A Compact Elliptical Microstrip Patch Antenna for Future 5G Mobile Wireless Communication

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Abstract

In this paper an elliptical inset fed microstrip patch antenna is proposed for future fifth generation (5G) mobile communications. The antenna is mounted on a compact Fr-4 substrate having dimensions 5 X 5 X 1.6 mm^3 with relative permittivity (ε_r) 4.4.The antenna is simulated in the HFSS software and the simulated results shows that it is operating at 28 GHz for reflection co-efficient (S_{11}) below -10dB and has relatively stable radiation pattern.

Keywords

5G;
Fr-4;
Antenna Design;
HFSS (High Frequency Structure Simulator);
Wireless communication.

I. INTRODUCTION

In the past few years mobile wireless communication has experienced various generations from 0G to 4G technology[1-2].First generation (1G) mobile system supports only analog voice. Within few years after 1G there has been a drastic development in the field of mobile communication, which leads to birth of 2G, 3G, 3.5G, 4G, 4.5G and 5G as illustrated in Fig. 1. Each generation utilizes different digital communication techniques like cellular frequency reuse, packet switching, modulation etc [3].

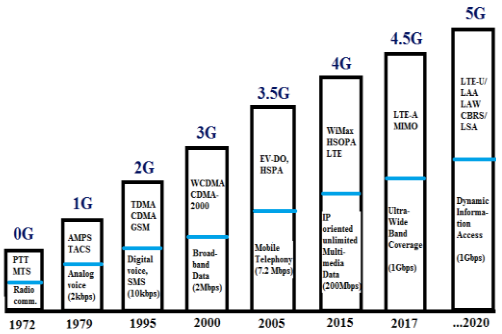

Fig. 1: Overview of generations in mobile wireless communication.

In the present day life mobile has become a very essential part of our life. Earlier mobile phones were carried out for the purpose of talking to people. But now, the mobile phone application has increased to such a high extent that it has emerged an important necessity for everyone to carry out their day to day activities [4] like shopping, trip planning, navigation etc. To meet all these needs a high speed data rate cellular network is required. The 4G wireless communication systems has already been deployed in almost all countries. However 4G still cannot accommodate some challenges like spectrum crisis, high energy consumption, poor coverage, bad interconnectivity, poor Quality of Service (QoS) and flexibility [5-6]. To address all these demands 5G wireless system are expected to be deployed in the future by 2020 [7].

To fulfill all the needs of fifth generation (5G) wireless system to facilitate higher data rate, better reliability, more connectivity, lower latency and improved security features wireless system designers need a new concept and design approach [8-9]. Recently some work has done by the authors in designing 5G antennas that has published [10-12].The millimeter wave (mm-wave) frequencies are likely to use by 5G [13]. In the present work 28 GHz inset feed elliptical antenna for future 5G wireless communication has proposed. The antenna is designed in HFSS and simulated results are presented.

II. ANTENNA DESIGN

A. Design I

The geometry of the proposed antenna for future 5G wireless mobile communications is shown in Fig. 2. The patch of the antenna is in the shape of ellipse and its dimensions are illustrated in Table 1. The antenna is designed on a compact Fr-4 substrate with relative permittivity (ε_r) of 4.4 having dimensions W X L X h mm^3 . The proposed geometry is simulated in HFSS and reflection co-efficient (S_{11}) is observed and shown in Fig. 3.

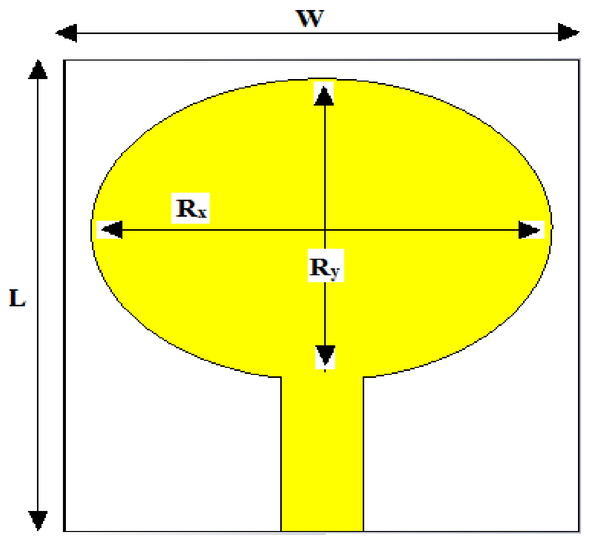

Fig. 2(a): Design I top view.

