ANTENNA DESIGNS

A PROJECT REPORT

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In partial fulfillment for the award of the degree of

BACHELOR OF ENGINEERING IN ELECTRONICS AND COMMUNICATION ENGINEERING

By

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BONAFIDE CERTIFICATE

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ALURU PRAVEEN

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PART - A

Design and Analysis of With and Without Slot Correlation Circular Patch Antenna Reflection Coefficient at 2.4 GHz

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Keywords:

Reconfigurable antenna, Patch antenna, RT/Duroid 5880mm Substrate material, Reflection coefficient, Innovative slot cut antenna, Antenna design.

ABSTRACT:

Aim: The reflection coefficient of circular patch antenna for with and without slot creations are analyzed for 2.4 GHz by varying the sweep frequency ranging from 1GHz to 3GHz. **Material and methods:** The resonance frequency of with slot antenna (2.4GHz) was compared with without slot creation (2.4GHz) by varying the sweep frequency ranging from 1GHz to 3GHz in the High-frequency structure simulator environment. **Results:** The circular patch without slot reflection coefficient appeared to be higher (-11.5181dB) than with slot reflection coefficient (-10.4445dB). The maximum reflection coefficient without slot creation. **Conclusion:** Within the limits of this study, the without slot of circular patch antenna with the frequency of 2.4GHz offers a good reflection coefficient.

Keywords:

Reconfigurable antenna, Patch antenna, RT/Duroid 5880mm Substrate material, Reflection coefficient, Innovative slot cut antenna, Antenna design.

INTRODUCTION

The circular patch antenna with and without slot creation was designed in the range of 1GHz to 3GHz to enhance the reflection coefficient. Reconfigurable antenna research has gotten a lot of coverage in recent years (Behera et al. 2018),(Cai et al. 2016). Comparing Circular Polarization (CP) and Linear Polarization (LP) is extremely sensitive to some of these parameters (Chen et al. 2018). Parameters can increase manufacturing difficulties and reduce the production yield rate but the resonant antenna with quality factor is high and fading losses due to multipath. Improving the efficiency of signal propagation reliably and saving electricity (Fakharian, Rezaei, and Orouji 2015),(Rajagopalan, Kovitz, and Rahmat-Samii 2014). The Antenna is an electromagnetic device that can transmit and receive radio waves (Yang et al. 2019). It consists of an electronic conductor designed for operating in radiofrequency. The circular patch and coaxial feed point antenna had a wide range of applications in ISM, WLAN band, etc (Hussain, Khan, and Sharawi 2018),(Choukiker and Behera 2017).

The antenna has designed a novel stable gain printed log-periodic circular patch antenna in the frequency range of (1GHz -3GHz) and obtained a reflection coefficient of -10dB (Lee and Sung 2015),(Lu et al. 2017). (Rahmatia et al. 2017), a circular patch antenna for TV applications and circular coaxial feed point antenna working at 2.4GHz for radar applications. The Circular antenna was made of aluminum and iron where the dielectric substrate material used in coaxial feed was RTduroid 5880mm. (Row and Tsai 2014), has designed circular patch antennas for GPS applications and it is designed at an operating frequency of 1.2GHz. (Row and Shih 2012), has designed a circular patch coaxial antenna for ISM band frequency of 2.4GHz that can be used in wifi applications. (Guo, Luk, and Lee 1999),(Babakhani and Sharma 2015), has designed a new slot creation of circular patch at 2.4Ghz frequency for LTE applications.

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 existing polarization reconfigurable antenna works are implemented using diodes and the antenna frequency reflection coefficient decreases. In this proposed work, optimizing the frequency of an antenna is an important parameter that takes into consideration. Here, a comparison of with and without slot creation was carried out for a frequency 2.4GHz. The main aim of the study is to enhance and compare the frequency and reflection coefficient of without slot and innovative slot cut antenna.

MATERIALS AND METHODS

The research was conducted in the Department of Electronics and Communication Engineering at Saveetha School of Engineering, SIMATS, Chennai. In this research work, there are two groups. One group refers to with slot of the circular patch antenna and the other group refers to without slot of the circular patch antenna. The antenna with slot referred to be group 1 and the antenna without slot referred to be group 2. For each group, the sample size is 16. The total sample size of the research work is 32. The Alpha value is 0.05. The Beta value is 0.2, and The G power 0.8. The required samples for the analysis are calculated based on G power calculation (Bcps et al. 2020). The pre-test analysis is found to be 80% for the total sample size of with slot of the circular patch antenna and without slot circular patch antenna.

To simulate the with and without slot of circular patch antenna, the High-frequency structure simulator software 14.version. For group 1, create a slot creation at the top of a circular patch antenna (-45^0), and for group 2, designed a simple circular patch antenna in 3-dimensional coordinate geometry (x,y,z) on RT/Duroid 5880mm substrate and. In both groups, the antenna below part to build a ground plane similar to circular patch antenna with same dimensions, To give coaxial feed point center of the circular patch antenna. After completing the designing of circular patch antenna to give the radiation between 0^0 to 360^0 and then to assign the boundary conditions to perfect E. The radiating material is designed to varying the frequency of 2.4GHz. For the study of the proposed geometry, the transmission line model and TM_{mn} (m = 1 and n = 1) model were chosen.

To analyzing the circular patch antenna design and the sweep frequency range from 1GHz to 3GHz to get a resonating frequency at 2.45GHz then the reflection coefficient is -10dB below will be stimulated. The dependent variable of the work is the frequency and the independent variable of the work is the reflection coefficient for both with and without slot configurations.

RESULTS

Table 1 shows the data collection of the frequency and reflection coefficient for with slot circular patch antenna. Table 2 shows the data collection of the frequency and reflection coefficient for without slot circular patch antenna. Table 3 shows the group statistics of T-test comparison of with slot of the circular patch antenna and without slot of circular patch antenna by varying the frequency ranging from 1GHz to 3GHz. There is a statistically significant difference between with slot of the circular patch antenna and without the slot of the circular patch antenna. The reflection coefficient of with slot of circular patch antenna has the highest mean 12.2907 and without slot of circular patch antenna has the lowest mean 2.0279. The frequency of with slot of circular patch antenna has a mean of 7.2257 which is higher and without slot of circular patch antenna has the lowest mean of 4.6352. Table 4 shows the Independent T-test Mean, standard deviation, and significant difference of the frequency and reflection coefficient of with slot of the circular patch antenna and without slot of the circular patch antenna. There is a significant difference between the two groups since $p>0.05$ (Independent T-Test). Fig.1 (a) and (b) show the top and side view of a circular patch with slot antenna geometry. Fig.2 shows the with slot reflection coefficient at 2.4 GHz. Fig.3 (a) and (b) show the top and side view of the circular patch without slot antenna geometry. Similarly, Fig.4 shows the without slot reflection coefficient at 2.4 GHz. Fig.5 shows the Bar chart and compares the mean(+-1SD) frequency and reflection coefficient for with slot and without slot of the circular patch antenna.

DISCUSSIONS

In the overall investigation of our proposed work, the antenna reflection coefficient has a slight variation with, and without slot and frequency remains the same at 2.4 GHz.The reflection coefficient for without slot is good compared to with slot.

The previous work conducted by (Mak et al. 2017) on the circular patch with slot technique and Phaisan Choukiker (M and Choukiker 2018) has designed a circular ring slot antenna in the frequency range of (2.45 & 5) GHz for wifi systems are similar to our research work and their findings are almost related to our study. Any other research article that does not oppose the finding of our result. As it involves 16 samples for each group, significance results are obtained and if the sample size increases further it achieves significant results.

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 feed position, substrate material, and fringing field of the antenna are the factors that affect the reflection coefficients. To achieve a good reflection coefficient, the feed position is matched with a 50-ohm high impedance. The limitation of the work is reflection coefficient is not exceeded below -10 dB while creating a slot in with and without slot. In the future, the simulated designed antenna is fabricated and measured practically using VNA (vector network analyzer).

CONCLUSION

The frequency remains almost the same at 2.4GHz frequency in both with and without slot creation on circular patch antenna and slight changes in reflection coefficient. The antenna shows a good impedance matching with -10 dB.

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DECLARATIONS:

Conflict of interests

No conflict of interest in this manuscript

Authors Contributions

Author AP was involved in the design, data collection, data analysis, manuscript writing. Author SK was involved in the design, data analysis, critical review of the manuscript.

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TABLES AND FIGURES:

Table 1: shows the simulation of group1 of the frequency and reflection coefficient of with slot of the circular patch antenna by varying the sweep frequency range from 1GHz to 3GHz.

S.NO	GROUP-1	FREQUENCY(GHz)	REFLECTION-COEFFICINT(dB)
1	1	2.25	-.8423
2	1	2.30	-1.5602
3	1	2.35	-3.6561
4	1	2.40	-10.4445
5	1	2.45	-8.4376
6	1	2.50	-4.2479
7	1	2.55	-2.0437
8	1	2.60	-1.2294
9	1	2.65	-0.8586
10	1	2.70	-0.6634
11	1	2.75	-0.5507
12	1	2.80	-0.4819
13	1	2.85	-0.4388
14	1	2.90	-0.4120
15	1	2.95	-0.3963
16	1	3.00	0

Table 2: shows the simulation of group2 of the frequency and reflection coefficient of without slot of the circular patch antenna by varying the sweep frequency range from 1GHz to 3GHz.

S.NO	GROUP-2	FREQUENCY(GHz)	REFLECTION-COEFFICINT(dB)
1	2	2.25	-0.6139
2	2	2.30	-1.0333
3	2	2.35	-2.039
4	2	2.40	-11.5181
5	2	2.45	-5.3322
6	2	2.50	-4.6105
7	2	2.55	-2.0854
8	2	2.60	-1.2073
9	2	2.65	-0.8240
10	2	2.70	-0.6282
11	2	2.75	-0.5176
12	2	2.80	0.4513
13	2	2.85	-0.4105
14	2	2.90	-0.3856
15	2	2.95	-0.3713
16	2	3.00	-0.3646

Table 3: T-test comparison of with and without a slot of circular patch antenna by varying the frequency ranging from 1GHz to 3GHz. There is a statistically significant difference between with slot of the circular patch antenna and without the slot of the circular patch antenna.

GROUP STATISTICS

	group	N	Mean	Std. Deviation	Std. Error Mean
Frequency	With slot	16	7.2257	.23805	.05951
	Without slot	16	4.6352	.23805	.05951
Reflection coefficient	With slot	16	12.290757	3.0435335	.7608834
	Without slot	16	2.027977	2.9475509	.7368877

Table 4: **Independent T-test shows the Mean, standard deviation, and significant difference of the frequency and reflection coefficient of with slot of the circular patch antenna and without slot of the circular patch antenna.**

INDEPENDENT SAMPLE TEST

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
frequency	Equal variances assumed	0.213	0.845	6.564	30

	Equal variances not assumed			2.343	27.65
Reflection coefficient	Equal variances assumed	0.128	0.723	6.564	30
	Equal variances not assumed			2.234	27.969

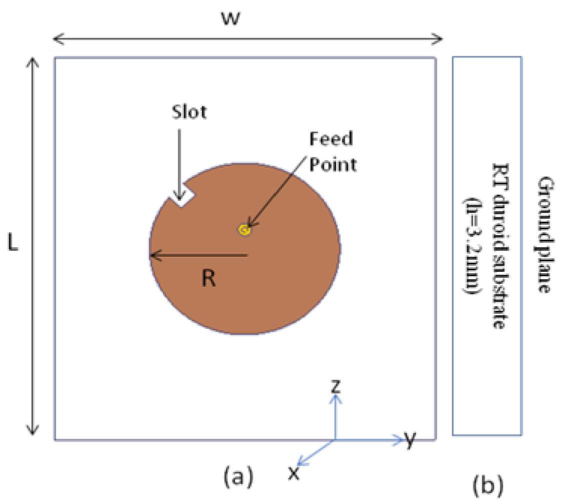

Fig.1: circular patch with slot antenna geometry (a) top view (b) side view shows the design of a circular patch with a slot creation antenna(R=20.95mm) placed on the top of the RT/Duroid 5880mm substrate material of L×W(10×9mm), height=3.2mm on one side and the other side is the ground plane.

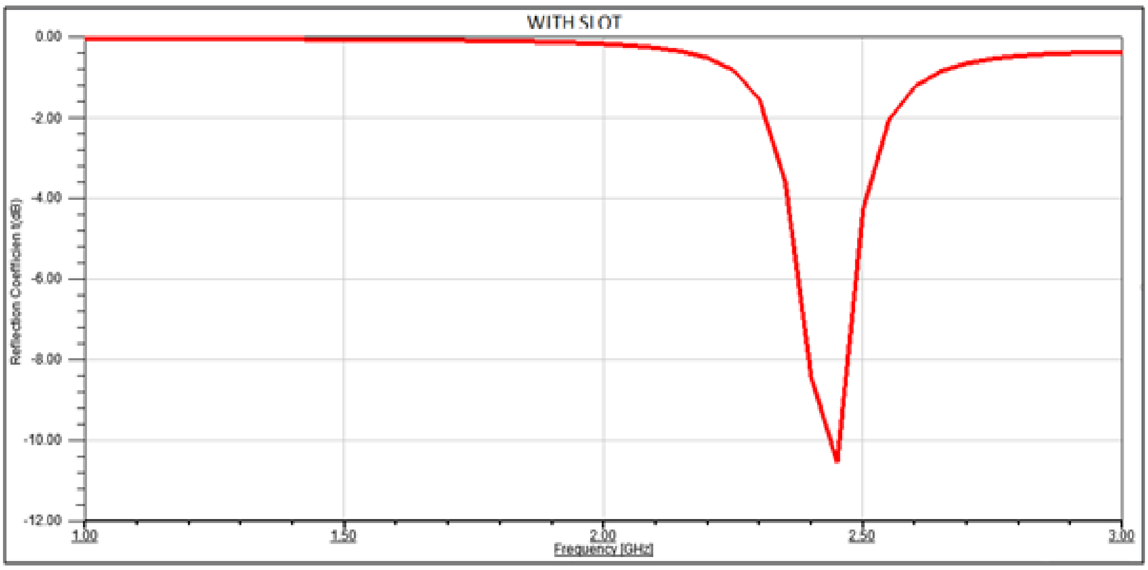

Fig.2: Frequency at 2.4GHz shows the reflection coefficient of with slot of circular patch antenna by varying the sweep frequency range from 1GHz to 3GHz and the reflection coefficient is -10.44dB.

