RES MILITARIS Social Science Journal

Design and analysis of Compact Microstrip Patch Antenna Design for wireless communication

Kirti Choudhary[1] and Namrata Sahayam[2]
[1]Research Scholar, Department of Electronics and Telecommunication Engineering, Jabalpur Engineering College, Jabalpur (M.P.) 482011
Email. Id: kirticho123@gmail.com
[2] Assistant Professor, Department of Electronics and Telecommunication Engineering, Jabalpur Engineering College, Jabalpur (M.P.) 482011
Email. Id: sahayam.namr@gmail.com

ABSTRACT-

Microstrip patch antennas plays an increasingly important role in today's wireless communication systems. There are many different types of antennas, some of which are folding dipole antennas, slot antennas, patch antennas and parabolic reflectors. We can say that antennas are the backbone of almost everything in wireless communication, without which the world could not have reached this era of technology, and there is a wide variety of applications in the current era of technology. The result obtained from this simulation is better than previous work. As a result, it can be used as a viable candidate for wireless technology. The results of this proposed antenna are better than the existing antenna. As a result, it is likely that this antenna will meet the needs of wireless communication systems.

KEYWORDS - Microstrip Patch Antenna; Wireless; Feeding Method.

1. INTRODUCTION

Microstrip patch antennas play an increasingly important role in current wireless communications systems. There are many different types of antennas, some of which are folding dipole antennas, slot antennas, patch antennas, and parabolic reflectors. Each type of antenna has its own characteristics as well as a particular application. We can say that antennas are the backbone of practically everything in wireless communication, without which the world could not have reached this era of technology and has a variety of applications in the current era of technology. Radio frequency (RF) and wireless communication technologies are now widely used in everyday human activities and in various industrial applications. Many wireless communication technologies have emerged in recent years, including wireless local area networks, wireless interoperability for microwave access, wireless broadband, etc. Microstrip patch antenna is suitable for the needs of RF communication system, and has poor gain, disordered radiation pattern and limited bandwidth.

Researchers and scientists are engaged in this topic due to the wide range of wireless applications. Many researchers have published the concept of microstrip patch antenna, which can be produced on printed circuit boards and is a new technology in electronics. These are extremely important in today's wireless communication systems. The word "antenna" is derived from the Latin word "antennae". The IEEE defines an antenna as "a component of a transmitting or receiving system designed to transmit or receive electromagnetic waves". It is extremely simple to fabricate a microstrip antenna using traditional microstrip manufacturing techniques. To design a compact microstrip patch antenna a substrate with high dielectric constant must be used, which will result in low efficiency. In the era of modern technology, fifth generation (5G) applications are increasing rapidly. It can provide many services, such as medical treatment and remote control of industrial equipment. It also improves the security of the society ensuring security and promotes economic development of the country. As we step into the fourth industrial revolution, the demands of people across the world have increased to a great extent which can only be met by 5G applications.

5G wireless communication system has become the most important part of our lives. Almost all the equipment in our daily life depends on it. The 4G system cannot meet the demand of people around the world due to its low speed, unstable connection, and loss of streaming capabilities. Whereas 5G is capable of providing higher speed, stable connection and higher bandwidth and most importantly, the transmission delay is much less than 4G. 5G networks will be used by industries and consumers for many purposes, especially in wireless devices.

2. LITERATURE SURVEY

B. Sahoo, N. Patnaik, A. Ravi, S. Behera, and B. B. Mangaraj (2020), Patch antennas have a very important function in the world of wireless communication networks that we live in today. The construction of the microstrip patch antenna is quite simple and it uses the microstrip fabrication method which is more commonly used. Patches can be configured in any imaginable way; However, rectangular and circular configurations are those that are used most often. These patch antennas are used in the simplest way for a wide range of applications which are also most demanding.

Irfansyah, B. B. Harianto, and N. Pambudiyatno (2021), This section discusses the technical work of various papers on microstrip patch antennas. In this article, a broadband elliptical-shaped slot antenna is proposed that can be used for future 5G wireless applications. **J. A. Al-Gburi, Z. Zakaria, I. M. Ibrahim, and E. B. A. Halim (2022),** The recommended antenna for 5G communications achieves broadband impedance bandwidth of greater than 67 percent (20 GHz to over 40 GHz) at an S11 value of less than -10 dB. The bandwidth achieved is enough to span both the upcoming 5G bands (28/38 GHz). The suggested antenna has a nearly omnidirectional pattern, relatively flat gain, and good radiation efficiency across the frequency band, with the exception of the band that will be rejected.

J. Colaco and R. Lohani (2020), different designs for rectangular microstrip antennas are presented. One of the specific frequencies for 5G communications is 28 GHz and all these antennas operate on that frequency. To achieve more accurate impedance matching, an array arrangement uses corporate feeding networks. This enhances performance factors such as return loss characteristics, impedance bandwidth, gain and radiation pattern. Other performance metrics that benefit from this are profit and directivity. In conclusion, this eight-element microstrip patch array that has been proposed with its modified corporate feeding is an excellent choice for potential future 5G applications.

