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BROADBAND SECTORAL MICROSTRIP ANTENNA

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ABSTRACT

An antenna is a single port device which is capable of sending (directing) or receiving signals efficiently. Antennas, basically is used to optimise the matching between the source of electromagnetic energy and the surrounding atmosphere. This paper provides an insight into the basics of Sectoral MSA using IE3D software, with the help of which various antenna parameters are varied and measured post simulation through a graph of dB versus frequency. Since the antenna is broadband, it will resonate at more than one frequency. The antenna is simulated based on 1.6mm thick Flame Retardant 4(FR4) substrate with a dielectric constant of 4.4. Microstrip antenna consists of a metallic patch and a substrate which is grounded. The patch can take up any shape, like rectangular, triangular, circular, etc. In Sectoral MSA, the substrate is in the shape of a sectoral, having minor angle theta, which has a direct consequence on its resonant frequency.

Keywords- Gain, proximity feed, resonant frequency, sectoral microstrip antenna, VSWR,

I. INTRODUCTION

Antennas are classified into various types:

- Wire antennas: These are the most commonly seen, comprising of wire bent into various shapes.
- Aperture antennas: It consists of an aperture of various shapes, protected by dielectric material.
- Microstrip antennas: It has metallic patch on substrate which is grounded.
- Array antennas: It consists of a number of antennas arranged in the form of an array.
- Reflector antennas: These are usually parabolic in shape, gives a high gain in distance communication.

  Some of the properties of an antenna are:

- Field intensity for various directions (antenna pattern)
- Total power radiated when the antenna is excited by a current or voltage of unknown intensity
- Radiation efficiency which is the ratio of power radiated to the total power
- The input impedance of the antenna for maximum power transfer (matching)
- The bandwidth of the antenna or range of frequencies over which the above properties are almost constant

II. BASIC PARAMETERS OF AN ANTENNA

2.1. RADIATION PATTERN

Radiation pattern is basically a graphical representation of the spatial distribution of the radiation properties of the antenna. It gives an approximate measure of the flux, power intensity, field strength, phase or polarisation. Radiation pattern consists of principle lobe or the main lobe, and may also contain a number of side lobes.

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2.2. FIELD REGION

Although, there is no strict demarcation of the field regions, but field region of an antenna basically, can be categorised into three regions, namely:

- Reactive near field region- It is the region immediately surrounding the antenna, where the reactive field is present principally.
- Radiating near field region (Fresnel Region) - It is the region between reactive near field and far field, marked by the presence of radiating field mainly and the radiation pattern is dependent on the distance from the antenna.
- Far field region (Fraunhofer) – In this region, the annular field region is not dependent on the distance of the antenna

2.3. BEAMWIDTH

Beamwidth is defined as the annular separation that is measured on the reverse side of the pattern maxima between two identical points. One of the most commonly used beamwidth is the Half Power Beam Width (HPBW) which is defined by IEEE as “In a plane containing the direction of the maximum of a beam, the angle between two directions in which the radiation intensity is one half the value of the beam. There is a trade off between the beamwidth and the side lobe

2.4. DIRECTIVITY

Directivity is referred to as the ratio of the intensity in a given direction from the antenna to the radiation intensity averaged over all the directions.

Mathematically,

$$\boxed{D=\frac{U}{Uo}=\frac{4\pi U}{P}}$$

D= Directivity

U= Radiation Intensity

Uo= Radiation Intensity of isotropic source

P= Total radiated power

2.5. ANTENNA EFFICIENCY

Antenna efficiency is a measure of the losses that are incurred by the antenna on account of its structure and end terminals. Mathematically,

$$\boxed{A_0= A_R\, A_C\, A_D}$$

A_0=Total Efficiency

A_R=Reflection Efficiency

A_C=Conduction Efficiency

A_D=Dielectric Efficiency

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2.6 GAIN

It is one of the most important parameter of an antenna. Higher the gain of an antenna better is its performance. It is defined as the ratio of the intensity radiated in a particular direction to the power produced by hypothetical isotropic lossless antenna.

It can be written as:

$$\text{Gain} = 4\pi \frac{\text{Radiation Intensity}}{\text{Total input poer}}$$

2.7. BANDWIDTH

Bandwidth is defined as the range of frequencies over which the parameters of an antenna and its performance in terms of gain, directivity, and efficiency are approximately same as the standard values.

For broadband antennas, the bandwidth is usually referred to as the ratio of higher frequency to the lower frequency, whereas in the case of narrowband antennas, the bandwidth is expressed in percentage as the difference in the frequency.

2.8. POLARISATION

In a given direction, it is the orientation of flux lines of the wave transmitted by the antenna. Effective short range communication is obtained when the transmitting and receiving antennas are having same polarisation, and ineffective communication takes place when they are placed orthogonally.

