International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-6 Issue-5, June 2017

Single Layered Planar Monopole Antenna for High Frequency Applications

Sunil Kumar Singh, Manshree Mishra, Mahaveer Prasad Sharma, Prahlad Kumar Rahul, Deepti Thakur

Abstract: In recent years, the most sought after topic in antenna theory and design is the planar monopole antenna and are progressively finding large application in modern microwave system. This paper start with the theoretical explanation of the planar monopole antenna and then focus on the most significant evolution in the planar monopole antenna technology that have been made in the last few year. Emphasis is made on the antenna parameter enhancement technique.

Index Terms: Bandwidth, Microstrip Feed Line, Planar Monopole Antenna, Ultra Wideband.

I. INTRODUCTION

Monopole antenna and its family is one of the most popular antennas which is used in the mobile communication systems. Quarter wave monopole is the simplest member of the monopole antenna family. The impedance bandwidth (BW) of the quarter wave monopole antenna is increases with the increase in radius of the cylindrical stub. This is correct at a point, where the stepped radius becomes abrupt from the feed probe to the cylindrical element. An easy technique, is to replace the cylindrical stub by a planar element, which forms a planar monopole. In 1968, Meinke and Gundlach first described the planar monopole and in 1976, Dubost and Zisler described it in details. Circular and elliptical disk monopoles discovered by Agrawall in 1998. By exchanging the wire element of a conventional monopole with a planar element, a planar monopole antenna is formed. Surface areas of the monopoles increases by replacing the wire element with planar element, with various shapes, which has an direct impact on impedance bandwidth. Planar monopole antennas are widely used in mobile communications.

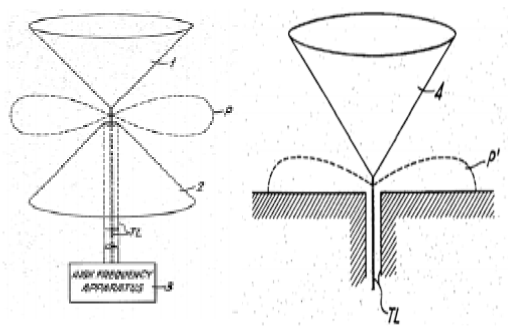
Planar monopole antenna have been analyzed in a large range such as circular, elliptical, square, rectangular, hexagonal and pentagonal, which provide the wide impedance bandwidth. Now if a rectangular patch without the substrate is fed by a coaxial feed with a perpendicular ground plane, it will result into effective dielectric constant of one and a substantial increase in height "h". Both these factors will yield a large BW.

A monopole antenna consists of straight rod-shaped conductor mounted perpendicularly on ground plane. Since the monopole antenna radiates half the space of dipole antenna, its gain will have 3 db greater than the gain of the similar dipole antenna.

Apart from that, monopole antenna have various advantages like less interference, low cost, high data rate, secure, low cost, multi-path propagation immunity, easy hardware configuration [1].Now a days, the planar structure monopole antennas are widely used for ultra wideband communication because of their useful features, such as low profile, less weight, easily fabrication, integration with other MMIC devices, very large bandwidth and Omni-directional radiation characteristics.

The origin of the planar ultra wide band antenna is "spark-gap" transmitters that pioneered radio technology. The paper which discovered the concept of the narrowband frequency domain radio also give some idea of the first ultra wide band antenna. In 1898, Oliver lodge inaugurated spherical dipoles, square plate dipoles, triangular or bow tie dipoles, biconical dipoles and also give the ideas of monopole antenna using the earth as a ground [2]. In 1939, Carter rediscovered the conical monopole antenna for wideband applications [3]. Carter biconical antenna and conical monopole antenna is shown in figure 1.Carter improved the lodge design by the use of tapered feed [4].Some of the application of ultra wide band antenna is given in table 1.

In the following section theoretical explanation on planar monopole antenna are briefly reviewed; because of limited space, more details must be left to the references. Section **I11** discusses the techniques used to enhance the antenna parameters like bandwidth, gain, power factor, efficiency and also discuss the pulse preserving capabilities of ultra wide band antenna. Section IV closes with a conclusions.



(a) (b)

Fig1. (a) Carter's biconical antenna, (b) Carter's monopole antenna [2].

Manuscript published on 30 June 2017.
***** Correspondence Author (s)
Mr. Sunil Kumar Singh*, Department of Electronics and Telecommunications, Jabalpur Engineering College, Jabalpur, Madhya Pradesh, India, E-mail: sspjec2007@gmail.com
Manshree Mishra, Department of Electronics and Telecommunications, Jabalpur Engineering College, Jabalpur, Madhya Pradesh, India, E-mail: mmishra.ec14@gmail.com

Table 1. Major Application areas of UWB

Areas	Application
Communication	Wireless Audio, Data& Video Distribution, RF Tagging & Identification
Radar	Ground and Ice penetrating Radar, wall Imaging Radar System, Through wall Radar system, vehicular radar systems
Precision Geo location	Asset Tracking, Personnel Localization
Military application	Tactical Handheld & Network LPI/D Radios, Non-Los LPI/D Ground wave communication, Tags, Intrusion detection radar, precision Geolocation systems, UAV/UGV Data links.
Commercial	High speed WLAN, Altimeter/obstacles Avoidance Radars, Collision Avoidance sensors

II. THEORETICAL EXPLANATION ON PLANAR MONOPOLE ANTENNA

The straight forward method to enhance the bandwidth of monopole antenna is to use a thick, low dielectric constant substrate, but this surely persuade to undesirable spurious feed radiation, surface wave generation, or feed inductance. The efficiency of the MSA decreases and cross-polar levels increases when the substrate thickness increases. Also when substrate thickness increases, probe height increases. When probe length increases, probe inductance increases and hence the input impedance will become too inductive to obtain impedance matching. This configuration has been shown in fig 2(a).

