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Design of Wearable Textile Based Microstrip Patch antenna for Bandwidth Enhancement

Priyesh Jaiswal and Dr. Poonam Sinha

Department of Electronics Engineering, University Institute of Technology, Barkatullah University, Bhopal, Madhya Pradesh, India.

Abstract

A used of wearable antenna by using textile material is very common due to miniaturization of wireless communication devises. The design of wearable antenna is suitable due their low dielectric constant or relative permittivity characteristic. The proposed antenna is designed by using polyester substrate with a permittivity of 1.44 and thickness of 3mm. The structure is simple, compact and easy to manufacture by using textile materials. The proposed antenna is design by using a slot of length λ/2 0n ground as well as exiting patch 3mm x 25mm open slot with a via hole of dimension 0.3mm between ground and exiting patch. The antenna is suitable for medical application. The wearable antenna is designed to achieve a bandwidth of 85%. for VSWR<2, the directivity and return loss for proposed antenna is 5dBi and 22.5dB.The proposed antenna is investigated for S band application. The Proposed antenna is design by using IE3D Simulator.

Keywords: Wearable antennas Broadband, IE3D simulator, Shortening technique, probe feeding, slot .

INTRODUCTION

The used of an antenna is rapidly increasing recently due to varieties of wireless communication systems launched into the advertise like 4G mobile services, marine or land vehicle navigations (GPS), wireless LANs access, sensors for monitoring systems, and many small devices embedded with Bluetooth, UWB, Zigbee, DVB etc.[1] Nowadays, handheld communication devices and human body communication systems need wide-gain, wideband with compact sizes which should be an combined part of the wearer clothing [1–6].These are wearable mobile phones; Note pad; personal digital assistant (PDA) devices, sports activities, body area networks (BAN); industrial, scientific, and medical (ISM) band; WLAN; so on. The cloth-based wearable antenna should communicate the voice data, or biotelemetry signals at high data rates. It should have features like weight is less, comfortable, bendable, need to be secret, and it heath conscious of user. In practice, man-made or normal cloth materials are used as dielectric substrate to manufacture the textile or cloth-based wearable antennas. These substrate are polyester, wet cotton, dry cotton,liquid crystal polymer (LCP), fleece fabric, Nomex, nylon, foam, copper ribbon, insulated wire, conducting coat, copper coated material, and so on .The author work on bending effect for different part of human body actions for impedance matching of textile-based rectangular microstrip patch antenna is proposed and analyzed [5]. The remove of the metal segment of the rectangular microstrip patch antenna by making the slots inside the patch to excite lower resonant frequency. The conductor removing method helps not only to decrease the effect due to human body movements on the antenna but also to reduce the Specific absorption rate (SAR). The metal material square split ring resonator (SRR) is set in inside the slot to achieve the better matching in the WLAN. The wearable antenna plays an important role in between wireless communication and on body sensor and other devices. The design of wearable antenna is different from the normal antenna.[1] [2]. The multiband antenna design in which textile material are used it proposed the three design in which curtain cotton and polycot as a substrate material is used to achieved the multiband [3]-[7] Some researchers antenna is recognized on body for communication of signal along the surface of the human body and discussed about the directional pattern propagating normal to the surface of a human body. In WBAN (wireless body area network) flat antenna surface cannot be provided in general [4]. Bending effect of the wearable antenna some is work on electronics band gap to improve the bandwidth and input impedance matching [5-6]. In this requires a possible integration of the wearable antenna device for daily usable clothing.[7]. Here we are approach the microstip patch antenna design technique for wearable antenna design to achieved the wide band and high gain antenna.

