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A PORTABLE L-SHAPED MICROSTRIP PATCH ANTENNA WITH ENHANCED GAIN FOR ISM- BAND IoT APPLICATIONS

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ABSTRACT:

Wireless communication technology integration is necessary for internet of effects grounded operations to make their data fluently accessible. This design proposes a new, portable L- Shaped microstrip patch antenna with enhanced gain for IoT 3.6 GHz Industrial, scientific and medical (ISM) operations. The antenna design is simply comprised of an L- shape Strip line, with a full ground applied in the back side and integrated with a bitsy blockish niche, with increased bandwidth and lower number of base stations, and it's multi barred for multiple operations. This antenna designing and simulation have been performed by using CST software.

Keywords: ISM Applications, IoT Applications, CST Software, Multi-banded.

1.INTRODUCTION:

The Internet of Things (IoT) will transform our homes, public spaces, and shopping in the next two decades. By enabling a broad local net of devices with smart cross-referencing and real-time data adaption and analysis, IoT will enable far greater levels of manual and automatic remote control and reactive behavior from machinery, from toasters to doors to self-driving cars. The importance of an IoT product’s antenna cannot be overstated. It is the interface to the outside world. In this article I will discuss why the antenna is important and how good or poor antenna performance can shape the customer’s perception of a product and thereby influence the product’s success.

In the period of the Internet of Things (IoT), wireless communication plays a vital part in connecting colorful bias seamlessly. Among the plethora of wireless technologies, the Industrial, Scientific, and Medical (ISM) band stands out for its wide relinquishment due to its unlicensed operation and global vacuity. To harness the eventuality of ISM band for IoT operations, the design of compact and effective antennas becomes pivotal. This paper introduces a new approach towards achieving enhanced gain and portability in ISM band IoT operations through the application of L- shaped microstrip patch antennas.

Microstrip patch antennas offer advantages similar as low profile, featherlight, and ease of integration, making them ideal campaigners for IoT bias which frequently bear compact and invisible designs. The L-shaped configuration is chosen for its capability to further enhance the antenna's performance characteristics, including gain, bandwidth, and radiation pattern control. By strategically designing the figure and confines of the antenna, our end is to achieve bettered signal event and transmission capabilities, thereby enhancing the overall effectiveness and responsibility of IoT systems operating in the ISM band. pivotal features of our proposed antenna design include its compact form factor, ease of fabrication, and harmony with portable IoT bias. Through rigorous simulation and analysis, we demonstrate the superior performance of the L- shaped microstrip patch antenna compared to conventional designs, particularly in terms of gain enhancement and impedance matching within the ISM band frequency range.

The wireless communication needs light weight, tiny antennas with affordable fabrication. An antenna with limited size and certain frequency operation is said be a compact microstrip antenna. In addition to that there is another difficulty for communication systems is because of low bandwidth and low gain. In order to improve bandwidth, gain and efficiency researches set a path which are of complicated shapes and with satisfying radiation characteristics. The main drawbacks of a microstrip antenna is single frequency and small bandwidth. To correct this problem, a fork is attached to microstrip slotted antenna. On a 1.57 mm thick Rogers 5880 Substrate and a capacitive load was applied to increase the gain with fractional bandwidth which improves impedance matching, it represents difference in the performance of the proposed antenna.

“Taper design of Vivaldi and co-planar tapered slot antenna (TSA) by Chebyshev transformer,”
A new method for the flare's opening rate for a single radiator tapered slot antenna (TSA) is presented. A stepped quarter-wave Chebyshev transformer is calculated to minimize the frequency domain reflection and maximize the power transfer gain. Then slot widths are computed to match the Chebychev design, and smooth curves are fit to the computed steps. Different smoothing functions are compared, including the conventional exponential function, as well as cubic spline and Gaussian. The validity of the method is verified through simulations and measurements of experimental designs for the 1 to 3 GHz frequency range.

