Reconfigurable Monopole Antenna for WLAN/ Bluetooth/ ISM/GPS/ LTE Applications

K. Dharani, V. Rajesh, B.T.P. Madhav, B. Prudhvi Nadh

Abstract*: The paper presents a triple band reconfigurable antenna is designed for various wireless applications. The BAR 64-02 V PIN diode is used for attaining the reconfigurability of antenna. The antenna is compact in size and can be applicable for WLAN/ Bluetooth/ ISM/GPS/ GLONASS/GALILEO (2.4-2.48GHz) and LTE42/43 (3.4-3.8GHz) applications. This antenna is reconfigurable up to three frequency bands ranging 2 GHz to 5 GHz and simulated using ANSYS HFSS software and fabricated on a FR-4 epoxy substrate with 30×30 mm2 dimensions. The proposed antenna operates in the frequency range of 2.4 to 2.52 GHz, 3.06 to 3.13 GHz, 3.37 to 3.71 GHz when diode is ON state and the antenna operates in the range of 2.44 to 2.5 GHz, 3.17 to 3.29 GHz, 3.71 to 3.99 GHz when diode is OFF state.

***Keywords*: LTE, ISM, PIN diode, Reconfigurable, GLONASS.**

I. INTRODUCTION

Advanced Wireless Communications systems, Telecommunications, Frequency transfer centers, Military applications widely use microstrip patch antennas due to the enticing tendency like compactness, economical, weightless and effortless fabrication [1]. Radio Frequency technology is widely associated with the Wireless Communications where patch antennas are used for novel structures to achieve the desired patterns, polarization and operating frequencies such as two telecommunication frequency bands (1.8 GHz and 1.9 GHz) and for Bluetooth (2.4 GHz) with use of MEMS structures in patch antennas [2]. Triple band U-shaped microstrip antenna with distinct lengths and widths operating at 3.6 GHz and 5.5 GHz which are applicable for WIMAX and WLAN applications by using two PIN diodes for switching of an antenna [1]. Recently, wireless communications for Wireless Local Area Network and Worldwide Interoperability for Microwave Access is used widely which operates at the frequencies 2.4-2.484 GHz, 5.15-5.35 GHz, 5.725-5.85 GHz and 2.5-2.69 GHz, 3.40-3.69 GHz respectively with the use of slot and patch antennas by positioning the three lumped inductors in the three monopoles where the designed antenna operates at required triple band [3]. To get the high gain triband frequency reconfigurable antenna Vivaldi antenna is proposed where by increasing the SNR of the antenna by quarter stubs to curb the resonating band where the RF-MEMS switches are used two of them in each of the stubs [4]. For LTE triple band operating frequency, the IFA antenna (inverted F loop antenna) is used which resonates at three bands low, middle and high procured with passive elements without any changes in the antenna IFA dimensions [5]. Slot antennas are essentially favorable as it serves at various frequencies, easy method of fabrication and using MMIC's to make it compatible by using the Sickle structured slots which resonates at three distinct frequencies applicable for Bluetooth-2.4 GHz, WLAN-5.8 GHz and WiMAX-3.5 GHz [6-8].

In this paper triple band reconfigurable antenna with SRR (Split Ring Resonator) structure with a PIN diode for switching purpose and the proposed antenna operates at 2.4 to 2.52 GHz, 3.06 to 3.13 GHz, 3.37 to 3.71 GHz when diode is ON state and at 2.44 to 2.5 GHz, 3.17 to 3.29 GHz, 3.71 to 3.99 GHz diode is OFF state having the applications of WLAN/ISM (2.4-2.48GHz) and LTE42/43 (3.4-3.8GHz)..

II. ANTENNA DESIGN

From Fig 1, we observe three iterations by using a splint ring structure in the antenna design. At the stage of first iteration a ring is added, and the partial ground structure is considered and a small opening of 0.75 mm to insert the diode, in the second another ring is inserted to previous and the last iteration is the proposed design to which a PIN diode is used for accessible frequency applications. The total structure looks like the ring loaded antenna with partial ground.

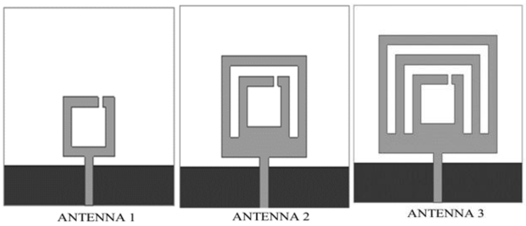

Figure: 1 Proposed antenna Iterations.

