A Study on Broadband Printed Bell-Shaped Monopole Antenna with Short Stub

Nobuyasu Takemura, Takayoshi Moriyama, Joichiro Suzuki, Takuya Takeda, and Takefumi Hiraguri
Department of Electrical and Electronics Engineering, Faculty of Engineering,
Nippon Institute of Technology,
Minami-saitama, Saitama, Japan
takemura@nit.ac.jp

Abstract - **In this paper, a study on a miniaturized broadband printed monopole antenna is described. The design integrates a printed bell-shaped monopole antenna with short stub. The antenna improve the impedance matching in the lower frequency band by attaching the short stub. The designed antenna operates impedance bandwidth of 3.1~10.6 GHz. The radiation patterns of omni-directional are obtained over the frequency range. This antenna acquired broadband characteristic covering the frequency band of UWB system by simulation.**

Index Terms — **Broadband antenna, Printed antenna, Monopole antenna, Short stub.**

1. Introduction

Monopole antenna is examined for various wireless applications because of its simple structure and characteristic of omni-directional radiation pattern. UWB (Ultra Wideband) system is considered about the applicability to the various application: radar, position estimation and BAN (Body area network) etc. as well as application to high-speed radio communication [1][2], and a broadband antenna satisfying the frequency band is required. Recently, various monopole antenna structures have been reported for UWB applications: such as circular, elliptical, square, rectangular, pentagonal, and hexagonal [3]-[6]. Moreover, the antenna impedance matching techniques for broadband monopole antenna have been reported: such as slitted ground plane, duel-microstrip transmission line, and multiple feeding structure [7]-[9]. The broadband printed monopole antennas achieve a wide band characteristic by changing three dimensional structure of biconical antenna and volcano smoke antenna known as wide band antenna to the planar structure.

2. Antenna Design

The miniaturization and wider bandwidth of a printed bell-shaped monopole antenna by using a short stub are examined. Fig.1 shows the structure of the proposed broadband printed bell-shaped monopole antenna with short stub. The antenna is fed by the microstrip transmission line to the hanging bell shape monopole on the dielectric substrate, and the short stub is composited to the ground plane of the microstrip transmission line from the central lower part of the monopole. The hanging bell shape monopole and the microstrip transmission line are formed on the front side of the dielectric substrate, and the ground plane of part circularity and the shot stub line are formed on the back side of the dielectric substrate. Those are connected by the through-hole.

The proposed antenna is formed on a FR-4 dielectric substrate of thickness of 1.6 mm, relative permittivity ε_r=4.4 and loss tangent tanδ=0.02. The size of the dielectric substrate is the length L=28 mm and the width W=20 mm. The interval between the feed point and through-hole is P_L=12.5 mm, the width of short stub is W_S=0.6 mm, the diameter of the through hole is D_S=1 mm, and the width and length of the ground plane is L_G=6 mm and W_2=1.8 mm. The width and length of the microstrip transmission line is W_L=1.8 mm and L_L=9.5 mm. The characteristic impedance is 50 ohms.

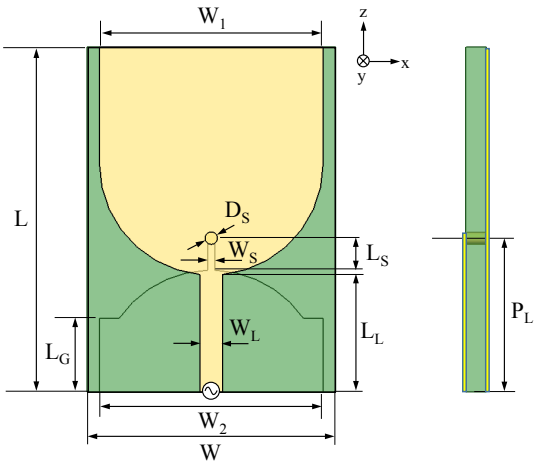
The short stub operates as a parallel inductor to the broadband printed monopole antenna. It is possible to match the antenna impedance by adjusting the parameter of the short stub appropriately. The configuration of the ground plane of the antenna is rounded for impedance matching. The proposed antenna can improve the antenna impedance matching in the lower frequency band by attaching the short stub.

3. Simulation Results

The proposed broadband printed bell-shaped monopole antenna with short stub is simulated. The antenna was simulated using the 3D electromagnetic simulator of Keysight EMPro.

A. VSWR

Fig.2 shows the simulation result of VSWR. In this figure, the characteristic of the proposed antenna with short stub is shown. In the case of the w/o short stub, the antenna is not satisfied VSWR $\leqq 2$ in the lower frequency band. It is difficult to match the antenna impedance by only applying the rounded ground plane because the antenna size is small. On the other hand, the proposed antenna can improve the impedance matching in the low frequency band side by attaching the short stub. From the calculation result, the proposed antenna acquired the wideband characteristic needed to achieve the required frequency band of UWB system.



(a) (b)

Fig. 1. Structure of the proposed broadbanrd printed bell-shaped monopole antenna with short stub: (a) is front-side view and (b) is lateral-side view.

