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Design of Microstrip Patch Array Antenna for Wireless Local Area Network (WLAN) Using 5GHz Frequency

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ABSTRACT

This paper presents a microstrip patch array antenna designed using computer simulation technology (CST) Studio Suit Software at a resonant frequency of 5GHz. The antenna consists of three layers, the upper layer called metallic patch, the bottom layer called ground and the dielectric layer in between the conduction layers called the substrate. The antenna has the advantage of minimal weight, low profile and can maintain high performance over a wide spectrum of frequencies. The performance characteristics of the antenna patch array elements 1X1, 1X2, 1X4 and 2X2 were compared. The aim of designing an antenna with improved gain, reduced losses and use for X band applications such as radar, satellite communication, medical applications and other wireless systems was achieved. The performance of the designed antenna in terms of radiation efficiency, gain, reflection coefficients and radiation patterns were verified and found suitable for wireless local area network (WLAN) applications.

KEYWORDS: Patch antenna, Radar technology, Radiation efficiency, Microstrip

INTRODUCTION

Antenna is one of the most important components of any wireless system. An antenna is an electronic device that transmits and (or) receives electromagnetic waves. In most cases, it operates as a resonant device that efficiently operates in a relatively narrow frequency band. For the antenna to work efficient, its frequency must be tuned to the frequency band of the communication system to which it is connected, otherwise, the signal transmission will be impaired. The receiving antenna is responsible for turning the electrical signal into its original form. In recent years, the development in communication systems necessitates the requirement of low cost, minimal weight, low power, and low profile antennas that are capable of maintaining high efficiency over a wide band of frequencies. A microstrip patch antenna is a single layer design that in most cases contains four main parts the patch, the ground plane, the substrate in between patch and ground, and the feeding port.

The design and construction of the antenna are very simple using the conventional microstrip feed line method. The patch can be designed in any shape and we designed square shape. The ground plane can be finite or infinite depending on the model used for the analysis of dimensions. Relative permittivity (ϵ_r) and height (h) are the two most important characteristics considered for any antenna type. Single microstrip patch antenna presents the advantages of low cost, light-weight, conformal and low profile. The drawbacks are very little which are low gain, low directivity, low efficiency, and narrow bandwidth.

LITERATURE SURVEY

In the recent era of wireless communication, Microstrip antenna (MSA) is hot research topic attracting attentions of many researchers .MSA are low profile, lightweight and have a compatibility with integrated circuit technology. There are several drawbacks of MSAs likes their narrow impedance, bandwidth, axial ratio, lower power handling capacity small gain etc. Here the overview of air fed high gain patch antenna is presented. Various gain enhancement methods like micro strip antenna array, super strate structure, change in dielectric material and partial removal of substrate will be studied also the presentation of review. Air is used as dielectric medium between feed patch and ground plane. **[1]**

In this paper, we present a new approach to improve the radiation effectiveness and the performance of antennas by miniaturization of the size. The printed antenna is one of the best antenna structures, due to its low cost and compact design. Indeed, we have studied the performance of ultra wideband antenna which consists of a ring-shaped patch. The complete frequency band of UWB which is ranging from 2.5GHz to 9.4GHz and the geometry of the antenna and to obtained results the simulation software CST Studio microwaves is used. **[2]**

A stacked microstrip antenna with C-type feed is designed in order to enhance the bandwidth. The effect of the various parameters, such as the rotation feed angle (θ), the variations of relative permittivity of parasitic patch , the distance of the feed point from the center (r), and the separation between two stacked patches , have been discussed. Some designs give a good return loss under -40 dB and wide VSWR bandwidth, such as case#2 with εr2 =4.26 case#4 with r = 6.2mm, case#5 with 6.8 , 2 h h2=2 mm case#1,and case#2 with h2=8.2 mm. The simulated data are obtained using the IE3D simulator with method of moments (MoM) commercial code. An infinite ground plane has been considered for simulations; however, and due to a software constrain, substrate dimensions are infinite. **[3]**