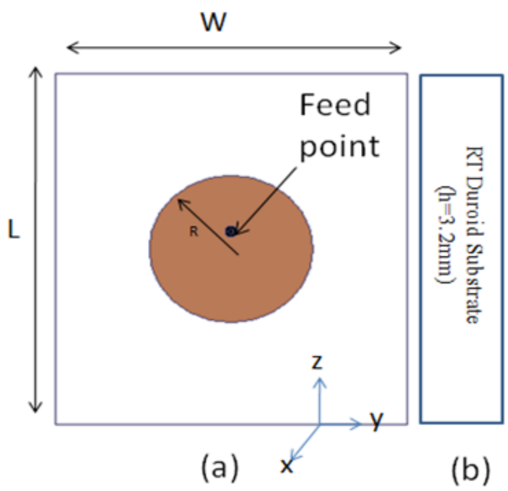

Fig.3: circular patch without slot antenna geometry(a) top view (b) side view consists of a coaxial feed point center of the circular patch without slot antenna R=20.95mm with RT/Duroid 5880mm substrate material of L×W(10×9mm), height=3.2mm on one side and the other side is the ground plane.

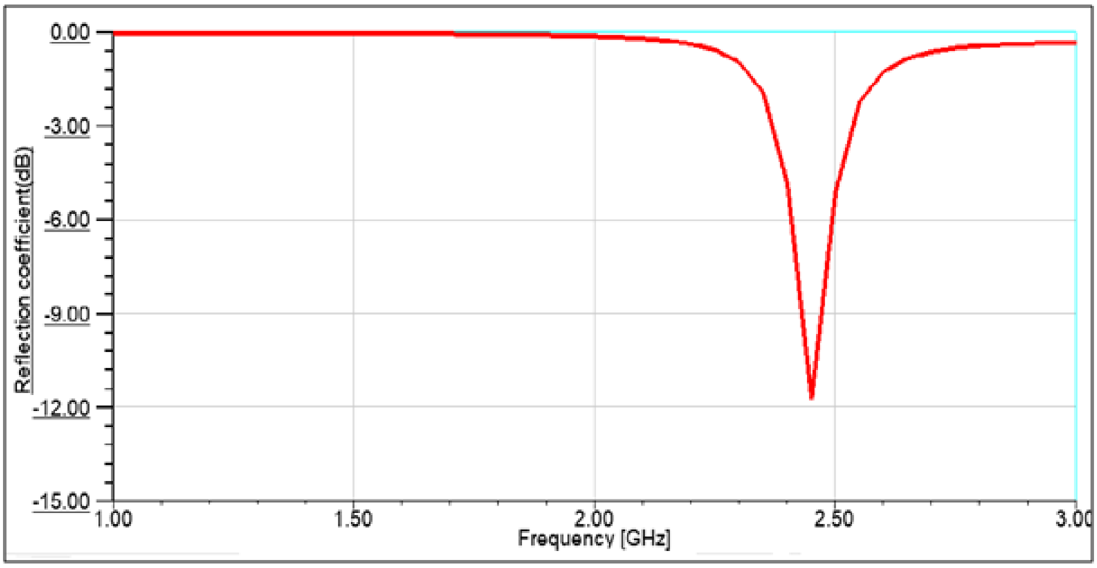

Fig.4: Frequency at 2.4GHz shows the reflection coefficient of without slot of the circular patch antenna by varying the sweep frequency range from 1GHz to 3GHz and the reflection coefficient is -11.51dB.

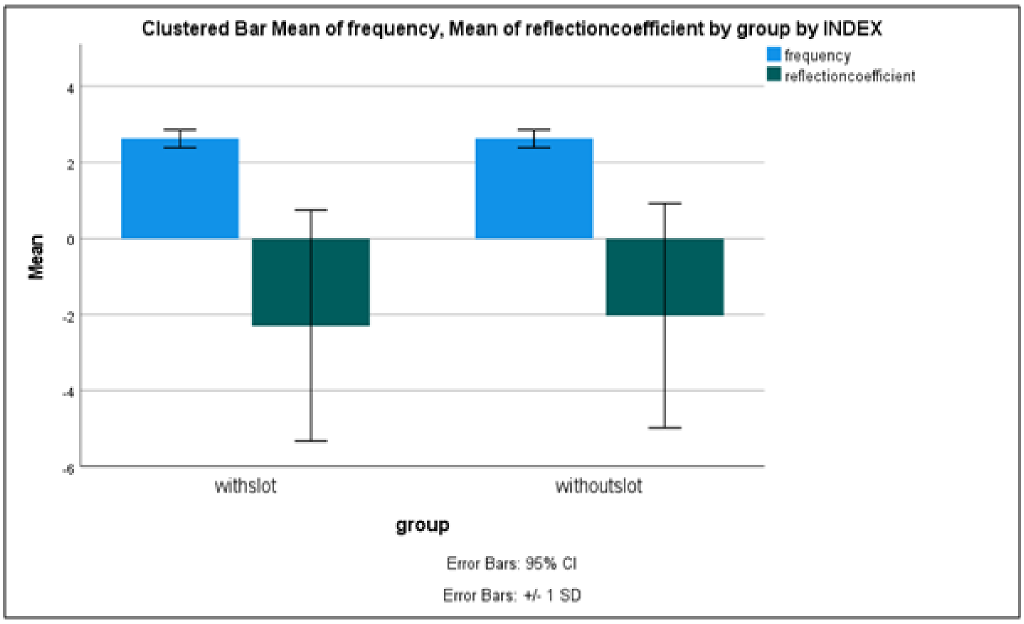

Fig.5: Bar chart and comparing the mean(+-1SD) frequency and reflection coefficient of with slot of the circular patch antenna and without slot of circular patch antenna by varying sweep frequency. There is no significant difference between the two groups P > 0.05 (Independent Sample T-Test).

PART -B

Design and Analysis of Surface Current Distribution for With and Without Slot Circular Patch Correlation at 2.4 GHz

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Keywords:

Reconfigurable antenna, Patch antenna, RT/Duroid 5880mm substrate material, surface current distribution, Innovative slot cut antenna, Antenna design.

ABSTRACT:

Aim: The surface current distribution of circular patch antenna with slot and without slot creations are analyzed by varying the sweep frequency ranging from 1GHz to 3GHz. **Material and methods:** The resonance frequency of with slot antenna (2.4GHz) was compared with without slot creation (2.4GHz) by varying the sweep frequency ranging from 1GHz to 3GHz in the High-frequency structure simulator environment. **Results:** The current orientation is varied without slot linear polarization (LP) and with slot circular polarization (CP) at a stable frequency of 2.4GHz. **Conclusion:** Within the limits of this study, the proposed antenna attained linear, LHCP surface current orientation without and with a slot at a constant frequency. The results are verified using the HFSS simulation modeling.

Keywords:

Reconfigurable antenna, Patch antenna, RTduroid 5880mm substrate material, surface current distribution, Innovative slot cut antenna, Antenna design.

INTRODUCTION

The circular patch antenna with and without slot creation was designed in the frequency range of 1GHz to 3GHz to enhance the surface current distribution. Comparing Circular Polarization (CP), Right Hand Circular Polarization (RHCP), and Linear Polarization (LP) (Mak et al. 2017), some of these parameters are extremely important and Parameters can make manufacturing more complex and minimize output yield, but there is a significant antenna with a high-quality factor and fading losses due to multipath. (Chen et al. 2016) has designed an antenna with Dual-Band Dual-Polarization Slot in the frequency of 1.575GHz GPS and 2.4GHz for Wi-Fi Applications.

In the last five years, several research papers on rectangular patch antennas have been published. IEEE Xplore published 121 early access papers, and Google Scholar published 16,300 research articles. (Mandal and Pattnaik 2018) wearable Slot Antenna for 1.8 GHz DCS, 2.4 GHz WLAN, and 3.6/5.5 GHz WiMAX Applications with Low SAR Values. (Saravanan and Rangachar 2018) has designed of circular ring-shaped polarisation reconfiguration, a separate biassing network is used to bias the pin diodes in the feed network, resulting in three polarisation states (linear, left-hand, and right-hand circular polarization), the antenna is intended for use in the 2.4GHz ISM band and wireless applications. (Chen et al. 2016) has designed a patch antenna with dual bands and dual polarisation slots for the Global Positioning System (GPS) and cellular LAN networks. (Chakraborty et al. 2016;Chattha et al. 2018; Satyanarayana and Mulgi 2015) has designed circular microstrip antennas (5.15-5.35 GHz). frequency bands at 2.4 GHz, Bluetooth band (2.4-2.48 GHz), and WLAN band (5.725-5.825 GHz) applications. (Baudha and Yadav 2019) has designed planar antennas that can be used for 2.4 (WiFi), 2.5/3.5/5.5 GHz (WiMAX), 2.5/5.2/5.8 GHz (WLAN), and other UWB wireless networking applications. (Xiong and Gao 2012; Gao et al. 2018). Vehicles and base stations are scattered in separate directions around a moving car on the lane. (Chattha et al. 2018; Satyanarayana and Mulgi 2015), (Xiong and Gao 2012; Gao et al. 2018) has designed a frequency reconfigurable patch antenna 0.9 GHz, 1.4 GHz, 1.5 GHz, 1.6 GHz, 1.7 GHz, 1.8 GHz, 2.6 GHz, 3.5 GHz, and WLAN band 2.5 GHz are among the eight 4G LTE frequency bands that can be reconfigured 4G LTE applications. (Chattha et al. 2018; Rao, Singh, and Mishra 2018) has designed a single band notch Microstrip patch antenna with a circle outline is explored for use in Bluetooth (2.4 to 2.485 GHz), Wi-Fi (2.4 to 5.8 GHz), Ultra-wideband (UWB) (3.1 to 10.6 GHz), and X-band (8 to 12 GHz) applications.

The existing polarization reconfigurable antenna works are implemented using diodes and the antenna frequency surface current distribution decreases. In this proposed work,the innovative slot cut antenna with optimizing the frequency of an antenna is an important parameter that takes into consideration. Here, a comparison of with and without slot creation was carried out for a frequency 2.4GHz. The main aim of the study is to enhance and compare the frequency and surface current distribution without a slot creation antenna.

MATERIALS AND METHODS

The research was conducted in the department of electronics and communication engineering at saveetha school of engineering, SIMATS, Chennai.In this research work, there are two groups. One group refers to with slot of the circular patch antenna and the other group refers to without slot of the circular patch antenna. The antenna with slot referred to be group 1 and the antenna without slot referred to be group 2. For each group, the sample size is 16. The Alpha value is 0.05. The Beta value is 0.2, and The G power 0.8. The required samples for the analysis are calculated based on G power calculation (Bcps et al. 2020). The total sample size of the research work is 32. The pre-test analysis is found to be 80% for the total sample size of with slot of the circular patch antenna and without slot circular patch antenna.

To simulate the with and without slot of circular patch antenna, the High-frequency structure simulator software 14.version. For group 1, create a slot creation at the top of a circular patch antenna (-45^0), and for group 2, designed a simple circular patch antenna in 3-dimensional coordinate geometry (x,y,z) on RT/Duroid 5880mm substrate and. In both groups, the antenna below part to build a ground plane similar to circular patch antenna with same dimensions, To give coaxial feed point center of the circular patch antenna. After completing the designing of circular patch antenna to give the radiation between 0^0 to 360^0 and then to assign the boundary conditions to perfect E. The radiating material is designed to varying the frequency of 2.4GHz. For the study of the proposed geometry, the transmission line model and TM_{mn} (m = 1 and n = 1) model were chosen.

To analyzing the circular patch antenna design and the sweep frequency range from 1GHz to 3GHz to get a resonating frequency at 2.45GHz then the current distribution of without slot is left-hand circular polarization (LHCP) and with the slot is circularly polarized (CP) The dependent variable of the work is the frequency and the independent variable of the work is the surface current distribution for both with and without slot configurations.

RESULTS

Table 1 shows the data collection of the frequency and surface current distribution for with slot circular patch antenna. Table 2 shows the data collection of the frequency and surface current distribution for without slot circular patch antenna. Table 3 shows the group statistics of T-test comparison of with slot of the circular patch antenna and without slot of circular patch antenna by varying the frequency ranging from 1GHz to 3GHz. There is a statistically significant difference between with slot of the circular patch antenna and without the slot of the circular patch antenna. The surface current distribution with slot of circular patch antenna has the lowest mean 40.9125 and without slot of circular patch antenna has the highest mean 44.3562. The frequency of with slot of circular patch antenna has a mean of 2.6250 which is lowest and without slot of circular patch antenna has the highest mean of 3.6451. Table 4 shows the Independent T-test Mean, standard deviation, and significant difference of the frequency and surface current distribution of with slot of the circular patch antenna and without slot of the circular patch antenna. There is a significant difference between the two groups since $p>0.05$ (Independent T-Test).

Fig.1 (a) and Fig.1 (b) show the top and side view of circular patch slot antenna geometry. Fig.2 (a) and Fig.2 (b) show the top and side view of the circular patch without slot antenna geometry. Fig.3 shows the slot surfaces current distribution at 2.4 GHz. Similarly, Fig.4 shows the without slot surfaces current distribution at 2.4 GHz. Fig.5 shows the Bar chart and compares the mean(+-1SD) frequency and current distribution for with slot and without slot of the circular patch antenna.

DISCUSSIONS

In the overall investigation of our proposed work, the antenna surface current distribution has a slight variation with, and without slot and frequency remains the same at 2.4 GHz.The surface current distribution for without slot is good compared to with slot.

The previous work conducted by (Mak et al. 2017) on the circular patch with slot technique and (Chakraborty et al. 2016), (Mandal and Pattnaik 2018), has designed circular microstrip antennas (5.15-5.35 GHz). (Chattha et al. 2018), (Rao, Singh, and Mishra 2018) Frequency bands at 2.4 GHz, Bluetooth band (2.4-2.48 GHz), and WLAN band (5.725-5.825 GHz) applications to our research work and their findings are almost related to our study. Any other research article that does not oppose the finding of our result. As it involves 16 samples for each group, significance results are obtained and if the sample size increases further it achieves significant results.

