Wideband Characteristics of Rounded Circular and Semi-Circular Monopole Antennas

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Abstract

Semi-circular monopole antennas have wideband characteristics and compact size when they are rounded cylindrically. And, disc circular monopole antennas also have wideband characteristics and simple structure. So it is expected that the frequency band of circular monopole antennas are as wide as that of semi-circular monopole antennas when they are rounded cylindrically.

This paper describes wideband characteristics of rounded circular and semi-circular monopole antennas. Especially, the optimum antenna shape, the degree of roll and the characteristic impedance are studied.

1. Introduction

Circular disc monopole antennas have wideband characteristics [1]. And, rounded semi-circular disc monopole antennas are compact and have wideband characteristics [2]. Thus, it is expected that circular disc monopole antennas with rounded element have good performances.

This paper describes the performances of the circular and semi-circular antennas when these antennas are rounded. Also, the relationship between the relative frequency bandwidth and structure is described.

2. Antenna Model

We consider a circular disc monopole antenna and a semi-circular disc monopole antenna shown in Fig.1. A semi-circular antenna consists of the only half lower part of the circular antenna. Each antenna is rounded cylindrically gradually. The aperture angle ά is an angle between the edge of the antenna and the center of the cylinder. For example, when the ά=360deg., the antenna correspond to a plane antenna. When ά=0 deg., an antenna is a complete cylindrical antenna. Here, the characteristics of antennas are calculated by moment method (EEM-MoM).

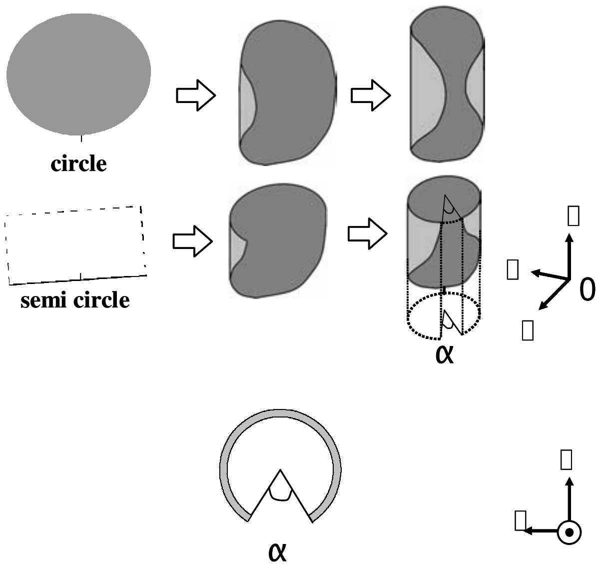
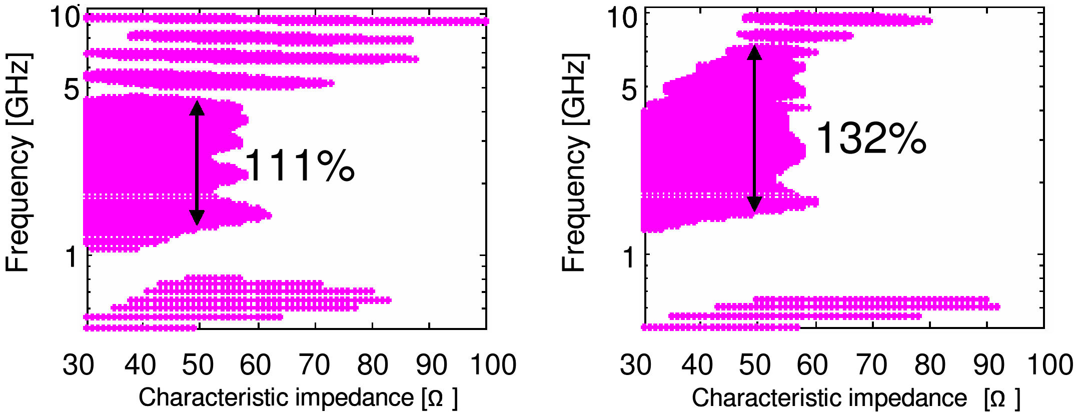


