IJE TRANSACTIONS B: Applications Vol. 38, No. 11, (November 2025) 2493-2501

International Journal of Engineering

Journal Homepage: www.ije.ir

Analysis of a Low-Profile Reconfigurable Wideband L-shaped Printed Antenna for 5G/ISM-Band Applications

P. Pushadapu*[a], M. Siva Kumar[b]

[a] *Department of ECE, KLEF, Vaddeswaram, Guntur, Andhra Pradesh, India*
[b] *Department of ECE, BWEC, Bapatla, Andhra Pradesh, India*

P A P E R I N F O

Paper history:
Received 23 November 2024
Received in revised form 26 December 2024
Accepted 16 January 2025

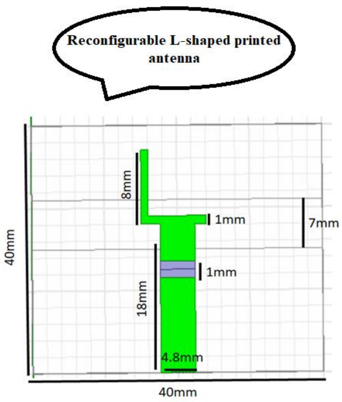
Keywords:
Frequency Reconfigurable
5G-sub-6GHz
ISM Band
X-band Satellite Communication Applications

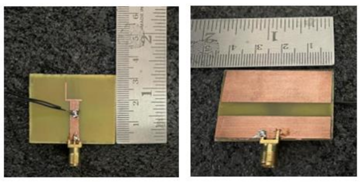
A B S T R A C T

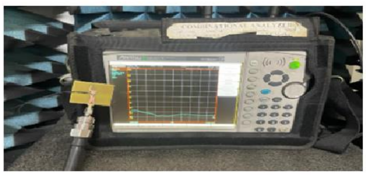
A low-profile frequency reconfigurable L-shaped printed antenna operating in microwave frequency band is presented in this article. The proposed antenna is fabricated on FR4 material having δ of 0.02, relative permittivity of 4.4 and thickness of 1.6 mm. HSCH 3486 PIN diode is inserted in between the feed line and the L-shaped structure for switching. The proposed antenna is resonating at 3.5 GHz and 6.6 GHz and offered an impedance bandwidth of 0.9 GHz and 3.5 GHz. Voltage standing wave ratio of the antenna is less than 1.5 at both the resonating frequencies. Efficiency of the designed antenna is 87% and 3 dBi gain of the antenna is 4.61 dBi. The proposed antenna is simulated by utilizing finite element method tool Ansoft HFSS v13 and the simulated results are experimentally validated. Due to its compact size the proposed antenna can be used for 5G-sub-6GHz and ISM band, X-band satellite communication applications.

doi: *10.5829/ije.2025.38.11b.02*

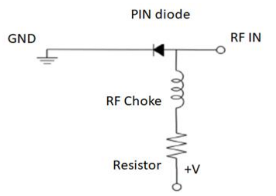
Graphical Abstract

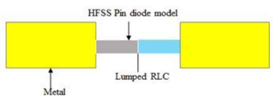






Measurement of L-Shaped Printed antenna using MS2037C Anritsu Combinational Analyser





HSCH 3486 PIN Diode Biasing Circuit and HFSS model

1. INTRODUCTION

The demand for compact devices and the development of new technologies such as 5G and the Internet of Things (IoT) have led to a significant increase in interest in multifunctional antennas during the past ten years. The advantages of reconfigurable antennas have made them widely known. By displaying switching frequency, polarisation and radiation patterns using different approaches, these antennas can replace several antennas (1, 2). Reconfigurability is achieved through the widespread usage of RF-PIN diodes, optical switches,

*Corresponding Author Email: pratyushapushadapu25@gmail.com
(P. Pratyusha)

Please cite this article as: Pushadapu P, Siva Kumar M. Analysis of a Low-Profile Reconfigurable Wideband L-shaped Printed Antenna for 5G/ISM-Band Applications. International Journal of Engineering, Transactions B: Applications. 2025;38(11): 2493-501.

microfluids, meta-surface, Micro Electrical and Mechanical Switches (MEMS) and electrically phase change materials (3, 4). The majority of reported works on the various kinds of antennas proposed for sub-6-GHz applications are related to reconfigurable antennas, where researchers extensively studied the RF-PIN diode for frequency reconfigurability to achieve single band, dual band and multiple band reconfigurable operations (5-17). A wideband antenna for Long-Term Evolution (LTE) and Wireless Wide Area Network (WWAN) applications was designed by Jin et al. (5). The antenna has a simple design and performs well across a large operational band. Nevertheless, the antenna has number of disadvantages, such as larger size, poor gain and lack of reconfigurability. For ISM and 5G-sub-6-GHz applications, a compact wideband monopole antenna is transformed into a tri-band antenna by Feng et al. (6).

The antenna does not permit frequency reconfiguration, despite having a small size and flexible features. Similarly, another antenna covering WLAN and 5G-sub-6-GHz was introduced by Zhao et al. (7)using the proximity-coupling feed. On the other hand, the complicated antenna design of the proposed antenna consists of two substrates that are separated by an air gap. It is recommended to use a number of single band frequency reconfigurable antennas in the frequency band spectrum range of 2–4.5 GHz (8-12). The antennas described in [8–10] feature many layered structures that lead to greater thickness and structural complexity, even though they give very high gain characteristics. Despite their small size, the work presented antennas by Tutuncu and Kösem, (11) and Ali et al. (12) have a relatively narrow bandwidth, which means that modern electronics operating in broader frequency spectrums cannot use them.

