A COMPACT OMNI-DIRECTIONAL UHF ANTENNA FOR DTV BROADCASTING RECEPTION

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ABSTRACT

Based on the features of the OFDM (Orthogonal Frequency Division Multiplexing) and the SFN (Single Frequency Network) techniques used in the modern digital TV broadcasting systems, for example, the European DVB-T, a compact planar antenna is developed. This antenna is operated in the UHF band and owns the characteristics of horizontal polarization reception and wideband.

To meet the wideband operation requirement, the similar printed Log-periodic planar antenna array is arranged, on the other hand, for the omni-directional pattern purpose, a four-quarter concept is adopted to further arrange the whole antenna. Rampart lines are used as the elements of the Log-periodic planar antenna array to make the planar area more compact. A multiplayer PCB is layout as the base of the antenna, and is to be a low cost design. The presented antenna has been preliminarily applied in Taiwan to receive the DVB-T programs either by mobile reception in vehicles or indoor portable reception.

INTRODUCTION

Currently, there have been three transmission standards in the world for the digital TV terrestrial broadcasting, namely, DVB-T COFDM (Coded Orthogonal Frequency Division Multiplexing, adopted as the Digital Video Broadcasting-Terrestrial standard) promoted by Europe, ATSC 8-VSB (Trellis-Coded 8-Level Vestigial Side-Band), promoted by the Advanced Television Systems Committee, USA and ISDB-T (Terrestrial Integrated Service Digital Broadcasting) BST-OFDM (Band Segmented Transmission - OFDM) promoted by Japan [1]. The countries who have announced to adopted the ATSC 8-VSB system are United States, Canada, South Korea, and Argentina. However, the trial testing in Baltimore executed by Sinclair broadcasting company [2] had raised deep concern worldwide about the performance comparison between the European DVB-T COFDM and ATSC 8-VSB. A project had been also undertaken to have a field measurement for the performance comparison between DVB-T COFDM and ATSC 8-VSB in 2001 in Taiwan [3]. As what have observed by that project and the other countries, the DVB-T is found indeed to be more capable than the ATSC in handling the DTV multipath waves often happening in the metropolitan area. Moreover, it is observed too that, without using a large outdoor directional Yagi-Uda antenna for ATSC 8-VSB, DVB-T is possible to work well by employing an omni-directional antenna to have a reception indoor. The modulation technique OFDM used in the DVB-T is believed to be very effective for solving the multipath signal problem. Actually received signal could be enhanced by adding the multipath. So, in stead of being with directional gain, being omni-directional of a receiving antenna is more preferred when the circumstance of multipath, for example, moving in a city or in a room, is encountered. As a new broadcasting business chance, mobile reception is considered to be a good option of DVB-T system. especially when the data broadcasting service is added. Then, considering the good appearance, a compact antenna suitable for being installed either on the car roof or inside it, or deployed inside a room, is strongly expected. The objective of this present project is to meet such a purpose.

DESIGN STRATEGIES

To function as a reception antenna of the TV broadcasting, an ultra broadband specification is quite

fundamental, because the spectrum allocation could not be continuous in the UHF bands in some countries. For example, the bands for the DTV broadcasting in Taiwan are allocated within from 537.25MHz to 709.75MHz, ten '6MHz' bands. On the other hand, since the DVB-T is based on the OFDM technology, multipath reception is more preferred to the traditional directional reception, consequently, the wanted antenna should be omni-directional. Moreover, because the horizontal polarization is used in the most of circumstances of TV broadcasting, it should be horizontally polarized too. Due to the fact that this antenna is to be employed in a car or indoor, it should not be large in size, hence, the 'compactness' is an another important specification. What follows are the design approach description for these features of the present innovative antenna:

a) *Compact Design* - if the dipole-like elements are used, an obvious problem is that their resonant length are too long in the free space for the UHF band. For example, for a 450MHz frequency, it is length is approximately to be 333 mm ($\lambda_0/2$). Both concepts of the rampart lines and PCB printed lines are applied in this design to aim the 'compactness' goal. Fig. 1 shows the demonstration of a meandered dipole on a FR4 PCB and its simulated resonant $|S_{11}|$ curve. Its equivalent length is only 128 mm. This technique does also take the horizontal polarized operation into account.

