Regular paper

Journal of the KIECS. pp. 745-750, vol. 13, no. 4, Aug. 31 2018, t. 90, pISSN 1975-8170 | eISSN 2288-2189
http://dx.doi.org/10.13067/JKIECS.2018.13.4.745

WLAN 적용을 위한 위상 반전 장치를 갖는 슬롯 배열 안테나

박성일* · 정진우**

Slot Array Antenna with Phase Reversal Device for WLAN Application

Sung-Il Park* · Jin-Woo Jung**

요 약

WLAN 통신 기술 적용을 위한 위상 반전 장치를 갖는 슬롯 배열 안테나가 제안되었다. 제안된 안테나 설계를 위해 배열 안테나의 Array Factor와 방사 특성을 분석하였고 실질적인 적용이 가능한 방사 패턴을 위해, 위상 반전 장치를 사용하였다. 제안된 안테나는 30 mm × 96 mm × 0.2 mm의 유전 기판의 양면에 구현되었다. 제안된 안테나의 측정 결과, 임피던스 대역폭은 156 MHz (2.392-2.548 GHz)이고, 최대 이득은 8.31 dBi 이다.

ABSTRACT

A Slot array antenna with a phase reversal device is presented for WLAN operation. The array factor and radiation characteristics of the antenna are investigated. For practical application of the radiation pattern, the phase reversal device is used. The antenna is formed on both sides of the substrate (30 mm × 96 mm × 0.2 mm). The measured results show that the proposed antenna has a 10 dB return loss bandwidth of 156 MHz (2.392 – 2.548 GHz) and the measured maximum gain was 8.31 dBi.

키워드

Slot Antenna, Phase Reversal Device, Array Antenna, WLAN
슬롯 안테나, 위상 반전 장치, 배열 안테나, WLAN

Ⅰ. Introduction

Recently, with the rapid development of wireless local area network (WLAN) technology, antennas for WLAN systems have become one of the key technologies [1-5]. In addition, for various applications of WLAN systems, high gain operation of antennas is demanded.

For high gain operation, several antennas with an array, parasitic elements, phase canceled devices, and partially reflecting surfaces have been studied [6-10].

In this letters, we proposed a slot array antenna with a phase reversal device. For high gain operation, we used the phase reversal device, which is realized by a cross-over line. By the phase reversal device and the E-field distribution of the

* 동신대학교 정보통신공학과(psi@dsu.ac.kr)
** 교신저자 : 전남대학교 전자컴퓨터공학과
• 접 수 일 : 2018. 06. 12
• 수정완료일 : 2018. 07. 14
• 게재확정일 : 2018. 08. 15

• Received : Jun. 12, 2018, Revised : Jul. 14, 2018, Accepted : Aug. 15, 2018
• Corresponding Author : Jin-Woo Jung
Dept. of Electronics and Computer Engineering, Chonnam National University,
Email : crazytis@hanmail.net

slot, the pattern characteristics are analyzed. Details of the antenna design and the experimental results are presented and discussed in subsequent sections.

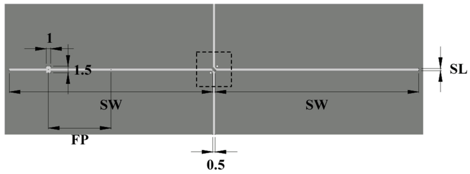
II. Antenna Design and Results

The proposed antenna consists of two radiating elements and a cross-over line. Each radiating element is a half wavelength slot antenna. Each radiating element is linear arrayed with the cross-over line. For practical application of the radiation pattern, the phase reversal device is used. The phase reversal device is realized by the cross-over line.

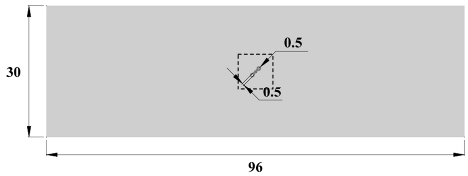
Figures 1(a) and (b) show the top and bottom copper layer, respectively. The copper layer is printed on the both sides of an FR4 substrate with a relative permittivity of 4.2 and a thickness of 0.2 mm. Figure 1(c) shows the expanding geometry of the cross-over line; the expanding section is the dotted line section of Figures 1(a) and (b).

The radiating element is a half wavelength slot with the dimensions of SW (46.75 mm) and SL (0.5 mm). When considering the limited conditions (the substrate and dimensions of the copper), the electrical length of the SW is approximately a half wave length at 2.45 GHz. Each radiating element is connected by the cross-over line. Therefore, when one radiating element is fed, the other radiating element also operates. To feed the proposed antenna, a 50 Ohm coaxial cable is used.

