

MULTIPLE-RING MONOPOLE ANTENNA WITH SLEEVE-SHAPED GROUND FOR DVB-T APPLICATIONS

B.-M. Jeng, C.-M. Lee, and C.-H. Luo

Department of Electrical Engineering
National Cheng Kung University
Tainan City 701, Taiwan, R.O.C.

Abstract—This work presents a novel broadband monopole antenna for digital video broadcasting-terrestrial (DVB-T) application. The proposed antenna consists of a multiple-ring radiating patch and a sleeve-shaped ground plane. The multiple-ring monopole is used to realize the antenna height reduction at a fixed operating frequency. It shows a wide operating 2.5:1 VSWR bandwidth of 408 MHz achieved by using an impedance-matching technique. The technique applies cutting a notch at the ground plane opposite to the microstrip line and adjusting the height of the sleeve-shaped ground. The proposed antenna can operate in the 463–871 MHz frequency range and cover the DVB-T operating bandwidth (470–862 MHz). The radiation pattern of the proposed antenna in the xy -plane is omni-directional with a peak antenna gain of 4.2 dBi.

1. INTRODUCTION

Digital Video Broadcasting-Terrestrial (DVB-T) system has been adopted by many countries, and this system is expected to replace all the conventional analog TV broadcasting systems in the near future. This DVB-T system offers high-data-rate transmission, provides interactive services, and operates on small amounts of power. Due to their attractive wide bandwidth, simple structure and omni-directional radiation pattern, monopole antennas are considered the potential candidates for applications of DVB-T [1–4]. Several types of antennas have been developed to achieve the broad bandwidth that is needed for DVB-T applications.

Corresponding author: C.-H. Luo (robin@ee.ncku.edu.tw).

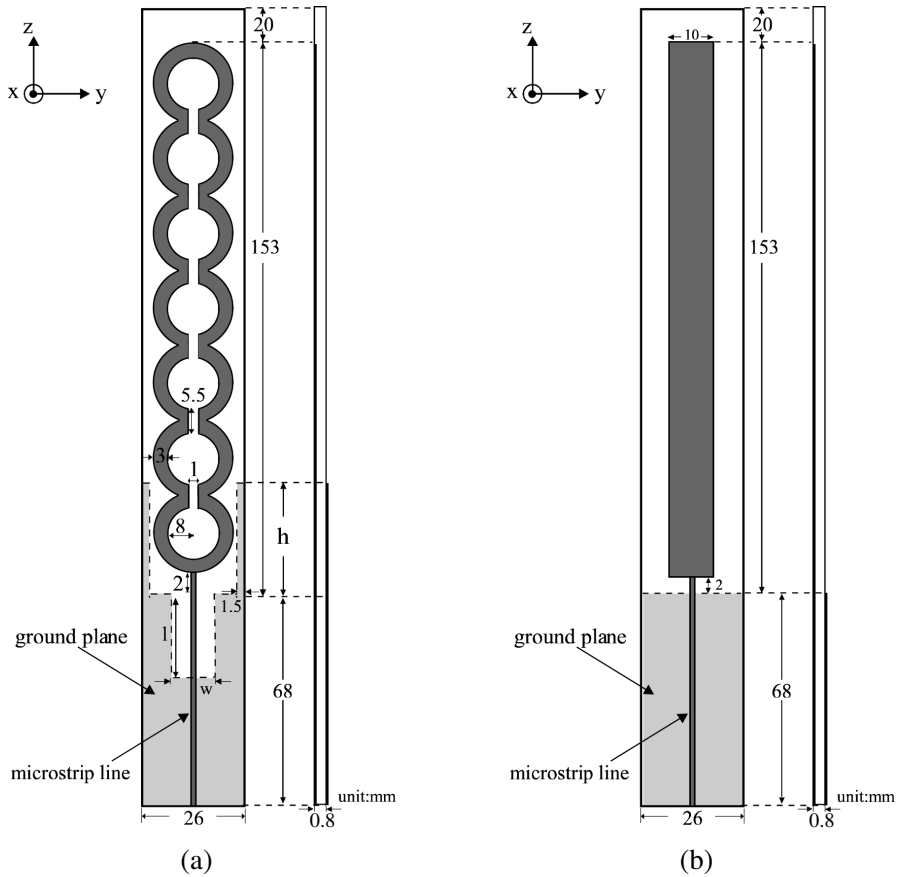


Figure 1. Geometry of (a) the multiple-ring monopole antenna with sleeve-shaped ground plane and (b) conventional monopole antenna.

