Dipole and Loop Combined Antenna for Switchable Radiation Patterns

Yongjin Kim[1], Se-Gyoon Mok[2], Sang-Jun Ha[3], Chang-Won Chung[3]

[1] Department of Electrical Information, Inha Technical College
253 Yonghyun dong, Nam-gu, Inchon, Korea, yongjink@inhatc.ac.kr
[2] Department of Information and Telecommunication, Inchon University
119 academy rd., Yeonsu-gu, Inchon, Korea, mokse001@incheon.ac.kr
[3] Graduate School of NID Fusion Technology, Seoul National University of Science and Technology
232 kongruong rd., Nowon-gu, Seoul, Korea,changwoj@snut.ac.kr

Abstract

In this paper, we propose a dipole and loop combined antenna structure for switchable radiation beam patterns. This antenna is designed to generate a switchable antenna radiation pattern for wireless communication device. The frequency bandwidth defined by S11<-10 dB is from approximately 1.8 – 2 GHz with maximum gain of 3.35dBi. Maximum beam direction can be steered by changing switch on/off configurations with maximum tilted beam of 90 degree in E-plane

Keywords : Switchanble antenna beam, dipole and loop combined antenna

1. Introduction

Reconfigurable/switchable antenna beam patterns have recently received increasing interest in antenna design technologies for modern wireless devices. Due to the rapid growth of new wireless communication techniques including MIMO and LTE applications, reconfigurable beam steering radiation patterns are main topic areas of antenna development. The efforts of changing or controlling the antenna beam pattern have been progressed [1]-[5]. In this paper, we propose a dipole and loop combined antenna structure for controlling antenna beam pattern. The proposed antenna works as a planar inverted-F antenna (PIFA). When there is a need to change beam pattern to the z-axis direction, the antenna structure is changed to the PIFA and the loop combined structure. Therefore, the antenna beam can be changed by the switch on/off configurations.

2. Antenna geometry

The geometry of dipole and loop antenna is shown in Fig. 1. Typical PIFA antenna is designed and shown in Fig. 1. The antenna radiator size is 33 mm x 11 mm x 4 mm. The total length of the loop antenna is 12.6 cm (approximately 0.84 λ at 2GHz). The simulated ground plane size is 100 mm x 40 mm x 1 mm. The ground plane is a copper-coated plane and on the top layer of the substrate (FR4-Epoxy board, ε_r=4.4). The switch is located at the connection part between ground plane and loop antenna. The antenna beam can be changed by the switch on/off configurations. The switch for changing radiation beam patterns is shown in Fig. 1.

3. Simulation Results

By means of simulation using Ansoft HFSS simulation software based on the finite element method, the characteristics of the proposed antenna was computed. Simulation results show that the center frequency is 2.01GHz and the simulated S11 < -10dB bandwidth covers frequency range from 1.88GHz to 2.17GHz in switch ‘on’ case (combined model). In switch ‘off’ case (PIFA model), the center frequency is 2.02GHz and the simulated S11 < -10dB bandwidth covers frequency range

from 1.88GHz to 2.15GHz.

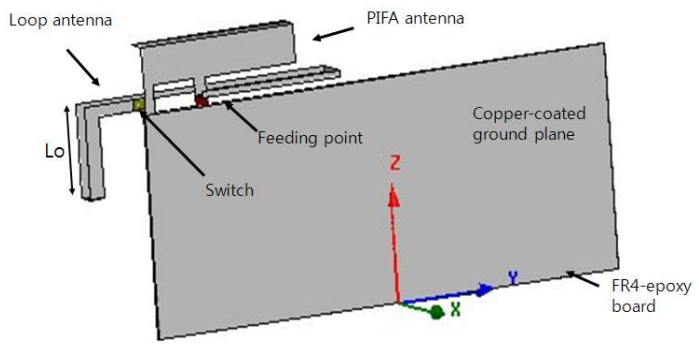
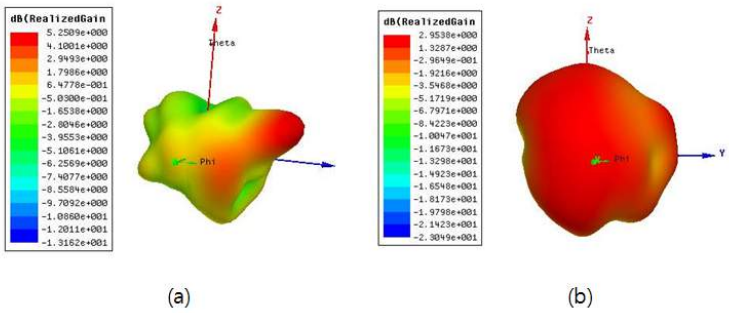


Figure 1: Proposed antenna geometry.

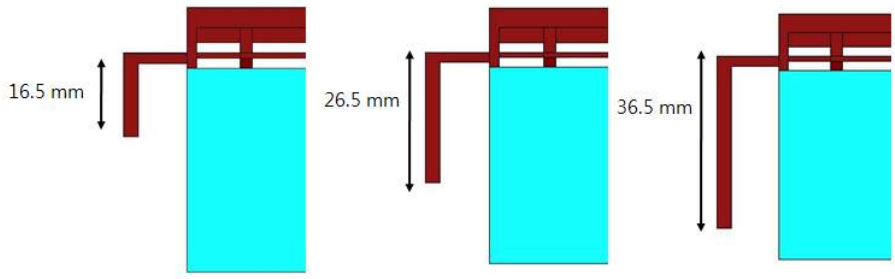
The simulated radiation patterns of the proposed antenna are shown in Fig 2. When the switch is 'on' state, the proposed antenna works as PIFA and loop combined antenna. When the switch is 'off' state, the antenna works as a PIFA. Fig. 2 (a) shows the 3-D radiation pattern of the switch 'off' state and Fig. 2 (b) shows the 3-D radiation pattern of the switch 'on' state. It is noted that the radiation patterns are changed significantly. In the case of the switch off, main radiation beam pattern is on +y-axis direction. When the switch is 'on' state, the main radiation beam is on the +z-axis direction.



