DESIGN OF FREQUENCY RECONFIGURABLE SLOTTED ANTENNA BY USING TEACHING LEARNING BASED OPTIMIZATION (TLBO) ALGORITHM

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Abstract— The idea of reconfigurability has been linked to the existing single usable microstrip patch antennas by making the necessary geometrical structure alterations through exchanging and displaying the antenna, especially when considering resounding frequency, polarization, and impedance bandwidth. A small, straightforward antenna with a microstrip line feed and a frequency reconfiguration mechanism is constructed and evaluated. A Slotted Microstrip Patch Antenna with a UWB frequency reconfigurable is designed for cognitive radio applications. A microstrip patch, feed, and ground are all constructed in accordance with the parameter values in this specific design. In order to provide frequency reconfigurability, two diodes are positioned on a patch's rectangular slot. Applications for the proposed antenna include Ku-band (12.7–13.80) GHz and X-band satellite communications (8.05–9.75) GHz. It has been demonstrated that altering switch configurations can modify the antenna's operating frequency without altering the emission pattern. Finally, this suggested UWB Frequency Reconfigurable Slotted Antenna was to be developed using the Teaching Learning Based Optimization (TLBO) algorithm.

Keywords — Frequency Reconfigurable, Ultra wide band, PIN Diodes, Cognitive Radio, TLBO

I. Overview

Frequency Reconfigurable receiving wires are made up of radio wire components that can independently change their physical configuration, altering the reception apparatus's recurrence characteristics while maintaining constant radiation conduct. Reconfiguring one normal for the receiving wire eventually affects the other parameters, such as design variety and recurrence reaction, and vice versa. One of the main obstacles to the advancement of reconfigurable reception apparatuses is this relationship. This type of reconfiguration includes multiband or possibly stop band characteristics, coordinated impedance switching or relocating a resounding recurrence.

These adjustable reception devices fall into two kinds; they are constantly swapped out. In order to work at specific and isolated recurrence groups, exchanged tunable recurrence reconfigurable radio wires consider unmistakably changing instruments. The degree of variations in the electrical length that allow for tunability over different recurrence groups and the techniques to achieve these changes are where the two types truly differ from one another. The most popular approach to achieve recurrence reconfigurability involves implementing a transmitter adjustment reconfiguration system to the microstrip receiving wires to change the successful electrical length, which allegedly changes working recurrence.

The working recurrence is mostly determined by the antenna's electrical length. In the most well-known straight dipole radio wire, for instance, when the receiving wire is half a wavelength long and has an unidirectional radiation example fixed on and ordinary to the dipole pivot, it resounds at its initial principal mode. The radio wire needs to be cut precisely to the half wavelength at the new recurrence with a similar radiation design in the unlikely event that one wants to operate the receiving device at greater recurrence. Frequency reconfigurable radio wires have the advantage of limiting the amount of general reception equipment by allowing the absolute receiving wire volume to be reused through their unique operating modes.

