# Wearable Textile Patch Antenna for Medical Applications

**K. S. Chakradhar, Inumula Veeraraghava Rao, DT. Durga Prasad, P.Raju, V. Malleswara Rao**

***Abstract: In recent years of electronics industrialization, antennas are more popular components; wearable antennas play an important role due to their properties such as wireless communication and miniaturization. The design of wearable antennas have distinction in the area of antenna design and development, in this paper a thorough study had been carried out wearable antennas blended with textile, which has significant dielectric constant. This work describes the design a textile antenna, namely, a rectangular microstrip patch antenna and then rectangular with U-slot antenna with slits. After designing two kinds of antennas, a comparison will be made between their results. Conductive textile, a copper-plated polyester fabric, will be used for fabricating antenna radiators and grounds. An insulating denim fabric with dielectric constant 1.7 with a thickness of 0.7 is used for preparing the substrates. The proposed antenna is designed and all the results will calculated using Ansoft HFSS Software. After evaluating the results of a rectangular microstrip antenna and U-slot Antenna on textile substrate, the rectangular patch resonate at 2.5 GHz with the return loss of -16.86dB and the U-slot Antenna resonated at 2.2 GHz with return loss of -41.68dB and 3.9 GHz return loss of -16.16dB.***

***Keywords : wearable, textile antenna, wireless communication, Medical applications Microstrip, Antenna, microwave, HFSS***

## I. INTRODUCTION

Wearable antennas have become more popular in the recent research. Affluent mechanism of body centric communication is prevalent in the society promoting vast usage of wearable antennae. Wearable antennas are easily installable, less weight, cheap and maintenance free and are used universally. Many occupational segments of communication in real-time systems, such as health care, medical, time-critical systems, mission-critical systems need them. Besides, they are also used in in-house closed systems such as monitoring personalities, progression of behavior etc,. Several candidate antenna types are suitable to build a wearable antenna. Preferably, PIFAs, micro strips and planar monopoles, microstrip antenna out-perform amongst these categories, pre-fetch more compatibility for design and development of on-body wearable communication.

Patch antennas are particularlyfeasible for both on-body and off-body communication dueto the low profile they utilize [1]. Antennas consisting ofplanar sheets are ideal to be fabricated using conventionalmanufacturing processes of textile industry. Furthermore,the ground plane of such antenna effectively shields theantenna from the body tissues [2]. This minimizes bothdetuning and reduction of antenna efficiency. However,circularly polarized patch antennas tend to be sensitive tobending effects [3 – 4].Rectangular patch geometry isadopted for further examination of circularly polarizedtextile antenna. This geometry is shown to be relativelyrobust against bending effects [5].

Wireless communication technology is ushering in the research and playing a very important role in developing new stereotypes and prototype of products and in the revise of Wireless Body Area Networks (WBANs). The expanse of WBAN is the living body and it connects the different electronic devices inside with on the human body. The urge of WBAN applications pays dire attention today in the fields of medical, national defense and wearable computing. The constitutional elements of WBANs run on varied frequencies especially on Medical Implant Communication Systems (MICS: 400 MHz) band, the Industrial Scientifics Medical (ISM: 2.4 GHz and 5.9 GHz) band and the Ultra-Wideband (UWB: 3-10 GHz) [6]. According to IEEE 802.15.6, WBAN applications that insist on military, ubiquitous health care, sports, entertainment and many others, are classified into two areas, such as middle and non-medical. [8].

## II. DESIGN AND GEOMETRY OF TEXTILEANTENNA

The general considerations for the design of wearable communication systems are compact transmitter, minimized power consumption, optimized signal transmission over the human body, which are the rudimentary criteria pose the design challenge. Miniaturization, invisibility, omni-directional radiation pattern are the technical considerations for transmission, which should always take into account the antenna orientation, position of the receiver, adjustment and adjustment to compensate for body conditions. Recent studies on development of wearable antennas satisfying the requirements follow in this section.

A denim substrates with relative permittivity of $\varepsilon_r$ = 1.7 and thickness (h) = 3.5mm, losses tangent (tanδ ) = 0.01 is considered for design and demonstration of proposed antenna in the experiments. The location and fitting of the antenna by respect to its width, length of patch, ground plane and reflectors are mathematically analyzed and ascertained its usage [1].

