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Compact CPW-Fed Uniplanar Antenna for Multiband Wireless Applications

V.Sandhya Rani¹, P.Lokesh Kumar², S.Varunkumar³, B.Srinivas⁴, K. Prasanna Kumar⁵

Department of Electronics and Communication Engineering, LIET, Jonnada, JNTUK, India^{1,2,3,4,5}

ABSTRACT: Patch Antennas are widely used in microwave frequency region because of their computability with Printed Circuit Board (PCB) technology and its simplicity in manufacture. A compact coplanar waveguide (CPW) fed uniplanar antenna for quad band applications is performed. This uniplanar antenna resonates in four bands so that this antenna is named as quad band antenna. The quad band operation is realized by imposing various current paths in a modified T-shaped radiating element. The antenna covers GSM 900, DCS 1800, IEEE 802.1.a, IEEE 802.1.B.b and Hiper LAN-2 bands and exhibits good radiation characteristics. This low profile antenna has a dimensions of 32mm*31mm when printed on a substrate of dielectric constant 4.4 and height 1.6mm. Simulated return loss and pattern results obtained through software package of HFSS provided and results are obtained.

KEYWORDS: Bluetooth antenna, Compact antenna, CPW-fed antenna, Uniplanar antenna, Quad band antenna

I. INTRODUCTION

The emergence of Coplanar Waveguide (CPW) fed antennas revolutionized the antenna industry in terms of cost, compactness, bandwidth etc. The uniplanar characteristics of CPW structures together with their attractive features like low radiation loss and less dispersion in comparison with a micro-strip, little dependence of characteristic impedance on substrate parameters etc made them Popular. A conventional Coplanar Waveguide (CPW) on a dielectric substrate consists of a center strip conductor with semi-infinite ground planes on either side separated by a small gap. CPW structures supporting quasi TEM mode have gained great attention in microwave and millimeter wave applications due to uniplanar structure. They are commonly used in Monolithic Microwave Integrated Circuits (MMIC).

The CPW transmission lines have lower radiation loss and less dispersion than micro-strip lines. Moreover, the characteristic impedance and phase velocity of CPW are less dependent on the substrate height and more dependent on the dimensions in the plane of the conducting surface. Due to this exceptional behavior, CPW structures have been explored a lot for compatible modern wireless communication gadgets. The introduction of multisystem applications in present wireless communication gadgets, demands the requirement of frequency bands corresponding to system application such as GSM900 (870–960MHz), IEEE802.11.b (2400–2484MHz) bands. Since no compromise can be made on compactness of these electronic gadgets, the multiple antennas must be replaced by multiband antennas with good radiation characteristics, which are of great scenario.

Literature Survey:

- A new dual-frequency design of coplanar waveguide (CPW)-fed monopole antenna is proposed and experimentally studied.
- The proposed antenna utilizes the advantages of the CPW line to simplify the structure of the antenna into a single metallic level, thereby making easier the integration with the microwave integrated circuits.

II. ANTENNA GEOMETRY

The proposed antenna operates in four bands so that this antenna is named as quad band antenna. In this design we have four iterations for implementing the antenna. The prototype is fabricated on a substrate of dielectric constant 4.4 and thickness (H) 1.6mm. To excite additional current paths a slit is incorporated in the T-shaped structure resulting in the final proposed antenna geometry. The width of the strip and gap (G) of the coplanar waveguide feed are derived using standard equations for 50 ohm input impedance.

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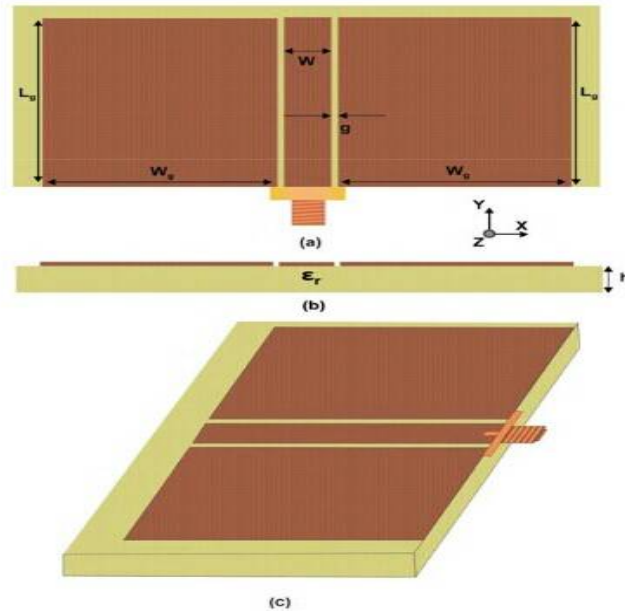


