COMPACT PATCH ANTENNA WITH VERTICAL POLARISATION

THESIS REPORT

Submitted in partial fulfillment of the requirements for the award of the Degree of Master of Technology in Electronics and Communication Engineering with specialization in Communication Systems by the A P J Abdul Kalam Technological University

by

RESHMA R

Reg.No TKM21ECCS10

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

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CERTIFICATE

Certified that this Project report titled **"COMPACT PATCH ANTENNA WITH VERTICAL POLARISATION"** is a bonafide record of the work done by **RESHMA R** (Reg.No.TKM21ECCS10) under my supervision, in partial fulfillment of the requirements for the award of the Degree of Master of Technology in Electronics and Communication Engineering with specialization in Communication Systems by the A P J Abdul Kalam Technological University.

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At the outset, I consider it my duty to thank Almighty God for giving me the necessary wisdom to successfully complete this project presentation.

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I would also like to express my sincere gratitude to all my teachers, friends and my parents for their much needed support during the preparation and presentation of the project.

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ABSTRACT

This communication proposes a compact, low-profile patch antenna with vertical polarization.A pair of shorted patches are excited in-phase to achieve the vertical polarisation. The principle is to excite two back-to-back arranged shorted patches to generate symmetrical electric-field (E-field) distributions normal to the ground plane. Based on this study, we found that the spacing in between the two patches have little influence on the radiation characteristics, which provides another flexibility in the design. In addition,the shape of the patch and the corresponding field distribution . To improve the impedance bandwidth,gain and reduces the power losses.

In this work, the beam steering controlled by the transmitter's frequency without use of any phase shifter . The beam steering is a simple function of the frequency.which can alter the phase or signal delay electronically, thus steering the beam of radio waves to a different direction. showing that the proposed antenna is suitable for potential surface-mount wireless applications.

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Chapter 1

Introduction

A compact patch antenna is a type of antenna that is relatively small in size and designed to transmit and receive electromagnetic signals. These antennas often consist of a metal patch placed on a substrate, which is typically a thin layer of dielectric material.The design of a compact patch antenna is optimized to ensure that it operates efficiently at a particular frequency or range of frequencies. The size of the patch and the substrate, as well as the shape and placement of the patch, all play a critical role in determining the antenna's performance.One advantage of a compact patch antenna is its small size, which makes it suitable for use in portable or space-constrained applications. Additionally, these antennas often have a directional radiation pattern, which can help to improve their signal strength and quality. However, compact patch antennas may have some limitations in terms of their bandwidth and efficiency. Careful design and optimization are therefore necessary to ensure that these antennas meet the requirements of the intended application Antenna with omni directional radiation characteristics in theazimuthal plane has shown many advantages in short-distance wireless applications, such as intelligent transportation system (ITS), wireless broadcasting, and wearable devices. An antenna can ensure a steady connection with other signal sources around when the positions and orientations of the receiving and transmitting antennas are altered . Traditionally, can be achieved by using a dipole or a mono pole. However, these approaches suffer from high profile, and thus, they are not suitable for portable devices, especially the surface mount devices. Antennas with both circular polarization and linear polarization characteristics. In the TM10 and TM20-mode of the patch are excited to generate the vertical polarization and circular strips or slots to generate the horizontal polarization in the azimuthal plane, resulting in Circular polarisation radiation. Antenna with LP radiation in vertical plane can also find potential applications in Internet of Things (IoT), on-body wearable applications.

On-body wearable applications so on. Various linearly polarized antennas with broadband width have been reported . A common way is to excited a symmetrical patch at the center and load the antenna with capacitive plate and shorted pins. Although good performance can be achieved,these antennas have up-tilt radiation pattern due to the excitation of the higher modes.

In this communication, a new method of realizing the LP patch antenna is proposed by employing two back-to-back arranged shorted patches. Such a layout can generate symmetrical electric-field distribution, and therefore, radiation pattern in the azimuthal plane. An analytical study is first carried out to the principles of producing the vertical polarization,switching the antenna elements or altering the relative phases of the RF signals driving the elements, beam steering technique.

A patch antenna has a curved path of coverage; hanging on a wall, it can spread to a width of degrees. This type of antenna is usually lightweight and can be easily hung on walls, encased in white or black plastic to make it inconspicuous to the observer. Moreover, the plastic casing protects the assembly from damage and also makes it easy to mount. A patch antenna is easy to make and can be customized and modified without much of an effort. It is commonly manufactured using the same materials and process for constructing printed circuit boards on a dielectric material. work includes. A distributed method to design vertically polarized omni directional patch antenna by exciting a pair of back-to-back arranged shorted patch. Analytical study and experimental validation of the proposed antenna. Investigation of the methods of improving the omni directivity by modifying the shape of the patch and the corresponding current distribution. A new method of enhancing the bandwidth by introducing two strip lines between the two patches without increasing antenna's thickness. Moreover, the antenna performance is investigated when it is placed on a large copper plane and human phantom, respectively.

Polarization and pattern reconfigurable antennas have attracted considerable attention from researchers due to their advantages in increasing channel capacity, suppressing interference, and overcoming multi path fading. Moreover, rather limited space restriction of future 5G terminals or platforms makes the compact low-profile antenna structure more competitive . Although the multi functional reconfigurable antenna can save size and cost, it is still a challenge to simultaneously realize a compact low-profile polarization and pattern reconfigurable antenna.A patch antenna is a low-profile directional radio antenna that is used for indoor locations covering single-floor offices, stores and small studios. It is mounted on a small, rectangular, flat surface and consists of two metallic plates placed upon each other.patch antenna has a curved path of coverage; hanging on a wall, it can spread to a width of 30 to 180 degrees. This type of antenna is usually lightweight and can be easily hung on walls, encased in white or black plastic to make it inconspicuous to the observer. Moreover, the plastic casing protects the assembly from damage and also makes it easy to mount. A patch antenna is easy to make and can be customized and modified without much of an effort. It is commonly manufactured using the same materials and process for constructing printed circuit boards on a dielectric material.Antenna polarisation is an important factor when designing and erecting radio antennas or even incorporating them into small wireless or mobile communications systems. Some antennas are vertically polarised, others horizontal, and yet other antenna types have different forms of polarisation. When designing an antenna, deciding on a particular form of antenna, it is important to understand which way it needs to be polarised. Radio antennas with a particular polarisation will not be effective receiving electromagnetic wave signals with a different polarisation. Polarisation of an electromagnetic wave An electromagnetic wave That said, many wireless and mobile phone systems may rely on the fact that there are likely to be many reflections between the transmitter and the receiver and these will tend to mean that a signal will have a particular polarisation when it reaches the receiver. Nevertheless, the polarisation of the antenna is still important.Beam steering of an antenna refers to the capability to direct the main lobe or beam of the antenna towards a specific direction without physically moving the antenna. This is usually accomplished by adjusting the phase and amplitude of the signals fed to the different elements of an antenna array, also known as a phased array antenna.Phased array antennas consist of individual radiating elements that are spaced apart at specific intervals. By controlling the phase and amplitude of the signals fed to these elements, the antenna can steer its beam in a particular direction.Beam steering offers numerous advantages, including the ability to track multiple targets simultaneously and to adjust the direction of the antenna beam quickly and accurately. It can be used in various applications, including radar systems, satellite communications, and wireless networks.However, beam steering requires sophisticated signal processing and control mechanisms to adjust the phase and amplitude of the signals. Additionally, the design of the antenna elements and overall array must be carefully optimized to ensure efficient and effective beam steering.

