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Slotted E-Shaped Antenna Design with foremost Position of Probe Feeding using HFSS

Imran Basha Syed
Assistant Professor, Department of Electronics and Communication , Bapatla Engineering College, India

Abstract: In this paper, an E-shaped microstrip patch antenna is presented for internet of things (IoT) applications via Bluetooth communication. The visionary flattened structure designed to operate at 2.4 GHz. For this band, radiation, pattern is omnidirectional and the return loss at resonance frequencies is less than -10dB. Mathematical equations of microstrip patch antenna are used for design. The HFSS simulation tool are handy, used extensively to find appropriate feed position, optimize return loss, gain and to tune the resonance frequencies. The simulation and performance analysis is done using HFSS tool. The design considers simple, easily available printed circuit board (PCB) with RT/Duriod 5880 dielectric material between the patch and ground plane, which is inexpensive, fulfills the basic need of the application.
Keywords: E-shaped patch antenna, Internet of Things, Bluetooth, and Simulation using HFSS.

I. INTRODUCTION

A micro strip patch antenna is a metallic strip or patch mounted on a dielectric layer over a grounded plane, useful for high performance in extreme applications. They are low profile, conformable, simple and inexpensive to manufacture, mechanically robust and very versatile. Low efficiency low power, high quality factor are the salient features of micro strip patch antenna. In modern era most of the communication devices such as mobile phones, tabs, and Wi-Fi modem are using the micro strip patch antennas due their low profile and conformability.

Most of the IoT applications need narrow bandwidth. IoT is the buzzword used for short range communication. As there is exponential growth in demand for Internet of Things, the spectrum regulatory authorities worldwide have been releasing new frequency bands at various spectrum ranges from sub GHz to several GHz. The Antenna design for IOT applications should fit in the range of spectrum released for the purpose.

This paper makes an attempt to design an Antenna for IOT needs in the allocated frequency band i.e. 2.4GHz. The focus of this work is on the tight narrow band criteria essential for the above need. The performance of the micro strip patch antennas often depends on the type of substrate used along with the thickness of the substrate.

II. GEOMETRY OF ANTENNA

The Geometry of the E-shaped microstrip was showed in figure 1. The geometrical parameters were the patch length L, the patch width W, the height H, the slot length L_S , the slot's width W_S , and the feed position X. And the resonant frequency and bandwidth could be optimized by adjusting these six parameters.

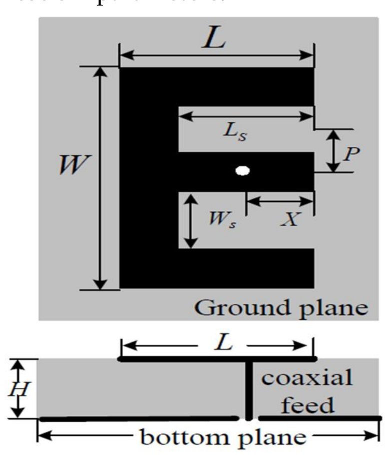

Fig 1: Configuration of E-Shaped Antenna

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For a normal path antenna, its radiation excitation could be equivalent with a simple LC resonant circuit. And for an E-shaped patch antenna, because of its slots, it could be equivalent with a dual-frequency resonant circuit, further more; its bandwidth would be expanded due to the coupling of the two channel of resonant circuit.

III. DESIGN AND ANALYSIS

This Microstrip patch Antenna is modeled based on well-established theory of design of Antennas for high frequencies simple structures, which become readily available, inexpensive PCB like structures.

Simple PCB board with glass epoxy (RT/Duriod 5880) is considered as the dielectric material of thickness copper or any other material which is perfect electric conductor (PEC) on both sides of the dielectric material. The physical shape, dimensions and the feeding method for excitation are mentioned in Fig. 2

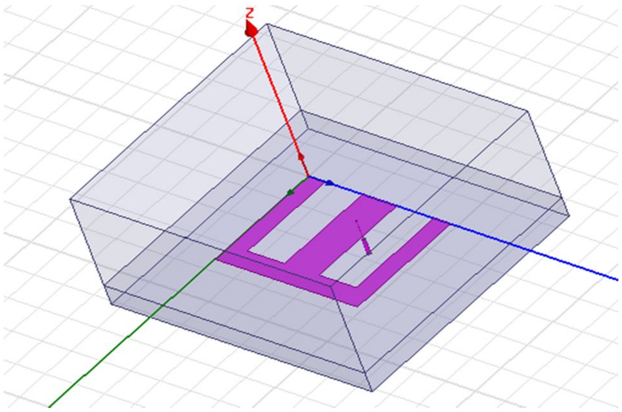

Fig. 2: E-shaped microstrip patch antenna.

