Conformal antennas with pattern diversity for mmWave 5G smartphones

Karthikeya G. S, Mahesh P. Abegaonkar and Shiban K Koul
Centre for Applied Research in Electronics (CARE), IIT Delhi, New Delhi India
karthikeya@care.iitd.ac.in, mpjosh@care.iitd.ac.in, shiban_koul@hotmail.com

***Abstract*— conformal antennas with microstrip feed and high pattern integrity are designed at 28 GHz for mobile terminals. First, a strongly resonant microstrip patch antenna with 90° bend is investigated which offers a bandwidth of 27-29 GHz and a forward gain of 9 dBi. The second element is a conformal tapered slot antenna optimized for the corner bend that resonates at 28 GHz with a gain of 7 dBi. The third element is conformal tapered slot antenna loaded with a parasitic ellipse with a gain of 9 dBi and aperture efficiency of upto 80%. All the three elements are integrated with common ground for pattern diversity. Detailed simulated and measured results are presented.**

Keywords—conformal antennas, mmWave 5G smartphone, high gain, high aperture efficiency

I. INTRODUCTION

The past few decades has seen a humongous growth of smartphone users across the globe. This number is close to 350 million in India alone, with a penetration rate of 30% among the population [1]. Hence leading researchers in academia and industry propose to design and develop transceiver radios that would accommodate high bandwidths, which in-turn means high carrier frequency. 28 GHz band is one of the potential candidates for future cellular communication systems. Therefore antenna designs on both base stations and mobile terminals must operate at 28 GHz [2]. The path loss at these frequencies is high, which could be mitigated by deploying high gain antennas on both the mobile terminal and the base stations. In order to maintain the link budget, the transmitted powers could be dynamically adjusted depending on the distance. But the available power on the mobile terminal is limited by the battery [3]. Therefore, high gain antennas with minimal physical footprint is necessary for integration with the mobile terminal. Hence, conformal antennas with high gain is presented in this paper.

II. CONFORMAL PATCH ANTENNA

The proposed conformal microstrip fed patch antenna is illustrated in Fig.1. It is designed on Nelco NY9220 substrate with ε_r of 2.2 and a thickness of 0.508 mm. The dimensions of the resonant patch was optimized for an operating frequency of 28 GHz. The overall width of the antenna was chosen to be 20mm, to accommodate the 2.92mm end-launch connector. The planar antenna would lead to a physically large footprint, when integrated onto a smartphone. Hence, the corner bending of the microstrip patch antenna is investigated. The conformal antenna reported in [4] might not be operational for a 90° bend. Thinner substrates would be relatively more flexible but requires additional scaffolding [4], which would alter the radiation characteristics of the antenna, thus the 20mil substrate is a reasonable choice. The impedance bandwidth is from 27-29 GHz as shown in the simulated and measured curves of Fig.2. The input impedance has minimal effect after the 90° bend. The co-polarized and cross-polarized radiation patterns of the conformal patch antenna is depicted in Fig. 3 for both the principal planes at 28 GHz. The forward gain of the proposed antenna is 7-9 dBi as illustrated in Fig. 2, which is similar to the planar version of the microstrip patch antenna with the same dimensions of the radiator.

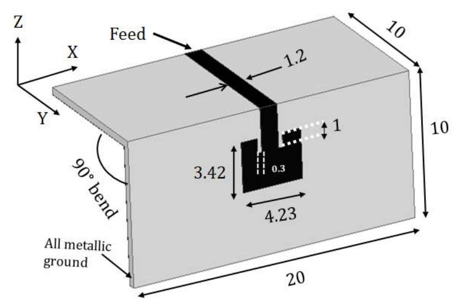

Fig.1. Schematic of the conformal patch antenna

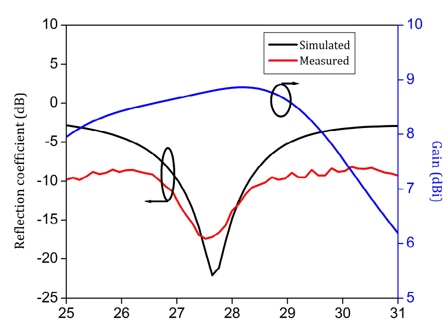

Fig.2. $|S_{11}|$ and forward gain of conformal patch antenna

III. CONFORMAL TAPERED SLOT ANTENNA

Log-periodic dipole antennas such as [5] would lead to gain variation across the band and requires multi-stepped impedance transformers for a conformal feed design. Hence, a conformal tapered slot antenna is investigated. The schematic of the proposed antenna is depicted in Fig.4.

