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A Parametric Study on Impedance Matching of A CPW Fed T-shaped UWB Antenna

D. Ujwala, D. S. Ram Kiran, B. Jyothi, Shaik Saira Fathima, P. Harish, Y. M. S. R. Koushik

Abstract:- A CPW fed novel compact Ultra wide band antenna is proposed in this paper. The size of the antenna is 20mm x 20mm x 0.6mm and it is prototyped on FR4-Epoxy substrate material which has a dielectric constant of 4.4. The proposed antenna provides a bandwidth of 5.45 GHz from 4.76 GHz to 10.21 GHz which can be used for wireless applications. A parametric study is carried out by varying the horizontal and vertical gaps 'g' and 'd' between the conducting patch and ground. The output parameters and the dimensional variation effects on the proposed antenna are presented in this paper. Simulations are carried out using Finite Element based Ansoft High Frequency Structure Simulator.

Index Terms:- CPW fed, Ultra Wide band, Wireless applications.

I. INTRODUCTION

As high data rate wireless communication technologies are gaining importance in modern communication systems, design of an antenna with compact size, simple structure and wide operating frequency range is a challenge. Ultra wide band systems provide wide bandwidth with high data transfer rates and less multi path interference. In 2002, Federal Communication Commission allocated a band range from 3.1GHz to 10.6 GHz for UWB systems. Different varieties of printed slot antennas like L-shaped slot, inverted T-shaped slot etc., [1-2] are used for UWB applications but they are larger in size. Antenna with parasitic elements [3] also increase the bandwidth but at the cost of size. Planar monopole antennas provide wide band with small size [4-5]. There are two different feeding techniques to excite UWB antennas. Microstrip line feed [6] or CPW [7-8] feed provide wide band operation but CPW has more advantages like ease of integration with monolithic Integrated circuits, Low dispersion loss, less radiation leakage and low profile. In this paper, a miniature CPW fed T-Shaped Ultra wide band antenna prototyped on FR4-Epoxy substrate for wireless applications is proposed. The antenna geometry is presented in section II. A brief discussion on the simulation results and parametric study is presented in section III. Gist of the paper is presented in section IV.

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D.Ujwala, M.Tech, Communication and Radar Systems, Department of ECE, KLUniversity.
D.S.Ram Kiran, Associate Professor, Department of ECE, KLUniversity.
Shaik Saira Fathima, P.Harish, Y.M.S.R.Koushik, B.Tech, Department of ECE, KLUniversity.

II. UWB ANTENNA GEOMETRY

A novel CPW fed T-Shaped UWB antenna configuration is shown in Figure 1. The antenna is designed on FR4 substrate of dielectric constant 4.4 and a thickness of 0.6mm.

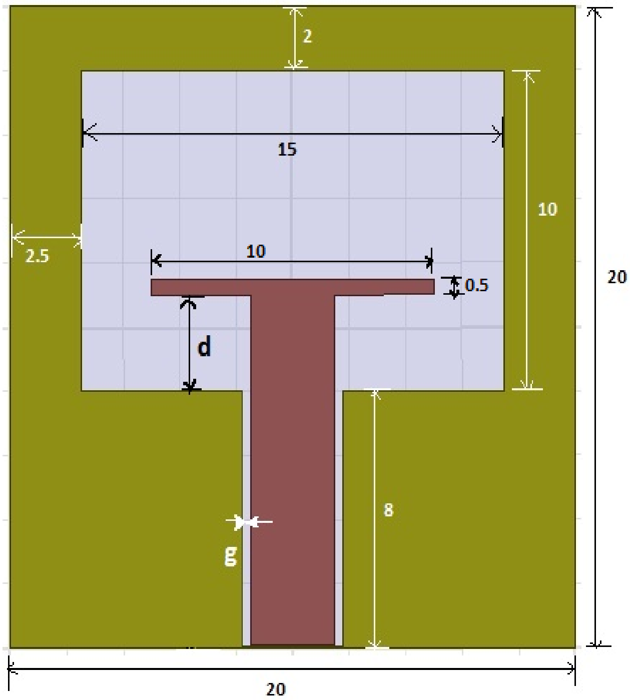

Figure 1: Proposed antenna Geometry

The antenna is fed by Coplanar Waveguide (CPW) line of input impedance 50 Ω. The antenna has a compact size of 20mm x 20mm x 0.6mm. A rectangular slot of size 15mm x 10mm is made in the ground. A T-Shaped patch is constructed with the dimensions as shown in figure. A parametric study is carried out by varying the parameters 'g' and 'd'. The proposed antenna resonates at three frequencies for the given dimensions. The resonant frequency variations, bandwidth and the impedance matching dependence of the antenna on the gap between the CPW feed line and ground are presented in this paper. Finite Element Method based Ansoft HFSS is used to analyze the antenna.