Such antennas are the monopole antenna with a concave shape in the ground plane [5], sleeve monopole antenna [6–8], and circular-ring monopole antennas [9]. This work presents a novel multiple-ring monopole antenna with a sleeve-shaped ground plane. This antenna is proposed for DVB-T signal reception in the UHF band (470–862 MHz).

The proposed broadband DVB-T monopole antenna has a VSWR greater than 60% in the frequency range of 470–862 MHz. The antenna performance including the frequency bandwidth and the radiation pattern is assessed numerically. The analytical results of this work demonstrate the suitability of the proposed antenna for DVB-T applications.

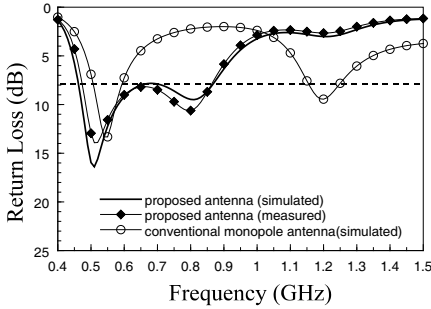


Figure 2. Simulated and measured return loss of the proposed antenna; $l = 23$ mm, $w = 14.5$ mm, $h = 20$ mm.

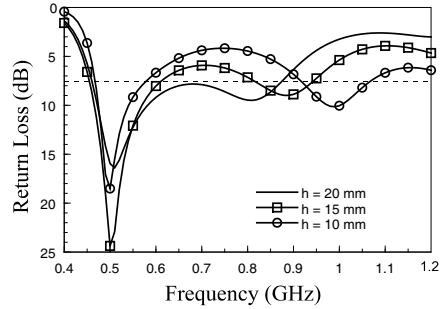


Figure 3. Simulated return loss against frequency for different parasitic element length h .

2. ANTENNA DESIGN

The structure of the proposed antenna and conventional monopole antenna is shown in Fig. 1. The proposed antenna consists of the multiple-ring radiating patch and a sleeve-shaped ground plane. The antenna is printed on an FR-4 substrate 0.8 mm thick with a relative permittivity of $\epsilon_r = 4.4$. A 50Ω microstrip feed line is utilized to excite the monopole antenna. The area of the ground on the backside is $68 \times 26 \text{ mm}^2$.

It has a concave slot $23 \times 14.5 \text{ mm}^2$ and sleeve-shaped ground of height h on the ground plane. The parameter h and concave slot are used to adjust the characteristic impedance of the antenna in order to increase its bandwidth.

3. EXPERIMENTAL RESULTS

Figure 2 shows the simulated and measured return loss against frequency for the proposed antenna and conventional monopole antenna, which is expected to provide reliable results for proposed antenna. The bandwidth of conventional monopole antenna is narrow, but it can be improved by adding the extended metal line from the ground plane. Clearly, the generated two adjacent resonant modes form a wide operating band of roughly 61% ($2.5 : 1$ VSWR) bandwidth centered at roughly the desired center frequency of 665 MHz to cover the DVB-T band of 463–871 MHz. The simulated results are obtained using Ansoft simulation software HFSS v.11 (High Frequency Structure Simulator) [10].

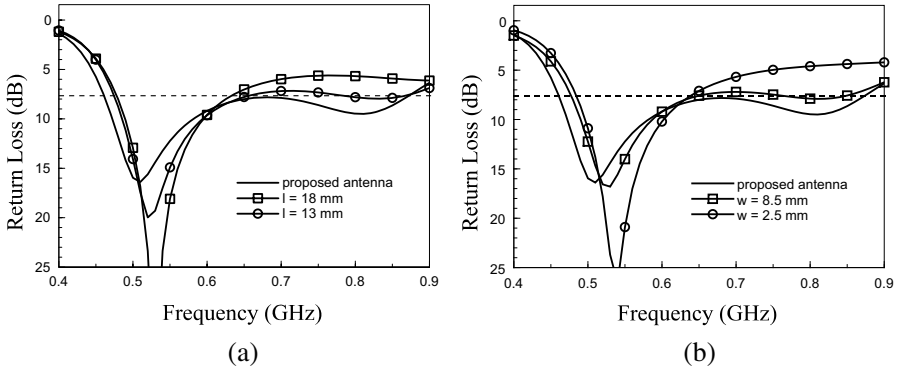


Figure 4. Simulated return loss against frequency for different (a) length l and (b) width w of cutting notch on the ground plane.