MATHEMATICAL ANALYSIS

In order to demonstrate the design of proposed antenna with a frequency range of 2.4GHz, Polyester substrate with relative permittivity $\varepsilon_{r=}$1.44, and thickness (h) = 3mm, Loss tangent (tanδ)=0.01. By performing mathematical analysis we calculate width and length of the patch, ground plane, and reflectors.[10]

$$W = \frac{c}{2f\sqrt{(\varepsilon_{r+1})}/2} \quad (1)$$

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

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)\,((W/h) + 0.264)}{(\varepsilon_{reff} + 0.258)\,((W/h) + 0.8)} \quad (3)$$

$$L = \frac{c}{2f\sqrt{\varepsilon_{reff}}} - 2\Delta L \qquad (4)$$

$$L_0 = L + 6h$$
$$W_0 = W + 6h \qquad (5)$$

where:

f = Operating frequency

ε_r = Permittivity of the dielectric

ε_{reff} = Effective permittivity of the dielectric

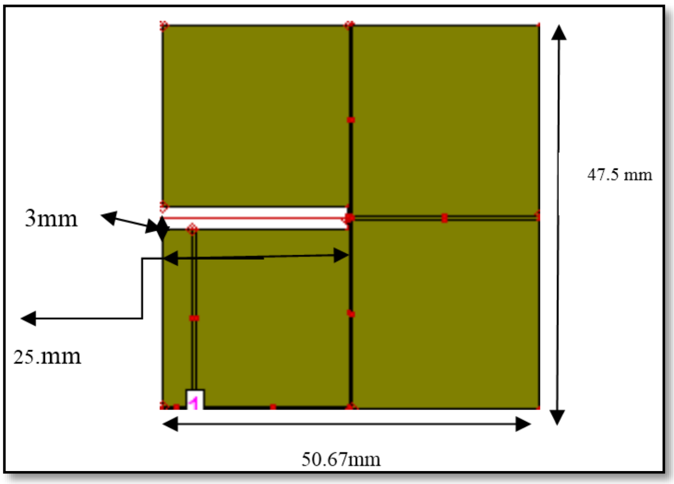
W = Patch's width

L = Patch's length

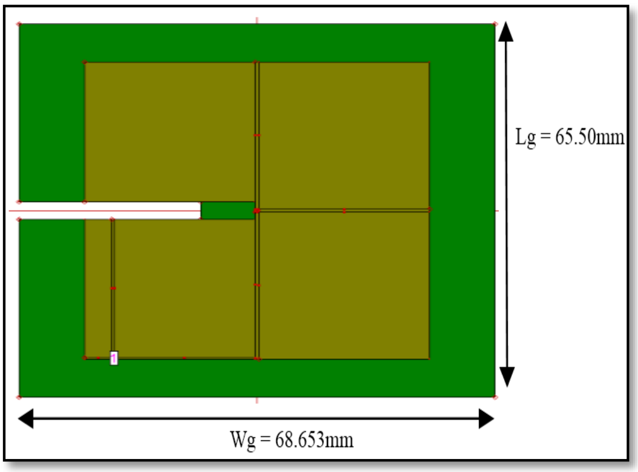
h = Thickness of the dielectric

L_0 = Length of ground plate

W_0 = Width of ground plate



(a)



(b)

Figure 1. Geometry of the proposed antenna (a)Exiting patches (b) Ground plane by using shorting pin.

The structure of proposed antenna with a slot of λ/4 is place on exciting patch and ground plane and shorting pin is as shown in figure1. it shows the pass band of 1.8 to 4 GHz. The antenna is design by 47.567mm x 50.65mm x 3mm.For further increase the bandwidth we connect a shorting pin between the ground and excited patch. The table shown different parameter for designing of microstrip patch antenna by using equation from 1 to 5

ANTENNA DESIGN AND RESULT ANLYSIS

A. Antenna Design by Using IE3D Software.

The architecture of proposed designed is consists of two slot of λ/2. The two conducting layer are separated by a via hole of radius 0.3mm to improve the bandwidth and polyester substrate. The feeding is probe feeding by using a polyester substrate which has a substrate thickness of 3mm and dielectric constant of 1.44 that the return loss, directivity, and the radiation pattern can be obtained by using the wearable antenna which is simulated by electromagnetic software IE3D (version 9.0).Based on the simulator and mathematical Analysis [10]. The length and width of rectangular microstrip patch antenna is calculated as shown in table 1.