The feed position and fringing field of the antenna are the factors that affect the surface current distribution. To achieve good surface current distribution, the feed position is matched with 50-ohm high impedance. The limitation of the work is the surface current is low if the impedance is mismatched. The simulated built antenna will be constructed and calculate the surface current orientation .The tested antenna will be used for wireless LAN applications.

CONCLUSION

The frequency remains almost the same at 2.4GHz frequency in both with and without slot creation on innovative circular patch antenna and slight changes in the surface current distribution. The surface current distribution is higher for both with and without slot the surface current distribution is in linear polarization. For slot conditions, the surface current is rotated in left-hand circular polarization.

DECLARATIONS:

Conflict of interests

No conflict of interest in this manuscript

Authors Contributions

Author AP was involved in the design, data collection, data analysis, manuscript writing. Author SK was involved in the design, data analysis, critical review of the manuscript.

Acknowledgement

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2. Saveetha University
3. Saveetha Institute of Medical and Technical Sciences.
4. Saveetha School of Engineering.

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TABLE AND FIGURES

Table 1: Shows by varying the sweep frequency spectrum from 1GHz to 3GHz, the simulation of group1 of the frequency and surface current distribution of the circular patch antenna with a slot is seen.

S.NO	GROUP-1	FREQUENCY(GHz)	SURFACE CURRENT DISTRIBUTION
1	1	2.25	1.000
2	1	2.30	0.92857
3	1	2.35	0.85714
4	1	2.40	0.78571
5	1	2.45	0.71429
6	1	2.50	0.64286
7	1	2.55	0.57143
8	1	2.60	0.50000
9	1	2.65	0.42857
10	1	2.70	0.35714
11	1	2.75	0.28571
12	1	2.80	0.21429
13	1	2.85	0.14286
14	1	2.90	0.71429
15	1	2.95	0.00000
16	1	3.00	0.78690

Table 2: shows by varying the sweep frequency spectrum from 1GHz to 3GHz, the simulation of group2 of the frequency and surface current distribution of the circular patch antenna without slot is seen.

S.NO	GROUP-2	FREQUENCY(GHz)	SURFACE CURRENT DISTRIBUTION
1	2	2.25	1.000
2	2	2.30	0.96429
3	2	2.35	0.92857
4	2	2.40	0.89286
5	2	2.45	0.85714
6	2	2.50	0.82143
7	2	2.55	0.78571
8	2	2.60	0.75000
9	2	2.65	0.71429
10	2	2.70	0.67857
11	2	2.75	0.64286
12	2	2.80	0.60714
13	2	2.85	0.57143
14	2	2.90	0.53571
15	2	2.95	0.50000
16	2	3.00	0.46579

Table 3: T-Test comparison of with and without a slot of circular patch antenna by varying the frequency ranging from 1GHz to 3GHz. There is a statistically significant difference between with slot of the circular patch antenna and without the slot of the circular patch antenna.

	group	N	Mean	Std. Deviation	Std. Error Mean
frequency	With slot	16	2.6250	.23805	.05951
	Without slot	16	3.6451	.23805	.05951
Current distribution	With slot	16	40.9125	24.48607	.0612152
	Without slot	16	44.3562	22.59251	.0564813

Table 4: **Independent T-test shows the Mean, standard deviation, and significant difference of the frequency and surface current distribution of with slot of the circular patch antenna and without slot of the circular patch antenna.**

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
frequency	Equal variances assumed	.000	0.453	.000	30
	Equal variances not assumed			.000	30.000

Current distribution	Equal variances assumed	.022	0.434	.413	30
	Equal variances not assumed			.413	29.808

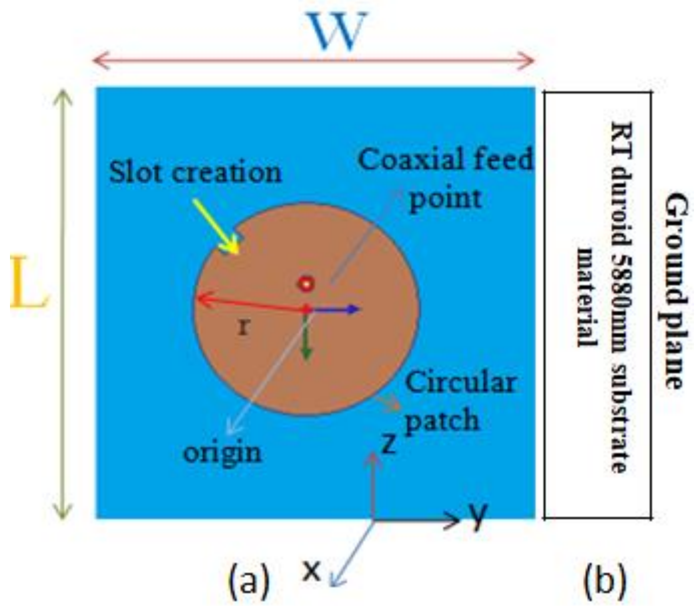


Fig.1: circular patch with slot antenna geometry (a) top view (b) side view shows the design of a circular patch with a slot creation antenna(R=20.95mm) placed on the top of the RT/Duroid 5880mm substrate material of L×W(10×9mm),height=3.2mm on one side and the other side is the ground plane.

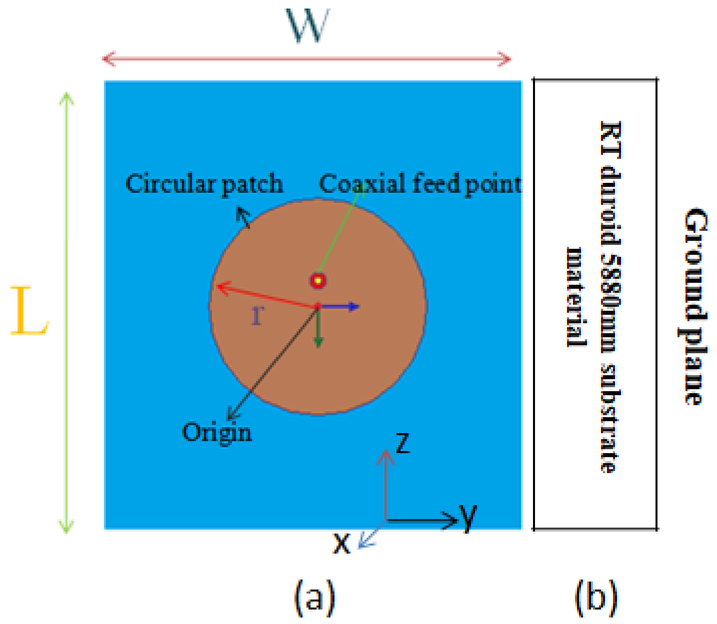
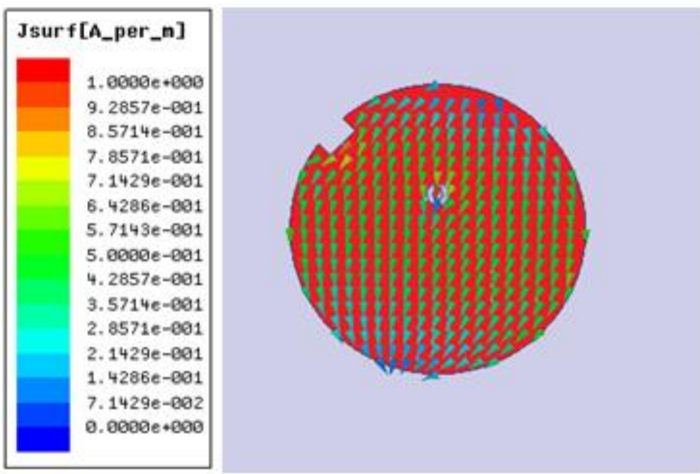
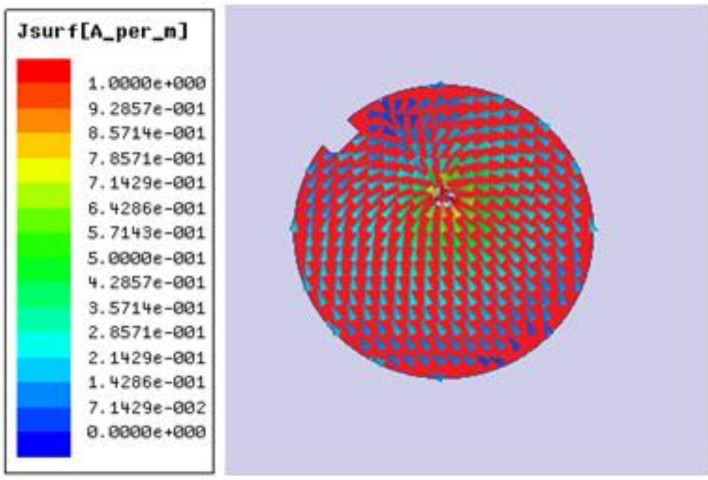


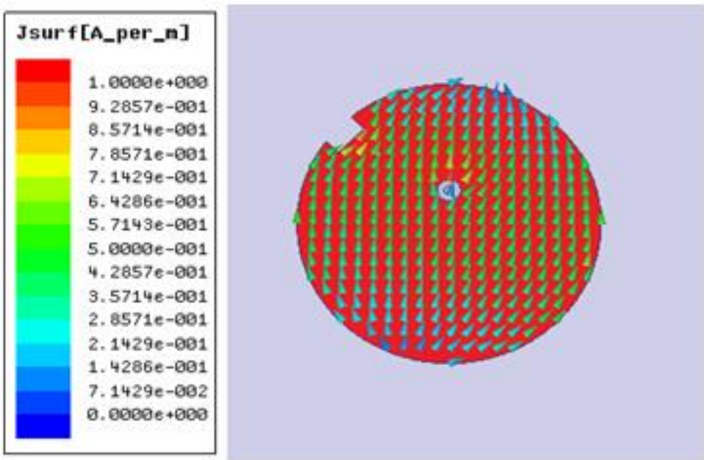
Fig.2: circular patch without slot antenna geometry(a) top view (b) side view consists of a coaxial feed point center of the circular patch without slot antenna R=20.95mm with RT/Duroid 5880mm substrate material of L×W(10×9mm), height=3.2mm on one side and the other side is the ground plane.



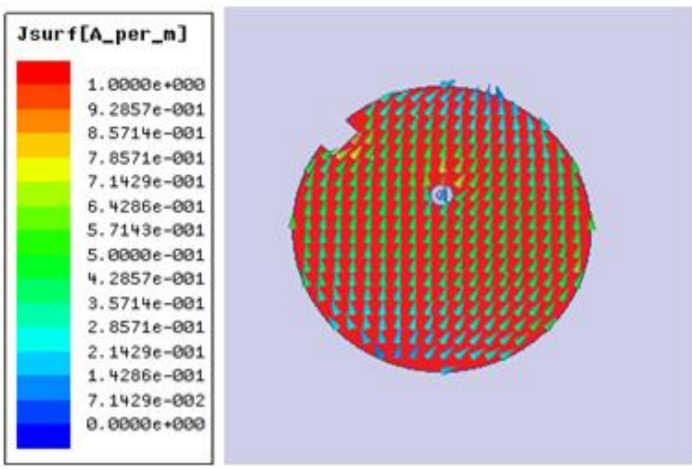
0° for LHCP



90° for LHCP

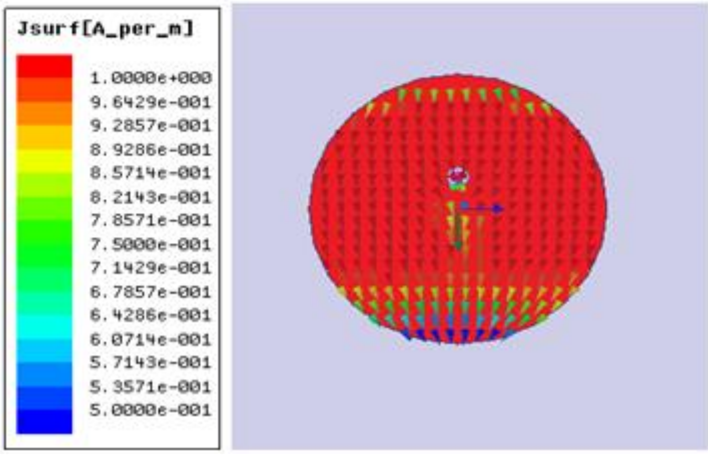


180° for LHCP

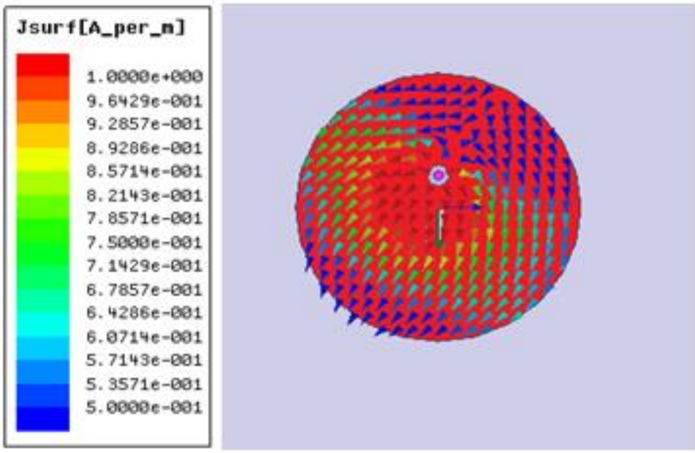


270° for LHCP

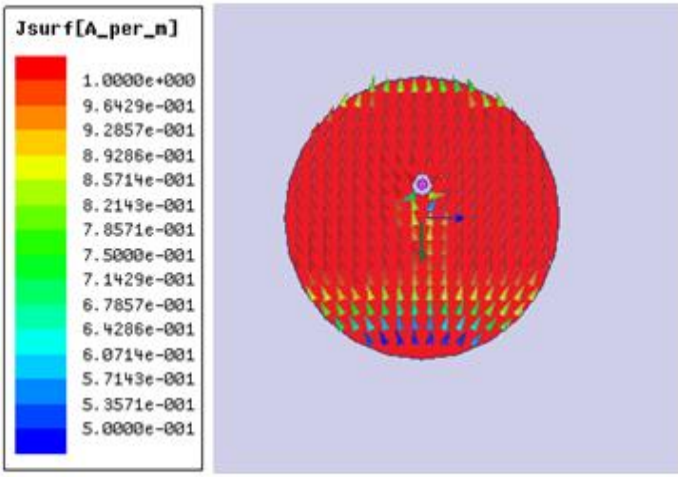
Fig.3: Left Hand Circular Polarization(LHCP) surface current distribution at 2.4 GHz from 0° to 270° view.



