Design of the Novel DVB-H Antenna for the Folder-Type Mobile Handheld Terminal

Jung-Nam Lee · Jong-Kweon Park · Jin-Suk Kim

Abstract

We have proposed a novel DVB-H(Digital Video Broadcast for Handheld) antenna for folder-type mobile handheld terminal by using a coupling element, a stub, and an L-type matching circuit. The L-type matching circuit consisting of two chip inductors is used for achieving an improved impedance matching over the DVB-H frequency band (470~702 MHz). Simulated results showed the stub worked to more knot the lower and upper frequency ends of the input impedance curve. The antenna exhibits a flat gain characteristic from 2 to 2.8 dBi over the DVB-H frequency band. The radiation patterns are a stable Figure-of-eight radiation pattern in the frequency range.

Key words : DVB-H Antenna, Coupling Element, L-Type Matching Circuit, Mobile Handheld Terminal, Hand Phantom.

Ⅰ. Introduction

DVB-H is a new European standard for mobile television. The standard is derived from the digital terrestrial television standard DVB-T by adding enhancements for the reception in mobile environment and integration with mobile networks. Comparing to digital terrestrial television, handheld television is much more difficult from technical standpoint. First, mobile reception is expected virtually in every place, especially inside buildings and in vehicles. Second, mobile terminals have microscopic antenna size comparing to standard television antennas[1]. DVB-H system uses the frequency band of 470~702 MHz, the free space wavelength 640~430 mm and the assigned bandwidth is very large(232 MHz). Due to the long wavelength, any antenna placed inside a mobile terminal will be electrically small. In [2], a very large bandwidth IFA(Inverted-F Antenna) has been designed with four parasitic elements and a matching improvement using an LC network. The bandwidth for a VSWR of 2 has been enough improved to cover the DVB-H band, but the volume is too big to be used in a mobile terminal. Several PIFA(Planar Inverted-F Antenna) antennas [3]~[5] have been tried but bandwidth is not enough to cover all DVB-H bands and the necessary volume is too big.

In this paper, we present the design of a novel DVB-H antenna for the folder-type mobile handheld terminal. The proposed DVB-H antenna uses the upper and lower ground planes of the folder-type mobile phone. The proposed antenna consists of a stub, a coupling element, and an L-type matching circuit[6]. Recently, we have proposed a novel DVB-H antenna for mobile handheld terminal using a U-shaped radiator and a simple matching circuit[7]. By selecting a proper value of the lumped elements(series chip inductor and parallel chip inductor) in the L-type matching circuit, improved impedance matching of the antenna over the proposed DVB-H band (470~784 MHz) can be obtained[8]. The impedance bandwidth of the proposed antenna defined by VSWR<3 is approximately 314 MHz. The upper ground plane is the cover of the mobile phone and accommodates the LCD. The lower ground plane accommodates the keypad and the battery. The proposed antenna is designed, fabricated, and measured in the case of including the mobile case(ε_r=2), LCD, keypad, battery and hand phantom. The antenna exhibits a flat gain characteristic from 2 to 2.8 dBi over the DVB-H frequency band. The obtained radiation patterns are a stable Figure-of eight radiation pattern in the frequency range. Ansoft high frequency structure simulator(HFSS)[9] is used to simulate the proposed antenna.

Ⅱ. Antenna Design and Broadband Matching

In this paper, our objective is to develop an ultra-wideband DVB-H antenna with omni-directional radiation for the folder-type mobile handheld terminal. For this objective, the structure of the proposed antenna is shown in Fig. 1, where the two ground plane has the dimensions of 100×50 mm^2, respectively, and the FR-4 substrate of thickness h=0.8 mm and relative permitti-