For LTE and Wireless Local Area Network (WLAN) applications, antennas with frequency reconfigurable features are shown by Kiani et al. (13) and Hasan and Islam (14). Three PIN diodes were added to a traditional rectangular patch antenna in order to switch the operation and enable wideband operation using Defected Ground Structure (DGS) [13]. Two pin diodes, asymmetric feed and various kinds of slots are used by Hasan and Islam (14) to provide frequency reconfigurability. Single and dual band operating bandwidths of these antennas are constrained, despite their compact and simple form. A dual-band to quad-band and a dual-band to tri-band frequency reconfigurable antenna were introduced by Ahmad et al. (15, 16). Both of these antenna designs have limitations due to their restricted bandwidth, intricate geometric structures and limited number of operational modes, although covering a wide range of frequencies. Furthermore, the antenna described by Ahmad et al. (15) has the disadvantage of having greater dimensions. A flexible frequency reconfigurable antenna for sub-6 GHz applications was introduced by Shehata et al. (17). This work presents two dual-band and wideband operational modes with a simple design. Nevertheless, its dimensions are greater and its operating bandwidth is smaller.

Various substrate materials were studied for sub-6 GHz range in literature (18-22). Unfortunately, a number of disadvantages were incorporated into the ground plane (23), which affects the antenna's radiation performance. A double-layered meta-surface antenna with better isolation and gain was suggested by Naveen Kumar et al. (24) for the sub-6 GHz 5G spectrum. While taking up more substrate space, the simulated antenna design complexity was high. Reconfigurable antenna designs were published by Majji et al. (25) for 5G systems operating at sub-6 GHz. To accomplish reconfigurability, however, the antenna designs examined by Madhavareddy et al. (26) and Govardhaniet al. (27) requires a large number of active elements (2/4 RF PIN diodes). For the upper 5G application band, a quad-port log-periodic dipole antenna array with epsilon around zero metamaterial was studied by Kumar Kusumanchi and Pappula (28), Soltan and Neshati (29).

This research proposes a compact frequency reconfigurable antenna to address the aforementioned issues. Antenna design consists of an L-shaped patch and a PIN diode has been utilized to attain frequency reconfigurability. The work that is being presented demonstrates an effective combination of small size, simple geometric configuration, large operational region and reasonable gain. This is how the remaining part of the paper is structured. The theoretical analysis and design process of the proposed antenna are presented in section 2. Section 3 describing the discussion of the performance parameters and concluding the paper with section 4.

2. DESIGN METHODOLOGY

2. 1. Reconfigurable Antenna The L-shaped printed antenna is designed by utilizing FR4 material having δ of 0.02, relative permittivity of 4.4 and thickness of 1.6 mm. The proposed antenna consists of a L-shaped patch united by a 50 Ω microstrip transmission line, a rectangle has been subtracted from the ground plane to attain a wider bandwidth and high gain. The simulations of the L-shaped printed antenna were performed by utilizing finite element method Ansoft HFSSv13. The antenna occupies the dimensions of $0.47\lambda_0$ x $0.47\lambda_0$ x $0.0185\lambda_0$. The mathematical formula that were utilized while designing the L-shaped printed antenna are represented below (30-35).

$$\frac{W}{h}=\frac{8\ x\ e^{A}}{e^{2A}-1} \quad (1)$$

$$L=\frac{\lambda}{4}\left(1-\frac{97.82}{Z_C}\right) \quad (2)$$

$$\lambda=\frac{c}{f_r} \tag{3}$$

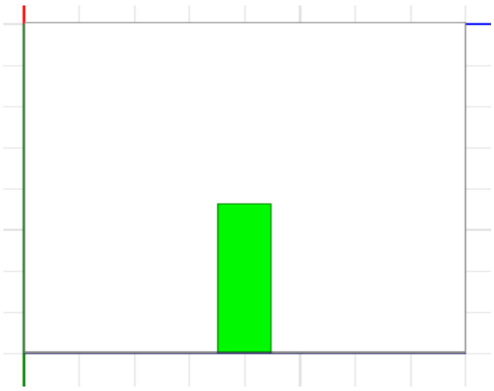
$$Z_C= 120\ \ln(\mathrm{ctg}(\frac{\theta_0}{4})) \tag{4}$$

$$A=\frac{Z_0}{60}\sqrt{\frac{\varepsilon_{r+1}}{2}+\frac{\varepsilon_r+1}{\varepsilon_r-1}}*(0.23+\frac{0.11}{\varepsilon_r}) \tag{5}$$

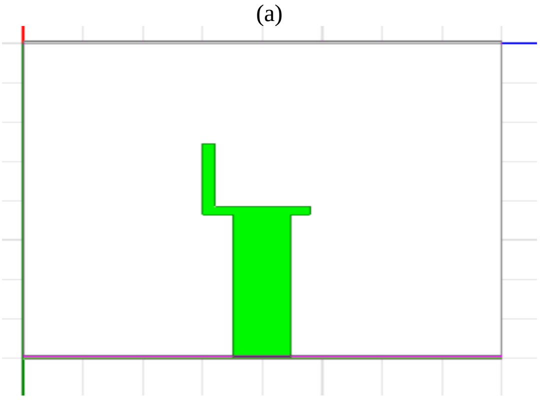
where f_r is the resonant frequency, ε_r is the relative permittivity of the substrate, h is the thickness of the substrate, L and W are length and width of the patch. Width of the patch is calculated by using Equation 1 and length of the patch is calculated by using Equation 2. Z_c is the characteristic impedance of the antennaand is obtained by using Equation 4.

Figure 1 represents the evolutionary stages of the L-shaped printed antenna. The evolutionary process of the antenna was investigated by utilizing Ansoft HFSSv13. At first a monopole antenna has been designed with a dimension of 18 x 4.8 mm^2. There after two rectangles with a length of 8 mm and width of 1 mm has been united to form a L-shaped printed antenna with a full ground plane. In step 3 a rectangle having a length of 40 mm and width of 7 mm has been subtracted from the ground plane to attain wider bandwidth and high gain.

