A Novel Folded T-matched Dipole in Base Station

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Abstract

In this paper, a novel wideband base station antenna element, T-match folded dipole, is presented and simulated which can cover the WCDMA, UMTS and GSM bands. The T-match dipole is evolved from folded dipole, and can provide 28% impedance bandwidth for VSWR<2, with nearly 8 dBi peak gain. Compared with conventional folded dipole, the T-match dipole provides more flexibility and easy to match with the feed line.

1. Introduction

The demand for wireless wideband communications is rapidly increasing due to the need to support more users and to provide more information with higher data rates. [1]. Bandwidth improvement of an antenna is highly desired for wireless communication applications. The bandwidth-improved broadband antenna can support several frequency bands, reducing the number of needed antennas [2]. In base station antennas, printed dipole antennas and microstrip patch antenna are often used as radiating elements. The impedance bandwidth of printed dipoles is usually 15% for VSWR<2 [3], and the patch antennas often have complicated structure to achieve broad band. In this paper we proposed a radiation element named "T-match dipole", which evolved from folded dipole. There were papers about the applications of the folded dipole [4]-[6]. But few referred to T-match dipole. The T-match dipole proposed has the advantage of tuning easily and simple structure. Besides, it also has smaller dimension than ordinary half-wave dipoles whose arms extend widely for broad band. It is fed by strip line. Simulation results demonstrate that its impedance bandwidth is 28% for VSWR<2. It can cover 3G, DCS and PCS frequency bands. The far field patterns are stable across the bands. So it makes possible to share the existing base station sites with the 3G system, which can save resource and reduce the installation costs and interference between multiple antennas.

2. Antenna Design

It is known that a folded dipole [7] has a fourfold input impedance than an ordinary dipole as its equivalent radius is larger than ordinary dipole and when the frequency deviate the center frequency, its input impedance changes gently, which results in a broad impedance bandwidth. Based on the performance of the folded dipole, a novel broadband radiation element, T-match folded dipole is presented, as shown in Figure 1. T-match is an effective shunt-matching technique [7]. The T-match connection is a general form of a folded dipole since its two legs are usually not of the same length or diameter. The total current at the input terminals is divided between the two conductors in a way that depends on the relative radii of the two conductors and the spacing between them. Accordingly, the impedance of the T-match dipole can be changed by changing the lengths, L, L', radiuses a, a' and distance s to achieve the needed impedance bandwidth.

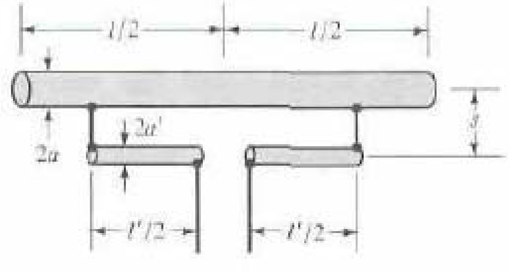

Figure 1. T-match

According to [7], we can get the current division factor α

$$\alpha = \frac{\ln(\upsilon)}{\ln(\upsilon) - \ln(u)}$$

$$u = \frac{a}{a'} \tag{1}$$

$$\upsilon = \frac{s}{a'}$$

the total input impedance of the T-matched dipole can be written as

$$Z_{in} = \frac{2Z_l[(1+\alpha)^2 Z_a]}{2Z_t + (1+\alpha)^2 Z_a} \tag{2}$$

where Z_a is the center point free-space input impedance of the antenna in the absence of the T-match connection, and

$$Z_l = jZ_0 \tan(k\frac{l'}{2})$$

$$Z_0 = 60\cosh^{-1}(\frac{s^2 - a^2 - a'^2}{2aa'}) \qquad (3)$$

If $l' = \lambda/2$ and two radii are equal, the input impedance becomes

$$Z_{in} \approx 4Z_a \qquad (4)$$

It is the input impedance of the folded dipole.

Figure 2 shows the designed structure of the T-match dipole. The element is mounted on the ground plane, and an air microstrip is coupled to feed the dipole by a balun which matches the unbalanced feedline with the balanced dipole arm. The balun is shaped like an inverted U. The upper arm of the dipole is only 4mm, and lower one is 5.5mm. The gap between two arms is 4mm.The electrical length of the open-circuited strip line is about 90° at the center frequency.