By feeding the patch with a shorter probe of length p, inductive input impedance effect can be reduced which is shown in fig 2(b). In this case, an extra perpendicular ground plane is needed because patch is fed along the periphery. The effect of bottom ground plane reduces by increasing the dielectric height and hence ground plane can be removed. Planar monopole antenna has been shown in figure 2(c) [4-7]. Large impedance bandwidth can be achieved by the planar disc monopole antennas which can be described in the following two ways:

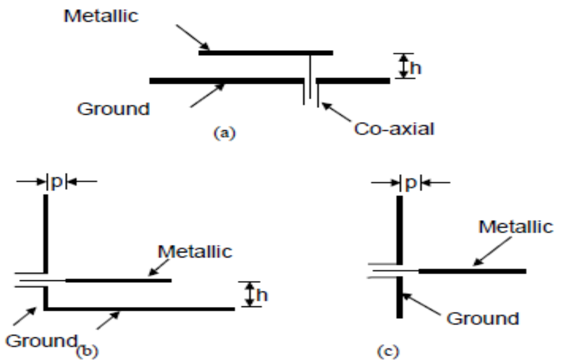


Fig 2. (a) MSA suspended in air. (b) Modified MSA with side feed. (c) Planar monopole antenna[4].

1. Cylindrical monopole antenna with large effective diameter can be equated to the planar monopole antenna. Bandwidth increases by increasing the diameter of a thin vertical wire which is mounted over the ground plane [8].
2. Planar monopole antenna becomes equivalent to the microstrip antenna, when the substrate of the microstrip antenna is very large. Various higher order modes will get excited, for these radiating patches and since all the modes will have larger bandwidth therefore smaller impedance variation can be achieved. A very large impedance bandwidth can be achieved when the shape and size of planar antenna can be optimized to bring all the modes within VSWR = 2 circle in the Smith chart and hence broadband planar monopole antenna can be achieved.

Hence planar rectangular disc monopole antenna can be equated to the rectangular microstrip antennas in which the horizontal ground plane is located at infinity.

III. FEEDING TECHNIQUES AND ANTENNA PARAMETERS ENHANCEMENT TECHNIQUES

A. Feeding Techniques

Co-planar (CPW) fed and microstrip line fed are the two types of feeding method which is commonly employed for monopole antenna. In CPW fed, ground plane is on the same side of radiating elements. In microstrip line fed, ground plane is on the backside of the radiating elements [9] .Due to this quality, the CPW fed antenna gained wide acceptance as compared to the microstrip fed line and also CPW fed is easy to integrate with the monolithic microwave integrated circuit[10].For small mobile appliances, a CPW feed makes antennas more applicable, due to its some useful characteristics like on-plane geometry, simple manufacturing and circuit combination. For wideband wireless application, the most effective and promising antenna is CPW fed slot antenna**.** Narrow bandwidth and gain, these are the some drawback of CPW fed antenna.

The advantage of CPW fed slot antenna is its wide band characteristics. Hence CPW fed slot antenna is most effective and promising antenna for wideband wireless application. However, they also have some drawbacks, like narrow bandwidth and low gain.

Another type of the feed which is used in the planar monopole antenna is the offset microstrip line feed as shown in fig(3). On the top and bottom edges of the rectangular patch, by cutting two symmetric and parallel vertical slots, The Psi- shaped patch was obtained. By cutting two slots along the bottom corners of the radiating patch, the feeding structure has been modified. Induced current reduces due to the increase in the distance of the ground plane from the radiating patch .The effect of the patch parameter like dimensions of the slots which forms modified feeding structure, dimensions of vertical slots and distance between them, and the air gap between modified feeding structure and the backed ground plane has been optimized.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

Effects of these antenna parameters on the modified Psi-shaped patch resonant modes is explained by the resonance curve plots and surface current distributions. Ultra-wide bandwidth was achieved by the use of offset microstrip line feed[11].

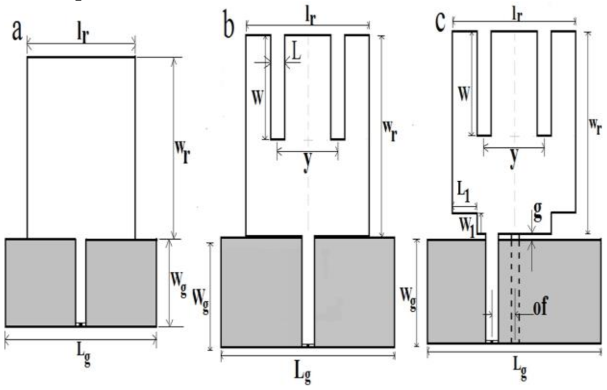


Fig 3. Geometry of (a) printed rectangular monopole antenna; (b) pair of slots cut printed rectangular monopole antenna; and (c) Psi-shaped monopole antenna.[11]

B. Bandwidth

The straightforward method to enhance the bandwidth of monopole antenna is to use a thick, low dielectric constant substrate[12],but this surely persuade to undesirable spurious feed radiation, surface wave generation, or feed inductance.

Different parasitic structure and arrangements are used to improve the bandwidth[13-15].Round cut are attached to the lower and upper corners of the patch and also a triangular cut on the ground plane are added in order to enhance the impedance bandwidth and matching [16]. The gap between the patch and the ground plane has been intensified by cutting the steps at the bottom of the patch, which tunes the capacitive coupling between patch and ground plane. Inductive part of the antenna is tuned by cutting the steps in the upper corners of the patch and because of that the capacitive coupling between the ground plane and patch neutralizes to get the pure resistive input impedance. Inductive nature of the patch neutralizes the capacitive effects to obtain pure resistive input impedance.

Some other technique to intensify the impedance bandwidth are exponential tapering[17-19] , klopfenstein tapering[20] and triangular tapering[20-23]. Apart from that, techniques like adding shorting posts , beveling technique [24], rounding the lower edge , double-feed technique and use of trident-shaped feeding strip are used to enhance the bandwidth performance and reduce the antenna height.

In beveling technique, square plane near the ground plane is trimmed providing either an asymmetrical or symmetrical pentagonal monopole [24]as shown in figure 4. By varying the trim angle of the cut, a good control on the impedance bandwidth can be achieved. For the simple square element 2.4:1 impedance bandwidth ratio is achieved where as by the use of beveling technique 6.6:1 impedance bandwidth is achieved.

