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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.

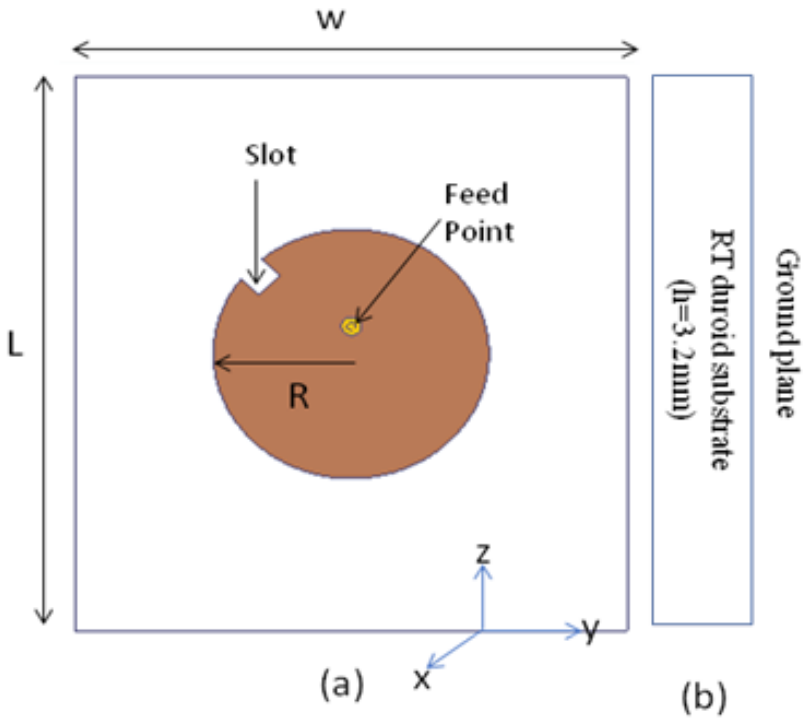

Fig. 2 - Frequency at 2.4GHz shows the reflection coefficient of with slot of circular patch antenna by varying the sweep frequency range from 1GHz to 3GHz and the reflection coefficient is -10.44dB