Fig 2.1 a).top view b). side view(c)3D view ($W_g=14\text{mm}$, $L_g=10\text{mm}$, $W=3\text{mm}$, $g=0.35\text{mm}$, $h=1.6\text{mm}$ and $\epsilon_r=4.4$)

III. DESIGN OF THE QUAD BAND ANTENNA

The proposed antenna designed in four steps. This low profile antenna has a dimensions of $32\text{mm} \times 31\text{mm}$ when printed on a substrate of dielectric constant 4.4 and height 1.6mm. Simulated return loss and pattern results obtained through software package of HFSS provided.

DESIGN PARAMETERS AND ITS VALUES

Parameter	Value
Length of the ground plane(L_g)	10mm
Width of the ground plane(w_{gL})	14mm
Width of the ground plane(W_{gR})	14mm
Substrate($L \times W \times S$)	$35 \times 34 \times 1.6$
Lengths of the strip($L_1, L_{2L}, L_{2R}, L_3, L_4, L_5$)	18mm, 22mm, 4mm, 8mm, 31mm
Substrate permittivity(E_r)	4.4
Slit perimeter	3mm
Gap in between ground planes	0.35mm
Cd, bc	10mm, 29mm
De, ha	1mm

3.1 step 1

For designing this proposed antenna at first we consider the basic monopole structure (Antenna 1) resonates at 3.6GHz, corresponds to its quarter wavelength. The CPW-fed monopole antenna generates two operating modes corresponding to the two monopole lengths.

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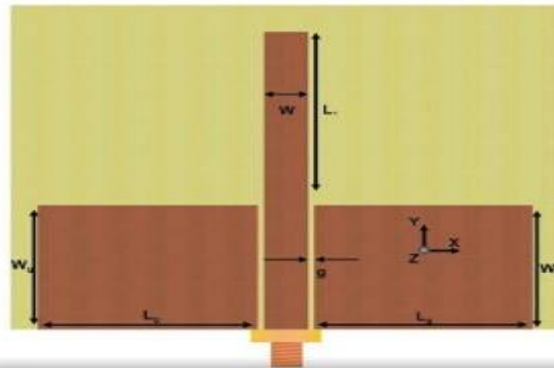


Figure 3.1 Finite Ground Coplanar Waveguide monopole antenna ($W_g=14\text{mm}$, $L_g=10\text{mm}$, $L_1=18\text{mm}$, $W=3\text{mm}$, $g=0.35\text{mm}$, $h=1.6\text{mm}$ and $\epsilon_r=4.4$)

3.2 Step 2

By top loading the monopole we can generate T-shaped monopole (Antenna 2). The dual frequency operation is achieved using a rectangular meander monopole, in this T shaped monopole structure left and right arms of the antenna are equal. It exhibiting dual bands centered at 1.77 GHz and 5.54 GHz. We can generate additional resonance by extending the left arm of the antenna

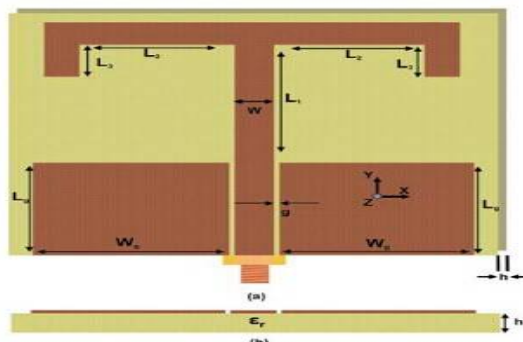


Figure 3.2 T shaped monopole antenna ($W_g=214\text{mm}$, $L_g=10\text{mm}$, $L_1=18\text{mm}$, $W=3\text{mm}$, $g=0.35\text{mm}$, $h=1.6\text{mm}$ and $\epsilon_r=4.4$)