In this work the TSA is fabricated on one side of a single layer Droid substrate with dielectric constant 6.15. Although the Chebyshev transformer is an old concept, the novelty of this method is applying the transformer to design the TSA slot line taper profile, leading to a closed design procedure rather than an optimization. Advantages of this novel method are the straightforward mathematics of the design and that a simple simulation program can be written in a short time [1].

“In-phase power divider with three octaves band using microstrip to slot line transitions and loosely coupled microstrip lines,”The design of an in-phase planar power divider operating over a wide frequency band is presented. The proposed device uses a modified single section Wilkinson structure. The main feature of the proposed device is a broadside coupled microstrip/slot line configuration instead of using T-junction at the input port of the traditional design. Moreover, a pair of loosely coupled microstrip lines with two isolation resistors is used to enhance the matching of the output ports. The proposed structure provides 140% fractional bandwidth based on 15 dB isolation reference. The equivalent overall size of the structure is $0.25\ \lambda_g \times 0.25\ \lambda_g$, where λ_g is the guided wavelength at the lowest operating frequency.

The device has equal power division between the two output ports with less than 0.5 dB amplitude imbalances and less than 2° phase imbalance across the band 1-8 GHz [2].

“Design of a notched-band Vivaldi antenna with high selectivity,” In this letter, a notched-band Vivaldi antenna with high-frequency selectivity is designed and investigated. To obtain two notched poles inside the stopband, an open-circuited half-wavelength resonator and a short-circuited stepped impedance resonator are properly introduced into the traditional Vivaldi antenna. To validate the feasibility of this new approach, a notched band antenna with a fractional bandwidth of 145.8% is fabricated and tested. Results indicate that good frequency selectivity of the notched band from 4.9 to 6.6 GHz is realized, and the antenna exhibits good impedance match, high radiation gain, and excellent radiation directivity in the passband. Both the simulation and measurement results are provided with good agreement [3].

“Compact continuously tunable microstrip low-pass filter,” A tunable bandpass filter using coupled line with a wide tuning range is proposed. The proposed filter has a simple structure which is composed of a coupled-line section and two pairs of varactors. Meanwhile, simultaneously tuning on bandwidth and centre frequency are introduced by varactors. The tunability is mainly realized by varactors connected to one end of the coupled line and varactors between ports and coupled line provide an impedance matching the measured results show that the tunable bandpass filter achieves a tunable centre frequency of 0.494-1.257 GHz (87.15%) and a 3-dB bandwidth of 0.282-0.943 GHz (334%) [4].Monofilar-Archimedean metamaterial inspired leaky-wave antenna for scanning application for passive radar systems. A novel backfire-to-end fire leaky-wave antenna is presented with ability to scan from -25o to +45o. The antenna is based on metamaterial transmission-lines (MTM-TLs) and is implemented using Monofilar Archimedean spiral and rectangular slots, spiral inductors and metallic via-holes. The slots act as series left-handed capacitances, and the spirals with via-holes provide the shunt left-handed inductances to realize the metamaterial antenna.[5] Investigation of epidermal loop antennas for biotelemetry IoT applications. The Quadruple Loop (QL) antenna was designed and investigated to deliver a robust body-worn antenna for bio-medical applications. The QL antenna is a very thin single-layer groundless structure which allows for the installation of neighbouring electronics and sensors which need to be extremely close to the epidermis layer. The performance of the proposed antennas was investigated for three main standards: GSM-900, GSM-1800, and Bluetooth low energy (BLE). Radiation pattern measurements were conducted to compare their results with their simulation counterparts. [6,7]

