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Step Shaped Wideband Microstrip Patch Antenna With Dgs For Mimo Applications

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Abstract: This letter presents the design of a compact size wideband Microstrip line feed square with step shaped patch antenna suitable implementation for Bluetooth, 4G LTE, WLAN, and WiMAX applications. The proposed compact size wideband Microstrip antenna consist of a microstrip feed line on one side of the substrate with defective ground structure with rectangular slot, other side of ground plane. The antenna system resonates at 9.13GHz for VSWR=1.The proposed antenna is suitable for wireless communication systems.

Keywords: MPA, Wireless Local Area Networks; Long Term Evolution; Worldwide Interoperability for Microwave Access, VSWR.

I.INTRODUCTION

Recently, demand on wireless communication has been rapidly increasing resulting in deployment of modern wireless communication systems such as Wi-Fi, WiMAX, and 3G/4G. Along with these applications, modern antennas are required to have small size and light weight. Antenna [1] is a transducer which transmits or receives electromagnetic waves. Microstrip antennas have several advantages over conventional microwave antenna and therefore are used in a variety of practical applications. Microstrip antenna was first introduced in the 1950s. However, this concept had to wait for about 20 years to be realized after the development of the printed circuit board (PCB) technology in the 1970s. Since then, microstrip antennas are the most common types of antennas with wide range of applications due to their apparent advantages of light weight, low profile, low cost, planar configuration, easy of conformal, superior portability, suitable for array with the ease of fabrication and integration with microwave monolithic integrate circuits (MMICs).They have been widely engaged for the civilian and military applications such as radio-frequency identification (RFID), broadcast radio, mobile systems, global positioning system (GPS), television, multiple-input multiple-output (MIMO) systems, vehicle collision avoidance system, satellite communications, surveillance systems, direction founding, radar systems, remote sensing, missile guidance, and so on. Microstrip antenna in its simplest design is shown in Figure 1. It consists of a radiating patch on one side of dielectric substrate ($\epsilon_r \leq 10$), with a ground plane on other side.

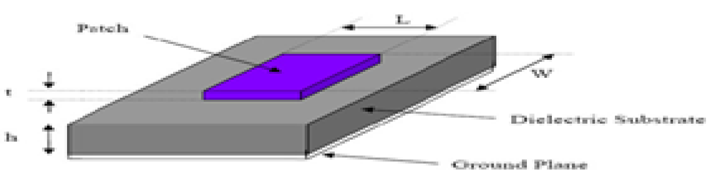


Figure 1: Microstrip antenna configuration

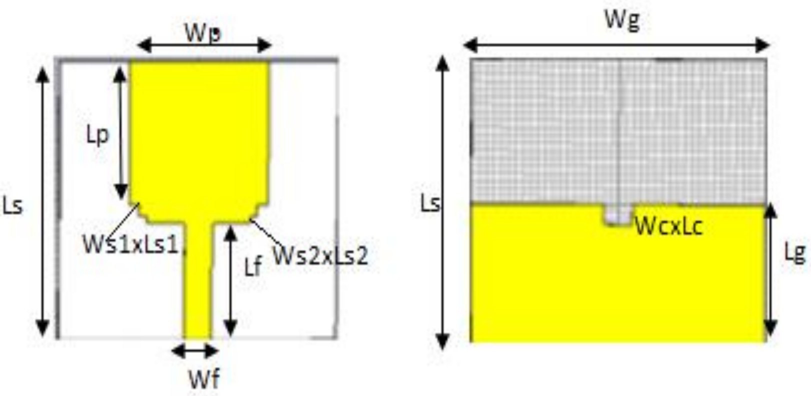
A microstrip patch antenna (MPA) consists of a conducting patch of any non-planar or planar geometry on one side of a dielectric substrate and a ground plane on other side. It is a printed resonant antenna for narrow-band microwave wireless links requiring semi-hemispherical coverage. Due to its planar configuration and ease of integration with microstrip technology, the microstrip patch antenna has been deeply. The rectangular and circular patches are the basic and most commonly used microstrip antennas.