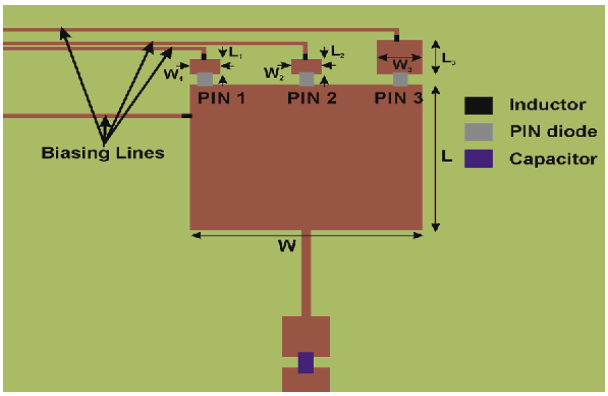

Figure 1: Frequency Reconfigurable Antenna

II. Teaching Learning Based Optimization

Teaching Learning Based Optimization is an optimization technique based on population that mimics the teaching-learning dynamics of an actual classroom. Students (learners) and an instructor make up the algorithm's components. This algorithm is divided into two stages: the teacher phase, where students learn from the teacher, and the learner phase, where students learn from other students. Student grades are seen as algorithmic outputs that rely on the caliber of the instructor. Conversely, new wireless communication systems have recently focused on frequency reconfigurable antennas, or FRAs. The elimination of the need for multiple antennas in a single system, the ability to tune an antenna for various uses, the resolution of microstrip antennas' narrow band, the suppression of unwanted signals and noises from non-operating bands, and sufficiency for cognitive radio applications are some significant benefits of frequency reconfigurable antennas. Due to their inherent design complexity in comparison to more conventional varieties, optimization algorithms are quite helpful when designing such antennas. This work aimed to bring the Teaching Learning Based Optimization (TLBO) method to the design of frequency reconfigurable antennas and enhance its performance by using a chaos system.

III. Antenna Design with modes of operation

The planning and analysis of a straightforward and conservative antenna with a frequency reconfiguration mechanism and microstrip line feed is done. For cognitive radio applications, an opening microstrip fix receiving wire with a customizable UWB frequency is designed. This specific design includes feed and ground as well as a microstrip patch that is created based on the parameter values. This design uses two diodes in a rectangular slot on the patch to achieve frequency reconfigurability. Figure 2 is a representation of the planned patch antenna's geometry and dimensions, while Figure 3 shows the completed antenna. The antenna is etched into a single layer of inexpensive FR4 substrate that has a thickness of 1.6 mm and a dielectric constant of 4.4.The suggested antenna features a complete ground plane and a straightforward patch. The usual micro strip patch antenna design formulae were used to determine the patch's dimensions. The center frequency of the antenna's design was 6.4 GHz. High gain can be achieved by reducing the patch dimensions by truncating the corners of microstrip patches with varying dimensions.

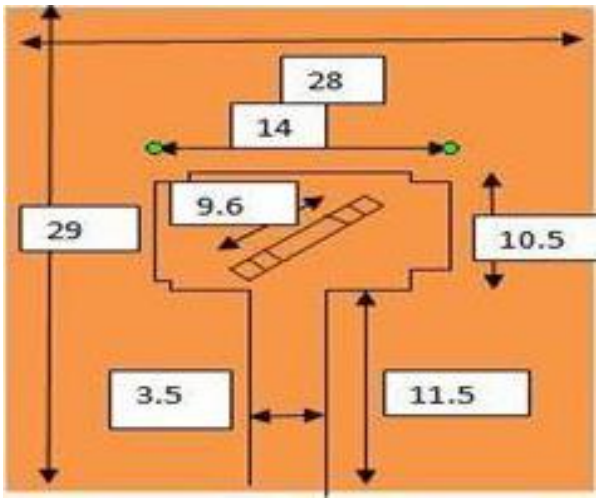

Figure 2: Proposed Slotted Patch Design

Two PIN diodes are positioned on a rectangular slot to achieve frequency reconfigurability. The recurrence of activity of the radio wires is altered by the variation of opening lengths; for this reason, PIN diodes are used in spaces with varying lengths. As lumped RLC organizes, PIN diodes are shown. In the proposed plans, HFND4005 PIN diodes are used. The PIN diode arrangement has an obstruction value (R=4KΩ) while it is in the forward bias (ON) state and a capacitance (C=0.017pf) when it is in the switch bias (OFF) state.

Figure 3: Fabricated Microstrip Patch Antenna

The 1.5 x 0.75 mm diodes are positioned on the corners of the rectangular slot that is 45 degrees rotated along the z axis. Since HPND4005 pin diodes are widely

accessible and best suited for fabrication, they are utilized. Pin diode switching allows for frequency range reconfiguration. Thus, the antenna may flip between several frequency ranges. Table 1 shows the geometrical parameters of the suggested microstrip patch antenna. Figure 4 depicts the biasing configuration of the manufactured antenna.

Table 1: Geometrical Parameters of Proposed Design.

