Design of A Handy Tripleband Micro- Strip Patch Antenna for Satellite Based Iot Applications

B. Srikanth Deepak, R. Naveen Kumar, M. Madhavi, P. Avinash, K. Yaswanth

Abstract*: Design of a handy triple band micro-strip patch antenna for satellite based IoT applications is presented in this paper. The proposed antenna operates at three distinct frequencies, 3.05 GHz, 7.275 GHz and 8.55 GHz respectively in the ultra wide band region. This antenna has been designed using high dielectric material Rogers RT/duroid 6010/6010LM (εr = 10.2 of height 0.8mm) in the HFSS electromagnetic simulation tool and compared its performance with the same design on FR4 substrate and recorded the results. The proposed model with RT/duroid has exhibited better performance in terms of radiation efficiency, peak gain as well as the number of operating frequencies, when compared to antenna model with FR4 substrate. It is an application specific design meant for satellite based IoT applications (Miracast, X band uplink and X band downlink respectively). The proposed antenna provides a peak gain of 5.45 dB with an average efficiency of 78% in the operating band. The combination of Miracast (Screen Sharing), satellite uplink and downlink applications made this particular antenna very handy as well as application specific with lesser cost and complexity.

***Index Terms*: Rogers RT/duroid 6010/6010LM, FR4 epoxy, Triple band, Defected ground structure (DGS) .**

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, Wi-Fi modems[9] are using the micro strip patch antennas due their low profile and conformability.

The performance of the micro strip patch antennas often depends on the type of substrate used along with the thickness of the substrate. Depending on the permittivities of substrates, the amount of radiation varies. Higher the permittivity, higher is the amount of energy stored and vice-versa. The performance of the antenna is graded by using the parameters like return loss and voltage standing wave ratio.In media transmission, a micro-strip patch antenna[20] more often than not implies a receiving wire created utilizing micro-strip techniques on a printed circuit board (PCB). It is a sort of internal Antenna and utilized mostly at microwave frequencies. The most normal kind of Micro-strip. Reception apparatus is the fix radio wire. Receiving wires utilizing patches as constitutive components in a cluster are additionally conceivable. A fix reception apparatus is a narrowband, wide-shaft receiving wire manufactured by drawing the radio wire component design in metal follow attached to a protecting dielectric substrate, for example, a printed circuit load up, with a ceaseless metal layer clung to the contrary side of the substrate which frames a ground plane. Regular micro-strip radio wire shapes are square, rectangular, and roundabout and curved, yet any nonstop shape is possible. In our task we think about rectangular fix reception apparatus. Some fix receiving wires utilize a dielectric substrate and rather they are made of a metal fix mounted over a ground plane utilizing dielectric spacers and their subsequent structure is less tough which prompts a more extensive transmission capacity .The Micro strip patch antennas are easily perceived choice for handheld and compact wireless devices[13] because of their advantages like small size and weight .The size of wireless devices is reducing exponentially which demands more compact and high-performance antenna devices. Most of the modern handheld wireless devices are operating in the multiple bands of frequency. More gadgets are working in the numerous groups of recurrence. Many research works have been accounted for dependent on scaling down of the antenna without influencing reception apparatus execution. A large portion of them depend on modifying the fix shapes, for example, introducing slots, blemished ground structures. Defected ground structure (DGS)[16] is popularly used technology for enhancing the bandwidth.

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The slots etched pertaining to the ground plane are referred to as defected ground structures (DGS) . In DGS, the defected structures may be single or multiple in number aiding the enhancement of gain, operating bandwidths as well as suppressing higher mode harmonics and mutual coupling. Initially DGS was reported for filters underneath the micro-strip line .Later, the defected ground structures are used for obtaining stop band characteristics as well. Hence, the DGSs gradually became the powerful inclusions in modifying the characteristics of micro strip antennas such as radiation pattern, operating bandwidth, gain and the return loss towards the requirement of the desired applications.