A compact ultra-wideband monopole antenna has been presented. The antenna consists of a microstrip-fed rectangle radiator as well as a ground plane with a rectangle slit and an L-shaped stub. The critical factor in achieving a small size is a careful design procedure involving numerical optimisation of all geometry parameters of the antenna aiming at explicit size reduction while maintaining acceptable electrical performance. [8,9] delay-lines loaded broadband reflectarray antenna is proposed for X-band applications. The array cells contain slotted square patch and quad meander delay-lines. The slotted square patch elements are combined with delay-lines to increase the reflection phase range. A smooth linear phase variation of 650° is realized through varying the length of delay-lines. The reflectarray unit element resonant behaviour is observed through an equivalent circuit model approach. The reflectarray antenna is simulated and measured on a low-cost FR-4 substrate. A 23 × 23 elements reflectarray antenna is designed and simulated using a hybrid finite element boundary integral (FEBI) method.[10] It has been demonstrated that by embedding suitable slots in an antenna's radiating patch, compact microstrip antennas can be obtained. However, for such designs, the antenna gain and impedance bandwidth are also decreased, causing severe limitations for practical applications. We propose a new design of compact microstrip antennas with a slotted ground plane. It is found that by properly embedding a pair of narrow slots in the ground plane of a microstrip antenna, the antenna's fundamental resonant frequency can be lowered. Reduced antenna size at a fixed frequency can thus be achieved. Moreover, enhanced bandwidth and gain for the proposed design are also observed, which is different from that observed for compact designs with a slotted radiating patch.[11]

A microstrip square-ring slot antenna (MSRSA) for UWB (ultra wideband) antenna applications is proposed and improved by compaction. This structure is fed by a single microstrip line with a fork like-tuning stub. By splitting the square-ring slot antenna (SRSA) and optimization of the feeding network, the required impedance bandwidth is achieved over the UWB frequency range (3.1 to 10.6 GHz). The experimental and simulation results exhibit good agreement together. Parametric study is applied to compaction of structure. This compaction provides a good radiation pattern and a relatively constant gain over the entire band of frequency.[12] a compact printed meander antenna with enhanced peak gain for 2.4-GHz applications was investigated. Inductive feed and capacitive load techniques were used in the meander antenna's design to optimize peak gain performance. A measured maximum peak gain of 4.49 dBi, input reflection coefficient of −15 dB, and fractional bandwidth of 7.23% were achieved using a 1.6-mm-thick FR4 substrate. The low-profile antenna occupied an area of 26 × 15.6 mm^2. The proposed antenna can be implemented in standard printed circuit board processes without any lumped elements or via holes, and it introduces very little fabrication complexity.[13] Metamaterial structure conducts like an inductance–capacitance (LC) resonant circuit. Two characteristics properties are considered for creating the metamaterial resonances: firstly, a split gap and then a metal strip. The metal strip line is excited via the magnetic field, which is parallel to the metal axis. However, the electric field is caused in the unit cell split gape. The LC resonance frequency leads to a decrease or increase in the resonance towards lower or higher frequency by controlling the split gap capacitance.[14]

An integrated massive multiple-input multiple-output (mMIMO) antenna system loaded with metamaterial (MTM) is proposed in this article for fifth-generation (5G) applications. Besides, achievement of duple negative characteristics using a proposed compact complementary split-ring resonator (SRR), a broad epsilon negative metamaterial with more than 1 GHz bandwidth (BW), and near-zero refractive index features are presented. The proposed mMIMO antenna consists of eight subarrays with three layers that operate in the 5G mind band at 3.5 GHz.[15] A new method to increase the gain of a conventional microstrip patch antenna is presented. A rectangular loop shaped parasitic radiator placed a specific distance away from the patch surface increases the gain by about 3.3 dB The impedance and radiation performances of the proposed antenna are presented with excellent agreement between simulated and measured results.[16] a compact internal antenna of the modified planar inverted F antenna type with a parasitic patch. It also considers the influences of the handset case and battery. A low-profile design is implemented on both the top and bottom sides of the FR-4 substrate. The proposed antenna, with the small size of 27.5/spl times/12/spl times/7 mm/sup 3/, can be easily placed in the actual handset. The measured bandwidths of the proposed antenna with handset case and battery can cover 140 MHz (1740-1880 MHz) in the Korean personal communication service band and 90 MHz (2400-2490 MHz) in the Bluetooth band. Numerical simulation and experiment results of antenna electrical performance are investigated by considering the antenna, the phone case, and the battery.[17]