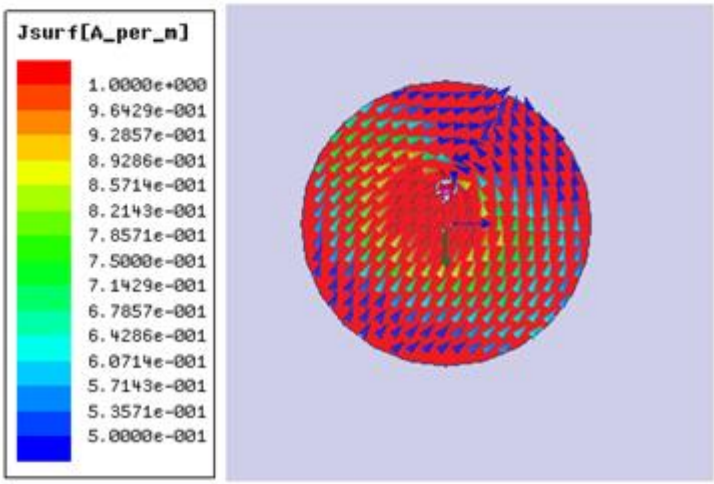
0° for linear



90° for linear



180° for linear



270° for linear

Fig.4: Linear Polarization (LP) surface current distribution at 2.4GHz from 0° to 270° view.

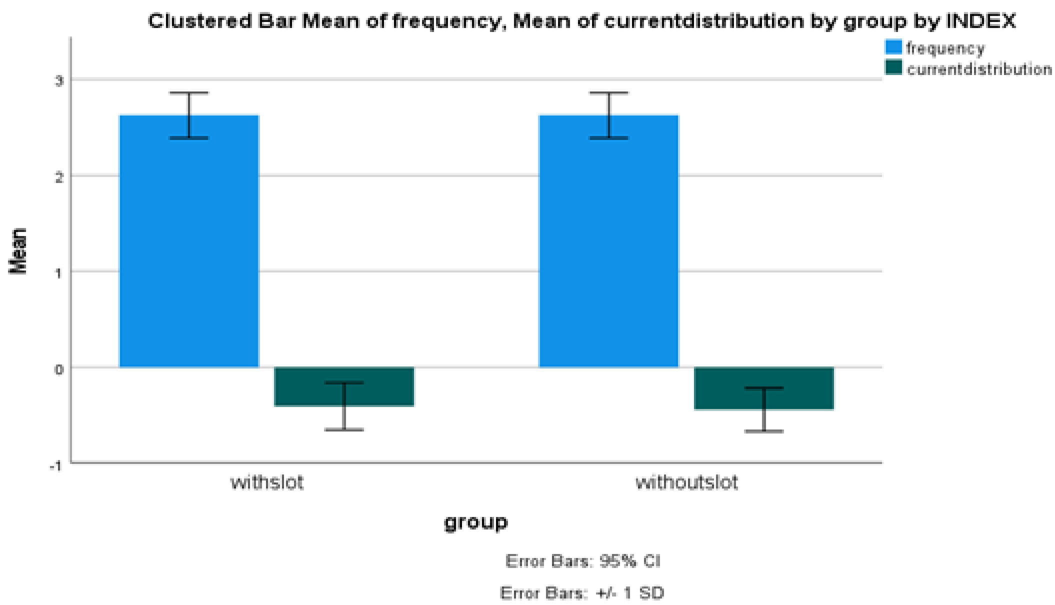


Fig.5: Bar chart and comparing the mean(+-1SD) frequency and current distribution with slot of the circular patch antenna and without slot of circular patch antenna by varying sweep frequency. There is no significant difference between the two groups P > 0.05 (Independent Sample T-Test).

PART - C

Design and Analysis of With and Without Slot Correlation Circular Patch Antenna Gain Pattern at 2.4 GHz

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Keywords:

Reconfigurable antenna, Patch antenna, RT/Duroid 5880mm substrate material, Gain pattern, Innovative slot cut antenna, Antenna design.

ABSTRACT:

Aim: The gain pattern of circular patch antenna for with and without slot creations are analyzed for 2.4 GHz by varying the sweep frequency ranging from 1GHz to 3GHz. **Material and methods:** The resonance frequency of with slot antenna (2.4GHz) was compared with without slot creation (2.4GHz) by varying the sweep frequency ranging from 1GHz to 3GHz in the High-frequency structure simulator environment. The antenna with slot referred to be group 1 and the antenna without slot referred to be group 2. For each group, the sample size is 16. The total sample size of the research work is 32. **Results:** The circular patch without slot gain pattern (7.2119dB) appeared to be higher than with slot gain pattern (2.3151dB). The maximum gain pattern without slot creation. **Conclusion:** Within the limits of this study, the slot of circular patch antenna with the frequency of 2.4GHz offers a good gain pattern.

Keywords:

Reconfigurable antenna, Patch antenna, RT/Duroid 5880mm substrate material, Gain pattern, Innovative slot cut antenna, Antenna design.

INTRODUCTION

The frequency range of 1GHz to 3GHz, a circular patch antenna with and without slot creation was planned to improve the gain pattern (Sirunyan et al. 2021).The importance of gain parameter is to calculate the efficiency of the antenna.If the gain is high the antenna efficiency will be high.

Some of these parameters are highly sensitive when comparing Circular Polarization (CP) and Linear Polarization (LP) (J. K. Chen and Thyssen 2018). The resonant antenna with a high quality-factor and fading losses due to multipath will increase manufacturing problems and decrease the production yield rate, but the resonant antenna with a high-quality factor and fading losses can reduce the production yield rate. Fakharian, Rezaei, and Orouji (2015) increased the efficiency of signal transmission while saving energy (Yurish, n.d.). An antenna is a type of electromagnetic instrument that can send and receive radio waves (Liu et al. 2021)

In the last five years, several research papers on rectangular patch antennas have been published. IEEE Xplore published 121 early access papers, and Google Scholar published 16,300 research articles. (Pozar and Schaubert 1995) has designed a circular patch antenna that operates at terahertz frequencies. The engineered antenna has a substrate with a length of 100 meters, a width of 100 meters, and a thickness of 10 meters. The patch's radius is estimated to be 40 meters for WBAN (Wireless Body Area Network) applications. (Pozar and Schaubert 1995) has designed Circular Patch Antenna 2x1 and 4x1 arrays with High Gain for 2.4 GHz Applications. (Gao, Luo, and Zhu 2013) has a circular patch antenna with a single-fed broadband circularly polarised feed that operates at 2.4 GHz for ISM Band Biomedical Applications. (Sainati 1996) has designed circular microstrip antennas for 2.4GHz working or resonant frequency Wireless networking (WLAN) applications that may use the 2.4 GHz bandwidth. (Z. N. Chen 2016) has designed a circular patch antenna with an omnidirectional radiation pattern with a resonating frequency at 2.4Ghz For wireless LAN applications. (Pozar and Schaubert 1995) has designed antenna arrays that are tuned to a resonant frequency of 2.4GHz suitable for WLAN applications.

Previously our team has a rich experience in working on various research projects across multiple disciplines (Prakash et al. 2020; Jayaseelan 2020; Sathish et al. 2020; Varadharaj et al. 2020; Nandhini, Rajeshkumar, and Mythili 2019; Subramani and Venu 2019; Jayaraman et al. 2019; Sathish, Sabarirajan, and Karthick 2020; Murthykumar, Arjunkumar, and Jayaseelan 2019; Mehta et al. 2020; Balachandar et al. 2020; Wang et al. 2019; Sekar et al. 2019; Kumaran et al. 2020; Suchithra et al. 2020) Now the growing trend in this area motivated us to pursue this project.

The existing polarization reconfigurable antenna works implemented on diodes are used to incorporate current polarisation reconfigurable antenna designs, the antenna frequency gain pattern decreases. The frequency of an antenna is a critical parameter that is taken into account in this innovative slot cut antenna. For a frequency of 2.4GHz, a comparison of with and without slot formation was performed. The study's main goal is to improve and compare the frequency and gain patterns of antennas with and without slot construction.

MATERIALS AND METHODS

The research was conducted in the department of electronics and communication engineering at saveetha school of engineering, SIMATS, Chennai.In this research work, there are two groups. One group refers to with slot of the circular patch antenna and the other group refers to without slot of the circular patch antenna. The antenna with slot referred to be group 1 and the antenna without slot referred to be group 2. For each group, the sample size is 16. The total sample size of the research work is 32. The Alpha value is 0.05. The beta value is 0.2, and The G power 0.8. The required samples for the analysis are calculated based on G power calculation (Bcps et al. 2020)). The pre-test analysis is found to be 80% for the total sample size of with slot of the circular patch antenna and without slot circular patch antenna.

To simulate the with and without slot of circular patch antenna, the High-frequency structure simulator software 14.version. For group 1, create a slot creation at the top of a circular patch antenna (-45^0), and for group 2, design a simple circular patch antenna in 3-dimensional coordinate geometry (x,y,z) on RT/Duroid 5880mm substrate and. In both groups, the antenna below part to build a ground plane similar to circular patch antenna with same dimensions, To give coaxial feed point center of the circular patch antenna. After completing the designing of circular patch antenna to give the radiation between 0^0 to 360^0 and then to assign the boundary conditions to perfect E. The radiating material is designed to varying the frequency of 2.4GHz. For the study of the proposed geometry, the transmission line model and TM_{mn} (m = 1 and n = 1) model were chosen.

To analyzing the circular patch antenna design and the sweep frequency range from 1GHz to 3GHz to get a resonating frequency at 2.45GHz then the gain pattern of 3dB below will be stimulated. The dependent variable of the work is the frequency and the independent variable of the work is the gain pattern for both with and without slot configurations.

RESULTS

Table 1 shows the data collection of the frequency and gain pattern for with slot circular patch antenna. Table 2 shows the data collection of the frequency and gain pattern for without slot circular patch antenna. Table 3 shows the group statistics of T-test comparison with slot of the circular patch antenna and without slot of circular patch antenna by varying the frequency ranging from 1GHz to 3GHz. There is a statistically significant difference between with slot of the circular patch antenna and without the slot of the circular patch antenna. The gain pattern of with slot of circular patch antenna has the highest mean 12.2907 and without slot of circular patch antenna has the lowest mean 2.0279. The frequency of with slot of circular patch antenna has a mean of 7.2257 which is higher and without slot of circular patch antenna has the lowest mean of 4.6352. Table 4 shows the Independent T-test Mean, standard deviation, and significant difference of the frequency and gain pattern of with slot of the circular patch antenna and without slot of the circular patch antenna. There is a significant difference between the two groups since $p>0.05$ (Independent T-Test).

Fig.1 (a) and Fig.1 (b) show the top and side view of circular patch slot antenna geometry. Fig.2 (a) and Fig.2 (b) show the top and side view of the circular patch without slot antenna geometry. Fig.3 shows the without slot gain pattern at 2.4 GHz. Similarly, Fig.4 shows the slot gain pattern at 2.4 GHz. Fig.5 shows the Bar chart and compares the mean(+-1SD) frequency and gain pattern for with slot and without slot of the circular patch antenna.

DISCUSSIONS

In the overall investigation of proposed work, the antenna gain pattern has a small difference with and without slot, and the frequency stays the same at 2.4 GHz. In contrast to with slot, the gain pattern for without slot is fine.

The previous work conducted by (Mak et al. 2017) on the circular patch with slot technique and Phaisan Choukiker (M and Choukiker 2018) has designed a circular ring slot antenna in the frequency range of (2.45 & 5) GHz for wifi systems are similar to our research work and their findings are almost related to our study. Any other research article that does not oppose the finding of our result.

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 gain patterns are influenced by the feed location, substrate content, and antenna fringing area. The feed direction is combined with a 50-ohm high impedance to achieve a reasonable gain pattern. The gain trend is not surpassed below 0 dB when building a slot in both with and without slot, which is the work's constraint. The simulated built antenna will be constructed and the maximum gain has been tested using an anechoic chamber in the future.The tested antenna will be used for wireless LAN applications.

CONCLUSION

The frequency remains almost the same at 2.4GHz frequency in both with and without slot creation on innovative circular patch antennas and slight variation in gain pattern. The antenna shows a good impedance matching with 3 dB.

DECLARATIONS:

Conflict of interests

No conflict of interest in this manuscript

Authors Contributions

Author AP was involved in the design, data collection, data analysis, manuscript writing. Author SK was involved in the design, data analysis, critical review of the manuscript.

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TABLES AND FIGURES

Table 1: shows the simulation of group1 of the frequency and gain pattern with slot of the circular patch antenna by varying the sweep frequency range from 1GHz to 3GHz.

S.NO	GROUP 1	FREQUENCY	GAINPHI,PHI=0	GAINPHI,PHI=90	GAINPHI,THETA=0	GAINPHI,THETA=90
1	1	2.25	-45.6154	-28.4796	-1.58775	-15.486
2	1	2.30	-39.5956	-22.458	-1.56883	-15.5071
3	1	2.35	-36.0752	-18.9345	-1.53749	-15.5424
4	1	2.40	-33.5785	-16.4336	-1.49401	-15.5918
5	1	2.45	-31.6431	-14.4927	-1.43879	-15.6556
6	1	2.50	-30.0631	-12.9061	-1.37231	-15.7337
7	1	2.55	-28.7288	-11.5639	-1.29515	-15.8262
8	1	2.60	-27.5748	-10.4007	-1.20797	-15.9333
9	1	2.65	-26.5588	-9.37446	-1.11149	-16.0551
10	1	2.70	-25.6523	-8.45636	-1.00652	-16.1916
11	1	2.75	-24.8348	-7.62607	-0.89386	-16.343
12	1	2.80	-24.0913	-6.8686	-0.77439	-16.5091
13	1	2.85	-23.4105	-6.17263	-0.64899	-16.6899
14	1	2.90	-22.7837	-5.52946	-0.51855	-16.8852
15	1	2.95	-22.2041	-4.93224	-0.38397	-17.0945
16	1	3.00	-21.6661	-4.37551	-0.24614	-17.3172

Table 2: shows the simulation of group2 of the gain pattern without slot of the circular patch antenna by varying the sweep frequency range from 1GHz to 3GHz.

