ISSN 2320 - 2599
Volume 5, No.2, March – April 2016
International Journal of Microwaves Applications
Available Online at http://www.warse.org/IJMA/static/pdf/file/ijma04522016.pdf

Triple Band U-Capping Slotted Microstrip Patch Antenna Using DGS for Wireless Applications

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ABSTRACT

Proposed triple band microstrip patch antenna is successfully designed at 3.5 GHz for Wi-MAX, 5.8 GHz for WLAN and 7.5 GHz for broadcasters' applications. The rectangular geometry of antenna is described by having a single via in center of U-capping slotted patch to ground and using L-slotted DGS.

Such types of microstrip patch antenna meets the requirement of triple band frequency operation for wireless communication by modifying the shaped of U-capping slot on the patch. The parameters of antenna like gain, bandwidth and reflection co-efficient (return loss, S11) have been improved in this work at acceptable limit with reasonable radiation performance. Proposed antenna is simulated using CST V.12 simulator using swarm optimization algorithm technique.

Key words: Microstrip antenna (MSA), L-slot, U-slot, defected ground structure (DGS), tripal band application, gap coupling, Wi-MAX, WLAN, broadcasters.

1. INTRODUCTION

In wireless Communications, different application works over different frequency bands like GSM, UMTS, WLAN, and Bluetooth, Wi-MAX etc. Gain enhancement & size reduction are the major considerations for practical applications of microstrip antennas, considering the fact that a trade off exist between the two i.e. enhancement of one results in degradation of other. At lower frequency of operations, the size of antennas poses a problem to achieve compact structures. Miniaturization of antennas to meet this increasing demand of smaller hand held devices is required therefore different techniques to design microstrip patch antenna with reduced size have been used for antenna design [1-3].

Microstrip patch antenna consists of a metallic patch and ground plane; both are separated by a sheet known as substrate. The patch may be of different shapes such as U shaped, L shaped, triangular and rectangular shaped, etc. Rectangular shaped patch antenna is used for multiband operations, size reduction and fractal designs for wide band applications [4-5]. Patch is designed in such a way that radiating maximum power is to its normal and radiation pattern so exhibited is known as broadside pattern. The patch can be of broadside pattern by selection of proper mode. Microstrip patch antennas can act as a good radiator if thicker substrate of low permittivity material is used. Moreover it does not bound field. Conversely thin substrate of high permittivity confines field within substrate.

Gap coupling is an important feeding technique for designing broadband antennas. Here via is used to attach ground and patch while through gap between microstrip line and patch. Capacitive matching has been achieved.

The bandwidth of patch antenna can be increased by three ways. The first technique is simply increasing the thickness of the substrate. The second technique to increase bandwidth is decreasing the relative permittivity, which has an obvious limitation based on size. The third method is by means of a wideband matching network. However, this concept is not feasible until an impedance-matching technique is proposed. In this paper, simulations are carried out using CST Microwave Studio 2012. The geometry of antennas is discussed in section 2. Results of multiband at 3.5 GHz, 5.8 GHz and 7.5 GHz are discussed in section 3 and finally brief conclusion is given in section 4.

2. ANTENNA DESIGN

A. Antenna Configuration

The geometrical design of microstrip patch antennas are introduced to capacitive matching through gap coupling between microstrip line and patch. The rectangular patch size and L-slot DGS dimensions are also important parameters for frequency selection of bands. By changing these dimensions, various frequency selection bands can be obtained. In Figure. 2 the antenna configured according to dual band frequencies requirement, gap for capacitive matching and dimensions of L-slot are selected one by one respectively [6-7]. The L-slot DGS simplicity in fabrication is a privilege aspect of this design.