III. RESULTS AND DISCUSSIONS

A. Return Loss

The three resonant frequencies of the proposed antenna are 5.56 GHz, 8.44 GHz and 9.67 GHz. The operating frequency range is from 4.76 GHz to 10.21 GHz with a bandwidth of 5.45 GHz.

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The Return Loss values at the resonant frequencies are -17.6 dB, -33.1 dB and -19.1 dB and the return loss plot is shown in figure 2.

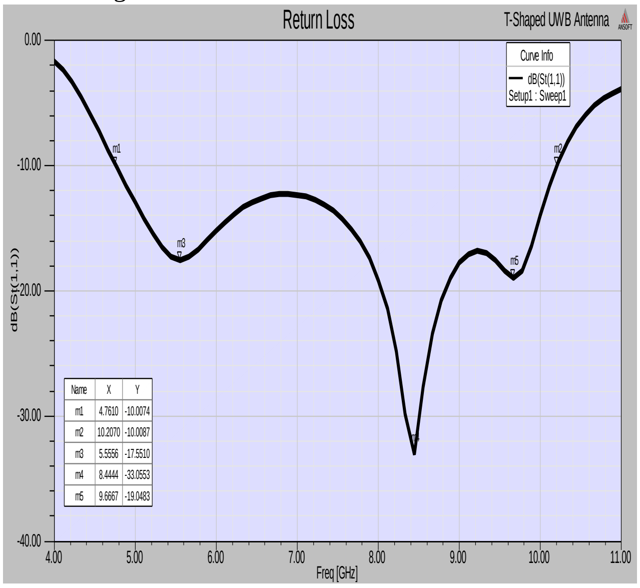

Figure 2: Return Loss vs Frequency

The gap ‘g’ between the CPW feed line and ground is varied and the variation in impedance matching which effects the bandwidth and resonant frequencies is observed in figure 3.

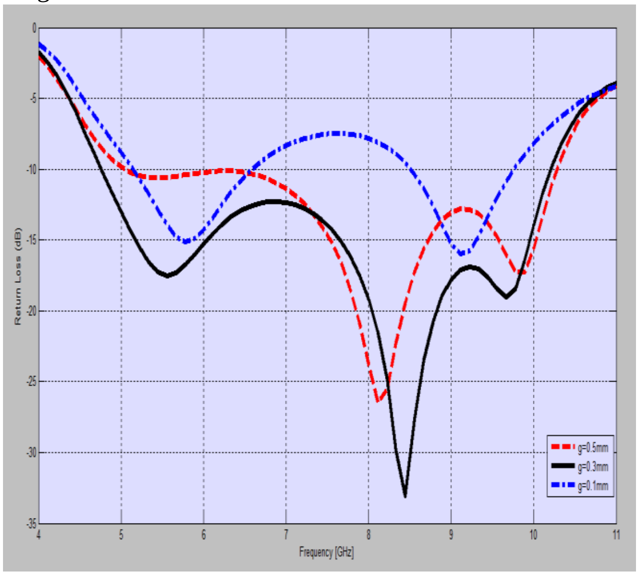

Figure 3: Return Loss versus Frequency for g=0.1mm, 0.3mm, 0.5mm

For different gaps g=0.1mm, 0.3mm, 0.5mm, wide operating band is obtained for g=0.3mm which shows that there is a perfect impedance matching for g=0.3mm. For g=0.5mm, there is better impedance matching but the bandwidth is less than the one obtained for g=0.3mm. For g=0.1mm, the antenna resonated at two frequencies which can be used for dual band applications rather than Ultra wide band applications.

