

WIDEBAND DIRECTIONAL PATCH ANTENNA DESIGN FOR 2GHzBAND WIRELESS APPLICATIONS

Submitted in partial fulfilment of the requirements for the award of
Bachelor of Engineering degree in Electronics and Communication Engineering

By

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

SCHOOL OF ELECTRONICS

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

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APRIL-2023



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **SEGU SREEHARI (39130408)** and **G.S.V. SUBRAMANYAM (3913044)** who carried out the project entitled **"AWIDE BAND DIRECTIONAL PATCH ANTENNA DESIGN FOR 2GHz WIRELSS APPLICATIONS"** under our supervision from November 2022 to April 2023.

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DECLARATION

We, **SEGU SREEHARI (39130408)** and **G.S.V. SUBRAMANYAM (39130444)** and hereby declare that the Project Report entitled “**Wideband Directional Patch Antenna Design for 2GHz band wireless Applications**” done by us under the guidance of **Dr. M. SUGADEV, M Tech, Ph D**, Associate professor, Dept. of Electronics and Communication Engineering, SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY, CHENNAI, is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in **Electronics and Communication Engineering**.

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2. 

ACKNOWLEDGEMENT

We pleased to acknowledge our sincere thanks to the **Board of Management** of **SATHYABAMA** for their kind encouragement in doing this project and for completing it successfully. We grateful to them.

We convey our thanks to **Dr. N. M. NANDHITHA, M.E., Ph.D. Dean**, School of Electronics and **Dr. T. RAVI, M.E., Ph.D.** Head of the Department, Department of Electronics and Communication Engineering for providing us necessary support and details at the right time during the progressive reviews.

We would like to express my sincere and deep sense of gratitude to our Project Guide **Dr. M. SUGADEV, MTech., Ph.D.**, Associate professor, Dept. of Electronics and Communication Engineering, for his valuable guidance, suggestions and constant encouragement for the successful completion of our project work.

We wish to express our thanks to all Teaching and Non-teaching staff members of the **Department of Electronics and Communication Engineering** who they are helpful in many ways for the completion of the project.

ABSTRACT

The huge demand of the modern wireless communication systems has led to the employment of microstrip patch antenna since they are compact, minimal height and inexpensive. The advancement in printed circuit board technology has allotted the fabrication of microstrip patch antenna on a flat surface to be easily realized. The potential applications attracted the attention of many researchers and industry operators in the area of communication engineering to embrace the design and analysis of various shapes of microstrip patch antenna in order to improve several characteristics of the antenna.

In general, Microstrip Antenna has basically two main parts. It consists of a ground plane that supports the radiating part. Microstrip patch antenna has many advantages like easy fabrication, low cost, small size, and high efficiency but has narrow bandwidth and omni-directional characteristics. In this work, we are proposing the design and simulation of a wideband, directional patch antenna for 2GHz band applications.

The objective of the work is to enhance vital antenna parameters such as gain and bandwidth and to reduce beam width below 60 degrees. Beam width reduction will be achieved using array techniques.

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CHAPTER 1

INTRODUCTION

An antenna is mainly used as a metallic device for radiating or receiving radio waves which is basically used for transmitting signals, transmitting antenna is used to transmit information and for receiving signal, receiving antenna is used at receiver end to receive signals.

The first antennas they are built in 1888 by German physicist Heinrich Hertz in his pioneering experiments to prove the *existence* of waves predicted by the electromagnetic theory of James Clerk Maxwell. Hertz placed dipole antennas at the focal point of parabolic reflectors for both transmitting and receiving. Starting in 1895, Guglielmo Marconi began development of antennas practical for long-distance, wireless telegraphy, for which he received a Nobel Prize.

In radio engineering, an antenna or aerial is the interface between radio waves propagating through space and electric currents moving in metal conductors, used with a transmitter or receiver. In transmission, a radio transmitter supplies an electric current to the antenna's terminals, and the antenna radiates the energy from the current as electromagnetic waves (radio waves). In reception, an antenna intercepts a radio wave in order to produce an electric current at its terminals, that is applied to a receiver to be amplified. Antennas are essential components of all radio equipment.

An antenna is an array of conductors (elements), electrically connected to the receiver or transmitter. Antennas can be designed to transmit and receive radio waves in all horizontal directions equally, or preferentially in a particular direction. An antenna may include components not connected to the transmitter, parabolic reflectors, horns, or parasitic elements, which serve to direct the radio waves into a beam or other desired radiation pattern. Strong directivity and good efficiency when transmitting are hard to achieve with antennas with dimensions that are much smaller than a half wavelength.

There are many types of antennas

1.1 OMNI-DIRECTIONAL ANTENNA

In this type of antenna, it radiates equal radio in all directions perpendicular to an axis, with varying angle to the axis, declining to zero on the axis.

1.2 DIRECTIONAL ANTENNA

In this type of antenna, it radiates or receives greater in specific directions allowing increased performance and reduced interference from unwanted sources.

A **directional antenna** or **beam antenna** is an antenna which radiates or receives greater in specific directions allowing increased performance and reduced interference from unwanted sources. Directional antennas provide increased performance over dipole antennas—or omnidirectional antennas in general—when greater concentration of radiation in a certain direction is desired.

A **high-gain antenna** is a directional antenna with a focused, narrow radio wave beam width, permitting more precise targeting of the radio signals. Most commonly referred to during space missions, these antennas are also in use all over Earth, most successfully in flat, open areas where there are no mountains to disrupt radio waves. By contrast, a **low-gain antenna** is an omnidirectional antenna with a broad radio wave beam width, that allows the signal to propagate reasonably they'll even in mountainous regions and is thus more reliable regardless of terrain. Low-gain antennas are often used in spacecraft as a backup to the *high-gain antenna*, which transmits a much another beam and is therefore susceptible to loss of signal.

All practical antennas are at least somewhat directional, although usually only the direction in the plane parallel to the earth is considered, and practical antennas can easily be omnidirectional in one plane. The most common types are the Yagi antenna, the log-periodic antenna, and the corner reflector antenna, which are frequently combined and commercially sold as residential TV antennas. Cellular repeaters often make use of external directional antennas to give a far greater signal than can be obtained on a standard cell phone. Satellite television receivers usually use parabolic antennas. For long and medium wavelength frequencies, the arrays are used in most cases as directional antennas.

1.2.1 Principle of Operation

When transmitting, a high-gain antenna allows more of the transmitted to be

sent in the direction of the receiver, increasing the received signal strength. When receiving, a high gain antenna captures more of the signal, again increasing signal strength. Due to reciprocity, these two effects are equal—an antenna that makes a transmitted signal 100 times stronger (compared to an isotropic radiator) will also capture 100 times as much energy as the isotropic antenna when used as a receiving antenna. As a consequence of their directivity, directional antennas also send less (and receive less) signal from directions other than the main beam. This property may be used to reduce interference.

There are many ways to make a high-gain antenna; the most common are parabolic antennas, helical antennas, Yagi antennas, and phased arrays of smaller antennas of any kind. Horn antennas can also be constructed with high gain, but are less commonly seen. Still other configurations are possible—the Arecibo Observatory used a combination of a line feed with an enormous spherical reflector (as opposed to a more usual parabolic reflector), to achieve extremely high gains at specific frequencies.

1.2.2 Antenna Gain

Antenna gain is often quoted with respect to a hypothetical antenna that radiates equally in all directions, an isotropic radiator. This gain, when measured in decibels, is called dB. Conservation of energy dictates that high gain antennas must have narrow beams. For example, if a high gain antenna makes a 1-watt transmitter look like a 100-watt transmitter, then the beam can cover at most $\frac{1}{100}$ of the sky (otherwise the total amount of energy radiated in all directions would sum to more than the transmitter, which is not possible). In turn this implies that high-gain antennas must be physically large, since according to the diffraction limit, the beam desired, the larger the antenna must be (measured in wavelengths).

Antenna gain can also be measured in dB, which is gain in Decibels compared to the maximum intensity direction of a half wave dipole. In the case of Yagi type aeriels this more or less equates to the gain one would expect from the aerial under test minus all its directors and reflector. It is important not to confuse two figures that differ by 2.15 dB, with the dB figure being higher, since a dipole has 2.15 dB of gain with respect to an isotropic antenna.

Gain is also dependent on the number of elements and the tuning of those elements. Antennas can be tuned to be resonant over a wider spread of

frequencies but, all other things being equal, this will mean the gain of the aerial is than one tuned for a single frequency or a group of frequencies. For example, in the case of wideband TV antennas the fall off in gain is particularly large at the bottom of the TV transmitting band. In the UK this bottom third of the TV band is known as group A; see gain graph comparing grouped aerials to a wideband aerial of the same size/model.

Other factors may also affect gain such as aperture (the area the antenna collects signal from, almost entirely related to the size of the antenna but for small antennas can be increased by adding a ferrite rod), and efficiency (again, affected by size, but also resistivity of the materials used and impedance matching). These factors are easy to improve without adjusting other features of the antennas or coincidentally improved by the same factors that increase directivity, and so are typically not emphasized.

1.2.3 Applications

High gain antennas are typically the largest component of deep space probes, and the highest gain radio antennas are physically enormous structures, such as the Arecibo Observatory. The Deep Space Network uses 35 m dishes at about 1 cm wavelengths. This combination gives the antenna gain of about 100,000,000 (or 80 dB, as normally measured), making the transmitter appear about 100 million times stronger, and a receiver about 100 million times more sensitive, provided the target is within the beam. This beam can cover at most one hundred millionth (10^{-8}) of the sky, so very accurate pointing is required.

Use of high gain and Milli meter -wave communication in WPAN gaining increases the probability of concurrent scheduling of non-interfering transmissions in a localized area, which results in an immense increase in network throughput. However, the optimum scheduling of concurrent transmission is an NP- Hard problem.

1.3 MICROSTRIP ANTENNA

In telecommunication, a microstrip antenna (also known as a printed antenna) usually means an antenna fabricated using photolithographic techniques on a printed circuit board (PCB). It is a kind of internal antenna. They are mostly used at microwave frequencies. An individual microstrip antenna consists of a patch of metal foil of various shapes (a patch antenna) on the surface of a PCB (printed

circuit board), with a metal foil ground plane on the other side of the board. Most microstrip antennas consist of multiple patches in a two-dimensional array. The antenna is usually connected to the transmitter or receiver through foil microstrip transmission lines. The radio frequency current is applied (or in receiving antennas the received signal is produced) between the antenna and ground plane. Microstrip antennas have become very popular in recent decades due to their thin planar profile which can be incorporated into the surfaces of consumer products, aircraft and missiles; their ease of fabrication using printed circuit techniques; the ease of integrating the antenna on the same board with the rest of the circuit, and the possibility of adding active devices such as microwave integrated circuits to the antenna itself to make active antennas Patch antenna.

