www.revistageintec.net
ISSN: 2237-0722
revista GEINTEC
Gestão, Inovação e Tecnologias

Reduction in Return Loss of a Novel Reconfigurable Antenna at 3.4 GHz by FR4 Substrate Using Double PIN Diodes

Nandi Srividya[1]; R. Swaminathan[2*]

[1]Research Scholar, Department of Electronics and Communication Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamil Nadu, India.

[1]nandisrividya17@saveetha.com

[2*]Project Guide, Department of Electronics and Communication Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamil Nadu India.

[2*]swaminathanr.sse@saveetha.com

Abstract

Aim: *The main objective of the project is to reduce the return loss of a reconfigurable antenna at 3.4 GHz by using FR4 substrate with Double PIN diodes.* ***Materials and Methods:*** *Two diode configurations of single PIN diode and Four diodes configuration of double PIN diodes are used with a sample size of 6.* ***Results****: From HFSS simulation software Return Loss(-30.2dB) and VSWR (1.10) of Reconfigurable Monopole antenna is improved by FR4 substrate using Double PIN diodes. Attained significance ratio(P=0.05) in statistical analysis.* ***Conclusion:*** *Double PIN diode of a reconfigurable Monopole antenna performs well (Return Loss is reduced by -7dB) when compared with a single PIN diode of a reconfigurable Monopole antenna.*

Key-words: Monopole Antenna, PIN Diode, WLAN, WIFI, Return Loss, VSWR, FR4 Substrate, Novel Reconfigurable Monopole Antenna, Antenna Design.

1. Introduction

The research is about reducing the return loss of reconfigurable monopole antennas using a double PIN diode(Shah et al. 2019). The importance of this project is the need for low return loss antennas for satellite communication(Kumar, Kishan Kumar, and Prasanth 2015). The reconfigurable antennas are used in current portable devices WLAN and WIFI applications (Dwivedy, Behera, and Mishra 2015), (Zarin et al. 2019).

Antenna plays a major role in many portable devices for the purpose of point to point communication with increased VSWR and reduced Return loss (Unru, Ashcherbagin, and Arashtaev 2019). Because of its advantages such as a simple design, small dimensions, and ease of manufacturing, the monopole antenna is favoured in reconfigurable antenna design (Palsokar and Lahudkar 2017).Many techniques are available to reduce the return Loss by adding the PIN diodes(Reddy et al. 2015).The proposed reconfigurable Monopole antennas with better return loss can be used for various applications (Shah et al. 2019).The use of different shapes such as E-shape monopole, B-shape monopole, and other techniques are used to design multi-band antennas for wireless communication applications(Thao et al. 2015).

Previously our team has a rich experience in working on various research projects across multiple disciplines (Sathish and Karthick 2020; Varghese, Ramesh, and Veeraiyan 2019; S. R. Samuel, Acharya, and Rao 2020; Venu, Raju, and Subramani 2019; M. S. Samuel et al. 2019; Venu, Subramani, and Raju 2019; Mehta et al. 2019; Sharma et al. 2019; Malli Sureshbabu et al. 2019; Krishnaswamy et al. 2020; Muthukrishnan et al. 2020; Gheena and Ezhilarasan 2019; Vignesh et al. 2019; Ke et al. 2019; Vijayakumar Jain et al. 2019; Jose, Ajitha, and Subbaiyan 2020). Now the growing trend in this area motivated us to pursue this project.

The unanswered problem is the reduction in Return Loss of Reconfigurable Monopole antenna for high frequencies. The purpose of this project is to reduce the return loss of reconfigurable monopole antennas using PIN diodes with FR4 substrate at 3.4 GHz frequency for different diode configurations.

2. Materials and Methods

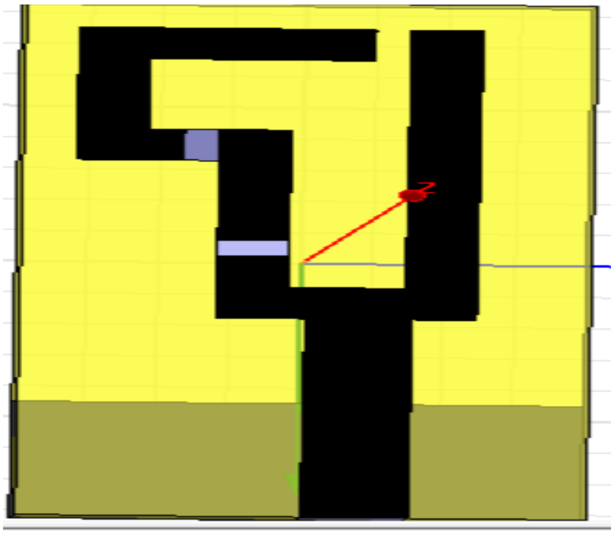
This study was conducted at Antenna and Wave propagation lab in Saveetha School of engineering. The study was based on Return Loss reduction of Reconfigurable Monopole antenna using Double PIN diodes comparing with a Reconfigurable antenna using Single PIN diode, Sample size was calculated by using previous study Results (Shoukat et al. 2016) using clincalc.com by keeping alpha error-threshold by 0.05, 95% confidence interval, Power 80%. In this study we compare the Parameters like Return Loss, VSWR by taking 6 samples, one sample group by using previous literature (Shoukat et al. 2016).

