Frequency and Pattern Reconfigurable Antenna with Chip inductors and Parasitic elements

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1. Introduction

A reconfigurable antenna recently has been researched with the development of wireless communication systems in order to improve the overall system performance of diversity characteristics in polarizations, frequencies and radiation patterns. The wireless standard operating in 5.15-5.35 GHz frequency range has newly received attention because of the overpopulated 2.4-2.48 GHz in wireless local area network (WLAN) system in recent years. Various dual WLAN frequency antennas have been studied [1]-[3]. The pattern reconfigurable antennas also have been developed in order to avoid noise source and save energy by better directing signal toward intended direction in wireless communication systems [4]-[6]. There are little studies on the reconfigurable antennas for WLAN systems which can switch frequency band and the direction of the main beam simultaneously. In this paper, a compact and printed reconfigurable antenna which can switch frequency range for WLAN and radiation pattern is proposed. Details for the design and the characteristics are proposed and discussed.

2. Design of the antenna

The geometry of the proposed antenna is shown in Fig. 1. The antenna is printed on an FR-4 substrate with relative permittivity of 4.3 and thickness of 1.6 mm, and so that $\lambda_{eff} \approx 2.8$. The antenna consists of radiator which has two chip inductors and four parasitic elements as reflectors arranged around the radiator. The radiator behaves like both a longer dipole resonating at the lower frequency and a shorter dipole that resonates at the upper frequency due to the chip inductors located at both side of the feed. The length of the longer thin-dipole is 35.5 mm and the length of the shorter thin-dipole is 23.5 mm and the width of each thin-dipole is 1 mm.

3. Characteristic of the antenna

A frequency and pattern reconfigurable antenna using chip inductors and parasitic elements as reflectors arranged around the radiator is proposed. Each chip inductor acts as a short circuit at the lower frequency while the inductor is regarded as an open circuit at the upper frequency. The electrical length for the wavelength at the lower frequency is longer than at the upper frequency because the resonant frequency is inversely proportional to wavelength so that the radiator can operate at both lower and upper frequency. Each reflector which has corresponding radiator is arranged around at both side of each radiator. Each reflector has own switch which controls the direction of beam. If the switch is on, the total length of the parasitic element is used as a reflector. On the other hand, if the switch is off, parasitic element does not operate as a reflector any more. Each switching state of the antenna is shown in Fig. 2.

4. Simulation results and discussion

The reflection coefficient of the antenna is shown in Fig. 3. The frequency ranges of the antenna are 2.34-2.54 GHz and 5.0-5.44 GHz for state 1 or 2. For state 3 or 4, 2.34-2.54 GHz and 4.99-5.49 GHz can be obtained. The obtained frequency ranges are appropriate for bandwidth requirement for IEEE 802.11b/g and 802.11a standards. Figs. 4 and 5 show current distributions at the lower and the upper frequencies, respectively. As shown in Figs. 4(b) and 5(b), at 5.2 GHz, there are no current toward each chip inductor so that practical current path length of the shorter thin-dipole is less than 23.5 mm. It is about 16.5 mm ($\approx 0.5\lambda_{eff}$). The length of each reflector is a little longer than each corresponding thin-dipole. The distance between reflector and thin-dipole is commonly $0.15\sim0.25\lambda_{eff}$. The value of inductor has to be adjusted to realize an impedance matching for antenna resonance. The parametric analyzed value is 3.9 nH after numerical simulations by using commercial full-wave simulator with CST Microwave Studio software [7]. Figs. 6 and 7 present the simulated radiation patterns at the lower and upper frequency. The radiation pattern is directional at both frequency bands. Due to symmetric characteristic of the antenna geometry, both directions of beam are opposite. The antenna gain levels are 6.1 dBi and 4.6 dBi for 2.45 GHz and 5.2 GHz band at state 1 while the gain levels are 6.1 dBi and 3.7 dBi for each band at state 2.

5. Conclusions

A reconfigurable antenna to switch frequency band and radiation pattern is proposed. Frequency switching can be obtained by composition of two thin-dipoles which have different electrical lengths and pattern switching can be realized by using parasitic elements as reflectors. The bandwidths are 2.34-2.54 GHz (8.16%) / 5.0-5.44 GHz (8.46%) for state 1 and 2. In addition, 2.34-2.54 GHz (8.16%) / 4.99-5.49 GHz (9.54%) for 3 and 4 are obtained. The gain levels of antenna are 6.1 dBi and 4.6 dBi for 2.45 GHz and 5.2 GHz for state 1 and 2. For state 3 and 4, antenna gain levels are 6.1 dBi and 3.7 dBi for each band. The normalized radiation patterns are also observed in dual frequencies to verify main beam switching performance of the antenna.

