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FREQUENCY RECONFIGURABLE RECTANGULAR MICROSTRIP PATCH ANTENNA WITH DGS STRUCTURE FOR 5G APPLICATIONS

Mr. J. Navarajan[1], Mr. A. Vijaya ganesh[2], Mr. SP. Alagappan[3], Mr. M. Vineethkumaran[4]

[1,2,3,4]*Panimalar Institute of Technology, Chennai, Tamilnadu.*

ABSTRACT: The 5G cellular networks have a wide spectrum. This paper presents a design of frequency reconfigurable microstrip antenna which operates in sub-6GHz band for 5G applications. The proposed Antenna design will use simple microstrip patch with inset feed and a ground plane with two square concentric ring slots as Defected Ground Structure (DGS) and Rogers RT 5880 as the substrate of antenna. The main aim of the design is to improve the performance of antenna in terms of gain, return loss, radiation and bandwidth at easy to integrate with circuits at 4-6GHz spectrum for 5G WLAN, Wi-Fi and WIMAX applications . The frequency reconfigurability is achieved by placing two BAR63-02V pin diodes at different positions on the ground plane DGS slots. The operating frequency band of antenna is controlled by varying switch state of pin diodes to modify the surface current paths between the slots. The antenna is designed and simulated in Computer Simulation Technology (CST) studio suite.

Keywords : Microstrip Antenna, Inset Feed, DGS, Pin Diodes, CST.

INTRODUCTION:

In Future 5G wireless technology, more and more users getting their devices connected to the network causing much enormous need for faster data speed and larger bandwidth capacity in the network. The most important requirement of an antenna is to provide low profile with good compatability and flexibility. 5G Technology is the next generation wireless technology for mobile communication. 5G technology is a packet switched wireless system with a wide area coverage of network and high throughput. 5G will use frequency spectrum in existing LTE range (600MHz to 6GHz) as sub-6GHz band and (24 to 86GHz) as millimeter wave band. 5G speed in sub-6GHz band is similar to 4G network.The most preferred and extensively used antenna for wireless technology are Microstrip antennas because of easy to integrate with circuits. Performance of microstrip antenna improves with thickness and low dielectric of the substrate.

Microstrip antenna provides low impedance bandwidth for thin substrate. Thus the substrate of proposed antenna is designed with Rogers RT 5880 sustrate with dielectric constant of εr=2.2 at thickness of 0.789mm. The dimensions of the proposed antenna is 60mm x 50mm x 0.789mm with input characteristic impedance of 50 Ω . RF Pin diodes are used in slots which acts as switch to reconfigure the antenna for multiple frequency bands. In the upcoming sections, we will discuss about design, measurements, results, conclusion and references as follows.

ANTENNA DESIGN AND STRUCTURE :

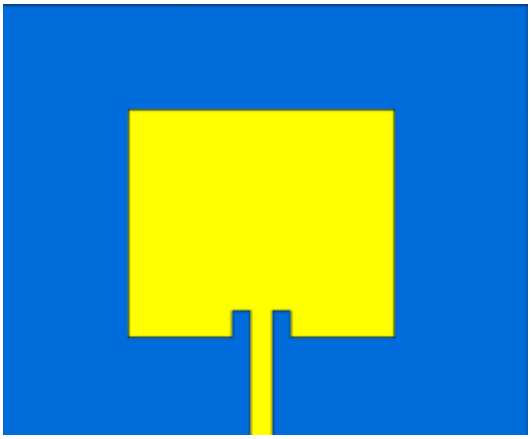
The proposed microstrip antenna is designed using CST studio suite. A substrate with low dielectric constant is choosen for the design. Microstrip antenna consists of three layers as the top radiating patch made of copper with thickness of 0.035mm, middle layer made of Rogers RT 5880 substrate with dielectric constant εr = 2.2, loss tangent (δ) = 0.009 and thickness of substrate h = 0.789 mm is designed, the bottom layer is copper with thickness of 0.035mm. In this paper, an Inset Feed Patch Antenna is designed for sub-6GHz band 5G applications. The Defected Ground Structure (DGS) technique is used for size reduction and to improve the overall performance of the patch antenna. DGS has been used in patch antennas for bandwidth and gain enhancement, harmonic suppression, reduction of cross polarization. For the proposed antenna square rings slots are etched out from the ground plane and RF-switches are incorporated to change the current distribution beneath the patch to reconfigure the operating frequency.

The length, width and thickness of the Rectangular microstrip patch and the DGS slots on the ground plane are designed for the proposed antenna.