S.NO	GROUP1	FREQUENCY	GAINPHI,PHI=0	GAINPHI,PHI=90	GAINPHI,THETA=0	GAINPHI,THETA=90
1	2	2.25	-37.77	-23.50	2.63	-22.95
2	2	2.30	-31.75	-17.48	2.65	-22.89
3	2	2.35	-28.23	-13.96	2.69	-22.79
4	2	2.40	-25.73	-11.46	2.75	-22.65
5	2	2.45	-23.79	-9.51	2.81	-22.46
6	2	2.50	-22.21	-7.93	2.90	-22.22
7	2	2.55	-20.87	-6.58	2.99	-21.93
8	2	2.60	-19.71	-5.42	3.10	-21.57
9	2	2.65	-18.69	-4.39	3.22	-21.17
10	2	2.70	-17.78	-3.48	3.35	-20.72
11	2	2.75	-16.96	-2.65	3.49	-20.22
12	2	2.80	-16.21	-1.89	3.64	-19.70
13	2	2.85	-15.52	-1.19	3.79	-19.15
14	2	2.90	-14.89	-.55	3.95	-18.58
15	2	2.95	-14.31	.05	4.11	-18.01
16	2	3.00	-13.76	.60	4.28	-17.43

Table 3: Group Statistics shows a T-test comparison of with and without a slot of circular patch antenna by varying the frequency ranging from 1GHz to 3GHz. There is a statistically significant difference between with slot of the circular patch antenna and without the slot of the circular patch antenna.

	group	N	Mean	Std. Deviation	Std. Error Mean
gainphi0	Without slot	16	-21.1357	6.83738	1.70934
	With slot	16	-29.0047	6.82175	1.70544
gainphi90	Without slot	16	-6.8336	6.86547	1.71637
	With slot	16	-11.8128	6.86409	1.71602
gaintheta0	Without slot	16	3.2720	.54841	.13710
	With slot	16	-1.0679	.44476	.11119
gaintheta90	Without slot	16	-20.9029	1.85117	.46279
	With slot	16	-16.1476	.59821	.14955

Table 4: Independent T-test shows the Mean, standard deviation, and significant difference of the frequency and gain pattern of with slot of the circular patch antenna and without slot of the circular patch antenna.

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
gainphi0	Equal variances assumed	.000	.493	3.259	30
	Equal variances not assumed			3.259	30.000
gainphi90	Equal variances assumed	.000	.349	2.052	30
	Equal variances not assumed			2.052	30.000
gaintheta0	Equal variances assumed	1.033	.418	24.586	30
	Equal variances not assumed			24.586	28.773
gaintheta90	Equal variances assumed	20.032	.324	-9.777	30
	Equal variances not assumed			-9.777	18.099

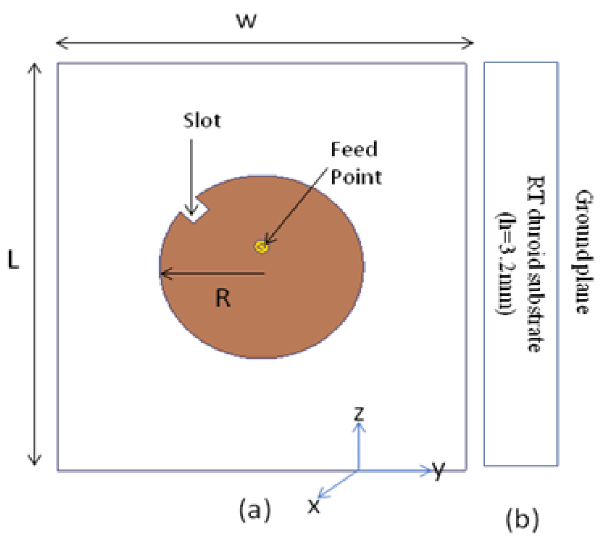

Fig.1 circular patch with slot antenna geometry (a) top view (b) side view shows the design of a circular patch with a slot creation antenna(R=20.95mm) placed on the top of the RT/Duroid 5880mm substrate material of L×W(10×9mm),height=3.2mm on one side and the other side is the ground plane.

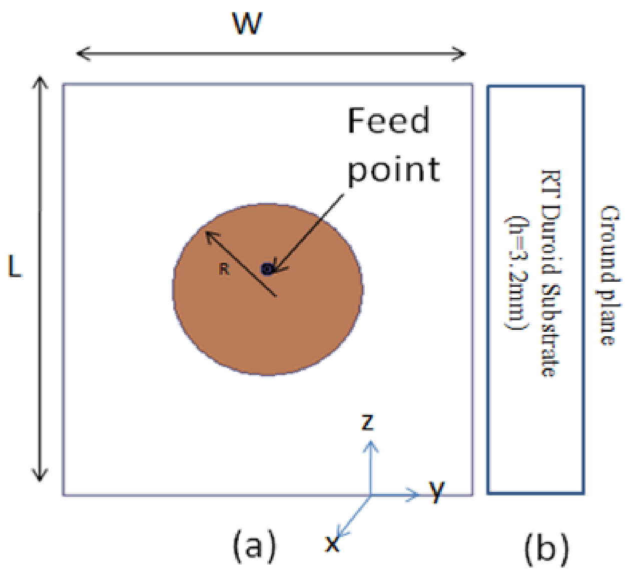

Fig.2 circular patch without slot antenna geometry(a) top view (b) side view consists of a coaxial feed point center of the circular patch without slot antenna R=20.95mm with RT/Duroid 5880mm substrate material of L×W(10×9mm),height=3.2mm on one side and the other side is the ground plane.

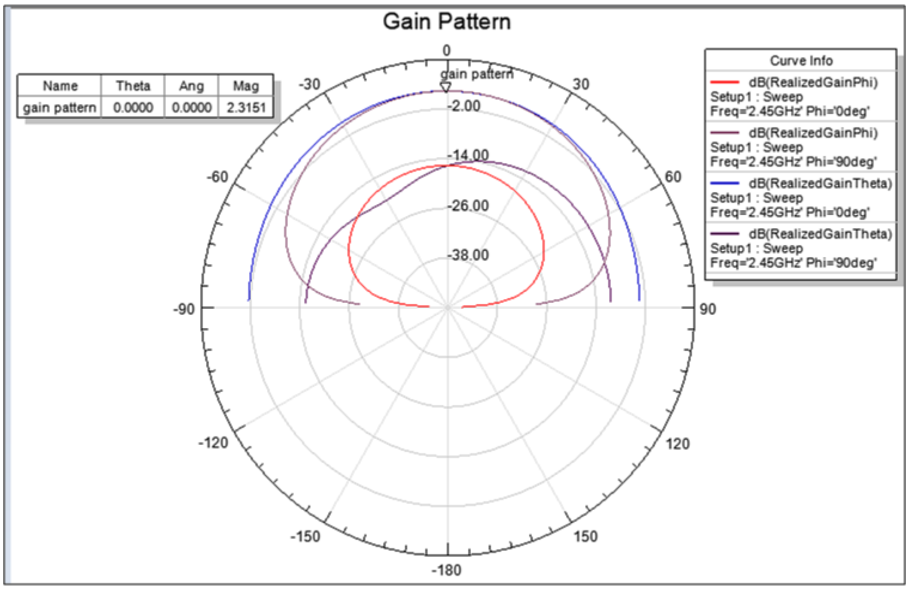

Fig.3 Frequency at 2.4GHz **s**hows the gain pattern of with slot of circular patch antenna by varying the sweep frequency range from 1GHz to 3GHz and the gain pattern is 2.3151dB.

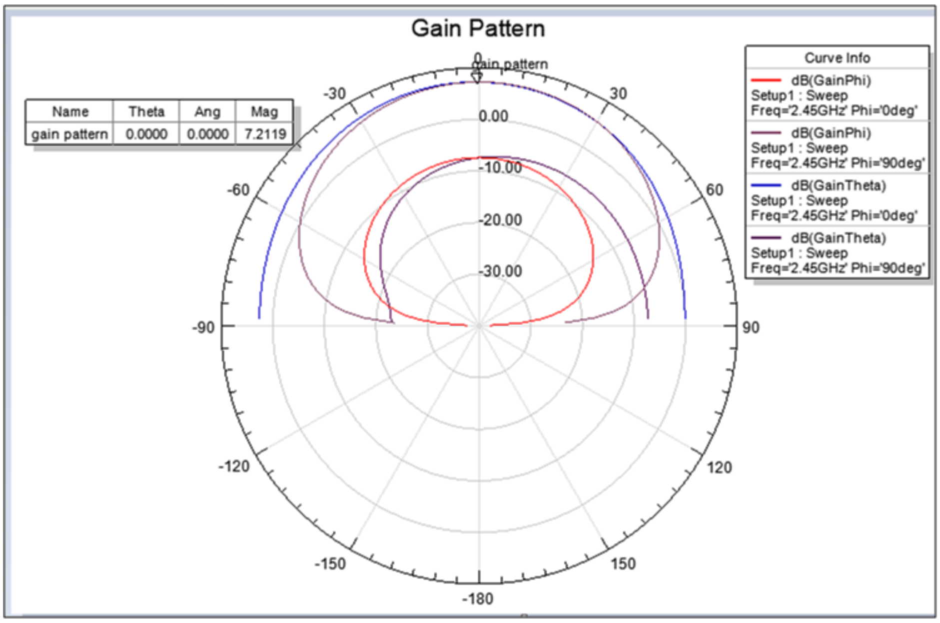

Fig.4 Frequency at 2.4GHz shows the gain pattern without a slot of the circular patch antenna by varying the sweep frequency range from 1GHz to 3GHz and the gain pattern is 7.2119 dB.

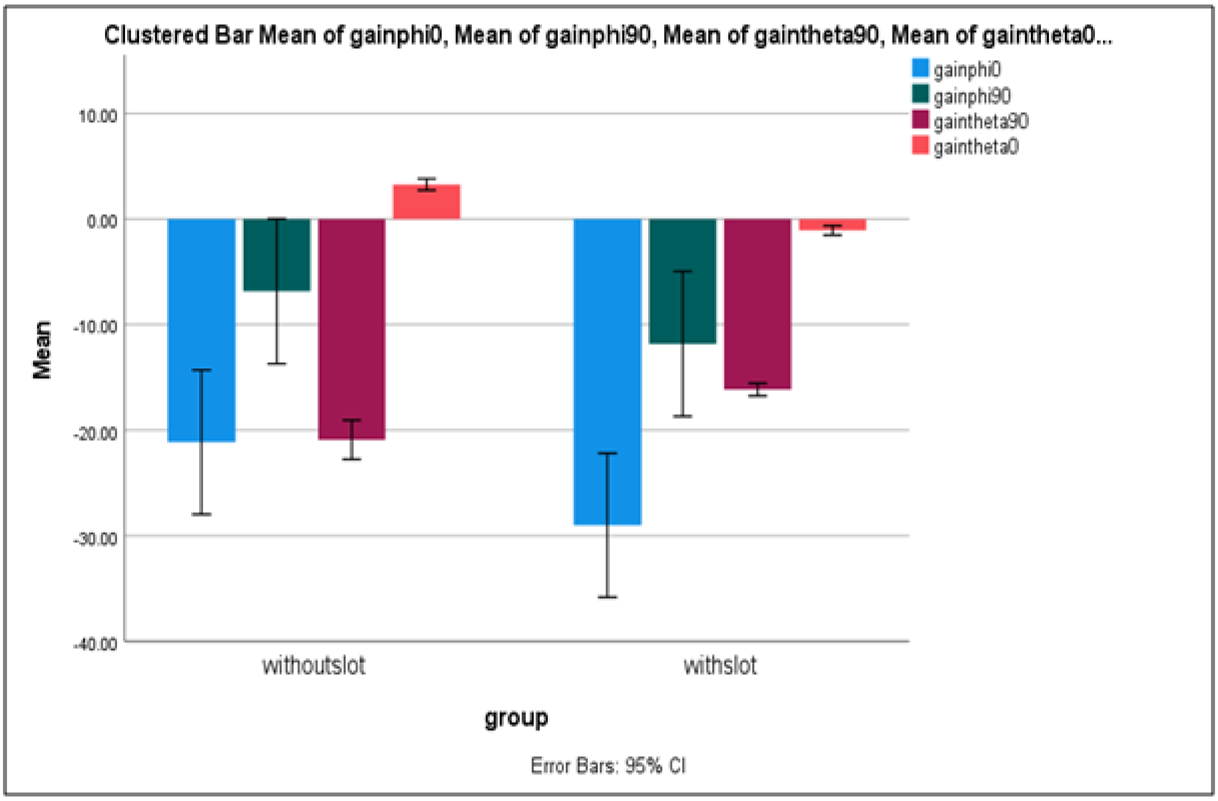

Fig.5 Bar chart and comparing the mean(+-1SD) frequency and gain pattern of with slot of the circular patch antenna and without slot of circular patch antenna by varying sweep frequency. There is no significant difference between the two groups P > 0.05 (Independent Sample T-Test).

PART - D

Design and Analysis of With and Without Slot Correlation Circular Patch Antenna Axial Ratio at 2.4 GHz

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Keywords:

Reconfigurable antenna, Patch antenna, RT/Duroid 5880mm substrate material, Axial ratio, Innovative slot cut antenna, Antenna design.

ABSTRACT:

Aim: The axial ratio of circular patch antenna for with and without slot creations are analyzed for 2.4 GHz by varying the sweep frequency ranging from 1GHz to 3GHz. **Material and methods:** The resonance frequency of with slot antenna (2.4GHz) was compared with without slot creation (2.4GHz) by varying the sweep frequency ranging from 1GHz to 3GHz in the High-frequency structure simulator environment. The antenna with slot referred to be group 1 and the antenna without slot referred to be group 2. For each group, the sample size is 16. The total sample size of the research work is 32. **Results:** The circular patch without slot axial ratio appeared to be higher (14.8315dB) than with slot axial ratio (5.4583dB). The maximum axial ratio without slot creation. **Conclusion:** Within the limits of this study, the without slot of circular patch antenna with the frequency of 2.4GHz offers a good axial ratio.

