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# A Pine Shaped Dual-Band Frequency Reconfigurable Antenna

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***Authors' contributions***

*This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.*

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## ABSTRACT

In recent years reconfigurable antennas have attracted a lot of attention in modern wireless communication systems. In satellite communication and ECM system, there has always been a continuous demand for smaller size, lighter weight antenna system that has properties to accomplish selectivity in frequency, bandwidth, polarization and gain. A frequency reconfigurable antenna is proposed for wireless communication. We can achieve Frequency reconfiguration by modifying physical or electrical dimensions of the antenna using RF-switches, impedance loading or tunable material. The design and simulation of the proposed antennas are done using ANSYS high-frequency structure simulator (HFSS) version-19. The proposed antenna is taken as a triangular shape whose length and width are 50mm and 25mm respectively. Here reconfigurability is achieved by RF switches placed in the radiator. The antenna analysis is done by taking different conditions of the switch. Total four switching condition is simulated and for each case, distinctive resonating frequencies are accomplished with acceptable reflection coefficient. The frequency bands of the antenna are varied from 2.12 GHz to 5.27 GHz. This antenna covers S-band and C band. After simulating the design the gain and efficiency of the antenna are verified successfully. Antenna fabrication and measurement of different parameters will be done in future. A comparison of the measured result will be analyzed with some existing antenna outcomes.

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*Keywords: Frequency reconfigurable antenna; dual-band; PIN diode switch; wireless communication.*

## 1. INTRODUCTION

In modern day wireless devices various antennas are required to ensure that it can be used for numerous correspondence benefits, this make the system cumbersome as well as additional. In frequency reconfigurable antenna a solitary antenna can supplant them making system low profile and handheld devices all the light weight and vitality proficient [1]. Joining wideband and narrowband usefulness makes the antenna progressively valuable in multimode activity and reduces size and expands flexibility of operations for clients [2-5]. This paper presents an antenna with a switchable operating band. The desired adaptability is achieved by changing configuration through PIN diode. Quick switching speed, low operating voltage and edge of integration are the factors which make it increasingly appropriate. PIN diodes are utilized to tune the frequency of the antenna array. To eliminate the need for multiple antennas, reconfigurable antenna is implemented [6-10]. This is the main inspiration for the current work on this point. There are a few explanations behind utilize this sort of antenna, high information rate, low development cost, and low power consumption.

For the present quickly creating mobile communication devices. There are same requirement for minimal antenna. Micro strip antenna is utilized in a huge extent of employment from business correspondence framework to RADAR and also biomedical application contributes significantly to the basics of fundamental of patch antenna addressed in this section of the thesis.

An antenna which has an ability to change its tendency of qualities as per the status of encompassing is named as reconfigurable antenna. It is generally utilized in multiband system because of its proficient re allocation of the dynamic range. Reconfigurable antenna replaces the numerous reception apparatuses to single antenna by which lessens the number and size of the antenna contrasted with conventional antenna system.

The proposed reconfigurable antenna in the thesis work uses PIN diodes as switching elements for the shorting strips. The antenna is fabricated on FR4 substrate having 1.6mm thickness and a dielectric constant of 4.4. Two PIN diodes (BAR 64-02) are placed at the strips. Each of the diodes contains two inductors 0.45nH.

The lumped elements used in the proposed work are selected based on the information provided by the manufacturers in their respective datasheets, as the value of the resistor is taken as 1.5ohm for the “ON” condition and 2.5Kohm for the “OFF” condition. The value of the capacitor is 0.25pF for the OFF case. The PIN diodes used in this work are from NXP Semiconductors (BAR 64-02). The design parameters values are shown in Table 1.

The shape of the patch is taken as triangular as it reduces the size for which the fabrication cost will be less. Three triangles are taken and PIN diodes are inserted between the two strips. PIN diodes are utilized in this design by changing the state of the switches. This design proposes a frequency reconfigurable antenna (FRA) that operates across a 7GHz frequency band. The design is then simulated using HFSS software and all the performance parameters extracted from the software are then discussed and analyzed in detail in the section-II & III. Here the design of FRA is discussed in detail.

