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AN INVESTIGATION OF CPW-FED DUAL RECTANGULAR SLOT (DRS) MICROSTRIP PATCH FOR WLAN AND 5G-NR APPLICATIONS

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Abstract:

This research paper represents the investigation of CPW-fed microstrip slot antenna for WLAN applications. A dual rectangular slot based micrstrip patch antenna placed on dielectric substrate is fed by a 50Ω CPW transmission line, results an impedance bandwidth of 2.2 GHz for 5.2 to 7.4 GHz frequency band with. Gain of 2.4 dB and 2.2 dB at 5.6 GHz and 6.8 GHz, respectively. The CPW fed antenna performance are studied for different feed gap height (h) and ground plane width (W) in order to obtain its optimized performance at 5.6 GHz and 6.8 GHz for wide band based WLAN and 5G-NR (n-96) applications, respectively.

Keywords: Microstrip Patch Antenna, CPW, 5G, WLAN.

1. INTRODUCTION

Now a day, 5G and WLAN based wireless communication technology has gained major growth due to their extensive use in portable devices such as mobile phones, laptops and smart TVs. During this decade the 5G-NR based communication devices have grown rapidly due to their high speed data communication with high accessibility. Similarly the WLAN based wireless communication devices got major attention due to their high internet speed as for localized users [1-2]. Hence the microstrip patch antennas get tremendous growth for these wireless communication techniques, due to their light weight, low profile, with single feed facilitates provide an easy connection for portable devices and other equipment's. Therefore the microstrip patch antenna should satisfy the WLAN standards for 2.4GHz, 5.2GHz, or 5.8 GHz operating bands and 5G-NR (n-96) standard for high speed wireless communication [3]. The 2.4 GHz WLAN system has the frequency range from 2.4 GHz to 2.48GHz, whereas the 5GHz WLAN system has the frequency range of 5.15 GHz-5.35GHz and 5.725GHz-5.825GHz for IEEE 802.11b IEEE 802.11a specifications respectively. At present, the 2.4GHz band has been explored for WLAN application. The market demands show the shifting to 5GHz WLAN system instead of 2.4GHz for mobile applications [3-4]. So far various microstrip patch antennas have been developed which satisfies the IEEE 802.11 standards. However a very limited work is done for 5G-NR based mobile communication. Recently, various planar wideband monopole antennas have been developed by using either a microstrip line or cpw feeds, because of their attractive characteristics in terms of wideband, better radiation pattern

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[5-6]. Here the ground plane is placed along with the radiating patch on the same side of the substrate with the help of CPW transmission line, owing the ease of fabrication. Therefore these patch antennas emit less radiation loss, which allows them to permit the shunt as well as series connections on one side of the substrate [7]. Hence the thick substrate can be integrated with microstrip antenna, which results in better efficiency and improved bandwidth [4].

In this paper, the cpw-fed slot antenna is investigated for wideband and multiband characteristics. The design parameters of the antenna such as dimension of the coplanar ground planes is extensively analyzed through Ansoft HFSS simulations for the optimal radiation characteristics of microstrip patch for 5G-NR and WLAN Applications.

2. DESIGN OF CPW FED SLOT ANTENNA

This paper presents a cpw-fed single layered metallic dual rectangular slot patch antenna. The antenna has been designed on a Rogers Duroid substrate with relative dielectric constant of 2.33, loss tangent of 0.0012 and thickness of 1.59 mm. Here the proposed microtrip patch designed with substrate dimensions for width (W) and the length (L_{AS}) is 40mm and 24mm respectively. Here Lp and Wp are the length and width of the patch, connected to the 50Ω cpw feed line of a central conductor strip width (W_f = 1.55mm) with gap (S_p=0.2mm). Here a rectangular patch consists the length L_p and width W_p at a feedgap height of (h) from ground plane. Further there are two rectangular slots are created inside the patch with the slot width of (P_s=0.6mm) as shown in fig. 1(a).