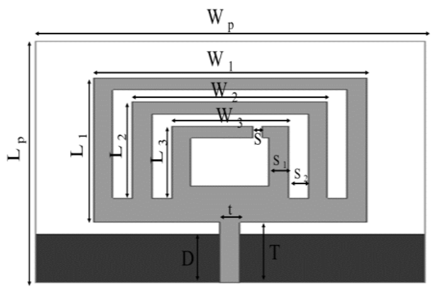

Figure: 2 Geometry of proposed antenna.

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As shown in above Fig.2, the proposed antenna is fabricated on FR-4 epoxy substrate having thickness h=0.8 mm, loss tangent 0.023, dielectric constant 4.4 with size of 30×30 mm2 by using a PIN diode BAR 64-02V, with ON state resistance and inductance 2.1 Ω and 0.16µH respectively. The PIN diode with OFF state having 0.17pF and 3kΩ shunt capacitance and reverse resistance respectively.

Table: 1 Parameters of the proposed antenna.

Parameters	Value (mm)	Parameters	Value (mm)
L_p	30	W_3	9
W_p	30	T	7.5
L_1	15	T	1.5
W_1	21	D	6
L_2	12	S	0.75
W_2	15	S_1	1.5
L_3	9	S_2	1.5

III. RESULTS AND DISCUSSION

From Fig.1, Antenna 1 consists of a single ring at which antenna doesn't operate and Antenna 2, by adding another ring to antenna 1 which is of two rings and operates at dual bands 3.09-3.23 GHz, 3.55-3.85 GHz respectively and Antenna 3, proposed antenna which by adding another ring to previous antenna, operating at triple bands 2.44-2.55 GHz, 3.17-3.29 GHz and 3.71-3.99 GHz respectively which are applicable for LTE42/43 and WLAN Wireless communications.

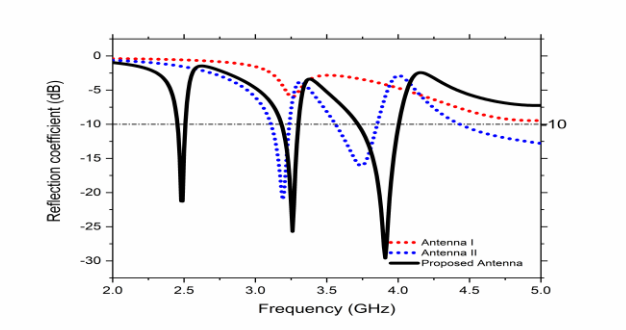


Figure: 3 Simulated Return Losses of the Iterations

IV. HELPFUL HINTS

A. Parametric Study

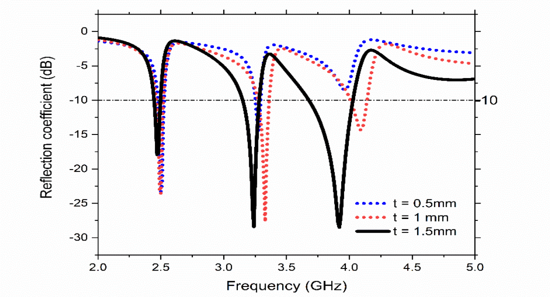


Figure: 4 Parametric study for varying the width of the feed(t).

As shown in Fig.4, study of the proposed antenna design is achieved by varying the width of the feed 't' from 0.5 mm to 1.5 mm. At 0.5mm of 't' it operates at 2.46 GHz to 2.51 GHz with S11of -23.09 dB, at 1 mm of 't' it operates from 2.45 GHz to 2.51 GHz with S11 of -23.38 dB, 3.26 GHz to 3.35 GHz with S11 of -27.41 dB where we observe the dual bands and at 1.5 mm of 't' it operates from 2.43 GHz to 2.49 GHz with S11 of -17.76 dB, from 3.14 GHz to 3.27 GHz with S11 of -28.34 dB, 3.67 GHz to 4.02 GHz with S11 of -28.27 dB where we observe the triple bands.