Defected ground structure (DGS) has similar microwave circuit properties as EBG, it can also modify guided wave properties to provide a band-pass or band-stop like filter and can easily define the unit element. The geometry of DGS can be one or few etched structure which is simpler and does not need a large area to implement it DGS structure disturbs the shield current distribution in the ground plane, which influences the input impedance and current flow of the antenna.

In today's environment, technology demands antennas which can operate on different wireless bands and should have different features like low cost, minimal weight, low profile and are capable of maintaining high performance over a large spectrum of frequencies. In next generation networks require high data rate and size of devices are getting smaller day by day. In this evolution three important standards are 4G LTE, WiFi (WLAN) and WiMAX. Wireless local area network (WLAN) and WiMAX technology is most rapidly growing area in the modern wireless communication.

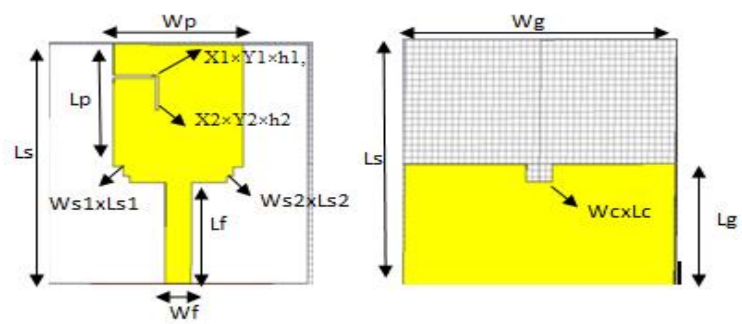
In this paper present, a microstrip patch antenna with L shaped slot meandered on patch and Defected Ground Structure used in ground plane is proposed which can be operated at single band. The designed antenna resonates at 9.32GHz, which is suitable for ultra-wideband applications. The antenna design is simulated using the CST simulator. In section 2, the proposed antenna geometry is presented and in Section 3 the results are presented. The final conclusion of the paper is given in Section 4.

II. ANTENNA DESIGN



(a) (b)

Figure 2 Geometry of the proposed antenna without filter (a) Top view, (b) Side view.



(a) (b)

Figure 3 Geometry of the proposed antenna with filter: (a) Top view, (b) Side view

The proposed antennas are designed on FR4 substrate with thickness (hs) of 1.6mm having relative permittivity (Ɛr) of 4.4. The patch has the dimensions of 19.5 × 20 mm with height (hp) of 0.1 mm. The ground has the dimensions of 20 mm × 19 mm with height (hg) of 0.1 mm. Antenna is excited with microstrip feed having characteristics impedance of 50 Ω. The feed has dimension of 16mm × 4 mm with height (hf) of 0.1 mm. The complete geometry of simple MPA is shown in Figure 2. In order to improve the Bandwidth and Return loss, ground is defected with square-Shape slot. The dimension of slot along Y-axis is 3.5×5.5×11.3 mm and the dimension of slot along X-axis is 6.5×5.5×5mm as shown in Figure 3. Also this slot made on ground helps in the reduction of overall weight and size of proposed antenna. The Proposed antenna resonates at frequency (fr) of 9.32GHz. The resonant frequency, also called the center frequency, is selected as the one at which the return loss is minimum. For the designing of rectangular microstrip patch antenna, the following relationships are used to calculate the dimensions of the rectangular microstrip patch antenna. The width of the patch is calculated using the following equation (1)

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

Where, W = Width of the patch C= Speed of light ε_r= value of the dielectric substrate

The effective refractive index value of a patch is an important parameter in the designing procedure of a microstrip patch antenna. The radiations traveling from the patch towards the ground pass through air and some through the substrate (called as fringing). Bath the air and the substrates have different dielectric values, therefore in order to account this we find the value of effective dielectric constant. The value of the effective dielectric constant (ε_r) is calculated using the following equation(1)

$$\varepsilon_{reff} = \left(\frac{\varepsilon_r + 1}{2}\right) + \left(\frac{\varepsilon_r - 1}{2}\right)\left[1 + 12\,\frac{h}{W}\right]^{-\frac{1}{2}}$$

Due to fringing, electrically the size of the antenna is increased by an amount of (ΔL). Therefore, the actual increase in length (ΔL) of the patch is to be calculated using the following equation(1).