Kaur and D. Parkash (2015), This article presents a dual-band printed slot antenna as a potential solution for future 5G mobile network infrastructure. The suggested antenna provides a nearly omnidirectional pattern, relatively flat gain, and good radiation efficiency across the entire frequency band, with the exception of the band that will be rejected. As the simulation results show, the suggested dual-band antenna shows dual-band response at both 28 and 38 GHz for 5G systems. An L-shaped slot is dug in the feed line to create a notched band in the frequency range of 30–35 GHz. This is done to limit the amount of interference that occurs between 5G systems and other applications. The dual-band antennas being considered have gains of up to 7 dBi, although there is a significant reduction in the notch-frequency band near 31 GHz. **M. A. Jiddney, M. Z. Mahmud, M. Rahman, L. C. Paul, and M. T. Islam (2020),** Antenna performance can be evaluated based on several important characteristics, including return loss, voltage standing wave ratio (VSWR), bandwidth, resonance frequency, and gain. A return loss of less than -10 dB is considered to be of outstanding value. The value range of VSWR is 1-2. CST Microwave Studio is a state-of-the-art software application that enables users to create and evaluate a variety of antennas, filters, and other types of devices.

M. Attaran (2021). For use in 5G communication applications, the study describes a high-gain linear 1×4 antenna array that is fabricated using a circular slotted patch. The suggested antenna is developed for a frequency of 28 GHz and is capable of supporting TM11 as a fundamental mode when tuned at resonance. The concept of the proposed antenna has been validated through the use of a vector network analyzer (VNA) and an anechoic chamber to characterize the prototype of the antenna. The suggested array antenna has a central frequency of 28 GHz, return loss of 16 dB, and impedance bandwidth of 10 dB spanning 10 percent of the millimeter-wave band between 24.6 and 27.24 GHz. **M. Ali, O. Haraz, S. Alshebeili, and A. Sebak (2016),** 3.5 GHz hexagonal microstrip patch antennas are designed and simulated. Four types of antennas, ranging from single elements to 1×8 arrays, were simulated using CST software. The proposed 1×8 array antenna has a microstrip feed line. Its directional radiation helps the base station provide high quality, high capacity network connectivity. This antenna is for long distance point-to-point connections. The final antenna had 6.938 dB gain and -10 dB return loss at 3.5 GHz. **M. S. Ibrahim (2018),** the antenna operates at 27.97 GHz and has directivity of 7.6 dB, bandwidth of 1.06 GHz, 7.5 dB and reflection coefficient of -20.95 dB. Also its efficiency is 99.98%. An investigation of the design of patch antennas for use in 5G wireless communication systems is provided here.

3. MICROSTRIP PATCH ANTENNA

In its most basic form, the microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate with a ground plane on the other side as shown in Figure 1. The patch is usually made of a conductive material such as copper or gold and can take any possible shape. The irradiated patches and feed lines are usually photoetched onto the dielectric substrate.

The most popular methods for analyzing patch microstrip antennas are the transmission line model, the cavity model, and the full wave model (mainly including the integral/transient method). The power line model is the simplest and provides a good physical understanding, but is less accurate. The advantages of microstrip antennas are small size, low profile and light weight, adaptable to flat and non-flat surfaces. It requires a very small volume of the structure during assembly. They are simple and inexpensive to manufacture using modern printed circuit technology. However, patch antennas do have drawbacks. The main disadvantages of microstrip antennas are: low efficiency, narrow bandwidth of less than 5%, low RF power due to small separation between the radiation patch and the ground plane (not suitable for high power applications. The model Cavity models are very accurate and provide good understanding of physics but are complex in nature. Full wave models are extremely accurate, versatile and can handle single elements, finite and infinite arrays, stacked elements, elements of arbitrary shape and intersections.