Chapter 2

Literature Review

This section, presents an overview of some works related to the proposed approach.

Son XuatTa and Ikmo Park *et.a.*,and proposed ancompact wideband circularly polarized (CP) antenna array, which is a set of 2 metasurface based CP patchantennas fed by a sequential-phase (SP) network.which consists of a set of 2 × 2 meta surface-based patch antennas fed by an SP network.The two substrates are made of Rogers RO4003 material (r = 3.38 and tan = 0.0027) with thicknesses h1 =0.8128 mm and h2 = 1.524 mm.The patches and the SP network are printed on the top side of substrate 1, whereas the meta surface structures are placed on the top side of substrate 2.To achieve a low profile and easy fabrication, substrate 2 is stacked above substrate 1 without an air gap.

-Zhong Wang, WeiShao, and YanZhang *et.al.*, they proposed a The designed results indicate that two orthogonal modes of TM10 and TM01 can be excited simultaneously in the antenna,resonate at two close frequencies, and also are matched well.Bandwidth enhancing characteristic is achieved. Substrate dielectric parameters are fixed with and (FR4).The thickness of the substrate is only 1The operation frequency band with a return loss less than -10dB.

In antenna design, RuinaLian *et.al.*, A microstrip-fed dual-polarized stepped impedance (SI) slot antenna element with a low profile is first proposed. The antenna is composed of two pairs of SI slots excited by two orthogonal stepped microstrip feedlines.The broadband characteristic is achieved by combining the fundamental and spurious resonances of the SI slot resonators.The good cross polarization is mainly due to the introduction of the shorting pins. Secondly, based on the proposed antenna,Average efficiency 87.7

Chao Sun,. *et.al.*, proposed model A compact frequency-reconfigurable shorting loaded patch antenna with the capability to switch between three operating bands of Beidou (COMPASS) navigation system.Rotating the top layer of the antenna, the shorting probe in the top layer can be shorted to the ground by different sets of shorting pins with different length in the bottom layer of the antenna, the frequency agility is achieved.By rotating antenna 120degree clockwise E=2.65.

Byung-Chul Park *et.al.*,proposed model, The proposed antenna is based on the circular mushroom structure. Which consist of 4 unit cell ,it is denoted that a unit cell corresponds to quarter of a circular patch. It has no air gap between cell coaxial is placed on the circular mushroom.It is omnidirectional radiation pattern vertical polarization the simulated.

The model proposed by Rahmat-Samiil *et.al.*, A novel patch-fed surface wave antenna (PFSWA) that realises a monopole-like radiation pattern with an attractivelow-profile configuration is presented.Surface wave antenna consists of a thin grounded dielectric slab loaded with periodic square patches,support the propagation of surface waves, and a centre-fed circular patch.Return loss- 6dB (microstrip antenna has a high input impedance large q factor resulting in a poor return loss of only-6 dB.).

H. Iwaoka,*et.al.*,Antenna composed of a conducting body of revolution(BOR) and a parasitic ring shorted to a finite-sized ground plate, BOR-SPR, is designed for realizing a low-profile base station antenna with a wideband VSWR characteristic. The design of the BOR-SPR starts with a center-fed patch antenna. To match the antenna input impedance to a 50-ohm feed line, as a first step, a slot is cut into the patch,and as a second step, shorted parasitic conducting pins are added to the periphery of Ant-I . Ant-II has a VSWR bandwidth of approximately 28

et.al. proposed a A wideband vertically polarised omni-directional antenna, which ischaracterised with a height of 0.1 L (L: the wavelengthat low frequency), a relative operating bandwidth of 48

indentZhaoyangTang *et.a.*,Compact wideband patch antenna is presented. The antenna consists of two simple patch pairs with opposite phase feedThe coupling between two patchesin the design, an antenna with a size about 54.5 22 20 mm is constructed and tested.The simulated and measured results show that the antenna has the active reflection coefficient less than 9.6 dB in the band 2.6–6 GHz.

indentTian Hong Loh,*et.a.*, Compact dual-band antenna that can achieve electronic beam steering in the horizontal plane across a range from 0 to 360 and adaptive beam-forming is presented.Multiple radiation patterns can be generated by the antenna for interference canceling.prototype antenna was developed whose frequency bands are 1.8–2.2 and 2.85–3.15 GHz. The height of the antenna has been reduced to 0.12 at 1.8 GHz.

indentDANIEL,*et.a*,Substrate is used the antenna is Rogers TMM6 the Structure is square patch antenna.The boresight gain of antenna 2wave frequency with various of pf. Pf (position feed point) moves the feed point towards the center the two resonances move reverse to each other.The feed position has the opposite effect with the load position.

indentWanlan Yang,,*et.a.*Substrate is used Rogers RO4003L Dimension of the antenna is thickn ess.203 mm, relative permittivity338lostangent of .027 thickness of material 17um. The radiation efficiency obtained from the measured gain estimated directivity of the antenna array is about67percentage to 60 GHz

indent JinhaiLiu,*et.a.*,Wideband omni- directional antenna with novel feeding structure for improving radiation patternsA wideband vertically polarised omni-directional antenna, which is characterised with a height of 0.1 L (L: the wavelengthat low frequency), a relative operating bandwidth of 48A pair of /4 resonators is introduced to broaden the bandwidth a symmetrical hook-shaped probe is employed to improve the cross-polarization.The shorting pins between the patch radiator and ground plane are used to reduce the dimension of the antenna.10dB Bandwidth about 48

indent HangWong,*et.a.*Circularly-Polarized Conical Beam Antenna With Wide Bandwidth and Low Profile Circularly-polarized (CP) conical-beam antenna with low profile and wide impedance axial ratio (AR) bandwidths.The antenna structure simply consists of a wideband monopolar patch antenna and eight parasitic loop stubs for generating vertically-polarized electricfield E and horizontally-polarized field E,respectively.The proposed antenna is low profile but wideband because of merging the TM01 and TM02 modes at around the center frequency. In order to obtain the wideband CP radiation.