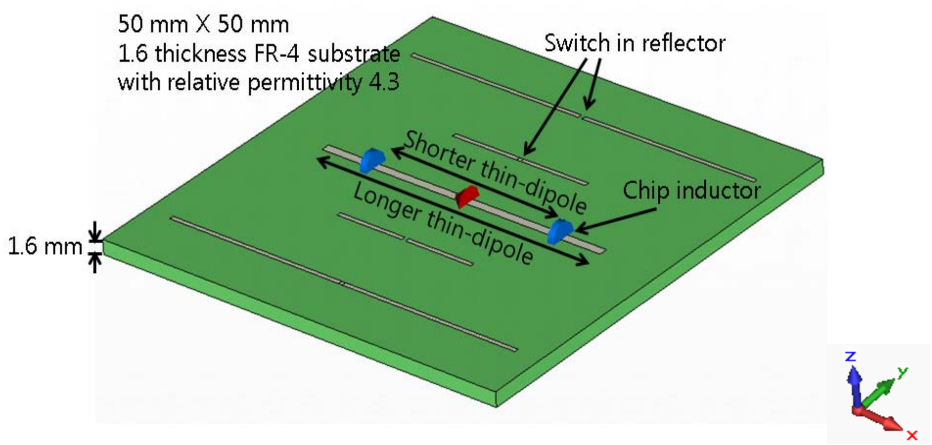
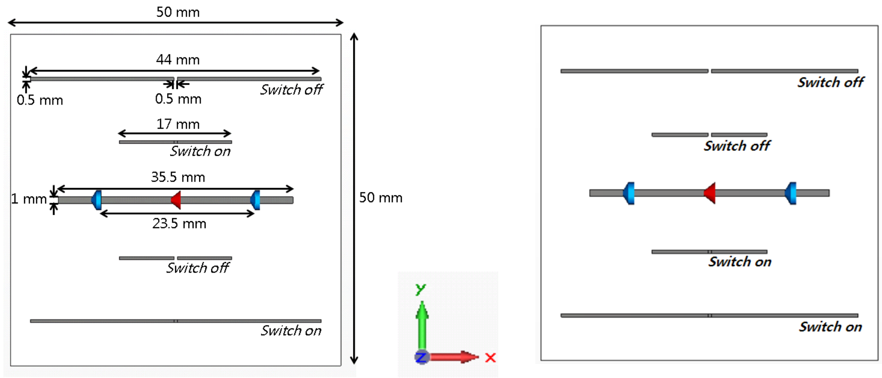
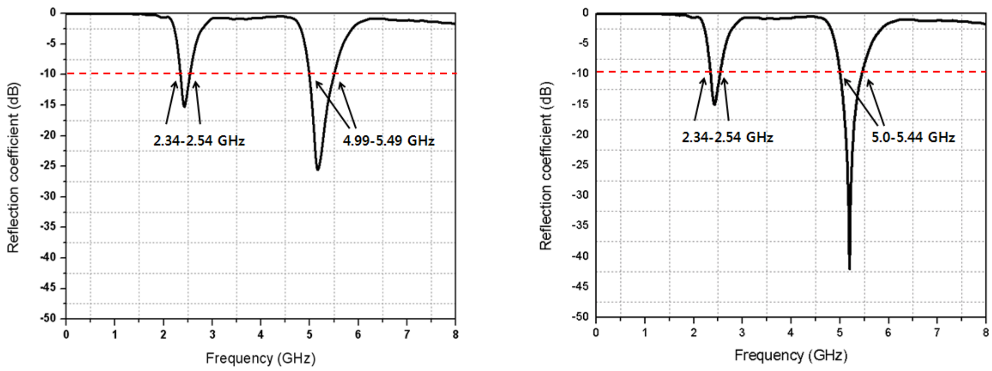


