International Journal of Engineering & Technology, 7 (4.1) (2018) 81-85

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paperer

Analysis of Performance on Circular Patch Antenna Based on Different Feeding Techniques

Saidatul Hamidah Abd Hamid[1]*, Goh Chin Hock[2], M.T. Ali[3]

[1] College of Engineering, Universiti Tenaga Nasional, Kajang, Malaysia,
[2] Institute of Sustainable Energy, Universiti Tenaga Nasional, Kajang, Malaysia,
[3] Faculty of Electrical Engineering, Universiti Teknologi MARA, Shah Alam, Malaysia
**Corresponding author E-mail:* Saidatul.Hamidah@uniten.edu.my

Abstract

This paper presents a simulation and analysis of a circular patch antenna with different feeding techniques. The objectives of this analysis are to design the microstrip circular patch antennas using five types of feedings techniques which are stepped feed, inset feed, coaxial feed, aperture coupled feed, and proximity feed, to analyze and compares the performance of the antenna design. Performance characteristics of the antenna such as return loss S_{11} parameter <-10dB, directivity, gain, bandwidth, side lobe level, beam width, and voltage standing wave ratio (VSWR) parameters of each of the feeding methods designs are obtained and compared.

Keywords: *Antenna; Circular; Feeding technique; Micro strip; Patch.*

1. Introduction

A lot of methods which can improve the patch antenna performance have been proposed by many researchers [1]. One of the methods to lead maximum power of transmission in patch antenna is the feeding techniques. It is important in designing of the patch antenna and the techniques that choose in the design plays an important role in the impedance matching. The microstrip patch antenna is well-known in suffers from the limitation of narrow impedance bandwidth. For example, Inset feed types offer high gain but less efficient in radiation efficiency. For the proximity feed, it has low in radiation performance. With this statements result from the previous research study, it is clear that different feeding techniques give different characteristic performances. Therefore, selecting types of feedings is one of the most important features in designing the microstrip circular patch antenna to meets the design requirements.

2. Research Methodology

2.1. Identification of Project Requirement

Design requirements of this project are to have a circular shape microstrip patch antenna with five types of feeding techniques [2] using FR-4 (Lossy) as the substrate with a dielectric constant value equal to 4.3. The simulation of a patch antenna is done using CST microwave studio software. Each of the design structures as shown in figure 1 to figure 5 respectively.

2.1.1. Stepped feed technique

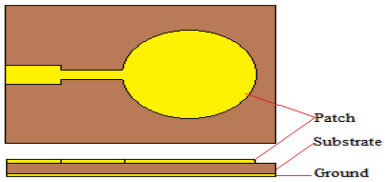


Fig. 1: Stepped feed technique structure

2.1.2. Inset feed technique

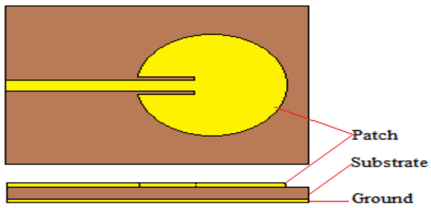


Fig. 2: Inset feed technique structure

2.1.3. Coaxial feed technique

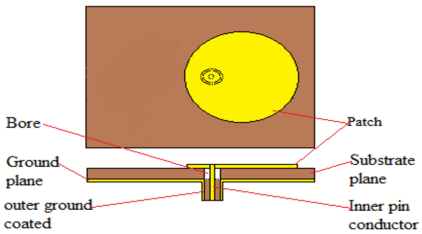


Fig. 3: Coaxial feed technique structure

2.1.4. Proximity feed technique

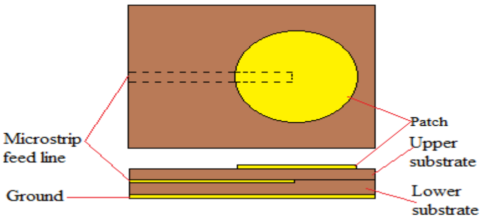


Fig. 4: Proximity feed technique structure

2.1.5. Aperture feed technique

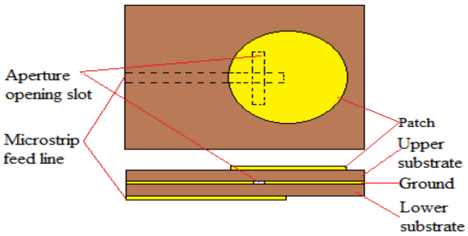


Fig. 5: Aperture feed technique structure

3. Antenna Design

3.1. Elementary Design

By using the basic line feed technique as in figure 6, this design is considered as the elementary design of this circular patch antenna. The parameters are shown in table 1. The simulation results as shown in figure 7 and figure 8.