Parameter	Value (mm)
Substrate Length (Ls)	29
Substrate Width (Ws)	28
Substrate Height	1.6
Patch Length (L)	10.5
Patch Width (W)	14
Microstrip Feed Width	3.5

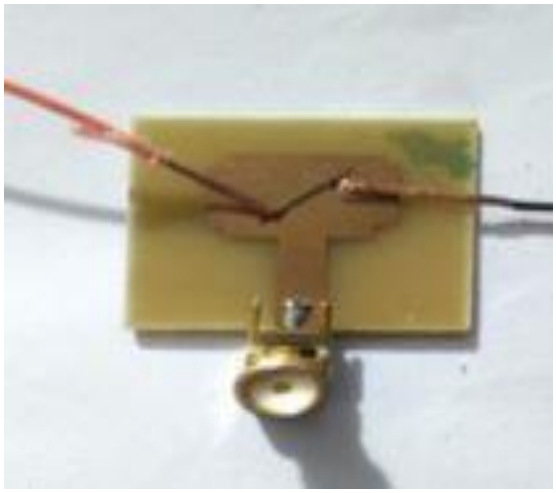

Figure 4: Biasing setup of Fabricated Reconfigurable Antenna

IV. Simulated & Experimental Results

The antenna is made on a 1.6mm thick FR4 substrate with a misfortune digression of tan δ=0.027. Reception apparatus is made using a typical photolithography process. Both single band and double band modes of operation are possible with the specified antenna. Figure 5 shows the return losses curve for both simulated and experimental values, and Figure 6 shows the voltage standing wave ratio (VSWR) curve for both simulated and experimental values. The optimal recurrence range is less than 2 and more than 10dB, respectively. Return losses will be more significant than 10dB in the double band configuration (maximum of 16.2dB) between 12.7GHz and 13.8GHz. 13.2GHz is the thundering frequency (fr) in this double band scenario. A comparison of the two groups in this double band arrangement reveals that this resounding recurrence band has some elevated esteems.

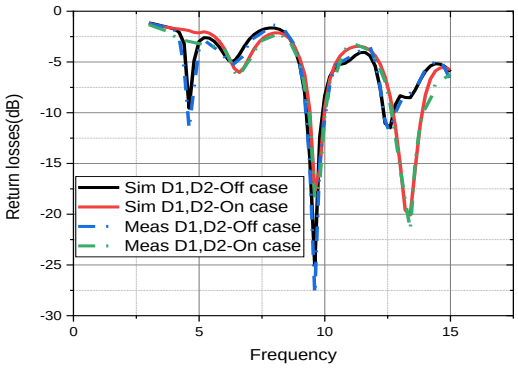

Figure 5: Simulated & Measured S11 of Proposed Antenna when (Diode D1,D2- ON,OFF cases)

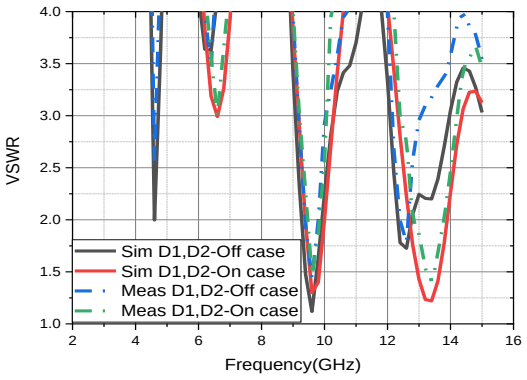

Figure 6: Simulated & Measured VSWR of Proposed Antenna when (Diode D1,D2- ON,OFF cases)

The single band configuration will function exceptionally well between 9.19GHz and 9.76GHz. The 2D radiation patterns and 3D polar plots for the D1&D2 on and off cases are shown in Figs. 7 and 8. Four switching states—00,01,10,11—are included in this suggested design when all cases are taken into account, with the 00,11 cases accounting for both diodes D1, D2-On and Off situations. In these states, single and double bands are present.