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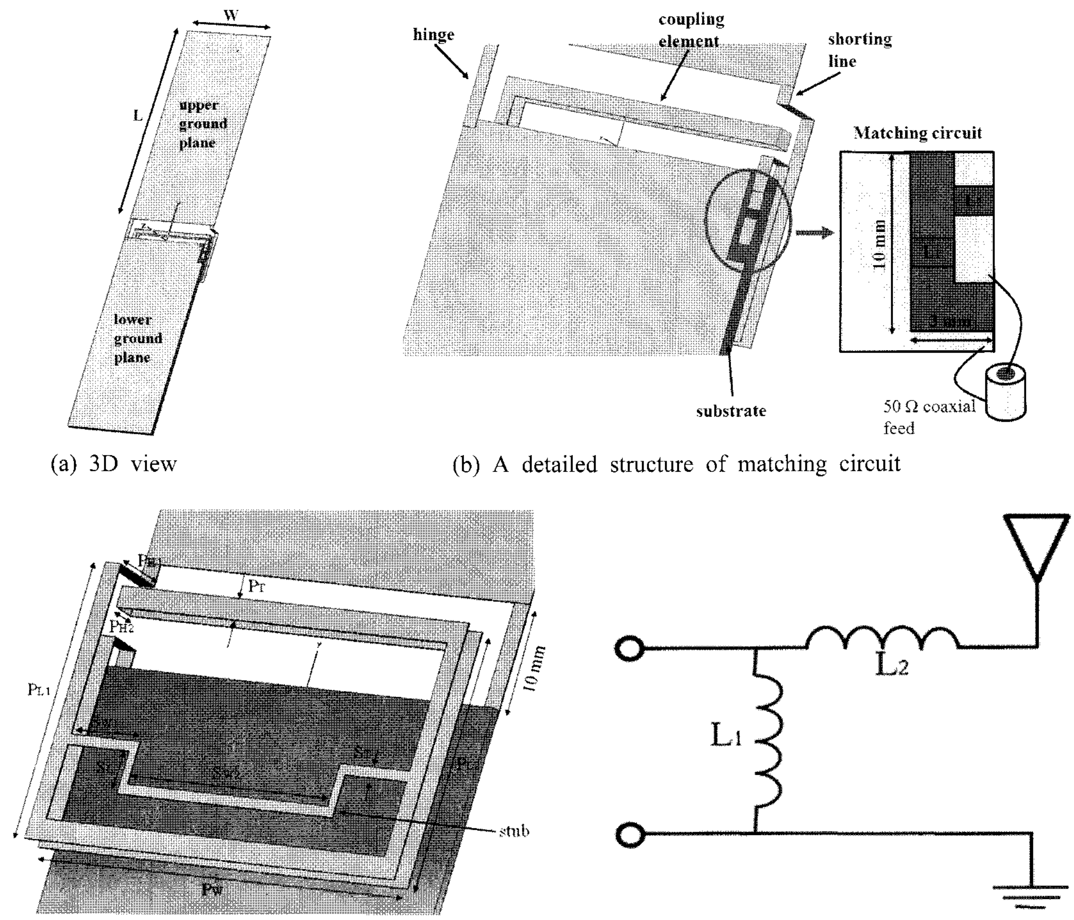


(a) 3D view

(b) A detailed structure of matching circuit

(c) A detailed structure of the coupling element

(d) L-type matching circuit

Fig. 1. The proposed DVB-H antenna structure.

vity ε_r=4.5 is used for the lower ground plane. The two ground planes are connected with hinge and a coupling element is located behind the lower ground plane. We have utilized a coupling element concept of [6]. A stub and an L-type matching circuit are also used for achieving an improved impedance matching over the DVB-H frequency band. To optimize the antenna structure, we have carried out a parametric study with regard to the effect of many parameters on the performance of the proposed antenna. From the extensive simulations by commercial simulator HFSS the optimal parameters are chosen as W=50 mm, L=100 mm, PL_1=26 mm, PL_2=24 mm, PW=48 mm, PH_1=5 mm, PH_2=2 mm, PT=2 mm, SW_1=9 mm, SW_2=26 mm, SL=4 mm, ST=1 mm, L_1=135 nH, and L_2=12 nH. Fig. 1(b), (c) is the detailed structure of the matching circuit and coupling element and Fig. 1(d) is the L-type matching circuit used for impedance matching.

Fig. 2 and 3 show the effects of a stub and the L-type matching circuit of the proposed antenna. In the case of without a stub and matching circuit, the impedance bandwidth is large by the effect of the coupling element but the impedance bandwidth is not enough to cover the DVB-H frequency band. From the Fig. 3(a), it can be seen that by adding a stub to the coupling element(see Fig. 1(c)), the lower frequency and upper frequency ends of the impedance curve can be more knotted and it is still necessary to move the impedance point outside the VSWR 3:1 circle into the definition circle(VSWR 3:1). Using the L-type matching circuit(a series chip inductor and a parallel chip inductor), more improved impedance matching is obtained. The inductances(L_1 and L_2) were chosen as 135 nH and 12 nH, respectively.