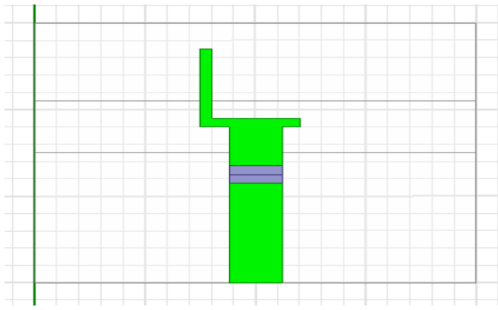
Figure 2 represents the S_{11} of the antenna at different evolutionary stages. In step 1 the monopole antenna is resonating at 3 GHz with S_{11} of -25 dB suitable for sub-6 GHz applications. In step 2 the monopole antenna is attached with a rectangle forming an L-shape and the L-shaped printed antenna is also resonating at 3.2 GHz suitable for sub-6 GHz applications. In step 3 two rectangles has been subtracted from the feed line to attain reconfigurability. Step 3 antenna is resonating at 3.5 GHz (3.1-4.0 GHz) with S_{11} of -25.1 dB suitable Sub-6 GHz bands covering N78 band. Figure 3 represents the top view and bottom view of the reconfigurable L-shaped printed antenna along with its dimensions. Figure 4 represents the photograph of the proposed antenna attained by utilizing chemical etching.



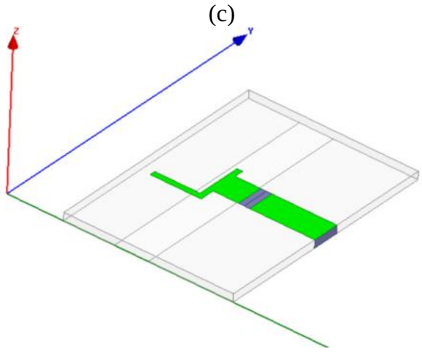
(a)



(b)



(c)



(d)

Figure 1. Evolutionary process of the Reconfigurable L-shaped printed antenna (a) Step 1 (b) Step 2 (c) Step 3 (d) 3D view of the proposed antenna

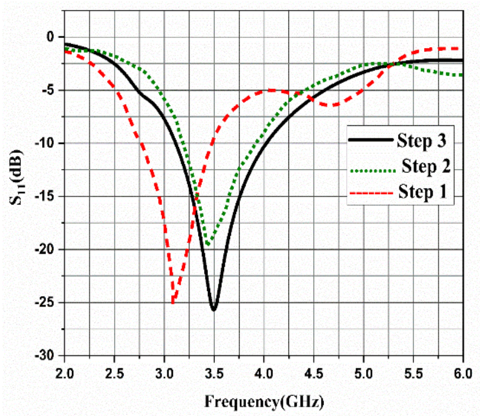


Figure 2. Reflection Co-efficient of the antenna at different evolutionary stages

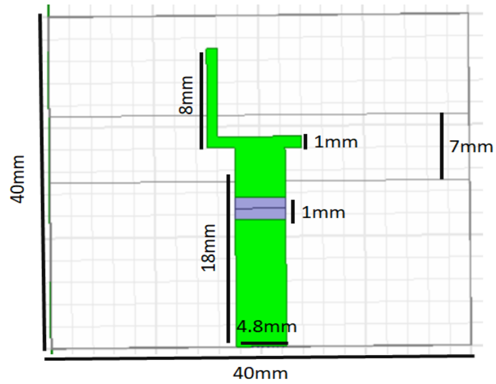
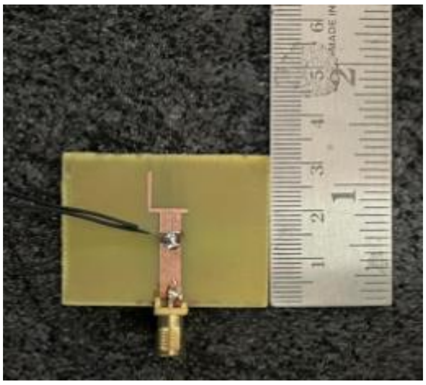
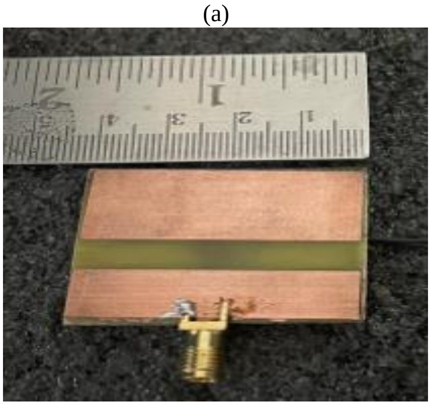


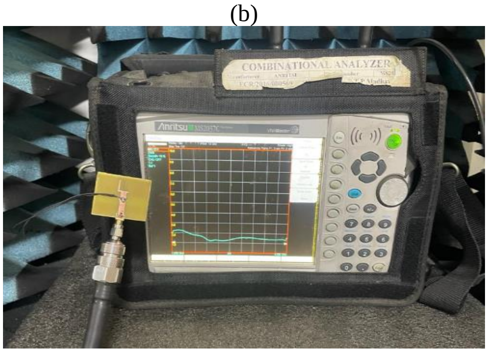
Figure 3. Reconfigurable L-shaped printed antenna



(a)



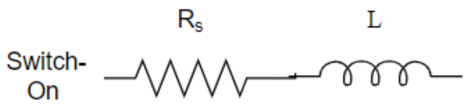
(b)



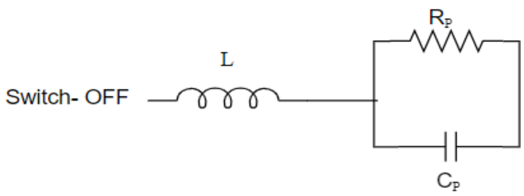
(c)

Figure 4. Photograph of the Reconfigurable L-shaped printed antenna (a) Top plane (b) Bottom plane(c) Measurement setup

