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Bandwidth Enhancement in CPW Fed Rectangular Patch Antenna by Modified Ground Structure

Kirti Vyas, P. K. Singhal

***Abstract*— This paper presents a novel compact CPW fed patch antenna operating in broadband from 2.6 GHz- 9.1 GHz. The antenna is compact with dimensions 30 x 32 x 1.6 mm^3, built over FR4-epoxy substrate (ε_r=4.4). Bandwidth enhancement has been achieved by using the concept of modified ground structure (MGS). The structural design of the antenna has been optimized by CST MWS. The proposed antenna is able to operate well in various wireless communication applications such as 5.725 GHz- 5.825 GHz WLAN IEEE 802.11 g/a, 3.5/5.5/ 5.8 GHz Wi-Fi, Wi-MAX bands at 3.4 - 3.69 GHz, and 5.25 - 5.85 GHz bands, lower UWB band from 3.1-9.1 GHz. The measured results show that gain of antenna is maximum 4.9 dBi at 8 GHz. The proposed antenna performance is analyzed in terms of reflection coefficient, radiation characteristics, current distribution and gain.**

***Index Terms*— Broadband antenna, Compact, CPW fed, Modified Ground Structure, WLAN, Wi-Fi, Wi-Max, CST MWS.**

I. Introduction

Rapid increase in use of mobile wireless communication systems has lead to advancements in conventional printed antennas such that they are able to fulfill the requirement of broadband operations. Since the printed antennas have narrow bandwidth; so to improve upon this coplanar waveguide (CPW) feed type is favored which can be integrated with active devices and MMIC. The planar monopole antennas with coplanar waveguide feeding mechanism have gained researchers attention due to their advantages over microstrip line fed antennas, as they have low dispersion characteristics, low radiation leakage, the ability to effectively control the characteristic impedance, and the ease of integration with active devices. Also there has been rising need to build compact antenna which can be fitted in small devices and can cover wideband operations. For this purpose, antennas with broadband characteristics are in strong demand [1-12]. These broadband antennas should be able to serve for various wireless applications such as WLAN IEEE 802.11 g/a (5.725 GHz- 5.825 GHz), 5.5/ 5.8 GHz Wi-Fi applications, Wi-MAX bands at, 3.4 - 3.69 GHz, and 5.25 - 5.85 GHz bands, HIPERLAN/2 specified 5.470 to 5.725 GHz band.

This work explains design of a compact broadband patch antenna using MGS technique which can cover various wireless applications listed above and which is easy to implement. The MGS concept and cutting slots in the radiating patch at optimized locations is used to enhance the bandwidth and improve the impedance matching [12].

II. PROPOSED ANTENNA CONFIGURATION

Figure 1 shows proposed CPW fed patch antenna with modified ground planes. Four rectangular slots are cut in the the radiating patch to enhance the bandwidth. The width of the central strip of CPW antennas is of W_f= 3 mm, and the gap between the central strip and ground planes is 'g'= 0.5 mm.

The final design parameters obtained for the proposed patch antenna are L= 32 mm, W = 30 mm, g = 0.5 mm, W_f = 3mm, L_1 = 5 mm, L2 = 1 mm, W2 = 1 mm, Lg1 = 9.5 mm, Lg2 = 7.5mm, Lg3 = 3.9 mm, W1= 5 mm. Fr4 is used as dielectric substrate having relative dielectric constant (εr) of 4.4, loss tangent value of 0.02 and thickness 'h' of 1.6 mm.