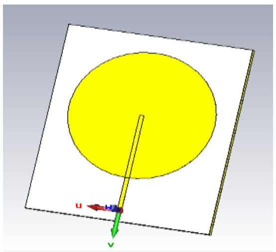
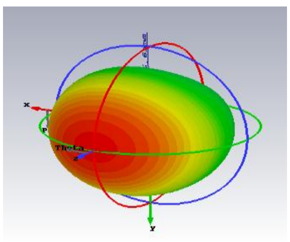


Fig. 6: Basic design of Circular Microstrip Patch Antenna with stripline feed method

Table 1: Design measurements

Parameters Definition		Measurements (mm)
Patch radius	a	17.675
Length of the feed line	Ps	12
Height of the patch	hp	0.035
Height of the substrate	hs	1.6
Width of gap	Wg	4.5
Width of feed line	Ws	1.0



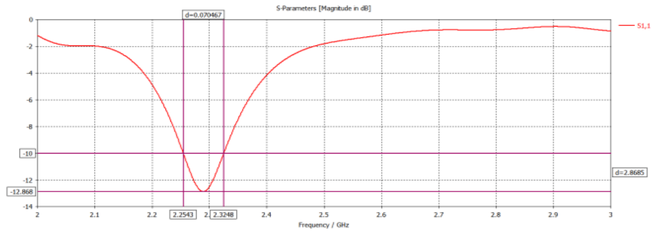


Fig. 7: Return loss S_{11} and bandwidth performances

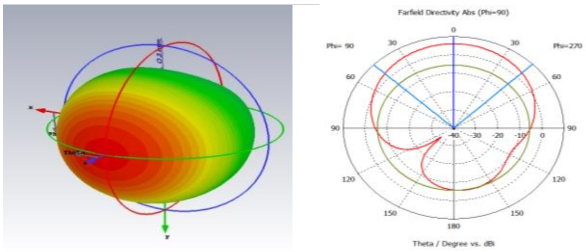


Fig. 8: 3D Farfield Radiation pattern and in polar form

3.2. Antenna design with different feeding techniques

In this section presented the optimize design achieved and the results after the optimization according to the feeding design techniques.

3.2.1. Stepped feeding technique

For the final design, after optimization for stepped feed design, length of stepped feed, *Lf* is chosen to be equal to 4mm as in figure 9 and the parameter shows in table 2.

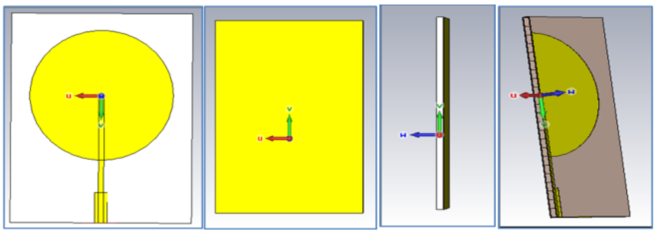


Fig. 9: Antenna with Stepped feed design

Table 2: Design measurements of Stepped-feed

Parameters Definition		Measurements (mm)
Patch radius	a	17.25
Length of the feed line	Ps	16.638
Length of stepped feed	***Lf***	***4***
Height of the patch	hp	0.035
Height of the substrate	hs	1.6
Width of gap	Wg	4.5
Width of feed line	Ws	2.574
Width of stepped feed	Wf	3

Stepped feed length has been manipulated in order to see its effects to the performance result as shown in figure 10 and figure 11.

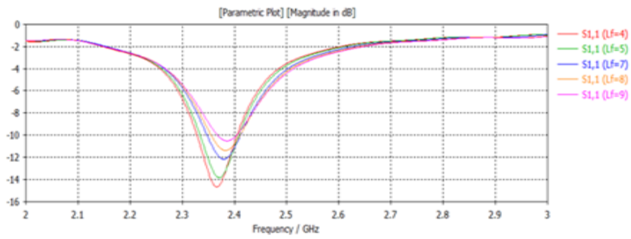


Fig. 10: Stepped length vs Return loss S_{11}

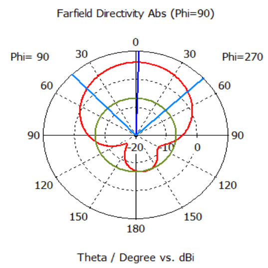


Fig. 11: 3D Farfield Radiation pattern and in polar**.**

3.2.2. Inset feeding technique

After design optimization, as shown in figure 12, Inset feed position; *Lp* is chosen to be equal to 7mm as shown in table 3.