Table No 1. Different parameter of the proposed antenna.

S. N.	Parameters	Values for proposed antenna
1	Design frequency(f_o)	2.4GHz
2	Dielectric constant(ε_r)	1.44
3	Height of substrate(h)	2.85
4	Loss tangent for polyester	0.01
5	Width of rectangular patch(W)	50.67mm
6	Length of rectangular patch(L)	47.5 mm
7	Width of ground plan (W_g)	68.65 mm
8	Length of ground plan(L_g)	65 .50mm
9	Shorting pin radius xf, yf	0mm 0mm
10	Feed location: X_f (along length), Y_f (along width)	-19.41mm -25.32mm

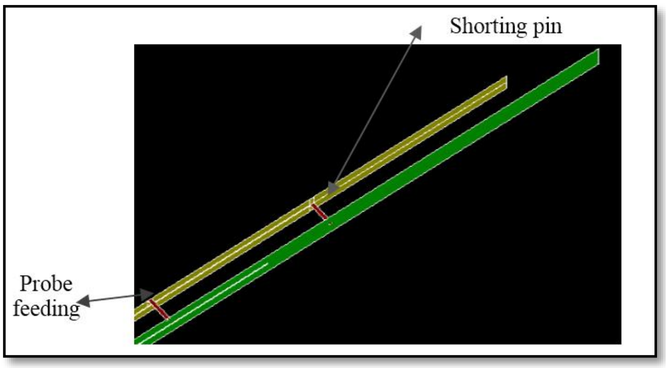


Figure 2. 3D view of proposed antenna

As shown in the 3D view of a geometry. The upper side is an excited patch and the ground plane in between shorting pin and probe feeding is given. The shorting pin in between ground plan and exiting patch radius is 0.3mm

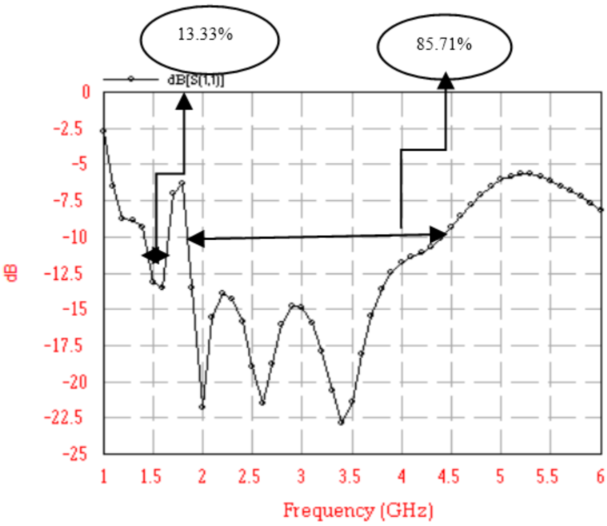


Figure 3. Return loss curve for antenna with O slot shorting pin

In this section we analysis the return losses and calculate the bandwidth and return loss of a proposed antenna. The proposed design of proposed design the antenna have dual band form 1.4 GHz to 1.6 GHz and 1.8 to 4.5 GHz, The Return Loss for notch is effective in between 1.4 GHz to 1.6 GHz and 1.8 to 4.5 GHz.

