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Design of Quatrefoil Shape Antennas for GSM1800 MHz and UMTS2.1 GHz Rectenna Applications

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Abstract

In this paper Quatrefoil shape CPW-Fed monopole antenna and slot antenna operating at GSM1800 MHz and UMTS2.1 GHz cellular bands are proposed. Simulated results show that the radiation efficiency of CPW fed monopole antenna and slot antenna at GSM1800 MHz and UMTS2.1 GHz are 93% and 81% respectively. Similarly the realized gains of monopole antenna and slot antenna operating at GSM1800 MHz and UMTS 2.1 GHz are 2.49 dB and 2.2 dB respectively.

1. Introduction

The world population as of May 2018 is approximately 7.6 billion. Currently we have approximately 26 billion connected devices that is more than three times population of earth [1]. Now a days the research is fast growing in wireless communication because of we have implementing more number of wireless connected devices [2]. In addition to this, huge number of autonomous wireless connected systems (e.g. autonomous wireless sensor networks, IoT, smart buildings etc.) are also implementing for next generation wireless communication systems [3]. For these systems we need to give power continuously. In environment within small distances we have lot of RF power available from cell towers, and Wi-Fi routers everywhere [4]. In urban environment the cell towers are placed on the building rooftop. If we utilize this wasted RF energy properly it is useful to drive the wireless connected low power electronic devices. It is possible due to RF energy harvesting and wireless power transmission. The rectenna is a device consists of antenna , matching network, rectifier, DC pass filter and load resistor. In order to implement complete rectenna, high efficiency rectifier with matching network is needed. Now, the RF to DC conversion efficiency reaches more than 100% [5]. But this efficiency is not stable for wide input power range [6] especially for low input power levels. Recently single and dual band rectifiers based on transmission line resistance/impedance compression networks are reported [7]. The matching network and rectifying circuit plays an important role in wireless power transmission. The idea to improve and maintain stable efficiency for low input power levels is to compress the variable input impedance of the rectifier circuit. Because both input impedance and efficiency of rectifier are depends on operating frequency, input power and load resistance. Due to the variation of input impedance the rectifier efficiency is also varies.

In this paper high efficiency Quatrefoil shape antennas operating at GSM1800 MHz and UMTS2.1 GHz (3G) are presented for rectenna applications. These two bands are contributing more RF power in environment. The GSM1800 MHz transmit band is (1.71GHz-1.785GHz) and receiving band is (1.805GHz-1.88GHz). The 3G transmit band is (1.92 GHz-1.98 GHz) and receiving band is (2.11 GHz-2.12GHz).

2. Quatrefoil Monopole Antenna Design

The configuration of Quatrefoil shape CPW-Fed monopole antenna is shown in Fig.1. The antenna was designed on a low cost FR4 substrate with dielectric constant of 4.3 and loss tangent of 0.025. The height of substrate is 1.58 mm. The antenna was excited GSM1800 MHz RF signals through a CPW-Fed 50 ohm feed line. The width of feed line is 3.1 mm. The dimension of substrate is 95 mm ×80mm. The dimension of ground is 25 mm × 37.65 mm. The gap between ground and feed line is 0.8 mm.

