Performance Enhancement of Microstrip UWB Patch Antenna with SRR for Wireless Body Area Networks

S. Sesha Vidhya, D. Rukmani Devi, K.G. Shanthi, S.Venkatesan

Abstract-This paper presents a square shape Split Ring Resonator (SRR) loaded with micro strip patch antenna operating in UWB (Ultra Wide Band) range (3.1GHz -10.6GHz) for Bio-medical applications. The Ultra-Wideband is a wireless technology which is used to send large data over a wide range of frequencies by using very narrow pulses at low PSD (Power Spectral Density). UWB provides wireless transmission of audio, video and data with wide bandwidth. The proposed antenna specifically operates at 4.1GHz and is designed on a 23.19mm x 23.19mm x 1.35mm board of Arlon AD1000 substrate. This SRR antenna has been simulated using High-Frequency Structure Simulator (HFSS) software. The results show enhanced performance in terms of high gain, return loss (<10dB), Voltage Standing Wave Ratio (VSWR)<2, low Specific Absorption Rate (SAR), high Directivity, high radiation Efficiency.

Keywords— PSD (Power Spectral Density), SRR (Split Ring Resonator), UWB (Ultra-Wideband), WBAN (Wireless Body Area Networks), SAR (Specific Absorption Rate).

I. INTRODUCTION

In the recent years, the Wireless Body Area Networks (WBAN) field has grown extensively, sustaining an outsized number of applications, including custom-made health care systems, patient monitoring systems, rescue systems etc.,

Several frequency bands have been allocated by FCC (Federal Communications commission) to commercialize WBAN communication systems, which include the Medical Implantable Communication Systems band (402–405 MHz), Industrial Scientific Medical (ISM) band (2.40–2.48 GHz), and UWB (3.1GHz -10.6GHz). For best possible performance, the antennas intended for WBAN applications are required to be compact, lightweight, low power consumption, mechanically robust, and preferably comfortable while being worn [1].

The performance of an antenna may demean drastically while working in close proximity with the human body. Due to the near field coupling with the body, antenna's surface currents may be affected which in turn affects the impedance matching of the antenna. Exclusively, for narrowband operation, the main cause of the body proximity is a shift of the resonance frequency. This causes a mismatch at the intended frequency of operation resulting in a considerable degradation of the total radiation efficiency (Power radiated/Power incident). Designing a short band wearable antenna with a high radiation efficiency is a tough task, as it is expected to have low profile, low power consumption, lightweight and conformal characteristics.

UWB technology has gained enormous recognition in recent research and industrial areas due to its higher data rate wireless communication capability. The performance of body worn antennas is of greater concern in terms of maximum allowable Specific Absorption Rate (SAR) parameter.

II. BACKGROUND

A compact EBG-backed planar monopole antenna [2] designed on a 68 × 38 ×1.57 mm^3 board of semiflexible RT/Duroid 5880 substrate, operating at 2.45 GHz in ISM band which yields 6.88 dBi as gain and SAR of 0.244W/Kg is presented.

Disc-Like Antenna [3] for Body-Centric Communication operating at 61 GHz, with a size of (5x200x200) mm^3 is depicted by Jan Puskely et al., that was not comfortable to wear due to its size, had lower efficiency of 25% and gain of 5.2dB.The slotted patch antenna [4] operating in Ultra Wide Band (UWB) frequency band was portrayed. It offered a bandwidth of more than 2GHz and reflection coefficient of less than -10dB. But designed to operate only in lower abdominal region. The 40 × 40 × 1.44mm^3, Micro strip Line fed antenna [5] operating at 5.93GHz with FR4 as substrate has been presented with higher fidelity and lower sensitivity to angular misalignment. But it had size constraints and restrictions on data exchange capacity.

Wireless performance evaluation of Off-body antenna in a housing environment [6] operating at 2.4GHz is presented. The size of the antenna is too big to be considered as wearable device. The reconfigurable wearable antenna [7] is designed at 2.4GHz, fabricated on textile material.

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A shoelace antenna [8] is portrayed for Blind people to avoid collision. The loosening and tightening influences the performance of an antenna and resonates at 2.43 GHz.

The Flower shaped patch [9] structured antenna with two ports and four capacitive coupled feeds is presented. A Cavity structure was introduced to improve gain of the antenna. One of the most important elements of meta-material is the split ring resonator [10] to attain negative permeability in a certain frequency range. Marques et al.,[11] proved that an edge and broadside attached split ring resonators can be used for the design of small antennas for RF and wireless communication systems.

