J. Integr. Sci. Technol. 2022, 10(3), 189-192 Article

Journal of Integrated
SCIENCE & TECHNOLOGY

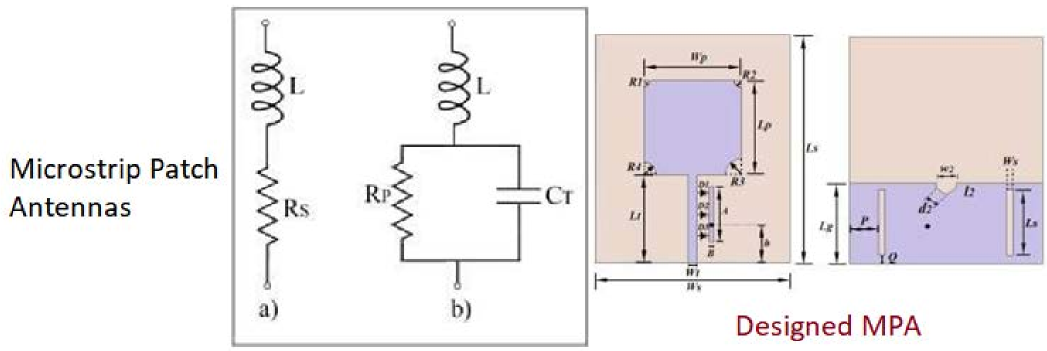
Multiband frequency switchable Microstrip antenna design for satellite application

Keshav Dutt,[1*] Dharmanshu Singh Sodha[2]

[1]National Institute of Technology Srinagar, Hazratbal, Jammu and Kashmir 190006. India. [2]Malaviya National institute of Technology, Jawaharlal Nehru Nagar Marg, Jaipur, 302017. Rajasthan, India.

Received on: 25-May-2022, Accepted and Published on: 31-Aug-2022

ABSTRACT



This article illustrates a novel PIN diode-based small microstrip multiband reconfigurable antenna design. Three frequencies, 4.85GHz, 10.04GHz, and 15.09GHz, are resonant with the proposed design. These bands cover the roughly equivalent C band (4-8GHz), X band (8-12GHz), and Ku band (12-18GHz) microwave frequency bands. The PIN diodes are then added to this antenna to enable reconfigurability. A novel reconfigurability technique is put forth to address the difficulties associated with multiband operation. In close proximity to the microstrip line, the three pin diodes are sorted to ground with parasitic for each of the three bands. The parasitic element is connected to a particular PIN diode microstrip line that, when turned ON, for single frequency band. The scattering parameters loss plots analyzed with far field radiation pattern along with smith chart.

Keywords: PIN diodes, C-band, X-band, Ku-band, frequency Switchable, antenna design, circular antenna.

INTRODUCTION

Microstrip patch antennas (MPAs) are a popular component of contemporary wireless communication systems, and demand for these systems has risen dramatically in recent years.[1] MPAs are lightweight planar antennas that are very simple to construct. In contemporary wireless communication systems, it is commonly employed.[2] The MPAs, however, have significant limitations due to their limited bandwidth, making them unsuitable for many contemporary wireless communication systems.[1]

Future technologies will benefit greatly from the capacity to operate at multiple frequency bands while keeping the physical dimensions of the antenna constant.[2] Additionally, reconfigurable antennas have drawn a lot of interest in recent years[3] because of their several significant benefits, including their adaptability, high performance,[4] and multipurpose roles.[5] Reconfigurable antennas provide a high degree of separation between several operating bands.[9,11] Due to its lightweight design, low fabrication cost, compact construction, and simple RF device integration, MPAs are frequently utilized for reconfigurability.[6]

With reconfigurable antennas, the system can be used for a multitude of applications at the user's discretion while only requiring a single physical antenna.[7]

There are four distinct divisions that can be made for the reconfigurable antennas. The category in electrical reconfiguration antenna using PIN-diodes, RF-MEMS, and varactor diodes. The optical switches also use to control antenna switching parameters. In this case, optical operation is used to control the optical switches. Third place in this group goes to Substrate Reconfigurable Antennas, which may alter the substrate's components (such ferrite, liquid crystals, etc.). Physically altering the antenna's radiating components makes these antennas the last in this categorization.[8] The PIN diode is used in this article to apply the electrically reconfigurable approach.

