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Bandwidth Enhancement in CPW Fed Compact Rectangular Patch Antenna

Kirti Vyas, P. K. Singhal

***Abstract*—**This paper presents a novel CPW fed patch antenna supporting a wide band from 2.7 GHz – 6.5 GHz. The antenna is compact with size 32 x 30 x 1.6mm^3, built over FR4-epoxy substrate (ε_r=4.4). Bandwidth enhancement has been achieved by using the concept of modified ground structure (MGS). For this purpose structural design has been optimized by parametric simulations in CST MWS. The proposed antenna can perform well in variety of wireless communication services including 5.15 GHz- 5.35 GHz and 5.725 GHz- 5.825 GHz WLAN IEEE 802.11 g/a, 5.2/ 5.5/ 5.8 GHz Wi-Fi, 3.5/5.5 GHz WiMax applications and 3.7 - 4.2 GHz C band satellite communications bands. The measured experimental results show that bandwidth (S_{11} < -10 dB) of antenna is 3.8 GHz. The performance of antenna is studied in terms of reflection coefficient, radiation characteristics, current distribution and gain.

***Keywords*—**Broad band antenna, Compact, CPW fed, WLAN, Wi-Fi, Wi-Max, CST MWS.

I. Introduction

DUE to increasing demand of mobile wireless communication systems there has been tremendous growth in the research potential for advanced compact planar antennas which can fulfill the demand of broadband characteristics. However these antennas suffer the limitation of narrow bandwidth which can be mitigated with use of suitable feeding technology such as coplanar waveguide feed which gives a uniplanar structure to the printed antennas. The planar monopole antennas with coplanar waveguide (CPW) feeding mechanism has gained researchers attention due to its advantages over microstrip type feed lines, such as low dispersion, low radiation leakage, the ability to effectively control the characteristic impedance, and the ease of integration with active devices. For this purpose, antennas with broadband characteristics are in strong demand [1-12]. These broadband antennas should have the potential to serve for various applications such as WLAN IEEE 802.11 g/a (5.15 GHz- 5.35 GHz and 5.725 GHz- 5.825 GHz), 5.2/ 5.5/ 5.8 GHz Wi-Fi applications, WiMax 3.5/5.5 and C band satellite communications 3.7 - 4.2 GHz band, HIPERLAN/2 specified in two bands: from 5.15 to 5.35 GHz and from 5.470 to 5.725 GHz and lower Ultra wide band (UWB) applications with the band of 3.1-6.5 GHz.

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The purpose of this work is to design a compact broadband antenna using MGS technique which can cover various wireless applications which are listed above and which is easy to implement.

II. Proposed CPW Fed Antenna

Fig. 1 shows proposed CPW fed patch antenna with modified ground planes. Two bevels are cut in the lower portion of the rectangular patch to enhance the bandwidth. The width of the central strip of CPW antennas is of 3 mm, and the gap between the central strip and ground planes is 0.5mm. Two symmetric stepped ground planes are placed on both side of the central strip. The optimized design parameters obtained for the proposed patch antenna are L = 32mm, W = 30mm, g = 0.5mm, W_f = 3mm, L_{g1} = 9.5mm, L_{g2} = 6.5mm, L_{g3} = 3.9mm, LS1 = LS2 = Ws1= Ws2 = 5mm. Used dielectric substrate (FR4 epoxy) has relative dielectric constant ε_r of 4.4, loss tangent of 0.02 and thickness of 1.6mm.

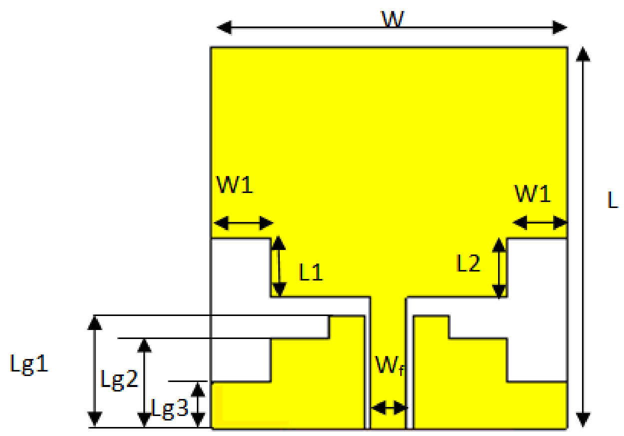


Fig. 1 The geometric design of proposed antenna

The antenna has a single layer metallic structure on one side of the substrate (top) where as other side (bottom) is without any metallization. Fig. 2 shows the fabricated cost effective patch antenna.