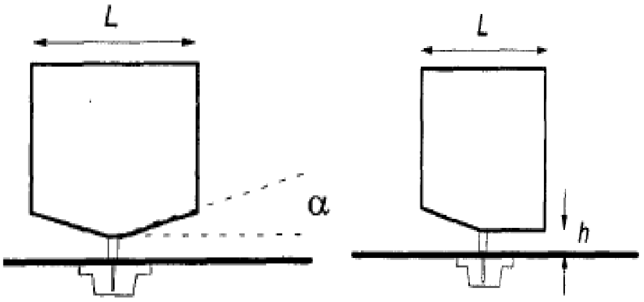


Fig 4 .(a) Square planar monopole with asymmetrical beveling (b) Square planar monopole with symmetrical beveling[24]

Measured values of upper and lower edge frequencies of a planar monopole (25mm x 25mm) with various bevel angles α, on one and both sides of the feed probe are tabulated in the Table2. This showed good control of the upper edge frequency. The lower edge frequency remained fairly constant at around 2.10-2.35 GHz, but the upper edge frequency could be varied from 4.95-12.5 GHz, depending on the value of the bevel angle.

Shorting post is another technique to enhance the bandwidth of the planar monopole element as shown in fig 5 .At one of the corner of the planar element, shorting strip is attached. The diameter of the shorting strip is 1mm and width of the strip is 2 mm. Due to the asymmetries in the geometrical shape, distortions in the radiation pattern occurred.

An impedance BW of 800 MHz to 11 GHz can be achieved by combining the shorting post and bevel. The shorting strip is located at one corner of the planar element, and is generally about 1mm diameter or a strip of width 2mm. Also the feed gap as already discussed needs to be optimized to get optimum BW [24], since it greatly affects the impedance characteristics.

Table 2. Measured impedance BW for a square element with both asymmetrical and symmetrical bevels of various angles show an increase in upper edge frequency with an increase in bevel angle[24].

Trim angle@ (degrees)	2:1 VWSR BW (GHz) Asymmetrically Trimmed	2:1 VSWR BW (GHz) Symmetrically Trimmed
No trimming	2.35-4.95	2.35-4.95
10	2.20-5.30	2.12-5.95
20	2.19-5.75	2.11-6.75
30	2.17-5.97	2.10-7.25
40	2.17-6.00	2.10-12.50

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

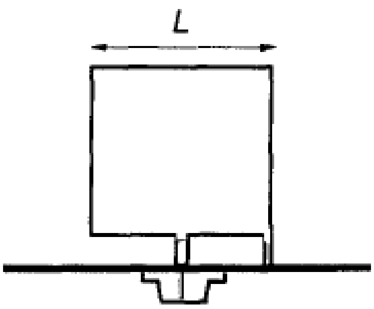


Fig 5. Square planar monopole with shorting pin

Also in general larger the feed gap lower will be the frequency corresponding to the lower edge of the passband.

C. Quality Factor

In order to achieve direct matching with a 50 ohm microstrip line feed a 1 Ohm chip resistor was introduced near the edge of a circular patch reported in [25].However, the chip resistor loading technique is employed to improve the quality factor or to enhance the bandwidth. Quality factor represents the antenna losses and also reflects its performance. Quality factor is inversely proportional to the antenna fractional bandwidth given below

$$\frac{\Delta f}{f} = (VSWR - 1)/(Q_t\sqrt{VSWR}) \qquad (1)$$

where Qt is the total quality factor, Df/fo is the fractional bandwidth. With a constant VSWR. By introducing losses to the antenna a compromise between the fractional bandwidth and quality factor is done reported in [26].

Different values (1, 1.5, 3.5,5.6 Ω) of chip resistors represents the losses. Two chip resistors of values 0.3 and 1 Ω was introduced and compared in [27]. By the use of 1 Ω resistor ,fractional bandwidth is increased by 6.8% and 2.6% for the 0.3 Ω. Instead of shorting pin between the antenna and the ground, different resistor values were introduced. These resistors are in the range of 1 to 10 Ω and the analysis for 3 Ω resistor are reported in[28].Reduction of about 42% in fractional bandwidth was observed. There is a inversely proportional relationship between the fractional bandwidth and quality factor therefore when bandwidth decreases, quality factor increases.

D. Gain

Various techniques such as Parasitic element technique , folding the ground plane technique, suspended ground and metamaterial superstrates technique, inserting slits technique and metal patch reflection technique are employed to improve the gain of the antenna[29]. Yagi-Uda antenna is used in the parasitic element technique. To increase the antenna gain and bandwidth L-shaped arm is used. One another technique to enhance the gain of the antenna is the fractal antenna concept.

Fractal antennas concept was discovered by Nathan in 1995.The two important properties of the fractal antennas are space-filling and self similarity which are used to achieve wideband and multiband characteristics and also widely used in wireless applications [30].Long electrical length are produced due to the space filling and multiband are produced due to self-similarity[31-32].

Radiation property and bandwidth were increased by the discontinuities present in the shape of fractal antenna[33].Sierpinski carpet fractal antenna [34], Koch-curves and Sierpinski gasket [35] are the different shapes of fractal antenna which have been designed so far.

By the addition of fractal elements to the nine corners of the nonagon patch, gain of the antenna was improved[36].The gain of the antenna was improved from 1.24dB to 7.96dB by the addition of fractal elements.

Both the gain and bandwidth was improved by the use of fractal antenna[37] as shown in fig [6].

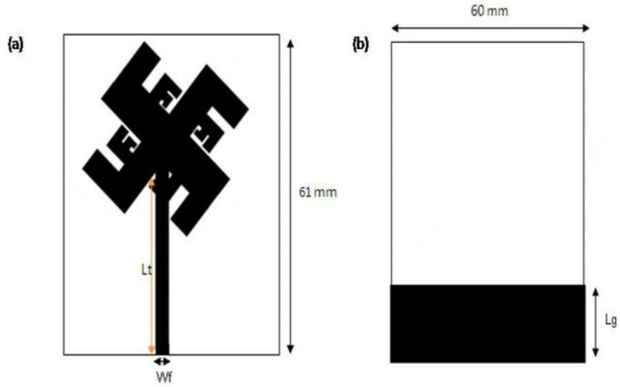


Fig. 6. The geometry of the fractal antenna (a) Radiating patch; (b) Ground plane[37]

E. Efficiency

The range of dielectric constant of the substrates employed for microstrip antennas are 2.2 < εr < 12. The bandwidth and efficiency of the antenna will be larger if the permittivity of the substrate decreases , due to the fringing field becomes wider and better radiation obtained. By decreasing the permittivity, input impedance decreases and the size of the antenna increases .Antenna efficiency will be decreases if the thickness of substrate increases due to surface waves are produced within the substrate as a result of this undesired radiation occur and introduces spurious coupling between antenna elements.