Keywords:

Reconfigurable antenna, Patch antenna, RT/Duroid 5880mm substrate material. Axial ratio, Innovative slot cut antenna, Antenna design.

INTRODUCTION

The ratio between the major and minor axis of a polarized antenna is defined using the axial ratio.The importance of axial ratio is to find the antenna is linear or circular or elliptical polarization.In recent years, working on reconfigurable antennas has received a lot of attention (Pandey 2019). (Cai et al. 2016). Some of these parameters are highly sensitive when comparing Circular Polarization (CP) and Linear Polarization (LP) (Chen et al. 2018). The resonant antenna with a high-quality factor and fading losses due to multipath will increase manufacturing problems and decrease the production yield rate, but the resonant antenna with a high quality-factor and fading losses can reduce the production yield rate. Fakharian, Rezaei, and Orouji (2015) improved the reliability of signal transmission while saving energy (Rajagopalan, Kovitz, and Rahmat-Samii 2014). An antenna is a type of electromagnetic instrument that can send and receive radio waves (Yang et al. 2019). It is made up of an optical conductor that can operate at radiofrequency. The circular patch and coaxial feed point antennas (Hussain, Khan, and Sharawi 2018) had a broad variety of applications in the ISM and WLAN bands, among others (Bialkowski and Zagriatski, n.d.), (Choukiker and Behera 2017).

In the last five years, several research papers on rectangular patch antennas have been published. IEEE Xplore published 121 early access papers, and Google Scholar published 16,300 research articles.(Goudos 2017), (Zhang et al. 2017) has designed capacitive-fed slot patch antenna with dual-band and dual-polarization will run at 1.575 GHz for the Global Positioning System and 2.4 GHz for Wi-Fi. 120 MHz is the measured 3-dB axial-ratio bandwidth for GPS and WI-FI Applications. (Gao, Luo, and Zhu 2013) has designed a pin-loaded patch antenna with circular polarisation running at 2.4-2.48 GHz in the commercial, scientific, and medical (ISM) band for biomedical applications. (Waterhouse 2013) ; (Sarkar and Gupta 2020) creation and fabrication of a two-element truncated square microstrip patch antenna array that operates in the S-band microwave frequency (2.4 GHz). (Row and Tsai 2014), has designed circular patch antennas for GPS applications and it is designed at an operating frequency of 1.2GHz. (Row and Shih 2012), has designed a circular patch coaxial antenna for ISM band frequency of 2.4GHz that can be used in wifi applications. (Guo, Luk, and Lee 1999), (Babakhani and Sharma 2015), has designed a new slot creation of circular patch at 2.4Ghz frequency for LTE applications.

Previously our team has a rich experience in working on various research projects across multiple disciplines (Prakash et al. 2020; Jayaseelan 2020; Sathish et al. 2020; Varadharaj et al. 2020; Nandhini, Rajeshkumar, and Mythili 2019; Subramani and Venu 2019; Jayaraman et al. 2019; Sathish, Sabarirajan, and Karthick 2020; Murthykumar, Arjunkumar, and Jayaseelan 2019; Mehta et al. 2020; Balachandar et al. 2020; Wang et al. 2019; Sekar et al. 2019; Kumaran et al. 2020; Suchithra et al. 2020) Now the growing trend in this area motivated us to pursue this project.

The existing polarization reconfigurable antenna works are the antenna frequency axial ratio reduced as diodes are used. The frequency of an antenna is an important parameter that is taken into account in this innovative slot cut antenna. For a frequency of 2.4GHz, a comparison of with and without slot formation was performed. The study's main objective is to boost and compare the frequency and axial ratio of antennas with and without slot formation.

MATERIALS AND METHODS

The research was conducted in the department of electronics and communication engineering at saveetha school of engineering, SIMATS, Chennai. In this research work, there are two groups. One group refers to with slot of the circular patch antenna and the other group refers to without slot of the circular patch antenna. The antenna with slot referred to be group 1 and the antenna without slot referred to be group 2. For each group, the sample size is 16. The total sample size of the research work is 32. The Alpha value is 0.05. The Beta value is 0.2, and The G power 0.8. The required samples for the analysis are calculated based on G power calculation (Bcps et al. 2020). The pre-test analysis is found to be 80% for the total sample size of with slot of the circular patch antenna and without slot circular patch antenna.

To simulate the with and without slot of circular patch antenna, the High-frequency structure simulator software 14.version. For group 1, create a slot creation at the top of a circular patch antenna (-45^0), and for group 2, design a simple circular patch antenna in 3-dimensional coordinate geometry (x,y,z) on RT/Duroid 5880mm substrate and. In both groups, the antenna below part to build a ground plane similar to circular patch antenna with same dimensions, To give coaxial feed point center of the circular patch antenna. After completing the designing of circular patch antenna to give the radiation between 0^0 to 360^0 and then to assign the boundary conditions to perfect E. The radiating material is designed to varying the frequency of 2.4GHz. For the study of the proposed geometry, the transmission line model and TM_{mn} (m = 1 and n = 1) model were chosen.

To analyzing the circular patch antenna design and the sweep frequency range from 1GHz to 3GHz to get a resonating frequency at 2.45GHz then the axial ratio is -10dB below will be stimulated. The dependent variable of the work is the frequency and the independent variable of the work is the axial ratio for both with and without slot configurations.

RESULTS

Table 1 shows the data collection of the frequency and axial ratio for with slot circular patch antenna. Table 2 shows the data collection of the frequency and axial ratio for without slot circular patch antenna. Table 3 shows the group statistics of T-test comparison with slot of the circular patch antenna and without slot of circular patch antenna by varying the frequency ranging from 1GHz to 3GHz. There is a statistically significant difference between with slot of the circular patch antenna and without the slot of the circular patch antenna. The axial ratio of with slot of circular patch antenna has the highest mean 12.2907 and without slot of circular patch antenna has the lowest mean 2.0279. The frequency of with slot of circular patch antenna has a mean of 7.2257 which is higher and without slot of circular patch antenna has the lowest mean of 4.6352. Table 4 shows the Independent T-test Mean, standard deviation, and significant difference of the frequency and axial ratio of the slot of the circular patch antenna and without slot of the circular patch antenna. There is a significant difference between the two groups since $p>0.05$ (Independent T-Test).

Fig.1 (a) and Fig.1 (b) show the top and side view of circular patch slot antenna geometry. Fig.2 (a) and Fig.2 (b) show the top and side view of the circular patch without slot antenna geometry. Similarly, Fig.3 shows the slot axial ratio at 2.4 GHz. Fig.4 shows the without slot axial ratio at 2.4 GHz. Fig.5 shows the Bar chart and compares the mean(+-1SD) frequency and axial ratio for with slot and without slot of the circular patch antenna.

DISCUSSIONS

In the overall investigation of our proposed work, the antenna axial ratio has a slight variation with, and without slot and frequency remains the same at 2.4 GHz.The axial ratio for without slot is good compared to with slot.

The previous work conducted by (Mak et al. 2017), (Yang et al. 2019), (Luo and Li 2009) on the circular patch with slot technique (M and Choukiker 2018), (Row and Shih 2012) has designed a circular ring slot antenna for wifi systems in the frequency range of (2.45 & 5) GHz is close to our research work, and their results are almost identical to our findings. Any other study paper that does not refute our conclusions. Since each group has 16 samples, significant results are obtained, and if the sample size is expanded further, significant results are obtained.

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 axial ratio is affected by the feed location, substrate content, and antenna fringing area. The feed direction is combined with a 50-ohm high impedance to obtain a strong axial ratio. When building a slot in both with and without a slot, the work's disadvantage is that the axial ratio is not exceeded below -10 dB. The simulated built antenna will be constructed and the axial ratio is tested using an anechoic chamber in the future.The tested antenna will be used for wireless LAN applications.

CONCLUSION

The circular patch antennas for both with and without slot formation have minor improvements in axial ratio and the frequency stays almost the same at 2.4GHz. With a -10 dB impedance match, the antenna performs well.

DECLARATIONS:

Conflict of interests

No conflict of interest in this manuscript

Authors Contributions

Author AP was involved in the design, data collection, data analysis, manuscript writing. Author SK was involved in the design, data analysis, critical review of the manuscript.

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TABLES AND FIGURES

Table 1: shows the simulation of group1 of the frequency and the axial ratio of with slot of the circular patch antenna by varying the sweep frequency range from 1GHz to 3GHz.

S.NO	GROUP-1	FREQUENCY(GHz)	AXIAL RATIO
1	1	2.25	36.06
2	1	2.30	30.20
3	1	2.35	21.80
4	1	2.40	5.4583
5	1	2.45	21.16
6	1	2.50	28.77
7	1	2.55	34.14
8	1	2.60	38.01
9	1	2.65	40.94
10	1	2.70	43.21
11	1	2.75	44.99
12	1	2.80	46.36
13	1	2.85	47.39
14	1	2.90	48.11
15	1	2.95	48.54
16	1	3.00	48.70

Table 2: shows the simulation of group2 of the frequency and the axial ratio of without slots of the circular patch antenna by varying the sweep frequency range from 1GHz to 3GHz.

S.NO	GROUP-2	FREQUENCY(GHz)	AXIAL RATIO
1	2	2.25	57.37
2	2	2.30	31.90
3	2	2.35	12.83
4	2	2.40	14.83
5	2	2.45	2.56
6	2	2.50	5.25
7	2	2.55	11.68
8	2	2.60	20.75
9	2	2.65	31.62
10	2	2.70	43.62
11	2	2.75	56.26
12	2	2.80	69.22
13	2	2.85	82.28
14	2	2.90	95.32
15	2	2.95	108.29
16	2	3.00	121.21

Table 3: Group Statistics shows a T-test comparison of with and without a slot of circular patch antenna by varying the frequency ranging from 1GHz to 3GHz. There is a statistically significant difference between with slot of the circular patch antenna and without the slot of the circular patch antenna.

	group	N	Mean	Std. Deviation	Std. Error Mean
frequency	Without slot	16	2.6250	.23805	.05951
	With slot	16	2.6250	.23805	.05951
Axial ratio	Without slot	16	37.0751	10.96832	2.74208
	With slot	16	47.3525	38.66077	9.66519

Table 4: Independent T-test shows the Mean, standard deviation, and significant difference of the frequency and axial ratio of the slot of the circular patch antenna and without slot of the circular patch antenna.

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	dif
frequency	Equal variances assumed	0.232	0.445	6.564	30
	Equal variances not assumed			2.343	27.65

Axial ratio	Equal variances assumed	20.899	0.323	6.564	30
	Equal variances not assumed			2.234	27.969

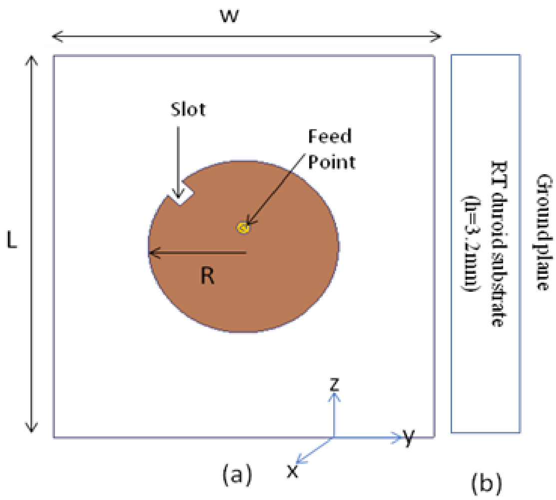

Fig.1 circular patch with slot antenna geometry (a) top view (b) side view shows the design of a circular patch with a slot creation antenna(R=20.95mm) placed on the top of the RT/Duroid 5880mm substrate material of L×W(10×9mm),height=3.2mm on one side and the other side is the ground plane.

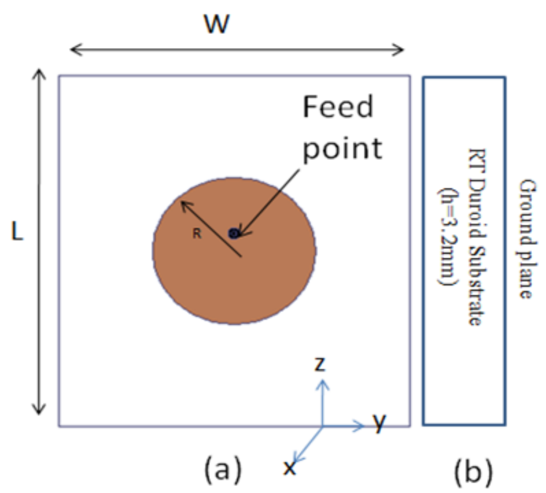

Fig.2 circular patch without slot antenna geometry(a) top view (b) side view consists of a coaxial feed point center of the circular patch without slot antenna R=20.95mm with RT/Duroid 5880mm substrate material of L×W(10×9mm),height=3.2mm on one side and the other side is the ground plane.

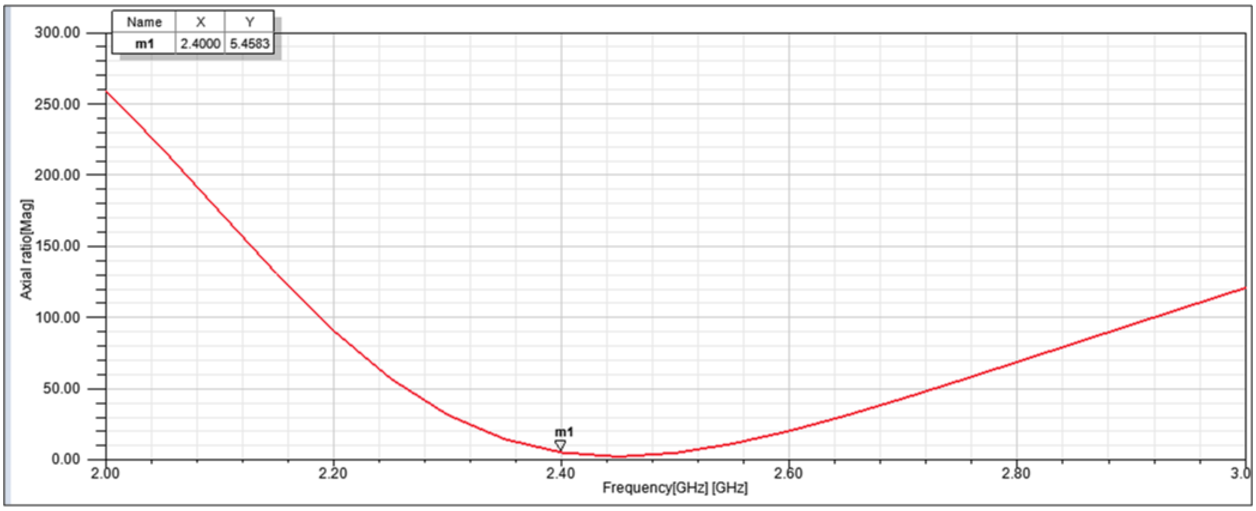

Fig.3 Frequency at 2.4GHz **s**hows the axial ratio of with slot of circular patch antenna by varying the sweep frequency range from 1GHz to 3GHz and the axial ratio is 5.4583dB.