Corresponding Author: Keshav Dutt
NIT Srinagar, J&K, India.
Email: kdsrathore22@gmail.com

Cite as: *J. Integr. Sci. Technol., 2022, 10(3), 189-192.*

 ISSN: 2321-4635 http://pubs.iscience.in/jist

PIN DIODE

PIN diodes are utilized in this cutting-edge design for switching. The PIN diode's main advantage is that it always behaves at microwave frequencies as a pure resistance. These resistances commonly have values between one and ten thousand.[10] It is also utilized because of its strong nominal isolation.[6]

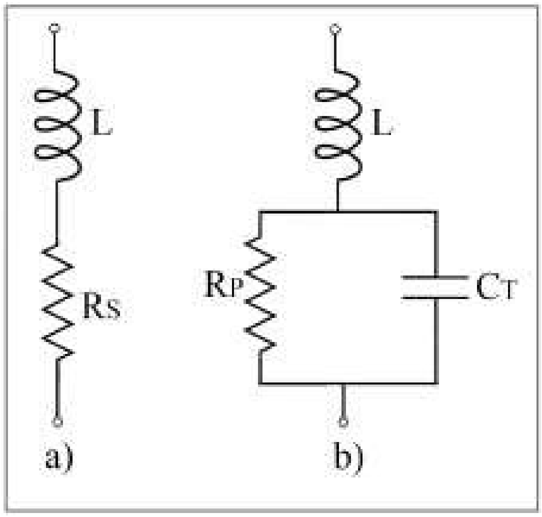
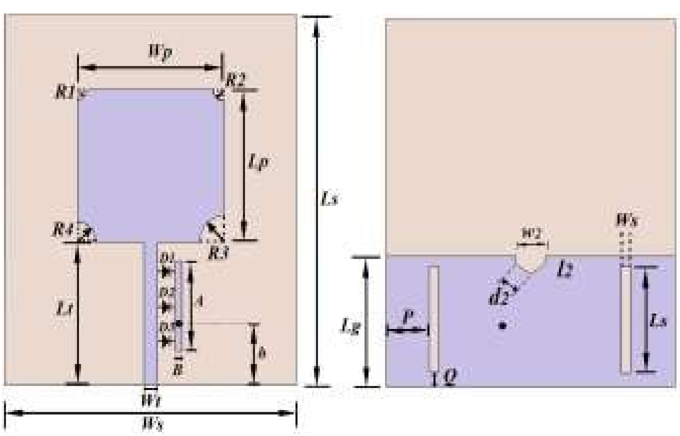


Figure 1. PIN diode equivalent circuits ON state and OFF state conditions.

Figure 1 depicts the PIN diode's analogous circuit. It has an inductance L that is present in both the on and off states. L and RS are connected in series for the ON state. However, in the OFF state, L is connected in series to RP & CT in a parallel configuration.

PROPOSED ANTENNA DESIGN

In Figure 2, the compact structure is displayed. The patch has a rectangular shape and is fed via a 50 impedance microstrip line. It has circular incisions along each of its four corners, extending the surface currents' useful length and lowering return loss.[12]



a) b)

Figure 2. Proposed antenna structure a) Patch b) Ground Plane.

A single parasitic shorted element is used to implement the special reconfigurable approach. The size and placement of this strip were carefully considered in order to preserve the antenna's original features. Three PIN diodes are used to link the strip line to this element. The antenna can be used in a certain band by turning ON a specific PIN diode. From the black dot in Figure 2 a, it is possible to see that the element is shorting to ground.

