MULTI BAND MICROSTRIP ANTENNA STRUCTURES FOR BROADBANDING

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ABSTRACT: A U-Slot Micro strip antenna has introduced for simplifies fabrication, facilitates easy shunt as well as series surface mounting, eliminates the need for wraparound and via holes, and reduces radiation loss and the size. U-Slot circuits can be made denser than conventional microstrip circuits. A thorough parametric analysis is performed with the chosen physical dimensions of the stub and radiating patch. The effect of each parameter on the bandwidth is analyzed and presented. Furthermore, this design has been modified with a sharp grove to enhance the broad banding. The investigation is performed in the form of parametric analysis which revealed the fact that the multi-resonant patch antenna is sensitive to change in magnitudes of its dimensions. It covers the entire UWB range.

***Keywords**: Rectangular patch, U- Slot MPA, UWB*

1. INTRODUCTION

Broad banding is a technology by which large amounts of data is transmitted in a short span of time. In the recent past, a huge development in electronics and VLSI technologies made it possible to handle wide spectrum data with ease. However, designing the associated radiating elements to handle multiple frequencies with consistency in performance in terms of various electromagnetic parameters has emerged as a serious problem. In order to meet the requirements of BB, the embedded antenna should exhibit similar characteristics over a wide range of frequency which is treated as the BW of the antenna. This accomplishes the task of BB in its simplest form.

In addition to the above, the emerging applications of wireless communication in personal, civil and commercial platforms have placed an appealing forced demand of antennas with multitasking and multi frequency operations. The developments in radio frequency technology had too wide spread application [1]. Some of the applications are Wi-Fi, WiMax, WLAN, 3G, 4G and Long Term Evolution (LTE). All of these applications require several distinct features like BB as discussed above. In addition to BB, the antenna required to be maintained a low profile with the associated circuitry. This allows for the system to maintain the decorum.

Many design and geometries have proposed that account for both BB as well as low profiles. This is accomplished by many techniques like generating slots on a continuous patch, patterning loop structures to form loop antenna and continuous progressive loops to form a spiral antenna. In order to achieve a confined pattern, a reflection antenna model by placing the radiating dipole at a quarter-wave distance from a reflector surface is often used. In order to control the size of the antenna, the suggested technique is to employ a band gap structure [2]. The choice of this artificial material as substrate could report a size reduction to 10% of its actual size in the case of a simple planar dipole, folded and looped dipoles. However, the method suffers from the band limiting drawbacks. In an attempt to enhance the BW at the same time maintaining low profile characteristics, the choice of microstrip patch as proved to be the best [3]. The main limitation of a patch antenna is its BW which is less than 5%. Several techniques are proposed in order to enhance this BW. L-probe fed, coplanar coupled fed, aperture coupled fed, stacked patch layers and multi-resonant structures are some popular techniques.

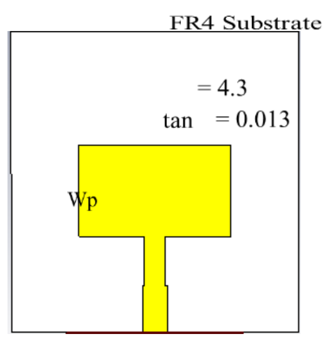
RECTANGULAR PATCH

Partial Ground for BW Enhancement

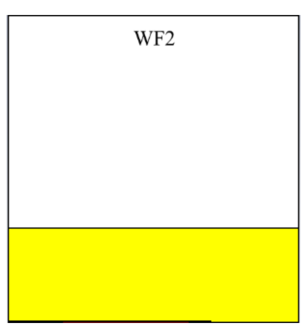
Patch antennas are an inherently narrow band (fractional bandwidth ~1–2 %). There is a well-known technique to increase the bandwidth of a narrowband patch antenna. Instead of using a full ground plane, the partial ground plane must be used because of the BW is inversely proportional to Q factor of the patch antenna. Full-size ground plane makes a high Q-patch antenna (higher capacitance between patch and ground plane), hence BW is narrow. By reducing the ground plane size, capacitance and Q factor will be decreased and so that BW increases up to several GHz .Since BW x Gain = Constant, by increase, the BW using a partial ground plane, the gain of the patch reduces to ~2 dBi, whereas for a narrowband patch, usually gain is in the order of 6–7 dBi and narrowband patch antenna are directional with a broadside radiation pattern while wideband patch antenna is not. So, there is a slight trade-off between BW, Gain and desired Radiation pattern [4].