The first group contains 2 samples of Single PIN diodes, while the second group contains 4 samples of double PIN diodes,

Design of Reconfigurable Monopole Antenna Using Double PIN diode

The antenna was designed **(Fig.1)** on FR4 dielectric substrate with a thickness of 1.6mm and a dielectric constant of 4.4 and simulated in HFSS Software. The dimensions of the microstrip antenna are calculated using following formulae mentioned in equations (1-7):

Fig. 1 - Design of Reconfigurable Monopole antenna(21.8mm,50mm) with dielectric constant εr=4.4 using Double PIN diodes in HFSS



Width of the patch is calculated as follows:

$$Patch\ width = \frac{c}{2f\sqrt{(\varepsilon_r+1)}/\sqrt{2}} \quad (1)$$

Effective Dielectric Constant (εe) of antenna is calculated as:

$$\varepsilon e = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1 + \frac{12h}{Patch\ width}\right]^{-\left(\frac{1}{2}\right)} \quad (2)$$

Effective length of patch is calculated as:

$$\text{Eff. Length } Le = \frac{c}{2f\sqrt{\varepsilon}} \quad (3)$$

Length of extension ΔL is the additional length due to the fringing fields and it is calculated as:

$$\Delta L = \frac{0.412h\,(\varepsilon e+0.3)\left(\frac{Patch\ width}{h}+0.264\right)}{(\varepsilon e-0.258)\left(\frac{Patch\ width}{h}+0.8\right)} \quad (4)$$

Actual length of patch is calculated using:

$$Patch\ length = Le - 2\Delta L \quad (5)$$

Proposed antenna Width and Length of patch calculated from the above equations are:

$$\text{Patch Width } (W1 = 2.5mm, W2 = 4mm, W3 = 8.5mm, W4 = 2mm) = 21.8mm \quad (6)$$

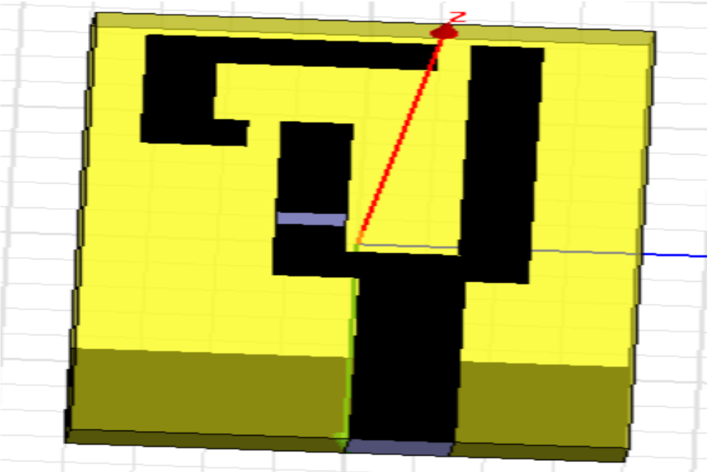
Patch Length $(L1 = 12.8mm, L2 = 10.1mm, L3 = 8.5mm, L4 = 18.6mm) = 50mm$ (7)

The antenna is simulated by using the above design equations in HFSS Software.

Design of Reconfigurable Monopole Antenna Using Single PIN Diode

Single PIN diode is inserted at one of the slots in a patch of a Reconfigurable Monopole antenna design **(Fig.2)** where we need to change the resistance values(0.1uohms,1000Gohms) for ON and OFF conditions of a PIN diode switch.

Fig. 2 - Design of Reconfigurable Monopole antenna(21.8mm,50mm) with dielectric constant εr=4.4 using Single PIN diode in HFSS.



The 8th Generation Intel core processor(up to 8MB cache) was used in the testing setup configuration to design the antenna in the HFSS software. The antenna is designed at a frequency of (3.4GHz) and is used as the testing input. The antenna can be constructed by defining the variables(L,W,H,F) and assigning the boundaries and lumped ports of the antenna using HFSS software. The frequency sweep is applied to the configuration to validate and to obtain the results.

Data Collected by Making the ON and OFF Conditions of PIN Diodes

Statistical analysis: SPSS version 21 was used for statistical comparison of parameters like Return Loss and VSWR**.** The independent sample test and group statistics are calculated using SPSS software. The width of the substrate, height of the substrate and the length of the antenna are independent variables, while return loss and VSWR are dependent variables

ISSN: 2237-0722
Vol. 11 No. 4 (2021)
Received: 18.05.2021 – Accepted: 10.06.2021

3. Results

Table 1 - Return Loss(dB) and VSWR Values obtained for Proposed Reconfigurable Monopole Antennas using Double PIN Diodes(Diode ON and OFF Conditions) with FR4 Substrate

D1	D2	Return Loss	VSWR
ON	ON	-30.2	1.10
ON	OFF	-17.18	1.4
OFF	ON	-17.18	1.4
OFF	OFF	-18.05	1.32

Table 2: Return Loss(dB) and VSWR values obtained for reconfigurable monopole antennas using single PIN diodes (Diode ON and OFF conditions with FR4 Substrate.

