ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 3, Issue 8, August 2016

# Dual-Polarized Antenna with Four Capacitive Feeds at Ultra-Wideband Range

[1] G. Surendra Babu [2] Dr..P.Geetha [3] Dr.D.Leela Rani
[1][2][3] Department of Electronics and Communication Engineering,
Sree Vidyanikethan Engineering College, A P, India

*Abstract:* -- **The design and analysis of a UWB (Ultra-Wideband) dualpolarized antenna with four capacitively coupled feed micro strip antenna suspended above the ground plane is presented. It has been demonstrated that the proposed approach can used for designing antennas with high impedance bandwidth and gain at UWB range. The proposed work includes the designing of dual-polarized UWB antenna for the applications of Global positioning system in handheld equipment and radar imaging. The UWB antenna will operate at the range of 3 to 11 GHz. An FR4 substrate of dielectric constant 4.4 and dielectric loss tangent of 0.027 is used in the present work. This antenna configuration can be used for Bidirectional radiation patterns required over wider bandwidth.**

*Keywords:* -- **Capacitive coupled feeds, patch antenna, UWB antenna, cavity and FR4.**

## I. INTRODUCTION

Ultra-wideband (UWB) uses very low energy-level for short range, high bandwidth communication system over a large portion of radio spectrum.UWB transmits in a manner that do not interfere with a conventional narrowband and carrier wave transmission in same frequency band. UWB was formerly known as pulse radio, but FCC (Federal Communications Commission)and International Telecommunication Union (ITU-R) Radio Communication currently define UWB as an antenna transmission for which the emitted signal B.W exceeds [1].UWB transmit information by generating radio signals at specific intervals and occupying larger B.W, thus enabling pulse position (or) time modulation. UWB (Ultra wide-Band) pulses can be sent periodically at relatively at low-pulse rates to support pulse position (or) time modulation. Recently China allowed up to 24 GHZ for UWB automotive short range radar [2-3].
Now-a-days UWB communication has been most popularly used because of its merits such as, high speed data rate and power spectral density as low. The frequency range of UWB communication is 3.1 to 11 GHZ as given by FCC in 2002. Generally for UWB communications, Microstrip Patch antennas are widely used because of their characteristics like low-cost, easy of fabrication and their low-profile characteristics [2]. A single-polarized UWB antenna has many limitations which cannot cover the whole range of frequency in UWB. To overcome these limitations, we prefer an UWB dual-polarized patch antenna which can cover the whole frequency range.

The main challenges of UWB antenna are high polarization between the ports, wide impedance matching, low cross polarization across wide bandwidth, low-cost and ease of fabrication, because of enhancing microstrip patch antenna. Mainly dual-polarization antennas are used in GPS/WLAN/WMAX systems thus enabling multi-thread communication, and achieve the device to transmit data on one polarization and receive data on another polarization simultaneously. In dual polarization both E-plane and H-plane components are equal in amplitude and their phases are not equal, if the phases are equal they possess circular polarization [2,4].Now-a-days base station antennas are dual-polarized and placed diagonally ($\pm 45^0$) and the angle between the elements should be $90^0$.Dual-band antennas are not a new idea, many years ago several manufactures are combined with multiple elements to create antenna that would operate in two separate bands.

It has been found that dual-polarized antennas are most widely used in wireless communication systems, target detection, non-co-operative radar imaging and locating precision. It also finds application for commercial purpose that possesses the frequency range of UWB[5]. A feed line is used to excite to radiate a direct (or) indirect contact, and there are several feeding methods used in different dual-polarized antennas are classified as follows,

### *A. Micro strip line feed :-*

It is one of the easiest methods to fabricate, because it consists of a conducting strip connecting to a patch and therefore can be considered as extension of patch. It is simple to model and easy topatch by controlling the inset position. In the microstrip line feed as substrate thickness increases, surface wave spurious feed radiation also increase which leads to limit the B.W and is not suitable for UWB communication because its B.W must be high.