**Table 1. Design parameters of FRA**

| Parameter Name | Designed Value | Parameter Name | Designed Value |
|---|---|---|---|
| L | 50mm | F1 | 4mm |
| W | 25mm | F2 | 4mm |
| WF1 | 2mm | F3 | 4mm |
| WF2 | 22mm | F4 | 2mm |
| WF3 | 20mm | D1,D2 | 2mm |
| WF4 | 18mm | H | 1.6mm |

## 2. ANTENNA DESIGN

The frequency reconfigurable antenna is planned to utilize a micro strip patch antenna having two P-I-N diodes to shift the resonating frequency and bandwidth.

To design a FRA in HFSS the first step is to draw a substrate and the length and width are taken as per table 1, after that the ground plane is designed whose values are mentioned in the above table 4.2.1. In the next step we have drawn a patch and a feed line of a given diameter given in the table, and then two PIN diodes D1 and D2 are placed between the strips of the patch. By changing the axis, we can draw the port of the antenna where we can assign the port as a lumped port and give the impedance value 50ohm.

One more box is drawn for assigning the radiation to the antenna. Finally, the ground plane and patch are assigned as perfect-E, and two diodes are assigned as lumped RLC.

First, the values were assigned to the parameters by using design property under HFSS. Then patch with feed line, substrate, ground and radiation box was designed. After that, excitation was given to the lumped port. Patch and ground were assigned as perfect E. And radiation Box was assigned as radiation of infinite sphere. Then, the design was analyzed. After successful analysis, reports of output parameters were created. The values of return loss $S_{11}$ , VSWR, Bandwidth and Gain were measured and calculated.

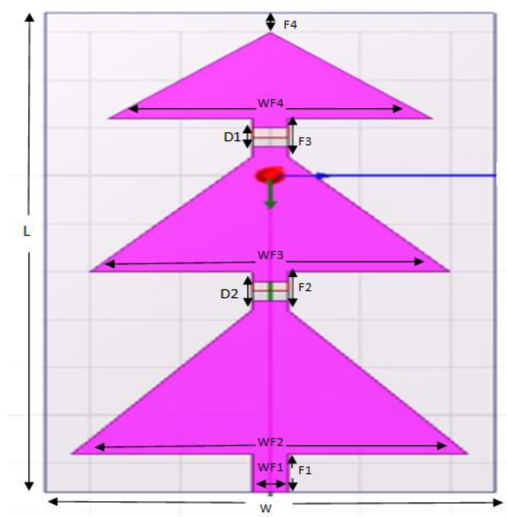


**Fig. 1. Schematic design of antenna using PIN diode**

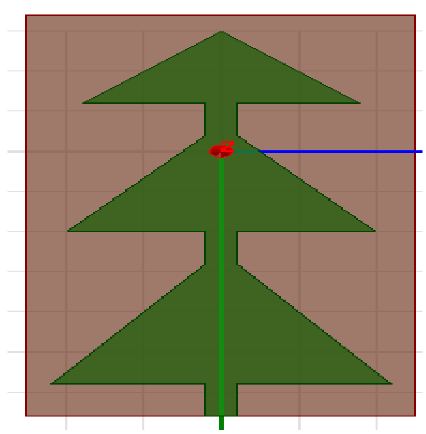

**Fig. 2. Schematic design of antennawithout using PIN diode**

## 3. SIMULATION RESULTS

The simulations were performed using HFSS. It provides the complete technology for High-Frequency 3D EM field simulation. In this section the FRA is simulated and return loss, Z parameter, bandwidth, radiation pattern and gain are measured which is shown in the performance parameter section in Table 2.