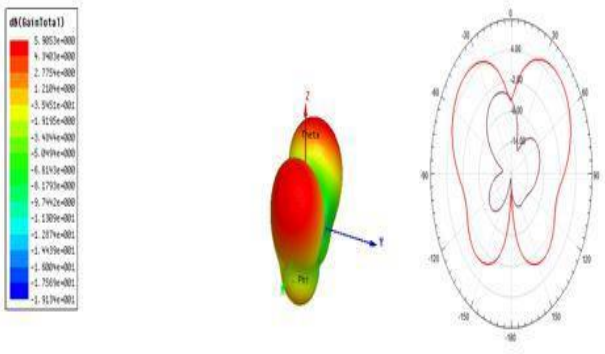

Figure 7: 3D polar plot & 2D radiation pattern of Proposed design when Diode D1,D2-OFF case.

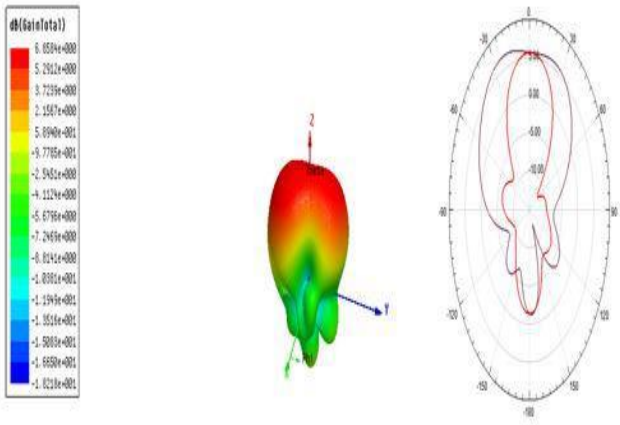

Figure 8: 3D polar plot & 2D radiation pattern of Proposed design when Diode D1,D2-ON case

V. Summary

Table 2 summarizes the suggested frequency reconfigurable slotted patch antenna with two diodes to achieve reconfigurability.

Diode State (D1,D2)	Bandwidth (GHz) & mode of operation	Resonant Frequency (GHz)	Return Loss (S11)	VSWR
0,0	(9.19 —9.76) (Single band)	9.54	-26.4	1.2
1,1	(12.70-13.80) (9.31 -9.80) (Double band	13.4	-20.34	1.4

Table 2: Summary of the Proposed Reconfigurable Antenna (2 Diodes).

VI. CONCLUSION

Reconfigurable antennas must function in a dynamic environment while maintaining favorable electromagnetic properties. Implementing a switching mechanism introduces the idea of reconfigurability. In order to adjust the electrical length of the antenna, which in turn regulates the operational frequency, switching technology is employed utilizing PIN diodes to modify the physical geometry. A frequency-reconfigurable slotted printed antenna with two diodes that function at separate operating bands is proposed in this paper. The antenna is suitable for Ku-band applications (12.7–13.80 GHz) and X-band satellite communications (8.05–9.75 GHz). For commercial applications such laptops and mobile phones that need dynamic band switching, the suggested antennas would be a good fit.

REFERENCES

[1] Subrahmanyam Grandhi Venkata, and Sri Rama Krishna Kalva, "UWB Monopole Antenna with Dual Notched Bands Verified by Characteristic Mode Analysis (CMA)," *Progress In Electromagnetics Research C*, Vol.121,39-48,2022. doi:10.2528/ PIER C 22051105

[2] N. Tasouji, J. Nourinia, C. Ghobadi and F. Tofigh, "A Novel Printed UWB Slot Antenna With Reconfigurable Band-Notch Characteristics," in *IEEE Antennas and Wireless Propagation Letters*, vol. 12, pp. 922-925, 2013, doi: 10.1109/LAWP.2013.2273452.

[3] H. Boudaghi, M. N. Azarmanesh and M. Mehranpour, "A frequency-reconfigurable monopole antenna using switchable slotted ground structure", *IEEE Antennas Wireless Propag. Lett.*, vol. 11, pp. 655-658, 2012.

