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High Gain Textile Microstrip Patch Antenna for Radio Navigation Applications

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***Abstract*— In the recent days, the textile microstrip patch antennas are widely used in the wireless communication due to salient feature like small size, simplicity, flexibility, easy fabrication and low cost of production. This paper presents the design and performance analysis of textile rectangular microstrip patch antenna for Radio navigation applications. The proposed antenna has been designed and simulated using curtain cotton having dielectric constant (ε_r) 1.47. A textile material curtain cotton has been used as substrate material with thickness 3 mm and the size has 65.8mm×73 mm. The proposed antenna has a high gain of 8.68 dB, directivity 8.512 dBi with return loss -49.99 dB at resonant frequency of 3.136 GHz. The textile antenna radiates with resonant frequency of 3.136 GHz having 316 MHz bandwidth. The proposed textile antenna has VSWR of 1.3 and HPBW of 57 degrees. The performance of proposed textile antenna has been analyzed in term of parameters return loss in dB, gain in dB, directivity in dBi, bandwidth in MHz and half-power beamwidth in degrees. The microstrip feed line techniques has been used for proper impedance matching (50 ohms) with SMA connector. The antenna has been designed and simulated using computer simulation technology (CST) Microwave Studio 2014.**

***Index Terms* — Bandwidth; CST studio; HPBW; Return loss; SMA connector; VSWR**

I. Introduction

The recent advances in the field of electronics and communication technology and the development of wearable computers has allowed the creation of a wide range of handheld devices that can be carried in pockets or attached to the bodies [1]. The advances in communication and electronic technologies have enabled the development of compact and intelligent devices that can be placed on the human body or implanted inside it, thus facilitating the introduction of BAN's [2]. An increasingly mobile lifestyle of mankind is creating the need for Wireless Personal Area Net (WPAN) consisting of ad-hoc communications between portable computing devices such as laptops, PDAs, pagers and cellular Body Area Networks (BANs) are natural progression from the Personal Area Network (PAN) concept. These are wireless networks with nodes normally situated on the human body or in close proximity [3]. The wireless BANs can be applied in many fields like emergency services, military applications etc. The ultimate WBAN should allow user to enjoy such applications with minimum interference, low transmission power and low complexity [4].

The portable electronic devices have become part of everyday human life. Modern mobile phones are quite often carried throughout the day and they allow not just telephone calls alone but also provide internet access, multimedia and personal digital assistant. This form of `always on' and constantly connected status is a step towards the pervasive computing paradigm. In the future, a person is likely to carry a range of devices and sensors, including medical sensors that 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 antennas. Moreover, the UWB transmission devices does not need to transmit a high-power signal to the receiver and can have a longer battery life or be smaller to reduce the wearable devices size [5].

The development of wearable intelligent textile systems has altered the concept of clothing. The new generation garments are capable of monitoring the wearer's vital signs and activity as well as the environment [6,7]. Additionally, the introduction of these intelligent textiles has uncovered the need for wireless communication systems that are unnoticeably integrated into clothing [8].

Due to modern technological advances, the technical demands for wearable textile microstrip patch antenna has been increased in various applications. The wearable electronic devices are such devices worn by a person as un-obstructively as clothing to provide intelligent assistance. In addition, a wearable antenna is meant to be a part of the clothing used for communication purposes such as tracking, navigation, mobile computing and public safety [5]. A wearable textile antenna is an essential part of any body-centered Wireless LAN and it plays a paramount role in an optimal design of any wearable system [8].

The paper presents an antenna design capable of meeting the requirements of textile or wearable electronic devices such as being robust, flexible, small size, consume a small amount of power, and comfortable to wear. The simulated results of the proposed antenna design such as return loss, bandwidth and input impedance locus using smith chart has been observed. The Section II deals with the antenna design specifications which describes the dimensions of the designed antenna. Section III illustrates the performance of proposed microstrip antenna in terms of impedance bandwidth, return loss (S11), gain, directivity and VSWR plot. Section IV describes the nutshell of the research along with its proposed application areas.

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II. MATERIALS AND METHODS

The Textile materials generally have a very low dielectric constant which reduces the surface wave losses and improves the impedance bandwidth of the antenna [9]. The several antennas have been developed for wearable applications in the form of flexible metal patches on textile substrates [9]. In this paper, an UWB wearable textile antenna has been designed and analyzed. The substrate of the designed antenna was made from jeans fabric. In order to model the fabric, it is important to have an idea of its relative permittivity. The relative permittivity for jeans fabric was almost 1.7.

III. ANTENNA DESIGN

The proposed antenna has been designed and simulated in CST Microwave Studio 2014. The certain cotton substrate of thickness 1.47 mm has been sandwiched between copper radiating patch and ground plane of thickness 0.05mm. Further to enhance the bandwidth, the defected ground has been employed. The reduced ground is rectangular shaped structure as illustrated in fig. 3. As depicted in fig. 4, the antenna has compact area of 65.8×73mm^2. The dimensions of antenna have been listed in Table I.