***B. Coaxial-probe feed :-***

The Co-axial feed (or) probe feed is very common technique used for feeding microstrip patch antennas. The inner conductor of coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to ground plane. The main advantage of this feed is, that the feed can be placed at any desired location inside the patch in order to match input impedance, and main limitation is this type of feed provides a narrower B.W , and is not suitable for UWB applications and difficult to model.

***C. Proximity Coupled feed :-***

It is also called as EM (Electromagnetic) coupling. Two dielectric substrates are used, such that the feed line is between two substrates and the radiating patch is on the top of upper substrate, and the main merit is its spurious radiation and provide high isolation and B.W due to overall increase and it causes difficult to model, and return also high due to its dielectric substrates.

***D. Aperture coupling :-***

Aperture coupling is more attractive because of its advantages such as no physical contact between the feed and radiator, wider B.W, and better isolation between antennas and feed network, Aperture coupling feed allows independent optimization of antennas and feed networks by using substrates of thickness or permittivity. And it is difficult to fabricate due to its multiple layers, which also increases antenna thickness.

***E. Capacitive Coupled Probe :-***

The use of thick substrate leads to the inductive nature of input impedance associated with the probe fed patch [6]. In order to overcome the inductive nature, the fed is placed at a distance from the resonant patch and is capacitively coupled to resonant patch. A capacitively coupling fed is a new co-planar feeding method developed for dual-polarized antennas. Capacitively coupled fed is often un-intended, such as capacitance between wires or PCB traces that are next to each other. In capacitively coupling fed one signal can couple another signal and cause to appear noise in antenna.

A capactively coupled feed is a new co-planar feeding method developed for dual-polarized and circularly polarized patch antennas. This type of feed is often un-intended, as capacitance between wires or PCB traces that are next to each other. In capacitively coupling feed one signal is fed to other signal. To reduce coupling, wires or traces are separated as possible or ground lines run in between signals that might affect each other. So that lines are coupled to ground plane rather than each other [2]. Generally dual-polarized patch antennas mostly use Microstrip patch antennas because of its low-profile characteristics.

A single layer co-planar capacitive fed wideband microstrip antenna is simple to fabricate and assemble. This type of antenna is unidirectional radiation pattern because of the presence of ground plane. The capacitive feed strip is placed along one of the radiating edge of the patch compensates for probe inductance[4]. Input impedances of microstrip antenna plays a major role in determining the matching between antenna terminals and transmission lines. In coplanar capacitive with two feeds provide a B.W of 58.2% at 10 GHz and also and the radiation patterns are less.

To overcome the limitation we prefer four feeds instead of using two feeds, by this we can significantly increase B.W and input impedance, for which the proposed antenna is excited by two baluns, thus achieving High isolation, less X-polarization and minimum backward radiation which increases the gain.

## II. ANTENNA GEOMETRY AND ITS OPTIMIZATION

An antenna is a transducer that converts a guided Electromagnetic energy in to a transmission line to be radiated as electromagnetic energy in free space. Antennas may also be viewed as an impedance transformer, coupling between an input or line impedance, and the impedance of a free space. UWB antennas have been in active commercial use for decades. In a sense, even the AM broadcast band antenna is "UWB" since it covers a frequency band from 535-1705 kHz for a fractional bandwidth in the excess of a 100%. Even-though a very high quality broadcast AM [3] antenna is really a tuned antenna designed to pick up an individual narrowband (10 kHz) channel, with the effective fractional bandwidth thatisreally0.6-1.9% and for only one channel can be received at a time. Since a patch antennas with dual-band operation are more attractive due to the advantage of low-profile, broadside radiation and easy of

ISSN (Online) 2394-6849
International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 3, Issue 8, August 2016

fabrication [5-7]. A patch antenna fed by the substrate integrated meandering probe is proposed to achieve dual band low X-polarization. Nevertheless, a UWB system requires an antenna capable of receiving on all frequencies at the same time. Thus the antenna behavior and performance must be consistent and predictable across the entire band, ideally, pattern should be stableacross the entire band. Many applications [2,4] require dual-polarized operating antennas including airborne-based synthetic aperture radar (SAR), and wireless communication. Generally dual polarized antennas excite two orthogonal modes, which generates vertically polarized electric field and the horizontally polarized electric field. Therefore, a dual polarized antennas adds the body of information by providing two co-polarizations and two cross-polarizations. Thus the antennas reduce side effects of multi-path fading and also increase channel capacity per frequency in many applications.

