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WIDEBAND ROD-DIPOLE ANTENNA WITH A MODIFIED FEED FOR DTV SIGNAL RECEPTION

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Abstract—A wideband rod-dipole antenna with a modified feed for DTV signal reception in the 470–862-MHz UHF band is presented. The antenna consists of two retractable rod-dipole arms, which are connected to the opposite top corners of the modified feed. The feed is in the shape of a rectangle with dimensions 20 mm × 40 mm and divided into two portions by a U slit. The antenna can generate nearby resonant modes to attain a wide operating band, exceeding 60% bandwidth with VSWR below 3, much larger than that of the conventional center-fed dipole antenna. In addition, with the two dipole arms designed at the production stage to be able to swivel around, the antenna radiation and polarization thereof can easily be adjusted for better DTV signal reception without moving the whole antenna structure.

1. INTRODUCTION

Digital television (DTV) broadcast services have been available in many countries for a few years. The DTV reception is becoming an alluring feature for applications to mobile devices, such as laptops and mobile phones, and vehicles. Several standalone DTV antennas have been reported [1–4], and each of them has its merits. A folded dipole antenna with stubs to cover the upper-edge frequency at 710 MHz is studied in [1] as vehicle antennas. In [2], an earpiece cord is utilized

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as the DTV antenna for mobile-phone end users. Two asymmetrical dipole antennas with a step-shaped [3] and an L-shaped [4] feed gaps for DTV reception in the 470–806 MHz band are demonstrated. The broadband operation in [3, 4] is obtained by combining the one-wavelength and half-wavelength resonant modes. These promising designs, however, can not cover the entire 470–862-MHz UHF band of broadcast TV channels in most regions of the world [5], which are usually required by specifications in industry. Recently, a printed monopole antenna consisting of two asymmetric strips to achieve a wideband DVB-T operation is presented [6]. Despite that the antenna can yield a 470-862 MHz bandwidth, the overall size (3.5 cm $\times$ 24.2 cm) makes it quite bulky and a high profile. In addition, it is needed to move or rotate the whole structure of all the aforementioned antennas to adjust for better DTV signal reception when required.

In this paper, we introduce a new and simple rod-dipole antenna capable of wideband operation in the 470–862 MHz band for DTV signal reception. With the incorporation of a modified feed replacing the straight feed gap into a conventional rod dipole, good impedance matching over the first higher-order mode, which is excited close to the antenna fundamental resonant mode, can be achieved. The two resonances can form a wide operating band of above 60% bandwidth (3 : 1 VSWR) centered at about 666 MHz. In addition, with the retractable dipole-arm structure, the antenna is able to be stored away when not in use (see Fig. 3). When the antenna is in use, the retractable rods are also flexible to tilt and even swivel for better signal reception and polarization. This feature is very attractive for practical applications because the end user does not need to change the orientation of the whole antenna, such as moving the conventional rod monopole from vertical to horizontal position, improving signal reception when necessary. Details of the proposed design concept and experimental results of a prototype are presented and discussed.

2. ANTENNA CONFIGURATION AND DESIGN CONSIDERATIONS

Figure 1 shows the proposed wideband rod-dipole antenna for DTV reception. The antenna comprises two symmetrical dipole arms of the same size (diameter 3 mm, length 120 mm when the antenna is in use) and a modified feed (the antenna feeding portion). The modified feed is etched on a single-layered, 0.8 mm FR4 substrate and of a rectangular shape. With the overall dipole length selected, the dipole antenna can generate a fundamental (0.5-wavelength) resonant mode at about 530 MHz to cover the lower-edge frequency (470 MHz) of the DTV

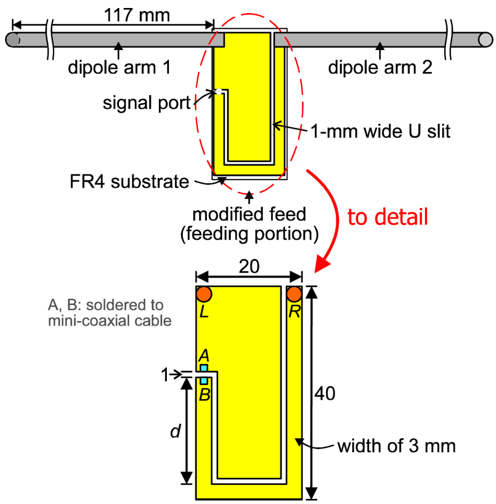

Figure 1. Configuration of the proposed wideband DTV rod-dipole antenna.

band. However, to attain wideband operation and include the upper-edge frequency at 862 MHz, additional resonance is needed. When a U slit is inserted in the feeding portion to replace the simple straight feed gap, the excited surface currents round the antenna signal port are perturbed. Null currents no longer occur round feed points A, B for the second (1-wavelength) resonant mode of the dipole. In this case, the effective resonant path is lengthened, which in turn lowered the operating frequency of the 1-wavelength resonance. This 1-wavelength mode can be manipulated by the U-slit length and used as an additional resonance that is excited close to the antenna fundamental mode. By choosing a proper value of d (that is to adjust the slit length), wide bandwidth above 60% can be realized and easily cover the DTV reception in the 470–862 MHz band.

