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Design and Performance Analysis of Reconfigurable Antenna in WBAN Applications

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ABSTRACT—The paper proposes the design of a reconfigurable antenna and its implementation for Wireless Body Area Network (WBAN) applications Reconfigurable antennas reconfigure to reverberate multiple frequencies to provide support to a variety of functions. Such antennas provide remarkable benefits, such as liability and compact design. Properties such as polarization, radiation pattern, and frequency are altered in such antennas as per changing ecological conditions or fluctuating system requirements in a restricted manner and hence is best suited for usage in WBAN applications. A reconfigurable micro strip patch antenna operating at two frequencies is designed in this paper. The concept of switching the lumping element i.e. pin diode between ON and OFF state, to save the energy and reduce power consumption is introduced in antenna. The proposed antenna incorporates advantages like the multi-functional operation of the micro strip patch antenna and symmetry of radiation pattern on reconfiguring it at the two frequencies in ONN and OFF state. The performance of the antenna is assessed based on S_{11} and the gain of the antenna for ISM and UWB in ON and OFF state. The desired resonant frequency in ON state is 2.45GHz (IS M band) achieved with a return loss of -20dB and for OFF
state is at 4.8GHz, which lies in the safe Ultra-Wide Band (UWB) range and is achieved with a return loss of - 14dB. The gain obtained in ON state is 5.203dB and in OFF state is 3.679dB.

Keywords: DGS, IEEE 802.15.6, ISM band, UWB, WBAN.

I. INTRODUCTION

Wireless Body Area Network is afield which makes use of sensors that are ready to be utilized on, around, in, or embedded in the human body. It is significant in remote patient monitoring, biofeedback, defense, healthcare, and assisted living. Due to high reliability, minimal power consumption, no delay, independent node functioning, and with its capability of supporting a wide range of communication, the usage of WBAN is considered suitable for regular patient monitoring[1].WBAN is a wireless network technology based on a radio frequency that interconnects small nodes with sensors that are in the Periphery, on or inside a human body. The sensor nodes are connected to the sink node/central node which is energy constrained with more processing capabilities. Re configurability of an antenna intends to achieve modification in antenna's operating frequency, polarization, and radiation characteristics by redistributing the current in the antenna[2]. The advantages a reconfigurable antenna holds in WBAN applications are the improved antenna performance in RF systems, the capacity to alter antenna geometries, and behavior by adjusting to changes in surrounding conditions[3]. Much work has been done in designing the reconfigurable antenna for WBAN applications. IEEE 802.15 built a task group IEEE 802.15.6 for fruitful development and optimization of a standard for low-power in-body/on-body mode communication. WBAN can offer services in multiple fields complementing the Reconfigurable antenna.
The antenna design and operation of a reconfigurable antenna are optimized by the removal of unwanted repetitive switches thereby increasing the performance of the system and the biasing concern. The antenna is capable of switching between ON mode and OFF mode with respective ISM and Ultra Wide Band reconfigurable frequencies of 2.45GHz and within the range of 3-10GHz [4]. The ISM band is chosen as it supports high data rate applications in the

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industrial, scientific, and medical fields and is available worldwide. On the other hand, UWB is chosen as it uses low energy levels for short-range communication [5]. For obtaining high gain and the ideal bandwidth concept of Deflected Ground Structure (DGS) is used, It suppresses the higher harmonics and mutual coupling thereby making antenna more efficient.[6]. The various advantages which are offered by antennas include multi-functional capability, Multi Front-End processing efforts and eliminates the requirement of filtering element.

.Numerous structures are proposed that are appropriate for implementation in wireless communication, for example, Cognitive Radio(CR), MIMO, and Ultra Wide Band (UWB). The reflection coefficients S 11 associated with a patch antenna along with the gain are used to record the overall performance of the system.[7] Other than PIN diodes, elements like RF Micro Electrochemical Systems [MEMS], varactor diodes, and optically activated switches are used to change the antenna operations. Usually, the RF frequency range, the properties of a variable resistor can be observed in PIN Diode. The design of antenna when switched to ON state and OFF state respectively have high complex circuitry. [8].

