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Design & Analysis of WLAN Microstrip Patch Antenna

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***Abstract*— In the work, a microstrip patch antenna with the name slotted patch-defected ground is designed with an operating frequency of 5.75 GHz. This antenna is then analyzed on factors such as VSWR, Return Loss, Impendence, and efficiency. These factors are compared to antennas with operating frequencies of 1.8 GHz and 2.45 GHz using a piece of software called the High Function Structure Simulator. Because of its compact size and affordable price, the suggested antenna has potential uses in a variety of industries, including mobile and satellite communication, global positioning systems (GPS), and radio frequency identification (RFID) technologies.**

Keywords—; HFSS, Microstrip Patch Antenna, Return Loss

I. Introduction

It has become clear that the ability to communicate is the characteristic that is most critical to the survival of all social organisms. Prior to the creation of various pieces of technology, the majority of human interaction consisted of people speaking to one another using their voices. However, when people started moving to other regions of the globe for a number of reasons, that mode of communication progressively became outdated and was eventually phased out completely. Because of this, the need for the development of technologies that enable us to connect wirelessly and in a convenient way arose as a consequence of the need to meet this demand. Antennas are one kind of technologies that fall within this category.

The present trend in communication devices of miniaturizing the item in question is essential if one wishes to achieve better levels of efficiency and mobility while maintaining (or even enhancing) the device's capacity for processing information. This tendency emerged as a direct result of the ongoing trend toward miniaturization in the world of communication devices.
[4]

Antennas that are capable of concurrently operating at many frequencies and bandwidths have garnered much more attention as a result of recent advancements in wireless communication technology. In some applications, the antenna must be able to operate on two or more frequencies that are quite far apart from one another. It is not feasible to build an antenna that has such a high bandwidth in order to serve these applications since the spacing between the bands is so enormous. In addition, even if we were to be successful in acquiring the appropriate bandwidth, we would still be outputting power in a frequency range that we do not intend to make use of, and the system might be susceptible to interference as a result of this. We may either utilize narrowband antennas that are tailored to the requirements of each application, or we can make use of a single antenna that is capable of functioning as a multi-band antenna. Both of these solutions are available to us as potential solutions to this problem. There have been a number of research articles that have offered the ways that may be used to acquire multi band antennas. These publications have been found online. They have shown a number of different designs that are conceivable for a multi band microstrip antenna depending on the different uses. [5]

The microstrip patch antenna is the kind of antenna that is used in wireless applications the most often because of its low profile, conformability to both planar and non-planar surfaces, and simplicity of manufacture. Additionally, it is the most common type of antenna used. In this particular antenna, the patch and ground regions are situated on opposing sides of the dielectric substrate. During the examination of the physical and radiation consequences, the substrate of the antenna is something that has to be taken into consideration. Selecting the optimal substrate for a certain application may have a beneficial impact on not only the performance but also the functionality. The patch on the antenna is made up of conducting materials, and these materials may be fashioned into a number of different patterns. Some of these patterns include squares, rectangles, dipoles, circular rings, elliptical rings, and triangular circular rings. The square patch was developed because of the simplicity of its form as well as the convenience with which it could be manufactured. In order to construct the feed and patch on the substrate of the antenna, photo etching is commonly used as the method of choice. In order to successfully produce the microstrip patch antenna, it is necessary to fulfill the criteria of the kind of substrate, the feeding mechanism, the patch size, and the patch shape. [6] As a result of the recent revolution in electronic circuits, antenna designers have been put under a great deal of pressure to produce radiating structures that are small, lightweight, and affordable. As a result of this need, a variety of alternative antenna configurations have been created, one of which, the printed microstrip antenna, has attracted a considerable amount of attention in the recent years. Because of their low profile and conformable construction, they are often used as embedded antennas in portable wireless devices and military equipment. Extensive research is necessary, however, in order to solve the inherent limitations of this antenna, such as its limited power capacity, narrow bandwidth, low efficiency, spurious feed radiation, and poor polarization purity. The following are some of the aspects that are taken into account throughout the process of choosing different components for an antenna when it is being designed: Microstrip antennas may be formed into a wide range of geometries, including but not limited to rectangular, circular, triangular, annular, and other patch topologies. This is possible because of the strip's ability to be cut into narrow strips. [7] In this day and age of digital technology, it is essential for the communication systems that are in use today to make use of antennas that are compact, interoperable, and affordable. In order to transform electromagnetic waves into electrical waves and then electrical waves back into electromagnetic waves, an electric inducer called an antenna is employed. Antennas may also be used to convert electrical waves into electromagnetic waves when properly configured. When the current that is flowing through the conductor of an antenna is changed, for example by increasing or decreasing the amount of current that is flowing through a straight wire, the antenna will start to emit electromagnetic waves. As a consequence of this, the conductor will eventually develop a discontinuity, which will ultimately result in the antenna emitting radiation. Microstrip patch antennas have a number of advantages over traditional antennas, including the fact that they are less difficult to fabricate, that they conform to standards, that they have a lower profile, that they are less bulky, that they have smaller dimensions, that they weigh less, and that they save money. Because of its compact size and flat construction, microstrips may be used in a broad number of applications. Radars, telemetry, navigation, radio frequency identification (RFID), biomedical systems, mobile and satellite communications, missile systems, global positioning system (GPS) for remote sensing, and other applications are some examples of these kinds of uses. An MPA layout that is reflective of a general design would typically include the patch, the substrate, and the ground plane as its principal components, respectively. [8]