The most common type of microstrip antenna is commonly known as patch antenna. Antennas using patches as constitutive elements in an array are also possible. A patch antenna is a narrowband, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate, such as a printed circuit board, with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane. Common microstrip antenna shapes are square, rectangular, circular and elliptical, but any continuous shape is possible. Some patch antennas do not use a dielectric substrate and instead are made of a metal patch mounted above a ground plane using dielectric spacers; the resulting structure is less rugged but has a wider bandwidth. Because such antennas have a very low profile, are mechanically rugged and can be shaped to conform to the curving skin of a vehicle, they are often mounted on the exterior of aircraft and spacecraft, or are incorporated into mobile radio communications devices.

In the microstrip antenna the upper surface of the dielectric substrate supports the printed copper conducting strip which is suitably contoured while the lower surface of the substrate is backed by a conducting ground plane. Such antenna sometimes called a printed antenna because the fabrication procedure is like that of a printed circuit board. Many types of microstrip antennas have been evolved which are variations of the basic structure. Microstrip antennas can be designed as very thin planar printed antennas and they are very useful elements.

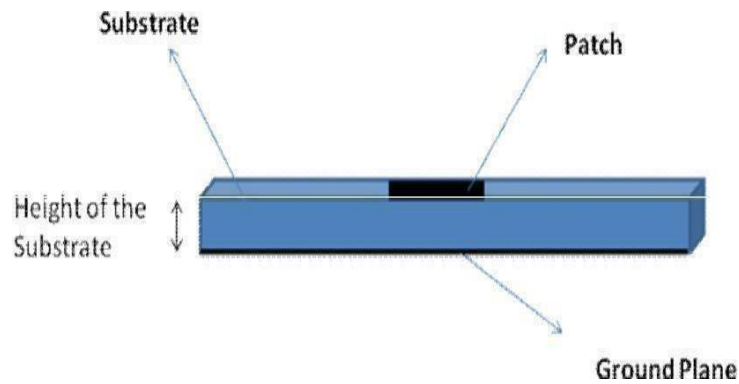


Fig: 1.1 Basic Structure of Microstrip Patch Antenna

So many advantages and applications can be mentioned for microstrip patch antennas over conventional antennas. There are several undesirable features were encountered with conventional antennas like they are bulky, conformability problems and difficult to perform multiband operations so on. The advantages include planar surface, possible integration with circuit elements, small surface, generate with printed circuit technology and can be designed for dual and multiband frequencies. Disadvantages include narrow bandwidth, low RF power handling capability, larger ohmic losses and low efficiency because of surface waves etc. For the last two decades, researchers have been struggling to overcome these problems and they succeeded many times with their novel designs and new findings.

1.3.1 Advantages

Microstrip antennas are relatively inexpensive to manufacture and design because of the simple 2-dimensional physical geometry. They are usually employed at UHF and higher frequencies because the size of the antenna is directly tied to the wavelength at the resonant frequency. A single patch antenna provides a maximum directive gain of around 6–9 db.

It is relatively easy to print an array of patches on a single (large) substrate using lithographic techniques. Patch arrays can provide much higher gains than a single patch at little additional cost; matching and phase adjustment can be performed with printed microstrip feed structures, again in the same operations that form the radiating patches. The ability to create high gain arrays in a low-

profile antenna is one reason that patch arrays are common on airplanes and in other military applications.

Such an array of patch antennas is an easy way to make a phased array of antennas with dynamic beamforming ability. An advantage inherent to patch antennas is the ability to have polarization diversity. Patch antennas can easily be designed to have vertical, horizontal, right hand circular (RHCP) or left hand circular (LHCP) polarizations, using multiple feed points, or a single feed point with asymmetric patch structures. This unique property allows patch antennas to be used in many types of communications links that may have varied requirements.

1.4 RECTANGULAR PATCH ANTENNA

The most commonly employed microstrip antenna is a rectangular patch which looks like a truncated microstrip transmission line. It is approximately one-half wavelength long. When air is used as the dielectric substrate, the length of the rectangular microstrip antenna is approximately one-half of a free-space wavelength. As the antenna is loaded with a dielectric as its substrate, the length of the antenna decreases as the relative dielectric constant of the substrate increases. The resonant length of the antenna is slightly shorter because of the extended electric "fringing fields" which increase the electrical length of the antenna slightly. An early model of the microstrip antenna is a section of microstrip transmission line with equivalent load on either end to represent the radiation loss.

1.4.1 Specifications

The dielectric loading of a microstrip antenna affects both its radiation pattern and impedance bandwidth. As the dielectric constant of the substrate increases, the antenna bandwidth decreases which increases the Q factor of the antenna and therefore decreases the impedance bandwidth. This relationship did not immediately follow when using the transmission line model of the antenna, but is apparent when using the cavity model which was introduced in 1973 by Itoh and Mittra. The radiation from a rectangular microstrip antenna may be understood as a pair of equivalent slots. These slots act as an array and have the highest directivity when the antenna has an air dielectric and decreases when it is replaced by a dielectric substrate with increasing relative permittivity.

The half-wave rectangular microstrip antenna has a virtual shorting plane along its centre. This may be replaced with a physical shorting plane to create a quarter-wavelength microstrip antenna. This is sometimes called a half-patch. The antenna only has a single radiation edge (equivalent slot) which determines the directivity/gain of the antenna. The impedance bandwidth is slightly less than a half-wavelength full patch as the coupling between radiating edges has been eliminated.

1.4.2 Other Types

Another type of patch antenna is the planar inverted-F antenna (PIFA). The PIFA is common in cellular phones (mobile phones) as a built-in structure. These antennas are derived from a quarter-wave half-patch antenna. The shorting plane of the half-patch is reduced in length which decreases the resonance frequency. It offers a low profile and also with acceptable SAR properties. This antenna resembles an inverted F, which explains the PIFA name. It is popular as a compact antenna with an omnidirectional pattern.

Often PIFA antennas have multiple branches to resonate at the various cellular bands. On some phones, grounded parasitic elements are used to enhance the radiation bandwidth characteristics.

The folded inverted conformal antenna (FICA) has some advantages with respect to the PIFA, because it allows better volume reuse.

Defected Ground Structure (DGS)-integrated microstrip patch has been popular for multiple purposes. This technique introduces a limited number of small-sized slots, termed as 'defects' on the ground plane beneath the patch, and is potentially capable of improving its far-field as well as near-field properties. This was conceived and introduced in 2005 by Guha to control the cross-polarized radiations without involving any extra component, volume, height, or cost. The technique is advanced enough to reduce cross-polarized radiations even over the diagonal-planes of a microstrip patch. DGS-technique is equally effective in reducing the mutual coupling in large microstrip arrays.

CHAPTER 2

LITERATURE SURVEY AND EXISTING MODEL

2.1 LITERATURE SURVEY

Many people done projects on Directional Patch Antenna using different ways. Here they collected some references. And they came up with a project which Directional patch antenna. Here they listed some of the references related to Directional patch antenna.

Churngjout Sai (2011) et al. presented a work on a WLAN/Wi-Max printed antenna executed by using microstrip feeding and matching. This antenna is constructed with a double-sided FR4 substrate with the radiator mounted on one side which contains one circle and one square element, the microstrip line fed on the other side to bring the wideband impedance match on the microstrip line and perform the dual and wide band effect. The frequency bands can meet the applications at 802.11b/g/n/a/p/h, 2.4-2.497GHz (Worldwide), 4.9-5.1GHz (Japan), 5.15-5.35/5.47-5.725/5.725-5.875GHz, 5.86-5.925GHz (America) and the Worldwide Interoperability for Microwave Access (WiMAX) M2300T-01/02 2.3-2.4GHz, M2500T-01 2.496- 2.696GHz, M3500T-02/03/05 3.4-3.6GHz, M3500T-01/04 3.4-3.8GHz. In this paper, the evaluation from the simulations and experiments reveals the dual and wide band antenna still have good radiation quality.

In this they get 2 to 5.8GHz by every 200MHz and also the error tolerance gain on low frequency is larger and also, they got some losses in this project they decrease the losses and they use dimensions 1mm in thickness, and the total dimension is 24*46mm². One 50: SMA connector, as a node for input and output, is connected to the end of the feed line and grounded to the edge of the circle element and here also they decrease those dimensions to obtain better results in my project.

Sonal N. Dahake (2017) et al. presented work on A Novel S-band Antenna for Synthetic aperture radar for Satellite application has been designed, fabricated, and validated. The objective of this project is to design an antenna working at 2.4GHz frequency for SAR. The features of microstrip antenna are small in size, light

in height, low cost, compatible to rigid surface, microstrip antennas are low profile antennas. In the first, they have designed a single patch Microstrip Antenna. After that they have designed a 2x1 square patch microstrip antenna array and after that 2x2 square patch microstrip antenna array. In this project gain of 11.4dB is achieved with 2x2 patch antenna array in this project, the antenna structure is designed, simulated and validated using HFSS 15.0 software.

In this they get 11.4dB is achieved with 2*2 patch antenna array frequency and also, they got some losses in this project they decrease the losses. We decrease those dimensions to obtain better results in my project.

Yehuda giay et al. presented work on Microstrip patch antenna array has been used in wide range of IoT RF-link applications. This paper presents two patches microstrip antenna array with feeding method using design tool. Each patch is designed with same dimension using FV substrate which has value of dielectric constant 4.3 and operates in 2.4 GHz with thickness of dimension is 1.5 mm. the final simulation produces 8.32 dB of the directivity, 72.1% of the efficiency and 6.9 dBi of the gain. Frequency range tested in this simulation start from 2-3 GHz. radiation resulted is 0.002 Watt and input in the microstrip antenna is 0.002 Watt.

In this they got 2.4 GHz with thickness of dimension is 1.5 mm. in my project they get more than 2.4GHz with less thickness of dimensions. Here they got 72.1% of the efficiency in my project We get more than this efficiency and gain also more.

Natraj B et al. presented work on, the design of rectangular inset fed microstrip patch antenna is presented, which is the most commonly used device in modern communication systems. The antenna design focuses on the Wi-Fi and Wireless Local Area Networks (WLAN) application with the operating frequency of 2.4GHz. The most widely researched area in the wireless technology is the operation of the antennas which are to be light they right, cost efficient and needs improvement in antenna parameters such as return loss, gain, radiation pattern, directivity and especially impedance matching for better performance so that the overall performance of the communication system improves.

