Design Of Multiband Microstrip Patch Antenna For Wlan,Wimax And X-Band Applications

Pronami Bora, Challapalli guna sekhar, Phatan Sameer khan, Kokatam.vinay reddy, Marthala.Venkat sai, P. Pardhasaradhi

Abstract: This letter describes a small, single-feed, circularly polarized patch antenna for broadband. The antenna consists of an microstrip patch and pins on the Reactive Impedance Surface (RIS) inspired by metamaterials. The RIS structure, consisting of 4 or 4 standard metallic square patches and four shorting pins which helps to improve the antenna bandwidth. The final optimized structure exhibits an impedance bandwidth of 53.75%(4.650GHz-7.617GHz) alongwith a 3-dB axial ratio bandwidth of 30.4%(4.6242GHz-6.3036GHz). Moreover, the proposed antenna yields a good broadside gain of 5.8 dBi at 5.52Ghz.

Key terms: Circular polarization, patch antenna, reactive impedance surface, broadband

I. INTRODUCTION

Circular polarized microstrip patch antennas were widely used in many applications such as satellite technology, radar systems and global positioning (GPS) systems because they have many advantages such as lightweight, low profile, low cost and ease of manufacturing[2]. Circularly polarized microstrip antenna (CPMA) enables the transmission of signal regardless of the direction of the receiving antenna with respect to the transmitting antenna and also has the ability to suppress the interference of multipaths. They do suffer from narrow impedance and axialratio(AR) bandwidths, however, usually mostly 5% or less for impedance and 3 dB for AR values. Circularly polarized radiation is generated by exciting two orthogonal modes of the same amplitude. Using thick structures, square slot methods, defective ground structures, bandwidth enhancement can be accomplished. The structure of the microstrip patch antenna where only one patch is fed and other patches are parasitically coupled. By using a small gap between them, the connection between the parasite patch and the resonating patch is understood. Two parasitic patches of the same width are placed along both sides of the fed patch with small gap between them. By adding parasitic patch along the fed patch, bandwidth increases as well as an antenna gain. This also increased the size of the antenna. The antenna single and dual feeds help to miniaturize the antenna size and to maximize the bandwidth of a RIS antenna system. The two-dimensional square metal patches are made of the RIS antenna model. On the underside of the main patch substructure, a set of uniform square patches with equal distances are made. The RIS also reduces the interaction between the ground plane and the built antenna structure. Therefore, it offers wide bandwidth, compact size, and improoved radiation efficiency when RIS structure is built in antenna. The X-band corresponds to a frequency band in the electro-magnetic spectrum microwave radio field. The frequency range of the X band is in some cases quite indefinitely set at about 7.0–11.2 GHz, for instance in communication technology. For radar technology, the Institute of Electrical and Electronics Engineers determines the frequency range. The wireless local area network (WLAN) is usually used with antennas.The little model makes it ideal for wardriving for mobile applications.Antennas could be used to increase the range of cellular telephones, improve coverage and increasing the noise level. The measurements of the 5.5 GHz antenna are almost ideal as they blend in well with the regular Satellite TV. A high-quality, low-cost antenna is the result. Such settings are commonly used for long-range Wi-Fi connections in wireless area networks. WIMAX is a family of internet broadband broadband connectivity standards based on IEEE 802.16 specifications world-wide interoperability of microwave access. The flexible layer structure that makes data rates easy to quantify with WiMAX network wide bandwidth and distance makes it suited to the following potential applications: delivering portable high-speed mobile broadband connectivity across different devices through cities and countries. WiMAX can offer internet access to cities or countries at home or by mobile device. In many cases this has brought competition to markets that previously only had access to the traditional DSL (or similar) provider. In addition it is cost effective for the last-mile broadband internet for remote locations today, given the relatively low costs associated with the introduction of WiFi networks (compared to 3 G, HSDPA, xDSL, HFC or FTTx). Uses spatial multiplexing for the removal of "blind spots" in the coverage over a cloudy zone such as an Orthogonal frequency division multiplexing (OFDM) wall: although the 5 GHz band typically is not regarded as the frequency of choice to pass, this is the only one which can accommodate interference in a 2.4GHz band. There are a range of uses for wireless LANs. Users can access the Internet from the WLAN Hotspots at cafes, resorts and now with portable devices connected to 3 G or 4 G network. Their network connectivity can be reached through the Internet. Such kinds of public points of entry also do not require a network registration or password.

