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A Compact Low Cost and Lightweight Microwave Components Designing in CPW Configuration

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***Abstract* - Over the past few years, due to fast advancement in wireless communication technology, the use of the small size of these components but its cost, performance, ease of installation everything has been taken care of while designing. To meet this entire requirement, we intend to propose CPW fed microwave components. The emergence of coplanar waveguide (CPW) fed antenna can revolutionize the antenna industry in terms of cost, compactness, Bandwidth, etc. Hence, our project is dedicated to the study of coplanar waveguide and emphasis the design of microwave components through it.**

Keywords: IE3D software, QUCS software.

I. INTRODUCTION

Microwaves are widely used for point-to-point communication because their small wavelength allows conveniently-sized antennas to direct them in narrow beams, which can be pointed directly at the receiving antenna. This allows nearby microwave equipment to use the same frequencies without interfering with each other, as lower frequency radio waves do. This frequency reuse conserves scarce radio spectrum bandwidth. Another advantage is that the higher frequency of microwaves gives the microwave band a very large information-carrying capacity. Our result for various components is optimized to the best we could and achieve low radiation loss and less dispersion in comparison with another transmission line for the design of the components. We can operate the same design components in UWB as well for specific bandwidth such as the ISM band. The unipolar characteristics of CPW structure together with their attractive features like low radiation loss and less dispersion in comparison with a micro strip, little dependence of characteristics impedance on substrate parameters, etc. made them popular the objective of this paper in the study of coplanar waveguide transmission lines investigation is to be performed both on the ground plane and the signal strip of a coplanar waveguide transmission guide to create effective radiation characteristics. The main aim is to convert CPW lines to microwave components suitable for various industrial, mobile, satellites, radio, etc. applications.

In this study, we have gone through various research papers, books, and online sources and gathered information about the characteristic behavior of coplanar waveguide transmission lines, and concerning these characteristics, a list of microwave components suitable to design was made. The first step was its software design and simulation and then its actual fabrication. For designing any of the components, the very first step is to calculate the ground plane dimensions of CPW for that particular component. Depending upon the components the ground plane dimension also gets changed. The very first component which we have attempted to design is a monopole antenna in CPW configuration.

II. MONOPOLE ANTENNA

A monopole antenna is a class of radio antenna consisting of a straight rod-shaped conductor, often mounted perpendicularly over some type of conductive surface called a ground plane.

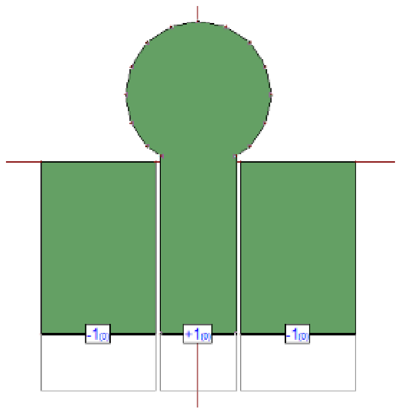

Figure 1: Top view of ours proposed Monopole antenna in CPW configuration

For the above monopole antenna, the ground plane dimensions can be calculated provided, knowing some basic parameters for an FR4 substrate, Relative dielectric constant (Ɛr):4.4, Dielectric thickness (h):1.59mm (approximately 1.6mm), Loss tangent should be 0.01, desired characteristics impedance (zo)=50 ohms, knowing this prerequisite one can move towards the calculation of the ground plane dimension of CPW and find out the desired track width(a), gap width(W), length, etc. The original equation is in the transmission line design handbook by brian C Wadell, Artech House, and "b" for the Sum of the track width and "b" for the sum of the track width plus the gaps on either side.

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$$Zo = \frac{60.0\pi}{\sqrt{\varepsilon eff}} \frac{1.0}{\frac{K(kl)}{K(K')} + \frac{K(kl)}{K(Kl')}}$$

$$k = \frac{a}{b}$$

$$k' = \sqrt{1.0 - k^2}$$

$$kl' = \sqrt{1.0 - k^2}$$

$$kl = \frac{\tanh(\frac{\pi}{4.0}\frac{a}{h})}{\tanh(\frac{\pi}{4.0}\frac{b}{h})}$$

$$\varepsilon eff = \frac{1.0 + \varepsilon r \frac{K(k')}{K(K)} + \frac{K(kl)}{K(Kl)}}{1.0 + \frac{K(k')}{K(K)} + \frac{K(kl)}{K(Kl')}}$$

Table 1: Monopole Antenna Dimensions

Gap Width	0.8 mm
Transmission Line Dimensions	30x13.2mm
Ground Plane Dimension	20x30mm
Radius	12.8mm

The parameters once calculated are used in the process of design, which can be done by using software like IE3D, HFSS, etc. We have used IE3D software for designing the components. The antenna when designed concerning the above parameter can be used to operate in the ISM band i.e.,(2.4GHz-2.48 GHz).

