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International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

A Review of Microstrip Patch Antenna using Metamaterial Structure for Improved Radiation

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ABSTRACT-

A new high gain, wideband T-shape slot loaded microstrip patch antenna is presented in this paper. The antenna is printed on a dielectric substrate, supported by a metal board, and fed directly through a 50 Ω coaxial cable. Using the CST software package according to the set size, the antenna is simulated. The combined effect of combining these techniques and introducing a novel mounted clip provides a low profile, wide bandwidth, high gain and compact antenna feature. Computer simulation results show that the antenna can detect wide band characters. With the adjusted parameters, the antenna has a compact size of 82 mm x 65 mm at 1.09 GHz. The antenna resonates at 1.09 GHz which is common in ADS-B systems.

KEYWORDS - Microstrip antenna, wideband, T-shape.

1. INTRODUCTION

It consists of a rectangular metal patch on a dielectric substrate and is excited by a voltage source across the metal patch and the ground plane of the substrate. A microstrip antenna produces high radiation over a wide area (θ = 0), with no radiation at the edge of the substrate (θ = 90°). In global positioning satellite (GPS) systems, small circular antennas are used. They are more compact in size and more expensive due to their shape. Microstrip antennas are also used in the fields of RFID (radio frequency identification), mobile communications and healthcare. There are three types of microstrip antenna: Microstrip patch antenna, Microstrip slot/mobile antenna and printed dipole antenna. Among the three types above, the microstrip patch antenna can have any shape. Microstrip slots/rods are usually rectangular or circular. They play an important role in wireless communication systems due to their lightweight and thin profile. Another advantage of patch antennas is that they are easy to make and are compatible with integrated circuits. Patch antennas are very useful in wireless communication systems. The rapid development of wireless communication systems has increased the demand for compact microstrip antennas with high gain and wideband operating frequencies. Microstrip patch antenna has advantages such as low profile, conformal, light weight, simple realization process and low production cost. However, conventional microstrip patch antennas have some disadvantages such as low bandwidth etc. Performance improvements to cover the required bandwidth are required. There are many and well-known ways to increase the bandwidth of antennas, including increasing the thickness of the substrate, the use of a low dielectric substrate, the use of various matching and feeding methods, and the use of multiple resonators. -coaxial probe is introduced. The antenna is modeled using Agilent Advanced Design System (ADS) technology. The results show that the impedance bandwidth achieved a good match.

2. LITERATURE SURVEY

Ahsan M.R., HabibUllah M. and Mansor F. (2014), "Analysis of a compact wideband slotted antenna for ku band applications" International Journal of antennas and propagation, antenna characteristics are found in terms of return loss, gain and bandwidth. It is observed that the proposed new configuration can work in two different bands with good amount of bandwidth i.e. 12.05% bandwidth in 1.25GHz frequency band and 19.82% bandwidth in 2GHz frequency band. The resonant behavior in different frequency bands makes this antenna structure suitable for different types of applications with an antenna gain of 5.509dBi and an antenna efficiency of 89%. The design and simulation of the antenna structure was done with IE3D simulation software version 15.02. Parabolic reflector, Yagi antenna, Horn antenna are some examples of antenna structures with a good amount of bandwidth and gain. There is no doubt that these antennas are sufficient in terms of their performance but the main drawback of these types of antennas is the 3D structure that limits the use of these types of antennas, that is why small antennas are very necessary for those communication devices, and that if we get any antenna structure with 2D structure and small size and will play an important role in the field of wireless communication.

