Proceedings of ISAP'04, Sendai, JAPAN

Design of a Wide-Band Slot Antenna with CPW-Fed

Kyung-sup Shin and Hong-min Lee
Department of Electronics Engineering Kyonggi University
San 94-6, Yiui-Dong, Young tong-Gu, Suwon-Si, Kyonggi-do, Korea
E-mail: kal2s@dreamwiz.com

1. Introduction

New communication environments typically consist of a broad range of application devices providing data, video, and audio services. The rapid developments in the wireless communications industry demand novel antennas that can be used in wide frequency bands. In order to accomplish these requirements, we start a new design with two main concepts; a CPW feed line and a slot radiating element. The slot antenna is known as a wide bandwidth operation antenna, and the CPW feed line provides a broad band and balanced feed structure. For operating wide band, several techniques are studied such as using high order modes[1] (TE_{10}, TE_{20}, $TE_{30}\ldots$), parasitic patch[2,3] or meandering slits[4] at opposite edges. The designs of the CPW fed[5] slot antennas have recently much more attention due to the advantages of wide bandwidth and easy integration with monolithic microwave integrated circuits.

In this paper, we propose a new printed slot antenna with a CPW feeding structure. The proposed antenna has a compact size and shows wide bandwidth characteristics comparing with microstrip line fed ones. Antenna design concepts and the details of experimental results are discussed.

2. Antenna Design

The proposed antenna geometry is shown in Figure 1. This antenna has a planar configuration which consists of a slot, ground plane and CPW feeder line. The characteristic impedance of the CPW feed transmission line is 50Ω. The semicircle tuning stub connected at the end of the CPW feeder line

By adjusting the size and shape of the semicircle tuning stub, a good impedance matching can be achieved. A wide impedance bandwidth is obtained by these tapered slot and semicircle tuning stub. The radiating slot is also chosen to be tapered as the slot length getting increase. The incoming source signal through a CPW feeder line, induce electric fields between ground plane and tapered slot. Basically a dominant resonant mode(TE_{10}) is formed in a slot at one frequency. As the source frequency is increased high order resonant modes produced in a slot. By these multi-resonance effects, the proposed antenna shows the wide band frequency characteristics.

In this paper, the proposed slot antenna which is operated from 2.0GHz to 25.9GHz frequency bands, is designed and fabricated using a CPW fed asymmetric hemisphere slot. The substrate which

ISBN: 4-88552-207-2 C3055©IEICE

has a dielectric constant of $\varepsilon_r = 4.4$ (FR-4) is used, and it's thickness is about $1.6mm$. At first, we set the parameters of the slot length, stub shape and ground plane at a frequency of 3.7GHz. The additional rectangular slot is attached to extend the lower band operating frequency. Figure 2 shows the simulated return loss of the designed antenna for with or without an additional rectangular slot. Without an additional rectangular slot, the lowest resonance frequency of the antenna is occurred at 6.6GHz. On the other hand, when an additional rectangular slot is attached, the lowest resonance frequency is changed to 2.0GHz. This additional rectangular slot makes the lowest resonance mode possible, which requires longer length of tapered slot. As a result novel antenna with an additional rectangular slot, shows increased impedance bandwidth about 4GHz. Experimental results shows the impedance bandwidth (10dB return loss) of a fabricated antenna is 23.9GHz (about 2.0GHz~25.9GHz). By adjusting the rectangular slot length, multi resonant modes with good impedance matching are excited in the slot of the antenna, these makes the antenna possible to operated for wide frequency bands.

Figure 3 shows the tangential components of electric field at each mode. It can be seen that the tangential components of electric field occurred between the ground plane and tapered slot through CPW feed structure. The dominant resonant mode (TE_{10}) is generated at 3.7GHz. The several resonant modes are generated by an effect that the slot length is increased according to change the frequency higher. At 10.0GHz, the second order mode (TE_{20}) is generated. The third (TE_{30}) and fourth (TE_{40}) order modes are generated at 17.0GHz and 23.0GHz. In this ways, not only dominant resonant mode but also high order resonant modes can be generated inside the slot. Consequently, the proposed antenna shows wide frequency bandwidth operation.

