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CPW Fed Circular Stub Wideband and Multiband Antennas for Wireless Applications

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Abstract— In this paper, a novel CPW fed slot antenna for multiband and wideband application with rectangle shaped ground planes is presented and discussed. It is printed on a dielectric substrate. The proposed antenna is fed by Coplanar waveguide (CPW) by 50Ω microstrip feed line. The planned antenna is simulated by means of HFSS (version 13) software by Ansoft. The antenna cover (2-12) GHz range which can meet the requirement of WLAN, WiMAX applications along with that it provide wide frequency band, reasonable gain and return loss. The stub introduced on the geometry will also decide the working of antenna as either wideband or multiband operation. In this work, we investigated its outcome on different places i.e. on centre of patch, on centre of grounds and everywhere on geometry. Placement and existence of stub may be at any point on the geometry. This design offers the enhanced gain and directivity of antenna which is applied for high efficiency antenna. A relationship is drawn among the performances of the antennas in terms of gain, return loss, VSWR and directivity of the antennas.

Keywords- *CPW (Coplanar Waveguide), Microstrip Antennas, UWB (Ultra Wide Band), Circular monopole, CPW-Feed, WLAN/WiMAX, HFSS Simulation.*

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I. INTRODUCTION

Present era is witnessing a very quick intensification of wireless communications, for which compact antennas are in strong insist as they can be without complexity incorporated with wireless devices. For superior antenna performance, broadband antennas are in strong claim as they offer truthful to utilize the different wireless communications in particular juncture. The CPW feeding line also has reward over microstrip feed lines such as low dispersion, low radiation leakage, their uncomplicated integration with active devices like SOC's (System On Chip) or MMICs (Monolithic Microwave Integrated Circuits) and capacity to manage their characteristics impedance. CPW has been extensively used in microstrip patch antenna in modern times. Compared with the microstrip feed line it has inferior transmission loss, low dispersion, low radiation leakage and inferior profile chiefly on high frequency band. To design an antenna to work in the UWB and MWB is somewhat exigent because it has to assure the requirements such as ultra wide impedance bandwidth, omni-directional radiation pattern, stable gain, high radiation efficiency, stable group delay, low profile, compact and easy manufacturing. The multiband frequency is obtained by introducing 5mm stub at different locations and frequency is tuned by varying the location of the stubs provided a good impedance matching which is appropriate for Wi-Fi and WiMAX applications. The shapes of the ground planes are cautiously designed in order to elevate both gain and bandwidth for a multi wideband operation at a central frequency of 6GHz which is a solution frequency. The CPW is designed for 50Ω characteristic impedance. The broad impedance matching with condensed size of the antenna is the resultant of the introduction of stubs in the ground planes, which upset the surface magnetic currents to accomplish a wide bandwidth. HFSS uses a numerical technique called the Finite Element Method (FEM). This is a method where a structure is subdivided into several smaller subsections called finite elements. The finite elements used by HFSS are tetrahedra, and the entire collection of tetrahedra is called a mesh. A solution is established for the fields within the finite elements, and these fields are interrelated so that Maxwell's equations are satisfied across inter-element boundaries [12]. Yielding a field result for the entire and exclusive structure. Once the field result has been set up, the generalized S-matrix solution is determined.

II. ANTENNA STRUCTURE

The composition of the antenna is shown in Fig 1. The parameters W and L are the width and length of the rectangular ground. The geometry of the planned antenna is shown in Fig.2. In this study a dielectric material (FR4) with thickness of 1.6mm with relative permittivity of 4.4 with W=55mm and L=68 mm surface area is selected as substrate referred from [1]. The length and width of microstrip feed line is preset at 32.6 and 3.2mm respectively to accomplish 50Ω characteristic impedance. In order to get UWB and MWB operation, stubs with 5mm radius are inserted at different locations i.e. ground, patch, on both, etc. The stubs annihilate the surface current on the ground, so that the antenna makes negative response at the desired frequency. Coplanar waveguide feed structure comprises of the feed-forward signal band and the feed-forward signal with both sides of the slit.