II. ANTENNA CONFIGURATION

A. GEOMETRY OF ANTENNA

Fig. 1 shows the proposed Circularly Polarized Microstrip Antenna (CPMA) with the RIS structure. The H-shaped patch is printed on top of a dual layer Rogers RO4003 substrate (εr= 3.38 and tan δ = 0.0027) of thickness $h_1 + h_2$ = 5.032mm. The ground plane lies at the bottom of the structure and the RIS is incorporated at the interface between the two dielectric layers at a height of h_1 = 3mm from the ground. The H- shaped patch radiator is developed by perturbing the sides of a simple square patch of dimensions A × B and a perturbation of d as shown in Fig. 1(b). The patch is probe fed at one of its arms diagonally The radiated beam turns out to be right-hand circularly polarized (RHCP) or left-hand circularly polarized (LHCP) depending on the orientation of the perturbation with respect to the feed point location.

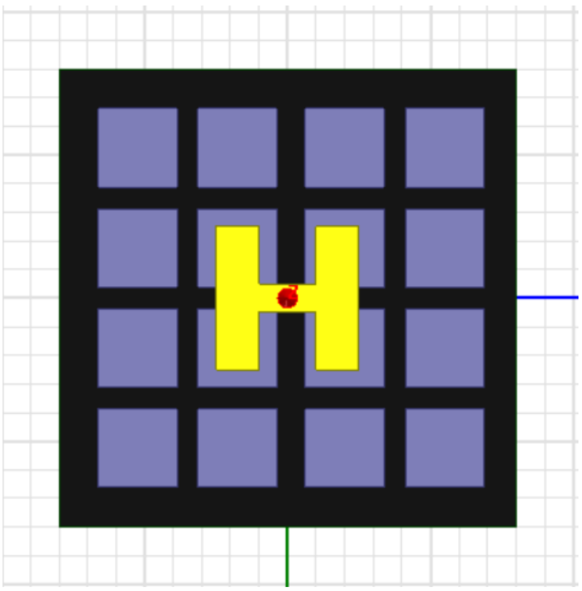
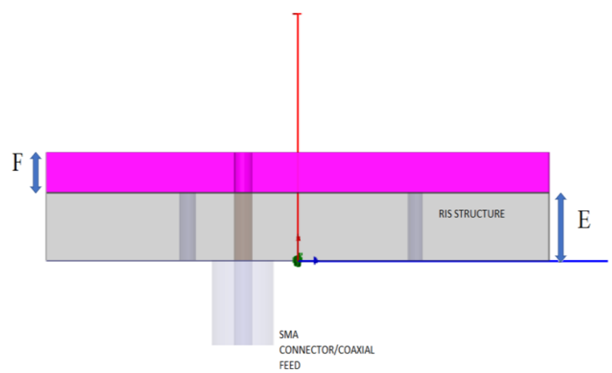
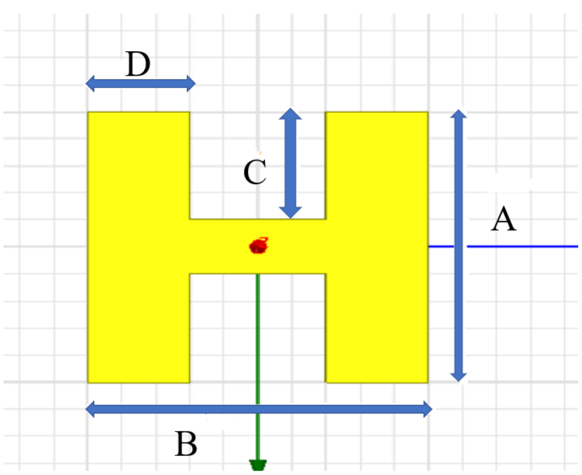


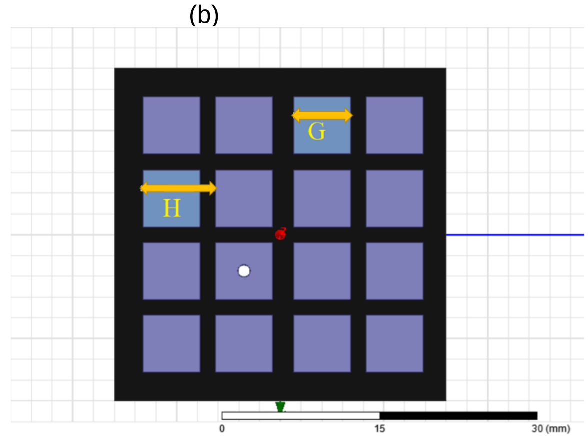
Fig 1:*praposed antenna design*



(a)



(b)



(c)

Fig 1: configuration of the proposed antenna. (a) side view.(b) Top View of patch(layer-1).(c) Top view of RIS Structure(Layer-2).