In open microstrip structure, when the surface wave reaches the outer boundaries are reflected and diffracted by the edges. Additional contribution to radiation is provided by these diffracted waves therefore antenna pattern degrade due to increase in the side lobe and cross polarization levels. Thus thickness is an important parameter and it should be chosen such that surface waves are minimized.

Better efficiency, larger bandwidth and better radiation are obtained by choosing a thick substrate with low dielectric constant. On the other hand, a thin substrate with higher dielectric constant provides a compact antenna, with less efficiency and narrower bandwidth. Thus a compromise has to be made between the smaller antenna size and good performance of antenna parameters. Generally substrate thickness is chosen such that h > 0.06λg *where* λg is the guided wavelength [38].

Another technique to enhance the efficiency of the antenna is fractal antenna. Some of the useful features of fractal antennas are good efficiencies, good gains, structure easiness, and robustness, small size in comparison with antennas of regular designs, Wideband and multiband frequency response.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

The attachment of discrete components does not yield these features but it is due to its structure.

With the use of fractal antennas we can obtain resonant frequencies that are multiband and not show harmonics, as stated by Cohen [39]. Koch fractal geometry was introduced by Helge Von Koch in 1904. Koch fractal geometry is designed by the use of iterative function system (IFS) which is explained by affine transformation [40,41].In order to obtain two iteration versions a simple folded slot Koch iteration antenna was designed[42].

By a multi-objective genetic algorithm (GA) and numerical electromagnetic code (NEC),the antenna parameter like bandwidth, efficiency and electrical size have been analyzed for the development of Koch antennas [43].

F. Polarization

Circularly polarized antennas is much superior as compared to linearly polarized antennas due to high degree of mobility, easy orientation between transmitter and receiver, anti-interference in bad weather, reduction in multipath reflection[44] and also remove other kind of interference. For WLAN/Wi-Fi applications , Circularly polarized antennas are more popular than linearly polarized antennas. An unequal width ground plane is utilized by a planar monopole antenna is to excite circular polarization[49]. In [50], For obtaining the circular polarization performance, a vertical stub and a horizontal slit are used.

Linear polarization is generated by the use of single feed point. Single feed point is also used to generate the circular polarization [45],[46] but they have usually narrow- band. Two feed points are used to generate the circular polarization in which two orthogonal modes on the patch are excited with a 90° phase shift between their excitations as shown in Fig 7 (a). Sequentially phase the excitations of an array of patches that radiate orthogonal sets of linear (or circular) polarizations [47],[48] is the another technique that works well for small sub arrays as shown in Fig 7 (b).

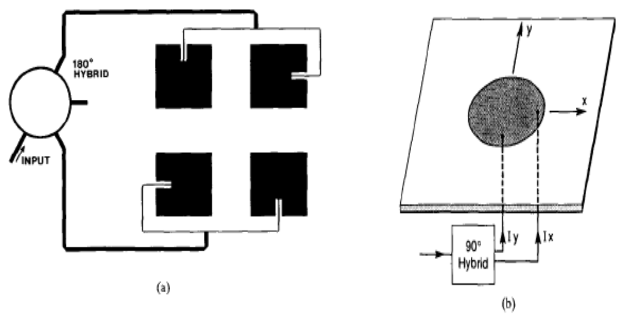


Fig. 7. Techniques for obtaining circular polarization.

(a) Using two feed points for exciting two orthogonal modes on the patch with a 90 degree phase difference.

(b) Using a sub array of orthogonally polarized elements with sequential phase rotations (the phasing's at the four patches are $0^{\circ}, 90^{\circ}, 180^{\circ}, 270^{\circ}$)[47],[48]

In previous studies [51]-[54], for the WLAN and WiMAX applications dual-band and multiband planar circularly polarized antennas were reported. In [51], by adding orthogonally located slots on the circular patch, a dual-band CP radiation was presented. For triple-band applications, by inserting three L-shaped slit arms on a hexagonal slot, a compact slot antenna [52] was realized. To generate dual-band CP, in [53] the F-shaped radiator and inverted-L strip-sleeve were used. A quad-band CP antenna [54] was proposed for 3.5GHz WiMAX and 2.4/5.2/5.8GHz WLAN applications, by placing a U-shaped radiator above a frequency selective surface. However, narrow 3-dB AR bandwidth was achieved by the above antennas

To obtain a good impedance match and CP performance in the upper band, a "C"-shaped strip is mainly used in the upper band and the "L"-shaped strip is mainly used in the lower band, For producing resonance in the upper band, The "C"-shaped strip having length approximately a quarter-wavelength at its operating frequency which lies on the left of the radiator is employed[55] as shown in figure 8 . For producing resonance in the lower band, The "L"-shaped strip having length approximately a quarter-wavelength which lies on the right of the radiator is used.

For creating circular polarization operation, T- shaped and one L-shaped strip is used. Square monopole (SM) provides smaller BW than the circular monopole (CM), its radiation pattern suffers less degradation within the impedance BW

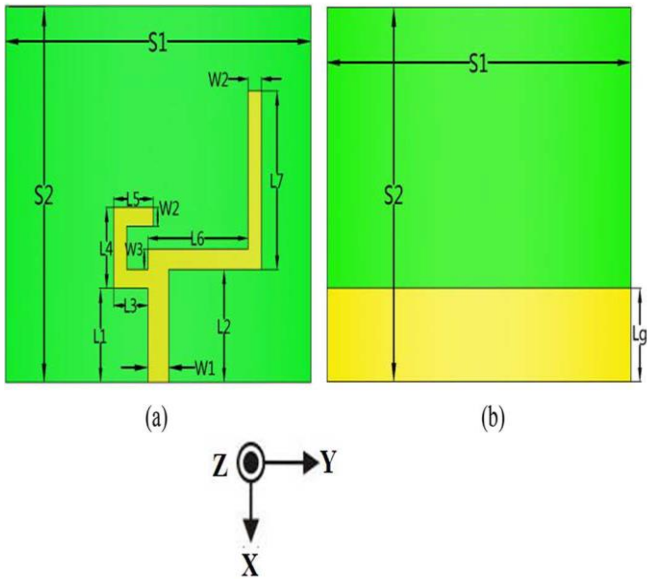


Fig. 8. Configuration of the proposed antenna. (a) Front view. (b) Back view [51]