III. COPLANAR WAVEGUIDE FEED STRUCTURE

A coplanar waveguide (CPW) is a one type of strip transmission line defined as a planar transmission structure for transmitting microwave signals. It comprises of at least one flat conductive strip of small thickness, and conductive ground surface as mentioned in Fig .1. A CPW structure comprises of a median metallic strip deposited on the surface of a dielectric substrate slab with two narrow slits grounds running adjacent and parallel to the strip on the alike surface.

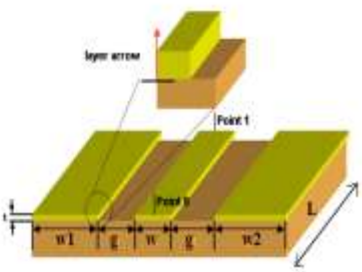

Fig. 1 CPW Structure

Beside the microstrip line, the CPW is the most frequent use as planar transmission line in RF/microwave integrated circuits. It can be regarded as two coupled slot lines. Therefore, akin properties of a slot line may be expected. The CPW comprises of three conductors with the exterior ones used as ground plates. The CPW fed antennas have newly become more attractive because of its striking features such as wider bandwidth, enhanced impedance matching, and uncomplicated integration with active devices or monolithic microwave integrated circuits. Etching the slot and the feed line on the identical side of the substrate eliminates the alignment crisis essential in other wideband feeding techniques such as aperture coupled and proximity feed.

IV. BASIC GEOMETRY

Figure 2 shows the basic geometry of the antenna. The geometry is fundamentally a CPW fed monopole antenna. The substrate used for design and analysis is a glass epoxy material whose properties are selected as listed in Table 1. Effective dielectric constant can be estimated from the design expressions listed in [10, 11]. The antenna was optimized using the Ansoft HFSS [v13] as mentioned in [12] which is the commercially existing electromagnetic software. The physical dimensions of the antenna are listed in Table. 1.

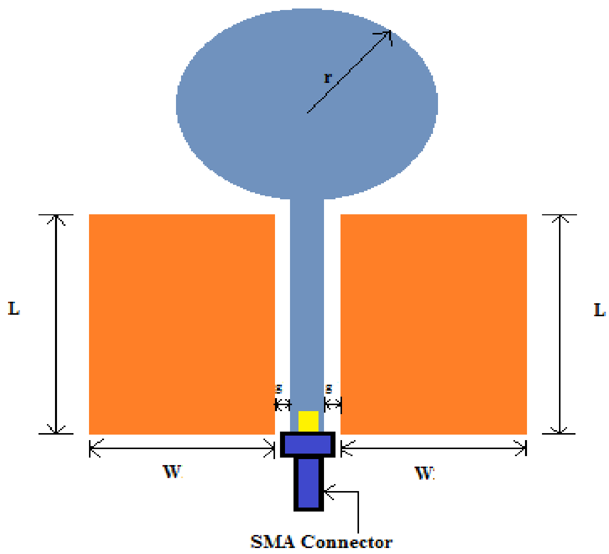

Fig.2 Basic Geometry of CPW monopole antenna

From the Figure 2 it can be noted that the fundamental geometry offers the ultra wideband operation and multiband operation (2-12GHz). This corresponds to additional than

100% impedance bandwidth with superior gain and radiation characteristics all over the band of operation.