By loading a parasitic patch, a novel broadband unidirectional dipole antenna is presented. The antenna fed by a coaxial balun consists of a folded dipole, a parasitic patch, and a ground plane. The folded dipole has two bowtie elements and a U-shaped structure. In the low operating band, the folded dipole works as an electric dipole and the parasitic patch works as a director. By using the director, the impedance matching performance is improved dramatically.[18] A novel monopole antenna for ultrawide-band (UWB) applications. Printed on a dielectric substrate and fed by a 50 /spl Omega/ microstrip line, a planar circular disc monopole has been demonstrated to provide an ultra wide 10 dB return loss bandwidth with satisfactory radiation properties. The parameters which affect the performance of the antenna in terms of its frequency domain characteristics are investigated. A good agreement is achieved between the simulation and the experiment. In addition, the time domain performance of the proposed antenna is also evaluated in simulations.[19] a self-shape blending algorithm to improve antenna bandwidth. A printed antenna is designed for bandwidth enhancement based on the proposed algorithm; this approach can also be used to enhance bandwidth in other applications. The antenna completely covers WLAN bands and WiMAX bands after the proposed algorithm is applied. The shape of the rotating slot and the parasitic patch also changes, which excites additional resonance and improves the impedance matching at high frequencies.[20]

Table1: Reference table

Year	**Ref.**	**Antenna Shape**	**Antenna Size**	**Fractional BW(%)**	**Rad.Eff (.%)**	**Gain**	**Applications**
2014	[11]	Meander line	32.00 *01.60	7.60	-	0.50	*NS
2017	[23]	Spiral slot	12.45*13.05	7.50	-	1.33	*NS
2018	[24]	Uniplanar	10.00*19.00	8.00	-	1.20	2.5GHz applications
2018	[25]	Bowtie antenna	29.00*13.70	-	89	1.47	Wearable application
2019	[26]	Meander line	40.00*10.00	12.5	79	1.34	IoT
2020	[27]	Slotted SIW	120.0*395.4	2.10	-	4.80	WLAN
2021	[28]	Slot Antenna	105.0*85.00	3.20	-	4.00	IoT
2022	[29]	Cage antenna	49.00*49.00	3.20	93	3.00	WLAN
2023	[30]	L-shaped	28.00*21.00	5.80	98	2.09	IoT
2024	This Study	L-shaped	21.0*13.0			1.879	3.6GHz applications

2.ANTENNA DESIGN:

The proposed L-shaped antenna (Fig 1) was constructed on a Rogers 5880 substrate, with εr=2.2 permittivity, consistence of 1.57 mm, and loss tangent = 0.0009. The antenna measured 20 mm × 13 mm in confines. The microstrip patch, which is a main radiator is in the shape of reversed L-Shape formed by two perpendicular lines. The proposed main radiator was designed as a simple microstrip strip line patch, which was directly linked to the harborage feeding. It was followed by a vertical line that formed an L-shape, which was modified and optimized within several ways to find the optimal band of interest at 2.4 GHz, as demonstrated in Fig.1. The proposed antenna's impedance was 51 ohms, whereas the feed line was linked to matching a 50-ohm impedance. In order to find the impedance-matching bandwidth, a rectangular slot was also created in the ground plane's middle section, not far from the feed line. Using parametric study for various values, the impact of the L shape and ground slot was clarified. The proposed antenna was created and measured to confirm its validity.