2.1 Simulation Results of Monopole Antenna

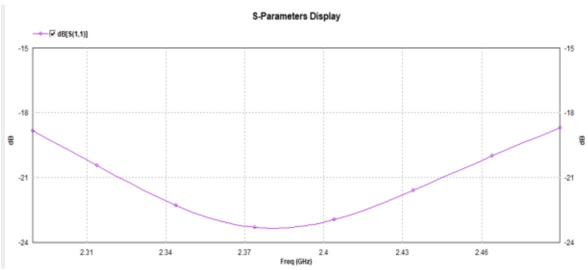

Figure 2: Return Loss

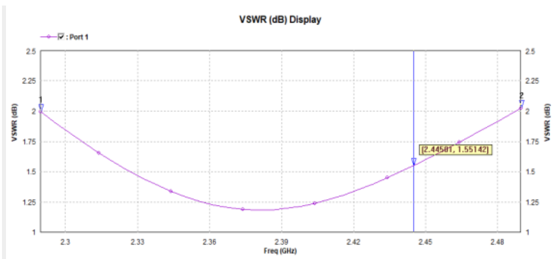

Figure 3: VSWR

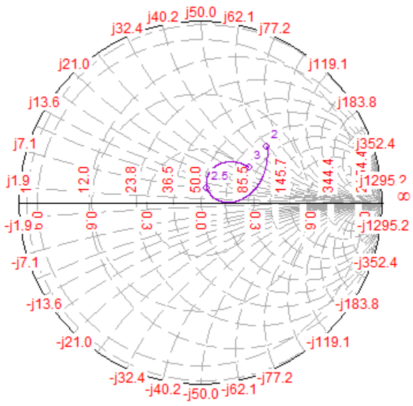

Figure 4: Smith Chart

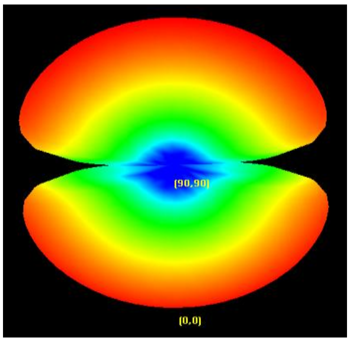

Figure 5: 3D pattern

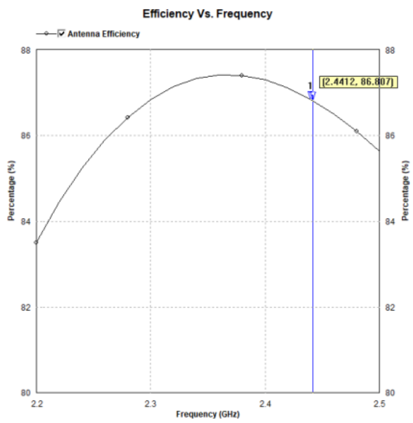

Figure 6: Antenna Efficiency

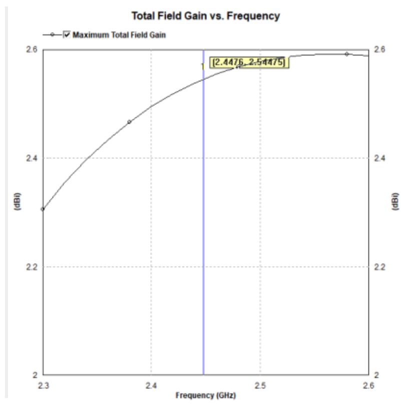

Figure 7: Antenna Gain

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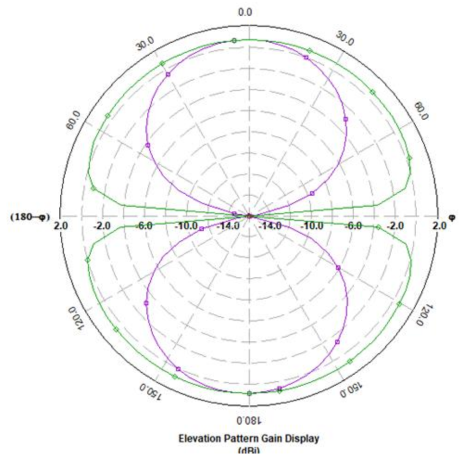

