DESIGN AND SIMULATION OF WEARABLE ON-BODY ANTENNA FOR BODY MONITORING APPLICATIONS

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Abstract

This paper presents the design of a wearable rectangular shaped patch with L-cuts, antenna.Wireless communication and networking are widely developed in every field. The antenna has a low profile and is printed on a common 2 mm FR4 epoxy ("*r* = 4.1)and its loss tangent was tan δ = 0.024. The antenna is designed in a compact size which is 62mm x 36 mm much smaller than the substrate and in a wearable and flexible manner. The radiation pattern is observed at various central frequencies and different planes such a horizontal (XY) and vertical (XZ) suitable for data communication. The design is produced with very minimal current in the surface which does not affect the human body tissue.

Key words : Loss tangent , Multiband , Surface Current Distribution.

I. INTRODUCTION

1.1. Origin of the proposal

A wearable antenna can be used in a variety of applications such as GPS navigation, military, monitoring of athletes fitness, telemedicine, satellite communication, digital watches, and RFID. Since there is a need to connect wearable technologies to other data acquisition stations, flexible antennas integrated into wearable technologies are expected to play an important role. To ensure practical suitability, wearable antennas need to be user friendly, comfortable, flexible, durable, inexpensive, low weight and compact.

1.2. Substrate Selection

For wearable textile antennas there must be low dielectric constant, low surface wave and must not harm human body. In the design process of wearable antennas, different substrate and conductive materials have been proposed based on the application need. Presently, most applications utilise rigid substrates such as polytetrafluoroethylene (PTFE) Taconic ceramic substrate ("*r* = 10). Hence, for a comfortable user experience, integration of wearable electronics on low dielectric substrate, which is strong, durable made up of FR4 epoxy, has been used as the substrate material here, to improve on body monitoring. Some of the materials and their return loss are mentioned in the table below (Table1).

Type of material used	Return loss	Software used
PDMS+ Glass	-38.84	CST
Polyester	Without EBG -29.42 With EBG -38.42	CST
FR4	-31.42	CST

Table1. Comparative Analysis of different Wearable Antenna for ISM band [8]

1.3. Objectives

- To identify a good dielectric substrate to fabricate antenna (FR4 ("*r* =4.1)).
- To design the antenna in a wearable manner.
- To obtain minimum SAR values for a safer wearable use.
- To design the antenna in a compact size for better user comfortability.

II. ANTENNA GEOMENTARY CONFIGURATIONS

An antenna which consists of two symmetricalL-cuts on a rectangularpatch designed on a FR4 (low loss) substrate with a relativedielectric constant of 4.1 and loss tangent of tanδ = 0.02. The geomentry of the proposed antenna ispresented in Figure (2.1), and details of the antenna dimensions are given in Table 2.Copper adhesive tape which has a layer thickness of 0.035mm,which is a common hardware used to fabricate the antenna.Size of the antenna is very small and compactable,the dimensions are 62mm x 36 mm patch and thesubstrate size did not adversely affect the antenna performance becauseit is bigger than the conductive area.[2]

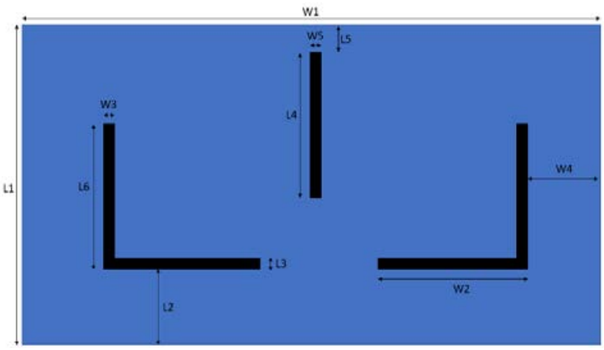

Figure (2.1). Antenna design

Parameter	Length	Parameter	Length
W1	62	L2	12
W2	12	L3	1
W3	1	L4	15
W4	9	L5	7
W5	2	L6	10
L1	36		

*All the values are in millimetre

Table2. Dimensions of the proposed antenna design

III.DESIGN IN ANSYS HFSS

The proposed antenna was designed in Ansys HFSS and the excitation fields are set for the ground ,patch and substrate.The patch was fed by the co-axial feed mechanism. After complete analysis of our design with no errors and warnings,we proceeded for validation totake the simulation results[5]. The 3D design of the antenna in HFSS is shown in Figure (3.1).