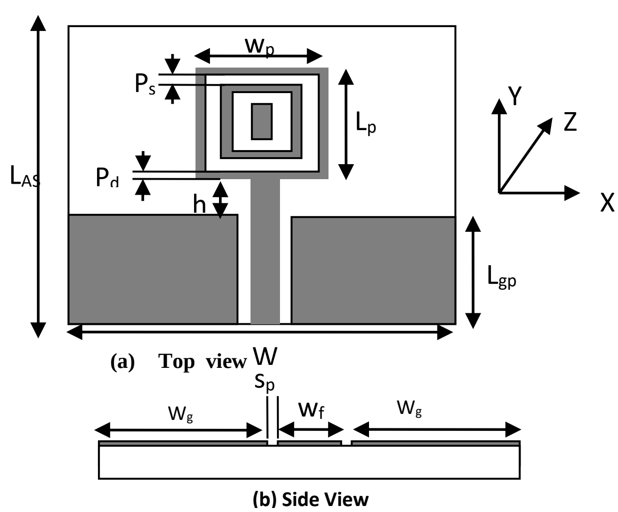

Fig. 1: Schematic view of the CPW fed rectangular slot patch antenna design: L_{AS} =24mm, W =40mm, L_{gp} = 15mm, W_p = 6mm, L_p = 7mm, S_p = 0.2mm, P_s = 0.6mm, P_d = 0.3mm, h=0.7mm

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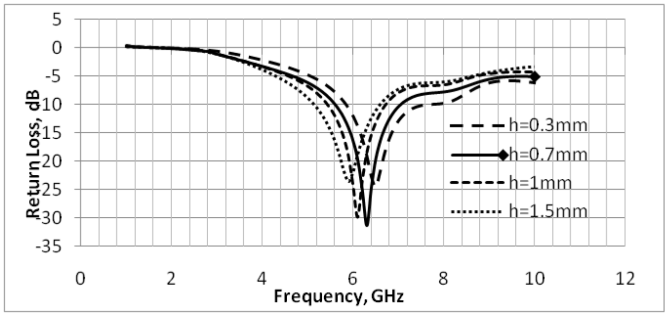

Fig. 2: The return loss curves for single rectangular patch (without slots) for various feed gap height (h) with ground width W=35mm

3. EFFECTS OF DESIGN PARAMETERS

The optimized performance of the proposed CPW fed slot based microstrip patch antenna is majorly dependent on feed gap height (h), and width of ground plane (W) for the CPW transmission line. Hence it is required to optimize these parameters for multiband resonance and bandwidth enhancement.

A. The feed gap height (h) effect

The return loss curves are plotted for the various feed gap height (h =0.3mm, 0.7mm, 1mm and 1.5 mm) when the ground plane width (W) is 35 mm as shown in fig. 2. Here it is seen that the -10 dB bandwidth changes significantly with the variation of feed gap height (h). Here it is also observed that the bandwidth increases when the feed gap (h) gets smaller and also it has been noticed that the resonant frequency gets increases when (h) reduces. For lower values of feed gap height (h) the bandwidth increases, however the resonant frequency get shifted to higher frequency band at feed gap h=0.3mm as shown in fig. 2. Therefore the feed gap (h=0.3mm) cannot be used for 5GHz WLAN standards because of higher resonant frequencies. Therefore the gap height (h) is chosen 0.7 mm for better impedance matching and wideband characteristics with minimal resonant frequency variation.

B. The ground plane width effect

The simulated return loss curves Dual rectangular slots with optimal feed gap (h) of 0.7 mm for different widths (W =35mm and 40mm) of the ground planes are shown in Fig.3. Here it is observed that the return loss curves vary remarkably, as it seems that the width (W) of ground plane also plays a major role for the impedance matching and bandwidth enhancement. It is also clearly seen that at W=40mm and h=0.7mm, the proposed slot based microstrip patch exhibit wideband resonance from 5.2 GHz to 7.6 GHz. Here it is observed that as the lower value of ground plane width results with a narrow bandwidth. Hence the ground plane width is chosen 40 mm for wide bandwidth applications for 5G and WLAN based wireless communication.

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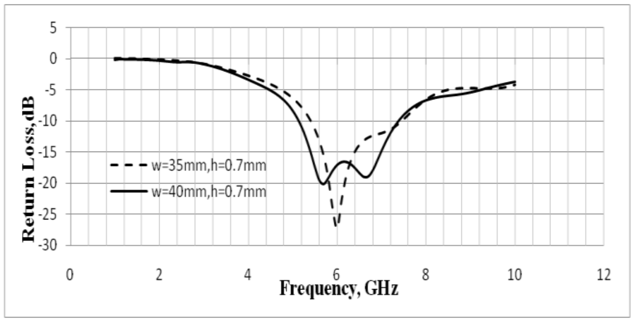

Fig. 3: The return loss curve for Dual rectangular slots for various ground plane width (W) with feed gap height h =0.7mm