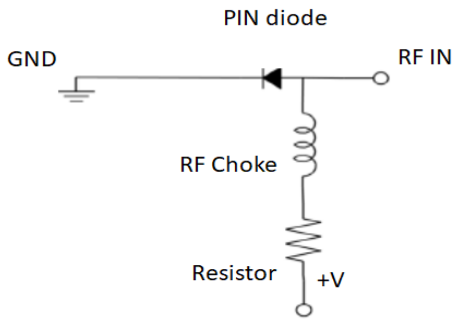
2. 1. Analysis of PIN Diode PIN diodes are used in microwave and ultrahigh frequency applications. Similar to a variable resistor in RF and microwaves, its bias current directly regulates its frequency (11). Moreover, the PIN diode requires a significantly smaller amount of control power to regulate high RF signal strengths (12). The low resistance R_s of the equivalent circuit in the ON state is what causes forward biassed. All of the values needed for the circuit models are included in the data sheets that the manufacturers provide for each PIN diode. The application of the PIN diode in HFSS with lumped RLC values is shown in Figure 5. L is the first component, while the second is either a shunt combination of R_p and C_p for the OFF state, or R_s for the ON state. These diodes are utilized to offer a high degree of frequency band reconfiguration dependability.



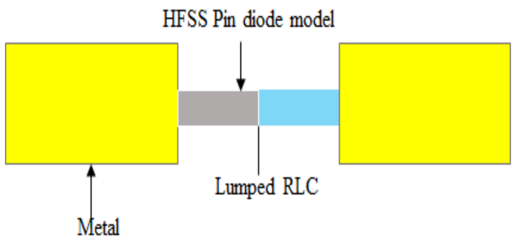
(a)



(b)



(c)



(d)

Figure 5. HSCH 3486 PIN Diode (a) Diode ON condition (b) Diode OFF condition (c) Biasing Circuit (d) HFSS model

HSCH 3486 PIN diode has been utilized for switching and the RF behaviour of a PIN diode is often similar to a variable resistor. These diodes operate at a frequency range from 10 MHz to 10 GHz. The resonant frequency of the antenna varies when the PIN diodes are utilized. There are open and short-circuit behaviours in these PIN diodes. Figure 5 presents the equivalent circuits for PIN diode switches in both the ON and OFF modes. The circuit consists only of an inductor (L) and a low-value resistor (R_L) while it is in the "ON" position. A capacitor ("C") is connected in parallel with the remaining three parts, and a high-value resistor ("R_H") is connected in series with an inductor. The manufacturer's data sheet states that the RLC boundary values of the diodes in the HFSS are L = 0.3 nH and Rs = 20 Ω while the diodes are in the ON state, and R_p = 244 Ω and C_p = 0.01 pF when they are in the OFF state. Figures 6 and 7 represents the parametric analysis of the antenna during the ON and OFF conditions of the diode. By varying width of the feed line a significant return loss has obtained when length and width of the rectangles was 1mm and has attained at a frequency range from 3.1 GHz-4 GHz (Diode ON) and 5.6 GHz-9.1 GHz with a return loss of -25 dB and -24 dB.

3. RESULTS AND DISCUSSIONS

MS2037C Anrtisu Combinational Analyzer has been utilized to measure the antenna parameters. A commercial far-field measurement system in a shielded RF anechoic chamber is used to measure the antenna's far-field properties. The proposed antenna was measured as a receiving antenna and the horn antenna (SGH-series) with a typical gain of 24 dBi is used as a transmitter. Stable power reception was achieved by the use of power amplifiers. The far-field results are measured by rotating

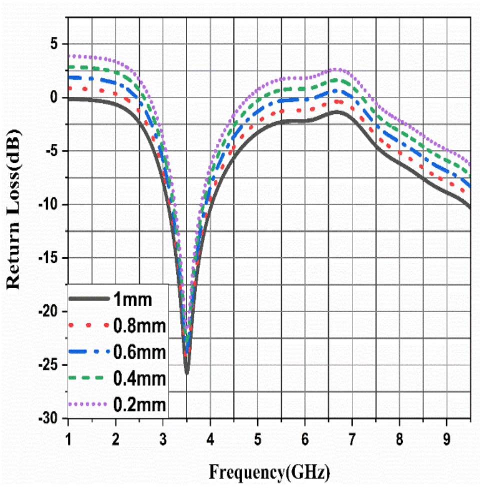


Figure 6. Parametric Analysis of the Reconfigurable L-shaped printed antenna by varying feed width (Diode ON)

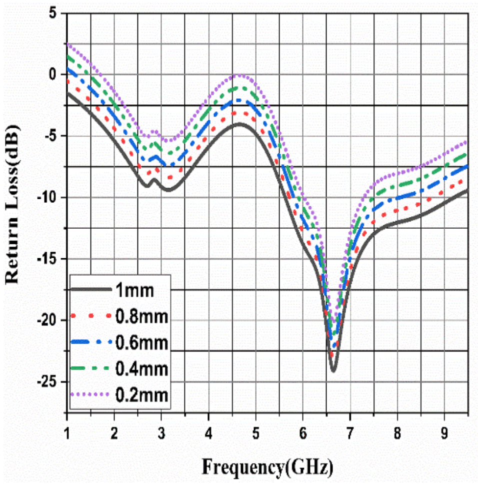


Figure 7. Parametric Analysis of the Reconfigurable L-shaped printed antenna by varying feed width (Diode OFF)

