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INTEGRATED DTV ANTENNA FOR PORTABLE MEDIA PLAYER APPLICATION

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Abstract—A broadband antenna integrated with the system ground plane of the Portable Media Player (PMP) device for digital television (DTV) signal reception is proposed. The antenna comprises of a quarter-wavelength monopole and a gaps-coupled open loop antenna that can generate two adjacent resonant modes to form a wide operation band. Result shows a wide bandwidth of 464–856 MHz to cover the DTV signal reception in 470–806 MHz band Details of the proposed antenna designs and experimental results of the construct prototypes are presented.

1. INTRODUCTION

The portable media player (PMP) device is a widespread mobile entertainment device and attractive while it also equipped with DTV function. However, DTV antenna is an accessory to those of mobile device [1–4]. The demand for wider bandwidth to cover the DTV system operates in UHF bands (470–806 MHz) is need. Many kinds of broadband antenna application have been presented [3–13]. A simple open loop antenna with coupled gaps has been proposed to generating a new half-wavelength resonant mode [3–7]. It is a challenging task to achieve a wideband DTV receiving antenna operated as an integrated antenna for PMP device. In this paper, we present a novel design of broadband antenna for PMP application. A combination structure of antenna consists of an open loop antenna and an additional branch for monopole has been proposed. The proposed open loop antenna uses gaps couple to the ground plane instead of direct shorted ground to adjust the resonant frequency and uses a meander ground plane

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for further compact size. The two adjacent resonant modes, a half-wavelength gaps-coupled open loop antenna and a quarter-wavelength monopole antenna, form a wide operation band. More detailed results and of the coupled gap are described and discussed.

2. ANTENNA DESIGN AND EXPERIMENTAL RESULTS

Figure 1 shows the combination structure of the proposed broadband antenna for DTV application. The geometry of the proposed antenna with the radiating patch is etched on a thickness 0.8 mm FR4 substrate with relative permittivity $\varepsilon_r = 4.4$. A ground plane of size $140 \times 60\,\text{mm}^2$

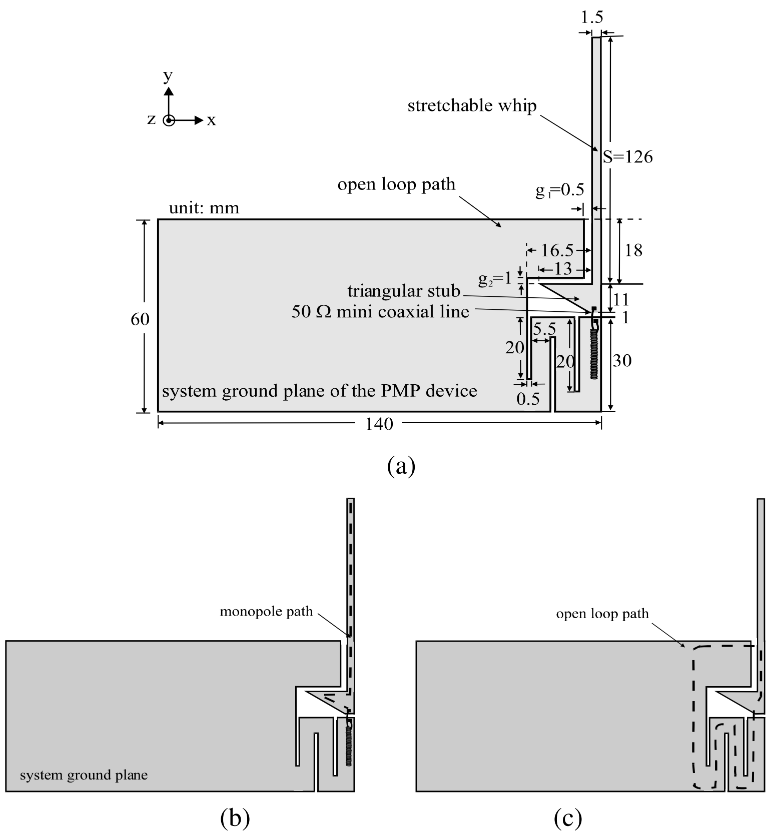


Figure 1. Combination structure of the proposed integrated DTV antenna for PMP application.

is applied for PMP device. A 50-Ω coaxial line is used to across the feed gap to test the proposed antenna in the experiment, with the central conductor and outer grounding sheath of the coaxial line connected to the triangle stub and system ground, respectively. The monopole antenna consists of a stretchable whip of length 126 mm and a triangle stub for impedance matching with a meander ground pane. The proposed antenna was fabricated and tested.