indent JingliGuo,Yanlinzou,ChaoLiu,*et.a.*Compact Broad band Crescent Moon shape

Patch pair Antenna,Compact wideband patch antenna is presented. The antenna consists of two simple patch pairs with opposite phase fee The coupling between two patchesin the design, an antenna with a size about 54.5 22 20 mm is constructed and tested.The simulated and measured results show that the antenna has the active reflection coefficient less than 9.6 dB in the band 2.6–6 GHz.

indent Haitao Liu, Steven Gao, and Tian Hon Loh,*et.a.*Compact Dual-Band Antenna With Electronic Beam-Steering and Beamforming Capability,Compact dual-band antenna that can achieve electronic beam steering in the horizontal plane across a range from 0 to 360 and adaptive beamforming is presented.Multiple radiation patterns can be generated by the antenna for interference canceling.prototype antenna was developed whose frequency bands are 1.8–2.2 and 2.85–3.15 GHz. The height of the antenna has been reduced to 0.12 at 1.8 GHz.

indent Yuejun Zheng1, Yulong Zhou1,*et.a.*Ultra-wideband polarization,Propose two application cases by applying the polarization conversion structures to aperture coupling patch antenna (ACPA).Due to the existence of air-flled gap of ACPA, air substrate and dielectric substrate are used to construct the double-layer MS. The polarization conversion bandwidth is broadened toward low-frequency range. Subsequently, two application cases of antenna are proposed and investigated.The simultaneous improvement of radiation and scattering performance of antenna is normally considered as a contradiction.The contradiction is addressed in these two application cases. According to diferent mechanism of scattering suppression (i.e.,polarization conversion and phase cancellation) the polarization conversion structures are utilized to construct uniform and orthogonal arrangement confgurations. And then, the confguration are integrated into ACPA and two diferent kinds of meta surface-based (MS-based) ACPA are formed.Radiation properties of the two MS-based ACPAs are improved by optimizing the uniform and orthogonal arrangement confgurations.

indent Bilawal Khan1, Babar Kamal2,,*D*esign and experimental analysis of dual-band polarization converting meta surface for microwave applications,The meta surface consists of a 22× 22 element array of periodic unit cells.The geometry of the unit cell consists of three layers, including a 45° inclined dipole shape metal patch on top, which is backed by a 1.6 mm thick FR-4 substrate in the middle, and a fully refractive metallic mirror at the bottom. The proposed surface is exposed to horizontally

(x) or vertically (y) polarized plane waves and the co and cross polarization refection coeffcients of the reflected waves are investigated experimentally in the 6–26GHz frequency range.The meta surface is designed to convert incident waves of known polarization state (horizontal or vertical) to orthogonal polarization state (vertical and horizontal) in two distinct frequency bands, i.e. 7.1–8GHz and13.3–25.8GHz.

indentSaptarshi Ghosh2,A Wideband Cross Polarization ConversionUsing Metasurface The unit cell of the proposed meta surface is made of metallic patch of single circular split-ring imprinted on top surface of ametal-backed single-layer dielectric substrate.The polarization conversion phenomena at these four frequencies have been analyzed in the light of electromagnetic resonances.The proposed structure has been studied under oblique incidence, both for transverse electric and transverse magnetic polarizations.

indent Changlong Qi, Yuehui Cui,The quad-polarization antenna consists of a circular loop for horizontal polarization (HP) and atop-loaded monopole for vertical polarization (VP).The lefthanded circular polarization (LHCP) and the right-handed circular polarization (RHCP) are obtained by exciting the loop and the monopole simultaneously with different phases. bandwidth overlapped for HP, VP, LHCP, and RHCP is about 30

indent Wanlan Yang, Kaixue Ma,A compact high performance patch antenna array for 60GHZ applications,Substrate is used Rogers RO4003L Dimension of the antenna is thickness.203 mm, relative permittivity338 lostangent of .027 thickness of material 17um. The radiation efficiency obtained from the measured gain estimated directivity of the antenna array is about .67percentage to 60 GHz

Chapter 3

Proposed Model

In this section, a low-profile, vertically polarized planar antenna with radiation pattern is presented and studied. First,the approaches of achieving the radiation pattern and vertical polarization are studied. Then, studies of how to improve the omni directivity of the pattern and the bandwidth are carried out.Configurations the configuration of the antenna. The antenna has a single substrate with a ground plane on the bottom layer. On the top layer, two T-shaped patches are placed back-to-back and fed by a probe at the center. Two rows of metallic pins are inserted to short the patches to the ground plane on the bottom. The length from the opened end to the shorted end of the patch .Two strip lines are inserted in between the patches to enhance the impedance bandwidth of the antenna, which will be detailed in Section II-C. The antenna is implemented on a FR4substrate.Different from traditional patch antenna that only two slots contribute to the radiation, the far-field radiation of the proposed antenna is attributed by all four slots with uniform electric-field direction in the z -axis direction. Such an E-field distribution can be equivalent to a magnetic current loop in the xy plane. It is well known that a magnetic current loop in horizontal plane will result in vertical polarization radiation (E) in the far-field. The far-field E-field distribution intensity of the proposed antenna can be derived by calculating the radiations of the four magnetic currents. According to the methods of calculating the radiation of a rectangular radiating slot , the far-field E-field of one opening slot in the y-axis direction .Another issue to be concerned is the bandwidth. To enhance it, the patch is split into two parts and two strip lines are inserted in between them,This structural modification does not change the field distribution and

$$E_{\theta 1} = -\frac{jkbhEe^{-jkr}}{4\pi r}\left(\cos\phi \cdot \frac{\sin(X)}{X} \cdot \frac{\sin(Y)}{Y}\right)$$

$$\begin{cases} X = \dfrac{kb\sin\theta \cdot \sin\phi}{2} \\ Y = \dfrac{kh\cos\theta}{2} \end{cases}$$

where k is the wavenumber at the designed frequency, h is the height of the substrate, E is the electric-field intensity.