The simulated feed system with the boundary attributes is given in Fig.1.1a. This feed appears to be complex but often considered as the simplest with remaining feed technique. The CST Microwave Studio simulation tool is effectively employed for all simulation-based experimentation [5]. In this thesis, as a result, the corresponding simulated E-plane and H-plane feed systems are as shown in Fig.1.1 (c) and (d) respectively. The dimensions of the patch length and width are calculated using the tabulated in Table 1.1, which corresponds to the modified ground plane for enhanced BW. The effect of the partial ground can be analyzed in terms of several simulated results by solving the designed geometry in the EM simulation tool [6].

A thorough analysis is made possible in our case by using reports such as return loss and VSWR. Later, the radiation characteristics are also generated in order to confirm with the above reports.



(a)



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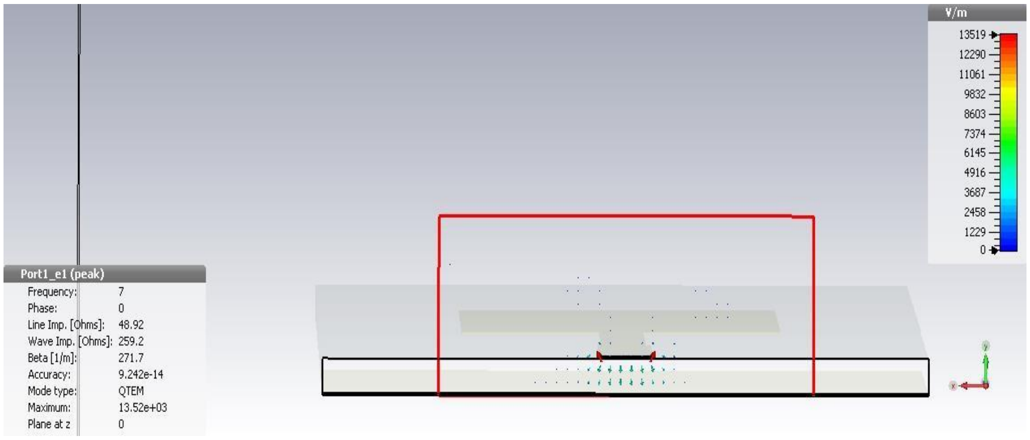

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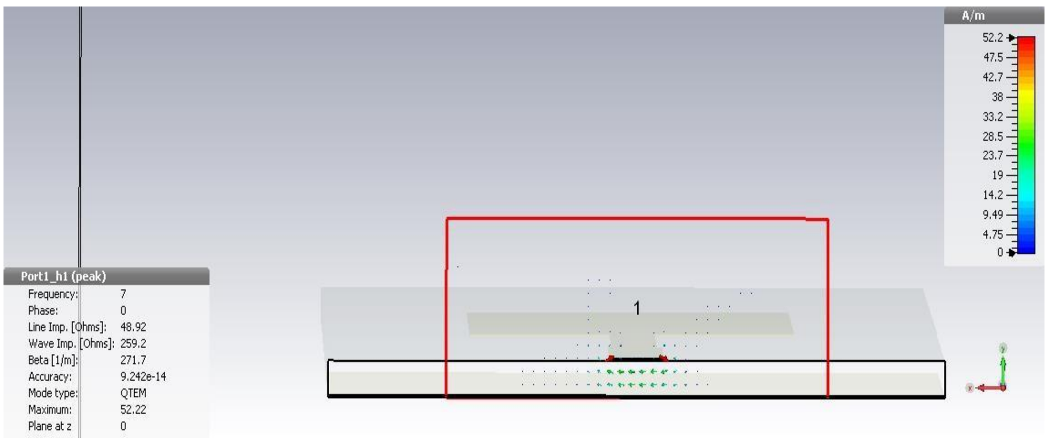


(d)

Figure1..1: Geometry of Rectangular MPA (a) Front View (b) Back View (c) E-plane Feed system (d) H-plane Feed system.