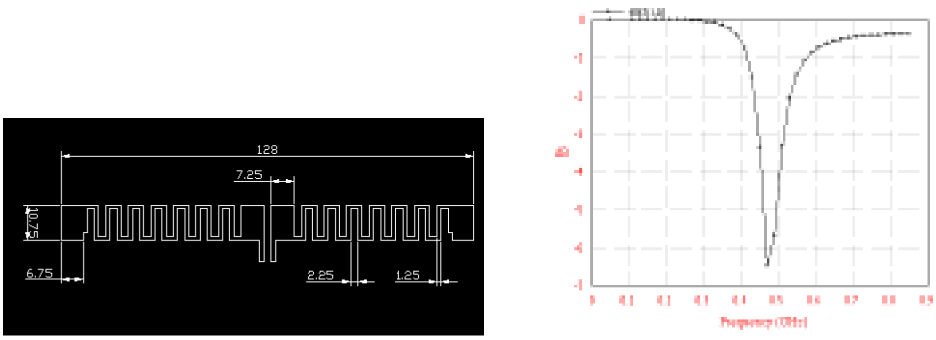


Fig. 1 A dipole of rampart line

b) *Broadband design* – usually, the log-periodic concept may be applied if a broadband antenna is to be designed. Several length-varied dipole-like elements are formed by a special feeding network to be an array antenna. This strategy is followed in the present antenna. Three resonant lengths are used to cover the broadband under consideration, referring to Fig. 2, and are fed by a pair of near-differential lines which are printed on the each side of a PCB. For each resonant meandered dipole, its two arms are not necessary to be on the same side of a PCB. Even the whole antenna is fed by a coaxial connector, which is at the mid-point of the main feeding lines, no balun is added between the connector and feeding lines transition, because of the consideration of broadband operation.

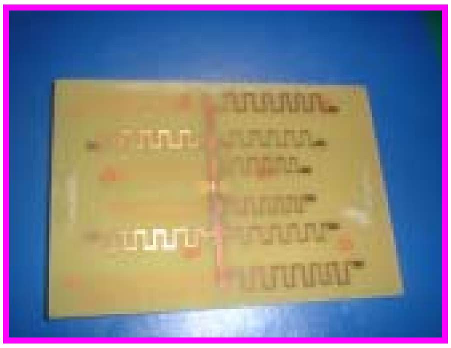
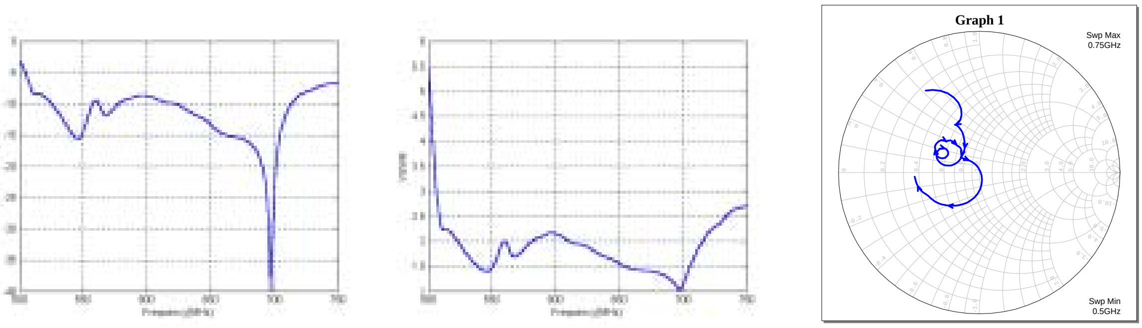


Fig. 2 Two quarters of a log-periodic array

c) *Omni-directional design* – One group of three rampart line dipoles are designed to serve for one quarter only of the azimuth plane of antenna radiation pattern. The layout in the Fig. 2 is to serve for two quarters. The ‘orthogonality’ idea may be applied, that means, four groups of the log-periodic array antenna mentioned above are constructed by a multi-layered PCB to form a completed DTV reception antenna. Two quarters, say, south and north, are printed on the both sides of a PCB, and the other two quarters, say, west and east, are printed on the other one PCB. However, they are stacked together orthogonally to function as an omni-directional antenna.

MEASUREMENT AND ANALYSIS

For checking if the operating characteristics of the designed antenna are met or not, its return loss ($|S_{11}|$ S-parameter of the input terminal) and the radiation patterns within the interested frequency band are measured. The resultant $|S_{11}|$ shown in the Fig. 3 (a) indicates that most portions of the interested band from 525 – 715MHz are below –10dB, even some worse parts (around 600 MHz) may be raised up to –9 dB. In terms of VSWR shown in the Fig. 3 (b), it is equivalently to said that, most parts are below 2.0. Fig. 3 (c) is the resultant input impedance displayed on a Smith Chart. As what expected, this broadband antenna is composed of several resonant modes which are caused by the length-varied meandered dipoles in a log-periodic structure.

