A 28 GHz 4 × 4 U-Slot Patch Array Antenna for mm-wave Communication

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***Abstract* – In this paper, a 28 GHz 4×4 U-slot patch array antenna for mm-wave communication is proposed. The proposed antenna is comprised of 16 rectangular patchs with U-slot and microstrip line feed network. Rectangular patch antennas are arrayed in 4×4 formation to obtain a high gain. The -10dB reflection coefficient bandwidth of array antenna is 4.91 GHz (25.16 GHz – 30.7 GHz) and the maximum gain is 17.01 dBi in the y-z plane.**

***Index Terms* — 5G, array antenna, U-shpated slot, wideband.**

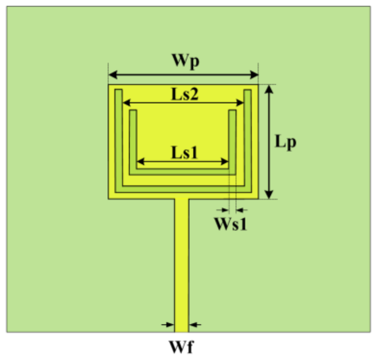
1. Introduction

With the fast development of a wireless transmission and mobile network techniques, data traffic of wireless network has been increased rapidly in recent years. To support the expected requirements for higher data traffics in the near future, fifth-generation (5G) cellular system has been researched intensively [1]. Sinse 5G cellular systems are expected to operate near millimeter-wave(mm-Wave) frequency band of 30-300 GHz [2], a highly directional array antenna is required to overcome the potential path loss problems. Microstrip antenna has advantages of low profile, light weight, low cost, and ease to fabrication for use in mobile application [3]. However, its use has been limited in mobile communication due to the its narrow bandwidth. Of the various techniques to increase bandwidth, the use of U-slot in a microstrip patch is an efficient method to achieve wideband property and to radiates electromagnetic wave efficiently [4].

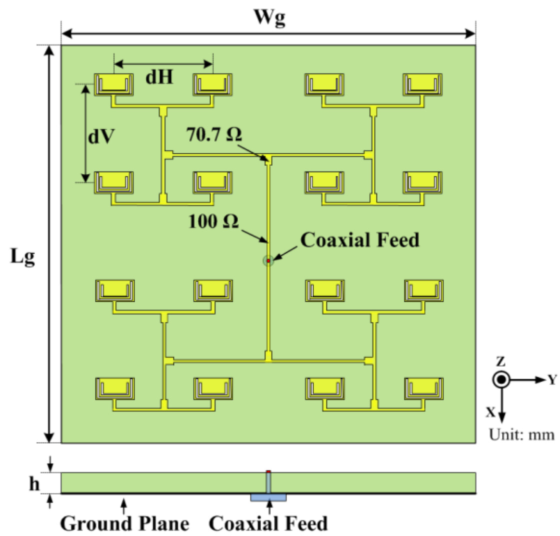
In this paper, a 28 GHz 4 × 4 U-slot patch array antenna for mm-wave communication is proposed. The proposed antenna is designed to have the center frequency of 28 GHz for 5G application. The proposed antenna consists of 16 rectangular patches with microstrip line feed network. The patch antennas are arrayed in 4x4 formation to obtain a high gain and U-shape slots are utilized to increase the bandwidth.

2. Antenna Design

The configuration of the proposed antenna is shown in Fig 1. The antenna is designed on a Taconic TLY substrate(dielectric constant=2.2, loss tangent=0.0009) with a thickness of 0.508 mm. The demension of substrates is 53.1 mm × 55 mm × 0.508 mm, and the patch size is 6 mm × 4 mm. The single microstrip antenna has two U-shaped slots inside a patch for wide bandwidth as shown in Fig 1. (a). The array antenna consists of 16 doubly U-slotted rectangular patches in 4×4 formation and microstrip power dividers to feed array elements. A quarter-wavelength transformer of 70.7 Ω is employed to match the impedance line of 100 Ω to the impedance line of 50 Ω. Fig. 1 (b) shows the 4 × 4 microstrip array antenna with the feed network. The design parameters of the proposed antenna are shown in Table 1.