Figure 4 plot the simulated radiation patterns of the proposed antenna at each resonant frequency. The radiation patterns are varied due to the change of the operating modes. The radiation pattern is normalized to the maximum value in each frequency. For each resonant frequency, the proposed antenna shows good radiation patterns in the X-Z and Y-Z plane. It is observed that the radiation patterns at 3.7GHz is alike a half wavelength dipole antenna in Y-Z plane, and shows near omni-directional in X-Z plane. The antenna shows similar radiation patterns characteristics over the wide band frequency in X-Z and Y-Z plane, but as the frequency is increased the numbers of lobes are increased. This is due to the generation of higher order modes.

The simulated antenna gains over the operating frequency band, are presented in figure 5. The gains are quite high over entire bands from 2.0GHz to 25.9GHz. The proposed slot antenna exhibits a gain of more than 5dBi over a broad frequency range and small gain variations less than 1.5dBi are observed for each mode. The antenna gain level is about 5.1dBi, 5.3 dBi, 5.6 dBi and 6.5dBi for the 3.7 GHz, 10.0 GHz, 17.0 GHz and 23.0GHz, respectively. Figure 6 represents the measured return loss and fabricated antenna using CPW fed slot. The values of measured return loss are -35dB, -49dB, -56dB, and -47dB at 3.7GHz, 10.3GHz, 17.2GHz, and 24.0GHz, respectively. The measured bandwidth of an optimized antenna is 13:1 (return loss less than -10dB). The results are in good agreement with the simulated ones. The measured return loss is about -30dB~-50dB. The antenna radiation patterns and gain are simulated using software CST Microwave Studio.

3. Conclusions

In this paper, a novel wide band antenna is studied and fabricated by simulation and experimentally. In order to increase the bandwidth of the antenna, a CPW feed line structure, tuning stub and tapered slot are used. Through the adjustment of the stub, good impedance matching of more than 13:1(2.0GHz~25.9GHz) bandwidth are achieved and this result shows much broader characteristics than conventional patch antennas. The proposed antenna shows high gain of 4.75 dBi ~ 6.54 dBi and good radiation patterns for wide frequency bands.

References

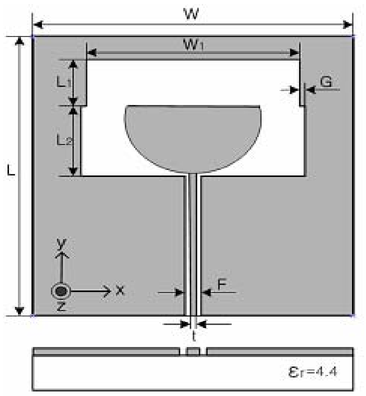
[1] S. Maci, G. Biffi Gentili and G. Avitabile, "Single-layer dual frequency patch antenna," *Electronics Letters*, Vol. 29, No. 16, pp. 1441-1443, Aug. 1993.

[2] Kumar, G., and K. C. Gupta, "Non-radiation edges and four edges gap-coupled Multiple resonator broad-band microstrip antenna," *IEEE Trans. Antennas Propagat.,* Vol. AP-33, No. 2, pp. 173-178, Feb. 1985.

[3] Kumar, G., and K. C. Gupta, "Directly coupled multiple resonator wide-band microstrip antennas," *IEEE Trans. Antennas Propagat.*, Vol. AP-33, No. 6, pp. 588-593, Jun. 1985.

[4] Gwo-Yun Lee and Kin-Lu Wong, "Very low profile bent planar monopole antenna for GSM/DCS dual band mobile phone," *Microwave Opt. Technology Lett,*. Vol. 34, No. 6, Sep. 2002.

[5] Laurent Giauffret, Jean-Marc Laheurte and A. Papoernik, "Study of various shapes of the coupling slot in CPW-fed microstrip antennas," *IEEE Trans. Antennas Propagat.,* Vol. 45, No. 4, pp. 642-647, Apr. 1977.



$L \times W = 60mm \times 60mm, L_1 \times W_1 = 10mm \times 40mm$
$L_2 = 15mm, G = 2mm, F = 4mm, t = 2.4mm$
$radious = 15mm$

Fig. 1 Wide-band slot antenna with CPW-fed.

