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TWO-PORT ANTENNA WITH HIGH ISOLATION FOR DTV/GSM/UMTS INDOOR APPLICATIONS

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Abstract—A two-port antenna with high isolation for digital television system (DTV), global system for mobile communication (GSM), and universal mobile telecommunications system (UMTS) indoor applications is presented. The antenna consists of a disk loaded sleeve monopole antenna and an inverted-L plate antenna, which are combined into one radiation structure. In addition, by using a choke tube and C-shaped slot inserted into the plate, the isolation between the two ports is improved. A prototype is constructed and tested. The simulated and measured results are given.

1. INTRODUCTION

Recently, digital television (DTV) system has become more and more attractive since it has the advantage of providing super-sharp high-definition television programs. The DTV standard uses the frequency range of 470–862 MHz in the UHF band [1]. Owing to the propagation loss in walls of buildings, indoor DTV wireless networks are needed to be installed in many buildings and malls to increase the level of signal. Similarly, many indoor base stations for the global system for mobile communication (GSM) and universal mobile telecommunications system (UMTS) have also been installed in the same buildings and malls. The GSM standard uses the frequency range of 824–960 MHz (GSM900), 1710–1880 MHz (DCS1800) and 1850–1990 MHz (PCS1900). The UMTS standard uses the frequency range of 1920–2170 MHz. It is desirable to develop muti-band antennas for the DTV, GSM and UMTS indoor applications.

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Many promising designs of broadband antennas for DTV applications have been reported. Some of the antennas have the features of compact size [2–4] and others broad bandwidth [5–7]. However, these antennas are not suitable for multiband and indoor applications. It is a challenging task to design a multiband antenna for all the DTV, GSM, DCS, PCS and UMTS indoor applications.

In this paper, a novel combination antenna with two ports is proposed, which consists of a monopole sleeve antenna and an inverted-L plate antenna. A top loaded disk is used to reduce the height of the monopole sleeve antenna. A C-shaped slot is used to improve the bandwidth of the inverted-L plate antenna. Because there are two ports in the proposed antenna, the isolation between the two ports must be considered. There are many valuable researches for antenna isolation [8–10]. In this paper, a choke tube, along with the C-shaped slot, is used to increase the isolation between the two ports of the

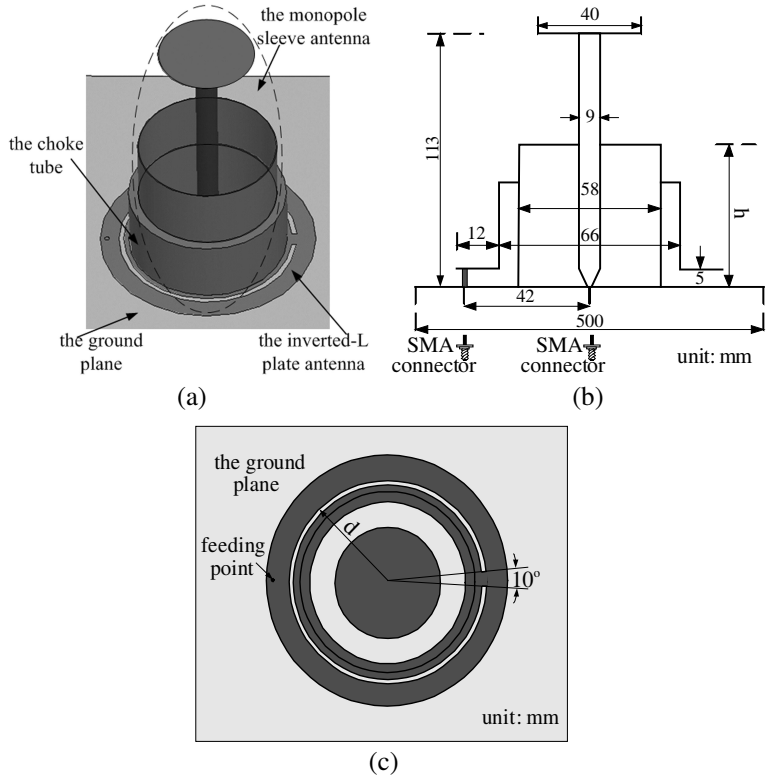

Figure 1. Configuration of proposed antenna. (a) 3D view. (b) Front view. (c) Top View.

antenna. A prototype of the proposed antenna is constructed and tested. The simulated and measured results are given and discussed.

