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TAPERED STEP CPW-FED ANTENNA FOR WIDEBAND APPLICATIONS

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ABSTRACT

A novel CPW-fed tapered step grounded antenna is proposed for wideband applications. We observed that there is an enhancement in the bandwidth with the addition of tapered step ground in the geometry of monopole antenna. Antenna is prototyped on FR4 substrate (ε_r =4.4) with dimensions of 20x20x1.6 mm. It has been observed that circular aperture with tapered step grounded model is operating over wide range bandwidth from 5-18 GHz. Good agreement is attained between simulation and measured results. Parametric analysis with change in substrate material is also studied and presented in the current work.

Keywords: monopole antenna, tapered step, coplanar wave guide feeding (CPW), bandwidth.

1. INTRODUCTION

A Microstrip patch antenna suffers with narrow bandwidth, which is one of the main drawbacks in these systems. So many techniques are been proposed to overcome this limitation and researchers are succeeded in some cases by increasing substrate thickness, decreasing substrate permittivity etc [1-2]. There is a great demand for ultra wideband antennas with low profile and omnidirectional radiation pattern. Because of so many advantages like low cost, low profile, simple structure, low weight and good impedance bandwidth, monopole antennas are gaining their demand from past few years [3-4]. Several printed monopole antennas are been designed by the researchers after Federal Communications Commission (FCC) release of Ultra Wideband range from 3.1 to 10.6 GHz.

Over the operating bandwidth of the UWB systems, there exist several narrow bands that are used by wireless communication systems, such as Dedicated Short-Range Communication (DSRC) systems for IEEE 802.11p operating in the 5.850-5.925-GHz band and WLAN operating in 5.15-5.35 and 5.725-5.825 GHz. In order to minimize such frequency interferences, the UWB antennas with band-notched characteristics can be used. So many methods are there like π-shaped patch, inserting split, embedding tuning stub etc to have the band rejection characteristics [5-6]. By using these methods and defected ground structures we can eliminate certain band of frequencies and can allow certain band like filter characteristics. Conventional antennas with this kind of characteristics are suffering with the problems of large size and improper H-Plane radiation characteristics.

In this paper we are proposing different printed monopole wideband antennas with tapered step ground around the structure on the single side of the model. Basically four types are been considered in the current study and presented their performance characteristics. We started with single monopole by taking ground on other side [7] and later considered ground plane of same side of the patch with tapered step serrations. Figure-1 gives the antenna geometry for four models. For all these models we preferred coplanar wave guide feeding for simplicity in the design. Impedance matching of 50 ohms is obtained with standard equations for CPW fed models. Substrate permittivity effects on the antennas also studied and presented in this work [8-11].

