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A Study on the Design of Dual Band Antenna for Wireless LAN Access Point

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Abstract

In this study a 2.4GHz and 5GHz band antenna for access point for wireless short-range communication was designed and the antenna characteristics according to design value were analyzed. The base structure was based on slot antenna that has relatively broadband characteristics compared to other antennas to design a dual resonance broadband antenna structure with tapered structure as medium. It was designed in a PCB circuit board printed form and characteristic changes according to antenna length, thickness of short circuit stubs, spacing between feed line and short circuit stub, spacing between antenna and ground plane, thickness of antenna, thickness of circuit board, and permittivity of circuit board was researched. The design value was tuned according to change according to the design value characteristic graph to design the optimum antenna. The designed antenna satisfied VSWR<2.7 at 2.4~2.4835GHz, and satisfied VSWR<2 at 5.725~5.825GHz. It is considered that through tuning of omni-direction radiation pattern it will be also possible to use outdoors.

Keywords: Antenna, Bandwidth, Dual Band, Micro-strip, Wireless-LAN

1. Introduction

Due to the rapid development in wireless communications various forms of data transmission services were commercialized and due to the advantages of users being able to freely access to backbone network anywhere and anytime, the need for service using Wireless-LAN by users is rapidly rising[1]. Also there is an active research about Bluetooth system as a short range wireless communication system that uses 2.4GHz ISM frequency band. In addition, due to the increase in use of easily portable computers and need for high transmission speed the frequency band of Wireless-LAN is increasing to 5GHz band[2,3]. It needs to be possible for simultaneous transmission of data and voice in the portable environment and it needs to be possible to implement at low cost.

As above, as wireless communication rapidly develops the development of single communications equipment that can provide various services and the development of antenna that operates in dual band to support this is essential. The antenna used in Wireless-LAN system is small and easy to produce, and micro strip antenna that is easy to integrate is widely used. However due to the disadvantage of having small bandwidth the switch to broadband by using circuit boards with low permittivity, changing power supply method, and inserting various forms of slots is being sought[4,5,10–12].

For this the study conducted research on the design method of antenna using micro strip form power supply method in the permittivity state within the air by boring slot on the conductor plate.

First in the study, for analysis of previous antenna, using a field analysis program High Frequency Structure Simulation (HFSS) of Ansoft that uses Finite Element Method (FEM) a dual band structure antenna that could be used both in 2.4GHz band and 5.8GHz band was designed, and the design condition was satisfied at the two frequency bands (2.4～2.5GHz, 5.725～5.85GHz) of W-LAN.

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2. Structure and Properties of the Antenna

Due to the characteristics of being light and small and planar structure micro strip antenna have the advantage of being easy to apply to various forms of systems and characteristics of being easy to produce at low production cost. Also during the design of the antenna the power supply line and matching circuit can be implemented simultaneously, and because it can be easily combined with ultra-high band frequency circuits such as oscillator, amplifier, frequency mixer, it is a frequently used antenna structure[7,8].

The general form of micro strip antenna patch is square. Length, *L*, width *W*, thickness *t*, and electrical conductivity is assumed as open transmission line to interpret. Length of antenna L is a factor that determines the resonant frequency of the antenna, *W* determines the input impedance, and it is designed so that the antennas input impedance and power feeder line's characteristic Impedance is matched. In this case the resonant frequency is expressed as shown in equation (1).

$$f_r = \frac{mc}{2(L+\Delta l)\sqrt{\varepsilon_{eff}}} \tag{1}$$

Here, integer *m* is mode number, *c* is speed of light, and σ is effective permittivity. Permittivity is ε so that it operates under resonance frequency *f* and when designing rectangular micro-strip patch antenna on circuit board with thickness *h*, the actual width *W* is like shown in equation (2).

$$W = \frac{c}{2fr}\left(\frac{\varepsilon_r + 1}{2}\right)^{\frac{-1}{2}} \tag{2}$$

When *W* is designed narrow the radiation efficiency deteriorates, but if it is designed wide the radiation efficiency improves but due to occurrence of higher mode distortion of the electric field can occur. Because the length and width of resonant patch is finite, in the base and width of resonant patch edge, fringe effect occurs. Fringe effect is the function of the size of resonant patch and height of circuit board, and it needs to be considered because it influences resonant frequency in the antenna[9,10]. On micro strip line most of line of electric force exist on the circuit board and part of it exist on the air. Thus because part of the wave proceeds to circuit board and part of it proceeds to the air, the effective permittivity is introduced to calculate fringe effect and electric wave on the line. The effective permittivity ε_{eff} can be shown as equation (3).

