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Multiband MSP antenna for IoT application

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***Abstract*—The multiband *Microstrip Patch* antenna is designed in CST simulation software for IoT (Internet of Things) application. In this paper, the antenna resonant frequency range was 100MHz and 5.8GHz, which is suitable for IoT application. The antenna is designed using CST simulation software operating in the frequency range of 5.8GHz. The antenna has a compact structure with dimensions of 60mm × 60mm × 1.6mm, modified as a ring hole. The proposed antenna can achieve a gain of 6.5dBi at a frequency of 5.8GHz and a maximum of 8.0dB. The power efficiency of the antenna is high, reaching 95.8%, and the voltage standing wave ratio(VSWR) is about 1.22. The bandwidth, size and stable electrical characteristics of this antenna make it successful for IoT applications.**

Keywords: Multiband* Microstrip Patch *antenna; IoT application; MSP antenna; 5.8 GHz frequency band

I. Introduction

IoT can be characterised as a computer network with integrated technology to assist the device in wireless setting. By enabling wireless communication over the network, IoT makes it possible to remotely control these devices, which has a positive impact on the economy and increases productivity.

IoT is becoming a part of contemporary life and is utilised for long-distance wireless connection and data collection. No matter the IoT application profile, extremely effective antennas enable any wireless communication transmission. Thus, the antenna plays a crucial role that cannot be underestimated. Due to the rising demand for IoT applications, new antenna designs are constantly needed to improve antenna technologies, raising the performance level of wireless sensor networks and boosting their effectiveness by providing a long-range and low error-rate communication link.

Sensors that can send data in a wireless network configuration are typically used to execute the IoT idea. smart cities, health-care systems, the military, smart homes, and agricultural applications aimed at boosting productivity and optimising resource allocation are just a few of the industries that utilise wireless sensor networks technology. Bluetooth, long-range modulation, and 5G technologies are only a few examples of the wireless communication protocols that enable data transmission and support this IoT penetration. Every wireless communication transfer is made possible by extremely effective antennas, regardless of the IoT application profile.

The antenna plays a crucial role that shouldn't be overlooked. The antenna must be simple to make, small in size, light in weight, inexpensive to produce, and compatible with a variety of integrated circuit layouts. These restrictions can be met by a MSP antenna, which is very simple to design for various configurations. Various types of MSP antennas can be created in geometric shapes like rectangles, squares, and circles.

A. MSP (Microstrip Patch) Antenna

The characteristics of low profile, light weight, and simple network integration make MSP antenna one of the most popular antennas in contemporary communication. The working principle of MSP antenna is based on the electrical power of the antenna for patching. When electromagnetic waves occur on the surface, some of it is absorbed and the rest is reflected. Low profile, affordable, lightweight, and simple project integration are some benefits of MSP antennas. Mobile phones, satellite radio communications, wireless local area networks, and radio frequency identification are only a few examples of the numerous uses for them.

B. Literature Survey

Innovative antennas are being developed more frequently now for IoT applications. High directivity and gain are still issues with some of these antennas, though. Numerous researchers have made contributions to the literature in the area of antenna design and analysis. Pentagonal patches perform the best when compared to other patches, according to Sidhu et al. Rectangular patch antennas, on the other hand, were claimed to be more affordable, have equivalent performance, and are simpler to produce than microstrip antennas.

Ambresh et al. state that the gain and bandwidth of a basic microstrip antenna are 2dB and less than 2%, respectively. The applicability for IoT was not, however, determined. Furthermore, Lizzi et al. observed that as long as the antenna's frequency of range is 5.8GHz or below, there is no special bandwidth requirement in IoT applications. This work was completed in order to assess these claims. So, a thorough analysis of the performance of microstrip antennas for IoT applications was done in this work.

II. ANTENNA DESIGN AND GEOMETRICAL DETAILS

The rectangular patch antenna in the first proposed design is created with dimensions of approximately 60mm in length and 60mm in width on a FR-4(lossy) substrate with a 4.4 dielectric constant and 1.6mm in thickness. A 50 microstrip line is used to feed the patch. The inserted microstrip feed measures 2.0 mm in width and 20 mm in length.

Copper was chosen for its excellent conductivity and high reactivity, which allow it to effectively distribute electrical energy. Additionally, copper is harder than materials such as silver or gold and is relatively affordable. FR-4(lossy) material is chosen as the substrate for designing antennas because it is more cost-effective and has a higher tolerance for fabrication.