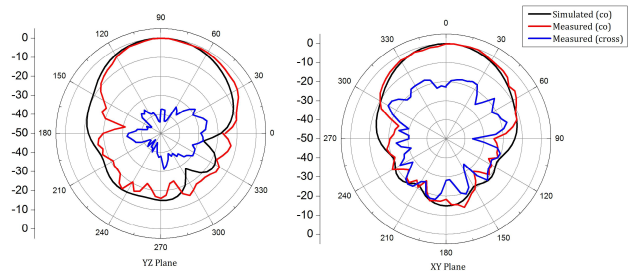

Fig.3. Radiation patterns of conformal patch antenna at 28 GHz

The feed line is a standard 50Ω which must be transitioned to the high impedance of 194Ω created by the microstrip to slotline transition. Hence, a quarterwave impedance transformer of impedance 96Ω is added in series in addition to the multiple stubs to support the right angled radiation with respect to the feed. The impedance bandwidth is 27-30 GHz (10%). The simulated and measured patterns at 28 GHz are illustrated in Fig.5. The gain is 7 dBi at 28 GHz with minimal variation across the band.

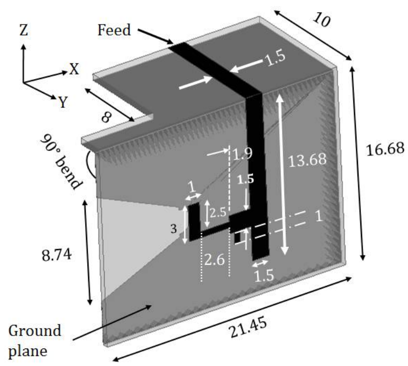

Fig.4. Schematic of the conformal tapered slot antenna

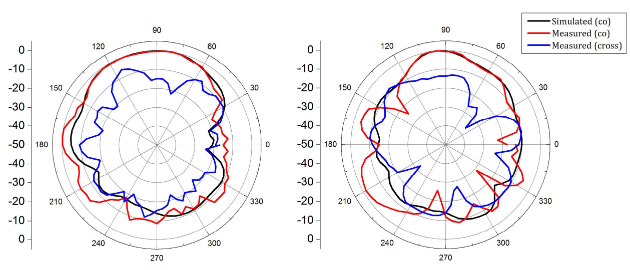

Fig.5. Radiation patterns of conformal tapered slot antenna at 28 GHz

IV. Conformal Pattern Diversity

In order to cater to the landscape modes and portrait mode, a conformal shared ground pattern diversity is proposed. The third element is also a conformal tapered slot antenna integrated with a parasitic ellipse to achieve a gain of 9dBi and aperture efficiency of 80% to compensate for the finger blockage of the landscape mode. The schematic and the corresponding photograph is depicted in Fig.6. The measured mutual coupling is less than 35 dB throughout the band and across the ports. It must also be observed that the patterns post integration is similar the characteristics of the individual conformal elements as evident from Fig. 7.

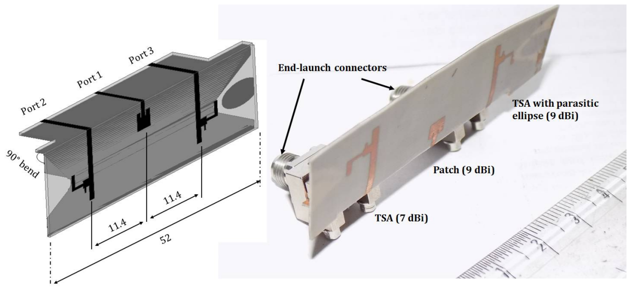

Fig.6. Schematic and photograph of pattern diversity module

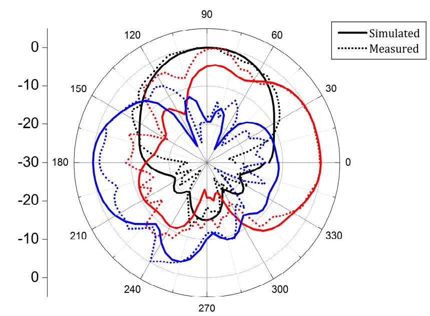

Fig.7. Radiation patterns of pattern diversity module at 28 GHz

V. Conclusion

Conformal antennas operating at 28 GHz are presented in this paper. First, a conformal microstrip fed patch antenna operating at 28 GHz with a gain close to 9 dBi is reported. This was followed by a conformal tapered slot antenna at 28 GHz with high pattern integrity and a gain of 7 dBi. The conformal pattern diversity module is designed and characterized. The compact module would be a suitable candidate for future mmWave 5G mobile terminals which yields high gain for low occupied volume.

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