D1	Return Loss(dB)	VSWR
ON	-23.8	1.09
OFF	-16.7	1.02

Table 3 - Return Loss(dB) and VSWR Values obtained for Proposed Reconfigurable Monopole Antennas using Double PIN Diodes(Diode ON and OFF Conditions) with FR4 Substrate

D1	D2	Return Loss	VSWR
ON	ON	-30.2	1.10
ON	OFF	-17.18	1.4
OFF	ON	-17.18	1.4
OFF	OFF	-18.05	1.32

Table 4 - Independent Sample T-test Result Reveals that (P=0.05) which shows Statistically significant when Compared for Return Loss between single PIN Diode and Double PIN Diode

Independent Sample Test

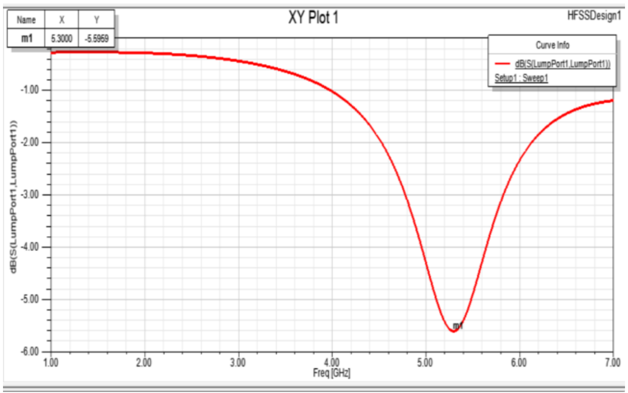
Independent Samples Test										
Groups		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Return Loss	Equal variances assumed	.088	.052663	-2.38	4	0.75	-12.63000	5.28825	-27.31254	2.05254
	Equal variances not assumed			-2.20	1.753	.178	-12.63000	5.73131	-41.36584	16.10584
VSWR	Equal variances assumed	.984	.03567	-2.29	4	.083	-.22500	.09803	-.4917	0.4717
	Equal variances not assumed			-3.09	3.993	.037	-.22500	0.7274	-.42711	-1.2299

Table 5 - Group statistics results reveal Mean value of Return Loss and standard deviation for Double PIN Diodes

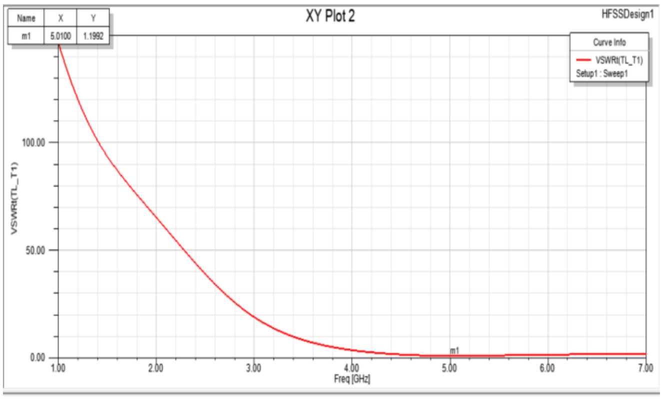
Group	N	Mean	Standard deviation	Standard Error mean
Return loss Single PIN diode	2	-31.7500	7.0036	4.95000
Double PIN diodes	4	-19.1200	5.77768	2.88848

The Results of Reconfigurable monopole antenna by using Double PIN diodes are obtained. The minimum Return Loss and VSWR obtained is represented in **Fig.3** & **Fig.4** . It shows the variations of Return Loss and VSWR for ON and OFF conditions. The amount of loss of power is minimum when the diode is ON and the power loss is maximum when the diode is OFF. VSWR is minimum when the diode is ON and Maximum when the diode is OFF.

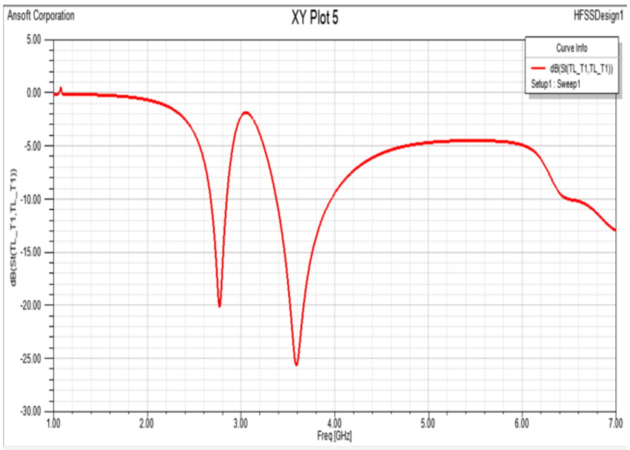
Fig. 3 - Single PIN Diode (a) Return loss Vs Frequency, when Diode is ON. (b) VSWR Vs Frequency, when DIODE is ON. (c) Return loss Vs Frequency, when DIODE is OFF. (d) VSWR Vs Frequency, when DIODE is OFF.



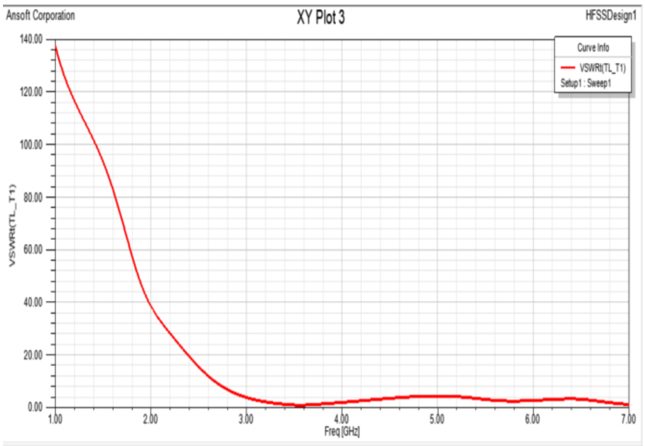
(a)



(b)



(c)



(d)

From **Fig. 3(a)**, It was observed that the Return Loss Vs Frequency at 3.4GHz is plotted and the minimum return loss for Reconfigurable monopole antenna using Single PIN diode is -23.8dB, when the Diode is ON.