To simulate the antenna design, CST studio is used. A reconfigurable microstrip patch antenna operating at two frequencies for its implementation in WBAN applications is designed in this paper. This paper is bifurcated as follows: The reconfigurable antenna design is briefly discussed in Section II antenna simulation results in Section III of paper. The summary of the work done is presented in Section IV.

II. RECONFIGURABLE ANTENNA DESIGN

The antenna design is threefold, consisting of the ground plane, dielectric substrate, and microstrip patch. The MSPA is used as it has a low profile, can be easily fabricated provides high-speed data transfer. The microstrip patch is of dimension (23.5mm X 19mm). The dielectric substrate is made up of FR-4 with dimensions of (47mm X 38mm). The copper ground plane is of dimensions as (47mm X 38mm.) The antenna has a feed of length 23mm and width 2.88mm. For feeding the antenna inset feeding is used. The motive of inset feed is to suit the impedance of patch to feed line without the want of any additional matching element. Inset feed is a smooth feeding method since it is simple to model and easy to fabricate in addition to proper impedance matching which results in a good return loss (S11 ≤ −10dB) of the antenna at favorable frequency. A gap after 3/4th length of the patch is introduced in antenna to insert the lumping element i.e. a PIN diode used for switching between the operating frequencies for ON body and of body. The PIN diode is well-established on account of its quick exchanging time and appropriate handling of high current capability. It is used in the design consists of an "intrinsic" layer present between the P and N layers of the diode. During the state of being forward biased, the diode enables the RF energy to flow and blocks the RF energy when reversing biased. Due to this reason PIN diode is used in a large variety of RF switch topologies.[9]. To operate the antenna in ON state the diode is provided with the resistance value of 1.5 ohms and to switch it back to the OFF state a capacitive value of 0.4 pF is provided to the diode.
Given below is the general antenna equations taken into consideration for calculating dimensions of design [10]:

$$W = \frac{c}{2f_0\sqrt{\frac{\varepsilon_r+1}{2}}} \quad (1)$$

$$L = \frac{c}{2f_0\sqrt{\varepsilon_{eff}}} - 2\Delta L$$

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-1/2} \quad (3)$$

Where
W= Microstrip patch width
L= Microstrip patch length
ΔL=Length extension
c = 3x10^8 m/sec, speed of light;
f_0=5.8GHz, resonance frequency;
s_r=4.3,relative permittivity of substrate;
h=1.6mm, height of the substrate;
s_{reff}= effective dielectric constant;

Table I Dimensions of various components in the antenna design

Element	Length	Width
Ground Plane	47mm	38mm
Dielectric Substrate	47mm	38mm
Microstrip Copper Patch	23.5mm	19mm
Feedline	23mm	2.88mm

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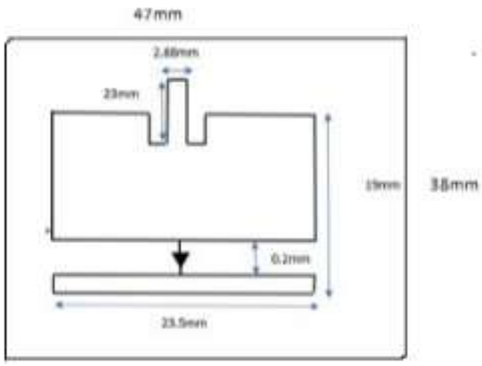

Figure2.1Frontview ofMSPA

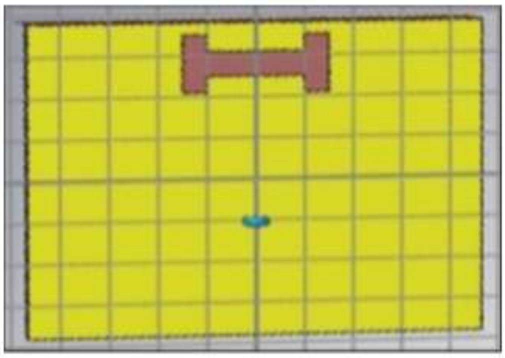
Figure 2.4 Back side of MSPA with DGS

Dumbbell shape Defected Ground Structure is used as it improves the performance parameter of antenna based on gain. It increases gain thereby making the antenna more efficient.DGS gained popularity because of its simple structural design and low cost. It suppresses higher harmonics and mutual coupling in the antenna enhancing its bandwidth and gain[11].