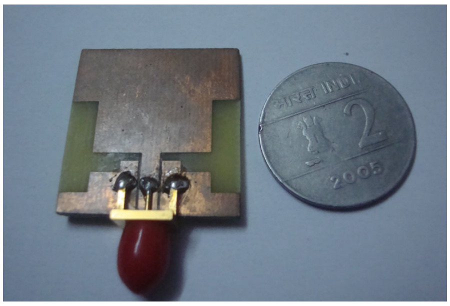


Fig. 2 The fabricated prototype of antenna

III. Results and Discussions

Designed antenna is simulated using CST MWS. The CPW central metal strip width, length and the gap (g) of distance between the strip and the coplanar ground plane are fixed at 3mm, 11 m and 0.5mm, respectively, in order to achieve 50 Ω CPW feed line. The radiating element of designed antenna has two square shaded bevels of dimension **'L1 X W1'** and **'L1 X W2'** of 5 X 5mm^2 each to enhance impedance bandwidth. The fabricated antenna is characterized with Rohde and Schwarz vector network analyzer ZVA40 for reflection coefficient versus frequency, which has been plotted with the simulated results in Fig. 3.

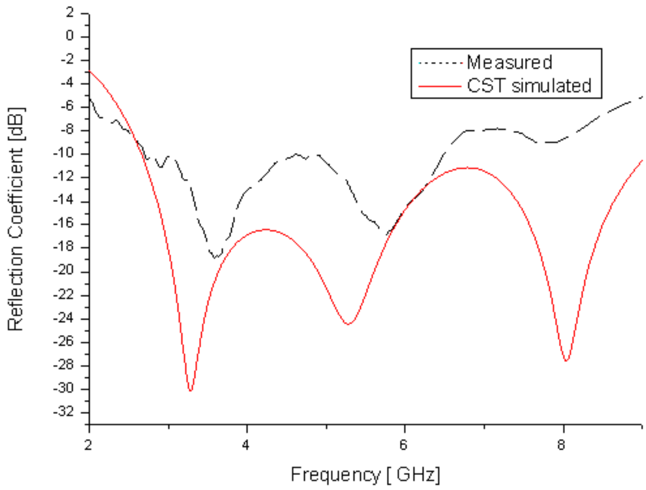


Fig. 3 Reflection Coefficient of proposed antenna

The simulated results of reflection coefficient versus frequency are in good agreement in the lower cut off frequency and with. The CPW fed antenna has attained huge impedance bandwidth with modified symmetrical ground planes. This proposed antenna achieves a significant bandwidth of 3.8 GHz ranging from 2.7- 6.5 GHz with respect to the central frequency at 4.5 GHz which makes this antenna a good candidate for wireless applications.

We find a slight variation between the simulated and experimentally measured results at higher frequencies. This can be due to the dielectric losses introduced at high frequencies or uncertainty of the purchased dielectric constant of the substrate. In order to achieve a good impedance matching we need to optimize the dimensions of the bevels **'L1 X W1'** and **'L1 X W2'.** Hence we start analysis with varying Length of the bevel 'Ls1' keeping all parameters same. Fig. 4 shows the effect of length 'Ls1' on the proposed antenna. As per the simulated results; most desired wideband is obtained at Ls1 = 5mm. For 'Ls1' values lesser than 5mm, the antenna is not able to radiate properly for frequencies around 6.5 GHz and gives poor impedance matching. The parametric analysis is performed on the width of the bevel 'Ws1' in Fig. 6. It can be seen from Fig. 5 that decreasing the bevel width below 5mm makes antenna nonresonating from 6-7 GHz. However increasing the WS1 value above 5mm reduces antenna bandwidth, so WS1= 5mm is the optimized dimension for this design.

