Monopole-slot Antenna Having Complementary Structure Constituted on a Conducting Box

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1. Introduction

With the advance of wideband wireless systems, such as 3G mobile, multi-media mobile access and broadband wireless network, the development of wideband antenna systems has become imperative. In this paper, application of the self-complementary structure (SCS) to an antenna system is considered as a high promise of antenna systems for such wideband wireless system. This antenna system is composed of a monopole and a complementary slot on a rectangular conducting box. The conducting body can simulate a small mobile terminal. VSWR characteristics, radiation efficiencies and radiation patterns are obtained from the current distributions, which are calculated by using the method of moment. The analyses here aim to show the wide bandwidth of this antenna although it is not perfectly self-complementary and to analyze the dependence of the bandwidth characteristics on the antenna dimensions and the load impedance. Particularly the bandwidth is discussed here in terms of radiation efficiency as well as VSWR because it is essential for wideband antennas.

2 Performance of the Self-Complementary Antenna

The principle of SCS[1,2,3] shows that the impedance characteristics are independent of frequency when it has perfect SCS. The concept of SCS has been applied to create various types of wideband antennas[2] and subsequently practical applications have been made so far. In practical antenna systems, the truncation effect due to the finite size results in the deterioration of the bandwidth. Hence it is necessary to investigate the relation between the bandwidth and the antenna dimension and its load impedance. In the following part, the performance of an antenna having self-complementary structure (thereafter called SCA) is analyzed to show its wide bandwidth although it is not a perfect one. The SCA consisting of a monopole and a slot on a rectangular conducting box is shown in Figure 1. A load resistance R_L is placed at the opposite side to the feed. The method of moment is applied to obtain current distributions on the antenna structure, from which impedance characteristics, radiation efficiency and radiation patterns are calculated. Table 1 provides the parameters of the antenna structure and of figures numbers, which show data. In this paper, R_N denotes the normalized impedance. Compared with [5] presented in the ISAP2000 for which a SCA on a flat plate is researched and the bandwidth is defined by VSWR, this paper treats a SCA on a conducting box and the bandwidth will be discussed by the radiation efficiency as well as VSWR.

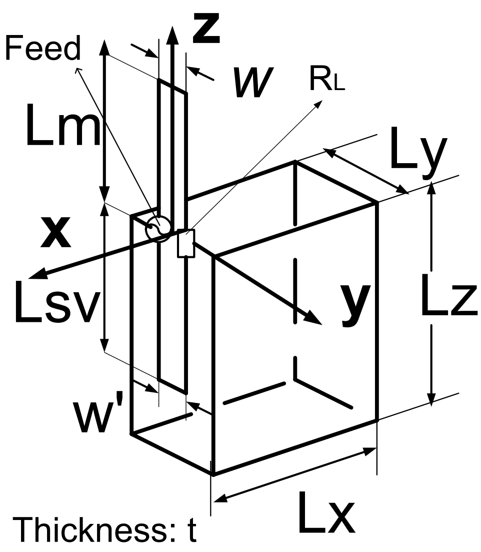

Figure 1. Structure of the SCA

Model	Lm (mm)	Lsv (mm)	Lx=40mm Ly=10mm Lz=80mm *w*=*w*'=4mm t= 0.5 mm	Figure Numbers
SCA A	30	30		Figure 2,5
SCA B	20	20	Lx=10mm Ly=35mm Lz=80mm *w*=*w*'=4mm t= 0.5 mm	Figure 3,4,6,7,8

Table 1. Parameters of the antennas and the figure numbers

2.1 VSWR

Figure 2 and 3 respectively are the calculated VSWR of SCA A and B with three different load resistances. It can be noted that the VSWR of the SCA B is low over very wide frequency range, while that of the SCA A is not.

The different R_N's are used in Figure 2 and 3 because R_N influences the VSWR and bandwidth greatly, which also can be seen from Figure 4.

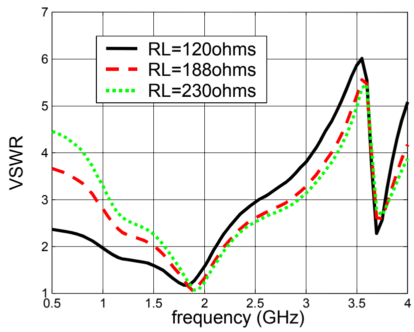

Figure 2. VSWR of SCA A (R_N=50ohms)

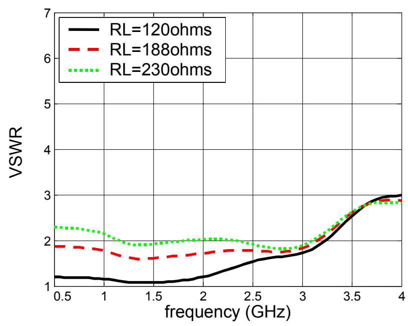

Figure 3. VSWR of SCA B (R_N=100ohms)

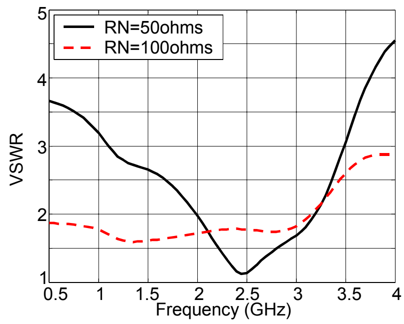

Figure 4. VSWR of SCA B with different R_N

2.2 Radiation Efficiency and Bandwidth

Figure 5 and 6 respectively illustrate the radiation efficiency of the SCA A and B. If bandwidth is defined as a frequency band, for which radiation efficiency is more than 55% and VSWR is less than 2, it can be seen that the bandwidth of the SCA A is 38%, and that of the SCA B is over 17% when R_L is 188ohms.

