An UWB Omnidirectional Monopole for Broadband Electromagnetic Environment Monitoring

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Introduction

With the development of electronic technology, signals of multiple formats have been widely used in military and civilian equipment such as radars and wireless communications. Because of this, the management of spectrum resources is in face of increasingly severe tests.

The management of spectrum resources is usually realised by environment monitoring. Broadband environment monitoring system is composed of collection, processing, recording, playback, and analysis of signals. As the front end of the broadband environment monitoring system, the performance of the antenna plays an important role in the effectiveness and quality of electromagnetic environment monitoring. Wideband, compact size, low cost are the basic requirements for a suitable antenna or sensor. Wideband antenna can receive signals in wider bands without replacement. Antenna with small size and light weight won't disturb the surrounding electromagnetic environment intensely and is easy to move. For the electromagnetic environment monitoring system aiming at detecting signal's frequency and format, the antenna should be omnidirectional, and the roundness over the entire band should not be higher than 3dB; in order to increase the dynamic range of the entire system, the antenna should have a flat realized gain in the entire band.

Basic Principles

As the monopole antenna is mirrored by a dipole antenna. The dipole can be equaled as a series of numerous electric short dipole units with current I(z) and length dz. According to the principle of superposition of electromagnetic fields in a linear media, the radiation field of a dipole is the sum of the radiation fields of these short dipole units. The current distribution of the dipole is approximately:

$$I(z) = I_M \sin \alpha_a (l - |z|) \qquad -l < z < l \ \ and \ \ z \neq 0$$

Where α_a is the phase shift constant of the dipole. If ignoring the attenuation of the current caused by radiating, and the effect of the thickness of the dipole arms, , the pattern function of the dipole is:

$$\alpha_a \approx k = 2\pi / \lambda$$

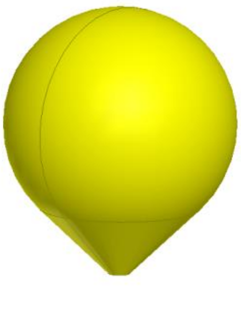
$$f(\theta) = \frac{\cos(\beta l \cos\theta) - \cos(\beta l)}{\sin\theta}$$

As the gap width of the feeding port of the monopole is only half that of the dipole, the input voltage of the monopole is only half that of the dipole as a result according to the line integral of the voltage equal to the electric field. The current distribution on the monopole is the same as that on the dipole due to the symmetry, so the input impedance of the monopole is only half that of the dipole. Therefore, the radiated power of the monopole is also half that of the dipole. The monopole radiates in the upper space, while the dipole radiates in the entire space, thus the direction of the monopole is twice that of the dipole. When producing the same field in the upper space, the monopole needs only half the input power of the dipole, as expressed in equation:

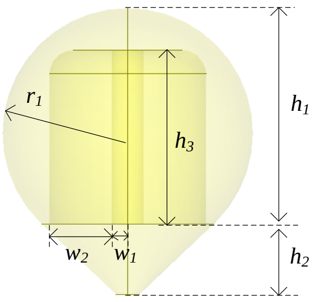
$$D_{mono} = \frac{4\pi}{\Omega_{A,\mathrm{mono}}} = \frac{4\pi}{\Omega_{A,\mathrm{mono}} / 2} = 2D_{dipole}$$

Antenna Optimization

The planar monopole can be well matched in a wide bandwidth, and is simple to manufacture. However, the printed monopole will generate current in reverse direction at high frequency, which will cause the radiation pattern to be distorted. The proposed compact monopole antenna is shown in the Fig.1, which is made of a coaxial cable feed, circular floor, and eyeball-like radiator. With the outer conductor of the open coaxial line and the eyeball-shaped inner conductor connected, the proposed antenna has a wide bandwidth. Combined with the monopole antenna surface distribution principle, three-dimensional curve shaping is used on the radiating surface of the antenna, so that the antenna can meet the impedance matching and keep omnidirectional ra-wideband with compact size.



