5.8 GHz Circular Polarized Microstrip Feeding Antenna for Point to Point Communication

Sharifah Nur Ariffah 1,*, Wan Azani Mustafa1, Syed Zulkarnain Syed Idrus2, Atiqah Muhammad1

1Faculty of Engineering Technology, Universiti Malaysia Perlis, UniCITI Alam Campus, Sungai Chuchuh, 02100 Padang Besar, Perlis, Malaysia
2Center of Excellent Geopolymer and Green Technology, Universiti Malaysia Perlis, 01000, Kangar, Perlis, Malaysia

1wanazani@unimap.edu.my

Abstract. In this paper, the circular polarized 5.8 GHz patch antenna has successfully designed and simulated. This paper presented a design where both of the opposite edges of the rectangular patch of the antenna are truncated using micro strip feeding technique. Both simulations of the proposed antennas had been analyzed. The objectives of this paper has been achieved which is to design and simulate the circular polarized antenna with operating frequency of 5.8 GHz. From the results, the proposed antennas with different feeding technique that radiate at a constant frequency showed some distinct value towards the size of the antenna and the characteristic of its radiation. The results indicate that the antenna that uses micro strip feed line technique yields 2.337 dB directive gain, return loss and axial ratio at -14.042 dB and 3.193 dB respectively. Meanwhile, the directivity values for the antennas is 5.31 dBi. It can be conclude that the designed 5.8 GHz antenna is ideal for point to pint communication antenna due to its performances.

1. Introduction
Antenna is one of the most important components in communication system as it can improve overall system and at the same time relax the system requirements when it has an excellent design system. In other words, the antenna is a type of device used to convert guided electromagnetic waves into radiating waves in an unbounded medium or free space [1]. The antenna indicates a feature where it is called reciprocity which means the antenna will retain its feature regardless if it is transmitting or receiving. Antennas are frequency-dependent device [1]. Most antennas operate efficiently over a band that is relatively narrow frequency. In order an antenna to operate properly, it must be set to have the same frequency band as the radio system that it is connected. This is because if the antenna and the radio system do not have the same frequency, it may results in the transmission and the reception will be impaired.

For micro strip feeding, the patch of the antenna is fed by a micro strip line. The micro strip line is located on the same plane with the patch as it will connected directly to the edge of the micro strip patch and will form a structure. This technique shows simplicity in modelling, simple to fabricate and can be easily matched. Despite that, micro strip feeding also has its own disadvantage as it has narrow bandwidth and may results in undesirable cross polarization effects when the thickness of the...
dielectric substrate increases, the spurious feed radiation will also increases, resulting hampers the bandwidth of the antenna[2]. This feeding technique can be classified into 3 groups which are direct feed, inset feed and gap-coupled feed [3].

Polarization is very significant in a wireless communication system. A wave polarization can be explained as the property that expressed the rotation of the electric field at a fixed point when a wave travelled through space as a function of time. A polarization can be consistent or fixed that exist in a distinct orientation at all time but may vary in minor loops. A plane that contains magnetic and electric field vectors is known as the polarization plane. It is said that the polarization plane is always perpendicular towards the plane of propagation [4][5]. The wave polarization is determined by the path traced by the tip of the electric field vector which commonly found to be in a shape of a circle, an ellipse or a line [4][5].

Circular polarization is very influential in antenna design industry. This is because it able to enhance weather mobility and penetration as well as proving so much more flexibility to the angle between both transmitting antenna and receiving antenna [8][9]. In contrast, to build a good circular polarized antenna is quite challenging [10]. To generate circular polarization, some changes need to be done to the micro strip patch antenna as the antenna itself cannot produce that kind of polarization. Two modes that are equal in magnitude and 90 out of phase are need in order to produce a circular polarization in a micro strip antenna [11][12].

2. Antenna Design and Performances

The first stage is to design the rectangular antenna design with the working frequency of 5.8GHz. The first design structure of proposed antenna is consists of rectangular patch which will be printed on FR-4 (lossy) substrate with dielectric constant of \( \varepsilon_r = 4.3 \), impedance value with 50 Ω, while the thickness of the substrate, \( h = 1.6 \) mm and with a value of 0.035 mm for the copper thickness. The proposed design will be simulated in CST Microwave Studio simulation software. The equation that is used in designing the rectangular micro strip patch antenna is given as below [13]. The width of the patch is calculated by using equation (3.1) and it gives the initial value for the width of a rectangular micro strip antenna to utilize at 5.8 GHz [14].

\[
\frac{c}{2f_r \sqrt{\frac{\varepsilon_r+1}{2}}} = w
\]

By using equation (3.1), the width for the rectangular patch micro strip antenna operating at 5.8 GHz is calculated and the width is equal to 15.88 mm while the length of the patch has the value of 11.88 mm. After the width and the length of the patch are discovered, the next step is to generate circular polarization for the antenna. In this paper, the patch will apply perturbation segment where both of the opposite edges of the rectangular patch are truncated with a cutting angle of 45° in order to obtain circular polarization with an axial ratio of \( \leq 3 \) dB. By applying truncated technique to the patch, this will alter the design parameter of the antenna that may lead to adjustment in the calculated value for the patch width and length. The rectangular patch antenna with truncated corner usually has the range about 2 mm to 10 mm for the cutting edge with 45° of cutting angle. Table 1 shows the initial dimensions for the rectangular patch antenna design.
Table 1: Initial parameter of rectangular patch antenna

| Parameter | Value of parameter (mm) |
|-----------|-------------------------|
| W         | 15.88                   |
| L         | 11.88                   |
| w         | 3.137                   |

The third stage is where slot is added at the centre of the rectangular patch. By cutting a slot in the micro strip patch, this will contribute in the reduction for the size of the antenna thus making the antenna more compact. This is because by increasing the length of the slot, the resonant frequency will also decrease. The outcome from the decrease in the value of resonant frequency will result in the decreasing in the antenna size. It is also used to enhance the value for return loss.