2. ANTENNA DESIGN

The geometry of the proposed combination antenna along with its design parameters is shown in Figure 1. The antenna is located above a rectangular metal ground plane with a size of $500 \times 500\,\text{mm}^2$. As illustrated in Figure 1, the proposed antenna contains two parts: A monopole sleeve antenna and an inverted-L plate antenna. The monopole sleeve antenna operates in the lower frequency band (470–960 MHz) which has a height of 113 mm. A top loaded disk is used to reduce the height of the monopole sleeve antenna [11]. By properly adjusting the parameters of the antenna and the loaded disk, a wide bandwidth covering 470–960 MHz can be obtained. The inverted-L plate antenna operates in the higher frequency band (1.71–2.17 GHz), which contains a feeding probe and a circular ring. A C-shaped slot with 1 mm-width is inserted into the circular ring. By properly adjusting the parameters of the circular ring and the C-shaped slot, a wide bandwidth covering 1.71–2.17 GHz is achieved. The two antennas are combined into one radiation structure. A choke tube is designed with its top connected to the sleeve and its bottom connected to the circular ring. The choke tube, along with the C-shaped slot, increases the isolation between the two ports of the antenna. A good isolation between the two feeding ports can be obtained by adjusting the height of the choke tube and the length of the C-shaped slot.

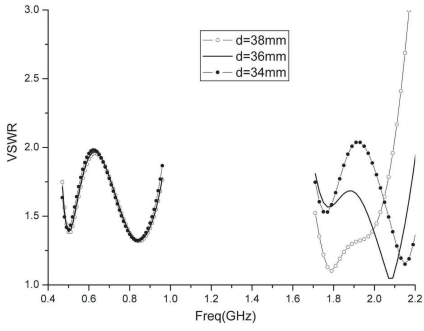

Figure 2. Simulated VSWR for various d.

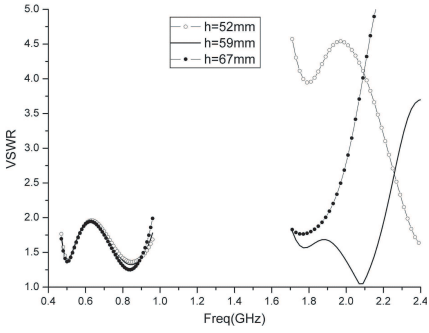

Figure 3. Simulated VSWR for various h.

3. RESULTS AND DISCUSSION

The performance of the proposed antenna is simulated using the electromagnetic software Ansoft HFSS. Figures 2, 3 show the simulated VSWR results for the proposed antenna in terms of the different positions of the C-shaped slot (d) and lengths of the choke tube (h), respectively. The lower band results are for the first port of the sleeve antenna, and the higher band results are for the other port of the inverted-L plate antenna. As shown in Figure 2 and Figure 3, d and h affect the VSWR in the higher bands obviously. Figures 4, 5 show the simulated isolation results for the proposed antenna in terms of the different d and h, respectively. It is obvious that the satisfying

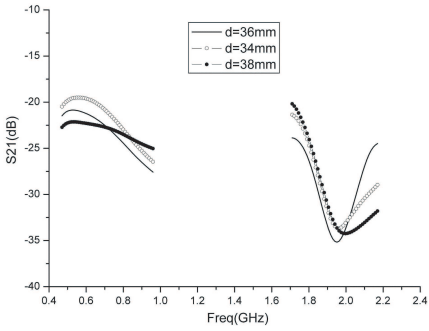

Figure 4. Simulated S_{21} for various d.

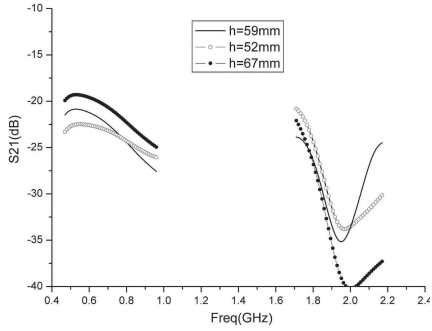

Figure 5. Simulated S_{21} for various h.

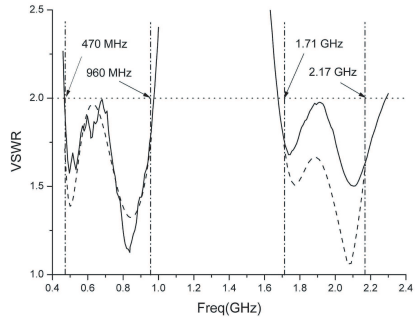

Figure 6. Measured and simulated VSWR for the proposed antenna. Measured (——), simulated (- - -).