The outer part of 50 Ω SMA connector is connected to the ground at the bottom whereas innnerconductor extends through the dual layer substrate and connects to the patch at the feeding location

TABLE 1

A	B	C	D	E	F	G	H
10mm	10mm	4mm	3mm	3mm	2.03mm	5.5mm	7mm

B. THEORETICAL FORMULAE

Wale length = $\frac{c}{f}$

Calculation of width (W):

$$w = \frac{1}{2 f_r \sqrt{\mu_0 \varepsilon_0}} \sqrt{\frac{2}{\varepsilon_r + 1}} = \frac{c}{2 f_r} \sqrt{\frac{2}{\varepsilon_r + 1}}$$

Where

c= free space velocity of light

ε_r= Dielectric constant of substrate

Calculation of effective dielectric constant

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} \left(\frac{1}{\sqrt{1 + \frac{12h}{w}}} \right)$$

The actual length of the patch(L)

$$L = L_{eff} - 2\Delta L$$

Where $$L_{eff} = \frac{c}{2 f_r \sqrt{\varepsilon_{eff}}}$$

Calculation of length extension

$$\frac{\Delta L}{h} = 0.412 \frac{(\varepsilon_{eff} + 0.3)\left(\frac{w}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{w}{h} + 0.8\right)}$$

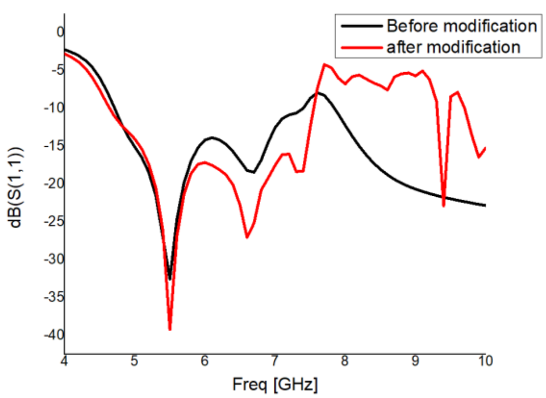
BANDWIDTH ENHANCEMENT

The RIS structure's effect on increasing the bandwidth of the antenna is justified here. At first a simple square patch that has a diagonal feed and resonates at 5.5 GHz is considered.

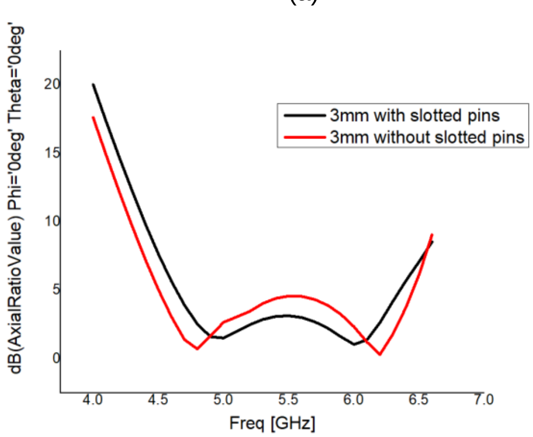
This system is infamous for its linear polarization. At two of its borders, the square patch will then be perturbed to create a H-shape, which will be fed into one of its arms diagonally. The patch in fig 1(b) is optimized to generate CP radiations. The H-shaped patch radiator is then inserted into the RIS layer consisting of square patches of dimensions a and periodicity p from the ground at a height of h2, as shown in Fig 1(c). If this surface is inserted under the patch radiator, its impedance band width and ARBW are considerably increasing. This RIS layer spatially distributes the image stream so that the antenna current and its image interact mutually. The inductive surface reaction cancels the H-shaped patch antenna near-field capability resulting in wider and compact bandwidth.

The reflective phase characteristics of the RIS structure unit cell as shown in Figure to achieve bandwidth enhancement. 1(c) must be strengthened.