The basic geometry of antenna design is shown in fig .1 and its optimized dimensions are listed below in Table 1. The UWB antenna configuration is basically a suspended microstrip antenna in which square radiating patch and the feed strip are placed above the substrate of thickness of height "h" mm. A long pin SMA connector is used to connect the feed strip , which capacitively couples the energy of a square radiating patch. The square radiating patch with a side length of W is supported by Rohacell foam of relative permittivity $\varepsilon_1$ = 1.03 and thickness $H_1$ = 3 mm, and capacitively excited by four identical feeds which are symmetrically located with respect to center of antenna, and each feed consists of two portions i.e , the horizontal part is an isosceles triangular patch and the vertical part is an isosceles trapezoidal patch and which are of same length.

The three essential parameters for design of a UWB antenna are:

A. Frequency of operation ($f_o$): The resonant frequency of the antenna must be selected appropriately. The resonant frequency selected for design is in the range of 3 to 11 GHZ, which is appropriate suitable for UWB communication.

B. Dielectric constant and height of the substrate ($\varepsilon_r$, h): The dielectric materials selected for design is FR4 substrate($\varepsilon_{1}$=4.55, $h_1$=0.8 mm) and Rohacell foam($\varepsilon_2$ = 1.03, $h_2$= 3mm). The dielectric substrate Rohacell foam [4,5] is inserted between the ground plane and bottom side of capacitive feed.

To achieve good impedance matching we should select the proper dimensions of feeds. In order to realize a good feed which can lead to high isolation and low X polarization with a simple tapered balun operates at 3 to 11 GHZ.

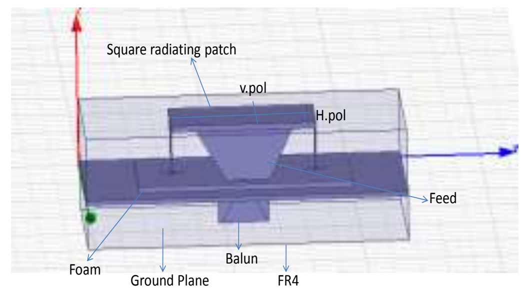


**Fig. 1**.Configuration of proposed UWB antenna in 3D view

As shown in fig.1, the dual-polarized UWB antenna consists of square radiating patch, vertical & horizontal polarization, and consists of four feeds that are capacitively coupled with a Rohacell Foam [5]. The antenna can cover a wide frequency range and its height depends on its lowest operating frequency about its quarter wavelength. To increase the antenna gain and to reduce side lobe reduction we had placed a surface mounted cavity. By placing a cavity in UWB dual-polarized antenna the parameters should be of same length .We can predict the lowest operating frequency of dual-polarized antenna ($f_{L\_(d)}$)is

$$f_{L\_2(d)} = \frac{c}{2(W+2\Delta W)\sqrt{\epsilon_{er}}} \quad (1)$$

$$\Delta W \approx 0.412 + \frac{(\epsilon_{er}+0.3)(\frac{W}{H_t}+0.264)}{(\epsilon_{er}-0.258)(\frac{W}{H_t}+0.813)} H_t \quad (2)$$

$$H_t = H_1 + H_2 + h_1 \quad (3)$$

Where $\epsilon_{er}$ is the effective dielectric constant and is selected based on design. ΔW is the resonance edge extension of the patch and $H_t$ is the distance between ground plane and patch, speed of a light in free space-C and the initial dimensions are : W = 30 mm, $H_1$ = 5 mm, $H_2$ = 11 mm & $h_1$ = 2 mm and the corresponding lowest operating frequency is 4.47 GHz (3GHz-5GHz). A dual-polarized antenna can cover a wide frequency band and the height of the antenna is about its quarter wavelength.

