PERFORMANCE OF ANTENNA SYSTEM HAVING COMPLEMENTARY STRUCTURE USING A MONOPOLE AND A SLOT

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1. Introduction

Performance of antenna systems with self-complementary structure (SCS) is studied theoretically. In the previous papers[1, 2] it has shown that a monopole system with SCS has fairly wide bandwidth, even though the antenna system is of small size and has not perfect SCS. The antenna system introduced here also has finite size and is composed of a monopole and a slot. The analysis in this paper is to find out the optimum parameters for wideband performance with antennas of small size and imperfect SCS. The method of moment (MoM) is applied to obtain current distributions on the antenna structure, from which VSWR-frequency characteristics and radiation patterns are obtained. Based on these results, dependence of the bandwidth characteristics on the antenna dimension and loading impedance are found and the important parameters, from which wideband performance can be achieved, are discussed. The significance of this type of antenna systems should be recognized in the application to the communication systems such as software radio, particularly for cases where they are down-sized.

2. Analysis of the complementary antenna

The principle of SCS was introduced by Professor Mushiake[3, 4]. It has shown that the impedance characteristics are independent of frequency when it has perfect SCS. In practice, however, antennas can hardly have perfect SCS so that the bandwidth would not be infinite. Nevertheless, previous study has shown antennas having SCS can have fairly wideband characteristics even with imperfect structure and hence the antenna system could be applied to not only wideband communication systems but also small antennas, which have narrow bandwidth. The analysis here aims to find out optimum parameters, from which wide bandwidth would be obtained. The antenna structure consisting of a monopole and a slot, is shown in Fig. 1, where the coordinate system and the dimension of the antenna system are shown. The antenna system uses a rectangular ground plane, on which a slot element is formed. A loading resistance, normally 60π ohms when the SCS is perfect, is placed at the opposite side to the feed. The antenna structure is modeled by wire-grids and the method of moment is applied to obtain current distributions on the antenna structure, from which impedance characteristics and radiation patterns are calculated.

VSWR-frequency characteristics of an antenna having SCS are shown in Fig.2 by the real line, which illustrates experimental result[1], while Fig. 3 shows calculated result. In Fig.2, the similar characteristics of a monopole antenna are shown by the broken line for the sake of comparison. The mnopole antenna here is designed to have a half-wavelength at 1923 MHz and placed on a rectangular ground plane, which has the same size with that used in other antennas of SCS.

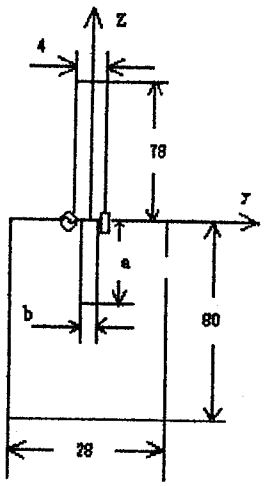

Figure 1. Structure of the complementary antenna

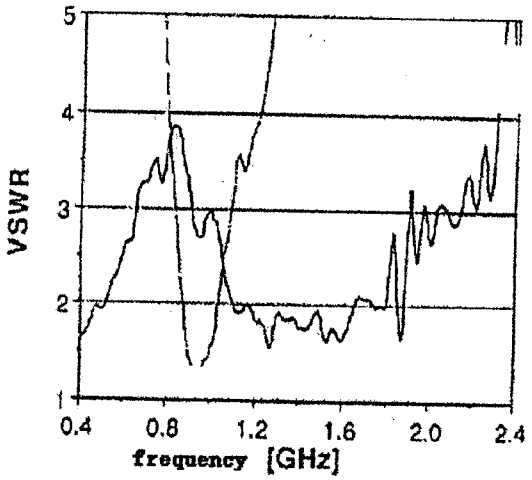

Figure 2. VSWR characteristics (experiment)

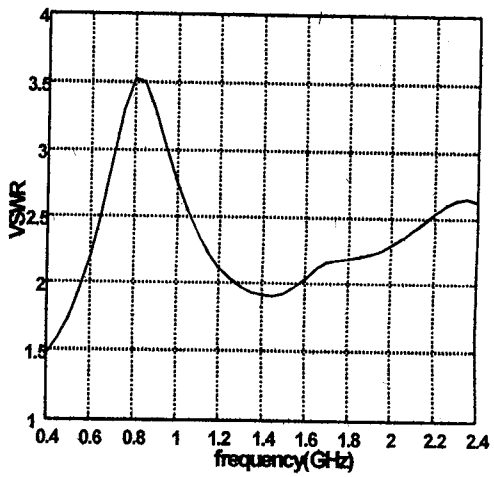

Figure 3. VSWR characteristics (calculation)

Variations of the bandwidth depending on the parameters such as the width of a slot and the value of the loading resistance are shown in Figs. 4 and 5, respectively, where the width of the slot is changed from 1.2mm to 6mm, the length of the slot is 24mm, and the loading resistance is taken from 50ohms to 250ohms. The estimation of the bandwidth differs with the value of normalized resistance. This implies that if matching impedance is changed from 60 π ohms we will have different bandwidth characteristics as shown in Fig. 6 where the size (length × width) of slot is 78mm ×4mm, the loading impedance is 250ohms, and the normalized resistance is 180ohms. From these results, it can be observed that:

(1) The wider the width of the slot is, the smaller the bandwidth will be. The bandwidth is widest when the slot size is 24 mm ×1.2 mm among the sizes used in this paper with the same length.