The antenna design short and a better return loss of -25dB and the antenna parameters such as radiation pattern, directivity, gain, radiation efficiency and bandwidth is obtained. The improved bandwidth of the patch antenna design can be used for wide band communication applications.

And they got 2.4GHz frequency but we proposed project, we get more

frequency with less dimensions, here we got this 2.4GHz by the width patch is 38.04mm and length is 29.42mm in my project I got this frequency with less than this length and width.

Ashokan V et al. presented work on Microstrip Patch antenna is designed in Ansoft HFSSV13. The designed antennas are double-sided printed microstrip patch antenna. The antenna is designed over the operating frequency is 2.4GHz using the substrate material as FR4 which has the dielectric constant of 4.4(Er). The designed antenna can be used for ISM (industrial, scientific and medical) band and WLAN applications. The designed antenna has low profile, low cost, easy fabrication and good isolation. The antenna is designed by using Ansoft HFSSV13 simulation software and designed antenna provides return loss less than -10dB. The parameters such as return loss, voltage standing wave ratio (VSWR), mutual coupling, gain, radiation pattern has been simulated and analyzed.

In this they got 2.4GHz frequency using substrate material as FR4 and which have dielectric constant of 4.4epsilon. In my project I got more frequency than this using other material and I got more dielectric constant. So that's why we use better than this material and dielectric constant.

Ali muddin Manda et al. are proposed work on multi-layer parasitic microstrip bi-quad patch antenna is designed and simulated for WLAN applications at 2.4 GHz ISM band. This antenna is composed by five elements bi-quad patch 1/4 wavelength with addition of flat reflector. Low-cost FR-4 material is used as antenna substrate. The antenna is designed and simulated using Computer Simulation Technology (CST) Microwave Studio software. The results show that return loss is -31.13 dB, VSWR of 1.05 with bandwidth of 183.42 MHz at return loss below -10 dB. This antenna has a linear polarization with unidirectional radiation pattern. Directivity is 12.28 dB and maximum gain is 11.71 dB. Thus, the results indicated that it's a great performance of long-range antenna for WLAN's communications at operating band is possible in practice.

In this project they got 2.4GHz for this they used five elements bi-quad patch 1/4 wavelength with addition of flat reflector but in my project I used better than this to obtain more frequency and also they used FR-4 material we can use better material and that too cost of the material is less than this FR-4 material.

Muhammad Ammar Wibisono et al. are proposed a work on the design and

implementation of high gain 2.4GHz patch antenna array for wireless communications application in rural area is presented. The patch antenna array with high gain is expected to minimize the need of tower that almost requires high cost of construction. In order to achieve high gain, the proposed antenna is constructed by 4×4 rectangular patches fed by microstrip line corporate feeding network which is developed using a $\lambda/4$ transformer impedance matching technique. The antenna structure is then deployed on a Flame Retardant (FR) 4 Epoxy dielectric substrate which the thickness and dielectric constant of 1.6mm, and 4.4, respectively. Prior hardware realization, some antenna parameters including return loss, voltage standing wave ratio (VSWR), radiation pattern, and gain are characterized through simulation to obtain an optimum design of antenna. While from the measurement, it shows that the characteristics of realized patch antenna array have good agreements with the design results in which the realized antenna has the measured gain of 15.59dB at the centre frequency with the return loss of 19.52dB which corresponds to VSWR of 1.24 and the bandwidth response of 130MHz ranges from the frequency of 2.31GHz - 2.44GHz.

In this they achieve high gain, there antenna is constructed by 4x4 rectangular patches but in my project, we use less length and width but also, I got more gain and high frequency and also, they are used $\lambda/4$ transformer impedance matching technique.

Walter Gustav Fano et al. are proposed work on the application of EBG structures (metamaterials), working at frequency of 2.4 GHz to improve the behaviour of the patch antenna widely used in communications. It is explained how the dimensions of the design are obtained to achieve the objectives, and how the radiating element with the metamaterial works together. The distance between the patch and metamaterial to improve several parameters simultaneously: antenna impedance, SWR, Reflection Coefficient, Gain, Radiation Pattern, have been a contribution of this work, because this distance is not in the bibliography. An isolated patch, and two patches with metamaterials were constructed to study the behavior between the metamaterial and the patch antenna. Construction was performed with commercially used FR4 material, showing that working properly at the frequency $f = 2.4$ GHz.

In this project they use height of the material is 1.6mm and radius of the

material is 0.25mm and W_c is 22mm and g is 1.25mm to obtain 2.4GHz frequency but in my project the whole measurements and dimensions are less than they use to obtain better frequency so that is the drawback of this project while I study this project.

Xing jiang et al. are used to work on the upcoming fifth generation of mobile communication (5G) that can future enhance the capacity and data rates requires novel antennas. In this paper, three novel zeroth-order resonator-based (ZOR) Circularly Polarized (CP) antennas were proposed as candidates for 5G terminal applications. The radii of the antennas are 0.125 λ , 0.16 λ and 0.22 λ , respectively. All of the antennas radiate omni-directional patterns.

The prototype of the proposed antennas had been studied. The reflection coefficient and axial ratio of antenna are simulated. For antenna 1, the bandwidth of return loss is from 24.86GHz to 25.09GHz (230MHz), and axial ratio (AR) bandwidth is from 24GHz to 26GHz (2GHz). For antenna 2 and antenna 3, the bandwidth of return loss are from 24.87GHz to 25.2 GHz (330MHz) and 24.27GHz to 24.62GHz (350MHz), respectively. And AR bandwidths are from 24.3GHz to 26.2GHz (1.9GHz) and 24.25GHz to 25.35 GHz (1.1GHz), respectively.

All antennas achieve circular polarization performance and omni-directional radiation within the operational band.

In this project they concentrate mainly on directional antenna but here they got 24.87GHz to 24.62GHz using directional antenna and they got the impedance bandwidths of 0.92%, 1.32% and 1.43% respectively. But in my project we got better result than this impedance bandwidth and also they got antenna gain are 1.78dbi, 1.83dbi and 1.87dbi respectively. But in my project, I got more than this antenna gain.

D.I. Laurenson et al. are proposed a work on the art antenna array systems require detailed information about the channel in order to maximise usable capacity. Such systems require both detailed analysis and realistic simulation-based testing. To

date there has been little work carried out in the area of directional channel characterization when one of the terminals is in motion.

This paper will describe a dynamic measurement campaign, conducted at Bristol University, employing antenna arrays, both for a SIMO configuration with a ULA, and a MIMO configuration employing CUBAs. Associated with the SIMO

measurements, a modelling strategy was developed for simulating directional multipath propagation.

The model is based on stochastic processes controlling the birth and death of observable multipath components, the temporal and spatial correlation of multipath components, the variation of the spatial and temporal properties of components as the terminal moves, and the spectral characteristics of these components. The generic framework is fitted to the measurements obtained.

In this project also there are some drawbacks so in my project those drawbacks are also corrected.

Ibrahim-Tekin et al. are proposed a work on the design, implementation and inter port isolation performance evaluation of three dual port, dual polarized 2.4GHz microstrip patch antennas. Input matching and inter port isolation (both DC and RF) performance of implemented antennas has been compared by measuring the input return losses (S_{11} , S_{22}) and interport isolation (S_{12}) respectively at 2.4GHz. Two implemented single layer antennas provide around 40dB RF interport isolation while the multilayer antenna has 60dB isolation between transmit and receive ports at centerfrequency with DC isolated ports. The multilayer antenna provides more than 55dB interport isolation for antenna's 10 dB input impedance bandwidth of 50MHz. In this project they got 55dB interport isolation for antenna's 10 dB input impedance bandwidth of 50MHz but in my project I got better efficient than this output.

Dominic B.O kandite et al. proposed a work on a design of an inset-fed cross-shaped microstrip patch array to operate at dual band frequencies for wireless communication. A rectangular cut-out is done in the ground plane to obtain the dual band. A high gain is obtained by the use of a cross shaped patch aperture. It is shown that the cross shapes are more effective in suppressing surface wave thus resulting in a higher gain. Several antenna parameters such as radiation pattern and directivity for single and two elements are plotted and good results have been found. High-frequency structure simulator software (HFSS) has been used to obtain experimental results. As a substrate material, a Duroid 5887 has been used having a dielectric constant of 2.2.

The main objective of my project is to improve the characteristics and design(dimensions) of antenna.

2.1 EXISTING MODEL

In existing model there are 4 rectangular strips due to this the size, cost and dimensions are high. The rectangular microstrip antenna array with non-uniform amplitude and uniform spacing is designed. The microstrip antenna is probe fed. A linear array is designed at 2.4 GHz. The designed antenna array is simulated at 2.2-2.6 GHz. The analysis is based on method of moments. The radiation pattern is generated and the gain is obtained at 2.4GHz for linear polarization and circular polarization. The sidelobe level for linear polarization for circular polarization is measured and tabulated. The sidelobes present will degrade the performance of an antenna array however the reduction in the sidelobe is achieved using the binomial distribution.

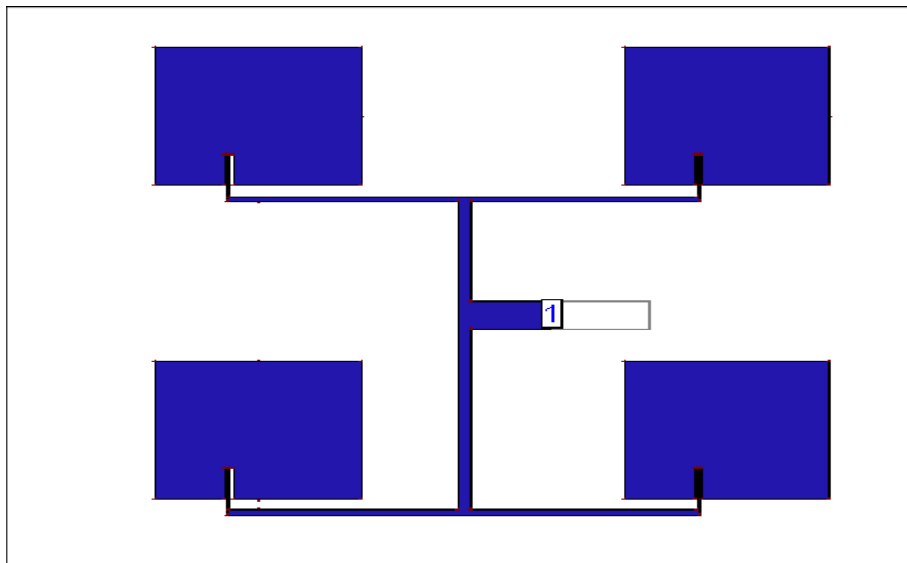


FIG: 3.1. Existing Antenna Model

The dimensions of the microstrip antenna depend on the substrate material and the antenna performance mostly depends on dielectric constant and loss tangent of

that material. The dielectric constant determines the speed at which a signal travels along a transmission line, and in microwave circuitry also affects the geometry of etched features on the board. The speed can be fine-tuned by the designers with proper selection of materials with different dielectric constants. Another important factor is the dissipation factor, which will contribute to the amount of signals power that is dissipated as it travels along a transmission line.