The contemporary industry of communications has established its domination across all fronts, most notably in the field of printed antennas, which has become the industry standard. This is made feasible by the low profile of these antennas, as well as their compatibility with monolithic microwave integrated circuits (MMIC), their light weight, and the reasonable price that they are offered for. As a direct result of this, the microstrip patch antenna has become well-known as being one of the most innovative and fruitful developments in the area of small-scale microwave systems. This is due to the fact that it has been able to successfully improve the performance of these systems. A microstrip patch antenna is made up almost entirely of a radiating patch made of metal that is grafted onto a dielectric substrate that is grounded. This patch is what provides the antenna with its structure so it can function properly. [9]

The microstrip patch antenna is a component that fulfills a role that is of the utmost significance in the field of wireless communication. A ground plane, a ground plane dielectric, and a metallic patch made of copper or gold are the components that make up this part. In the region between the patch and the ground plane, there is a boundary that provides isolation from the dielectric substrate. Patch antennas are available in a wide range of forms and shapes, including circular, rectangular, square, elliptical, triangular, and dipole variants, among others. The most common configurations for microstrip antennas are circular and rectangular shapes, with circular being the second most common. The two patch antennas in issue have the applications that provide the greatest amount of difficulty, notably those that are associated with 5G. [12] Microstrip patch antennas are of the utmost importance in the field of wireless communication systems due to their bandwidth, versatility, ability to operate across several bands, and compact dimensions. This is because of the fact that microstrip patch antennas can operate across multiple bands. They are essential components in wireless communication because to the advantages they provide, which include a cheap manufacturing cost, a small size, the fact that they are lightweight, and the ease with which they may be integrated into microwave circuits. Microstrip Patch antennas are well-known for their high efficiency, minimal return loss, and directed emission patterns. Patch antennas are often made of copper or aluminium. Patch antennas are capable of simultaneously functioning in two or more frequency bands.[16]

II. Previous Work

M. S. Rana et al. [1] The objective of this project is to develop and conduct research on a Microstrip Patch Antenna in order to prepare for its use in the next generation of wireless communication technology that utilises a frequency of 2.4 GHz.

K. R. Prabha et al. [2] In this work, the design and analysis of microstrip patch antennas for use in wireless communication applications that operate in the sub-6GHz frequency spectrum are provided. These antennas are intended for use in applications where the frequency range is less than 6GHz.

L. C. Paul et al. [3] An directional wideband microstrip line fed rectangular patch antenna is one design option for an antenna that might be used for 5G applications that operate at 28 GHz.

M. F. Rafdzi et al. [4] In this specific piece of study, there is a suggestion made on the use of a microstrip patch antenna as a means of achieving 5G broadband wireless communication.

R. Kumar et al. [5] A design for a tri band microstrip patch antenna as well as a simulation of the antenna is presented in this paper.