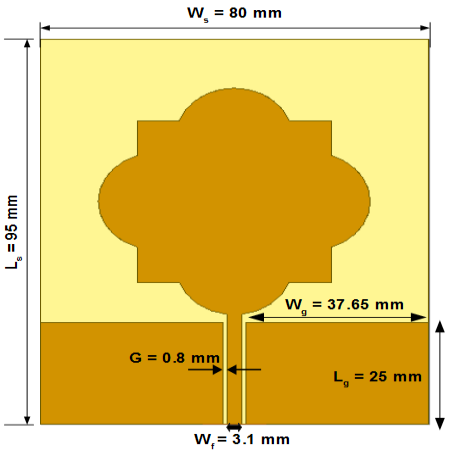

Figure 1. Configuration of proposed Quatrefoil shape CPW-Fed monopole antenna

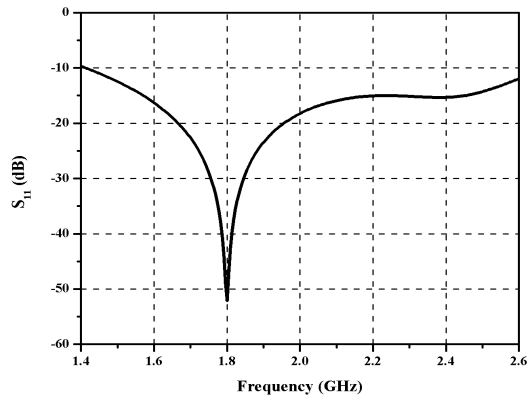

Figure 2. Reflection coefficient of monopole antenna

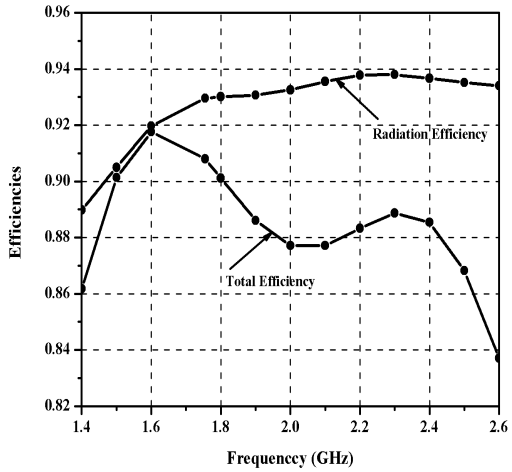

Figure 3. Efficiency of monopole antenna

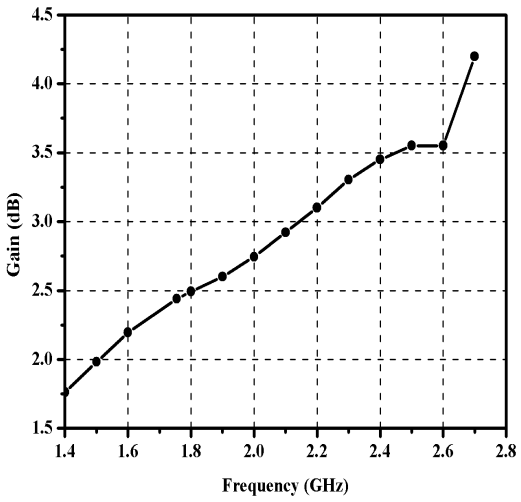

Figure 4. Gain of monopole antenna

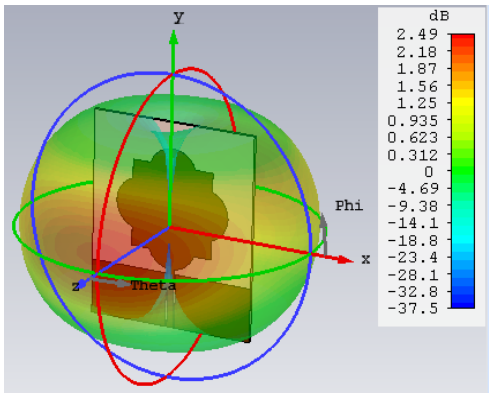

Figure 5. The 3-D Gain **r**adiation pattern of monopole antenna at GSM1800 MHz

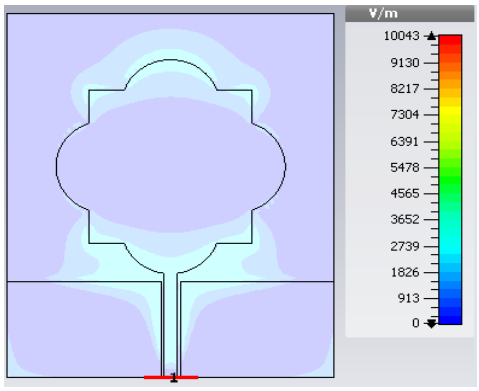

Figure 6. Electric field of monopole antenna at GSM1800 MHz (φ=90)

3. Quatrefoil Slot Antenna Design

The front side and back side configurations of proposed Quatrefoil shape slot antenna are shown in Fig.7 and Fig.8. The dimension of substrate is 45 mm×40mm. The width and length of 50 ohm feed line are 3.1 mm and 29.75 mm respectively.