Figure 1: The geometry of the antenna



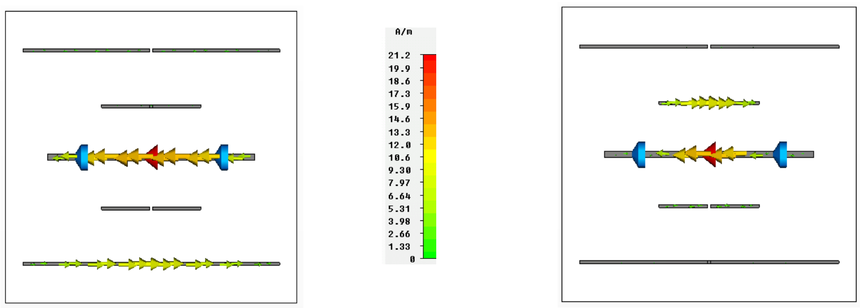
(a) (b)

Figure 2: The switching state of the antenna (a) state 1 (b) state 2



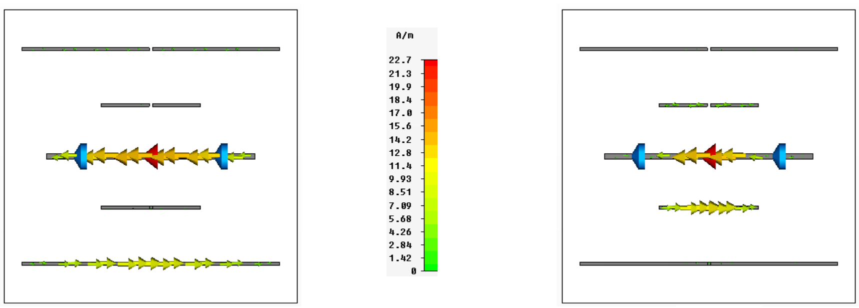
(a) (b)

Figure 3: Reflection coefficient of the antenna (a) state 1 (b) state 2



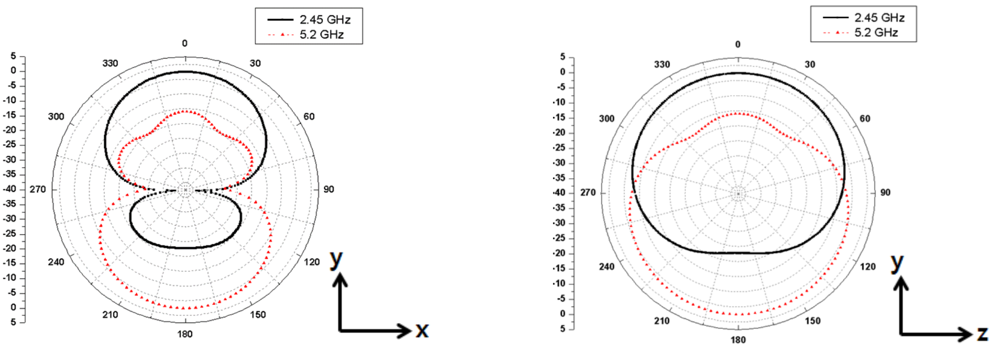
(a) (b)

Figure 4: Current distributions of the antenna for state 1 (a) at the lower frequency 2.45 GHz (b) at the upper frequency 5.2 GHz



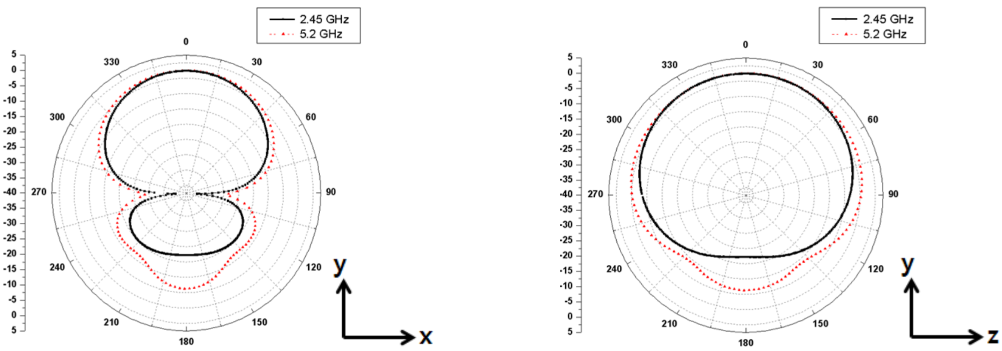
(a) (b)

Figure 5: Current distributions of the antenna for state 2 (a) at the lower frequency 2.45 GHz (b) at the upper frequency 5.2 GHz



(a) (b)

Figure 6: Normalized radiation patterns of the antenna for state 1 (a) x-y plane (b) y-z plane



(a) (b)

Figure 7: Normalized radiation patterns of the antenna for state 2 (a) x-y plane (b) y-z plane

Acknowledgments

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