Design and Development of Frequency Reconfigurable Multi Band Slotted Antenna for Wireless Applications

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DESIGN AND DEVELOPMENT OF FREQUENCY RECONFIGURABLE MULTI BAND SLOTTED ANTENNA FOR WIRELESS APPLICATIONS

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Abstract: This pioneering work suggests a multi-band antenna that can be reconfigured for applications. In the wireless network the miniaturisation and multi-band feature of the mounted antenna is done by insertion of rectangular holes, and the reconfiguration of the frequency is achieved by utilizing a PIN diode switch. The ON and OFF condition of the PIN diode determines the surface current distribution of the radiant patch leading to multiband resonance and reconfiguration of the proposed device. Application and analysis depend on parameters of the antenna such as lack of return loss, VSWR, gain, and radiation pattern. The developed antenna is used for the intended application of wireless communication. Simulation is performed using Ansys HFSS.

Keywords: MSPA, slot, PIN diodes, Wireless communication, and Reconfigurable antenna.

INTRODUCTION

MICROSTRIP PATCH ANTENNA (MPA) has been very popular due to their many advantages, such as low pro-file and cost, light weight, and small size [1]. However, the MPA suffers from the narrow impedance BW as well as the sensitive fabrication errors. A proximity coupled U-slot MPA with an impedance BW of 20% and a 7.5-dBi gain was presented in [2], which is fed by a -shaped stub. Recently, a double- stub proximity feed U-slot MPA was reported [3], which shows an impedance BW of 26% and tolerance to lateral displacement of the feed, however, it shows a lower gain of 6 dBi and small dips on the radiation patterns of H plane. Moreover, the MPAs in the two papers occupy a relatively large space due to the large feed stubs extending out of the patch, which causes a requirement of a large element spacing to form a two-dimension array, consequently undesirable grating lobes [4]. Another U-slot MPA with a proximity coupled double -shaped feed line was given for arrays [5], and the single element presents a 21% BW and a 9-dBi gain.

Frequency reconfigurability in antennas is beneficial for diverse applications, as it reduces the bandwidth requirement of spread spectrum signals. Frequency reconfigurability antennas include their miniaturized size, low cost and use for a variety of applications resulting in their integration into most modern wireless.

CONVENTIONAL ANTENNA DESIGN AND STRUCTURE

In this section the traditional MSPA diagram is seen in figure.1. A typical micro strip patch antenna modelling substrate FR-4 epoxy and permittivity (πr=4.4), the height of the substrate is 3.6 mm. The area length and thickness:70mmx70 mm. The definition square patch antenna diameter and length are equal to 27.9mmx38mm. The feeding procedure used as a quarter wave equivalent to 50 impedances. The thickness and length of the quarter wave feed line 33mm and 2.8mm. Traditional return loss as shown in figure.2 and traditional radiation pattern as shown in figure.3.

Elemental width (W):
The width of the RRMSA is given by
$W= (c/2 f_r) [(\varepsilon_r+1)/2)]-1/2$
Extension length (Δl):
The extension length (Δl) is given by
$\Delta l=0.412h[(\varepsilon r+0.3)$ $((w/h)$ $+0.264)/\varepsilon e0.258)$ $((w/h)$ $+0.8)]$.
Where ε_e is effective constant, which is calculated using the formula
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Where εe is effective constant, which is calculated using the formula
$\varepsilon_e= [(\varepsilon_r+1)/2] +[(\varepsilon_r-1)/2] [1+12h/w]-1/2$
The Elemental length (L):
Once the elemental width (w), extension length(Δl), the effective dielectric constant (ε_e) is determined using the above equations then the elemental length is found by using the formula:
$L=c/2 fr\surd \varepsilon_e-2\Delta l$.