$$\Delta L = 0.412h\left[\frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)}\right]$$

Where h= height of the substrate

The length (L) of the patch is now to be calculated using the below mentioned equation(1).

$$\lambda_g = \frac{c}{f\sqrt{\varepsilon_{reff}}}$$

$$L = \frac{\lambda_g}{2} - 2\Delta L$$

Now the dimensions of a patch are known. The length and width of a substrate is equal to that of the ground plane. The length of a ground plane (Lg) and the width of a ground plane (Wg) are calculated using the following equations (1).

$$Lg=6h+L$$

$$Wg=6h+W$$

Table 1. Common design specifications for both antennas

Sl. N o	Parameters	Dimensions are in mm/values
1	Ground (Lg×Wg×Wg1xWg2×hg)	20×19×1×1×0.1
2	Substrate (Ls×Ws×hs)	38×40×1.6
3	Patch (Lp×Wp×hp)	19.5×20 × 0.1
4	Feed (Lf×Wf×hf)	16×4 ×0.1
5	Permittivity of substrate material FR4	4.4
6	Step 1(Ws1×Ls1)	1.5×1.5
7	Step 2(Ws2×Ls2)	1×1
8	Slot on patch(X1×Y1×h1×t1, X2×Y2×h2×2)	6.5×5.5×5×0.4,3. 5×5.5×11.3×0.2
9	Slot on ground plane(Wc×Lc)	3.8×2.7

III. RESULTS

The proposed modified microstrip patch antenna is designed using a CST Microwave studio suit 2015 which works on principle of FIT (Finite Integration Technique). The simulation results of the return loss of both the antennas are compared in Figure 8. From the figure we can conclude that the microstrip patch has S11values of -26.23 dB at the resonant frequency 9.312 GHz and -31.23 dB at the resonant frequency 9.256GHz. Hence, the proposed patch antenna is better in all the aspects compared to the normal square shaped antenna. The radiation patterns of the modified E shaped patch antenna are shown in fig 4 and fig 5 for the resonant frequencies 5.36GHz and 5.89GHz respectively. The VSWR of the proposed antenna is presented in the Figure 9. The plot gives the satisfactory results of VSWR at the resonant frequency. The VSWR value is observed as =1 providing improved matching conditions.

Return loss (S11) and bandwidth

It is evident from Figure 4 that when L shaped slot introduced on patch, the proposed antenna resonates at resonant frequency fr = 9.256GHz. A very good return loss of -31.23 dB at fr = 9.256GHz GHz is obtained for this structure. At this resonant frequency, it gives a maximum bandwidth of 132.3 MHz (i.e. MX1 – MX2). While the Figure 5 depicts that MPA without slotting on patch also resonates at resonant frequency fr = 9.312 GHz. The bandwidth of the microstrip patch antenna with same dimensions as mentioned above but without slotting is 126.2 MHz at fr=9.312 GHz. GHz. The value of return loss (S11) obtained from MPA is -26.23 dB.