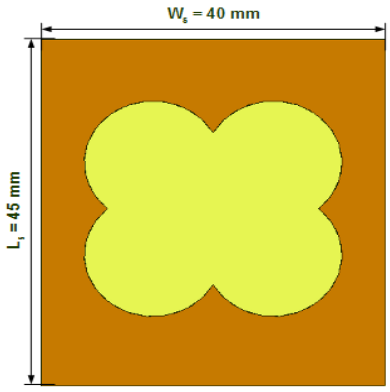

Figure 7. Front side Configuration of proposed Quatrefoil shape slot antenna

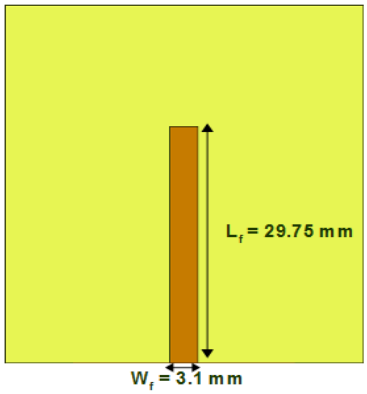

Figure 8. Back side Configuration of proposed Quatrefoil shape slot antenna

The parametric analysis and optimization results show that the antenna resonates at 2.1 GHz at a particular feed length. The antenna was designed on a low cost FR4 substrate with dielectric constant of 4.3 and loss tangent of 0.025. The height of substrate is 1.58 mm.

The input impedance of monopole antenna at GSM1800 MHz is (50.36+j0.00041)Ω and the input impedance of slot antenna at UMTS2.1 GHz is (49.45-j0.326)Ω. The rectenna is to be implemented by simply matching the input impedance of rectifying circuit to input impedance of antenna. The real values of input impedance of proposed antennas are close to 50Ω and imaginary values are close to zero. The aforementioned antennas are called as 50Ω antennas. So, there is no need to co-simulate proposed antennas with corresponding rectifiers but simply matching the input impedance of rectifying circuit to 50Ω impedance is enough. That is 50Ω antenna is matching to 50Ω rectifying circuit.