To achieve the Circular polarization the magnitudes of the two components of current or electrical field must be the same and the phase difference between them should odd multiples of $\pi/2$.

$$Jx = Jy \tag{2}$$

$$\Delta\varphi = \varphi_y - \varphi_x = \pm\left(\frac{1}{2} + 2n\right)\pi \tag{3}$$

For n=0, 1, 2, ..., (+)

When the resultant vector rotates in the clockwise direction it shows (-) sign while the propagation is in the +z direction due to which left hand circular polarization (LHCP) is achieved. Also when the resultant vector rotates in the counter-clockwise it shows (+) sign while the propagation is in the +Z direction. This gives right hand circular polarization (RHCP)[56].The value of AR changes between 1 to infinity which depends on the magnitude values of the two current components. AR is equal to 1, when the magnitudes of the two components are the same.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

Fig. 9(a) shows the falcate-shaped printed monopole antenna which produces the circular polarization. A curved structure can be considered as the base radiating patch which is used to achieve the CP. This should produce two perpendicular current components on the patch with the same magnitudes. By adding a slot to the falcate-shaped patch antenna, CP characteristics

Has been improved which is shown in Fig 9 (b)[57].

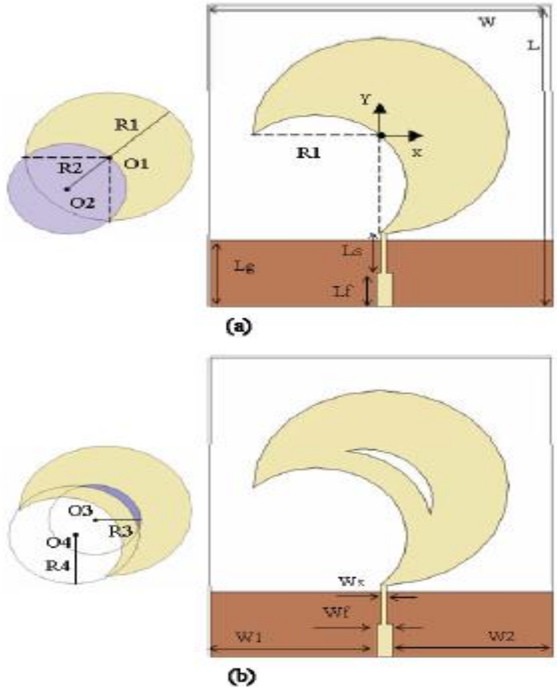


Fig. 9. Broadband circularly polarized monopole antenna

(a) Simple falcate shaped patch

(b) Slot loaded falcate-shaped patch.[57]

G. Pulse Preserving Capabilities Of UWB

One major problem in the ultra wide band antenna is that it is greatly affected by the dispersion. Some sources of the waveform dispersion are RF circuitry, frequency-dependent variations of antenna characteristics and reflection/transmission coefficients for multipath components.

Fidelity factor and the pulse width stretch ratio are the two parameter which are used to measure the pulse preserving capabilities of UWB antenna and are analyzed with respect to antenna gain and the group delay of the radiated field[58].Shape of the radiated impulse will be preserve if we obtain the constant gain and constant group delay. Larger deterioration of the performance parameters from their ideal values produce when larger variations from constant profiles occurred.

Both simulation and measurement of a system fidelity factor can be done in a easy manner.

For obtaining the impulse response system, transfer function or transmission parameter S_{21} is required and it also plays an important role both in the simulation and measurement result. System transfer function is equal to the product of the H_{TX}, H_{RX}, H_{CH} .Representation of it in frequency domain is given below

$$H(w)=H_{TX}H_{RX}H_{CH} \quad (4)$$

From the simulation, S_{21} can be directly obtained but with the several problems like limited distance between the antennas, greater computing cost, large amount of time needed for getting the result since for each desired angle ,one simulation is required[58]. Two identical antennas placed at any distance and at any angle of rotation, the transmission coefficient between them is easily calculated by the simulation of a single antenna.

The transfer function is defined as the ratio of the voltage received at the Rx-antenna terminals to the voltage at the input of the Tx-antenna[59] . This ratio can be obtained from the Friis' Transmission equation

$$\frac{P_{RX}}{P_{TX}} = e_{pol}\,(1-|\Gamma_{TX}|^2)(1-|\Gamma_{RX}|^2)G_{TX}\,G_{RX}\left(\frac{\lambda}{4\pi r}\right)^2 \quad (5)$$

Where, e_{pol} =polarization efficiency of the system

r = mismatch at each antenna terminal,

G = the total antenna gain

λ =wavelength

r= distance between antennas

From the simulation of a single antenna G and r can be easily calculated and from that H(w) of two identical antennas can be obtained.

Now equation (5) can be simplified as

e_{pol}=1 since antennas located in the same plane therefore no polarization losses occur. $\Gamma_{Tx} = \Gamma_{Rx} = S_{11}$ Since transmitting and receiving antenna are identical. We know that $P_{Rx} = \frac{V_{Rx}^2}{Z_{Rx}}$ .Antenna impedance are identical therefore $Z_{TX} = Z_{RX}$. Now the amplitude of the transfer function can be given by

$$\left|\frac{V_{Rx}}{V_{Tx}}\right| = (1-|S_{11}|^2)\frac{\lambda}{4\pi r}\,G_A \quad (6)$$

The phase of H(w) can be calculated by calculating the phase of the channel and the phase distortion inside the antennas separately. universal function e^{-jkr} give the phase change in the channel. ϕ_{TX} and ϕ_{RX} are the phase distortion produced at the transmitting and receiving antenna. Phase of the transfer function is given below.