Figure 8: 2D pattern (Polar plot)

III. TRANSMISSION LINE DESIGNED IN CPW CONFIGURATION

The next component which we have tried to design is a Transmission line in CPW Configuration, as it is one of the basic and frequently used components. To say about it, we know that, Transmission lines in microwave engineering are known as distributed parameter networks. As their voltage and current show variation over their entire length. It enables the transfer of electrical signals by a pair of conducting wires that are separated from each other by a dielectric medium which is usually air. The transmission line can be broadly classified into three categories-Open-wire transmission line, Coaxial cable lines, Waveguides, here we are dealing with Waveguides, as shown in the figure.

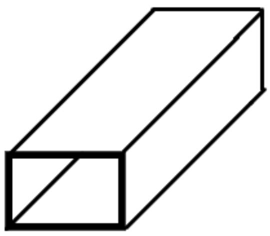

Figure 9: Rectangular Waveguide

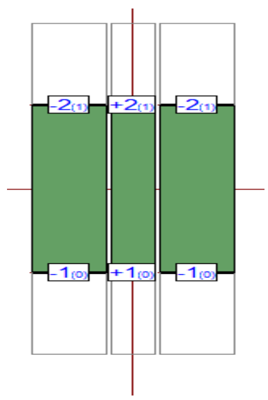

Figure 10: Transmission Line Designed in CPW Configuration

The substrate used is Fr4 and the dimensions for the above design are calculated in the same way as in Monopole Antenna.

Table 2: Transmission Line Dimensions

Transmission line dimension	20x3mm
Height of substrate	1.59mm
Ground plane dimension	20x5mm
The gap between transmission line & ground plane	0.3mm

3.1 Simulation Results of Transmission Line

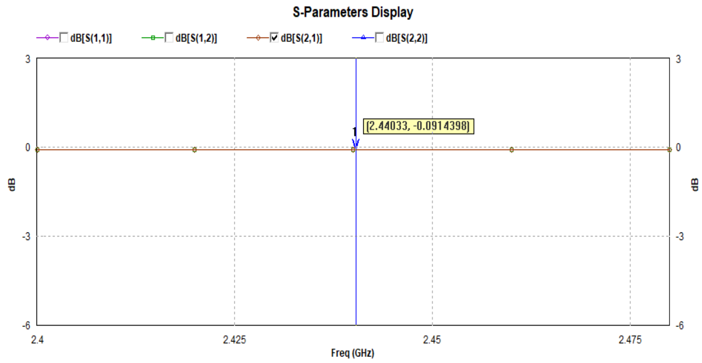

Figure 11: Return Loss

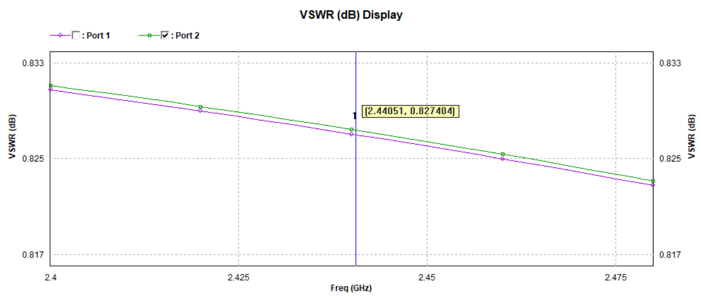

Figure 12: VSWR

From the above-stimulated results, a transmission line is successfully designed, which has minimum reflecting losses and maximum transmission.