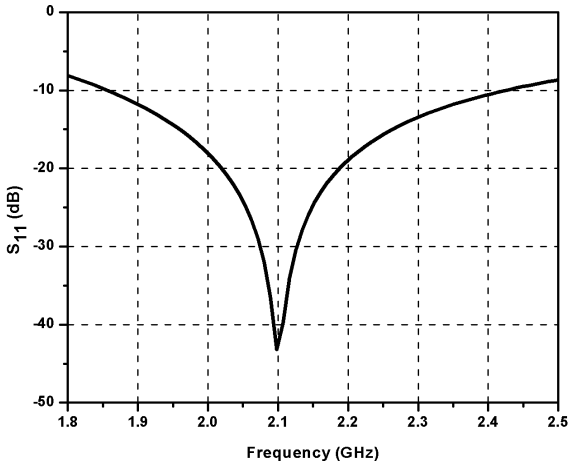

Figure 9. Reflection coefficient of proposed slot antenna

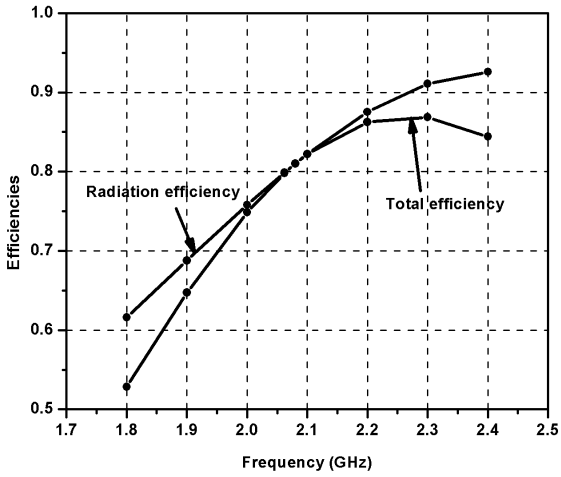

Figure 10. Efficiency of proposed slot antenna

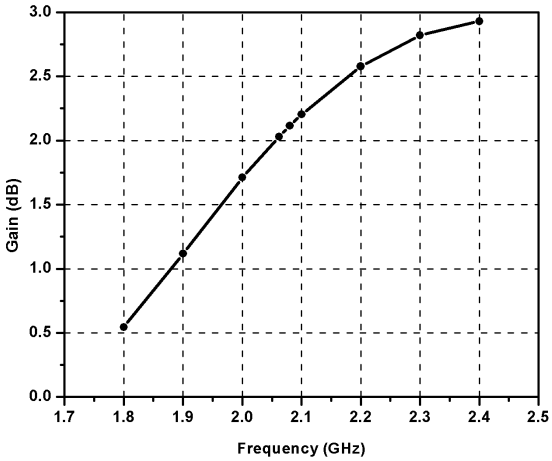

Figure 11. Gain of proposed slot antenna

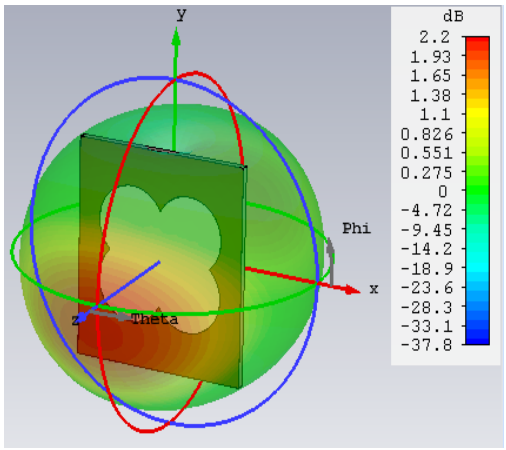

Figure 12. The 3-D Gain radiation pattern of slot antenna at UMTS2.1 GHz

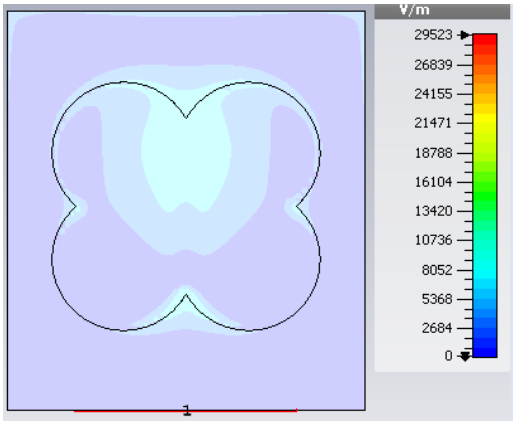

Figure 13. Electric field of slot antenna at UMTS2.1 GHz (φ=180)

4. Conclusion

The Quatrefoil shape antennas operating at GSM1800 MHz and UMTS2.1 GHz cellular communication systems are presented. These bands are contributing more RF power in environment. The antenna receive RF power and transfer to rectifier. The rectifier converts RF power to DC power. The impedance bandwidth of monopole and slot antenna are 1200 MHz (1.4 GHz -2.6 GHz) and 600 MHz (1.85 GHz-2.45 GHz). The peak gains of monopole and slot antenna are 3.6 dB and 3 dB. These two antennas covers up link and down link frequency range of GSM1800 MHz and UMTS2.1GHz frequency bands. The proposed antennas are useful for designing the rectennas for converting RF to DC power.

5. References

1. O. Björkqvist et al "Wireless Sensor Network Utilizing Radio-Frequency Energy Harvesting for Smart Building Applications", IEEE Antennas & Propagation Magazine, 2018.
2. Mohammad Alibakhshikenari et al " Wideband printed monopole antenna for application in wireless communication", IET Microwaves, Antennas & Propagation, Vol. 12 Iss. 7, pp. 1222-1230, 2018.
3. R. Xu , J.-Y. Li , J. Liu, S.-G. Zhou , K.Wei , and Z.-J. Xing, " A Simple Design of Compact Dual Wideband Square Slot Antenna With Dual-Sense Circularly Polarized Radiation for WLAN/Wi-Fi Communications", IEEE Trans. on Antennas and Propagation, Vol. 66, No. 9, 2018.
4. Yang Yang , Jun Li, Lu Li, Yilin Liu , Bing Zhang, "A 5.8 GHz Circularly Polarized Rectenna With Harmonic Suppression and Rectenna Array for Wireless Power Transfer", IEEE Antennas and wireless propagation letters, Vol. 17, No. 7, 2018.
5. Mohamed El Badawe and Omar M. Ramahi, "Efficient Metasurface Rectenna for Electromagnetic Wireless Power Transfer and Energy Harvesting", Progress In Electromagnetics Research, Vol. 161, 35–40, 2018.
6. Zhi-Xia Du , and Xiu Yin Zhang , " High-Efficiency Single- and Dual-Band Rectifiers Using a Complex Impedance Compression Network for Wireless Power Transfer", IEEE Transactions on industrial electronics, vol.65, No. 6, 2018.
7. Jian Liu, Xiu Yin Zhang, and Chun-Ling Yang, " Analysis and Design of Dual-Band Rectifier Using Novel Matching Network", IEEETransactions on circuits and systems, Vol. 65, No. 4, 2018.