

CPW-Fed U-Shaped Loop Monopole Antenna for Dual-Band Wireless Communication Applications in Biomedical IoT and Smart Healthcare Systems

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ABSTRACT

A novel coplanar waveguide fed dualband antenna for wireless application is discussed in the paper. Primary focus is on the 2.45GHz and 5.2GHz WLAN band. The presented configuration has 25 x 35.5mm dimensions with U shaped loop radiation structure and a capacitivelycoupled ground plane. The proposed design mainly focusses on FR-4 Epoxy as the substrate. Other materials like RT Duroid and zelt was used for performance comparison. For FR-4 Epoxy, the first band was obtained at 2.45GHz and a second band was obtained at 3.8 to 5.9 GHz. The return loss obtained for the first band is -18 and the second band has appreciable return loss. The proposed design produces two bands which are in compliance with the current microwave standards for mobile communications.

KEYWORDS: Coplanar waveguide, R T Duroid, Radiation pattern, Return loss

1. INTRODUCTION

All Wireless communication devices have been playing a very important part in our daily life especially for past 15 years. Due to this reason, antennas designed for wireless applications have attracted much attention from researches all over the world. Multiband antennas are capable of providing multiple reception and transmission functionalities.[1] It is therefore much desirable to have a single antenna using a single feed point that covers multiple frequency bands. The designed antenna is expected to be compact and simple and such as to be integrated well with other communication devices. In applications where size, weight, cost, performance, ease of installation and that of aerodynamic profile are constraints, low-profile antennas like microstrip and printed slot antennas are required. Because microstrip antennas inherently have narrow bandwidths and, in general, are half-wavelength structures operating at the fundamental resonant mode, researchers have made efforts to overcome the problem of narrow bandwidth, and various configurations have been presented to extend the bandwidth by introducing slots in the microstrip patch.

Printed slot antennas that are fed by coplanar waveguide (CPW) have several advantages over microstrip patch antennas. Slot antennas exhibit wider bandwidth, lower dispersion, and lower radiation loss than microstrip antennas, and CPW also provides an easy means of parallel and series connection with active and passive elements required for matching and gain improvement, and with ease of integration with monolithic microwave integrated circuits (MMIC).[2]

Wireless Fidelity, commonly known as Wi-Fi is defined under the IEEE 802.11x standards and WiMAX, stands for worldwide interoperability for microwave access. Wi-Fi networks have a bandwidth of 20MHz, whereas WiMAX networks have a flexible bandwidth option which ranges from 1.25MHz to 20MHz

2. MATERIALS AND METHODS

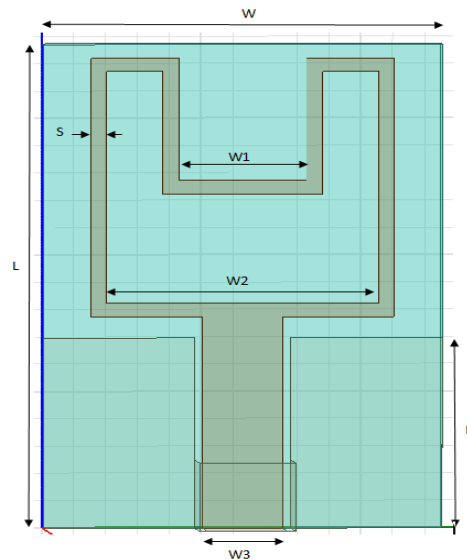
Coplanar Waveguide Antennas

CPW-fed antenna designs presented here are suitable for WiFi and WiMAX operations. These antennas are suitable for practical portable devices. A coplanar waveguide (CPW) is a strip transmission line defined as a planar transmission structure for transmitting microwave signals. It consists of at least one flat conductive strip of small thickness, and conductive ground plates. A CPW structure consists of a median metallic strip of deposited on the surface of a dielectric substrate slab with two narrow slits ground electrodes running adjacent and parallel to the strip on the same surface. Apart from the microstrip line, CPW is most frequently used as planar transmission line in RF/microwave integrated circuits. It can be considered as two coupled slot lines. Hence, similar properties of a slot line could be expected. It consists of three conductors with the exterior ones used as ground plates. These need not necessarily have same potential.[3]