$$\angle H(w) = -\phi_{Tx} - Kr + \phi_{Rx} \quad (7)$$

For obtaining the accuracy in the time domain signal, Gain, Return Loss and radiated E-field phase are simulated over a band larger than the desired band . The antenna gain and E-field phase should be calculated at each angle of the desired plane. the channel transfer function is given by the following equation

$$H_{CH} = \frac{\lambda}{4\pi r}\,e^{-jkr} \quad (8)$$

The transfer function of two identical antennas are related through the reciprocity theorem

$$|H_{Tx}|e^{-j\phi_{Tx}} = \frac{w}{2\pi c}|H_{Rx}|e^{j\phi_{Rx}}\,e^{-j\frac{\pi}{2}} \quad (9)$$

Substitute (8) and (9) in (4) and (7)

$$|H(w)| = \frac{w}{2\pi c}|H_{Rx}||H_{CH}||H_{Rx}| \quad (10)$$

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

$$\angle H(w) = \phi_{Rx} - kr + \phi_{Rx} - \frac{\pi}{2} \quad (11)$$

And solving for H_{Rx} and H_{Tx} using (6)

$$H_{Rx} = \sqrt{\frac{2\pi c(1-|S_{11}|^2)G_A}{w}}\, e^{j\phi_{Rx}} \quad (12)$$

$$H_{Tx} = \sqrt{\frac{w(1-|S_{11}|^2)G_A}{2\pi c}}\, e^{j\phi_{Rx}}\, e^{-j\frac{\pi}{2}} \quad (13)$$

For any point in the space, the transfer function of the two antennas (Tx and Rx) can be calculated from the above equations.

The fidelity factor shows that how much similarity between the radiated E-field waveform of a transmitting antenna and the driving voltage. This is obtained by cross correlation of the radiated E-field and the input signal. Due to the difficulty to measure or simulate the radiated E-field, hence it is not always easy to calculate it in real applications.

To compare the received R_s and transmitted signal T_s , System Fidelity Factor uses the standard S_{21} parameter. It also give the information about how much antenna system affects the input pulse. The distortion induced by the two antennas Can be taken into account by system fidelity factor whereas the transmit antenna effect can be taken into account by the fidelity factor.

Normalized Received and transmitted signal equation is given below .To compare the shapes of the pulses and not their magnitude, normalization is done.

$$\tilde{R}_s(t) = \frac{R_s(t)}{\left[\int_{-\infty}^{\infty} |R_s(t)|^2\, dt\right]^{1/2}} \quad (14)$$

$$\tilde{T}_s(t) = \frac{T_s(t)}{\left[\int_{-\infty}^{\infty} |T_s(t)|^2\, dt\right]^{1/2}} \quad (15)$$

The cross-correlation between both transmitted and received signals is done in order to obtain the system fidelity factor. When both pulses overlap than the maximum value of this correlation is obtained.

$$\text{SFF} = \max_n \int_{-\infty}^{\infty} \tilde{T}_s(t)\tilde{R}_s(t+\tau)\, dt \quad (16)$$

If the received pulse is identical to the input pulse, the system fidelity factor is equal to 1 and hence signal degradation not occurred. If the system fidelity factor is equal to 0 then the received signal is completely different then the transmitted signal[60].

IV. CONCLUSIONS

This paper has focused on two major characteristics of the modern developments in planar monopole antenna technology, antenna parameter enhancement technique and advances in the analytical modeling of planar monopole antennas. A fraction of the large volume of work on planar monopole antennas performed by researchers throughout the world has been given in the comprehensive list of references. One of the most novel topics in antenna technology are the Planar monopole antennas these days, and this trend will be continued because the features of monopole antennas make them very fascinating from a systems perspective. Besides electrical characteristics of the planar monopole antenna, it also shows mechanical and fabricational features such as low profile, less weight, easily fabrication, integration with other MMIC devices and omni-directional radiation characteristics Research and development in recent years that has gone toward improving the electrical characteristics of the planar monopole antenna, such as novel feeding techniques, antenna parameter enhancement technique and pulse preserving capabilities of ultra wide band antenna has been one of the main topics in this review.

REFERENCES

1. Lodge, “Electric Telegraphy,” U.S. Patent 609,154 (August 16, 1898).
2. P.S. Carter, “Short Wave Antenna,” U.S. Patent 2,175,252 (October 10, 1939).
3. P.S. Carter, “Wide Band, Short Wave Antenna and Transmission Line System,” U.S. Patent 2,181,870 (December 5, 1939).
4. Broadband Micro strip Antennas By Artech House
5. Honda, S., Ito M., Seki H., and Jingo Y., “A Disc Monopole Antenna with 1:8 Impedance Bandwidth and Omnidirectional Radiation Pattern,” Proc. ISAP, Sapporo, Japan, 1992, pp. 1145-1148.
6. Hammoud, Poey P., and Colomel F., “Matching the Input Impedance of a Broadband Disc Monopole,” Electronics Letters, Vol. 29, Feb. 1993, pp. 406-407.
7. Agarwall, N. P., Kumar G., and Ray K. P., “Wide-Band Planar Monopole Antennas,” IEEE Trans. Antennas Propagation, Vol. 46, No. 2, 1998, pp. 294-295.
8. Ray, K. P., Anob P. V., Kapur R., and Kumar G., “Broadband Planar Rectangular Monopole Antennas,” Microwave Optical Tech. Letters, Vol. 28, No. 1, 2001, pp. 55-59.
9. Amirah Filzah Mat Zaida, Low Ching Yub and Muhammad Ramlee Kamarudin, “CPW Fed WLAN Monopole Antenna with Gain Improvement”, Procedia Computer Science 86 (2016) 23 – 26
10. Agarwal, A., Singhal, P. K., Ojha, S. S., & Gupta, A. K. (2013). Design of CPW-fed Printed Rectangular Monopole Antenna for Wideband Dual-Frequency Applications. International Journal of Innovation and Applied Studies, 3(3), 758-764.
11. Amit A. Deshmukh., Payal Mohadikar., Kshitij Lele., Gaurav Panchal., Adil Parvez., “Psi-shaped Ultra- wideband Monopole Antenna with a Modified Feeding Structure”, Procedia Computer Science 93 (2016) 60 – 66.
12. DAVID M. POZAR,“ Microstrip Antennas,” IEEE, VOL. 80, NO 1, JANUARY 1992.
13. Ojaroudi, M., Yazdanifard, S., Ojaroudi, N., Naser-Moghaddasi, M., 2011. Small square monopole antenna with enhanced bandwidth by using inverted T-shaped slot and conductor-backed plane. IEEE Trans. Antennas Propag. 59 (2), 670–674.
14. Chen, K.-R., Chow-Yen-Desmond, S., Jeen-sheen, R., 2011. A compact monopole antenna for super wideband applications. IEEE Antennas Wirel. Propag. Lett. 10, 488–491.
15. Rahayu, Y., Razali, N., Tharek, R., 2010. Various slotted UWB antenna design. In: 6th International Conference on Wireless and Mobile Communications, pp. 107–110.
16. Noor M. Awad ., Mohamed K. Abdelazeez.,“ Multislot microstrip antenna for ultra-wide band applications”, Journal of King Saud University – Engineering Sciences (2016)
17. Y. Chen, W. T. Joines, Z. Xie ,G. Shi, Q. H. Liu, and L. Carin “Double-Sided Exponentially Tapered GPR Antenna and Its Transmission Line Feed Structure,” IEEE Trans. Antenna Propagat.,vol. 54, no. 9, pp. 2615-2623,Sep. 2006.
18. S. P. Mathur, and A. K. Sinha, “Design of microstrip exponentially tapered lines to match helical antenna to standard coaxial transmission lines,” IEE Proc. Microw. Antenna and Propag., vol. 135, no. 4, pp. 272-274,1988.
19. D. Raicu, “Universal Taper for Compensation of Step Discontinuities in Microstrip Lines,” IEEE Trans. Antenna Propagat., vol. 1, no.9, pp. 249-251,Sep. 1991.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