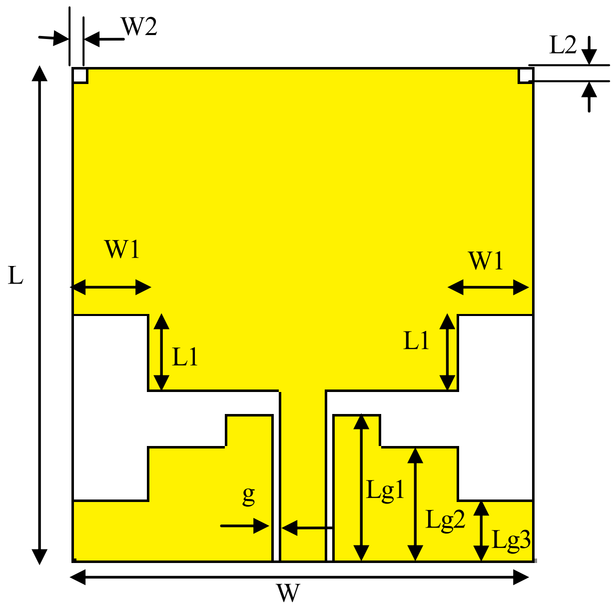

Fig.1. The structural design of proposed antenna

The proposed antenna has printed metallic structure on top of the substrate where as remaining bottom side is without any metallization. Figure 2 shows the fabricated patch

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Kirti Vyas, Research scholar, ECE Deptt. Bhagwant University, Ajmer, Rajasthan, India, 9929164029(e-mail: kirtivyas19@gamil.com).She is M. Tech Coordinator in ECE Deptt. ACEIT, Kukas, Jaipur.
P. K. Singhal, ECE Deptt., MITS Gwalior India, 09425341555.,(e-mail: pks_65@yahoo.com).

antenna prototype. The next section shows the characterized results and the parametric study performed on the antenna structure.

Fig.2. The fabricated prototype of antenna

III. RESULTS AND DISCUSSIONS

Proposed antenna is simulated with CST MWS. The CPW fed central metal strip width W_f, length and the gap (g) between the central metal strip and the coplanar waveguide ground planes are 3mm, 11 mm and 0.5 mm, respectively, in order to obtain 50 Ω CPW feed line. The rectangular radiating element of designed antenna has four rectangular slots etched from four corners to enhance impedance bandwidth. The fabricated antenna is characterized with Rohde and Schwarz vector network analyzer ZVA40 for reflection coefficient versus frequency characteristics, which is plotted with the simulated results in figure 3.

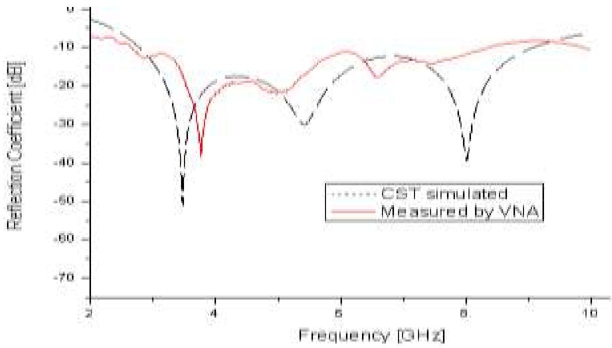

Fig.3. Return loss of proposed antenna

The simulated results of reflection coefficient versus frequency are in good agreement. The proposed CPW fed antenna has a huge impedance bandwidth with modified symmetrical ground planes. The proposed antenna is covering an appreciable bandwidth of 2.6 GHz to 9.1 GHz and thus becomes practical for present wireless applications. In order to achieve good impedance matching; optimized dimensions of the MGS 'Lg1', 'Lg2' and 'Lg3' are calculated**.** Figure 4 show the effect of variation of length 'Lg1' with the frequency and it is noted that the optimized value of 'Lg1' chosen is 9.5 mm as the other value gives lesser bandwidth.