ISSN (Online) 2394-6849
International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 3, Issue 8, August 2016

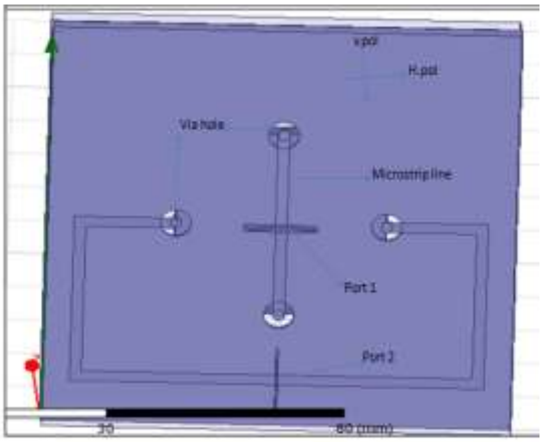


**Fig 2 .** Bottom layer of grounded FR4 substrate

In fig 2.the bottom layer of grounded FR4 substrate is shown. The bottom layer consists of two ports that are connected to two pairs of L- shaped microstrip lines and two baluns are soldered to ports, port 1 achieves horizontal polarization and port 2 achieves vertical polarization [6]. The proposed study had found that, the antenna gain can be increased by increasing the height of cavity placed above the ground plane.

## III. SOFTWARE REQUIREMENTS

***An soft HFSS***

It is frequency based Linux operating system. HFSS is an industry standard simulation tool for 2D & 3D full wave EM field simulation. HFSS generates E and H field currents, s-parameter and near and far field results. And intrinsic to get the success of HFSS as an engineering design tool at higher frequencies is automated solution where users are only required to specify geometry and material properties that provides a desired output [7]. With the help of HFSS we can automatically provide an efficient and appropriate result for solving the problem at higher frequencies.

## IV. RESULTS AND DISCUSSIONS

To validate the performance of UWB antenna, we had placed four feeds to the antenna which provides a maximum bandwidth and gain. The simulated results of reflection coefficient and mutual coupling are shown in fig.3.

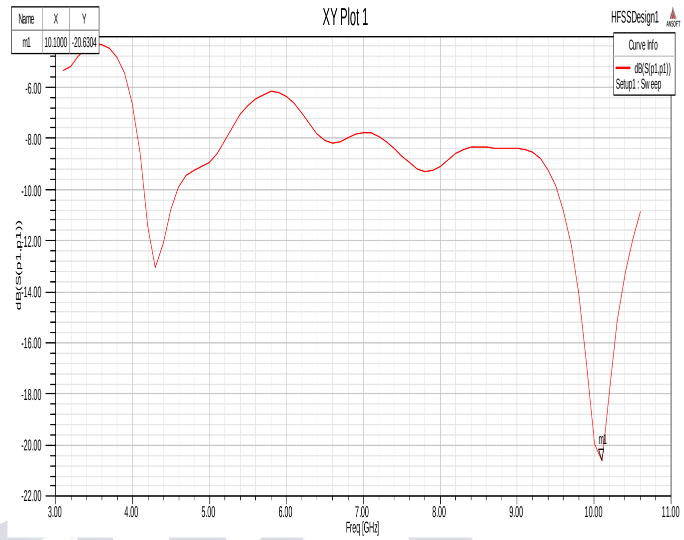


**Fig.3**. Reflection coefficient of antenna

Reflection coefficient is a parameter that defines how much quantity of an electromagnetic wave is reflected by an impedance discontinuity in a transmission medium of a wave and is equal to the ratio of the amplitude of reflected wave to the incident wave. The reflection coefficient of proposed antenna is |s11 = -20.53dB |. In general the reflection should be less than -10 dB. And thus the obtained the reflected coefficient at 11 GHZ is -21.53 db, which is suitable for efficient communication in imaging system in radars.