A novel design of compact micro strip UWB antenna with step impedance micro strip line is proposed. The proposed antenna is analyzed in both frequency and time domain to check its appropriateness for UWB applications. For feeding used connector is SMA female. Antenna features like as return loss and radiation pattern show reasonable agreement with the simulated results. The omni-directional radiation pattern on most of the operating band. Radiation pattern is measured in antenna anechoic chamber. Feed line used has characteristic impedance of 50 -. The antenna consists of a partial ground with slots at the rear end and a rectangular patch with slits on the top face. The antenna with dimension of L=34mm £ W=36mm is fabricated on FR-4 epoxy dielectric with relative permittivity of 4.4. The designed antenna has the capability of operating between 3 GHz to 10.26 GHz with a 7.26 GHz bandwidth (fh-fl). **[4]**

A novel multiple slot microstrip patch antenna for wireless communication is proposed. This paper presents stacked probe fed inverted multiple slot microstrip patch antenna. The composite effect of integrating these techniques and by introducing the novel multiple shaped patch, offer a low profile, high gain, and compact antenna element. Simulated results for main parameters such as return loss, impedance bandwidth, 8 radiation patterns and gains are also discussed herein. The study showed maximum achievable gain of about 11.44 dBi with simplicity in designing and feeding, can well meet for wireless communication system especially for base station. **[5]**

In this paper an Ultra Wideband (UWB) micro strip antenna consisting of a circular monopole patch along with stepped feed line, a 10 dB return loss bandwidth from 3.1 to 10 GHz is proposed. This antenna was designed on FR4 substrate with overall size of 40 x 31.17 x 0.787 mm3 and dielectric substrate with *εr* = 2.2 This antenna designed by using CST Software based on the characteristic impedance for the transmission line model and operated at UWB frequency . The parameters like feed size, ground plane and substrate dimension which affect the performance of the antenna in terms of its time domain and frequency domain characteristics are investigated. **[6]**

A Rectangular Microstrip Patch Antenna to Enhance Bandwidth at 2.4 GHz for WLAN Applications has been proposed in this paper. In this bandwidth of antenna has been improved. This antenna was presented for WLAN and satellite application. **[7]**

EXISTING SYSTEM

In Existing Method they designed a rectangular microstrip patch array antenna for 2.4GHz using CST Studio Suit. The substrate material was used in existing method is FR-4. The antenna array was designed and simulated using computer simulation technology (CST) Studio Suit Software. CST is a 3D full-wave electromagnetic field simulator; it uses the finite element method together with adaptive meshing to solve the wave equation. If a 3D model has been made, CST sets up the mesh automatically.

The CST computes S-parameters can be calculated and plot both the near and far-field radiation. It also computes important parameters such as gain and radiation efficiency. This software was used to vary the sizes of patches, microstrip feed line, and ground plane to come up with the desired results. The dimension of any antenna type is design based on its area of application.

TABLE I. DIMENSIONS OF WLAN ANTENNA:

Frequency	2.4GHz
Substrate	FR-4(lossy)
Dielectric constant	4.7
Loss tangent	0.019
Substrate Height	1.6 mm
Conductor thickness	0.035mm

Table1: Dimensions of WLAN Antenna

TABLE II. DIMENSIONS OF RECTANGULAR PATCH ANTENNA ARRAY:

Patch	
Width, w (mm)	30.03
Length, L (mm)	30.10
50Ωfeedline	
Width, w (mm)	3.20
Length, L (mm)	17.00
100Ωfeedline	
Width, w (mm)	0.70
Length, L (mm)	14.00
75Ωfeedline (λ/4 transformer)	
Width, w (mm)	1.60
Length, L (mm)	15.00

Table2: Dimensions of Rectangular Patch Antenna Array

PROPOSAL METHOD

The antenna array was designed and simulated using computer simulation technology (CST) Studio Suit Software. CST is a 3D full-wave electromagnetic field simulator; it uses the finite element method together with adaptive meshing to solve the wave equation. If a 3D model has been made, CST sets up the mesh automatically. The CST computes S-parameters can be calculated and plot both the near and far-field radiation. It also computes important parameters such as gain and radiation efficiency.

This software was used to vary the sizes of patches, microstrip feed line, and ground plane to come up with the desired results.The dimension of any antenna type is design based on its area of application. The present antenna was designed based on WLAN application and the specification for WLAN antenna is given in the Table I.

