Wideband Sectored Antennas using CPW-fed Slot with Shaping the Reflectors

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1. Introduction

Recently, high speed wireless data transmission is demanded. The degradation of transmission quality caused by multipath propagation often becomes a serious problem in such system. The sectored antenna is one of the techniques to compensate this degradation of the transmission quality, which leads to higher data transmission rate. The coverage sectorization via the utilization of directional antennas potentially increases system capacity of wireless communications. Pattern shaping of the base station antenna can yield benefits in controlling interference but it is not the dominant factor in determining the cell shape. So far, various kinds of sectored antennas have been proposed and developed, but most of these antennas have complex structures [1]-[3]. The use of Yagi antenna with microstrip patch elements was proposed for use in mobile terminals in [4]. In [5], an antenna based on slot Yagi-Uda array was studied. For some applications of the sectored antennas, it is desirable to be able to adjust the beamwidth of the radiation characteristic. This paper proposes that a variable beamwidth antenna can be achieved by making a shaped reflector. The design examples of wideband antennas with the H-plane half-power beamwidths of 72^0, 90^0 and 120^0, suitable for 5 sectors, 4 sectors and 3 sectors, respectively, are shown.

2. Antenna Configurations

The geometry of the CPW-FSLW antenna without reflector is depicted in Fig. 1(a). From our previous work [6] which the impedance matching of the antenna can have an impedance bandwidth larger than 67% (1475-2966 MHz) at the center frequency. This antenna located above several types of the reflector shapes including flat reflector, Λ and inverted-Λ shape reflectors as shown in Fig. 1. By changing the parameters of each reflector such as size of reflector, the distance between radiation element and reflector, and the angle between horizontal plate and the two sides slope reflector of Λ and inverted-Λ shape reflectors, it will affect the impedance bandwidth, resonant frequency and radiation characteristics especially HPBW. Firstly, the antennas located above an infinite and a finite reflector planes [Fig. 1(b)] were analyzed [7]. The reflector has dimensions of $W_{b1} \times W_{b2}$ and distance between the reflector and radiation element is h_b. Also, The Λ-shape reflector, having a horizontal flat section dimensions of $W_{c1} \times W_{c3}$, is bent with a bent angle of β. The width of the bent section of the Λ reflector is W_{c2}. The distance between the antenna and the flat section is h_c. Lastly, The inverted-Λ shape reflector, having a horizontal flat section dimensions of $W_{d1} \times W_{d3}$, is bent with a bent angle of α. The width of the bent section of the inverted-Λ reflector is W_{d2}. The distance between the antenna and the flat section is h_d.

3. Simulation and Experimental Results

In this paper, we focus on the HPBW because the impedance bandwidth and some pattern characteristics were reported in our previous work [7], not repeated here. The calculated HPBWs of the antennas with an infinite and a finite reflectors by varying separate distance of h_b = 30, 50 and 70 mm are shown in Fig. 2. It can be seen that the HPBW gets wider when the distance between the radiating element and flat reflector (h_b) is increased. Besides, the HPBW is affected not only by the distance between the radiating element and flat reflector and reflector size, but also by frequency dependence. From the results of the flat reflectors, the HPBWs are frequency dependent which restrict a wider application for sectored antennas. In order to solve this problem, the shape of the reflector corresponds to the constant beamwidth which provides sectored antenna with wideband operation. The reflectors are used to shape the azimuth radiation pattern. The shape of the beam can be controlled by varying the geometry of the reflector, no other redesign is needed. Various H-plane HPBWs have been obtained by proper selection of the reflector dimensions, reflector spacing (h_c and h_d), bent angles (β and α), and reflector sizes (W_{c1}, W_{c2}, W_{d1} and W_{d2}). Some simulated designs have been developed producing the reflectors that are able to change from a configuration with three sector beams of 120^0 wide in H-plane to other consisting of four sector beams of 90^0 and five sector beams of 72^0. Comparison of the simulated HPBWs obtained by eight different reflector sizes and shapes are presented in Fig. 3. It is evident that there are three separate groups of the HPBW. For inverted-Λ shape with h_d=50 mm, the HPBWs have more than 100^0 depends on the angle of α. For these cases, the α increases the HPBWs are decreased. As can be seen in Fig. 3, the Λ-shape reflector with h_c=30 mm cases showed the HPBWs of 90^0-150^0 over the frequency range 1.2-2.8 GHz. The results for antennas with coverage sectors of 72^0 are obtained by the flat reflector with h_a=30 mm, W_{b1}= W_{c1}=214 mm (one-wavelength at 1.4 GHz). Another way to obtain a structure with coverage sectors of 72^0 over a wide frequency range is to employ the Λ-shape reflector with h_c=30 mm, α=150^0 and extended W_{c1}= 200 mm. Three typical cases are investigated : (1) for the Λ-shape, h_c=30 mm, β=150^0, W_{c1}=214 mm, W_{c2}=44 mm, beamwidth in H-plane is around 72^0, as called 72DegAnt, (2) for the Λ-shape, h_c=30 mm, β = 60^0, W_{c1}=72 mm, W_{c2}=44 mm, beamwidth in H-plane is around 90^0, as called 90DegAnt, and (3) for the inverted Λ-shape, h_c=50 mm, α=90^0, W_{d1}=72 mm, W_{d2}=44 mm, beamwidth in H-plane is around 120^0, as called 120DegAnt. There are shown in Fig. 4 where the main beams of normalized H-plane patterns at 1.4, 2.0, and 2.6 GHz are plotted for three different reflector shapes. Over the whole frequency range, the three of investigated antennas provide the H-plane beamwidths of 121^0-127^0, 95^0-100^0 and 75^0-80^0. It is observed that the radiation patterns in H-plane are almost unchanged for the different frequencies, having the symmetrical shapes with respect to boresight and without additional dips. The side-lobes including back-lobes are much lower than -12 dB. Fig. 5 shows simulated radiation patterns in H-plane coverage sector for three different reflectors, 72^0, 90^0 and 120^0 over a wide frequency range. Some beamwidth variations with frequency are also presented. It is also observed that the HPBWs are approximately 72^0, 90^0 and 120^0 and are fairly stable over the whole frequency range. Comparisons of calculated gain obtained by using 3 different reflector shapes are presented in Fig. 6.

