Development of Compact Loop Antenna Sensors Onboard Space Electromagnetic Environment Monitoring System

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In various human activities in space expected in the near future, monitoring of electromagnetic environment around artificial structures such as spacecraft and space stations will become essential in understanding the interaction between human activities and space plasmas. We have been developing a new system for monitoring the electromagnetic environment in space, named as Monitor system for Space Electromagnetic Environment (MSEE). This system consists of a lot of scattered sensor nodes which form a sensor network, to measure the detailed electromagnetic environment around the artificial structures in space plasmas.

Each sensor node carries electric and magnetic vector sensors to measure the six components of AC electromagnetic field. Since we are targeting the monitoring of rather intense artificial electromagnetic turbulence, we need no high-quality sensors and receivers which achieve high accuracy and high time resolution. Instead, each sensor node can be small-sized, light-weight and cheap, where the sensors, preamplifiers, receivers, and a wireless communication module are equipped together in a compact body.

As an AC magnetic field sensor to be installed on such a sensor node, we have been developing a small-sized and light-weight loop antenna system. Three loop antennas are mounted orthogonally to one another around the chassis of the sensor node. The loop wiring as well as the chassis are covered with an electrostatic shielding to prevent the sensor from picking up any AC electric field. To reduce the magnetic field noise to be radiated from the electronics inside the chassis, we will put a high-permeability magnetic sheet on the surface of the chassis. The eddy current loss induced on the surface of the chassis should also be avoided. The voltages induced at each loop antenna are amplified by a preamplifier inside the chassis, and then their intensities in multiple frequency channels are detected on an ASIC chip receiver which has been developed by RISH, Kyoto University. The digitized data are transmitted through a wireless sensor network communication and gathered by the master node of the network.

Supposing we set up 15-cm square loop antennas around the 10-cm cubic-shaped chassis of a sensor node, we have evaluated the performance as a magnetic sensor. With 10 turns of loop winding, we have designed a small, light and power-saving preamplifier circuit. By adopting a low-supply-voltage and low-noise operational amplifier, the magnetic sensitivities obtained are: 10pT/sqrt(Hz) at 1kHz, 1pT/sqrt(Hz) at 10kHz and 0.1pT/sqrt(Hz) at 100kHz, respectively. We will present the structure and performance of a BBM model of the tri-axial loop antennas, and discuss the possibility of measuring the magnetic environment around the artificial structures in space plasmas.