JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

# Design of Textile Antenna for Wearable 5G and IOT application

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***Abstract:*** In this paper, a design of a textile microstrip patch antenna is proposed for wearable communication which can be used for 5G and IOT applications. Over the years, IOT has become one of the most important technologies. The aim of this paper is to optimize the performance of microstrip patch antenna. Our concentration is in 5G technology so we operate the antenna at mid 5G range i.e.,1-6 GHz. We use a felt substrate with dielectric constant, Ɛr=1.3 and tangent loss, δ = 0.044 having dimensions 57 x 50 x 3 mm3. The antenna is analyzed by using Computer Simulation Technology (CST) software. The simulated outputs of the antenna such as return loss, gain, VSWR and SAR are compared with the existing antenna models. The designed antenna is a miniature antenna so it has a low profile and mechanically flexible. Due to this reason the gain of the antenna is -3.82dBi and SAR is 0.37 W/kg. The designed antenna measured results demonstrate that the proposed antenna is suitable for wearable communication.

***IndexTerms- Microstrip patch antenna, IOT and 5G***

## I. INTRODUCTION

The study of body-centric communication networks is quickly becoming one of the most widely researched subjects on the planet. Flexible wearable antennas are being created to enable communications in body area network (BAN) systems by enabling data transmission between on-body devices and off-body nodes. These wearable antennas are needed to gather patient health data in order to send data with greater capability using multiple 5G carrier bands. Because of their cheap cost, simplicity of fabrication, and compact size, planar antennas are one of the important antenna types that meet these criteria. Several variables must be examined in order to achieve the desired performance traits; for example, a wideband design can achieve the desired bandwidth. Textile-based wearable devices are getting appeal as a result of their potential uses.

Patch antennas are made up of three layers: layer 1 is a conducting material patch, layer 2 is an insulating base, and layer 3 is a conducting material ground plane. A microstrip patch antenna is a form of antenna that is made up of a narrow metallic patch printed on a dielectric base with a ground plane on the other side. Because of its low profile, light weight, simplicity of fabrication, and ability to be integrated with other electrical components, it is a common and extensively used antenna. The patch can be rectangular, circular, or elliptical in form, and it can be supplied by a variety of techniques, including coaxial probes, microstrip lines, and aperture coupling. Patch microstrip antennas are commonly used in wireless communication systems, including mobile phones, Wi-Fi networks, and satellite communications. They offer several advantages over other types of antennas, such as ease of integration, low cost, and good radiation efficiency, and can be designed to operate over a wide range of frequencies. However, they also have some disadvantages, such as narrow bandwidth and low gain, which can be addressed through various design techniques.

5G and IoT are two closely related technologies that are shaping the future of connectivity and digital transformation. 5G is the fifth generation of mobile network technology that promises faster internet speeds, lower latency, and more reliable connections. It has the potential to revolutionize many industries by enabling new use cases such as remote surgery, autonomous vehicles, and smart cities. IoT, on the other hand, is a network of interconnected devices that communicate with each other and share data over the internet. It includes a wide range of devices, such as sensors, smart appliances, and wearable devices, that are designed to make our lives easier and more efficient. The relationship between 5G and IoT is symbiotic, as they both depend on each other to reach their full potential. 5G provides the high-speed connectivity and low latency required for IoT devices to communicate with each other in real-time. IoT, on the other hand, generates massive amounts of data that 5G networks can handle efficiently. Together, 5G and IoT can create a world of interconnected devices that communicate seamlessly and share data in real-time. This can lead to new opportunities in industries such as healthcare, transportation, and manufacturing, where IoT devices and 5G networks can work together to create more efficient and effective systems.

We used a dielectric substance with a dielectric constant, Ɛr=1.3 and a tangent loss, δ= 0.044 and dimensions of 57 x 50 x 3 mm3. For the patch's execution, we used copper alloy. Because this is a textile antenna, the substrate is important in its application, and the miniature antenna does not require any area needed recessions. CST software is used to model the antenna. The major needed factors of the antenna are gain, return loss, SAR, and VSWR. We determine the performance of our antenna by comparing the obtained findings to the current models.

## II. ANTENNA DESIGN

Figure 1 shows the proposed antenna designed on a felt textile substrate with a thickness (h) of 3 mm, dielectric constant of approximately 1.3, and loss tangent of 0.044. The single layered substrate ensures a low-profile structure and reduces potential complexities in fabrication

and integration with clothing. The top patch and partial bottom ground are made using a copper metal. The overall antenna is fed by a microstrip feed line, with its width (wf) optimized to ensure good impedance matching. The WST antenna has been simulated in CST simulator software for the 1 to 6 GHz frequency range,
and different antenna parameters have been analysed.