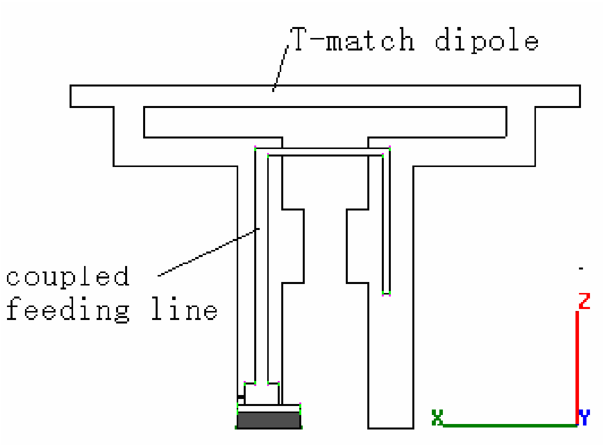

Figure 2. The structure of presented dipole

3. Results and discussion

The radiation element shown in Figure 2 with an infinite ground plate is simulated using Ansoft HFSS. Figure 3 and Figure 4 show the return loss and VSWR curves of the proposed dipole, referenced to a 50-Ω input impedance. It is observed that the second resonant point appeared over a range of frequencies from 1.6GHz to 2.4GHz, leading to broad bandwidth. An impedance bandwidth of 28% is obtained for return loss less than -10dB, which satisfy the requirement of the DCS, PCS and 3G communication systems. Its E-plane and H-plane radiation patterns at 1.9GHz are shown in Figure 5 and Figure 6. The E-plane pattern is the radiation pattern in a plane containing the radiation element and the H-plane is the radiation pattern in a plane orthogonal to the E-plane. Its gain can achieve 7.8dB. By varying the reflector shape, the beam width in the H-plane can easily be changed. We can also construct dual-polarization dipoles by placing the two presented dipole orthogonally. From the equation (2), we find out that the total input impedance of T-match dipole is inductive, so introducing serial capacitor can eliminate the reactance at a given center frequency, and make the total input impedance equal to the characteristic impedance of the feed line, as shown in Figure 7. It will lead to broader bandwidth. We will discuss the improved structure in further paper.

4. Summary

A wideband base station antenna element in a compact and low-profile geometry fed by a parallel strip lines has been proposed for DCS, PCS and 3G frequency bands. Due to the bandwidth enhancement feature of T-match structure, the element can achieve the impedance bandwidth of 28% for VSWR<2.

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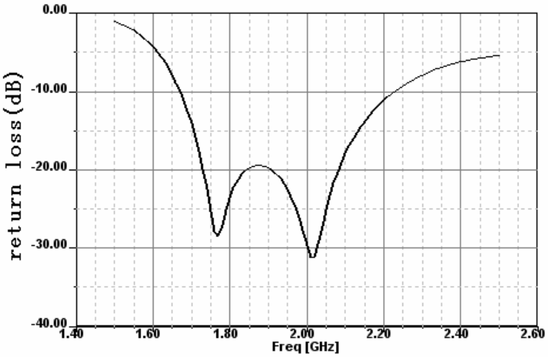

Figure 3. Return loss of the proposed dipole

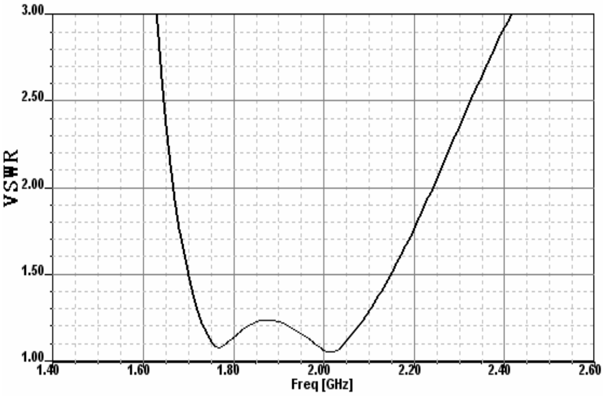

Figure 4. VSWR of the proposed dipole

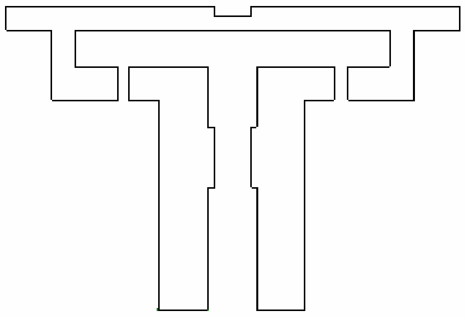

Figure 7. Improved structure of T-match dipole

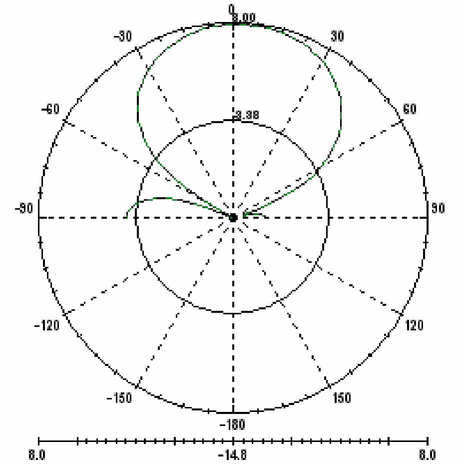

Figure 5. E-plane(x-z plane) radiation pattern at 1.9GHz

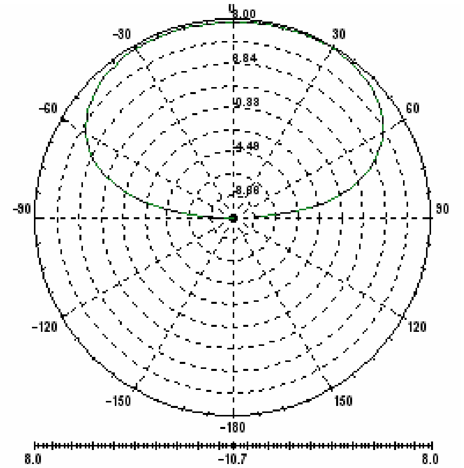

Figure 6. H-plane(y-z plane) radiation pattern at 1.9GHz