D. S. Kumar et al. [6] In order to improve the functionality of the antenna, the authors of this study create a patch antenna in

the shape of a square and use a particular kind of material for the substrate.
F. Atalah et al. [7] The design, simulation, building, and testing of a ground-fed circular patch antenna is presented in this article. The antenna has a shape that is round.
A. A. Bhoot et al. [8] The purpose of this article is to give a comparative analysis of the performance of four distinct forms of antennas with regard to their respective shapes.
H. Chemkha et al. [9] The usage of the electromagnetic simulator HFSS is the primary subject of this investigation, which is centered on the building of a rectangular microstrip patch antenna. R. Parikh et al. undertook the research so that they could report their results after they were finished. [10] Constructing a rectangular microstrip patch antenna that is capable of resonating at 2.48 gigahertz is the purpose of this study.
P. Reis et al. [11] The development of a tiny microstrip patch antenna that may be used for wireless applications such as Wi-Fi, WiMax, WLAN, and Satellite Communication is the major purpose of this work.
J. Colaco et al. [12] For the purpose of providing high-quality online education as well as other 5G applications that make use of 5G millimeter wave bands, the authors of this research study developed a microstrip patch antenna with a resonance frequency of 26 GHz.
R. Jyosthna and colleagues [13] The microstrip patch antenna, which is intended for use in space applications, is modelled and developed as part of the scope of this project. The operating frequency for the antenna is in the extremely high frequency (EHF) category and is 31.5 gigahertz.
M. T. Khan et al. [14] In this work, we describe a microstrip patch antenna that is capable of detecting and recognizing water content, despite its small size and microstrip form factor.
T. Kshitija et al. [15] The purpose of this investigation is to investigate the feasibility of constructing a microstrip rectangular patch antenna and to evaluate the effectiveness of the antenna with respect to a number of distinct methods of providing its power supply.
K. Anusury and the other individuals. [16] This article discusses how a patch antenna may be constructed to function in a variety of different wireless applications.
N. H. Biddut et al. [17] An ultra-wide multi-slotted microstrip patch antenna is what the author of this paper recommends should be used in the subsequent generation of wireless communication technologies. The V band is where this antenna will function best.
Talkder et al. [18] This paper presents the findings of a simulation study that was out using HFSS on an E-shaped slotted Microstrip patch antenna in order to investigate its potential use in 5G, GPS, and WiMAX/WLAN applications. This research was carried out in order to investigate its potential use in 5G, GPS, and WiMAX/WLAN applications.

III. IMPLEMENTATION

Small and tiny antennas, which allow digital devices to be carried about easily, are the most vital component of digital communication. Consequently, we used the HFSS programme to construct a microstrip patch antenna. A step slotted patch has been included into the antenna in order to both improve its overall performance and reduce the overall size of the antenna. Additionally, drastically lower ground planes contribute to a gain in bandwidth.

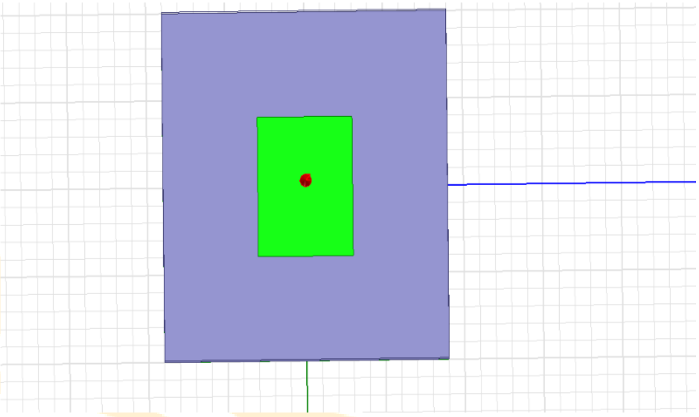

Figure 1: 2.45GHz Design of Micro strip patch antenna

Within the HFSS programme, figures 2 and 3 illustrate the planned antenna layout and design. Components of the microstrip patch antenna include the dielectric substrate, which is a Rogers RT/duroid with a r value of 6.15, and the conducting ground plane, which is built out of copper.

