iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** VI **Month of publication:** June 2020

DOI: http://doi.org/10.22214/ijraset.2020.6268

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue VI June 2020- Available at www.ijraset.com

Design and Analysis of Rectangular Patch Antenna for UWB Applications

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Abstract: The structure of rectangular monopole antenna of compact size is presented. The antenna consists of a rectangular patch with inset feed, so that the impedance matching is improved. In addition, rectangular shaped slots are introduced to patch to change the surface current paths to spread more uniformly and thus bandwidth of the proposed design is enhanced. Furthermore parasitic elements are added to design structure. The antenna is compact having size of 17.5 × 21.5 mm. The partial ground plane has been modified with a centre notch and edge trimming. The antenna operates over frequency range from 3.51 GHz to 14.14 GHz having bandwidth of 10.63 GHz.
Keywords: Wireless Communication, Ultra-Wideband antenna, Patch antenna, Monopole, Microstrip, Partial ground.

I. INTRODUCTION

In the domain of wireless communications, the antenna plays a requisite role in transmission and reception of EM (Electromagnetic) signals, and there are many different types of antennas with different properties. The bandwidth is a crucial factor for selecting an antenna for the intended application and this is a requirement for Ultra-Wideband (UWB).Federal Communications Commission (FCC) enacted the "First Report and Order" allowing ultra-wideband (UWB) equipment to operate commercially and has issued the permit for use within the frequency range (3.1 – 10.6 GHz) [1].The research on ultra-wideband (UWB) technology has been conducted for over a decade [2]. UWB is a technology capable of transmitting and receiving very high speed data, with minimal power requirements [3]. In applications such as security systems [4], medical applications [5] and the Internet of Things (IoT) [6], UWB frameworks have been identified. Unfortunately, the design of miniaturized UWB antennas is very challenging due to certain simple limitations for electrically small antennas [7]. In other words, reducing the size of the structure leads to a shortening of the current path and, consequently, to a lower impedance match for lower frequencies [8]. A number of techniques have been developed to deal with this problem, including quasi-self-complementary planar/uni-planar designs [9,10], ground plane modifications (I-shaped slots [11], protruded ground plane structures [12], L-shaped stubs [13,11]), introduction of slots within radiators to enhance the current flow within them [14], as well as the structures with shorting pins [15]. To improve the impedance bandwidth of the monopole antennas, several techniques such as using various disc shapes [16], a bevel and a shorting pin [17], and parasitic elements [18], have been studied.

In this Letter, we describe a structure of a compact UWB monopole antenna for UWB applications. The various geometrical parameters of the antenna are the dimensions of the patch and ground planes and the separation between them and it also includes the height of the substrate material. This is a simulation based study. The design and simulation of the antenna is carried out using CST microwave Studio simulation software [19]. To sharpen the resonances, slots are added on a radiating side of the patch. Details of the antenna design along with stimulated results are presented and discussed.

II. STRUCTURE OF RECTANGULAR PATCH ANTENNA

Consider a rectangular monopole antenna of compact size shown in Fig. 1. The proposed structured is based on Compact UWB monopole antenna for Iot applications with significantly partial ground plane [20].The design is implemented on 1.6 mm thick FR-4 Epoxy. The "FR" stands for Flame Retardant, this material is non-flammable. And relative permittivity of FR-4 is 4.4. The antenna comprises of a rectangular radiator with inset feed, a partial ground plane with a notch, rectangular slots and parasitic elements. The parasitic elements are added to design structure so that their radiation pattern is merged with the main patch and give consistent radiation pattern over high frequency. The modifications of slits, slots and parasitic elements are introduced to ensure operation within the UWB frequency range. The unit for all dimensions is in mm. The computational model of antenna is implemented using CST microwave studio suit software. The size of the antenna has been calculated and the optimized values are obtained during simulation using parametric sweep available in the simulation software.

III.RESULTS

The optimized antenna structure has been obtained using the procedure of [20]. The dimensions of the miniaturized design are 17.5 × 21.5 mm. It should be noted that the algorithm has been configured in such a way that it allows explicit reduction of the structure dimensions while maintaining the condition |S11| ≤ –10 dB for the UWB band. The antenna has been analysed and designed using CST Studio Suit. Structure of the designed antenna using CST is shown in Fig. 1. The obtained results indicate that designed structure fulfils the UWB band requirements within the frequency range from 3.51 GHz to 14.14 GHz having bandwidth of 10.63 GHz. The Maximum Gain over frequency of the Antenna is shown in the Fig. 2. The Gain obtained in the entire UWB range of frequencies is above 2dB which is sufficient for many devices, as the coverage area is typically around the 40Meter range. The radiation pattern plots are illustrated in the Fig. 3, it can be seen that the radiation patterns are more consistent in all the frequency ranges in the H-Plane and is Omni-directional pattern.

