A Reconfigurable Wearable Antenna for Mid Band 5G Applications

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Abstract. Soon, everything should be connected by 5G wireless, including wearable devices that are booming fast recently. Wearable antennas are becoming increasingly common in consumer electronics. To achieve 5G, wearable devices should support much wide band width and high rate of data with better consistency. In this paper a reconfigurable wearable antenna is implemented on a fabric substrate. The proposed antenna may fit for reconfiguration of the frequency to work on MID band (3 – 5.5GHz) of 5G. The proposed antenna can be a part of military uniform or any other garment and can be employed in Wi-Fi, WLAN, Satellite,5G mobile and cognitive radio communication. The shape of the antenna has been accomplished by placing each feature of reconfiguration mentioned above in the same antenna and performing the parametric analysis to obtain an optimal prototype that could allow the achievement of good results with fabric such as polyester as substrate.

Keywords—wearable device; reconfigurable antenna; wearable antenna; conducting thread.

1. INTRODUCTION

Due to the pristine growth of antennas and wi-fi conversation in current years, there is a full-size utilization of wi-fi digital gadgets which might be turning into smaller and smaller each day. Wearable era is getting extra not unusual place in current years, and there's a developing call for wearable gadgets in an extensive variety of fields which include sports activities and fitness, medicinal drug and with inside the defence forces [1].Progresses in communication and technologies have permitted the advancement of small sized and smart devices that can be situated on the physical body of human beings or inserted inside it[2].In wearable antenna design, we have a tendency to may use a garment as a material substrate whereas a copper sheet hooked up as an electrical conductor. This structure is comfortable for the user, light weight and flexible. And our proposed structure gives the Impedance bandwidth of 2.5 GHz. The most essential thing in our designed structure is it can achieve narrowband to wideband functionality, which can be employed in cognitive radio application and additional applications where there is a requirement of sensing and communication.
2. WEARABLE ANTENNA CHALLENGES

The antenna style is one of the highest necessary components of the optimum wearable gadget that ought to operate dependably for an extended amount of your time while not limiting the user activity and inflicting any modification in behaviour. [3]

2.1 Challenges in Design from materials

Materials of conventional inflexible nature have been applied in the conventional antennas which are uncomfortable and not appropriate for wearable antennas. To beat this problem, textile materials may be used. The semi conductive textiles have the anisotropic and non-perfect electrical conductor (PEC) properties thus their physical phenomenon characteristics are totally different from traditional conductors. Another issue relating to materials is that electrical and non-conductor properties of the materials do not seem to be pronto available. [4]

2.2 Design challenges from body

Human body has different tissues with various dielectric properties and gain with different frequencies. So, the gain of the wearable antenna differs from that of a normal antenna. Also, the input impedance is reliant on the humidity conditions of the human body. And the stance of the placement of the antenna. [5,6].

3. DESIGN CONSIDERATION

We began with a rectangular Ultra-Wide Band monopole antenna (Figure 1). The operating frequency of the antenna we designed is 4 GHz. The antenna is conceived with a low-cost dielectric substrate Polyester ($\varepsilon_r=3.4$) with thickness of 1.5mm and ground plane followed by micro strip and patch were designed. The dimensions of the UWB monopole antenna are in table 1.

![Figure 1. Structure of the proposed monopole antenna](image)

| Parameter | LB mm | LP mm | LF mm | PW mm | WP mm |
|-----------|-------|-------|-------|-------|-------|
| Value     | 2.5   | 19.5  | 17    | 0.5   | 17    |
Insets are designed at both the sides of feedline to rise both bandwidths along with return loss. Later micro strip and patch are connected so that current flows. After design, an UWB monopole antenna (figure 1) we modified the antenna with five switching elements (1, 2, 3, 4, and 5) at specified gap (figure 2) to prevent two radios from simultaneously trying to transmit from same antenna. Element switches in OFF condition behaves as 5000 k ohm resistor and in ON condition 1 k ohm resistor for the purpose of simulation.

![Figure 2. Structure of proposed antenna with switches](image)

4. RESULTS AND DISCUSSIONS

The proposed antenna operates at the frequency range from 3 to 5.5 GHz with center frequency of 4GHz.

![Figure 3. S-parameter for proposed antenna when all switches are ON.](image)

In the figure 3 it is noticeable that when all the switches are in on condition then it behaves like an UWB antenna.
Figure 4. S-parameter for proposed antenna when second and third switches are off

In the figure 4 it is noticeable that when the second and third switches are in closed condition and switches (1, 4 and 5) are in open condition then 4.6024 GHz band is achieved, and remaining bands are eliminated.

Figure 5. S-parameter for proposed antenna when only second switch is off

In the figure 5 it is noticeable that when only switch 2 is in closed condition and switches (1, 3, 4 and 5) are in open condition then 4.8195 GHz band is achieved, and remaining bands are eliminated.

Figure 6. S-parameter for proposed antenna when only third switch is off.
In the figure 6 it is noticeable that when only switch 3 is in closed condition and switches (1, 2, 4 and 5) are in open condition then 3.052 GHz band is achieved, and remaining bands are eliminated.

![Image](image_url)

**Figure 7.** S-parameter for proposed antenna when only fifth switch is on

In figure 7 it is noticeable that when the switch 5 is in open condition and switches (1, 2, 3 and 4) are in closed condition then 5.1783 band is achieved and remaining bands are eliminated.

![Image](image_url)

**Figure 8.** S-parameter for proposed antenna when second and fifth switches are on

In figure 8 it is noticeable that when the switches (2 and 5) are in open condition and switches (1, 3 and 4) are in closed condition then 2.4408 GHz band is achieved, and remaining bands are eliminated.
In the figure 9 it is noticeable that when both the switches (1 and 4) are in closed condition and switches (2,3 and 5) are in open condition then 4.6634 GHz band is achieved, and remaining bands are eliminated.
Figure 10: E-field pattern for antenna (a) E field pattern for figure 1and 3 antennas. (b) when second and third switches are off (c) when second and third switches are off (d) when only third switch is off (e) when only fifth switch is on (f) when second and fifth switches are on (g) when first and fourth switches are off.
Figure 11: 3D-Radiation pattern for antenna

Figure 11 illustrates the radiation patterns of our proposed antenna and for the Ultra-wide band antenna where we got similar radiation patterns. On the other hand, we got different narrowband by changing the conditions of switches.

5. CONCLUSIONS

From all the above results this proposed antenna can be used in military applications as tracking device, monitoring the performance at 3 to 5.5 GHz frequency range also we can implement this antenna in Wi-Fi (2.4 GHz and 5.4 GHz), satellite and 5G mobile communication. To switch between the notches, we switched the elements ON or OFF as needed. When all switches are on, the antenna acts like an UWB antenna. As this antenna has wide band to narrowband functionality so it can be a good deterrent for cognitive radio application. These devices track our health, steps, fitness, and more, and send these data to our mobile phones wirelessly. The main advantage of wearables is that they provide us with freedom of movement.

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