When $W/h > 1$

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + \frac{12h}{W}\right)^{\frac{-1}{2}} \tag{3}$$

Due to the fringe effect the resonant patch of micro strip antenna can seem larger electrically than it is physically. On basic E-plane (x-y plane), the size of resonant patch about length was expanded by Δl from each edge. Δl is a Hammerstad empirical formula which is an expansion effect due to fringing field and it is shown in equation (4).

$$\Delta l = 0.412\frac{(\varepsilon_{eff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \tag{4}$$

The length of the radiator is determined by the effective dielectric constant and the line extensions are as equation (5).

$$L = \frac{c}{2fr\sqrt{\varepsilon_{eff}}} - 2\Delta l \tag{5}$$

3. Antenna Design and Simulation

Due to the development in mobile communication technology the size of terminals are decreasing and the need for variety in functions is increasing. Especially the biggest limiting factor in terminal size is the antenna and because it becomes exterior burden, thus decreasing its size has emerged as a problem. Therefore there are researches being conducted to downsize antennas and making it multi band and broadband. The disadvantage of micro strip antenna is that originally the bandwidth is very narrow. To solve these problems and to provide stable communication service with low transmission power which is an important factor in frequency reuse, the use of antenna with high efficiency is absolutely necessary. The antennas used in W-LAN has function of transmitting and receiving signals by access point antenna that plays the role of gateway between terminal antenna and each terminal and wired-LAN.

To execute these functions efficiently the beam-width of the antenna needs to be designed to be appropriate for the system, and to receive signals most appropriately it needs to be designed to have low reflection loss and good benefits.

Considering actual production of antenna design that satisfies these parameters, the study conducted simulation in permittivity of the air without using high cost dielectric such as FR-4. The basic structure is divided into 3 parts, fine slot, wide width slot, and slot that link these slots in tapered form, and it has bonding method structure rather than power supply and non-bonding method of micro strip form.

The structure used in this antenna is based on slot antenna that has relatively broadband characteristics compared to other antennas and it was designed as a dual resonance broadband antenna using tapered structure as medium. The size of reflection plate in the structure is 60 × 68 (mm). The size of the patch is 63 × 55 (mm), the width of micro strip feed is 0.8mm, and the height between the slot-patch is 2mm. The box that looks like dielectric was designated as er = 1 to conduct the simulation. The optimum result was derived when the height of reflection plate and slot-patch was 18mm, and tuning work was attempted through changes in parameters (x: length of slot, width of slot, etc).

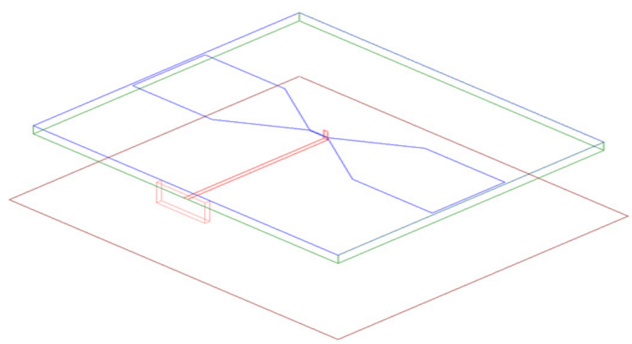

Figure 1. 3D View of the proposed antenna structure.

To briefly introduce the characteristics and advantages of the designed antenna, as it is designed for access point, the goal was to design a directional structure that can have more radiation on the front of the antenna using reflection plate structure, and to decrease costs of production it was designed without dielectric. And to improve gain power supply method using direct bonding rather than power supply method using coupling was chosen. Figure 2 shows the specification of the antenna's slot-patch.

The simulation result of the antenna designed according to Figure 2 is shown in Figure 3 and Figure 4.

Figure 3 is showing a simulation result of the 2.4GHz band, Figure 4 shows the simulation results of the 5GHz band.

