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Design of Flexible Antenna for Wearable Applications

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Abstract- ***The proposed vivaldi antenna for wearable applications is done using flexible material. The designed antenna has the length of 8 cm and width is 6 cm. For the gain enhancement, strip lines are added in the vivaldi. There are six strip lines and the length of the strip is varied. By adding the strip line, gain of the antenna is increased compared to without strip lines. It has high gain and directivity. Poly-Ethylene Terephthalate (PET) is used as a substrate for achieving the flexibility and it has high resist to moisture. It has board range of use temperature, -60 to 130°C. For every iteration, a strip line is added one by one upto six lines. The gain and directivity of the antenna is 5.4 dB for both the parameters.***

Keywords : Flexible antenna, High gain, .Poly-Ethylene Terephthalate (PET), Wearable applications

I. INTRODUCTION

The development of wireless technology has increased the researches in many areas including wearable applications. It plays major role in day today life. It makes our life more convenient than it was before. Some of the wearable applications are sports, military, remote sensing, tracking, bio feedback and monitoring health parameters. It is used widely in patient monitoring and tracking purpose by using RFID.

Nowadays antennas are widely preferred for wearable devices for medical applications. Wearable devices are used for monitoring the patient's health parameters. Smart watches, wristbands and smart clothing with built-in technology are some of the examples of wearable devices. It measures blood pressure, body temperature, sweat level, glucose and it is also monitoring heartbeat, physical activity, breathing and tumor detection.

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This system allows the people to stay their place without going the nursing home. By using this kind of devices, man work, cost and time can be reduced. Instead of going to nursery home we can get the information of our health from our place.

Antenna might be fixed for any kind of devices or it can be directly fitted in skin. Non flexible materials do not be affected by bending. But human body is not a flat surface.

In this application Vivaldi antenna is chosen which is used for imaging task. It is based on advanced image reconstruction algorithms. In microwave imaging, the antenna is used as a transceiver which means the antenna acts as both transmitter andreceiver in microwave signalsinto the tissues. This principle is based on the variation of electrical properties of different tissues such as the relative permittivity and conductivity.The scattered signal reflectedfrom the antenna is used to detect the contrast in the dielectric properties between normal and tumor tissue.

Vivaldi antenna has high directivity and high gain. High gain antennas are designed by using some techniques. Adding load on the antenna enhance the gain. But sometimes it increases the antenna gain and reduces the flexibility. Gain is the measurement of antenna's capability. To overcome this problem, flexible materials are used for designing. Some of the techniques are to improve the gain. But there is also problem of bending and wetting performances of the antenna. Due to bending and wetting the antenna performance should not be affected. While bending the antenna resonant frequency is slightly changed. Mostly low frequency is prepared for medical applications because higher frequencies should not penetrate in depth of the skin. Objective of the proposed design is to obtain high gain, low cost flexible antenna for wearable devices. To achieve high gain strip, lines are added. Reduce the complexity, simple antenna structure is focused.Hemispherical lens is fixed at end fire direction of the antenna. Teflon is used for creating lens. Beam well is improves at higher frequencies. By using this hemispherical lens beam well is achieved at lower frequencies and also the beam get focused. This increases the gain of the antenna around 3 dB [1]. By using this fractal EBG, scattered surface waves are more effectively suppressed in all the directions and higher can be obtained [2]. FR4 is used as a substrate and it is designed for ISM band. The maximum acceptable value of Specific absorption rate (SAR) is 0.467 W/kg. It has SAR of 0.0005 W/kg. Input power is 1 mW. Copper is used as substrate for feed line and return loss is -63.062 dB. VSWR is 1.0014067 which is acceptable. Gain is 3.07 dB and radiation efficiency is -3.05 dB [3]. Microstrip antenna is designed in denim material and the conducting layers were in copper and nickel plated polyester fabric.

If bending is occurred across the width of the antenna, it will affect the frequency and if it is happened across the length, antenna performance will be affected [4].