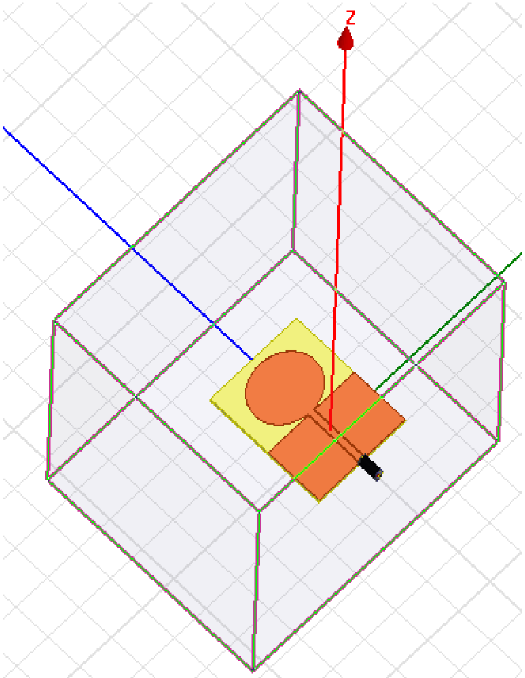

Fig.3 Simulation fundamental setup design in HFSS

Table 1. Dimensions of fundamental antenna

Parameter	Value
Length of Substrate	68mm
Width of Substrate	55mm
Length of ground (L)	31.8mm
Width of ground (W)	25.4mm
Radius of circle (r)	16mm
Dielectric constant (εr)	4.4
CPW feedline length	32.6mm
CPW feedline width	3.2mm

V. ITERATIONS DONE ON FUNDAMENTAL GEOMETRY

5.1 Circular stub introduced on patch

In the first iteration made on fundamental geometry, we have introduced a circular stub of 5mm radius on the centre of the patch for the cause of tuning the antenna and examine the effects of introducing this stubs on parameters such as VSWR, Return Loss, Antenna Gain, Radiation, pattern, etc. observed and compared with the fundamental geometry.

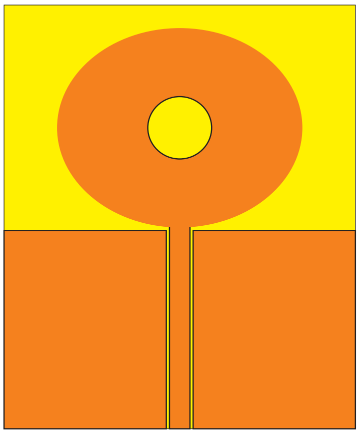

Fig.4 Circular stub introduced on patch

The obtained results in our simulation influence the working of antenna from frequency range as given in table 2.

5.2 Circular stub introduced on ground

In the second iteration, the 5mm circular stub is introduced on both the grounds which are adjacent to the feedline and positioned on the top surface of the substrate as shown in Fig.5.

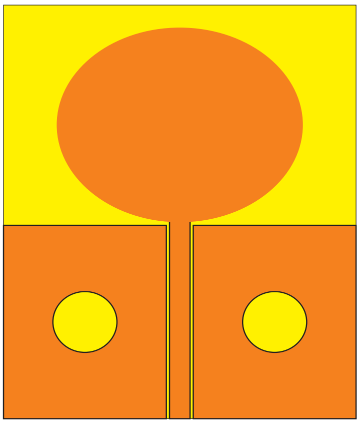

Fig.5 Circular stub introduced on grounds

The results obtained after simulation of the above antenna is shown in table 2

5.3 Circular stub introduced on patch and ground

In this iteration the 5mm circular stub is introduced on both patch as well as ground. The alteration in results are mentioned in table 2

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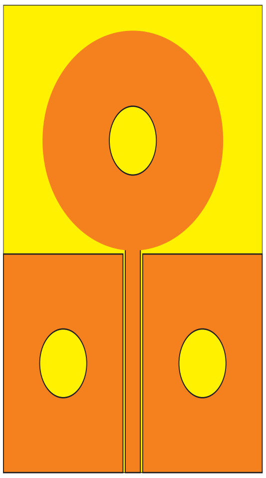

Fig.6 Circular stub introduced on patch and ground

VI. SIMULATED RESULTS

The aim of the work is to acquire a planar antenna with low return loss, with high gain and directivity, with enhanced radiation patterns, in the band between 1 and 12 GHz. We performed enormous numerical simulation by means of the HFSS [v13], which utilizes the finite element method for electromagnetic computation, in order to notice a good tradeoff amid these requirements. One of the weaknesses of the CPW is antenna's gain and it is usually 1 to 7dB but the gain of prototype antenna is 4-8.5dB and could attain superior gain by applying the thin metal reflectors.