Ⅲ. Simulated and Measured Results

Fig. 4 shows the simulated and measured results of $|S_{11}|$ versus frequency for the proposed antenna with a stub and the L-type matching circuit. The simulated results are in reasonable agreement with the measured results and the measured impedance bandwidth for VSWR <3 is approximately 314 MHz(470~784 MHz). The effects of various element values of the matching circuit on the return loss are shown in Fig. 5. As shown in Fig. 5(a), an increase in L_1 has an appreciable effect on the

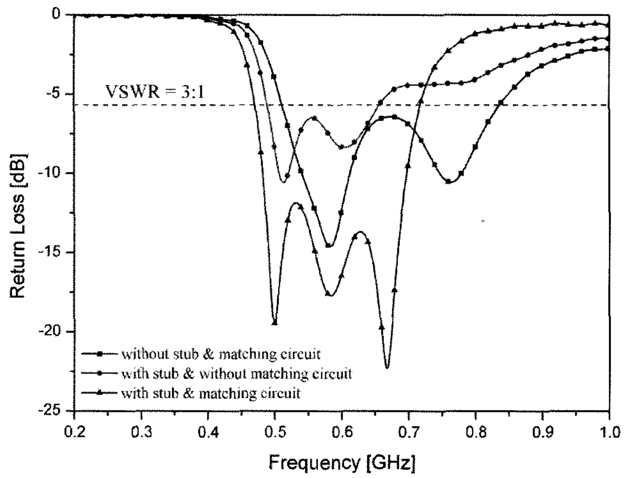


Fig. 2. Effect of a stub and the L-type matching circuit on the return loss.

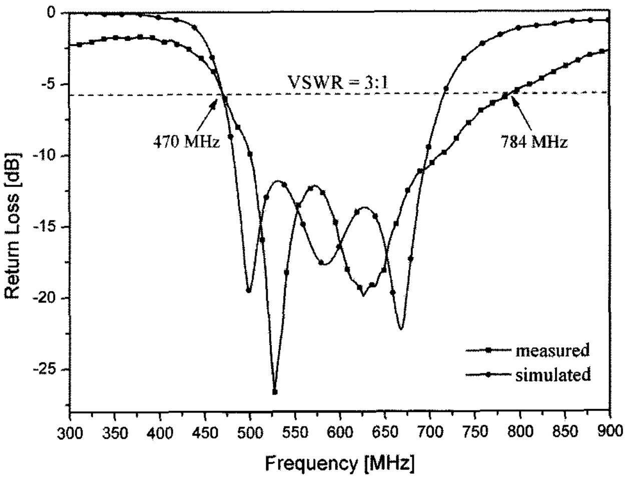
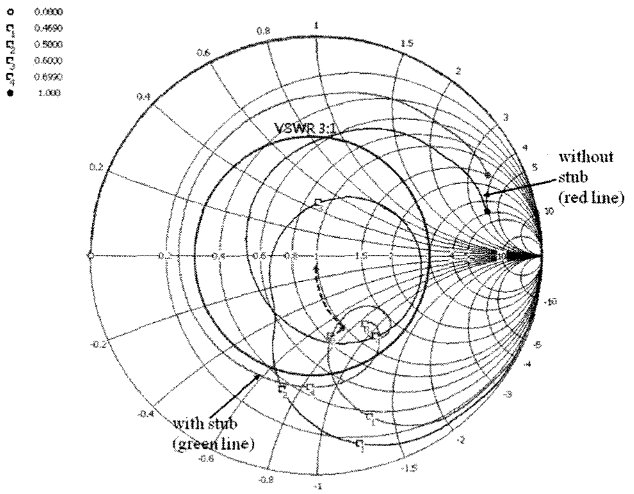
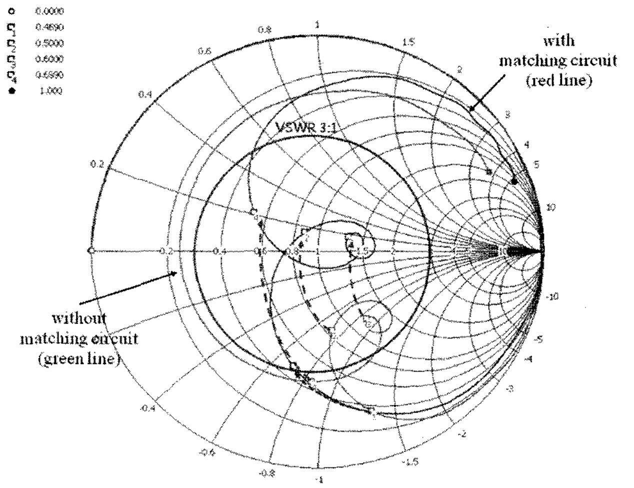


Fig. 4. Measured and simulated results of $|S_{11}|$ versus frequency(with a stub and the L-type matching circuit).