[4] R. Jothi Chitra and V. Nagarajan, "Frequency reconfigurable antenna using pin diode", Communication Twentieth National Conference, *2014.*

[5] Nishant Kumar, P. Ananda Raju and Santanu Kumar Behera, "Frequency reconfigurable microstrip antenna for cognitive radio applications", *Communication and Signal Processing (ICSSP) International Conference*, 2015.

[6] T. Prem Bosco, P. Rohit, M. Satyanarayana and K. Anitha, "Design of Circularly Polarized E-Slot Aperture Coupled Dielectric Resonator Antenna for Wideband Applications," *2023 International Conference on Microwave, Optical, and Communication Engineering (ICMOCE)*, Bhubaneswar, India, 2023, pp. 1-5, doi: 10.1109 / ICMOCE57812.2023.10165708.

[7] A. Mansoul, F. Ghanem, Mohamad Rijal Hamid and Mohamed Trabelsi, "A selective frequency-reconfigurable antenna for cognitive radio

applications", *IEEE Antennas and Wireless Propagation Letters*, vol. 13, pp. 515-518, 2014.

[8] Christos G. Christodoulou, Youssef Tawk, Steven A. Lane and Scott R. Erwin, "Reconfigurable antennas for wireless and spaceapplications", *Proceedings of the IEEE*, vol. 100, pp. 2250-226, 2012.

[9] P. Rohit, A. Datta and M. Satyanarayana, "Design of High Gain Metasurface Antennas using Hybrid Atomic Orbital Search and Human Mental Search Algorithm for IoT Application," *2023 10th International Conference on Signal Processing and Integrated Networks (SPIN)*, Noida, India, 2023, pp. 20-24, doi: 10.1109/SPIN57001.2023.10116841.

[10] S. Yang, C. Zhang, H. K. Pan, A. E. Fathy and V. K. Nair, "Frequency-reconfigurable antennas for multiradiowireless platforms", *IEEE Microw. Mag.*, vol. 10, no. 1, pp. 66-83, Feb. 2009.

[11]Rohit, P., Datta, A. and Satyanarayana, M. (2024), Optimized Graph Sample and Aggregate-Attention Network-Based High Gain Meta Surface Antenna Design for IoT Application. Int J Commun Syst e6043. https: // doi.org /10.1002/ dac.6043

[12] G. P. Jin, D. L. Zhang and R. L. Li, "Optically controlled reconfigurable antenna for cognitive radio applications", *Electron. Lett.*, vol. 47, no. 17, pp. 948-950, Aug. 2011.

[13] A. Tariq and H. Ghafouri-Shiraz, "Frequency-reconfigurable monopole antennas", *IEEE Trans. Antennas Propag.*, vol. 60, no. 1, pp. 44-50, Jan. 2012.

[14] J. Kiriazi, H. Ghali, H. Ragaie and H. Haddara, "Reconfigurable dual-band dipole antenna on silicon using series MEMS switches", *Proc. IEEE AP-S Int. Symp.*, vol. 1, pp. 403-406, 2003.

[15] P. Rohit, A. Datta and M. S. Narayana, "Design of Circular Microstrip Antenna with Metasurface Superstate for Wifi Applications," *2024 IEEE Wireless Antenna and Microwave Symposium (WAMS)*, Visakhapatnam, India, 2024, pp. 1-5, doi: 10.1109 / WAMS 59642. 2024. 10527949.

[16] Z. Shi, R. Zheng, J. Ding and C. Guo, "A novel pattern-reconfigurable antenna using switched printed elements", *IEEE Antennas Wireless Propag. Lett*, vol. 11, pp. 100-1103, 2012.

[17] P.Rohit, K.Anitha, Dr.M.Satyanarayana, Development Of Small Disk Microstrip Inegrated Defected Ground Structure (Dgs) Antenna Using Particle Swarm Optimization, vol. 13, no. no.6, p. 2, 2023.