Figure 2 b illustrates the partial grounding technique utilized at the back side. The initial multiband operation is carried out by two symmetric slots in the ground plane. The following design parameters are use: Ws=30mm, Wp=15mm, R1=1mm, R3=2.5mm, Lt=13.5mm, Lg=12.5mm, Q=1mm, l2=0.75mm,

Ls=10mm, A=7mm, h=6mm, Ls=35mm, Lp=14.5mm, R2=1.1mm, R4=1.9mm, Wt=1.45mm, P=4.5mm, w2=3mm,

d2=1.8mm, Ws=1 mm, and B=0.5mm.

RESULTS AND DISCUSSIONS

CST Studio Suite is used to run the simulation [13]. The antenna is initially intended for use in three separate frequency bands, including 4.85 GHz (4.05-7.10 GHz), 10.04 GHz (9.05-

12 GHz), and 15.09 GHz (13.77-16 GHz). In Figure 3, this is depicted. The S11 value and resonance frequency are displayed, when diodes D1, D2, and D3 are in OFF.

Now, in the first scenario, the copper strip line is connected to the main feeding line when the diode D1 is turned ON. The joint is situated near the top of the strip. Figure4 is observed first band is active and renaining bands are rejected.

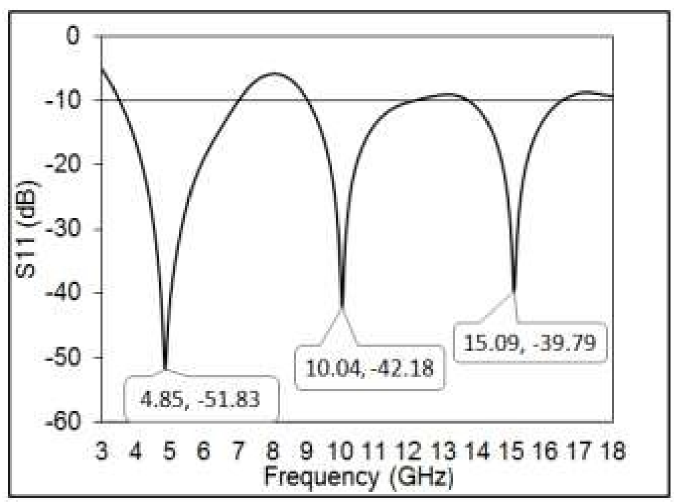


Figure 3. S11 plot of the intended antenna with all of the diodes off.

Similar to the main microstrip feed line is connected to the copper line at the centre, when Diode D2 is ON. enabling the antenna to function at 10.04 GHz (9.05–12 GHz) in the middle band.

The antenna will work for third band, when the main feed line connected to copper microstrip line at bottom end. when D3 is ON condition as shown in Figure 5.

As a result, we can infer that the specific diode is to blame for the antenna operating as the user intended at a certain application.

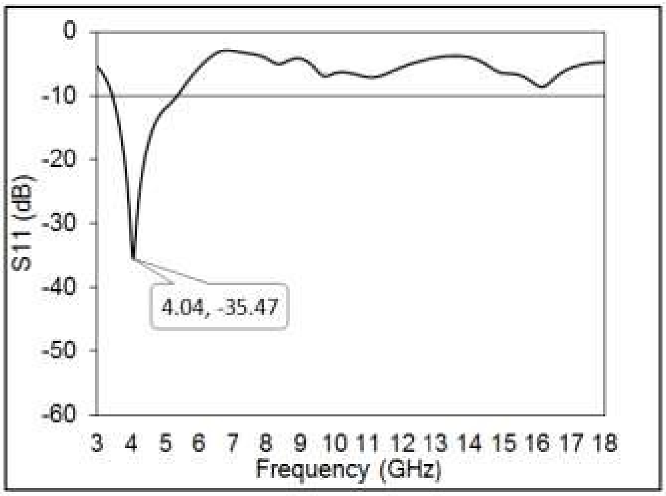


Figure 4. S11 plot, when D1 is in onn condition.