**Without using PIN diode**

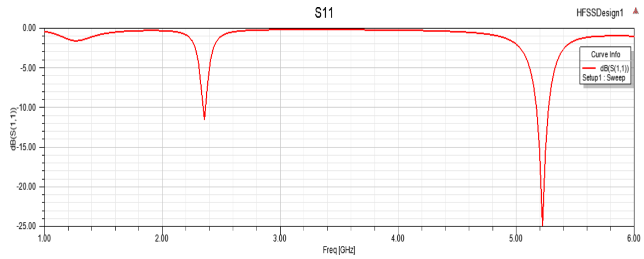


**Fig. 3. (a) Return loss parameter $S_{11}$without using PIN diode**

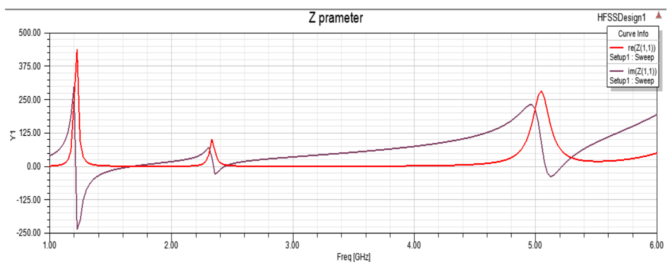


**Fig. 3. (b) Z-parameter without using PIN diode**

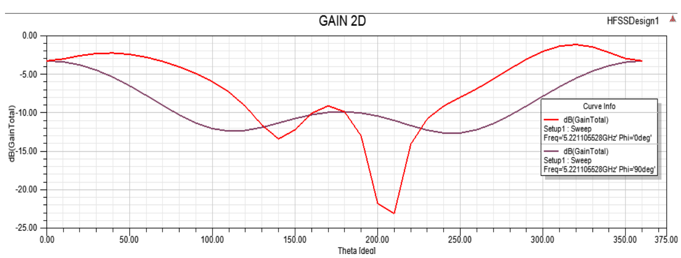


**Fig. 3. (c) Gain 2D without using PIN diode**

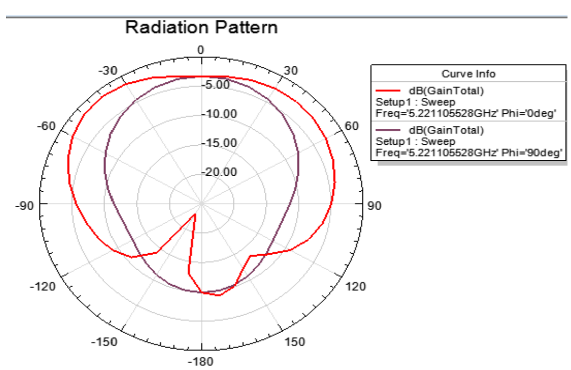


**Fig. 3. (d) Radiation pattern without using PIN diode**

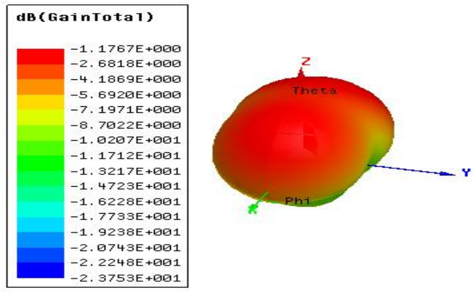


**Fig. 4. 3-D polar plot without using PIN diode**

**For D1 and D2 ON state**

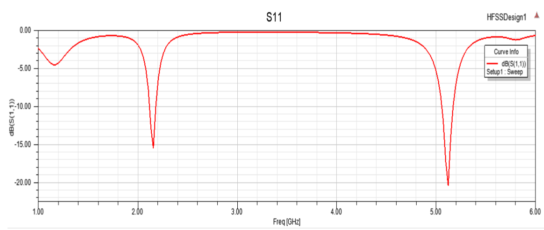


**Fig. 5. Return loss parameter $S_{11}$ for D1, D2 in ON state**

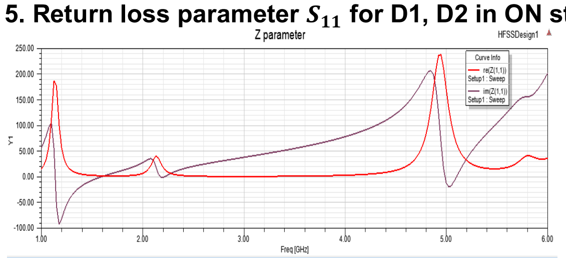


**Fig. 6. Z-parameter for D1, D2 in ON state**

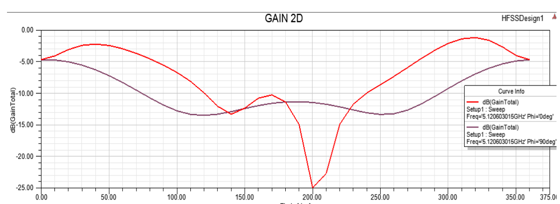


**Fig. 7. 2D gain for D1, D2 in ON state**

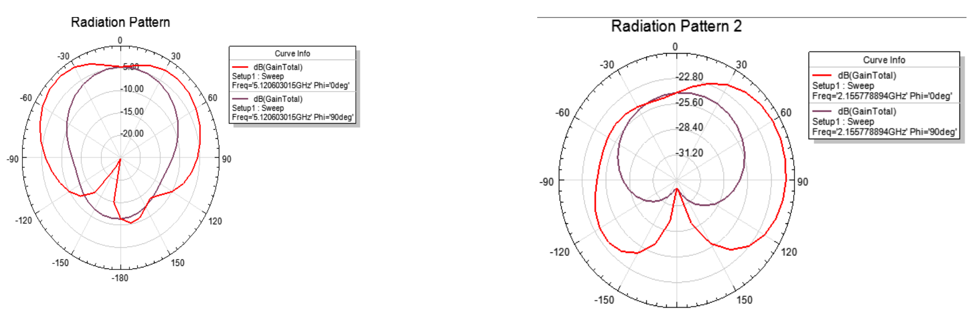


**Fig. 8. Radiation pattern for D1, D2 in ON state**

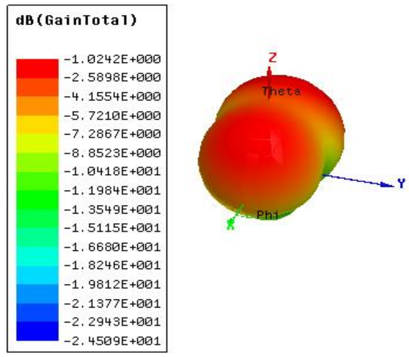


**Fig. 9. 3-D polar plot for D1, D2 in ON state**

**For D1 “ON”andD2 “OFF” state**

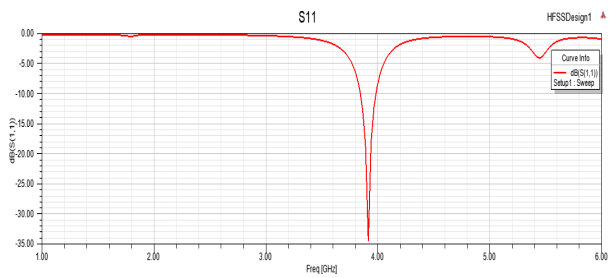