The main purpose of the thesis is to investigate the performance characteristics of compact and wideband antennas with respect to different physical structures. In this work lot of methods are verified and multiband characteristics are also analysed.

When one decides to design an antenna using a different defected structure, the time-consuming design process must be fully repeated. In such situations, the designers are interested in having simple design formulas that provide a very good approximation to the final design when sophisticated EM analysis and design software packages are applied. This thesis addresses this issue and provides simple design formulas with respect to the resonant frequency and wavelength, which are suitable for the antenna design.

**TABLE 2.1 EXSISTING ANTENNA PARAMETERS VALUES AT 2GHZ
FREQUENCY**

PARAMETERS	RESULTS AT 2GHz
$S_{11}(\text{dB})$	-19.31
Gain	11.42
Directivity	12.17
VSWR	1.65

CHAPTER 3

PROPOSED MODEL

3.1 PROPOSED METHODOLOGY

It is important to carefully select the substrate material for designing the microstrip antenna to ensure optimal antenna performance. In my proposed model, I have used a substrate material with stable mechanical and electrical properties over various ambient operating conditions. The substrate material selected also has a low cost and favorable dielectric constant and loss tangent values for optimal antenna performance. The proposed antenna design involves three strips that are carefully placed to achieve the desired parameters of that antenna like gain, VSWR, and so many parameters. Performance of given model what I proposed design has been evaluated by Ansys software and validated experimentally. In addition to substrate properties, other factors such as antenna geometry, feed line configuration, and ground plane design also an important role in the performance of microstrip Patch antennas.

Microstrip antennas are relatively inexpensive to manufacture and design because of the simple 2-dimensional physical geometry. They are usually employed at UHF and higher frequencies because the size of the antenna is directly tied to the wavelength at the resonant frequency. A single patch antenna provides a maximum directive gain of around 6–9 db.

3.1.1 Hardware required

- Substrate material (FR4 material)
- SMA connector
- Vector Network Analyzer.

3.1.1.1 Substrate Material

FR4 is a widely used substrate material in the field of electronics and printed circuit boards (PCBs). It is a type of flame-retardant glass-reinforced epoxy laminate, which is composed of a woven glass fabric impregnated with epoxy resin and cured under high temperature and pressure. FR4 is known for its excellent mechanical and electrical properties, making it a popular choice for a wide range of electronic applications. One of the key properties of FR4 is its flame retardancy. The glass-reinforced epoxy laminate composition of FR4 gives it inherent flame-retardant properties, making it resistant to combustion and self-extinguishing when

exposed to heat or flame. This makes FR4 ideal for applications where fire safety is critical, such as in aerospace, automotive, and consumer electronics industries.

In addition to its flame retardancy, FR4 also offers excellent mechanical properties. The woven glass fabric in FR4 provides high tensile strength, flexural strength, and impact resistance, making it durable and capable of withstanding mechanical stresses in various environments. FR4 is also known for its good dimensional stability, which ensures that PCBs made with FR4 substrates maintain their shape and size under different temperature and humidity conditions. Furthermore, FR4 has excellent electrical properties, including low dielectric constant and low dissipation factor, which make it suitable for high-frequency applications. It also has good electrical insulation properties, which prevent short-circuits and leakage currents. FR4 is also compatible with standard PCB fabrication processes, making it easy to work with in manufacturing.

In conclusion, FR4 is a versatile and widely used substrate material in the electronics industry due to its flame-retardant properties, excellent mechanical strength, dimensional stability, and good electrical performance. Its combination of properties makes it suitable for a wide range of applications, from consumer electronics to aerospace and automotive industries. As a result, FR4 has become the standard material for many printed circuit board applications.

3.1.1.2 SMA Connector

SMA (SubMiniature version A) connector is a type of coaxial RF (Radio Frequency) connector that is widely used in various communication and electronic systems. It is a threaded, subminiature connector that is designed for use in high-frequency applications. Here are three paragraphs providing information about SMA connectors:

SMA connectors are known for their small size and high frequency performance. They are commonly used in applications that require precise and reliable signal transmission, such as in wireless communication systems, test and measurement equipment, and aerospace and defense systems. SMA connectors are designed to operate in a frequency range of up to 18 GHz, making them suitable for microwave and high-frequency applications. They have a threaded coupling mechanism, which provides a secure and stable connection, and they are available in various configurations, including male and female connectors, straight and right-

angle connectors, and bulkhead and panel mount connectors. SMA connectors are characterized by their excellent electrical performance. They have low insertion loss, low VSWR (Voltage Standing Wave Ratio), and high shielding effectiveness, which help to maintain signal integrity and minimize signal loss in high-frequency systems. SMA connectors are also known for their high-power handling capabilities, which make them suitable for high-power RF applications. They are typically made of brass or stainless steel, and they may have gold or nickel plating to improve their electrical performance and corrosion resistance.

SMA connectors are widely used in the electronics industry due to their versatility and reliability. They are commonly used in a variety of applications, including RF antennas, PCBs (Printed Circuit Boards), RF cables, RF modules, and test and measurement equipment. SMA connectors are also compatible with other coaxial connector types, such as SMB (SubMiniature version B) and SMC (SubMiniature version C), which allows for easy interconnection with different types of coaxial connectors. However, it's important to note that SMA connectors are not suitable for high-vibration or high-torque environments, as their small size and threaded coupling mechanism may not provide sufficient mechanical strength in such conditions. SMA connectors are designed to have a constant 50-ohm impedance across the connector. The SMA connectors were originally designed and specified for operation up to 18 GHz, although some versions have top frequencies of 12.4 GHz, some less and some are specified up to 24 or 26.5 GHz. The higher frequency top limits may need to operate with a higher return loss. The SMA connector uses a 1/4-inch diameter, 36-thread-per-inch threaded barrel.

SMA connectors are also known for their high-power handling capabilities, which make them suitable for high-power RF applications. They are typically made of brass or stainless steel, and they may have gold or nickel plating to improve their electrical performance and corrosion resistance.

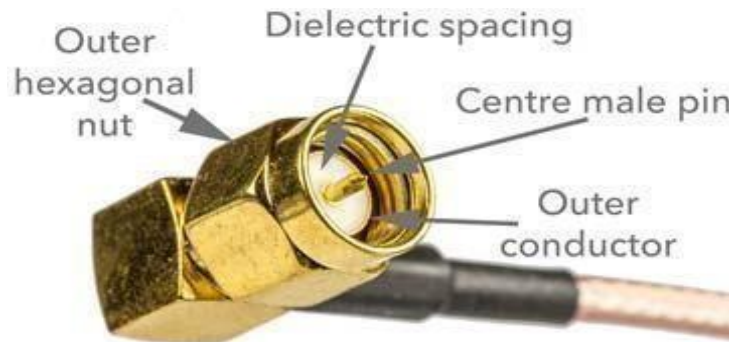


Fig: 3.1 SMA Connector

3.1.1.3 Vector Network Analyzer

A vector network analyzer (VNA) is a sophisticated electronic test instrument used in RF and microwave engineering for measuring and analysing the performance of RF and microwave devices, circuits, and systems. It is a powerful tool that provides precise and comprehensive information about the behavior of RF and microwave components, such as filters, amplifiers, antennas, and transmission lines. Here are three paragraphs providing information about vector network analyzers:

VNA operates on the principle of vector measurement, which involves measuring both the magnitude and phase of the RF or microwave signals. This allows for complete characterization of the behavior of a device or circuit, including its amplitude and phase response, group delay, and impedance. VNAs typically have multiple ports, allowing for the measurement of both forward and reflected waves at different ports simultaneously, which enables comprehensive analysis of complex systems. VNAs operate over a wide frequency range, from a few kilohertz (kHz) to hundreds of gigahertz (GHz), making them suitable for a wide range of RF and microwave applications. VNAs provide a wealth of information about the performance of RF and microwave devices. They can measure various parameters, such as S-parameters (scattering parameters), which describe the behavior of a device in terms of its transmission and reflection characteristics; impedance, which provides information about the device's characteristic impedance and its matching to the system; group delay, which measures the time delay of a signal through the device; and many other parameters that are critical for understanding and optimizing the performance of RF and microwave circuits. VNAs also provide graphical

displays, such as Smith charts, polar plots, and time domain displays, which facilitate the analysis and visualization of complex data.

VNAs are widely used in various industries, including telecommunications, aerospace and defense, automotive, and wireless communication, among others. They are used in research and development, production testing, quality control, and troubleshooting of RF and microwave devices and systems. VNAs are essential tools for design engineers to characterize and optimize the performance of RF and microwave components, and for production engineers to ensure the quality and reliability of manufactured products. VNAs come in different form factors, ranging from benchtop units for lab and production environments to portable and handheld units for field testing and on-site measurements.

Vector Network Analyzers perform two types of measurements – transmission and reflection. Transmission measurements pass the Vector Network Analyzer stimulus signal through the device under test, which is then measured by the Vector Network Analyzer receivers on the other side. The most common transmission S-parameter measurements are S_{21} and S_{12} (S_{xy} for greater than 2-ports). Swept power measurements are a form of transmission measurement. Some other examples of transmission measurements include gain, insertion loss/ phase, electrical length/delay and group delay. Comparatively, reflection measurements measure the part of the VNA stimulus signal that is incident upon the DUT, but does not pass through it. Instead, the reflection measurement measures the signal that travels back towards the source due to reflections.

