

Ultra Wideband Antenna of Tilted Triangular Monopoles

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Introduction

To meet the challenging demands of modern wireless communications, such as high speed data transmission and multimedia services, the ultra wide band (UWB) and multiband antennas have made rapid advances in the past few years [1-7]. One of the possible solutions for achieving very large impedance bandwidth, is the use a self-complementary antenna [8]. Unfortunately, when the angle of the metallic part is 90 degrees, the input impedance is theoretically equal to one half of the free space intrinsic impedance. Therefore it is very difficult to match such an antenna to the 50 ohm characteristic impedance in a wide frequency band.

In this paper, we propose two novel antennas for ceiling-mount base station applications. Conceptually, they are based on the self-complementary principle, but overcome the mentioned drawbacks of such antennas. Two slightly different topologies with triangular monopoles are presented to improve the impedance matching and the pattern stability across the operating bandwidth from 1 to 5.5 GHz. Therefore, both experimental and computational results of the antennas impedance and radiating properties are shown. The numerical analysis of the antennas are performed using a commercial computer software package (FEKO), based on the method of moments. The proposed antennas exhibit acceptable UWB performances, good radiation properties, simple construction, and show potential for finding applications in ceiling-mount base stations and small terminals, covering simultaneously GSM, PCS, IMT-2000, WLAN (2450 MHz), and ISM 2.4 and 5 GHz bands.

Antenna Configuration and Results

Our first design (Antenna 1) is a compact UWB radiating structure based on self-complementary antenna principle (Fig. 1). By employing monopoles the antenna input impedance is halved. Two 0.5 mm thick right angle triangular copper plates having 100 mm base are mounted upside down, and tilted by 40° from the vertical axis resulting in a butterfly shaped structure. This ensures an arraying effect [7], providing additional halving of the impedance, so the total input impedance of the Antenna 1 equals around one eighth of the intrinsic wave impedance, $\eta = 376.7 \Omega$, that is $Z_{in} \approx \eta/8 = 47 \Omega$. Such V-shaped butterfly antenna is fed by type-N connector from the opposite side of a square grounded plate ($300 \times 300 \text{ mm}^2$).

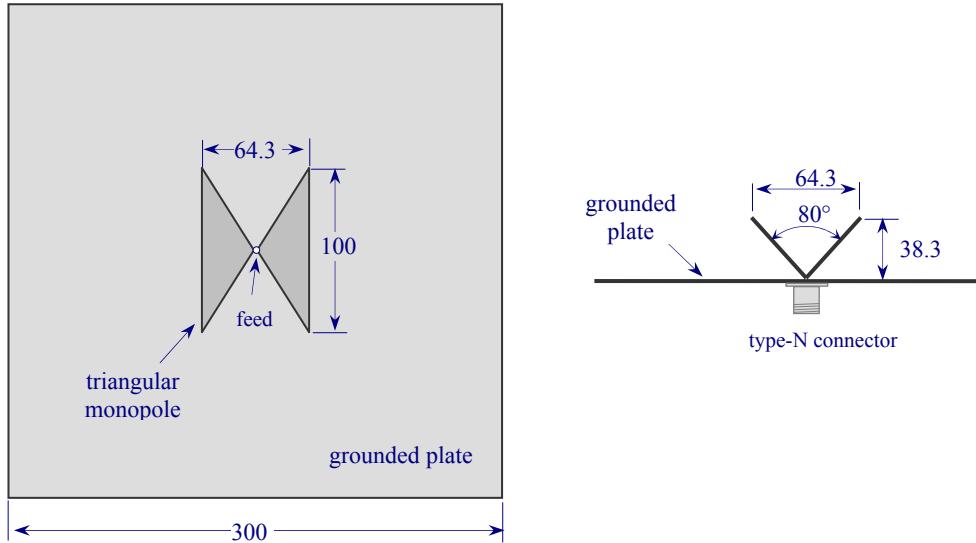


Figure 1. The geometric configuration of the Antenna 1; all dimensions are in millimeters

The main advantage of the proposed design is that it retains UWB impedance properties of a self-complementary antenna and a simple mechanical construction. The input impedance properties of the Antenna 1 are measured in the frequency range from 0.5 to 5.5 GHz using a vector network analyzer (HP8720B), and are presented in Fig.2.