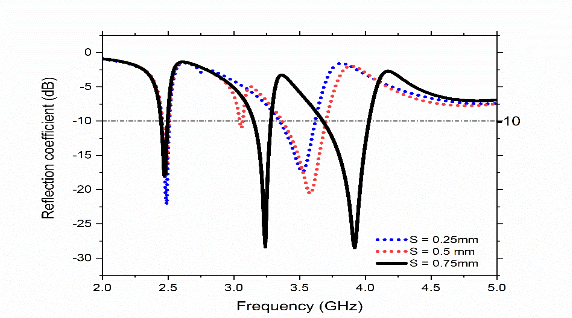


Figure: 5 Parametric study for varying the slot size in first ring (s).

From Fig.5, parameter S varying from 0.25 mm to 0.75 mm, at S=0.75 mm antenna operates at triple bands ranging from 2.43 GHz to 2.48 GHz with S11 of -17.76 dB, 3.14-3.27 GHz having S11 of -28.34 dB and 3.67-4.02 GHz with S11 of -28.27 dB respectively. At S=0.25 mm it operates from 2.44 GHz to 2.50 GHz with S11 of -22.15 dB, 3.34-3.61 GHz with S11 -17.19 dB where we observe the dual bands and at S=0.5mm antenna operates at 2.44-2.50 GHz with S11of -17.48 dB, 3.35-3.69 GHz with return loss of -20.43 dB getting dual bands.

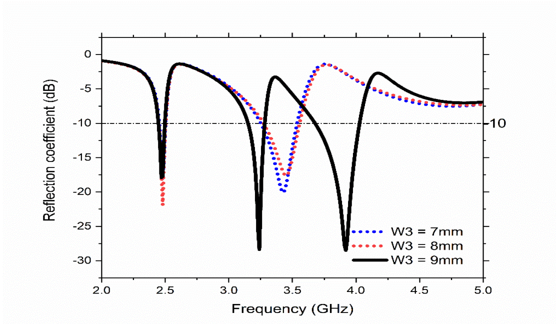


Figure: 6 Parametric study for varying the width of the third split ting(w3).

W3 varies from 7 mm to 9 mm of the proposed antenna as shown in above Fig.6, When W3=7 mm antenna operates at 2.44-2.49 GHz, with S11 of -19.85 dB and 3.24-3.53 GHz with S11 of -17.48 dB where we get dual band. At W3=8 mm the design operates at 2.44-2.49 GHz with S11 of -21.72 dB, 3.26-3.55 GHz with S11 of -17.23 dB gets dual band and at W3=9 mm antenna operates at triple bands ranging from 2.43 GHz to 2.48 GHz with Return loss -17.76 dB, 3.14-3.27 GHz having Return loss of -28.34 dB and 3.67-4.02 GHz with Return loss of -28.27 dB respectively.

B. Surface Current Distribution

As shown in Fig.7, at the PIN diode ON state condition maximum current is distributed on outer rings of the patch antenna and feed line of antenna and when the diode is in OFF state condition the current is distributed maximum on inner patch and feed line of proposed antenna and the edges of the ground structure.

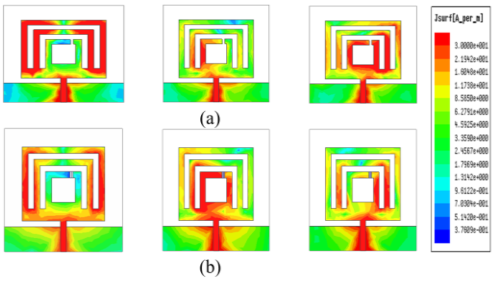


Figure: 7 Proposed antenna Surface Current Distributions (a) 2.47 GHz, 3.25 GHz and 3.9 GHz (OFF State) (b) 2.45 GHz, 3.11 GHz and 3.5 GHz (ON state).

C. Reconfigurability

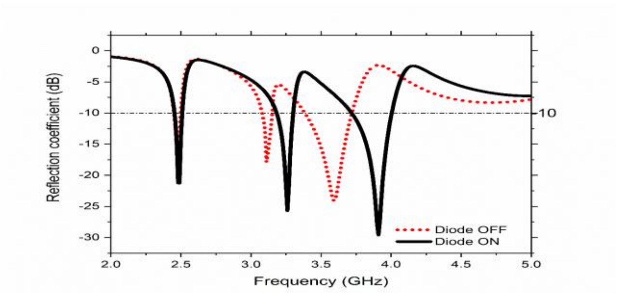


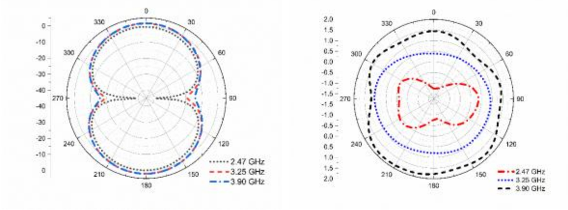
Figure: 8 Proposed Triple band antenna Simulated Results.