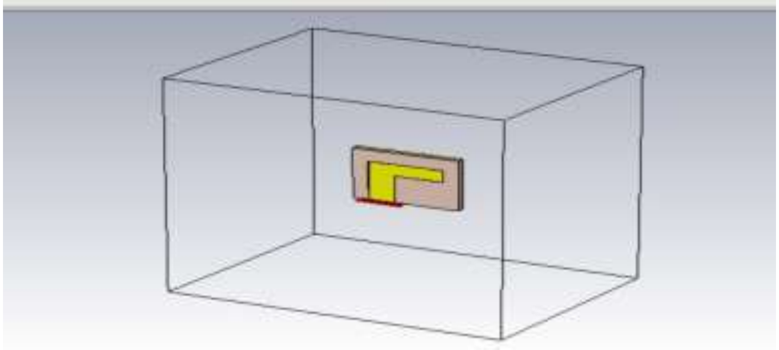


Fig.1 Design of L-Shaped antenna

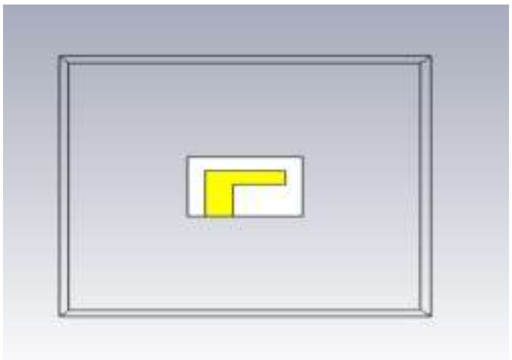


Fig. 1(a). Front Patch

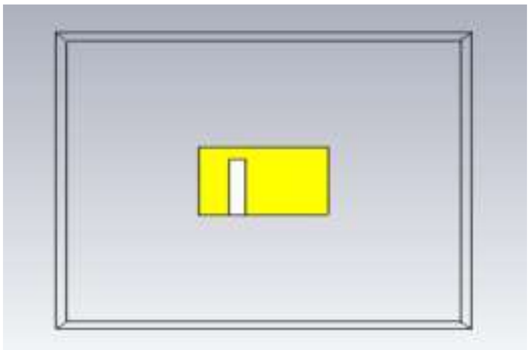


Fig.1(b). Back side of ground plane

3.WORKING PRINCIPLES

The implemented design mainly depends on the size of the antenna, L-shaped strip and as well as height and width of the ground plane. this is how the parameters affects functionality of the antenna. The progressed current distribution is observed and studied in order to light on the Operating principles and Characteristics of the proposed antenna. Proposed Antenna displays the distribution of Current at 3.6 GHz. The majority of the Current Distribution is focused on the external edge portions of the L-Shaped radiating element of the proposed antenna. The Upper side of the L-Shaped patch has high current distribution which helps the antennas resonance through changing it at 3.6Ghz, and if the top portion of L-Shaped antenna is increased, having impact on the gain in order to appearance of the extraordinary current on the upper part.

The existing antenna which is of 2.4Ghz frequency is consists of limited sized slot which results limited and single band. By improving the width of slot in the proposed antenna we achieved frequency at 3.5GHz and with better bandwidth than existing antenna. This is all because of the size of the slot. The slot width of the existing antenna is increased for best results. Figure 4(a) shows the size of the slot in existing antenna. In order to increase the bandwidth at 2.4GHz we need to increase the slot and patch lines length. When the width of patch and slot are very small, we observed very narrow bandwidth. In existing antenna, the operation of it is slightly changes from 2.48 GHz to 2.58 GHz. When the width of the slot and patch are being increased the narrow band is shifting towards higher frequency there by increased the bandwidth.

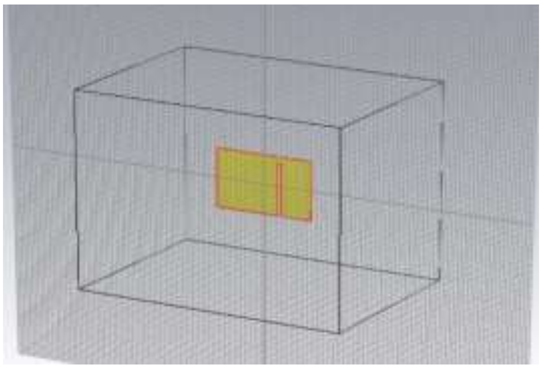


Fig. 4(a)

Fig 4(b) shows the size of the slot in proposed antenna which is relatively bigger than existing one, and reducing one of the main drawbacks of slot antennas.