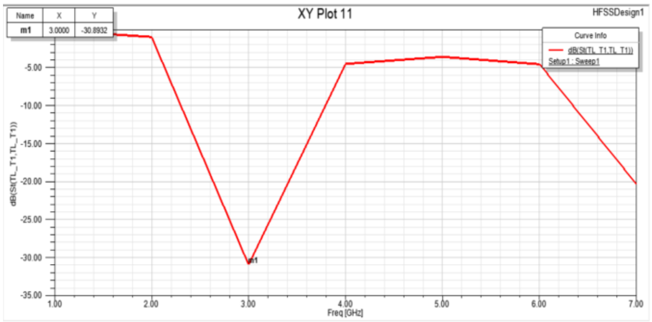
From **Fig. 3(b),** The VSWR against Frequency graph is plotted using Single PIN diode and the minimum VSWR at 3.4 GHz is 1.09, When the Diode is ON.

From **Fig. 3(c)**, Return Loss Vs Frequency graph is plotted using Single PIN diode and the minimum Return Loss at 3.4 GHz is -16.7dB, When the Diode is OFF.

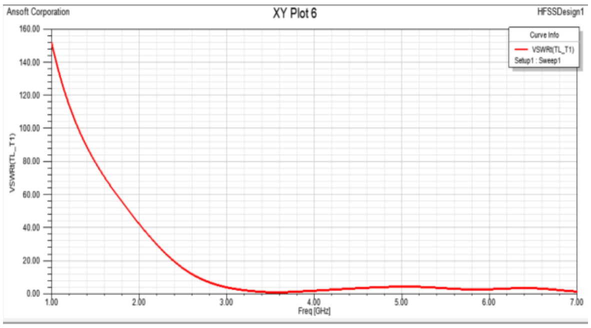
ISSN: 2237-0722
Vol. 11 No. 4 (2021)
Received: 18.05.2021 – Accepted: 10.06.2021

From **Fig. 3(d)**, The VSWR against Frequency graph is plotted using Single PIN diode and the minimum VSWR at 3.4 GHz is 1.02, When the Diode is OFF.

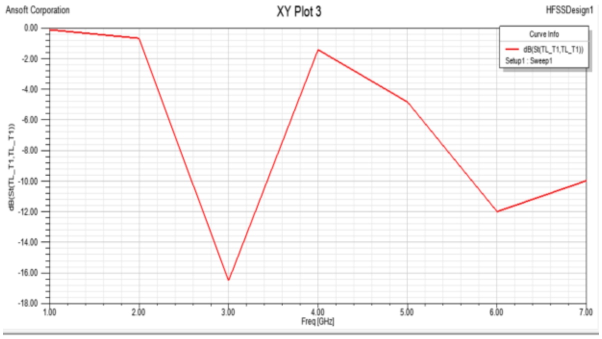
Fig. 4 - Double PIN diodes (a) Return loss Vs Frequency, when the DIODES (D1= D2 =ON). (b) VSWR Vs Frequency, when the DIODES (D1= D2 =ON). (c) Return loss Vs Frequency, when the DIODES (D1= ON, D2 =OFF). (d) VSWR Vs Frequency, when the DIODES (D1= ON, D2 =OFF). (e) Return loss Vs Frequency, when the DIODES (D1= OFF, D2 =ON). (f) VSWR Vs Frequency, when the DIODES (D1= ON, D2 =OFF). (g) Return loss Vs Frequency, when the DIODES (D1= D2 =OFF). (h) VSWR Vs Frequency, when the DIODES (D1= D2 =OFF).



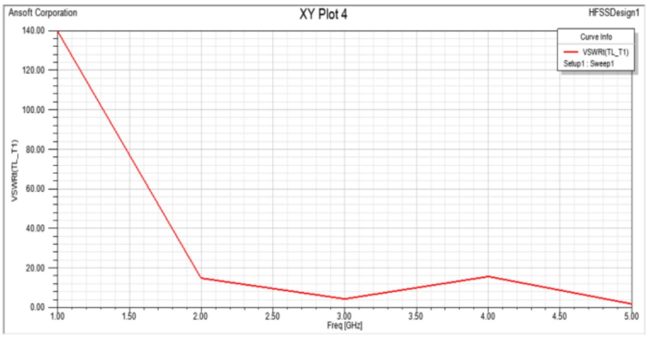
(a)



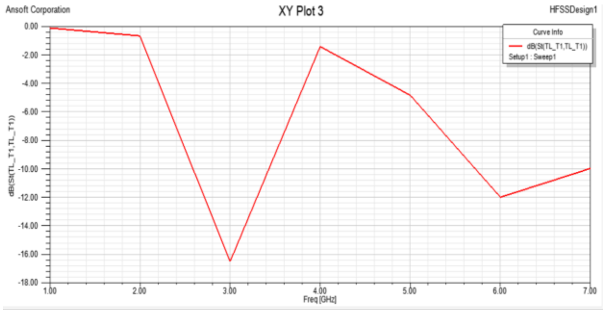
(b)