3.3 Step 3

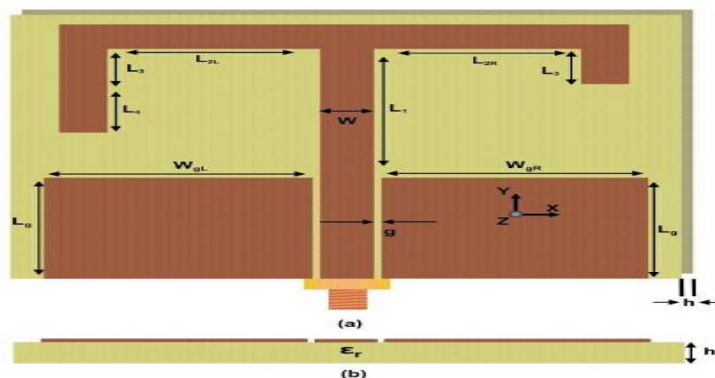


Figure 3.3 Measured and Simulated reflection characteristics of the triple band antenna ($L_1=18\text{mm}$, $L_2=11\text{mm}$, $L_3=7\text{mm}$, $W=3\text{mm}$, $W_g=14\text{mm}$, $L_g=10\text{mm}$, $h=1.6\text{mm}$, $\epsilon_r=4.4$ and $g=0.35\text{mm}$)

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For achieving the triple band characteristics we are using slot monopole antenna, it uses asymmetric grounds. By extending left arm of the T shaped monopole antenna we can generate this Antenna 3. it resonates at 1.61 GHz, 2.4 GHz and 5.2 GHz.

3.4 Step 4

In order to provide better insight to the antenna performance the current distribution on the antenna should be analyzed. A quarter wavelength variations are found along the resonating length for the first two resonances as in the figure. The first resonant path is due to the longer asymmetrical path and the second is due to smaller path. A three quarter variation of current is observed along the shorter asymmetrical path and larger asymmetrical path. Since these two resonances are close to each other they merge together to give a wide bandwidth corresponding to the third resonance.

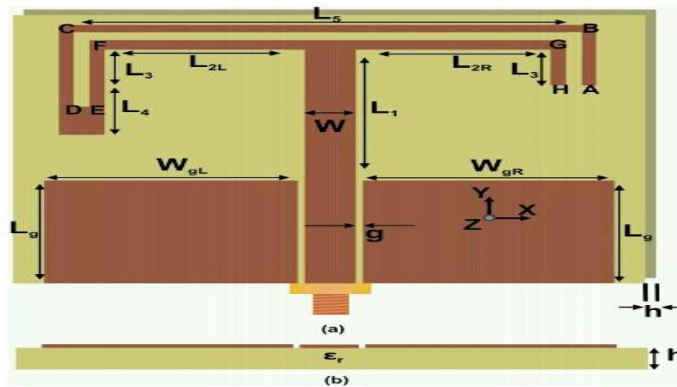


Figure 3.4 Geometry of the Quad band antenna (a) front view (b) side view ($L_1=18\text{mm}$, $L_{2R}=L_{2L}=11\text{mm}$, $L_3=4\text{mm}$, $L_4=8\text{mm}$, $L_5=31\text{mm}$, $L_g=10\text{mm}$, $W_{gR}=W_{gL}=14\text{mm}$, $W_s=3\text{mm}$, $CD=10\text{mm}$, $BC=29\text{mm}$, $DE=ha=1\text{mm}$, $h=1.6\text{mm}$, $\epsilon_r=4.4$ and $g=0.35\text{mm}$)

In addition to the three resonances of the antenna the next aim is to generate an additional resonance at 900MHz together with better match for the present bands; preserving the compactness. It is really challenging to excite a lower frequency without trading the compactness of the antenna.

3.5. Modifications in design

For achieving different radiation patterns and for observing the variations in return loss we have to modify the design by placing T shaped slots on either side of the rectangular slots. So that gain and return losses are varied in accordance with the dimensions of T shaped slots.