Polarisation can further be classified as Linear, Circular or Elliptical polarisation.

2.9. INPUT IMPEDANCE

Input impedance is defined as the ratio of the voltage to the current at any of its terminals. In the absence of a load, the input impedance of an antenna is given by

$$\boxed{Z = R + jX}$$

III. ANTENNA DESIGN AND GEOMETRY

The proposed S-MSA was first optimized using IE3D software and followed by experimental verifications. The proximity fed S-MSA of an angle 320° having a radius of 7cm has been realised in this paper and resonant curve plots and current distribution has been obtained. The material used is FR4 having dielectric constant of 4.4

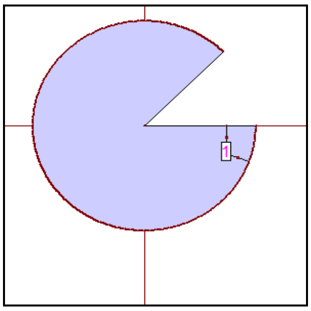

Figure 1: Antenna Patch

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3.1 RETURN LOSS MAGNITUDE IN dB

Return loss S_{11} is a measure of how much power is reflected back from the antenna. If S_{11}=0 dB, it implies that all the power is reflected. If S_{11}= -10dB, then -7dB is the reflected power and the rest is absorbed by the antenna.

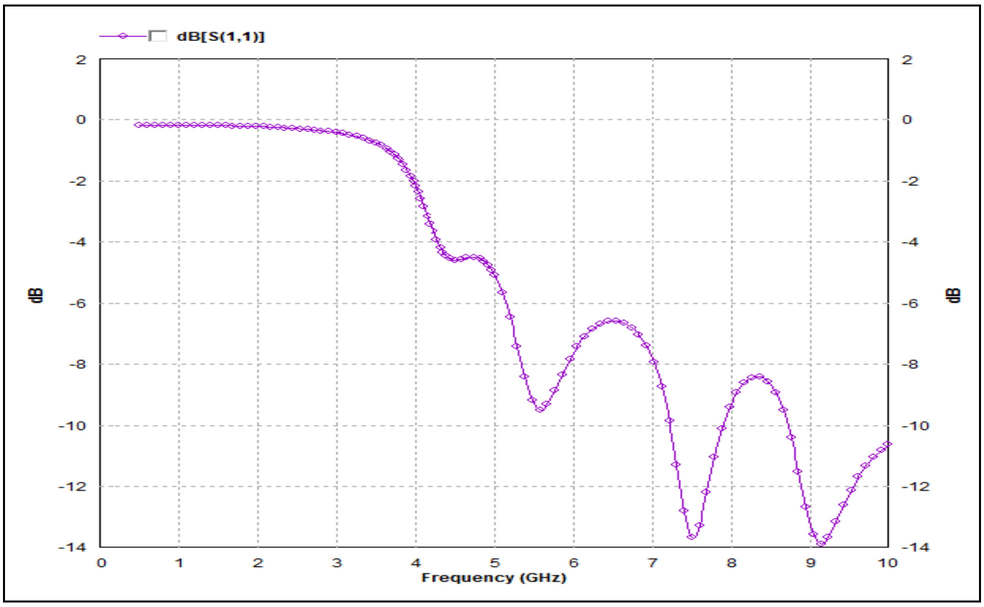

Figure 2: Graph of S_{11} versus frequency

3.2 VSWR

Voltage Standing Wave Ratio is a function of reflection coefficient which denotes the power reflected from the antenna. Mathematically, it is given as