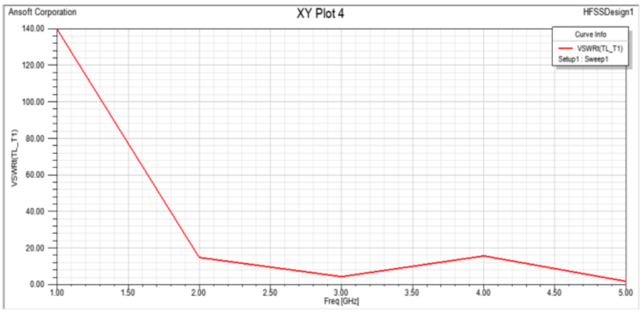
(c)



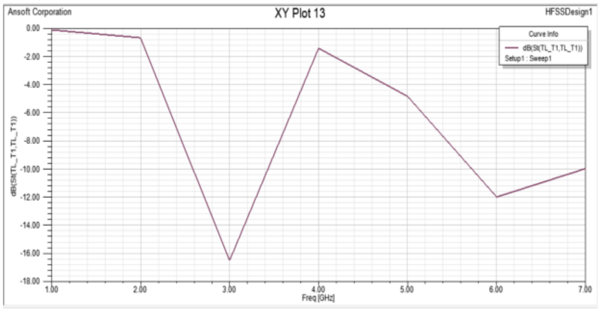
(d)



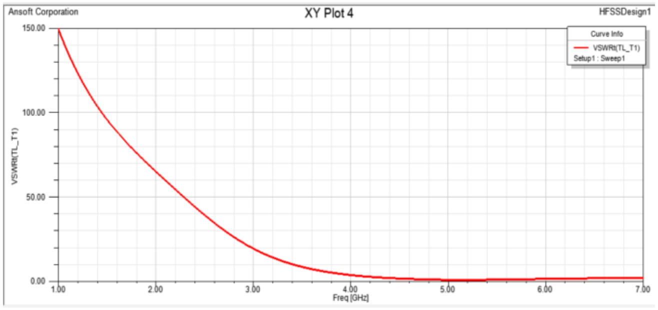
(e)



(f)



(g)



(h)

ISSN: 2237-0722
Vol. 11 No. 4 (2021)
Received: 18.05.2021 – Accepted: 10.06.2021

From **Fig.4(a)**, it was observed that the Return Loss Vs Frequency graph is plotted using a Double PIN diode and the minimum Return Loss at 3.4GHz is -30.2dB, when both the Diodes are ON.

From **Fig.4(b)**, The VSWR against Frequency graph is plotted using Double PIN diodes and the minimum VSWR at 3.4 GHz is 1.10, When both the Diodes are ON.

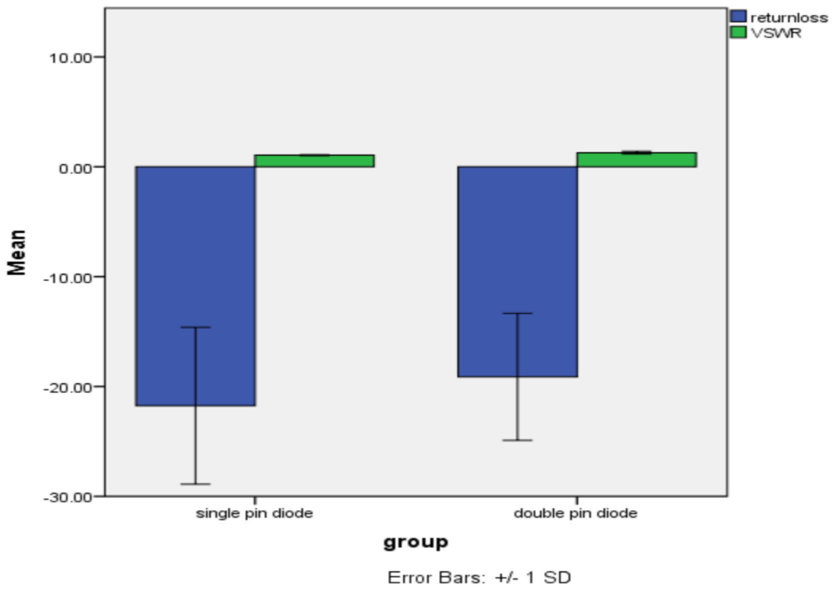
From **Fig.[4(c),4(e)]**, it was observed that the Return Loss Vs Frequency graph is plotted using a Double PIN diode and the minimum Return Loss at 3.4GHz is -17.8dB, when the Diodes are D1=ON, D2=OFF (or) D1=OFF, D2=ON.

From **Fig.[4(d),4(f)]**, The VSWR against Frequency graph is plotted using Double PIN diodes and the minimum VSWR at 3.4 GHz is 1.4, When the Diodes are D1=ON, D2=OFF (or) D1=OFF, D2=ON.

From **Fig.4(g)**, it was observed that the Return Loss Vs Frequency graph is plotted using a Double PIN diode and the minimum Return Loss at 3.4GHz is -18.5dB, when both the Diodes are OFF.

