Simulation and Experimental Investigation of Jig Using Semi-Rigid Cable for S-Parameter Method

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***Abstract* - Recently, the S-parameter method using a vector network analyzer was proposed whereby the differential input impedance of a balanced-fed antenna was obtained. To improve measurement accuracy of the S-parameter method, the dependence on the thickness of the semi-rigid cable used for the measurement jig is obtained from the results of calculations using the FDTD method. Three types of jigs each made from semi-rigid cables of differing thickness were fabricated, and the input impedance of the dipole antenna are calculated and measured using the S-parameter method. The impedances were compared with those obtained from the available theories by King. Results from the S-parameter method was found that using the thinner diameter coaxial cable can be more accurate measurements.**

***Index Terms* — S-parameter method, balanced fed antenna, modified open correction, measurement jig, semi-rigid cable**

1. Introduction

Recently, the S-parameter method is proposed to measure the balanced impedance of the antenna using a jig instead of the balun, and two ports of a vector network analyzer (VNA) [1]. However, if the measured frequency rises, measurement accuracy decreases because in measurements the influence of the jig cannot be disregarded. To account for this jig influence, we proposed a modified open correction that uses the ABCD-matrix [2]. To improve the measurement accuracy of the S-parameter method, the influence of the thickness of the semi-rigid cables used for the measurement jig is assessed using calculations developed within the FDTD method. Three types of jigs are fabricated from semi-rigid cables of different thicknesses, and the input impedance of the dipole antenna is calculated and measured using the S-parameter method. The input impedance obtained by the S-parameter method is compared with the available theories developed by King.

2. Results and Discussion

A diagram is given by the measurement system for the input impedance of a balanced antenna using the S-parameter method (Fig. 1). Each port of the balanced antenna is connected to one of the ports of the vector network analyzer using a measurement jig.

Fig. 2 depicts the FDTD model of the semi-rigid coaxial cable to calculate an open end impedance. To connect the antenna element, the inner conductor is longer than the outer conductor by 2 mm. The open-end impedance is calculated from the electric and magnetic fields at the end of the outer conductor. Given the specifications of the semi-rigid cable (Table 1), we fabricated three types of jigs from semi-rigid cables with different thickness. Open-end impedances were obtained at the open end of the semi-rigid coaxial cable at 5GHz, respectively. Capacitance is determined from the open-end reactance as $C = -1/\omega X$.

To obtain the analysis results of the input impedance, an FDTD model of a dipole antenna is employed. Fig. 3 shows the calculation model of the dipole elements with a

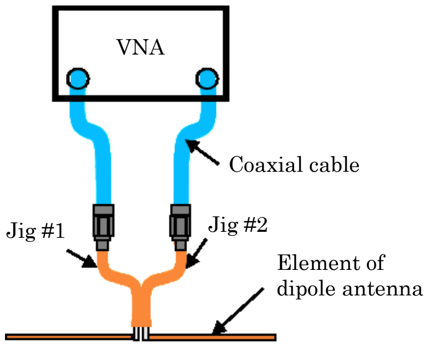

Fig. 1. Measurement system.

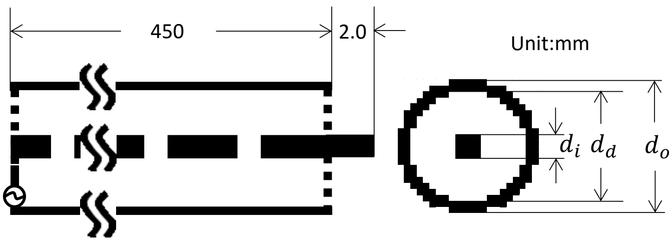

Fig. 2. Calculation model of a semi-rigid cable.

TABLE 1
Specification of Semi-Rigid Coaxial Cable

	Type A	Type B	Type C
Diameter of outer conductor: d_0	1.2 mm	2.2 mm	3.6 mm
Diameter of insulation: d_d	0.9 mm	1.7 mm	3.0 mm
Diameter of inner conductor: d_i	0.3 mm	0.5 mm	0.9 mm
Relative permittivity	2.1		
tan δ	0.0002		
Characteristic impedance	50 Ω		
Open-end resistance	30.0 Ω	18.6 Ω	13.4 Ω
Open-end reactance	540 Ω	435 Ω	344 Ω
Capacitance	0.060pF	0.073pF	0.093pF

measurement jig for the S-parameter method. The cross-section of the dipole element is roughly circular of diameter 0.8 mm, and total length of about 57.0 mm.

Fig. 4 shows the calculated input impedance of the dipole antenna. Using the three types of jigs fabricated, the input impedance of the dipole antenna are calculated using the S-parameter method, and compared with the available theories by King. The results of the S-parameter method were corrected by the modified open correction [2]. At roughly 3 GHz and below, the three results of the S-parameter method and results of King are in good agreement. On the other hand, it can be seen that the result of the jig fabricated by thinner cable is preferred as frequency rises. It is thought that more correct measurements are obtained, when a thin cable is used, the space of the antenna device is small.

Fig 5 shows the measured input impedance of the dipole antenna. Fig. 5 is also shown similar results. Peak waveform seen at 2.6 GHz agree maximum value of measured input impedance at the open end of the semi-rigid coaxial cable at 2.6 GHz. That is a numerical error of the modified open correction.