2. ANTENNA GEOMETRY

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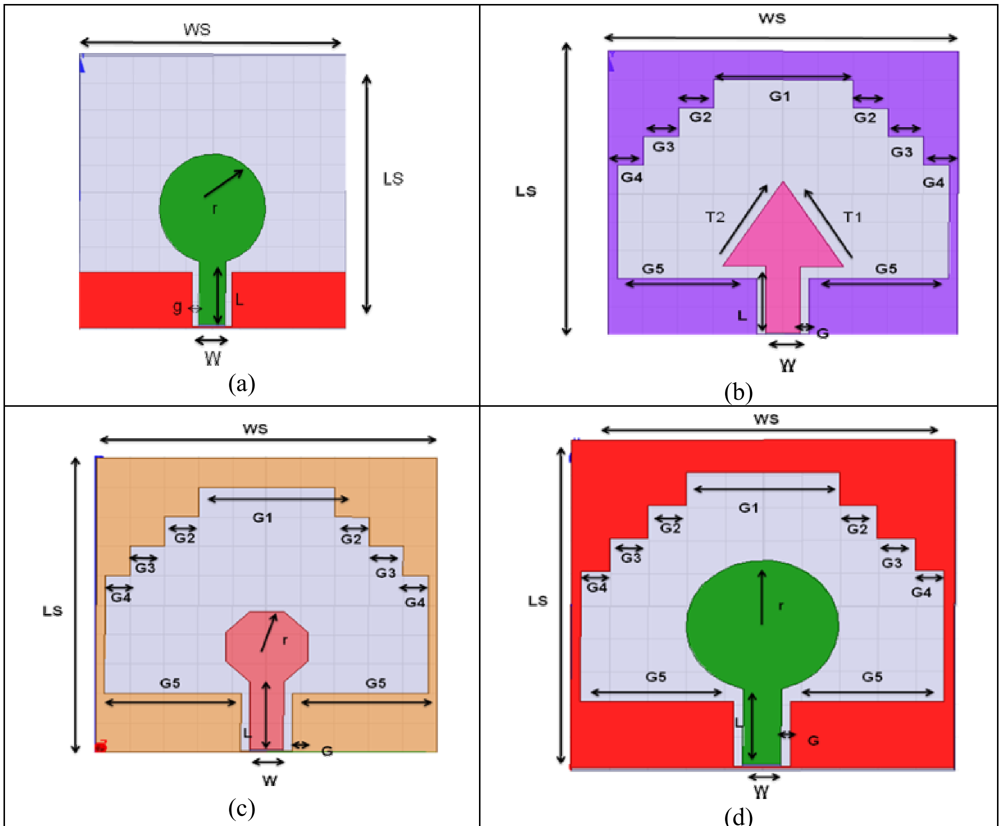

Figure-1. Antenna Models (a) CPW fed circular monopole, (b) Tapered step triangular monopole, (c) Tapered step polygon monopole, (d) Tapered step circular monopole.

Figure-1 is giving pictorial representation of all the models and Table-1 is giving information regarding their dimensions. The overall size of all these models is 20x20x1.6 mm. Antenna 1 and Antenna 4 are fabricated on FR4 substrate material (ε_r = 4.4) with thickness of 1.6 mm. Coplanar wave guide feeding is used in the design with 50 ohm impedance. The antenna models 1 and 4 are operating in the wideband and model models 2 and 3 are showing notch band characteristics. Detailed discussions regarding results obtained are presented in this work.

Table-1. Antenna Dimensions.

S. No.	Parameter	Antenna 1	Antenna 2	Antenna 3	Antenna 4
1	W	2 mm	2 mm	2 mm	2 mm
2	Ws	20 mm	20 mm	20 mm	20 mm
3	Ls	20 mm	20 mm	20 mm	20 mm
4	G	0.5 mm	0.5 mm	0.5 mm	0.5 mm
5	L	4 mm	4 mm	4 mm	4 mm
6	r	4 mm	-	3 mm	4 mm
7	G1	-	8 mm	8 mm	8 mm
8	G2	-	2 mm	2 mm	2 mm
9	G3	-	2 mm	2 mm	2 mm
10	G4	-	2 mm	2 mm	2 mm
11	G5	-	8 mm	8 mm	8 mm
12	T1	-	4 mm	-	-
13	T2	-	4 mm	-	-
14	Sub H	1.6 mm	1.6 mm	1.6 mm	1.6 mm

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3. RESULTS AND DISCUSSIONS

Figure-2 shows the reflection coefficient of all the models. It is observed that antenna 1 and antenna 4 are covering large bandwidth compared to the antenna 2 and 3. Antenna 1 is having impedance bandwidth of 104%, where as antenna 4 is showing impedance bandwidth of 129%. By the addition of tapered steps in the ground plane the improvement in the bandwidth is observed. The flow of current through this new patch leads to improvement in antenna bandwidth and impedance matching. Antenna 2 and 3 are stopping certain band of frequencies, especially antenna 2 is resonating at particular frequencies with narrow bandwidth. There is an improvement in the antenna bandwidth when compared to antenna 2 for the case of antenna 3.

