# Compact Polarization Diversity Antenna for 28/38 GHz Bands

Syed S. Haider[1], Farooq A. Tahir[1], Hassan Tariq Chattha[2], Qammer H. Abbasi[3]

[1]Research Institute for Microwave and Millimeter-wave Studies, National University of Sciences and Technology, Islamabad, Pakistan

[2]Department of Electrical Engineering, Faculty of Engineering, Islamic University of Madinah, Al-Madinah, Saudi Arabia

[3]Department of Electrical and Electronic Engineering, University of Glasgow, Glasgow, UK

{shaider.msee15seecs, farooq.tahir}@seecs.edu.pk, chattha43@hotmail.com, qammer.abbasi@glasgow.ac.uk

***Abstract*— In this paper, design and analysis of a millimeter wave dual- and dual-polarized antenna for 5G millimeter communications system is presented. The proposed design has a compact structure with size of 5×5 mm². It consists of a rectangular patch with a crossed-slot etched off in the patch to reduce the interference between the two targeted 5G bands of 28 and 38 GHz. To achieve dual polarization performance, the radiating patch is fed by two different 50-Ω microstrip transmission lines. The antenna has -10dB impedance bandwidths of 2.6GHz (26.8-29.4 GHz) and 2.5GHz (37.7-40.2GHz) to cover 28/38 GHz mobile communication bands respectively. The antenna has the merits of miniaturized dimensions, stable broadside radiation patterns with high gains and low cross polarization in both bands of operation.**

***Keywords*— Fifth generation (5G), polarization diversity, orthogonal polarization, cross polarization, front to back ratio (FBR).***

## I. Introduction

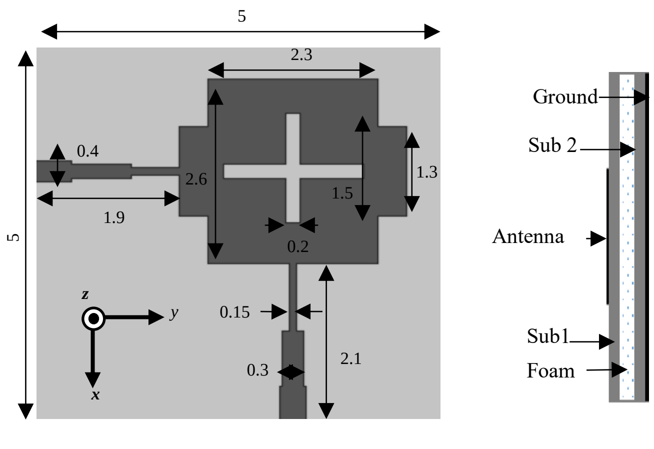
The accelerating utilization of information for social interactions has triggered research on millimeter-wave communications systems expected to provide thousand times channel capacity compared to 3G and 4G standards [1]. The main concern of millimeter wave communications is path loss and multi-channel fading due to shorter wavelengths. In multipath propagation environment, the antennas with polarization diversity play critical role in mitigating fading for reliable communications with improved channel capacity. Moreover, multi-band antennas perceive antenna miniaturization as they can realize functions of several antennas. Therefore, the antenna that exhibits dual-band and dual polarization characteristics will have great potential to meet the challenging requirements of 5G. The 28 and 38 GHz bands are potential frequencies for future 5G communications systems. To design an antenna which covers these two bands with capability of dual polarization is a challenging task.

In recent literature, various antennas targeting 5G requirements have been presented [2-9]. Although these antennas operate in different 5G bands, however, there is rarely any antenna design which is both dual band and dual polarized at a time. A cavity-backed aperture antenna operating at 28 GHz band and a Fabry-Perot cavity antenna (FPCA) operating at 38 GHz band are presented in [2] and [3] respectively. Although they have dual polarization with very good port-to-port isolation, yet they operate only in single 5G band. Some antennas [4-9] achieve dual-band characteristics however they lack dual polarization operation needed for reliable communications for 5G systems.

In this perspective, the authors have proposed dual polarized rectangular cross slot patch antenna operating at 28/38 GHz bands with high gain and better isolation between the ports. The designed single element antenna can further be extended into an array to achieve higher directivities.