II. DESIGN AND ANALYSIS

The proposed antenna is designed in HFSS microwave simulation software using Rogers RT/duroid 6010/6010LM as shown in Figure 1. Initially, the antenna has been designed using FR4 substrate for which, the obtained results in terms of return loss were very poor. Later, as a remedy, the substrate has been replaced with Rogers RT/duroid 6010/6010LM and then simulated. Both the results were compared and the witness is so strong that, the return loss parameter in case of RT/duroid (εr = 10.2) being the substrate has been over par of -10dB at three distinct frequencies as shown in the Figure 2. Whereas, the former case failed to prove that it is a worthwhile. The dimensions of the proposed antenna which is designed using Rogers RT/duroid 6010/6010LM are specified as shown in the Table 1.The results pertaining to the various antenna parameters like return loss, radiation pattern and gain have been recorded.

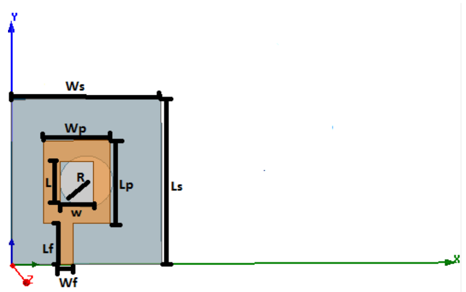

Fig 1. Design of the proposed antenna

Table1. Design Specifications of the Proposed Antenna

Parameter	Substrate	Patch	Ground Plane	Feed Line	Slot	DGS (CIRCLE)
Length (L)	32mm (Ls)	16mm (Lp)	32mm (Lg)	8mm (L)	8mm (L)	-
Breadth (B)	28mm (Ws)	12.45 mm (Wp)	28mm (Wg)	2.46 mm (Wf)	6.225 mm (W)	-
Height (H)	0.8mm (h)	-	-	-	-	-
Radius (R)	-	-	-	-	-	5mm (R)

The proposed antenna operates at three distinct frequencies 3.05 GHz,7.275GHz and 8.55GHz in the ultra wide band[12] region, where the chance for interference between any two of the three working bands has been barely minimum due to the high dielectric substrate used.The higher permittivity of the RT/duroid substrate (εr = 10.2) constituted the 1comprehensive isolation between each of the operating bands, where the amount of return loss is substantially high. This particular characteristic of the proposed antenna has made it a distinct tool which can be dedicatedly used for real time screen sharing of satellite data. The patch and the slot dimensions are based on the mathematical expressions of width, length and radius which are depending on various important parameters such as, relative permittivity, speed of the EM wave, operating frequency, height and width of the substrate. The design specifications of the proposed antenna have been extracted from the following mathematical expressions.

$$Width = \frac{c}{2f_o\sqrt{\frac{\varepsilon_R+1}{2}}}; \quad \varepsilon_{eff} = \frac{\varepsilon_R+1}{2} + \frac{\varepsilon_R-1}{2}\left[\frac{1}{\sqrt{1+12\left(\frac{h}{w}\right)}}\right]$$

$$Length = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}} - 0.824h\left(\frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)}\right)$$

$$a = \frac{F}{\left\{1+\frac{2h}{\pi\varepsilon F}\left[\ln\left(\frac{\pi F}{2h}\right)+1.7726\right]\right\}^{\frac{1}{2}}}$$

$$\text{Where } F = \frac{8.791\times10^{9}}{f_r\sqrt{\varepsilon}}$$

Parameters involved in designing of antenna

w -Width of antenna

h- Height of antenna

f**o-** operating frequency

εeff- effective dielectric constant.

a-radius of the circular slot.

III. RESULTS AND DISCUSSION

The comparison of return loss parameter for antennas designed using FR-4 as well as RT/duroid is as shown in the Figure 2.