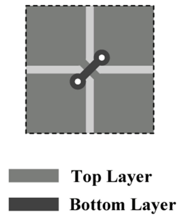
The input resistance at the center of a resonant half wavelength slot is very high, because of the electromagnetic field distribution on around the half wavelength slot. Therefore, for a better impedance matching, an off-center feeding method is used as shown in Figure 1. The FP is the distance from the center of the half wavelength slot. For the proposed antenna, the FP is 14.4 mm. In addition, for smooth feeding by a coaxial cable, the slot



(a) Top View



(b) Bottom view



(c) Phase reversal device

Fig. 1 Configuration of proposed antenna

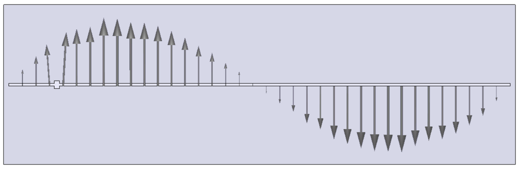
(with the dimensions of 1 mm × 1.5 mm) is situated at the feeding position.

For the slot radiator, the radiation pattern is influenced by the length of the copper sheet (GL). When the length (GL) is increased, the pattern undulations become more numerous. Therefore, the pattern nulls appear in the radiation pattern. In the proposed antenna, for practical application of the radiation pattern, the length of the copper sheet (GL) is set at 30 mm.

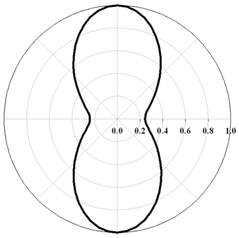
The width of the copper sheet (GW) does not greatly influence the radiation patterns. Considering the array of the two radiating elements, the width of the copper sheet is set at 96 mm.

Each radiating element is connected by the cross-over line (width of 0.5 mm). In addition, to connect the top and bottom copper layers, a via-hole (with a diameter of 0.35 mm) and a via-landing (with a radius of 0.5 mm) are used.

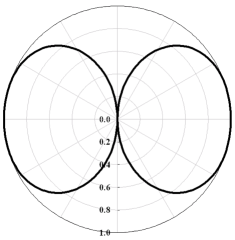
The proposed antenna is a slot array antenna with a phase reversal device. To observe the effect



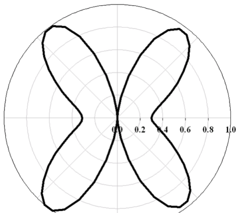
(a) Geometry and E-filed distribution



(b) Normalized pattern of single element



(c) Normalized Array factor



(d) Normalized pattern

Fig. 2 E-field and radiation patterns of reference antenna

of the phase reversal device, we used a reference antenna, which is the slot array antenna without the cross-over line. Because there is no the cross-over line, the geometry of the reference antenna becomes a one wave length slot antenna, as shown in Figure 2. Figure 2(a) shows the geometry and E-field distribution of the reference antenna. Based on the E-field distribution, the reference antenna is considered as a two slot antenna array with opposite phases. The electrical length of each slot antenna is a half wavelength.

For practical application of the radiation patterns, we analyze the array factor and pattern multiplication. Figure 2(b) shows the simulated normalized pattern of a single element, which is a half wavelength slot antenna for the given dimensions (SW, SL, and GL).

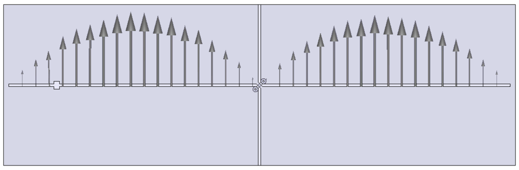
The normalized array factor for the two isotropic elements, uniformly excited, linear array is given by

$$AF(\theta)=\left|\frac{\sin(\beta d\cos\theta+\alpha)}{2\sin(0.5\beta d\cos\theta+0.5\alpha)} RIGHT\right| \qquad (1)$$

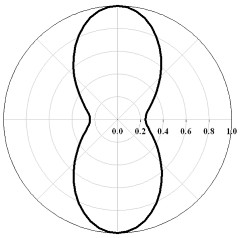
where β is wavenumber, d and α are the distance and the difference in phase excitation between the two elements, respectively.

The reference antenna, we can consider the arrayed slot antenna with a uniformly excite, linear array, spaced half wavelength ($d=\lambda/2$), and opposite phases ($\alpha=\pi$). Figure 2(c) shows the calculated normalized pattern of the array factor by equation (1), for the given conditions. Figure 2(d) shows the total pattern, which is obtained by the pattern multiplication. The obtained result indicates that the phase reversal device is needed for practical application of the radiation pattern.

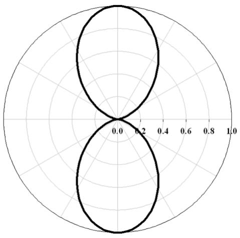
Figure 3 shows the E-field distribution and patterns of the proposed antenna. In the case of the proposed antenna, by the phase reversal device (the cross-over line), the phase of each radiating element is the same, as shown in Figure 3(a). Therefore, we can consider the arrayed slot antenna with a uniformly excite, linear array, spaced half wavelength ($d=\lambda/2$), and same phases ($\alpha=0$). As a result, by equation (1), the array factor is obtained, as shown in Figure 3(c). By the result of the pattern multiplication, the obtained result is satisfactory for practical application of high gain WLAN operation, as shown in Figure 3(d).