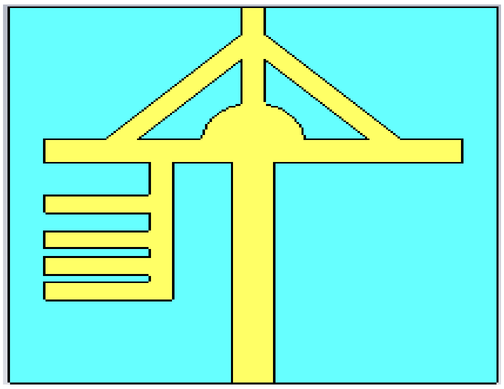

Fig. 1. Front view of Textile Microstrip patch Antenna.

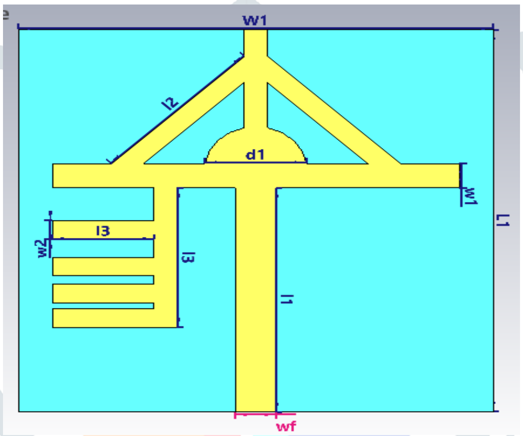

Fig. 2. Dimensional view of Designed Antenna.

The below Table. 1 shows the dimensions of designed antenna structure.

Table. 1. Dimensions of Antenna structure

| Dimension Name | Dimension length in mm |
|---|---|
| L1 | 50 |
| W1 | 57 |
| l1 | 24.6 |
| l2 | 16.4 |
| l3 | 15.3 |
| w1 | 2.46 |
| w2 | 2 |
| d1 | 8.95 |
| wf | 3.6 |

## III. SIMULATION RESULTS

Antenna simulation is the process of using computer simulation tools to build, analyze, and optimize the performance of antennas. Antennas are essential components of communication systems, and their effectiveness can have a substantial influence on wireless transmission quality and dependability. Engineers and designers can use antenna simulation to simulate the behavior of antennas in a virtual environment, where they can evaluate and improve the antenna's performance under various circumstances such as different frequencies, polarizations, and external variables. Antenna modeling software solves Maxwell's equations and predicts the electromagnetic behavior of antennas using numerical methods such as the method of moments, finite element method, and finite-difference time-domain method. These models can be used by engineers to assess antenna factors such as gain, radiation pattern, impedance, and frequency.

Antenna simulation is extensively used in sectors such as telecommunications, aerospace, defense, and automotive to build and improve antennas for various uses such as cellular networks, satellite transmission, radar systems, and wireless sensor networks. It can help engineers create high-performance and reliable antennas for contemporary communication systems by greatly reducing the time and expense of antenna design and testing.

### *RETURN LOSS*

Return loss is an essential parameter in antenna construction because it impacts the antenna system's efficiency and performance. A large return loss shows that very little power is reflected back to the transmitter, implying that the antenna radiates the majority of the power. A minimal return loss, on the other hand, suggests that a substantial quantity of power is being reflected back to the transmitter, which can reduce signal strength and overall system efficiency. Return loss data are used by antenna builders to improve antenna efficiency and minimize unwanted reflections. In reality, most antenna devices should have a return loss of -10 dB or less. The planned antenna has a return loss of -35.53dB in this case.

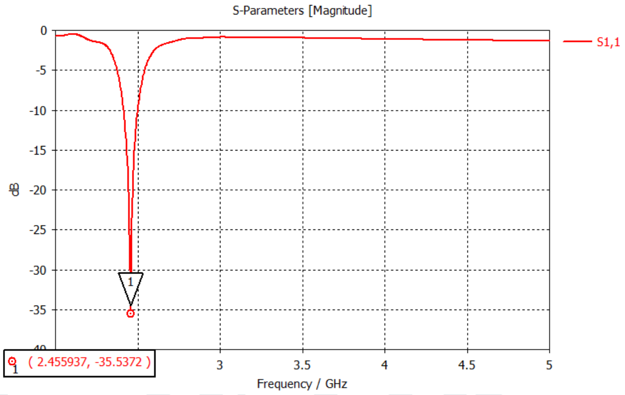

Fig. 3. Return loss of Designed Antenna

### *VSWR (Voltage Standing Wave Ratio)*

VSWR stands for "Voltage Standing Wave Ratio" and is a gauge of an antenna's effectiveness. It is described as the ratio of the maximum voltage of a transmission line's standing wave to the lowest voltage of the same line's standing wave. An antenna's VSWR number shows how well the antenna is suited to the transmission line and the emitter or receiver to which it is attached. A VSWR of 1:1 indicates that the antenna is exactly suited to the transmission line and that no reflected power exists. A VSWR of 2:1 indicates that half of the power is reflected back to the emitter, while a VSWR of 3:1 indicates that two-thirds of the power is reflected back to the transmission.