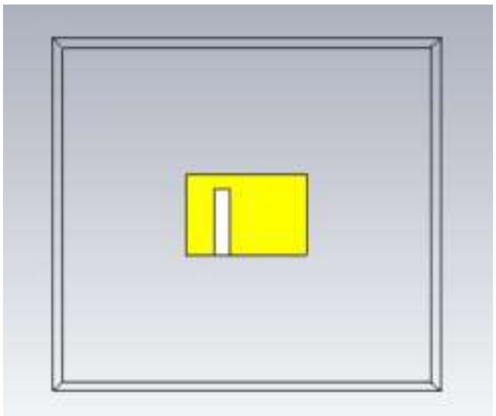


Fig. 4(b)

4.RESULTS AND DISCUSSION

To achieve the better performance in terms of bandwidth, size, gain and band of interest are the crucial characteristics of proposed L-Shaped antenna were important to the selection and manufacture of the final structure of antenna. Fig. 5(a)shows that the simulation and final prototype bandwidth of the L-Shaped antenna. The overall dimensions of the optimized compact antenna are 20mm*13mm. The proposed antenna realized bandwidth is from minimum of 3.6GHz and maximum of 3.6GHz. The exhibited radiation and total efficiency have peaks of 98 and 97 respectively. With that, the proposed antenna gain is achieved in the operation bandwidth. The realized gain is reached up to 1.87dBi as demonstrated in the fig.5(b). The measured and simulated finding showed great agreement. Fig.5(c) shows the measured and simulated 3.6GHz azimuth plane radiation patterns. The proposed antenna radiates in H-plane with limited amount of vertical polarization and cross polarization. Fig.5(a) shows the S11 Reflection coefficient of the proposed antenna.

