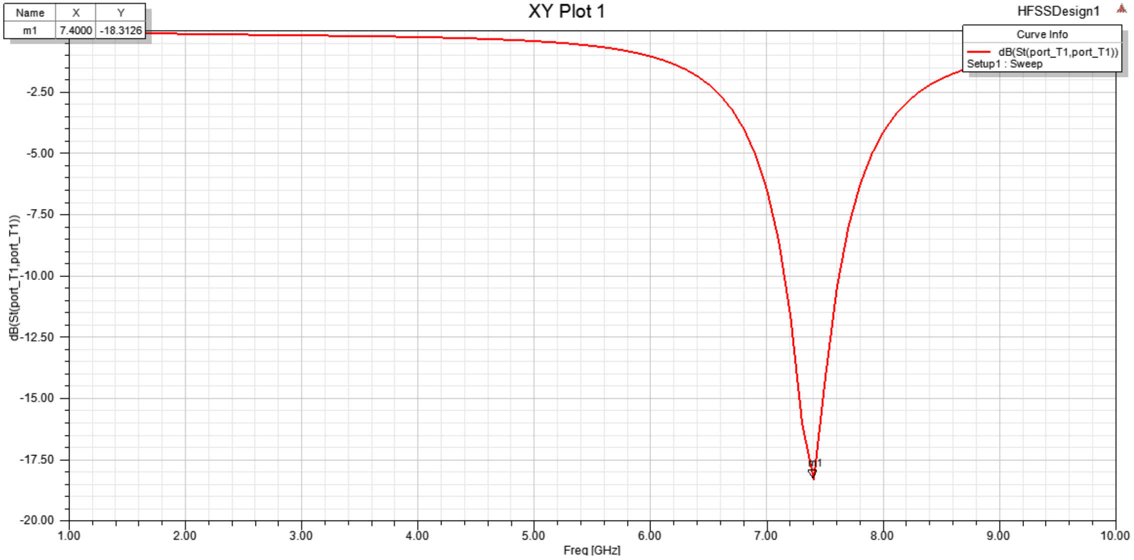

Fig:1.1 S11 for 7.4 GHz frequency

5.1.1 Scattering parameter (s11)

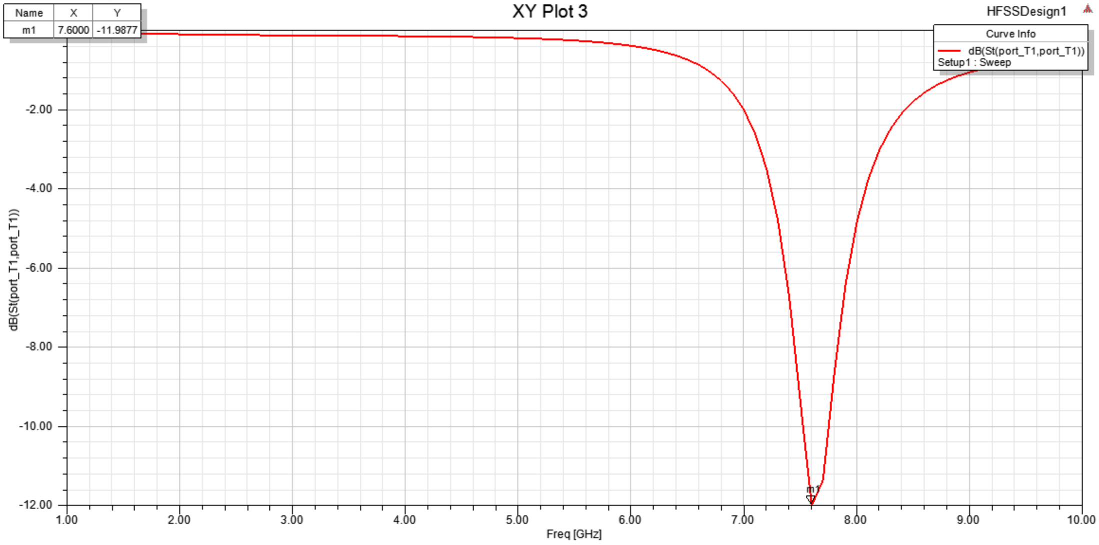

Fig:2.1 S11 for 7.6 GHz frequency

5.2 VSWR

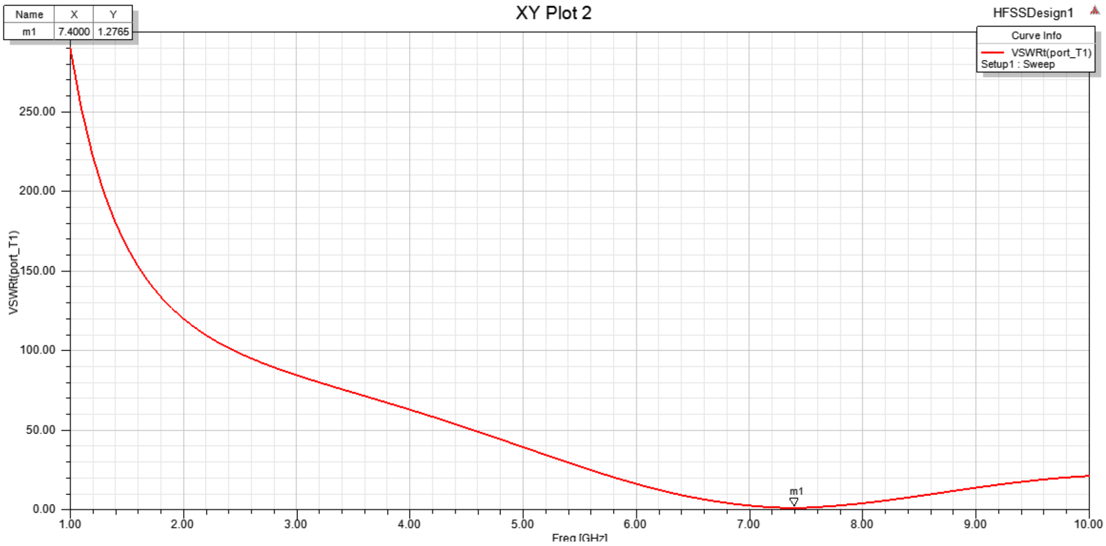

Fig: 1.2 VSWR for 7.4 GHz frequency

5.2.1 VSWR