Table I: Design parameters and values

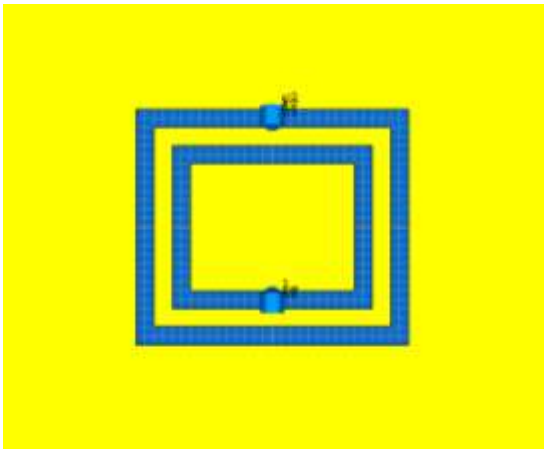
S.No	Parameters	Values (mm)
1.	Patch Width (Wp)	30
2.	Patch Length(Lp)	26
3.	Patch Thickness(Tp)	0.035
4.	Substrate Width(W)	60
5.	Substrate Length(L)	50
6.	Substrate Height(T)	0.789
7.	Feed Width(Wf)	2.5
8.	Feed Length(Lf)	15
9.	Inset Gap(Gi)	2
10.	Inset Length(Li)	3
11.	Slot Width(Ws)	2

Figure 1 : Front view of proposed antenna



The radiating patch of proposed antenna is designed with the parameters and values in millimeters on the top surface of substrate with provided dimensions in Table 1. The inset feed for the antenna is provided with a width of 2.5 mm to achieve the input characteristic impedance of Z0 = 50 ohms for perfect impedance matching at the feed point is shown in figure 1.

Figure 2: Back view of proposed antenna



The proposed antenna is designed by cutting two slots in ground to make it a slotted antenna. Cutting of slots in antenna ground increases the current path which increases the current intensity, as a result efficiency is increased. In Figure 2, the back view of the proposed antenna with two DGS slots of width 2mm loaded with two BAR63-02V pin diodes at different positions is shown.

The Infenion BAR63-02V pin diode is choosen for this antenna because of its suitable isolation value. The pin diodes are placed on the slots by means of lumped elements option in CST.

The datasheet for the selected diode as provided by the manufacturer gives these values as in ON state, L = 0.6 nH, Rs = 1.2 ohm; In OFF state, L=0.6 nH, Rp=15 Kohm, Cp=0.3 pF. The pin diode ON/OFF state is modified by changing the values of series resistance (Rs) and parallel capacitance (Cp) , resistance (Rp) in ON and OFF states respectively in RLC lumped circuits. The DC blocking capacitor C = 100 pF is used in the RLC lumped circuit to provide biasing to the pin diodes.

Equivalent circuit of pin diode:

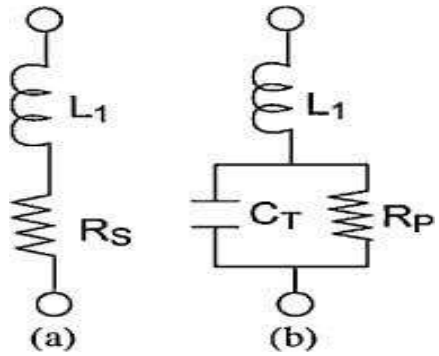


Figure (a): ON state,

Figure (b) :OFF state.

SIMULATED RESULTS:

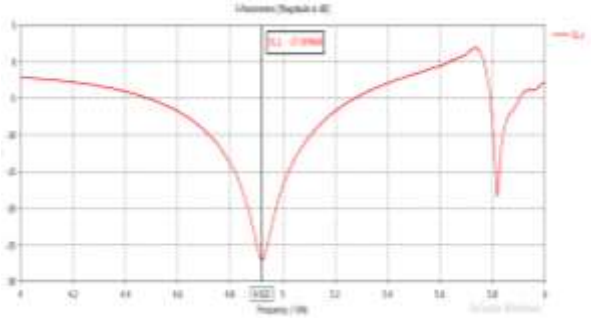
The designed antenna is simulated in the CST studio suite to analyse the S11 parameter, gain, VSWR, Characteristic impedance, and Radiation pattern of the proposed antenna. The frequency reconfigurability is analysed for different states of the pin diodes D1 and D2 in the RLC lumped circuits.

The pin diodes are switched to different switching modes as M1, M2 ,M3, M4 for different ON/OFF states which is shown in Table 2.

Table 2: Various Modes of PIN Diodes

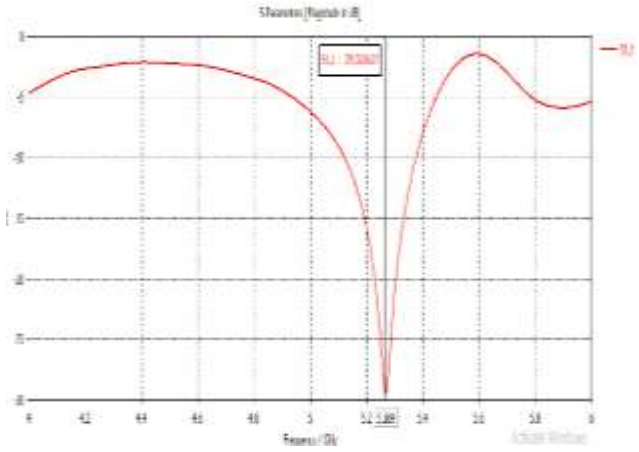
Modes	Diode (D1)	Diode (D2)
M1	OFF	OFF
M2	ON	OFF
M3	OFF	ON
M4	ON	ON

