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HF ANTENNA SYSTEM DEVELOPMENT OF THE IONOSPHERIC SOUNDING SATELLITE OF JAPAN

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Introduction

The ionospheric sounding satellite (ISS) planned by the National Space Development Agency of Japan (NASDA) is intended to be launched on to the circular orbit of 1000 km high for the purpose of world-wide upper-ionospheric sounding and cosmic noise measurement in the HF band, as well as particle measurement in the close vicinity of the satellite for the satellite life time of one and a half years.

In the ionospheric sounding, which is the primary experiment on board, upper ionosphere is investigated using a pulsed-radar technique sweeping in the frequency range of 0.5-15MHz, and in addition critical frequency is observed by receiving a signal from the earth coming through the ionosphere with a sweep frequency receiver.

In the cosmic noise measurement, it is performed in the guard bands of the standard frequencies of 2.5, 5, 10 and 25 MHz.

The design requirements for the antenna system for common use in both the measurements are optimized efficiency and no side lobes at all of the frequencies for the above two measurements, minimized interference between the measuring systems, reduced disturbance in particle measurement, high reliability, light weight, and the other requisites inherent to satellites. As a consequence of feasibility study under these requirements, the dipole antenna, whose length is less than a wavelength, was adopted. Antennas of this type has shown good performance in the experiments of Alouette I, II[1] and ISIS series [1,2].

In this paper are described the determination of dipole lengths and development of associated feeding networks.

Design

The lengths of the dipole antennas are determined to be one wavelength at the highest frequency of the bands so that the radiation patterns have no side lobes. The lowest frequency for the determined dipole length is limited by the antenna efficiency. To cover the wide operating frequency range, two dipole antennas are used, which are made of four monopoles arranged in the cross configuration in order to avoid their coupling. The antennas are different in length from each other, and cover the lower and upper bands of the required total frequency range, respectively.

The length of the shorter antenna is 11.4m tip to tip so that it becomes one wavelength at 25MHz. The efficiency of this antenna becomes -10 dB at about 8 MHz in the case of using the feeding network described later. Therefore, the length of the longer antenna is determined to be 36.8m tip to tip. The efficiency of this antenna is very low for the frequency below about 2 MHz, but sufficient for the purpose of the measurements.

As for the feeding network for antennas for the ionospheric sounding, no wide band matching circuit was used in consideration of the antenna efficiency decrease due to the radiation impedance change which may be caused by the surrounding plasma or mechanical deformation of the radiator. Instead of the wide band matching circuit, optimization of the source impedance was taken. When no matching circuit is used, antenna efficiency η is given by

$$\eta = \frac{4 Z_0 R}{(Z_0+R)^2+X^2} \quad (1)$$

where R and X are radiation resistance and reactance, respectively. Z_0 is the source impedance and is pure resistance. η takes maximum value at $Z_0^2 = R^2+X^2$. This is the condition for optimization. By using above result source impedance was chosen to be 300 ohms. Both long and short antennas are fed through a crossover network which transfers the input power from one dipole to the other at the crossover frequency 8 MHz.

In cosmic noise measurement, four matching circuits are connected through two step-up transformers to the antennas and are connected to the receiver by switches.

Engineering Model

The results of the above study were applied to the breadboard model and engineering model of the HF antenna system. Fig·1 shows the schematic diagram of the feeding networks and Fig.2 and Table 1 show their experimental results. Fig.3 is the outer view of the engineering model of the feeding networks.

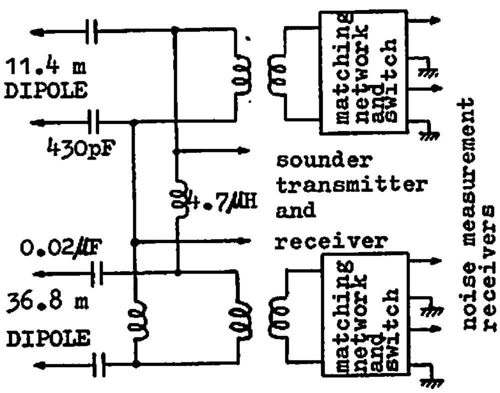

Fig.1 Feeding network.

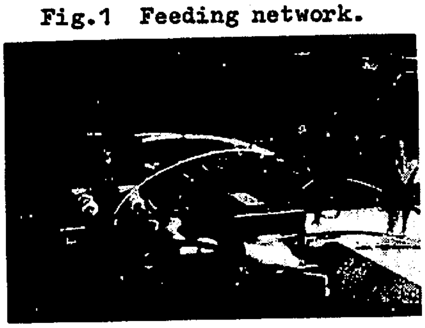

Fig. 3 Outer view of feeding network

Conclusion

As the result of study, ISS HF antenna system developed has such features as follows.

Good efficiency is obtained with relatively short antenna combination and simple feeding circuits by the optimization of dipole antenna lengths and source impedance. In addition, the dipole antennas of relatively short length mentioned above cause plasma sheath of such thin thickness that no ion guard is required for particle measurement.

References

1. C. A. Franklin and M. A. Maclean, "The Design of swept-Frequency Topside Sounders", PIEEE, vol. 57, No. 6, PP. 897-929, June 1969.

2. J. Zuran, "Antenna-system design of the ISIS-A scientific satellite", PIEE, vol. 116, No. 6, PP. 923-932, June 1969.

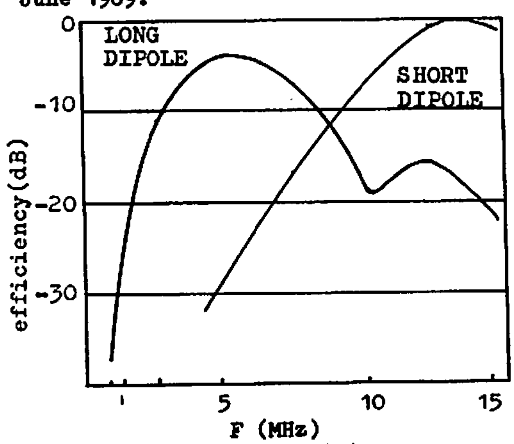

Fig. 2 Sounder Efficiency.

F(MHz)	Efficiency(dB)	SWR
2.5	-11.0	1.23
5	-7.0	1.19
10	-4.4	1.2
25	-4.5	1.8

Table 1 Noise measurement performance.