The dipole antenna with Fractal Koch is designed in denim material. Three fractal Koches are included. It is suitable for placing only backside area of human body. Antenna size is reduced by Fractal Koch. Because of bending and wetness, its resonant frequency is shifted. It has good performance of less than 2% of water absorption [5].

Complementary Split Ring Resonator (CSRR) is introduced near to the feed to rejecting unwanted WLAN signals. Anisotropic zero index meta materials (AZIM) is not burden for the Vivaldi antenna which enhance the directivity and gain in the bandwidth of AZIM [6, 7]. Vivaldi with EBG antenna has several circular slots to extend antenna bandwidth. It has two dielectric sheets and feed line is sandwiched in between them. Because of dual substrate layer gain is improved from 8dBi to 12dBi. Antenna is covered by radome to reach 15dBi [8]. Antenna width should be minimum to get high directivity which gives the accurate microwave image. Taper should be equal to half of the wavelength. Beam well is increased at high frequencies but usage of hemisphere lens improves at low frequency. This hemisphere lens increases the gain around 3dB and also beam gets focused. Main focus of this concept is to increase directivity [9]. Antenna gain has been increased by improving the Q factor of the antenna. This can be achieved by increasing number of EBG layers or high permittivity EBG layers. EBG controls the surface wave influence in antenna [10].

For flexibility, Poly-Ethylene Terephthalate (PET) is chosen as a substrate. It is like plastic which does not absorb the water. PET has broad range of use temperature, from -60 to 130°C. It is approved as safe for contact with Human body.

II. ANTENNA DESIGN

The antenna is designed on the low-cost PET substrate that has flexibility. It has the value of dielectric constant (ε_r) 3.1 respectively and loss tangentis 0.01. The length of the antenna (L) is 8 cm and the width of the antenna (W) is 6 cm.

For gain enhancement strip lines are added. Six strip lines are added. LS and WS are denoted as length and width of the strip lines. In first iteration, 22.5 mm strip line (LS1) is added which has the width (WS1) of 5mm. For second iteration, 20 mm strip line (LS2) is added for gain enhancement. In third iteration, 18 mm strip (LS3) line is added. For fourth iteration, 15 mm strip line (LS4) is added. Adding strip lines not only enhance the gain, but it also improves the directivity. In fifth iteration, 12.5 mm strip line (LS5) is added. In sixth iteration, 10 mm strip line (LS6) is added. All the strip lines has the same width as 5mm (WS1=WS2=WS3=WS4=WS5=WS6=5 mm). Adding strip lines also reduce the return loss and it will improve the overall antenna performance.

Table- I:Dimensions of the Antenna

Length of the antenna in mm	
L	8
Width of the antenna in mm	
W	6
Length of the strip lines in mm	
LS1	22.5
LS2	20
LS3	18
LS4	15
LS5	12.5
LS6	10
Width of the strip lines in mm	
WS1	5
WS2	5
WS3	5
WS4	5
WS5	5
WS6	5

By using this length and width, strip lines are added in the antenna. After adding the strip lines, the obtained antenna is shown in the Fig 1.

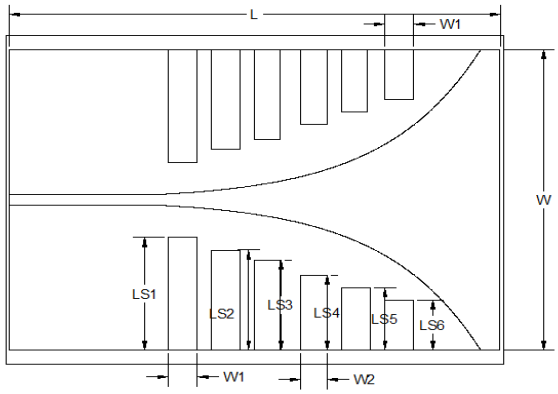

Fig. 1. Antenna after adding the strip lines

III. SIMULATION AND RESULTS

A. Bandwidth characteristics of antenna

For adding strip lines return loss is reduced. Compared to first and second iteration return loss (S11) is reduced by -5 dB PET substrate. By adding third strip return loss is increased by -1 dB. It has the reduction in return loss by adding strip lines. After adding sixth strip line return loss is achieved as -16 dB.