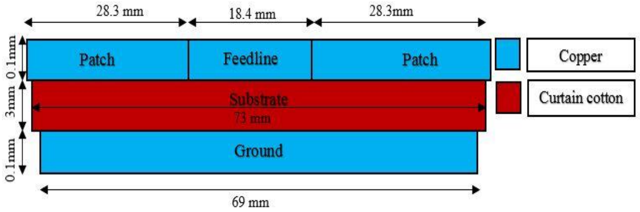

Fig.1 Side view of the proposed antenna in CST Microwave Studio 2014

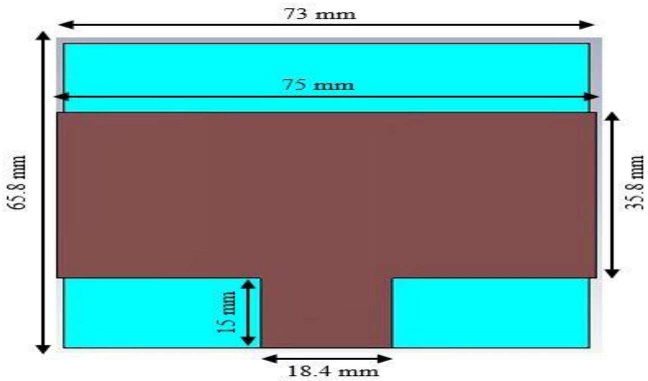

Fig. 2. Top view of the proposed antenna in CST Microwave Studio 2014

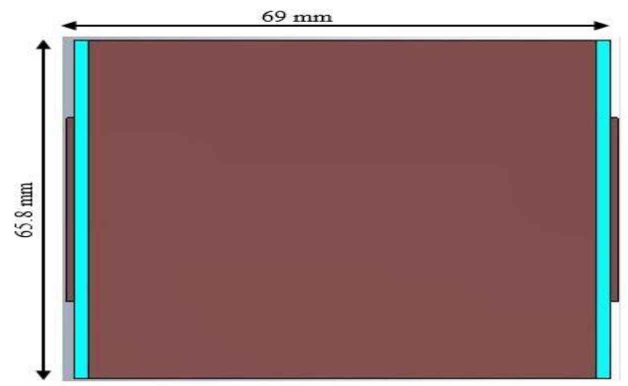

Fig. 3 Bottom view of the proposed antenna in CST Microwave Studio 2014

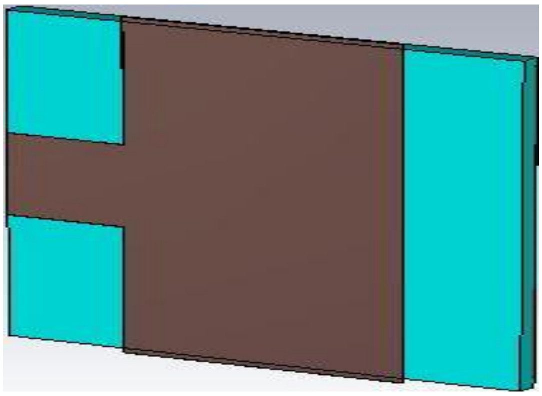

Fig. 4 Perspective view of the proposed antenna in CST Microwave Studio 2014

TABLE I – ANTENNA PARAMETERS

S. No.	Antenna Parameters	Value (mm)
1.	Height of substrate (h)	3
2.	Width of substrate (W_s)	73
3.	Length of substrate (L_s)	65.8
4.	Width of patch (W_p)	75
5.	Length of patch (L_p)	35.8
6.	Width of ground plane (W_g)	69
7.	Length of ground plane (L_g)	65.8
8.	Width of feedline (W_f)	18.4
9.	Length of feedline (L_f)	15

IV. RESULTS

The proposed antenna design has been simulated using CST Microwave Studio 2014. The performance of the proposed antenna has been analyzed in terms of bandwidth (MHz), return loss(S_{11}) plot, gain(dB), directivity (dBi), Voltage Standing Wave Ratio(VSWR) and Smith chart. The proposed antenna is resonant at 3.136 GHz with the minimal return loss of -49.99dB respectively as shown in fig. 5. The operating bandwidth of the proposed antenna has been depicted in fig. 6. The antenna operates within frequency range of 3.03GHz-3.35GHz thus making total operating bandwidth of 304.9MHz. The gain and directivity of proposed design is 8.683 dB and 8.512dBi, respectively. The Fig. 9 represents the VSWR value of proposed antenna in operating range of frequencies lie within 1.8372 to 1.0006, which is less than the maximum acceptable value of 2. The smith chart shown in fig 10 illustrates that input impedance of the proposed antenna has been matched to 50 Ω of impedance

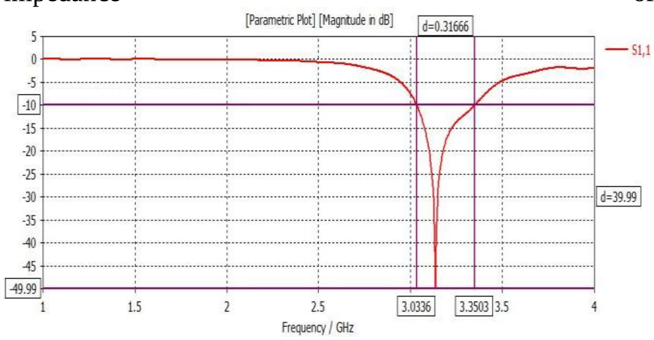

Fig. 5 Return loss(S_{11}) plot of the proposed antenna in CST Microwave Studio 2014

SMA connector. The impedance of simulated antenna has been found to be 50.09Ω.