**Revised Manuscript Received on December 13, 2019.**

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$$W = \frac{(velocity\ of\ light)}{2f\sqrt{\frac{\epsilon_r + 1}{2}}} \qquad (1)$$

Effective Dielectric constant $\varepsilon_{reff}$ is known by

for $\frac{w}{h} \geq 1$

$$\epsilon_{reff} = 0.5.(\epsilon_r + 1) + 0.5.(\epsilon_r - 1)\left[1 + 12\,h.w^{-1}\right]^{-0.5} \qquad (2)$$

The dimensions of the patch are extended to account the fringing effects. The extension is given by,

$$\Delta L = 0.412h\frac{(\epsilon_{reff} + 0.3)(w.h^{-1} + 0.264)}{(\epsilon_{reff} - 0.258)(w.h^{-1} + 0.8)} \qquad (3)$$

Since the length has been extended on each side of the patch, the effective length is given by,

$$L_{eff} = \frac{(0.5).(velocity\ of\ light)}{f\sqrt{\epsilon_{reff}}} \qquad (4)$$

***Patch Length = (Patch Length)$_{effective}$ – 2 (Change in Length)*** (5)

The ground plane dimensions are calculated by using the following formulae:

ground plane – length

$$L_g = 6h + L \qquad (6)$$

ground plane – width

$$W_g = 6h + W \qquad (7)$$

## III. SIMULATION OF TEXTILEANTENNA GEOMETRY

A rectangular patch antenna is an ISM band variant, with 2.4 GHz frequency is license free, adopted in wide range of applications. A jeans textile material, which has a dielectric constant 1.7, with height substrate of 3.5mm is a suitable form for designing wearable patch antenna. Since its substrate height (thickness) is 3.5 mm and less than 3.5 mm does not give $S_{11}$at desired level.

The performance of the antenna is improved by employing the U-slot inside the patch and which slits at the edge of the patch. Generally, textiles have low dielectric constant, reduced surface wave losses and increased impedance bandwidths, while in antenna. A self-adhesive copper tape is used to fabricate the prototype of wearable antenna and with scalar network analyzer in the experiments.

### *A. Structure of ReferenceAntenna*

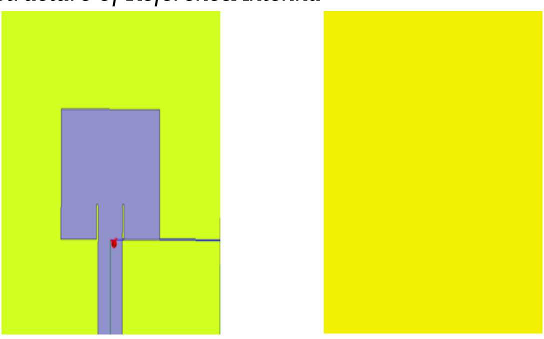

**Fig.1. A View of Wearable Textile Patch Antenna**

### *B. Structure of U-Slotted Antenna With Slits*

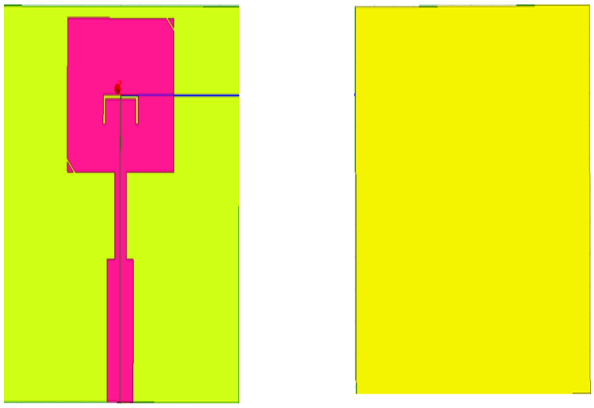

**Fig.2. A View of Wearable Textile Patch Antenna with U-Slot**

**Table-I:Dimensions of Reference Rectangular Textile Patch Antenna and with U-slot**

| Design Parameter | Calculated Value for Rectangular patch Antenna | Calculated Value for Rectangular MPA with U slot |
|---|---|---|
| Antenna Frequency | 2.4 GHz | 2.4 GHz |
| $\varepsilon_r$ | 1.7 | 1.7 |
| Antenna height | 3.5 mm | 3.5 mm |
| Antenna width | 53.6974 mm | 53.6974 mm |
| Antenna length | 46.6 mm | 46.6 mm |
| Microstrip Line width | 13.1197 mm | 13.1197 mm |
| Substrate dimensions | 120mm X 120 mm | 120mm X 120 mm |
| Length of feed line | 12.45mm | 43.307mm |