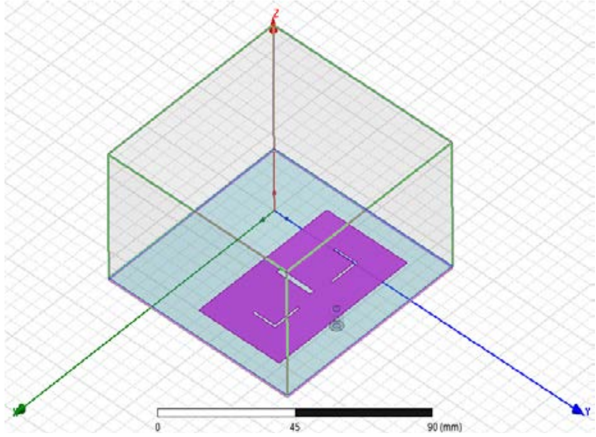

Figure (3.1).3D-design

IV. RESULTS

4.1 Return loss

After designing the prototype of the optimised antenna structure in Ansys HFSS, shown in figure (2.1),return loss characteristics has been simulated. A minicoaxial RF cable with 50 ohm impedance and the inner conductor of 2.4mm diameter and the outer conductor of 4.8mm diameter which is used tofeed the antenna[5].The return loss was simulated and although it shows the good excellence in certain frequencies which shows in the Figure (4.1). The antenna impedance bandwidth covered 2.15 GHz and 3 GHz bands.The voltage standing wave ratio (VSWR) for 2.15GHz and 2.9GHz was showed at 10 dB reference return loss at the input which is less than 2 which is showed in the Figure 4.2; hence the antenna accepted more than 80% of the excited power[6] .

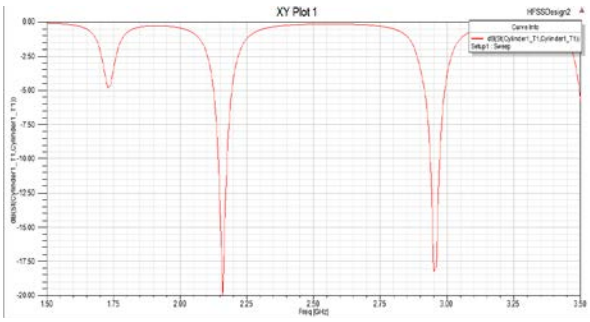

Figure (4.1). Return loss

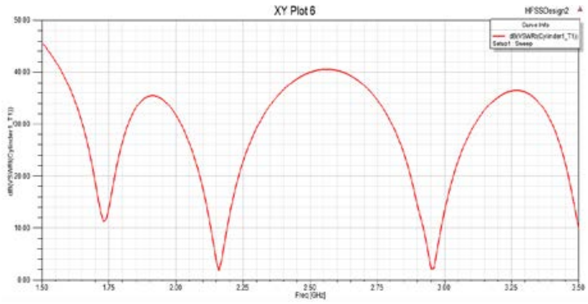

Figure (4.2). VSWR

4.2 Radiation pattern

The prototyped antenna radiation pattern was simulated in both the horizontal and vertical planes XY and XZ respectively by the Ansys HFSS. Simulated radiation pattern at 2.45 GHz and 5.25 GHz central frequencies.The simulated results should be seen as good which is shown the Figure (4.2.1), Figure (4.2.2) ,Figure (4.2.3), Figure (4.2.4). The antennahad linear polarisation and theelectric field vectors oscillated in YZplane with propagation directiontowards the *z*-axis.It is very important for a wearable antenna to have a semi-omnidirectional radiation pattern,Because it need to support for the data communication for IoT (Internet of Things) .When the person is walking in both horizontal(XY-Plane) or vertical(XZ-Plane) and as well as standing in horizontal and vertical planes this proposed antenna will gives the efficient data transmission and reception. The simulated results of the radiation pattern for the antenna in both the planes for our proposed design is showed below.