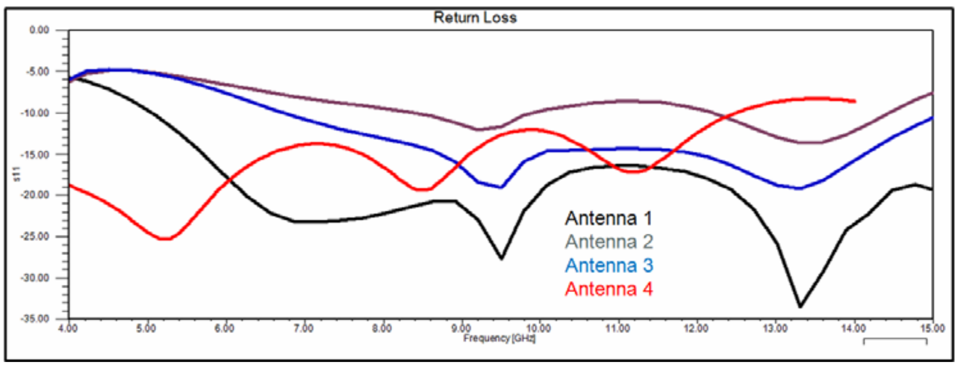

Figure-2. Reflection coefficient Vs Frequency.

From Figure-3 it is been observed that simulated and measured results are in very good agreement with each other. There is a slight shift in the frequency because of mismatch problems in the antenna fabrication. Figure-4 gives reflection coefficient over the frequency of antenna 4. In this case also both measured and simulated covering the desired band with VSWR<2.

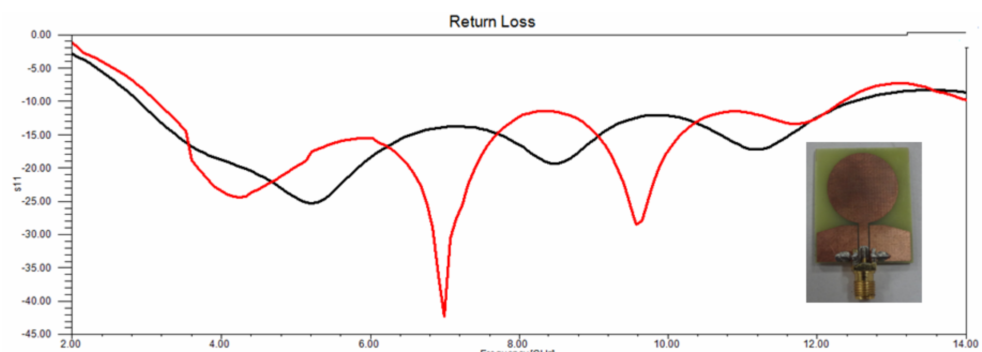

Figure-3. Antenna 1 Reflection coefficient Vs Frequency.

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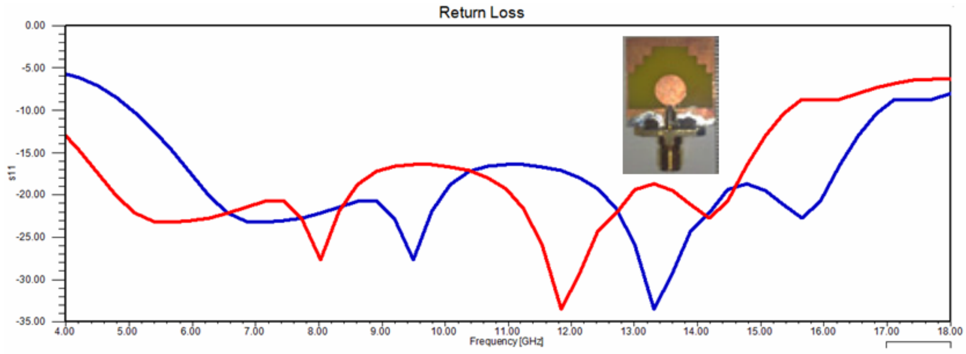

Figure-4. Antenna 4 Reflection coefficient Vs Frequency.

It was observed that circular patch model is exhibiting wider bandwidth over the other shapes. Parametric analysis with change in substrate height and width of the gap is done and presented in the Figures 5 and 6.

