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Research paper

CPW FED dual band antenna for IOT application

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Abstract

This work proposes a Coplanar Wave Guide (CPW) fed dual band antenna for Internet of Things (IoT) application. The substrate of the antenna is selected to be FR4 of dielectric constant 4.4 and loss tangent 0.02. The operating bands of the antenna are (4.17-5.06) GHz and (5.28-6) GHz with impedance bandwidth of 890 MHz and 720 MHz respectively. The simulated gain and efficiency of the antenna at 4.72 GHz and 5.73 GHz are 1.8 dBi, 83% and 2.5 dBi and 90% respectively. The operating frequency bands of antenna found to be in the WiFi range with the prerequisites of IoT application.

Keywords: *Coplanar Wave Guide (CPW); Dielectric Constant; Dual Ban; Internet of Things (IOT); Loss Tangent.*

1. Introduction

In this world, the wireless communication system is widely accepted as the main source of communication. The needs and deeds of the humans are rapidly increasing and it reflects in the communication systems also. So combining more than one wireless communication system became demanded. The new emerging integrated technology satisfies all these peculiarities. The Internet of Things, commonly known as IoT is an incorporation of wireless sensor network, wireless communication network, software etc, [1]. Each device used in this technology is identified by a unique address by the aid of Wireless Sensor Network (WSN) and communication between two devices without human interaction is provided through wireless communication network like Bluetooth, WiFi, WiMAX etc, [2], [3]. In order to maintain the compactness of the device, low rate data is allowed to transfer through this technology. Otherwise the memory space as well as the power dissipation of the device will become a threat to the technology.
Any person from anywhere in this world can access anything with the help of IoT technology at any time. The communication between the devices in this domain is done by the antenna which will work more than one frequency band. The wireless sensor network finds the needs of the request and informs the host through wireless communication network [4]. The accessing of more than one need at a time makes this technology more flexible. Hence the antenna used in this scenario should ensure that it can works in more than one frequency bands. More than that IoT prefer miniaturized antenna for the easier integration with the devices.
Since IoT is an emerging technology, low bit rated data only transferring through the technology. Otherwise, the memory requirement should be considered physically which makes the module more complex. The miniaturized antenna will increase the quality factor as well as provides narrow bandwidth. Since the antennas in the IoT domain prefers to work with low bandwidth, which is less than 1GHz.This, will adapts to reduce the interfering effects also [5].

2. Antenna design

This CPW fed dual band antenna is designed using the substrate FR4 which has the values of dielectric constant and loss tangent are 4.4 and 0.02 respectively. The CPW feeding makes the system easy to fabricate, less cost, low dispersion and small size. The dimension of the substrate is 41mm × 50mm × 1.6mm. It has been seen that by introducing circular shapes in the antenna structure will enhances the bandwidth [6]. But the size of such shapes should be optimized such that that bandwidth should not exceed 1GHz. The antenna geometry should be simple as well as it should satisfies the requirements of IoT as well.
Introducing turnings in the geometry of the antenna enables the antenna working in more than one frequency band [7], [8]. The current direction in the adjacent edges will be in opposite direction which stimulates the changes in the phase of the current flow. Since the surface current distribution alters by these edges and will enables the antenna operates in more than one frequency band [9], [10]. The geometrical structure of the proposed model is given in the figure 1.
The geometry consists of the combination of rectangular and circular patch and the dimension is obtained based on the following equations.

$$W = \frac{V_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \tag{1}$$

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(\frac{1}{\sqrt{1+\frac{12h}{W}}}\right) \tag{2}$$

$$\frac{\Delta L_{eff}}{h} = \frac{0.412(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{W}{h}+0.8\right)} \tag{3}$$

$$= \frac{V_0}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta L \tag{4}$$

$$L_{eff} = L + 2\Delta L_{eff} \quad (5)$$

$$F = \frac{8.791 \times 10^9}{f_r\sqrt{\varepsilon_r}} \quad (6)$$

$$a = \frac{F}{\left\{1+\frac{12h}{\pi\varepsilon_r F}\left(\sqrt{ln\left(\frac{\pi F}{2h}\right)}+1.7726\right)\right\}^{0.5}} \quad (7)$$

$$a_e = a\left\{1 + \frac{2h}{\pi\varepsilon_r a}\left[ln\left(\frac{\pi a}{2h}\right) + 1.7726\right]\right\}^{0.5} \quad (8)$$

The equation from (1) to (5) gives the dimensions of the rectangular surface and equation from (6) to (8) gives the dimensions of the circular surface.