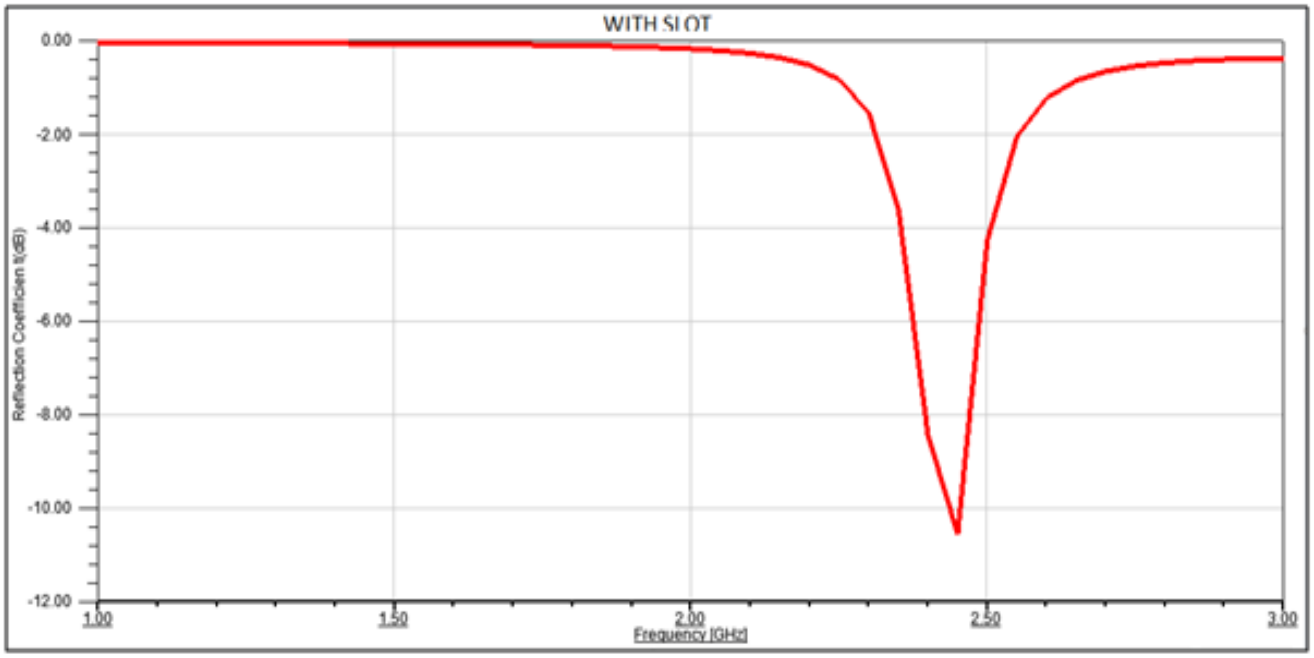

Fig. 3 - Circular Patch without Slot Antenna Geometry(a) Top View (b) Side View consists of a Coaxial Feed Point Center of the Circular Patch without Slot Antenna R=20.95mm with RT/Duroid 5880mm Substrate Material of L×W(10×9mm), height=3.2mm on One Side and the other side is the Ground Plane

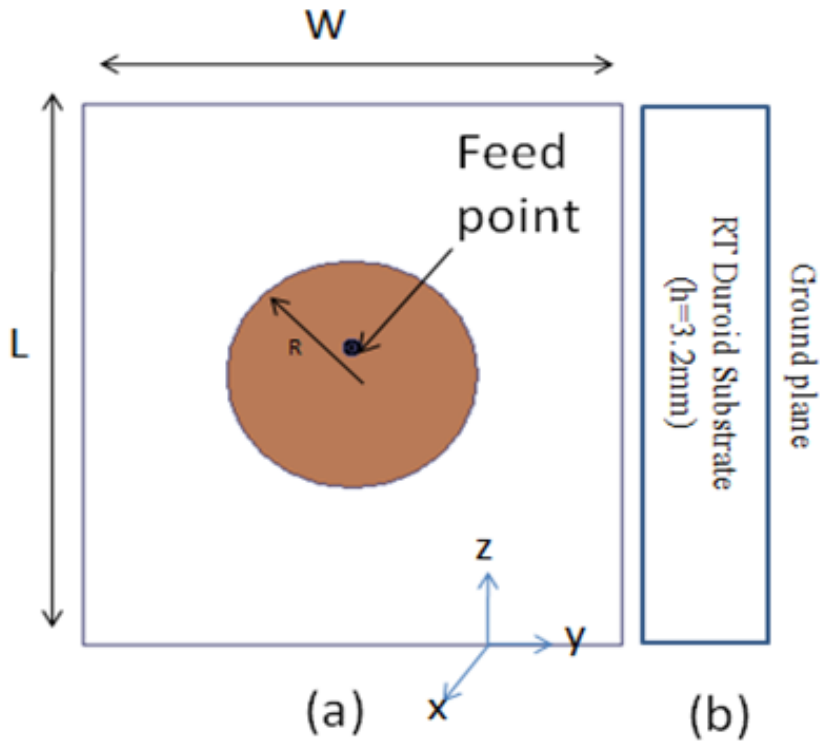

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Fig. 4 - Frequency at 2.4GHz Shows the Reflection Coefficient of without Slot of the Circular Patch Antenna by Varying the Sweep Frequency Range from 1GHz to 3GHz and the Reflection Coefficient is -11.51dB