Proposed Antenna Design

The proposed dual band CPW antenna consist of a compact coplanar field printed on 1.6mm thick flexible flame retarded epoxy (FR-4 epoxy) FR-4 glass epoxy is a popular high-pressure thermoset plastic laminate grade having good strength to weight ratios. The material is known to retain its high mechanical values and electrical insulating qualities in both dry and humid conditions. These properties, along with good fabrication characteristics, gives utility to this grade for a wide variety of electrical and mechanical applications, with relative permittivity of 4.4 .The conducting components such as coplanar feed line radiating elements and ground plane are on same plane. The antenna overall size is $35.5 \times 25\text{mm}$.

Figure 1:



Proposed Dual-band coplanar antenna model is featured by the following specifications
 $w1=8, s=1, w2=17, w3=5$

We have used three popular substrates for performance comparison of the proposed antenna. The antenna is originally designed using FR-4 epoxy with the substrate height of 1.6mm. The comparison of the antenna is made for different substrate thickness as well as substrate material. The other materials which is used for comparison is RT Duroid and Zelt. RT Duroid is characterized by low dielectric loss, superior electrical and mechanical properties. They are mechanically reliable and electrically stable choice for substrate. Zelt is a high-quality nylon based substrate. It is durable, tear resistant, and is easy to form and handle.[4]

3. RESULTS AND DISCUSSION

Return loss, realized gain and radiation patterns measurements are used to characterize a manufactured prototype.[5] The return loss and VSWR plot for the proposed antenna with FR4 epoxy substrate of height 1.6mm is shown in figure 2 and 3.

Figure 2:

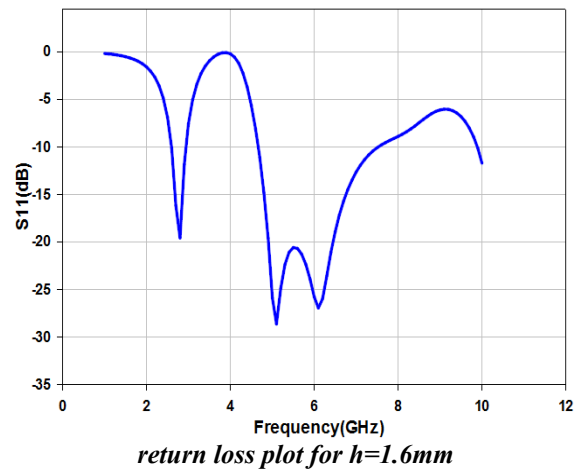
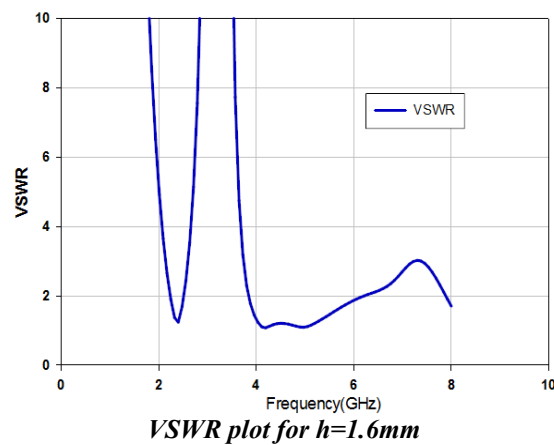
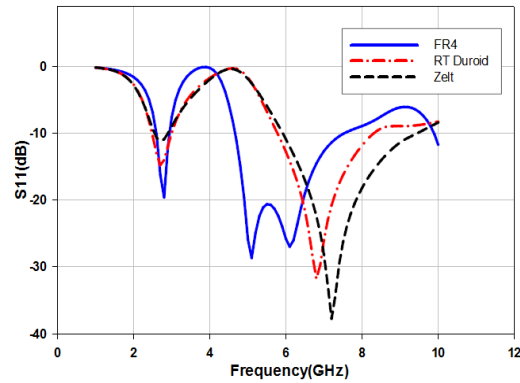