3.2 ANSYS-HFSS SOFTWARE

The antennas can be designed and simulated using software. Various software available in market are Magus, Cosmol, IE3D, Sonnet, HFSS, FEKO, CST Microwave studio, SEMCAD, efield, XFDTD, EXPIRE, WIPL-ProGEMS. Here we have chosen HFSS where it is convenient for the user. ANSOFT HFSS software is an industrial standard for simulating 3-D full-wave electromagnetic fields. It provides good standard accuracy. The computer technology has made it an essential tool for engineers who are designing high-frequency and high-speed electronic components. Ansys HFSS is a 3D electromagnetic (EM) simulation software for designing and simulating high-frequency electronic products such as antennas, antenna arrays, RF or microwave components, high-speed interconnects, filters, connectors, IC packages and printed circuit

boards. Engineers worldwide use Ansys HFSS to design high-frequency, high-speed electronics found in communications systems, radar systems, advanced driver assistance systems (ADAS), satellites, internet-of-things (IoT) products and other high-speed RF and digital devices.

HFSS (High Frequency Structure Simulator) employs versatile solvers and an intuitive GUI to give you unparalleled performance plus deep insight into all your 3D EM problems. Through integration with Ansys thermal, structural and fluid dynamics tools, HFSS provides a powerful and complete Metaphysics analysis of electronic products, ensuring their thermal and structural reliability. HFSS is synonymous with gold standard accuracy and reliability for tackling 3D EM challenges by virtue of its automatic adaptive meshing technique and sophisticated solvers, which can be accelerated through high performance computing (HPC) technology. The proposed wearable microstrip patch antenna is simulated using the ANSYS EM suite version 20 which is described above in detail and in the next part the simulated WMSPA is placed and given some detailisation on the design and done analysis in the proposed design.

3.2 Antenna Design

An antenna using 3 strips. The antenna technology has undergone remarkable achievements during past two decades. Antenna designers require a wide range of substrate materials availability with stable electrical, mechanical properties over the various ambient operating conditions. Along with favorable properties and parameters that are required for the perfect design of antennas, the cost of the material also should be less. In recent years, many varieties of antennas have been proposed and investigated on different substrate materials, depending on the applications.

The dimensions of the microstrip antenna depend on the substrate material and the antenna performance mostly depends on dielectric constant and loss tangent of that material. The dielectric constant determines the speed at which a signal travels along a transmission line, and in microwave circuitry also affects the geometry of etched features on the board. The speed can be fine-tuned by the designers with proper selection of materials with different dielectric constants. Another important factor is the dissipation factor, which will contribute to the amount of signals power that is dissipated as it travels along a transmission line. The main purpose of the thesis is to investigate the performance characteristics of compact and wideband antennas with respect to different physical structures. In this work lot of

methods are verified and multiband characteristics are also analyzed.

When one decides to design an antenna using a different defected structure, the time-consuming design process must be fully repeated. In such situations, the designers are interested in having simple design formulas that provide a very good approximation to the final design when sophisticated EM analysis and design software packages are applied. This thesis addresses this issue and provides simple design formulas with respect to the resonant frequency and wavelength, which are suitable for the antenna design. In this thesis, four types of models are considered to study their behavior with change in substrate permittivity.

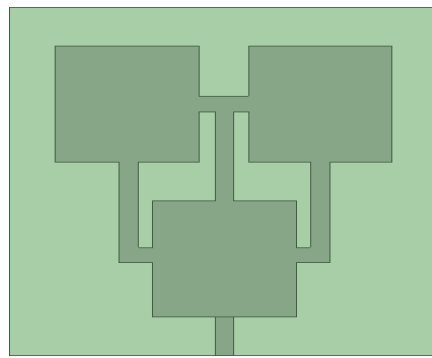


Fig: 3.2: Proposed model antenna (top view)

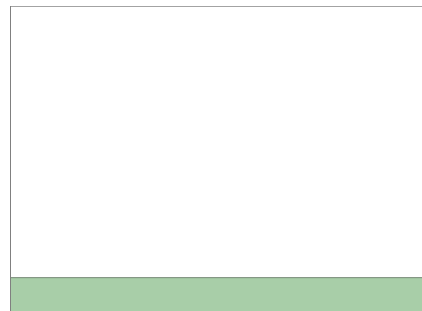


Fig: 3.3: Proposed antenna (bottom view)

In this model I used the following

dimensions. $L_g = W_g = 45 \text{ mm}^2$

Thickness = 1.6 mm Substrate: FR4

Material (Permittivity: 4.4)

$L = W = 44.6 \text{ mm}^2$ (Radiating Layer), Ground = $44.6 * 5 \text{ mm}^2$

When one decides to design an antenna using a different defected structure, the time-consuming design process must be fully repeated. In such situations, the

designers are interested in having simple design formulas that provide a very good approximation to the final design when sophisticated EM analysis and design softwarepackages are applied. This thesis addresses this issue and provides simple design formulas with respect to the resonant frequency and wavelength, which are suitable for the antenna design. In this thesis, four types of models are considered to study their behavior with change in substrate permittivity.

CHAPTER 4

RESULT ANALYSIS

4.1 ANSYS-HFSS RESULTS

In this section various electromagnetic parameters are analyzed for the proposed WBDPA by placing all the obtained simulated results with the help of ANSYS HFSS suite version 20. The performances are observed and it is shown next in this letter.

The S11 parameter plot of the wideband directional patch antenna has been given in the fig 2. From the simulated results below, it observed that the proposed WBDPA is resonated at 2.2212 GHz with bandwidth of 2.00 GHz-2.54 GHz & at 4.7525GHz with bandwidth of 4.59 GHz-4.90GHz and with the corresponding return loss at -21.4099 dB for Sub-6 GHz applications & -25.0292 dB for Sub-7 GHz applications. From the analysis the proposed WBDPA transmits the data in the both reported applications with low reflections.

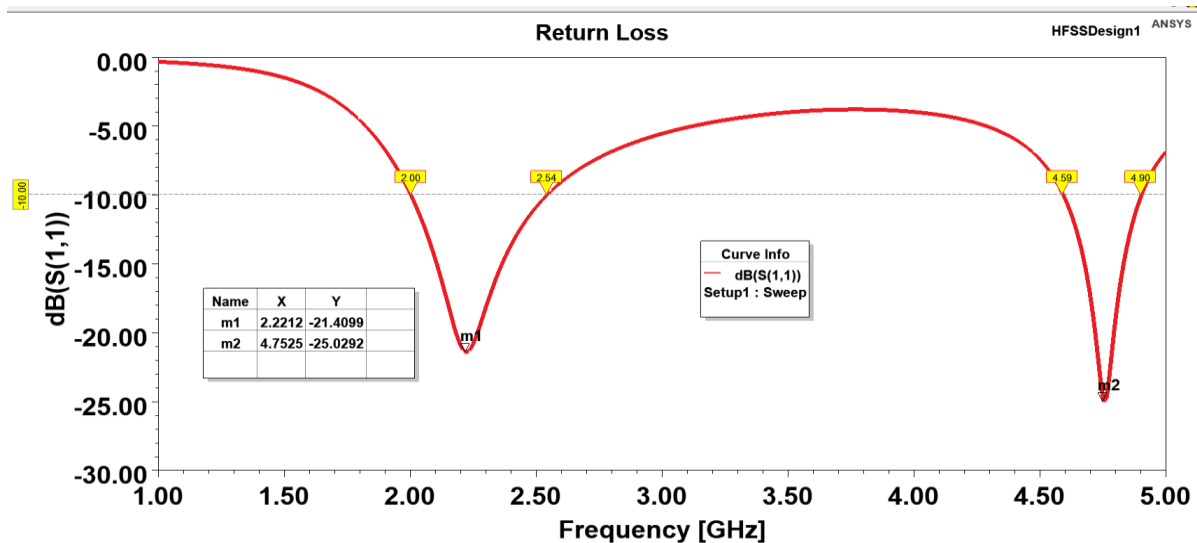


Fig: 4.1: REPRESENT THE S11 PLOT OF THE PROPOSED WBDPA

As we know that S11 parameter is directly proportional to the VSWR so the proposed MSPA has a direct impact on the VSWR due to the decrease in the reflection coefficient in the proposed MSPA in this letter. From the analysis of presented simulated result in figure 4.2 all the reported frequency bands falls near unity so its performance rate is also high.

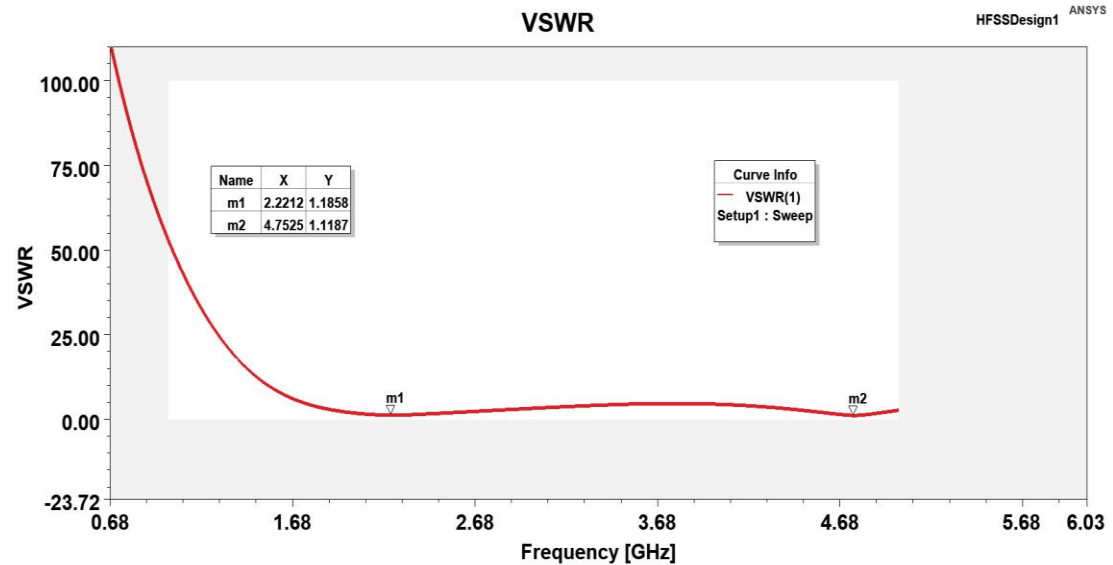


Fig. 4.2: Represent the VSWR plot of the proposed WBDPA

The below figure represented the impedance plot graph for the WBDPA for the proposed designs. The term impedance in the patch antenna relates input voltage and current to the antenna. The Y parameters, Z parameters, reflection coefficient for the proposed WBDPA design is plotted in the smith chart and analyzed and this WBDPA provides good impedance matching.