6.1 Result of antenna having stub on patch and ground mentioned in fig3.3

6.1.1 Return Loss

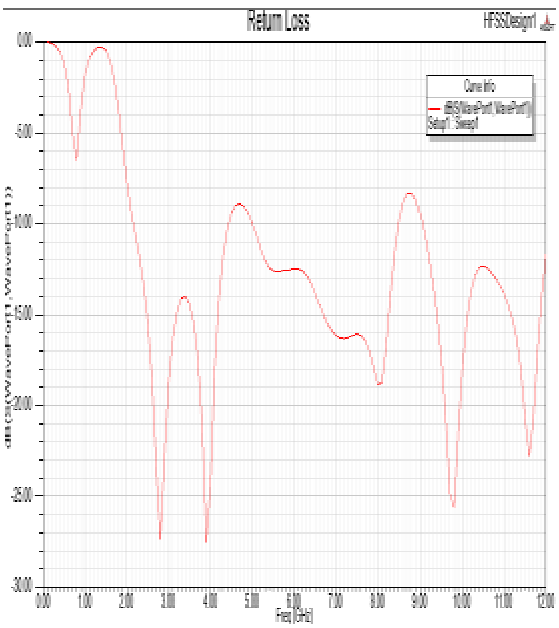

Fig.7 Return loss

The obtained -10dB impedance bandwidths are 2250MHz (2.15-4.4GHz), 3500MHz (5-8.5GHz) and 2950MHz (9.05-12GHz).

6.1.2 VSWR

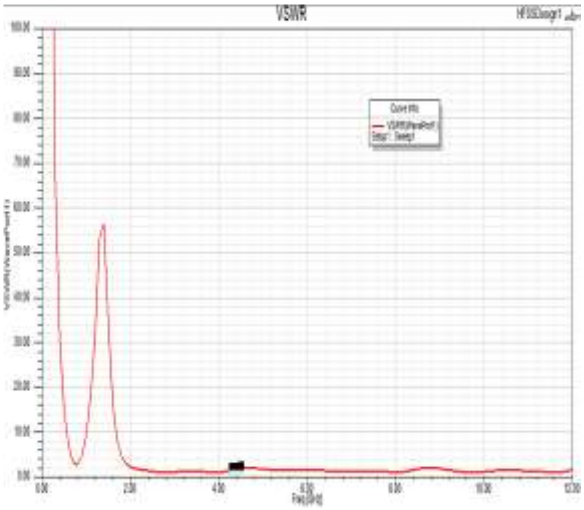

Fig.8 VSWR

Ideal case is VSWR=1, but of course it does not subsist in the real life so the superior ratio fluctuating between 1.0 to 1.2, over 1.5 is bad. As signal amplitude (voltage) is a amount of impedance so VSWR equal to ratio between load impedance and transmit media, any difference will cause high VSWR. Here (VSWR) < 2 is from 2GHz to 12GHz.

6.1.3 Directivity

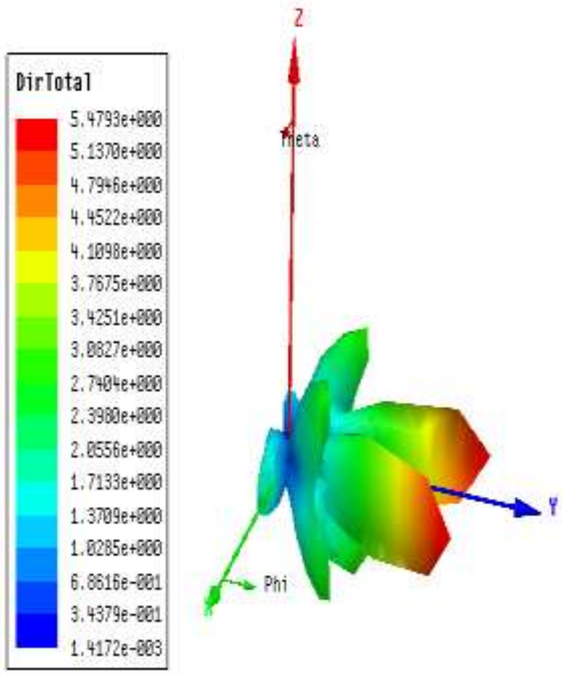

Fig.9 Directivity

As from the above outcome we can examine that antenna model in fig 3.3 is very directional.