Fig. 1 Structure of antennas

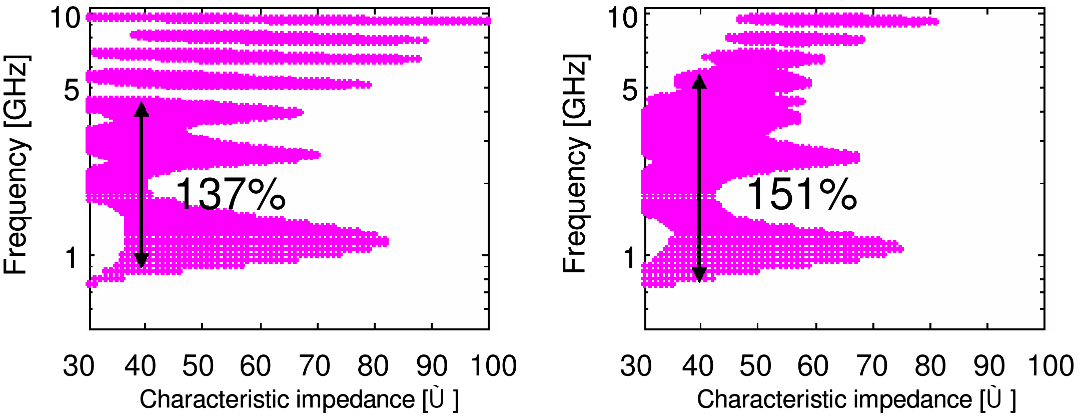
3. Effects of Characteristic Impedance on Wideband Characteristics

The relationship between characteristic impedance of the feeding line and a frequency band is shown in Fig.2 and Fig.3. Figures 2 and 3 correspond to the circular element antenna and the semi-circular antenna, respectively. Figures (a) and (b) are the cases of ά=360deg. and ά=11deg, respectively. In Fig.2, the horizontal axis is characteristic impedance, the vertical axis represents frequency. The hatched areas show frequency bands within 1.5 for VSWR.



(a) Circular disc (ó=360deg.) (b) Circular cylinder (ó=11deg.)

Fig.2 The relationship between characteristic impedance and a frequency range (circle)



(a) Semi-circular disc (ó=360deg.) (b) Semi-circular cylinder (ó=11deg.)

Fig.3 The relationship between characteristic impedance and a frequency range (semi circle)

As shown in Fig.2 (a), we can find that the relative bandwidth of the disc circular antenna is 111% when the characteristic impedance is almost 50ohms.

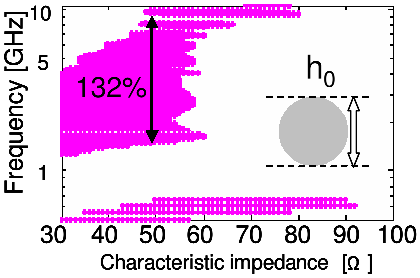
In the case of cylindrical antenna (Fig.2 (b)), the areas within 1.5 for VSWR join together around 50ohms. In short, separated bands are combined and 132% wide relative bandwidth is achieved.

When the semi-circular antenna is rounded, the relative bandwidth is 151% at the characteristic impedance of 40ohms as shown in Fig.3. Thus, we can say that the rounding the element of disc monopole antenna is effective to widening the frequency band.

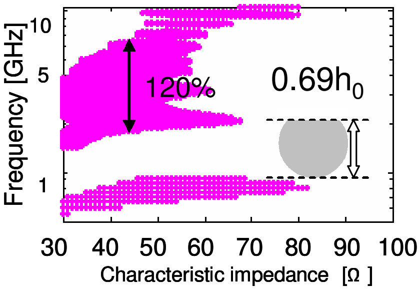
4. Effects of Antenna Shape on Wideband Characteristics

We consider the variation of frequency band when the upper part of the circular antenna is cut off horizontally. The relationship between characteristic impedance of the feeding line and the frequency band when ó=11deg. is shown in Fig.4. In the figure, the horizontal axis is characteristic impedance, the vertical axis represents frequency. The hatched areas show frequency bands within 1.5 for VSWR.

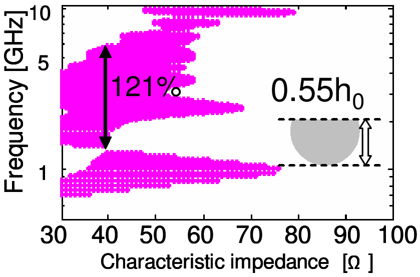
The reference of antenna height h is the diameter of the circle h_0. Figures 4(a), 4(b), 4(c) and 4(d) are the cases of $h=h_0$ (circular), $h=0.69h_0$, $h=0.55h_0$ and $h=0.5h_0$ (semi-circular), respectively. As shown in Fig.4, as the antenna height decreases, the resonance area in the low frequency band becomes narrow.



