Design of Compact Wearable Antenna for ISM Band

M. Annakamatchi
M.E E II[nd] year, Dept of ECE,
K.Ramakrishnan College of Engineering,
Trichy, India
annakamatchiece@gmail.com

P. Priesh
Assistant Professor,Dept of ECE,
K.Ramakrishnan college of Engineering,
Trichy, India
Priesh.kumar23@gmail.com

Abstract— **The design of the first wearable active receiving textile antenna in the 2.45 GHz ISM band is addressed for use in personal area networks. The conventional antennas are not flexible and difficult for user to movements. There is a need of antennas made of flexible textile materials that can be part of user clothing defined as wearable candidates for body-worn applications, as they mainly radiate perpendicularly to the planar structure and also their ground plane efficiently shields the body tissues. The proposed antenna design is based on CPW- feeding technique with two U-shaped connected slots on rectangular shaped patch which is operating in the Industrial, Scientific and Medical (ISM) 2.45 band. The antenna parameters like radiation pattern, gain and VSWR is analyzed for the proposed antenna. The antenna with compact size of 21X28X1.6 mm^3 provides the VSWR value as <2 and gain of about 1.0466 dB. The reflection loss in the proposed antenna was found about -20.0725 dB at 1.9 GHz.**

***Index Terms*—Wearable antenna, CPW-fed, ISM Band, Microstrip antenna.**

I. Introduction

Wearable antenna is an emerging technology that finds application in many fields that include military, telemedicine, sports and tracking [1]. Telemedicine is becoming increasingly utilized by health care providers due to the growing demand for remote monitoring of human vital signs. The antenna is required to act in close proximity to the human body, which has a very high dielectric constant. The influence of this high-dielectric surface leads to frequency detuning. Eventually, the backlobe radiations from the antenna also affect the human body [2].

For integration into clothing, antennas are usually required to be small, light weight and flexible. They should have stability and exhibit safe to person health when placed close to the body. There are several candidate antenna types suitable for wearable antennas, which are PIFA's, microstrip antennas and planar monopoles [3]. Microstrip antennas are usually preferred among these options. Microstrip antennas are useful for on-body wearable communication, because of their ease of construction, their cost effectiveness. One of the main advantage of patch antenna as wearable application is that its associated metallic ground plane that when used between the body and the radiating elements can significantly reduce the energy absorbed by the body [4]. However, microstrip antennas tend to have narrow bandwidth and may need to be relatively large if they are to be robust against perturbation by the body. However monopole and dipole has no ground plane so there its radiation pattern is effect to the body. So patch antenna is preferable.

In this paper, a compact CPW-fed wearable microstrip patch antenna with notch characteristics is investigated. By using two U-shaped slots in the radiation patch and a rectangle slot in the CPW ground, the potential interference has been reduced [5].

A. Wearable Antenna

Wearable antennas represent a fast growing field of research with many developments in the last decade which can be used to continuously monitor the activity, such as heart beat or body temperature as well as environmental parameters of rescue workers. The wearable antenna system also provides our future garments with additional functionalities, enhancing the quality of life without obstructing the movements of the user. These emerging technologies find its application in e.g., health care and the protective clothing industry.

B. Microstrip patch antenna

Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side. The patch is generally made of conducting material such as copper, silver or gold and can take any possible shape like square, rectangular, circular. The radiating patch and the feed lines are usually photo etched on the dielectric substrate.

Planar microstrip patch antennas, made of nonconductive textile materials, used as substrate, and electro textiles, used as conductive layers, are of particular interest because they are easy to manufacture, lightweight, flexible, and conformable to the wearer. The metallic ground plane, placed between the body and the radiating elements, reduces the energy absorbed by the human body. For wearable patch antenna substrate is textile material, here textile material is polyester having the relative permittivity 2.65, a loss tangent of 0.002 and a thickness of 1.6mm.

C. Antenna design and geometry

i. Calculation of patch width

The patch width (W) has a minor effect on the resonant frequency (fr), and it is calculated using the following formula,

$$w = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \tag{1}$$

Where c is the speed of light in free space and ε_r is the relative permittivity of the fabric material.

ii. Calculation of Effective dielectric constant (εreff)

The microstrip patch lies between air and the dielectric material, and thus, the EM waves an effective permittivity (εreff) is given by,

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}[1 + 12\,h/w]^{-1/2} \tag{2}$$

Where *h* is the thickness of the substrate.

iii. Calculation of actual length of patch

The patch length (*L*) determines the resonant frequency and it is a critical parameter in design because of the inherent narrow bandwidth of the patch. The design value for *L* is given by .