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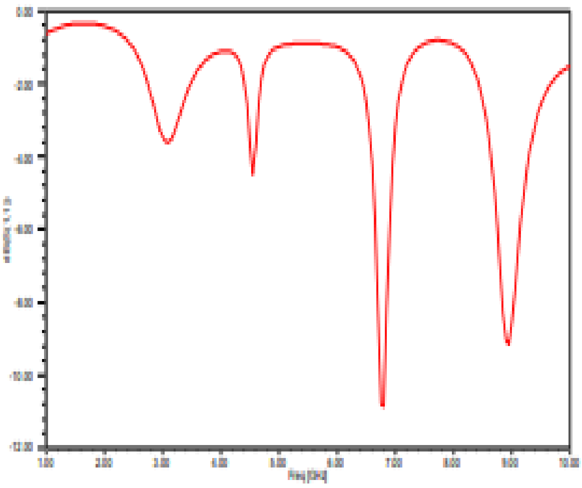
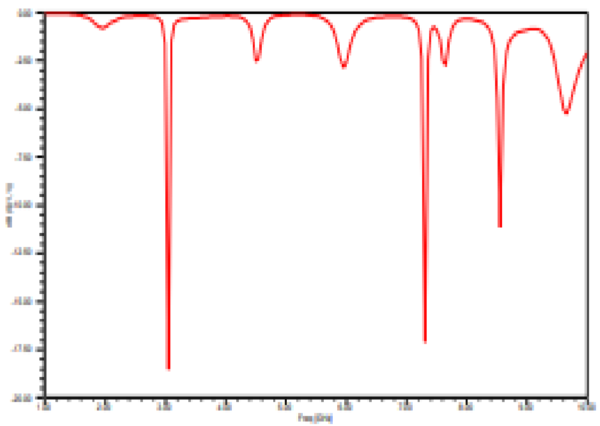
The results clearly depict that, the antenna designed using RT/duroid is much efficient when compared to the antenna designed using FR4 epoxy. For the designed rectangular patch along with a rectangular slot and the ground structure perforated with a circle, the impedance matching has been poor and thus with FR-4 (εr = 4.4) as substrate there is hardly a frequency at which the antenna tends to work. On the other hand the antenna with RT/duroid having very high permittivity (εr = 10.2) in combination with impedance mismatch, acquired the tendency of radiating the fields inspite of sustaining them through. With this transformation of impedance at distinguished frequencies within the ultra wide (3.1-10.6 GHz) region, the proposed antenna operates at the three (3.05 GHz, 7.275 GHz and 8.55 GHz) distinct frequencies, when the height of the substrate (RT/duroid) is chosen as 0.8mm.



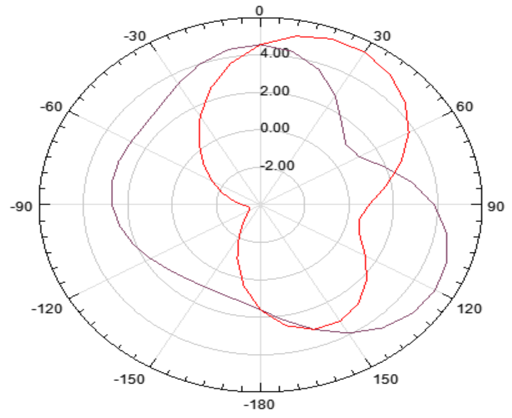
(A)



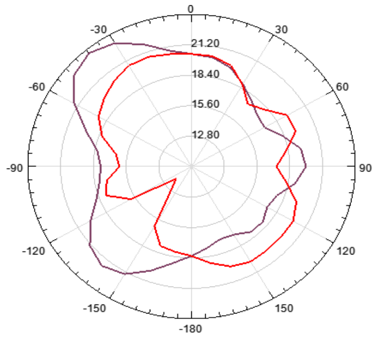
(B)

Fig 2. Return loss in dB for (A) design using FR4 epoxy;(B) design using RT/duroid

The results for radiation pattern of the proposed antenna at 3.05 GHz, 7.275 GHz, 8.55 GHz are as shown in Figure 3.



(A)



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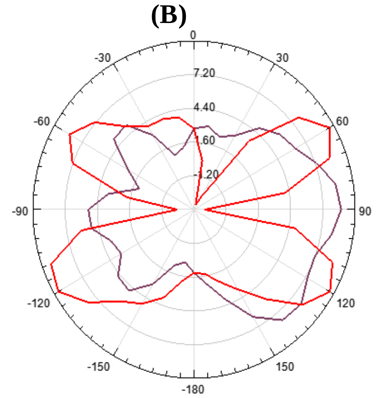

(C)

Fig 3. Radiation Pattern of the designed antenna at (A) 3.05 GHz (B) 7.275 GHz (C) 8.55 GHz respectively.