Figure 3 : Mode M1; D1 - OFF;D2 – OFF;



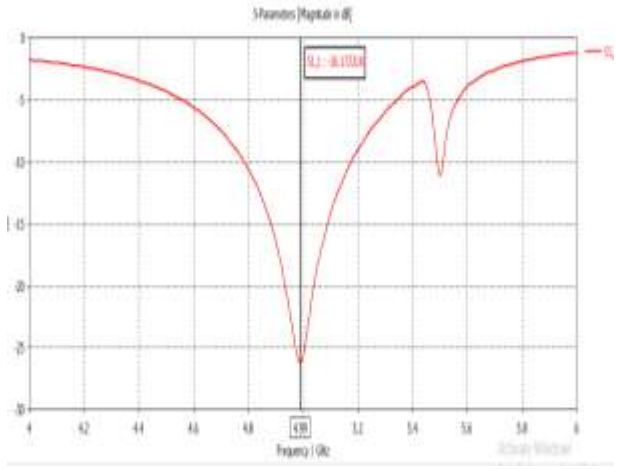
When both diodes D1 and D2 are in OFF state, which provides a frequency range of 4.72 – 5.1 GHz and 5.8 – 5.83 GHz,with return loss of -27.01dB and -18.33 dB respectively.

Figure 4 : Mode M2; D1 – ON;D2 – OFF;



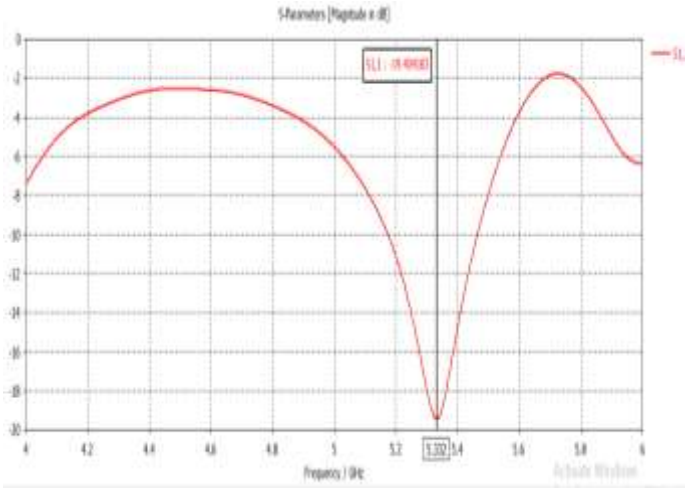
When diodes D1 in ON state and D2 in OFF state, which provides a frequency range of 5.12 – 5.37 GHz, with return loss of -29.50 dB.

Figure 5 : Mode M3; D1 – OFF; D2 – ON;



When diodes D1 in OFF state and D2 in ON state, which provides a frequency range of 4.78 – 5.17 GHz, with return loss of -26.17 dB.

Figure 6: Mode M4; D1 – ON; D2 – ON;



When both diodes D! and D2 are in ON state, which provides a frequency range of 5.17 – 5.46 GHz, with return loss of -19.40 dB.

The propsed antenna design an operating frequency reconfigurability between 4.72 – 5.83 GHz with maximum retun loss of -30dB and gain of 3.7 – 6.8 dB is obtained in CST simulation results.

Figure 7 : 3D view of Radiation Pattern

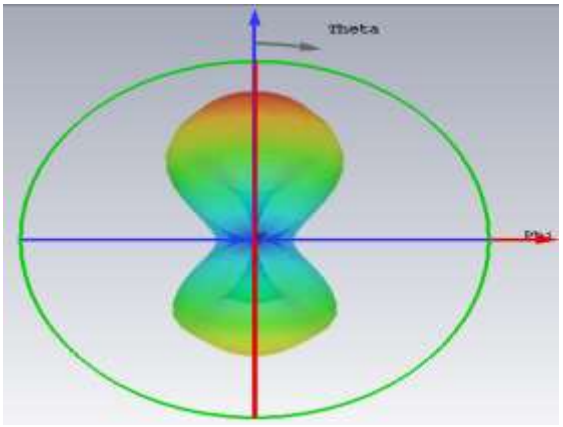


Table 3 : Frequency, return loss and gain of proposed antenna

Modes	Freq (GHz)	S11 (dB)	Gain (dB)
M1	4.92 / 5.81	-27.01 / -18.33	4.277 / 3.711
M2	5.26	-29.50	5.035
M3	5	-26.17	4.225
M4	5.33	-19.40	4.325

CONCLUSION:

In this paper, a rectangular microstrip patch antenna has been proposed for a 5G wireless communication at sub-6 GHz band. The antenna resonates at 4-6GHz frequency and provides a gain of 3-7 dB. The antenna produce an improved impedance bandwidth of about 500MHz and an characteristic impedance Z0 of 50 ohms which can be used for the future 5G WLAN and WIMAX applications.

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