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A Y-Shaped Planar Monopole Antenna for Wide Band Applications

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Abstract*: A Y shaped monopole utilizing a modified notch in the ground is presented. The monopole is developed from a triangular monopole and has increased the impedance bandwidth from ~550MHz to ~6GHz for reflection coefficient less than -10dB. Since the antenna shows a bandwidth ratio of 3.9:1, it can be considered as an Ultra Wide Band antenna. Use of stepped notch under feed line provides here the better impedance matching and increased bandwidth. We use ANSOFT High Frequency Structure Simulator (ANSOFT HFSS 13.0) which uses Finite Element Method (FEM) for its processing. The monopole is fabricated on FR4 epoxy dielectric substrate and both simulated and measured results are found to be in agreement.

Index Terms*: Impedance Bandwidth, Monopole Antenna, Reflection Coefficient, Ultra Wideband.

I. INTRODUCTION

UWB antennas are very popular among researchers due to the advantages provided like high speed communication, signal robustness, low power consumption and hardware simplicity. These features are useful in high resolution radar imaging, breast cancer detection, and high speed secure communication in multiuser network environment and military surveillance. Generally an antenna is said to be ultra wideband if it radiates over bandwidth more than 20% of the centre frequency or more than 500 Mhz. Apart from this, in 2002 the Federal Communication Commission (FCC) officially assigned an unlicensed 3.1-10.6 GHz band for UWB applications, [1]. The frequency band 8-12 GHz formally known as X band which is mostly used for radars, satellite communication, weather monitoring and forecasting, air traffic control etc., which are mostly long distance and space based applications. Most of the ground based short distance applications are covered under 2-8 GHz band when we include Wi-Fi and Bluetooth applications too. Some methods to increase the bandwidth of monopoles are reported, [2]-[6]. But they are mainly focused towards the multi band operation or limited to communication only. Only a few are there which can be used for communication as well as for imaging due to insufficient bandwidth. So here we present a monopole antenna for this particular 2-8 GHz band.

In this paper a Y-shaped monopole antenna is developed from a triangular monopole antenna designed with the help of the formulae given in [6] and [7]. Micro strip line feed is used to make the antenna low profile. Notch is cut from ground and the radiating element both, because patch shape influences the bandwidth of printed antenna and ground plane acts as impedance matching circuit for printed monopole antennas, [6]. Bandwidth ratio of 4:1 is achieved with the proposed design. All simulations are done in ANSOFT HFSS 13.0 software. Simulated results are found to be in good agreement with the measured one.

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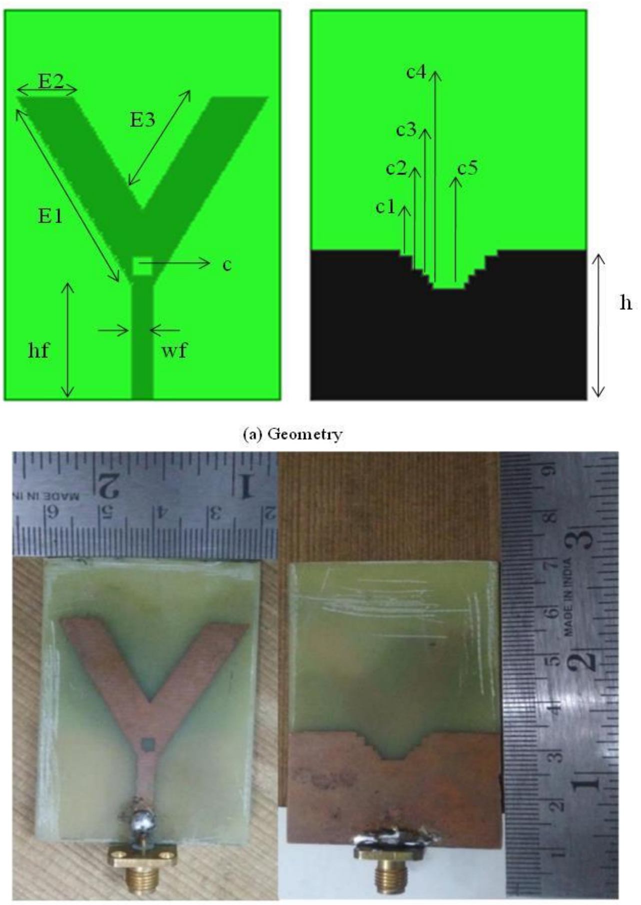
II. DESIGN AND ANALYSIS OF THE PROPOSED ANTENNA

A. Design of Proposed Antenna

Here the geometry of proposed antenna is shown and the photograph of monopole with scale is also given.