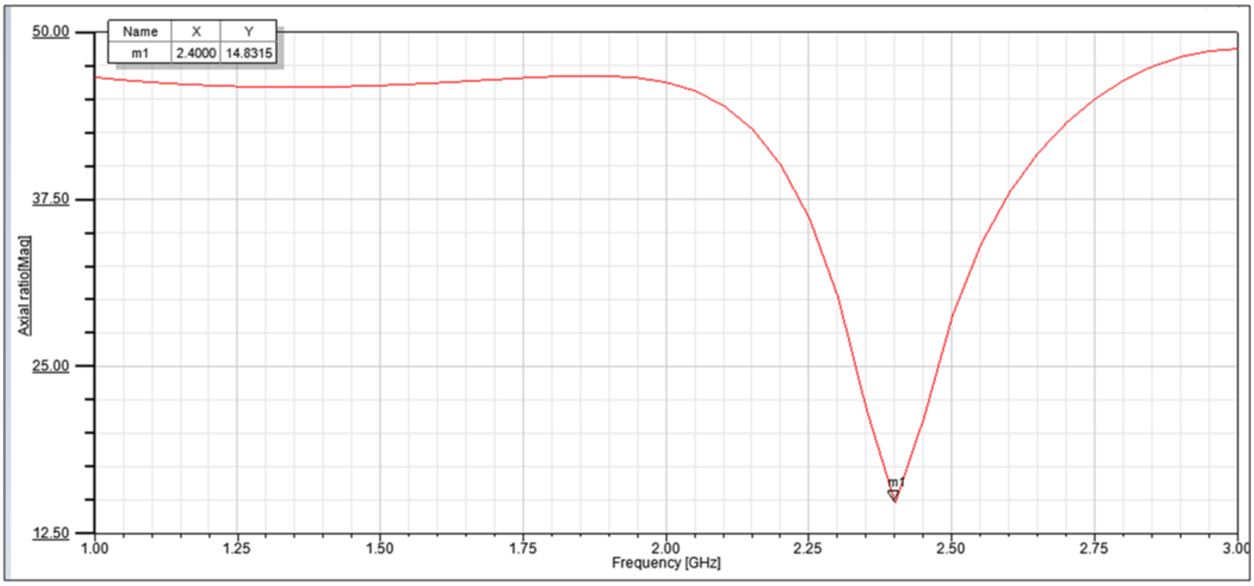

Fig.4 Frequency at 2.4GHz shows the axial ratio of without slot of the circular patch antenna by varying the sweep frequency range from 1GHz to 3GHz and the axial ratio is 14.8315dB.

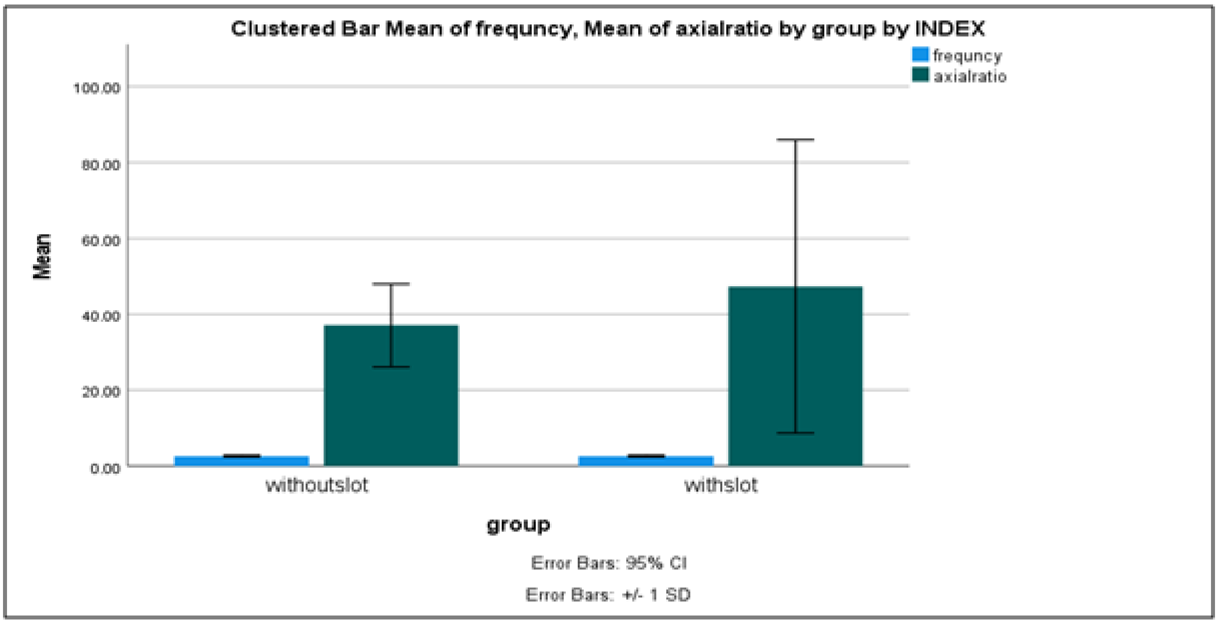

Fig.5 Bar chart and comparing the mean(+-1SD) frequency and the axial ratio of with slot of the circular patch antenna and without slot of circular patch antenna by varying sweep frequency. There is no significant difference between the two groups P > 0.05 (Independent Sample T-Test).

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Design and Analysis of With and Without Slot Correlation Circular Patch Antenna Reflection Coefficient at 2.4 GHz

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Abstract

Aim: *The reflection coefficient of circular patch antenna for with and without slot creations are analyzed for 2.4 GHz by varying the sweep frequency ranging from 1GHz to 3GHz.* ***Material and methods:*** *The resonance frequency of with slot antenna (2.4GHz) was compared with without slot creation (2.4GHz) by varying the sweep frequency ranging from 1GHz to 3GHz in the High-frequency structure simulator environment.* ***Results:*** *The circular patch without slot reflection coefficient appeared to be higher (-11.5181dB) than with slot reflection coefficient (-10.4445dB). The maximum reflection coefficient without slot creation.* ***Conclusion:*** *Within the limits of this study, the without slot of circular patch antenna with the frequency of 2.4GHz offers a good reflection coefficient.*

Key-words: Reconfigurable Antenna, Patch Antenna, RT/Duroid 5880mm Substrate Material, Reflection Coefficient, Innovative Slot Cut Antenna, Antenna Design.

1. Introduction

The circular patch antenna with and without slot creation was designed in the range of 1GHz to 3GHz to enhance the reflection coefficient. Reconfigurable antenna research has gotten a lot of coverage in recent years (Behera et al. 2018), (Cai et al. 2016). Comparing Circular Polarization (CP) and Linear Polarization (LP) is extremely sensitive to some of these parameters (Chen et al. 2018). Parameters can increase manufacturing difficulties and reduce the production yield rate but the resonant antenna with quality factor is high and fading losses due to multipath. Improving the efficiency of signal propagation reliably and saving electricity (Fakharian, Rezaei, and Orouji 2015), (Rajagopalan, Kovitz, and Rahmat-Samii 2014). The Antenna is an electromagnetic device that can transmit and receive radio waves (Yang et al. 2019). It consists of an electronic conductor designed for operating in radiofrequency. The circular patch and coaxial feed point antenna had a wide range of applications in ISM, WLAN band, etc (Hussain, Khan, and Sharawi 2018), (Choukiker and Behera 2017).

The antenna has designed a novel stable gain printed log-periodic circular patch antenna in the frequency range of (1GHz -3GHz) and obtained a reflection coefficient of -10dB (Lee and Sung 2015), (Lu et al. 2017). (Rahmatia et al. 2017), a circular patch antenna for TV applications and circular coaxial feed point antenna working at 2.4GHz for radar applications. The Circular antenna was made of aluminum and iron where the dielectric substrate material used in coaxial feed was RTduroid 5880mm. (Row and Tsai 2014), has designed circular patch antennas for GPS applications and it is designed at an operating frequency of 1.2GHz. (Row and Shih 2012), has designed a circular patch coaxial antenna for ISM band frequency of 2.4GHz that can be used in wifi applications. (Guo, Luk, and Lee 1999), (Babakhani and Sharma 2015), has designed a new slot creation of circular patch at 2.4Ghz frequency for LTE applications.

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 existing polarization reconfigurable antenna works are implemented using diodes and the antenna frequency reflection coefficient decreases. In this proposed work, optimizing the frequency of an antenna is an important parameter that takes into consideration. Here, a comparison of with and without slot creation was carried out for a frequency 2.4GHz. The main aim of the study is to enhance and compare the frequency and reflection coefficient of without slot and innovative slot cut antenna.

2. Materials and Methods

The research was conducted in the Department of Electronics and Communication Engineering at Saveetha School of Engineering, SIMATS, Chennai. In this research work, there are two groups. One group refers to with slot of the circular patch antenna and the other group refers to without slot of the circular patch antenna. The antenna with slot referred to be group 1 and the antenna without slot referred to be group 2. For each group, the sample size is 16. The total sample size of the research work is 32. The Alpha value is 0.05. The Beta value is 0.2, and The G power 0.8. The required samples for the analysis are calculated based on G power calculation (Bcps et al. 2020). The pre-test analysis is found to be 80% for the total sample size of with slot of the circular patch antenna and without slot circular patch antenna.

To simulate the with and without slot of circular patch antenna, the High-frequency structure simulator software 14.version. For group 1, create a slot creation at the top of a circular patch antenna (-45^0), and for group 2, designed a simple circular patch antenna in 3-dimensional coordinate geometry (x,y,z) on RT/Duroid 5880mm substrate and. In both groups, the antenna below part to build a ground plane similar to circular patch antenna with same dimensions, To give coaxial feed point center of the circular patch antenna. After completing the designing of circular patch antenna to give the radiation between 0^0 to 360^0 and then to assign the boundary conditions to perfect E. The radiating material is designed to varying the frequency of 2.4GHz. For the study of the proposed geometry, the transmission line model and TM_{mn} (m = 1 and n = 1) model were chosen.

To analyzing the circular patch antenna design and the sweep frequency range from 1GHz to 3GHz to get a resonating frequency at 2.45GHz then the reflection coefficient is -10dB below will be stimulated. The dependent variable of the work is the frequency and the independent variable of the work is the reflection coefficient for both with and without slot configurations.

3. Results

Table 1 shows the data collection of the frequency and reflection coefficient for with slot circular patch antenna. Table 2 shows the data collection of the frequency and reflection coefficient for without slot circular patch antenna. Table 3 shows the group statistics of T-test comparison of with slot of the circular patch antenna and without slot of circular patch antenna by varying the frequency ranging from 1GHz to 3GHz. There is a statistically significant difference between with slot of the circular patch antenna and without the slot of the circular patch antenna. The reflection coefficient of with slot of circular patch antenna has the highest mean 12.2907 and without slot of circular patch antenna has the lowest mean 2.0279. The frequency of with slot of circular patch antenna has a mean of 7.2257 which is higher and without slot of circular patch antenna has the lowest mean of 4.6352. Table 4 shows the Independent T-test Mean, standard deviation, and significant difference of the frequency and reflection coefficient of with slot of the circular patch antenna and without slot of the circular patch antenna. There is a significant difference between the two groups since p>0.05 (Independent T-Test). Fig.1 (a) and (b) show the top and side view of a circular patch with slot antenna geometry. Fig.2 shows the with slot reflection coefficient at 2.4 GHz. Fig.3 (a) and (b) show the top and side view of the circular patch without slot antenna geometry. Similarly, Fig.4 shows the without slot reflection coefficient at 2.4 GHz. Fig.5 shows the Bar chart and compares the mean(+-1SD) frequency and reflection coefficient for with slot and without slot of the circular patch antenna.

Table 1 - Shows the simulation of group1 of the frequency and reflection coefficient of with slot of the circular patch antenna by varying the sweep frequency range from 1GHz to 3GHz

S.NO	GROUP-1	FREQUENCY(GHz)	REFLECTION-COEFFICINT (dB)
1	1	2.25	-.8423
2	1	2.30	-1.5602
3	1	2.35	-3.6561
4	1	2.40	-10.4445
5	1	2.45	-8.4376
6	1	2.50	-4.2479
7	1	2.55	-2.0437
8	1	2.60	-1.2294
9	1	2.65	-0.8586
10	1	2.70	-0.6634
11	1	2.75	-0.5507
12	1	2.80	-0.4819
13	1	2.85	-0.4388
14	1	2.90	-0.4120
15	1	2.95	-0.3963
16	1	3.00	0

Table 2 - Shows the Simulation of group2 of the frequency and reflection coefficient of without slot of the circular patch antenna by varying the sweep frequency range from 1GHz to 3GHz.

S.NO	GROUP-2	FREQUENCY(GHz)	REFLECTION-COEFFICINT (dB)
1	2	2.25	-0.6139
2	2	2.30	-1.0333
3	2	2.35	-2.039
4	2	2.40	-11 5181
5	2	2.45	-5.3322
6	2	2.50	-4.6105
7	2	2.55	-2.0854
8	2	2.60	-1.2073
9	2	2.65	-0.8240
10	2	2.70	-0.6282
11	2	2.75	-0.5176

12	2	2.80	0.4513
13	2	2.85	-0.4105
14	2	2.90	-0.3856
15	2	2.95	-0.3713
16	2	3.00	-0.3646

Table 3 - T-test Comparison of with and without a slot of circular patch antenna by varying the frequency ranging from 1GHz to 3GHz. There is a statistically significant difference between with slot of the circular patch antenna and without the slot of the circular patch antenna

Group Statistics

	group	N	Mean	Std. Deviation	Std. Error Mean
Frequency	With slot	16	7.2257	0.23805	0.05951
	Without slot	16	4.6352	0.23805	0.05951
Reflection coefficient	With slot	16	12.2908	3.04353	0.76088
	Without slot	16	2.02798	2.94755	0.73689

Table 4 - Independent T-test shows the Mean, standard deviation, and significant difference of the frequency and reflection coefficient of with slot of the circular patch antenna and without slot of the circular patch antenna.