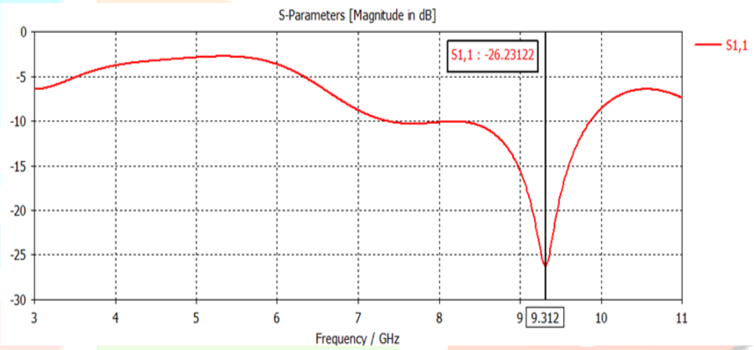


Figure 4: Return loss (S11) of microstrip patch antenna without slot

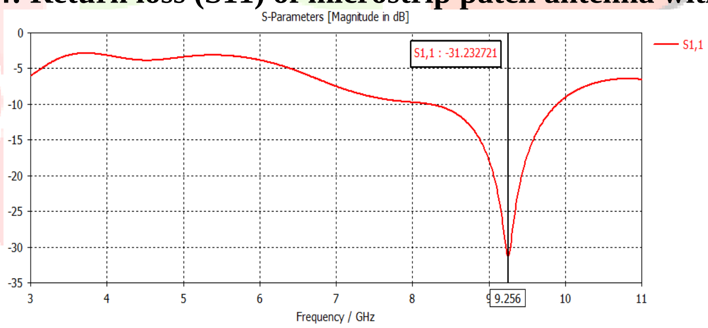


Figure 5: Return loss (S11) of microstrip patch antenna with slot

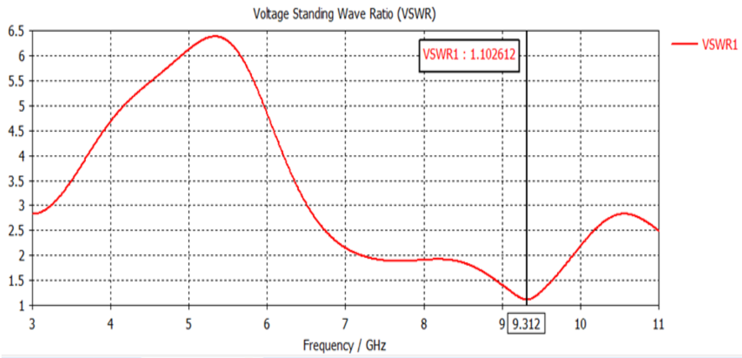


Figure 6: VSWR Plot of MPA

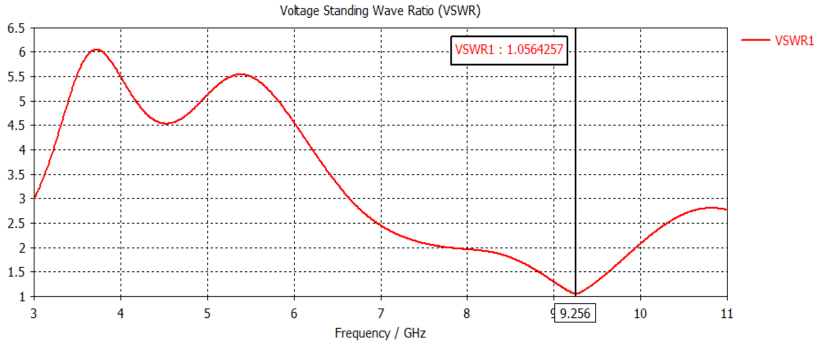


Figure 7: VSWR Plot of MPA

VSWR

Figure 6 shows VSWR plot of the proposed antenna. At frequency of 9.256GHz, the VSWR is 1.056. As the value of VSWR is approximately equal to 1 at resonant frequency (fr), proposed antenna results in perfect impedance matching. While the VSWR, in case of simple MPA i.e. without L shaped slot on patch at resonating frequency fr= 9.312 GHz is 1.1026 as shown in Figure7.