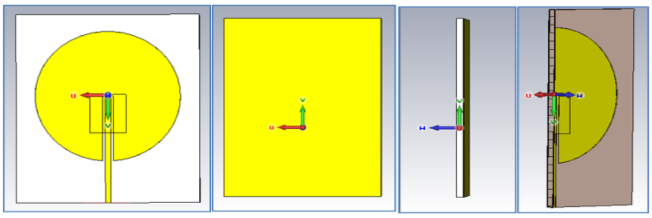


Fig. 12: Antenna with Inset feed design

Table 3: Design measurements of Inset-feed

Parameters Definition		Measurements (mm)
Patch radius	a	17.25
Length of the feed line	Ps	11.092
Length of inset feed	***Lp***	***7***
Height of the patch	hp	0.035
Height of the substrate	hs	1.6
Width of gap	Wg	4.5
Width of feed line	Ws	2.574
Width of feed slot	Wf	3.287

Inset feed length has been manipulated in order to see its effects on the performance and the results as shown in figure 13 and figure 14.

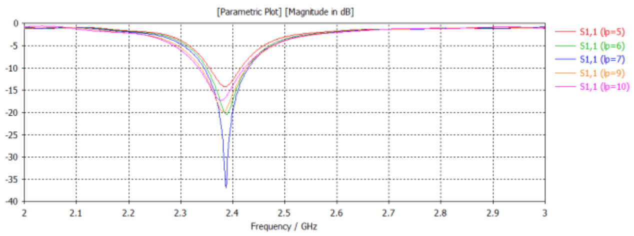


Fig. 13: Inset feed position vs Return loss S_{11}

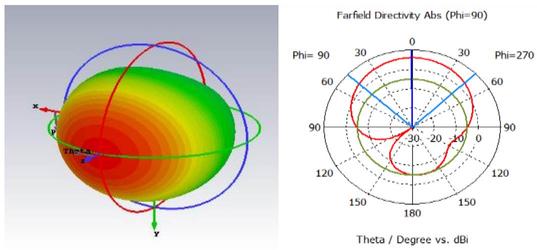


Fig. 14: 3D Farfield Radiation pattern and in polar

3.2.3. Coaxial feeding technique

Optimize design for the patch using coaxial feed techniques as shown in figure 15 and the final parameters of the design as in table 4. For final design after optimization, the radius of the inner pin, *r_in* is chosen to be equal to 0.5mm.

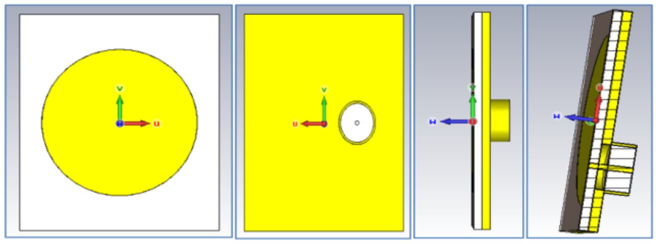


Fig. 15: Antenna with coaxial-feed design

Table 4: Design measurements of coaxial-feed

Parameters Definition		Measurements (mm)
Patch radius	a	16.95
Outer core radius	r_out	5
Inner core radius	***r_in***	***0.5***
Length of the feed line	Ps	7.45
Length of Substrate	Ls	43.5
Height of the patch	hp	0.035
Height of the substrate	hs	1.6
Height of ground	hg	1.6
Width of substrate	Ws	50.09

The radius of the inner core has been manipulated in order to see its effects on the performance result as shown in figure 16 and figure 17. The radius of the inner core design gives impacts to the performance of an antenna.

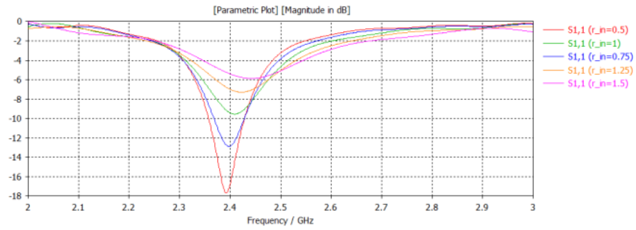


Fig. 16: Inner core radius vs Return loss S_{11}

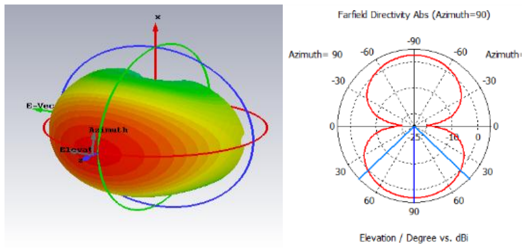


Fig. 17: 3D Farfield Radiation pattern and in polar

3.2.4. Proximity feeding technique

Optimize design for the patch using proximity feed techniques as shown in figure 18 and the final parameters of the design as in table 5. For final design after optimization, the radius of the patch, *a* is chosen to be equal to 16mm.

