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# Investigation of Patch Phase Array Antenna Orientation at 28 GHz for 5G Applications

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**Abstract**

In this paper, three different configurations of patch array antennas are designed to investigate their radiation patterns with different orientation and excitation phase at 28 GHz for 5G application. All antennas are fed by inset feed line. The excitation phases are changed to study the radiation pattern of each patch array antenna with different orientations. Simulated and measured S11, S12 and simulated radiation patterns are presented. The simulated result showed that the designed antennas are able to operate at 28GHz. Antenna 1 and 2 provide beam shifting covers the angles up to 66°, while for Antenna 3 is 94°.



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*Keywords:* 5G; millimeter wave; 28GHz; microstrip patch antenna; array antenna

## 1. Introduction

Wireless communication technology has developed so fast to meet the demand of high traffic capacity in electronic devices. The 5G technology uses higher frequency bands to provide large data capabilities for supporting multi-Gbps data rates, and to gather infinite data broadcast within newest mobile technology [1]. Many researches have been done at 28 GHz as Local Multipoint Distribution Service (LMDS) which operate at 28GHz to 30GHz provide fixed wireless, broadband and point-to-multipoint technology [2]. Millimeter-wave communication systems using narrow beams at the transmitter and receiver, which suppress the interference of neighboring beams. However, narrow transmitter and receiver beams cause the multipath components of millimeter waves to be limited. Therefore,

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by having the beam shifting, beam-forming weights can be adjusted to point toward the base station effectively [2]. Modern wireless communication systems require a low profile, lightweight, high gain and simple structure antennas to ensure reliability, mobility, and high efficiency [3]. Therefore, the microstrip patch antenna is preferred due to its low profile, easy to fabricate and feed, and even easy to use in the array or incorporate with other microstrip circuit elements [4]. Furthermore, patch antennas are used as simple and highly preferred in many applications such as circular polarizations, dual characteristics, dual frequency operation, frequency agility, broad bandwidth, feed line flexibility and beam scanning can be easily obtained from these patch antennas as described in [5].

In this paper, three different configurations of patch array antennas are designed to perform at 28 GHz. This is to study how the orientation of patch array antenna can affect the beam forming and which orientations give a maximum performance on the beam forming and beam steering.

## 2. Microstrip Patch Antenna with Inset Feed line

Fig. 1 shows the geometry of the rectangular microstrip patch antenna with inset feed line. The patch can be notched to provide an inset feed point ($y_0$). Table 1 shows the optimized parameters for a single patch design.

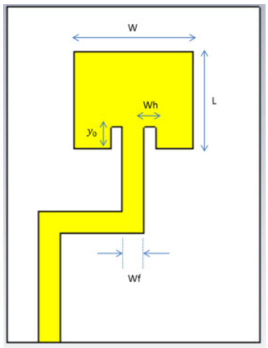


Fig. 1 Dimensions of single patch design

Table 1 Optimize parameters for a single patch design

| Parameter | Value (mm) |
|---|---|
| W | 4.24 |
| L | 3.27 |
| $y_0$ | 0.77 |
| Wh | 0.40 |
| Wf | 0.79 |

The calculations [4] on the dimensions of a single element of the rectangular patch antenna in Fig. 1 are shown below by equations (1) and (2).

$$W = \frac{c}{2 f_r \sqrt{\frac{\varepsilon_r + 1}{2}}} \tag{1}$$

Where $c$ is the velocity of light, while $f_r$ is the operating frequency, and $\varepsilon_r$ is the dielectric constant of the substrate. In the formula (2), the actual length of the patch ($L$) can be determined after obtaining the values of the effective length of the patch ($L_{eff}$) and the length extension ($\Delta L$).

$$L = L_{eff} - 2\Delta L \tag{2}$$

## 3. Microstrip Patch Array Antenna Configurations

Fig. 2 (a) (b) and (c) show the proposed antennas with three different configurations. Each antenna consists of three layers. The lower layer is a fully ground plane with copper. The middle substrate is Rogers 5880 with dielectric constant, $\varepsilon_r$ =2. 2 and dielectric loss tangent, tan δ=0.0009, and a height of substrate, h=0. 254mm. The