[18] Y. Zhou, R. S. Adve and S. V. Hum, "Design and evaluation of pattern reconfigurable antenna for MIMO applications", *IEEE Trans. Antennas Propag*, vol. 62, no. 3, pp. 1084-1092, Mar. 2014.

[19] J.L. Freeman, B.J. Lamberty and G.S. Andrews, "Optoelectronically reconfigurable monopole antenna", *IET Electron. Lett.*, vol. 28, no. 16, pp. 1502-1503, July 1992

[20] J. S. Row and C. W. Tsai, "Pattern reconfigurable antenna array with circular polarization", *IEEE Trans. Antennas Propag*, vol. 64, no. 4, pp. 1525-1530, Apr. 2016.

[21] L. Ge, Y. Li, J. Wang and C. Y. D. Sim, "A low-profile reconfigurable cavity-backed slot antenna with frequency polarization and radiation pattern agility", *IEEE Transactions on Antennas and Propagation*, vol. 65, no. 5, pp. 2182-2189, May 2017.

[22] U. Musa *et al*., "Recent Advancement of Wearable Reconfigurable Antenna Technologies: A Review," in *IEEE Access*, vol. 10, pp. 121831-121863, 2022, doi: 10.1109/ACCESS.2022.3222782.

[23] Datla, Rajitha & Karunakar, G. (2024). CAIWO based DRR usage in Antenna Array Synthesis. Journal of Systems Engineering and Electronics. 34. 51-53.

[24] Penki, Rohit & Datla, Rajitha & Vemulapati, Pavani & Thota, Jyothi Kumari. (2024). DESIGN OF UWB FRACTAL MONOPOLE ANTENNA BY USING DIFFERENTIAL EVOLUTION ALGORITHM. Kronika. 24. 125-135.

[25] Vemulapati, Pavani & Thota, Jyothi Kumari & Datla, Rajitha & Penki, Rohit. (2024). Design of Quasi Modified Rectangular Patch Antenna by using Ultra Wideband (UWB) Frequency for Radar Communications. Journal of Systems Engineering and Electronics. 34. 515-518.

[26] Penki, Rohit & Datla, Rajitha & Vemulapati, Pavani & Thota, Jyothi Kumari. (2024). FUTURE TRENDS IN DESIGN OF METAMATERIAL PRINTED ANTENNAS BY USING 5G APPLICATIONS. Fangzhi Gaoxiao Jichukexue Xuebao. 24. 133-145. 10.37896/JBSV24.8/3304.

[27] Penki, Rohit & Vemulapati, Pavani & Thota, Jyothi Kumari & Satyanarayana, Moturi. (2024). DESIGN OF FRACTAL WIDEBAND ANTENNA BY USING WIND DRIVEN OPTIMIZATION. Volume-11. 435-440.

[28] Penki, Rohit & Datta, Amlan & Satyanarayana, Moturi. (2024). DESIGN OF RECTANGULAR METASURFACE ANTENNA FOR WIRELESS COMMUNICATION DEVICES. Journal of Systems Engineering and Electronics. 34. 519-523.

[29] Penki, Rohit & Koppala, Anitha & Satyanarayana, Moturi. (2023). DESIGN OF UWB MONOPOLE BASED FRACTAL BINARY TREE ANTENNA FOR WIRELESS COMMUNICATION DEVICES. 10. 118-122.

[30]D. Rajitha, G. Karunakar, IWO based pattern synthesis of LAA based on tunning of parameters, Materials Today: Proceedings, Volume 33, Part 7, 2020, Pages 4349-4352, ISSN 2214 7853 ,https: // doi. org / 10. 1016 / j . matpr. 2020. 07. 577.

[31] R. K. Kushwaha, M. S. A. Ansari, J. V. N. Ramesh and P. Rohit, "MIMO Optimized Algorithm to Develop the Energy Efficiency Underwater," *2023 International Conference on New Frontiers in Communication, Automation, Management and Security (ICCAMS)*, Bangalore, India, 2023, pp. 1-5, doi: 10.1109/ICCAMS60113.2023.10525874.