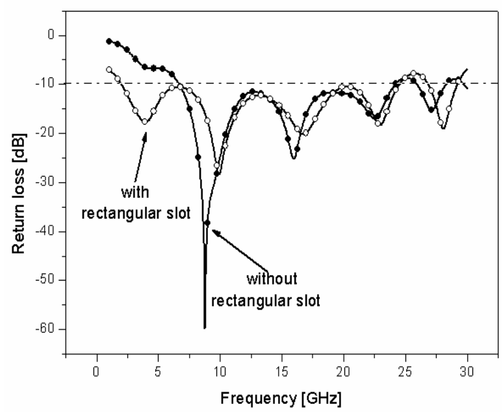
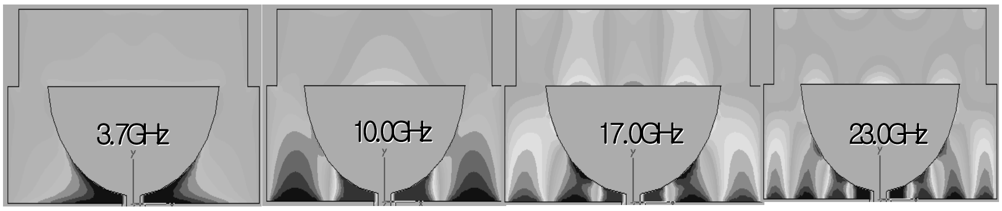
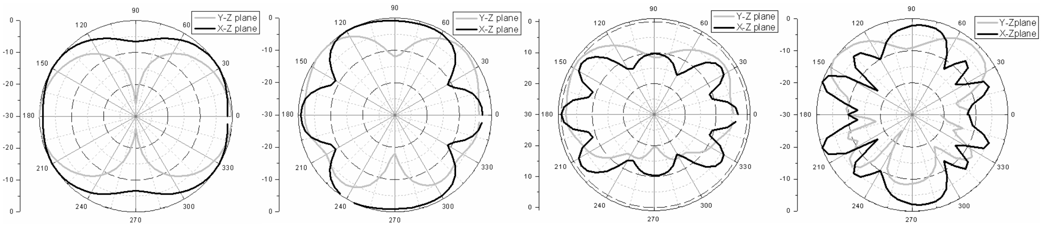


Fig. 2 Return loss with or without rectangular slot.



(a) TE_{10} (b) TE_{20} (c) TE_{30} (d) TE_{40}

Fig. 3 Tangential components of electric field at each mode.



(a) 3.7GHz (b) 10.0GHz (c) 17.0GHz (d) 23.0GHz

Fig. 4 The simulated radiation patterns.

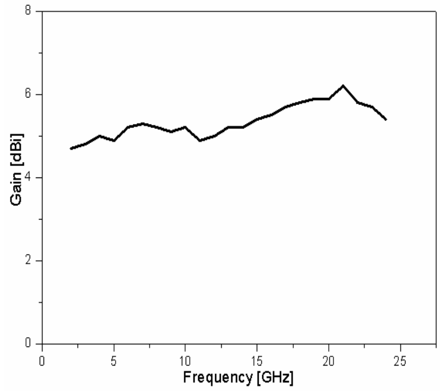


Fig. 5 The simulated gain of the proposed antenna.

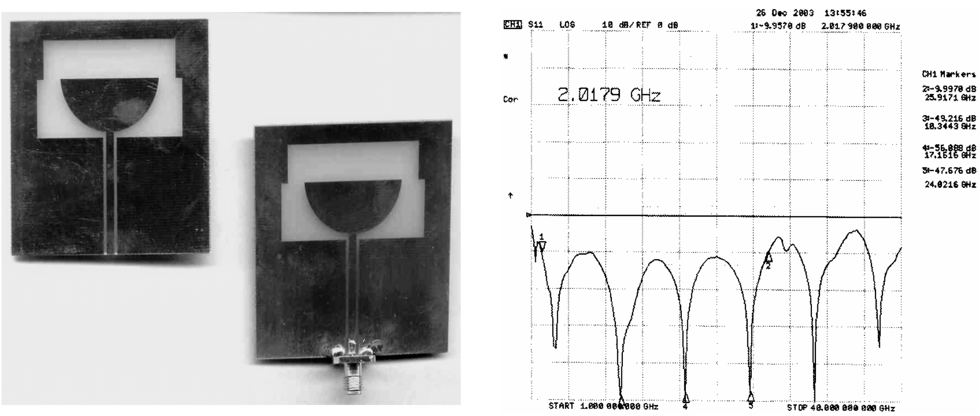


Fig. 6 The fabricated antenna and measured return loss.