From **Fig.4(f)**, The VSWR against Frequency graph is plotted using Double PIN diodes and the minimum VSWR at 3.4 GHz is 1.32, When both the Diodes are OFF.

Fig. 5 - Bar Graph Representing the Return loss and VSWR comparison between Single PIN diode and Double PIN diode with Independent sample T-test means=+/-1SD. It shows that the Return loss and VSWR is better for Double PIN diodes than the single PIN Diode



4. Discussions

Based on the above results, the performance of the Reconfigurable monopole antenna appears to be better for Double PIN Diodes than Single PIN diode and it is statistically significant (P=0.05).

ISSN: 2237-0722
Vol. 11 No. 4 (2021)
Received: 18.05.2021 – Accepted: 10.06.2021

For Double PIN diode monopole antenna, the obtained Return loss at 3.4GHz is -30.2dB and the VSWR 1.10 when both the Diodes are ON, and the Return Loss is -17.8dB, VSWR is 1.4 for the diodes D1 in ON and D2 in OFF Condition. When both the diodes are in OFF condition the Return Loss -18.05dB, VSWR is 1.32. These values of Return Loss and VSWR appears to be better compared to the Reconfigurable monopole antenna for polarization diversity (Sung 2018) in which Return Loss=-19.2dB is lesser value due to the usage of jean substrate and polarisation Reconfigurable structure. VSWR is better for the proposed reconfigurable monopole antenna compared to Hybrid Reconfigurable antenna ("Design and Analysis of a Reconfigurable Antenna for Dual Band ISM Medical and Wi-Fi Applications" 2019) due to the usage of frequency reconfigurable property of the antenna. The ReturnLoss is better compared to the Optimization of A Beam Reconfigurable Antenna using PIN Diodes (Luis, De Luis, and de Flaviis 2009) in which Return Loss= -16.4dB is lesser value due to beam reconfigurable property of an antenna. The Return Loss is better when compared with a reconfigurable slot ring antenna using PIN diodes (Shirazi, Li, and Gong 2015) with a Return Loss -27.8dBis lesser due to lesser frequency with slot ring. There is no opposing citation and the design done based on the above procedure appears to be good.

Our institution is passionate about high quality evidence based research and has excelled in various fields ((Vijayashree Priyadharsini 2019; Ezhilarasan, Apoorva, and Ashok Vardhan 2019; Ramesh et al. 2018; Mathew et al. 2020; Sridharan et al. 2019; Pc, Marimuthu, and Devadoss 2018; Ramadurai et al. 2019). We hope this study adds to this rich legacy.

The double PIN diode configuration to reduce the return loss of a reconfigurable monopole antenna is used to support only dual band operation.

Usage of reconfigurable monopole Antenna with reduction in Return Loss for quad band and penta band applications.

5. Conclusion

Reconfigurable Monopole antennas using Double PIN diodes appear to be better (Return Loss is reduced by -7dB) when compared with a single PIN diode. It operates in a dual band mode (WLAN, WIFI) when all the switches are in ON condition, and Single band when it is in OFF condition.

Declarations

Conflict of interests: No conflict of interest in this manuscript.

Authors Contributions

Author NS was involved in data collection, data analysis, manuscript writing. Author SWR was involved in conceptualization, data royalization and critical review of manuscript.

Acknowledgement

We would like to acknowledge Saveetha School of Engineering for providing all of the research information needed for this study, as well as their ongoing assistance and support.

Funding: We thank the following organizations for providing financial support that enabled us to complete the study.

1. Vajenthura Microwave Products Pvt.Ltd
2. Saveetha University
3. Saveetha Institute of Medical and Technical Sciences
4. Saveetha School of engineering.

References

"Design and Analysis of a Reconfigurable Antenna for Dual Band ISM Medical and Wi-Fi Applications." 2019. *Volume-8 Issue-10, August 2019, Regular Issue*. https://doi.org/10.35940/ijitee.j9794.0881019.

Dwivedy, Biswajit, Santanu Kumar Behera, and Debasis Mishra. 2015. "Frequency Reconfigurable Monopole Antenna Loaded with Dielectric Resonator." *2015 International Conference on Microwave, Optical and Communication Engineering (ICMOCE)*. https://doi.org/10.1109/icmoce.2015.7489677.

Ezhilarasan, Devaraj, Velluru S. Apoorva, and Nandhigam Ashok Vardhan. 2019. "Syzygium Cumini Extract Induced Reactive Oxygen Species-Mediated Apoptosis in Human Oral Squamous Carcinoma Cells." *Journal of Oral Pathology & Medicine: Official Publication of the International Association of Oral Pathologists and the American Academy of Oral Pathology* 48 (2): 115–21.

Gheena, S., and D. Ezhilarasan. 2019. "Syringic Acid Triggers Reactive Oxygen Species-Mediated Cytotoxicity in HepG2 Cells." *Human & Experimental Toxicology* 38 (6): 694–702.

Jose, Jerry, Ajitha, and Haripriya Subbaiyan. 2020. "Different Treatment Modalities Followed by Dental Practitioners for Ellis Class 2 Fracture – A Questionnaire-Based Survey." *The Open Dentistry Journal* 14 (1): 59–65.