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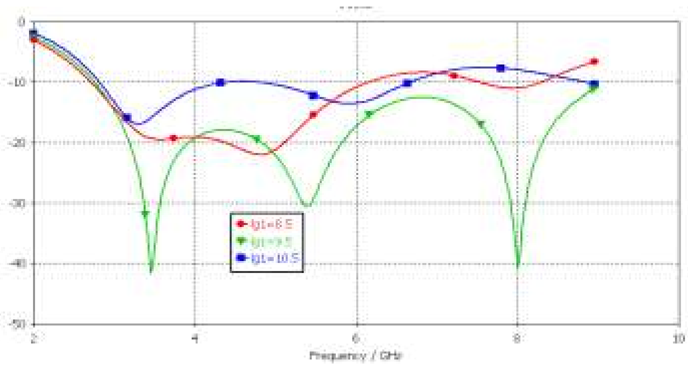


Fig. 4. Effect of Variation of Length 'Lg1'

Hence we start analysis with varying Length 'Lg2' keeping all parameters same. Figure 5 shows the effect of length 'Lg2' on the proposed antenna. As per the simulated results; most desired wideband is obtained at 'Lg2' = 7.5 mm. For 'Lg2' values lesser and greater than 7.5 mm yield poor impedance matching and may lead to fabrication tolerances.

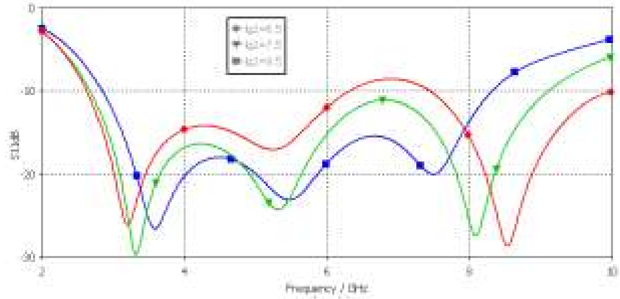


Fig.5 Effect of Lg2 on return loss

Figure 6 shows the parametric simulation of 'Lg3' with reflection coefficient. It shows S11 verses frequency curves for Length 'Lg3' varied from 2.9 mm to 4.9 mm. The results are best at 'Lg3' =3.9 mm as it gives better impedance matching. 'Lg3'=2.9mm gives less impedance bandwidth as it decreases the upper cut of frequency and 'Lg3'=4.9 mm gives poor impedance matching at higher frequencies.

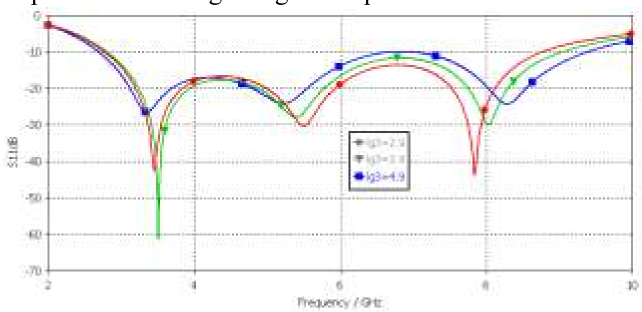


Fig.6 Effect of Lg3 on return loss

Figure 7 shows the smith chart of the proposed antenna. It can be seen that the antenna has well matched input impedance and also the smith chart curve lies within VSWR=1 circle for the entire band of operation.