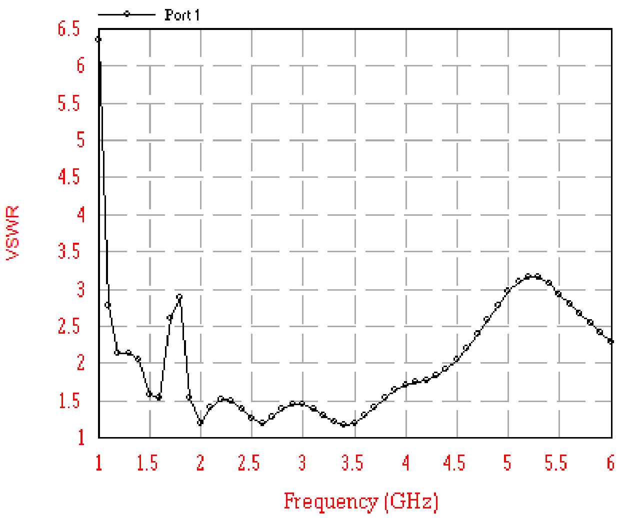


Figure 4. VSWR curve for proposed antenna

The VSWR is effectively less than 2 in between 1.2 to 1.5 GHz and 2.8 GHz to 3.3 GHz respectively, for this value of return loss is in between 1 and 2.

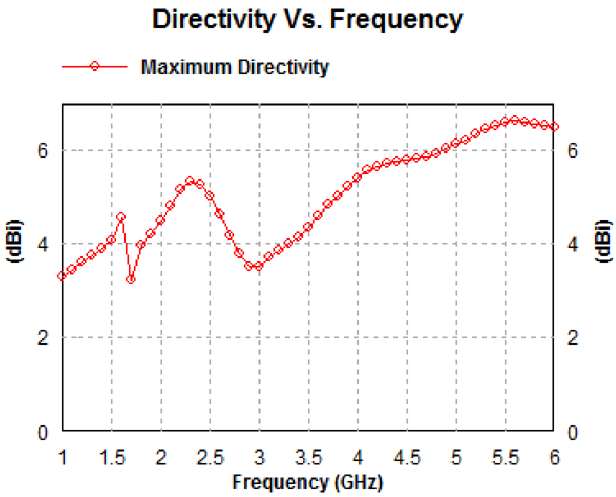


Figure 5. Directivity vs frequency curve for proposed antenna

The maximum directivity of proposed antenna is 6.9dBi at 3 to 3.7 GHz

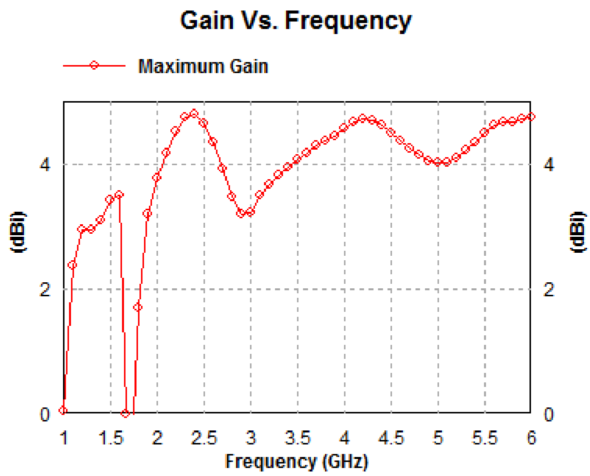


Figure 6. Gain vs frequency curve for proposed antenna

The maximum gain of proposed antenna is 6dBi.