Different switch cases, ON and OFF the proposed antenna are listed in Table: 2. Fig .8 shows the Return Losses of the PIN diode switching cases in ON and OFF state modes where we observe the triple bands. When PIN diode is OFF state it operates from 2.44-2.55 GHz applicable for WLAN frequency, 3.17-3.29 GHz and 3.71-3.99 GHz which is applicable for LTE 42/43 frequency. When the PIN diode is ON state it operates from 2.4-2.52 GHz, 3.06-3.13 GHz, 3.37-3.71GHz getting triple bands.

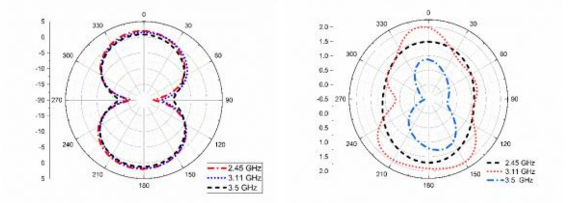
Table: 2 Proposed antenna Switching Modes.

States	Switch Status	Frequency bands (GHz)
Triple Band	OFF	2.47/3.25/3.9
Triple Band	ON	2.45/3.11/3.5

D. Radiation Pattern



(a)



(b)

Figure: 9 Radiation Characteristics of E-plane and H-plane (a) 2.47 GHz, 3.25 GHz and 3.9 GHz (OFF State) (b) 2.45 GHz, 3.11 GHz and 3.5 GHz (ON state).

In Fig.9 (a) the radiation pattern for both E plane and H plane can be observed for frequencies of 2.47 GHz, 3.25 GHz and 3.9 GHz (OFF State) where for E plane we can observe the bidirectional patterns. The radiation pattern achieved for frequencies 3.25GHz and 3.90 GHz is almost the same while the pattern for the frequency 2.47GHz differs from the other two frequencies. The H plane radiation pattern obtained for the above-mentioned frequencies an omni directional pattern. Unlike E plane for H plane the pattern obtained is different for different frequencies. Fig.9(b) depicts E plane and H plane patterns for ON state frequencies. The patterns obtained for the three frequencies 2.45GHz, 3.11GHz and 3.5GHz is almost the identical with very slight variations which explains the antenna radiation is same for all frequencies in ON state for E plane. Whereas foe H plane, the patterns vary for different frequencies just as in OFF state.

E. Peak Gain

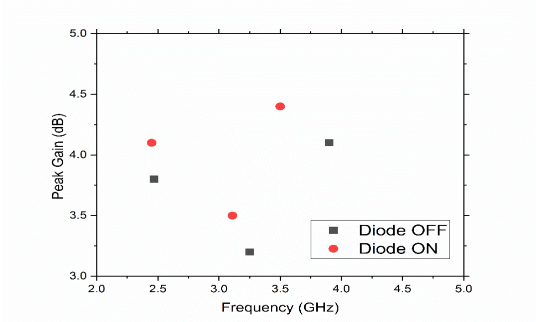


Figure: 10 Peak Gain of the proposed antenna

From Fig. 10 We observe the change in Gain response of antenna for both the ON and OFF state of diode with its reconfigurability, at ON state we see the peak gain from 3.52 dB to 4.45 dB and at OFF state from 3.2 dB to 4.21 dB of peak gain.

V. CONCLUSION

In this novel, the proposed design is used for WLAN and LTE 42/43 applications. The proposed antenna is fabricated on a low-cost FR-4 substrate with 30×30 mm2. This is a compact, economical, low weight and obtains a good frequency reconfigurability. By the PIN diode ON condition we attain 4.45 dB peak gain at 3.5 GHz frequency. In both the E-plane and H-plane, the radiation patterns are Omnidirectional and Bidirectional respectively used for WLAN and LTE applications of Wireless Communication.

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