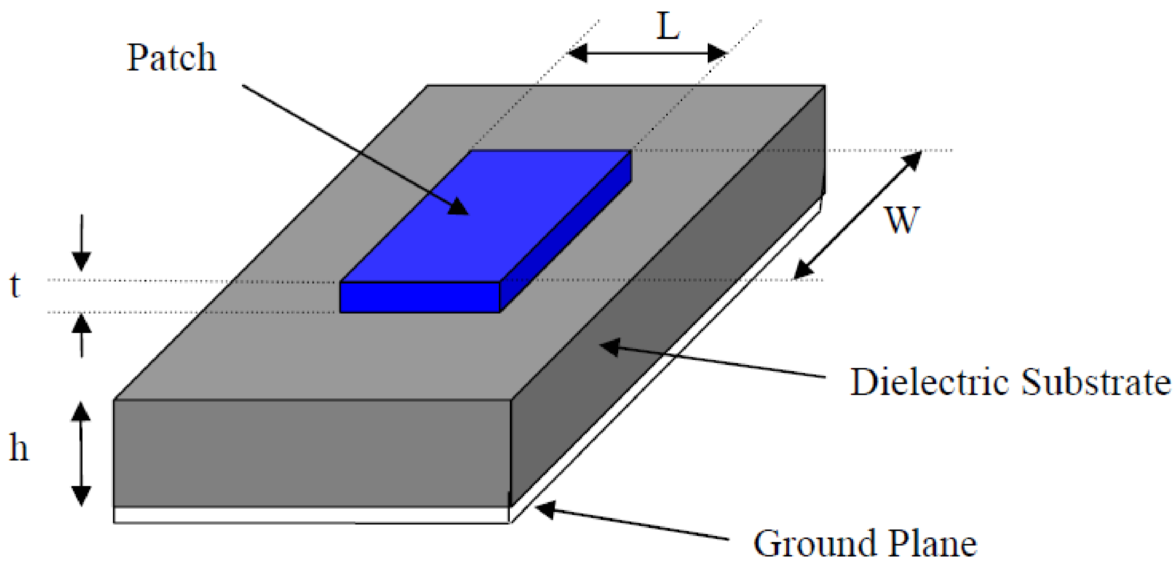

Figure 1. Structure of a Microstrip Patch Antenna

3.1. Radiation Pattern

The radiation pattern of an antenna is a plot of the far-field radiation properties of the antenna as a function of spatial coordinates specified by the elevation angle θ and azimuth angle φ. More specifically it is a plot of the power radiated from an antenna per unit solid angle which is nothing more than the radiation intensity. Let us consider the case of an isotropic antenna. An isotropic antenna is one that radiates equally in all directions. If the total power emitted by an isotropic antenna is P, then the power is spread over a sphere of radius r, so that the power density S over this distance in any direction is given by:

$$S = \frac{P}{area} = \frac{P}{4\pi r^2}$$

Then the radiation intensity for this isotropic antenna i U can be written as:

$$U_i = r^2 S = \frac{P}{4\pi}$$

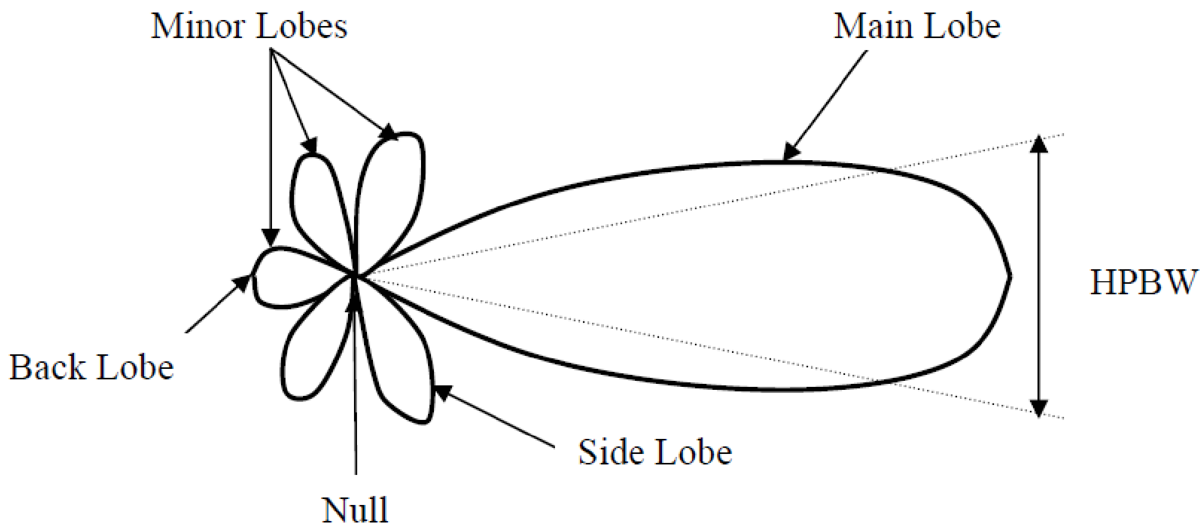

Figure 2. Radiation pattern of a generic directional antenna

3.2. Directivity

Antenna directivity is defined as "the ratio of the radiation intensity in a given direction from the antenna to the average radiation intensity in all directions". In other words, the directivity of a non-isotropic source is equal to the ratio of its radiation intensity in a given direction compared to that of an isotropic source.

$$D = \frac{U}{U_i} = \frac{4\pi U}{P}$$

Where

D is the directivity of the antenna
U is the radiation intensity of the antenna
i U is the radiation intensity of an isotropic source
P is the total power radiated

3.3. Return Loss (RL)

Return Loss (RL) is a parameter that indicates the amount of power that is "lost" due to the load and is not returned as reflection. As mentioned in the previous section, waves are reflected creating standing waves when the transmitter and antenna impedances do not match. Therefore RL is a parameter similar to VSWR that indicates how well matched there is between the transmitter and antenna. RL is given as:

$$RL = -20\log_{10}|\Gamma| \qquad \text{(dB)}$$

3.4. Antenna gain

Antenna gain is a parameter that is closely related to the directionality of the antenna. We know that directionality is how much energy an antenna concentrates in one direction while giving priority to radiation in other directions. Therefore, if the antenna is 100% efficient, the directionality will be equal to the antenna gain and the antenna will be an isotropic radiator. Since all antennas will radiate more in some direction than in others, gain is the amount of power that can be gained in one direction at the expense of power lost in the others. Gain is always relative to the main lobe and is specified in the direction of maximum radiation unless otherwise indicated. It is given as:

$$G(\theta,\phi) = e_{cd} D(\theta,\phi) \qquad \text{(dBi)}$$

3.5. POLARIZATIONS

Polarization of a radiated wave is defined as "the property of an electromagnetic wave that describes the changing direction and relative magnitude of the electric field vector with time". Polarization of the antenna refers to the polarization of the electric field vector of the radiated wave. In other words, the position and direction of the electric field with respect to the Earth's surface or ground determines the wave polarization. The most common types of polarization include linear (horizontal or vertical) and circular (right-handed polarization or left-handed polarization).