Figure 2 shows the measured and simulated return loss of the fabricated prototype. The simulated and measured return loss results, obtained using Ansoft simulation software HFSS (High Frequency Structure Simulator) [13] and the R&S ZVB40 vector network analyzer, are reasonable agreement. It is clearly seen that two resonant modes (quarter-wavelength monopole mode and half-wavelength resonant loop mode) at about 500 and 790 MHz are excited. It is also seen that a very wide operating band formed by two excited resonant modes is achieved and easily cover the frequencies across the DTV band. An impedance bandwidth better than 2.5 : 1 VSWR or 7 dB return loss of 392 MHz (464–856 MHz) is obtained The monopole path consists of a stretchable whip and a triangle stub as shown in Fig. 1(b) has a path of 156 mm, which is about 0.26 wavelength of 500 MHz. The resonant open loop path as denoted in dash line in Fig. 1(c) has 195 mm length which is about 0.51 wavelength of 790 MHz. Fig. 3 shows the trends of the simulated return loss for different gap g_1 between the ground pane and the whip. The monopole frequencies remain the same as the gap g_1 changes for they have the same whip length. It has 0.55 wavelength of 710 MHz at $g_1 = 0.2$ mm. The larger gap g_1 the larger open-loop frequency can be seen. Same trends with different gap g_2 can be seen

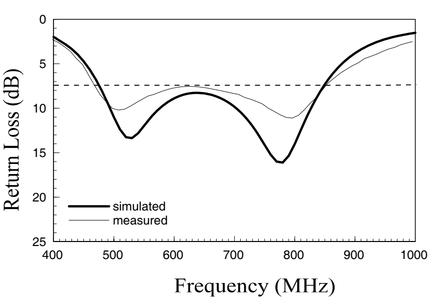


Figure 2. Measured and simulated return loss against frequency for proposed DTV antenna; $\varepsilon_r = 4.4$, $g_1 = 0.5$ mm, $g_2 = 1$ mm, $S = 126$ mm.

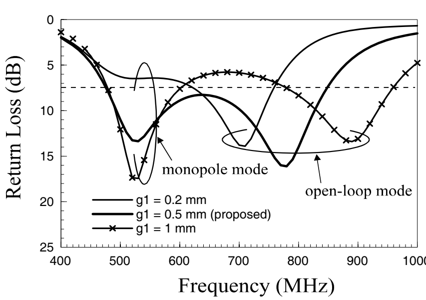


Figure 3. Simulated return loss against frequency for different gap g_1 between the ground pane and the whip; $g_2 = 1$ mm, $S = 126$ mm.

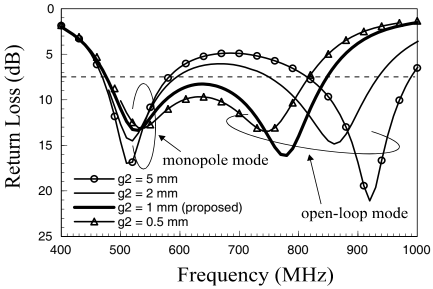


Figure 4. Simulated return loss against frequency for different gap g_2 between the ground pane and the whip; $g_1 = 0.5\,\mathrm{mm}$, $S = 126\,\mathrm{mm}$.

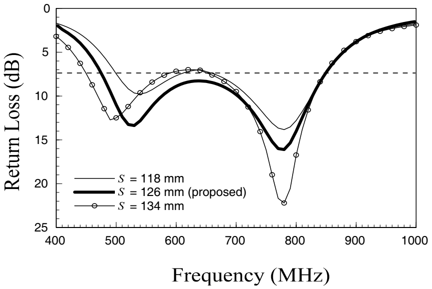


Figure 5. Simulated return loss against frequency for different monopole length S.