The VSWR is a measure the transmission line imperfections, end also define as maximum to minimum voltage of the transmission line [8,9,12]. The VSWR versus frequency of the antenna which provides a maximum bandwidth and gain, and the VSWR of dual-polarized antenna is shown in fig 4.The VSWR at 10.6 GHz is 1.602, which should be ≥ 1.

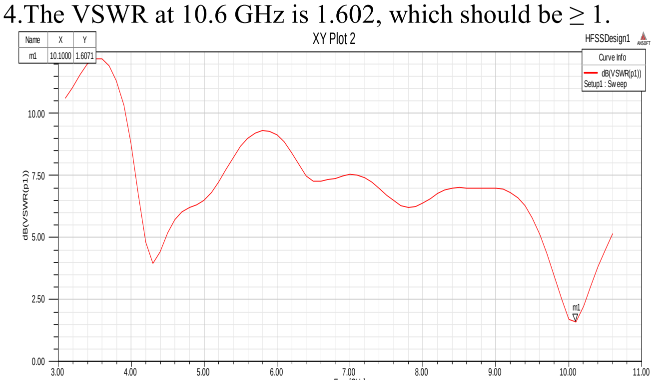


**Fig.4.** VSWR of UWB antenna at10.6 GHZ

In telecommunication [9], return loss is the loss of power in the signal returned reflected by a discontinuity in a

ISSN (Online) 2394-6849
International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 3, Issue 8, August 2016

transmission line/optical fiber. The discontinuity can be a mismatch with the terminating load or with a device inserted in the line. The return loss of an UWB antenna at 10.6 GHZ is -26.96 dB which best suites for high data communication in satellite communication for safe location of landing and for target detection in radar systems. In fact the return loss must [11] be low for efficient transmission of a signal in a medium. The return loss of proposed antenna is shown in fig 5.

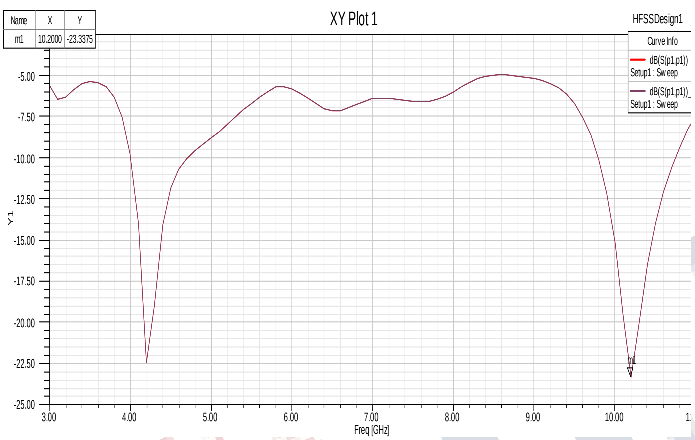


**Fig.5**. Return loss of antenna at 10.6 GHZ.

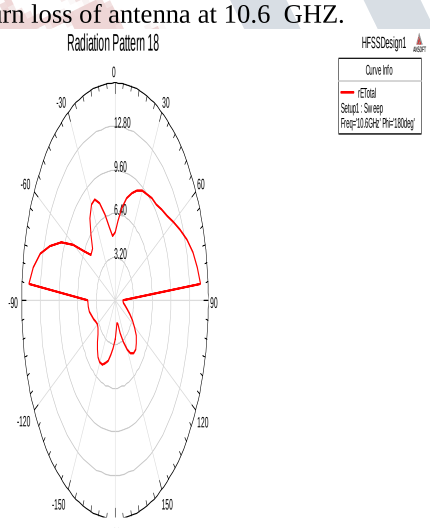


**Fig.6.** Radiation patterns at 10.6GHZ frequency.

Fig.6. illustrates the simulated radiation patterns of proposed antenna at 10.6GHZ frequencies of UWB range. The cross polarization in the E-plane increases the bandwidth [10] becomes narrower as the antenna operates at higher frequencies and the cross polarization level at 11 GHz is 4.80 dBi, at port 1 and from 4.08 to -0.72 dBi at port 2.