20. D. M. Pozar, Microwave Engineering, John Wiley & Sons,2005.
21. R. S. Kshetrimayum, and R. Pillalamarri,“ Novel UWB printed monopole antenna with triangular tapered feed lines ,”IEICE Electronics Express (ELEX), vol. 5, no. 8, pp. 242-247, April 25,2008.
22. M. Manohar, R. S. Kshetrimayum and A. K. Gogoi, Printed Monopole Antenna with Tapered Feed Line, Feed Region and Patch for Super Wideband Application, accepted for publication in IET Microwaves, Antenna and Propagation.
23. Q. Wu, R. Jin, J. Geng, and M. Ding, “Printed omni-directional UWB monopole antenna with very compact size,” IEEE Trans. Antenna Propag., vol. 56, no. 3, pp. 896-899, Mar. 2008.
24. Naffall Herscovici and Christos Christodouloc , “Wideband monopole antennas for multi-band wireless systems” IEEE Antennas and Propagation Magazine , Vol. 45, No.2, April 2003.
25. Wong, K.L., Lin, Y.F., 1998. Microstrip-line-feed compact broadband circular microstrip antenna with chip-resistor loading. Microwave and Optical Technology Letters 17, 53–55.
26. Alkanhal, Majeed, 2005. A new multi-band antenna for GSM/DCS/ GPS systems. Final Research Report No. 425/7. King Saud University, College of Engineering, Research center.
27. Khobragade, S.V., Talbar, S.N., 2004. Bandwidth enhancement using loading technique and comparison between square microstrip antenna. URSI EMTS, 576–578.
28. Mohammed A.I. Haj-Ahmed ., Mohammed K. Abedelazeez.,“ Design of a multi-band loop antenna for wireless communications: Simulation and analysis”, Journal of King Saud University – Engineering Sciences (2011) 23, 67–73.
29. Yeom, I., Kim, J. M., & Jung, C. W. (2014). Dual-band slot-coupled patch antenna with broad bandwidth and high directivity for WLAN access point.Electronics Letters, 50(10), 726-728.
30. Jeemon BK, Shambavi K and Alex ZC. Design and analysis of a multi-fractal antenna for UWB application. IEEE International Conference on Emerging Trends in Computing, Communication and Nanotechnology (ICECCN); 2013. p. 644-647.
31. Gouyet JF. Physics and Fractal Structures. Paris: Springer; 1996.
32. Werner DH, Haupt RL, Werner PL. Fractal antenna engineering: The theory and design of fractal antenna arrays. IEEE Antennas and Propagation Magazine 1999; 41(5): 37 - 58.
33. Lincy BH, Srinivasan A and Rajalakshmi B. Wideband fractal microstrip antenna for wireless applications. Proceedings of 2013 IEEE Conference on Information and Communication Technologies (ICT 2013); 2013. p. 735-738.
34. Khorramian M, Zakeri B and Ebrahimzadeh A. Design and analysis of a multiband sierpinski type monopole fractal antenna. 21st Telecommunications Forum TELFOR; 2013. p. 675-677.
35. Li DT and Mao JF. Koch like sided sierpinski gasket multifractal dipole antenna. Progress in Electromagnetics Research; 2012. p. 399-427.
36. Gurpreet Bhartia, Sumeet Bhatia, Jagtar Singh Sivia (supervisor),“ Analysis and Design of Triple Band Compact Microstrip Patch Antenna with Fractal Elements for Wireless Applications”, Procedia Computer Science 85 (2016) 380 – 385.
37. M. Ali. Dorostkar, R. Azim, M. T. Islam,“ A Novel Γ-shape Fractal Antenna for Wideband Communications”, Procedia Technology 11 (2013) 1285 – 1291.
38. Jolly Rajendran, Rakesh Peter, K.P. Soman,“ Design of Trapezoidal Monopole Antenna with truncated ground plane for 2.5 GHz Band,” Procedia Technology 6 (2012) 650 – 657.
39. Cohen N. Fractal antennas and fractal resonators; 2008.
40. Reddy VV, Sarma NVSN. Triband circularly polarized Koch fractal boundary microstrip antenna. IEEE Antennas Propag Lett 2014; 13:1057–60.
41. Orazi H, Soleimani H. Miniaturization of the triangular patch antenna by the novel dual-reverse-arrow fractal. IET Microwaves Antennas Propag 2014:1–7.
42. Sundaram S, Maddela M, Ramadoss R. Koch-fractal folded-slot antenna characteristics. IEEE Antennas Wirel Propag Lett 2007; 6:219–22.
43. Pantoja MF, Ruiz FG, Bretones AR, Martin RG, Arbesu JMG, Romeu J. GA design of wire pre-fractal antennas and comparison with other Euclidean geometries. IEEE Antennas Wirel Propag Lett 2003; 2:238–41.
44. C. F. Jou, J. W. Wu, and C. J. Wang, “Novel broadband monopole antennas with dual-band circular polarization,” IEEE Trans. Antennas Propag., vol. 57, no. 4, pp. 1027–1034, Apr. 2009.
45. K. R. Carver and J. W. Mink, “Microstrip antenna technology,” IEEE Trans. Antennas Propag., vol. AP-29, pp. 2-24, Jan. 1981.
46. J. R.James and P. S. Hall, Handbook of Microstrip Antennas. London, U.K.: Peter Peregrinus, 1989.
47. T. Teshirogi, M. Tanaka, and W. Chujo, “Wideband circularly polarized array antenna with sequential rotations and phase shift of elements,” in Proc. Int. Symp. on Antennas and Propagation, Japan, pp. 117-120, 1985.
48. P. S. Hall, J. Huang, E. Rammos, and A. Roederer, “Gain of circularly polarized arrays composed of linearly polarized elements,” Electron. Lett., vol. 25, pp. 124-125, Jan. 1989.
49. C. J. Wang and K. L. Hsiao, “CPW-fed monopole antenna for multiple system integration,” IEEE Trans. Antennas Propag., vol. 62, no. 2, pp. 1007–1011, Feb. 2014.
50. L. Zhang, Y. C. Jiao, Y. Ding, B. Chen, and Z. B. Weng, “CPW-fed broadband circularly polarized planar monopole antenna with improved ground-plane structure,” IEEE Trans. Antennas Propag., vol. 61, no. 9, pp. 4824–4828, Sep. 2013.
51. S.A. Rezaeieh, “Dual band dual sense circularly polarized monopole antenna for GPS and WLAN applications,” Electron. Lett., vol. 47, no. 22, pp. 1212–1214, Oct. 2011.
52. J.G. Beak, and K. C. H wang, “Triple-band unidirectional circularly polarized hexagonal slot antenna with multiple l-shaped slits,” IEEE Trans. Antennas Propag., vol. 61, no. 9, pp. 4831–4835, Sep. 2013.
53. J. H. Lu, and C. W. Liou, “Planar dual-band circular polarization monopole antenna for wireless local area networks,” IEEE Antennas Wireless Propag. Lett., vol. 14, pp. 478–481, 2015.
54. T. V. Hoang, T. T. Le, Q. Y. Li, and H. C. Park, “Quad-band circularly polarized antenna for 2.4/5.3/5.8-GHz WLAN and 3.5-GHz WiMAX applications,” IEEE Antennas Wireless Propag. Lett., vol. 15, pp. 1032–1035, 2016.
55. Ming-Tao Tan and Bing-Zhong Wang,“A Dual-Band Circularly Polarized Planar Monopole Antenna for WLAN/Wi-Fi Applications,” IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, VOL. 15, 2016.
56. C. A. Balanis, "Antenna theory", 3rd edition. Foudazi, H. R. Hassani, A. Frotanpour,“ A Novel Broadband Circularly Polarized Printed Monopole Antenna,” 14-15 November 2011, Loughborough, UK.
57. Do-Hoon Kwon,“ Effect of Antenna Gain and Group Delay Variations on Pulse-Preserving Capabilities of Ultrawideband Antennas,” IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. 54, NO. 8, AUGUST 2006.
58. D. M. Pozar, “Waveform optimizations for ultrawideband radio systems,” IEEE Trans. Antennas Propag., vol. 51, no. 9, pp. 2335–2345, Sept. 2003.
59. Gabriela Quintero, J.-F. Zürcher, and Anja K. Skrivervik,“ System Fidelity Factor: A New Method for Comparing UWB Antennas,” IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. 59, NO. 7, JULY 2011.