(a) (b)

Figure 2: Simulated antenna radiation pattern at 2GHz– (a) switch off, (b) switch on

Fig. 3 shows the different antenna geometries as a function of the length of parameter 'Lo' in Fig. 1. The case 1 is Lo=16.5 mm, and the case 2 is Lo=26.5 mm. Lo=36.5 mm is in the case 3. The radiation patterns for case 1-3 are shown in Fig. 4.



(a) (b) (c)

Figure 3: Different antenna geometries as a function of the length of parameter 'Lo' in Fig. 1.
(a) case 1, Lo=16.5 mm, (b) case 2, Lo=26.5 mm, (c) case 3, Lo =36.5 mm

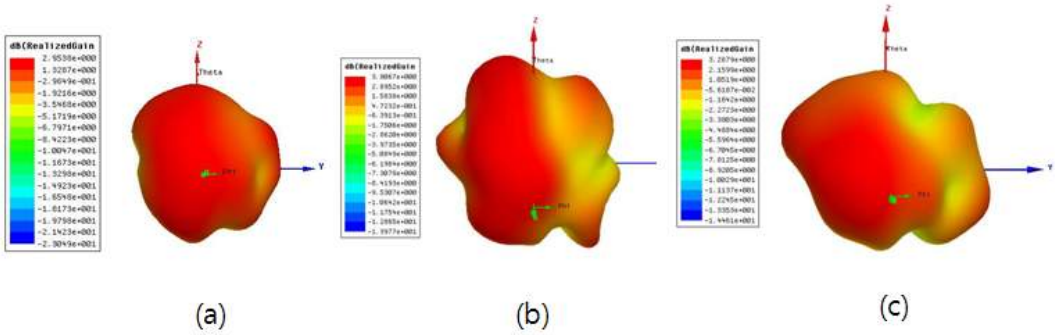


Figure 4: Different antenna radiation patterns as a function of the length of parameter 'Lo' in Fig. 1. (a) case 1, Lo=16.5 mm, (b) case 2, Lo=26.5 mm, (c) case 3, Lo =36.5 mm

4. Measured Results

The photo of the fabricated antennas for measurements is shown in Fig.5. The ground-plane is made of copper-coated plate on FR4-Epoxy board (ε_r=4.4). Measured S11 results of the proposed antenna are shown in Fig. 6. As shown in Fig. 6, the center frequency is around 2 GHz in every case. The band-width (s11<-10dB) is approximately 200MHz. It is noted that the center frequencies are maintained in the 1900 MHz – 2100 MHz with switch on/off configurations.

Figure 5: Photos of the proposed antenna.

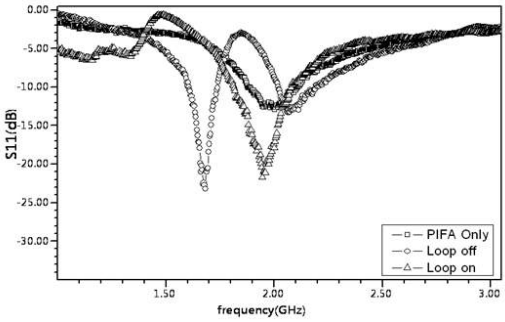


Figure 6: Measured S11 plots

Results of measured radiation patterns are shown in Fig. 7. Fig. 7 shows radiation patterns in the x-y plane. The patterns of PIFA and loop off (switch off case) are fairly similar. In the case of switch 'on', the antenna radiation pattern is changed that more energy is radiated in the z-axis direction. The gain difference is approximately 7 dB. This result explains that main beam is move the z-axis from the y-axis when the switch is on. Also, the degree of the peak gain is changed from 40-degree angle to 330-degree angle by changing switch on/off.

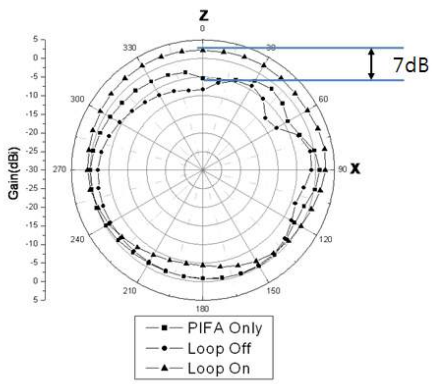


Figure 7: Measured radiation pattern in x-z plane

5. Conclusions

In this paper, we proposed dipole and loop combined antenna for changing antenna radiation pattern based on switch on/off configuration. Simulations and measured results show that radiation main beam can be changed to the z-axis direction with switch 'on'. The measured bandwidth is approximately 200 MHz with 2GHz of centre frequency. Also, different antenna geometries and variations of antenna radiation patterns as a function of the length of loop antenna are presented. The proposed antenna is appropriate for adaptive antenna radiation pattern for wireless communication devices.

References

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Acknowledgments

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (2010-0003839).