The dominant attribute of this design is just maintaining the proper dimensions as shown in Table 1, is sufficient to radiate or receive the signals in the appropriate frequency band. To design a microstrip patch antenna requires important equations as shown below. The mathematical expressions and relations used to design and meet the specifications mentioned in the table are,

Table 1: Key Antenna dimensions

Parameter	Value	Unit
subX	76	mm
subY	88	mm
subH	6.7	mm
coax_outer_rad	0.6	mm
gnd_x	subX	mm
gnd_y	subY	mm
patchX	36	mm
patchY	48	mm
coax_inner_rad	0.17	mm

Length of the patch is,

$L = L_{eff} - 2\Delta L$,

Effective Length,

$$L_{eff} = \frac{c}{2f_0 - \sqrt{\varepsilon_{eff}}} \quad \ldots.. (1)$$

Wavelength,

$$\lambda_g = \frac{\lambda}{\sqrt{\varepsilon_{eff}}}$$

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Incremental Length,

$$\Delta L = 0.412 * \frac{(\boldsymbol{\varepsilon_{eff}}+\mathbf{0.3})*(\frac{\mathbf{w}}{\mathbf{h}}+\mathbf{0.264})}{(\boldsymbol{\varepsilon_{eff}}-\mathbf{0.258})*(\frac{\mathbf{w}}{\mathbf{h}}+\mathbf{0.8})}$$

Bandwidth of the E-shaped Antenna,

$$W = \frac{\mathbf{c}}{\mathbf{2f_o}}\sqrt{\frac{\mathbf{2}}{\boldsymbol{\varepsilon_r}+\mathbf{1}}} \qquad \text{..... (2)}$$

Effective Dielectric constant,

$$\boldsymbol{\varepsilon_{eff}} = \frac{\boldsymbol{\varepsilon_r}+\mathbf{1}}{\mathbf{2}} + \frac{\frac{\boldsymbol{\varepsilon_r}-\mathbf{1}}{\mathbf{2}}}{\sqrt{(\mathbf{1}+\frac{\mathbf{12h}}{\mathbf{w}})}} \qquad \text{….. (3)}$$

IV. RESULTS

In this work the E-Shaped antenna is designed with important specification mentioned as in above table and experimental results regarding radiation characteristics are observed as in Table2. The simulated results were obtained by using the Ansoft simulation software; high frequency structure simulator HFSS.

Frequency	Return Loss(dB)	VSWR	Bandwidth
2.4GHz	-17.32	1.31	174 MHz

Table 2: Observed Radiation Characteristics

The measured simulated characteristics of the antenna are shown from the return loss, voltage standing-wave ratio (VSWR), radiation pattern as well as the current distribution in the patch. Good return loss and radiation pattern characteristics were all obtained in the frequency band of interest as shown as follows,