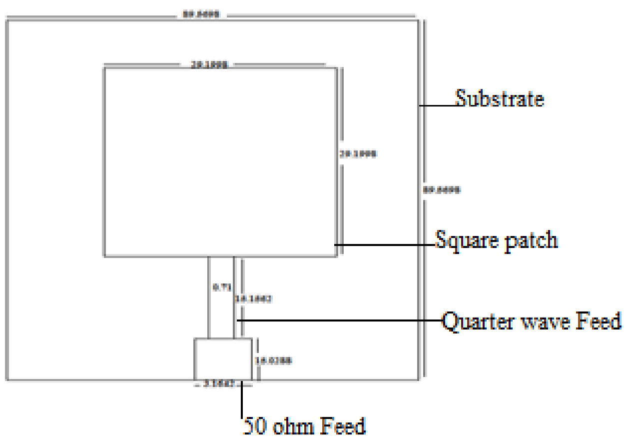

Figure 1Microstrip patch antenna

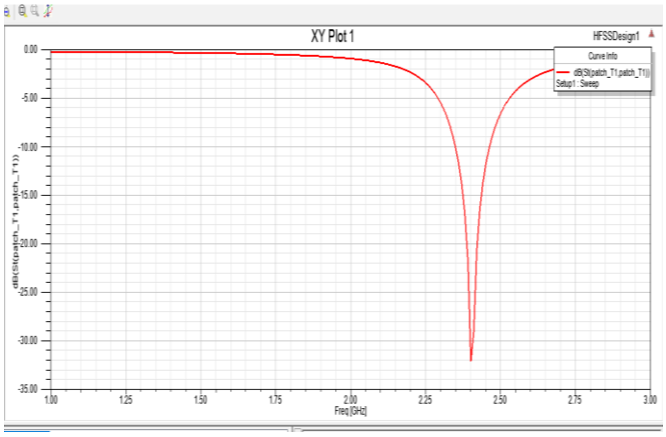

Figure 2 Return loss for 2.4 GHz

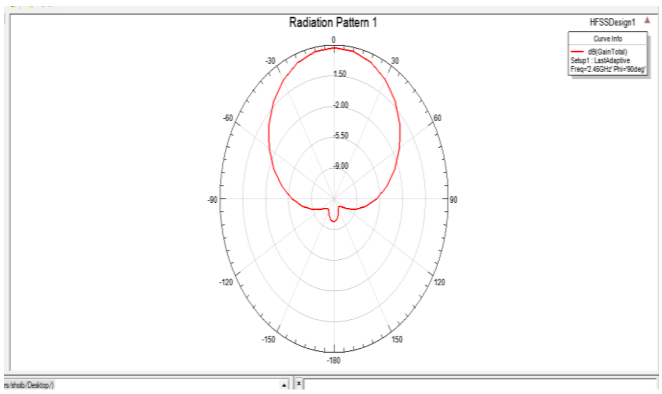

Figure 3 Radiation Pattern 2.4 GHz

MODIFIED SLOT ANTENNA

In this segment, the standard micro strip patch configuration has been modified by incorporating slot MSP antenna as shown in fig. 4. A modified slot MSP antenna modelling the FR-4 epoxy substrate and permittivity (εr=4.4), the substrate height is 3.6mm. The length and width of the ground 21mmx70mm.The design square patch antenna length and width equal to 27.9mmx38mm. The feeding technique used as a quarter wave 50Ω impedance matching. The quarter wave feed line length and width 33mm and 2.8mm. The modified slot MSPA return loss as shown in figure.5 and radiation pattern as shown figure.6.