## IV. RESULTS

### *A. Results of the Reference Antenna*

Figure 3 and 4 shows the resultant $S_{11}$ and VSWR of the reference patch. As it can practical that the antenna radiates at 2.5 GHz with -16.86dBof $S_{11}$. In parallel, the VSWR is obtained at 1.36.

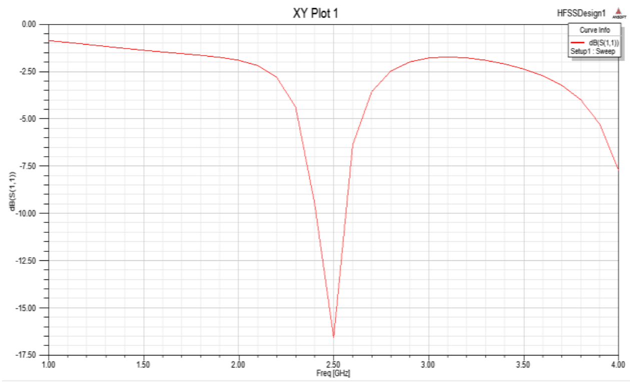


**Fig .3. Return loss of the reference Textile Antenna in HFSS**

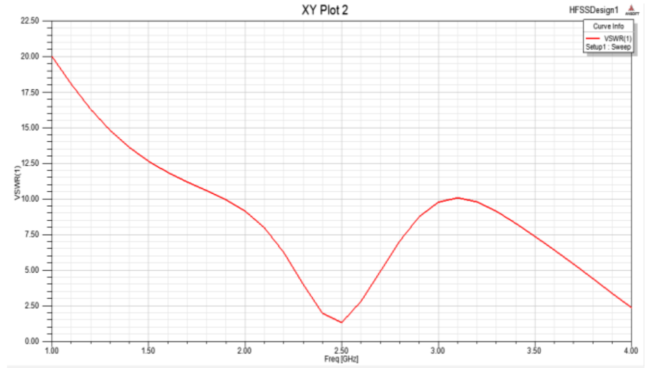


**Fig .4. VSWR of the reference Textile Antenna in HFSS**

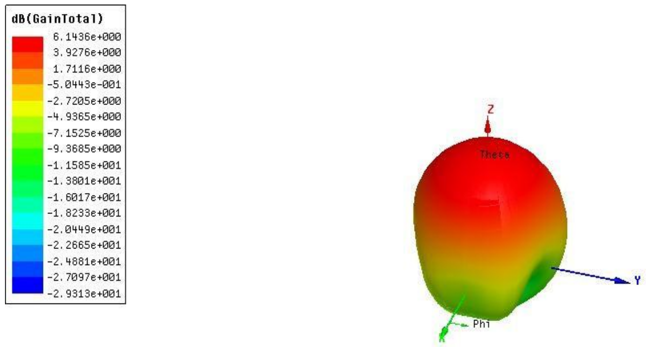

**Fig. 5.Gain of the reference Textile Antenna**

The gain of the antenna is obtained as 6.14 dB from the fig.5. The fig.6 shows the radiation pattern of the MPA

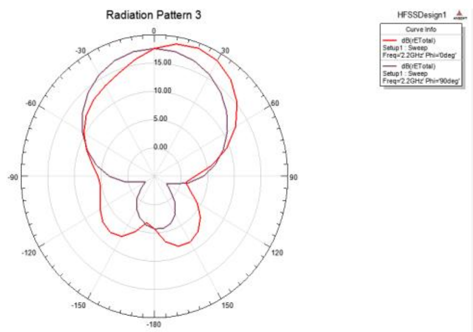


**Fig.6 Radiation Pattern of the reference TextileAntenna**

*B. Results of the U-Slotted Antenna withslits*

Figure 7 and8 show the simulated Return loss ($S_{11}$) and VSWR of the textile patch antenna with U- Slot . As it can observe that Textile antenna radiates at two bands 2.2 GHz and 3.9 GHz with -41.68dB and -16.16dBreturn loss respectively. On the Other hand, VSWR is 1 at 2.2 GHZ and 1.4 at 3.9 GHZ .

