ABSTRACT: A novel broadband planar antenna integrated in the USB dongle for digital television (DTV) signal reception is presented. The planar antenna is printed on a dielectric substrate and electrically connected to the system ground plane of the USB dongle. When in operation, the planar antenna is swung upward to be perpendicular to the system ground plane and can provide a wide operating bandwidth (2.5:1 VSWR) of larger than 50% centered at about 630 MHz, allowing it to cover the DTV signal reception in the 470–806-MHz band. While not in operation, the planar antenna can be swung downward and attached onto the housing of the USB dongle, keeping the aesthetic appearance of the device. Detailed design considerations of the proposed antenna are described, and obtained experimental and simulation results are presented and discussed. © 2007 Wiley Periodicals, Inc. Microwave Opt Technol Lett 49: 1018–1021, 2007; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.22329

Key words: mobile antennas; DTV antennas, broadband antennas, integrated antennas, USB dongle
about 270 mm in this design, which leads to the excitation of a resonant mode at about 500 MHz for the proposed antenna. Then, by properly selecting the position of the open gap, a second resonant mode controlled by strip 1 and the system ground plane can be excited. This second resonant mode is related to a half-wavelength dipole structure formed by two asymmetric dipole arms of strip 1 and the system ground plane. Thus, by adjusting the length $h$ of strip 1, this second resonant mode can be controlled. In this study, this second resonant mode is designed to occur at about 700 MHz. In addition, the length $g$ of the open gap is found to greatly affect the impedance matching of the antenna’s two resonant modes. By choosing a proper length of the open gap (1 mm in this study), good impedance matching of the antenna’s two resonant modes can be obtained, and a wide operating band formed by the two resonant modes can be achieved for the proposed antenna to cover the DTV band of 470–806 MHz. Note that the bandwidth definition of 2.5:1 VSWR (about 7.3-dB return loss) is used here, which is generally acceptable for DTV signal reception in practical applications.

To analyze the two excited resonant modes, Figure 4 shows the measured return loss for the constructed prototype studied in

3. RESULTS AND DISCUSSION

A preferred prototype of the proposed planar DTV antenna shown in Figure 1 with $g = 1$ mm, $h = 80$ mm, and $w = 10$ mm was first constructed and studied. Figure 3 shows the measured and simulated return loss for the constructed prototype. The simulated results are obtained using Ansoft simulation software HFSS (High Frequency Structure Simulator) [9], and good agreement between the measurement and simulation is obtained. From the measured results, it is clearly seen that two adjacent resonant modes are generated, which form a wide operating band of about 52% (2.5:1 VSWR bandwidth) centered at about the desired center frequency of 638 MHz to cover the DTV band of 470–806 MHz. Note that the bandwidth definition of 2.5:1 VSWR (about 7.3-dB return loss) is used here, which is generally acceptable for DTV signal reception in practical applications.

To analyze the two excited resonant modes, Figure 4 shows the measured return loss for the constructed prototype studied in
The antenna without strip 2, and the antenna without the open gap ($g = 0$). It is clearly seen that, when strip 2 is not present, the antenna’s first resonant mode disappears, with the second resonant successfully excited only. On the other hand, when the open gap is not present ($g = 0$), the antenna’s second resonant mode disappears and only the first resonant mode is excited. The obtained results are expected as described in Section 2. To analyze further, the antenna’s radiation efficiency contributed from various portions of the proposed antenna including the system ground plane is studied by using Zeland simulation software IE3D [10]. The simulated results at 500 and 700 MHz are listed in Table 1.

An experimental study for analyzing the effects of the parameters $h$ and $g$ on the impedance matching of the two excited resonant modes was also conducted. Figure 5 shows the measured return loss for the antenna with three different values of $h$ and $g$ varied from 5 to 15 mm, with other parameters the same as those in Figure 3. Generally, the resonant frequencies of the two excited resonant modes are about the same. However, by selecting a proper width ($w = 10$ mm in this study), improved impedance matching over the desired DTV band can be obtained.

Effects of the width $w$ of strip 1 on the impedance matching of the antenna were also studied. Figure 6 shows the measured return loss for the width $w$ varied from 5 to 15 mm, with other parameters the same as those in Figure 3. Radiation characteristics of the proposed antenna were also studied. Since our anechoic chamber cannot operate at low frequencies. On the other hand, it is seen that the resonant frequency of the antenna’s second resonant mode is shifted to higher frequencies when the length $h$ is smaller. This agrees with the expectation that the antenna’s second resonant mode is related to the half-wavelength dipole structure with strip 1 and the system ground plane as the two asymmetric arms. In this case, the smaller length in $h$ will lead to a smaller total length of the dipole structure, and thus the resonant frequency will be shifted to higher frequencies.

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>Simulated Radiation Efficiencies (Obtained From Zeland IE3D) for Different Portions of the Proposed Antenna and the System Ground Plane at 500 and 700 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency at 500 MHz (%)</td>
<td>Efficiency at 700 MHz (%)</td>
</tr>
<tr>
<td>System ground plane</td>
<td>9</td>
</tr>
<tr>
<td>Strip 1</td>
<td>19</td>
</tr>
<tr>
<td>Strip 2</td>
<td>72</td>
</tr>
<tr>
<td>Total efficiency</td>
<td>100</td>
</tr>
</tbody>
</table>

Figure 4 Measured return loss for the proposed antenna, the antenna without strip 2, and the antenna without the open gap ($g = 0$). The antenna parameters are the same as studied in Figure 3. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

Figure 5 Measured return loss for the proposed antenna as a function of $h$ (the length of strip 1) with the total length of $h$ and $g$ fixed to be 81 mm; other parameters are the same as studied in Figure 3. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

Figure 6 Measured return loss for the proposed antenna as a function of $w$ (the width of strip 1); other parameters are the same as studied in Figure 3. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]
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. Figure 7 shows the simulated radiation pattern at 500 MHz. In this case, monopole-like radiation pattern patterns with good omnidirectional radiation are observed. The corresponding results at 700 MHz are plotted in Figure 8. From the results, the obtained omnidirectional radiation characteristic is still good. Figure 9 shows the simulated antenna gain and radiation efficiency of the proposed antenna studied in Figure 3. The antenna gain is found to vary from about 0 to 1.9 dBi over the DTV band, while the radiation efficiency for frequencies over the band is all better than 60%.

4. CONCLUSION

A novel broadband integrated planar DTV antenna for USB dongle application has been proposed. The antenna is with a simple structure and is easy to fabricate with a low cost. In addition, the antenna can generate two adjacent resonant modes to provide a wide operating bandwidth of larger than 50% to cover the DTV band in the 470–806 MHz. The proposed antenna is designed to be perpendicular to the system ground plane of the USB dongle in the operation condition. However, when not in the operation condition, the planar structure of the proposed antenna makes it very promising to be swung downward and attached onto the surface of the dongle housing to achieve an aesthetic appearance of the device. The proposed antenna has been successfully fabricated and tested. Detailed design considerations for the proposed antenna have been described. Over the 470–806 MHz band for DTV signal reception, good radiation characteristics have also been obtained for the proposed antenna.

REFERENCES


© 2007 Wiley Periodicals, Inc.