임의의 타원율을 가진 타원형 디스크가 로딩된 모노폴 안테나의 입력 특성

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The Input Characteristics of Elliptic Disk-Loaded Antenna with Ellipticity Ratio

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ABSTRACT

In this paper, an elliptic disk-loaded antenna having frequency shift characteristics with the same height of the simple monopole is studied. The proposed antenna is composed of an ellitptic disk with arbitrary ellipticity ratio. The eigenmode representations in each region of given structure are useful for the analysis of the canonical monopole, circular disk-loaded monopole and circular dielectric-loaded top-hat monopole antennas using the artificical ground plane. The comparison between the elliptic and circular disk-loaded antenna is carried out. The effect of the shape of the loaded disk and the ellipticity ratio of the loaded disk on the input impedances, the return loss and frequency shift is also studied. We have computed the given structures using the CST MW Studio version 3.0. The typical blade antenna can be obtained by modifying and extending the proposed structure with the $\lambda/4$ balun removing the stray capacitances existing between the loaded disk and the ground plane.

1. Introduction

To improve the reflection characteristics, some techniques such as loading circular disk and dielectric on the simple monopole have been employed [1-3]. The circular disk loaded antenna has been studied using eigenmode expansions and artificial ground plane for mode-matching technique. The possibility of analyzing loaded antenna is limited to the simple structures such as circular disk-loaded, circular dielectric-loaded, and the circular top-sleeve monopole [2-3, 7]. When the shape of the loaded object is changed, the mathematical manipulations are very difficult due to the problem of the orientation of the coordinates. Especially, a physical insight and the simulation data for the proposed antenna can be useful for the novel-design of the blade antenna.

Due to the space limit, the smaller antennas are preferred. Strictly speaking, the antenna proposed in this paper is composed of four major parts as followings : (1) Signal Input Port(This port must handle the pre-defined average power within the designed 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 Region (This area comprises near- and far-field region). In order to improve the input characteristics, the position of the contact point between the radiator (this causes a near- and far-field) and feeding part can be changed. The VSWR with the different contact point are depicted in this paper.

2. Field Representations of Canonical Structures

Consider the elliptic/circular disk-loaded monopole antenna shown in Fig. 1. The antenna and radiating parts are divided into three regions [2]. The thickness of the loaded disk is assumed to be zero only for mathematical analysis. The purpose of loading circular or elliptic disk on the monopole is to improve the input impedance characteristics over a wide frequency range and to minimize the overall height of the antenna with the same performances. First, we mathematically investigate circular disk-loaded monopole antenna with the length of the elongated hollow wall, $l=0$ [mm] and the radius of the circular disk, $r_1 = r_2 = b = p$ where the parameter p represents the difference between the contact point and the end of the loaded disk. Using the artificial ground plane, we can get the field representations with cylindrical harmonic expansions in each region [2] as followings.

$$E_z^I(\rho,z) = \frac{1}{j\omega\varepsilon_I}\sum_{n=0}^{N_1}\gamma_n^2 \times\left[a_n H_0^{(1)}(\gamma_n\rho)+b_n H_0^{(2)}(\gamma_n\rho)\right]\cos\left(\frac{n\pi z}{h}\right) \qquad (1)$$

$$H_\phi^I(\rho,z) = \sum_{n=0}^{N_1}\gamma_n^2 \times\left[a_n H_1^{(1)}(\gamma_n\rho)+b_n H_1^{(2)}(\gamma_n\rho)\right]\cos\left(\frac{n\pi z}{h}\right) \qquad (2)$$

where $\gamma_n = \sqrt{\varepsilon_{rI}k_0^2-(n\pi/h)^2}$, $\varepsilon_I = \varepsilon_{rI}\varepsilon_0$, 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 order 0 or 1. However, the arbitrary shape of the top-hat disk is very difficult to analyze mathematically due to the problem in the orientation of the coordinates.

3. Evaluation of Simulation Results

Using the commercial software package CST MW Studio version 3.0, some simulation results related with input impedances and return loss at the input port have been obtained as a function of the shape of the loaded disk and the position of the contact point ($= p$) between the radiator and feeding part. In our simulation, the height, h and the radius, a of the monopole antenna are set to be 31.75[mm] and 1.19[mm], respectively as mentioned in [2-3]. The thickness, t of the loaded disk is fixed to be 0.79[mm]. We have also removed the artificial ground plane in executing the software package for physical environment. Fig. 2 shows the input impedances of top-hat monopole antenna using the parameters in Fig. 8 and Fig. 9 of [2]. It is shown that the results obtained using the software package agree well with the computed data using the eigenmode expansion and measured data in [2]. The compared data are omitted for conciseness. We can see that the impedance curve changes more rapidly as the circular radius increases. The reason of the abrupt changes is that the capacitances existing between the top-hat disk and the ground plane start affecting the input impedances and radiation characteristics. Inversely, we are using the capacitances existing among the hollow wall, ground plane and the loaded disk in Fig. 4. Fig. 3 shows that the position of the contact point, p bring a change of return loss of elliptic disk-loaded monopole antenna. The capacitances between the circular disk radiator and ground plane store the radisting energy and have an effect on the overall input reflection coefficients. Fig. 4 depicts the effect of the elongated hollow wall on the frequency shifting. With the same height, h, we can design the disk-loaded antenna working at the lower frequency. The structures can be applied to design the arbitrary shape disk-loaded antenna working at the lower frequency and having a low-profile.