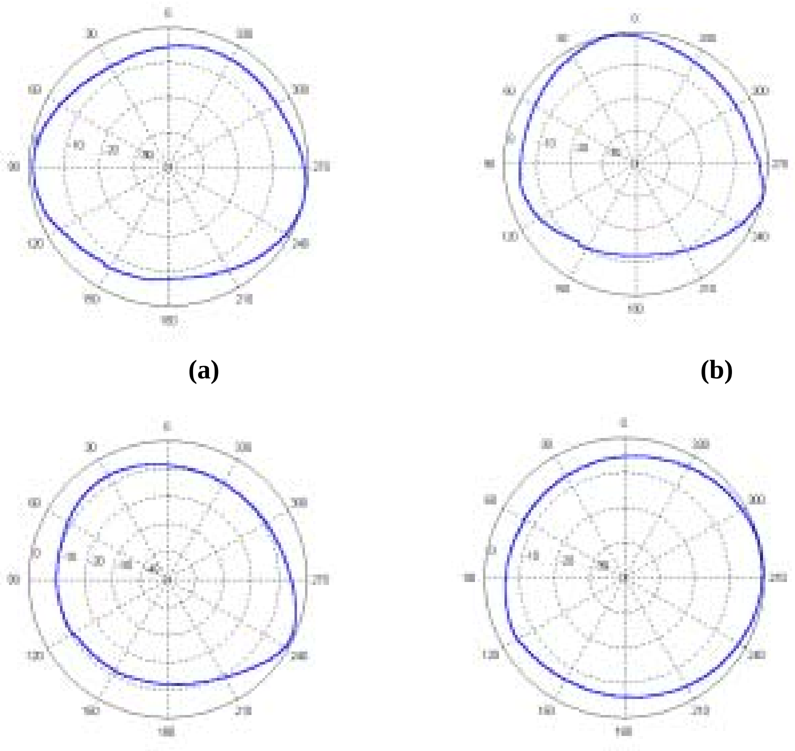


(a) (b) (c)

Fig. 3 Input response of the whole antenna

By the design specification of the present antenna, the radiation pattern is an another important parameter of the aim. The measured patterns shown in the Fig. 4 (a) (b) (c) and (d) are carried out at the resonant frequencies of 540MHz, 570MHz, 600MHz and 700MHz, respectively. The worst case (< -10dB related to the 0 dB directions) in terms of the omni-directional pattern is happening within some angular portions, especially of the 570MHz and 600MHz cases. Note that the latter situations are those which are of less resonance. It indeed looks forward to seeking a better length design of the rampart lines for them, such that their both of the return loss and radiation pattern could be optimized simultaneously. Additionally, as a capacitive coupling technique, a gap may be added between the main feeding lines and the radiating rampart lines. It have been found that this method indeed improves the bandwidth flatness.

Since the applications of mobile reception and indoor portable reception of the present antenna are its main functions, the field receptions have been done either in a car moving along the main streets of Taipei downtown and in the author’s office where the room is quite shielded by walls from the radiating station. The reception grade is quite compatible with a commercial, big and omni-directional active UHF antenna – ‘Omnimax’ of MAXVIEW brand, which is equipped with an amplifier of max. gain 20dB inside the antenna base. The present antenna is to have an option of being active if necessary in the future commercialization stage.



(a) (b) (c) (d)

Fig. 4 The measured radiation patterns of the compact DTV receiving antenna

COMMENT AND CONCLUSION

In this report paper, a compact, wideband, horizontally polarized and omni-directional antenna has been designed. Usually, the spectrum allocation of TV broadcasting for different countries may vary, hence, the receiving antenna is supposed to be redesigned by request when the operating bandwidth is changed. Based on the present proposed structure, and using a proper simulation tool, a suitable antenna with the features addressed above may be easily realized.

The presented antenna has been preliminarily applied in Taiwan to receive the DVB-T programs either by mobile reception in vehicles or indoor portable reception.

ACKNOWLEDGEMENT

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[1] Yiyang Wu, *et al*., 'Comparison of Terrestrial DTV Transmission Systems: The ATSC 8-VSB, the DVB-T COFDM, and the ISDB-T BST-OFDM,' IEEE Trans. on Broadcasting, pp. 101–113, vol. 46, no. 2, June 2000.

[2] http://www.sbgi.net/dtv/balt_test/cmprecs.pdf

[3] http://www.cts.com.tw/tvc/dtv/standard/endrep-idx.htm (in Chinese)