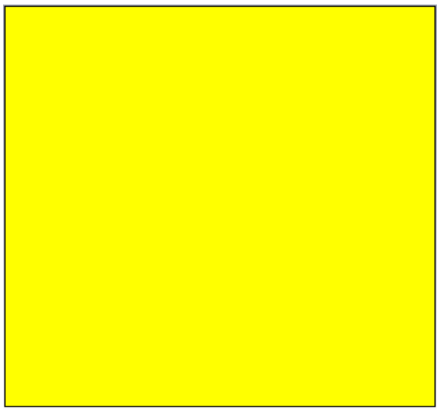

Fig. 2(b): Design I bottom view.

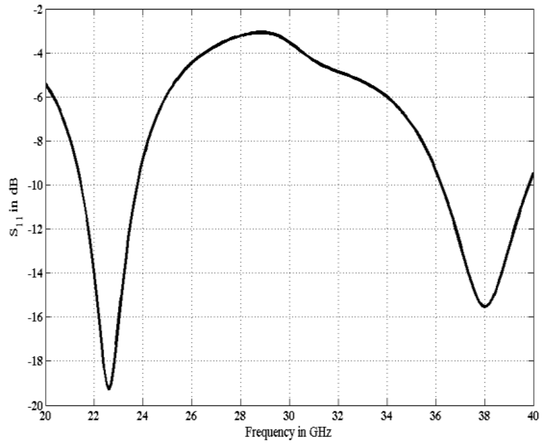

Fig. 3: Reflection co-efficient (S_{11}) of primary design.

B. Design II

To match the impedance of the antenna to 50 ohm inset feed is given to the primary design as shown in Fig. 4. The simulated reflection co-efficient (S_{11}) and input impedance results after inset feed are shown in Fig. 5 and Fig. 6 respectively.

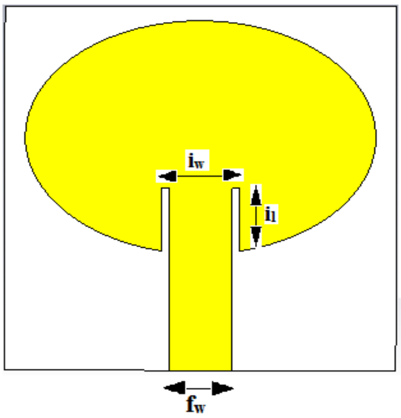

Fig. 4: Design II Top View.

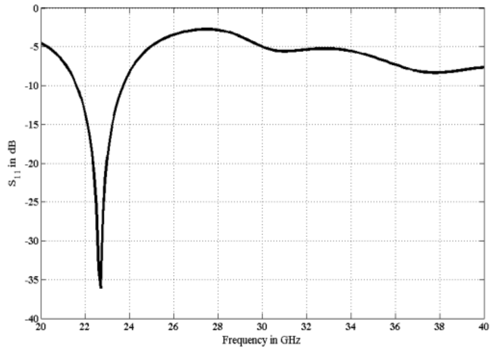

Fig. 5: Reflection co-efficient (S_{11}) with inset feed.

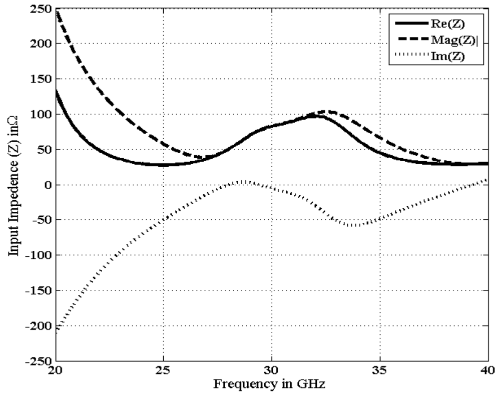

Fig. 6: Input impedance (Z) of Design II.