$$\text{VSWR}=\frac{1+|\tau|}{1-|\tau|}$$

τ = Reflection Coefficient

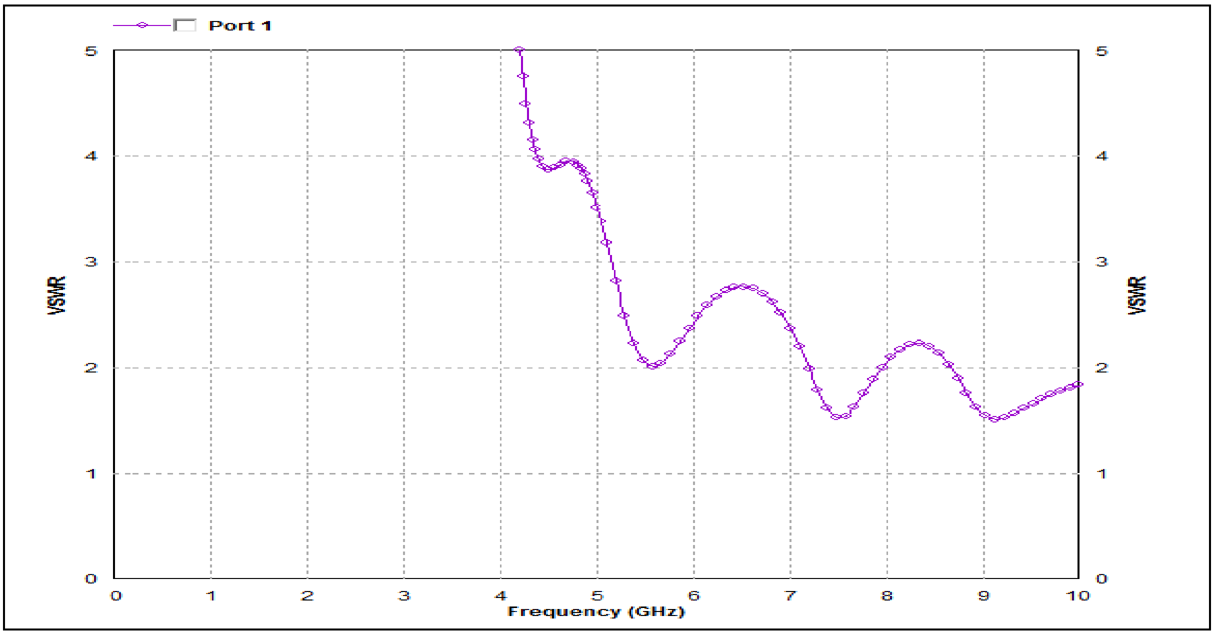

Figure 3: Graph of VSWR versus frequency

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3.3 CURRENT DISTRIBUTION

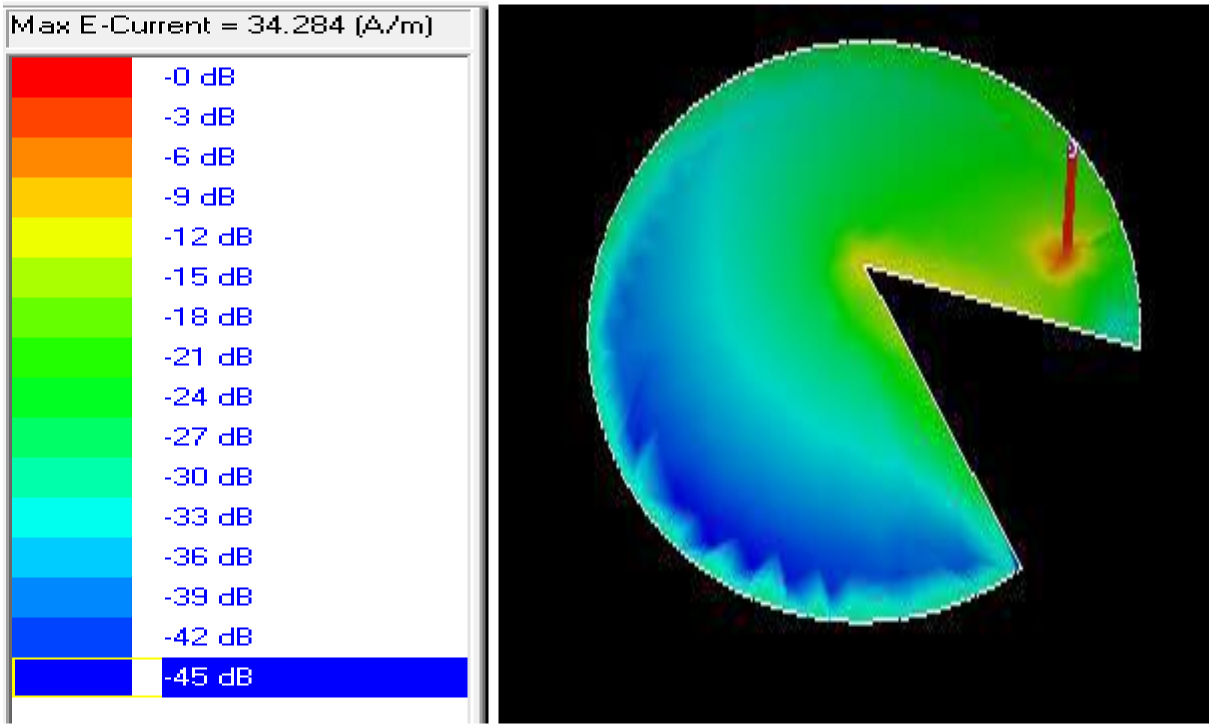
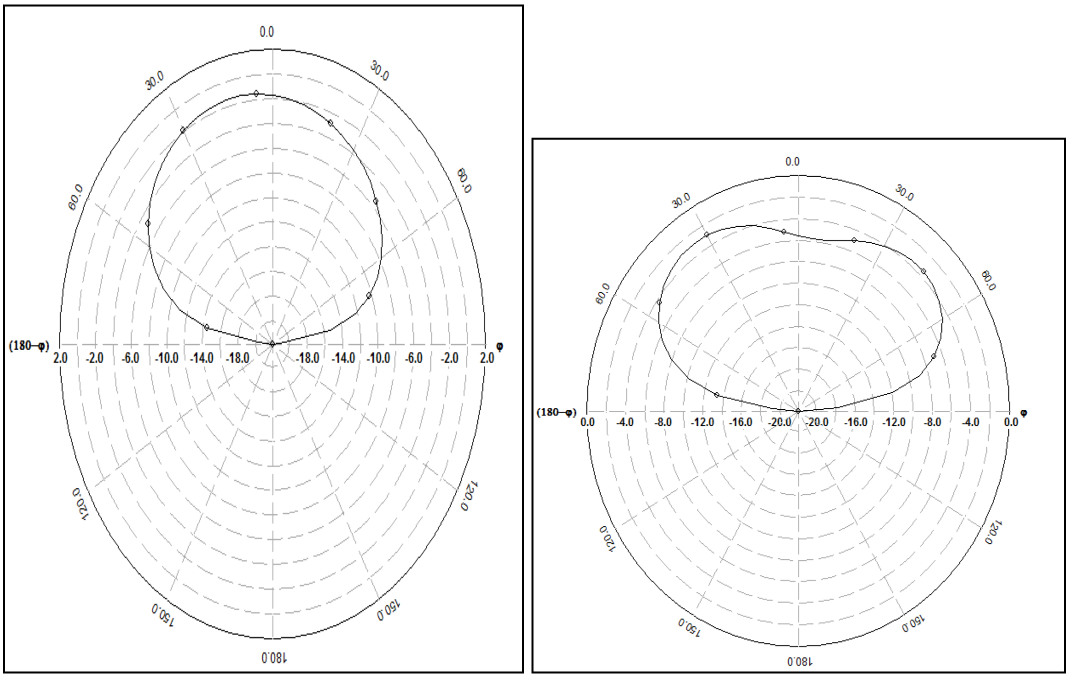