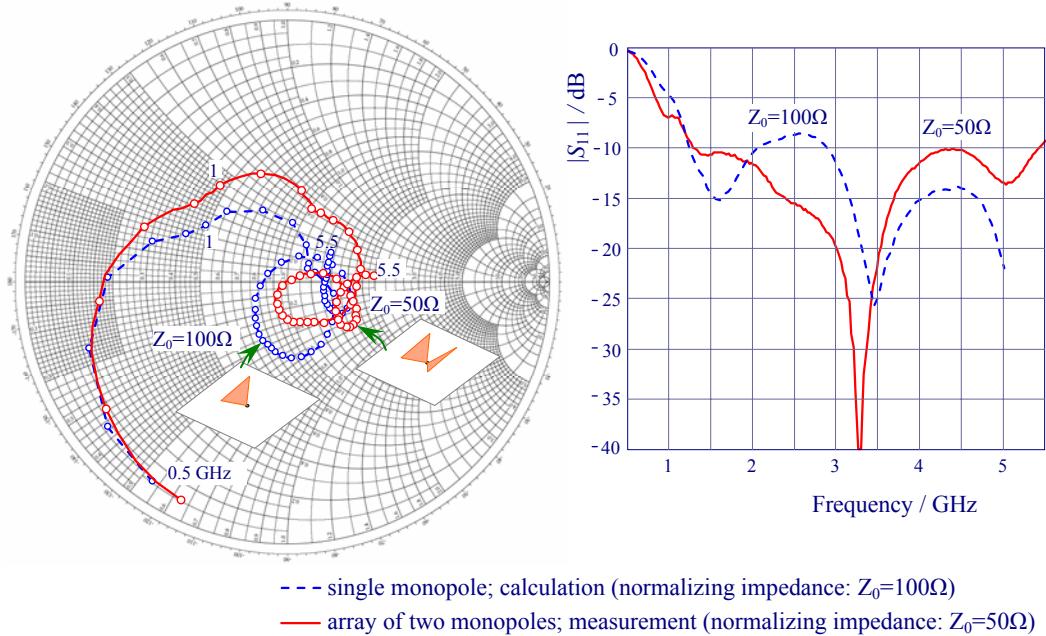


Figure 2. The input impedance properties of the Antenna 1. Measured results are shown for the two monopole array (full lines), and calculated results for a single monopole (dotted lines).

The same figure also shows the calculated impedance properties of the single monopole, but considering that its input impedance is approximately double in comparison to the arrayed monopoles, the locus of the single monopole is normalized to a 100 ohms characteristic impedance. Some discrepancies are mainly caused by not including mutual coupling effects in the case of the single monopole. Even in that case, the discrepancy between the two sets of results is pretty small.