Ke, Yang, Mohammed Saleh Al Aboody, Wael Alturaiki, Suliman A. Alsagaby, Faiz Abdulaziz Alfaiz, Vishnu Priya Veeraraghavan, and Suresh Mickymaray. 2019. "Photosynthesized Gold Nanoparticles from Catharanthus Roseus Induces Caspase-Mediated Apoptosis in Cervical Cancer Cells (HeLa)." *Artificial Cells, Nanomedicine, and Biotechnology* 47 (1): 1938–46.

Krishnaswamy, Haribabu, Sivaprakash Muthukrishnan, Sathish Thanikodi, Godwin Arockiaraj Antony, and Vijayan Venkatraman. 2020. "Investigation of Air Conditioning Temperature Variation by Modifying the Structure of Passenger Car Using Computational Fluid Dynamics.” *Thermal Science* 24 (1 Part B): 495–98.

Kumar, K. Kishan, K. Kishan Kumar, and Edward Stephen Prasanth. 2015. “A Novel Design Approach and Simulation of Frequency Reconfigurable Micro Strip Patch Antenna for Wi-Fi, WLAN and GPS Applications.” *2015 International Conference on Robotics, Automation, Control and Embedded Systems (RACE)*. https://doi.org/10.1109/race.2015.7097300.

Luis, Javier R. De, Javier R. De Luis, and Franco de Flaviis. 2009. “A Reconfigurable Dual Frequency Switched Beam Antenna Array and Phase Shifter Using PIN Diodes.” *2009 IEEE Antennas and Propagation Society International Symposium*. https://doi.org/10.1109/aps.2009.5171578.

Malli Sureshbabu, Nivedhitha, Kathiravan Selvarasu, Jayanth Kumar V, Mahalakshmi Nandakumar, and Deepak Selvam. 2019. “Concentrated Growth Factors as an Ingenious Biomaterial in Regeneration of Bony Defects after Periapical Surgery: A Report of Two Cases.” *Case Reports in Dentistry* 2019 (January): 7046203.

Mathew, M.G., S.R. Samuel, A.J. Soni, and K.B. Roopa. 2020. “Evaluation of Adhesion of Streptococcus Mutans, Plaque Accumulation on Zirconia and Stainless Steel Crowns, and Surrounding Gingival Inflammation in Primary ….” *Clinical Oral Investigations*. https://link.springer.com/article/10.1007/s00784-020-03204-9.

Mehta, Meenu, Deeksha, Devesh Tewari, Gaurav Gupta, Rajendra Awasthi, Harjeet Singh, Parijat Pandey, et al. 2019. “Oligonucleotide Therapy: An Emerging Focus Area for Drug Delivery in Chronic Inflammatory Respiratory Diseases.” *Chemico-Biological Interactions* 308 (August): 206–15.

Muthukrishnan, Sivaprakash, Haribabu Krishnaswamy, Sathish Thanikodi, Dinesh Sundaresan, and Vijayan Venkatraman. 2020. “Support Vector Machine for Modelling and Simulation of Heat Exchangers.” *Thermal Science* 24 (1 Part B): 499–503.

Palsokar, A.A., and S.L. Lahudkar. 2017. “Review of Reconfigurable Antennas for LTE, WiMAX and WLAN Application.” *Advanced Electromagnetics*. https://doi.org/10.7716/aem.v6i4.500.

Pc, J., T. Marimuthu, and P. Devadoss. 2018. “Prevalence and Measurement of Anterior Loop of the Mandibular Canal Using CBCT: A Cross Sectional Study.” *Clinical Implant Dentistry and Related Research*. https://europepmc.org/article/med/29624863.

Ramadurai, Neeraja, Deepa Gurunathan, A. Victor Samuel, Emg Subramanian, and Steven J. L. Rodrigues. 2019. “Effectiveness of 2% Articaine as an Anesthetic Agent in Children: Randomized Controlled Trial.” *Clinical Oral Investigations* 23 (9): 3543–50.

Ramesh, Asha, Sheeja Varghese, Nadathur D. Jayakumar, and Sankari Malaiappan. 2018. “Comparative Estimation of Sulfiredoxin Levels between Chronic Periodontitis and Healthy Patients - A Case-Control Study.” *Journal of Periodontology* 89 (10): 1241–48.

Reddy, S.S. Mohan, S.S. Mohan Reddy, P. Mallikarjuna Rao, and B.T.P. Madhav. 2015. “Asymmetric Defected Ground Structured Monopole Antenna for Wideband Communication Systems.” *International Journal on Communications Antenna and Propagation (IRECAP)*. https://doi.org/10.15866/irecap.v5i5.6005.

Samuel, Melvin S., Jayanta Bhattacharya, Sankalp Raj, Needhidasan Santhanam, Hemant Singh, and N. D. Pradeep Singh. 2019. “Efficient Removal of Chromium(VI) from Aqueous Solution Using Chitosan Grafted Graphene Oxide (CS-GO) Nanocomposite.” *International Journal of Biological Macromolecules* 121 (January): 285–92.

Samuel, Srinivasan Raj, Shashidhar Acharya, and Jeevika Chandrasekar Rao. 2020. "School Interventions-Based Prevention of Early-Childhood Caries among 3-5-Year-Old Children from Very Low Socioeconomic Status: Two-Year Randomized Trial." *Journal of Public Health Dentistry* 80 (1): 51–60.