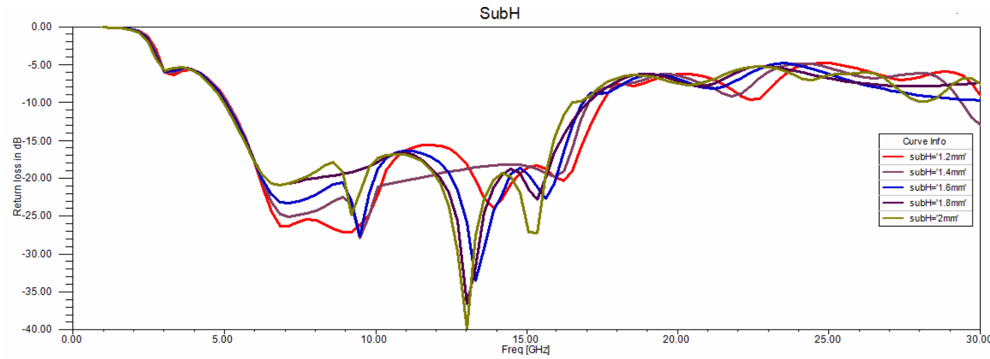

Figure-5(a). Parametric analysis with change in substrate height.

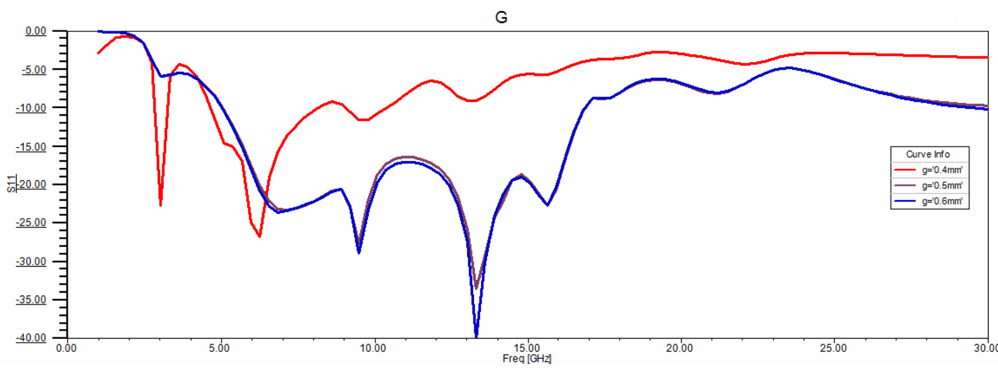

Figure-5(b). Parametric analysis with change in feed gap.

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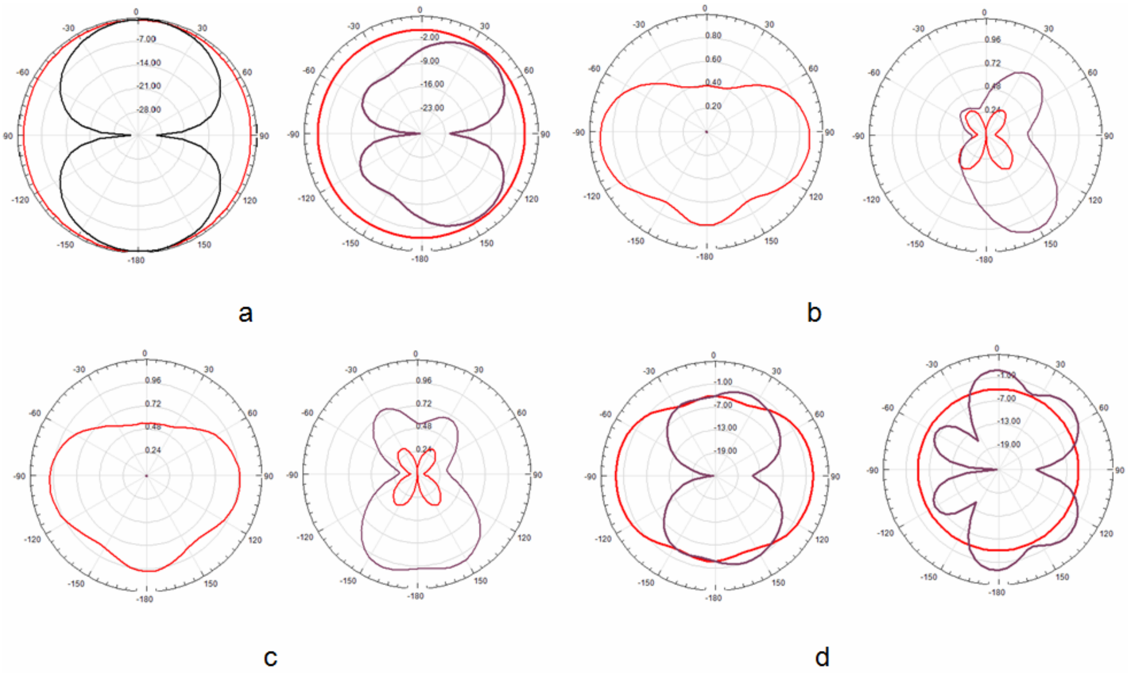

