Low frequency characteristics of a wire antenna with noise reduction shield

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The electric field observation of electromagnetic waves in space is an important purpose of scientific satellite. The electric field observed by a satellite is converted into a voltage by the electric field sensor, and it is transmitted to the earth after the A / D conversion. Therefore, in order to get the exact intensity of the electric field from the transmitted data, an accurate calibration is required. The effective length of the antenna is an important parameter for the calibration. For this reason, the effective length is assumed to be L in electrostatic field observations, and to be L/2 in wave observations in most of the actual analysis. A rheometry experiment is a method to estimate the effective length. The rheometry experiment is a method to measure the output voltage of an antenna generated from the known electric field which is provided by applying a low-frequency signal between two electrode plates arranged parallel to in the water. So that we calculate the effective length using the value of the known electric field and the output voltage. In previous studies using the rheometry experiment, we have found that the frequency characteristics of an effective length depends on the structure of the antenna. And we also found that the effective length becomes L at a low-frequency, and approaches to L/2 when the frequency becomes higher, in the case of a wire antenna which has insulation coating at the side of wire in conductive medium.
In this study, we analyzed the effect of a noise reduction shield in order to elucidate the effect of such an antenna structure further. In the many cases of actual satellite, the spacecraft body and near the base of wire are shielded, to prevent the antenna from being affected on its sensitivity by the artificial noise generated inside of the satellite. Therefore, we performed experiments for shielded wire antennas to analyze the frequency characteristics of the effective length.
According to the results of the experiments, we found that the output voltage becomes small compared to the case of non-shield one, when the frequency becomes higher. As the cause, there are two possible factors. One is the distortion of the potential distribution around the satellite which is caused by the shield. The other is the capacitance between the shield and the core wire. In order to analyze quantitatively, we analyzed potential distribution by computer simulations and calculated the output voltage theoretically by the equivalent circuit. As a result of simulation, we found that the potential distribution in the vicinity of the wire is non-linear, that is different from the linear distribution of the non-shield. And next, we made a theoretical calculation applying the potential distribution, which is the result of the simulation, to the equivalent circuit that includes the effect of the capacitance due to shield. Comparing the calculation result to the experimental results, the transition frequency in which the value of the effective length changes is very much consistent, and the difference of the output voltage value is below a few percent at all frequencies. From these results, it was clear that the capacitance between the shield and the core wire affects the impedance of the antenna, and it is the cause of decay of the output voltage when the frequency is high.
In our presentation, we will report the results of the experimental, the simulation and theoretical calculation in detail.

Keywords: wire antenna, effective length, rheometry experiment, noise reduction shield, satellite, quasi-electrostatic field