A dumbbell shape DGS has been incorporated on the ground as shown in figure 2.2

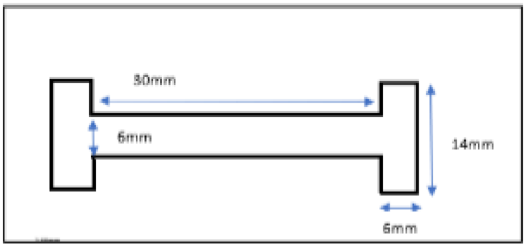

Figure2.2DumbbellshapedDGSwithdimensions

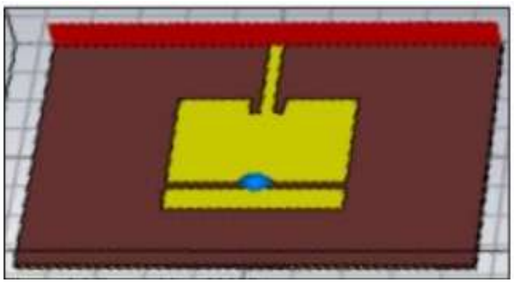
Figure2.3 Front side of MSPA

III. ANTENNA SIMULATION RESULTS

The parameters which are evaluated for the proper functioning of the antenna are:

3.1 Return loss(S 11)

The Scatter parameter of an antenna describes the relationship between the input and output terminals on the basis of power.. S_{11} parameters are a function of frequency i.e. they vary with frequency. The S_{11} parameter is the most frequently quoted parameter in respect to antennas .[12] This can be defined as amount of power radiated back from the antenna and hence is also referred to as return loss. Incase S_{11} parameter is 0, it indicates that no power is radiated. When S_{11} is obtained as -10dB, out of the value, -7dB is reflected and 3dB is radiated. Figure 3.1(a) shows the S_{11} of the simulated antenna at ON state and figure 3.1(b) depicts S_{11} of the simulated antenna at OFF state. The S_{11} for ON state at 2.45GHz is -20dB and for off-state at 4.8GHz is -14dB which shows that the antenna is best suited for the two given frequencies.

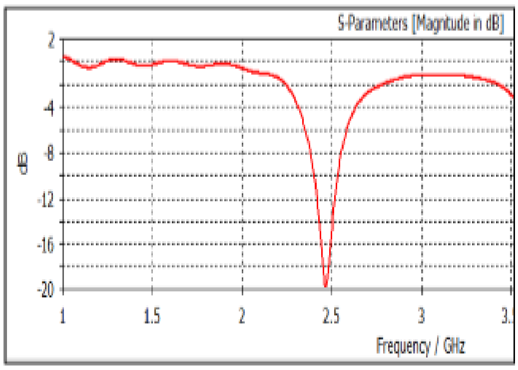

Figure 3.1(a) S_{11} Parameter at 2.45 GHz in ON state

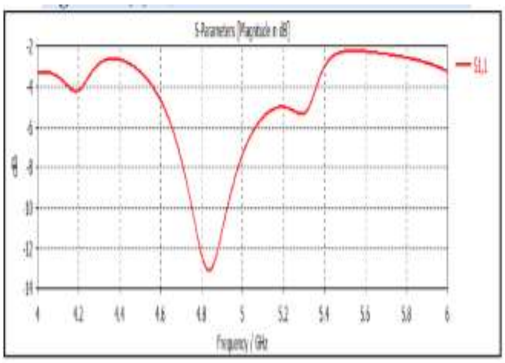

Figure3.1(b)S_{11}parameterat4.8GHzinOFFstate

3.2 Gain

The measure of intensity transmitted towards the peak radiation of an isotropic source is called a gain of the antenna. The gain of the antenna is obtained in two states i.e. On and OFF state and is found to be 5.203dB for ON state and 3.697dB for off state. The gain received in ON state is shown in Fig 3.2(a). and is 5.203dB on the 2.45GHz ISM band (ON state). The Gain obtained for the antenna at 4.8 GHz is 3.679dB shown in Fig 3.2(b).