**Fig. 10. Return loss parameter $S_{11}$ for D1 “ON” and D2 “OFF”**

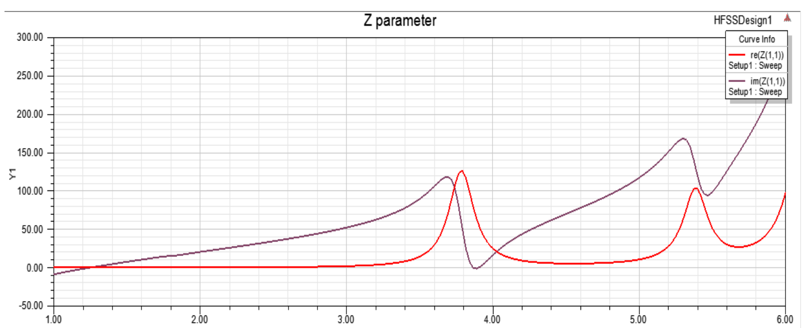


**Fig. 11. Z-parameter for D1 “ON” and D2 “OFF”**

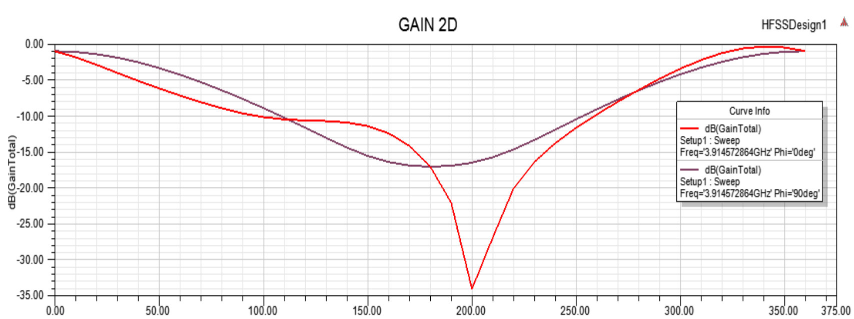


**Fig. 12. 2D Gain for D1 “ON” and D2 “OFF”**

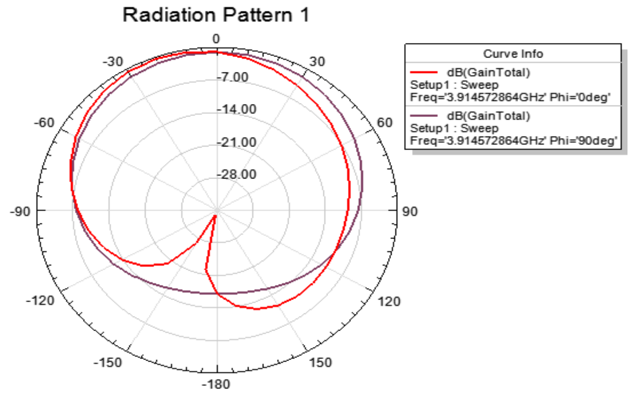


**Fig. 13. Radiation pattern for D1 "ON" and D2 "OFF"**

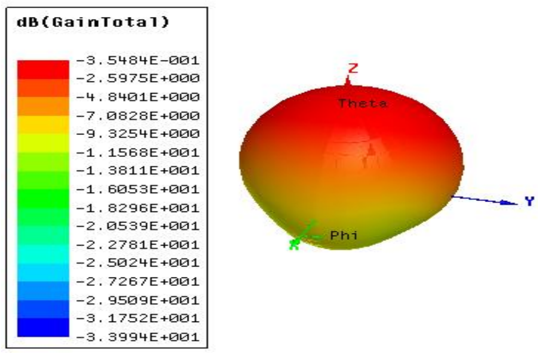


**Fig. 14. 3-D polar plot for D1 "ON" and D2 "OFF"**

**For D1 "OFF" and D2 "ON" state**

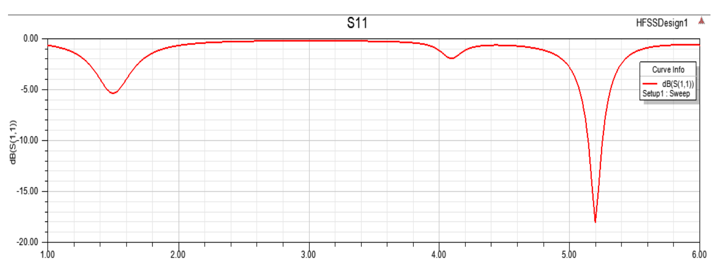


**Fig. 15. Return loss parameter $S_{11}$ for D1 "OFF" and D2 "ON"**

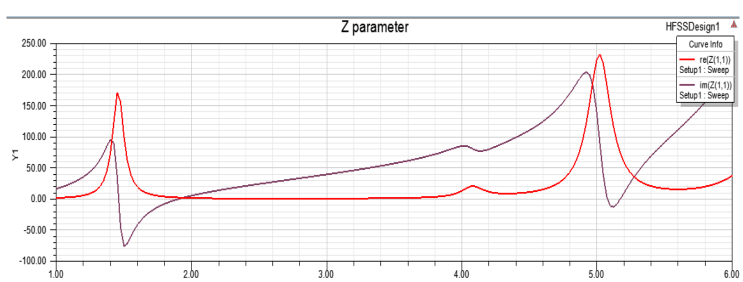


**Fig. 16. Z-parameter for D1 "OFF" and D2 "ON"**

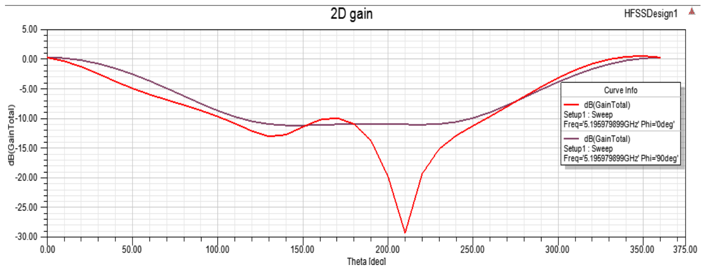


**Fig. 17. 2D gain for D1 "OFF" and D2 "ON"**

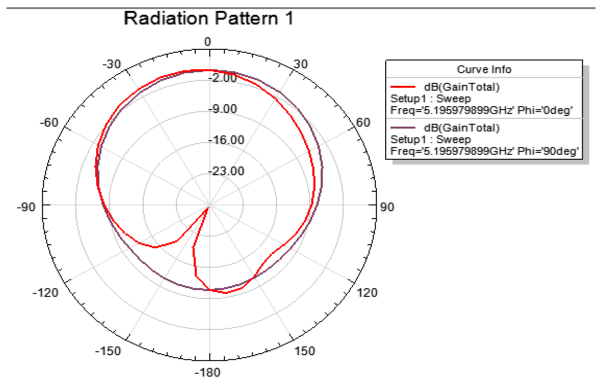


**Fig. 18. Radiation pattern for D1 "OFF" and D2 "ON"**

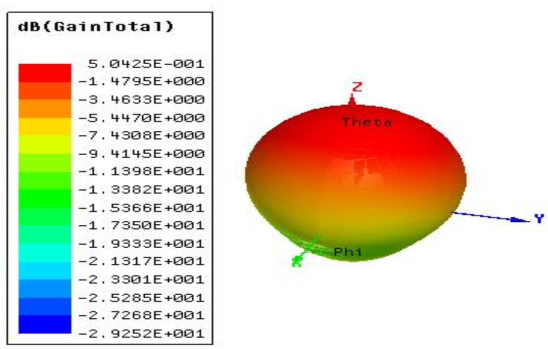


**Fig. 19. 3-D polar plot for D1 "OFF" and D2 "ON"**

**For OFF-OFF state**

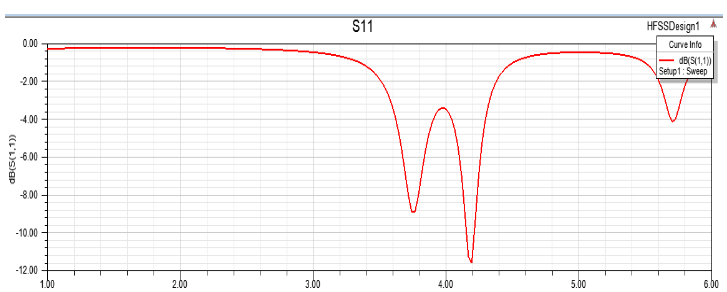