A photo of a prototype antenna is presented in Fig. 2, which shows that the feeding portion is of a low profile as compared to the two dipole arms. Further, the modified feed also divides into two portions: a small strip of width 3 mm and a large polygonal section. The two dipole arms are connected to the opposite top corners of the feeding portion: the arm 1 is soldered to point L on the large section; the arm 2 is soldered to point R on the small strip. This configuration allows the entire FR4 substrate to be concealed inside some plastic casing of good aesthetic appeal for practical applications. In this scenario, only the two retractable rods (dipole arms) are seen protruding from the casing and are also flexible to tilt or swivel for better signal reception and

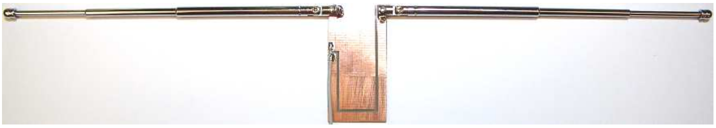

Figure 2. Photo of a constructed prototype.

Figure 3. DTV antennas in use versus not in use (photos by courtesy of Invax System Technology Corp.).

polarization (see industrial-design photos of a mass-production sample in Fig. 3; the two arms can be in V shape too). At the production stage for commodity, the two rods can pivot on the joints to cover one half-space respectively.

3. EXPERIMENTAL RESULTS AND DISCUSSION

Figure 4 shows the measured return loss. The impedance matching for frequencies across the 470–862 MHz band is all within VSWR of 3 (better than 6 dB), which covers both DVB-H band [2, 7] and channels 14–69 [8] for DTV reception. The studies on the corresponding center-fed dipole antenna with a feed gap of 3 mm were also conducted. The results (not shown for brevity) indicate that the achievable bandwidth is only about one-fifth bandwidth of the proposed antenna, which is far from covering the desired bandwidth. Fig. 5 gives the measured 3-D radiation patterns for the antenna at 666 MHz, the center frequency of the 470–862 MHz band. The radiation characteristics were obtained using ETS-Lindgren OTA test system in one CTIA authorized test laboratory [9]. It can be seen that similar omnidirectional radiation patterns to those of the conventional center-feed dipoles are obtained. Other frequencies in the bands of interest were also measured, and no appreciable difference in patterns was found. The measured peak antenna gain and radiation efficiency is shown in Fig. 6. The peak gain is in the range of 1.0–3.2 dBi; the radiation efficiency exceeds

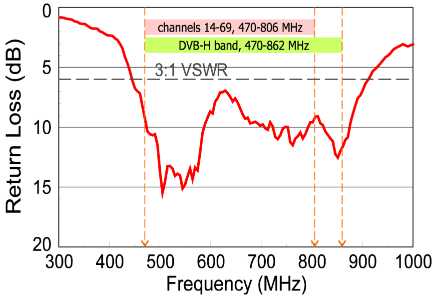

Figure 4. Measured return loss for the proposed antenna; d = 20 mm.

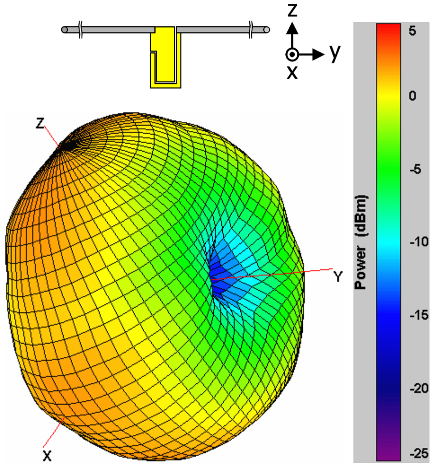

Figure 5. Measured radiation patterns at 666 MHz for the antenna studied in Fig. 4.

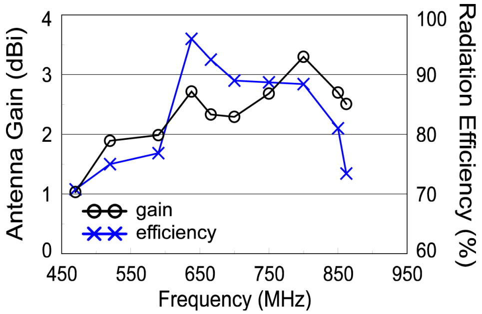

Figure 6. Measured peak antenna gain and radiation efficiency.

about 70%. The radiation efficiency here was obtained by calculating the total radiated power of the antenna under test (AUT) over the 3-D spherical radiation first and then dividing that total amount by the input power (default value is 0 dBm) given to the AUT. Notice that the radiation measurement here took account of the antenna mismatch loss, and the realized gain and the total efficiency were measured.

4. CONCLUSION

A wideband rod-dipole antenna capable of generating a wide operating band for DTV reception in the 470–862 MHz band has been studied and tested. The wide operating band is mainly attributed to the fundamental (0.5-wavelength) resonance of the rod dipole and the second (1.0-wavelength) resonance manipulated by the modified feed. Good radiation characteristics have been obtained across the operation band. When not in use, both dipole arms can be retracted, which makes the proposed antenna very attractive to applications to external standalone DTV receiving antennas. Compared to the related DTV antennas in the published papers, the proposed concept is the only design to allow the end user to adjust signal reception without moving the whole antenna structure to change the antenna orientation with respect to incoming waves.

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