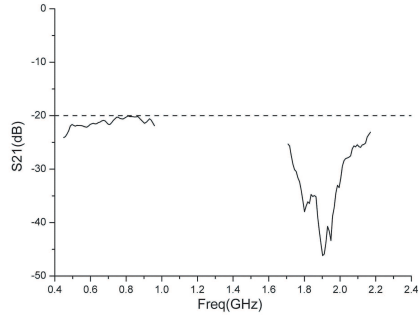

Figure 7. Measured isolation between the two feeding ports of proposed antenna.

isolation between the two ports can be obtained by adjusting d and h. After a lot of simulation work, the d and h are selected as 36 mm and 59 mm, respectively. An antenna prototype with the dimensions shown in Figure 1 ($d = 36$, $h = 59$) is fabricated and measured. Figure 6 shows the measured and simulated Voltage Standing Wave Ratio (VSWR), which shows a good agreement between the measured (using Agilent 8719ES vector network analyzer) and simulated results. It can be seen that the VSWR of the proposed antenna is less than 2.0 in the bands of 467–974 MHz and 1.68–2.28 GHz, which covers all

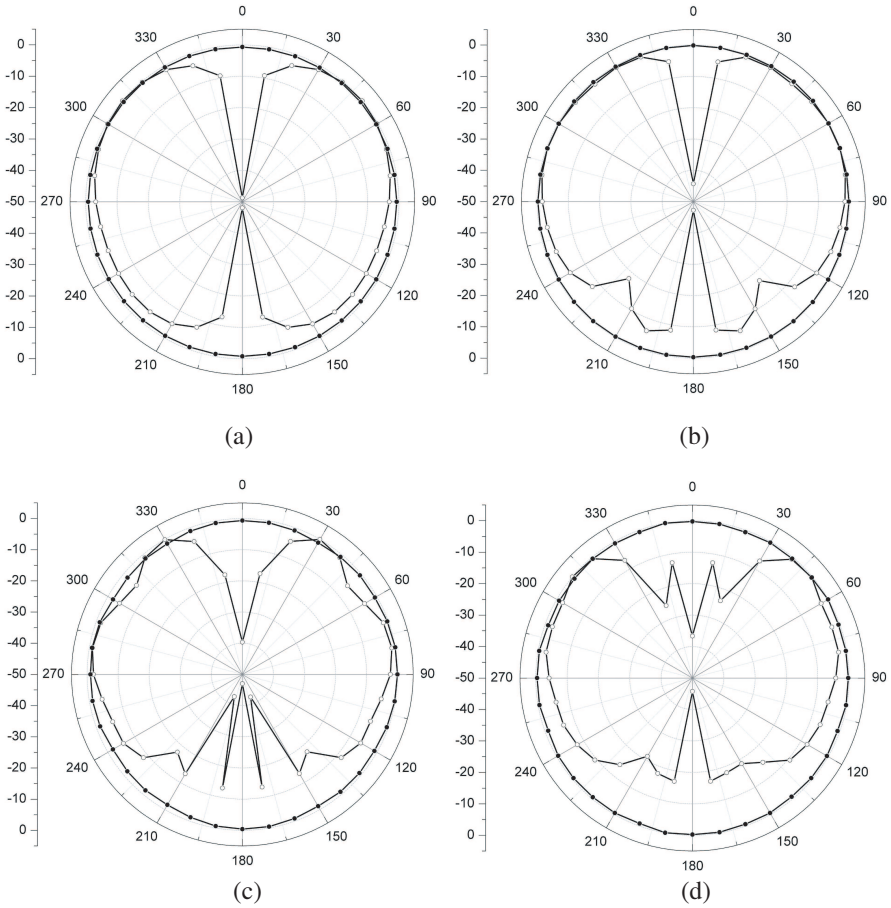

Figure 8. Measured radiation patterns of proposed antenna. (a) 470 MHz, (b) 960 MHz, (c) 1710 MHz, (d) 2170 MHz. E-plane (—◦—), H-plane(—•—).

the DTV, GSM, DCS, PCS and UMTS bands. Figure 7 shows the measured isolation between the two feeding ports. The measured S_{21} is less than -20 dB in the band of 470–960 MHz and less than -23 dB in the band of 1.71–2.17 GHz.

The radiation characteristics are also studied. Figure 8(a)–Figure 8(d) illustrate the measured radiation patterns of the proposed antenna at frequencies 470, 960, 1710 and 2170 MHz, respectively. The results show that the proposed antenna has monopole-like radiation patterns. The antenna gain ranges from 1.6 to 3.3 dB over the band of 470–960 MHz and 4.1 to 4.8 dB over the band of 1710–2170 MHz.

4. CONCLUSION

A two-port combination antenna has been proposed and implemented. The antenna has wide bandwidths covering 467–974 MHz (108.6%) and 1.68–2.28 GHz (35.7%) with VSWR less than 2.0. The isolation between the two feeding ports is larger than 20 dB. The radiation patterns are like that of monopole antennas. The results indicate that the proposed design is suitable for the DTV, GSM and UMTS indoor applications.

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