W – Width of the rectangular patch
V_O – The light velocity in free space
ε_r – Dielectric constant of the medium
ε_{reff} – Effective dielectric constant
ΔL_{eff} – Effective change in the length of the Patch
L – Actual length of the patch
a - Radius of the CSMPA
Ae - Effective radius of the CSMPA

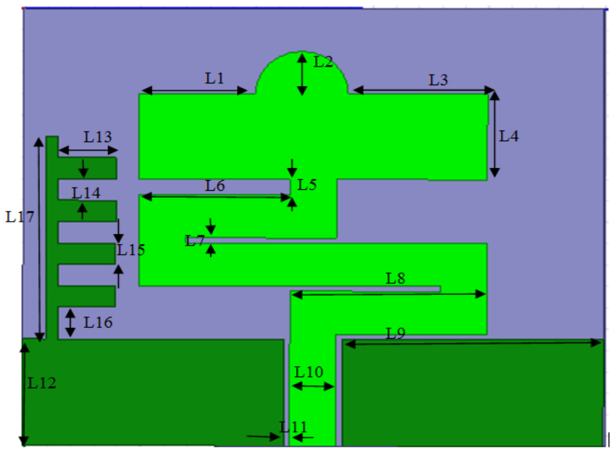

Fig. 1: The Proposed Antenna Model.

The equation connecting antenna radiation efficiency and quality factor is given in the equation (9). Since the IoT antenna requires only low band width hence they can have high quality factor with improved efficiency.

$$Q = \eta\left(\frac{1}{ka} + \frac{1}{ka^3}\right) \quad (9)$$

Q – The quality factor
k- The wave number
a – The radius of the sphere that encloses the antenna
η - Radiation efficiency

An asymmetrical ground surface is introduced in this antenna. The left ground structure is combined with a comb shaped parasitic stub which acts as well a radiator. The dimensions of the parasitic stub are optimized by iterative process, which gives better performance.

Table 1: The Dimensions of the Proposed Antenna

Parameter	Dimension (mm)	Parameter	Dimension (mm)
L1	10	L10	13
L2	4	L11	0.5
L3	12	L12	10
L4	8	L13	5
L5	1.5	L14	2
L6	13	L15	2
L7	0.5	L16	3
L8	17	L17	17
L9	22.5	-	-

3. Simulated results and discussion

The characteristics of an antenna is depending upon certain parameters like reflection coefficient, radiation pattern, VSWR, gain, directivity, radiation efficiency etc,. These parameters values are discussed here for the proposed antenna which obtained by the simulation using the EM simulator software.

3.1. Reflection coefficient

Reflection coefficient is simply gives the idea of how much power is reflected back by cause of the impedance mismatch in the transmission medium. Generally the impedance bandwidth of the antenna is to be selected in the range of frequencies at which have the reflection coefficient or S_{11} value less than -10dB. The simulated graph of reflection coefficient Vs frequency is given in fig.2. The operation frequency bands of the antenna are (4.17-5.06) GHz and (5.28-6) GHz with impedance bandwidth of 890 MHz and 720 MHz respectively. The resonance frequencies are 4.72 GHz and 5.73 GHz is in the ranges of the WiFi bands with the peculiarities of IoT applications. At 4.72 GHz the S11 value is -22.77 dB and at 5.73 GHz, it is -22.14 dB.

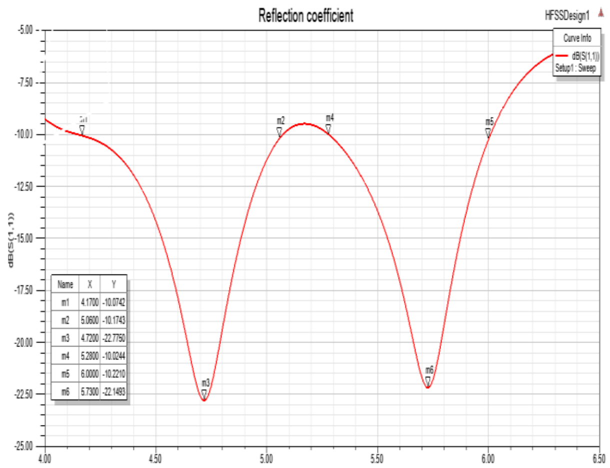

Fig. 2: The Plot of Reflection Coefficient of the Proposed Antenna.