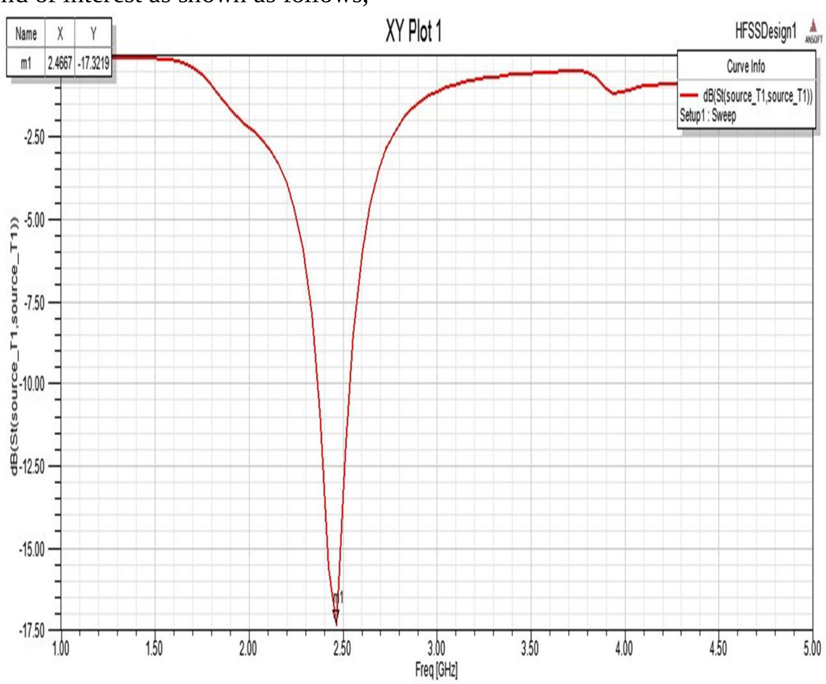

Fig 3: Return Loss (S11 in dB) w.r.t. Frequency plot

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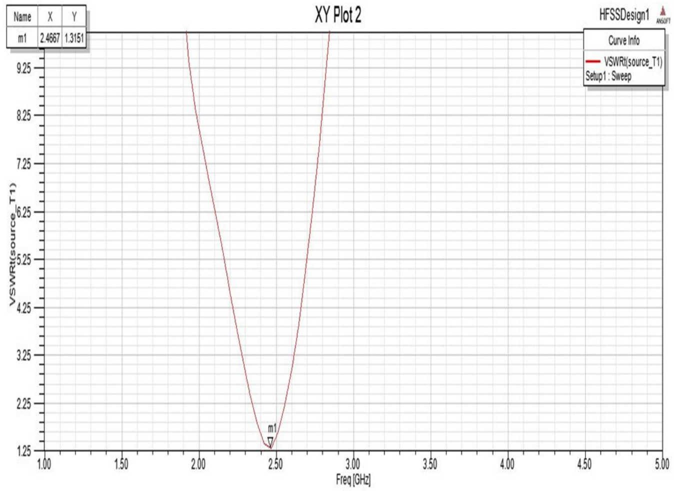

Fig. 4: VSWR w.r.t. Frequency plot.

The IOT applications demand omnidirectional antennas, the same is fulfilled by having almost uniform far field radiations except at $\theta = 0^0$ and $\theta = 180^0$. The Fig. 4 depicts the same.

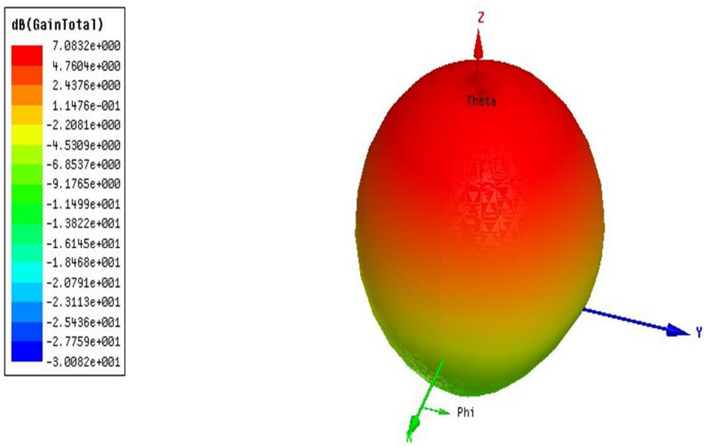

Fig. 5: Omnidirectional radiation pattern with gain variation.

The smith chart plot, Fig. 6 explains the variations of the input impedance for different values of the frequency. Helpful to position feed point appropriately along the Y axis and to tune optimally for achieving the desired results.

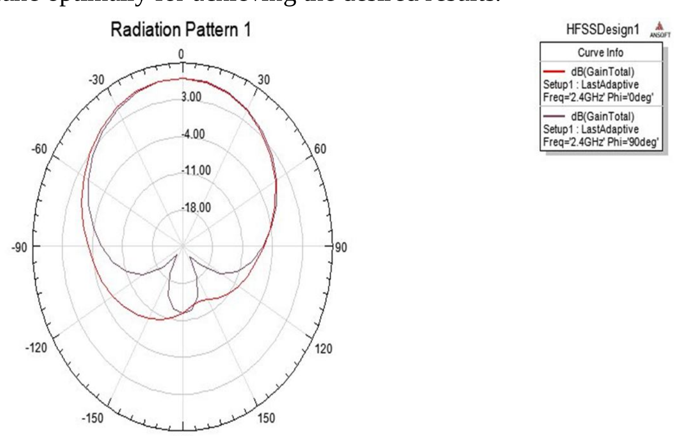

Fig. 6: Specifications of impedance variation at different frequencies.