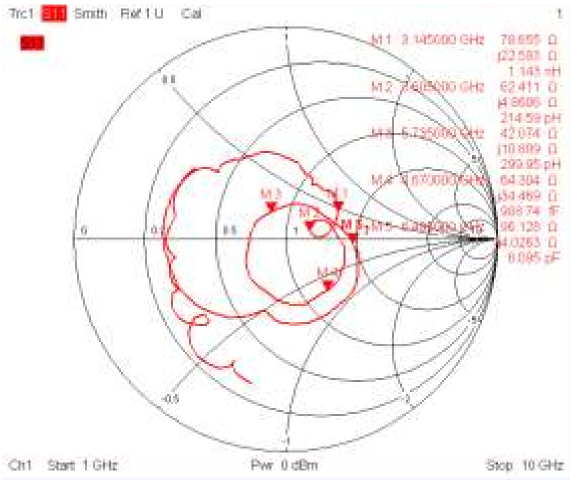
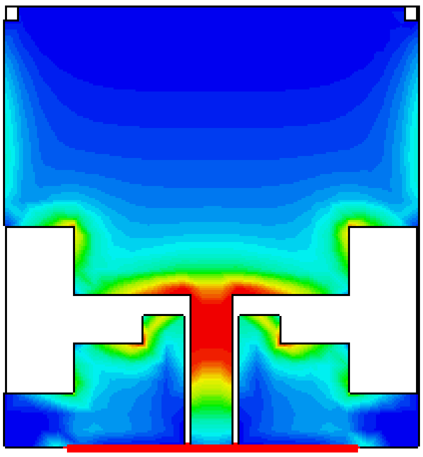
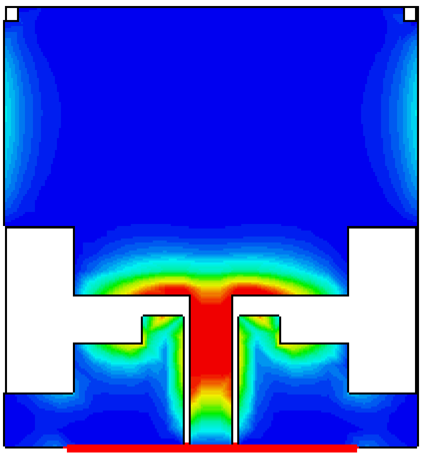


Fig. 7. Smith chart

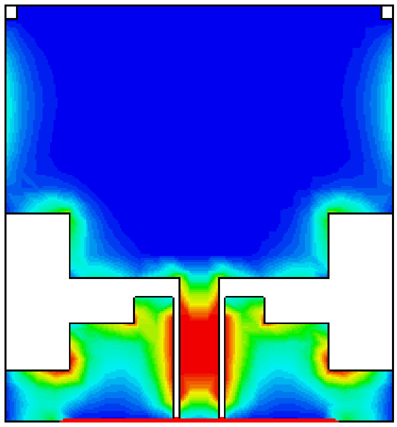
Figure 8 shows the current distribution in the antenna at various frequencies. The current value is high along central metallic strip of the CPW feed and lower edge of the main radiating patch of the proposed antenna for the lower frequency value around 3GHz and 5 GHz where at higher frequency around 8 GHz the current due to higher order modes is spreading in the upper edge of the radiating patch so as to improve the impedance matching (see figure 8).



(a) 3 GHz



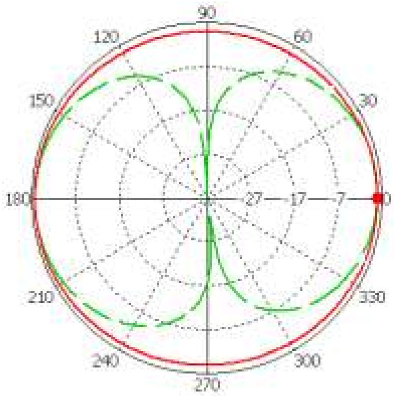
(b) 5 GHz



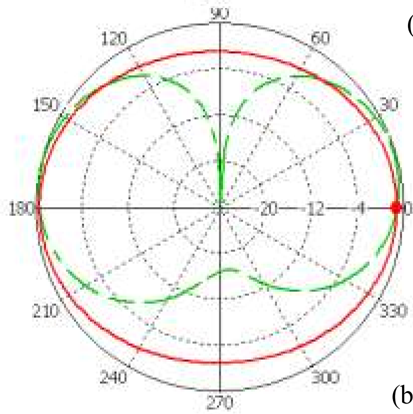
(c) 8 GHz

Fig.8. Simulated current distributions of the proposed antenna at various frequencies

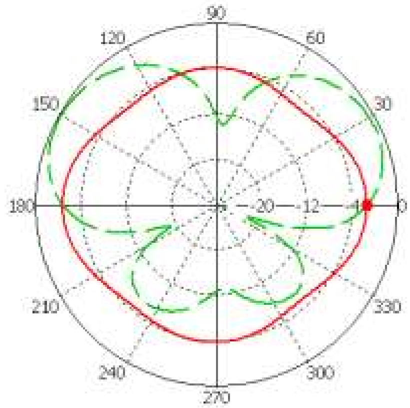
Figure 9 shows the radiation patterns of the proposed antenna at selective frequencies of 3 GHz, 5 GHz, 7 GHz, 9 GHz respectively.