## II. ANTEENA DESIGN

Fig. 1 depicts the physical geometry of the proposed antenna. The antenna is designed on a W×L=5×5 mm² Rogers's substrate (RT/Duroid 5880) with dielectric constant 2.2, thickness 0.254mm, and loss tangent 0.0009. The radiating patch is fed by two 50Ω microstrip lines to generate two orthogonal polarization modes.




(a) (b)

Fig. 1: Proposed antenna geometry (a) front view (b) side view.

A cross slot is etched off the radiating patch to reduce the interference between the two targeted 5G bands (28/38 GHz). A notch is thus created eliminating 31-37 GHz spectrum. The antenna is backed with a complete ground plane to achieve broadside radiation patterns with high gain as shown in Fig.1. A thin layer of foam [of thickness 0.6mm and $\varepsilon_r$=1.1] is added between the substrate 1 and 2.

## III. RESULTS AND DISCUSSION

The proposed antenna is simulated using full-wave EM simulator Ansoft HFSS. The simulated S-parameters are shown in Fig.2 which clearly illustrates -10dB common impedance bandwidth of both ports from 26.8-29.4 GHz and 37.7-40.2GHz

Achieved isolation between the two ports is better than -18dB. As the antenna structure is symmetric, $S_{12}$ and $S_{21}$ overlaps in Fig.2.

The simulated broadside gain is shown in Fig.3. A constant broadside gain of 7.7dBi in the first operating band (28GHz) and

9.4dBi in the second operating band (38GHz) are observed respectively. The cross-polarization gain is quite low as depicted in Fig. 3.

Fig.4 and Fig.5 demonstrates the radiation patterns (XZ cuts) of the designed antenna at 28GHz and 38GHz respectively. These radiation patterns are obtained by feeding one port while terminating other port with the 50Ω matched load. Fig.4 and Fig.5 shows very low cross polarization for both the ports.

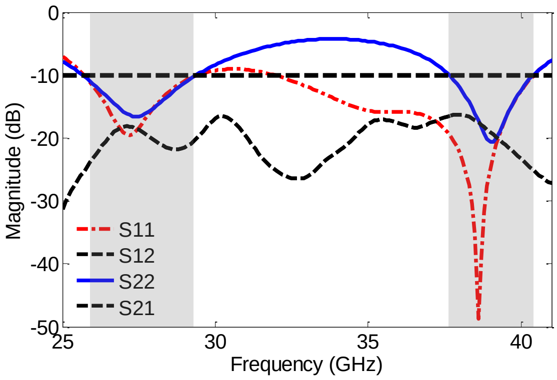



Fig. 2: Simulated S-parameters (dB)

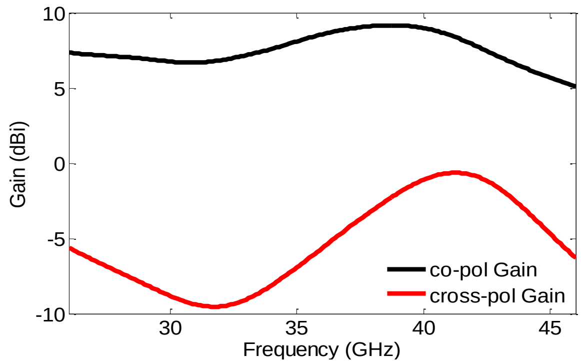



Fig. 3: Co and Cross polarization gain of port 1

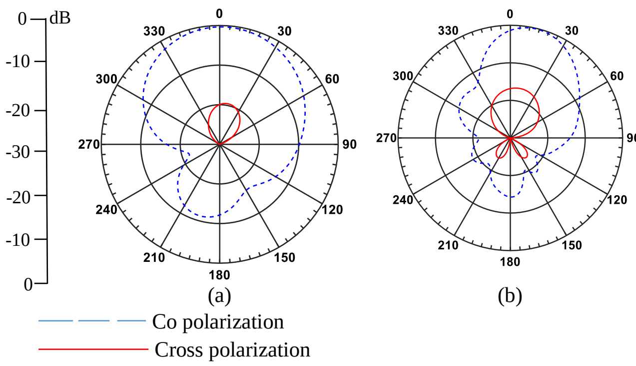



Fig. 4: Normalized radiation pattern (a) xz cut when port 1 is excited, (b) xz cut when port 2 is excited at 28GHz

