접지구조에 의한 원통형 모노폴 안테나의 대역특성 영향

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Effect of Grounding Structure on the Bandwidth Broadening for the Cylindrical Monopole Antenna

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요 약

PCS를 비롯하여 WLAN, DMB, W-CDMA, UWB 등의 무선통신 서비스가 증가함에 따라 안테나 동작 대역폭의 광대역화가 더욱 요구된다. 1/4 파장 선형 모노폴 안테나는 구조가 간단하고 전방향성을 갖는 복사특성으로 인하여 가장 널리 사용되는 안테나 중의 하나이다. 모노폴 안테나의 광대역화를 위해서 일반적으로 원통의 직경을 증가시키는 방법을 사용하지만, 평면 모노폴에 적용된 스텝 기법을 적용하여 광대역 특성을 얻을 수 있다. 그러나 스텝 모노폴 자체는 광대역 특성을 나타내지 않으며, 접지면에서도 일정 형태의 스텝 돌출부위가 필요하게 된다. 본 논문에서는 그라운드면의 볼록 계단 구조가 모노폴 안테나의 대역 특성에 미치는 영향을 분석하여 최적의 안테나 급전구조를 도출하고자 한다. 결과의 검증을 위해서 소프트웨어 시뮬레이션 및 측정결과를 제시한다.

Key words: Cylindrical monopole, wideband antenna, UWB, PCS, WLAN

I. Introduction

Wide band antennas are becoming more and more important for future wireless systems, so many approaches are investigated to increase the bandwidth of antenna, such as loading a small disk on the semi-circular disk[1], electromagnetically coupling shorting pins[2], and using orthogonal inverted triangular plates[3]. On the other hand, the planar types of monopole antennas are alternative structures due to its simplicity and efficiency. Typical types of planar monopole designs reported so far are circular disk[4], square plate[5], beveled square[6], and notched square[7]. Among them the notched square structure is most promising in the criterion of wide-band property.

It is well known that the larger the radius of monopole is, the wider the bandwidth becomes. But there exists the physical limitation. We have proposed a new type of a cylindrical monopole antenna for multiple band wireless applications[8]. In this report, the effect of the ground structure is re-analyzed for the bandwidth broadening. The optimized result is presented.

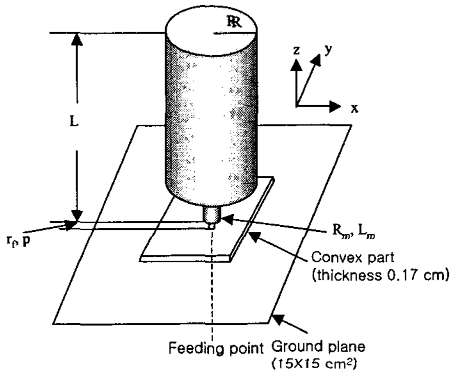


Fig. 1. Perspective view of the proposed cylindrical monopole antenna.

II. Antenna Design and Fabrication

The proposed antenna structure is depicted in Fig. 1. New features are the stepped base part of the cylinder and the convex part of the ground plane. Basically, the radius of the monopole should be increased for the property of wide bandwidth. In this case, the lowest resonant frequency can be calculated as follows:

$$f = \frac{7.2}{L + L_m + R + p} \text{ (GHz)}$$

where L is the length of the cylinder including the modified base part with length L_m, R is the radius of the cylinder, p represents the gap at the feeding point, and all dimensions are in cm. In our work, we set L=3 cm, R=0.48 cm, p=0.2 cm, and r_f=0.06 cm where r_f is the radius of the feeding probe. These parameters give the resonant frequency of about 2.06 GHz. The convex part of the ground plane has the size of $2g_{\perp} \times 2g_{\perp}$ with thickness 0.17 cm. Parameters, L_m and R_m, are optimized in advance as L_m=0.3 cm and R_m=0.15 cm through iterated simulations with the commercially available CST software, where R_m is the radius of the stepped part of the monopole.

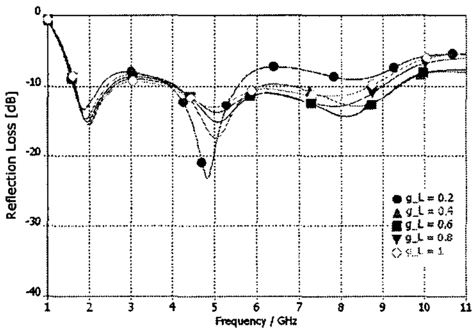


Fig. 2. Simulation results for the variation of the dimension $g_{\perp}$ (cm) with L_m=0.3 cm and R_m=0.15 cm.

The simulation results for the variation of the dimension $g_{\perp}$ (cm) with L_m=0.3 cm and R_m=0.15 cm are shown in Fig. 2. From these results, we can see that dimensions of $g_{\perp}$ plays an important role in determining the impedance bandwidth, particularly for the higher frequency band. The optimized value of $g_{\perp}$ is 0.6 cm. The fabricated antenna with brass is shown in Fig. 3.

