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電離圏イオン組成観測のための広帯域インピーダンスプローブの開発
Development of wideband impedance probe system for observation of the ionosphric ion composition

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Concept and design of new wideband impedance probe system for observation of the ionospheric ion composition have been investigated. Impedance probe system for measurement of the electron number density, which is called NEI, were developed by Oya [1966], and successfully utilized for numerous sounding rockets and spacecraft such as Denpa, Taiyo, Jikiken, Hinotori, Ohzora, and Akebono [e.g. Wakabayashi et al., 2013]. NEI measures the equivalent capacitance of the probe immersed in the magnetized plasma. By applying RF signal to the probe, we can identify the minimum of equivalent capacitance due to upper hybrid resonance (UHR). The frequency of RF signal is swept from 100 kHz to 25 MHz, in order to cover the UHR frequency range in the Earth's ionosphere. The equivalent capacitance of the probe in the magnetized plasma shows minimum not only at UHR frequency but also at another resonance frequency: Lower hybrid resonance (LHR). If we can measure LHR frequency with UHR frequency and electron cyclotron frequency, we can derive effective mass of ionospheric plasma and determine the ionospheric ion compositions. Because LHR frequency is about several kHz in the ionosphere, we have to extend the lower limit frequency of the current impedance probe system to 100 Hz. We changed the design of NEI as follows: (a) Coupling capacitor between the circuits is changed in order to pass the low-frequency AC signals. (b) Because long time is needed for frequency sweep in a low frequency range, high-frequency signal with short sweep period and low-frequency signal with long sweep period are combined and impressed to the probe in order to keep the high time resolution in the measurement of UHR frequency. We have performed the chamber experiment with bread-board model (BBM) of wideband impedance probe system in 2014. We confirmed that the new impedance probe system could measure (1) UHR in high frequency range as well as the current NEI could, and (2) equivalent capacitance profile from 100 Hz to 100 kHz, which indicates sheath capacitance of 120 pF and sheath resistance of 30 kohm. Unfortunately, LHR could not be identified in the chamber experiment because of high collision frequency in the chamber. The detectability of LHR with the wideband impedance probe system have to be verified through the future sounding rocket experiments in the ionosphere, where the collision frequency is enough low.

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