4. Conclusion

To design the disk-loaded antenna working at the lower frequency and having a low-profile compared with the simple monopole antenna maintaining the same performances, we have proposed a new type antenna having a hollow wall below the top-hat disk with ellipticity ratio. The advantages of using software package is that the arbitrary-shape disk-loaded antenna can be designed by changing the parameters simply. By appending a hollow wall below loaded disk, we obtained the results of frequency shifting with the same height of simple monopole. Our future studies include the circuit modeling of the proposed antenna systematically and the comparison between the radiation patterns using the equivalent currents on the given structure and those obtained by the simulation. The effect of various ellipticity ratio (r_1 / r_2) on the input characteristics will be studied after this work.

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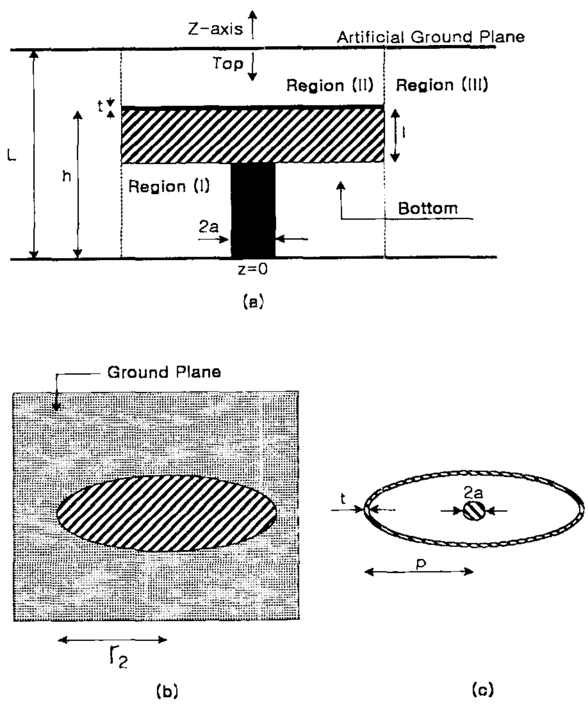

Fig. 1 : The scattering geometry (a) Side View (b) Bottom View

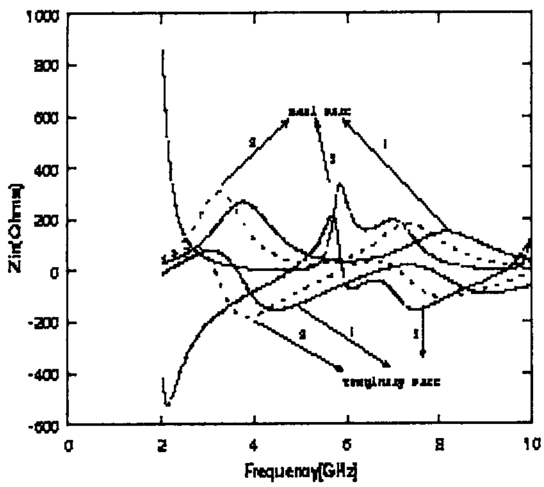

Fig. 2: The simulated input impedances of monopole antennas with the loaded circular disk (1) $b=0$ [mm] (simple monopole) (2) $b=3.11$ [mm] (3) $b=3.87$ [mm] when $h=31.75$ [mm], $a=1.19$ [mm], and $t=0.79$ [mm] as used in [2] (the compared data are not shown for conciseness)

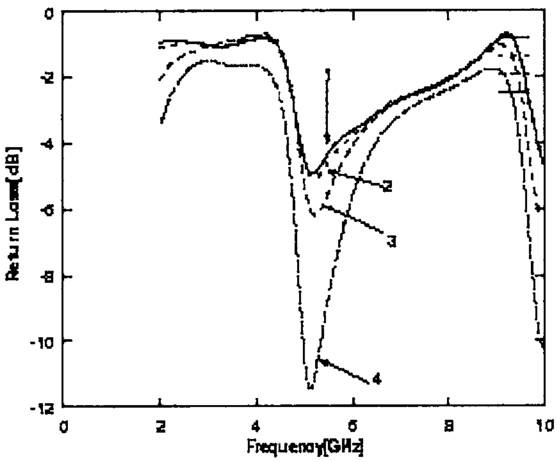

Fig. 3: The return loss as a function of the position of the contact point between the radiating part and antenna feeding part. when the elliptic disk with $r_1/r_2=2$, $r_1=38.7$ [mm] is loaded (1) p =38.7[mm] (2) p =28.7[mm] (3) p =18.7[mm] (4) p =8.7[mm]

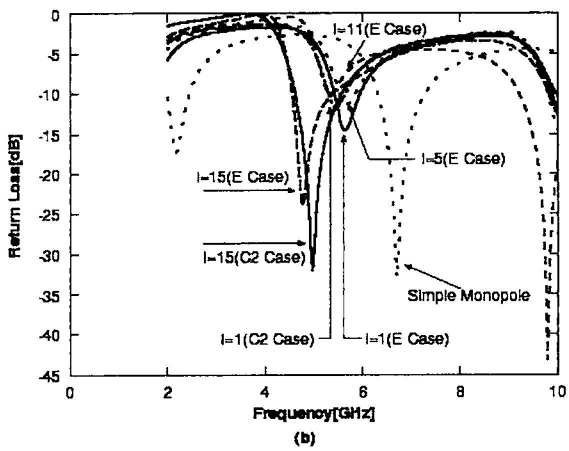

Fig. 4 : The return loss as a function of the hollow length, l [mm] (a) the radii of the circular disk are $b=3.11$ [mm](C1 case) and $b=6.22$ [mm](C2 case), respectively (b) the dimension of the elliptic disk is $r_1=6.22$ [mm] and $r_2=3.11$ [mm] (E case)