Microstrip patch antenna with 2D structure fulfills this requirement. Microstrip patch antenna is a two-dimensional planar antenna configuration with all the advantages of printed circuit board such as simple design and layout, low cost etc. Although this antenna structure has several advantages, it also has some disadvantages such as low, low bandwidth. profit, low efficiency etc. and to overcome this disadvantage various researches are in progress. The shape of these antennae's leaflets affects the performance of these antennas. Various ways to improve antenna performance are suggested by researchers such as cutting notches and gaps in regular rectangular, square, etc. shapes. , by introducing slits in the patch geometry, by using different dielectric materials , by using different feeding methods, by using air gap formation, by using stacked configuration etc. First of all considering its return loss curve, using this curve the bandwidth of the designed antenna is calculated, then consider the VSWR curve which will help determine if this antenna structure can. operate in the frequency bands shown in the return loss curve. Another important parameter gain is also considered to analyze the gain of the antenna, further another important parameter ie the directionality is shown. Finally the efficiency including antenna efficiency and radiation efficiency is considered. All these results are analyzed in this paper. The coaxial probe feed method is used for feeding.

Kevin Ming-Jiang Ho and Gabriel M.Rebeiz. (2014), "Dual band circularly polarized microstrip antenna for ku/ka band satellite communication arrays" in IEEE Antenna and wireless propagation, A compact microstrip patch antenna for Automatic dependence surveillance system (ADS-B) is introduced. The antenna is supplied with a 50Ω transmission line. A T-slot is carved into the ground plane to achieve a certain degree of miniaturization of the design. The proposed antenna has a compact size of 82 mm x 65 mm and a frequency of 0.297λ0 x 0.23λ0 at 1.09 GHz. The antenna resonates at 1.09 GHz which is common in ADS-B systems. The predicted gain of an ADS-B antenna ranges from 1dB to 5dB and the measured gain is around 3.10dB. It is expected that the proposed antenna can fulfill the ADS-B specification. The design is validated by fabrication and measurement of the prototype. Simulated and measured results are available and compared. Microstrip patch antennas (MPAs) have gained a lot of attention in the microwave community. MPAs are typically designed using different shapes and images etched on a dielectric substrate. Deployment techniques depend on the design specifications and location of the antenna. The most commonly used MPA is the rectangular patch. A rectangular patch antenna is approximately half the rectangular wavelength of a rectangular microstrip transmission line. Microstrip patch antennas with a completely flat plane are characterized by high directional gain. However, they suffer from low bandwidth. To achieve compact and small MPAs, slots are often carved into the ground plane so that the electrical size of the antenna is reduced. MPAs are light weight, low cost, low volume, and usually have a small profile planar arrangement. They are also easy to design and manufacture with low manufacturing costs. Several MPAs have been introduced with different geometries in an attempt to improve the performance characteristics of antennas- such as radiation pattern, gain, efficiency, size and directivity. However, the proposed MPA is designed for the operation of the Automatic Dependence Surveillance Broadcast System (ADB-S).

M. Vinoth, J. Belbin Lijjo, S. Allen, Dr. M. Sugadev (2020) "Design and Analysis of Insert-fed Reconfigurable Antenna for 5g (sub-6ghz) applications", Solid State Technology, In this paper, a rectangular dual band antenna with defects integrated in a metal ground plane is proposed. Originally a rectangular patch antenna was designed that resonated at 5.2 GHz. With the introduction of DGS on the metallic ground plane, the microstrip antenna is available with a frequency of 3.5 GHz and 5.2 GHz simultaneously, suitable for WiMAX and WLAN applications. Therefore the proposed antenna behaves as compact and dual frequency band active. The antenna is made of RT-Duriod substrate with a dielectric constant of 2.2 and a length of 0.762mm. This procedure is verified experimentally and the measured results were in good agreement with the simulated results.

Dual-band antennas are of interest for wireless communication systems that use two frequency bands, such as WLAN and WiMax, because they can replace two individual antennas. In addition, the miniaturization of antennas also became more important due to the growing demand for smaller antennas as the rapid development of wireless communications. Both methods reduce size, cost, and complexity. Microstrip antenna is widely used in wireless communication because of its light weight, low profile, low cost, simplicity and low cost. Efforts are being made to design an integrated microstrip antenna with a high percentage of miniaturization, as the need for smaller antennas at lower frequencies has been driven. Many efforts have been made to achieve a size reduction such as using a dielectric substrate of high permittivity, Defective Microstrip Structure (DMS), PBG recorded on a substrate based on limited numbers of defects, known as defected world structure (DGS).), or a combination thereof. As a result of these processes various effects on the microstrip antenna were observed which enabled the antenna to operate in the low frequency band. Similarly many methods have been reported to design low cost, small profile and active dual band notation. Other techniques have used a patch antenna in a higher order mode with a radiation pattern that is quasi fundamental mode. Parasitic element near the radiating element, emitting elements , stub attached to the radiating element . Microstrip antenna with DGS can also support this purpose with multiband that can operate on different frequencies of a single device.