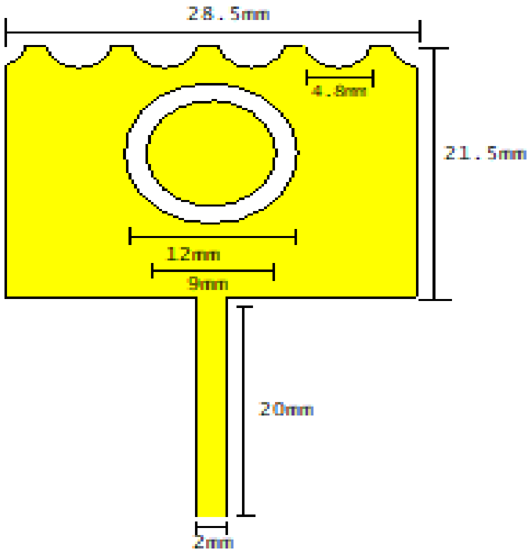

Figure 1 shows the front view of Multiband MSP antenna.

The antenna was constructed using all of the aforementioned materials, and dimensions of a rectangular MSP antenna were determined using the following equations.
the width w of the antenna is calculated by

$$W = \frac{c}{2f_o\sqrt{\frac{(\varepsilon_r+1)}{2}}} \tag{1}$$

Where,
ε_r = Relative permittivity of the substrate
c = Speed of the light in free space
f_0 = Resonant frequency

The effective dielectric constant is calculated by

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-\frac{1}{2}} \tag{2}$$

Where, h = Height

The effective length equation is given as

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{reff}}} \tag{3}$$

The length extension (ΔL) is calculated by

$$\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{W}{h}+0.8\right)} \tag{4}$$

The actual L (length of the patch) is given as

$$L = L_{eff} - 2\Delta L \tag{5}$$

TABLE 1 Dimensions for the proposed design

Name	Value
x	60
y	60
t	0.035
h	1.6
x1	28.5
y1	21.5
xf	2
yf	-20
k	5
r1	1.9
r2	1
yl	0
Rad	2.4

The proposed antenna has the following measurements: 60 mm ground and substrate width and length(60 x 60 mm), 6 mm outer ring radius, and 4.5 mm inner ring radius. The inserted microstrip feed is 2 mm wide and 20 mm long.

III. RESULT AND DISCUSSION

A. *Return Loss (RL)*

Return loss is an important metric used in antenna design to measure the efficiency of an antenna. It describes the proportion of the power of the reflected signal to the power of the incident signal. Fig 2 displays the simulated return loss plot of the proposed antenna design using CST simulation suite. The simulation results indicate that the proposed antenna demonstrates resonance at three different frequencies, namely 5.84GHz, 5.13GHz, and 6.81GHz, as shown in the obtained graph. The corresponding return loss values for these frequencies are -27.55dB, -16.12dB, and -12.73dB, respectively. The bandwidth of the resonant frequency spans from 2GHz to 10GHz. All these details are summarized in the return loss plot generated from the simulation.

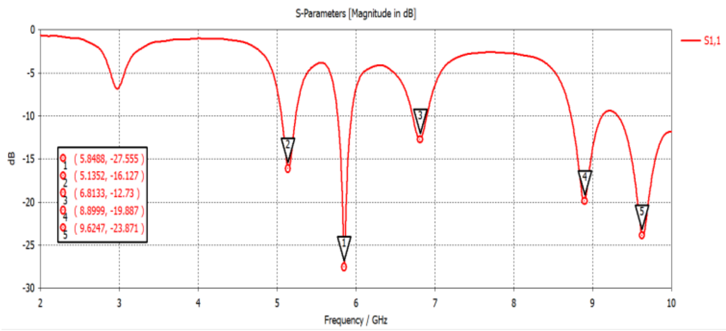

Fig. 2. S11 graph of proposed work

B. *VSWR*

The standing wave ratio, which manifests itself on transmission lines, is calculated as the ratio of the greatest voltage to the minimum voltage. A higher VSWR value indicates a greater degree of signal reflection, which can result in reduced efficiency and performance of the system. Its range should be between 1-2 Based on the analysis conducted on the designed antenna, it was found that the VSWR (VSWR) for the resonant frequency of 5.8GHz is 1.22.

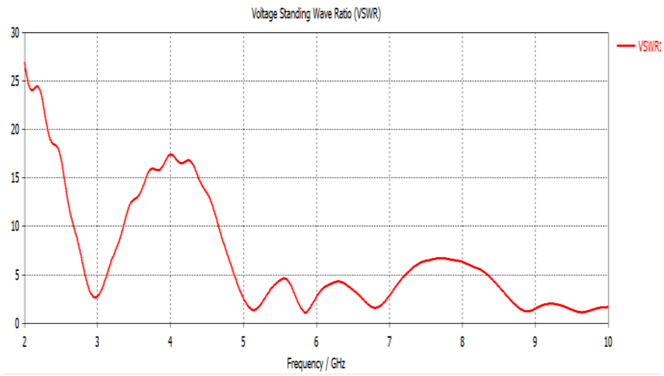

Fig. 3. VSWR plot of the proposed work

C. *Antenna gain and directivity*

The power emitted or obtained by an antenna in a specific direction as contrasted to the power received or transmitted by an idealized isotropic antenna (which radiates evenly in all directions) is known as antenna gain. Decibels in relation to isotropic (dBi) units are frequently used to express it.