Sunil Kumar Singh was born in Chitrakoot district of Uttar Pradesh, India, in 1979. He completed his B. Engineering from Govind Vallabh Pant Engineering College Pauri Garhwal, Uttarakhand in year 2000. He received his Masters degree in Microwave Engineering with gold medal from Government Engineering College, Jabalpur, in 2005. In 2007 he joined Jabalpur Engineering College, Jabalpur, India, as an Assistant Professor. He coauthored more than 50 research papers and got published in various national and international journals and conferences on micro strip antennas and Electronic Band Gap (EBG) Substrates. Along with them his current research interest is Ultra Wide Band (UWB) Monopoles and MIMO/Diversity antennas. Currently he is a reviewing member of various reputed journals including MOTL and IET.

Mahaveer Prasad Sharma was born in Sheopur, Madhya Pradesh, India, in 1986. He completed his B. Engineering in Electronics and Communication Engineering in 2008. He worked in a couple of Engineering colleges as a lecturer for four years. He started his Master of Engineering degree in Microwave Engineering from Jabalpur Engineering College, Jabalpur, Madhya Pradesh, in 2014. He presented his research work on UWB antennas in IEEE international conference ICIIS 2016. Currently he is working on Ultra Wide Band Antennas and Impulse Radio systems.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

Manshree Mishra was born in Gaya, Bihar, in 1992. She completed her B. Engineering in Electronics and Communication Engineering in 2014. She started her Master of Engineering degree in Microwave Engineering from Jabalpur Engineering College, Jabalpur, Madhya Pradesh, in 2015. Currently she is working on Ultra Wide Band(UWB), Super Wide Band(SWB) monopole Antennas and Metamaterials.

Prahlad Kumar Rahul was born in Chhatarpur district of Madhya Pradesh, in 1991.He completed his B. Engineering in Electronics and Communication Engineering in 2013. He started his Master of Engineering degree in Microwave Engineering from Jabalpur Engineering College, Jabalpur, Madhya Pradesh, in 2015. Currently he is working on Ultra Wide Band (UWB),Super Wide Band (SWB) monopole Antennas and Metamaterials

Deepti Thakur was born in Jabalpur of Madhya Pradesh, in 1992.She completed her B. Engineering in Electronics and Communication Engineering in 2014. She started her Master of Engineering degree in Microwave Engineering from Jabalpur Engineering College, Jabalpur, Madhya Pradesh, in 2015. Currently she is working on Ultra Wide Band (UWB),Super Wide Band (SWB) monopole Antennas and Metamaterials.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)