As it can be seen in the result of Figure 3, VSWR < 2.7 was achieved at 4 ~ 2.4835 GHz, and it was successful in achieving VSWR < 2 at 5.725 ~ 5.825Ghz. The result of satisfying VSWR < 3.5 in all sections between 2.2GHz to 7GHz, and it is thought that by doing tuning that has not yet been tried, it will be possible to implement a wider bandwidth and impedance matching.

The S11 value of the optimized antenna is shown in Figure 4. From this at central frequency 2.45GHz, 170MHz bandwidth and standing wave ratio of 1.6 was obtained, and at 5.8GHz, 510MHz bandwidth and standing wave ratio of 1.1 was obtained.

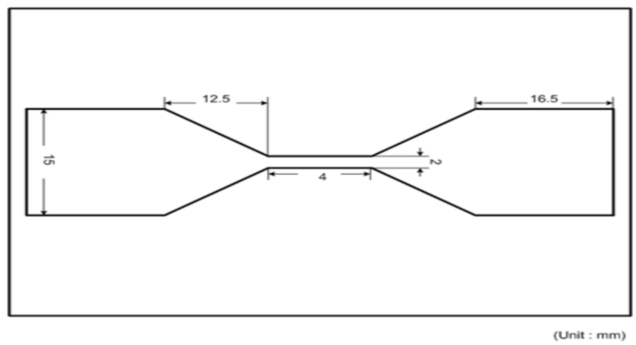

Figure 2. Specification of the slot patch.

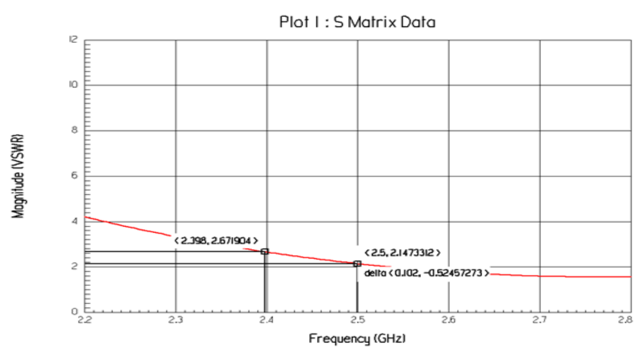

Figure 3. Voltage standing wave ratio (2.4GHz).

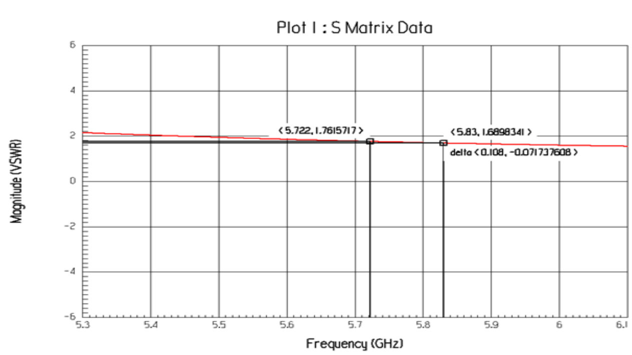

Figure 4. Voltage standing wave ratio (5Ghz).