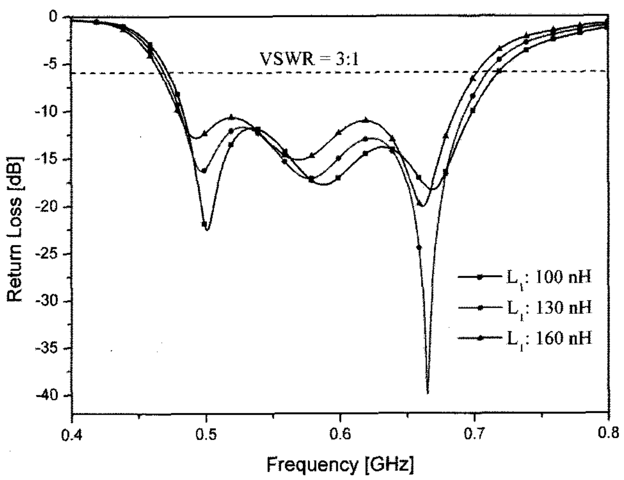


(a) A stub

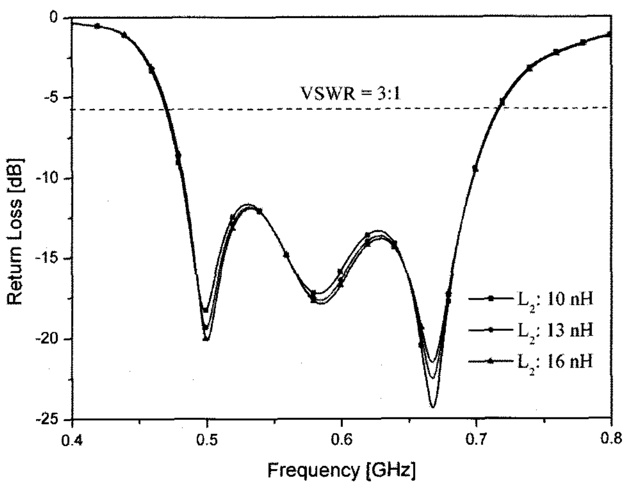


(b) A stub and the L-type matching circuit

Fig. 3. Effect of a stub and the L-type matching circuit on the input impedance.

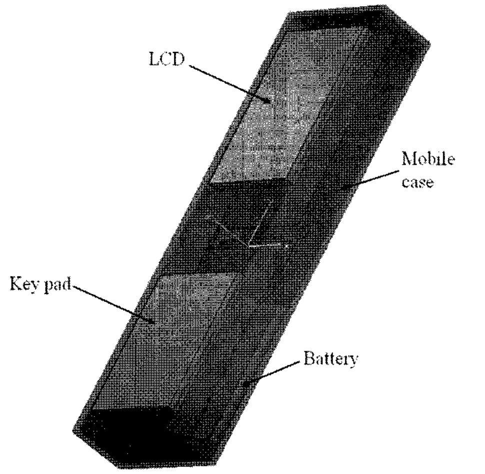


(a) L_1

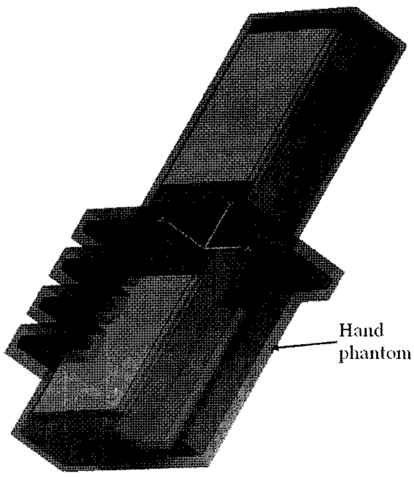


(b) L_2

Fig. 5. Effects of the various element values of the L-type matching circuit on the return loss.