$$L = L_{eff} - 2\Delta L \tag{3}$$

Where,

$$L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon_{reff}}} \tag{4}$$

Where ε_{reff} is the effective permittivity of the material.

iv. *Calculation of extension length* ΔL

At both ends of the patch length, due to the effect of fringing fields, the extension of length is given by

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \tag{5}$$

D. Proposed Antenna design

A compact and wearable CPW-fed microstrip patch antenna is designed with the compact size of 21mmX28mm. The frequency band is obtained by introducing two U-shaped connected slots in the radiation patch and a rectangular slot in the ground plane. The antenna is printed with relative permittivity 2.65, a loss tangent of 0.002 and a thickness of 1.6mm. The proposed antenna are caused by a rectangle slot with width 0.8mm in the CPW ground and a simple square patch with two U-shaped connected slots with width 0.2mm.

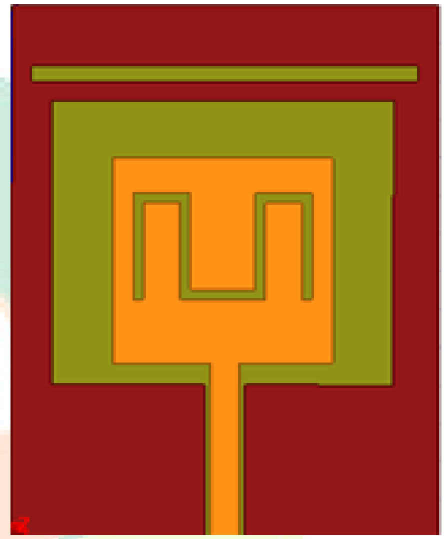

Figure 1 Geometry of wearable patch antenna with two U-shaped connected slots

Figure 1 illustrates the geometry of compact wearable antenna with two U-shaped connected slots. The length and width of the antenna is 28mm X 21mm X 1.6mm. The inner patch dimensions are respectively 15mm X 16.8 mm. The proposed antenna are caused by a rectangular slot with width 0.8mm in a CPW ground and a simple square patch with two U-shaped connected slots of 0.2mm. The lengths of the U-shaped connected slots are 5.6mm. The distance between the radiation patch and the CPW ground is 1.2mm.

E. Results and Discussions

(i) Return loss

The patch antenna was simulated by using High frequency structural simulator. The proposed antenna had a CPW feed with a full port impedance of 50Ω and rectangular slot in the ground plane which will improve the bandwidth. The frequency response of the existing antenna and proposed antenna is shown in Figure 2.

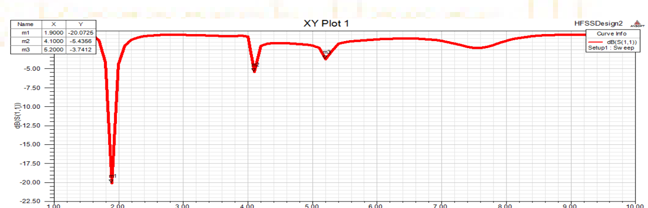

Figure 2 Return loss curve of wearable patch antenna with two U-shaped connected slots

(ii)Gain

The gain of the proposed antenna is shown in Figure 3. The gain obtained for the frequency 1.9GHz is 1.0466 dB. Antenna gain relates the intensity of an antenna in a given direction to the intensity that would be produced by a hypothetical ideal antenna that radiates equally in all directions and has no losses. The gain of an antenna is directly related to its directivity, the antenna gain is a measure that also takes into account the efficiency of the antenna.

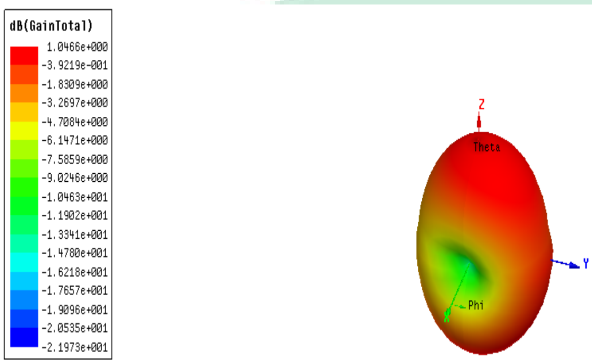

Figure 3 Gain of wearable patch antenna with two U-shaped connected slots

(iii) Radiation pattern

The radiation pattern of the proposed antenna is shown in Figure 4. The radiation pattern is found to be directional, which is radiating in a particular direction. The radiation pattern describes the relative strength of the radiated field in particular directions from the antenna, at a fixed or constant distance. In the field of antenna the term 'radiation pattern' most commonly refers to the directional dependence of radiation from the antenna. An antenna radiation pattern is defined as a mathematical function or a graphical representation of the radiation properties of the antenna as a function of space coordinates. Mostly it is determined in the far field region and is a function of directional coordinates. Radiation property is the two or three-dimensional spatial distribution of radiated energy.