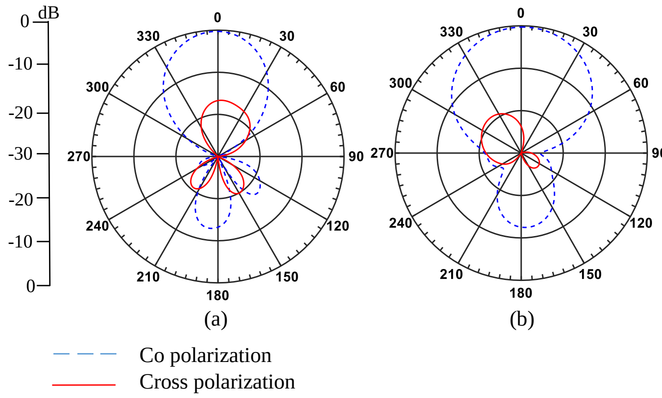



Fig. 5: Normalized radiation pattern (a) XZ cut when port 1 is excited, (b) xz cut when port 2 is excited at 38GHz

## IV. CONCLUSION

A compact microstrip dual band polarization diversity antenna for millimeter wave applications is proposed. The antenna operates at 28/38 GHz having 12% -10dB reflection coefficient bandwidth. The merits of the proposed design are compact dimensions, dual-band dual-polarized characteristics, stable radiation patterns and gains, good port-to-port isolation with very low cross polarization. These design capabilities make it a good candidate for future millimeter wave communications.

## REFERENCES


[1] Y. Wang, J. Li, L. Huang, Y. Jing, A. Georgakopoulos, and P. Demestichas, "5G mobile: spectrum broadening to higher-frequency bands to support high data rates," *IEEE Vehicular Technology Magazine*, vol. 9, no. 3, pp. 39–46, 2014.

[2] Liu, Shih-Ting, Yao-Wen Hsu, and Yi-Cheng Lin. "A dual polarized cavity-backed aperture antenna for 5G mmW MIMO applications." Microwaves, Communications, Antennas and Electronic Systems (COMCAS), 2015 IEEE International Conference on. IEEE, 2015.

[3] Tan, Guan-Nan, Xue-Xia Yang, and Bing Han. "A dual-polarized Fabry-Perot cavity antenna at millimeter wave band with high gain." *Antennas and Propagation (APCAP), 2015 IEEE 4th Asia-Pacific Conference on*. IEEE, 2015.

[4] Haraz, Osama M., et al. "Design of a 28/38 GHz dual-band printed slot antenna for the future 5G mobile communication Networks." *2015 IEEE International Symposium on Antennas and Propagation & USNC/URSI National Radio Science Meeting*. IEEE, 2015.

[5] Ali, Mohamed Mamdouh M., and Abdel-Razik Sebak. "Dual band (28/38 GHz) CPW slot directive antenna for future 5G cellular applications." *Antennas and Propagation (APSURSI), 2016 IEEE International Symposium on*. IEEE, 2016.

[6] Tan, Ming-Tao, and Bing-Zhong Wang. "A Compact Dual-Band Dual-Polarized Loop-Slot Planar Antenna." *IEEE Antennas and Wireless Propagation Letters"*, vol 14, pp., 1742-1745, 2015.

[7] H. Ullah, F. A. Tahir and M. U. Khan, "Dual-band planar spiral monopole antenna for 28/38 GHz frequency bands," 2017 IEEE International Symposium on Antennas and Propagation & USNC/URSI National Radio Science Meeting', San Diego, CA, USA, 2017, pp. 761-762. 2017.

[8] H. Ullah and F. A. Tahir, " A Broadband Planar Rhombus Monopole Antenna for 28 GHz Millimeter-Wave Communications," Accpeted, 12the European Conference on Antennas and Propagation, Apr 9-14, London, UK, 2018.

[9] H. Ullah, F. A. Tahir and M. U. Khan, " A Honeycomb-Shaped Planar Monopole Antenna for Broadband Millimeter-wave Applications", 11the European Confernce on Antennas and Propagation, Paris, France, 19-24 Mar, 2018.