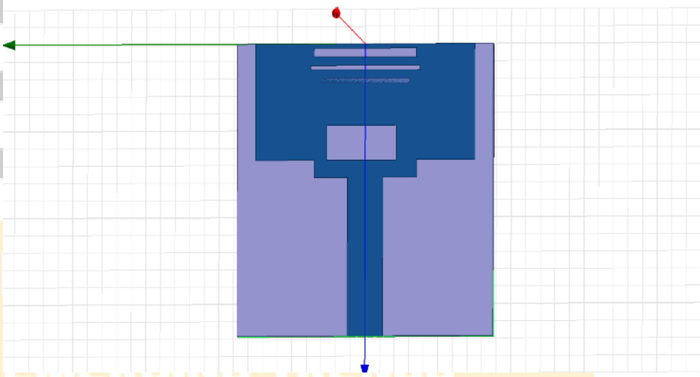

Figure 2: HFSS design of slotted patch

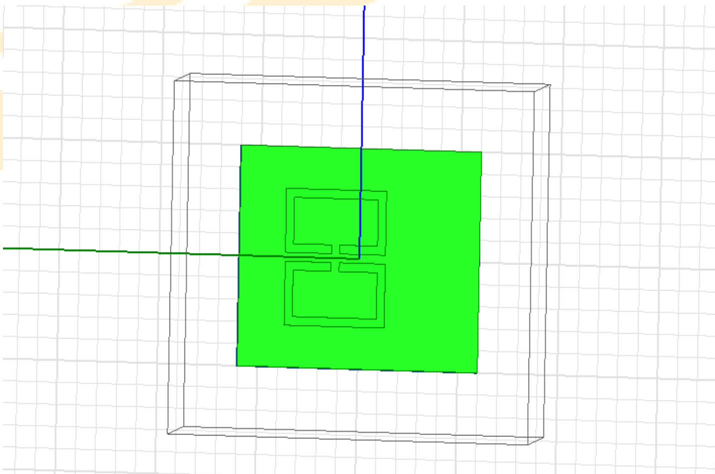

Figure 3: HFSS view of defected ground

IV. Result

The 1.8 GHz, 2.45 GHz, and 5.75 GHz antennas have all been simulated in the HFSS programme and studied with various parameter values. These parameter values include radiation pattern, VSWR, and return loss.

Radiation Pattern

Radiation is the word that is used to express the emission or receipt of wave front at the antenna, and it is used to define the intensity of the wave front. The drawing that is produced to illustrate the radiation of an antenna is referred to as its radiation pattern, and this picture may be used in any representation. By observing the radiation pattern of an antenna, one may quickly get an understanding of both its function and its degree of directivity.