Figure 3: Current Distribution

3.4. POLAR PLOT

Polar plot depicts a pattern of lobes, which include the lobe having maximum intensity that is most commonly known as the principal lobe. It also consists of side lobes that are usually present in the undesired directions.



(a) **(b)**

Figure 4: Polar Plot for frequencies (a) 7.8GHz (b) 9GHz

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3.5 . 3-D DISTRIBUTION

Smith Charts are also used to depict the impedance of the antenna, which is measured by the Vector Network Analyzer (VNA).

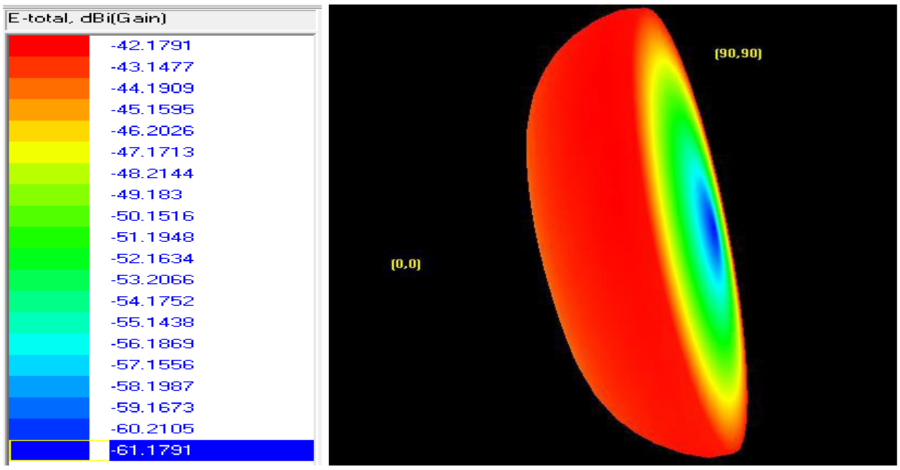

Figure 5: 3-D Distribution

IV. RESULT AND CONCLUSION

A Sectoral MSA has been designed, with FR4 substrate dielectric constant of which is 4.4. The optimization of parameters has been studied to observe their effect on resonance and radiation pattern. It can easily be inferred that the antenna resonates at two resonating frequencies, at 7.8GHz and 9GHz; hence it is termed as multiband antenna. Also, it can be observed that the VSWR value is not equal to 1, which implies that the antenna reflects a few of the incident waves.

Such antennas are widely used where multipath propagation environment is needed.

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