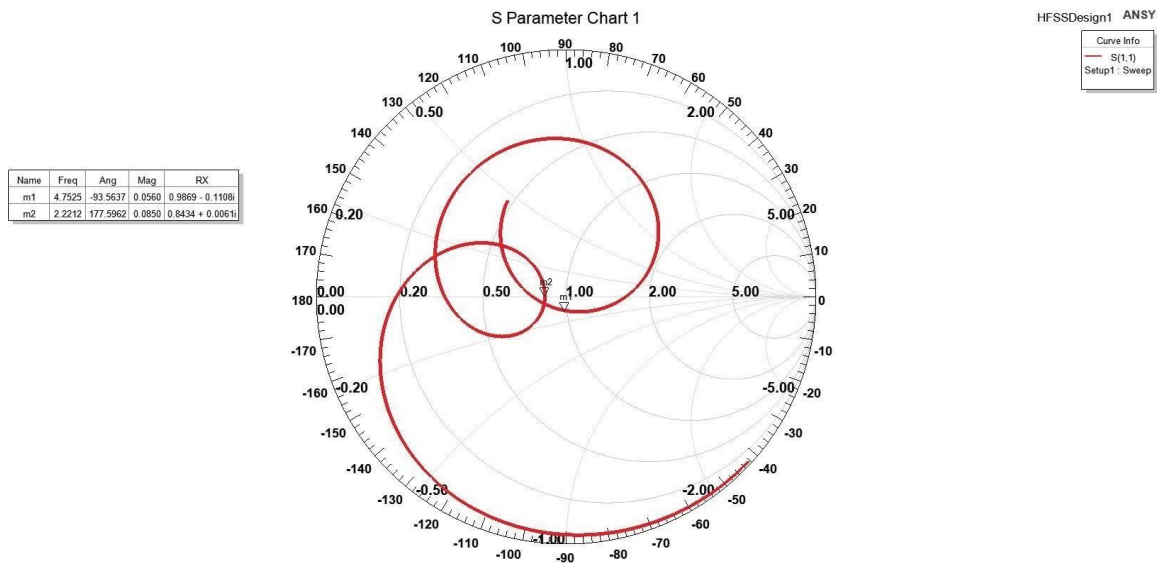


Fig. 4.3: Represent the impedance plot of the proposed WBDPA

The gain & directivity of the proposed WBDPA is represented in 3D polar plot in the fig. 4.4. From the obtained simulated result, the gain for the resonated Sub-6 & Sub-7GHz frequency is 2.2 dB and this value is considered as the maximum gain

of the proposed WBDPA. Gain should be positive and this parameter illustrates the capabilities of the WBDPA to focus energy in particular direction. From the obtained simulated result, the Directivity for the resonated Sub-6 & Sub-7 GHz frequency is 2.2dB and this value is considered as the maximum directivity of the proposed WBDPA.

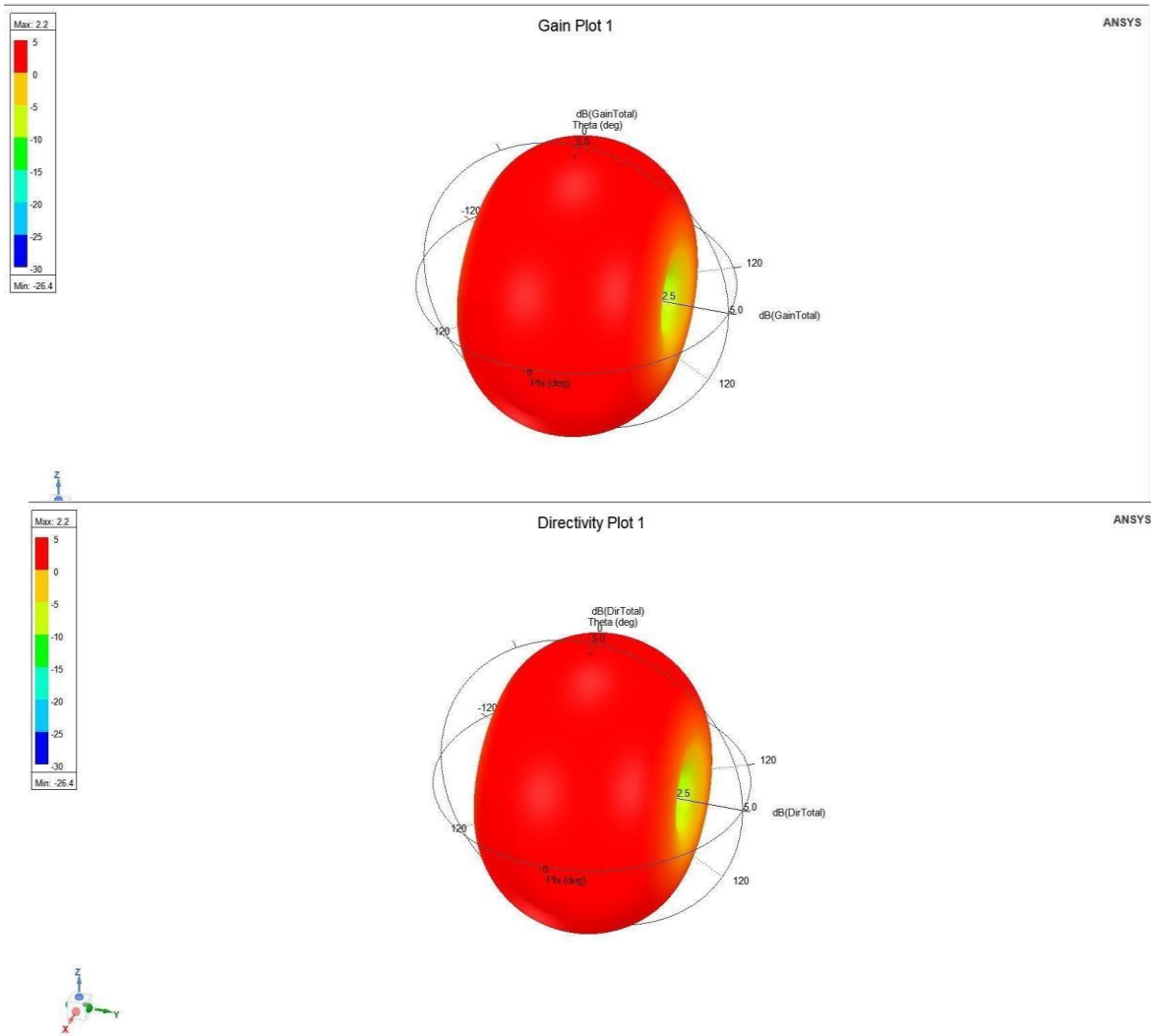


Fig: 4.4: Represent the Gain&Directivity of the proposed WBDPA

In this scenario the efficiency of the proposed WBDPA can be calculated as we know the simulated value for the gain & directivity and the formula used here we used is $\text{Efficiency} = \text{Gain} / \text{Directivity}$ so according to the formula the efficiency rate of the proposed WBDPA is exactly 100%, as here calculated the efficiency the simulated proposed WBDPA is also analyzed in the EM suite and obtained the result. From analysis the radiation efficiency of the proposed WBDPA at resonated frequency is similar to calculated value.

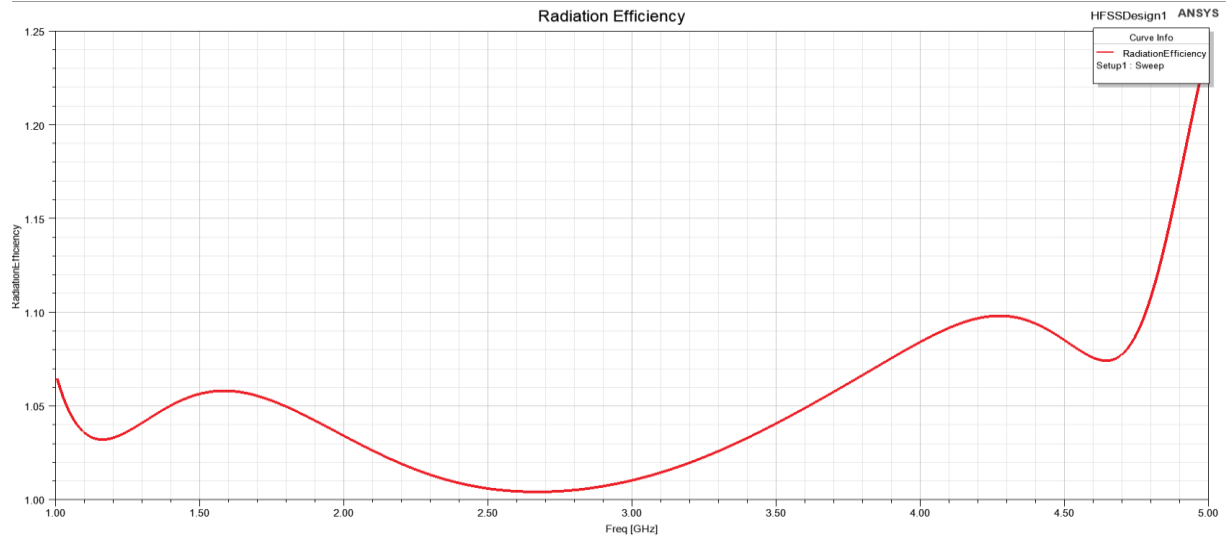
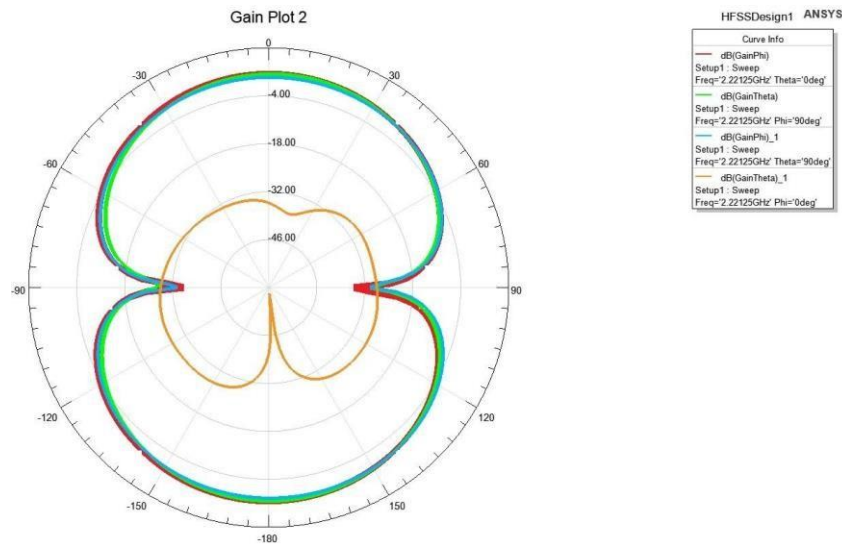


Fig: 4.5: Represent the Radiation Efficiency of the proposed WBDPA

The 2D radiation pattern of the strip line feed WBDPA is represented in fig 7 for the resonated frequency at 3.74 GHz & 5.3 GHz in zero & ninety degree and this obtained result is analyzed using the HFSS v20 EM suite. From analysis of the below figure the proposed MSPA provides linear polarization in zero degree and co-polarization in ninety degrees for the reported frequency bands above and it is presented in the figure 8 (A) & (B).