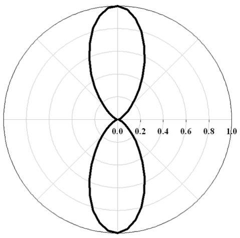
(a) Geometry and E-filed distribution



(b) Normalized pattern of single element

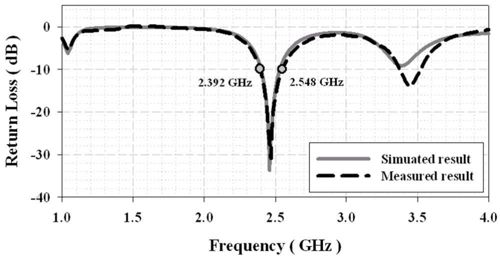


(c) Normalized Array factor

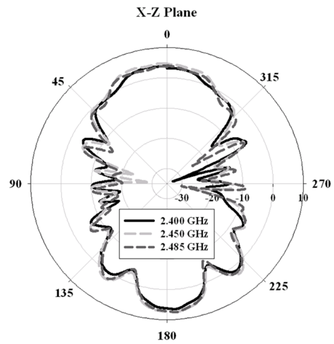


(d) Normalized pattern

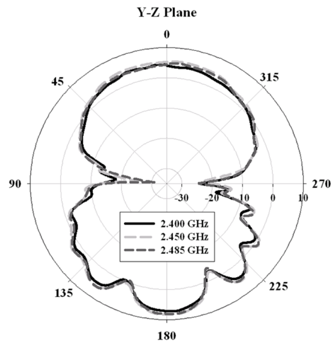
Fig. 3 E-field and radiation patterns of reference antenna



(a) Return Loss



(b) Radiation Pattern in x-z plane



(c) Radiation Pattern in y-z plane

Fig. 5 Measured results

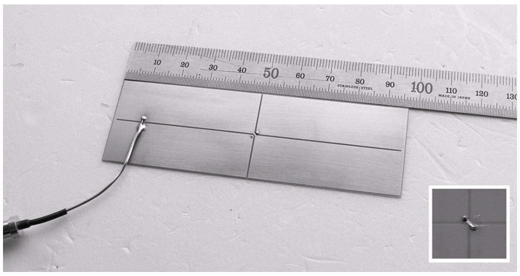


Fig. 4 Photograph of fabricated antenna

Figure 4 shows the photograph of the fabricated antenna. The right-bottom figure is the bottom copper layer, which is the expanding section of the cross-over line. The dimensions of the proposed antenna are 30 mm × 96 mm × 0.2 mm. The proposed antenna is fed by a coaxial cable.

Figure 5 shows the simulated and measured return loss for the given dimensions, confirms the good agreement between the simulated and measured results. The predicted and measured 10 dB return loss bandwidth was 134 MHz (2.399 - 2.533GHz) and 156 MHz (2.392 - 2.548GHz), respectively. In addition, the radiation characteristics of the proposed antenna were measured. The radiation characteristics were measured at 2.4, 2.45, and 2.485 GHz (WLAN; 2.4-2.485GHz). The maximum gain of the proposed antenna was 8.31 dBi at 2.45 GHz.

Ⅲ. Conclusions

A slot array antenna with a phase reversal device for WLAN application is proposed and investigated. For practical application of the radiation pattern, the characteristics of the array factor and pattern multiplication is analyzed. With the phase reversal device, the proposed antenna achieves a high gain operation. The proposed antenna has the dimensions of 30 mm × 96 mm × 0.2 mm. The obtained 10 dB return loss bandwidth was 156 MHz (2.392 - 2.548 GHz) and the measured maximum gain was 8.31 dBi.

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저자 소개

박성일(Sung-Il Park)

2002년 동신대학교 정보통신공학과 졸업 (공학사)
2004년 동신대학교 대학원 정보통신공학과 졸업 (공학석사)
2010년 전남대학교 대학원 전자정보통신공학과 졸업 (공학박사)
2014년 ~ 현재 동신대학교 정보통신공학과 교수
※ 관심분야 : 전자회로, RF부품, 이동통신안테나

정진우(Jin-Woo Jung)

2005년 전남대학교 정보통신공학과 졸업 (공학사)
2007년 전남대학교 대학원 전자정보통신공학과 졸업 (공학석사)
2011년 전남대학교 대학원 전자컴퓨터공학과 졸업(공학박사)
2012년 ~ 2017년 국방과학연구소 선임연구원
2017년 ~ 2018년 2월 국립전파연구원 공업연구사
※ 관심분야 : 안테나, 위상배열안테나, 적응형 빔 형성 알고리즘