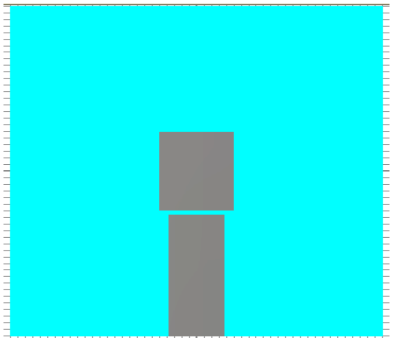


Figure 1: Geometry of basic antenna

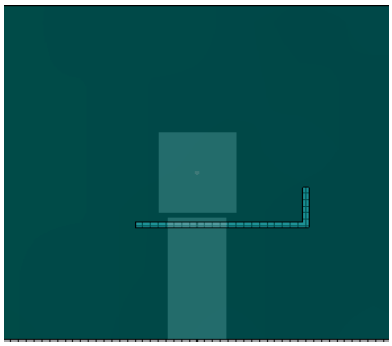


Figure 2: Geometry of basic antenna with DGS

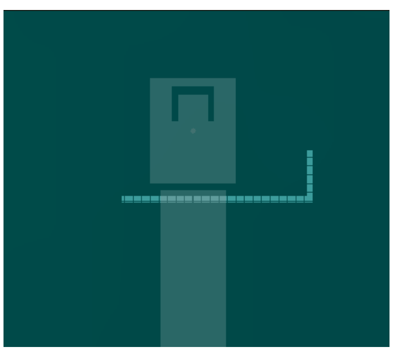


Figure 3: Geometry of proposed antenna with DGS and U-capping slotted patch

Three different geometries of antennas have same configuration and are described by having a single via in center of patch to ground. The antenna is printed on substrate whose relative permittivity is 3.2 with loss tangent of 0.0024 and height 3.064 mm. Dimension (W x L) of patch is (11.92 mm x 10 mm) and width of feeding line is 7.60 mm at 50 Ω characteristic impedance. The basic antenna (shown in fig. 1) has a single band and the same structure with DGS (shown in fig. 2) has obtained dual band operation. The dimensions of L-slot DGS are classified into the vertical line (6 x 0.8) mm, horizontal line (0.8 x 21.6) mm and thickness of patch and ground conductor is 0.07 mm.

B. Proposed Antenna Configuration

Figure. 3 shows the proposed antenna which has obtained triple band operation. The dimension of U-capping slotted Patch has (4.9 x 1) mm horizontal arm and (3 x 0.7) mm vertical arm respectively.

3. RESULTS AND DISCUSSION

This section discusses simulated results of three different types of patch antennas taken for study. The results include reflection co-efficient as well as other parametric values. S-parameters obtained during simulation can be seen in fig.4, 5, and 6. Generally reflection co-efficient (S11) has been taken less than -10 dB over the wide bandwidth of Wi-Max/WLAN applications but for simulation -20 dB is sufficient so that fabricated antenna must provide S11 around -10 dB.

The S-parameters of proposed antenna shown in Figure. 6 suggest that the center frequencies of each operation are 3.5 GHz for Wi-Max band, 5.8 GHz for WLAN band and 7.5 GHz for broadcasters. At the Wi-Max band, the return loss is more than -22 dB and the WLAN band the return loss is more than -20 dB that is acceptable limit of performance [8-11].