the antenna 360^0. In a shielded RF anechoic chamber, the antenna's properties are measured using a commercial far-field measurement device. The proposed antenna was measured as a receiving antenna and the horn antenna (SGH-series), which has a standard gain of 24 dBi is used as a transmitter. S_{11} is the most important parameter that has to be measured for any RF device. S-parameters and VSWR of the antenna were measured by utilizing MS2037C Anritsu Combinational Analyser. Figure 8 represents the reflection co-efficient of the reconfigurable L-shaped printed antenna during the ON and OFF conditions of the antenna. S_{11} at both the resonating frequencies is less than -10 dB and in fact even lesser than -10 dB. The reconfigurable L-shaped printed antenna resonates at 3.5 GHz and 6.6 GHz and it offers an impedance bandwidth of 0.9 GHz and 3.5 GHz with a return loss of -25 dB and -24 dB during the ON and OFF conditions of the diode. When the diode is in ON condition the reconfigurable L-shaped printed antenna operates at 3.5 GHz satisfies the requirement of n78 (3300 – 3800MHz) 5G applications. The frequency range of X-band is 8 GHz-12 GHz. The frequency range for X-band military communication applications with uplink and downlink frequency bands of 7.9 – 8.4 GHz and 7.25 – 7.75 GHz, respectively. The frequency range for ISM band is 5.725–5.850 GHz. When the diode is in OFF condition the reconfigurable L-shaped printed antenna operates at 6.6 GHz and offers an impedance bandwidth of 3.5 GHz (5.6 GHz-9.1 GHz) satisfies the requirement of ISM band and X-band satellite communication applications.

Figure 9 represents the radiation pattern of the reconfigurable L-shaped printed antenna during the ON and OFF conditions of the diode. Figure 10 represents the 3D gain of the reconfigurable L-shaped printed antenna at both the resonating frequencies and a gain of 4.61 dBi has obtained during the ON and OFF conditions of the diode. The measured and simulated model radiation pattern in the E- and H-plane at 3.50 GHz and 6.6 GHz is shown in Figure 9. Radiation pattern of the antenna was measured by utilizing Anechoic Chamber. Good co-polarization and cross-polarization difference in broadside direction, i.e., more than 20 dB at all the two resonant frequency bands and omnidirectional pattern are present in both the primary plane (E&H). Simulated and measured radiation pattern are in close agreement.

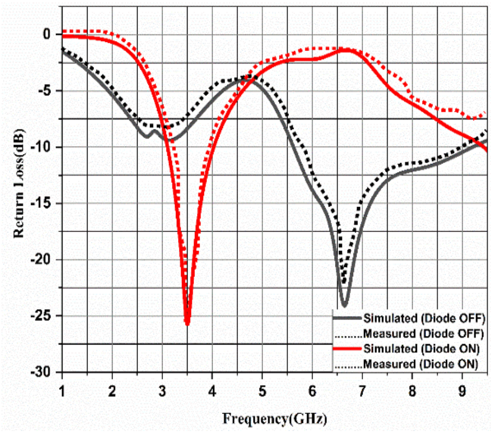
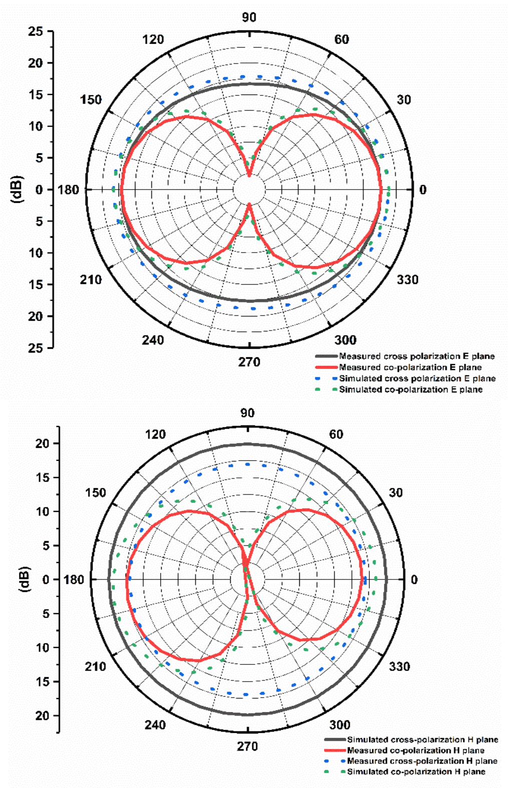
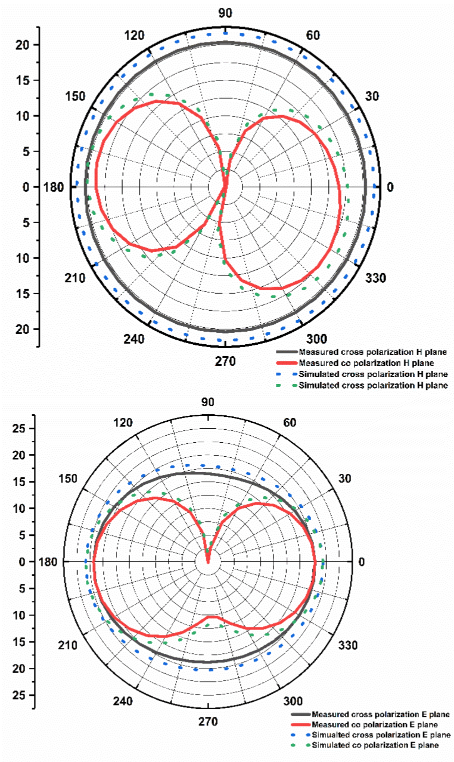


Figure 8. Reflection co-efficient of the Reconfigurable L-shaped printed antenna during the diodes ON and OFF conditions



(a)



(b)

Figure 9. Radiation pattern of the Reconfigurable L-shaped printed antenna (a) 3.5GHz (b) 6.6GHz

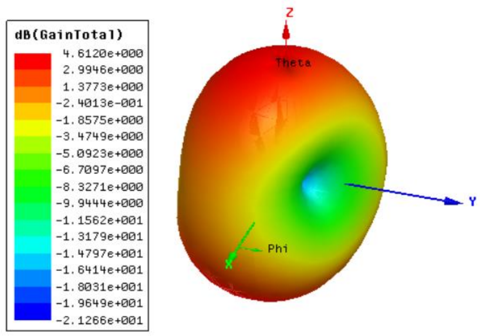


Figure 10. 3D gain of the Reconfigurable L-shaped printed antenna

Figures 11 represents the H-field distribution of the L-shaped printed antenna with partial ground plane. Figure 12 represents the vector current distribution of the reconfigurable L-shaped printed antenna. Maximum amount of current is distributed at the edges and center of the antenna. Red color indicates the maximum amount of field distribution, a maximum value 20 Am^{-1}, 50 Am^{-1} has been observed. Figure 13 represents the radiation efficiency of reconfigurable L-shaped printed antenna and a maximum efficiency of 87% has been observed. Figure 14 represents the axial ratio of the proposed reconfigurable L-shaped printed antenna.