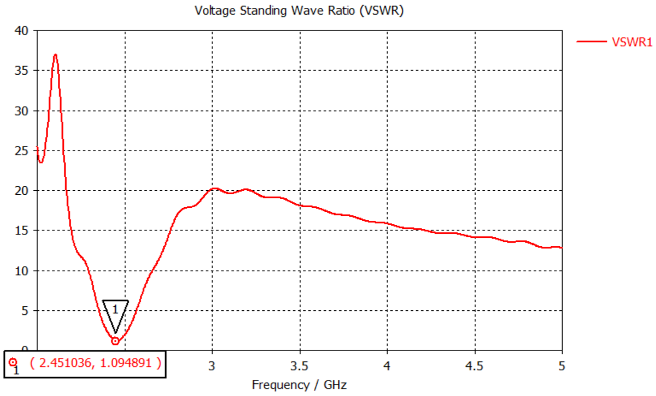

Fig. 4. VSWR of Designed Antenna

### *GAIN*

A miniature antenna's gain is determined by its size and construction, and it is usually smaller than that of a bigger antenna. However, there are several methods for increasing the gain of a tiny antenna, including: Using a substrate with a high dielectric constant reduces the area of the antenna while keeping the same resonant frequency. This raises the antenna's gain. The antenna's gain is -3.82dBi.

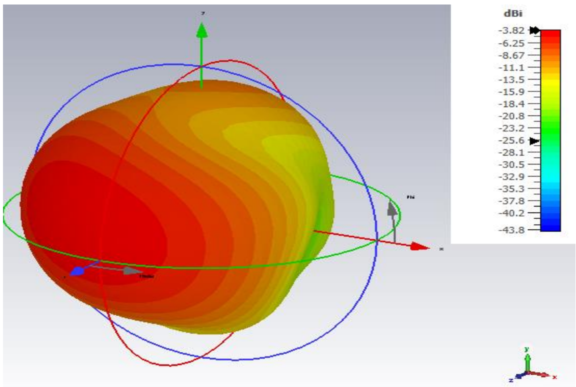

Fig. 5. Gain of Designed Antenna

### *SAR (Specific Absorption Ratio)*

The term "SAR" stands for Specific Absorption Rate, which is a measure of how much electromagnetic radiation is absorbed by the human body when exposed to an electromagnetic field, such as that generated by an antenna. The SAR of an antenna is the amount of energy that is absorbed by the body per unit of mass when exposed to the electromagnetic radiation emitted by the antenna. SAR is usually measured in watts per kilogram (W/kg) and is used to assess the potential health risks associated with exposure to electromagnetic radiation. The designed antenna has a SAR value of 0.0373 W/kg.

Antennas that are designed to operate at high power levels, such as those used in cellular base stations or microwave ovens, can have high SAR values and can potentially cause harm if the exposure levels are not controlled. For this reason, regulatory agencies in many countries have established guidelines and limits for SAR levels that must be adhered to by manufacturers of these types of devices.

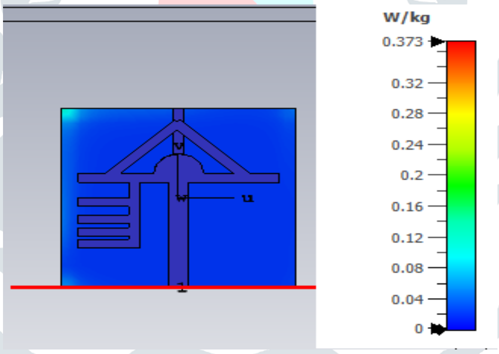

Fig. 6. SAR of Designed Antenna

## IV. CONCLUSION

This work proposes an innovative design of a Textile antenna for 5G applications. Moreover, the proposed antenna is wideband, mechanically flexible, low profile, and robust in performance. The proposed textile antenna shows a low SAR level even when it is placed near the skin of the human body. The experimental results validate that the prototype antenna can be used potentially for wearable applications.

Table.2. Parameters of the designed antenna

| *PARAMETER* | *OBTAINED RESULT(placed on body)* |
|---|---|
| S11 | -35.53 dB |
| VSWR | 1.09 |
| GAIN | -3.82 dBi |
| SAR | .0.373 W/kg |

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