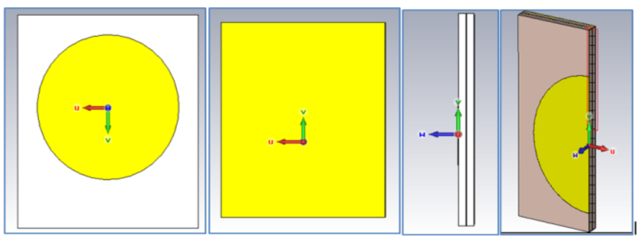


Fig. 18: Antenna with Proximity feed design

Table 5: Design measurements of proximity-feed

Parameters Definition		Measurements (mm)
Patch radius	***a***	***16***
Length of the feed line	Ps	11.092

Height of the patch	hp	0.035
Height of the substrate	hs	1.6
Height of ground	hg	1.6
Width of feed line	Wf	3

The radius of the patch is the variable factor in this particular feeding design technique. The radius of the patch has been manipulated in order to see its effects on the performance result as shown in figure 19 and figure 20.

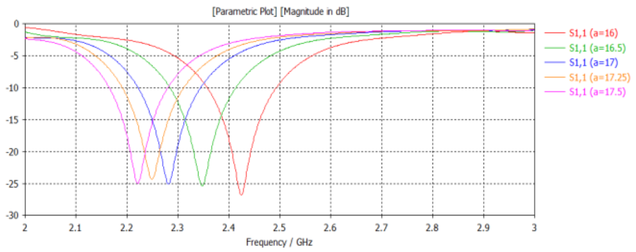


Fig. 19: Patch radius vs Return loss S_{11}

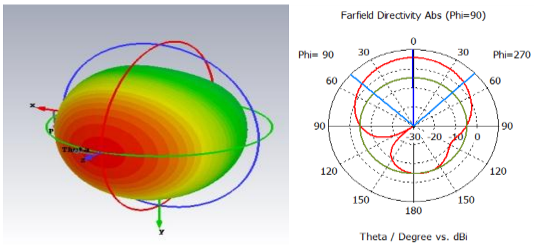


Fig. 20: 3D Farfield Radiation pattern and in polar

3.2.5. Aperture feeding technique

Aperture-slot width has been manipulated in order to see its effects on the performance. For final design after optimization, aperture-slot width, *Wgs* is chosen to be equal to 8.25mm. Design and final parameters show in figure 21 and table 6 respectively.

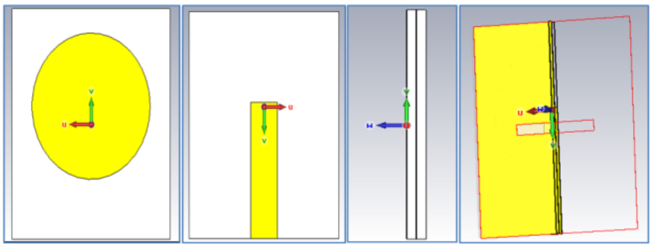


Fig. 21: Antenna with Aperture feed design

Table 6: Design measurements of aperture-feed

Parameters Definition		Measurements (mm)
Patch radius	a	12.25
Length of the feed line	Ps	11.092
Length of aperture slot	Lgs	1.0
Height of the patch	hp	0.035
Height of the substrate	hs	1.6
Height of ground	hg	1.6
Width of feed line	Wf	6
Width of aperture-slot	***Wgs***	***8.25***

Aperture-slot width has been manipulated in order to see its effects on the performance result as shown in figure 22 and figure 23.