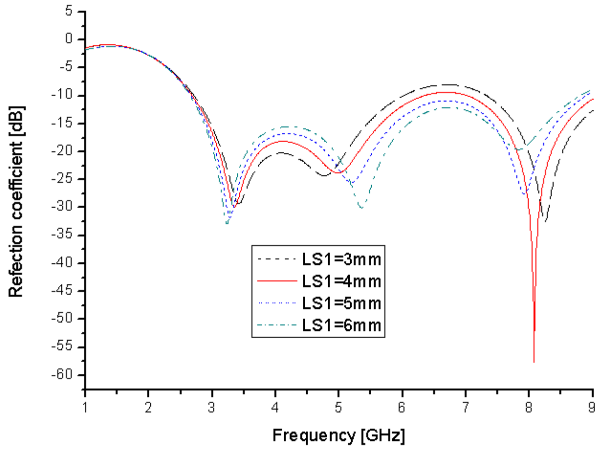


Fig. 4 Effect of Variation of Length Ls1

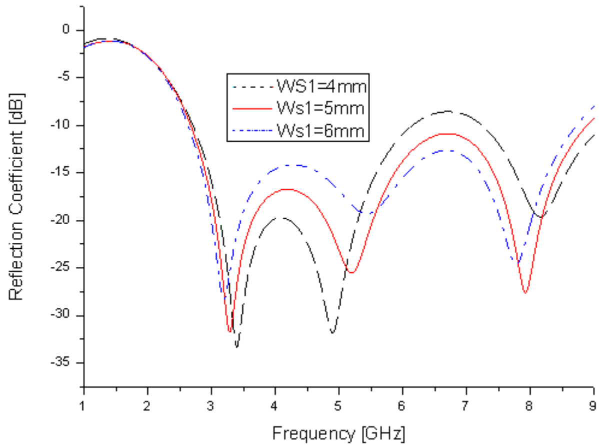


Fig. 5 Effect of Variation Ws1

Fig. 6 shows the parametric analysis results for various 'Lg1'. It is observed that the maximum bandwidth is obtained at Lg1=9.5, while increasing or decreasing the value of Lg1 reduces impedance bandwidth.

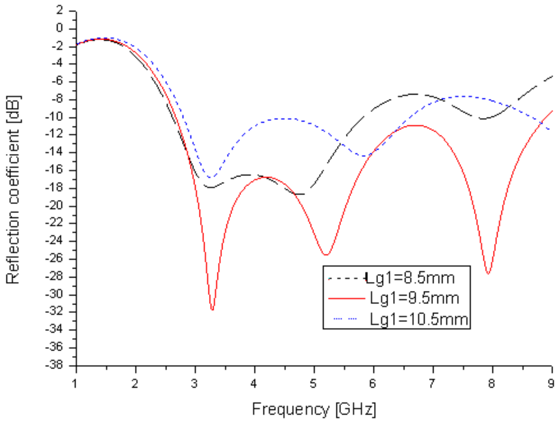
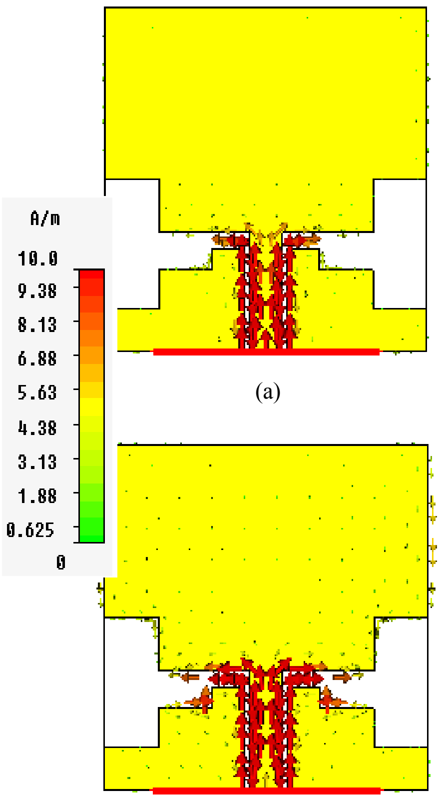


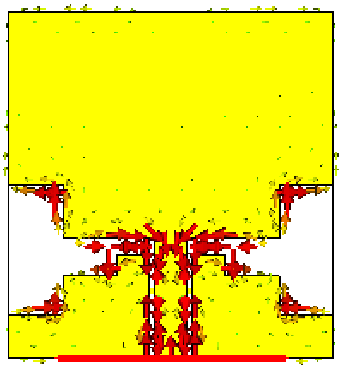
Fig. 6 Simulated result of proposed antenna with various 'Lg1'

Figs. 7 (a)-(c) show the current distribution in the antenna at 3GHz, 5 GHz and 8 GHz respectively. The current distribution is shown in form of vector plot showing surface current in form of arrows along the antenna structure. The area with more density of arrows shows the presence of large magnitude current values which can also be seen with the color scale given in left of the figure.