TABLE I. DIMENSIONS OF WLAN ANTENNA:

Frequency	5GHz
Substrate	Rogers RT 5880
Dielectric constant	2.2
Loss tangent	0.019
Substrate Height	1.6 mm
Conductor thickness	0.035mm

Table 3: Dimensions of WLAN Antenna

LAYOUT BASED SIMULATION:

The first step before designing the layouts, the dimensions of the desired antenna and feeds should be calculated. The layout design environment is brought out. The EM Structure on the PROJ tab is right-clicked. The New EM Structure option is selected. An empty design layout will appear in the main design window on the right. The parameters specification for the antenna used in this study is shown in Table II.

TABLE II. DIMENSIONS OF MICROSTRIP PATCH ANTENNA ARRAY:

Patch	
Width, w (mm)	60.00
Length, L (mm)	60.00
50Ωfeedline	
Width, w (mm)	4.00
Length, L (mm)	22.00
100Ωfeedline	
Width, w (mm)	40.00
Length, L (mm)	5.00
75Ωfeedline (λ/4 transformer)	
Width, w (mm)	10.00
Length, L (mm)	50.00

Table4: Dimensions of Microstrip Patch Antenna Array

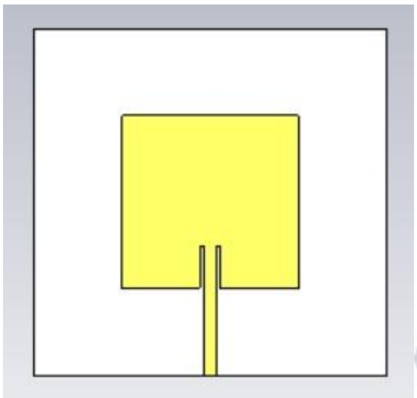

Figure1:1X1

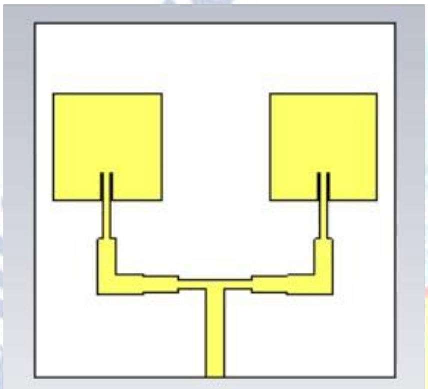

Figure2:1X2

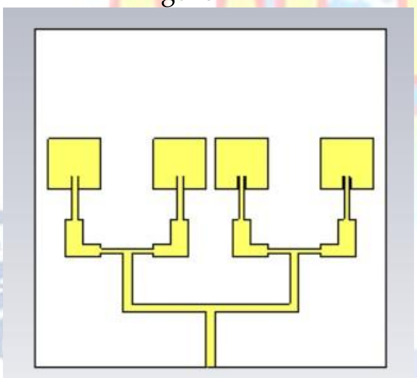

Figure3:1X4

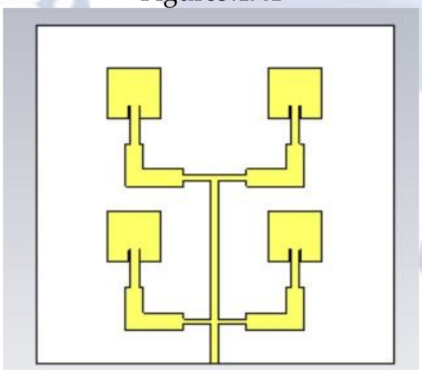

Figure4:2X2

Design Layout of (A) Single patch antenna, (B) Array Antenna 1x2, (C) Layout of Array Antenna 1x4, (D) Layout of Array Antenna 2x2.

Before starting to draw the conductors on the enclosure, the correct size and dimensions should be defined for the enclosure. This can be done by clicking on the Enclosure button. A substrate information option window will appear before the user, as brought in the CST. The desired size on x and y position (length and width) enough for the antenna and feed to be printed on the entered. Cell sizes are the distance of the point to the next point in the layout and it is determined by the value of and divisions. Once again, a refined cell size will give greater accuracy, however, at the expense of simulation resources.