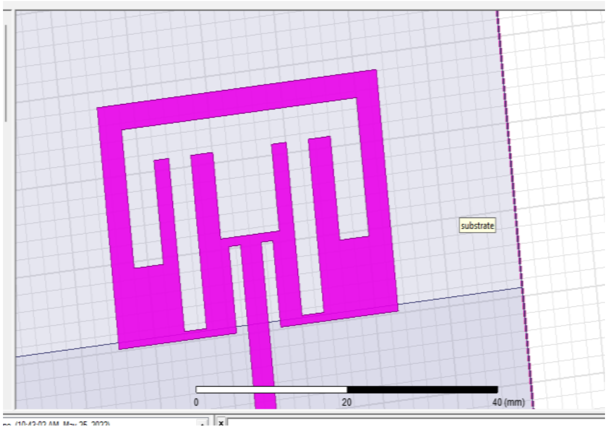

Figure 4 Modified Using Slot

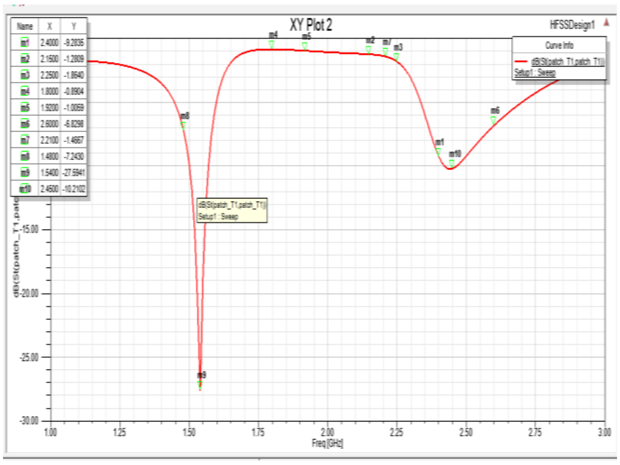

Figure 5 Modified Using Slot Antenna Return Loss 1.54 GHz and 2.45 GHz

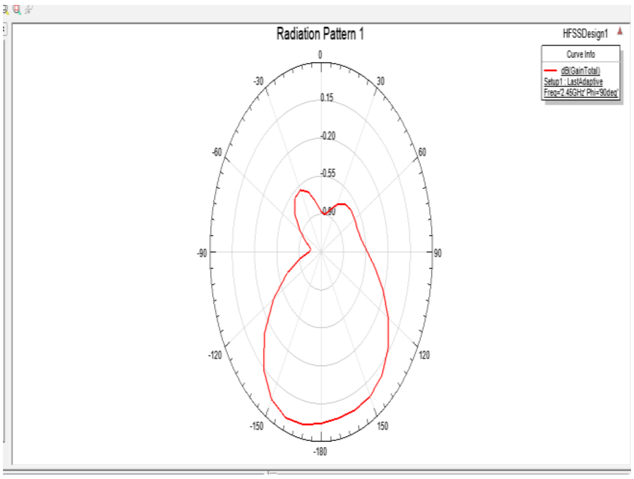

Figure 6 Modified Using Slot Radiation Pattern

PROPOSED RECONFIGURABLE ANTENNA

Configuration of the reconfigurable antenna with slot frequency is shown in figure 7. The antenna consists of a square patch with two slots and a PIN diode across the slot and the T shaped patch. The micro strip patch antenna is fabricated on a FR-4 epoxy substrates with a thickness of 3.6mm and relativity permittivity of 4.4mm. The patch has a dimension of (WxL) 27. 9mmx38mm.The quarter wave feed line has length and width 33mmx2.8mm. The proposed antenna return loss when two diodes are on as shown in figure.8, the radiation pattern two diodes are on as shown in figure.9. With the assistance of the modelling program Ansoft HFSS.

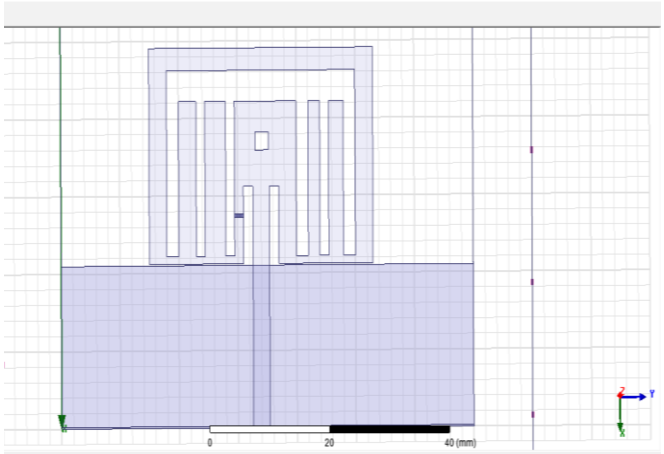

Figure 7 Proposed Reconfigurable Antenna

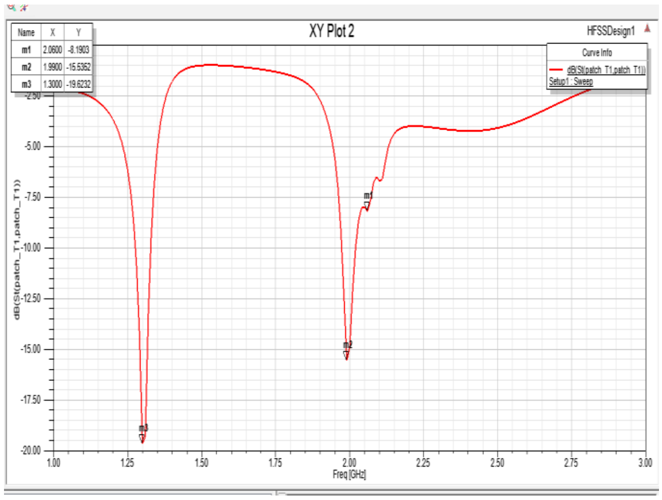

Figure 8 Proposed Reconfigurable Antenna Return Loss at 1.3 GHz and 1.99 GHz (Diode is On)