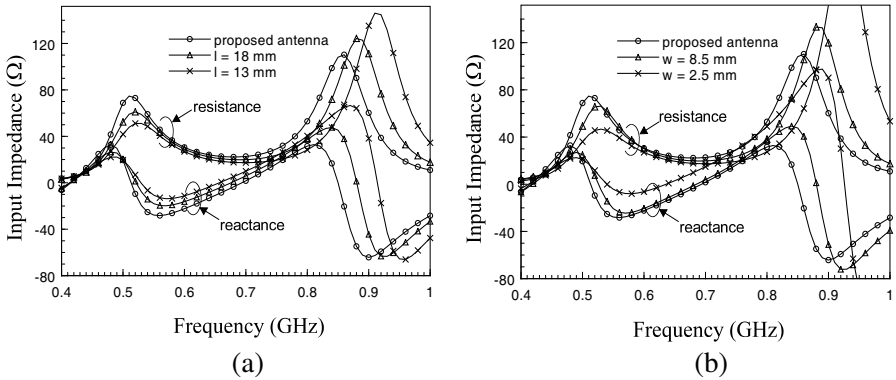


Figure 5. Simulated input impedance against frequency for different (a) length l and (b) width w of cutting notch on the ground plane.

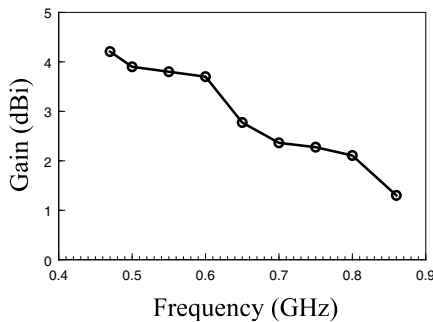


Figure 6. Measured antenna gains of the proposed antenna.

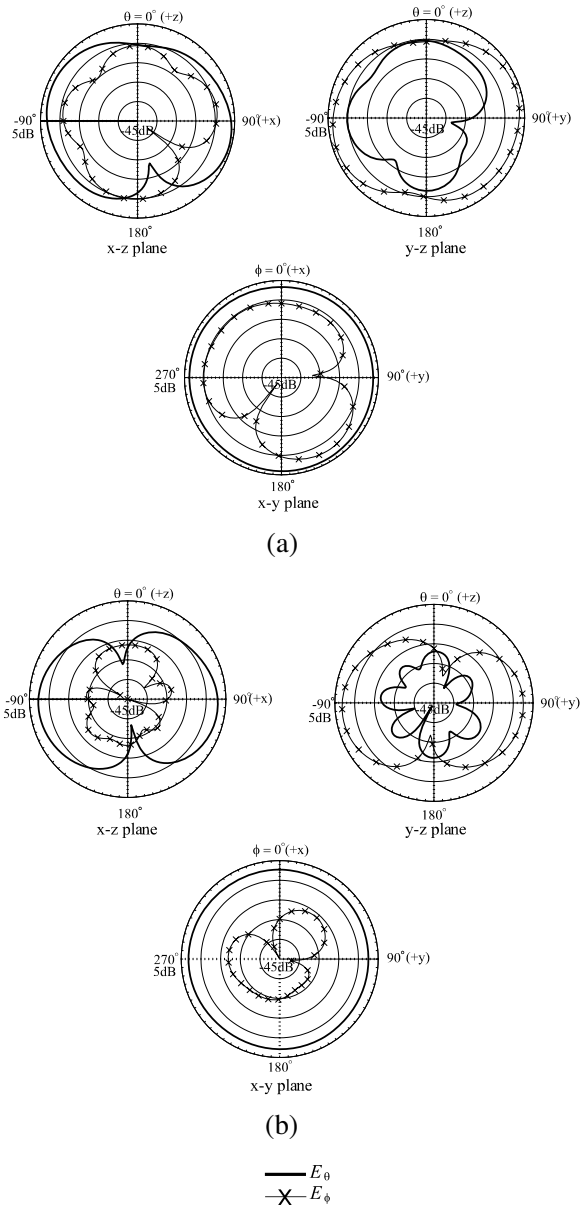


Figure 7. Measured radiation patterns of the proposed antenna at (a) 470 MHz, (b) 860 MHz.