Table 1.1: Dimensions of the Rectangular Patch Geometry

Variable	Dimension in mm
L	36
W	34
LF1	5.4
WF1	2.5
LF2	6
WF2	3

Lp	11
Wp	18
Lg	11

2. Discussions of the Designed Antenna

Analysis of the proposed partial ground MPA is possible with simulated reports given in this sub-section. The return loss characteristics are analyzed with the S11 plot as given in Fig 2. 1. The plot is basically drawn between frequency and the corresponding S11 in dB [7].

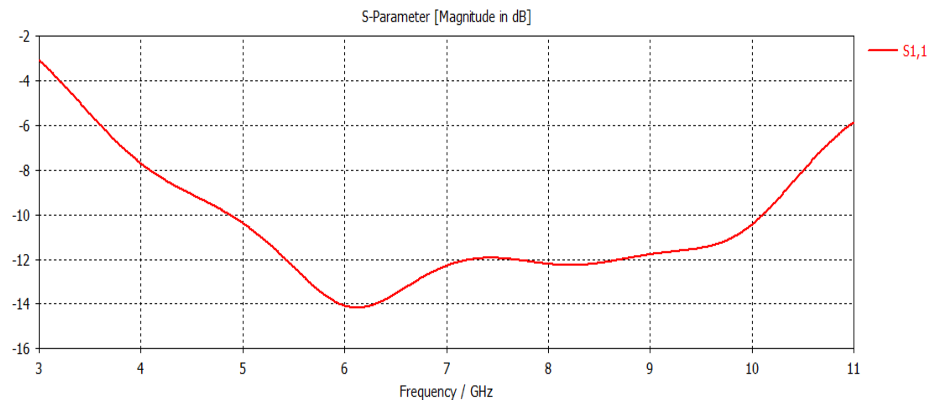


Figure 2.1: S11 plot.

It is evident from the plot that BW extends from 5 GHz to 10 GHz continuously. This allows us to arrive at the BW enhancement strategy of the partial ground model. The %BW can be further calculated using the following steps.

$$\%BW = \frac{10-5}{(10+5)/2} = 66.6\%$$

The same can be read from the corresponding VSWR plot as shown in Fig.2.2 (a). This plot shows 5% BW enhanced with respect to the simple MPA[8]. The BW improvement corresponds to the technique of partial ground is quite evident from these two reports. However, in order to verify the standard of these reports, it is often required to check with the corresponding radiation characteristics. Considering the center frequency is selected and the respective radiation pattern 3D are mentioned as shown in 2.2 (b) respectively.