(a)The overall view of the proposed antenna



(b) The inner structure of the proposed antenna
Fig 1 Configuration of the proposed antenna

The simulated VSWR of the proposed antenna is shown in Fig. 2. The VSWR remains lower than 2.5 from over 0.8 to at least 18 GHz. Fig. 3 shows the far field E- and H-plane radiation patterns of the antenna in the frequency range of 0.8–18 GHz. It can be seen that the radiation patterns remain relatively omnidirectional within the azimuth plane. The simulated realized gain results are shown in Fig. 5, which means that the antenna presents good omnidirectional radiation patterns and flat gain among the entire band.

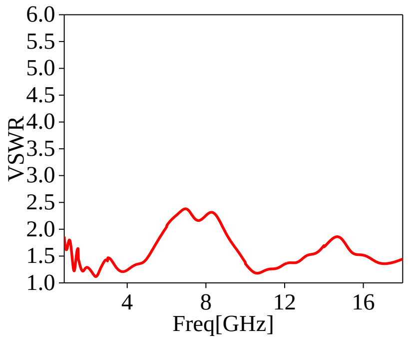
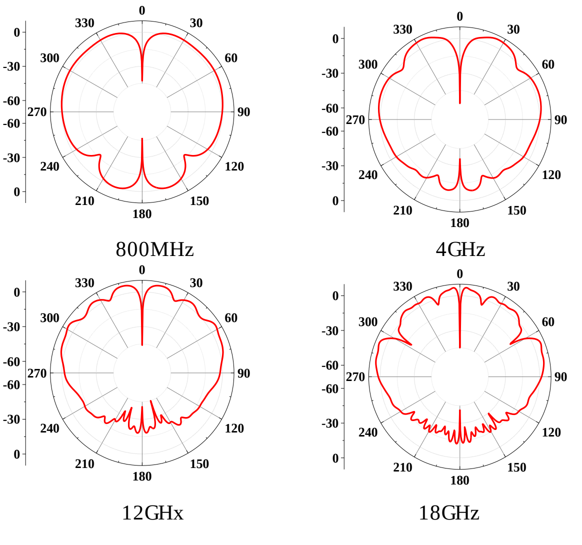
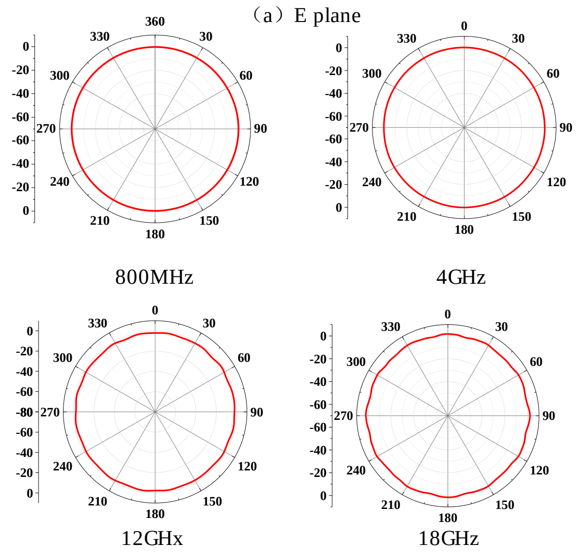


Fig 2 Simulated VSWR of the antenna



（a）E plane



（b）H plane

Fig 3 E- and H-plane radiation patterns of the proposed antenna

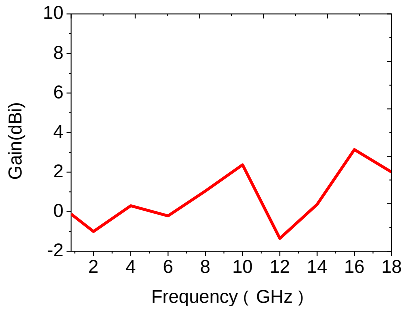


Fig 4 Simulated peak realized gain of the antenna