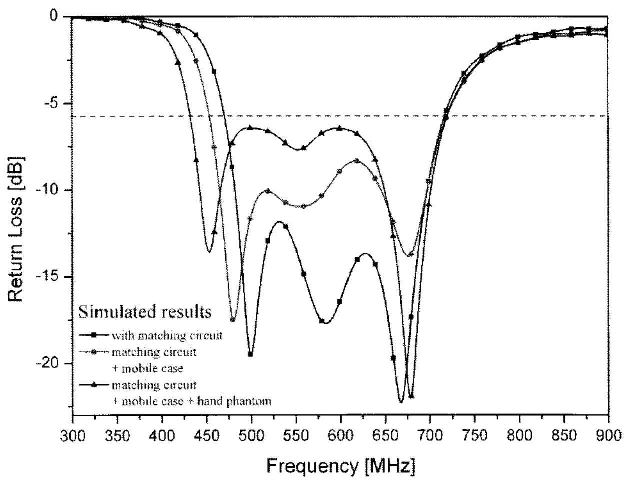


(a) Including mobile case, LCD, keypad, and battery

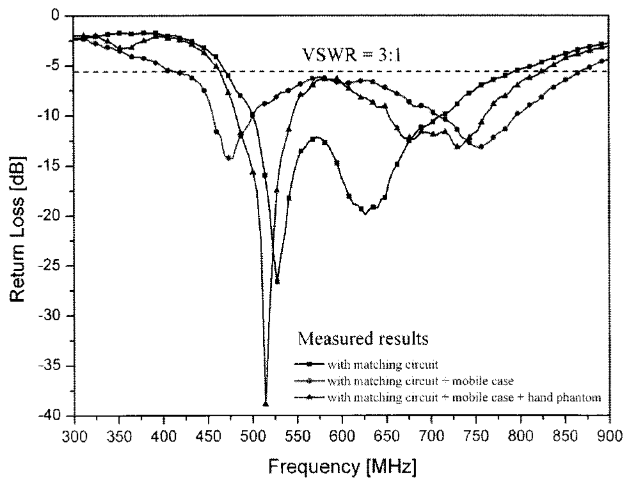


(b) Hand phantom modeling

Fig. 6. Modeling of real situations for the folder-type mobile handheld terminal.



(a) Simulated results



(b) Measured results

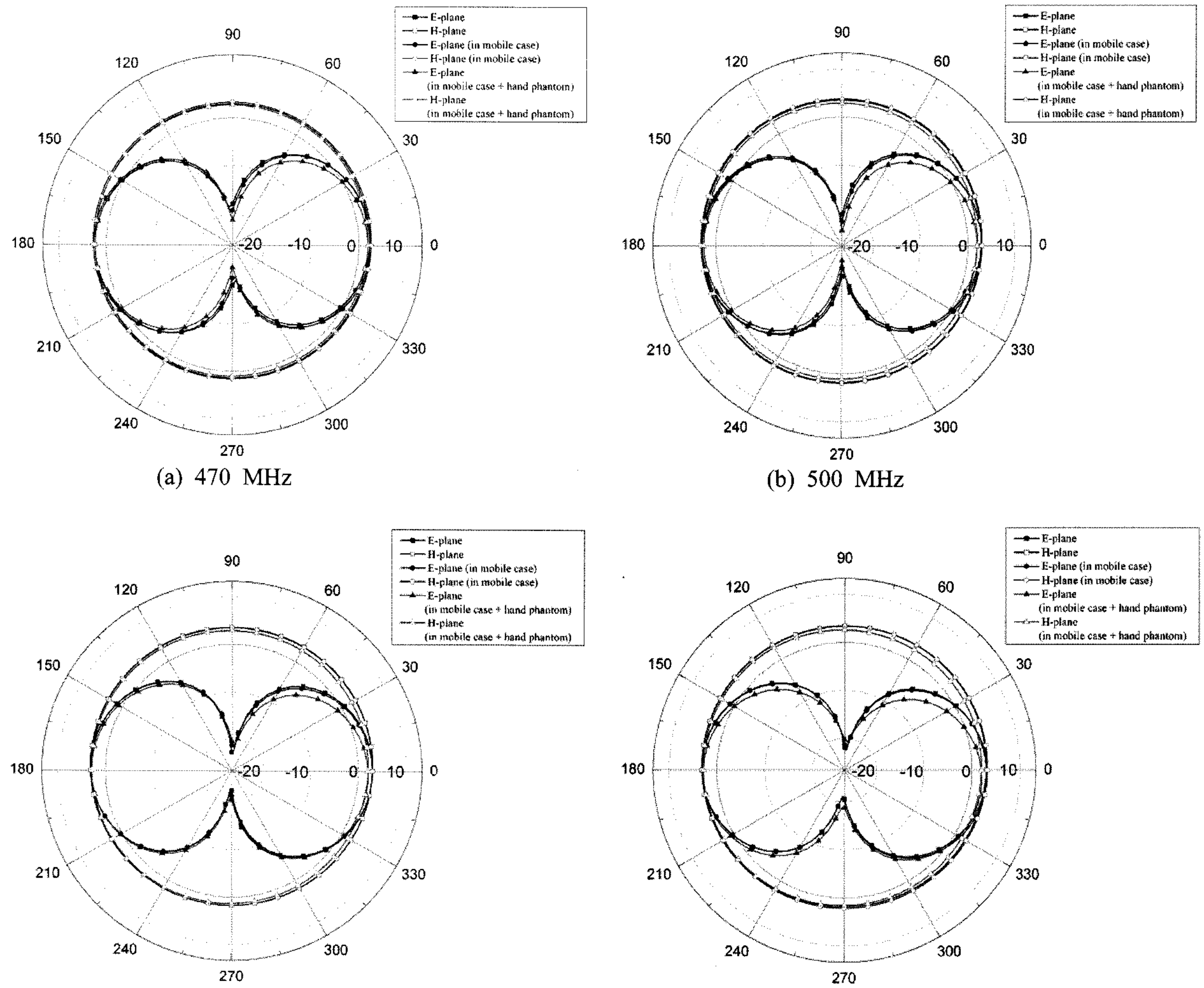
Fig. 7. Measured and simulated return losses for the various environments.