The degree to which an antenna directs energy in a specific direction is known as its directivity. It is the proportion of an antenna's radiation intensity in one direction to its overall radiation intensity. A dimensionless quantity known as directivity is frequently stated in dB.

Based on the simulation results, the proposed antenna design exhibits a gain of 6.5dBi and directivity of 8.0dB at a frequency of 5.8 GHz.

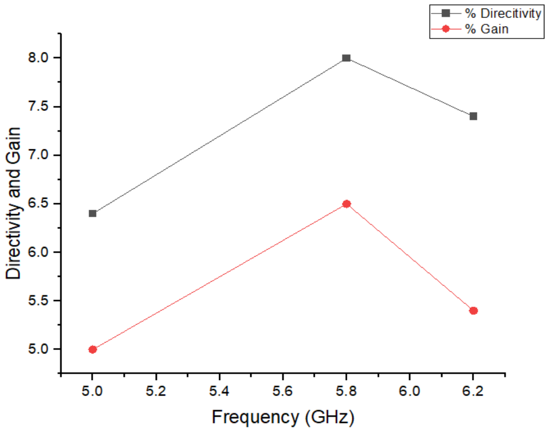

Fig. 4. Antenna gain and directivity plot

D. *RDE (Radiation Efficiency) and TE (Total Efficiency)*

RDE is defined as the ratio of the antenna's output power to its total input power. A greater voltage suggests that more energy is being transformed into usable energy. The TE is defined as the proportion of the total input power—which includes the power lost in the resistive and reactive parts of the antenna thread—to the power radiated by the antenna.

After analyzing the simulation results, it can be concluded that at a frequency of 5.8GHz, the RDE of the designed antenna is 95.8% and the TE is 95.4%.

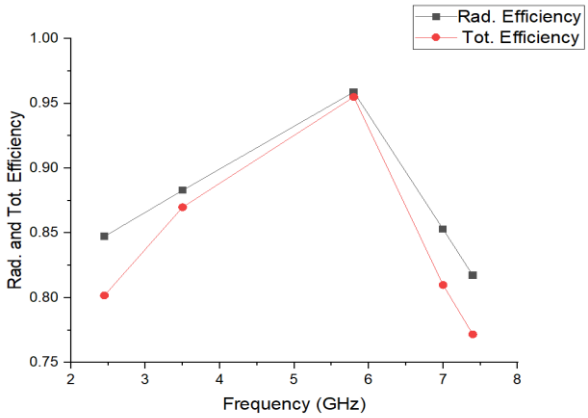

Fig. 5. Antenna RDE and TE plot

E. *Rad. P (Radiation Pattern)*

The Rad. P of an antenna is a visual representation of the directional properties of the antenna's radiation. It describes how the radiated energy is distributed in space as a function of direction. The simulated far-field Rad. P of the proposed antenna at the resonant frequency is presented in the fig.6 below, specifically for phi equal to 90 degrees. The Rad. Ps exhibit stables and omnidirectional characteristics, indicating that the antenna is capable of radiating in all directions with equal efficiency.

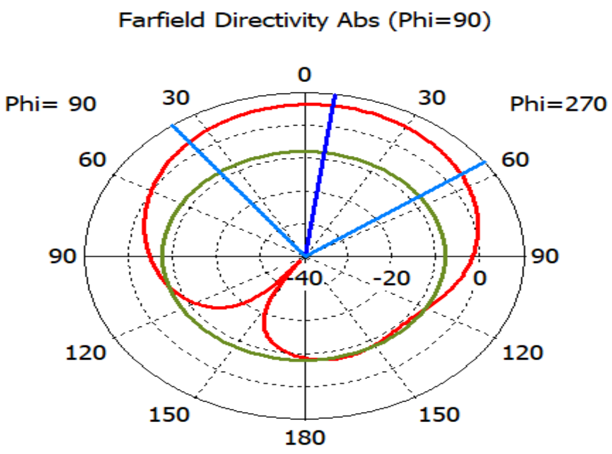

Fig. 6. Far-field Rad. P for the Multiband MSP antenna

V. CONCLUSION

Proposed design of multiband MSP antenna with at a resonant frequency of 5.8GHz. It exhibits a gain of 6.5dBi, directivity of 8.0dB, and a high RDE of 95.8%. The Rad. P is omnidirectional and stable. The antenna design has various applications in IoT applications. Due to its lightweight, compact size and good performance, this antenna design is suitable for various IoT applications where space and weight are a concern.

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