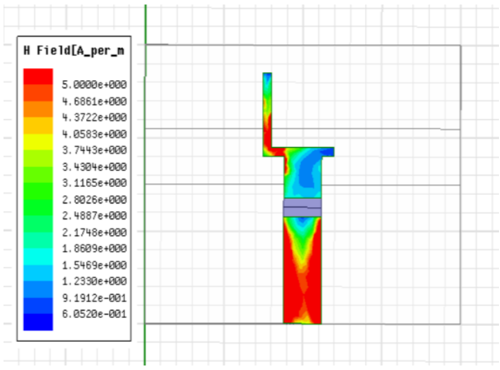


Figure 11. H-field distribution of the Reconfigurable L-shaped printed antenna

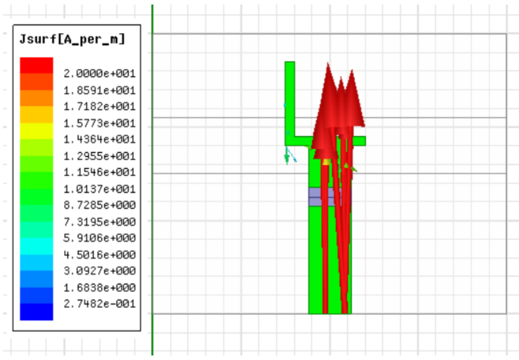


Figure 12. Vector current distribution of the Reconfigurable L-shaped printed antenna

Table 1 represents the comparison of the proposed antenna with the existing similar antennas in the literature. Comparison is done with respect to the performance of an antenna in terms of its parameters like antenna size, center frequency, reflection co-efficient, reconfigurable technique, gain and VSWR. From the comparison table it is noticed that the L-shaped printed antenna has shown excellent performance including reflection co-efficient and the highest gain. Many designs were presented in literature (16-26, 36-39), they offer high gain (or) low VSWR but not the both. The second highest gain offerted by Katireddy et al. (21) but the size of the antenna is twice of our proposed antenna. The proposed antenna is first in this area which offers high gain, low VSWR, low reflection co-efficient, occupies less space and is an ideal candidate for N78 Sub-6GHz applications as well as ISM band and X-band satellite communication applications.

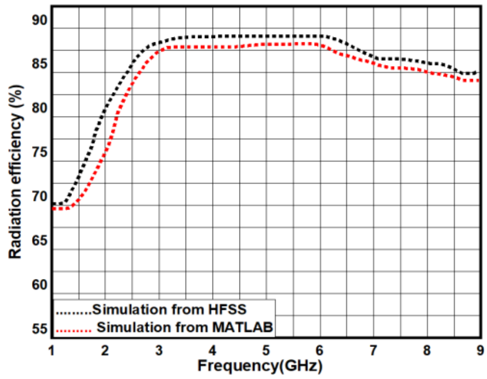


Figure 13. Radiation Efficiency of the Reconfigurable L-shaped printed antenna

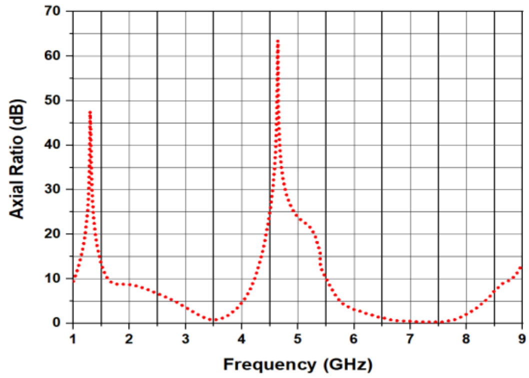


Figure 14. Simulated axial ratio of the Reconfigurable L-shaped printed antenna

TABLE 1. L-shaped printed antenna comparison with the existing antennas in the Literature

Reference	Antenna Size (λ_0^3)	F_c (GHz)	Reconfigurable Technique	S_{11} (dB)	Gain (dBi)	Efficiency	Impedance Bandwidth (GHz)
[16]	1.78 x 1.80 x 0.096	6	NA	-14	4	80%	0.87
[17]	1.72 x 1.60 x 0.19	3/6	Varicap	-12	3	75%	0.58
[21]	3.62 x 3.62 x 0.20	2/6.5	PIN diode	-24	3.2	69%	0.58
[22]	1.375 x 1.375 x0.275	3/5.5	RF MEMS	-12	1.25	75%	0.77
[23]	1.72 x 1.72 x 0.15	2.6/3.5	PIN diode	-16	2.5	78%	0.98
[24]	1.83 x 1.83 x 0.18	4.1/6	PIN diode	-18	4.1	79%	0.85
[25]	1.3 x 1.3 x 0.18	1/2.5	PIN diode	-17	3	81%	0.69
[26]	1.95 x 1.95 x 0.32	2/4	PIN diode	-15	3.1	82%	1.0
Proposed Model	0.47 x 0.47 x 0.0185	3.1-4.0/5.6-9.1	PIN diode	-25.1/-24	4.6/4.6	87%/87%	0.9/3.5

4. CONCLUSION

A frequency reconfigurable antenna has been designed, simulated and experimentally validated in this article. The proposed antenna is reconfigured depending on the ON and OFF states of the PIN diode switches. When the switch is in ON condition the proposed antenna resonates at 3.5 GHz and offers an impedance bandwidth of 0.9 GHz and when the switch is in OFF condition the proposed antenna resonates at 6.6 GHz and offers an impedance bandwidth of 3.5 GHz. The proposed antenna offers many advantages like compact size, low cost, light weight and easy of fabrication and supports N78 5G-Sub-6 GHz applications and ISM band as well as X-band satellite communication applications.