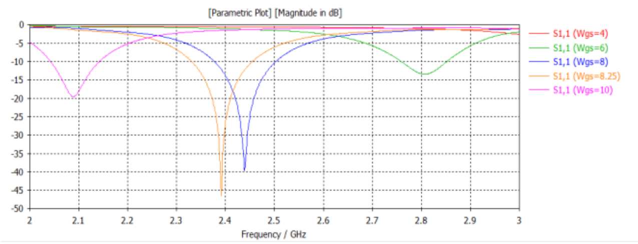


Fig. 22: Aperture-slot width vs Return loss S_{11}

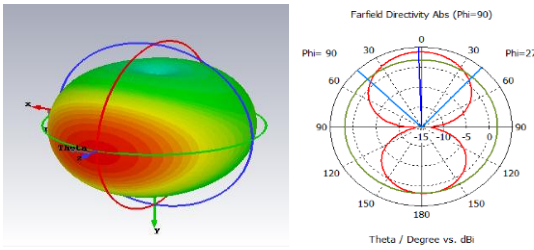


Fig. 23: 3D Farfield Radiation pattern and in polar

4. Discussion

Aperture feed has higher return loss bandwidth compares to others feeding methods. The stepped feed has the highest directivity that makes it an antenna representing more focused beams. The proximity feed method provides the highest gain; describes how well the antenna converts the input power into radio waves headed in a specified direction [3] and the lowest result is given by aperture feed. For bandwidth performance of an antenna, far in distance provides between a lower frequency and higher frequency under the cut off the magnitude of -10dB is desirable. Again, proximity feed design observed the higher bandwidth; describes that an antenna has the good impedance matching. For the side lobe level performance, the coaxial feed has the best result with a minimum sidelobe level. Proximity feed gives the highest beam width performance. Aperture feed has the lowest of the VSWR value nearly to 1; describes how well the antenna is impedance matched to the transmission line it is connected to [4]. The smaller the VSWR is, the better the antenna is matched to the transmission line and more power is delivered to the antenna. Complete results are shown in table 7.

Table 7: Comparison of the performances

1D Results / S-parameters	Feeding types		
	Basic	**Step**	**Inset**
Return Loss, S_{11}(dB)	-12.868	-14.693	-36.931
Directivity (dB)	5.964	**5.944**	5.87
Gain (dB)	2.581	2.306	2.589
Bandwidth (GHz)	0.0705	0.077	0.0854
Beam width (deg)	91.7	90.4	92.5
Side lobe level (dB)	-11.6	-12.7	-11
VSWR	1.622	1.452	1.315
Return Loss, S_{11}(dB)	-26.783	-17.67	**-46.591**
Directivity (dB)	5.667	5.779	3.749
Gain (dB)	**3.778**	1.701	1.297
Bandwidth (GHz)	**0.136**	0.071	0.124
Beam width (deg)	**93.7**	92.6	86.5
Side lobe level (dB)	-10.4	**0**	-2
VSWR	1.096	1.301	**1.009**

5. Conclusion

The circular patch antenna with several feeding methods design techniques has been successfully designing, simulated, analyzed and discussed. From this comparison, it is observed that the non-coupling feed method, proximity feed and aperture feed provides the best output desired results. The design is selected based on the requirement of the application, as the objective of this particular research is for Wi-Fi application. It is true that aperture feed shown the better performances among these five feed techniques which have the highest return loss value, least sidelobe level, and lowest VSWR and can be selected as the most efficient feeding methods with the circular patch antenna. However, high bandwidth which makes it the right choice for inside building reception, with higher gain, and higher beam width makes proximity feed technique with circular patch antenna is suitable for the application requirement.

Acknowledgement

This research work in Universiti Tenaga Nasional (UNITEN) and Institute of Sustainable Energy (ISE) is supported and funded by Innovation and Research Management Centre under Smart University Research Grant, grant number:- 10289176/SMART/2018/17

References

[1] Abdelazeez MK, Awad NM & Abbas AS, “UWB antenna with super bandwidth”, *2016 IEEE International Symposium on Antennas and Propagation (APSURSI)*, (2016).
[2] Chakravarthy SS, Sarveshwaran N, Sriharini S & Shanmugapriya M, “Comparative study on different feeding techniques of rectangular patch antenna”, *IEEE Conference Publications*, (2016), pp:1-6.
[3] Ndujiuba CU, Oloyede AO, “Selecting Best Feeding Technique of a Rectangular Patch Antenna for an Application”, *International Journal of Electromagnetic and application*, Vol.5, No.3, (2015), pp.99-107.
[4] Majumder A, “Rectangular Microstrip Patch Antenna Using Coaxial Probe Feeding Technique to Operate in S-Band”, *International Journal of Engineering Trends and Technology (IJETT)*, Vol.4, No.4, (2013), pp.1206-1210.