(a) Geometry

(b) Photograph of fabricated prototype

Fig.1. Geometry and Photograph of Proposed Antenna

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The antenna is fabricated with FR4 epoxy dielectric substrate which has relative permittivity $\varepsilon_r = 4.4$, dielectric loss tangent tan $\delta = 0.02$ and volume 60 X 40 X 1.6 mm^3.

The value of different dimension parameters of the antenna is given in table1. Radiating patch is printed in copper on one side and the copper ground is on another side of the FR4 substrate. All dimensions are in millimeters (mm) and rectangular ground cuts are represented by their area C_1-C_5 in mm^2.

Table1. Antenna Dimensions

Edges (mm)	E1	E2	E3	h	hf	wf
	33.37	8.08	20.20	23	17.59	3.0
Notch Area (mm^2)	C1	C2	C3	C4	C5	C
	14	22	8	6	5	8.4

Proposed monopole is fed by a micro strip line which is designed to have 50 ohm impedance as per the formulae given in [8].

B. Development of Antenna

First of all a micro strip fed triangular monopole antenna is designed. Since Ultra wide band monopole antennas work over a very wide range of frequencies, so to design them one has to take basic design suitable to work upon lower band edge frequency of the desired band. So here we take triangular monopole design suitable for lower cut off frequency of 2 GHz by using standard formulation given in [3] for cylindrical monopole antenna with suitable modifications for triangular geometry. These formulas are given in detail in [7]. The monopole designed is an equilateral triangle with edges 36.37 mm, feed length 17.59 mm, height of ground 17 mm and radiates over a bandwidth of 0.50 GHz having centre frequency 2 GHz. In order to increase its bandwidth we apply various notches to the radiating element and ground as well, which are optimized in ANSOFT HFSS 13.0.

The final design is shown in figure1. The Y shape of the radiating element has less metal as compared to the triangular patch which is to reduce ohmic losses, increases edges so that power can circulate easily throughout the patch and at the same time its shape has sufficient size to support lower band edge frequency. Ground is elongated and optimized rectangular notches to mimic a single staircase notch are provided for the better impedance matching which increases bandwidth here. To reduce spurious feed radiation a rectangular notch is cut in the patch exactly over the feed-patch junction which makes the power to go deep into patch although it is not necessary to cut a rectangular notch, most of the shapes with comparable size are found to work fine. The proposed monopole radiates over 2-7.8 GHz band as shown by the plot of measured S11.

III. MEASUREMENT, RESULTS AND DISCUSSION

As per the designing goal the antenna is developed to work over band of 2-8GHz and it is clear from the plot of reflection coefficient i.e. S11, that the measured values of S11 are in close agreement with that of simulation as the Fig. 2 Shows that measured and simulated values follow each other and also in terms of return loss values the measured results are somewhat better than the simulated results.

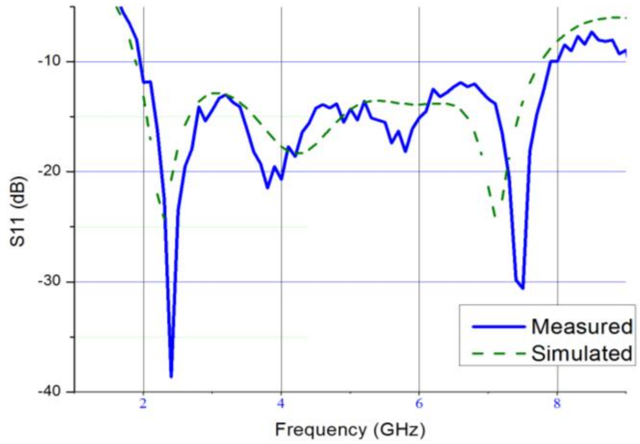

Fig.2. S11 of Proposed Y Shaped Monopole Antenna

The maximum return loss (or minimum reflection coefficient) values are obtained around 2.4 GHz and 7.4 GHz which makes it suitable for Wi-Fi/Bluetooth applications along with imaging applications. Also as per the need, one can easily insert notch in mid-band using various existing techniques to make it multiband antenna. Antenna radiation efficiency is good for desired band which is more than 80% as is clear from Fig. 3.