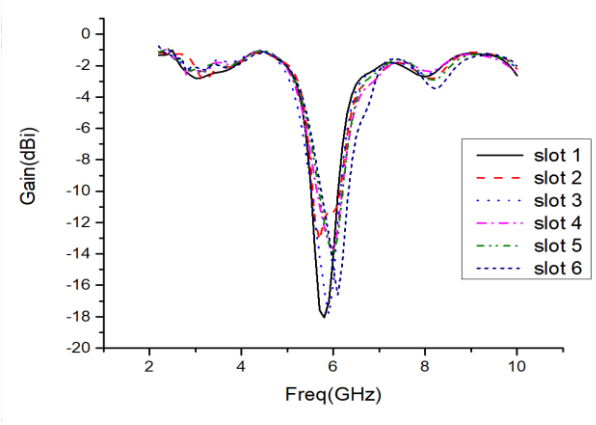

Fig. 2. Return loss after of the antenna

B. Gain and radiation characteristics of antenna

Result of adding strips, gain is improved compared to antenna without out strip lines.

In PET substrate, 4.9 dB is obtained for adding single and double strip lines. Further adding strip lines the gain is reduced until adding sixth strip line. After adding sixth strip line, the gain is obtained as 5.5 dB. It is shown in the Fig 3.

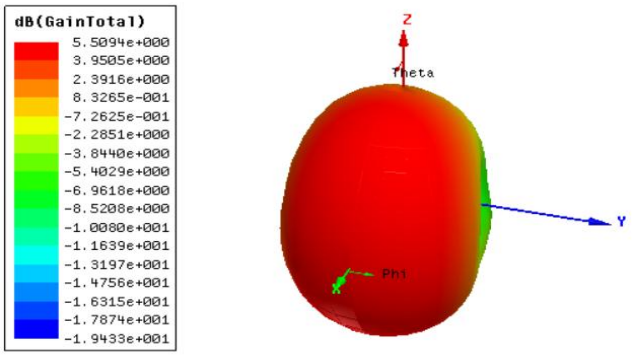

Fig. 3. Gain of the antenna

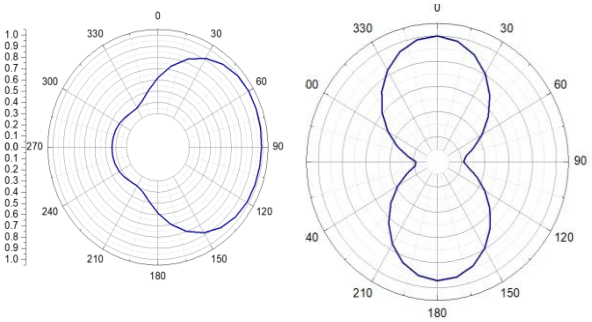

Fig. 4. Radiation pattern

Table- II: Comparison Table of Results for PET

No of strip lines	Return loss	Gain dB	Directivity dB	VSWR
Single	-13	4.9	4.9	3.5
Double	-18	4.9	4.6	2
Three	-17	4.3	4.3	2.2
Four	-13	3.9	4.0	3.1
Five	-14	3.7	3.7	3.7
Six	-16	5.5	5.5	2.5

IV. CONCLUSION

The proposed antenna is highly flexible and compactable for wearable applications. It has the gain of 5.4 dB. It is achieved by adding strip lines to the conventional vivaldi in the antenna. This can be used any kind of wearable application because it is designed in PET substrate. It resists moisture. Because of it is flexibility in watches, bracelet, clothes, shoes to monitor human health parameters, tracking and remote sensing.

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