Influence of Jig Made of Microstrip Line for S-Parameter Method

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***Abstract* - Recently, the S-parameter method, which is the measurement method of the input impedance of the balanced antenna, has been proposed. However, when the measured frequency rises, measurement accuracy decreases because the influence of the jig cannot be disregarded. To eliminate an influence of the measurement jig, we have proposed the modified open correction using the ABCD-matrix. In this report, to improve the measurement accuracy of the S-parameter method using a jig fabricated by microstrip lines, influence on the measured values of a ground conductor and a strip conductor of the microstrip line is examined by calculation using the FDTD method and experiment. As a result, it is shown that the influence of a strip conductor on measured result is bigger than a ground conductor.**

***Index Terms* — S parameter method, input impedance, balanced antenna.**

1. Introduction

It is known that the antenna characteristics of the portable radio terminal are changed greatly when the body of the terminal is held in the hand [1]. This problem is caused by the fact that the current distribution on the terminal changes by the hand. The effect of a balanced fed antenna was reported to reduce the influence of holding the terminal by hand [2]. The input impedance of the balanced antenna is measured conventionally by using a balun that forces opposite currents into each part of the antenna elements. Generally, due to narrow bandwidth, the balun is not suitable for the measurement of the wideband balanced antenna.

Recently, to measure the impedance of the balanced antenna, the S-parameter method has been developed that uses a jig instead of a balun, and the two-port vector network analyzer (VNA) [3]. Because no balun is used, it is possible to measure impedance over a wide frequency bandwidth. However, when the measured frequency rises, measurement accuracy decreases. We have proposed the modified open correction using the ABCD-matrix that can remove the influence of the jig including an open end impedance of the transmission line, and reported on the calculated result of an input impedance of a dipole antenna using a jig fabricated by coaxial cable [4]. Moreover, we have also reported the measured and calculated result of the input impedance of a bow tie antenna using a jig made of microstrip line (MSL) [5]. It was thought that the difference of the result of the S-parameter method and delta gap model was caused by the fact that a jig affects the electromagnetic field around the antenna.

In this report, to improve the measurement accuracy of the S-parameter method using a jig fabricated by MSL, influence on the measured values of a ground conductor and a strip conductor of the MSL is examined by numerical simulation using the FDTD method and experiment.

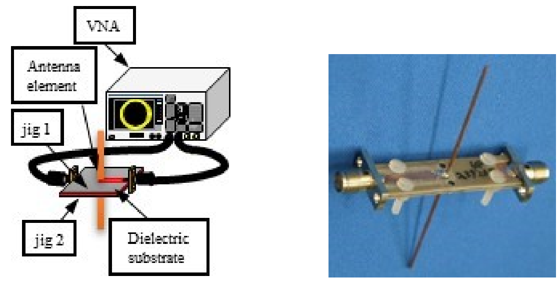
2. S-parameter method and antenna structure

Fig. 1 (a) shows a measurement system for input impedance of a dipole antenna by the S-parameter method. The measurement jig is composed of two dielectric substrates called jigs 1 and 2. The MSL is printed on the dielectric substrate, and an SMA connector is soldered to one end of the MSL. The two dielectric substrates are fixed back-to-back with nylon screws, as shown in Fig. 1 (b). Elements of the dipole antenna are soldered to the tips of MSL of the jig. After the VNA is calibrated at the end of coaxial cable using the full two port calibration technique (short, open, load and thru), the S-parameters of the jig with and without antenna elements are measured by the VNA. We use the ABCD-matrix compensation called the modified open correction to remove the influence of the jig with the open end impedance from the result of a measurement [4].

The ABCD-matrix K of antenna can be given by

$$K = K_{j1}^{-1} \times K' \times K_{j2}^{-1} \qquad (1)$$

where K_{j1} , K_{j2} and K' are ABCD-matrix of jigs 1, 2 and jig with antenna element, respectively. Consequently, the input impedance of a balanced antenna can be obtained when the ABCD parameter of matrix K is substituted into (2).



(a) Measurement system. (b) Measurement Jig (40x10mm^2) with antenna elements.

Fig. 1. MSL S-parameter method and dipole antenna.