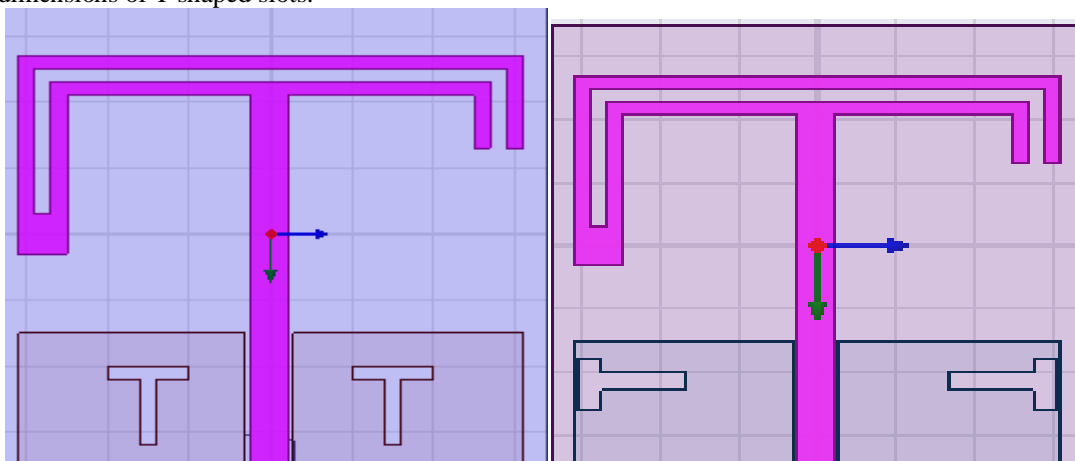


Fig 3. 5 modified CPW quad band antenna

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Parametric study for first, second, third, fourth and fifth iterations:

- The CPW fed monopole antenna generates two operating modes corresponding to the two monopole lengths. This antenna resonates at 3.6 GHz corresponding to its quarter wavelength.
- The dual frequency operation is achieved by using rectangular meander monopole. This proposed antenna is like a T shaped structure with equal left and right arms. It exhibiting dual bands centered at 1.77GHz and 5.54GHz.
- The slot monopole antenna uses asymmetric CPW grounds for achieving the triple band characteristics.
- Fourth resonance can be generated by introducing a slit. This forces the current to flow through a longer path around the slit.

Return loss for different type of iterations are shown in figures below and they are resonates at different types of frequency bands.

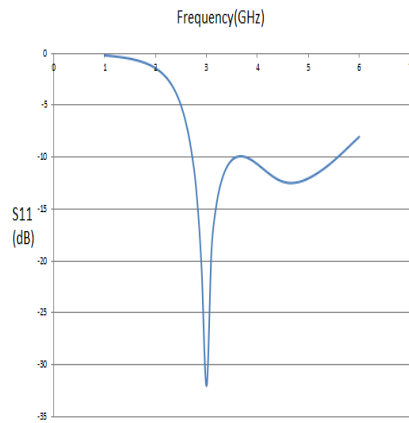


Fig 3.6 Return loss for Monopole antenna

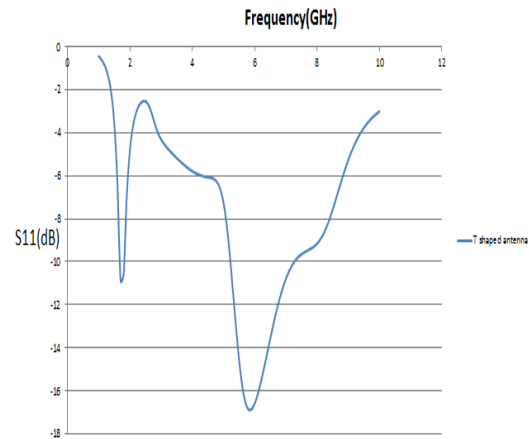


Fig 3.7 Return loss for T shaped antenna

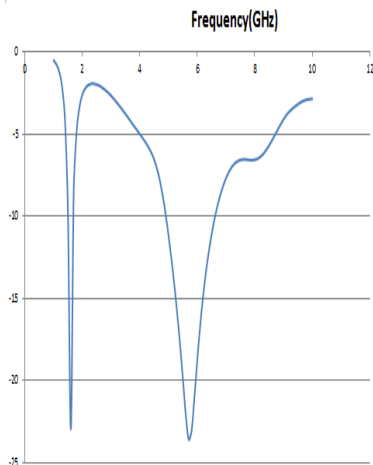


Fig 3.8 Return loss for the triple band antenna

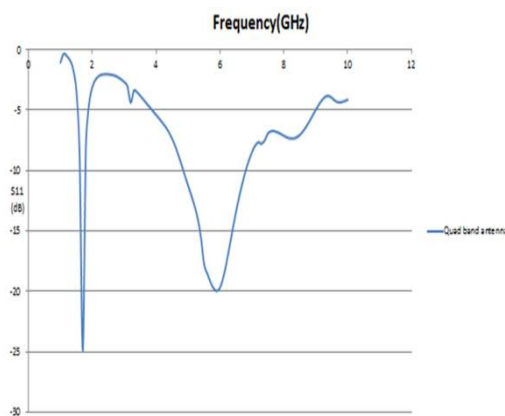


Fig 3.9 Return loss for Quad band antenna

IV.RESULTS AND DISCUSSIONS

Fig. 4.1 shows the parametric variation of return loss. From the graph it is observed that the return loss is varied for different iterations and is slightly increases for the modified quad band antenna, the bandwidth increases slightly while the impedance matching reduces.