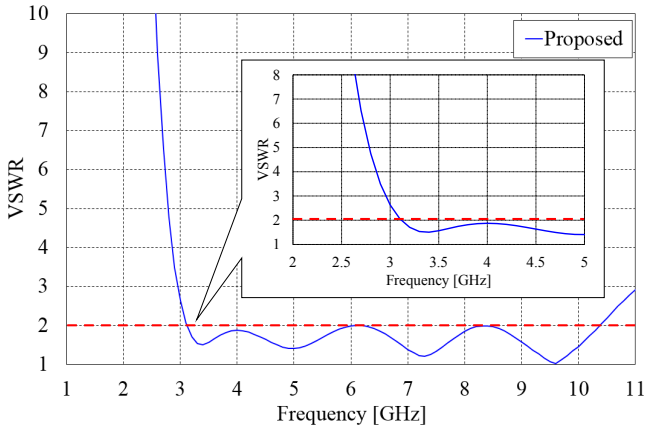


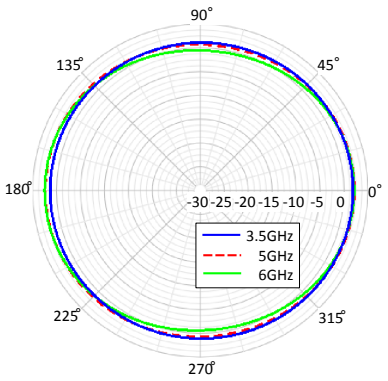
Fig. 2. Simulation result of VSWR.

B. Radiation Pattern

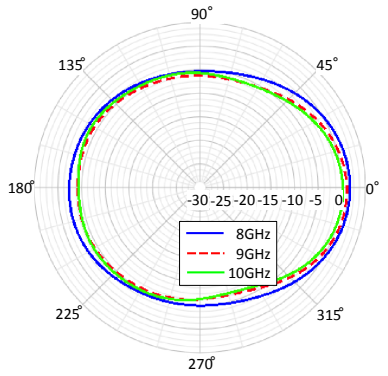
Fig.3 shows the simulation result of radiation patterns. (a) is the lower frequencies of 3.5 GHz, 5 GHz, and 6 GHz, (b) is the higher frequencies of 8 GHz, 9 GHz, and 10 GHz. The plot of radiation pattern is x-y plane. From the calculation results, the almost omni-directional radiation patterns are obtained in each frequency.

4. Conclusion

The authors have proposed the miniaturized broadband printed monopole antenna with short stub. This paper described the antenna design and characteristic and showed that it achieved the broadband characteristic required frequency band of UWB system.



(a)



(b)

Fig. 3. Simulation result of radiation patterns (x-y plane): (a) is the frequencies of 3.5GHz, 5GHz, and 6GHz, and (b) is the frequencies of 8GHz, 9GHz, and 10GHz.

References

[1] H. Xu and L. Yang, "Ultra-wideband tedchnology: Testerday, today, and tomorrow," IEEE Radio and Wireless Symp., pp. 715-718, 2008.

[2] M. Z. Win, D. Dardari, A. F. Molisch, W. Wiesbeck, and J. Zhang, "History and Applications of UWB," Proceedings of the IEEE, vol. 97, no. 2, Feb. 2009.

[3] N. P. Agrawall, G. Kumar, and K. P. Ray, "Wide Band Planar Monopole Antenna," IEEE Trans. Antennas Propag., vol. 46, no. 2, pp. 294–295, Feb. 1998.

[4] T. Taniguchi and T. Kobayashi, "An Omnidirectional and Low-VSWR Antenna for the FCC-approved UWB Frequency Band," IEEE AP-S International Symp., vol. 3, pp. 460-463, Jun. 2003.

[5] A. Kuramoto, "Flat Type UWB Antenna Consisting of Two Kinds of Elliptical Elements Located in Parallel," IEICE Trans. Comm., vol. 88-B, no. 9, pp. 1710-1717, Sep. 2005, (in Japanese).

[6] J. Liang, C. C. Chiau, X. Chen, and C. G. Parini, "Study of a Printed Circular Disc Monopole Antenna for UWB Systems," IEEE Trans. Antennas and Propag., vol. 53, no.11, pp.3500-3504, Nov. 2005.

[7] M. N. Srifi, S. K. Podilchak, M. Essaaidi, and Y. M. M. Antar, "Planar Circular Disc Monopole Antennas Using Compact Impedance Matching Networks for Ulrta-wideband (UWB) Applications," APMC 2009, pp.782-785, Dec. 2009.

[8] X. L. Bao, M. J. Ammann, "Investigation on UWB printed monopole antenna with rectangular slitted groundplane," Micro. Opt. Tech. Lett., vol. 49, no. 7, pp.1585-1587, Jul. 2007.

[9] K. L. Wong, C. H. Wu, and S. W. Su, "Ultrawide-Band Square Planar Metal-Plate Monopole Antenna With a Trident-Shaped Feeding Strip," IEEE Tran. on Antennas and Propag., vol. 53, no. 4, Apr. 2005.