Sathish, T., and S. Karthick. 2020. "Wear Behaviour Analysis on Aluminium Alloy 7050 with Reinforced SiC through Taguchi Approach." *Journal of Japan Research Institute for Advanced Copper-Base Materials and Technologies* 9(3): 3481–87.

Shah, I.A., S. Hayat, A. Basir, M. Zada, S.A.A. Shah, S. Ullah, and S. Ullah. 2019. "Design and Analysis of a Hexa-Band Frequency Reconfigurable Antenna for Wireless Communication." *AEU - International Journal of Electronics and Communications*. https://doi.org/10.1016/j.aeue.2018.10.012.

Sharma, Parvarish, Meenu Mehta, Daljeet Singh Dhanjal, Simran Kaur, Gaurav Gupta, Harjeet Singh, Lakshmi Thangavelu, et al. 2019. "Emerging Trends in the Novel Drug Delivery Approaches for the Treatment of Lung Cancer." *Chemico-Biological Interactions* 309 (August): 108720.

Shirazi, Mahmoud, Tianjiao Li, and Xun Gong. 2015. "A New Design of Reconfigurable Slot-Ring Antenna Using PIN Diodes." *2015 IEEE International Symposium on Antennas and Propagation & USNC/URSI National Radio Science Meeting*. https://doi.org/10.1109/aps.2015.7305524.

Shoukat, Saad, Sadiq Ullah, Sajjad Rahim, Babar Kamal, and Usman Ali. 2016. "Design of a Dual Band Frequency Reconfigurable Patch Antenna for GSM and Wi-Fi Applications." *2016 International Conference on Computing, Electronic and Electrical Engineering (ICE Cube)*. https://doi.org/10.1109/icecube.2016.7495260.

Sridharan, Gokul, Pratibha Ramani, Sangeeta Patankar, and Rajagopalan Vijayaraghavan. 2019. "Evaluation of Salivary Metabolomics in Oral Leukoplakia and Oral Squamous Cell Carcinoma." *Journal of Oral Pathology & Medicine: Official Publication of the International Association of Oral Pathologists and the American Academy of Oral Pathology* 48 (4): 299–306.

Sung, Youngje. 2018. "Dual-Band Reconfigurable Antenna for Polarization Diversity." *International Journal of Antennas and Propagation*. https://doi.org/10.1155/2018/6878607.

Thao, Hoangthi Phuong, Trinh Van Son, Nguyen Van Doai, Nguyen Trong Duc, and Vu Van Yem. 2015. "A Novel Frequency Reconfigurable Monopole Antenna Using PIN Diode for WLAN/WIMAX Applications." *2015 International Conference on Communications, Management and Telecommunications (ComManTel)*. https://doi.org/10.1109/commantel.2015.7394281.

Unru, N.I., E.I. Ashcherbagin, and A.V. Arashtaev. 2019. "Tunable band-stop Resonator and Filter on Microstrip with Defected Structure." *Issues of Radio Electronics*. https://doi.org/10.21778/2218-5453-2019-4-81-83.

Varghese, Sheeja Saji, Asha Ramesh, and Deepak Nallaswamy Veeraiyan. 2019. "Blended Module-Based Teaching in Biostatistics and Research Methodology: A Retrospective Study with Postgraduate Dental Students." *Journal of Dental Education* 83 (4): 445–50.

Venu, Harish, V. Dhana Raju, and Lingesan Subramani. 2019. "Combined Effect of Influence of Nano Additives, Combustion Chamber Geometry and Injection Timing in a DI Diesel Engine Fuelled with Ternary (diesel-Biodiesel-Ethanol) Blends." *Energy* 174 (May): 386–406.

Venu, Harish, Lingesan Subramani, and V. Dhana Raju. 2019. "Emission Reduction in a DI Diesel Engine Using Exhaust Gas Recirculation (EGR) of Palm Biodiesel Blended with TiO2 Nano Additives." *Renewable Energy* 140 (September): 245–63.

Vignesh, R., Ditto Sharmin, C. Vishnu Rekha, Sankar Annamalai, and Parisa Norouzi Baghkomeh. 2019. “Management of Complicated Crown-Root Fracture by Extra-Oral Fragment Reattachment and Intentional Reimplantation with 2 Years Review.” *Contemporary Clinical Dentistry* 10 (2): 397–401.

Vijayakumar Jain, S., M.R. Muthusekhar, M.F. Baig, P. Senthilnathan, S. Loganathan, P.U. Abdul Wahab, M. Madhulakshmi, and Yogaen Vohra. 2019. “Evaluation of Three-Dimensional Changes in Pharyngeal Airway Following Isolated Lefort One Osteotomy for the Correction of Vertical Maxillary Excess: A Prospective Study.” *Journal of Maxillofacial and Oral Surgery* 18 (1): 139–46.

Vijayashree Priyadharsini, Jayaseelan. 2019. “In Silico Validation of the Non-Antibiotic Drugs Acetaminophen and Ibuprofen as Antibacterial Agents against Red Complex Pathogens.” *Journal of Periodontology* 90 (12): 1441–48.

Zarin, Muhammad Tahir, Sayed Sabir Shah, Bakhti Rashad, and Sadiq Ullah. 2019. “A Hexa Band Antenna Having Frequency Reconfigurable Feature for Portable Devices Communication.” *2019 International Conference on Electrical, Communication, and Computer Engineering (ICECCE)*. https://doi.org/10.1109/icecce47252.2019.8940675.