thus the radiation can be kept. The strip lines serve as the first stage of the resonant circuit, whereas the shorted patches serve as the radiator and the last resonator. compares input impedance and S11 of the antennas with and without the strip lines. As observed, the proposed antenna , forming a second-order resonane characteristic , compares the impedance bandwidths between the Type-II and proposed antenna. It is observed that Type-II antenna has a bandwidth, which is enhanced to over the proposed antenna.Then to be added the beam steering technique,which help to change the direction of main loop .Which reduces interference,saves power, increases gain and directivity of the micro-strip antenna. May be accomplished by switching the antenna elements or by changing the relative phases of the RF signals driving the elements.

simplified by removing the two strip lines and combining the two patches together , The introduced metallic vias divide the patch into two identical sections and change the electric-field distribution characteristics, and therefore the far-field pattern. Dueto the symmetry, the patch has uniform electric-field distribution E on the two opening slots with a direction from ground to the patch(or reverse). These two opening slots can be equivalent as two magnetic current in opposite directions ($\pm$y-axis) Different from traditional patch antenna that only two slots contribute to the radiation [18], the far-field radiation of the proposed antenna is attributed by all four slots with uniform electric-field direction in the z -axis direction. Such an E-field distribution can be equivalent to a magnetic current loop in the xy plane, It is well known that a magnetic current loop in horizontal plane will result in vertical polarization radiation in the far-field. The far-field E-field distribution intensity of the proposed antenna can be derived by calculating the radiations of the four magnetic currents. According

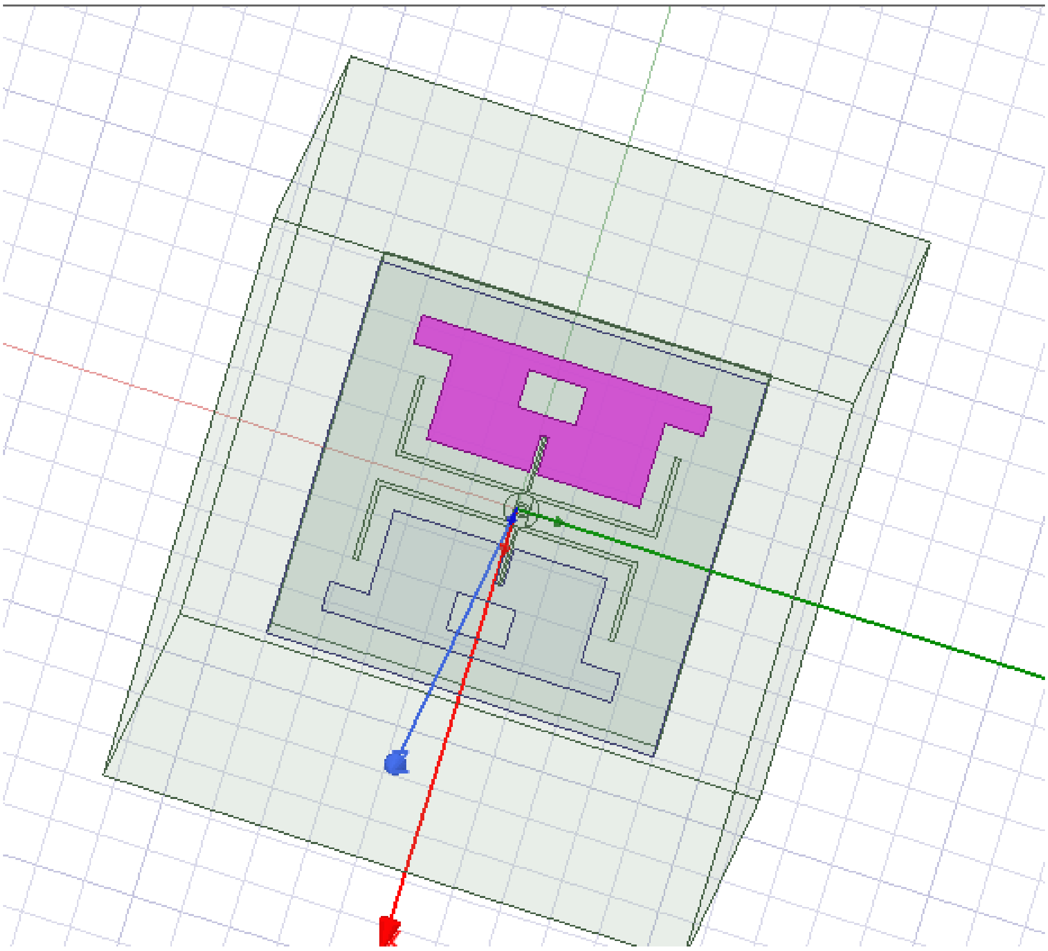

Figure 3.1: Proposed Model

$PCR = \frac{|Ryx|^2}{|Ryx|^2+|Rxx|^2}$ (3.1)

where $Rxy = E_{xr}/E_{yi}$ and $Ryy = E_{yr}/E_{yi}$ represent the reflection ratio

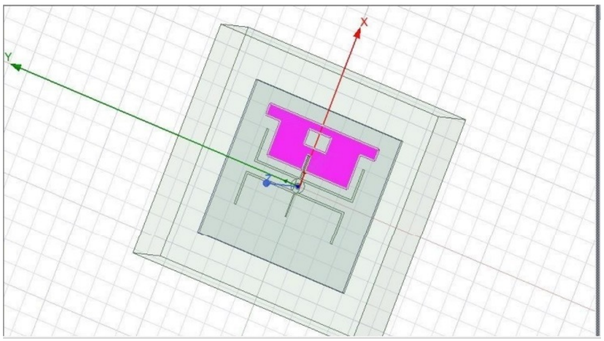

Figure 3.2: Second patch antenna

to the methods of calculating the radiation of a rectangular radiating slot , the far-field E-field of one opening slot in the y-axis direction ,Then to be the beam steering ,change the different degree of radiation.The beam direction is found by exciting any of the input ports, while terminating the remaining ports. By exciting four input ports separately, whilst terminating the other ports, four beams pointing in different directions are produced. In 3D beam patterns , from which it can be observed that by exciting the input ports.The realized radiation patterns based on the input port excitations at frequencies. These patterns are demonstrated in the theta range of 0 to 360°.Beam steering technique reduces interference, saves power, increases gain and directivity of the micro-strip antenna. Beam steering antennas are defined so that the antennas can be able to form narrow directional beams with relatively low side lobes so that the beams can be electronically steered towards an intended target of transmission and reception. Beam steering antennas provide beam forming gain as opposed to diversity gain . The polarisation ratio calculation equation is given below

