THE REFLECTION BEHAVIOURS OF ELLIPTICAL CYLINDER-LOADED MONOPOLE ANTENNA WITH CYLINDRICAL BALUN

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Abstract In this paper, a small elliptical cylinder-loaded monopole antenna having cylindrical balun inside the radiator is studied. The frequency and power ranges of the proposed antenna are aimed from 824MHz to 894MHz and average power 100Watts, respectively. The reflection coefficients are investigated by using the CST MW Studio ver. 3.2. The validity of the software has been confirmed by analysing many canonical structures related with monopole antenna problem. The given structure subsumes the scattering problem that is considered in the existing literature dealing with special cases. The simulated results of this antenna system are obtained for various values of the length of elliptical cylinder-wall loaded at the top and the contact point of cylindrical balun at the top-hat disk, through which the effects of these parameters on the reflection coefficients are studied. The typical blade antenna can be obtained by using the $\lambda/4$ cylindrical balun such as proposed in this paper

1. Introduction

To improve the bandwidth and input impedance matching performances, some techniques such as loading circular disk and dielectric on the simple monopole antenna have been investigated [3-5]. The sleeve monopole and double top-hat sleeve monopole antennas were also studied [7]. The referenced articles have used the mode matching techniques to evaluate the electromagnetic fields in each region by attaching the artificial ground plane at some distance away from the top-hat loaded materials. The simple numerical expressions treated in many literatures and the simulated return loss of the conventional monopole antenna are described. The possibility of analysing the monopole antenna is limited to the simple structures such as circular disk-loaded and the circular top-sleeve monopole. The present paper describes the reflection behaviours of the elliptical cylinder-loaded monopole antenna with balun at the input, which will be located on moving objects. The given antenna in this paper is composed of four major parts as followings : (1) Signal Input Port (This port must handle the average power 100Watts within the operating frequency bands.) (2) Antenna Feeding Part (This part has contact point between the radiating element and feeding cable.) (3) Antenna Region (This area is bounded by the given structure.) (4) Radiating Part (This area comprises near- and far-field region.) In order to improve the input characteristics, the position of the contact point between the radiator and feeding part can be changed. The return loss with the different contact point at the cylindrical radiator is described in this paper. A brief summary on the scattering analysis is given in Conclusion.

2. Field Representations of Canonical Structures

Consider the elliptical cylinder-loaded monopole antenna with balun and the modified monopole antennas shown in Fig. 1. The thickness of the loaded cylinder and disk is assumed to be zero only for mathematical analysis but is set to be 1[mm] for simulation and designed antenna. The purpose of loading cylinder on the monopole is to minimize the overall height of the antenna maintaining the same performances. By using the artificial ground plane, we can get the field representations with cylindrical

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harmonic expansions in each region [3-4] as followings.

$$E_z^I(\rho,z)=\frac{1}{j\omega\varepsilon_I}\sum_{n=0}^{N_1}\gamma_n^2$$

$$\times\left[a_n H_0^{(1)}(\gamma_n\rho)+b_n H_0^{(2)}(\gamma_n\rho)\right]\cos\left(\frac{n\pi z}{h}\right)$$

....in Fig. 1 (b) (1)

$$H_\phi^I(\rho,z)=\sum_{n=0}^{N_1}\gamma_n^2$$

$$\times\left[a_n H_1^{(1)}(\gamma_n\rho)+b_n H_1^{(2)}(\gamma_n\rho)\right]\cos\left(\frac{n\pi z}{h}\right)$$

....in Fig. 1 (b) (2)

where $\gamma_n=\sqrt{\varepsilon_{rI}k_0^2-(n\pi/h)^2}$, $\varepsilon=\varepsilon_{rI}\varepsilon_0$, and k_0 is the wavenumber in free space. Similarly, the field representations of the other regions can be obtained using the Bessel function of the first kind and the Hankel functions of the first and second kind of 0 or 1. The closed forms of field representations are only applied to the circular disk-loaded monopole shown in Fig. 1(b). Superscript I of the equations means the region surrounded by the loaded material and the ground plane [3].However, the scattering problem like the elliptical cylinder-loaded antenna with cylindrical balun is very difficult to analyze mathematically due to the difficulties in orientation of the coordinates.