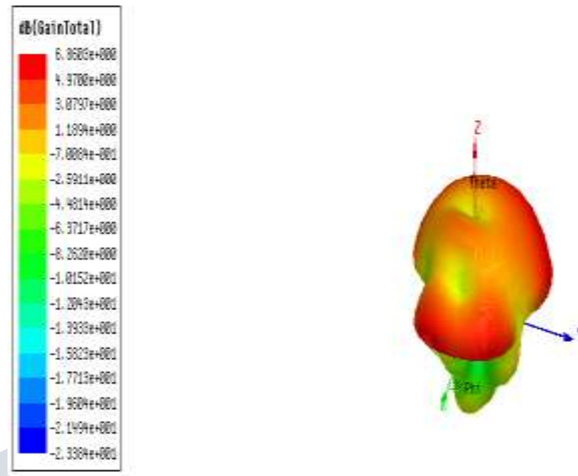


**Fig.7.** Gain of proposed antenna

Fig.7. represents the simulated antenna gain. The antenna gain ranges from 6.18 to 1.18 dBi, the obtained 3dB gain bandwidth for port 1 and port 2 are 88.06%(from 3 to 10 GHz).

**TABLE 1**
**ANTENNA PARAMETERS**

| Quantity | Value |
|---|---|
| Max U | 0.17524(W/sr) |
| Peak Directivity | 1.25576 |
| Peak Gain | 3.12665 |
| Peak Realized Gain | 2.20219 |
| Radiated Power | 1.75367(W) |
| Accepted Power | 0.704327(W) |
| Radiation Efficiency | 2.48985 |
| Front to Back Ratio | 2.73771 |

## V. APPLICATIONS:-

- UWB is used for real-time location systems, due to its precision and low power capability. It is well suited for Radio frequency [12-14] environments such as hospitals for ultra scan purpose to detect that the organs are in good condition or not.
- UWB technology is also used in personal area networks IEEE 802.15.3a for applications in imaging and multimedia systems.

## VI. SCOPE & CONCLUSION

- Dual-polarized UWB patch antenna consists of a square radiating patch and four feeds that are capacitively coupled.
- The current distributions on square patch at different frequencies has been observed based on the operating principle. The antenna [15] prototype can achieve a bandwidth of 80.59%.

- In coming days we can prefer a frequencies above 10.6 GHZ and the gain can improved and cross polarization level can be reduced, and suitable for applications like Radio astronomy, microwave devices/communications.

## REFERENCES

1) Fuguo Zhu, Steven Gao, Anthony T. S. Ho, Raed A. Abd- Alhameed, Chan H. See, Tim W. C. Brown, Jianzhou Li, Gao Wei, and JiadongXu' "Ultra-Wideband Dual-Polarized Patch Antenna With Four Capacitively Coupled Feeds," IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. 62, NO. 5, pp.2440-2448,MAY 2014.

2) Veeresh G. Kasabegoudar and K.J vinaoy, "Coplanar Capacitively coupled probe fed Microstrip Antennas for Wideband Applications," IEEE Trans. Antennas propag., vol.58,NO. 10, pp.3131-3138,2013.

3) M. Barba," A high-isolation, wideband and dual linear polarization patch antenna," IEEE Trans. Antennas propag., vol. 56.MO.5, pp.1472-1476,2008.

4) T. W. Chiou and K.L Wong."Broadband dual polarized single microstrip antenna with high isolation and low cross T. W. Chiou and K.L Wong."Broadband dual polarized single microstrip antenna with high isolation and low cross polarization," IEEE Trans. Antennas propag., vol.50, NO.3, pp.399-401,2012.