**Fig. 20. Return loss parameter $S_{11}$ for D1, D2 in OFF state**

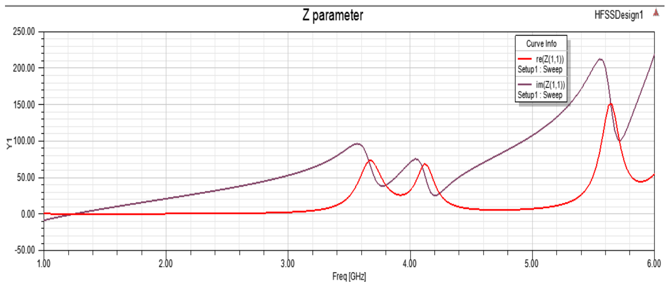


**Fig. 21. Z-parameter for D1, D2 in OFF state**

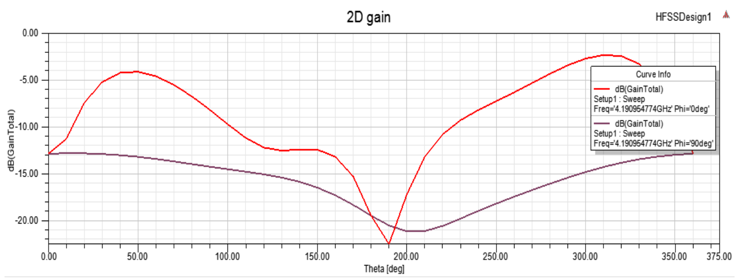


**Fig. 22. 2D Gain for D1, D2 in OFF state**

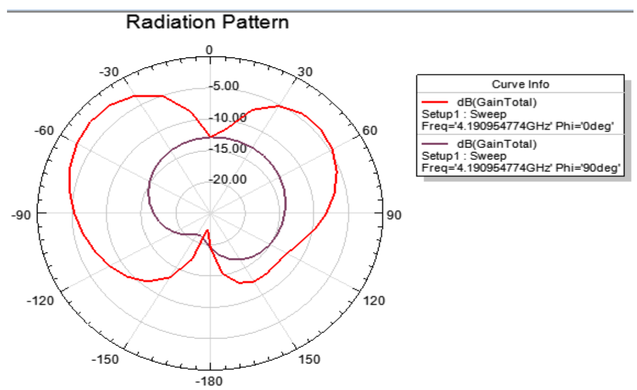


**Fig. 23. Radiation pattern for D1, D2 in OFF state**

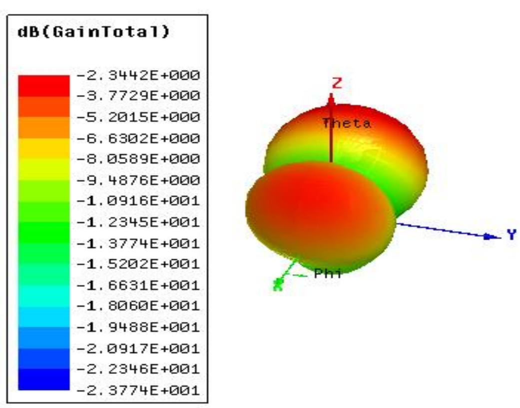


**Fig. 24. 3-D polar plot for D1, D2 in OFF state**

**Table 2. Performance parameters of FRA**

| Case | Frequency (in GHz) | S11 (in dB) | Bandwidth (in GHz) | Z parameter (in Ω) | Peak to Peak Gain (in dBi) |
|---|---|---|---|---|---|
| WITHOUT PIN DIODE | 5.22 | -24.90 | 5.17-5.27 | 55.20-3.21j | E Plane 21.88dBi<br>H Plane 9.34dBi |
| ON-ON | 2.15<br>5.12 | -15.50<br>-20.38 | 2.12-2.18<br>5.06-5.17 | 36.77-6.29j<br>54.13-8.98j | E Plane 23.70dBi<br>H Plane 8.79dBi |
| ON-OFF | 3.91 | -34.47 | 3.84-3.98 | 52.47-1.43j | E Plane 33.63dBi<br>H Plane 16.02dBi |