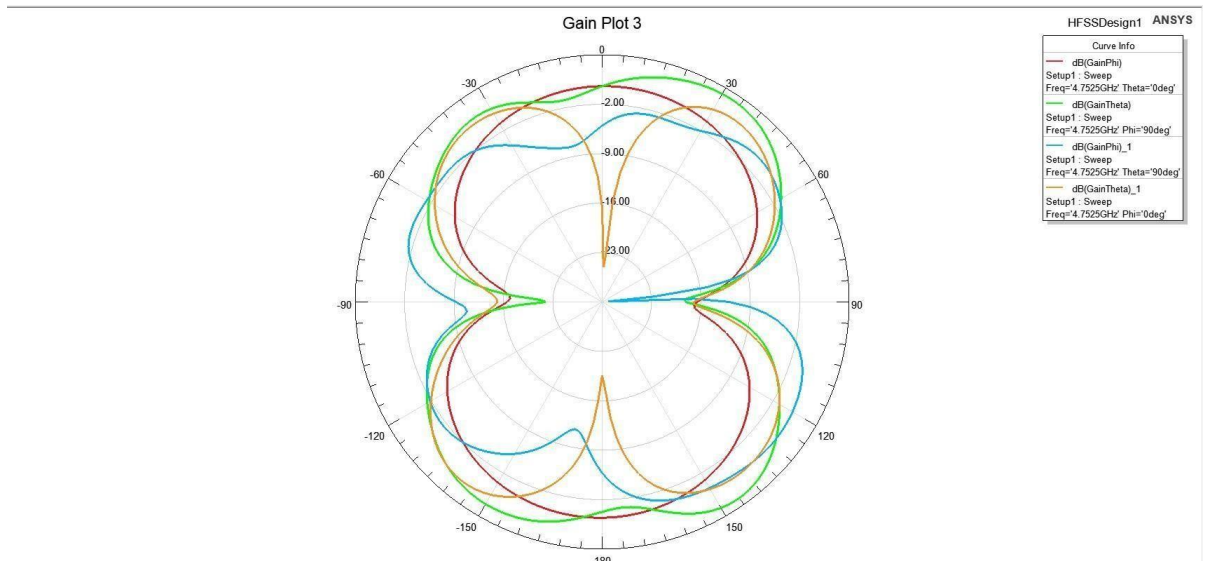


Fig. 4.6: Represent the Radiation pattern (A) For 2.2212 GHz (B) 4.7525 GHz

The FBR of the proposed WBDPA is represented in 2D plot in the fig. 5.8. From the analysis of obtained simulated results the proposed value in the graph is acceptable range, so the proposed WBDPA in this letter will work most efficiently in backward & forward direction and this is due to the methods & techniques implemented to design this WBDPA. The Y parameters, Z parameters, reflection coefficient for the suggested WBDPA sketch is plotted in the smith chart and analyzed.

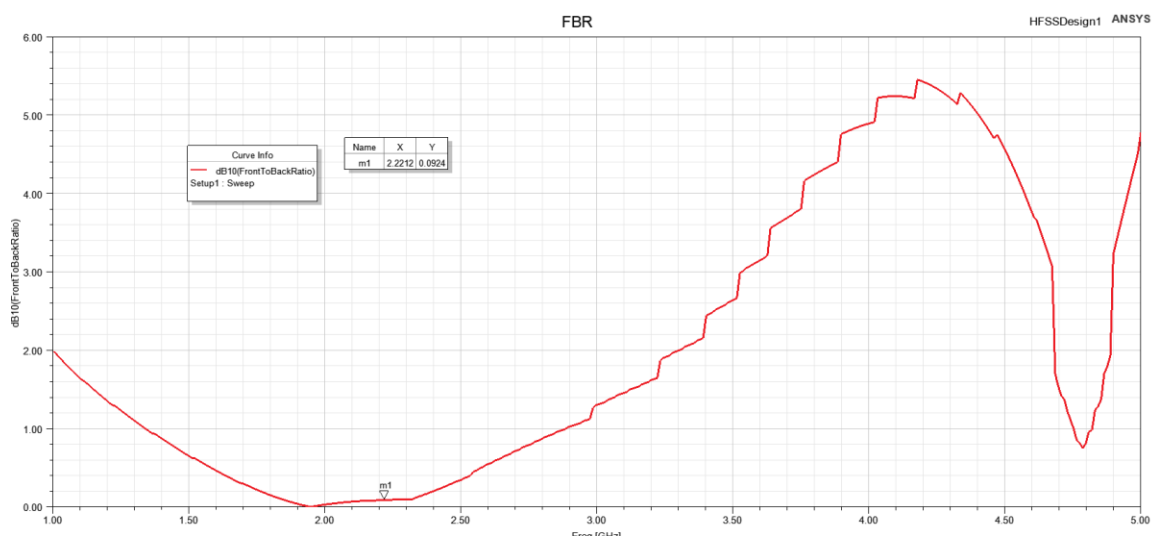


Figure 4.7 Represent the FBR of the proposed wearable WBDPA in 2D plot

In this scenario the one of the important parameters of the proposed WBDPA have to be analyzed that is the power consumption range of the proposed WBDPA and it also analyzed in the EM suite. From the obtained result the power consumption

range of the proposed WBDPA is simulated in dBm the values are nearer to the 30 dBm, so the power consumption range of the proposed WBDPA is less than the 1 watt.

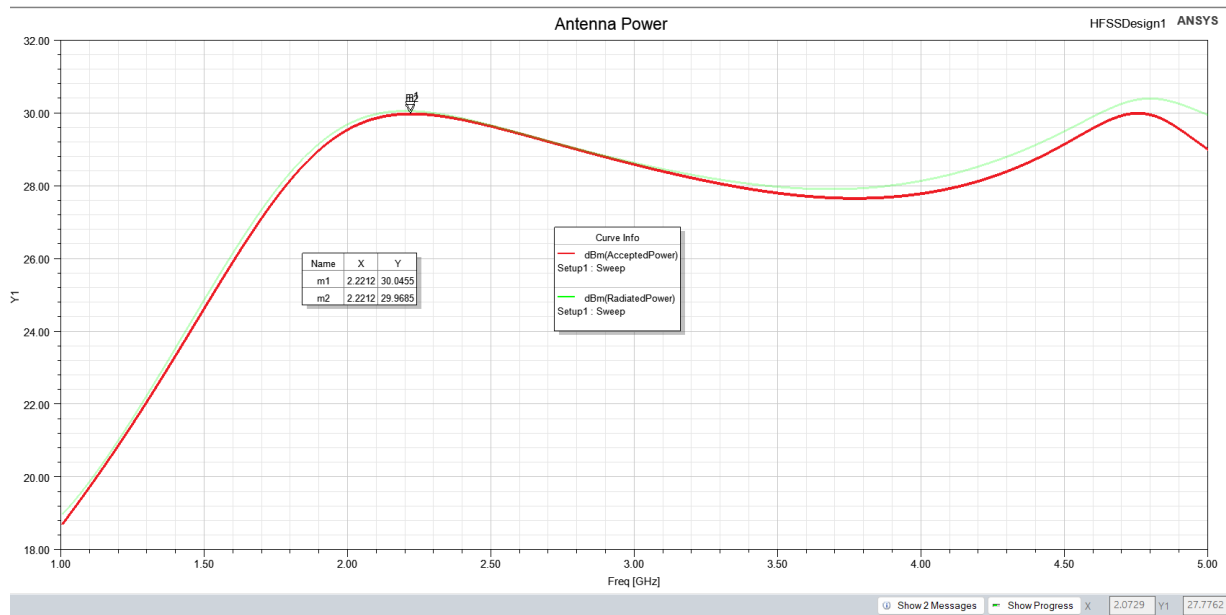


Fig. 4.8: Represent the Antenna Power consumption of the proposed WBDPA

Proposed antenna simulation, by this one can capable to get the parameters of the proposed antenna in the parameters like VSWR, return loss and directivity plot. The gain we get 2.2143, directivity is 2.2913, VSWR is 1.1858, Efficiency is 96.66%, and power loss due to insertion loss is 13.53%. these are all we mentioned in the below Fig (9-14) and these values are get by the help of ANSYS software. These are all we mentioned in the below Fig (9-14) and these values are get by the help of ANSYS software.

The below table represents the simulated parameter results for the proposed WBDPA for resonated frequency is tabulated in clear manner.

Table 4.1 ANTENNA PARAMETERS VALUES AT DIFFERENT FREQUENCIES

Parameters	AT 2.2212 GHz	AT 4.7525 GHz
S Parameter	-21.4099	-25.0292
VSWR	1.1858	1.1187
Gain	2.2	2.2
Directivity	2.2	2.2
Radiation Efficiency	1.1678	1.0572
FBR	0.0924 db10	-
Accepted power	29.96 dBm	29.98 dBm
Radiated Power	30.04 dBm	30.01 dBm

The proposed WBDPA is fabricated on FR4 substrate material and under gone with wet etching process while in the fabrication. The scattering parameter of the proposed WBDPA is measured using the Anritsu Vector Network Analyzer (VNA). Figure 11 presents the snap shot of the fabricated piece, as this fabricated WBDPA testing process is carried out in the VNA and the measured result is also placed in the fig 12 in the comparative manner. From the analysis both simulated and the measured results are in good agreement so the proposed WBDPA will work most efficiently in real time.

4.2 MEASURED RESULTS

The S_{11} parameter plot of the wideband directional patch antenna has been given in the fig 2. From the simulated results below, it observed that the proposed WBDPA is resonated at 2.2212 GHz with bandwidth of 2.00 GHz-2.54 GHz & at 4.7525GHz with bandwidth of 4.59 GHz-4.90GHz and with the corresponding return loss at -21.4099 dB for Sub-6 GHz applications & -25.0292 dB for Sub-7 GHz applications. From the analysis the proposed WBDPA transmits the data in the both reported applications with low reflections.