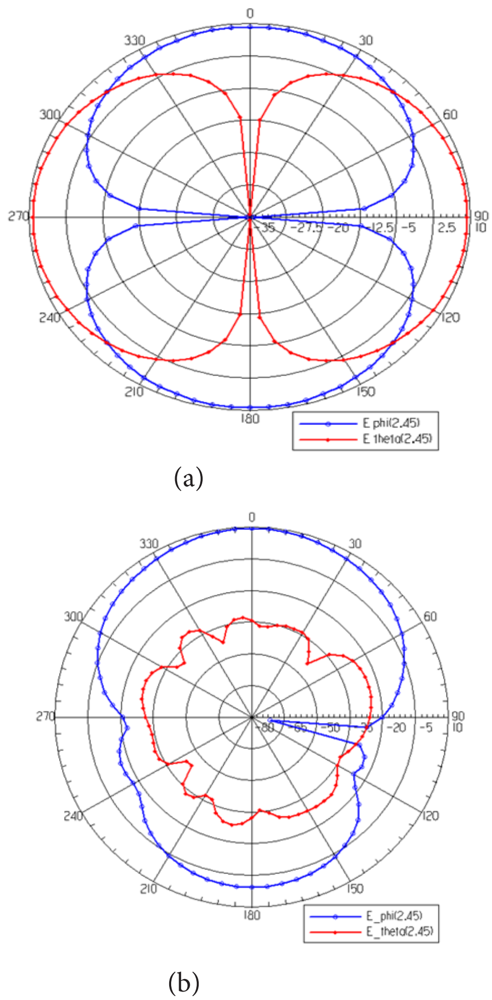

Figure 5. The gain pattern at 2.45GHz Eθ and Eφ, **(a)** xy-plane and **(b)** yz -plane.

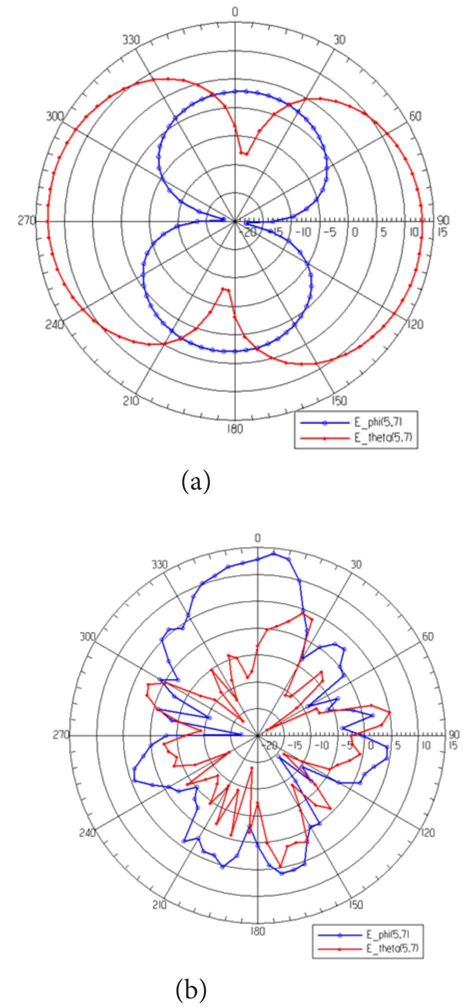

Figure 7. The gain pattern at 5.7GHz Eθ and Eφ, **(a)** xy-plane and **(b)** yz-plane.

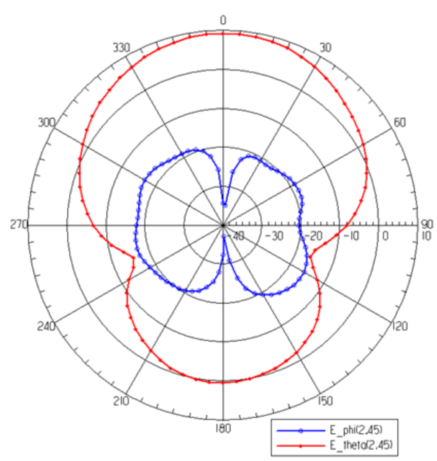

Figure 6. The gain pattern in the xz- plane at 2.45GHz Eθ and Eφ.

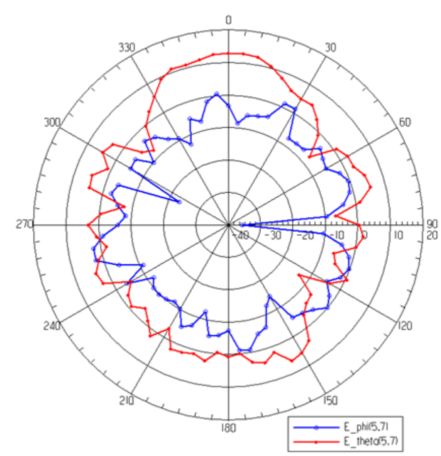

Figure 8. The gain pattern in the yz-plane at 5.7GHz Eθ and Eφ.