3. Evaluation of Simulated and Experimental Results

The simulation results (return loss and power radi ation pattern) of the various monopole antenna wi th loaded material and balun have been obtained by using the commercial software package CST MW Studio version 3.2. Fig. 1 describes the seve ral monopole antenna with/without balun and with /without loaded material. Fig. 1 (f) and (g) show the transparent inside structures of the modified m onopole antenna with/without balun, respectively. The perfect electric cylinder plays an important ro le of lowering the resonant frequency of the mon opole antenna. In our simulation, the overall height of antenna, h and the radius of the monopole, a_m are set to be 95[mm] and 3[mm], respectively. The radius a_b and the length, l_b of the cylindrical balun are 5[mm] and 95[mm], respectively. Also the length of the cylindrical radiator from the top-loaded disk is set to be 85[mm]. The artificial ground plane is removed in executing the software package for physical environment. Fig. 2 shows the return loss of the antenna shown in Fig. 1. It is shown that the modified monopole antenna with a different feeding point and balun has a best performance and a lower resonant frequency. By comparing the data obtained, (a), (b), (c), and (f), it is understood that the cylindrical radiator installed to increase the radiation size of the monopole and to handle easily the input matching performances at the lower frequency has a good performance. Fig. 2(g) and Fig. 4 show that the resonant frequencies deviates a little from each other. It is thought that the deviation is due to the moving of the contact point between the radiator and feeding point. We are using the capacitances existing between the loaded cylinder and the ground plane. It affects the return loss and the radiation characteristics. Fig. 3 shows the photograph of the designed and fabricated antenna using the same parameters as in simulation process. The dimension of the loaded elliptical disk and the ground plane of the antenna shown in Fig.3 are 40[mm]*24[mm] and 55[mm]*39[mm], respectively. The feeding point on cylindrical radiator is located at 31.5[mm] away from the top-loaded disk. The analysed structures can be applied to design the modified antenna working at the lower frequency and having a low-profile. Fig4. shows the measured reflection coefficients of the modified monopole antenna with cylindrical balun shown in Fig. 1(g) and Fig. 3. The measured data were obtained in a laboratory area simply.

4. Conclusion

The elliptical cylinder-loaded monopole antennas with finite ground plane and cylindrical balun have been investigated using the simple mathematical manipulations, simulation tool and the measurement of the fabricated antenna. In order to verify the validity of simulation results, we carried out the analysis of canonical problem treated in many literatures. In order to improve the performances of return loss, the cylindrical balun is inserted into the center point of the loaded elliptical disk. Typically, the antenna balun has been applied to remove the stray capacitances existing between the ground plane and the radiator and resulting in the unbalanced current distribution on the antenna structures. The results describing the radiation pattern and return loss show the validity of the simulation process. A simple mathematical manipulations and a physical insight to the modified monopole antennas may lead to the typical blade antenna design satisfying the specific purposes. The numerical, analytical analysis and systematical circuit-model of the effects of the various parameters on the return loss and radiation pattern are left as a further studies.