In this paper, we present the design of a square shape Split Ring Resonator (SRR) loaded with micro strip patch antenna operating at 4.1 GHz. The main purpose of this design is to enhance the gain, directivity which in turn enhances the radiation efficiency of the antenna and also to minimize the SAR.

The paper is ordered as follows; Third section represents the design and structure of Antenna. Fourth section presents the simulated output and analysis. Finally, the conclusion is presented in fifth section.

III. ANTENNA DESIGN AND STRUCTURE

The antennas designed for bio medical applications should have a substrate with relative permittivity ranging between 2.15-12.8. To meet this specification, the following materials can be used for bio medical applications such as FR4(4.4), Cotton (1.5), RT Duroid (2.2), Arlon (10.2).

First a square CRR (Closed Ring Resonator) loaded on the Microstrip patch antenna is designed using Arlon AD1000 as substrate that has a relative permittivity of 10.2. This CRR Microstrip patch antenna is designed using HFSS software to operate at 4.1GHz and has overall dimensions of 23.19mm x 23.19mm x 1.35mm. The antenna with CRR is depicted in Figure.1. The simulated results of CRR antenna are as follows: **Gain of 8.5dB, VSWR of 1.89, Return Loss of -12.15dB, Directivity of 8.14, SAR of 0.178 and Efficiency of 95.76%.**

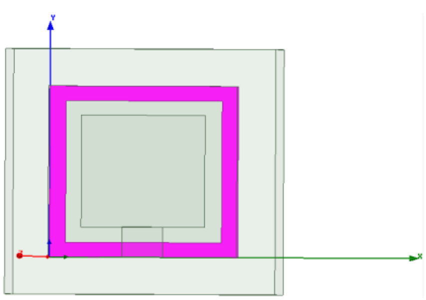

Fig. 1. Patch Antenna with CRR

To improve the performance of the patch antenna with the same specifications and dimensions, the Split Ring Resonator (SRR) is loaded on one part of the antenna. The resulting capacitance effect due to SRR allows the alternating current to pass. The SRR loaded with micro strip patch antenna operating at 4.1 GHz is shown in figure 2.

As the size of the proposed SRR antenna is much less when correlated with EBG structure [2] antenna, it is more compact to wear. The type of the feed used in this antenna is microstrip feed that offers good input impedance. The added advantage is that it also allows the current to be dominant at the mid area and least at the corners.

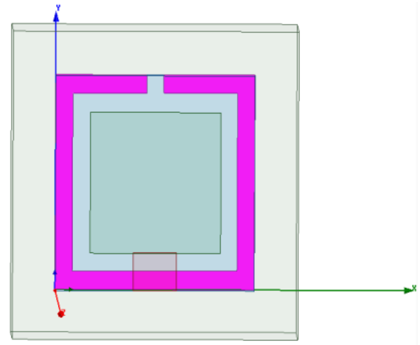

Fig. 2. Proposed Patch Antenna with SRR

The ground length (L_g)is 33.25mm and its width (W_g) is 33.25mm. The length of the substrate (L_s) is 23.19mm and width of the substrate is (W_s) is 23.19mm. The height of the antenna is 1.35mm. The patch length (L_p) is 15.19mm and the patch width (W_p) is 15.19mm. The feed length (L_f) is 4.1mm, the feed width (W_f) is 5mm.

IV. SIMULATION AND ANALYSIS

The proposed SRR antenna is simulated using HFSS and its performance is analyzed in terms of the free space parameters. The return loss (S_{11}) response of the antenna designed antenna with SRR is presented in Figure 3. It is experiential that SRR antenna resonates at 4.1 GHz with a return loss of -11.7 dB.

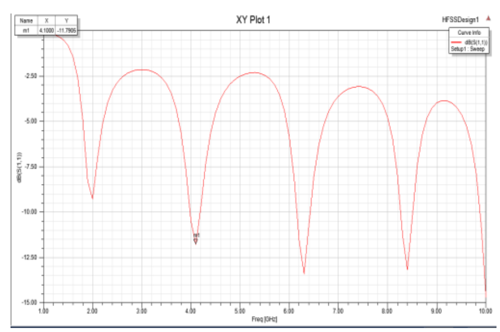

Fig 3. Return Loss of Proposed SRR Antenna

The gain of the designed antenna is 8.9 dB when operated at 4.1GHz as portrayed in figure 4. The directivity of this antenna is 8.7dB as depicted in Figure 5.

The radiation efficiency of the antenna is found to be 97.75%. The VSWR of the antenna is found to be 1.69 at 4.1GHz as shown in Figure 6.