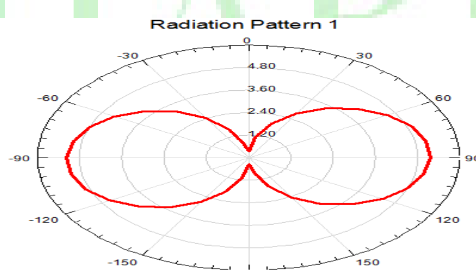

Figure 4 Gain of wearable patch antenna with two U-shaped connected slots

(iv) VSWR

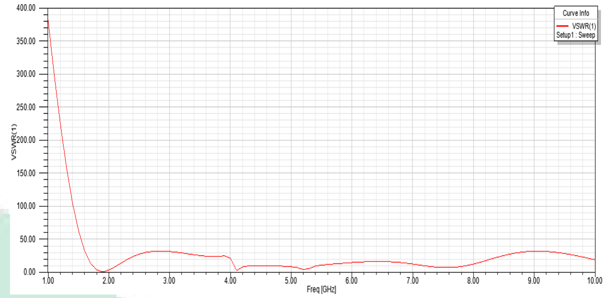

Figure 5 Voltage Standing Wave Ratio of wearable patch antenna with two U-shaped connected slots

The above Figure 5 represents the VSWR of the proposed antenna. Voltage standing wave ratio is a measure of impedance matching of loads to the characteristic impedance of a transmission line or waveguide. Impedance mismatches result in standing waves along the transmission line. The standing wave ratio is usually thought of in terms of the maximum and minimum AC voltages along the transmission line thus called the voltage standing wave ratio or VSWR.

F. Conclusion

The proposed antenna system is simulated using High Frequency Structural Simulator. A CPW fed patch antenna with two U-shaped connected slots resonates at the frequency of 2.45 GHz with gain 1.0466 dB and return loss of about -20.0725 dB. The results show that the antenna has good radiation pattern and also it is applicable for ISM Band and Telemedicine applications.

REFERENCES

[1] C. Hertleer, H. Rogier, L. Vallozi and L. van Langenhove (2009), "A Textile Antenna for Off-body communication Integrated into Protective Clothing for Firefighters", IEEE Transactions on Antennas and Propagation, vol. 57, no.4, pp.919-925.

[2] G. Conway and W. Scanlon (2009), "Antennas for over-body-surface Communication at 2.45 GHz", IEEE Transactions on Antennas and Propagation, vol 57, no.4, pp. 844-855.

[3] Haider R. Raad, Ayman I. Abbosh, Hussain M. Al- Rizzo and Daniel G. Rucker (2013), "Flexible and Compact AMC Based Antenna for Telemedicine Applications", IEEE Transactions on Antennas and Propagation, vol. 61, no. 2, pp.524-531

[4] Nurul Husna Mohd Rais, Ping Jack Soh, Mohd Fareq Abdul Malek and Guy A.E Vandenbosch (2013), "Dual-Band Suspended-Plate Wearable Textile Antenna", IEEE Antennas and Wireless Propogation Letters, vol. 12, pp. 583-586.

[5] P. Salonen, Y. Rahmat-Samii, H. Hurme and M. Kivikoski (2005),"Dual-band E-shaped patch wearable textile antenna", IEEE Transactions on Antennas and propogation, vol. 1A, pp. 466-469.

[6] S. Zhu and R. Langley (2009), "Dual-band Wearable Antenna on an EBG substrate", IEEE Transactions on Antennas and propagation, vol. 57, no. 4, pp. 926-935.

[7] Sangeetha Velan, Esther Florence Sundarsingh, Malathi Kanagasabai, Aswathy K. Sarma, Chinnambeti Raviteja, Ramprabhu Sivasamy and Jayaram Kizhekke pakkathillam (2015), "Dual-Band EBG Integrated Monopole Antenna Deploying Fractal Geometry for Wearable Applications", IEEE Antennas and Wireless Propagation Letters, vol. 14, pp.249-252.

[8] Tess Acti, Alford Chaurya, Shiyu Zhang, William G. Whittow, Rob Seager, J.C Vardaxoglou and Tilak Dias (2015), "Embroidered Wire Dipole Antennas Using Novel Copper Yarns", IEEE Antennas and Wireless Propagation Letters, vol. 14, pp. 638-641.