4. Conclusion

A CPW- fed slot antenna using loading metallic strips and a widened tuning stub above three different types of reflector shape, with different sector patterns, have been proposed. Directive radiation characteristics are achieved by proper reflector spacing and shape. With these designs, the antenna radiation patterns can easily be optimized to meet different requirements. A variety of azimuth beamwidths can be obtained. Three sectored antennas in wideband operation, for base station of wireless communication applications, with different sector patterns, have been designed and studied. This proposed sector antenna will be mounted on the roof of vehicles, and also used for indoor and outdoor base stations for micro, pico wireless communication systems.

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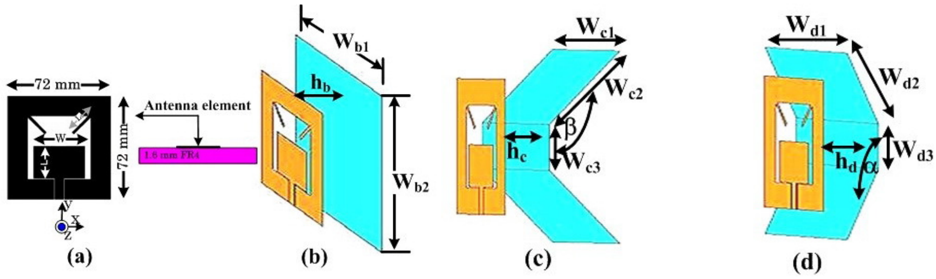

Fig. 1 CPW-FSLW (a) radiating element above (b) flat, (c) Λ-shape and (d) inverted-Λ shape reflectors

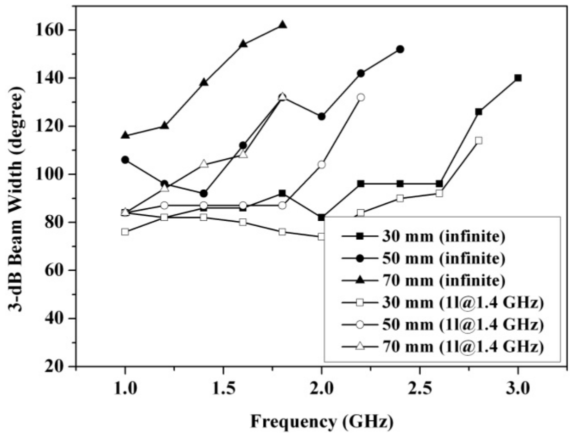

Fig. 2 HPBWs of an infinite and a finite flat reflectors backed CPW-FSLW antenna for different separations between the antenna and the reflector