(2) The best choice of the normalized resistance is 180ohms.

(3) When the matching resistance is 180ohms, the wider bandwidth can be obtained with greater loading resistance. Here the recommended value is 250 ohms.

(4) When the normalized resistance is 50ohms, the loading impedance should be smaller one. With the smaller impedance, the wider bandwidth can be obtained.

(5) When the slot size is 78mm ×4mm, that is to say, the antenna structure is SCS, the bandwidth is widest, when the loading impedance is 250ohm and the normalized resistance is 180ohms.

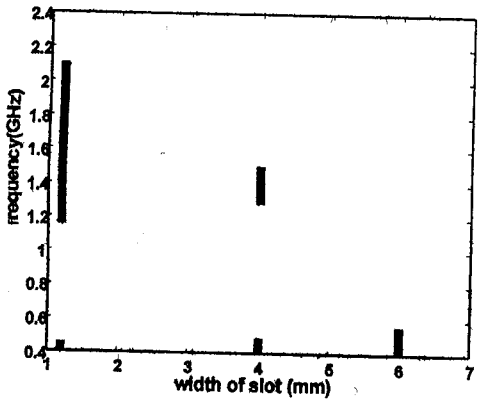

Figure 4. Bandwidth versus width of a slot

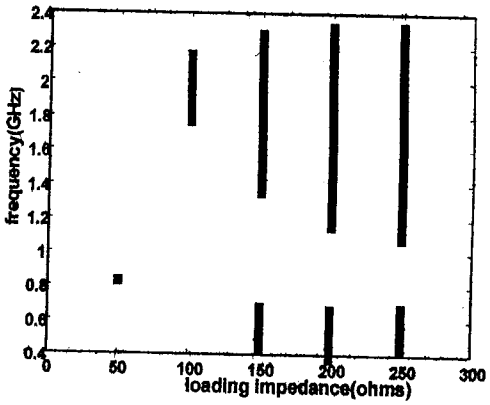

Figure 5. Bandwidth versus loading impedance

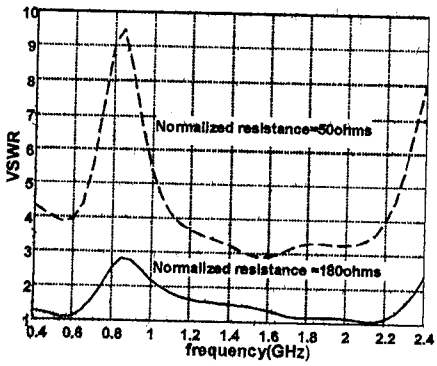

Figure 6. VSWR characteristics of SCS

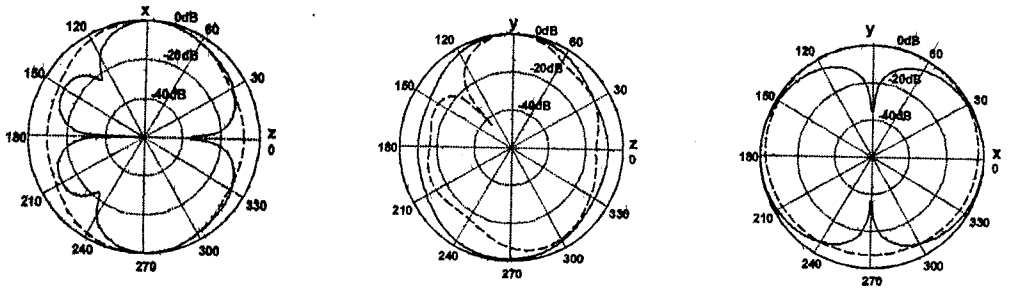

Figure 7. Radiation pattern (E_θ : —, E_φ : -----)

Fig. 7 illustrates typical radiation patterns with normalized level of the pattern maximum in each place, where the slot size is 78mm×4mm, the loading impedance is 250ohms and the frequency is 2.15GHz.

3. Conclusion

This paper has shown an analysis on the antenna parameters for obtaining wide bandwidth when an antenna system has imperfect SCS and small size. Further study is needed to find optimized dimensions of antenna and the loading impedance in order to realize an ideal bandwidth. It is, however, proved that if the proper parameters are chosen, the appropriate bandwidth to meet the requirements for a practical communication system can be realized.

References

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