Figure 1. The original designed of antenna

Figure 2. Side view of micro strip feed patch antenna
Some of the initial parameters have been optimized in order to obtain the best results for the working frequency of 5.8 GHz. Table 2 shows the final dimension for the micro strip rectangular patch antenna design.

### Table 2: Final dimension of Micro strip Rectangular Patch Antenna

| Parameter     | Value of parameter (mm) |
|---------------|--------------------------|
| W             | 12.53                    |
| L             | 9.655                    |
| w             | 3.137                    |
| ΔL            | 2.40                     |
| Slot length   | 1.25                     |

3. Simulation results

Figure 3 shows the simulation result of return loss versus frequency for patch antenna with micro strip feed while Figure 4 shows the value of axial ratio of the proposed antenna.

![Figure 3. The Return Loss of Designed Antenna](image)
Figure 4. The Axial Ratio of Designed Antenna

For S-Parameter plot, the simulated value of return loss (S11) for micro strip feed patch is -14.04 dB at 5.8 GHz which is good as the value is more than -10 dB at the desired frequency. As for the axial ratio, the proposed antenna has a value of 3.193 dB. Radiation pattern is a representation of the power or the energy that is radiated by the antenna. It is used to determine the directivity and also the gain of an antenna. For an antenna to be considered as a good antenna, it should have a high directivity in which it measures the degree of the radiated emitted that is focused on a single direction only [7]. From the radiation pattern plot above, the directivity and the gain of the antenna can be determined. The micro strip feed line patch antenna has the directivity of 5.973 dBi and the gain value of 2.337 dB as shown in Figure 5 and Figure 6 below.

Figure 5. The directivity of the proposed antenna
Figure 6: Gain value of micro strip feed line patch antenna

4. Conclusion
As conclusion, the circular polarized 5.8 GHz microstrip feeding patch antenna has successfully designed and simulated. Additional technique of truncated successfully realize the circular polarized antenna with operating frequency of 5.8 GHz. The antenna recorded 2.337 dB directive gain, return loss and axial ratio at -14.042 dB and 3.193 dB respectively with directivity of 5.31 dBi respectively.

References
[1] Ahmed A. Kishk, “Fundamental of Antennas”, Center of Electromagnetic System Research (CEDAR), University of Mississippi, January 2009
[2] S. Bisht, S. Saini, V. Prakash, B. Nautiyal, “Study The Various Feeding Technique of Microstrip Antenna Using Design and Simulation Using CST Microwave Studio”, International Journal of Engineering Technology and Advance Engineering, Vol 4, Issue 9, 2014.
[3] Jamlos, M.A., Jamlos, M.F., Khatun, S., Ismail, A.H, High performance of coaxial feed UWB antenna for human brain microwave imaging (2015) ISTT 2014 - 2014 IEEE 2nd International Symposium on Telecommunication Technologies, pp. 72-75.
[4] John L. Volakis, “Antenna Engineering Handbook 4th edition”, McGraw-Hill, 2009
[5] Nayan, M.K.A., Jamlos, M.F., Jamlos, M.A., Lago, H., MIMO 2×2 RHCP array antenna for point-to-point communication (2014) IEEE Symposium on Wireless Technology and Applications, ISWTA, pp. 121-124.
[6] R. Schmitt, Electromagnetic Explained, Elsevier Science, 2002.
[7] Jamlos, M.A., Jamlos, M.F., Khatun, S., Ismail, A.H., A compact super wide band antenna with high gain for medical applications (2014) IEEE Symposium on Wireless Technology and Applications, ISWTA, pp. 106-109.
[8] W. H. Hayt, J. J. Buck, “Engineering Electromagnetic 6th edition”, McGrawHill, 2001.
[9] M. Rahmani, A. Tavakoli, H. R. Aminovar, A. M. Reza, P. Dehkhoda,”Chalipa, a Novel Wideband Circularly Polarized Microstrip Fractal Antenna.”, 2009.
[10] Thomas A. Milligan, “Modern Antenna Design 2nd edition”, John Wiley& Sons, Inc, 2001.
[11] J. R. James, P. S. Hall, “Handbook of Microstrip Antenna”, Vol 1, Peter Peregrinus Ltd, 1989.
[12] Y. Suzuki, N. Miyano, T. Chiba, “Equilateral-Triangular Microstrip Antenna”, Proceeding of
Microwaves, Antenna and Propagation, Vol 134, Issue 2.

[13] F. A. Nayna, A. K. M. Baki, F. Ahmed, “Comparative Study of Rectangular and Circular Microstrip Patch Antennas in X Band”, International Conference on Electrical Engineering and Information & Communication Technology (ICEEICT), 2014.

[14] Jamlos, M.A., Jamlos, M.F., Khatun, S., Ismail, A.H. An optimum quarter-wave impedance matching feedline for circular UWB array antenna with high gain performance (2014) IEEE Symposium on Wireless Technology and Applications, ISWTA, pp. 165-169.