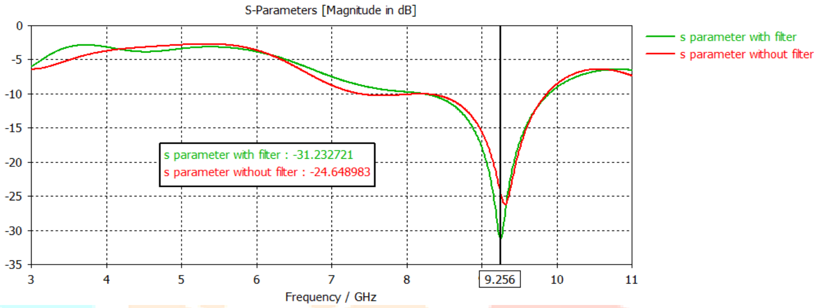


Figure 8 the compared return loss of both the antennas

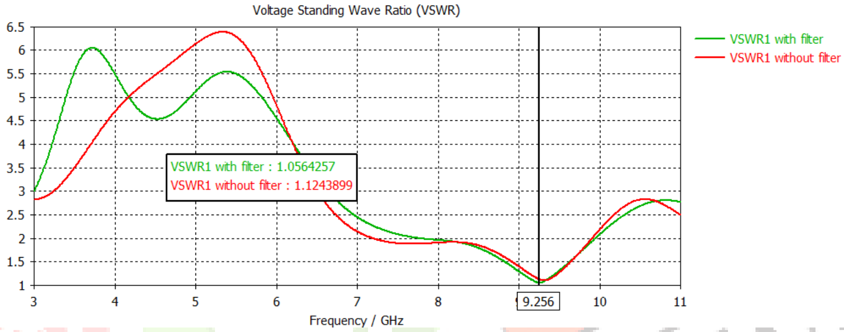


Figure 9 the compared VSWR of both the antennas

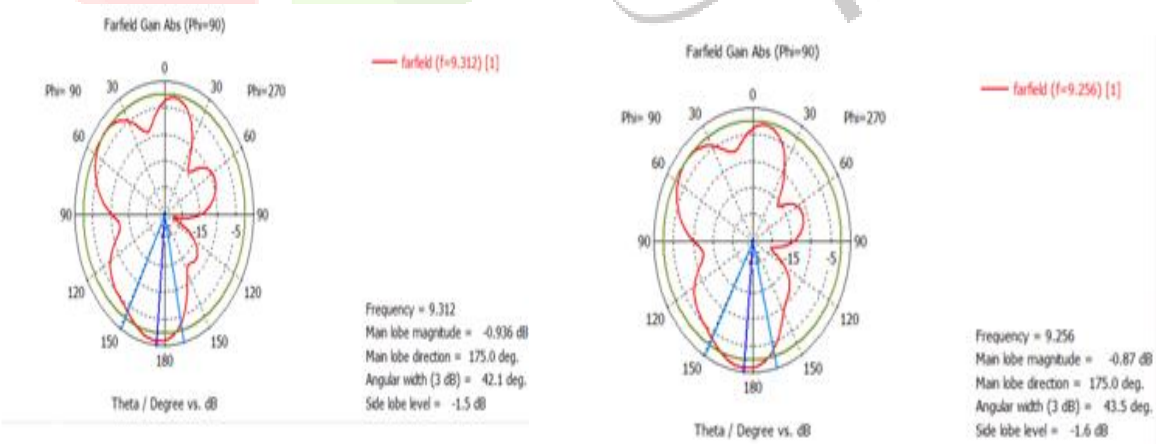


Figure 12 2-D Radiation Pattern of Patch antenna showing Gain at 9.312 GHz

Table 2 summarizes the obtained simulation features of the designed antennas.

Comparison of simulated results of both antennas

Sl.No	**Parameters**	**MPA Antenna without slot**	**L Shaped Slot Antenna**
1	Resonating Frequency (GHz)	9.312GHz	9.256GHz
2	Bandwidth (MHz)	1.6822GHz	1.8638GHz
3	Return Loss (dB)	-26.23dB	-31.23dB
4	VSWR	1.10	1.0
5	Gain	-0.936dB	-0.87dB

IV. CONCLUSION

A novel antenna design working in C-band has been successfully implemented in this paper. The bandwidth of the microstrip patch antenna with same dimensions as mentioned above but without slotting is 126.2 MHz at fr 6.2051 GHz with return losses (S11 = -27.72 dB) as shown in Fig. 4. While microstrip patch antenna with I-Shape DGS provides bandwidth of 132.3 MHz and return losses reaches up to -46.75 dB as shown in Fig. 3. Thus it has been concluded that with I-Shape DGS, the bandwidth of the microstrip patch antenna is increased by 6.1 MHz. with reduction in ground plane area by 5%. The proposed antenna design is useful for satellite communications as well as in RADAR.

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BIOGRAPHY

NAGARAJ HANCHINAMANI *was born in Karnataka, India in 1988. He received the B.E Degree in Electronics and Communication engineering and the M.Tech degree in Digital Communication and Networking from the VTU, Belgaum in 2010 and 2012 respectively. He is received Ph.D. from JAIN University Bangalore in 2019. He is currently working as Senior Grade lecturer in Electronics & Communication engineering department at Government Polytechnic Bankapura, Haveri. His research interest is on Microwave communication, Antennas and Wireless communication, Includes Analysis and design of patch antenna for wireless communication.*