The results for 3D polar plot of the proposed antenna at 3.05 GHz, 7.275 GHz, 8.55 GHz are as shown in Figure 4. The peak gains observed at 3.05 GHz, 7.275 GHz and 8.55 GHz frequencies are 5.5 dB, 2.41 dB and1.134 dB respectively.

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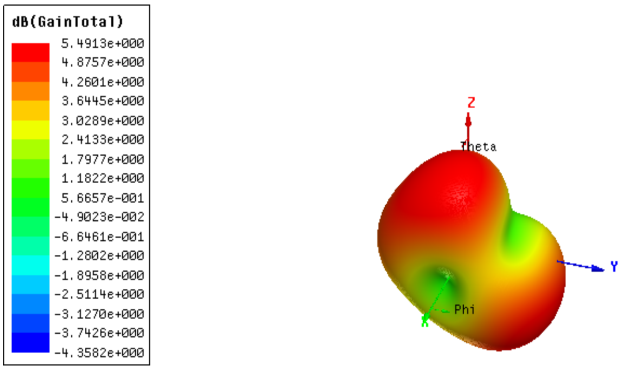
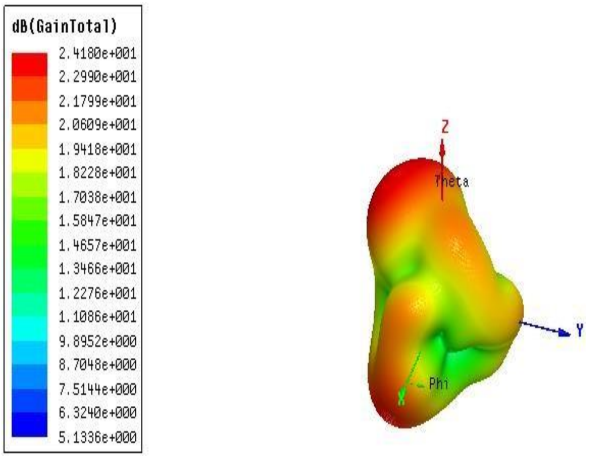
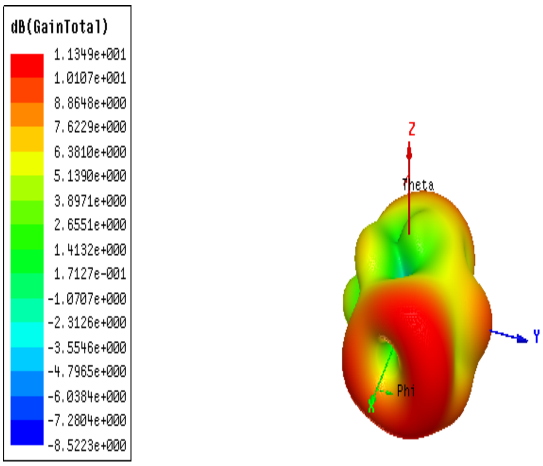


(A)



(B)



(C)

Fig 4. 3D polar plot along with respective gains at 3.05 GHz, 7.275 GHz and 8.55 GHz respectively.

Iv. CONCLUSION

The design of a miniaturized micro strip patch antenna that can be used for satellite based IoT applications such as Miracast, X band uplink and downlink has been presented with simulation results along with the comparison between the performances of the antenna model with FR-4 and RT/duroid substrates. Two slots have been etched on the patch and the ground plane (rectangular slot on patch and circular slot on ground plane) of the antenna respectively, in order to increase the operating bands in the ultra wide band [3] region with the cause of impedance transformation. The results achieved were quite evident that, the proposed antenna with RT/duroid substrate is much efficient when compared to that of the antenna with FR4 epoxy. Hence, the comparison has lead to strong conclusions, proving that the former case of the antenna design is inferior to that of the later case (proposed model) in terms of its performance efficiency in the ultra-wide band region.

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