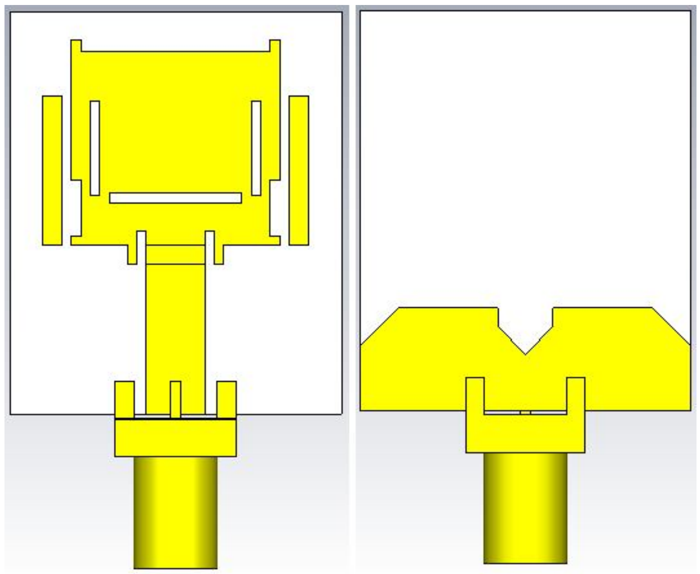

Fig. 1: CST model of the proposed antenna.

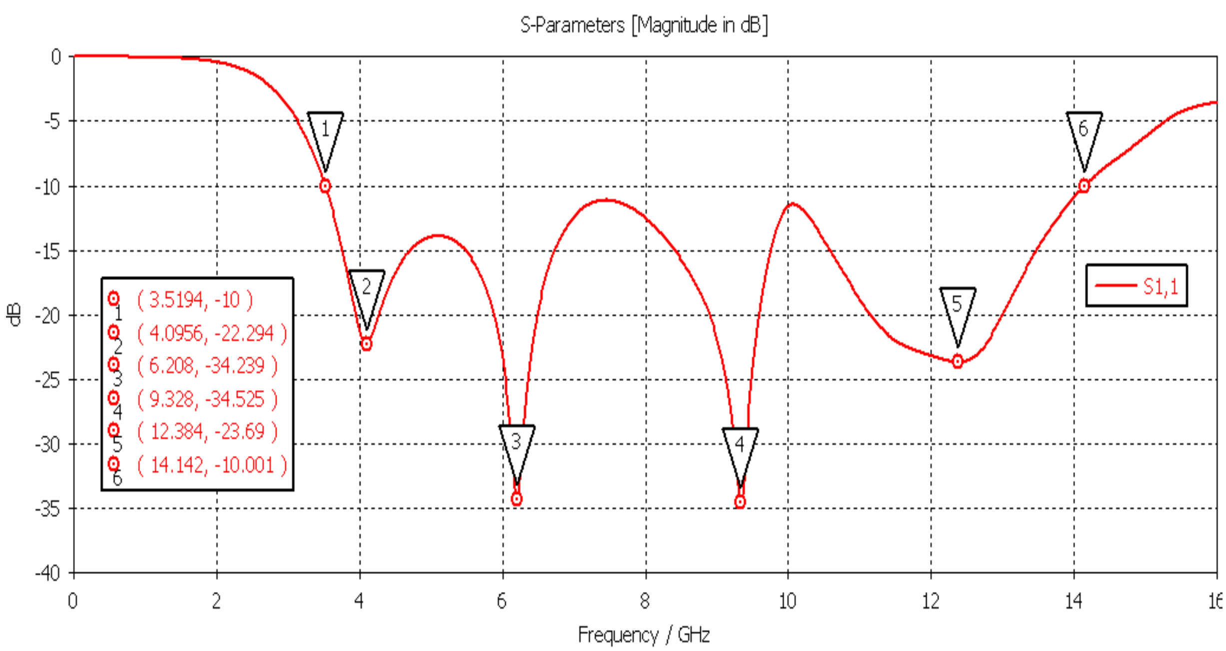

Fig. 2: S11 curve of antenna.

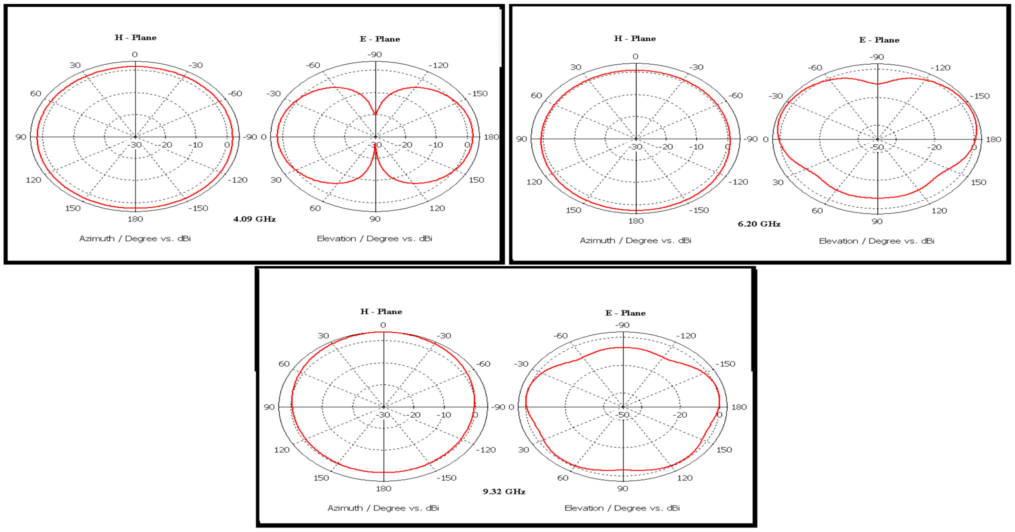

Fig. 3: Radiation pattern of the antenna at different frequencies a. At 4.09 GHz, b. At 6.20 GHz and c. At 9.32 GHz.