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V. CONCLUSION

In this paper the focus to design the desired band for IoT antenna at approximate resonate frequency 2.4 GHz, is simulated using HFSS software. The return loss achieved at resonance frequencies, meets the minimum criteria and optimized to -15dB, which is better than the minimum requirement of -10dB. Hence the performance of the antenna to meet the specifications of the application is fulfilled. Further focus to optimize return loss below -20dB and to improve radiation efficiency is the future scope of this work.

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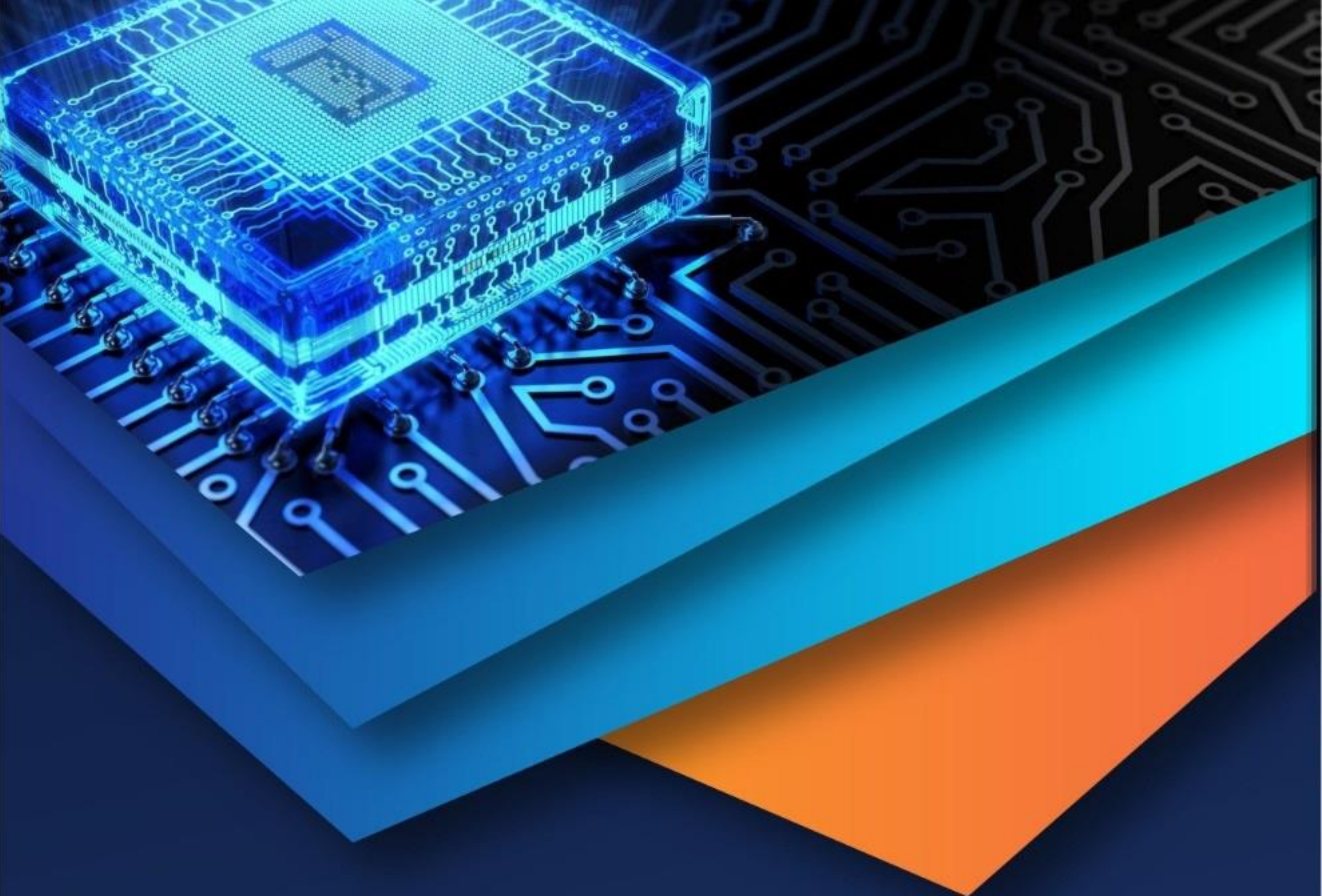

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