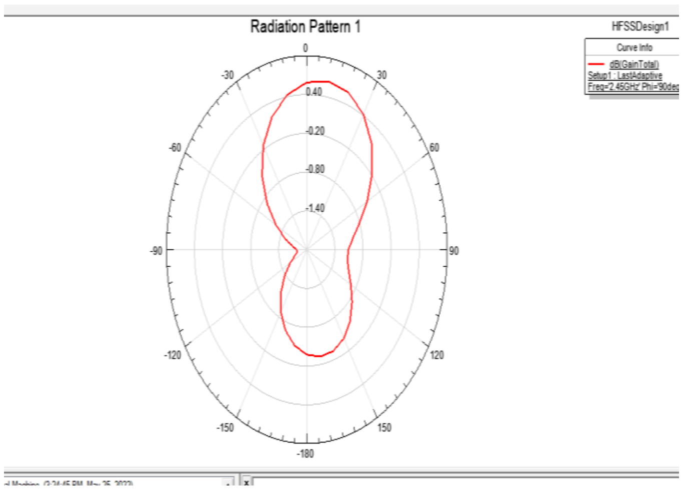

Figure 9 Proposed Reconfigurable Antenna Radiation Pattern (Diode is On)

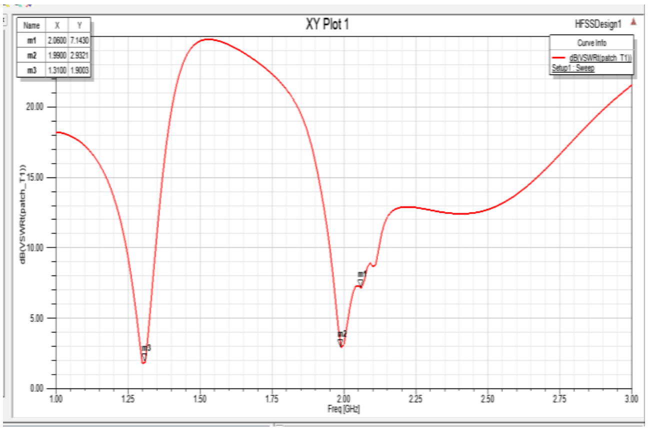

Figure 10 Proposed Reconfigurable Antenna VSWR at 1.31 GHz and 1.99 GHz (Diode is On)

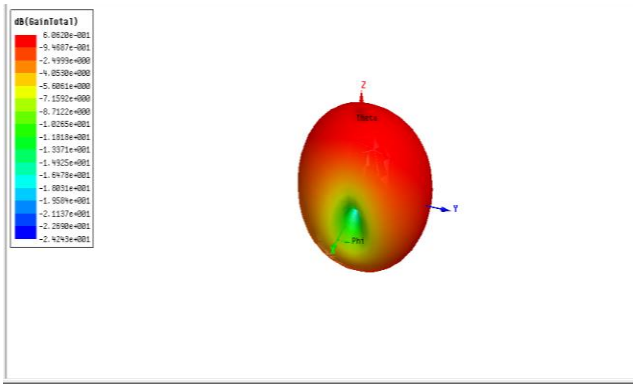

Figure 11 Proposed Reconfigurable Antenna 3D Polar Plot (Diode is On)

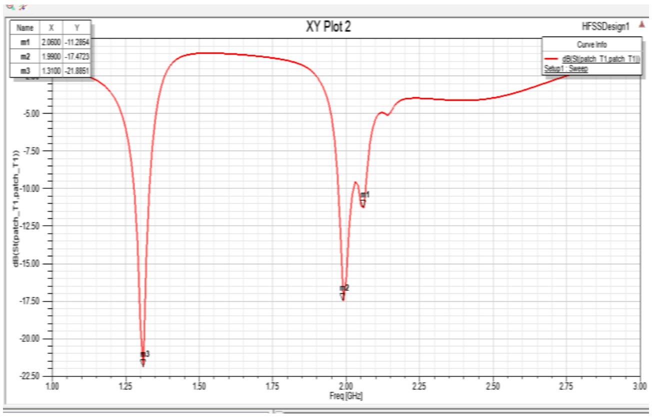

Figure 12 Proposed Reconfigurable Antenna Return Loss at 1.31 GHz, 1.99 GHz and 2.06 GHz (Diode is Off)