(a)

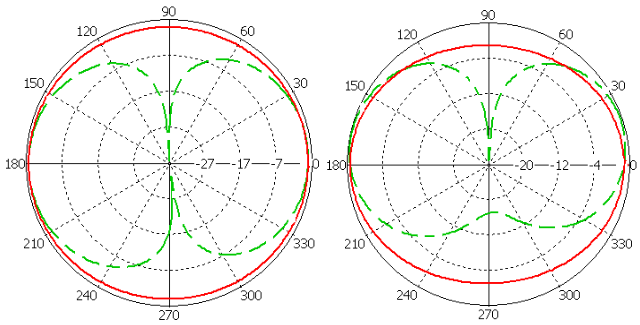
(b)



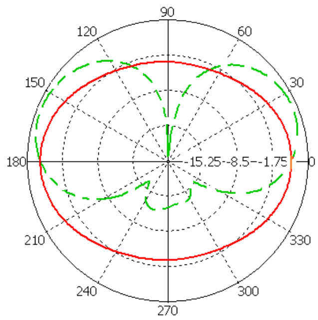
(c)

Fig. 7 Simulated current distributions of the proposed antenna at various frequencies

Here it can be seen that in low frequency ranges at 3 GHz (see Fig. 7 (a)) the maximum current distribution is around the central metallic conductor of the CPW feed and the lower region of the radiating patch and as the frequency increase the current components are also seen in the stepped ground planes and the bevels in the patch so as to improve the impedance matching which explains the role of stepped ground plane in improving the performance of the antenna in terms of improved impedance matching. Fig. 8 shows the radiation patterns of the proposed antenna at selective frequencies of 3, 5, 6 GHz respectively.



(a) (b)



(c)

Fig. 8 Stimulated radiation patterns of the proposed antenna (xz plane, omnidirectional-H plane, Bidirectional-E plane) at three different frequencies.

It is seen that the radiation patterns of the antenna with MGS in H-plane (*x-z* plane) are nearly omnidirectional in entire band of operation and radiation patterns in the E- plane (*y-z* plane) resembles figure of eight and are bidirectional. The obtained monopoles like radiation pattern are suitable for the practical wireless applications. The radiation patterns are stable.

Fig. 9 shows the simulated peak gain of the proposed antenna for the frequency band 2.7-8.3 GHz. Maximum gain of the antenna with MGS is 5 dBi at 8 GHz. It can be noticed that antenna has stable radiation patterns (see figure 8) and achieves improved gain values at higher frequencies (see Fig. 9). The gain of the proposed antenna is effectively high for practical wireless applications.

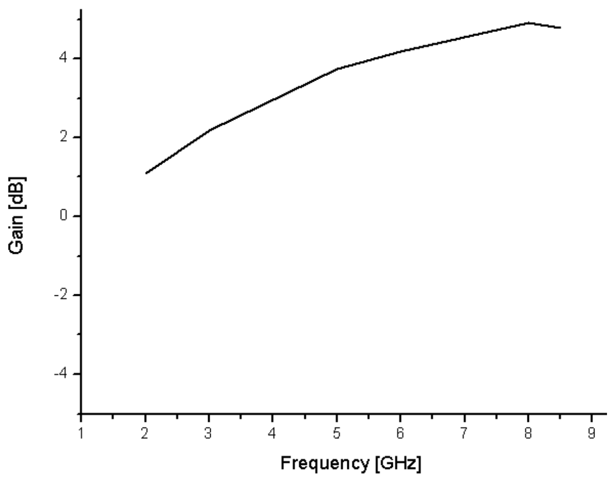


Fig. 9 Peak gain of the proposed antenna

IV. Conclusion

CPW fed patch antenna has been designed, fabricated, parametrically analyzed and characterized to obtain broad band characteristics with modified ground structure. The wideband has been achieved by optimizing the dimensions of the ground planes and by etching two symmetric square shaped bevels in radiating patch. The measured impedance bandwidth (VSWR< 2) of proposed antenna is 3.8 GHz. The antenna offers satisfactory gain across the operating band. The antenna geometry is simple and can be easily implemented.

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