5. REFERENCES

1. Nikolaou S, Bairavasubramanian R, Lugo C, Carrasquillo I, Thompson DC, Ponchak GE, et al. Pattern and frequency reconfigurable annular slot antenna using PIN diodes. IEEE Transactions on Antennas and Propagation. 2006;54(2):439-48.
2. Ojaroudi Parchin N, Jahanbakhsh Basherlou H, Al-Yasir YI, Abd-Alhameed RA, Abdulkhaleq AM, Noras JM. Recent developments of reconfigurable antennas for current and future wireless communication systems. Electronics. 2019;8(2):128.
3. Affandi A, Azim R, Alam MM, Islam MT. A low-profile wideband antenna for WWAN/LTE applications. Electronics. 2020;9(3):393.
4. Zaidi A, Awan WA, Hussain N, Baghdad A. A Wide and Tri-band Flexible Antennas with Independently Controllable Notch Bands for Sub-6-GHz Communication System. Radioengineering. 2020;29(1).
5. Jin G, Deng C, Yang J, Xu Y, Liao S. A new differentially-fed frequency reconfigurable antenna for WLAN and sub-6GHz 5G applications. IEEE Access. 2019;7:56539-46.
6. Feng G, Guo C, Ding J, editors. Frequency-reconfigurable slot antenna using metasurface. 2018 International Conference on Microwave and Millimeter Wave Technology (ICMMT); 2018: IEEE.
7. Zhao X, Riaz S. A dual-band frequency reconfigurable MIMO patch-slot antenna based on reconfigurable microstrip feedline. IEEE Access. 2018;6:41450-7.
8. Saraswat K, Harish AR. Flexible dual-band dual-polarised CPW-fed monopole antenna with discrete-frequency reconfigurability. IET Microwaves, Antennas & Propagation. 2019;13(12):2053-60.
9. Abbas A, Hussain N, Jeong M-J, Park J, Shin KS, Kim T, et al. A rectangular notch-band UWB antenna with controllable notched bandwidth and centre frequency. Sensors. 2020;20(3):777.
10. Awan WA, Hussain N, Le TT. Ultra-thin flexible fractal antenna for 2.45 GHz application with wideband harmonic rejection. AEU-International Journal of Electronics and Communications. 2019;110:152851.
11. Tütüncü B, Kösem M. Substrate analysis on the design of wide-band antenna for sub-6 GHz 5G communication. Wireless Personal Communications. 2022;125(2):1523-35.
12. Ali H, Ren X-C, Bari I, Bashir MA, Hashmi AM, Khan MA, et al. Four-port MIMO antenna system for 5G n79 band RF devices. Electronics. 2021;11(1):35.
13. Kiani SH, Altaf A, Anjum MR, Afridi S, Arain ZA, Anwar S, et al. MIMO antenna system for modern 5G handheld devices with healthcare and high rate delivery. Sensors. 2021;21(21):7415.
14. Hasan MM, Islam MT, Samsuzzaman M, Baharuddin MH, Soliman MS, Alzamil A, et al. Gain and isolation enhancement of a wideband MIMO antenna using metasurface for 5G sub-6 GHz communication systems. Scientific reports. 2022;12(1):9433.
15. Ahmad I, Dildar H, Khan WUR, Shah SAA, Ullah S, Ullah S, et al. Design and Experimental Analysis of Multiband Compound Reconfigurable 5G Antenna for Sub-6 GHz Wireless Applications. Wireless Communications and Mobile Computing. 2021;2021(1):5588105. https://doi.org/10.1155/2021/5588105
16. Ahmad I, Khan WUR, Dildar H, Ullah S, Ullah S, Mufti N, et al. A pentaband compound reconfigurable antenna for 5G and multi-standard sub-6GHz wireless applications. Electronics. 2021;10(20):2526.
17. Shehata REA, Elboushi A, Hindy M, Elmekati H. Metamaterial inspired LPDA MIMO array for upper band 5G applications. International Journal of RF and Microwave Computer-Aided Engineering. 2022;32(8):e23212.
18. Govardhani I, Narayana MV, Navya A, Venkatesh A, Spurjeon SC, Venkat SS, et al. Design of high directional crossed dipole antenna with metallic sheets for UHF and VHF applications. International Journal of Engineering & Technology. 2017;7(1.5):42-50. https://doi.org/10.14419/ijet.v7i1.5.9120
19. Imamdi G, Narayan MV, Navya A, Roja A. Reflector array antenna design at millimetric (mm) band for on the move applications. ARPN Journal of Engineering and Applied Sciences. 2018;13(1):352-9. https://doi.org/arpn.13.1.2018
20. Immadi G, Narayana MV, Navya A, Varma CA, Reddy AA, Deepika AM, et al. Analysis of substrate integrated frequency selective surface antenna for IoT applications. Indonesian Journal of Electrical Engineering and Computer Science. 2020;18(2):875-81. http://doi.org/10.11591/ijeecs.v18.i2.pp875-881
21. Reddy KH, Narayana MV, Immadi G, Satyanarayana P, Rajkamal K, Navya A. A Low-Profile Electrically Small Antenna with a Circular Slot for Global Positioning System Applications. Progress In Electromagnetics Research C. 2023;133. 10.2528/PIERC23021601
22. Rao LN, Immadi G, Narayana MV, Navya A, Madhuri AS, Rajkamal K. A compact multiband hybrid rectangular DRA for wireless applications. Progress In Electromagnetics Research Letters. 2024;117:89-96. 10.2528/PIERL23111804
23. Majji NK, Madhavareddy VN, Immadi G, Ambati N, Aovuthu SM. Analysis of a compact electrically small antenna with SRR for RFID applications. Engineering, Technology & Applied Science Research. 2024;14(1):12457-63. https://doi.org/10.48084/etasr.6418
24. Kumar MN, Narayana MV, Immadi G, Satyanarayana P, Navya A. Analysis of a low-profile, dual band patch antenna for wireless applications. AIMS Electronics & Electrical Engineering. 2023;7(2). 10.3934/electreng.2023010
25. Majji NK, Madhavareddy VN, Immadi G, Ambati N. A low-profile electrically small serrated rectangular patch antenna for RFID applications. Engineering, Technology & Applied Science Research. 2024;14(2):13611-6. https://doi.org/10.48084/etasr.6989
26. Narayana MV, Immadi G, Navya A, Swathi MV, Nikhitha M, Vineetha B, et al. Analysis of a quad port dual band MIMO antenna for sub-6 GHz applications. Progress In Electromagnetics Research B. 2024;105:137-51. 10.2528/PIERB24021504
27. Immadi G, Narayana MV, Navya A, Madhuri AS, Krishna BV, Gopi MVS. Analysis of a triple band MIMO antenna for sub-6 GHz applications. Progress In Electromagnetics Research B. 2024;107:47-62. 10.2528/PIERB24032802