IV. CONCLUSION

There are many researches in UWB antenna design with multiband features and band notching features. A number of works are studied prior to getting this project started. The proposed design achieves UWB operation along with several frequency bands, however most of the antennas reported in the [10, 11, 12, 20] either have good field patterns, proper gain, good reflection characteristics or compactness and neither of the antennas have all these features combined. The purpose for this project is to combine all the features into a single design which has good gain over frequency, omnidirectional radiation pattern in any one of the plane, compactness, good reflection characteristics.

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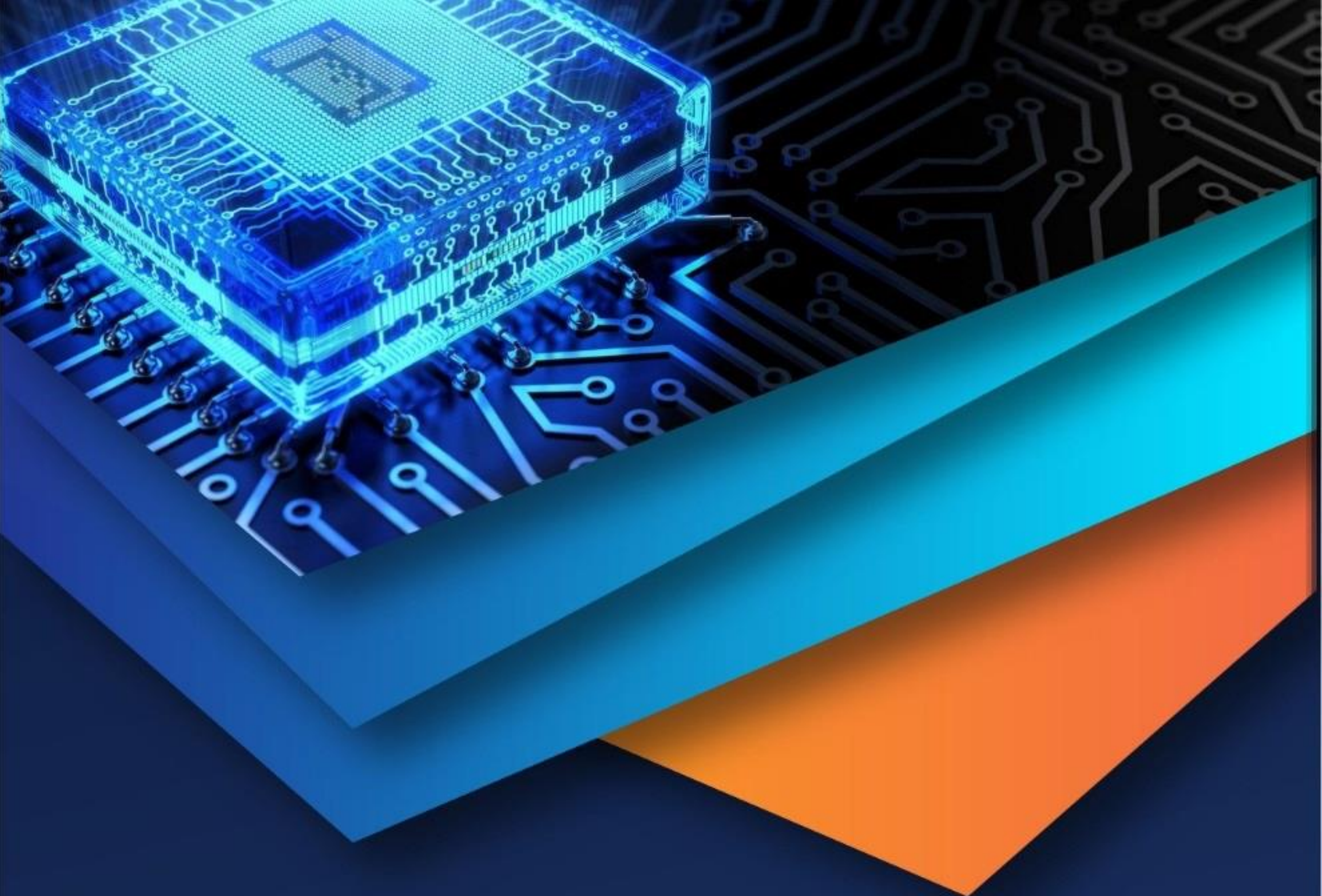

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