Paolo Squadrito, Shuai Zhang and GertFrolund Pedersen. (2018), "Wideband or dual band low profile circular patch antenna with high gain and sidelobe suppression" in IEEE Transaction on antennas and propagation, A rectangular microstrip patch antenna is presented in this paper for Ku-band satellite communication applications. The proposed E-shaped patch antenna is designed to cover various applications such as broadcasting, remote sensing and space communication. To include the effect of high frequency in the process, the concept of a microstrip-based Cole-Cole diagram is adopted to create a frequency-dependent characteristic impedance (loss). The simple method proposed in this study is compatible with Computer Aided Design (CAD) therefore; the design of Ku Band satellite microstrip antenna from this study will be fast and easy to use.

In recent years, the need for small antennas for wireless communication has increased significantly, which has led to extensive research on compact microstrip antenna design among microwave and RF engineers. Compact microstrip antennas such as VSAT systems are one of the most suitable applications to support advanced satellite communication equipment. Ku-band (12-18 GHz) is one of the most preferred options for VSAT applications. VSAT can be received by satellite television broadcasts and satellite television. In addition, VSAT is one of the best emergency support systems during disasters. Microstrip patch antenna is a two-dimensional dimensional planner antenna configuration that has all the advantages of a printed circuit board including but not limited to simple design, easy fabrication and low cost. Although these antenna structures have several advantages over other methods they also have the major disadvantages of low bandwidth, low gain, and low efficiency. There is a lot of research going on to overcome these disadvantages in order to take full advantage of the advantages such as simple design, ease of manufacturing and low cost in manufacturing these small microstrip antennas. The performance of these antennas depends on their physical configuration. Various ways to improve antenna performance in their physical configuration are suggested by researchers. Microstrip patch antennas are fed by means that are divided into contact and non-contact. In communication systems, RF power is supplied directly to the radiating surface using a linear microstrip link.

Rayuan Deng, ShenhengXu and Fan Yang. (2018), “An FSS backed ku/ka quad band reflect array antenna for satellite communications” in IEEE Transaction on antennas and propagation, A new high gain, wideband H-shape slot loaded microstrip patch antenna is presented in this paper. The antenna is printed on a dielectric substrate, supported by a metal board, and fed directly through a 50 Ω coaxial cable. Using the ADS software package according to the specified size, the antenna is simulated. The combined effect of combining these techniques and introducing a novel mounted clip provides a low profile, wide bandwidth, high gain and compact antenna feature. Computer simulation results show that the antenna can detect wide band characters. With adjusted parameters, it shows a wide impedance bandwidth at the frequency of 2.42 GHz.

The rapid development of wireless communication systems has increased the demand for compact microstrip antennas with high gain and wideband operating frequencies. Microstrip patch antenna has advantages such as low profile, conformal, light weight, simple realization process and low production cost. However, conventional microstrip patch antennas have some disadvantages such as small bandwidth etc. Performance improvements to cover the required bandwidth are required. There are many well-known ways to increase the bandwidth of antennas, including increasing the thickness of the substrate, the use of a low dielectric substrate, the use of various matching and feeding methods, and the use of multiple resonators in this paper. A printed wide-band antenna fed by a coaxial probe is presented. The antenna is modeled using Agilent Advanced Design System (ADS) technology. The results show that the impedance bandwidth achieved a good match. The dielectric constant of the substrate is closely related to the size and bandwidth of the microstrip antenna. A low dielectric constant of the substrate produces a large bandwidth, while a high dielectric constant of the substrate results in a small antenna size. A trade-off relationship exists between antenna size and bandwidth.