| OFF-ON | 5.19 | -18.06 | 5.14-5.25 | 63.16-7.42j | E Plane 29.75dBi<br>H Plane 11.42dBi |
| OFF -OFF | 4.19 | -11.60 | 4.15-4.21 | 45.84-25.72j | E Plane 20.13dBi<br>H Plane 8.31dBi |

After designing FRA at 7 GHz the simulated results are analyzed in terms of reflection coefficient characteristics (S11), VSWR, impedance characteristics (Z11) and 3-D polar plot. The performance table represents all the values of performance parameters for compact FRA. The results are stable for the implementation of the antenna. The impedance curve with the real part is found to be near 50Ω impedance and the imaginary part is found to be near 0 Ω reactance. The antenna design and analysis are presented with simulation and supporting test outcomes. These design concepts are acknowledged with basic electronic control methods. This part gives a careful review of the functional mechanism, advantages, application and limitation of the proposed FRA. To achieve frequency reconfigurabilty PIN diode is used. The simulation is performed using HFSS. The simulated results of $S_{11}$ parameters are found in good agreement.

## 4. CONCLUSIONS

In this paper pin diode is utilized as switches. For reconfigurability, PIN diodes are used between the patch. So that, the radiation pattern would not be distorted while changing the state of switches by fluctuating the physical length and electrical length of the patch utilizing distinctive switching condition, different resonant frequencies accomplished without changing the size of the antenna. Total four switching condition is simulated and for each case, distinctive resonating frequencies are accomplished with acceptable reflection coefficient. The frequency bands of the antenna are varied from 2.12 GHz to 5.27 GHz. This antenna covers S-band and C band. This work describes the frequency reconfigurable antenna and its application for satellite and RADAR communication. The simulated result gives a good radiation pattern, gain and efficiency are also very good for practical applications.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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