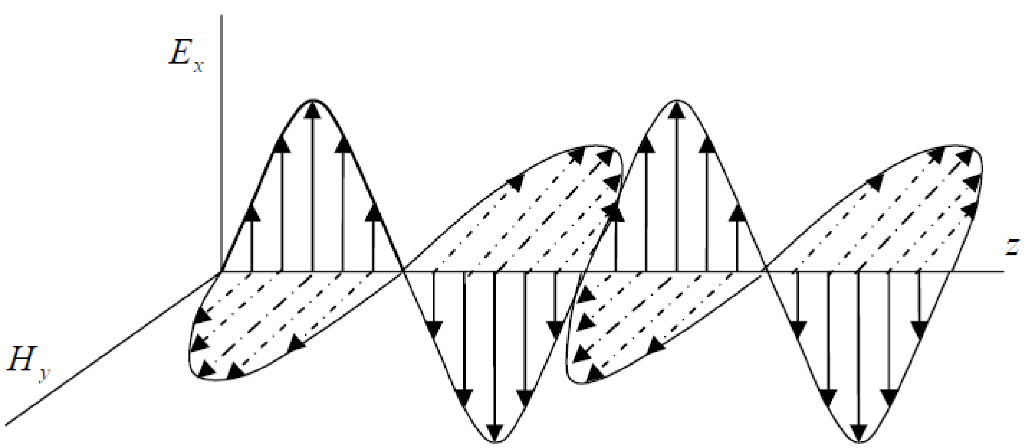

Figure 3. A linearly (vertically) polarized wave

4. PROPOSED MODAL

A conducting strip is attached directly to the edge of the microstrip patch. The conducting strip is smaller in width than the patch and the advantage of this type of feed arrangement is that the feed can be etched onto the same substrate to provide a flat structure. The purpose of the inset cut in the patch is to match the impedance of the feed line with that of the patch without the need for any additional matching element. This is achieved by precisely controlling the inset position. It is therefore a simpler feeding scheme, as it provides ease of substrate ground plane microstrip feed patch fabrication and modeling as well as simplicity in impedance matching. However as the thickness of the dielectric substrate being used increases, surface waves and spurious feed radiation also increase, which hinders the bandwidth of the antenna. The feed radiation also causes unwanted cross polarized radiation. The transmission line model is the simplest and gives good physical information but is less accurate. The microstrip patch antenna model is built using CST software for the requirements of wireless communication systems.

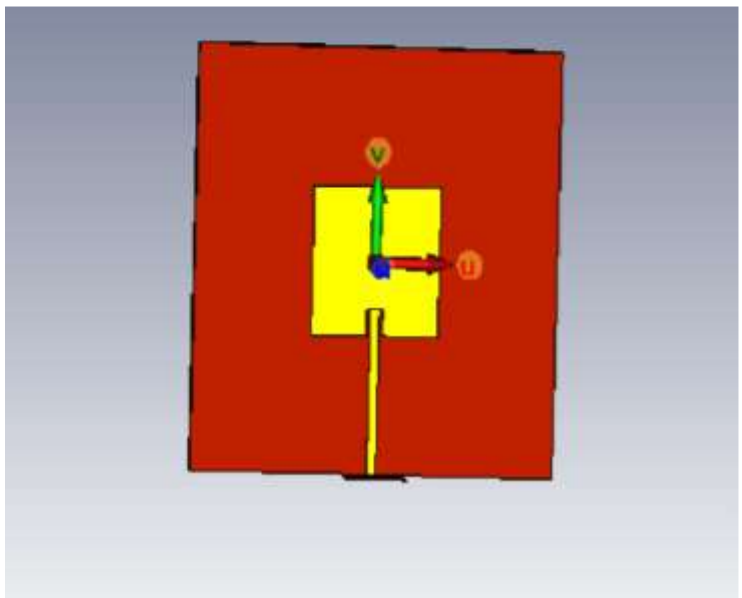

Figure 4. Geometry of microstrip patch antenna with strip

Name	Description	Magnitudes (mm)
S_1	Left solid slot	7
S_2	Right solid slot	7
S_3	Middle solid slot	11
S_4	Lower solid slot	12
L_1	Length of ground	20
L_2	Length of aperture	14
W_1	Width of ground	20
W_2	Width of aperture	14
d	Distance b/w slots	1

5. RESULTS AND DISCUSSION

11.1 Left solid slot (S_1= 6mm) and Right solid slot (S_2= 6mm)

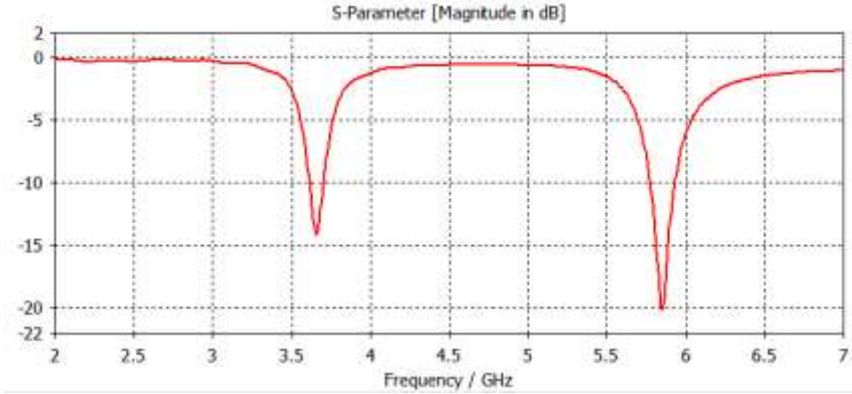

Figure 5. S-Parameter, the return losses are -14 dB and -20 dB.