return loss level. It is further observed that the optimal value in this design is 135 nH. From the Fig. 5(b), a very small effect of L_2 on the return loss over the DVB-H band is observed. Fig. 6 presents the modeling of real situations for the folder-type mobile handheld terminal including mobile case, LCD, keypad, battery, and hand phantom. As shown in Fig. 6(a), the mobile case is a plastic(ε_r=2), and LCD, keypad, and battery are PEC. Fig. 6(b) shows the case that hand phantom is applied on the above case. To model the hand phantom, we have used the liquid(ε_r=42, tangent δ=0.99, and material density=1,000 kg/m^3 at 800 MHz) and shell(ε_r = 5, tangent δ=0.05, and material density=1,000 kg/m^3 at 800 MHz) dielectric substrate. Fig. 7 shows the measured and simulated return losses for the real situations of Fig. 6. As shown in the Fig. 7, in all cases, the impedance bandwidth is changed substantially and the return loss decreases but frequency bandwidth increases.

Fig. 8 shows the simulated radiation patterns at 470, 500, 600, and 702 MHz for the various environments including the mobile case, LCD, keypad, battery, and hand phantom. The radiation patterns of all cases are a stable Figure-of-eight radiation pattern in the frequency range and the shape of the patterns are almost unchanged for all cases. Fig. 9 shows the simulated antenna gain and efficiency. The antenna exhibits a flat gain characteristic from 2 to 2.8 dBi over the DVB-H frequency band and the efficiency varies from 60 % to 99 % over the operating frequency range.

Ⅳ. Conclusion

DVB-H antenna having a stub, coupling element, and an L-type matching circuit has been proposed. The proposed DVB-H antenna used the upper and lower ground planes of the folder type mobile phone. By using an L-type matching circuit(two matching elements), a stub,



(a) 470 MHz (b) 500 MHz

(c) 600 MHz (d) 702 MHz

Fig. 8. Simulated radiation patterns.

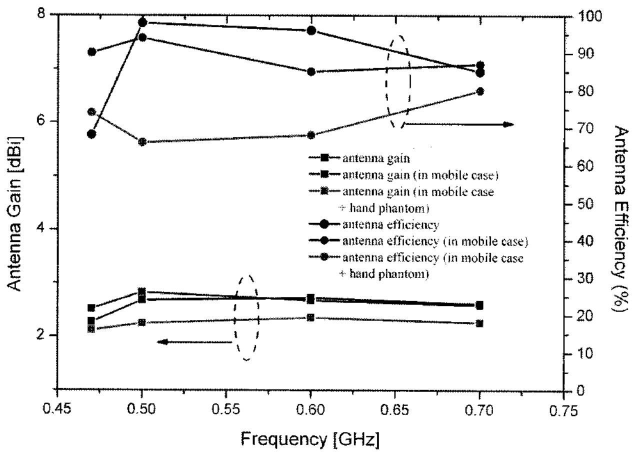


Fig. 9. Simulated antenna gain and efficiency.

and the coupling element, the proposed antenna can be achieved an ultra-wideband with good impedance matching covering the whole DVB-H band. Good radiation characteristics of dipole-like pattern and flat gain(2~2.8 dBi) were obtained over the DVB-H band and thus indicating that the proposed antenna is a good candidate for the DVB-H applications.

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