Design of Flexible Microstrip Antenna for Wearable Application

Jaydeep Sadashiv Chougule¹ and Dr. Uday V. Wali²

¹Jaydeep sadashiv Chougule, ECE, M.Tech (VLSI Design and embedded systems), KLE Dr. M.S.S.CET, Belagavi, VTU, Belagavi, India
²Dr. Uday V. Wali, ECE (VLSI Design and embedded systems)KLE Dr. M.S.S.CET, Belagavi, VTU,Belagavi,India

chougule.jaydeep@yahoo.com
udywali@rediffmail.com

ABSTRACT

This paper introduces a flexible microstrip patch antenna using rubber as the substrate. The flexible antennas have wide acceptance in the present days and these antennas play significant role in Wireless Body Area Network (WBAN) applications. The paper deals with natural rubber as substrate for microstrip patch antenna .The mechanical properties of the rubber makes the antenna flexible.The antenna is designed to operate at 1400MHz. Ansoft HFSS is used for design simulation. Resonant frequency after simulation is exactly 1320MHz with return loss of -30.92dB.

Keywords — Flexible antenna, Wireless body area network (WBAN), High Frequency Structure Simulator (HFSS), Return Loss ($S11$).

1. 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. 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. Rubber is a natural polymer so we have chosen it as flexible substrate. The mechanical properties of rubber make it a good candidate for this purpose. Rubber can naturally and forcibly retract to its original dimensions after deformation. Besides, rubber can be processed into a variety of shapes and can be attached to metal plates by using industrial Gum like FeviBond.

Flexible electronics can currently be considered a well-established technology that has reached a certain degree of maturity in meeting the requirements of tightly assembled electronic packages, providing reliable electrical connections where the assembly is required to flex during its normal use or where board thickness, weight, or space constraints are the driving factors. In this context, flexible substrate antennas (FSAs) play a key role in the integration and packaging of wireless communication devices and sensor networks. Those antennas, which are designed such that the resonant peak frequency remains unaffected after bending, stretching, or twisting, are currently being embedded into materials such as textile fabrics, bandages, stickers, and bendable displays. A Wireless Body Area Network typically consist of a collection of low power, miniaturized, lightweight devices with wireless communication capabilities operate in the proximity of a human body. The microstrip patch antennas are the best candidates for flexible antennas as they can be easily fabricated and are much reduced in size. The proposed flexible patch antenna is intended to operate with center frequency 1320MHz.The antenna design for BAN is a challenging problem as the WBAN uses a network of sensors that are operating in the close vicinity of body tissues. It should not harm the human body and should be of low profile and should account for the flexibility in accordance with the bending of the body. Section II deals with antenna design, Section III discusses the simulation results and its analysis, Section IV mentions the application and future works and finally Section V concludes the paper.

2. ANTENNA DESIGN
The rubber samples are prepared from local Rubber industry belgavi. The sample has a size of (25cm*17cm). The samples are of vulcanized rubber, the thickness of the rubber is 1.8 mm.

### 2.1. Antenna Design Equations

The dimensions of microstrip antenna are calculated from the basic equations as shown below. The center frequency of antenna is needed for the width and length calculation. We are designing the antenna on rubber substrate \(E_r=3\) and for center frequency of 1.4GHz, length of antenna also calculated from center frequency, these dimensions needed for designing. Eq(1) gives the width of the patch, Eq(2) gives effective dielectric constant, Eq(4) gives length of the patch.

\[
w = \left(\frac{c}{2f_r}\right) \times \sqrt{\frac{2}{er + 1}}
\]  

(1)

\[
E_{ref} = \frac{er + 1}{2} + \frac{er - 1}{2} \left(1 + 12 \frac{w}{h} \right)^{-\frac{1}{2}}
\]  

(2)

\[
\frac{Vl}{h} = 0.412 \left(\frac{E_{ref} + 0.3}{E_{ref} - 0.258} \right) \left(\frac{w}{h} + 0.264\right)
\]  

(3)

\[
L = \frac{1}{2f_r\sqrt{E_{ref} \mu_0 \varepsilon_0}} \frac{1}{2\Delta L}
\]  

(4)

### 2.2 Proposed antenna design

![Fig-1: Top view of antenna](image)

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Natural Rubber</th>
</tr>
</thead>
<tbody>
<tr>
<td>W1</td>
<td>83</td>
</tr>
<tr>
<td>L1</td>
<td>63</td>
</tr>
<tr>
<td>W2</td>
<td>27.67</td>
</tr>
<tr>
<td>W3</td>
<td>3</td>
</tr>
<tr>
<td>W</td>
<td>100</td>
</tr>
<tr>
<td>L</td>
<td>70</td>
</tr>
</tbody>
</table>

Table I

Optimised Antenna Dimensions (In Mm)

Where ‘c’ and ‘fr’ are velocity of light and operating frequency respectively. The microstrip patch antenna is designed as edge fed and has geometry as shown in Fig.1. The dimensions of the Rectangular patch are obtained using the design equations and the values are optimized to obtain better results. Table.I summarizes the values (in mm) of the parameters marked in Fig.1 for the antenna using rubber as substrates. A full ground plane of copper is used.

### 3. SIMULATION RESULTS AND ANALYSIS

The simulated results of the antenna are discussed. Fig.2 shows the return loss of the antenna using natural rubber as substrates. The results show that minimum return loss is obtained at 1320MHz. The voltage standing wave ratio (VSWR) is also less at the specified frequency of operation. It is evident from the

![Fig-2: Return loss of antenna using vulcanized rubber substrate](image)

![Fig-3](image)
As the antenna is designed for WBAN applications it should radiate with much reduced power. Fig.4 shows the 3D Radiation polar plot of the antenna using flexible substrate.

Fig-4: 3D Radiation pattern of antenna using vulcanized rubber substrate

The 2D polar radiation pattern is given which is on single direction, shown in fig.5. The 3D radiation plot also follows the same geometry.

4. APPLICATIONS AND FUTURE WORKS

The proposed antenna can be used for WBAN applications that enable the use of antenna for various applications in the same frequency. This antenna can be used as a Hub antenna for communication between nodes of the WBAN. The flexible antenna can be used for any applications in which the antenna is body worn. This antenna can be used for any applications in which the antenna is bent or twisted and also designed on textile substrate. The antenna can be made reconfigurable by providing suitable modifications to the designed antenna so that the same antenna can be used for several applications.

5. CONCLUSION

The proposed antenna is the primary approach to use natural rubber 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 1320MHz with minimum return loss (-30dB).

ACKNOWLEDGMENT
I extend my sincere gratitude to Dr. Uday V. Wali, Professor, KLE’s Dr.M.S.Sheshgiri college of engineering and technology, Belgavi for his support and Belgavi rubber industry, Belgavi for preparing the rubber samples and also grateful towards Miss. Mangala madam from C-Quad computers for her help in Etching process.

REFERENCES