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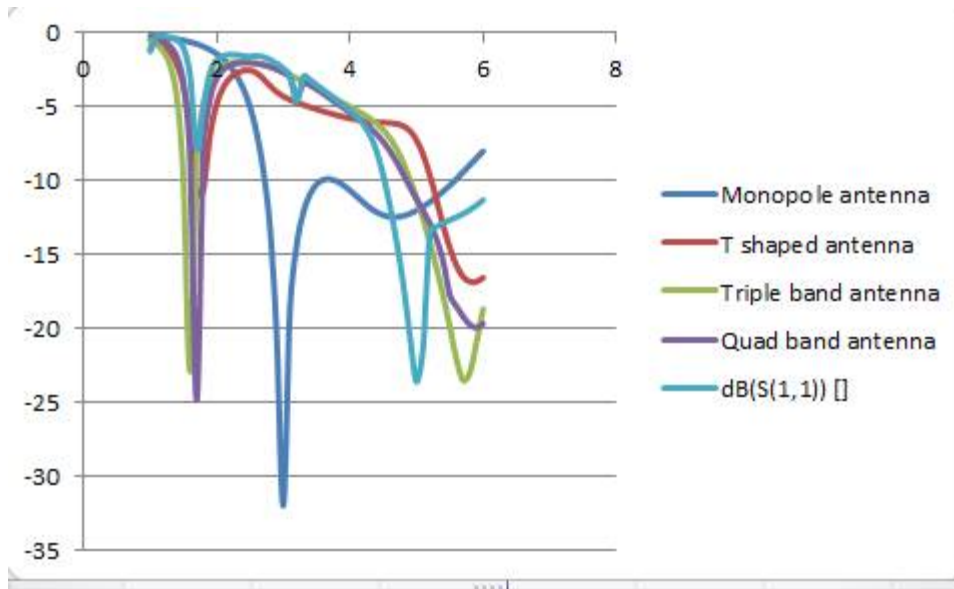
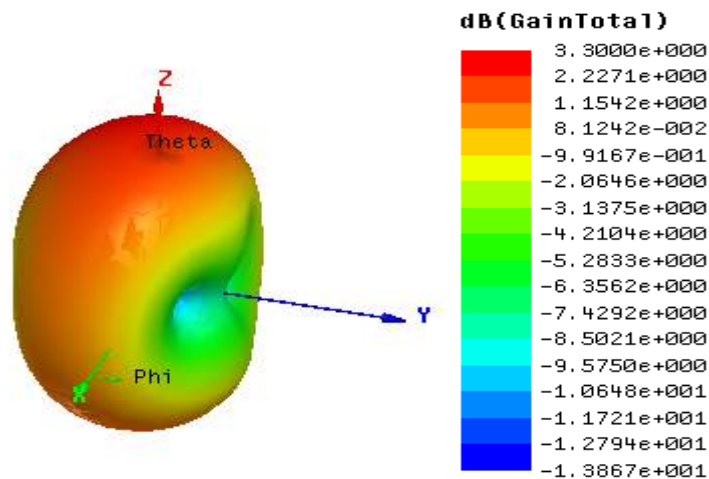


Fig 4.1 Parametric study for different iterations

Gain for the Quad band antenna is obtained as 2.94db is shown in fig 4.7



Tabular form representing results

Iteration	Band width	Gain
1	0.9	1.11
2	0.87	1.85
3	1.2	1.25
4	1.4	2.94
5	1.6	3.1



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V. CONCLUSION AND FUTURE SCOPE

This uniplanar antenna resonates in four bands. This proposed antenna having dimensions $0.14\lambda \times 0.136\lambda \times 0.007\lambda$ is presented. It is suitable for several applications like GSM, DCS, IEEE802.11.a, IEEE802.11.b and Hiper LAN-2 bands. The presented proposed antenna having good radiation characteristics with a gain of 3.3 dBi, 2.94 dBi. Future challenges of a micro strip antenna are bandwidth extension techniques, control of radiation patterns, reducing losses / increasing efficiency, improving feed networks.

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