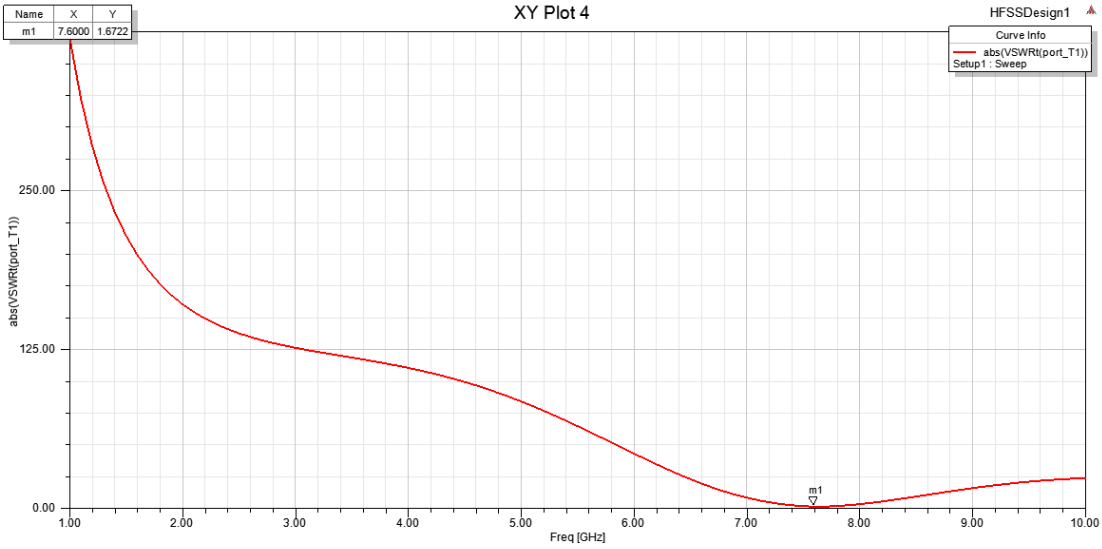

Fig: 2.2 VSWR for 7.6 GHz frequency

5.3 Radiation pattern

The co-polar and cross-polar radiation pattern of PRSMA is measured at X-Y plane at their resonating frequency and is depicted in Figure. The figure indicates that the antenna shows broader side radiation characteristic.