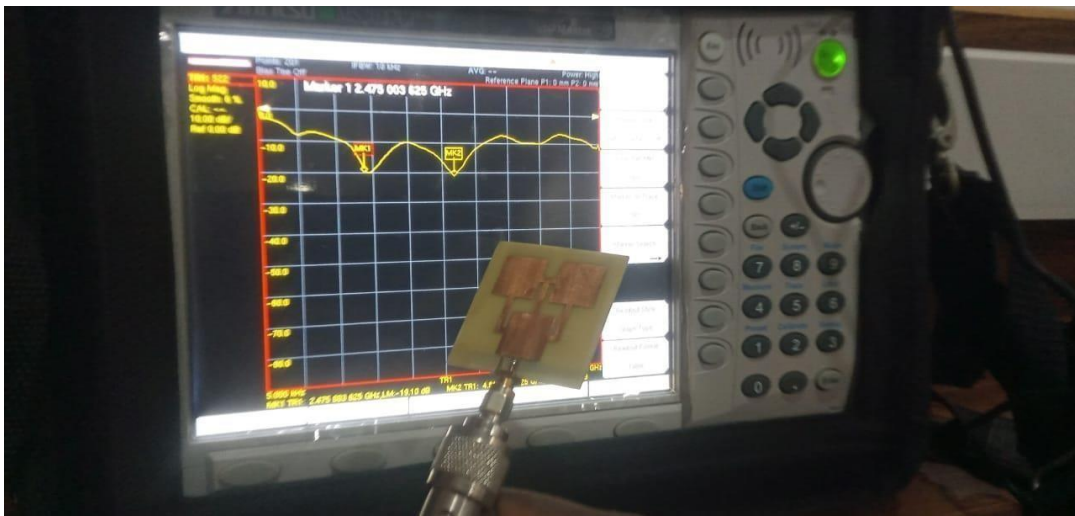


Fig: 4.9: Measured result of Rturnloss PLOT OF THE PROPOSED WBDPA

As we know that S_{11} parameter is directly proportional to the VSWR so the proposed MSPA has a direct impact on the VSWR due to the decrease in the reflection coefficient in the proposed MSPA in this letter. From the analysis of presented simulated result in figure 4.2 all the reported frequency bands falls near unity so its performance rate is also high.

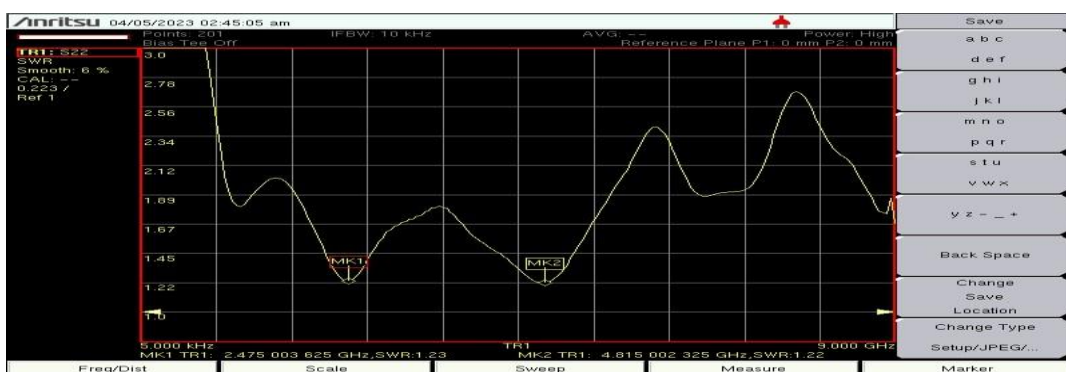


Fig: 4.10 Measured VSWR plot of the proposed WBDPA

The below figure represented the impedance plot graph for the WBDPA for the proposed designs. The term impedance in the patch antenna relates input voltage and current to the antenna. The Y parameters, Z parameters, reflection coefficient for the proposed WBDPA design is plotted in the smith chart and analyzed and this WBDPA provides good impedance matching

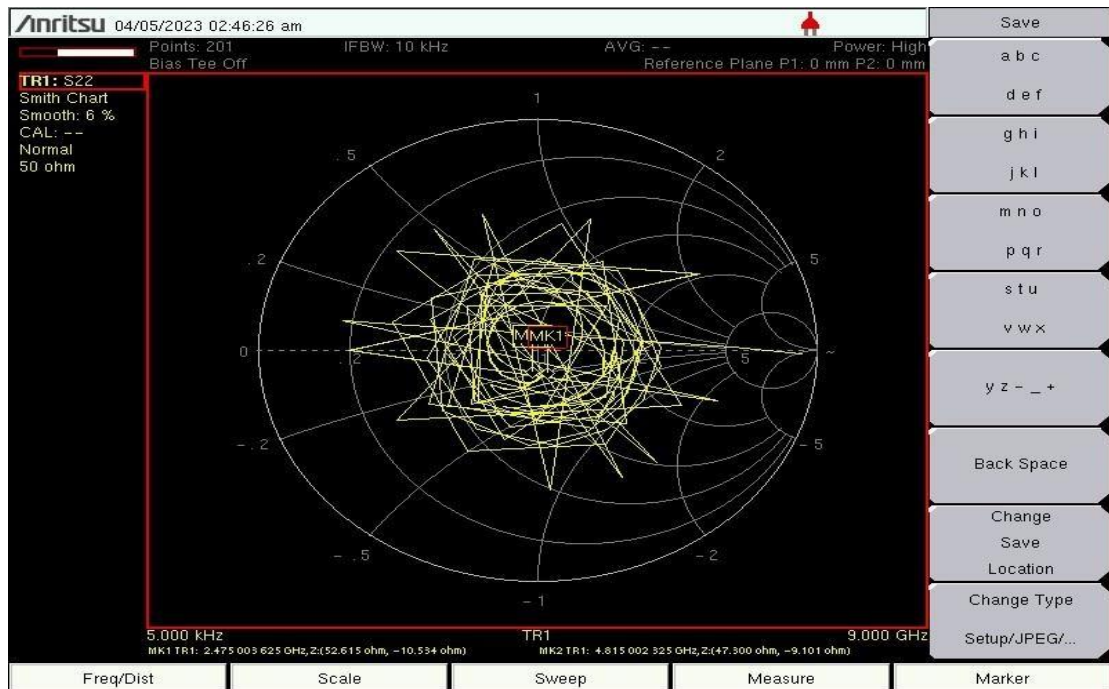


FIG 4.11 Measured impedance plot of the proposed WBDPA

CHAPTER 5

CONCLUSION

Micro Patch antenna are the effective antennas. We used the micro patch antenna with 3 patches in this project. From literature survey's I concluded that mostly used 2x2 or more areal network Antennas, due to this dimension and cost also increases.

The method proposed in this paper contains 3 strip patches. Due to this the size, cost and dimensions are less compared to existing model antennas. The efficiency and antenna gain also not effected to this dimension what I include in my design.

Finally, Microstrip patch antenna is designed for 2GHz using HFSS simulation software. The antenna we proposed in this is three microstrip patch antenna we can achieve and satisfy all the conditions and requirements for an antenna. The designed antenna structure operated at various frequency bands like 2.4 GHz, 3.6 GHz, 4.5 GHz, 6.1GHz and 7.1GHz. Those frequency bands can be applied for various applications. The applications are cub sat, LAN etc. The efficiency we achieved 96.66%.

Table 5.1 COMPARISION BETWEEN EXISISTING AND PROPOSED MODEL OF ANTENNA

PARAMETERS	EXSISTING MODEL	PROPOSED MODEL
S_{11}	-19.31	-21.4099
Gain	11.42	2.2
Directivity	12.17	2.2
VSWR	1.65	1.1858

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APPENDIX A

IEEE STANDARDS FOR WIRELESS APPLICATION OF 2 GHz

The “IEEE Standard Test Procedure for Antennas” dates back to 1948, when it was published as “Standards on Antennas—Methods of Testing,” 48IRE2S2. The first revision was prepared by the Subcommittee on Methods of Testing Antennas of the IEEE Antennas and Waveguides Committee and published as IEEE Standard 149-1965.

[1]. The second revision was prepared by Subcommittee 2.11 on Methods of Testing Antennas of the IEEE Antenna Standards Committee and published as IEEE Standard 149-1979.

[2]. The standard was then reaffirmed in 2008. As per the 2012 maintenance process of the IEEE Standards Association Standards Board (SASB), the standard can no longer be simply reaffirmed. A revision process should be initiated and completed within 10 years from the date that the standard was approved or last revised. A project authorization request (PAR) for the revision of IEEE Standard 149-1979 was, therefore, prepared by the IEEE Antennas and Propagation Society Standards Committee (AP-S/ SC) and submitted to the IEEE SASB New Standards Committee (NesCom).

[3]. The PAR was approved by the IEEE SASB NesCom on 5 December 2015 for a duration of four years; it was extended for an additional year in 2019 and again in 2020.

[4]. IEEE Standard 149-2021 is published as a recommended practice rather than a standard, i.e., with the use of the modal verb “should” (recommended) rather than “shall” (mandatory). The document focuses on the measurement of the fundamental property of any antenna, which is its radiation pattern. The antenna under test is assumed to be a passive, linear, and reciprocal device such that its radiation properties can be measured in either transmitting or receiving model.

APPENDIX B CONSTRAINTS

Effect Of Mobility

The reach-ability due to higher range in the communication between two nodes, Node X to Node Y, the coverage using omnidirectional antennas is in circle pattern while the coverage pattern using directional antennas is in lobes pattern. If the Node Y moves out of the circle area, it will be unable to receive any packet transmitted by Node

X. Since the gain of directional gain is higher, it is possible that Node Y is still in the directional range X and hence, Node Y is still able to receive the packet transmitted. If not, Node Y will still be unable to receive the packet transmitted.

Reach-Ability in Different Sector

In any area inside the circle area when using omnidirectional antennas, the Node X will be able to reach the Node Y. While using directional antennas with DMAC, Node X failed to reach the Node Y using the same sector. It is because Node Y has gone out of the range of the signal that is transmitted in that sector.

Un-Reach-Ability Due to Omni-Discovery

Node X tries to send the packet in its old direction. After failing to reach it after 'Directional retransmit limit', Node Y will try to send an omnidirectional signal. Since the Node Y is unreachable by directional signal, Node X cannot discover the Node Y and thus, Node X will assume that the Node Y is unreachable. Node X will never try to reach the Node Y using different sector even though it is to be done by transmitting directional signal in different sector.

Node X will report the error to the above routing layer and drops the packet due to no route. In fact, this problem can be solved by transmitting the packet directionally in another sector.