SIMULATION RESULTS AND DISCUSSION

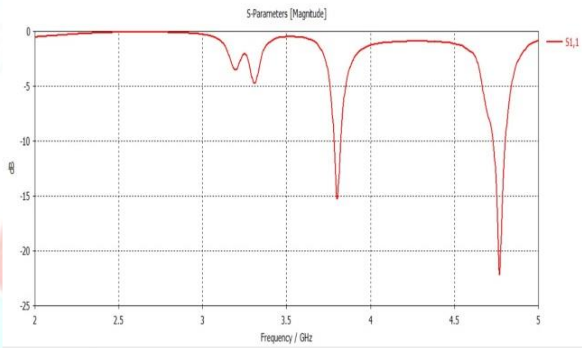

Figure5:1X1_S11 parameter

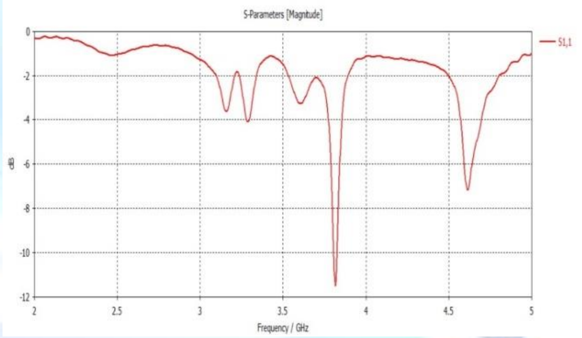

Figure6:1X2_S11 parameter

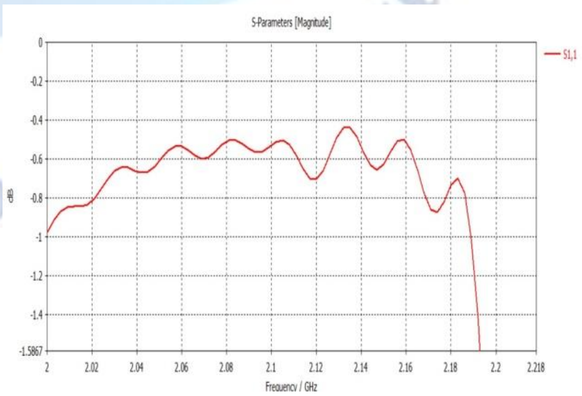

Figure7:1X4_S11 parameter

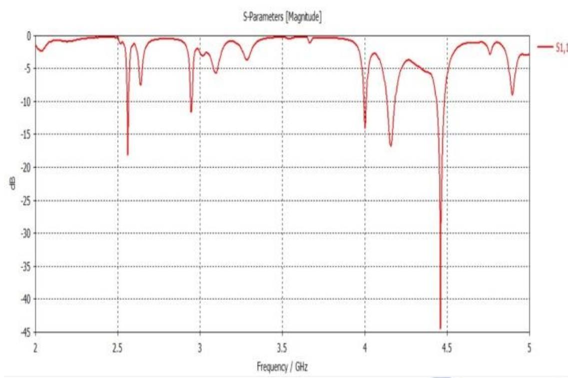

Figure8:2X2_S11 parameter

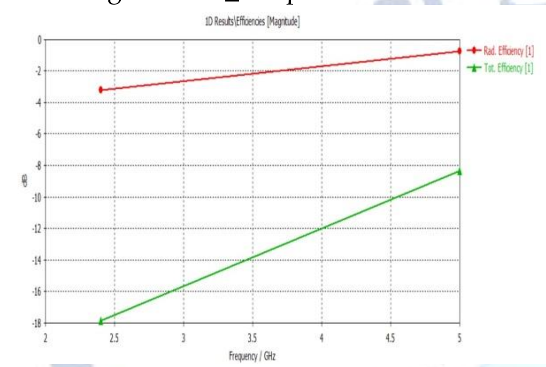

Figure9:1X1_Efficiency

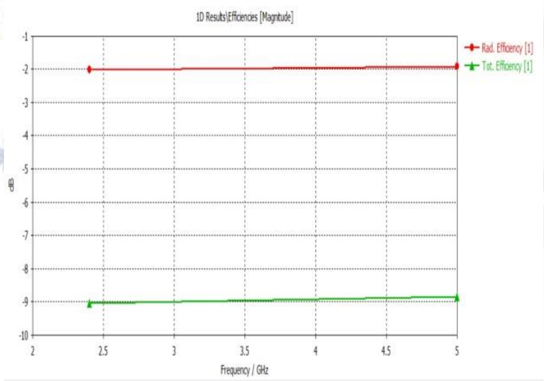

Figure10:1X2_Efficiency

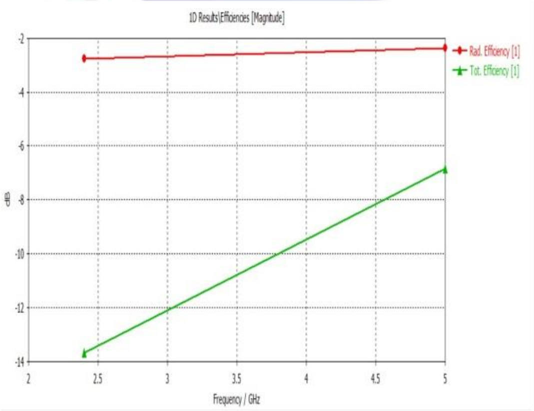

Figure11:1X4_Efficiency

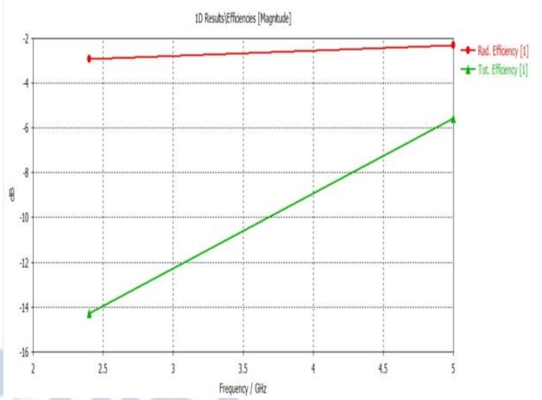

Figure12:2X2_Efficiency

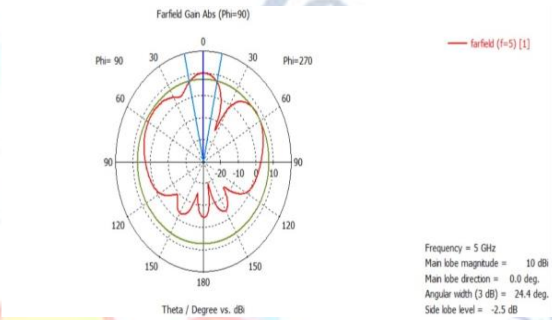

Figure13:1X1_1D_PLOT

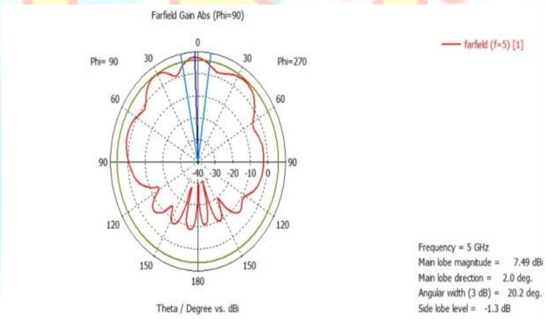