S. D. Mahamine, R. S. Parbat, S. H. Bodake and M. P. Aher (2016) "Effects of different substrates on Rectangular Microstrip patch Antenna for S-band," 2016 International Conference on Automatic Control and Dynamic Optimization Techniques In this paper a simple RMPA is designed and its performance parameters are compared with an RMPA with a deformed ground plane. The antenna is simulated at 2.4 GHz using CAD-FEKO simulation software. This work mainly involves the modification of the ground plane called Defected Ground Structure (DGS). Antenna parameters like Reflection coefficient, Gain, VSWR and bandwidth, with and without DGS are measured using Network Analyzer. The main focus of this paper is to improve the bandwidth for the patch antenna to be used for wideband applications and the research effect of DGS on the antenna parameters. Microstrip patch antennas are widely used now days due to their various advantages such as light weight, small volume, compatibility with integrated circuits, easy to install in a fixed location and low cost. Microstrip patch antennas are designed to work in dual band and multi-band systems either dual or circular.

These antennas are used in different handheld communication devices. A simple Microstrip patch Antenna. The radiation patch is on one side of the dielectric substrate and the ground plane is on the other side of the substrate. The metal patch may take any geometric shape like rectangle, triangle, circle, helical, ring, elliptical etc. The size of the patch corresponds to the frequency of the antenna ring. However, microstrip patch antennas have a small bandwidth and bandwidth enhancement is required in many practical applications, so bandwidth enhancement has been used in different ways. Defective Ground Structure is one of them. In addition, most applications using microstrip antennas are in communication systems such as handheld communication devices that require a small antenna size. Various tools developed for the design of highly compact microstrip patch antennas have been introduced over the past few years. The definition of DGS is that, at the bottom of the patch antenna a certain shape with a defect is introduced and depending on the different size, shape and size of the defect the protected current distribution will get disturbed. Input interference and antenna current flow will be affected due to interference in the protected current distribution. It can also control the excitation and electromagnetic waves that propagate through the substrate layer.

Sadiya Afrin Swarna, Salma Faria, Sakhawat Hussain & Anis Ahmed (2019) "Novel Microstrip Patch Antenna with Modified Ground Plane for 5G Wideband Applications", Global Journal of Researches in Engineering, This paper presents a broadband microstrip patch antenna for wireless communication. In its most basic form, a microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate with a ground plane on the other side. The patch is usually made of a portable material such as copper or gold and can take any possible shape. A rectangular patch is used as the main radiator. There are several advantages of this type of broadband antenna, such as planar, small in size, simple in structure, low price, and easy to fabricate, thus attractive in practical applications. This rectangular microstrip antenna patch is designed for wireless communication application operating at 2.4 GHz with 11 dB gain in outdoor environment. It also has a wide beam angle for its radiation pattern. The results show that the microstrip patch antenna can be used as a computer client antenna and an effective wireless antenna. One of the types of wireless communication at 2.4 GHz is Wireless Fidelity (WiFi). A WiFi-enabled device such as a personal computer, video game console, smartphone or digital audio player can connect to the Internet if it is within range of a wireless network connected to the Internet.

Coverage of one or more (connected) access points (hotspot) can cover an area as small as a few rooms or as large as several square miles. With the development of MIC and advanced semiconductor devices, microstrip has attracted much attention from the electronics community in recent years. Despite its various attractive features such as, light weight, low cost, simple construction, compatibility in curved surface and so on, the microstrip feature suffers from the inherent limitation of small impedance bandwidth.

The transmission line model represents a microstrip antenna with two slots of width W and length h, separated by a transmission line of length L. The microstrip is actually a constant line of two dielectrics, usually a substrate and air. most of the electric field lines reside in the substrate and parts of some lines in the air. As a result, this transmission line cannot support a pure electromagnetic transmission mode (TEM), since the phase velocities can be different in the air and the substrate. Instead, the dominant mode of propagation will be the quasi-TEM mode. Therefore, the effective dielectric constant (ε_{reff}) must be found to account for melting and wave propagation in the line.