28. Pappula. TPSKKL. Design and Optimization of High-gain Series and Parallel-fed Array Antennas for Enhanced Gain and Front-to-back Ratio in X-Band Applications. International Journal of Engineering Transactions C: Aspects. 2024;37(3):546-55. 10.5829/ije.2024.37.03c.12
29. Soltan A, Neshati M. Design and Development of High Gain, Low Profile and Circularly Polarized Cavitybacked Slot Antennas Using High-order Modes of Square Shaped Substrtae Integrated Waveguide Resonator. International Journal of Engineering. 2017;30(12):1840-7. 10.5829/ije.2017.30.12c.04
30. Khatami SA, Meiguni J, Elahi AA-e, Rezaei P. Compact via-coupling fed monopulse antenna with orthogonal tracking capability in radiation pattern. IEEE Antennas and Wireless Propagation Letters. 2020;19(8):1443-6. 10.1109/LAWP.2020.3005023
31. Kumar H, Kumar G. Broadband monopulse microstrip antenna array for X-band monopulse tracking. IET Microwaves, Antennas & Propagation. 2018;12(13):2109-14. 10.1049/ietmap.2018.5332
32. Lamul tree S PM, Kunkritthanachai P, Phong charoenpanich C. . Design of a Circular Patch Antenna with Parasitic Elements for 5G Applications. International Journal of Engineering Transactions C: Aspects. 2023;36(9):1686-94. 10.5829/ije.2023.36.09c.13
33. Fakharian M. A wideband fractal planar monopole antenna with a thin slot on radiating stub for radio frequency energy harvesting applications. International Journal of Engineering, Transactions B: Applications 2020;33(11):2181-7. 10.5829/IJE.2020.33.11B.08
34. Balanis CA. Balanis' Advanced Engineering Electromagnetics: John Wiley & Sons; 2024.
35. Sreelakshmi K, Rao GS, Kumar M. A compact grounded asymmetric coplanar strip-fed flexible multiband reconfigurable antenna for wireless applications. IEEE Access. 2020;8:194497-507. 10.1109/ACCESS.2020.3033502
36. Lavuri NR, Immadi G, Narayana MV. A compact hybrid dielectric resonator antenna for multiband in wireless applications. International Journal of Speech Technology. 2021;24:737-46.
37. Nageswara Rao L, Govardhani I, editors. A Novel Stacked Multilayer Antenna for ISM Band Applications. Soft Computing and Signal Processing: Proceedings of 2nd ICSCSP 2019 2; 2020: Springer.
38. Rao LN, Ramesh B, editors. A compact hybrid cylindrical dielectric resonator antenna for WLAN applications. 2017 International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS); 2017: IEEE. 10.1109/ICECDS.2017.8390089
39. Rao LN, editor Design of dual band dielectric resonator antenna with slot for WLAN applications. 2017 IEEE International Conference on Power, Control, Signals and Instrumentation Engineering (ICPCSI); 2017: IEEE. 10.1109/ICPCSI.2017.83921

Persian Abstract

چکیده

یک آنتن چاپی L شکل با قابلیت تنظیم مجدد فرکانس پایین که در باند فرکانس مایکروویو کار می کند در این مقاله ارائه شده است. آنتن پیشنهادی بر روی مواد FR4 با δ 0.02، گذردهی نسبی ٤.٤ و ضخامت ١.٦ میلی متر ساخته شده است. دیود پین HSCH 3486 بین خط تغذیه و ساختار L شکل برای سوئیچینگ قرار داده شده است. آنتن پیشنهادی در فرکانس‌های ۳.۵ گیگاهرتز و ٦.٦ گیگاهرتز طنین انداز است و پهنای باند امپدانس ۰.۹ گیگاهرتز و ۳.۵ گیگاهرتز را ارائه می‌کند. نسبت موج ایستاده ولتاژ آنتن در هر دو فرکانس تشدید کمتر از ۱.۵ است. راندمان آنتن طراحی شده ۸۷ درصد و بهره ۳ دسی بل آنتن ٤.٦١ دسی بل است. آنتن پیشنهادی با استفاده از ابزار روش المان محدود Ansoft HFSS v13 شبیه‌سازی شده و نتایج شبیه‌سازی شده به صورت تجربی تایید می‌شوند. با توجه به اندازه جمع و جور آن، آنتن پیشنهادی می تواند برای برنامه های ارتباطی ماهواره ای باند G-sub-6GHz۵ و ISM استفاده شود.