For Phi 90 deg

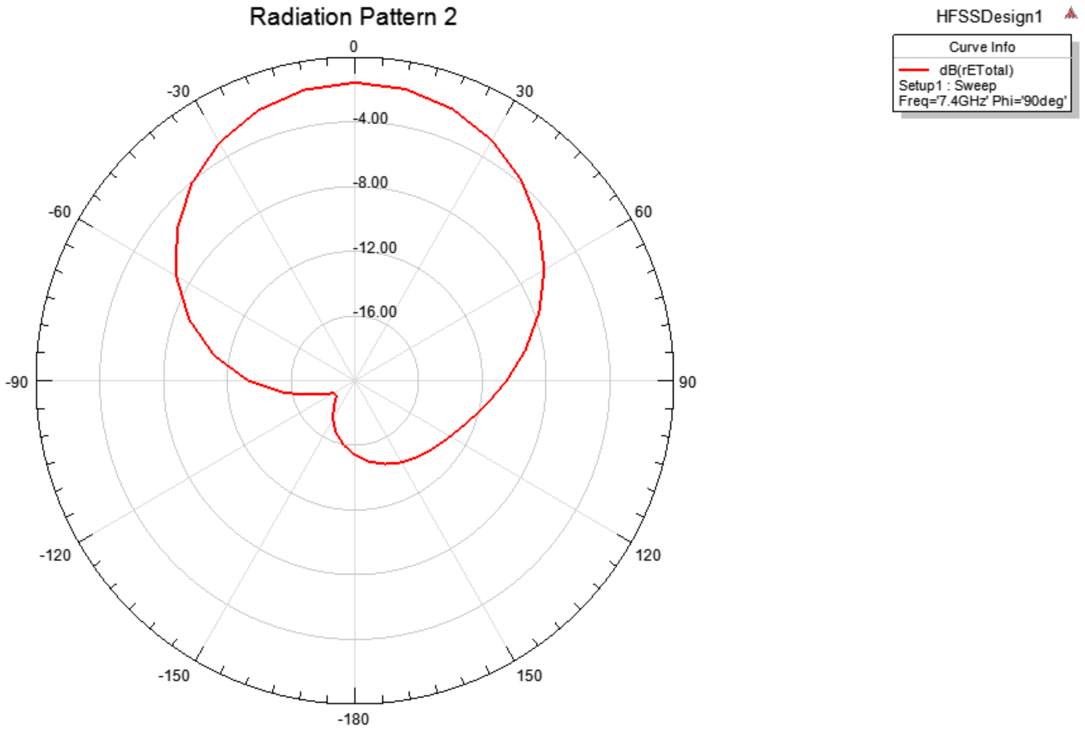

Fig: 1.3 Radiation pattern for 7.4 GHz frequency

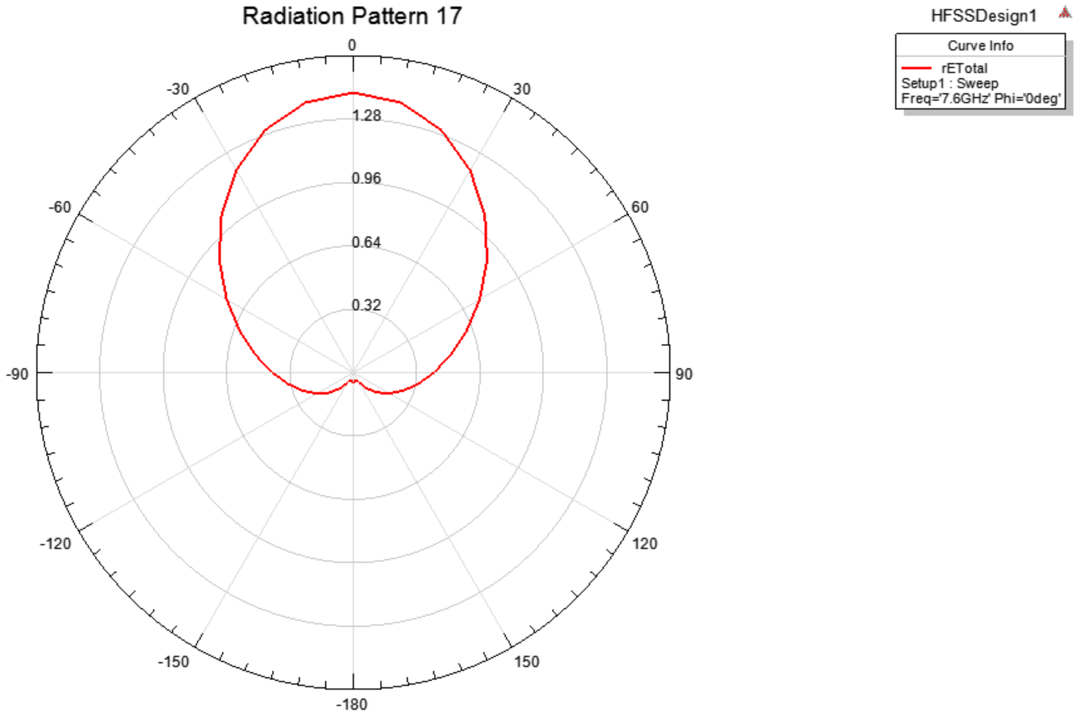

Fig: 2.3 Radiation pattern for 7.6 GHz frequency

5.3.1 Radiation pattern

For Theta 90 deg

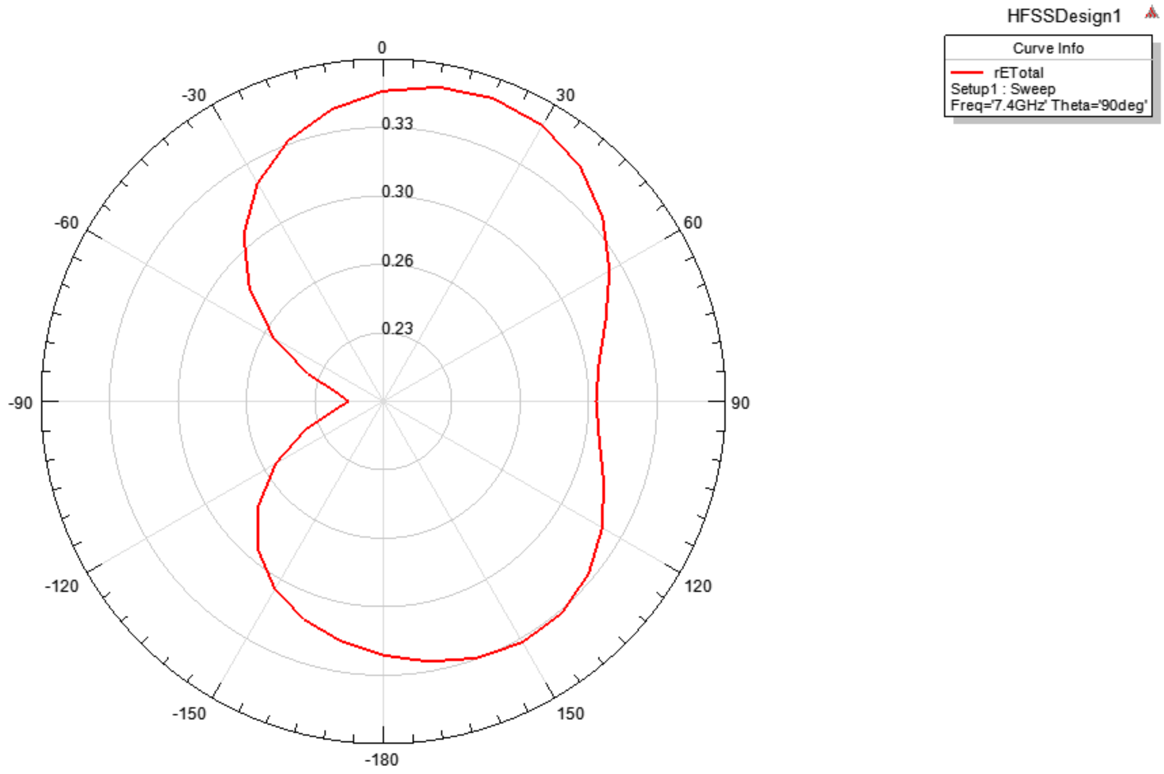

Fig: 1.4 Radiation pattern for 7.4 GHz frequency

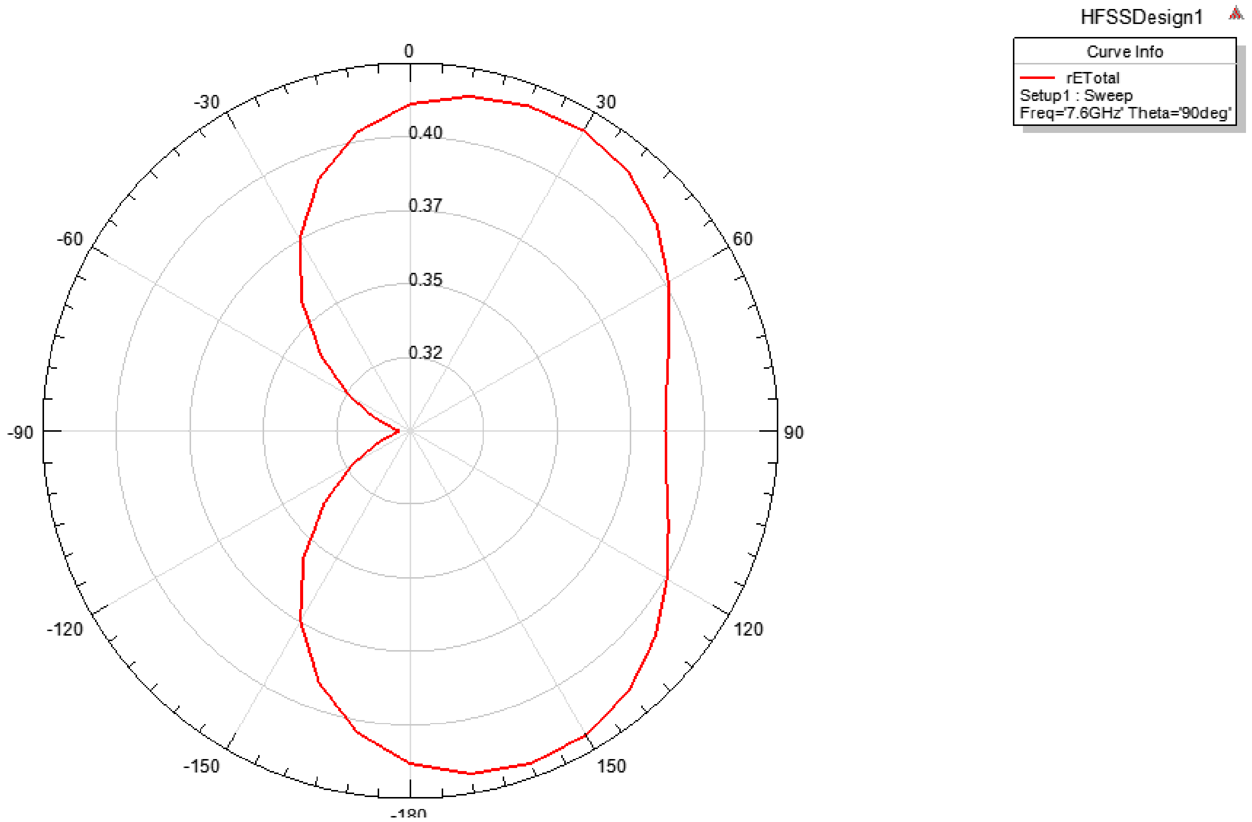

Fig: 2.4 Radiation pattern for 7.6 GHz frequency

6. ANTENNA PARAMETER

6.1 For frequency 7.4 GHz

Quantity	Value
Max U	923.775097 uW/sr
Peak Directivity	1.672388
Peak Gain	1.642773
Radiated Power	6.941435 mW
Accepted Power	7.066572 mW
Incident Power	7.187236 mW
Radiation Efficiency	0.982292
Front to Back Ratio	24.186421
rE Field	Value
Total	834.581586 mV
X	182.714871 mV

Y	834.510478 mV