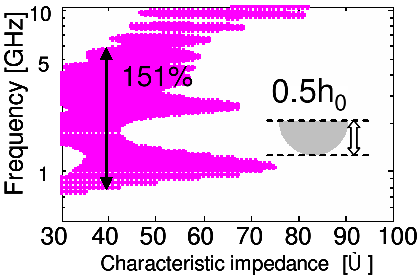
(a) $h=h_0$ (circular)



(b) $h=0.69h_0$ (circular)



(c) $h=0.55h_0$



(d) $h=0.5h_0$ (semi-circular)

Fig.4 The relationship between characteristic impedance and a frequency range

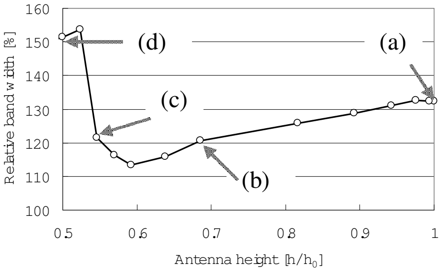


Fig.5 The relationship between the antenna height and relative band width

But, the resonance area in the lower frequency band approaches to the resonance area in the higher frequency band as the shape of the antenna close to semi-circular one.

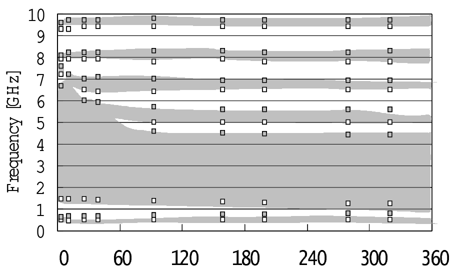
The relationship between the antenna height h and relative bandwidth when α=11 is shown in Fig.5. The horizontal axis indicates antenna height and the vertical axis indicates the relative bandwidth at the resonate area. Each the value of characteristic impedance is optimized for the case of maximum relative bandwidth.

It is found from Fig.5 that the relative bandwidth greatly depends on the antenna height. The relative bandwidth decreases with the antenna height going down when $h>0.6h_0$. However, when $h<0.6h_0$, the relative bandwidth is increased. The characteristic of wideband peaks in $h=0.52h_0$, the antenna has the shape of almost semi-circular. From the results, we can expect the almost semi-circular antenna has wideband characteristics than the circular antenna.

5. EFFECTS OF APERTURE ANGLE α ON WIDEBAND CHARACTERISTICS

The relationship between the angle α and characteristic of bandwidth is shown in Fig.6. The calculated results in case of a circular antenna and the semi-circular antenna are shown in Figs. 6 (a) and 6(b), respectively. The horizontal axis shows the angle α, the vertical axis represents frequency and the hatched areas are frequency bands within 1.5 for VSWR.

The characteristic impedances of feeding line of the circular antenna and the semi-circular antenna is 50ohms and 40ohms, respectively, because we can expect the widest bandwidth at the parameters from the result of previous section.



It is found from Fig.6 that the second resonance area and the first resonance area decide the band characteristics of the circular antenna and the semi-circular antenna, respectively. As monopole antennas are rounded cylindrically, each resonate area becomes wide, because the tip of low frequency doesn't vary and the tip of high frequency becomes high gradually.

The relationship between the angle α and relative bandwidth is shown in Fig.7. The horizontal axis is α and the vertical axis is relative bandwidth at the resonate point.

In case of both antennas, the relative bandwidths become rapidly wide when α≤ 80deg.. The only antenna which has similar shape to the cylinder has very wideband characteristics. Especially, the widest relative bandwidths are achieved when α is in 10 to 40 degrees. The best relative bandwidths of the circular antenna and the semi-circular antenna are 132% and 153%, respectively, then the α angles are 11deg., 38deg., respectively.

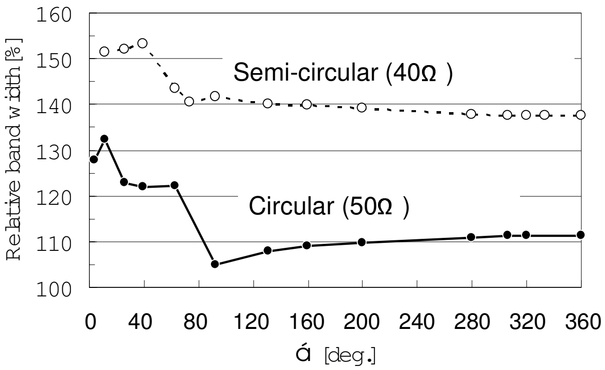


Fig.7 The relationship between the angle α and relative band width

6. CONCLUSION

Wideband characteristics of rounded circular and semi-circular monopole antennas were described in this paper. We considered the performances of the circular and semi-circular antennas when they were rounded cylindrically. When the characteristic impedances of the circular antenna and the semi-circular antenna were 40ohms and 50ohms, respectively, the cylindrical antennas had wideband characteristics than disc antennas. The optically rounded antenna had the shape of almost the semi-circular and the angle aperture α was less than 80 degrees. Maximum relative bandwidth of 155% was achieved in case of the semi-circular antenna with α=38 degrees.

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