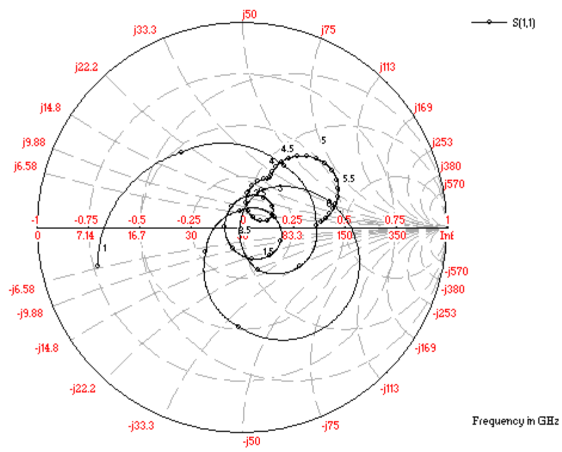


Figure 5. Smith chart for proposed antenna

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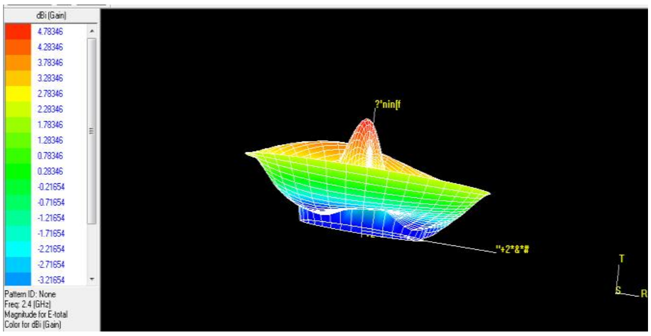

Figure 6. The 3D radiation pattern of the proposed antenna

The 3D radition pattern of the antenna at frequency 2.4 GHz is shown in Fig.6. It can be observed from this radiation that the design antenna has stable radiation pattern throughout the whole operating frequency range which is applicable for ISM band.

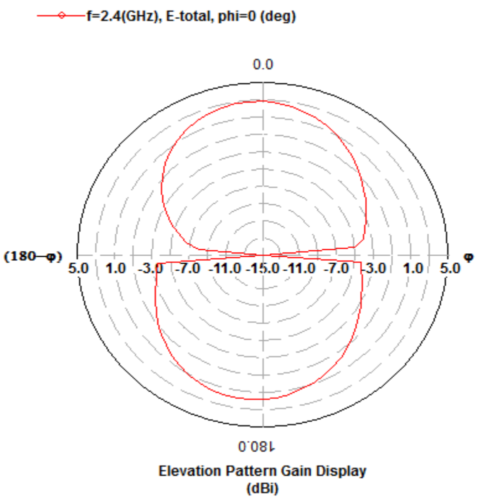

Figure 7. Elevation Pattern at 1.5 GHz

We have analyzed elevation at 2.4 GHz shown in figure 7. 3dB, beam width is 95.4581deg

Simulated Etotal of a radiation pattern of the proposed wearable antenna for ISM band at 2.4 GHz

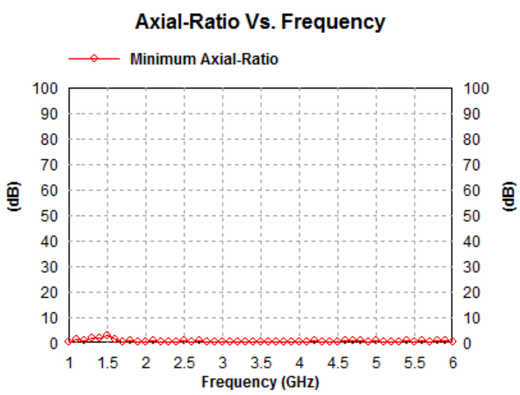

Figure 8. Axial ratio of simulated proposed antenna

The simulated axial ratio value for a particular direction is plotted in fig 8 as shown. It described that the antenna is operated in circular polarization. The axial ratio value is less than 3dB at all frequency from 1,8 GHz to 4.5 GHz.

CONCLUSION

The wearable antenna are design for by using polyester with a conducting coating on both sides of ground and existing patch with a via hole for medical application are simulated by using method of movement software (MOM) and validated through a software by using 2.4 GHz frequency. The proposed antenna is design with open stub slot and shorting pin, for bandwidth enhancement in textile wearable antenna. All the antenna parameters are calculated for 2.4 GHz frequency spectrum. The proposed antenna produces a bandwidth of approximately 85%, with a constant radiation pattern within the frequency range. On polyester substrate this antenna can be easily constructed by using polyester substrate and conducting plate of thickness 0.5mm to 1mm. The parameter of an proposed antenna is within acceptable limit so that it is suitable for wearable application. Here we use simple coaxial feeding technique is used for the design of this antenna.

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