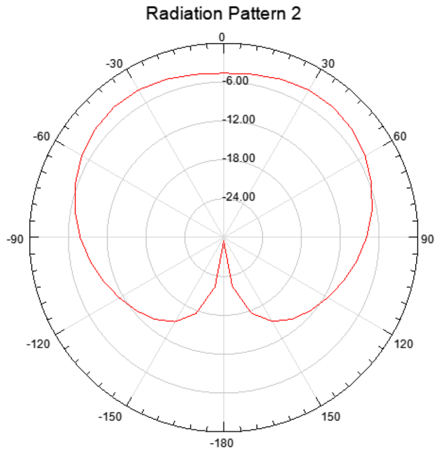

Figure (4.2.1). Simulated radiation pattern of antenna for XY-Plane at 2.45 GHz

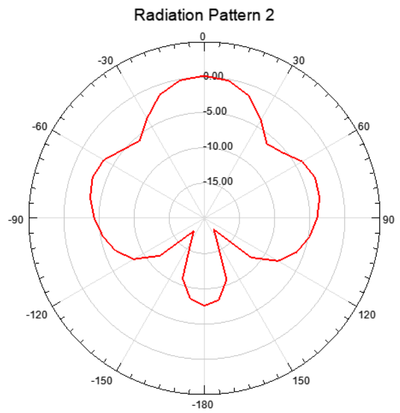

Figure (4.2.2). Simulated radiation pattern of antenna for XY-Plane at 5.25 GH

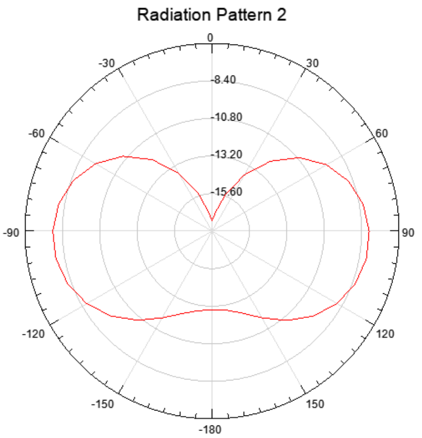

Figure (4.2.3). Simulated radiation pattern of antenna for XZ-Plane at 2.45 GHz

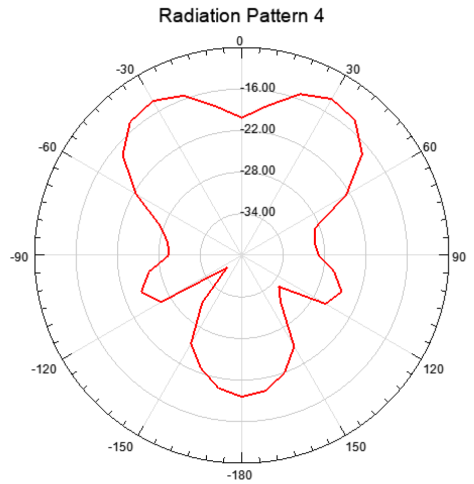

Figure (4.2.4). Simulated radiation pattern of antenna for XZ-Plane at 5.25 GHz

4.3Surface Current Distribution and Parametric Study

The simulated currect distribution for the proposed antenna is showed in tha Figure(4.3.1).It is seen from the Figure (4.3.1), the rectangular patch contributed considerably to supporting the desired frequency bands.The surface current distributes very equally in all regions of the antenna and it also attain a medium strength, only at the corner it acquires high strength that is also a very small area ,because of this it cannot affect the body tissue. For example, if the substrate or the material was changed in some other dimensions it produces high strength and therefore it affects the human body.Surface current distribution is very important parameter for considering while designing an antenna.

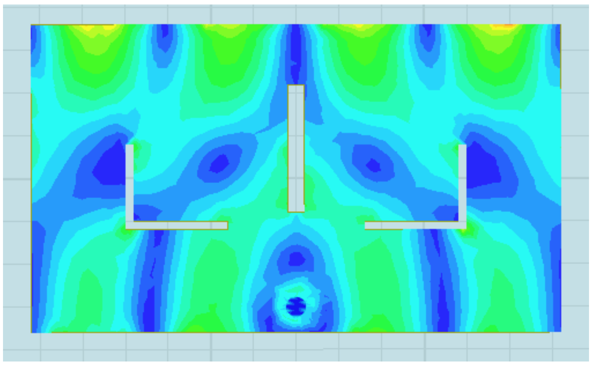

Figure (4.3.1). Current distribution

V. Conclusion

In this paper the two symmentrical L-Cuts in a Rectangular patch antenna was designed in Ansys HFSS and the simulation results are taken. The complete dimensions of the proposed antenna unit was very small and comfortability for the person who use.This can be integrated with the textile material which is used as a wearable one .The durability and the robust performance was good under different conditions.A semi-omnidirectional radiation pattern by which IoT wearable electronics can communicate easilywas achieved. Supported frequencies stayed in bands when the antenna was placed in proximity todifferent bodies. The antenna had low SAR and it was in directproportion to the input power. The 10 g averaged SAR stayed within standardlimitations for up to 100mW input referencepower considering direct contact between the antenna and body tissue.

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