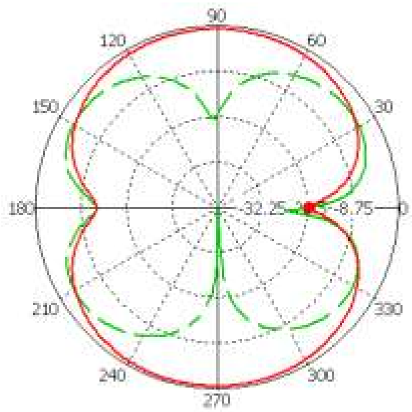
(a) 3GHz



(b) 5 GHz



(c) 7 GHz



(d) 9 GHz

Fig. 9. Stimulated radiation patterns of the proposed antenna (xz plane, omnidirectional (Red line (solid))-H plane, Bidirectional(Green line (dashed))-E plane at four 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[12]. Figure 10 shows the peak gain of the proposed antenna for the frequency band of 2.6 GHz- 9.1 GHz. Maximum gain of the antenna with MGS is 4.8 dBi at 8 GHz. It can be noticed that antenna has stable radiation patterns (see figure 9) and achieves improved gain values at higher frequencies (see figure 10). The gain of the proposed antenna is effectively high for practical wireless applications.

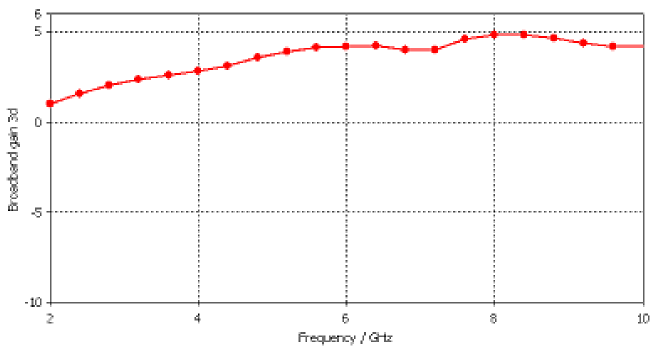


Fig.10 Gain verses frequency curve

IV. CONCLUSION

In this paper a novel compact CPW fed patch antenna with modified ground plane has been proposed to obtain broadband characteristics. The fabricated antenna is tested and is found to give impedance bandwidth in 2.6 GHz- 9.1 GHz band. The broadband characteristics have been achieved by stepped symmetric ground planes. The antenna offers sufficient gain across the operating band. The antenna structure is simple and easy to implement.

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Kirti Vyas was born in Jaipur (India). She received M.Tech degree in Electronics and communication from the Malvia National Institute of Technology, Jaipur, Rajasthan, India in 2008. She is M.Tech coordinator at the Arya College of Engineering and I.T., Kukas, Jaipur, Rajasthan, India. She is pursuing her Ph.D. from ECE Deptt. , Bhagwant University, Ajmer, Rajasthan, India. Her main research interests are design and optimization of patch antennas. She has about more than 30 publications to his credit at the national and international level.

Prof P.K. Singhal received his B.E. and Ph.D. Degrees in Electronics Engineering from Jiwaji University, Gwalior (MP) India, in 1987 and 1997, respectively, and the M.Tech degree in Microwave Electronics from the University of Delhi, India in 1989. Currently, he is working as Professor, in the department of Electronics Engineering, Madhav Institute of Technology and Science, Gwalior (MP), India. He has about more than 100 publications to his credit at the national and International level. His research interest includes electromagnetic, antennas, microwave circuits & communication systems.