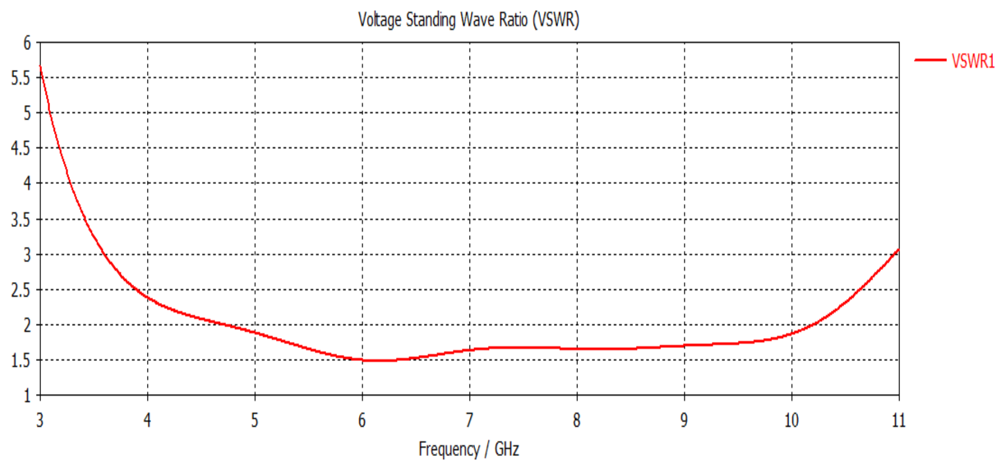
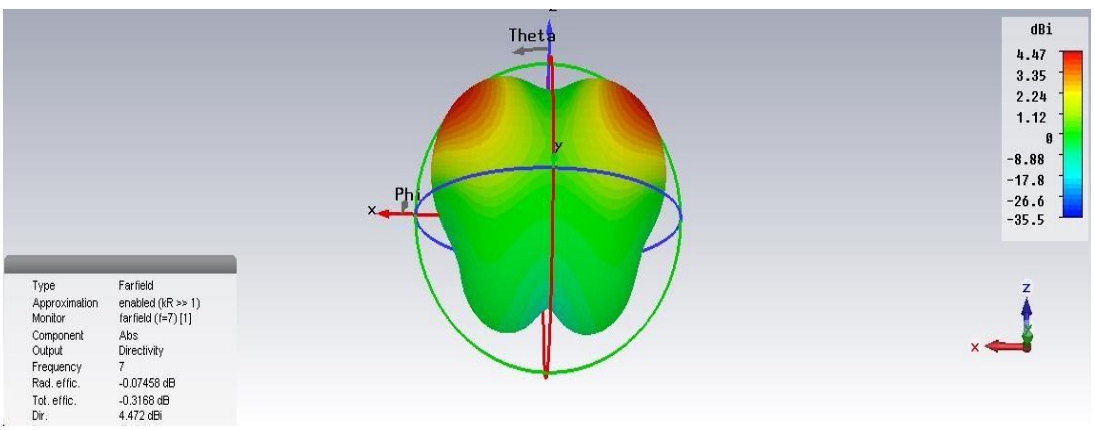


Figure 2.2 (a): VSWR plot.



(b)

Figure.2.2 (b): Radiation Patterns 3D view.

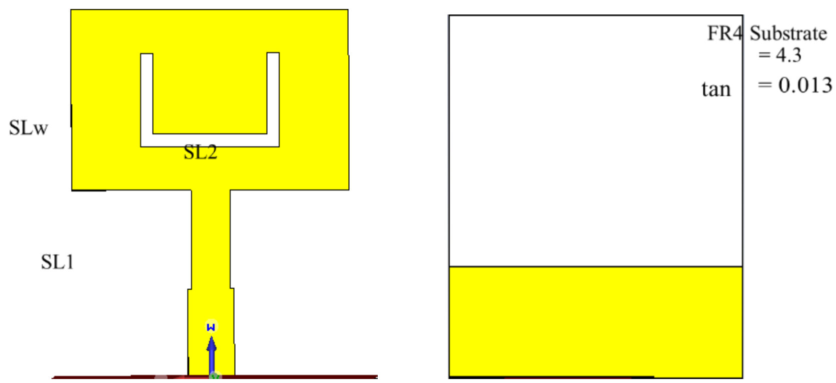
The magnitude of the main beam is reported to be 0.646 dBi in the direction of 78^0 with a half power beam width of 80.5^0 and gain 4.418 dB at 7 GHz frequency. The resultant graphs have shown a consistent radiation pattern that compares with the template radiation of a typical patch antenna profile [9].

3. U-Slot MPA

The dimensions of the U-slot are shown in Table 2.

Table 2: Dimensions of U-Slot MPA

Variable	Dimension in mm
SL2	5.7
SL1	9
SLw	0.8



(a) (b)

Figure.3: Geometry of U-Slot MPA (a) Front View (b) Back View.