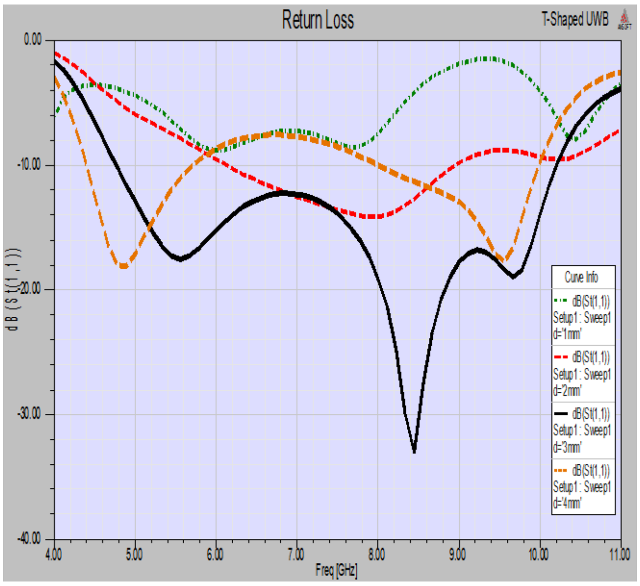

Figure 4: Return Loss versus Frequency for d=1mm, 2mm, 3mm, 4mm

Another parametric study is done by varying the height of the T-shaped patch as a function of ‘d’. For d=1mm, 2mm, 3mm, 4mm, the variation in return loss is shown in figure 4. There is a perfect impedance matching at d=3mm. For d=2mm, the bandwidth is reduced and less impedance matching is observed. For d=1mm, the return loss is above -10dB which doesn’t meet the standard conditions. For d=4mm, the antenna is used for dual band operation rather than UWB applications.

B. VSWR

Voltage standing wave ratio VSWR which is a function of reflection coefficient represents the amount of power reflected from the antenna.

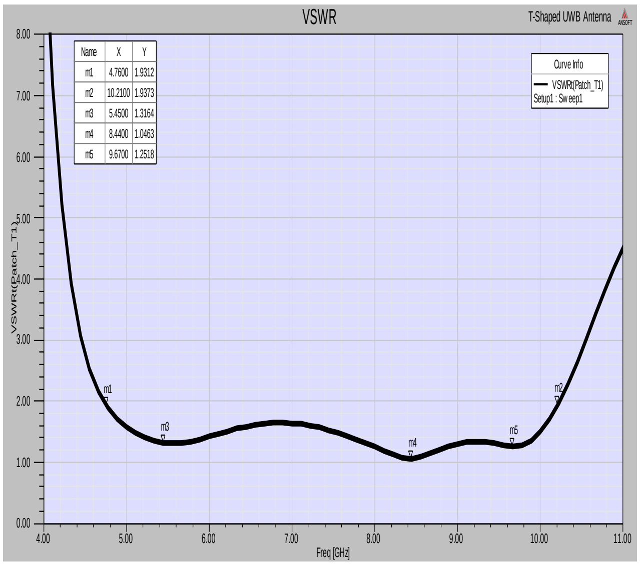

Figure 5: VSWR vs Frequency

An antenna is considered to be perfectly matched when the VSWR value is between 1and 2. Figure 5 shows the VSWR plot versus frequency.

It is observed that VSWR is between 1 and 2 in the entire operating range from 4.76 GHz to 10.21 GHz. The VSWR values at the three resonant frequencies are 1.32, 1.05 and 1.25.

C. Input Impedance

The impedance bandwidth for the proposed antenna is 72.81% in the operating range 4.76 GHz to 10.21 GHz and the formula to calculate the impedance bandwidth is as shown in the formula.

$$IPW = \frac{UF - LF}{UF + LF} X\ 200$$

Where IPW=Impedance Bandwidth (in %)
UF=Upper Frequency (GHz)
LF=Lower Frequency (GHz)

The input impedance smith chart is shown in figure 6.

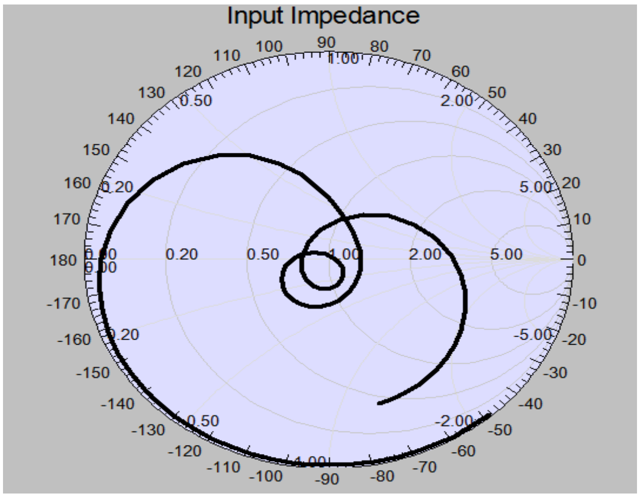

Figure 6: Input Impedance

D. GAIN

The gain of an antenna represents the amount of power transmitted in the direction of peak radiation to that of an isotropic source. It can be as high as 40-50 dBi for very large dish antennas and can be as low as 1.8 dBi for real antennas. Theoretically, it can never be less than 0dBi. The gain of the proposed antenna varies from 2.8 dBi to 5.4 dBi. The peak gain of the proposed antenna is 5.4 dBi at 9GHz. The gain versus frequency plot is shown in figure 7.