(a)



(b)

Fig. 1. The geometry of the proposed antenna: (a) single microstrip antenna (b) 4 ×4 microstrip array antenna

TABLE I
Design Parameters of the Proposed Antenna

meter	Value	Parameter	Value
Wp	6 mm	Lg	55 mm
Lp	4 mm	Wg	53.1 mm
Ls1	3.6 mm	dH	14.7 mm
Ls2	4.9 mm	dV	15 mm
Ws1	0.25 mm	h	0.508 mm
Wf	0.5 mm		

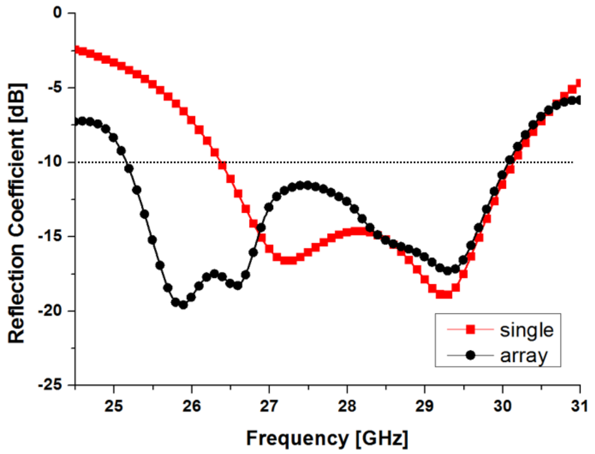


Fig. 2. Simulated reflection coefficients of the proposed antenna

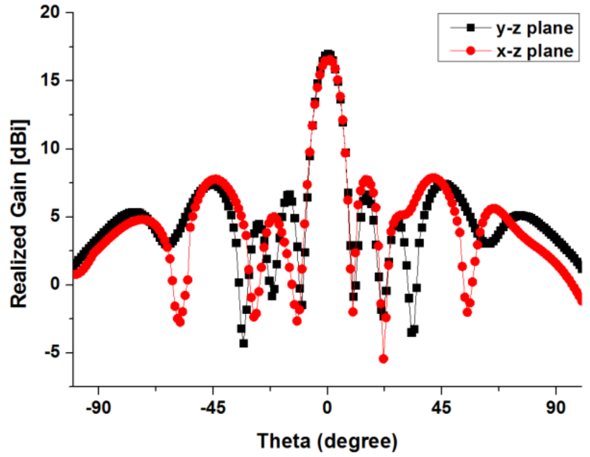


Fig. 3. Simulated radiation patterns of the proposed antenna (x-z and y-z planes)

3. Simulation Results

Fig. 2 shows the simulated reflection coefficients of single patch antenna and 4×4 microstrip array antenna. The -10dB reflection coefficient bandwidth of single patch antenna is 3.77 GHz (26.37 GHz – 30.14 GHz) and that of array antenna is 4.91 GHz (25.16 GHz – 30.7 GHz). As shown in Fig. 3, the simulated radiation patterns of the proposed antenna have directional property. In the x-z and y-z planes, the maximum gains of array antenna at 28 GHz, are 16.48 dBi, 17.01 dBi, repectively. This figure shows that the radiation patterns of array antenna have some minor lobes. These minor lobes are arised by the patches formed in array structure [5]. In addition, antenna array characteristic is affected by undesirable mutual coupling that degrades the gain, radiation pattern, and side lobe level performances. In other words, to diminish these side lobes, a feeding network structure to isolate the mutual coupling and to improve the impedance matching is requied.

4. Conclusion

In this paper, a 28 GHz 4x4 U-slot patch array antenna for mm-wave communication is proposed. By properly choosing the lengths of U-shaped slots and feeding network, and using a number of patch antenna elements, the wide bandwidth and high gain characteristics are obtained. Although the proposed antenna has some side lobes, this antenna can be applied to a mobile terminal with the wide bandwidth characteristics.

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