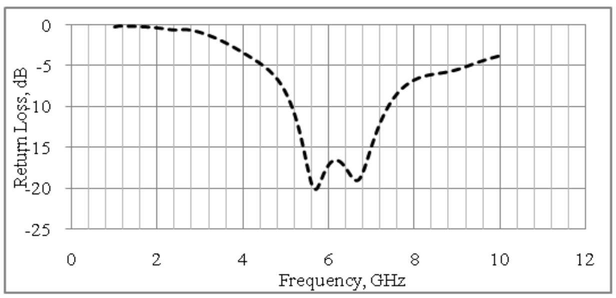

Fig.4: the Return loss plot for CPW-fed slot microstrip patch antenna with the feed gap height h =0.7mm and ground width of 40mm.

4. RESULTS AND DISCUSSION

The performance of the proposed cpw-fed dual rectangular slot (DRS) microstrip patch is analyzed through the Ansys HFSS simulations. Fig. 4 depicts the simulated results of S_{11} for the proposed dual rectangular slot. Here it is observed that by introducing slot inside the rectangular patch, a new resonance get excited through the resonator, whose resonant frequency is slightly higher than the rectangular patch resonant frequency. Here two slots are introduced to the rectangular patch, hence three resonators show three resonance frequencies, when these three resonators are get combined gives a wideband response as shown in fig. 2 [8]. The slot should be coupled with the cpw feed in order to provide the better radiation properties. Here it is also observed that the introduction of various slots generates an additional inductive reactance which ultimately balances the capacitive reactance of the whole microstrip patch [9-10].

The simulated radiation patterns at 5.6GHz and 6.8 GHz are plotted in Fig. 5 and 6, respectively. Here for E and H plane co-polar radiation patterns are simulated for E_θ at ϕ=90 and $E_\varnothing$ at ϕ=0 respectively, whereas E and H-plane cross-polar radiation pattern

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are simulated for E_{ϕ} at ϕ=90 and E_{θ} at ϕ=0 respectively. Fig. 5 (a) & (b) shows the simulated radiation pattern E and H plane for w=40 mm and h=0.7mm at 5.6 GHz with a gain of 2.4 dB.

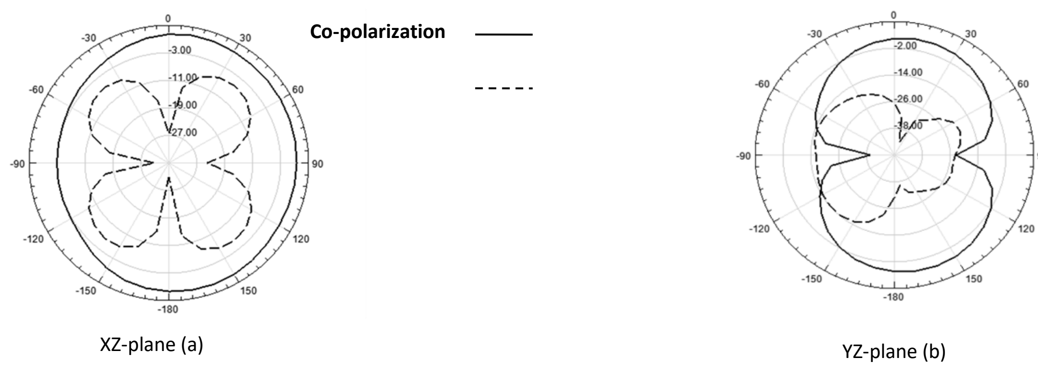

Fig. 5: The Simulated radiation pattern plots (a) E-plane (b) H-plane for CPW-fed Dual Rectangular Slot (DRS) microstrip patch at 5.6 GHz.

Fig. 6 (a) & (b) shows the simulated radiation pattern E plane and H plane for w=40 mm and h=0.7mm at 6.8 GHz. It is observed that this antenna radiate with gain of greater than 2.2 dB in both E & H planes. Here the cross-polarization is lower -10 dB & -20 dB as compared to co-polarization in both E & H Plane. According to IEEE standards the antenna designed with w=40 mm and h=0.7mm at 6.8 GHz is suitable 5G-NR communication and 5.6 GHz for WLAN applications.