3. ANTENNA DESIGN

The dielectric constant of the substrate is closely related to the size and bandwidth of the microstrip antenna. A low dielectric constant of the substrate produces a large bandwidth, while a high dielectric constant of the substrate results.

4. MICROSTRIP PATCH

The following diagram shows a patch antenna in its basic form: a flat plate on top of a ground plane (usually a PC board). The center conductor of the coax acts as a feed probe to couple the electromagnetic force into and/or out of the patch. The electric field distribution of a rectangular patch excited in its fundamental mode is also shown. The electric field is zero at the center of the patch, maximum (positive) on one side, and minimum (negative) on the other side. It should be mentioned that the minimum and maximum changes direction continuously according to the fast phase of the signal used. The electric field does not stop suddenly in a patch like in a hole; Instead, the fields extend the outer periphery to some extent.

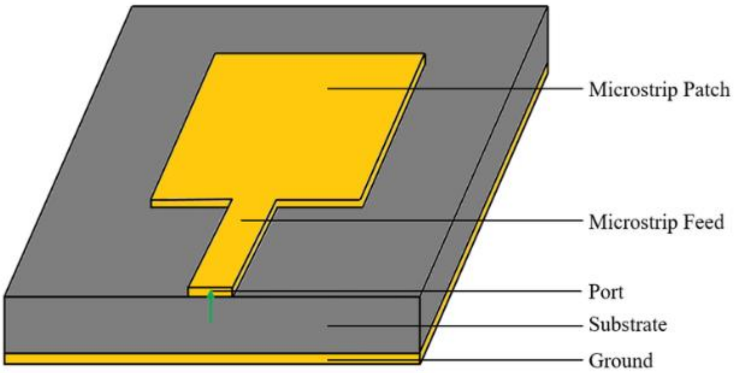

Figure.1. Basic Structure of a microstrip patch antenna

5. FEED METHODS

There are mainly four basic methods for the feeding to these antennas

Probe Coupling Method

Microstrip Line Feeding Method

Aperture Coupled Microstrip Feed Method

Proximity Coupling Method

5.1 PROBE COUPLING METHOD

Power coupling to a microstrip patch antenna can be done in a flip-flop manner. The inner conductor of the test line is connected to the ground connection through a slot in the ground plane and the substrate material. The simplicity of design and the correction of installation disturbances by positioning the feed, make this method of feeding popular. But there are other limitations such as larger lead for thicker substrate, difficulty in soldering array elements etc.

5.2 MICROSTRIP LINE FEEDING METHOD

This method is very easy to design and implement. But this process faces some limitations. If the thickness of the substrate is increased in the design, the surface waves and spurious radiation also increase. As a result, unwanted cross polarization radiation appears. Microstrip feeding can be used in situations where antenna performance is not a strong issue. Edge-coupled feeds can be improved with coplanar waveguide feeds.

5.3 PROXIMITY COUPLED METHOD

Typically in this configuration, the microstrip line will be placed on the bottom substrate and the patch feature will be placed on the top substrate. Another name for this diet is magnetically bonded foods. A strong environment will appear between the feed line and the patch in this case. By choosing a thin substrate layer and placing a patch on the top layer will improve bandwidth and reduce spurious radiation. The implementation of this feed is difficult due to problems with the alignment of the feed and the piece in the right place. A peaceful thing is soldering and related problems can be eliminated.

5.4 APERTURE COUPLED FEED METHOD

The hole will be placed on the ground plane and the feed line will be placed on the bottom substrate. This will be magnetically connected to the surface substrate through the ground plane surface. One must take care of the substrate parameters and must properly select the feed configuration and potential radiation independent operation. The coupling slot should be almost submerged in water so that the magnetic field of the patch is large.

6. METHODS OF ANALYSIS OF MICROSTRIP PATCH ANTENNA

The most popular methods for analyzing microstrip patch antennas are the transmission line model, the cavity model and the full-wave model (including mainly the integral/transient method). The power line model is the simplest and provides a good physical understanding but is less accurate.