Figure 3:



The performance of the antenna was evaluated at two instances. Firstly the comparison was made with substrate thickness of 1.6mm for three different materials namely FR4 epoxy, RT Duroid and Zelt. It is indicative from figure 4, that the return loss plot that antenna with FR4 epoxy substrate gives good return loss at 2.4 GHz and from 4.4 to 7.2 GHz, which is suitable for wireless application. The adoption of RT Duroid and Zelt in the same design did not provide with the required dual band. They resulted in a shifted bandwidth with reduced return loss.

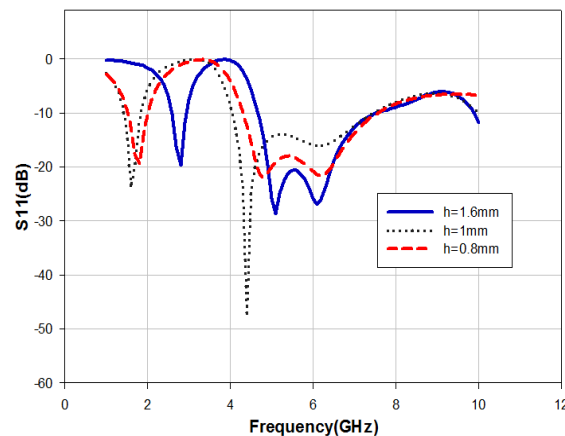
Figure 4:



Comparison plot of return loss with different substrate materials

The second comparison was on the basis of different substrate thickness for FR4 epoxy substrate material. From figure 5, it is evident that changing the height of the substrate would cause a change in the return loss patterns. When substrate thickness is 0.8mm and 1mm, the lower frequency of the antenna is centered around 1.8GHz ,not suitable for WiFi applications. Also the second band has shifted more to the right, hence not useful in WiMAX applications aswell. It is evident that FR4 substrate with thickness 1.6mm is more suitable for the intended applications.

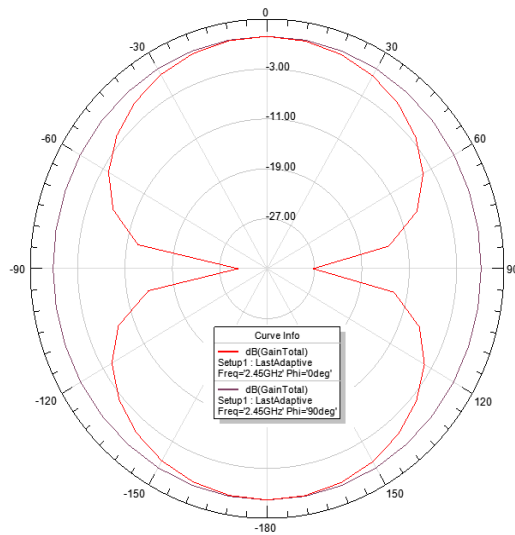
Figure 5:



Comparison plot of return loss with different substrate thickness

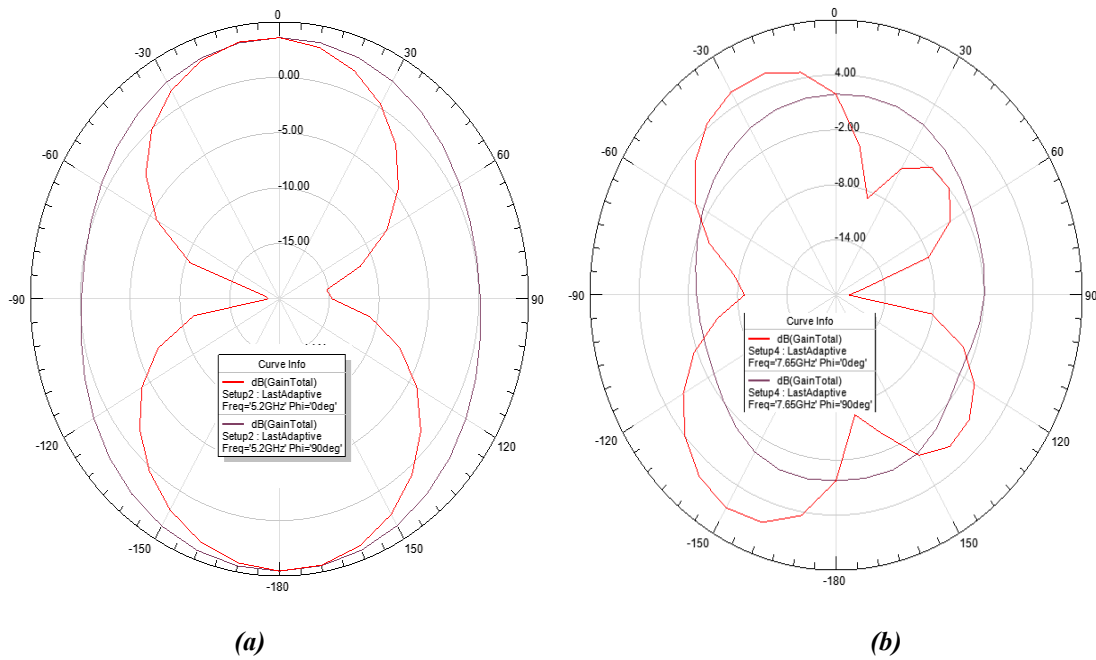
The radiation patterns for FR4 epoxy substrate of thickness 1.6mm is depicted in figures 6,7.

Figure 6:



Simulated radiation pattern at 2.45GHz

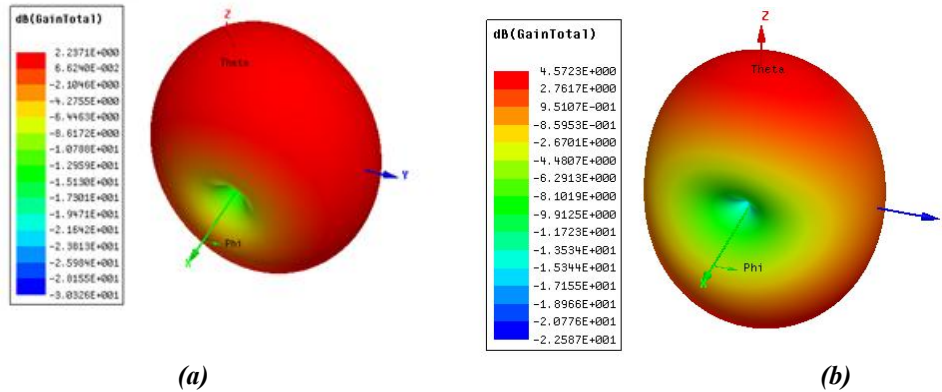
Figure7:



Simulated radiation pattern at a)5.2GHz b)7.85GHz

The 3D polar plot which is obtained after simulation in Ansys HFSS software at two centre frequencies of 5.2GHz and 2.45GHz is shown in figure 9.

Figure 9:



3D Polar plot of the proposed antenna of thickness 1.6mm ,FR 4substrate at a) $f=2.45\text{GHz}$ b) $f=5.2\text{GHz}$

4. CONCLUSION

A dualband antenna has been designed for wireless mobile applications. The performance comparison of the antenna has been made by using different substrate materials as well as by changing substrate thickness. From this it can be observed that better performance of the antenna is obtained when the substrate material is FR4 epoxy rather than with RT Duroid or Zelt. The design yielded two usable bands, the first band is centered around 2.4 GHz which is used for WiFi applications and the second band between 4.4 and 7.2 GHz which is for WiMAX applications.

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