Chapter 4

RESULT AND DISCUSSION

S-parameters, or scattering parameters, are a set of parameters used to describe the behavior and performance of an antenna or any other RF system. These parameters are used to characterize the linear behavior of the system, specifically how the system responds to input signals of different frequencies.There are several S-parameters used in antenna design, including S11, S12, S21, and S22. S11, also known as the return loss or reflection coefficient, describes how much of the signal reflected by the antenna is returned to the input port. S21, also known as the forward gain or transmission coefficient, describes the amount of signal transmitted from the input port to the output port. S12 and S22 describe the level of coupling between the input and output ports.By measuring the S-parameters of an antenna, engineers can evaluate its performance and identify any issues or areas for improvement. They can also use the S-parameters to design and optimize matching networks, which are used to ensure that the antenna is operating at its optimal resonant frequency.S-parameter measurements are typically performed using network analyzers. These measurements allow for precise understanding of the behavior of the antenna and RF system, enabling antenna designers to refine the design for optimal performance.shows the simulated and measured S-parameters and the gains of the proposed antenna.S-parameters are a way of expressing things with general waves instead of voltages and currents. It describes how much the waves are reflected or transmitted from/through a device.In this design s11 value equal to -20dB equal amount of radiation in all the directions. S11 represents how much power is reflected from the antenna,

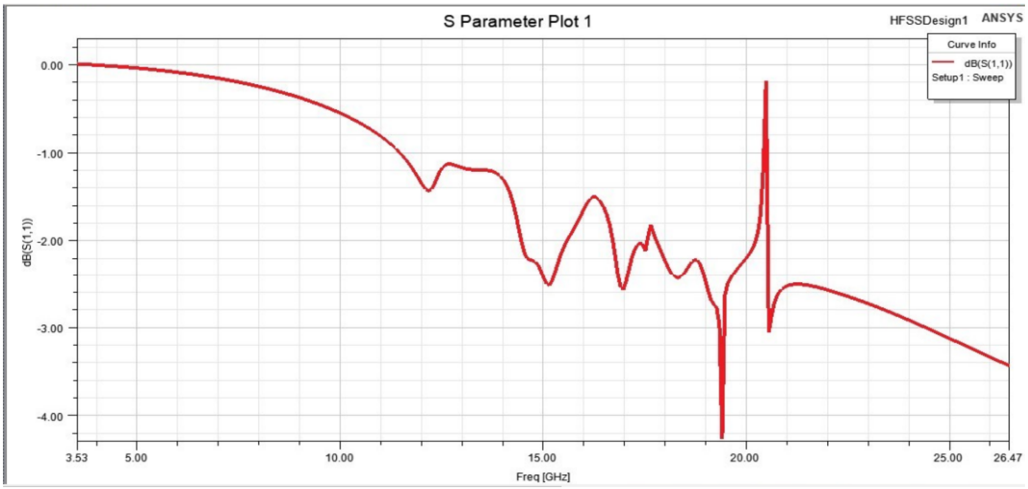

Figure 4.1: s parameter

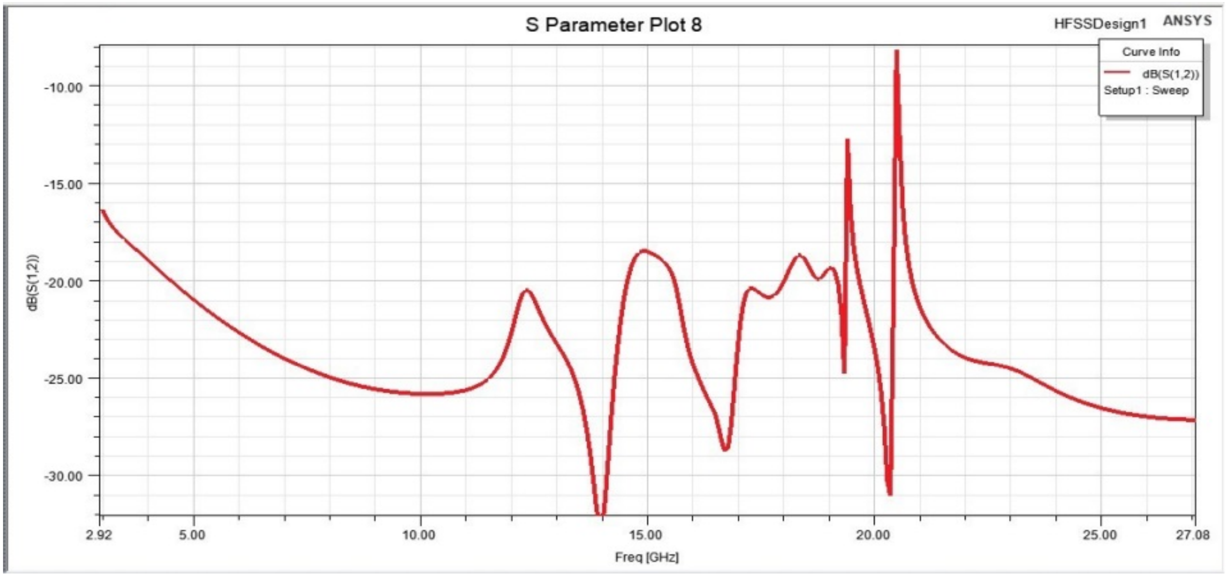

Figure 4.2: s parameter of second antenna

The second patch antenna design the gain should less as compared to first antenna design.It is observed that the radiation fluctuation is reduced from first antenna design.