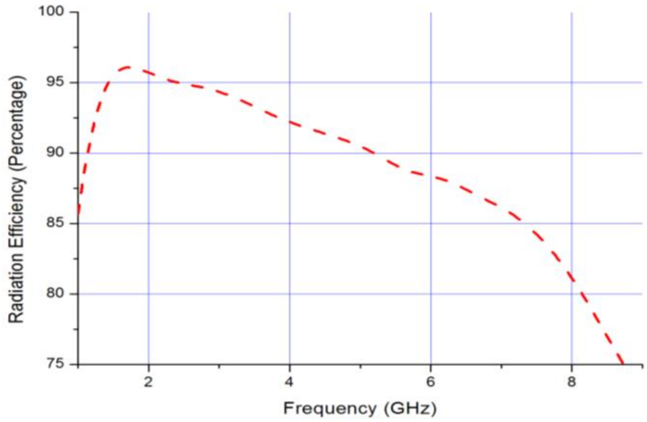

Fig.3. Simulated Radiation Efficiency of Proposed Antenna

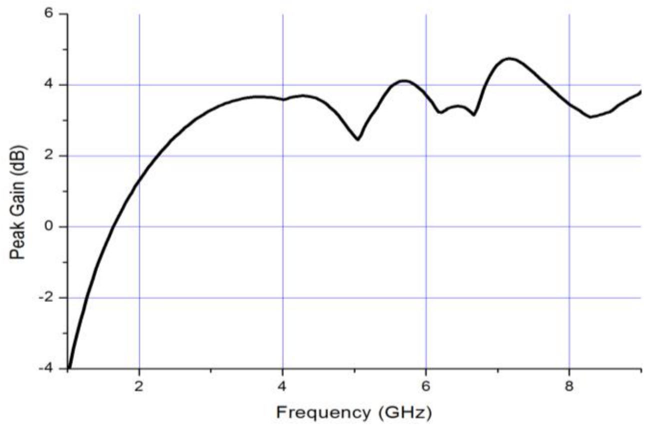

Fig.4. Peak Gain of Proposed Antenna

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Fig.4. shows the peak values of gain for different frequencies. It is clear that the gain is increasing as the frequency increases and the gain is within acceptable limits for any short range wideband antenna.

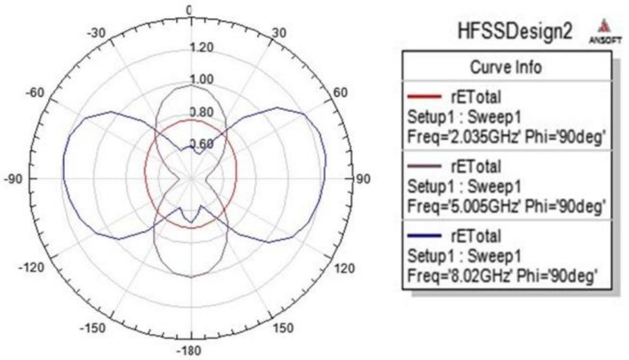

Fig. 5(a) E-Plane Radiation Pattern

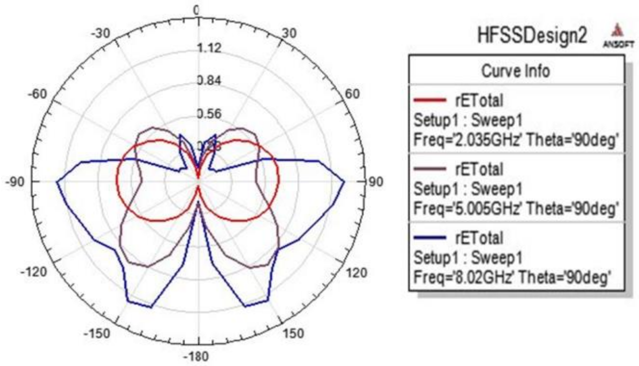

Fig. 5(b) H-Plane Radiation pattern

Fig. 5 represents the simulated 2D radiation pattern at 2, 5, and 8 GHz frequencies for E and H plane. The radiation pattern shape is a figure of eight in both the plane at lower frequency and butterfly for higher frequencies. Keeping in mind the various results shown here in this section, we can say that the proposed monopole is working on a bandwidth ratio of 3.9:1, which means it can be considered as UWB monopole antenna.

IV. CONCLUSION

A Y-shaped planar monopole antenna is developed for wideband operation using modifications in ground plane along with the radiating patch to exert a bandwidth ratio of 4:1 and successfully achieve the bandwidth ratio of 3.9:1 when measured, in this paper. This antenna is suitable not only for low power applications such as for short range communication, Wi-Fi/Bluetooth, WLAN or hyperthermia but can also be used for high power applications such as high resolution RADAR and medical imaging when used in array in beam formers. This paper presents and verifies the UWB performance of proposed Y-shaped monopole antenna. The future work can be carried out to configure this antenna for band specific performance by introducing band notches or by making it reconfigurable, also it can be tested for MIMO configurations.

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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.

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