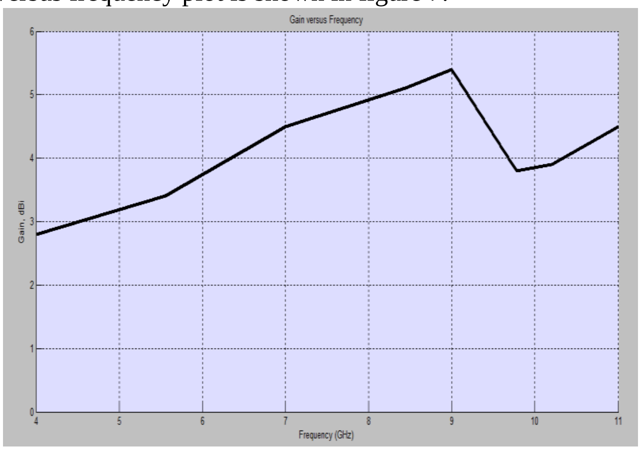

Figure 7: Gain vs Frequency

E. Radiation Patterns

The E-Plane plane radiation patterns at the three resonant frequencies for Phi=0 degrees and Phi=90 degrees are shown in figure 8.

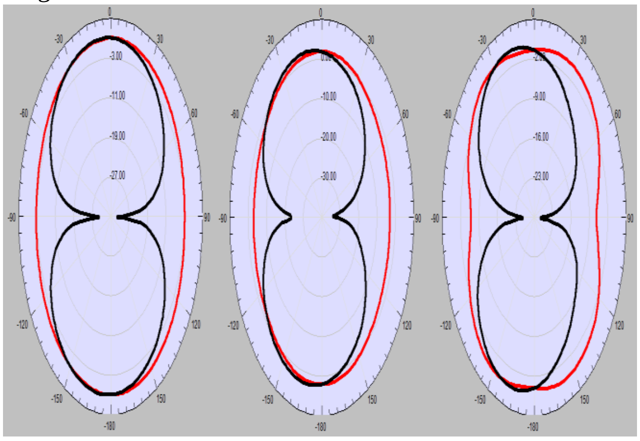

Figure 8: E-Plane Radiation Patterns at 5.56 GHz, 8.44 GHz and 9.67 GHz

The H-plane radiation patterns for Theta=0 degrees and Theta=90 degrees at the three resonant frequencies is shown figure 9.

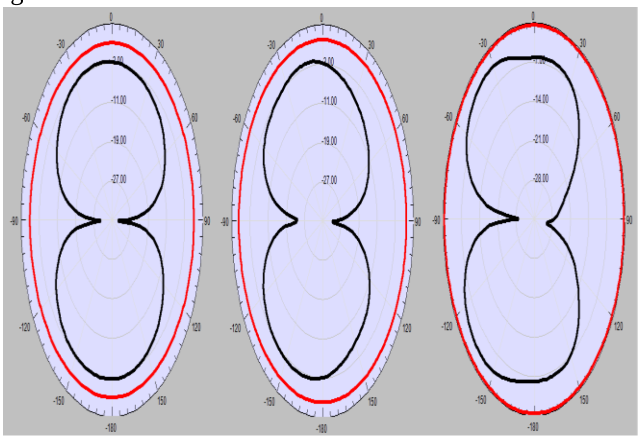

Figure 9: H-Plane Radiation Patterns at 5.56 GHz, 8.44 GHz and 9.67 GHz

The overall Radiation Efficiency of the proposed antenna is obtained as 99% which is a good characteristic.

IV. CONCLUSION

A novel CPW fed T-shaped UWB antenna is proposed for wireless applications. It has a compact size of 20mm x 20mm x 0.6mm prototyped on FR4-Epoxy substrate. The proposed antenna has a wide operating range from 4.76 GHz to 10.21 GHz with a bandwidth of 5.45 GHz. The impedance bandwidth is achieved as 72.81% with a desirable impedance matching. A parametric study is performed on impedance matching by varying the gap between the feed line and ground as well as by varying the height of the patch from the ground. The radiation patterns are almost stable with good radiation efficiency. The peak gain of the antenna is 5.4 dBi in the operating range.

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AUTHORS PROFILE

D. Ujwala was born in A.P, India in 1987. Completed B.Tech in 2008 from Koneru Lakshmaiah College of Enginering affiliated to Acharya Nagarjuna University. Worked as Associate Software Engineer for KLUniversity from 2009-2010. Presently pursuing her M.Tech, Communication and Radar Systems from KL University.

B.Jyothi was born in A.P, India in 1981. Completed her B.Tech in 2003 from CR Reddy College of Engineering affiliated to Andhra University. Presently pursuing her M.Tech, in Communications and Radar Systems from K L University.