4.0.0.1 VSWR CALCUTATION

Then should calculate the VSWR value ,Vmax/Vmin is about 1.646 the VSWR value under 2 is considered suitable for antenna application ,In this VSWR value should be below 2 therefor the less power being to transferred efficiently from the transmission line of the antenna.It indicates the amount of power that can be safely

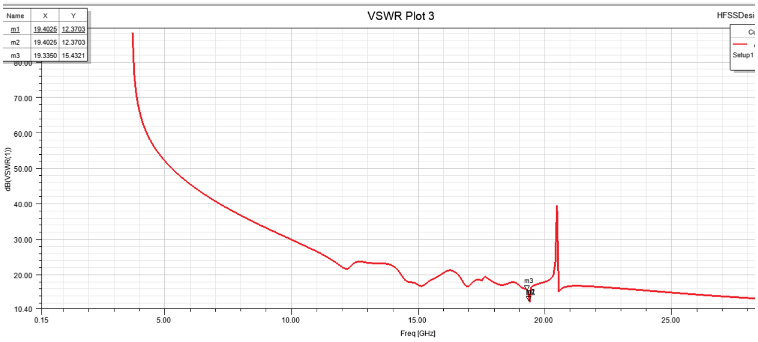

Figure 4.3: Vswr value

delivered to an antenna without damaging it. A low VSWR value means a better impedance match, and therefore more power being transferred.VSWR, which stands for Voltage Standing Wave Ratio, is a measure of the mismatch between the input and output impedance of a transmission line or device. It is commonly used in the field of radio frequency (RF) engineering to assess the performance and efficiency of RF systems.The VSWR is calculated based on the ratio of two parameters: the maximum amplitude of the forward wave (Vf) to the maximum amplitude of the reflected wave (Vr) along a transmission line. Mathematically, the VSWR is defined as:VSWR = (Vf + Vr) / (Vf - Vr) Where: Vf is the amplitude of the forward wave (the desired signal traveling towards the load),Vr is the amplitude of the reflected wave (the signal reflected back due to impedance mismatch or other factors).The VSWR can also be expressed in terms of power, using the square of the voltage values:VSWR = (Pf + Pr) / (Pf - Pr) ,Where:Pf is the power of the forward wave, Pr is the power of the reflected wave.The VSWR value indicates the degree of impedance mismatch between the transmission line and the load. A VSWR of 1:1 signifies a perfect match, meaning that all of the power is transferred to the load without any reflections. As the VSWR increases, it indicates a greater level of mismatch and more power is being reflected back.Typically, VSWR values are represented as a ratio, such as 1.2:1, 2:1, 3:1, etc., or in decibels (dB), where VSWR(dB) = 20 * log10(VSWR).It's important to note that a high VSWR can lead to various issues, including signal loss, reduced efficiency, increased heating, and potential damage to the transmission line or device. Therefore, minimizing VSWR is crucial for optimal performance and reliability in RF systems.
"*Vmax/Vmin*"

4.0.0.2 POLARIZATION

Polarisation ratio , a low angle of radiation which enables it to provide long distance transmission and reception .Axial ratio calculated by the longer axis divided by the shorter ,the polarisation ratio below the 2 dB.An antenna is a transducer that converts radio frequency (RF) electric current to electromagnetic waves that are then radiated in to space. Antenna polarization is an important consideration when selecting and installing antennas. Most wireless communication systems use either linear (vertical, horizontal) or circular polarization. Knowing the difference between polarizations can help maximize system performance for the use.the plane of polarization rotates in pattern making one complete revolution during each wavelength. A circularly polarized wave radiates energy in the horizontal, vertical planes as well as every plane in between. If the rotation is clockwise looking in the direction of propagation, the sense is called right-hand-circular (RHC). If the rotation is counterclockwise, the sense is called left-hand circular (LHC).Polarization in antennas refers to the orientation of the electric field generated by the antenna's radiating elements. It plays a crucial role in wireless communication systems as it affects the propagation characteristics of the electromagnetic waves and determines how well the antenna can transmit and receive signals.The electric field generated by an antenna can be oriented in different ways, typically categorized into three main types of polarization:Vertical polarization: In this case, the electric field vector of the radio waves is oriented vertically, parallel to the Earth's surface. This type of polarization is commonly used in broadcast television, FM radio, and mobile communication systems, where antennas are usually mounted in an upright position.Horizontal polarization: Here, the electric field vector is oriented horizontally, perpendicular to the Earth's surface. This polarization is often employed in satellite communication, point-to-point microwave links, and certain wireless networking applications. Circular polarization: Circularly polarized waves have an electric field vector that rotates in a circular pattern as the wave propagates. Circular polarization can be further classified into two types: right-hand circular polarization (RHCP) and left-hand circular polarization (LHCP). This type of polarization is commonly used in satellite communication, wireless systems with multipath propagation, and radio astronomy applications.The choice of polar-

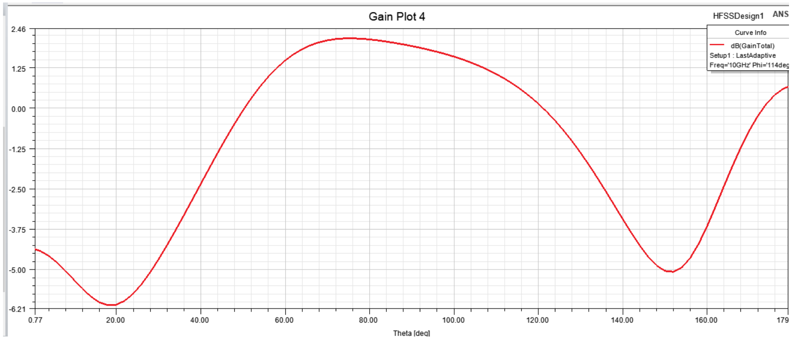

Figure 4.4: Polarization

ization for an antenna depends on various factors, including the specific application, environmental conditions, and the presence of obstacles or signal reflections. By using the appropriate polarization, engineers can minimize signal degradation caused by interference, multipath fading, and other propagation effects.It is important to note that for effective communication, the transmitting and receiving antennas must have matching polarization. When there is a mismatch, signal attenuation and loss can occur, resulting in reduced communication range and quality. Therefore, it is necessary to consider polarization when designing and deploying antennas in wireless communication systems. the antenna.

4.0.0.3 BEAM STEERING

Beam steering ,here can be used by the beam steering technique .It should reduce the interference save power and increase the gain and directivity , The element spacing the phased beam steering the change the direction of the main lobe,eliminated by the unwanted signals from desired directions. Beam steering antennas are defined so that the antennas can be able to form narrow directional beams with relatively low side lobes so that the beams can be electronically steered towards an intended target of transmission and reception. Increase in the beam width can alter the load transfer path from beam to joint core, thus enhancing the beam-column joint assemblies and result in the higher peak strength.