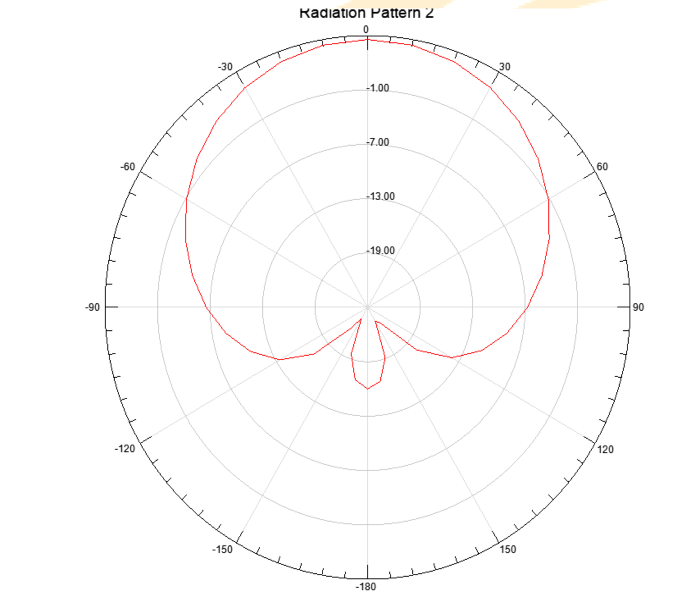

Figure 4: 5.75 GHz Radiation Pattern Polar Plot

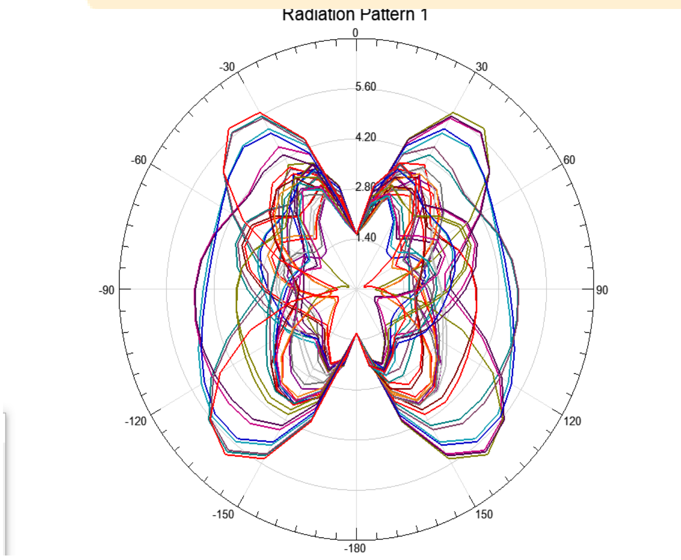

Figure 5: 2.45 GHz Radiation Pattern Polar Plot

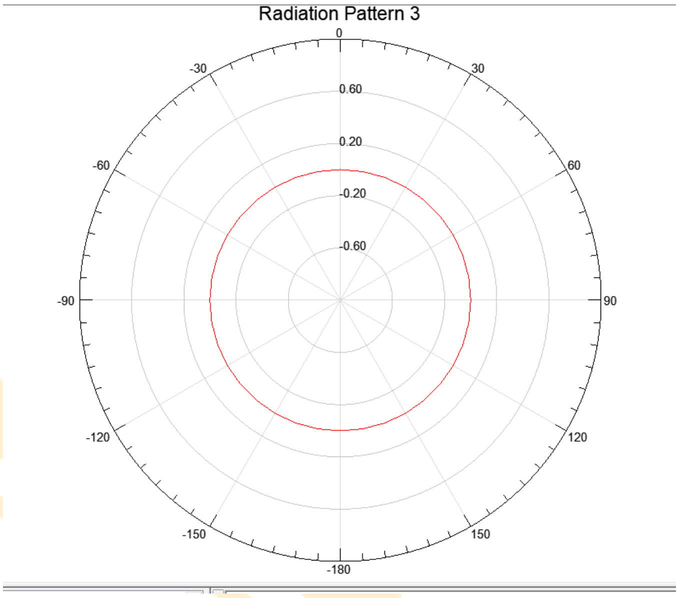

Figure 6: 1.8 GHz Radiation Pattern Polar Plot

The radiation pattern for each of the three antennas is shown in Figure 4, Figure 5, and Figure 6, respectively.

Return Loss

Return Loss is a figure that reflects the proportion of radio waves that are rejected by an antenna as they arrive at the antenna input as a ratio to the number of radio waves that are accepted by the antenna. This value is expressed as a percentage. This is evaluated as a percentage in relation to the whole quantity of radio waves that are permitted. In contrast to a short circuit, which represents a rejection rate of one hundred percent, it is expressed as a decibel (dB) measurement.

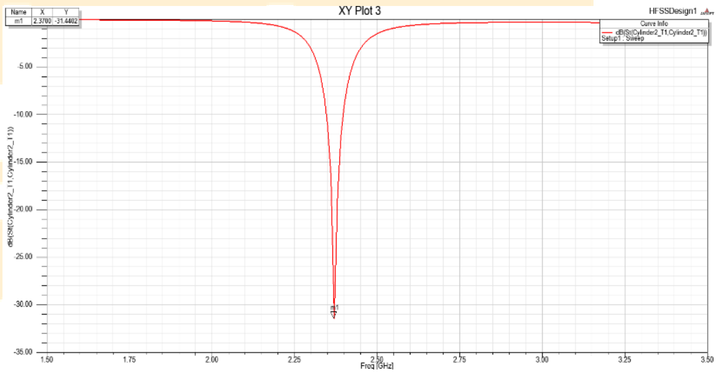

Figure 7: 2.45 GHz Frequency vs Return Loss Graph

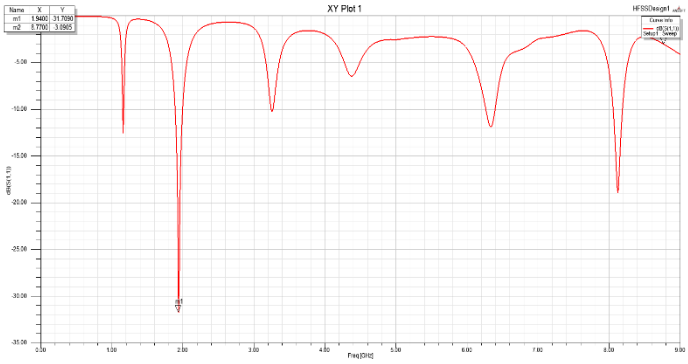

Figure 8: 5.75 GHz Frequency vs Return Loss Graph

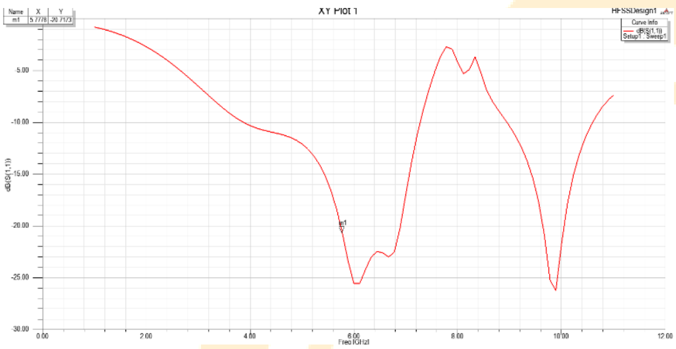

Figure 9: 1.8 GHz Frequency vs Return Loss Graph

The relationship between frequency and return loss is shown in Figure 8, Figure 9, and Figure 10, respectively, for all three antennas.