IV. QUARTER WAVE TRANSFORMER DESIGNED IN CPW CONFIGURATION

Further, we have tried to design a quarter-wave transformer by using FR4 substrate in CPW configuration, A quarter-wave impedance transformer, often written as $\lambda/4$ impedance transformer, is a transmission line or waveguide used in electrical engineering of length one-quarter wavelength (λ), terminated with some known impedance. The proposed design for the same is as follows:

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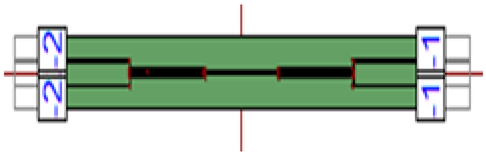

Figure 13: Quarter wave transmission line in CPW configuration

The transmission line here contains their different type of resistive waveguide, having different dimensions.

Table 3: Quarter wave Transformer Dimensions

Resistance (Ω)	Dimensions
50	13.54 x 2.99mm
70.7	18.79 x 0.70mm
100	0.20mm
Ground Plane Dimensions	
95.34 x 2.99	
The gap between Transmission Line & Ground Plane	
1.5mm	

4.1 Simulation Results of Quarter-Wave Transmission Line

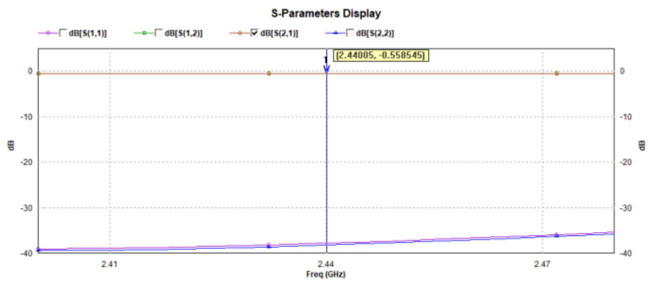

Figure 14: Return Loss

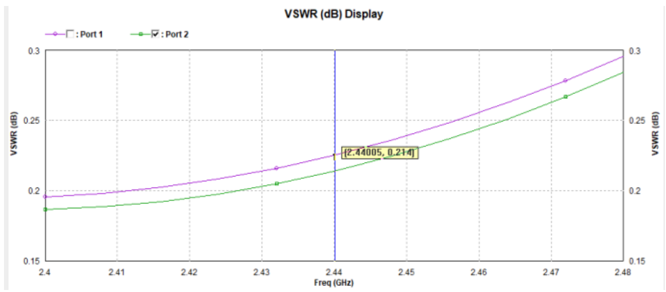

Figure 15: VSWR

From the above-stimulated results, a transmission line is successfully designed, which has minimum reflecting losses and maximum transmission.

V. FUTURE SCOPE

The microwave components designed in CPW configurations can be used in various fields of communication. As CPW provides a wide range of bandwidth, hence the designed components can be optimized, by altering the physical parameters. Apart from these, we are trying to design more microwave components in CPW configuration.

VI. ADVANTAGES

- Cost-Efficient
- Compact in Size
- Easy to Fabricate
- Wide Bandwidth
- Less Dispersion
- Excellent Performance
- Light Weight
- Large Application area

VII. RESULT

We discover that the output parameters of different microwave components depend upon the dimensions, spacing, characteristics impedance of the substrate. Hence, Optimization of the result depending upon the requirement was done considering these parameters.

VIII. LITERATURE SURVEY

Various papers related design of microwave components in CPW configuration were related to the proposed project. The basic information and knowledge about various types of antenna/components were gained. The following are the papers about various antenna/ components which were referred to and studied. In the book "Antenna Theory" analysis and design 3rd edition published by Wiley By Constantine. A. Balanis It told us about various antenna and also showed the design parameters of the antenna and told us how we can design our antenna and the measuring formulas for it. The smart antennas focus on the radiation pattern of the antenna and improving it and hence we tried our best to implement this concept in our project. The paper told us about the smart and adaptive techniques for the mobile communication antenna. It presented a brief idea about the antenna for futuristic use in a mobile handset communication application.

IX. CONCLUSION

Our results for various components are optimized to the best we could and achieve low radiation loss and less dispersion in comparison with another transmission line for the components designed. We can operate the same designed components in UWB as well for specific bandwidth such as ISM band. The uniplanar characteristics of CPW structures together with their attractive features like low radiation loss and less dispersion in comparison with a microstrip, little dependence of characteristic impedance on substrate parameters etc. made them popular.

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