Figure-6. Radiation Pattern of the four models in E and H Plane.

The antenna radiation patterns at fundamental resonant frequencies are plotted and presented in Figure-6. Antenna 1 and 4 are showing Omni and quasi omni directional radiation patterns at desired frequencies, but antenna 2 and 3 are showing semi quasi omni directional patterns.

4. PARAMETRIC ANALYSIS WITH CHANGE IN SUBSTRATE PERMITTIVITY

Parametric analysis with change in substrate permittivity is performed on antenna 1 and antenna 4. Figure-7 shows the variation in the reflection coefficient with change in substrate permittivity from 2.2 to 9.8. It is been observed that with permittivity of 3.2 the antenna 4 is showing wideband characteristics compared to other cases.

By using high permittivity of 9.8 antenna wideband characteristics are been disturbed and it is working like a multiband antenna with depreciation in the bandwidth. Figure-8 showing the radiation characteristics of antenna 4 with change in permittivity of the substrate material. Almost omni directional pattern is been observed in the H-plane from the Figure-8. Figure-9 showing the radiation characteristics of the antenna 1 at 7 GHz. Nearly constant and stable patterns is observed for all the cases. Figure-10 showing current distribution over the surface of the antenna at 13 GHz for all the models. By adding the tapered steps the current path is smoothened. When current is flowing through the new path, no sharper points are encountered and the bandwidth is improved.

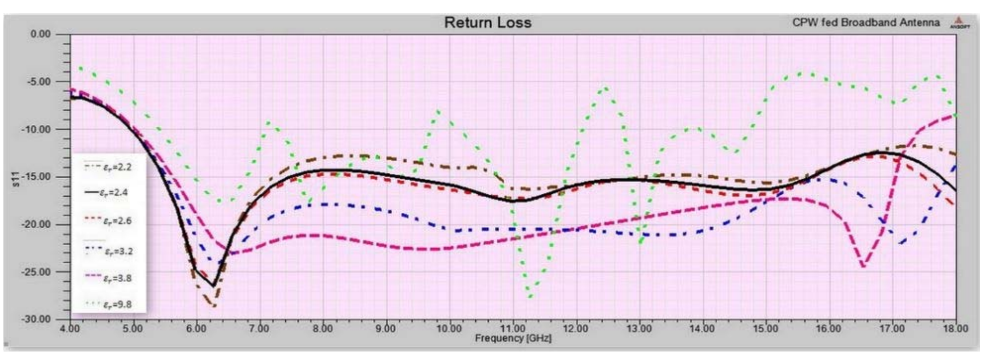

Figure-7. Antenna 4 VSWR.