4 Results and Discussions

The designed geometry is analyzed for its characteristics using S11, VSWR and radiation pattern plots. Similarly, in order to understand the field distribution and the respective current density from fed to the patch, it is often required to take the field distribution from the feed point end. Hence it is of interest to notice the variation in distribution. The multi-resonant characteristics are evident from the S11 report as shown in Fig.4.1 as well as the corresponding VSWR [199] report as shown in Fig.4.2.

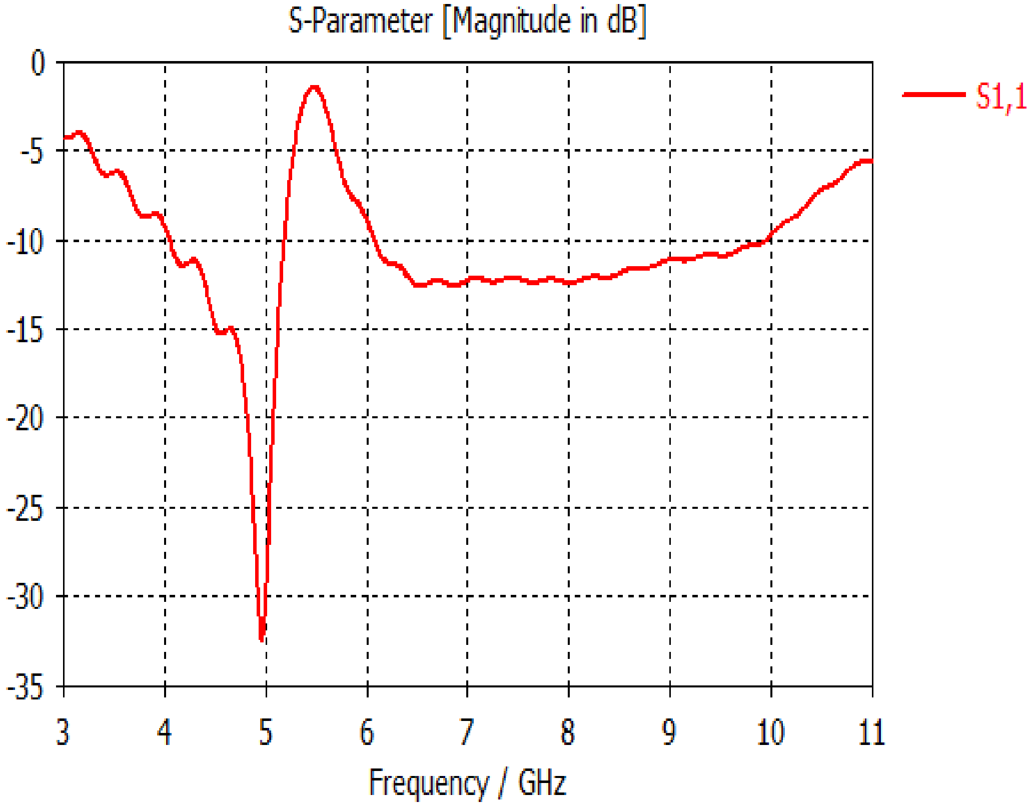


Figure 4.1: S11 Report for the U-Slot MPA.