The interaction of the unit cell with a TEM wave is taken into consideration, and PEC and PMC borders are built around the cell structure perpendicular to both the electrical and magnetic field. The structure is optimized by preserving the unit cell periodicity p and adjusting the parameter a to preserve the operating frequency in the inductivity area RIS that is below 6 GHz in this case. This is required because an inductive RIS not only miniatures the antenna but also provides a broad bandwidth of impedance. The unit length of the cell a is therefore 5.5 mm. In this respect. Simulations show that this value offers both in bandwidth and AR bandwidth optimized performance. The minimum AR points of the 4 to 4 cell configuration are at 4.85 GHz and 5.85GHz frequency with a maximum amplitude of 3 dB between the two dips which leads to a wide axial ratio of the bandwidth.



(a)

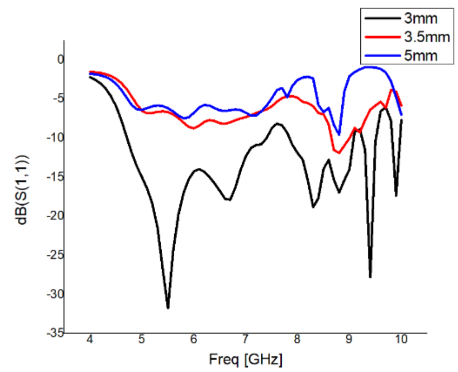


(b)

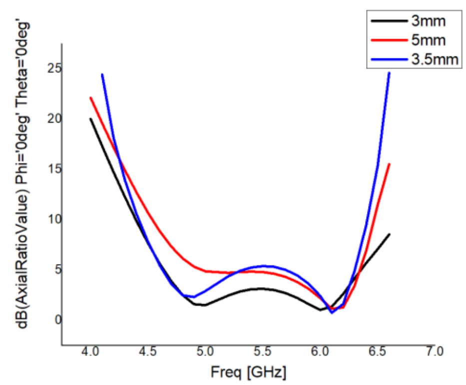
Fig 2. *. Simulated (a) S11 (b) Axial ratiowith modification and without modification.*

Parametric analysis

In order to achieve optimized design parameters, structural parametric analysis of the proposed CPMA is performed with the RIS substrate. Note that the rest are kept constant when one parameter is optimised. Firstly, First the CP output of the antenna is studied with the effects of perturbation d. The antenna quality is found to be very sensitive to disturbance.



(a)



(b)

Fig. 3*. Simulated (a) S11 (b) Axial ratio with different values of d*

As the chart shows. Fig.3, improves range at the lower frequencies with an increase of d from 3 mm to 5 mm.If the value of d is however, The two resonances can be brought closer to the output of AR, resulting in broader ARBW, increased from 3 to 5 mm. The minimum axial ratio is higher than 3dB and the ARBW is worse after further increasing the value from d to 5 mm. since we can observe optimized values at d=3mm the height of RIS structure is chosen 3mmAs shown in Fig.2 the s11 and azial ratio of above structure with slotted pins design and without slotted pins design.it is clear that the band width and axial ratio are more degenerated without slotted pins and a multiband is also generated at 8.5-9 GHz which is in the operating frequency of X-band. The location of feed points is critical for the development of CP radiation. An ideal feed point position with reasonable bandwidth and a large ARBW can be found at d=3mm and with slotted pins design so the final optimized design proposed for this structure are d=3mm,A=10mm,B=10mm,C=4mm,D=3mm, F=2.03mm,G=5.5mm,E=3mm,H=7mm.

RESULTS

The simulated S11 characteristics are shown in the Fig. 4(a). The measured impedance bandwidth of the proposed structure is 53.75%(4.650GHz-7.617GHz).
The axial ratio measured is also shown in the Fig4(b)
The measured 3-dB AR bandwidth is approximately 30.4%(4.6242GHz-6.3036GHz).
The standardized radiation patterns of 5.5 GHz are shown in Fig.5. As, observed from the figure the proposed antenna is a lefthand circularly polarized.