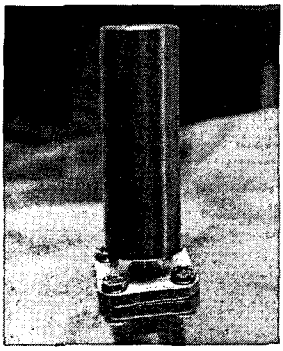
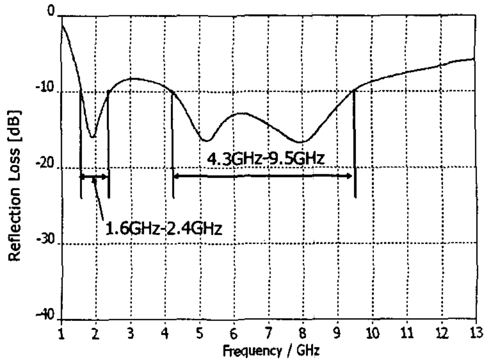
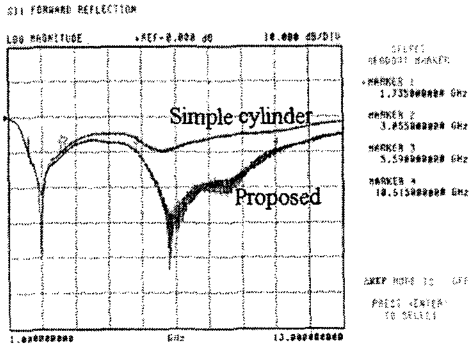


Fig. 3. Picture of the fabricated antenna.



(a) Simulated result for the proposed antenna



(b) Measured result

(Proposed: L=3.0 cm, R=0.48 cm, p=0.2 cm, r_f=0.06 cm, L_m=0.3 cm, R_m=0.15 cm; Simple cylinder: L=3.0 cm, R=0.48 cm, p=0.2 cm, r_f=0.06 cm, L_m=0)

Fig. 4. Simulation and measurement results for the reflection loss

III. Experimental Result

The fabricated antenna is mounted on the ground plane with dimensions 15 cm × 15 cm to demonstrate the proposed bandwidth enhancement technique. Fig. 4 shows the simulated result and the measured return loss. The impedance bandwidths for the proposed and a simple cylinder monopole antenna are plotted simultaneously for comparison in Fig. 4(b). The simple cylinder monopole has dimensions: L=3 cm, R=0.48 cm, p=0.2 cm r_f=0.06 cm, and L_m=0. From Fig. 4(b), we can see that 10 dB impedance bandwidths of the proposed monopole are 1.74 GHz-3.05 GHz (54.7 %) and 5.6 GHz-10.6 GHz (61.7 %), whereas the simple cylinder shows the bandwidth of 1.72 GHz-2.9 GHz (51.1 %) only in the lower frequency band. So, the modification of the coupling structure in a cylinder monopole produces an additional frequency range available with quite a wide bandwidth. The measured antenna gain for the propose geometry is presented in Fig. 5. The gain is about 2.0 dBi in the lower band (1.74 GHz-3.05 GHz), and about 5.0 dBi in the upper band (5.6 GHz-10.6 GHz).

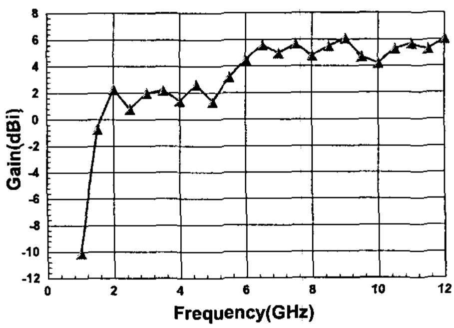


Fig. 5. Measured antenna gain for the proposed geometry

IV. Conclusions

The effect of the ground structure is analyzed for cylindrical monopole antenna. The fabricated antenna according to the scheme shows that -10 dB impedance bandwidths are 1.7-3.1 GHz and 5.6-10.6 GHz, and gains are 2-5 dBi. Inherently, the thick cylindrical monopole can cover the frequency range of 1.7-2.9 GHz. But the modification in the antenna base and the ground plane produces an additional frequency range suitable for the high-band UWB(7.2-10.2 GHz). Thus the proposed antenna cannot only cover wireless services operating in the vicinity of 2 GHz, but also be used for the higher range applications. The measured results for antenna gain are also presented.

References

[1] J. Lee, C. Cho, J. Kim, "Vertically Half Disc-Loaded Ultrawideband Monopole Antenna with Horizontally Top-Loaded Small Disc," *The Journal of Korea Electromagnetic Engineering Society*, vol. 15, no. 11, pp. 1051-1061, Nov. 2004.

[2]. J. Jung, Y. Moon, H. Choo, I. Park, "Characteristics of Electromagnetically Coupled Small Broadband Monopole Antenna with Multiple Shorting Pins," *The Journal of Korea Electromagnetic Engineering Society*, vol. 15, no. 12, pp. 1168-1177, Dec. 2004.

[3]. W. Lee, J. Son, J. Han, W. Yang, "Design and Implementation of 2.4/5 GHz Dual-Band Plate Type Antenna for Access Point of Wireless LAN," *The Journal of Korea Electromagnetic Engineering Society*, vol. 17, no. 5, pp. 401-407, May 2006.

[4] N. Agrawall, G. Kumar,K. Ray, "Wide-Band Planar Monopole Antennas," *IEEE Trans. Antennas Propagat.*, vol. 46, no. 2, pp. 294-295, Feb. 1998.

[5] M. J. Ammann, "Impedance Bandwidth of the Square Planar Monopole," *Microwave Opt. Technol. Letters*, vol. 24, no. 3, pp. 185-187, Feb. 2000.

[6] M. J. Ammann, "Control of the Impedance Bandwidth of Wideband Planar Monopole Antennas Using a Beveling Technique," *Microwave Opt. Technol. Letters*, vol. 30, no. 4, pp. 229-232, Aug. 2001.

[7] S. Su, K. Wong, C. Tang, "Ultra-Wideband Square Planar Monopole Antenna for IEEE 802.16a Operation in the 2-11 GHz Band," *Microwave Opt. Technol. Letters*, Vol. 42, No. 6, pp. 463-466, Sept. 2004.

[8] J. C. Chun, J. Shim, T. S. Kim, "Design of Wideband Cylindrical Monopole Antenna," Journal of KEES, accepted for the publication.