3. Conclusion

To improve the measurement accuracy of the S-parameter method, we analyzed using calculations developed by the FDTD method the influence of semi-rigid cable thickness used for the measurement jig. First, we formulated the S-parameter method based on the two-port network. We analyzed a practical application where we eliminate the influence of a measurement jig on the measurement of the input impedance. Furthermore, to show the validity of the proposed approach to this measurement, the results were given of input impedance using three types of jigs made from semi-rigid cables of different thickness. The results of the S-parameter method were shown that that using the thinner diameter coaxial cable can be more accurate measurements.

References

[1] R. Meys, and F. Janssens, "Measuring the impedance of balanced antennas by an S-parameter method," IEEE Antennas Propagat. Mag., vol.40, no. 6, pp. 62–65, Dec. 1998.

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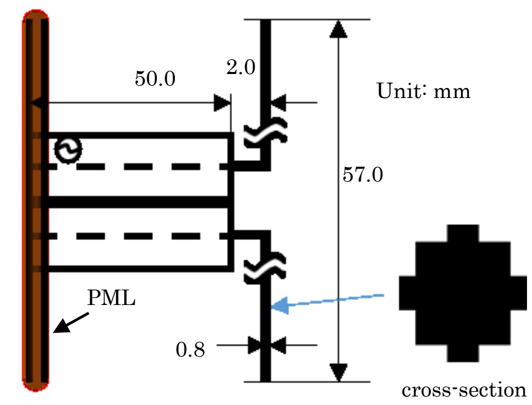
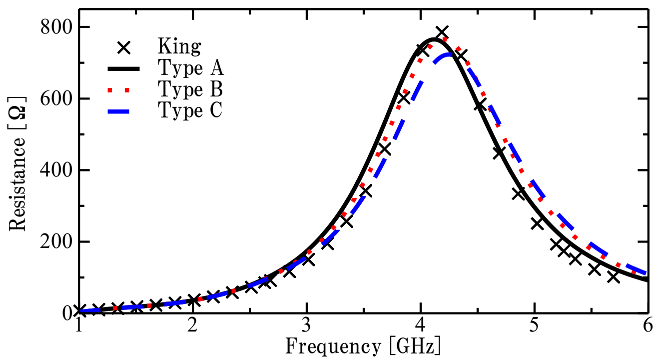
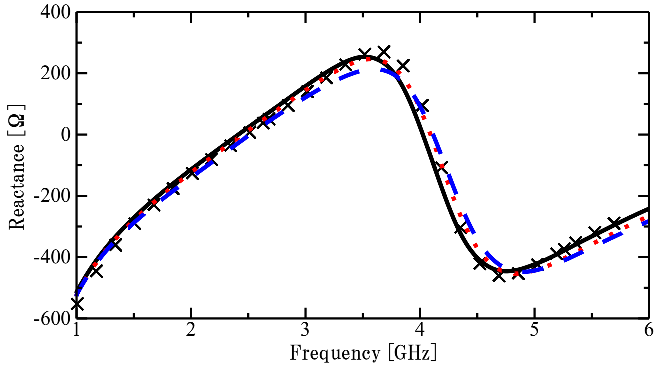


Fig. 3. Calculation model of a dipole antenna.

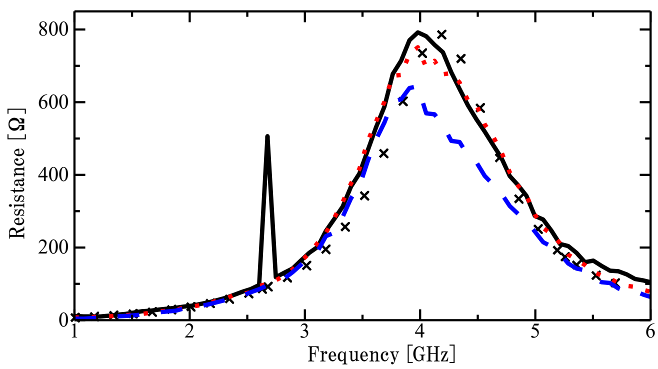


(a) Resistance



(b) Reactance

Fig. 4. Calculated input impedance.



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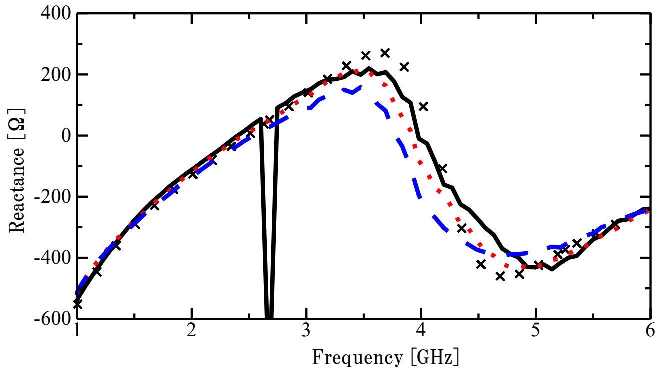

(b) Reactance

Fig. 5. Measured input impedance.