C. Design III

In order to tune the antenna to 28 GHz a portion of the ground of length 'g_l' is removed and parameter variation is done on variable 'g_l' and reflection co-efficient (S_{11}) at different values of g_l is shown in Fig. 7. At 'g_l=1.8mm' the antenna has good resonance at 28 GHz is observed. The final design and its reflection co-efficient (S_{11}) are shown in Fig. 8 and Fig. 9 respectively. The final antenna has a impedance bandwidth of 26.6 to 32.1 GHz.

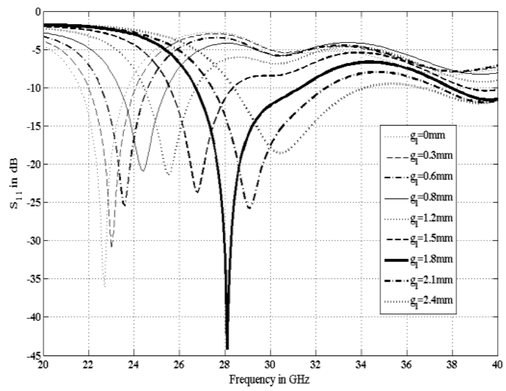

Fig. 7: Reflection co-efficient (S_{11}) with varying 'g_l'.

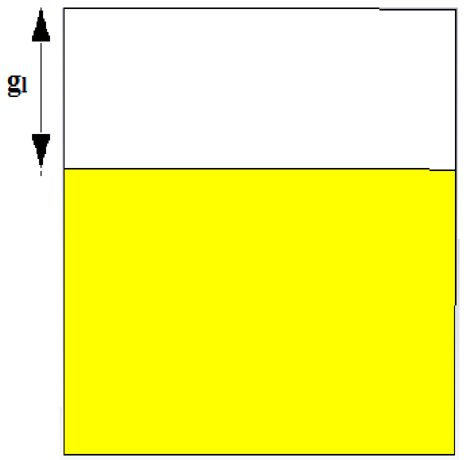

Fig. 8: Design III bottom view.

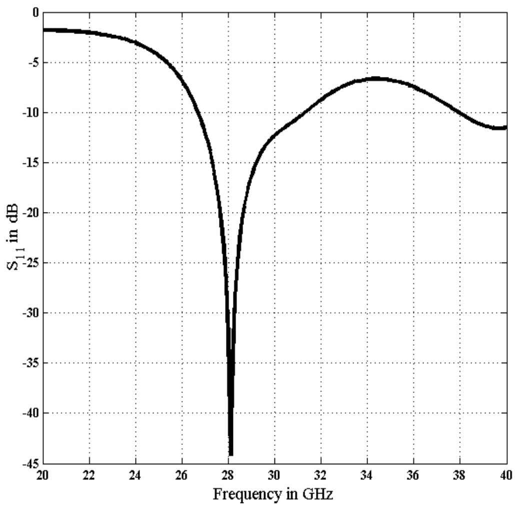

Fig. 9: Reflection co-efficient (S_{11}) of final design.

Table 1: Design Parameters

Parameters	Values in mm	Parameters	Values in mm
W	5	f_w	0.8
L	5	g_l	1.8
R_x	1.6	h	1.6
R_y	1.4	t	0.035

In the earlier section design methodology and the corresponding simulated results are discussed. In this section radiation pattern of the final design at 28 GHz is investigated using HFSS. The E and H plane patterns at 28 GHz are presented in Fig. 10 and Fig. 11 respectively.

III. Conclusion

In this paper a compact elliptical antenna is designed for future 5G mobile communication on a Fr-4 substrate. In literature such kind of compact antennas have not yet been reported. Simulated results show that the antenna has a good resonance at 28 GHz and achieved the impedance band width of 26.6-31.2 GHz.

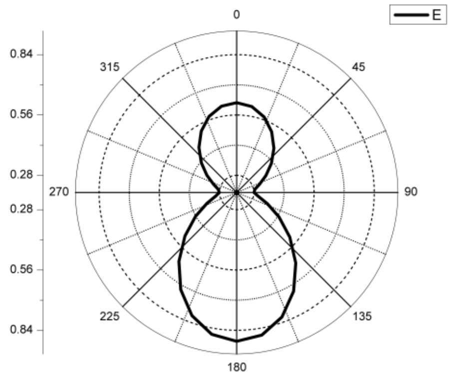

Fig. 10 : E-Plane pattern at 28 GHz.