6.1.4 Gain

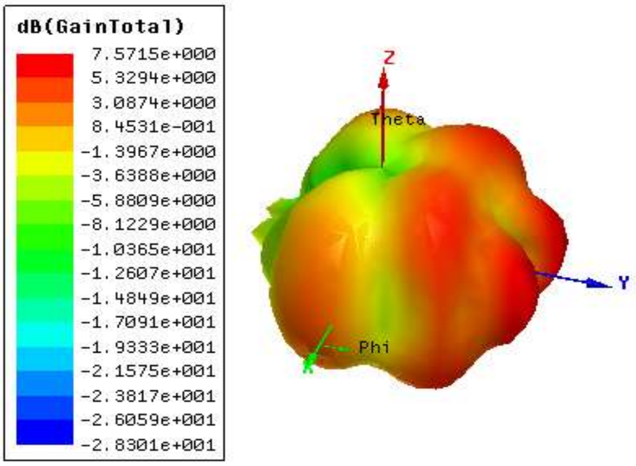

Fig.10 Gain

As revealed in the figure, the maximum achievable peak gain is 7.57dB from 2GHz to 12 GHz.

6.2 Effect of circular stub on antenna geometry

6.2.1 Effect of stub on patch

In the first iteration we have introduced a 5mm stub on 16mm patch so as to examine the response of the antenna and output parameters linked to it. The origin of circular stub precisely coincides with the origin of the patch. When such iteration is accomplished the antenna operates in dual bands of frequency ranging from 2.45 to 4.2 GHz and 7.5 to 11.8GHz with bandwidth of 1750MHz and 4300 MHz respectively.

The maximum gain obtained is 7.6511dB.

6.2.2 Effect of stub on ground

In the second iteration we have introduced 5mm stubs on both the grounds adjacent to feedline. The locations of these stubs are at centre position of ground. In this iteration the antenna operates in triple band of frequencies ranging from 2.1 to 4.45GHz, 5.5 to 8.5 and 8.35 to 12GHz with bandwidth of 2350MHz, 3000MHz and 3650MHz respectively. The maximum gain is 7.5363dB.

6.3 Comparative graph of Return Loss

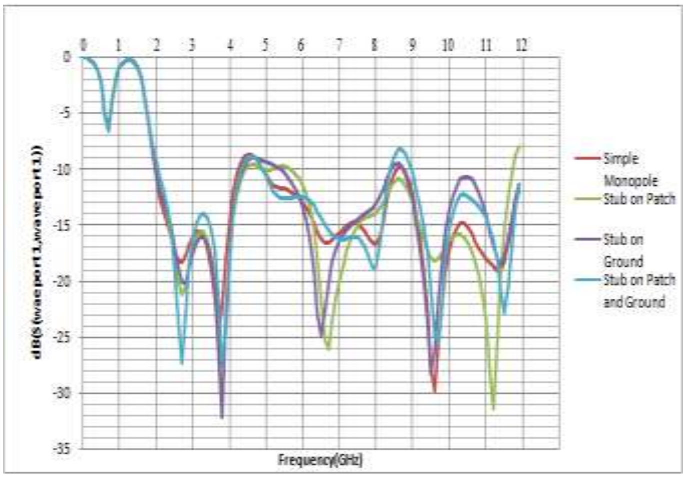

Fig.11 Comparison of all Return losses

Table 2 Effects of disparity in stub locations on bandwidth of the antenna

Antenna Type	Frequency Range (GHz)			Bandwidth (%)		
	1st	2nd	3rd	1st	2nd	3rd
Simple monopole	2.065-4.35	5-8.65	8.88-12	71.23	53.47	29.88
Stub on patch	2.1-4.5	5.8-8.3	-	72.72	35.46	-
Stub on ground	2.08-4.45	5.5-8.5	8.85-12	62.94	42.85	30.21
Stub on everything	2.15-4.41	5-8.5	9.05-12	68.90	51.85	28.02

VII. CONCLUSION

In this paper multiband antenna with CPW feeding has been recommended. The simulated antenna performance is obtained by HFSS (High Frequency Structured Simulator) version 13. The design of proposed antenna is compact and provides a wide bandwidth and enhanced return loss which is appropriate for WLAN, WiMAX. The introduction of circular stub causes antenna to operate in dual and multiband of operation with VSWR<2 and antenna is very omni directional with overall gain superior than 7dB.

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