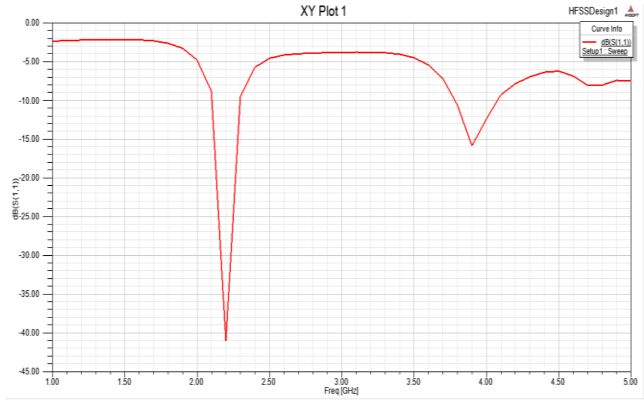


**Fig .7Return loss of the Wearable Textile Antenna**

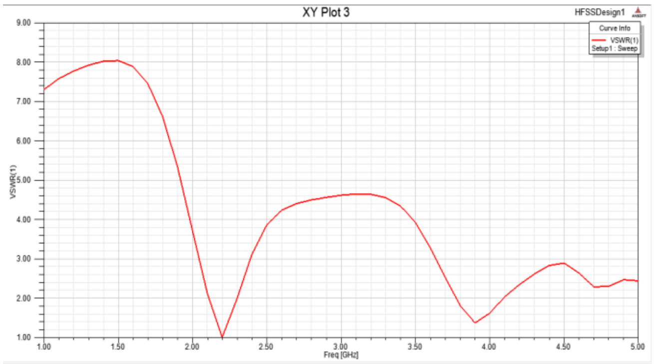


**Fig .8.VSWR of the Wearable Textile Antenna**

From the fig.8 the VSWR is obtained as 1 at 2.2 GHz and 1.4 at 3.9GHz

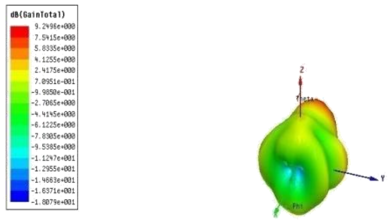

**Fig .9 Gain of the Wearable Textile Antenna**

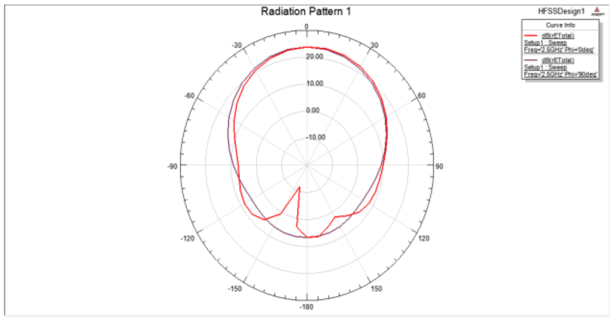


**Fig .10Radiation Pattern of the Wearable Textile Antenna**

**Table-II: Comparison of rectangular patch and U-slot antenna results**

| | *Resonating Frequency* | *Return Loss $S_{11}$* | *VSWR* | *Gain* |
|---|---|---|---|---|
| *Rectangular Microstrip patch Antenna* | 2.5 GHz | -16.86 dB | 1.36 | 6.14 |
| *Patch with U-slot* | 2.4 GHz | -41.68 dB | 1 | 9.24 |
| | 3.9 GHz | -16.16 dB | 1.4 | |

## V. CONCLUSION

The candidate antenna for wearable applications is a micro strip antenna. In general all textile material are assumed to have has low $\varepsilon_r$ as 1 to 2, a micro strip antenna can be a built-in into a fabric substrate material with a bandwidth of 200 MHz. Especially textiles has a distinct characteristic of reduced surface wave losses which gives improvised antenna bandwidth. In the proposed experimentation, textile antenna structures are tested and obtained results on their performances. The return loss of -41.68 dB at 2.2 GHz and VSWR is 1 for U-slot are noted according to simulated results.

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