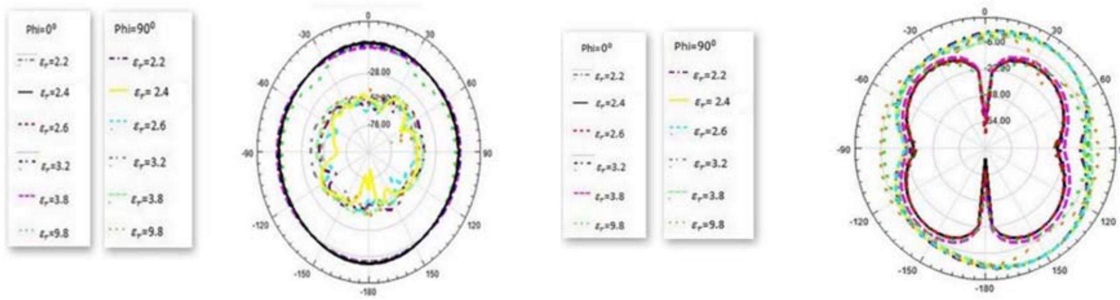

Figure-8. Radiation pattern of antenna 4 with change in substrate permittivity.

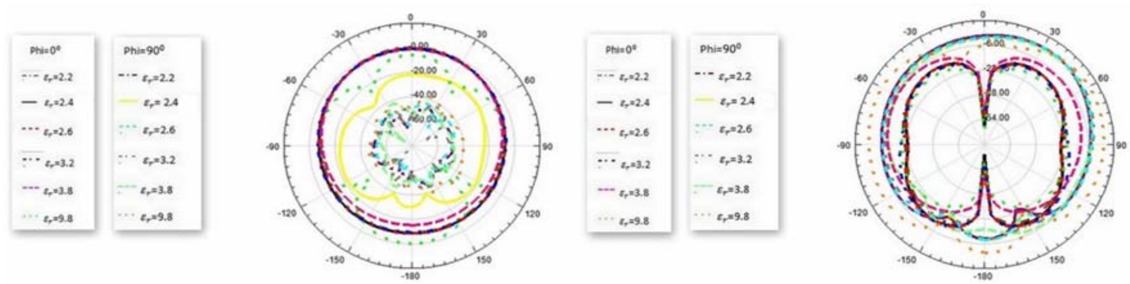

Figure-9. Radiation pattern of antenna 1 with change in substrate permittivity.

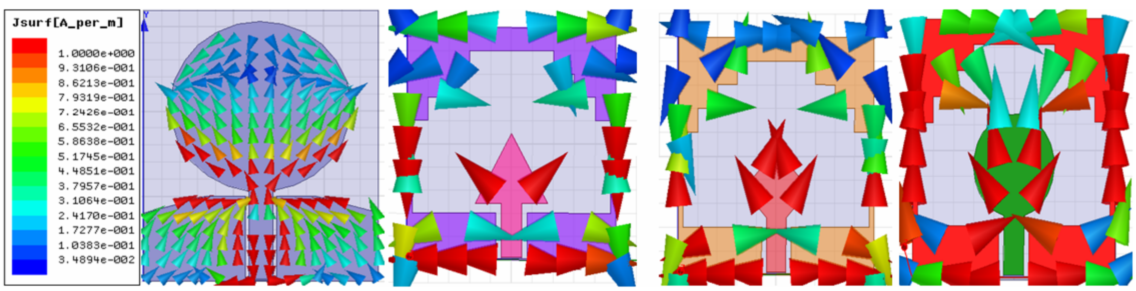

Figure-10. Current distribution over the antenna models at 13 GHz.

5. CONCLUSIONS

Simple circular monopole antenna is proposed and to improve the bandwidth, a tapered step configuration is introduced. Two more models of triangular and polygonal shaped antennas are proposed with tapered steps to achieve notch band characteristics. These models are successfully blocked certain range of frequencies and produced narrow band characteristics. The proposed model is covering the wideband of 3.1 to 16 GHz with peak realized gain of 5dB and average gain of 3.5 dB. The efficiency is also more than 85% in the entire band. The size of the antenna, cost and fabrication complexity is lesser compared to other wideband antennas. This proposed model is one of the good choices for UWB and some other high frequency applications.

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