Z	432.765465 mV
Phi	834.510478 mV
Theta	834.510478 mV
LHCP	588.706262 mV
RHCP	597.061800 mV

6.2 For Frequency 7.6GHz

Quantity	Value
Max U	2.646688 mW/sr
Peak Directivity	5.473960
Peak Gain	5.341208
Radiated Power	6.076049 mW
Accepted Power	6.227065 mW
Incident Power	7.188611 mW
Radiation Efficiency	0.975748
Front to Back Ratio	764.514829

rE Field	Value
Total	1.412658 V
X	224.942313 mV
Y	1.412654 V
Z	622.650953 mV
Phi	1.412654 V
Theta	1.412654 V
LHCP	1.006441 V
RHCP	1.004452 V

7. CONCLUSION

Microstrip antennas are one of the most innovative topics in antenna technology today, and this trend is likely to continue because the characteristics of microstrip antennas make them very appealing from a systems perspective.

The entire simulation result illustrates that the antenna is relatively simple in design and fabrication and quite fine in enhancing the bandwidth and gives super broadside radiation pattern at the resonating frequency also the gain is found to be better. The simple co-axial feed design has 5.4 bandwidth and 1.642773 of peak gain whereas the array (PRMSA) design has 3.68 of bandwidth and 5.341208 of peak gain. Therefore the array design is better than simple co-axial feed design.

8. REFERENCES

1. Constantine A. Balanis. Willey and Sons, "Antenna Theory", 2nd edition (1997), Chap 14.pp.722-783, ISBN 978-81-265-1393-4.
2. H. Gutton and G. Baissinot, "Flat aerial for ultra high frequen- cies," French Patent no. 703 113, 1955.
3. David M. Pozar, Microwave Engineering, Addison Wesley Publishing Company, Inc. 1990.
4. R. J. Mailloux, J. F. McIlvenna and N. P. Kemweis, "Microstrip array technology," IEEE Trans. Antennas Propagat., vol. AP- 29, pp. 25-37, Jan. 1981.
5. I. J. Bahl and P. Bhartia, MicrostripAntennas. Dedham, MA: Artech House, 1980.
6. K. Rambabu, M. Alam, J. Bornemann and M. A. Stuchly, "Compact Wideband Dual-Polarized Microstrip Patch Antenna", IEEE. 2004. www.ece.uvic.ca/~jbornema/Conferences/102-04aps-kabs.pdf.
7. N. Herscovici, "New considerations in the design of microstrip antennas," IEEE Trans. Antennas and Propagation, Vol. 46, pp. 807– 812, June 1998.
8. K. R. Carver and J. W. Mink, "Microstrip antenna technology," IEEE Trans. Antennas Propag., vol. AP-29, pp. 2-24, Jan. 1981.
9. Ramesh Garg, Microstrip antenna design handbook, Artech House, Noorwood, MA, 2001.