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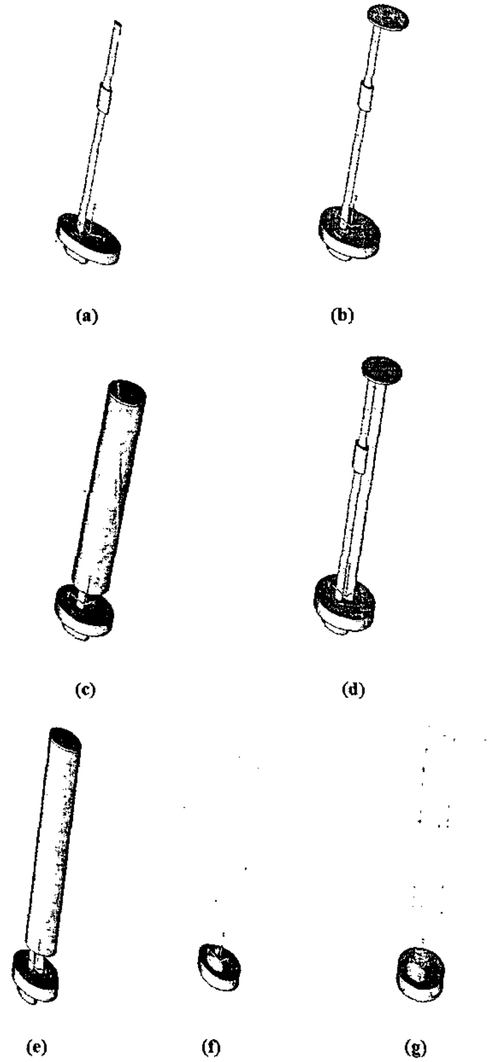

Fig. 1 (a)Simple monopole (b)Elliptical disk-loaded monopole (c)Elliptical cylinder-loaded monopole (d)Elliptical disk-loaded monopole with balun (e)Elliptical cylinder-loaded monopole with balun (f)Modified monopole antenna of (c) (g)Modified monopole antenna of (e) : (f),(g) transparent

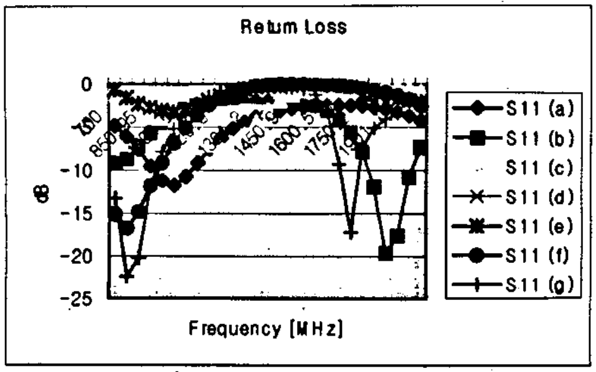

Fig.2 Return loss versus frequency when the overall height of antenna is 95[mm], the radius of balun is 5[mm], the radius of the monopole is 3[mm], the dimension of the ground plane is 55[mm]*39[mm], the length of the cylindrical radiator is 85[mm] and the dimension of the loaded elliptical disk is 40[mm]*24[mm].

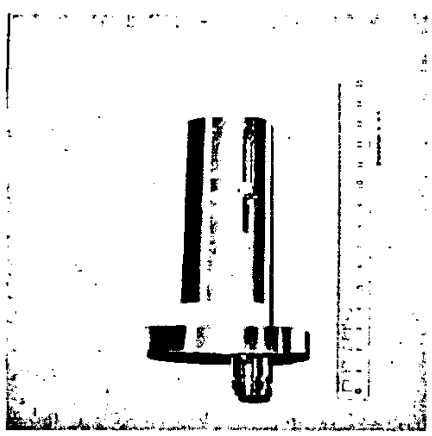

Fig. 3 Photograph of the physical antenna (height:9.5cm)

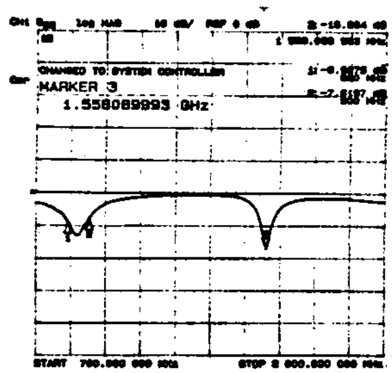

Fig. 4 The measured VSWR of the physical antenna in lab. area