3.2. Voltage standing wave ratio

The Voltage Standing Wave Ratio gives how much efficiently the power is transmitted. The value of VSWR is less than [2] indicates the perfect impedance match between the antenna and the transmission line. The simulated result of VSWR is shown in the figure 3.

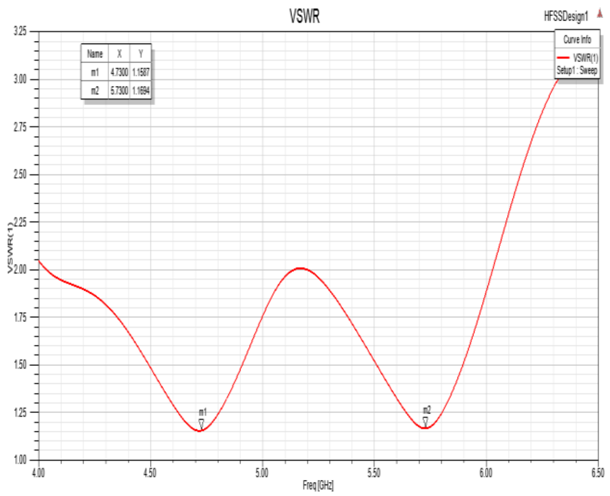

Fig. 3: The VSWR vs Frequency Plot of the Antenna.

The simulated results shows that the antenna exhibits perfect impedance match in the resonating frequencies 4.72 GHz and 5.73 GHz with the VSWR values of 1.15 and 1.16 respectively.

3.3. Radiation pattern

The radiation of the antenna in space is graphically illustrated by the radiation pattern plot. The primary sweep of the radiation pattern is the elevation angle. For the two values of azimuthal angle, zero degree and ninety degree, the radiation pattern is simulated and given in the figure 4 and figure 5 for the respected resonant frequencies.

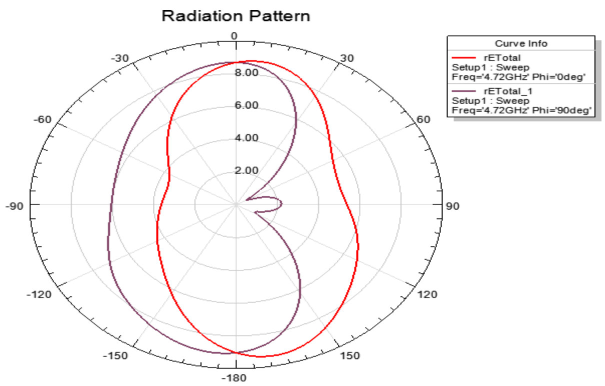

Fig. 4: The Radiation Pattern of the Antenna at 4.72 Ghz.

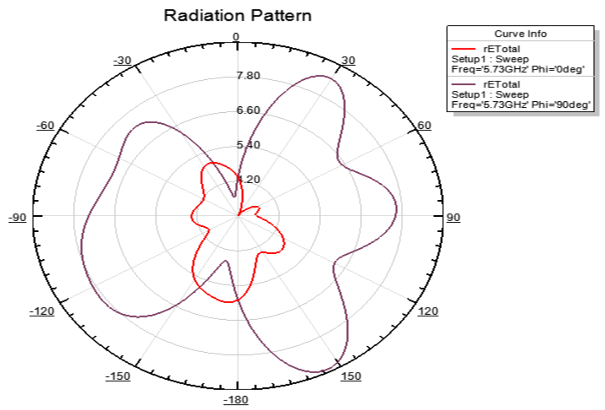

Fig. 5: The Radiation Pattern of the Antenna At 5.73 Ghz.

3.4. Gain

The gain of the antenna is the parameter which describes the performance of the antenna in the far field. The simulated the [3] –D plot of gain of the antenna at resonant frequencies are given in the figure 6 and 7.

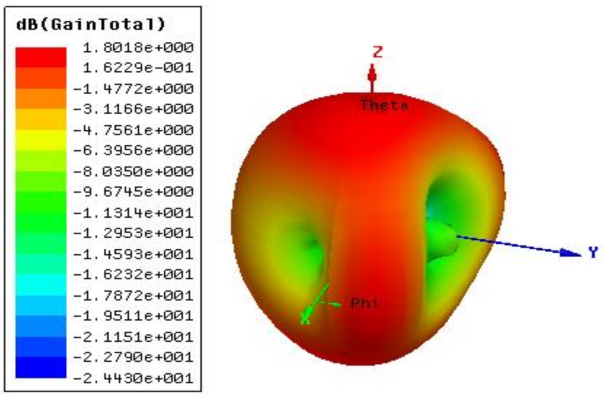

Fig. 6: The Gain of the Antenna at 4.72 Ghz.