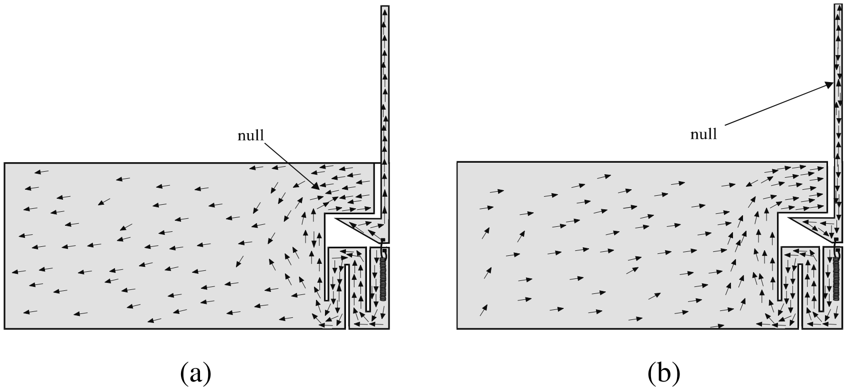
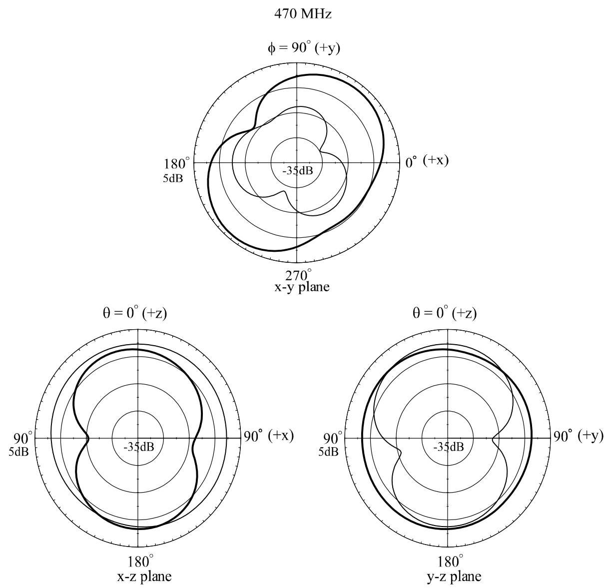


Figure 6. Simulated surface current at (a) 500 MHz for monopole mode. (b) 790 MHz for open-loop resonant mode.

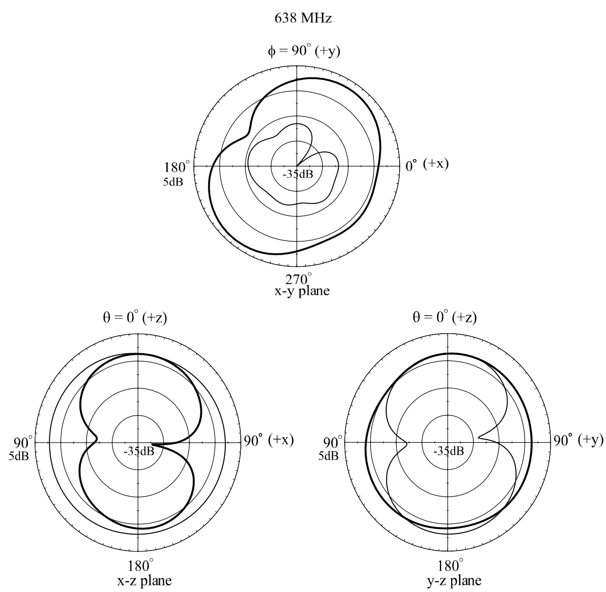
in Fig. 4.

The monopole frequencies remain the same as the gap g_2 changes and the larger gap g_2 the larger open-loop frequency can be seen. The longer the monopole length S the lower the monopole mode frequency but is insignificant to the higher open-loop mode as expected in Fig. 5. Fig. 6 shows the excited surface current distributions of the proposed antenna, it can be seen the surface currents of the monopole antenna path excite the first resonant mode at 500 MHz and the surface currents of the open loop antenna path excite the second resonant mode at 790 MHz.