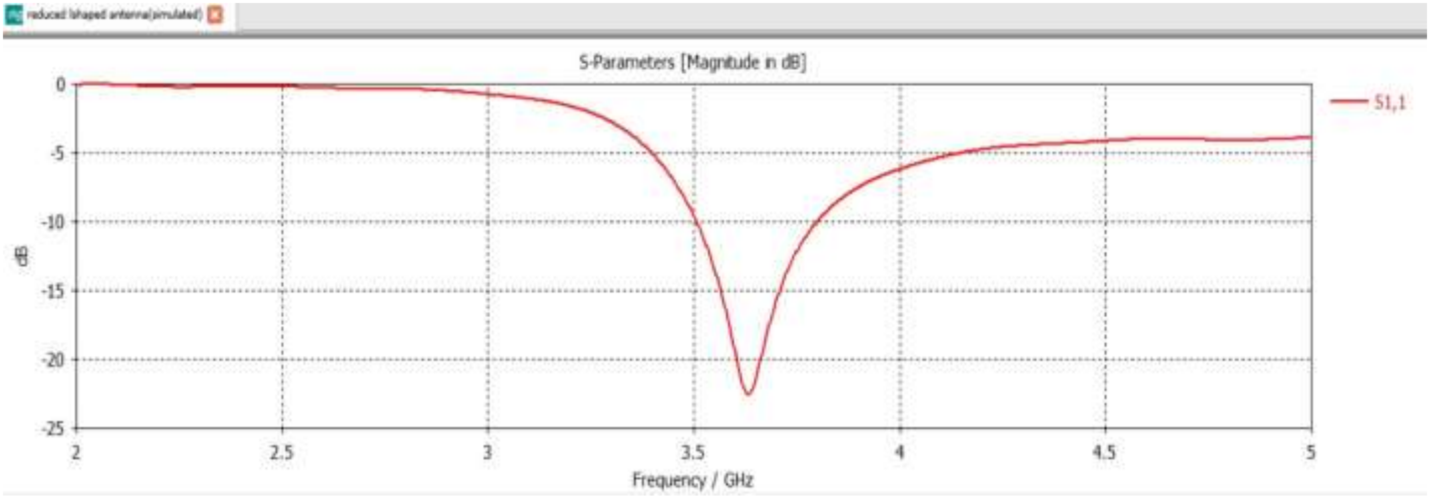
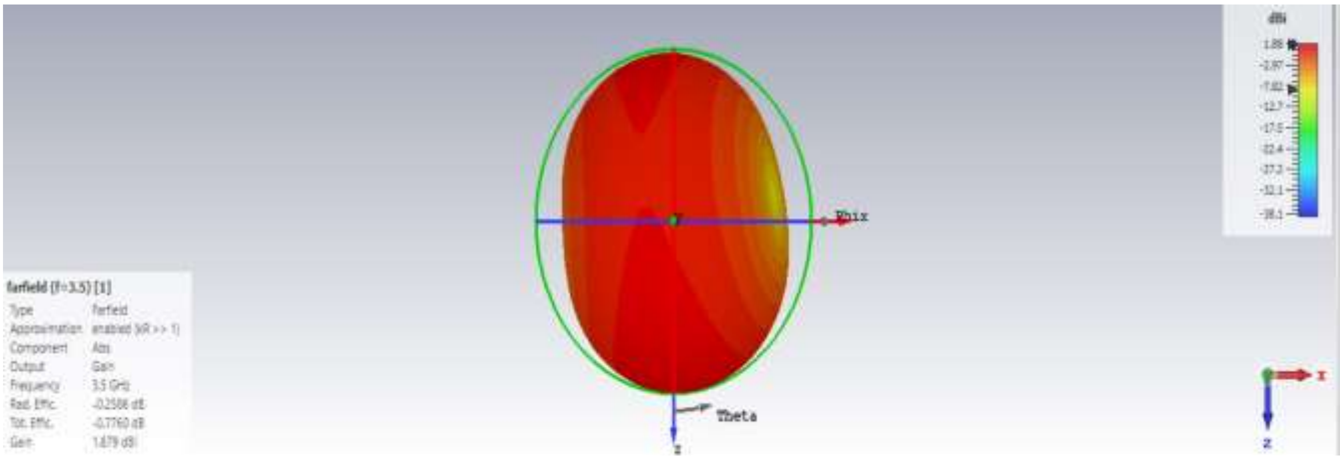
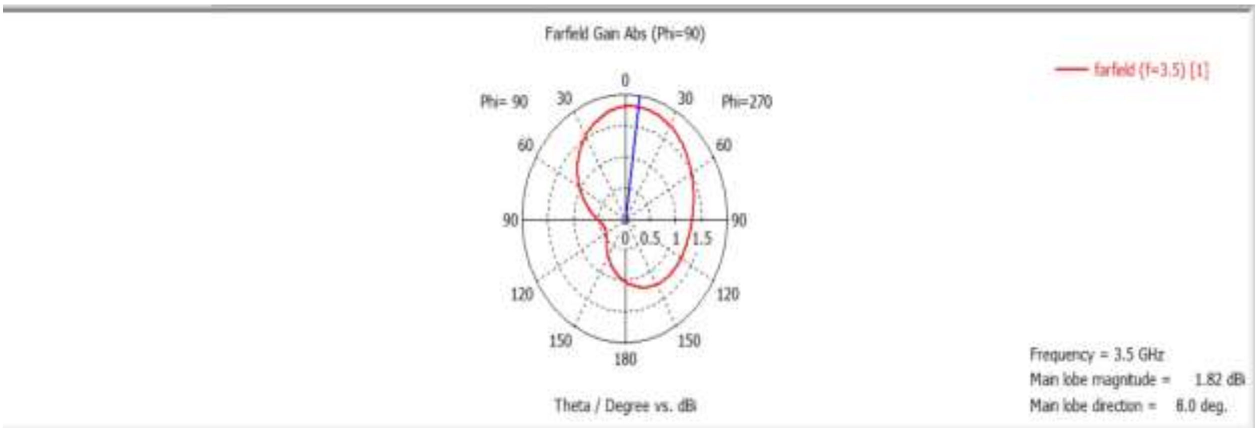