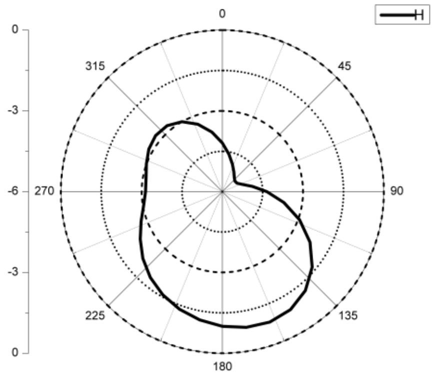

Fig. 11 : H-Plane pattern at 28 GHz.

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References

[1] Bhalla, M. R., & Bhalla, A. V. (2010). Generations of mobile wireless technology: A survey. *International Journal of Computer Applications*, *5*(4).

[2] Andrews, J. G., Buzzi, S., Choi, W., Hanly, S. V., Lozano, A., Soong, A. C., & Zhang, J. C. (2014). What will 5G be?. *IEEE Journal on selected areas in communications*, *32*(6), 1065-1082.

[3] Ashraf, N., Haraz, O., Ashraf, M. A., & Alshebeili, S. (2015, May). 28/38-GHz dual-band millimeter wave SIW array antenna with EBG structures for 5G applications. In *Information and Communication Technology Research (ICTRC), 2015 International Conference on* (pp. 5-8). IEEE.

[4] Ren, W., & Jiang, C. (2016). A novel design of multiband printed anchor-shaped slot

antenna. *Microwave and Optical Technology Letters*, *58*(3), 521-526.
[5] Aydemir, M., & Cengiz, K. (2016, May). A potential architecture and next generation technologies for 5G wireless networks. In *Signal Processing and Communication Application Conference (SIU), 2016 24th* (pp. 277-280). IEEE.
[6] Hong, W., Baek, K. H., Lee, Y., Kim, Y., & Ko, S. T. (2014). Study and prototyping of practically large-scale mmWave antenna systems for 5G cellular devices. *IEEE Communications Magazine*, *52*(9), 63-69.
[7] Zhang, L., Wen, H., Song, H., Tang, J., Jiang, Y., Dong, W., & Zhu, X. (2016, October). The performance of the MIMO physical layer security system with imperfect CSI. In *Communications and Network Security (CNS), 2016 IEEE Conference on* (pp. 346-347). IEEE.
[8] Haraz, Osama M., et al. "Design of a 28/38 GHz dual-band printed slot antenna for the future 5G mobile communication networks." Antennas and Propagation & USNC/URSI National Radio Science Meeting, 2015 IEEE International Symposium on. IEEE, 2015.
[9] Borah, J., Sheikh, T. A., & Roy, S. (2016). Compact CPW-fed tri-band antenna with a defected ground structure for GSM, WLAN and WiMAX applications. *Radioelectronics and Communications Systems*, *59*(7), 319-324.
[10] Sheikh, T. A., Borah, J., & Roy, S. (2016). Design of compact bandpass filter for WiMAX and UWB application using asymmetric SIRs and DGS. *Radioelectronics and Communications Systems*, *59*(6), 269-273.
[11] Ali, Mohamed Mamdouh M., et al. "Broadband printed slot antenna for the fifth generation (5G) mobile and wireless communications." Antenna Technology and Applied Electromagnetics (ANTEM), 2016 17th International Symposium on. IEEE, 2016.
[12] Gopal, B. G., and P. G. Kuppusamy. "A Comparative Study on 4G and 5G Technology for Wireless Applications." Journal of Electronics and Communication Engineering (IOSR-JECE) 10.6 (2015): 67-72.
[13] Mustafa, H. A. U., Imran, M. A., Shakir, M. Z., Imran, A., & Tafazolli, R. (2016). Separation framework: An enabler for cooperative and D2D communication for future 5G networks. *IEEE Communications Surveys & Tutorials*, *18*(1), 419-445.

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