11.2 Left solid slot (S_1= 8mm) and Right solid slot (S_2= 8mm)

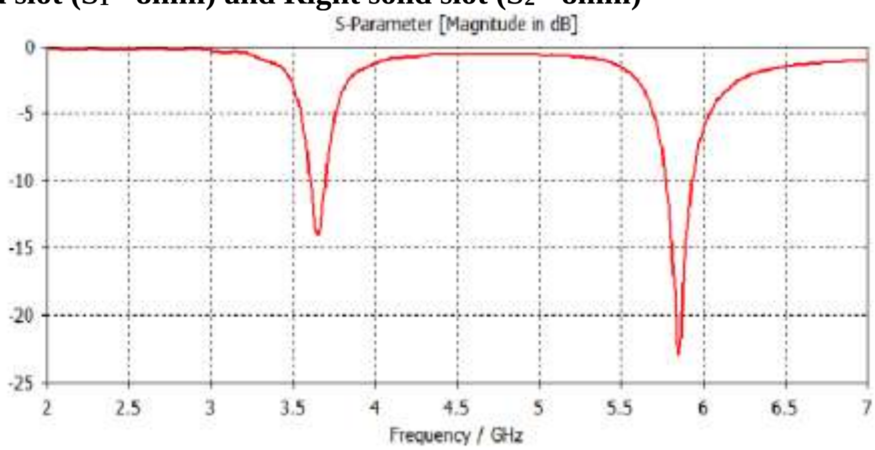

Figure 6. S-Parameter, the return losses are -14 dB and -23 dB.

11.3 Left solid slot (S_1= 7mm) and Right solid slot (S_2= 7mm)

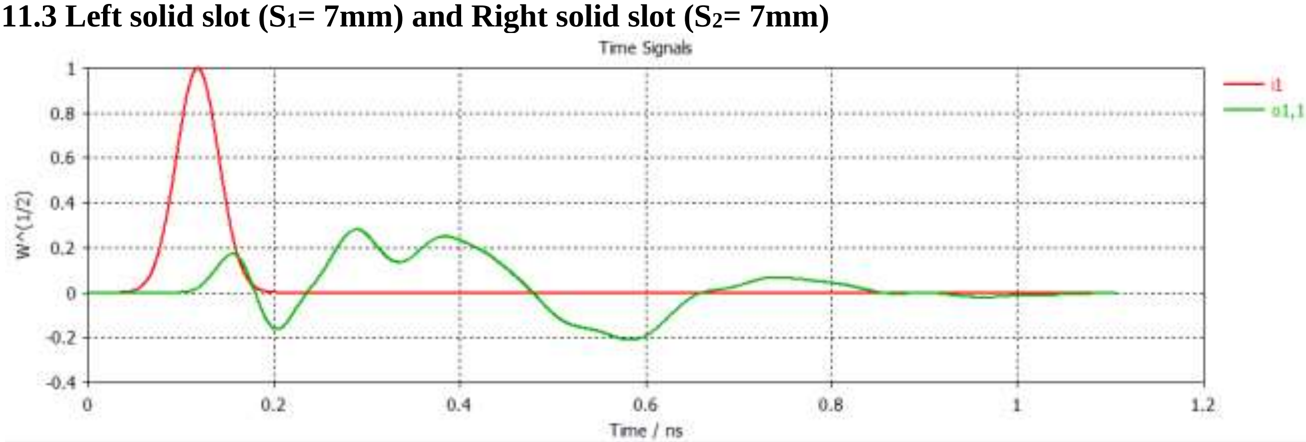

Figure 7. Time Signals

The former S_11 is also known as the reflection coefficient. In practice, the most commonly cited parameter regarding antennas is S11. S11 represents how much power is reflected from the antenna, and so is known as the reflection coefficient (sometimes written as gamma: or return loss. If S11=0 dB, then all the power is reflected back to the antenna. is transmitted, reflected from, and nothing else) is radiated. Since the s-parameter is a ratio of electric power (precisely, a square root of electric power), it is essentially a non-dimensional parameter (no units). However, when describing the magnitude of the S-parameter, the unit "dB" is usually used along with a common logarithm *1.