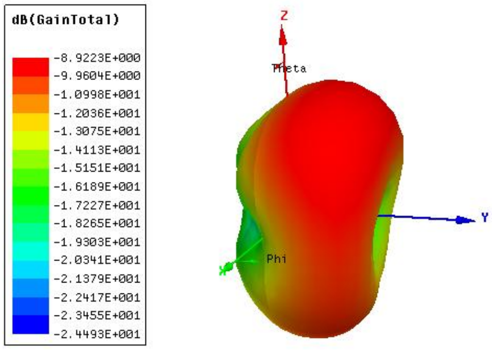

Fig.4. Gain of Proposed SRR Antenna

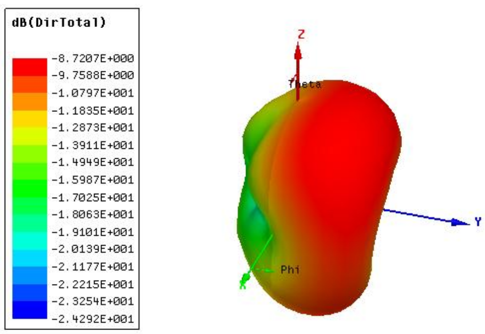

Fig.5. Directivity of Proposed SRR Antenna

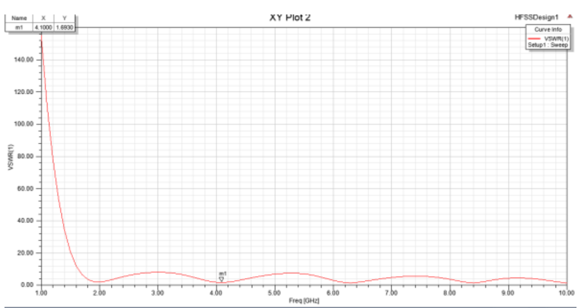

Fig.6. VSWR for the Proposed SRR Antenna

The radiation pattern at different degrees for the antenna proposed is Bi-directional as shown in figure 7.

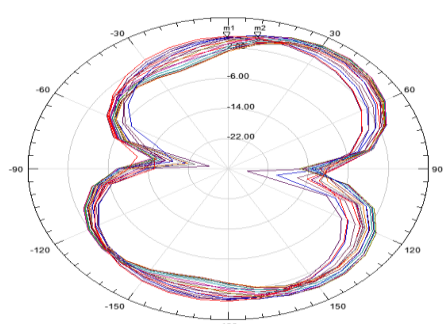

Fig.7. Radiation Pattern of Proposed SRR Antenna

The SAR value of proposed antenna is 0.163W/Kg over a volume of 1 g of tissue as shown in figure 8.

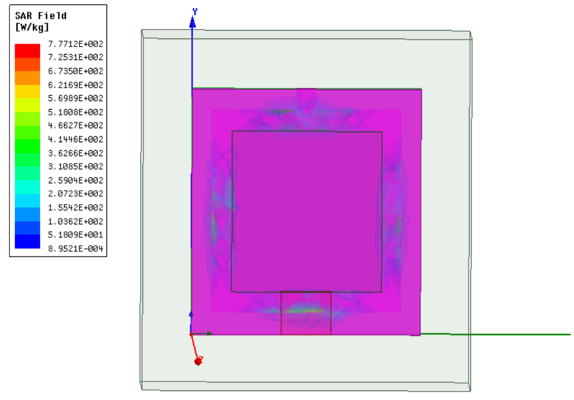

Fig.8. SAR of Proposed SRR Antenna

The performance metrics of both CRR and SRR antennas are depicted in Table-I which clearly portrays that the SRR antenna outperforms the CRR antenna.

Table- I: Comparison of Performance Metrics

Antenna Parameters	With CRR	With SRR
Gain	8.5dB	**8.9Db**
VSWR	1.89	**1.69**
Return Loss	-12.15 dB	-11.7 dB
Directivity	8.14	**8.7**
SAR	0.178	**0.163**
Efficiency	95.76%	**97.75%**

V. CONCLUSION

This paper elucidates the design of square SRR antenna for Bio-medical applications. The performance metrics of square SRR antenna is compared with a square CRR antenna. The proposed SRR antenna yielded a gain of 8.9dB, efficiency of 97.75% and SAR of 0.163W/Kg over a volume of 1 g of tissue. The compact size and less back radiation of the proposed SRR antenna permits it to be more appropriate for wearable Bio-medical applications.

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