The cavity model is very accurate and provides good physical understanding but is complex in nature. Full wave models are extremely accurate, versatile and can handle single elements, finite and infinite arrays, stacked elements, arbitrary shaped elements and intersections.

7. TRANSMISSION LINE MODEL

This model represents a microstrip antenna with two slots of width 'w' and length 'h', separated by a transmission line of length 'L'. A microstrip is essentially a disjoint line of two dielectrics, usually a substrate and air. Because of this, this transmission line cannot support a pure electromagnetic (TEM) transmission mode, since the phase velocities can be different in the air and the substrate. Instead, the diffusion mode will be a quasi-TEM mode. Therefore the effective dielectric constant (εreff) must be found to account for melting and wave propagation in the line.

8. CAVITY MODEL

In the cavity model, the region between the patch and the ground plane is considered as a space surrounded by magnetic walls around the periphery and electric walls from above and below. Since thin substrates are used, the field inside the cavity is proportional to the thickness of the substrate. Fields under a patch of common shapes such as rectangle, circle, triangle, and sphere can be expressed as a summation of the different resonant modes of a two-dimensional resonator.

The fringing fields around the boundary are taken care of by extending the patch boundary outward so that the effective dimensions are larger than the apparent size of the patch. The effect of radiation from the antenna and the conductor loss is calculated by adding this loss to the loss tangent of the dielectric substrate. The far field and the radiant power are calculated from the uniform magnetization around the edge. Another way to include the radiation effect in the cavity model is to introduce an impedance boundary condition at the cavity walls. The fringing and radiant energy fields are not included within the cavity but are localized at the edges of the cavity. However, the remote, walled field solution is difficult to test.

9. MULTIPORT NETWORK MODEL

The Multiport Network Model (MNM) for microstrip antenna analysis is an extension of the spatial model. In this way, the electromagnetic fields below.

10. METHOD OF MOMENTS

In the Method of Moments (MoM) surface currents are used to model the microstrip patch and the polarization currents in the dielectric slab are used to model the dielectric slab fields. The integral equation is formulated for the unknown currents in the microstrip patches, feed lines and their images in the ground plane. Important equations are converted into algebraic equations that can be easily solved using a computer. This method considers fringing fields outside the physical boundary of the two-dimensional patch, thus providing a more accurate solution.

11. SPECTRAL DOMAIN TECHNIQUE

In the Spectral Domain Technique (SDT), a two-dimensional Fourier transform along two orthogonal directions of the patch in the substrate plane is used. Boundary conditions are applied to the Fourier transform plane. The current distribution in the holding piece is expanded according to the selected basis functions and the resulting matrix equation is solved to evaluate the electric current distribution in the holding piece and the corresponding magnetic current distribution in the surrounding area of the substrate. Various parameters of the rods are then tested.

12. RETURN LOSS AND VSWR

The reflection coefficient at the antenna input is the ratio of the reflected voltage to the incident voltage and is the same as S11 when the antenna is connected to port 1 of the network analyzer. It is a measure of the impedance difference between the antenna and the source line. The level of contrast is usually defined in terms of return loss or VSWR.