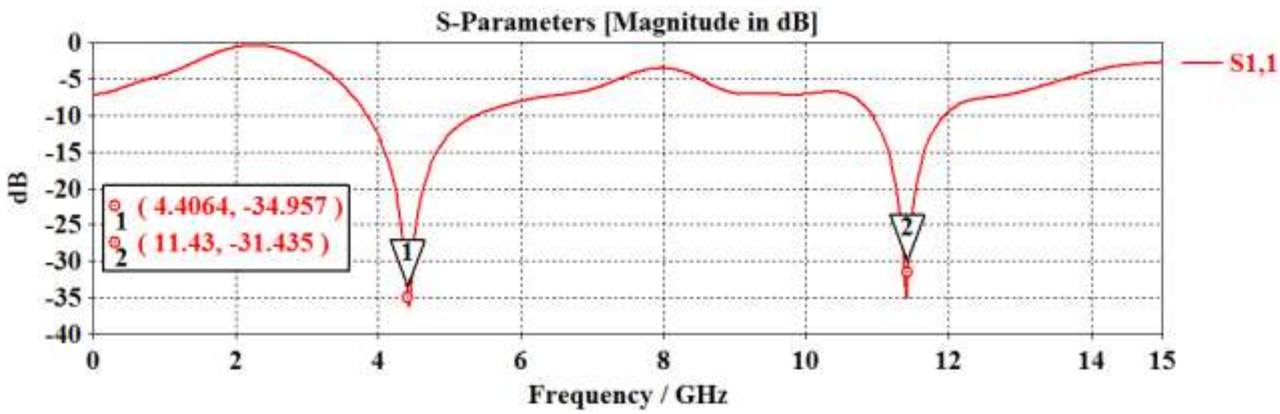

Figure 8. S-Parameter (S-parameters are a way of expressing things with normal waveforms instead of voltages and currents. It tells how many waves are reflected or transmitted from/through a device. With a device like an antenna, there are not just 1 but 4 S-parameters.)

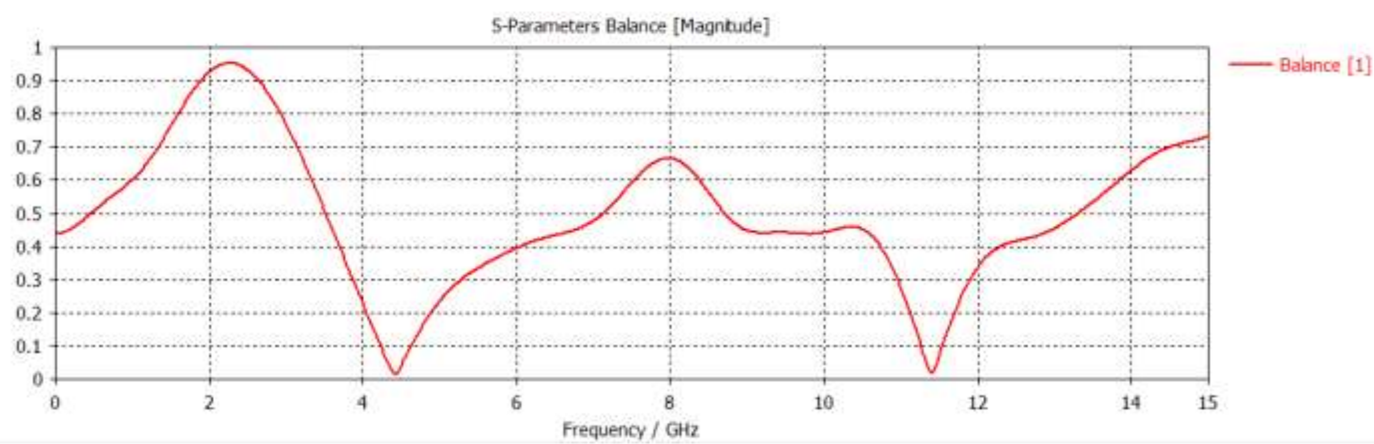

Figure 9. S-Parameter Balance

The radiated power per unit area multiplies the Planck energy density by c/4. It can be estimated numerically by multiplying the sum of the Planck radiation density values by the wavelength interval. The region where the electromagnetic field begins to transition from reactive to radiative is called the radiative near-field region or Fresnel region.