Fig. 5(a)-S-Parameter Plot



farfield (f=3.5) [1]
Type Farfield
Approximation enabled (kR >> 1)
Component Abs
Output Gain
Frequency 3.5 GHz
Rad. Effic. -0.2586 dB
Tot. Effic. -0.7760 dB
Gain 1.879 dBi

Fig. 5(b)-Radiation Pattern



Frequency = 3.5 GHz
Main lobe magnitude = 1.82 dBi
Main lobe direction = 8.0 deg.

Fig.5(c)-Azimuth-Plane Radiation Pattern at Phi=90

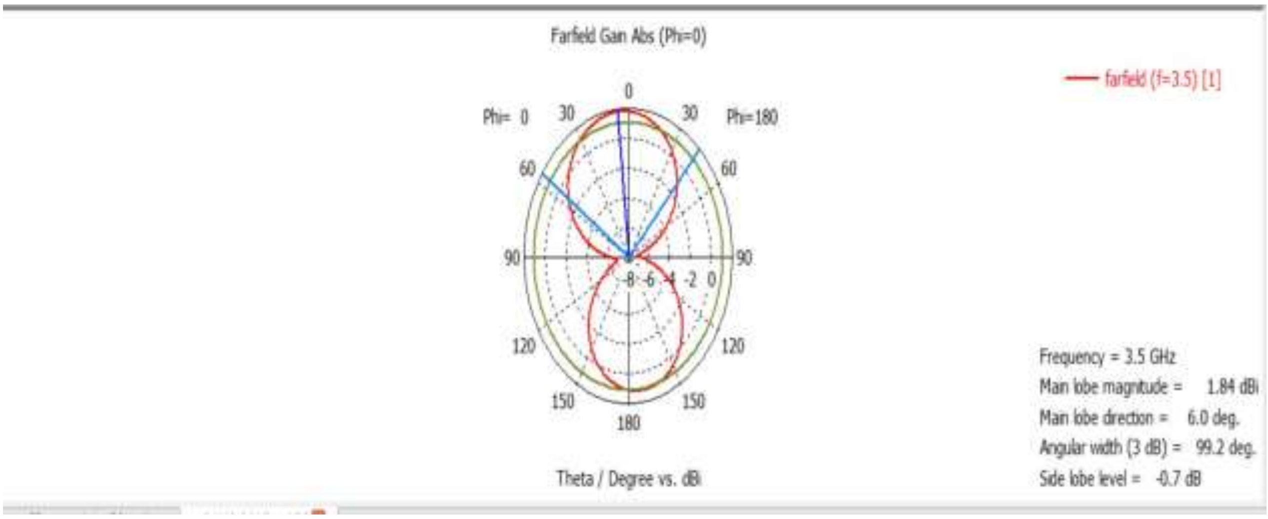


Fig.5(d).Azimuth-Plane Radiation Pattern at phi=0

5.CONCLUSION:

One of the benefits of IoT applications is the use of antenna as wireless sensor technologies. In this proposed Study, a solution for IoT applications is Introduced. The Proposed Portable antenna is modified and Constructed as an L-shaped antenna for ISM band at 3.6 GHz frequency band. The construction is of Straight L-shaped patch, along with etched rectangular backside slot in the ground was examined numerically and verified with particular measurements. The Achieved results shows that antenna had an better radiation efficiency and simulated gain up to 1.879dBi. This proposed antenna is good for wireless fourth-generation 4G and IoT, mainly for smart offices\homes in indoor development.

6.FUTURE SCOPE:

Upcoming work can be applied for reducing the number of base stations by frequently reducing the size of the antenna. We can also improve the bandwidth and number of bands (Multiband) by increasing the number of parasitic patches or slot of the antennas.

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