VSWR

The degree of mismatch that exists between an antenna and the feed line that is connected to it may be measured using a metric called the Voltage Standing Wave Ratio (VSWR). Another name for this concept is the Standing Wave Ratio (SWR). From 1 to ∞ is the range of possible values for the value of VSWR. A value of VSWR that is less than 2 is deemed appropriate for the majority of antenna applications.

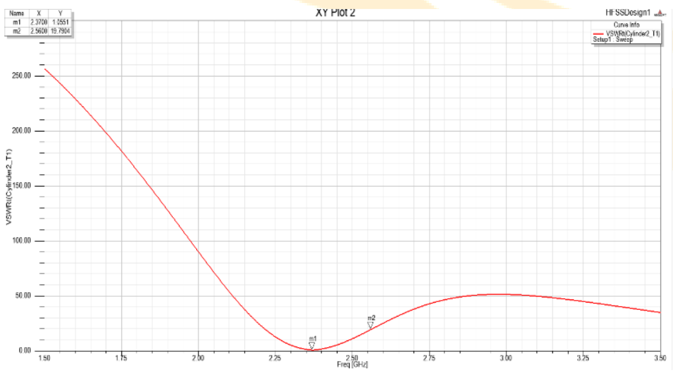

Figure 10: 2.45 GHz VSWR Graph

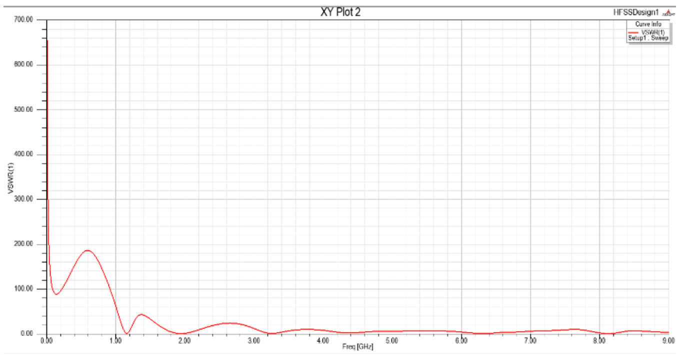

Figure 11: 5.75 GHz VSWR Graph

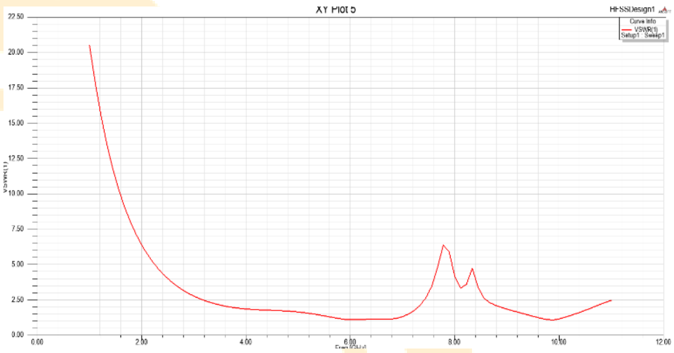

Figure 12: 1.8 GHz VSWR Graph

Figure 10, Figure 11 and Figure 12 shows the VSWR for all the three antennas

Efficiency

The ratio of the amount of power radiated (Prad) by an antenna to the amount of power that is provided (Ps) to the antenna is referred to as the antenna's efficiency.
All of the antennas that were modelled in the HFSS programme achieved the highest possible levels of effectiveness while also producing satisfactory outcomes..

V. CONCLUSION

Microstrip patch antennas with operating frequencies of 1.8 GHz, 2.45 GHz, and 5.75 GHz have been designed with the help of the High Function Structure Simulator software. These antennas have also been subjected to an analysis that takes into account a variety of physical parameters, including Radiation Parameter, Return Loss, VSWR, and Efficiency. The slotted patch and defective ground were used into the design of the antennas in order to lower their overall size while simultaneously improving their bandwidth and efficiency. Due to the antennas' compact size and affordable price, they are suitable for usage in a wide variety of applications, including RFID and GPS technologies.

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