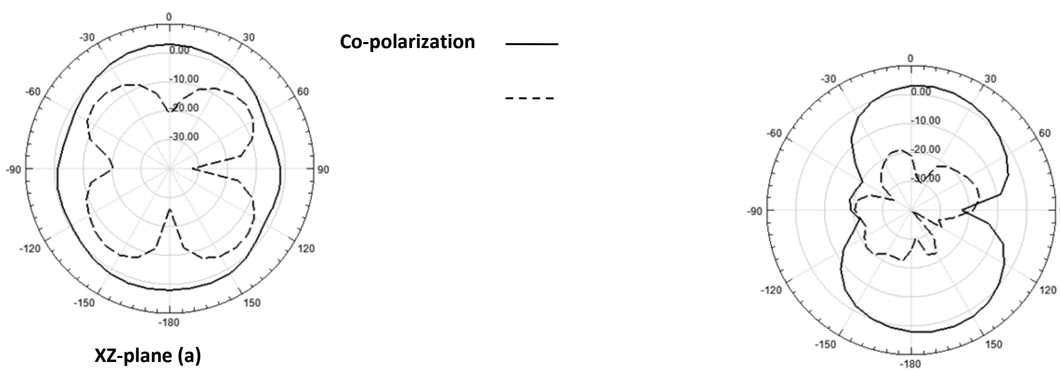

Fig. 6: The Simulated radiation pattern plots (a) E-plane (b) H-plane for CPW-fed Dual Rectangular Slot (DRS) microstrip patch 6.8 GHz.

5. CONCLUSION

A cpw-fed patch antenna with two rectangular slots has been designed and simulated. It has been observed that the feed gap height (h), the ground plane width (W) and the dual

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rectangular slots show great significance in deciding the performance of microstrip slot antenna. Here the proposed slot based antenna with feed gap (h) of 0.7mm and ground width (W) of 40mm can provide a large bandwidth of 2.2 GHz for the frequency range of 5.2 GHz to 7.4 GHz. Further it is observed that the same antenna can be used at multiple resonances at 5.6 GHz and 6.8 GHz with gain of 2.4 dB and 2.2 dB, respectively. Therefore the proposed antenna can be used for WLAN and 5G-NR (n96) based wireless communication applications as per the IEEE standards.

6. Acknowledgment

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References

❖ V. Niranjan, A.k Saxena and K.V Srivastava, " CPW-fed slot patch antenna for 5.2/5.8 GHz WLAN application", PIERS Proceedings, Kuala lumpur Malaysia, march 27-30, 2012.

❖ Swain, B. R., & Sharma, A. K... "An investigation of dual-band dual-squarering (DSR) based microstrip antenna for WiFi/WLAN and 5G-NR wireless applications". Progress in Electromagnetics Research M, 86, 17-26., 2019.

❖ H.-D. Chen, J.-S. Chen, and Y.-T Cheng, "Modified inverted-L monopole antenna for 2.4/5.2 GHz dual band operations", Electronic Letters, Vol. 39. No. 22, October 2003.

❖ Sahu, N. K., & Sharma, A. K. (2016, March). The investigation on bandwidth enhancement of microstrip slot antennas. In 2016 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET) (pp. 953-956). IEEE.

❖ S-M Deng, M-D Wu, and P. Hsu, "Analysis of coplanar waveguide-fed microstrip Antennas", IEEE Trans. Antennas Propag, Vol. 43, 734-737, July 1995.

❖ J. Liang, L. Guo, C.C Chiau, X. Chen and C.G Parini, "Study of cpw- fed circular disc monopole antenna for ultra wideband applications", IEE Proc.-Microw. Antennas Propag., Vol. 152, No. 6, December 2005.

❖ L. Giauffret, and J.-M Laheurte, "Theoritical and experimental characterization of cpw-fed microstrip antennas," IEEE Proc. – Micro. Antennas Propag., Vol. 143, No. 1, February 1996.

❖ Bonthu, M. K., & Sharma, A. K. (2019, March). An Investigation of Multiband Triangular Microstrip Patch Antenna using DGS. In 2019 International Conference on Wireless Communications Signal Processing and Networking (WiSPNET) (pp. 440-443). IEEE.

❖ W.-C. Liu, W.-C. And C.-M. Wu, "Broadband dual-frequency CPW-fed planar monopole antenna with rectangular notch," Electronic Letters, Vol. 40, No. 11, May 27, 2004.

❖ K. Chung, T. Yun, and J. Choi, "Wideband CPW-fed monopole antenna with parasitic elements and slots," Electronic Letters, Vol. 40, No. 27, August 2004.