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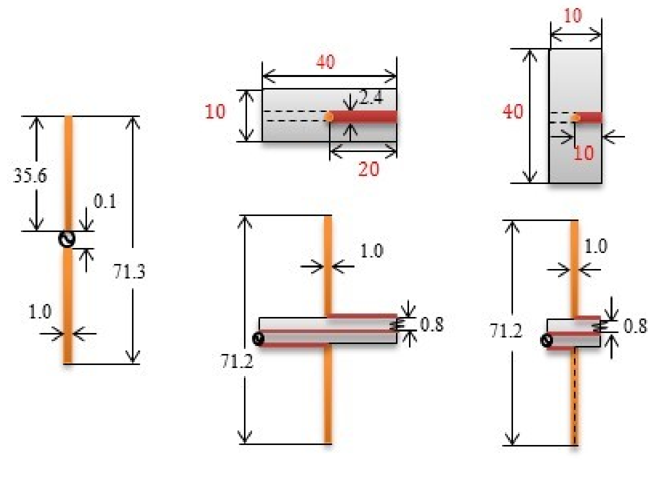
$$Z_{in} = \frac{2}{C}(A-1) \qquad (2)$$

3. Results and discussion

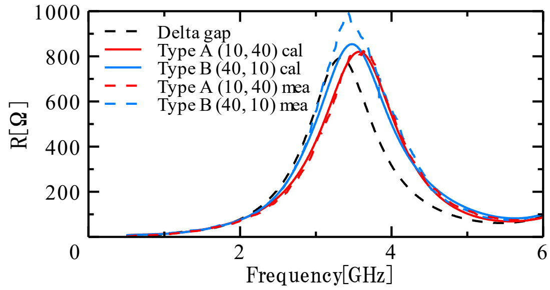
Fig. 2 (a) shows a calculation model of dipole antenna fed by a delta gap source whose actual length is 71.3 mm and diameter is 1.0 mm. Fig. 2 (b) and (c) shows a calculation model of the S-parameter method. We consider two types of rectangular jig called type A (10 x 40 mm^2) and type B (40 x 10 mm^2). The jigs are composed of two dielectric substrates with relative permittivity of 2.15 and an MSL with characteristic impedance of 50 Ω. The dimensions of the ground conductors of type A and B of the jig are equal. On the other hand, the strip conductor of type A is shorter than type B, and dimensions is smaller. The antenna elements are installed perpendicularly to the MSL. When the antenna element is not installed to the MSL, the open end impedance can be shown by capacitance as $C = -1/(\omega X) = 0.035$ pF, which is calculated from the electric and magnetic fields at the end of the MSL using the FDTD method.

Fig. 3 (a) and (b) show the frequency characteristics of the input impedance of the dipole antenna. The results of the S-parameter method are corrected by the modified open correction. For the jigs of each types, it is observed that calculated and measured results are good agreement respectively. It is thought that the cause of a little difference between the calculated and measured results is fabrication error. The calculated and measured results of the S-parameter method almost agree with the calculation result of the delta gap model at the frequency less than about 3.8GHz. About both the calculated and measured results, it is apparent that there is a difference between the results of type A and type B, as shown in Fig. 3 (a) and (b). As mentioned above, in these two kinds of jigs, the dimensions of the ground conductor are the same, but the dimensions of the strip conductor are different. Therefore, it can be understood that the difference between the result of type A and type B is due to differences in the dimensions of the strip conductor.

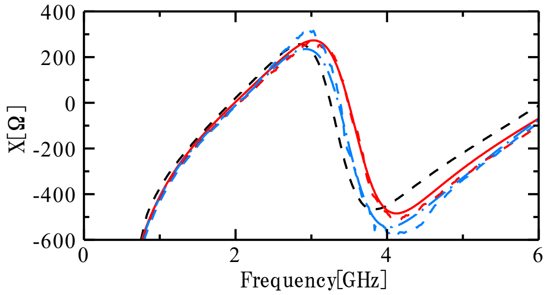


(a) Delta gap (b) Type A (c) Type B

Fig. 2. Calculated and measured model of dipole antenna.



(d) Resistance



(e) Reactance

Fig. 3. Calculated and measured model and input impedance.

4. Conclusion

In this report, to improve the measurement accuracy of the S-parameter method using a jig fabricated by MSL, influence on the measured values of a ground conductor and a strip conductor of the MSL was examined by numerical simulation using the FDTD method and experiment. We considered two types of rectangular jig. In these two kinds of jigs, the dimensions of the ground conductor were the same, but the dimensions of the strip conductor were different. As a result, it was shown that the influence of a strip conductor on measured result was bigger than a ground conductor.

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