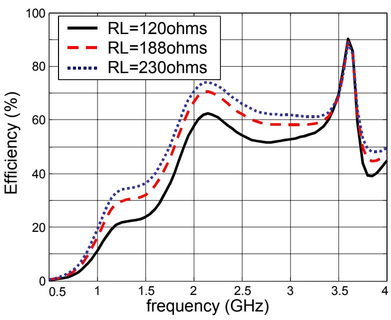

Figure 5. Radiation Efficiency of SCA A

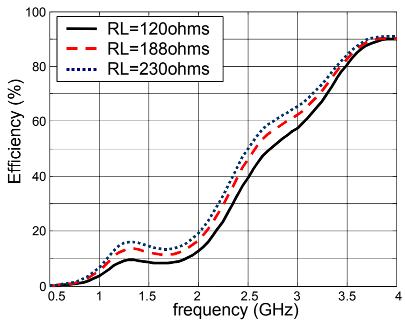

Figure 6. Radiation Efficiency of SCA B

2.3 Radiation Pattern

The calculated radiation patterns of SCA B are plotted in Figure 7 and 8. The patterns in these figures are normalized with their respective maxima on each plane. These patterns are produced by the contribution of currents on the monopole, the slot, and the rectangular box.

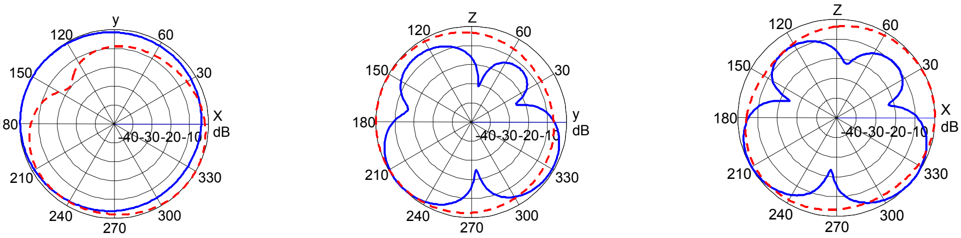

Figure 7. Radiation pattern of SCA B (E_θ : —, E_φ : -----)
(R_L=188ohms, frequency=2.0 (GHz))

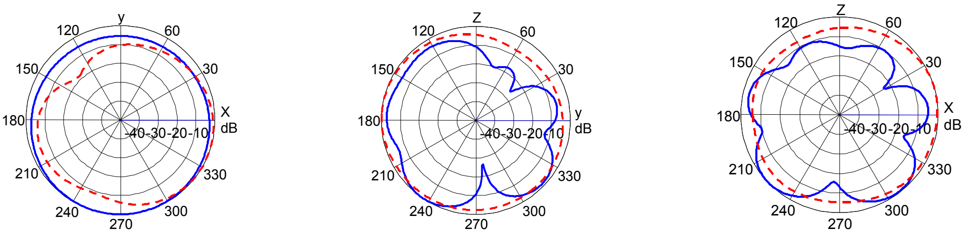

Figure 8. Radiation pattern of SCA B (E_θ : —, E_φ : -----)
(R_L=188ohms, frequency=3.5 (GHz))

2.4 Discussions

From the above simulation, it can be shown that the bandwidth depends on the dimensions of the antenna and the box, the position of the antenna, R_L and R_N. The bandwidth is discussed here in terms of radiation efficiency, because bandwidth defined with VSWR is not sufficient, as wideband antennas do not always radiate efficiently within the bandwidth defined by the VSWR. As a radiator, the efficiency is essential and so the bandwidth was also considered with it.

R_N changes the VSWR significantly while it has no influence on radiation efficiency. It is very important to obtain a wider bandwidth since it determines input power to the antenna structure.

Both efficiency and VSWR change with R_L though R_L doesn't vary much efficiency.

Bandwidth essentially depends on the dimensions of an antenna and the box on which the antenna is placed. Ly is important to have wider bandwidth. And it is also can be seen that dimension of the antenna structure is the most important factor to obtain the higher efficiency.

There is not very much change in patterns with frequency, as the nature of the type of SCS antenna.

The simulation shows that the very wide frequency range within which VSWR is less than 2 can be obtained because of the characteristic of SCS. But the parameters of the antenna system must be well organized in order to obtain higher radiation efficiency within the frequency range with low VSWR.

3 Conclusions

It is shown that even with imperfect SCS, that is, partly complementary structure constituted by a monopole, a slot, and a conducting box, that the antennas shown here have fairly wide bandwidth. It is not only due to the dimensions of the antenna parameters, but also placement of antenna element on the box and normalized impedance R_N as well as load resistance R_L. Further effort should be made for studying about antenna structure, by which wider bandwidth can be obtained. Also investigation on the relationships among the parameters regarding the antenna elements and its infrastructure is required in order to achieve antenna systems that can be applied to practical wireless systems.

References

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