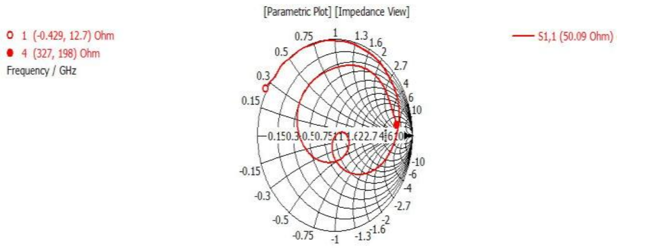

Fig. 6 Smith Chart of the proposed antenna in CST Microwave Studio 2014

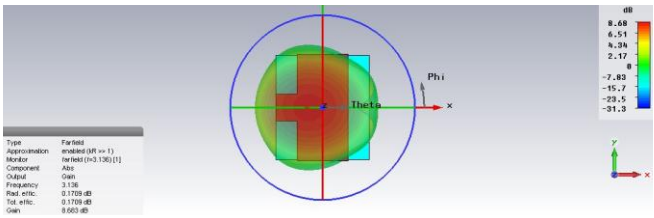

Fig. 7 Gain of the proposed antenna in CST Microwave Studio 2014

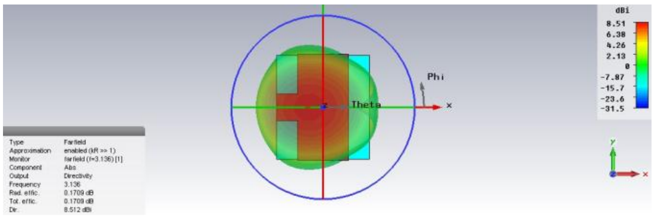

Fig.8 Directivity of the proposed antenna in CST Microwave Studio 2014

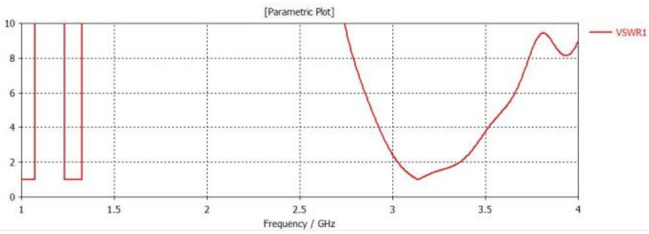

Fig. 9 VSWR plot of the proposed antenna in CST Microwave Studio 2014

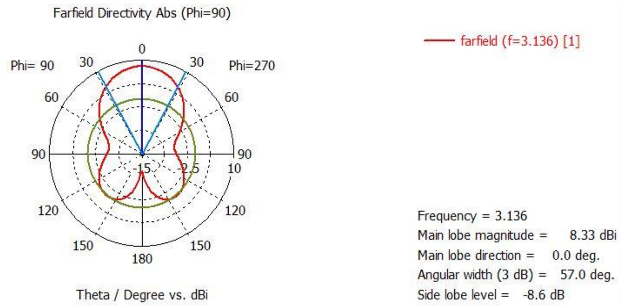

Fig. 10 HPBW of the proposed antenna in CST Microwave Studio 2014

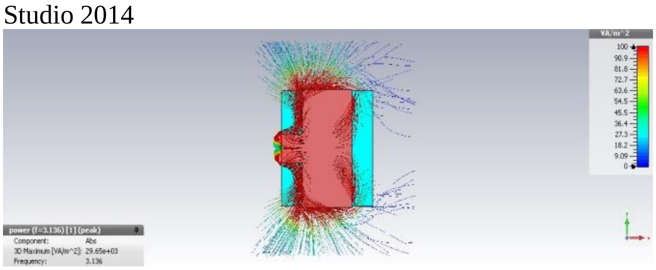

Fig. 11 Power flow pattern of the proposed antenna in CST Microwave Studio 2014

V. CONCLUSION

The proposed textile microstrip patch antenna has been simulated and designed in CST Microwave Studio 2014. The proposed antenna resonates at 3.03GHz-3.35GHz with operating bandwidth of 570 MHz and minimal return loss(S_{11}) of -49.99. The proposed antenna has gain of 8.683dB and directivity of 8.512dBi at 3.16GHz. The proposed antenna can be suitably employed for active satellite sensors, aeronautical navigation, radio determination, radiolocation (military and civil), shipborne and land and airborne surveillance and in ground based applications.

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