5) J. J. Xie, Y. Z. Yin, J. H. Wang, and X. L. Liu, "Wideband dual-polarized EM-fed patch antenna with high isolation and low Cross polarization," Electron. Lett., vol. 49,no.3,pp.1717-173,2013.

6) Kin-Lu Wong,Tzung- Chiou, "Broad-Band Single-Patch Circularly Polarized Microstrip Antenna with Dual Capacitively Coupled feeds," IEEE Trans2011.

7) P. Li, J. Liang, and X. D. Chen, "Study of printed elliptical/circular slot antennas for ultrawideband applications," IEEE Trans. Antennas Propag., vol. 54, no. 6, pp. 1670–1675, 2006.

8) H. G. Schantz, "A brief history of UWB antennas," IEEE A&E Syst. Mag., vol. 19, no. 4, pp. 22–26, 2004.

9) L. Siu, H. Wong, and K. M. Luk, "A dual-polarized magneto-electric dipole with dielectric loading," IEEE Trans. Antennas Propag., vol. 57, no. 7, pp. 616–623, 2009.

10) H. Wong, K. L. Lau, and K. M. Luk, "Design of dual-polarized L-probe patch antenna arrays with high isolation," IEEE Trans. Antennas Propag., vol. 52, no. 1, pp. 45–52, Jan. 2004.

11) K. S. Ryu and A. A. Kishk, "Wideband dual-polarized microstrip patch excited by hook shaped probe," IEEE Trans. Antennas Propag., vol. 56, no. 12, pp. 3645–3649, Dec. 2008.

12) S. Gao, L. W. Li, M. S. Leong, and T. S. Yeo, "A broad-band dual-polarized microstrip patch antenna with aperture coupling," IEEE Trans. Antennas Propag., vol. 51, no. 4, pp. 898–900, 2003.

13) A. Serra, P. Nepa, G. Manara, G. Tribellini, "A wideband dual-polarized stacked patch antenna," IEEE Antennas Wireless Propag. Lett., vol. 6, pp. 141–143, 2007.

14) R. C. Paryani, P. F. Wahid, and N. Behdad, "A wideband, dual-polarized, substrate-integrated cavity-backed slot antenna," IEEE Antennas Wireless Propag. Lett., vol. 9, pp. 645–648, 2010.

15) T. W. Chiou and K. L. Wong, "Broad-band dual-polarized single microstrip patch antenna with high isolation and low cross polarization," IEEE Trans. Antennas Propag., vol. 50, no. 3, pp. 399–401, 2002.

16) J. J. Xie, Y. Z. Yin, J. H. Wang, and X. L. Liu, “Wideband dual-polarised electromagnetic-fed patch antenna with high isolation and low cross-polarisation,” Electron. Lett., vol. 49, no. 3, pp. 171–173, 2013.


**Mr.G. Surendra Babu M.tech** has completed his diploma in Electronics (2011), and her under graduation in VITS and currently doing his research work on antennas at UWB range in Sree Vidyanikethan Engineering College with persuing post-graduation and area of interest in wireless communication and Nano -technology and image processing.


**Dr.D.Leela Rani Ph.D** Dr.D.Leela Rani Ph.D., is currently working as Professor in the Department of Electronics and Communication Engineering at Sree Vidyanikethan Engineering College, Tirupati. She has completed her Ph.D in Atmospheric Radar Signal Processing in SV University, Tirupati. Her research areas includes NEMS, Atmospheric Radar, Image and VLSI Signal Processing.


**Dr.P.Geetha Ph.D**
Dr.P.Geetha, Ph.D has completed her B.E in Electronics and Communication Engineering (1996) and M.E in Applied Electronics (2001) from University of Madras. She did her Ph.D in Anna University (2015) in Nano Electronics. She got her academic experience of 18 years from various institutions of engineering. She currently working as Assoc. Prof., in the Department of Electronics and Communication Engineering at Sree Vidyanikethan Engineering College, Tirupati. Her area of interest includes Nano Electronics, Signal & Image Processing.