The fundamental mode used is about 500 MHz when investigating the effects of height (h) variation of the sleeve-shaped ground on bandwidth performance of return loss. Fig. 3 illustrates the proposed antenna with sleeve-shaped ground. The first two resonant modes are excited to effectively increase impedance bandwidth. Fig. 4 shows the simulated return loss against frequency for different concave width w and length l . With $l = 23$ mm and $w = 14.5$ mm, a satisfactory bandwidth, defined by 2.5:1 VSWR, of 408 MHz (463–871 MHz) or 61% centered at 665 MHz is obtained. The slot of sleeve-shaped ground plane is used to adjust impedance-matching. Changing the size of the slot in this proposed antenna is equal to adjust the gap between the antenna and the ground in conventional monopole antenna. The simulated input impedance results are shown in Fig. 5.

Figure 6 shows the measured gain of the proposed antenna. The measurement results demonstrated good antenna gain, and the proposed antenna gain varies from 1.3 dBi to 4.2 dBi over the DVB-T band. Fig. 7 shows the measured radiation pattern of proposed antenna at 470 and 860 MHz respectively. The radiation patterns for E_θ polarization in the xy -plane are nearly omni-directional.

4. CONCLUSIONS

A novel multiple-ring monopole antenna with sleeve-shaped ground plane for application in DVB-T system has been successfully implemented in this work. The proposed antenna has a low-cost simple structure which can be fabricated easily. The proposed antenna is suitable for DVB-T applications. In this case, the proposed antenna generates two adjacent resonant modes to provide a wide operating bandwidth larger than 60% to cover the DVB-T band. The analytical results show omni-directional radiation characteristics for all the frequencies across the operating band.

REFERENCES

1. Huang, C. Y., B. M. Jeng, and J. S. Kuo, "Grating monopole antenna for DVB-T application," *IEEE Trans. Antennas Propag.*, Vol. 56, 1775–1776, 2008.
2. Su, C. M., L. C. Chou, C. I. Lin, and K. L. Wong, "Internal DTV receiving antenna for laptop application," *Microwave Optical Technol. Let.*, Vol. 44, 4–6, 2005.
3. Li, W. Y., K.L. Wong, and S.W. Su, "Broadband integrated DTV antenna for USB dongle application," *Microwave Optical Technol. Let.*, Vol. 49, 1018–1021, 2007.

4. Su, S. W. and F. S. Chang, "Wideband rod-dipole antenna with a modified feed for DTV signal reception," *Progress In Electromagnetics Research Letters*, Vol. 12, 127–132, 2009.
5. Huang, C. Y. and W. C. Hsia, "Planar elliptical antenna for ultra-wideband communications," *Electron. Lett.*, Vol. 37, 934–936, 2005.
6. Shen, Z. and R. H. MacPhie, "Theoretical modeling of multi-sleeve monopole antennas," *Progress In Electromagnetics Research*, Vol. 31, 31–54, 2001.
7. Moon, J. I., S. O. Park, and K. Y. Park, "Broadband sleeve monopole type antenna for dual-band PCS/IMT-2000," *Electron. Lett.*, Vol. 39, 1829–1930, 2000.
8. Dong, T. and Y. Chen, "Novel design of ultra-wideband printed double-sleeve monopole antenna," *Progress In Electromagnetics Research Letters*, Vol. 9, 165–173, 2009.
9. Liang, J., C. C. Chiau, X. Chen, and C. G. Parini, "Printed circular ring monopole antennas," *Microwave Opt. Technol. Lett.*, Vol. 45, 372–375, 2005.
10. <http://www.ansoft.com/products/hf/hfss/>, Ansoft Corporation HFSS.