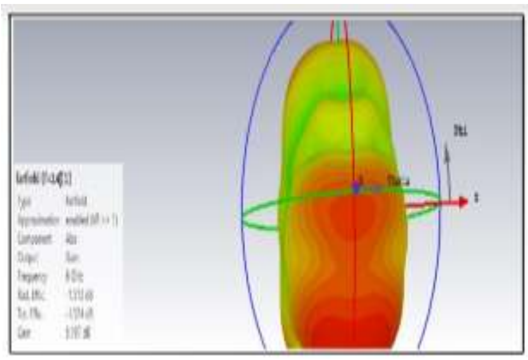

Figure3.2(a) Gain of 5.203 dB obtained in ON state

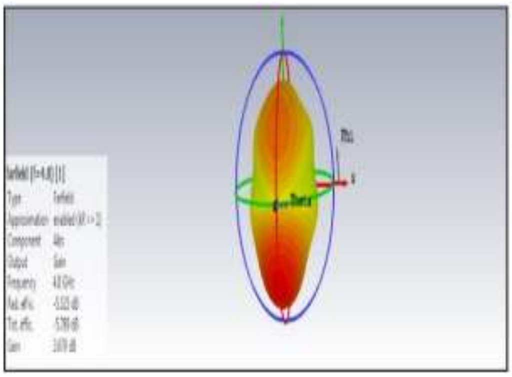

Figure3.2(b) Gain of 3.679 dB obtained in OFF state

3.3 Surface Current

The applied electromagnetic field induces an actual electric current. The electric field pushes charges around. The surface current for 2.4GHz is shown in Figure 3.3(a) and the Surface current for 4.8GHz is shown in Figure 3.3(b).

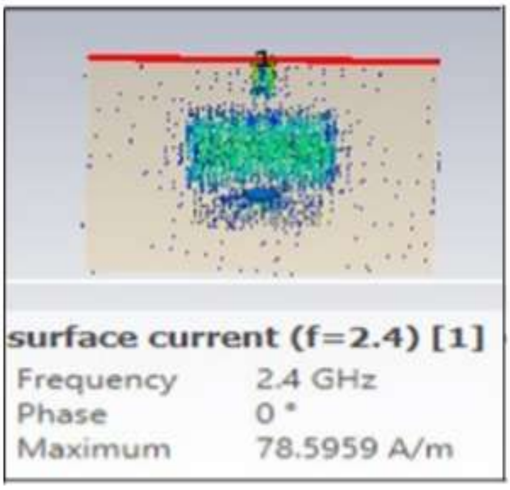

Figure 3.3(a) Surface current for ON state.

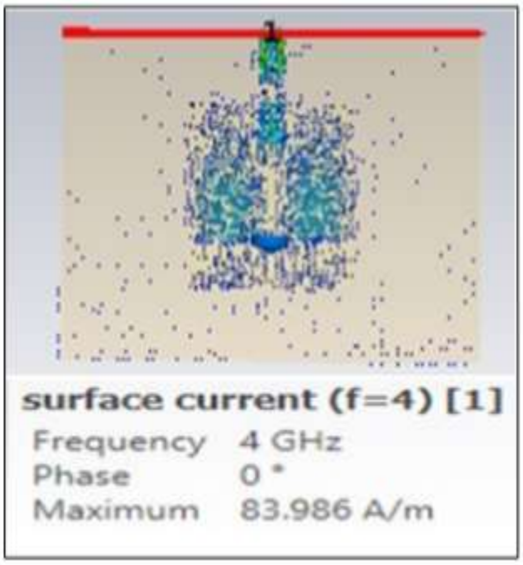

Figure 3.3(b) Surface current for OFF state

IV. CONCLUSION

This paper presents the design of an antenna that reconfigures at two operating frequencies of the ISM band in ON state and Ultrawide Band in OFF state for WBAN has been presented in this paper. It is observed that the model in the ISM band is suitable for a long-range while mode in the Ultrawide Band range is suitable for short-range communication. The S_{11} parameter and gain have been evaluated for two frequencies. In ON state ISM band the S_{11} value obtained at 2.45GHz is -

20dB and in OFF state the S $_{11}$ obtained at 4.8GHz is -14dB.

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