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A Compact Dual-Band Textile Antenna Design for Wearable Applications

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Abstract

A dual band printed textile antenna based on circular split ring elements is presented for wearable applications. The proposed split-ring textile antenna (SRTA) has a fairly compact design generates a dual band performance at 2.4/5.7 GHz WLAN bands, simultaneously. A full ground plane is located on the opposite side of the substrate as a reflector to avoid the influence of the human body on back side radiation of the antenna. Also, the SRTA exhibits directional radiation patterns at each operational frequency. Design and analysis of the antenna are conducted by using CST Microwave Studio.

Keywords: textile antenna, wearable antenna, dual band antenna, split ring.

1. INTRODUCTION

Wireless communication and mobile electronic devices are very important issue due to the need for fast and uninterruptable access to information. Thus portable mobile device used for this applications have become part and parcel of everyday human life. For instance, current mobile phones are usually carried throughout the day and they provide not just voice calls alone but also enable data access, multimedia, and GPS navigation. In future, a person is likely to carry a range of devices and sensors, including medical sensors which constantly communicate with each other and the outside world. It is of paramount importance to provide this functionality as unobtrusively as possible. A key technology to achieve this goal is wearable electronics and textile antennas. Because of its almost global availability, the 2.45 and 5.7 GHz ISM unlicensed bands are utilized for the development of wearable textile antennas. For the convenience of the user, wearable antennas need to be hidden and of miniature profile. This requires a possible integration of these antenna elements within everyday clothing. In this context, microstrip patch antennas are particularly good candidate for any wearable applications since their miniature, compact and conformal structures present clear opportunists for integration into clothing. In this context, various types and topologies of microstrip antenna designs for wearable applications were proposed in the open literature [1-8].

In the current paper, we propose a novel microstrip textile antenna based on split-ring elements. As well known, a split ring resonator (SRR) can exhibit resonant behavior for wavelengths that are much larger than its size. As such, SRRs have enabled the design of metamaterial based electrically small wearable antennas as reported in literature [7-8]. In addition, SRR based WLAN antenna designs were proposed in our previous study [9-10]. While main radiator of the proposed design consists of circular split ring elements, the radiator reported in [9-10] are composed of rectangular split-rings elements. In addition, the proposed design in this study is electrically small as compared to the all designs reported in [7-10]. The proposed split-ring textile antenna (SRTA) with novel configuration consists of concentric circular split-ring elements and metallic loadings appropriately placed between the rings as shown in Figure 1. The antenna is fed by a current-probe placed in one of the splits in its outer ring. The probe basically represents practical coaxial feeding, and in that proposed configuration, there are no additional matching networks. The SRTA has fairly small dimensions and provide dual-band operations at 2.4/5.7 GHz for WLAN band wearable application.

2. DAUL BAND TEXTILE ANTENNA DESIGN AND

The proposed SRTA configuration with its design parameters is depicted in Figure 1. As seen, main radiator of the antenna in the top plate consists of three concentric circular SR elements and metallic loadings appropriately placed between the rings. The outer-most ring with two splits is rather wider than the inner rings with one split each. The antenna is fed by a current-probe placed in one of the splits

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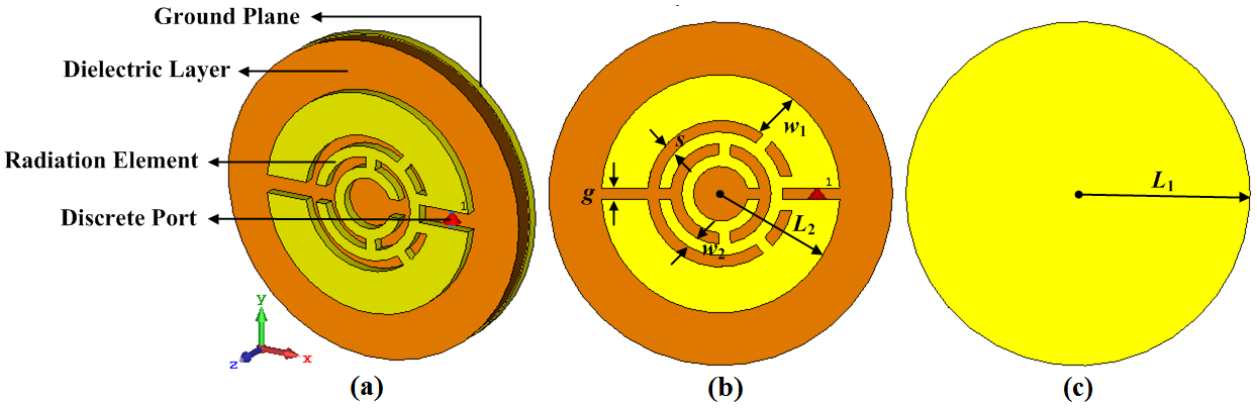


Figure 1: Proposed SRTA design with optimal parameters a) Perspective side b) front side and c) back side schematic views with dimension parameters of proposed antenna.
(L_1 = 15, L_2 = 10.4, w_1 =4, w_2 = 1, g = 1, s = 1 (all in mm)).

in the outer ring. The probe basically represents practical coaxial feeding and in this proposed configuration, there is no additional matching network. Also, there are six metallic loadings inserted appropriately between the ring elements. In addition, a full ground plane is directly used underneath the bottom layer as a reflector to avoid the influence of the human body on the antenna. The conductive components of the antenna such as SR elements and ground plane are built using ShieldIt conductive textile having a thickness of 0.17mm and an estimated conductivity of 1.18×10^5 S/m. Also, a thermally isolating material namely Denim with relative permittivity ε_r of 1.7 and a loss tangent (δ) of 0.02 is used as dielectric substrate layers of the antenna.