Figure 7 shows the simulated radiation pattern of the proposed


470 MHz
φ = 90° (+y)
180°
5dB
-35dB
0° (+x)
270°
x-y plane
θ = 0° (+z)
90°
5dB
-35dB
90° (+x)
180°
x-z plane
θ = 0° (+z)
90°
5dB
-35dB
90° (+y)
180°
y-z plane

(a)


638 MHz
φ = 90° (+y)
180°
5dB
-35dB
0° (+x)
270°
x-y plane
θ = 0° (+z)
90°
5dB
-35dB
90° (+x)
180°
x-z plane
θ = 0° (+z)
90°
5dB
-35dB
90° (+y)
180°
y-z plane

(b)

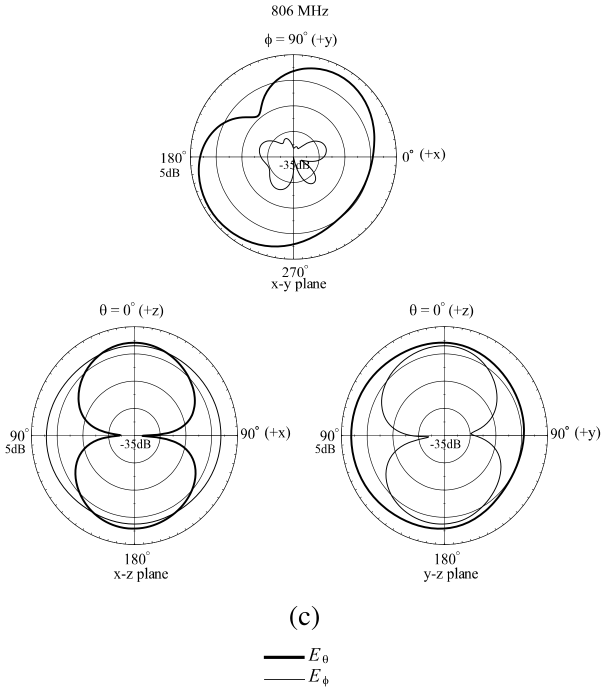


Figure 7. Simulated radiation patterns for proposed antenna given in Fig. 2 at (a) 470, (b) 638 and (c) 806 MHz.

antenna in three orthogonal planes at 470, 638 and 806 MHz. Since our anechoic chamber cannot operate at low frequencies such as those in the UHF band, the radiation characteristics of the proposed antenna were studied using Ansoft simulation software HFSS, which is expected to provide reliable results for the proposed antenna. It can be seen that the yz-plane radiation pattern is approximately omni-directional, which is advantageous for DTV signal reception in practical applications for it is horizontal linear polarized radiation. The system ground plane also radiate in omni-directional as we can see the cross-polarization in xz-plane radiation pattern. This radiation characteristic is an advantage for the proposed antenna for practical applications, especially for hand-held equipments, because their wave propagation environment is usually complex. Fig. 8 shows the simulated antenna and radiation efficiency of the proposed antenna. The antenna gain is found to vary from about 0.9 to 2.8 dBi over the DTV band, while the radiation efficiency for frequencies over the band is all better than 60%.

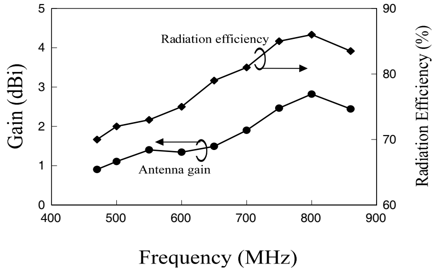


Figure 8. Simulated antenna gain against frequency for proposed antenna given in Fig. 2.

3. CONCLUSION

A novel printed DTV antenna integrated with the system ground plane of the PMP device has been proposed and studied. The broadband characteristic is formed by excited a resonant open loop mode and monopole mode into a very wide operating band to cover the whole DTV band. Detailed characteristics of the two excited resonant modes have been studied, and good radiation characteristics of the proposed antenna for frequencies over the whole DTV band have also been obtained.

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