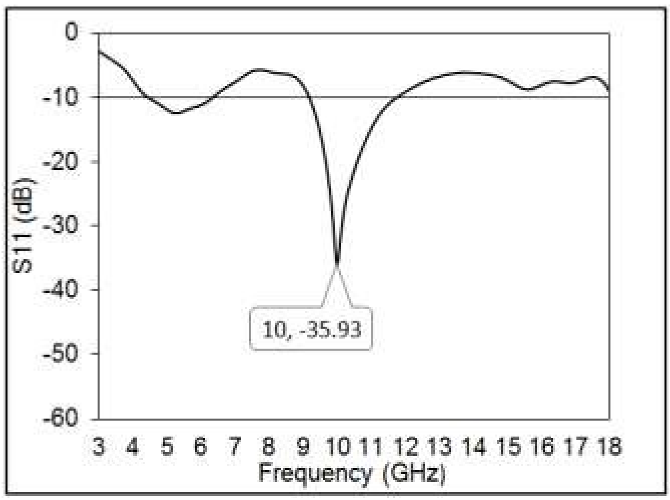


Figure 5. When the diode D2 is ON, the S11 plot of the intended antenna.

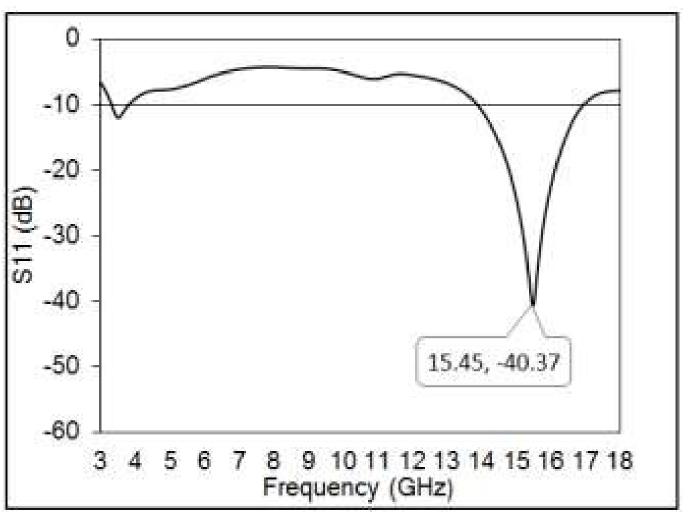


Figure 6. When the diode D3 is ON, the S11 plot of the intended antenna.

Figure 7 displays the combined plot of Total radiation efficiency and Directivity for the entire frequency range. It has been noted that all three bands' efficiency is high. Furthermore, the Directivity in dB is displayed. In this case, all three bands receive the desired directivity value.

The smith chart depiction provides the clearest understanding of the antenna's impedance matching characteristics. The suggested antenna is depicted in the same way in Figure 8. Microstrip line with a 50 impedance is used for feeding the patch. The feed line impedance matching with antenna should in order to deliver power to the patch as efficiently as possible. The reflected power is virtually zero and the supplied power is almost communicated if perfect matching takes place. As can be seen from the following chart as shown in Figure 8, the normalized impedance of microstrip feed line is equal to 1 and it is approx. real for all band when all diodes are on condition and little part are imaginary.[14-20]