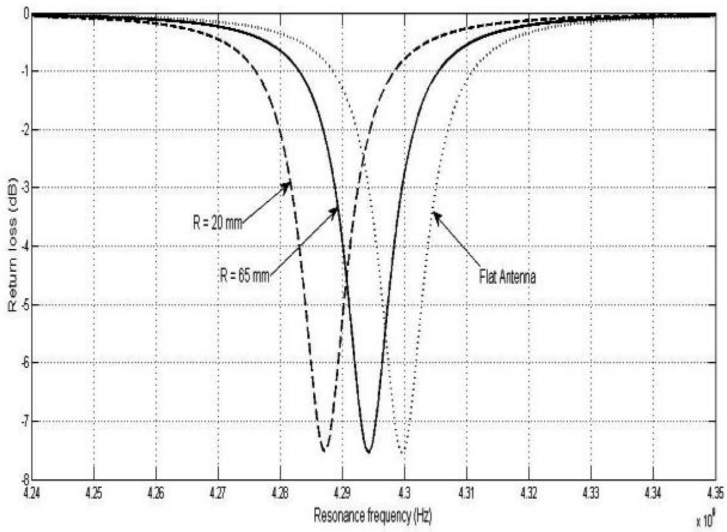

Figure .2. Return loss and VSWR

13. ANTENNA GAIN AND DIRECTIVITY

Antenna gain is a measure of the antenna's radiation intensity on the stronger side than the reference, when both antennas are fed the same input power. If the reference is an isotropic rod, the gain is usually expressed in dBi units. The advantage of the antenna is that the passive incident power is not added to the antenna, but is redistributed to provide radiated power in specific areas rather than transmitted by an isotropic antenna.

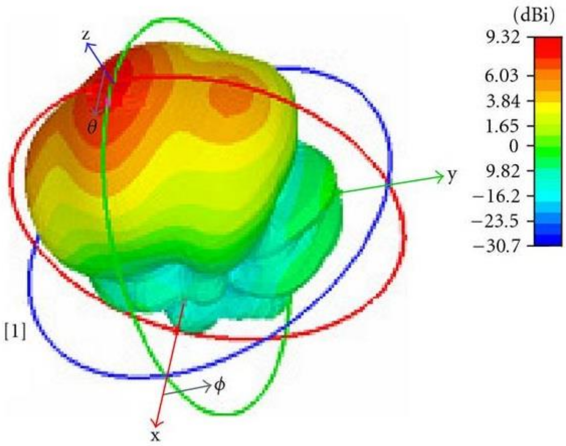

Figure .3. Antenna gain and Directivity

14. RADIATION PATTERN

The radiation pattern represents the spatial distribution of the electromagnetic field emitted by the antenna. The pattern will be taken in two planes, the E-plane and the H-plane. The E-plane is the plane containing the electric field vector and the direction of the maximum radiation and the H-plane is the plane containing the magnetic field vector and the maximum direction. By placing the antenna in receive mode inside an anechoic chamber, the E-plane and H-plane radiation patterns will be captured using the antenna calibration setup and network analysis. The antenna's radiation pattern in multiple frequency ranges can be measured with one rotation of the antenna's test position and calibration software.

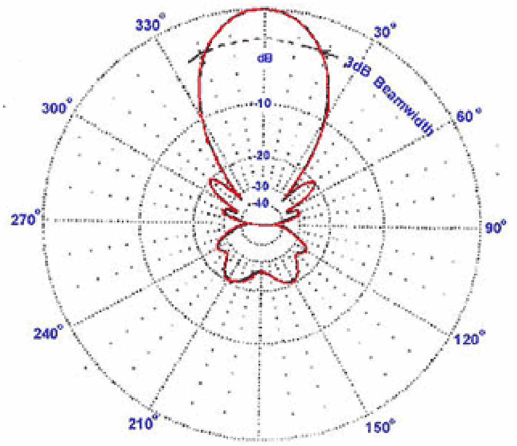

Figure .4. Radiation Pattern

15. CONCLUSIONS

Once the antenna is made with a certain design in a certain area under the substrate, we need to measure the parameters of the antenna such as return loss, VSWR, phase, input impedance and radiation characteristics using the Network Analyzer and setting the antenna scale. These devices are equipped with digital processors and programming devices so that the output can be obtained in the form of graphs or data. There are mainly two types of network analyzers available, scalar and vector network analyzers. A scalar network analyzer measures only the magnitude of transmission and reflection coefficients, while a vector network analyzer measures both magnitude and phase of the aforementioned parameters. A vector network analyzer consists of a microwave source, a signal processor, a measurement kit and usually a display unit. Computer simulation results show that the antenna can detect wide band characters. With the adjusted parameters, the antenna has a compact size of 82 mm x 65 mm at 1.09 GHz. The antenna resonates at 1.09 GHz which is common in ADS-B systems.

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