Analysis and design of the SRTA were obtained by means of CST microwave studio based on time domain integral technique. A series of parametric studies were carried out to achieve desired antenna performance, particularly for tuning the resonant frequencies and return loss characteristics. In this process, the substrate thickness and permittivity, dimensions of the ring elements as well as the ground plane, position of the feeding port, and positions of the metallic loadings were tuned to achieve optimal operation.

The return loss performance of the design is shown in Figure 2. As shown, a dual-band operation is achieved at 2.48 GHz and 5.73 GHz with %2.0 and %1.1 bandwidths, respectively. Thus, the SRTA offers a coverage of all WLAN bands (2.4/5.7 GHz). Radiation patterns of the SRTA design were also computed and the corresponding polar plots for f=2.48 GHz and f=5.73 GHz are displayed in Fig. 3. As seen, E/H-plane patterns demonstrate dipole like directional characteristics at each operational frequency bands. Also, Maximum simulated antenna gains are 0.026 and 0.645 in 2.488 and 5.734 GHz at linear scale, respectively.

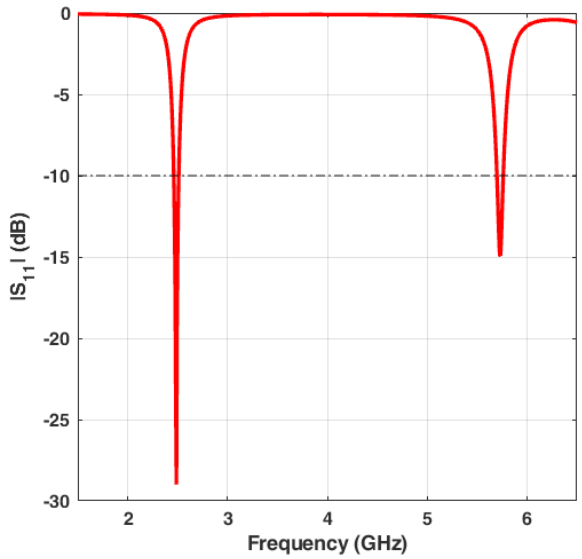


Figure 2: Simulated return loss (S_{11}) characteristics for the SRTA design.

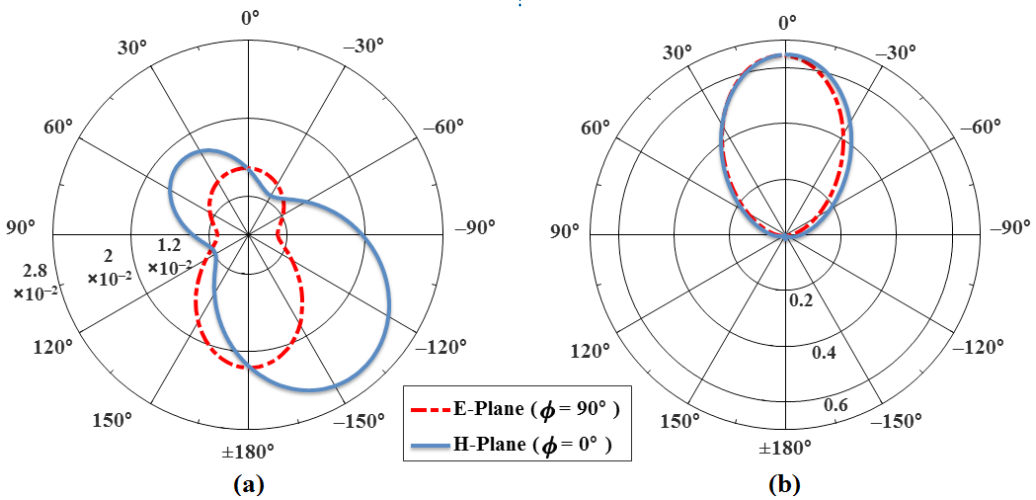


Figure 3: Simulated radiation pattern of SRTA design at linear scale for a) 2.48 GHz, b) 5.73 GHz.

3. CONCLUSION

In the paper, we have introduced a novel wearable textile antenna based on microstrip split-ring elements with metallic loadings. In the design, as the outer-most ring is fed by a current-probe, the inner rings with loadings provide frequency-tuning and impedance matching. Thus, the compact SRTA design performs dual-band operation at the designated WLAN bands (2.4/5.7 GHz) with 2% and 1.1% impedance bandwidth. The operational bands may seem rather narrow mainly due to highly-resonant split-ring elements involved. The bandwidth performance, however, can be improved by means of an additional matching network. Fabrication of the SRTA is in progress and measurements will follow.

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