High Gain of 2x1 Simulated Circularly Polarized Rectangular Microstrip Patch Array Antenna

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Abstract. This paper presents a high gain of 2x1 circularly polarized rectangular microstrip array antenna for wide communication. This paper study the design and the simulation of the array antenna in terms of gain, return loss and the axial ratio. The 2x1 array antenna with dimension of 130 × 80 mm is proposed. The presented design is composed of two elements of microstrip patch antenna with an array configuration. The truncated edge of the patch and the inclined slot are the techniques used that capable to achieve circular polarized capability. The antenna is fed by microstrip transmission line with full ground plane and etched on Rogers RT 5880 substrate with 2.1 and 1.53 mm of dielectric constant and the thickness respectively. The 2x1 array antenna achieved a gain of 10.77 dB with a return loss of -24.63 dB at a desired frequency of 5.8 GHz.

1 Introduction

The antenna is one of the important parts in wireless communications that acts as transmitting and receiving data communications. For the high demands in communication industries, the microstrip patch antenna are suitable used because it can indicate a good signal with a compact structure and easy to construct. The antennas which are used in these applications should be low profile, light weight, low volume and large bandwidth [1,2]. Microstrip antenna is most preferred since it meets these requirements. The antenna that mounted on the rigid surface should be low-profile, simple and inexpensive to manufacture [3]. Although microstrip antenna has a lot of advantages, it also has some disadvantages such as low gain, narrow bandwidth with low efficiency which can be overcome by constructing many patch antennas in array configuration [4,5].

Beside, polarization is important to limit the wireless communication distance and allowing the receiver to continuously receive the power at any wave angle [6]. The requirements of circular polarization are needed to make the transmission between two antennas more constant [7,8]. Circular polarization can be obtained if the axial ratio of the antenna is below than 3 dB at 0 phase shift [8]. This may be done by adjusting the physical dimensions of the microstrip patch array antenna. In demand to design circular polarization antenna, the patch must undergo some modification such as making perturbation on the patch oppositely truncated or locate an inclined slot with diagonal feeding [9]. Common-
ly, both edges of geometry parallel to its major axis are truncated. It is realized that the impedance bandwidth and axial ratio bandwidth of modified antenna are improved on proposed truncations in the edge [10].

In this paper, the design of (2x1) microstrip patch array antennas with microstrip line as feeding method is presented. Quarter-wave transformer is used to match the feeding line to the radiating patch of antennas, thus giving ease to impedance matching to the desired frequency [11]. The center frequency of the array antenna is determined to operate at 5.8 GHz. The 2x1 patch array antenna was then fabricated on the substrate type Rogers RT 5880.

2 Antenna Design

The design steps are presented in this section. The parameter of the proposed circularly polarized 2x1 patch array antenna are operate at 5.8 GHz. The Rogers RT 5880 with dielectric constant of 2.3 and thickness of 0.51 mm is choose as a dielectric material. The antenna dielectric substrate consists of 3 layer of Rogers RT 5880 which make the thickness of the antenna substrate is 1.53mm. The thick substrate is good to use in wide application because in can improve the gain, bandwidth and the radiation pattern of the antenna [12]. The side view of antenna design showing the layer of the substrate is presented in Fig. 1.

In this research, the design of 2 elements is configured as one dimensional in 2x1 array. The design of 2x1 (2 elements) rectangular microstrip patch antenna array with a resonance frequency of 5.8 GHz with different dimensions is presented in Fig. 2. The antenna consists of two rectangular patch design which has a truncated corner and the inclined slot at the centre of the patch to realize circular polariza-
tion [13,14]. Besides, it is found that the construction of many patch with an array can boosted the antenna gain [15]. The patch antenna is fed by using transmission line which separated into two lines based on the number of radiating elements. The quarter wave impedance matching technique is used to match the radiating patch to distribute the power to the surrounding area as well as to reduce the reflection loss [16]. The 50 Ω transmission line are utilized to be matching between 70 Ω and 100 Ω.

2.1 Formulation of Antenna Design

Equation of width and length of rectangular patch antenna: [17]

\[
L = \frac{c}{2f\sqrt{\varepsilon_{\text{eff}}}} - 2\Delta L
\]  

(1)

\[
W = \frac{c}{1+\varepsilon_r} \sqrt{\frac{S}{1+\varepsilon_r}}
\]  

(2)

\[
\varepsilon_{\text{eff}} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2} \left(1+\frac{12h}{w}\right)\frac{1}{2}
\]  

(3)

\[
\Delta L = \frac{0.412h(\varepsilon_{\text{eff}}+0.3)\left\{\frac{W}{h}+0.254\right\}}{(\varepsilon_{\text{eff}}-0.8)\left\{\frac{W}{h}+0.8\right\}}
\]  

(4)

Equation to find the size of truncation: [18,19]

\[
\Delta S = \Delta S_1 + \Delta S_2
\]

\[
\Delta S = S_2
\]

\[
L = L_p^2
\]

\[
\Delta S_1 = \Delta S_2 = \text{long diagonal patch pieces}
\]

\[
S = \text{long side of patch pieces}
\]

\[
L = \text{patch square}
\]

\[
L_p = \text{long side patch}
\]

| Parameter                | Value               |
|--------------------------|---------------------|
| Operating Frequency      | 5.8 GHz             |
| Dielectric Substrate     | 2.2                 |
| Thickness of substrate   | 1.53 mm             |
| Size of substrate        | 130mm x 80 mm       |
| Size of Patch            | 39.2 mm x 28.4 mm   |
| With of Truncation       | 6.24 mm             |
| Size of Slot             | 2mm x 20 mm         |
To realize the high gain antenna, the parameter of the array antenna is optimized such that it gives best radiation pattern and maximum gain. The rectangular patch has a length and width of 28.08 mm and 39.46 mm respectively. The center part of the rectangular patch has an inclined slot with a size of 12 mm X 2 mm. The truncation size was optimized to be 5.85 mm in order to achieve circular polarization.

### 3 Simulation Results and Discussion

The proposed 2x1 array antenna is simulated by CST software which presented in Fig. 3 and Fig. 4. The frequency is drop at 5.8 GHz with a return loss of -24.63 dB and the result of simulated axial ratio is 2.35dB which is below than 3 dB. Hence, the array antenna is circularly polarized.

![Fig. 3. Simulated Result of S_{11}](image)

![Fig. 4. Result of Axial Ratio Vs Frequency](image)
The farfield result in Fig. 5 showing a result of high gain antenna simulation which has a gain of 10.77 dB. Form the simulated result, it was claim that design an array antenna will contribute to a high gain.

![Farfield Antenna Gain](image)

Fig. 5. Farfield Antenna Gain

4 Conclusion

The proposed antenna with two element antenna array have been design and simulated successfully. The mathematical calculations and methods for the designs of 2x1 array of rectangular microstrip antennas resonating at 5.8 GHz is presented. The antennas performance characteristics such as return loss, gain and axial ratio were obtained in the simulation using CST. The modification on the antenna patch is make to realize the circular polarization and increase the antenna gain. The array is identified to be a good method to increase the antenna gain. The 2x1 rectangular microstrip antenna array is design and produced a good return loss of –24.63 dB at 5.8 GHz and the axial ratio result is 2.35 dB which is below 3 dB. The gain obtained is 10.77 dB which lead to high gain antenna. The simulation results show that the gain of an array antenna is established by using the novel designed of 2x1 rectangular microstrip antenna array.

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