IMPEDANCE OF WIRE ANTENNA ONBOARD SPACECRAFT

Minoru Tsutsui
Department of Information and Communication Sciences, Kyoto Sangyo University,
Kamigamo-Motoyama, Kita-ku, Kyoto 603-8555, Japan
tsutsui@cc.kyoto-su.ac.jp

ABSTRACT

Measurements of impedance of wire antenna aboard the GEOTAIL spacecraft were carried out in the earth's magnetosphere. The measured values of the antenna resistance were of the order from 10 MΩ to a few GΩ depending on the different magnetosphere regions. On the other hand, antenna resistances measured by the WIND spacecraft showed an appearance of antenna-base resistance. Since the antenna-base resistance has a serious effect on determining the field intensity of low frequency waves detected by the wire antenna, I here propose a structure of wire antennas which is able to avoid such the effect.

MEASUREMENTS OF IMPEDANCE OF WIRE ANTENNA

In the analysis of wave electric fields detected by wire antenna aboard spacecraft, it is important to take into account the antenna impedance, because the detected signal amplitude varies with the antenna impedance which varies with the density of plasma around the antenna. To make clear the relation between the antenna impedance and the plasma density in the earth's magnetosphere, we conducted its quantitative measurements using the GEOTAIL spacecraft [1]. GEOTAIL has two types of wire dipole antennas of 100 m tip-to-tip; one is a simple wire dipole (WANT) which is dedicated to measuring the AC electric field, and another is also wire dipole called PANT but with a sphere (10 cm in diameter) on each tip. Since the purpose of the PANT was to measure both the AC and the DC electric fields, the wire was covered by an electrically insulated sheet (Polyimide) except for a part of 1m from the tip. Since the antenna impedance was derived as a complex function of frequency, a resistance and a capacitance values can be obtained from its real and imaginary parts, respectively. Figure 1 shows relations between resistances and capacitances measured in different regions of the earth's magnetosphere [1]. Values of the precisely obtained resistances are in a range from 10 MΩ to a few GΩ, and capacitances are from 130 to 180 pF depending on the different plasma density regions of the magnetosphere. Using these data, précised analysis of plasma wave behavior was performed by Kojima et al. [2].

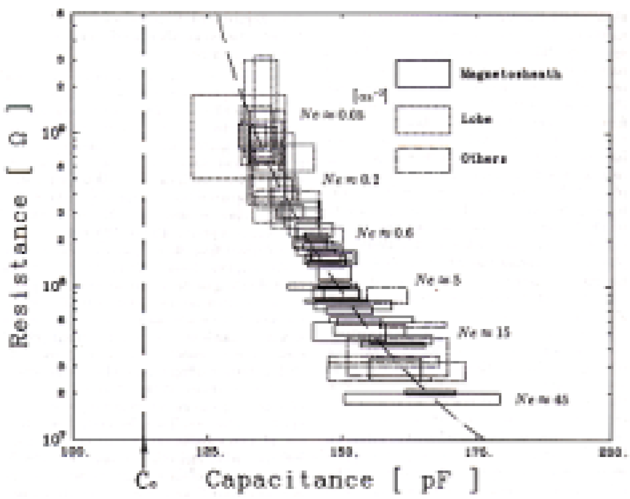

Fig. 1 (from Tsutsui et al., Radio Science, 1997)

On the other hand, Kellogg and Bale [3] attempted to derive the antenna-base resistance from measurements of antenna resistance by the WIND spacecraft. The result showed that the base resistance would be formed in an area between the foot part of the wire antenna and the spacecraft body as shown in Fig. 2. The result also showed that the antenna-base resistance reduced to about few tens of MΩ when the antenna is in the sunlight although the value of the antenna-plasma resistances are the consistent with the values obtained by GEOTAIL. They pointed

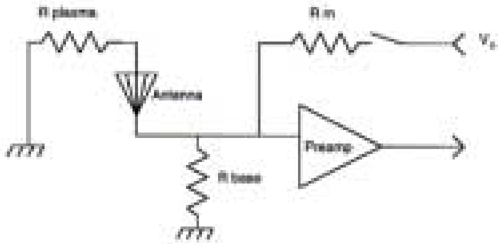

Fig. 2 (from Kellogg and Bale, JGR, 2001) out the necessity of taking into account of both the base resistance and the antenna-plasma resistance in determining the field intensity of low frequency waves especially when the spacecraft is in a rarefied plasma such as in the solar wind.

PROPOSISION FOR WIRE ANTENNA STRACTURE

Kellogg and Bale [3] show that the value of the base resistance became small when the wire antenna was in the sunlight and that the base resistance formed for a short antenna has more serious effect in determining intensity of low frequency waves when the spacecraft is in a rarefied plasma. As seen in Fig. 1, the variance range of the antenna resistance in the magnetosphere robe region is wider than those in other regions, in contrast that the variance range of capacitance is extremely small. This result also supports the easy reduction of the antenna-base resistance.

In the derivation of the antenna-base resistance given by Kellogg and Bale [3], they used a condition on a current balance between the escaping photoelectrons and the ambient plasma electrons. It is true that this situation is extremely effective in formation of the base resistance. Since a part of 10 m from the tip of WANT wire was exposed to the plasma and other part was covered by an electrically insulating sheet whereas most of PANT wire was covered by it except for a part of 1m from each tip, we checked the relations between resistance and capacitance values of PANT for the same events given in Fig. 1, in order to examine the effect of insulation of electron currents from/to the wire element, and to find out any differences of antenna resistance between the WANT and PANT. We obtained the similar feature as seen in Fig. 1 and that its trend was rather deviated to higher resistance value than those in Fig. 1.

Judging from the observational situations in the GEOTAIL and WIND spacecraft, I here propose a new structure of wire antennas aboard the spacecraft planned from now on. It is that wire antennas for observing wave electric field in space should be covered with a insulating sheet, because the key point is that the situation of DC electron current flows from/to the surface of the wire antenna should be avoid.

REFERENCES

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