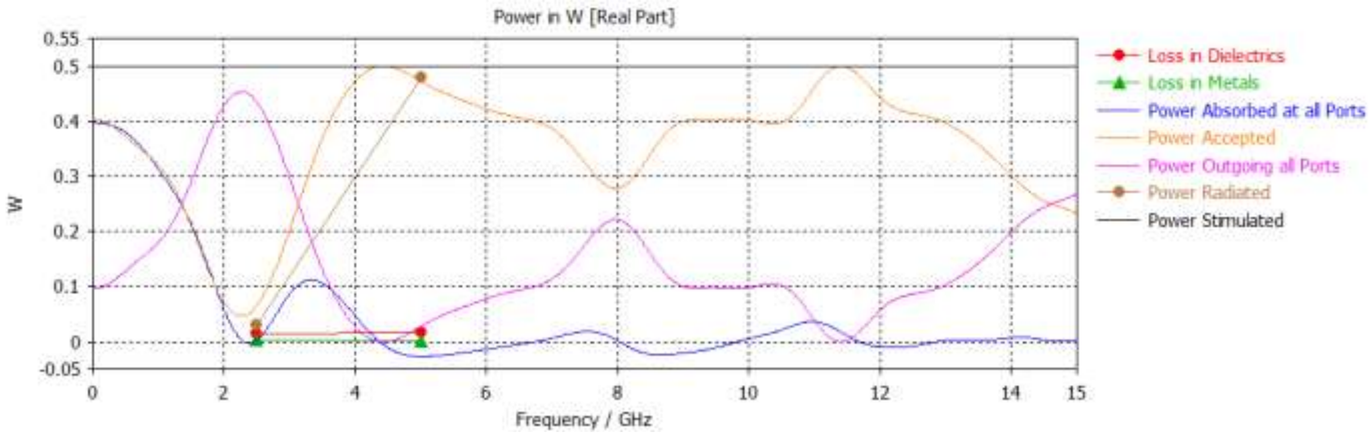

Figure 10. Power (W) A power antenna is an electric motor-driven automotive radio antenna that raises and lowers manually or automatically by turning the radio on or off with a dash-mounted switch. The automatic type will also dim when the ignition switch is off.

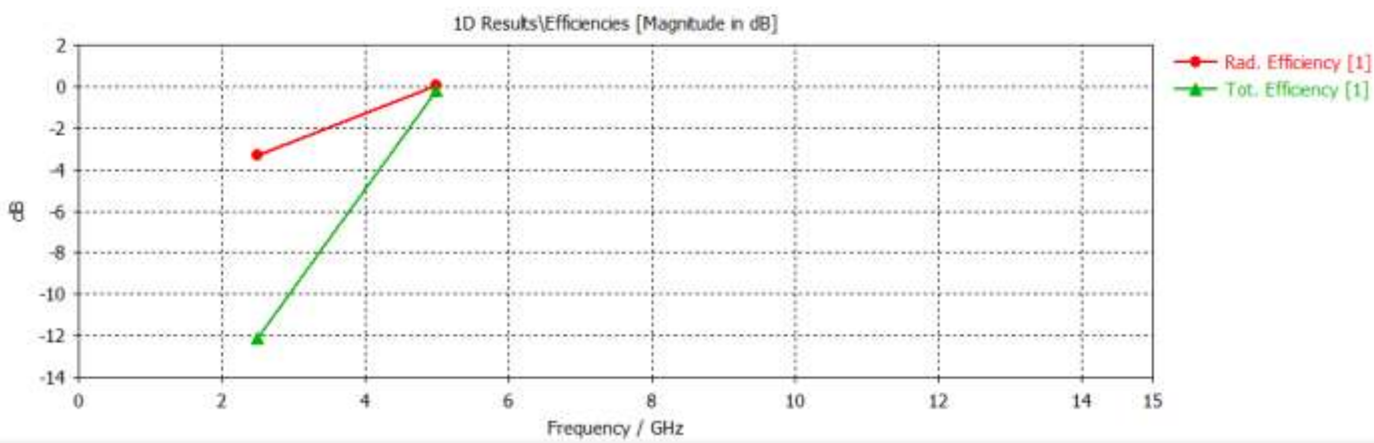

Figure 11. Efficiencies (Antenna efficiency is a parameter that takes into account the amount of losses at the antenna terminals and within the antenna structure.)

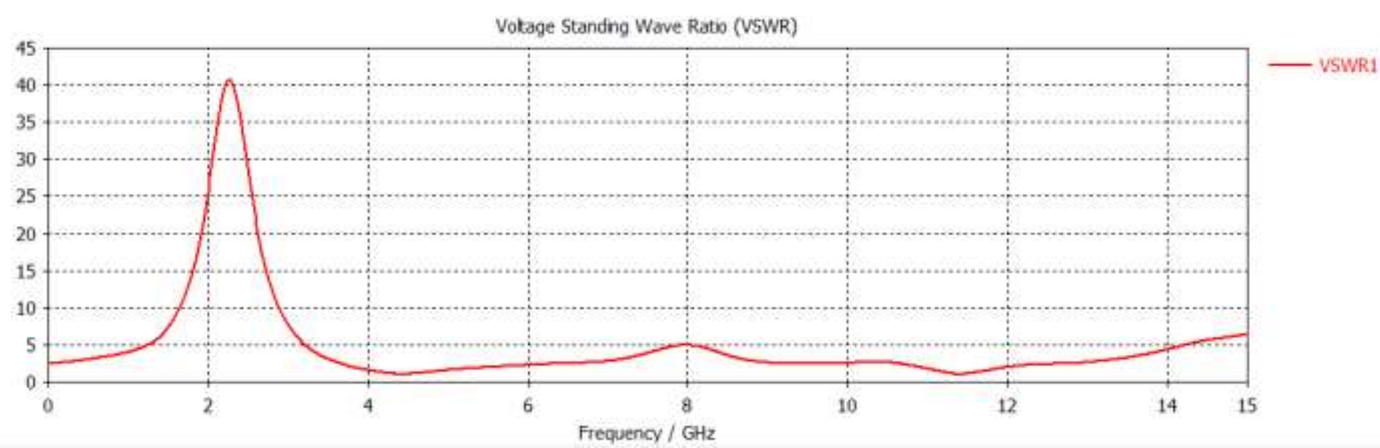

Figure 12. VSWR (VSWR is basically a measure of the impedance mismatch between the transmitter and antenna. The higher the VSWR, the greater the mismatch. The minimum VSWR

that corresponds to a perfect match is unity. A practical antenna design should have an input impedance of 50 Ω or 75 Ω as most radio equipment is built for this impedance.)

