Design And Analysis of Flexible Rounded Bow Tie Antenna for Wearable Application

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***Abstract*:**
A wideband Flexible Rounded Bow Tie Antenna is proposed and investigated.The flexible antennas have wide acceptance in the present days and these antennas play significant role in Wireless Body Area Network (WBAN) applications. The Rounded Bow tie antenna has been design on flexible polymide substrate having 4.3 dielectric constant & with thickness 0.3mm. The Bow tie antenna exhibits high gain around 7.0dB and wide frequency from 2.11GHz to 2.63GHz. Particularly the corners of the conventional triangular bowtie dipole are rounded by adding half semi-circle to achieve BW of 24.12% for return loss less than -20dB.This antenna is flexible and suitable for wearable applications. The flexible Bow tie antenna may be easily mounted on missiles, rockets and satellites without major alterations.

Keywords: *flexible antenna, flexible substrate, Wearable, Wideband, wireless body area network etc.*

I. INTRODUCTION

Flexible microstrip antennas are widely accepted due to lightweight and ease of fabrication. In order to make antenna flexible the rubber substrate can be made with different percentage of filler content. Wireless communication devices and techniques are flourishing, convalescing and escalating nowadays. The improvement of such devices should assemble precise requirements miniature dimension, light weight, low cost with attractive appearance.

The designed antenna resonates at 2.4 GHz ISM (Industrial, Scientific, and medicine) band with a return loss of less than −20 dB.The basic idea is to lay a very thin copper strip on top of a flexible substrate and bottom side also as ground plane. Several flexible substrates have been reported such as polymer, micro fluids/liquid metals, paper, plastic, etc.

II. MICROSTRIP ANTENNA DESIGN

Microstrip antenna in rectangular shape is the easiest geometry for designing and implementation. The basic rounded Bow tie microstrip patch antenna design is seen in below Figure.1 Here, L1 is the feed length W1 is the feed width, a is side length of bow, respectively.

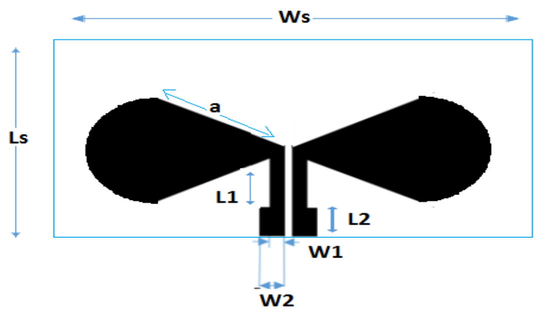

Figure 1: U-Slot Loaded Rectangular Micro Strip Antenna

A simple rounded flexible bowtie antenna is designed to operate at 2.4GHz. To develop light weight antenna, polyimide is used as the substrate material. The mechanical properties of the Polyimide makes the antenna flexible with permittivity εr=4.3, for flexibity purpose we take he thickness of 0.3mm. These properties make polyimide very attractive to be used as substrates for the fabrication of antennas in applications having low loss, reduced bill of materials, preserving the electromagnetic performance. The length and width of the patch are 86mm and 28.2mm respectively. The feed point is 7.5mm from the centre of the patch.

III. METHODOLOGY

The Bow tie antenna has been design at (Fr) is 2.4 GHz and dielectric constant of the substrate (εr) is 4.3 and Height of dielectric substrate (h) is 0.3mm.Next step is to calculate the other parameters like lambda and side length of micro strip patch is given as follows:

Lambda (λ)=c/f=3x10^8/2.4x10^9
=125mm at 2.4 GHz

Step 1: Side Length of Bow Tie (a)
The first fundamental resonant freq of antenna is given by

$$Fr=\frac{2c}{3a\sqrt{\varepsilon r}} \qquad a=\frac{2c}{3fr\sqrt{\varepsilon r}}$$

Where εr=4.3, c=3*10^8m/s^2 and fr=2.4*10^9
We get a=39mm
Step 2: Length of feed line of dipole (L1)
Length (L1) =λ/4*Sqrt (4.3)=125/4*2.073=15.07mm

We get L1=15.07mm
Step 3: Length of feed line of dipole (L2)
Length (L2)= λ/8*Sqrt(4.3)=125/8*2.073=7.53mm
We get L2=7.53mm
Step 4: Width of feed line of dipole (W2)

$$Z = \frac{377}{\frac{w}{t} - 1.37}$$

where

w=width of feed line

t=thickness of substrate=0.3mm

z=50ohm

W1=feed width= 2.8 mm for 50 ohm

IV. SIMULATION RESULTS

Simulation of this antenna has been carried out in HFSS. The simulation results are given in the following section:

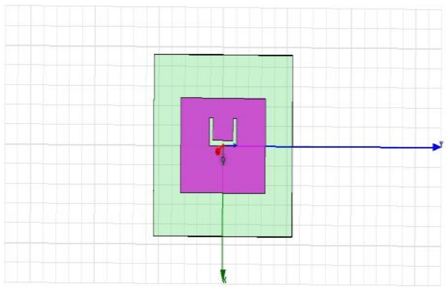

Figure 2: U Slot on Patch

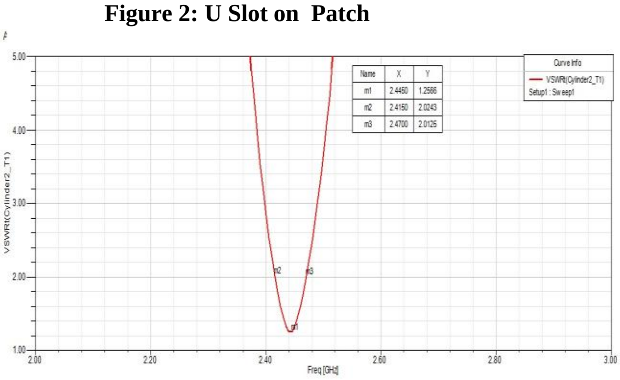

Figure3: VSWR

The ratio between the maximum voltage and the minimum voltage along the transmission line is defined as the Voltage Standing Wave Ratio or VSWR. The VSWR, which can be derived from the level of reflected and forward waves, is also an indication of how closely or efficiently an antenna's terminal input impedance is matched to the characteristic impedance of the transmission line. An increase in VSWR indicates an increase in the mismatch between the antenna and the transmission line. As shown in figure: 3 the value of VSWR is 1.25

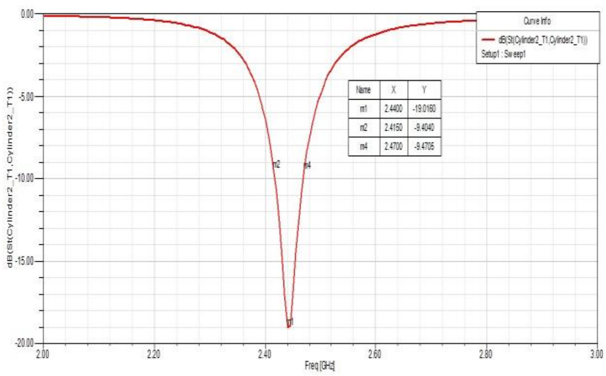

Figure 4: Return Loss

Return loss indicates the amount of power that is lost to load and does not return as reflection. Return loss is a parameter similar to VSWR to indicate how well the matching between transmitter and antenna has taken place. Ideal value of return loss is around -13dB which corresponds to VSWR of less than 2. As shown in figure: 4 the value of Return loss is -19.01dB.

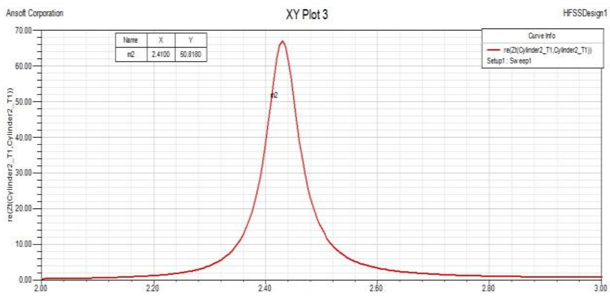

Figure 5: Impedence

The VSWR provides an indication of how closely the impedance of an antenna matches the impedance of the connecting transmission line. If an impedance mismatch exists, a reflected wave will be created towards the energy source. This reflected wave reduces the level of forward energy transferred from the transmission line to the antenna. This effectively reduces the total level of energy available for radiation thus reducing the effective gain of the antenna. As shown in figure: 5 the value of Impedance is 50.81.

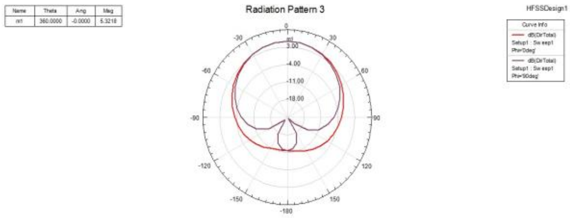

Figure 6: E & H Plane

In many cases, the protocol of an E-plane and H-plane sweep or pattern is used in the presentation of antenna pattern data. The E-plane is the plane that contains the antenna's radiated electric field potential while the H-plane is the plane that contains the antenna's radiated magnetic field potential. These planes are always orthogonal. These quantitative aspects generally include the 3 dB beam width (1/2 power level), directivity, side lobe level and front to back ratio. The 3 dB beam width of antenna is simply a measure of the angular width of the –3 dB points on the antenna pattern relative to the pattern maximum**.**

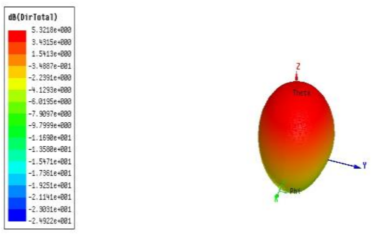

Figure7: Radiation Pattern

The radiation patterns of an antenna provide the information that describes how the antenna directs the energy it radiates. As stated earlier, an antenna cannot radiate more total energy than is delivered to its input terminals. All antennas, if 100% efficient will radiate the same total energy, for equal input power, regardless of pattern shape. Antenna radiation patterns are typically presented in the form of a polar plot for a 360 degree angular pattern in one of two sweep planes. The most common angular sweep planes used to describe antenna patterns are a horizontal or azimuth sweep plane and a vertical or elevation (zenith) sweep plane. As shown in figure: 7 the value of Directivity is 5.32dB.

V. COMPARISON TABLE

Sr. No	Type of flexible antenna	Frequency (GHZ)	Return Loss (db)	Bandwidth (MHZ)	Gain (db)
1	Bow Tie	2.49	-24.82	640	5.7
2	Half semicircle Bow Tie	2.40	-20.82	520	7.0

VI. CONCLUSION

The proposed antenna is the primary approach to use polymide as flexible substrate. The mechanical properties of the substrate make the antenna highly flexible. The designed antenna can be used for WBAN applications. The simulated results show that the designed antenna operates at 2.4GHz with minimum return loss (-20dB). The flexible antenna can be used for any applications in which the antenna is body worn.

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