Independent Sample Test

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
frequency	Equal variances assumed	0.213	0.845	6.564	30
	Equal variances not assumed			2.343	27.65
Reflection coefficient	Equal variances assumed	0.128	0.723	6.564	30
	Equal variances not assumed			2.234	27.969

Fig. 1 - Circular patch with slot antenna geometry (a) top view (b) side view shows the design of a circular patch with a slot creation antenna (R=20.95mm) placed on the top of the RT/Duroid 5880mm substrate material of L×W(10×9mm), height=3.2mm on one side and the other side is the ground plane.

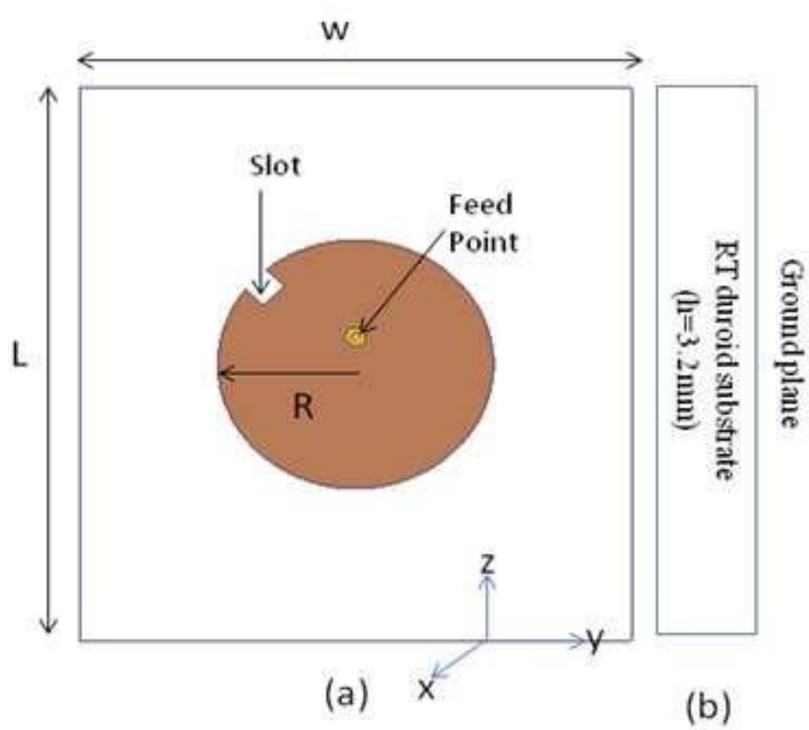


Fig. 2 - Frequency at 2.4GHz shows the reflection coefficient of with slot of circular patch antenna by varying the sweep frequency range from 1GHz to 3GHz and the reflection coefficient is -10.44dB

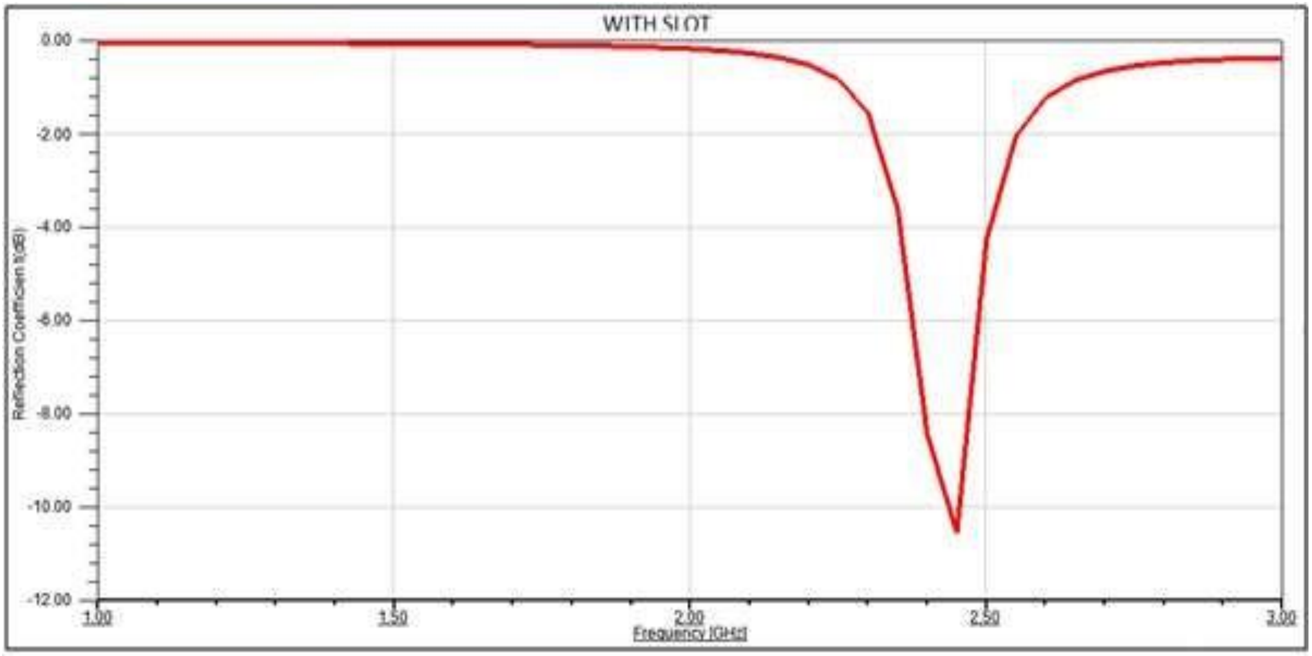


Fig. 3 - Circular Patch without Slot Antenna Geometry(a) Top View (b) Side View consists of a Coaxial Feed Point Center of the Circular Patch without Slot Antenna R=20.95mm with RT/Duroid 5880mm Substrate Material of L×W(10×9mm), height=3.2mm on One Side and the other side is the Ground Plane

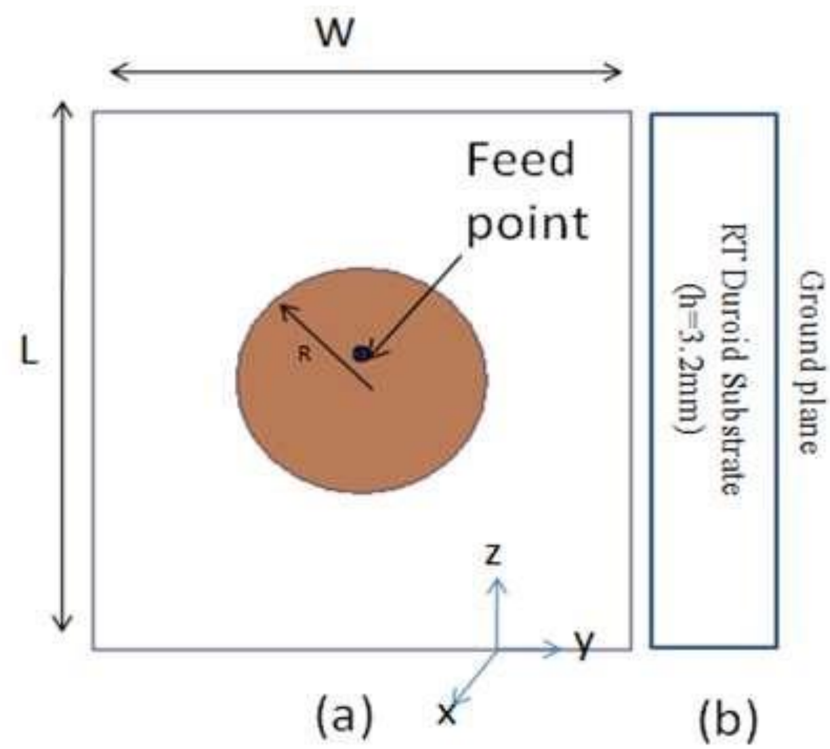


Fig. 4 - Frequency at 2.4GHz Shows the Reflection Coefficient of without Slot of the Circular Patch Antenna by Varying the Sweep Frequency Range from 1GHz to 3GHz and the Reflection Coefficient is -11.51dB

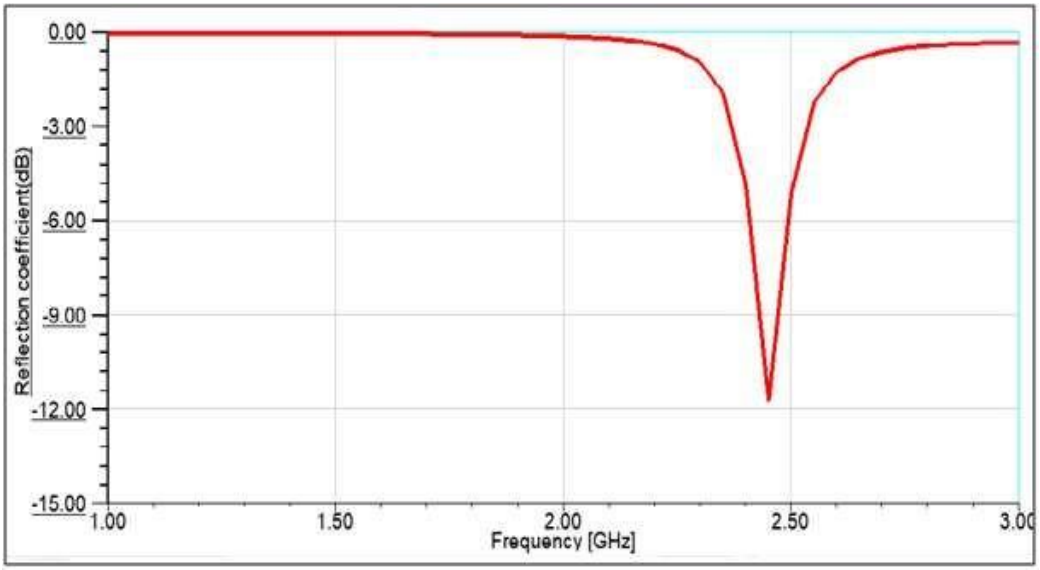
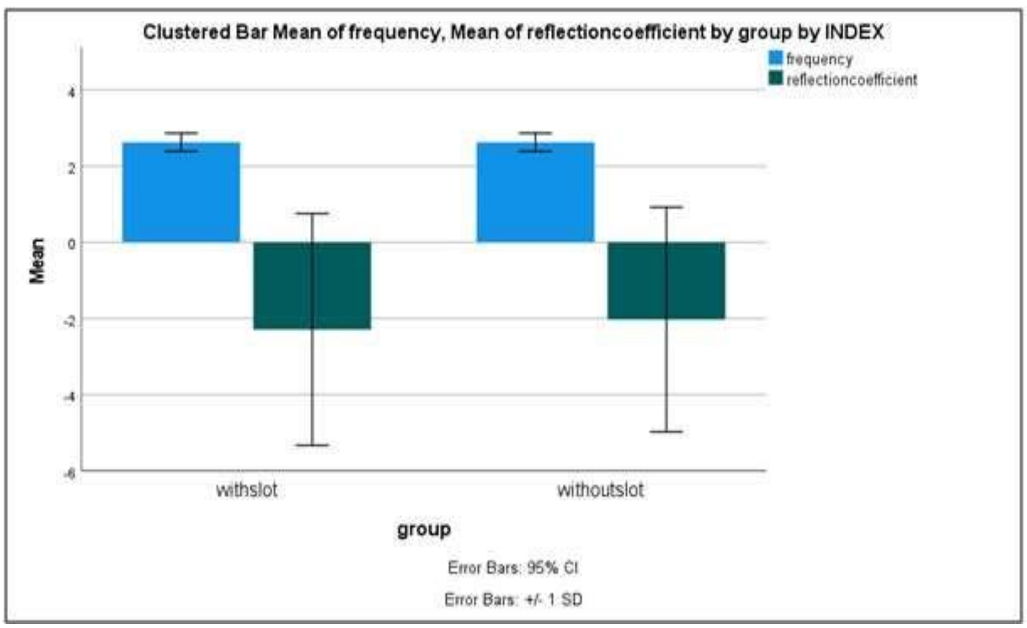


Fig. 5 - Bar Chart and Comparing the Mean(+-1SD) Frequency and Reflection Coefficient of with Slot of the Circular Patch Antenna and without Slot of Circular Patch Antenna by Varying Sweep Frequency. There is no Significant difference between the Two Groups P > 0.05 (Independent Sample T-Test).



4. Discussions

In the overall investigation of our proposed work, the antenna reflection coefficient has a slight variation with, and without slot and frequency remains the same at 2.4 GHz.The reflection coefficient for without slot is good compared to with slot.

The previous work conducted by (Mak et al. 2017) on the circular patch with slot technique and Phaisan Choukiker (M and Choukiker 2018) has designed a circular ring slot antenna in the frequency range of (2.45 & 5) GHz for wifi systems are similar to our research work and their findings are almost related to our study. Any other research article that does not oppose the finding of our result. As it involves 16 samples for each group, significance results are obtained and if the sample size increases further it achieves significant results.

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 feed position, substrate material, and fringing field of the antenna are the factors that affect the reflection coefficients. To achieve a good reflection coefficient, the feed position is matched with a 50-ohm high impedance. The limitation of the work is reflection coefficient is not exceeded below -10 dB while creating a slot in with and without slot. In the future, the simulated designed antenna is fabricated and measured practically using VNA (vector network analyzer).

5. Conclusion

The frequency remains almost the same at 2.4GHz frequency in both with and without slot creation on circular patch antenna and slight changes in reflection coefficient. The antenna shows a good impedance matching with -10 dB.

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Declarations

Conflict of Interests

No conflict of interest in this manuscript.

Authors Contributions

Author AP was involved in the design, data collection, data analysis, manuscript writing. Author SK was involved in the design, data analysis, critical review of the manuscript.

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