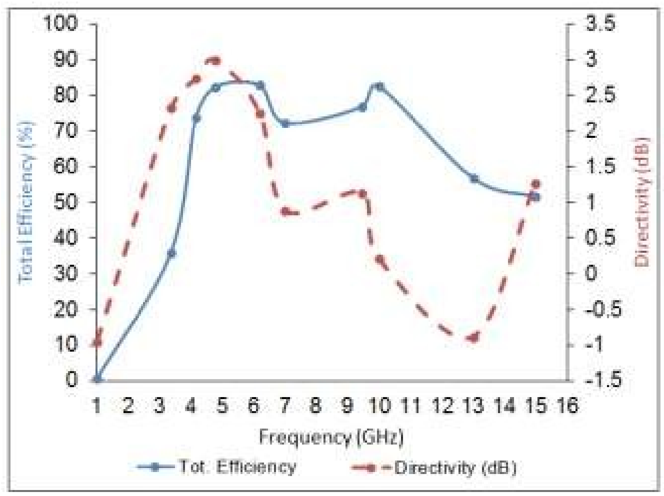


Figure 7. combined plot of directivity and total efficiency versus frequency.

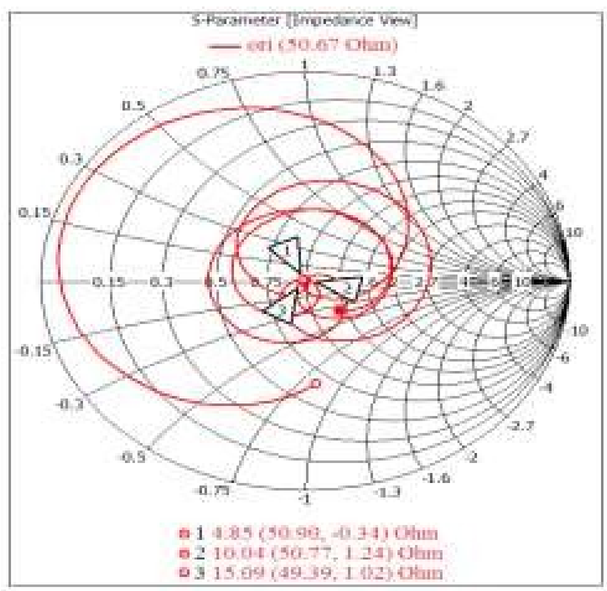


Figure 8. Smith Chart of the proposed antenna.

Table 1. Performance Of Proposed Antenna.

	Resonance frequency (GHz)	Returnloss (dB)	Radiation Directivity (dB)	Bandwidthat (-10dB) (GHz)
D1ON	4.02	-35.46	3.23	1.93
D2ON	10.1	-35.91	1.46	2.57
D3ON	15.44	-40.34	1.18	3.12
All Diodesare Off	4.84	-51.82	2.98	3.04
	10.0	-42.14	1.20	2.94
	15.01	-39.72	1.26	2.22

Conclusion

Simulating the intended antenna was successful. PIN diodes have been used to switch the three bands with adequate isolation. The 50 characteristic impedance strip line exactly matches the three bands. Additionally, the bands have adequate bandwidth for all three instances. The switching procedure has a minor impact on directivity and efficiency.

Concflict of Interest

Authors declared no conflict of interest is there for publication of this work.