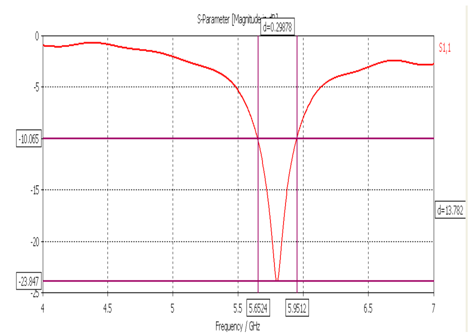


Figure 4: Reflection co-efficient of basic antenna of Figure. 1

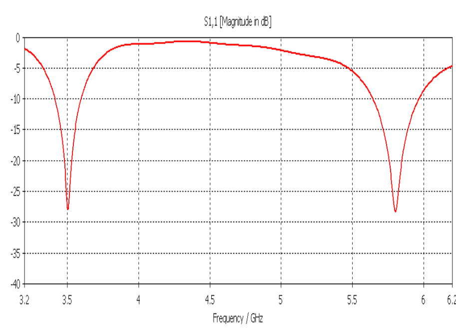


Figure 5: Reflection co-efficient of basic antenna with DGS of Figure. 2

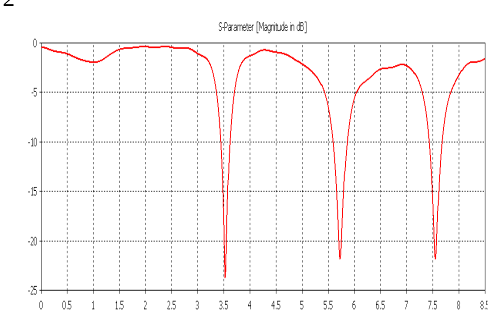
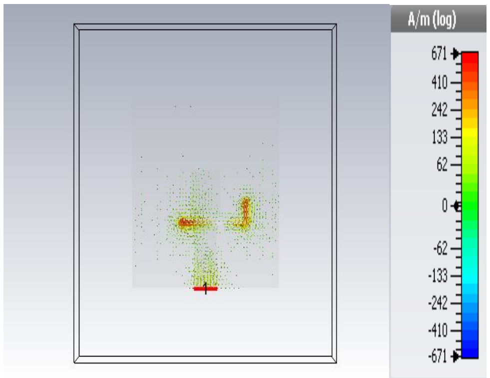
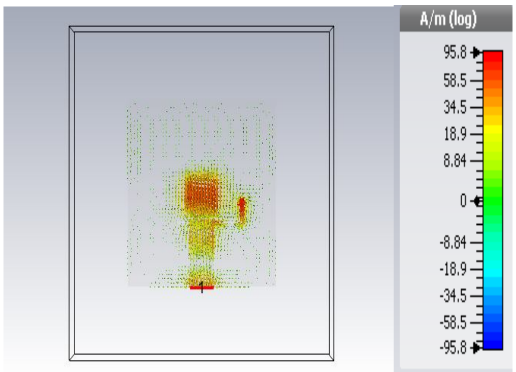


Figure 6: Reflection co-efficient of proposed antenna for triple band operation of Figure. 3

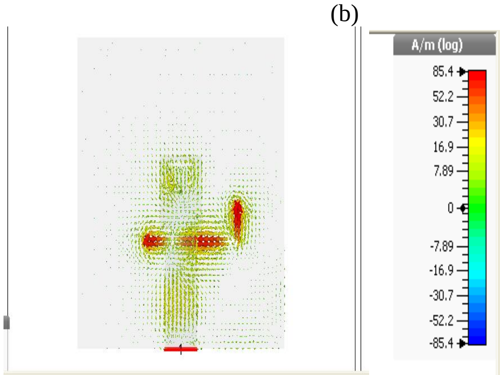
The other parameters of proposed antenna are shown in the Figure 7 and 8. The surface current densities at different operating frequencies have been shown in Figure. 7.



(a)



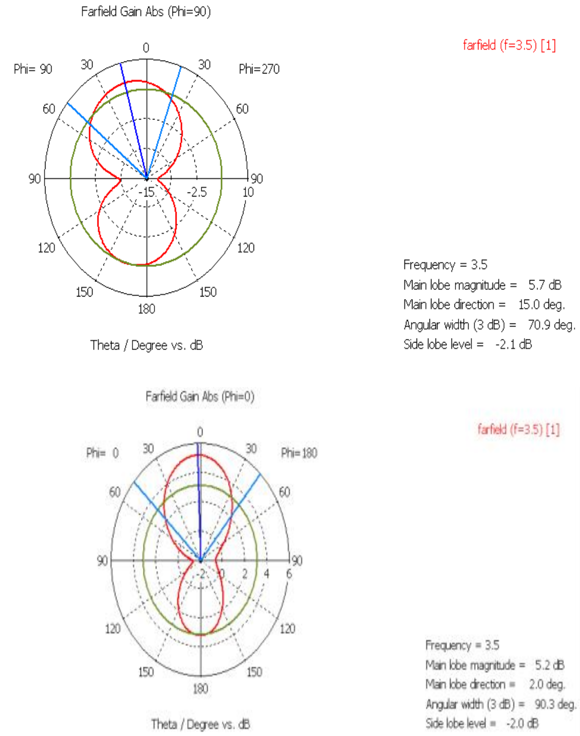
(b)