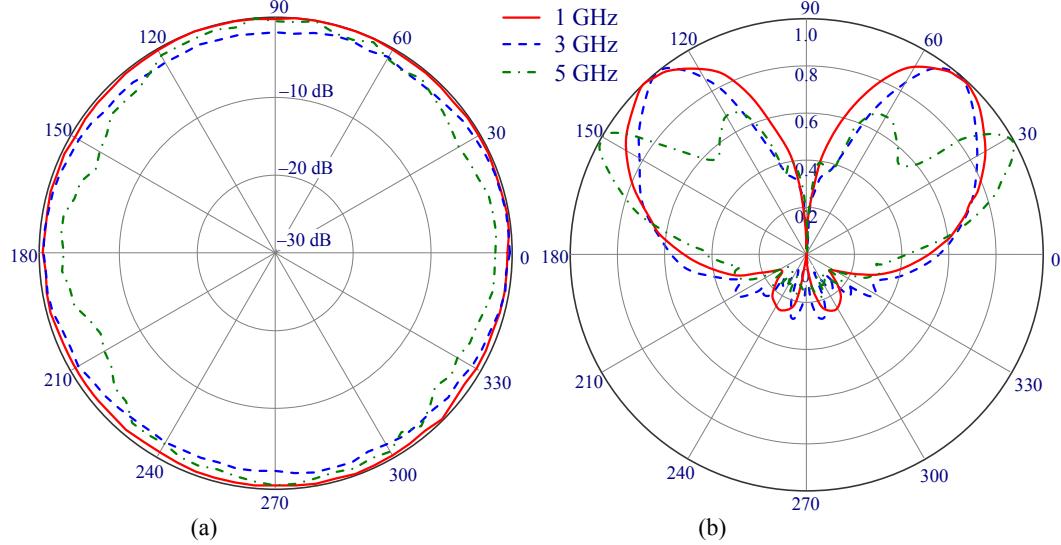


Figure 3. Measured radiation patterns of the Antenna 1: (a) *H*-plane; (b) *E*-plane.

Fig. 3 shows the radiation patterns in *H*- and *E*-planes, measured at 1, 3, and 5 GHz, for the proposed antenna. The measured radiation patterns are similar to the computed patterns obtained by the FEKO EM-solver. Radiation pattern in the *H*-plane is almost omnidirectional in the bandwidth considered. In the same range of frequencies the radiation pattern in the *E*-plane does not significantly change.

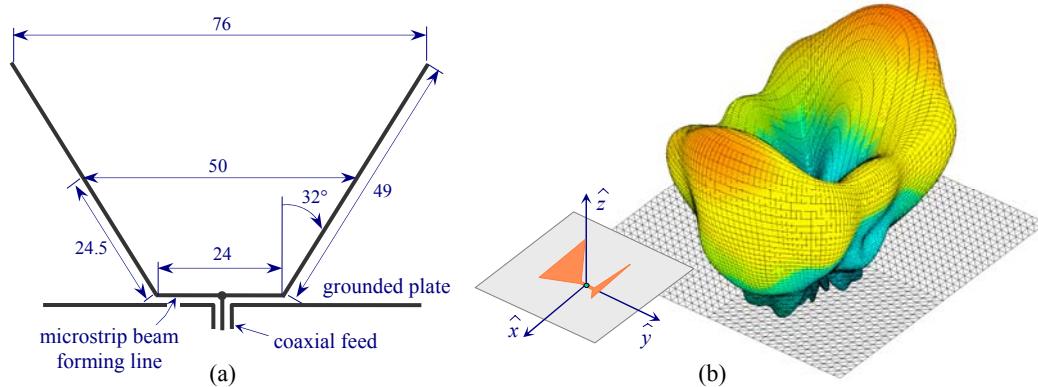


Figure 4. (a) The geometry of the Antenna 2; all dimensions are in millimeters; (b) 3D radiation pattern at 3 GHz.

To accommodate the *H*-plane radiation pattern to the desired coverage area with an elliptical footprint it is appropriate to increase the separation distance between

two triangular monopoles. Such a configuration is depicted in Fig. 4(a). Between the monopoles a microstrip feeding line (1.6 mm high and 2 mm wide) is inserted for matching and beam forming purposes. In this topology the triangular radiators are tilted by an angle of 32° to ensure almost frequency independent electric distance between the active parts of the radiators.

Remarkable changes in the radiation patterns are observed in comparison to the Antenna 1 design. The calculated 3D radiation pattern at 3 GHz in Fig. 4(b) shows a conical shape providing the desired elliptical coverage area.

Conclusions

Two novel ultra-wideband antennas for ceiling-mount base station and small terminal applications using very simple design have been proposed. Both antennas simultaneously cover GSM, PCS, IMT-2000, WLAN(2450 GHz), and ISM 2.4 and 5 GHz bands. The measured results of antenna input impedance showed reasonable agreement with the results generated by the FEKO software. In the operating frequency range from 1 to 5.5 GHz both designs exhibit a VSWR < 2:1. Stable conical radiation patterns have been measured at 1, 3, and 5 GHz.

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