References

1. S.L.S. Yang, A.A. Kishk, K.F. Lee. Frequency Reconfigurable U-Slot Microstrip Patch Antenna. *Antenna and Wireless Propagation Letters*, **2008**, 7, 127-129.
2. S. Muhamud Kayat, M.T. Ali, M.K.M. Salleh. A Reconfigurable Microstrip Antenna with a Slotted Patch at Dual Frequency. *8th International Symposium on Wireless Communication Systems.* **2011**, 695-699.
3. Z. Faiza, M. T. Ali, S. Subahir and A.L. Yusof. Design of Reconfigurable Dual-Band E-Shaped Microstrip Patch Antenna. *International Conference onComputer and Communication Engineering (ICCCE 2012).* **2012**, 113-117.
4. H.A. Majid, M.K.A. Rahim, M.R. Hamid, N.A. Murad, M.F. Ismail. Frequency-Reconfigurable Microstrip Patch-Slot Antenna. IEEE *Antenna and Wireless Propagation Letters*, **2013**, 12, 218-220.
5. N. Malathi, A. A.D., S. Chithrakkumar, et al. Digital sensors for detecting toxic gas leaks. *J. Mater. Nanosci.* **2022**, 9 (2), 147–152.
6. A. Mansoul, H. Kimouche. A Simple Frequency Reconfigurable Microstrip Patch Antenna for Wireless Communications. *8th International Workshop on Systems, Signal Processing and their Applications.* **2013**.
7. N. Ramli, M.T. Ali, A.L. Yusof, S.M. Kayat, A.A.A. Aziz. PIN Diode Switches for Frequency-Reconfigurable Stacked Patch Microstrip Array Antenna using Aperture-Coupled Technique. *Asia-Pacific Microwave Conference Proceedings*. **2013**, 1052-1054.
8. R. Marie, C. Cleetus, T. Sudha. Design and Analysis of a Frequency and Pattern Reconfigurable Microstrip Patch Antenna for Wireless Applications. *International Conference on Control Communication and Computing (ICCC)*. **2013**, 287-291.
9. Jeen-Sheen Row and Jia-Fu Tsai. Frequency-Reconfigurable Microstrip Patch Antennas with Circular Polarization. IEEE *Antenna and Wireless Propagation Letters*, **2014**, 13.
10. A. Bhattacharya, R. Jyoti. Frequency Reconfigurable Patch Antenna Using PIN Diode at X-Band. IEEE *2nd International Conference on Recent Trends in Information Systems (ReTIS)*, **2015**.
11. I.B. Sharma, F.L. Lohar, A. Deshpande, R.K. Maddila, M.M. Sharma. A Quad Band Frequency Reconfigurable Monopole Antenna with Shorted Stubs for Microwave Applications. *3rd URSI Regional Conference on Radio Science (URSI-RCRS)*, 1-4 March, **2017**.
12. R.N. Akhtar, A.A. Deshpande, A.K. Kureshi. Defected Top diamond shaped Patch Antenna for Multi-band operations. *J. Integr. Sci. Technol.* **2021**, 9 (2), 98–106.
13. CST Microwave Studio, User's Manual, 2017, www.cst.com.
14. Y. Allbadi, H.I. Hamd, I.H. Qaddoori.. Radiation effect of M-slot patch antenna for wireless application. *Bulletin of Electrical Engineering and Informatics*, **2022**, 11(5).
15. S.K. Dargar, A. Gupta, M. Sabir, A. Lakshmi. Design of U-Slot Microstrip Patch Antenna for Wireless Applications. In *2022 Second International Conference on Advances in Electrical, Computing, Communication and Sustainable Technologies* (ICAECT) **2022** (pp. 1-5). IEEE.
16. V. Mathur, P. Tyagi, A. Anjali, G. Jaiman, D. Nehra. Circular Slotted Microstrip Patch Antenna for Wireless Applications. In *2022 IEEE 7th International conference for Convergence in Technology (I2CT)* **2022** (pp. 1-4). IEEE.
17. K. Haripriya, A.S. Harini, M. Naveena, K. Anusha, D. Mohanageetha. Dual Slot Multiband Microstrip Patch Antenna for Wireless Applications. In 2022 8th International Conference on Advanced Computing and Communication Systems (ICACCS) **2022** (Vol. 1, pp. 1597-1601). IEEE.
18. M. Mujawar, T. Gunasekaran. Multiband Slot Microstrip Antenna for Wireless Applications. In Smart Antennas (pp. 23-34). **2022**. Springer, Cham.
19. S. Kannadhasan, R. Nagarajan, K. Venusamy. Miniaturized Dual Band U-Shaped Structure Microstrip Patch Antenna for Wireless Applications. In 2022 IEEE Wireless Antenna and Microwave Symposium (WAMS) (pp. 1-4). **2022**. IEEE.
20. N. Bisht, P.K. Malik. Adoption of Microstrip Antenna to Multiple Input Multiple Output Microstrip Antenna for Wireless Applications: A Review. *Recent Innovations in Computing*, **2022**, 189-206.