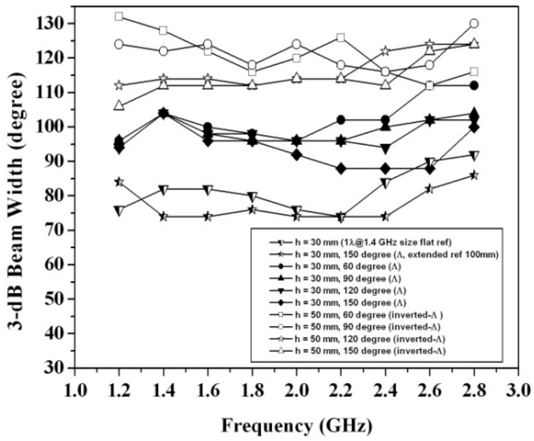

Fig. 3 Half power beamwidths of antenna above different size reflectors

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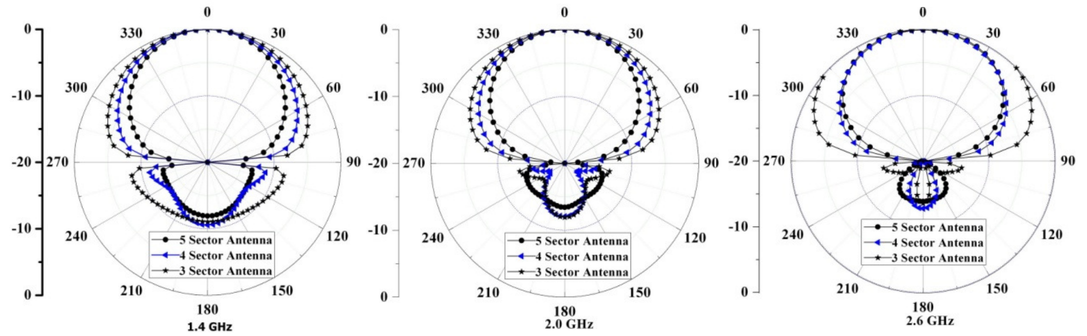
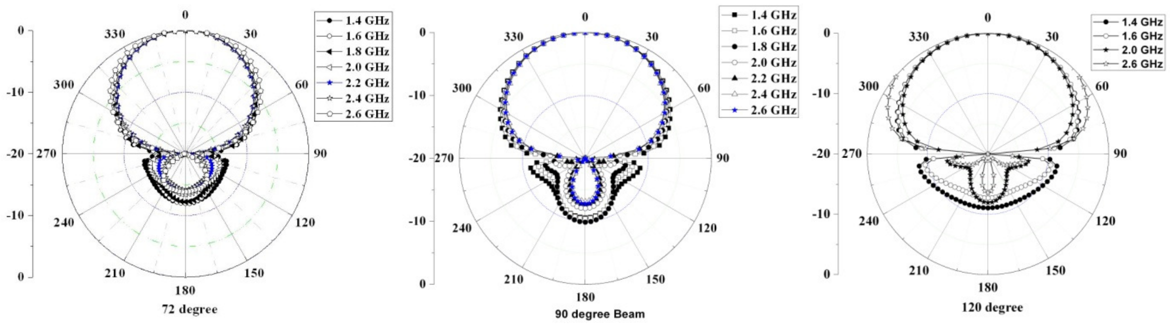


(a) (b) (c)

Fig. 4 Simulated radiation patterns in H-plane for three different reflectors at (a) 1400 MHz, (b) 2000 MHz and (c) 2600 MHz



(a) (b) (c)

Fig. 5 Simulated radiation patterns in H-plane coverage sector for three different reflectors (a) 72^0 (72DegAnt), (b) 90^0 (90DegAnt) and (c) 120^0 (120DegAnt)

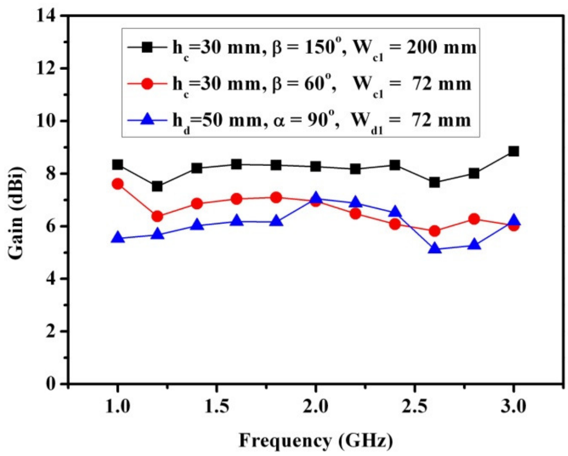


Fig. 6 Calculated gain of three reflector shapes (a) 72DegAnt, (b) 90DegAnt and (c) 120DegAnt