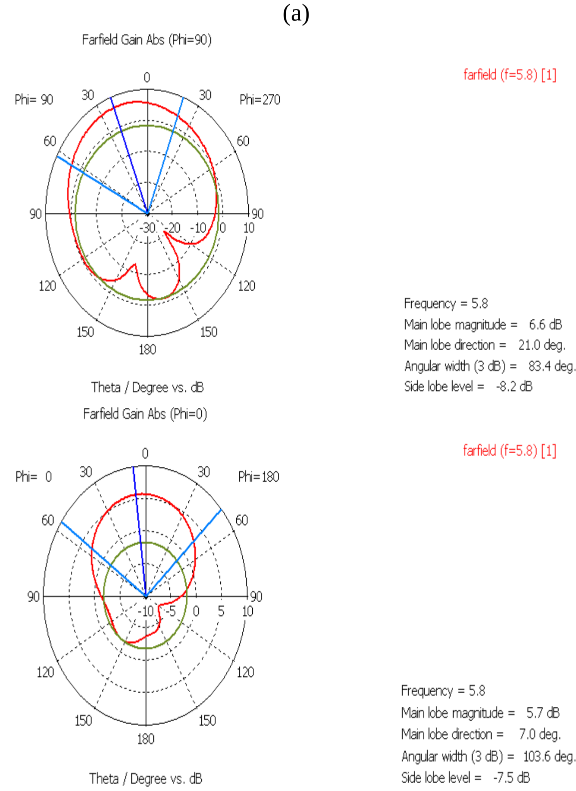
(c)

Figure 7: Surface current density of proposed antenna at (a) 3.5 GHz, (b) 5.8 GHz, and (c) 7.5 GHz.

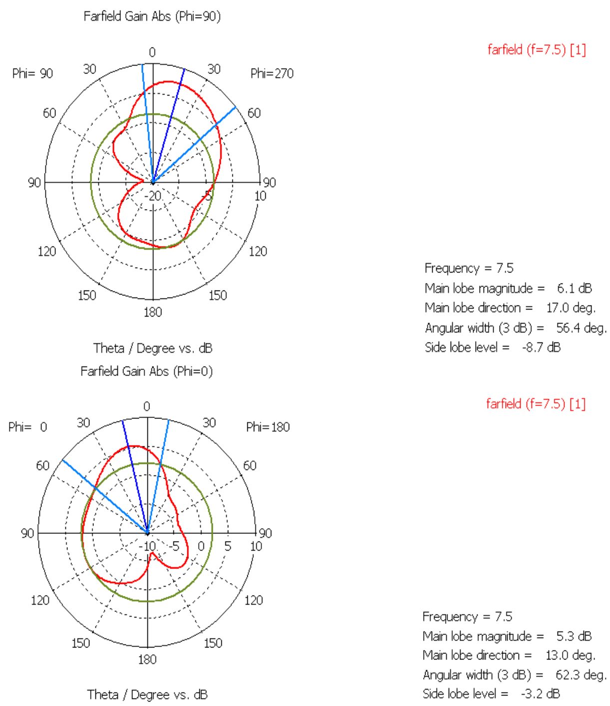
The polar plots in E-plane and H-plane shows the far field radiation pattern of antennas in Figure. 8.



(a)



(b)



(c)

Figure 8: Far field radiation pattern of proposed antenna at (a) 3.5 GHz, (b) 5.8 GHz, and (c) 7.5 GHz.

Table 1: Comparison between basic and proposed antenna

Antenna Design Parameters	**Single Band Antenna (Fig.1)**	**Dual Band Antenna (Fig.2)**	**Triple Band Antenna (Fig.3)**
Gain at 3.5 GHz	-	5.718 dB	5.756 dB
Bandwidth at 3.5 GHz	-	188 MHz	200 MHz
Return loss at 3.5 GHz	-	-27 dB	-24 dB
Gain at 5.8 GHz	6.591dB	6.617 dB	6.607 dB
Bandwidth at 5.8 GHz	298 MHz	308 MHz	260 MHz
Return loss at 5.8 GHz	-24 dB	-29 dB	-22 dB
Gain at 7.5 GHz	-	-	6.096 dB
Bandwidth at 7.5 GHz	-	-	240 MHz
Return loss at 7.5 GHz	-	-	-22 dB

4. CONCLUSION

In this paper, a triple-band planar microstrip antenna with DGS is presented. The rectangular U-capping slotted patch with DGS plays an important role in the structure. The proposed antenna is successfully designed at 3.5 GHz, 5.8 GHz and 7.5 GHz for wireless applications. By changing the width and length of the patch as well as adjusting the length and width of the DGS, we can design the triple-band with other different three frequencies.

The simulated results of proposed prototype are yet to be validated through fabrication of the prototype.

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