In this figure shows that the Beam steering increases all the lobes width but does not change the lobe peak. So, the peak value of the array factor is (or at least seems to be) the same for each scan angle.all active antennas is the loss of aperture gain as the beam is steered away from the bore sight direction . This characteristic, called

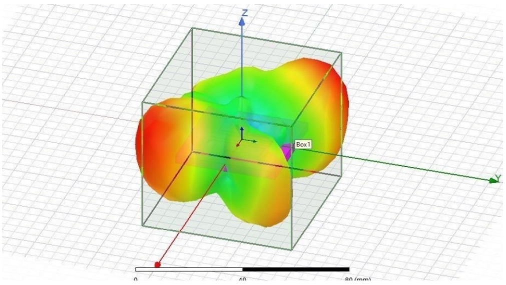

Figure 4.5: Beam steering

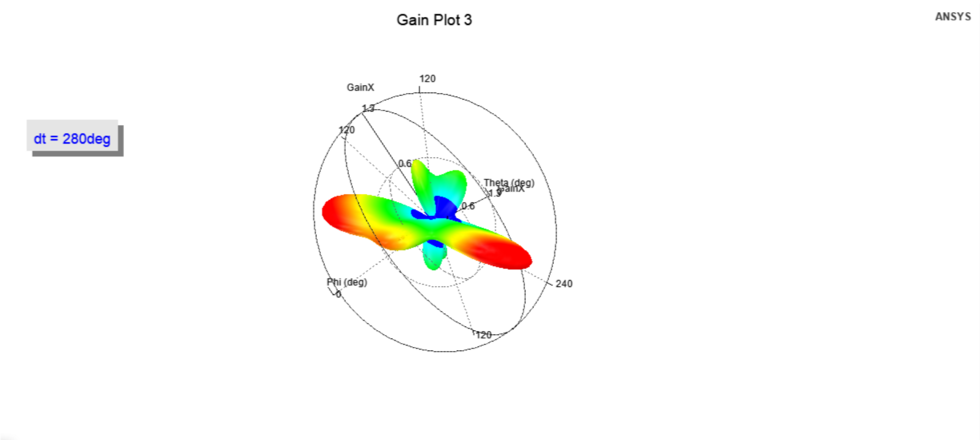

Figure 4.6: Gain of antenna design

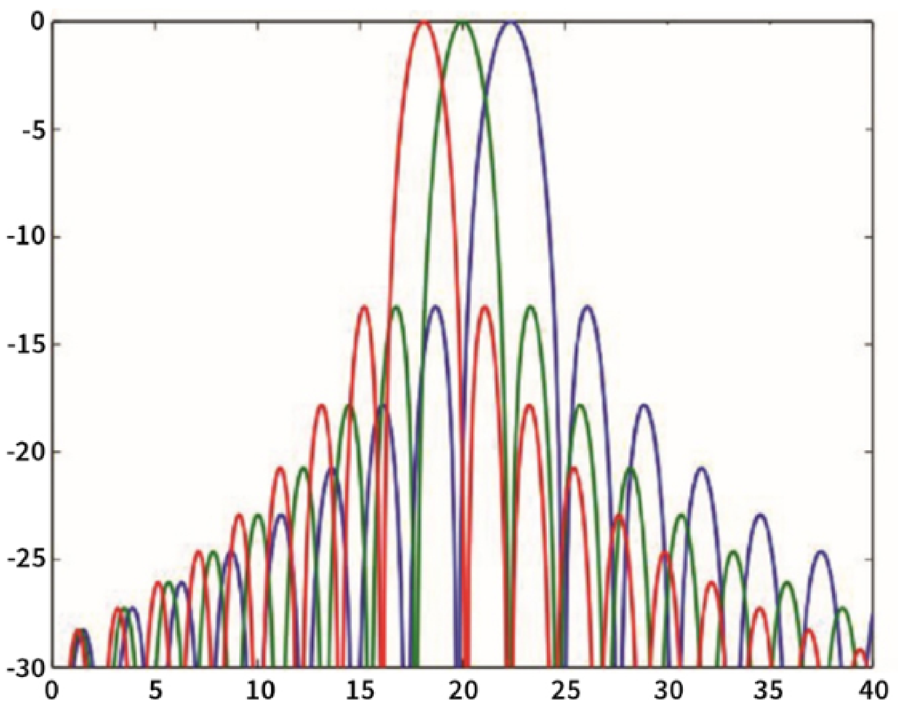

Figure 4.7: Different degree of beam steering

scan loss, power, where is the scan angle off bore sight and N is a numeric value. where the bore sight angle is zero, there is no scan loss. As the scan angle is increased to 45 degrees, there is 2 dB scan loss. If you increase scan angle to a practical limit of 60 degrees, there is 4 dB scan loss Therefore the antennas need to have enhanced gain and steerable radiation patterns. Therefore, beam steerable antennas have become very popular in modern day antenna propagation. Beam steering technique reduces interference, saves power, increases gain and directivity of the micro-strip antenna. Beam steering antennas are defined so that the antennas can be able to form narrow directional beams with relatively low side lobes so that the beams can be electronically steered towards an intended target of transmission and reception.

Δ is the wavelength of radiated microwave and L is the distance between each radiators. The degree of beam steering in an antenna refers to the angular range over which the antenna's main radiation beam can be electronically steered. Beam steering allows the antenna to adjust the direction of its beam without physically moving the antenna itself. This capability is particularly useful in applications where the antenna needs to track moving targets or communicate with multiple points.The degree of beam steering is determined by several factors, including the antenna design, the number and arrangement of antenna elements, and the signal processing techniques employed. Some of the key factors influencing beam steering are:Antenna Array Configuration: Antenna arrays consist of multiple individual antenna elements arranged in a specific geometry. The geometry of the array determines the antenna's ability to steer the beam in different directions. Common array configurations include linear arrays, planar arrays, and conformal arrays.Number of Antenna Elements: The more antenna elements in an array, the finer the control over beam steering. Increasing the number of elements allows for a greater angular range over which the beam can be steered. Antenna Element Spacing: The spacing between the antenna elements affects the beam's steering capabilities. Generally, larger spacing between elements allows for wider beam steering angles, while smaller spacing enables more precise steering at narrower angles. Beamforming Techniques: Beamforming is a signal processing technique used to shape and steer the antenna's beam. It involves manipulating the phase and amplitude of the signals across the antenna elements to create constructive or de-

$$\sin \theta_{st} = 0.514 \frac{\lambda}{e}$$

Where

$\sin \theta_{st}$ = sine of the maximum steering angle

λ = wavelength in test material

e = element width

Given the notation in Figure 1, the phase value for each TX channel is calculated as:

$$\vec{\emptyset} = [\emptyset_1\ \emptyset_2\ \emptyset_3\ \dots\ \emptyset_N] = [0\quad 2\pi\frac{d_2}{\lambda}\sin\theta\quad 2\pi\frac{d_3}{\lambda}\sin\theta\quad \dots\quad 2\pi\frac{d_N}{\lambda}\sin\theta]$$

structive interference. Various beamforming algorithms, such as digital beamforming and adaptive beamforming, can be employed to achieve different degrees of beam steering.Frequency of Operation: The frequency at which the antenna operates also influences the degree of beam steering. Higher frequencies tend to result in narrower beamwidths, which allow for more precise steering but may limit the overall angular range.It's important to note that the degree of beam steering is not solely determined by a single factor but rather the combined effect of various design considerations and system parameters. Antenna designers and engineers strive to optimize these factors to achieve the desired beam steering capabilities for specific applications.

$\boldsymbol{p}$hase shifter $\boldsymbol{\Delta = (2\Delta/\Lambda) L sin\theta}$ (4.0)

Transmitting antenna, the gain describes how well the antenna converts input power into radio waves headed in a specified direction. In a receiving antenna, the gain describes how well the antenna converts radio waves from a specified direction into electrical power.As compared to other type of antenna design, in this gain is high as compared to others.High-gain antennas transmit more power to the receiver, increasing the strength of the signal it receives. As a result of their reciprocity, high-gain antennas can also make transmitted signals 100 times stronger by capturing more energy when used in receiving antenna.Gain can be used to increase the

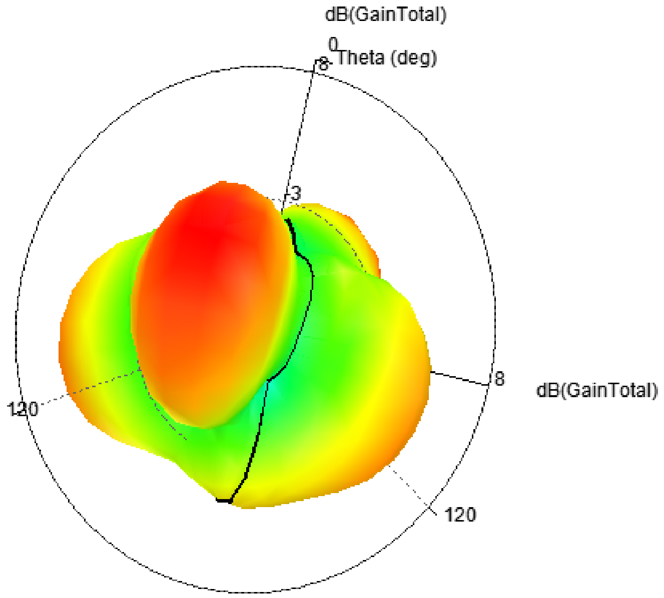

Figure 4.8: 3D design

power of a signal. For example, if we want to amplify a weak signal, we can use an amplifier with a high gain. Gain can also be used to decrease the power of a signal,The signal strength increases. high directivity

Chapter 5

Future Scope

Impedance bandwidth, an important characteristic of microstrip patch antennas can be significantly improved by using multi layer dielectric configuration.Such a design is expected to facilitate the use of antenna in defence applications in radar and communication systems to avoid detection by enemy.The advantage version is we combine the HFSS and matlab version with beam steering technique ,This help to increasing the bandwidth and gain of the antenna design.

patch antenna is mainly practical at microwave frequencies, at which wavelengths are short enough that the patches are conveniently small. It is widely used in portable wireless devices because of the ease of fabricating it on printed circuit boards.The antenna is also low profile and low cost and has ease of manufacturing.compact patch antennas looks promising as they continue to be widely used in various applications. Here are some potential advancements and areas of development for compact patch antennas, Efforts to further reduce the size of patch antennas will continue. Researchers will focus on developing new design techniques and materials to achieve smaller form factors without sacrificing performance. Compact patch antennas capable of operating across multiple frequency bands or providing wideband coverage will be in demand. This will enable support for diverse wireless communication standards and systems.

Combine the software ,analysis the radio and radar systems, beam steering may be accomplished by switching the antenna elements or by changing the relative phases of the RF signals driving the elements. In recent days, beam steering is playing a significant role in 5G communication because of quasi-optic nature of 5G frequencies.

Chapter 7

Conclusion

In this communication, a low-profile, LP antennawith has been proposed for potential IoT and wearable applications. The the LP in vertical plane have beenachieved by exciting two physically separated shorted patches. Such a distributed layout provides more flexibility inrealizing the antenna.

The methods of improving impedance bandwidth have been investigated.The predictions were validated by measurement results, demonstrating a good performance, rendering it suitable for awide range of wireless applications.Beam steering technique reduces interference, saves power, increases gain and directivity of the micro-strip antenna.

References

[1] Son Xuat Ta and Ikmo Park'Compact Wideband Circularly Polarized Patch antenna Array Using Meta surface"' *IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS*, VOL. 16, 2021.

[2] ShaoqiuXiao, Member, IEEE, Bing-Zhong Wang, WeiShao, and YanZhang, Member ,IEEE' Bandwidth-Enhancing Ultralow-Profile Compact Patch Antenna", *'IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION*, VOL. 53, NO. 11,NOVEMBER 2019

[3] Fahad Qureshi, Marco A. Antoniades, Student Member, IEEE, and George V. Eleftheriades, Senior Member, IEEE' A compact and Low-Profile Metamaterial Ring Antenna With Vertical Polarization" *'IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS*, VOL. 15, 2017

[4] RChao Sun, Huili Zheng, Lingfei Zhang, and Ying Liu, Member, IEEE' A Compact Frequency- Reconfigurable Patch Antenna for Beidou(COMPASS) Navigation System" *'IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS*, VOL. 13, 2017

[5] Byung-Chul Park and Jeong-Hae Lee' Omnidirectional Circularly Polarized Antenna Utilizing Zerot Order Resonance of Epsilon Negative Transmission Linemph" *IEEE Transactions On Circuits And Systems—I*'IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, VOL. 59, 2017

[6] DANIEL EDELGAARD SERUP , GERT FRØLUND PEDERSEN Compact wideband patch antenna for GNSS applications" *IEEE Transactions On Circuits And Systems—I*'IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, VOL. 59, 2016