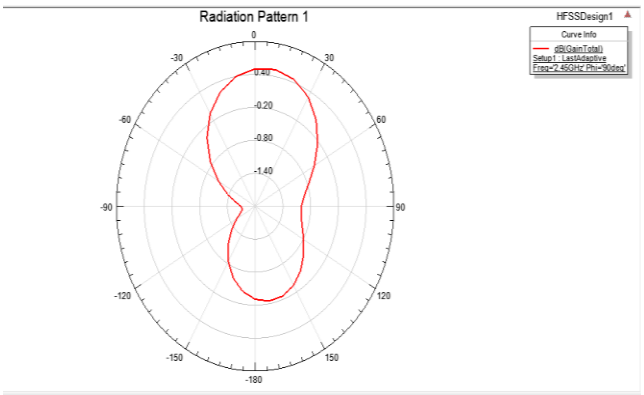

Figure 13Proposed Reconfigurable Antenna Radiation Pattern (Diode is Off)

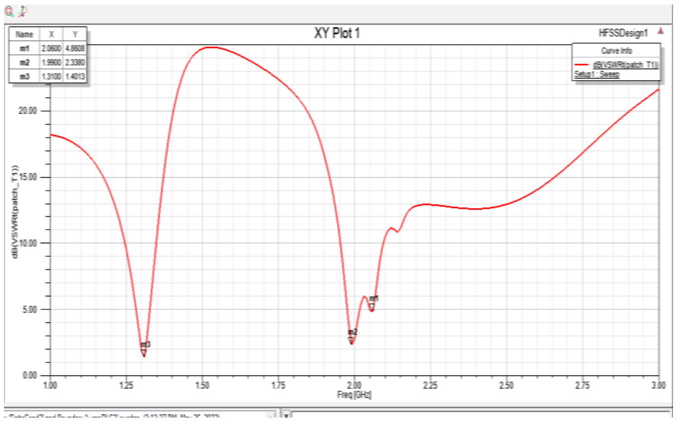

Figure 14 Proposed Reconfigurable Antenna VSWR at 1.31 GHz, 1.99 GHz and 2.06 GHz (Diode is Off)

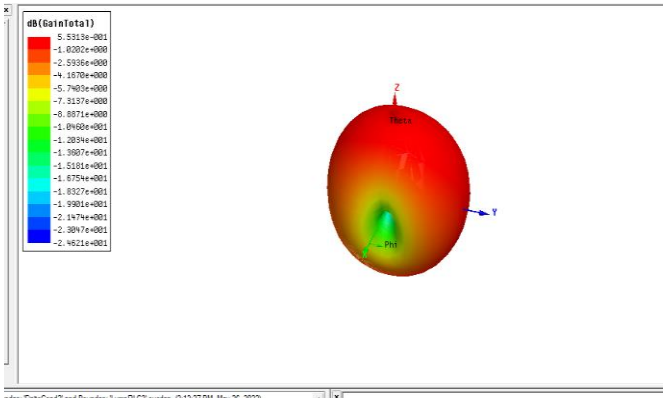

Figure 15 Proposed Reconfigurable Antenna 3D Polar Plot (Diode is Off)

RESULT AND DISCUSSION

The simulated results of prototype antenna were discussed in this section. The simulated values are obtained respectively via HFSS. It is observed that the frequency is radiating in L band (1-2GHz) and S band(2-4GHz). The different antenna parameters for the proposed antenna's two switching states are listed as below.

(a)Return Loss

1.The return loss of first case i.e., T shaped patch antenna is shown in figure 2.
2. The return loss of second case i.e., slotted antenna is shown in figure 5.
3. The return loss of third case i.e., diode D1 is ON is shown in figure 8.
4. The return loss of fourth case i.e., diode D1-OFF is shown in figure 12.
The Radiation Pattern, 3D Polar Plot and VSWR shown in figures. The resulting Bandwidth, Gain, Return loss and VSWR is tabulated.

Case	Description	Simulation Resonant Frequency (GHz)	Simulation Return Loss in dB	Simulation Bandwidth in %
1	T-shape patch antenna	2.4	-32.00	11
2	Slotted antenna	1.54 2.45	-27.5941 -10.2102	7 5
3	Diode D1-ON	1.30 1.99	-19.6232 -15.5352	5 5
4	Diode D1-OFF	1.31 1.99 2.06	-21.8851 -17.4723 -11.2854	2 7 5

CONCLUSION

The experimental study shows that the frequency reconfigurable antenna is fairly easy to design and produce and very efficient to improve the operation of multiband frequencies, providing a better pattern of broadside radiation. The other parameter of the antenna including gain, VSWR and loss of return is found to be perfect for this antenna. This antenna is ideal as it uses low-cost substratum material and finds applications in WLAN, Bluetooth, GPS, Two way Radio, Microwave ovens, TV broadcast and mobile phones band frequency ranges as in conventional wireless communication systems.

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