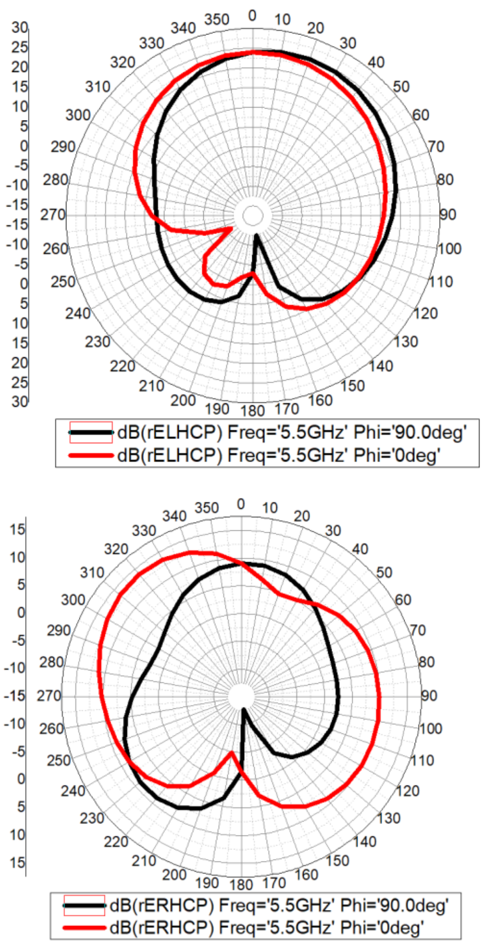


Fig 5 *Simulated and measured radiation patterns of the CP optimized antenna at 5.5 GHz.*

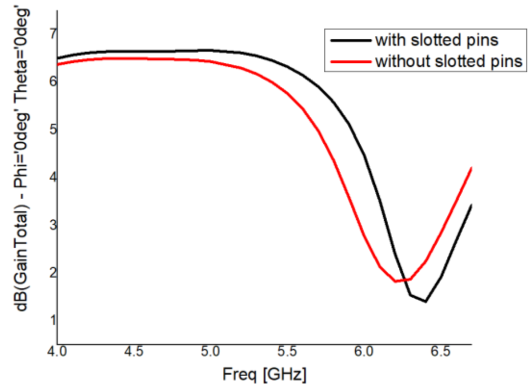


Fig. 10*. shows the peak gain of the proposed antenna.*

The measured gain is found to be approximately 6.32 dBi, At higher frequencies, because grating lobes appear, the antenna's radiation pattern degrades. This reduces the broadside direction, which decreases the gain. Any other different broadband systems in literature include a description of the proposed broadband h-shaped CPMA.

Table I *summarizes the results. This proposed simple H shaped patch antenna with classic RIS structure has provided a wider 3 dB AR bandwidth and is therefore, less complex compared with previous designs.*

Ref.	Center freq. (GHz)	Imp.BW (GHz, %)	3 dB ARBW (GHz, %)	Gain (dBi)
[1]	2.3	0.32, 14	0.35,15.3	5.7
[2]	6.0	2.78, 48.6	1.3, 20.4	6.5
[3]	5.5	2.9, 45.6	1.23,23.4	7.6
This paper	5.5	2.8, 47.5	1.5, 30	6.32

CONCLUSION

A circularly polarized multiband patch antenna with single feed H-form is mounted in this letter. We showed that the impedance bandwidth and ARBW were significantly improved by combining both the H-format radiator and the earth plane with the conventional square structure of RIS. This system reaches an impedance of 53.75% bandwidth and ARBW of 30.4%. The design also has a large gain of 6.32 dBI in center frequency, besides being small, low profile and big band, making it ideal for use on a range of wireless applications such as WLAN and WiMAX and X-band.

REFERENCES

[1] R. Nakamura and T. Fukusako, "Broadband design of circularly polarized microstrip patch antenna using artificial ground structure with rectangular unit cells,"

IEEE Trans. Antennas Propag., vol. 59, no. 6, pp. 2103–2110, Jun. 2011.

[2] L. Bernard, G. Chetier, and R. Sauleau, “Wideband circularly polarized patch antennas on reactive impedance substrates,” IEEE Antennas Wireless Propag. Lett., vol. 10, pp. 1015–1018, Sep. 2011.

[3] S. X. Ta and I. Park, “Low profile broadband circularly polarized patch antenna using metasurface,” IEEE Trans. Antennas Propag., vol. 63, no. 12, pp. 5929–5934, Dec. 2015.

[4] P.Bora, C.Paul, “Metamaterial Loaded CSRR Based Antenna for WLAN and IOT Band Applications”, International Journal of Scientific Technology Research, vol 8, issue 9, Sept. 2019.

[5] Baburao Dhanade Y., Sreelakshmi K., Bora P., Mudliar M., Madhav B.T.P., Frequency reconfigurable dual band antenna for wireless communications,2017 Journal of Advanced Research in Dynamical and Control Systems, Vol:9, issue: Special Issue 14, pp: 2328-2345, ISSN: 1943023X.

