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相互相関型電子サイクロトロン放射ラジオメーターの開発とLHDプラズマにおける乱流観測

Development of Correlation Electron Cyclotron Emission Radiometer and measuring turbulence of LHD plasma

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The aim of this study is to measure the turbulence. We use the electron cyclotron emission (ECE) for measuring the turbulence. ECE is used for electron temperature measurement of plasma. We have been trying to measure turbulence of the plasma by using ECE. Advantage of the ECE measurement is high spatial resolution and real-time measurement. But, ECE signal include large noise in measurement principles.Turbulence signal is considered to be very weak. So, turbulence signal is hid in the noise. We are trying to measure this signal, however, detecting this signal is difficult with a single measurement channel. So, cross-correlation analysis for turbulence signal measurement is required. Developed system receives signals from RADH. The RADH is existent ECE Measurement system on LHD. The RADH measures electron temperature profile. Frequency range of ECE is 105.5GHz－196GHz. The RADH is consist of L channel and H channel. Input signal of developed system is fed from L channel. L channel output frequency is 2GHz-26.5GHz. This is down converted signal originated from a raw ECE signal with frequency range from 105.5GHz-130GHz.

Details of the cross-correlation electron cyclotron emission radiometer(cECE) system is as follows. This system is multi-channel measurement. Each measurement area of the each channel is variable. Figure 1 shows the cECE system. The signal fed from the RADH is divied into 8 channels. Each divided signal is further down-converted individually by mixers and LO oscillators. Each measurement area is movable by changing frequency of LO. Cross-correlation analysis can be performed by using multiple channel. Crosscorrelation analysis enhances S/N ration of the signal.

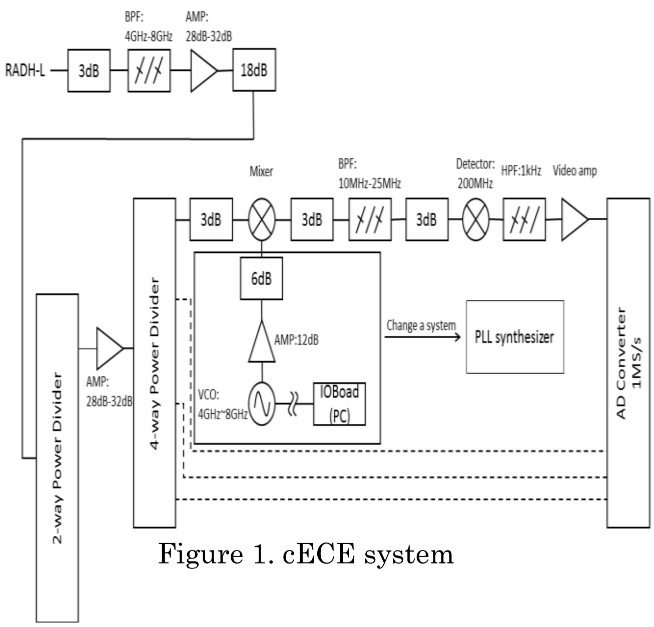

Figure 1. cECE system

In the previous experiments, we have performed cross-correlation analysis by using two different signal measured by the RADH system and cECE system. As a result, we could detect large amplitude of MHD mode like fluctuation in the cECE signal. However, we could not still detect turbulent signal which amplitude is smaller than the MHD signal. To detect turbulences, we need to improve S/N ratio of the total measurement system. But the S/N ratio of the signal source limit the total S/N ratio. Our system utilizes the signal source from RADH. It is difficult to improve the S/N ratio of the source immediately. So we plan to measure two signals which measurement positions are too close. It is very important to control the measurement position. In the present system, VCOs are utilized as LO, which frequency is controlled by analog voltage. This LO oscillator is changed to the digitally-controlled PLL synthesizer. PLL synthesizer can supply stable frequency source to the system.

The figure 2 shows correlation of two cannel as a function of LO frequency difference set by two LO oscillators. This experiment is performed in a laboratory. In this experiments, we use a noise source instead of ECE. This experiments is comparing two types of LO oscillators, i.e. a VCO and a PLL synthesizer. In the case of measurement area is same, horizontal axis value is zero. Correlation value of the PLL synthesizer is higher than correlation value of the VCO. But, when VCO was remeasured, the correlation value of VCO become higher. So, it is found that, the VCO frequency is not stable, because, 1st and 2nd measurement results are quite different. The VCO frequency is drifting due to the temperature change in oscillator. So, we employ the PLL synthesizer as a LO oscillator. Measurement position become accurate by the PLL.

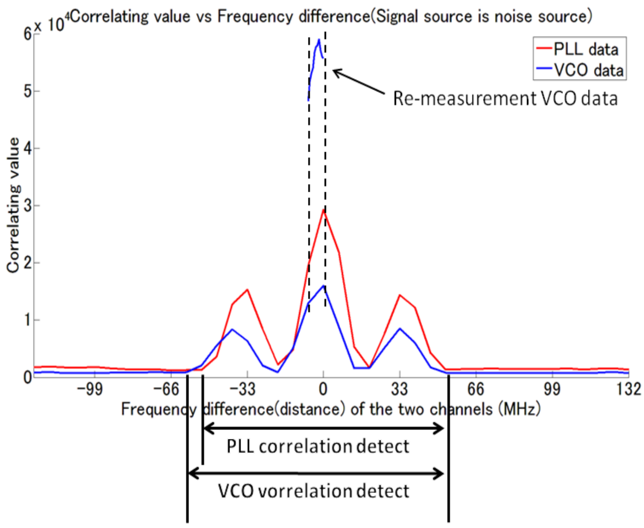

Figure 2. PLL and VCO Correlating value difference

Figure 3 shows right hand side of figure 2. No correlation value above 60MHz is detected due to the BPF cutoff, attached after the mixers. So, this cECE system is considered to measure a turbulent signal properly when the center frequency of two signal differ over 60MHz. We plan to apply this system in this experimental campaign.

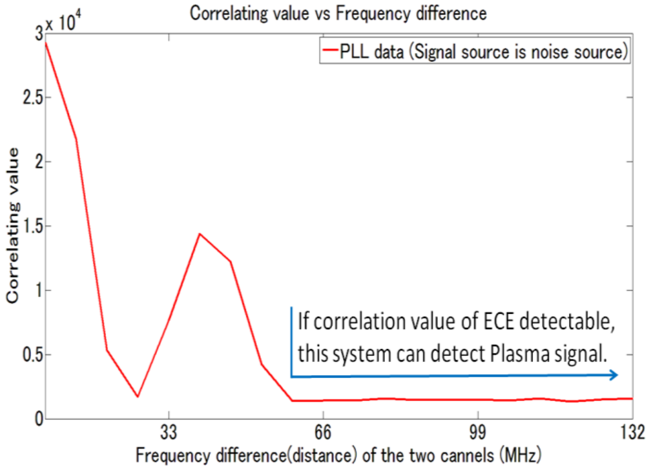

Figure 3. Correlating value graph