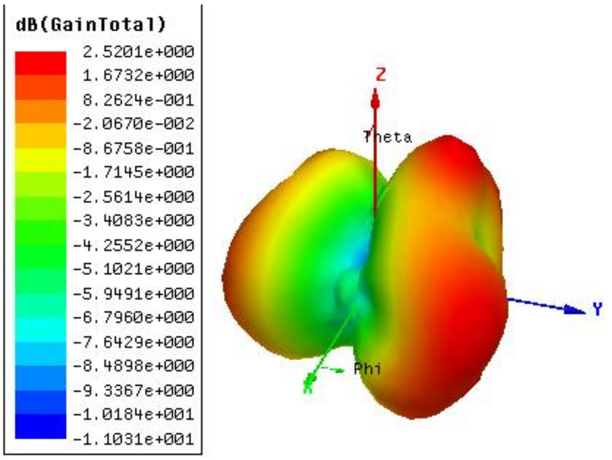

Fig. 7: The Gain of the Antenna at 5.73 Ghz.

The antenna proposed antenna is radiating in the far field with the gain of 1.8 dBi and 2.5 dBi at 4.72 GHz and 5.73 GHz respectively.

3.5. Directivity of the antenna

The directivity of the antenna is one of the fundamental parameter and it gives the idea about the direction of the radiation of the antenna in space. The 3-D plot of the directivity of the antenna at resonant frequency is simulated.

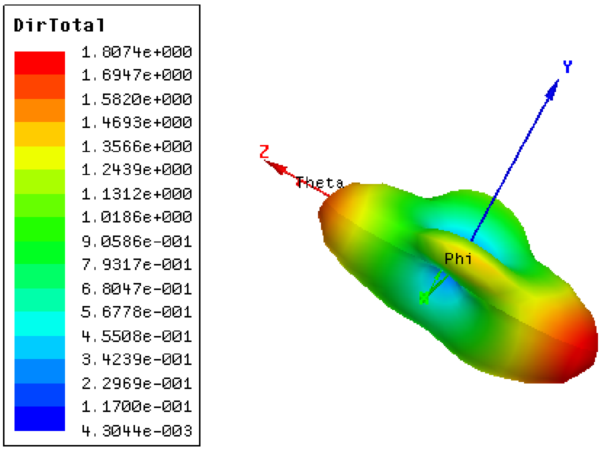

Fig. 8: The Directivity of the Antenna at 4.72 Ghz.

The directivity of the antenna at 4.72GHz is given in figure 8 and at 5.73GHz is given in figure 9.

Table 2: The Overall Performance of the Antenna

Parameter	Value at 4.72 GHz	Parameter	Value at 5.73 GHz
Bandwidth	890MHz	Bandwidth	720MHz
VSWR	1.15	VSWR	1.16
Gain	1.8 dBi	Gain	2.5dBi
Efficiency	83 %	Efficiency	90%

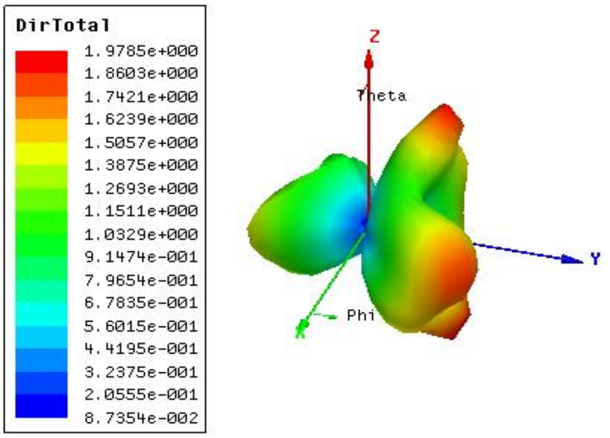

Fig. 9: The Directivity of the Antenna at 5.73 Ghz

4. Conclusion

The CPW fed dual band antenna is proposed for IoT application. The operating bandwidth of the antenna is 890MHz and 720 MHz at the resonant frequencies 4.72 GHz and 5.73 GHz respectively. These operating bandwidths of the antenna are found in the ranges of WiFi application. The requirements of the IoT technology is satisfied by this proposed antenna with 1.18 dBi and 2.5 dBi gain at 4.72GHz and 5.73GHz resonant frequencies.

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