[6] Mudaliar M., Dhanade Y.B., Sreelakshmi K., Bora P., Srivani K., Madhav B.T.P., Slot loaded defected ground structured CPW fed antenna for ISM band applications,2017 Journal of Advanced Research in Dynamical and Control Systems,Vol:9, issue: Special Issue 14,pp: 2346-2355, ISSN: 1943023X.

[7] Madhav B.T.P., Manjeera M., Navya M.S., Sharada Devi D., Sumanth V., Novel metamaterial loaded multiband patch antenna ,2016, Indian Journal of Science and Technology, Vol: 9, Issue: 38, ISSN 9746846.

[8] Venkateswara Rao M., Madhav B.T.P., Anilkumar T., Prudhvi Nadh B. .,"Metamaterial inspired quad band circularly polarized antenna for WLAN/ISM/Bluetooth/WiMAX and satellite communication applications",2018,International Journal of Simulation : Systems, Science and Technolgy,Vol:19,Issue:6,pp:22.1to::22.7,DOI:10.5013/IJSSST.a.19.06.22,ISSN:14738031.

[9] Naik K.K., Manikanta M.H.V..,"Design of Circular Slot on Rectangular Patch with Meander line Antenna for Satellite Communications", 2018,Proceedings of the 2nd International Conference on Electronics, Communication and Aerospace Technology, ICECA 2018,Vol: ,Issue:,pp:1548to::1551,DOI:10.1109/ ICECA. 2018.8474660, ISBN:9.78154E+12.

[10] Madhav B.T.P., Khan H., Sri Harsha B., Sai Kumar P., Lavanya M., Veena K., Venkateshwara Rao M. .," X-Slotted circularly polarized antenna with parasitic patches “, 2018, Journal of Advanced Research in Dynamical and Control Systems ,Vol: 10 ,Issue: 4 Special Issue ,pp: 129 to:: 136 ,DOI: ,ISSN: 1943023X.

[11] Aradhyula R., Rama Krishna T.V., Madhav B.T.P. .," Electromagnetic bandgap structured CPW fed circular Monopole antenna with bandwidth enhancement for wideband applications “, 2018, Journal of Advanced Research in Dynamical and Control Systems ,Vol: 10 ,Issue: 4 ,pp: 374 to:: 379 ,DOI: ,ISSN: 1943023X.

[12] Jayalakshmi S., Khan H., Madhav B.T.P., A CPW monopole antenna with dual band characteristics for WLAN and Wi-MAX applications,2017 Journal of Advanced Research in Dynamical and Control Systems, Vol:9, issue: Special Issue 18, pp: 52-60, ISSN: 1943023X.

[13] Poorna Priya P., Khan H., Anusha C.H., Sai Tejaswi G., Siva Rama Krishna C.H., Design of single feed circularly polarized harmonic suppressed micro strip patch antenna for X-band applications ,2016, Journal of Theoretical and Applied Information Technology, Vol: 88, Issue: 3, pp: 530 - 534, ISSN 19928645.

[14] Naik K.K., Krishna B.V., Srikanth G., Kumar L.V., Priya B.V., Sri P.A.V.,Compact circular patch with meander line monopole antenna for X-band applications,2017 Proceedings of the International Conference on Electronics, Communication and Aerospace Technology, ICECA 2017,Vol:2017-January, pp: 454-458,DOI: 10.1109/ICECA.2017.8203725.

[15] Sowjanya B., Govardhani I., Saikiran V., Triveni Y.L., Sushma N., Rehana S.,Analysis of inverted suspended circular patch antenna loaded with a square patch for LTE radar applications,2017 Journal of Advanced Research in Dynamical and Control Systems,Vol:9, pp: 2212-2218,DOI: ,ISSN: 1943023X

[16] Sri P.A.V., Yasasvini N., Anjum M., Manikanta A.V., Harsha D.N.S.S., Dattatreya G., Naik K.K.,Analysis of wideband circular ring with rectangular patch antenna for airborne radar application,2017 Proceedings of the International Conference on Electronics, Communication and Aerospace Technology, ICECA 2017,Vol:2017-January, pp: 459-461,DOI: 10.1109/ICECA.2017.8203726

[17] Sheik A.R., Krishna K.S.R., Madhav B.T.P. .," Circularly polarized defected ground broadband antennas for wireless communication applications “, 2018, Journal of Engineering Science and Technology Review ,Vol: 11 ,Issue: 1 ,pp: 151 to:: 155 ,DOI: 10.25103/jestr.111.18 ,ISSN: 17919320