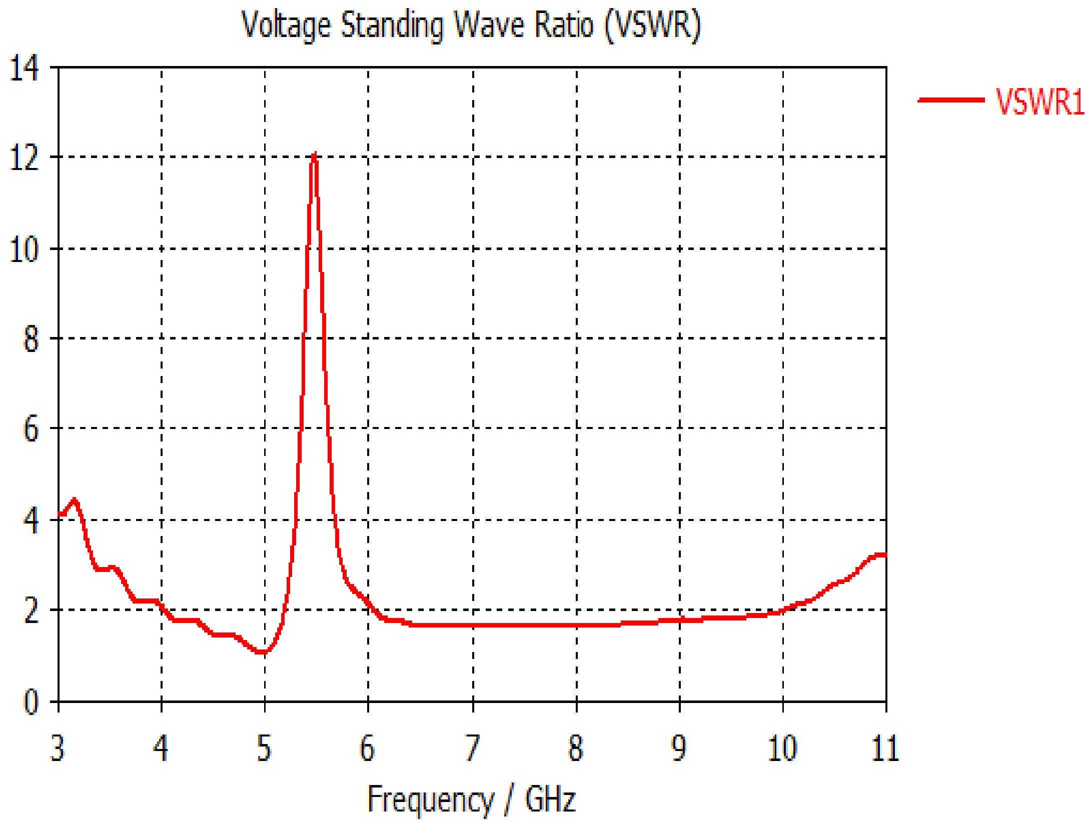


Figure 4.2: VSWR report for the U-Slot MPA.

The continuous band as seen in the case of a simple rectangular patch is split from 5.2 GHz to 6 GHz. However, the lower bound which used to be 5 GHz is further lowered to 4 GHz. Hence, as a result, there are two bands of operation which falls in the UWB region below -10 dB from return loss parameter. The same is evident even in the case of VSWR plot where the respective value of VSWR is less than 2 over a range of 4–5.2 GHz and 6–10 GHz in two different bands which are separated by a band gap of 5.2 GHz to 6 GHz.

The simulated and measured results agree within experimental uncertainties. The Gain of the antennas has been measured using Gain comparison method. The experimental setup is similar to the radiation pattern measurement set up.

Table 3: Measured Radiation Characteristics of U and Inverted U-Slot antenna

S.No	Frequency (GHz)	Plane	Beam width (degrees)	Gain (dBi)
1	4.5	V	87.09	1.39
		H	91.24	
2	8.5	V	142.88	4.13
		H	87.64	
3	9	V	55.33	4.38
		H	185.54	

5 CONCLUSION

The designs proposed are generated in order to study the impact of the U-shaped slots and patch structures on the radiation and resonant characteristics of a patch antenna. The case wise distribution and incremental number of U-slots enabled to identify the responsible features of the U-shapes. The study revealed that the antenna exhibits multi-resonant characteristics with the inclusion of several structures which are termed as multi-resonant structures. The U-slot design is further extended by introducing inverted U-slot and C-slots. Hence, the segmented triple operating band has a -10 dB impedance bandwidth of 1 GHz (4-5 GHz), 100 MHz (5.725-5.825 GHz) and 1.7 GHz (7.8-9.5 GHz). The maximum gain for the tri band antenna is 6.024 dB at 8.5 GHz. The triband antenna gets return loss above -10 dB for WLAN and WiMax frequency bands so has to avoid interference.

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