Figure14:1X2_1D_PLOT

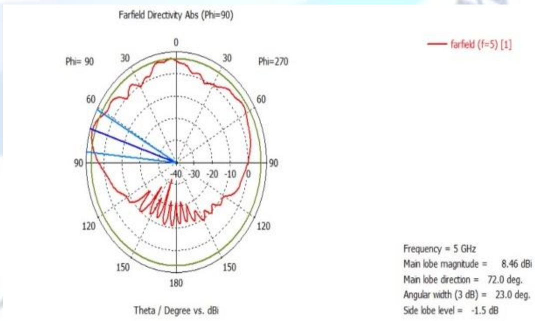

Figure15:1X4_1D_PLOT

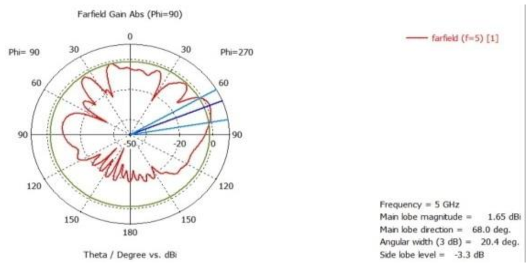

Figure16:2X2_1D_PLOT

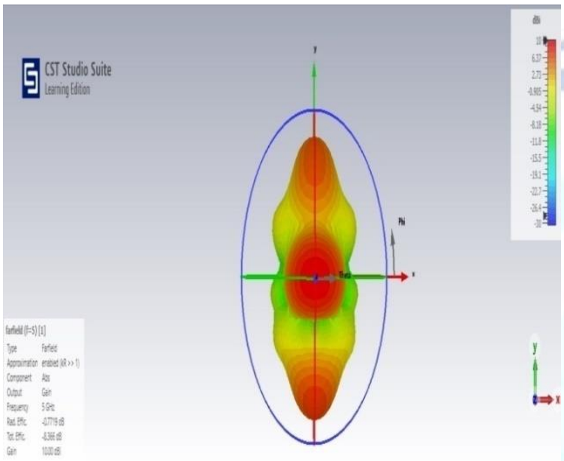

Figure17:1X1_3D_PLOT_RADIATION PATTERN

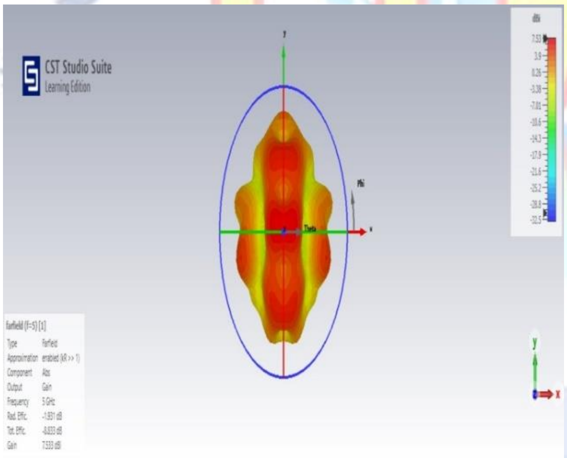

Figure18:1X2_3D_PLOT_RADIATION PATTERN

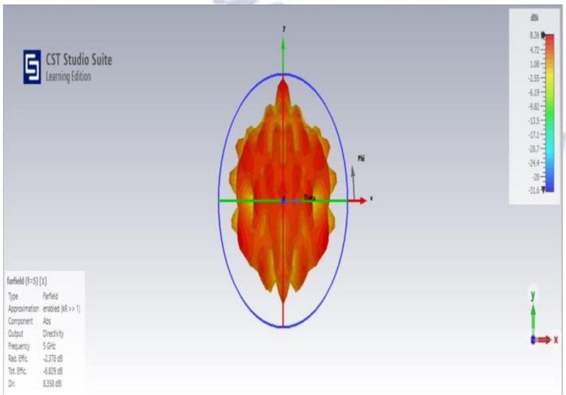

Figure19:1X4_3D_PLOT_RADIATION PATTERN

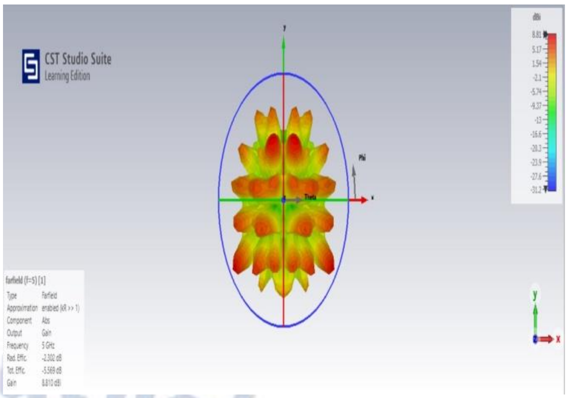

Figure20:2X2_3D_PLOT_RADIATION PATTERN

TABLE I. REFLECTION COEFFICIENT ANALYSES RESULTS:

Element	Gain	Directivity	Radiated Efficiency	Total Efficiency
1X1	10.0dBi	10.78 dBi	-0.772 dB	-8.366 dB
1X2	.533dBi	9.464 dBi	-1.93 dB	-8.833 dB
1X4	5.979dBi	8.358 dBi	-2.378dB	-6.829 dB
2X2	8.810dBi	11.11 dBi	-2.302dB	-5.569 dB

Table 5: REFLECTION COEFFICIENT ANALYSES RESULTS

CONCLUSION

A microstrip patch array antenna of a Square shaped radiating element was successfully designed and simulated using CST-STUDIO SUIT software Rogers RT 5880 substrate. During the simulation we observed that, the array antenna work in the 5GHZ ISM band by having a resonant frequency of 5GHz. Based on the results obtained, it was also observed that the gain and directivity increase with the increase in spacing of the antenna.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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