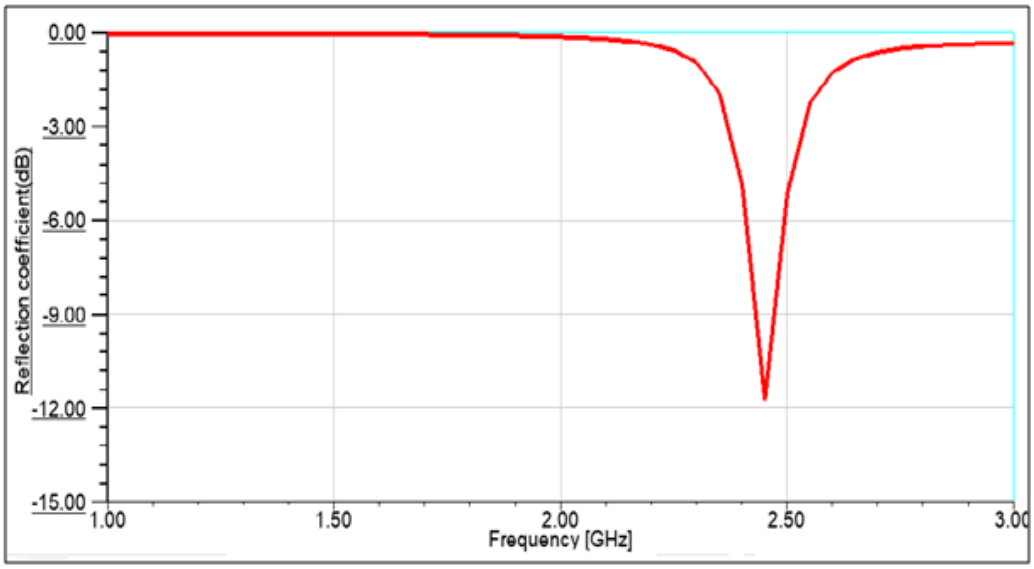
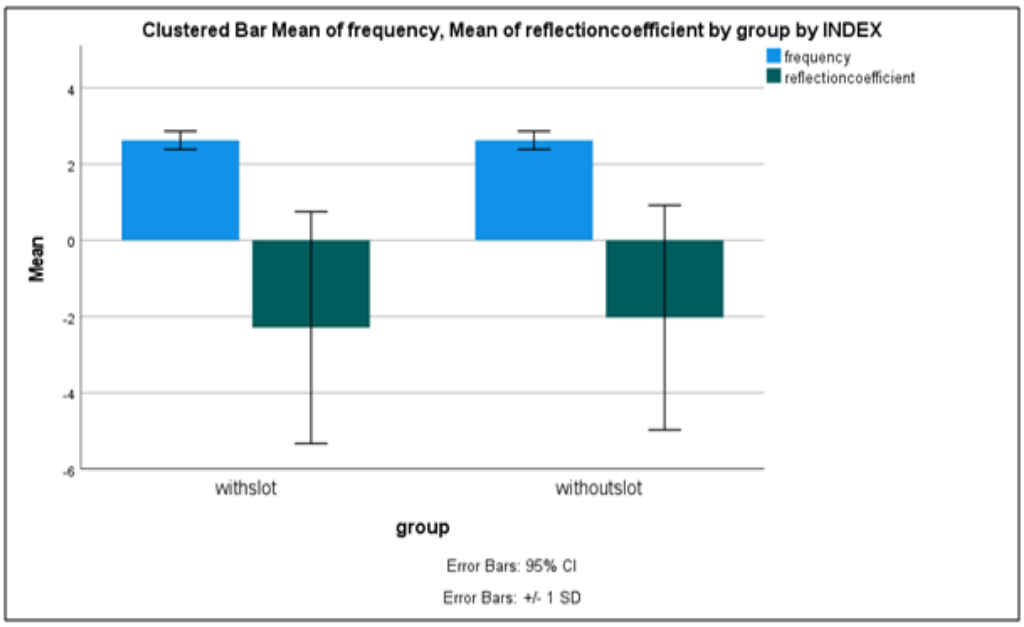


Fig. 5 - Bar Chart and Comparing the Mean(+-1SD) Frequency and Reflection Coefficient of with Slot of the Circular Patch Antenna and without Slot of Circular Patch Antenna by Varying Sweep Frequency. There is no Significant difference between the Two Groups P > 0.05 (Independent Sample T-Test).



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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