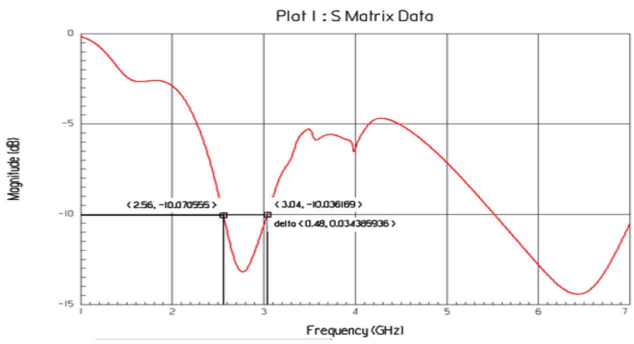

Figure 9. Low band range of VSWR<2.

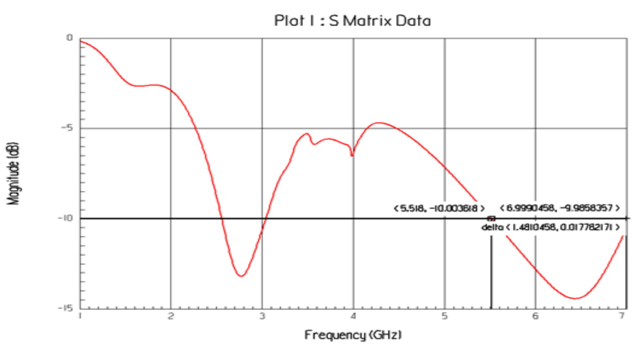

Figure 10. High band range of VSWR<2.

4. Conclusion

The study designed a chip-antenna that satisfies the band of IEEE 802.11b and IEEE 802.11a and through simulation the characteristics of the antenna was analyzed. The designed antenna is an antenna with broadband characteristics, and at low frequency band bandwidth 480MHz was displayed at enters frequency 2.77GHz and at high frequency band bandwidth over 1.5GHz was displayed at center frequency 6.44GHz. The results up to now should have satisfied VSWR under 2.7 in 2.4GHz band among the desired band of the study, but it will be possible to satisfy the specification of VSWR through simulation through various parameter changes that has not yet been tried, and it shows promise in improvement in band between the low and high bands that currently satisfy VSWR<3.5. Also, as seen in gain pattern, considering max gain is about 10dBi±α, which shows possibility to develop as an outdoor purpose on top of indoor access point antenna through tuning in omni-direction radiation pattern.

5. Acknowledgement

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6. References

1. Deschamps GA. Microstrip microwave antenna. 3rd USAF symposium Antennas; 1953.
2. Available from: http://standards.ieee.org/getieee802/802.11.html
3. Ollikainen J, Kivekas O, Icheln C, Vainikainen P. Internal multiband handset antenna realized with an integrated matching circuit. Proceedings of 12th International Confereence of Antennas and Propagation. 2009; 57(8):629–32.
4. Villanen J, Icheln C, Vainkainen P. A coupling element-based quad-band antenna structure for mobile terminals Microwave. Optical Technology Letter. 2007; 49(6):1277–82.
5. Liang J, Chiau CC, Chen X, Parini CG. Study of a printed disc monopole antenna for UWB systems. IEEE Trans Antennas Propagation. 2005; 53(11):3500–4.
6. Huang CY, Hsia WC. Planar elliptical antenna for ultra wideband application. Electron Letter. 2005; 41(6):296–7.
7. Qing X, Chia MYW, Wu X. Wide-slot antenna for UWB applications. Proceedings of IEEE AP-S International Symposium. 2003; 1(1):834–37.
8. Chair R, Kishk AA, Lee KF. Ultrawide-band coplanar waveguide-fed rectangular slot antenna. Antennas Wireless Propagation Letter. 2003; 3(1):227–9.
9. Abo Ghazala M, Zaghloul F, Zahra M. Performance evaluation of multimedia streams over Wireless Computer Networks (WLANs). International Journal of Advanced Science and Technology. 2009; 13(12):63–76.
10. Soo JH. Tracking analysis of user privacy damage using smartphone. Journal of Convergence Society for SMB. 2014; 4(1):13–8.
11. Sunghyuck H. Issues and security on IPSec: Survey. Journal of Digital Convergence. 2014; 12(8):243–8.
12. Lim J-S. Design of fusion multilabeling system controlled by wi-fi signals. Journal of the Korea Convergence Society. 2015; 6(1):1–5.