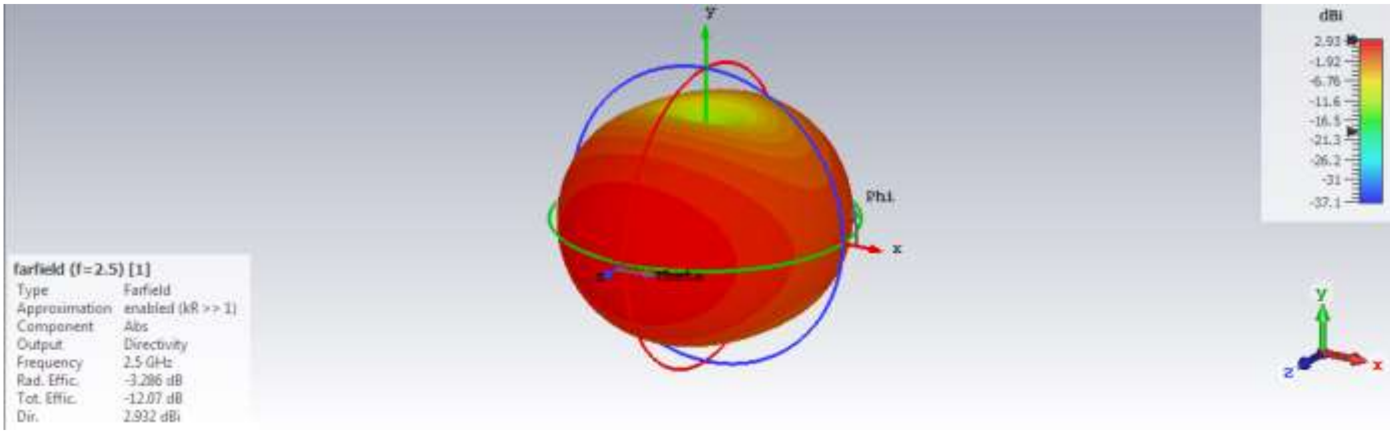

Figure .13. Farfields, one band (A simple formula based on transmission-line-model analysis has been developed to express the far field radiated by a rectangular microstrip patch. Through the volume equivalence theorem, electric and polarization current distributions are introduced. Literal formulas are presented specifically to express the e-plane radiation pattern and the worst-case cross polarization level.)

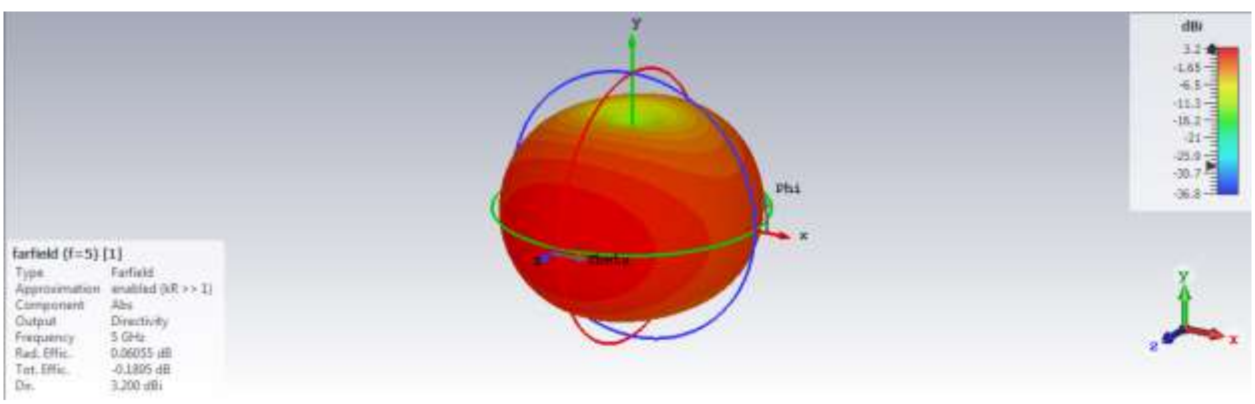

Figure .11. Far fields, other band

6. CONCLUSIONS

The simulated results demonstrate that the proposed antenna can be a good competitor for wireless communication systems. It can be built in the future to compare real results with simulated results. Figure 5. shows S-Parameter, the return losses are -14 dB and -20 dB using Left solid slot (S_1= 6mm) and Right solid slot (S_2= 6mm). Figure 6. shows S-Parameter, the return losses are -14 dB and -23 dB using Left solid slot (S_1= 8mm) and Right solid slot (S_2= 8mm). Figure 8. shows S-Parameter, the return losses are -34.957 dB and -31.435 dB using Left solid slot (S_1= 7mm) and Right solid slot (S_2= 7mm) and the maximum efficiencies was improved as 59.95% and 36.77%.

7. FUTURE SCOPE

A further enhancement is possible using various methods such as circular and ring-type array patches. Future research may use different approaches and materials to produce good results. The simulated results show that the proposed antenna can be a good contender for wireless communication systems. This can be used in the future to compare actual results with simulated results.

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