§5. Development of V-band Frequency Hopping Microwave Reflectometer for Density Fluctuation Measurement

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In order to measure the internal structure of density fluctuation, we have been developing a new type of reflectometer which is the broadband frequency tunable system and has the ability of fast and stable hopping operation. During one plasma discharge, the launching frequency increases step by step, which this operation is called as frequency hopping, and the cut-off position can be scanned in the wide area. One of the important issues of this measurement is the study of energetic particle driven magneto hydrodynamics instability.

The schematic of frequency hopping V-band reflectometer system is shown in Fig. 1. A microwave synthesizer is used as a source with a low phase noise. The output frequency is easily changed by the external controlled signal. For the direct phase measurement, the single side band (SSB) frequency modulation is utilized. The source output is split into the probe and the reference signal. The SSB modulator driven by a 220 MHz quartz oscillator shifts the frequency of the probe signal for the heterodyne I-Q detection. The output frequency is quadruple followed by an active multiplier to bring the launching frequency up to 50-72 GHz (V-band). The modulated microwaves launch from the outboard side along inverse the major radius direction on equatorial plane. The polarization of launching wave is set on the extraordinary mode and the right-hand cut-off layer is used as the reflected surface, because the electron density profile is sometimes flat in the LHD experiments. The reflected wave is received and mixed with reference wave and intermediate frequency (IF) signal is amplified and led to I-Q detection. The output signals of I-Q demodulator,

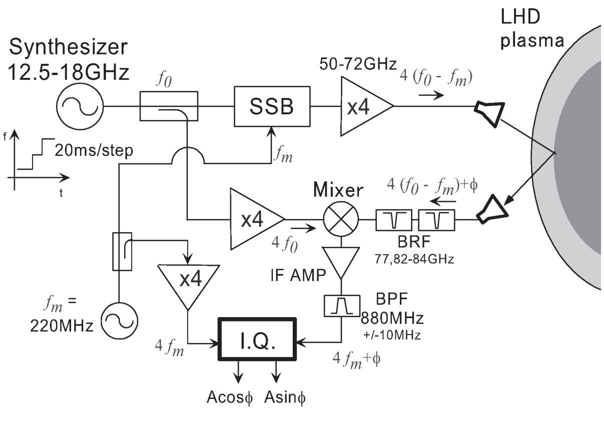

Fig. 1. Schematic of the V-band frequency hopping microwave reflectometer. f_0 is carrier frequency (12.5-18GHz), f_m is modulation frequency (220MHz), and ϕ is plasma fluctuation component.

which are described by $A\cos\phi$ and $A\sin\phi$, are acquired by real-time data acquisition system with the sampling rate of 1 MHz during the whole plasma discharge.

Here, we show a preliminary experimental result. The experiment is carried out the axial magnetic field strength is 2.0 T, the averaged electron density is under $0.4\times10^{19}m^{-3}$. During t=0.6-1.5s, the plasma condition is mostly steady and then the fluctuation frequency keeps constant. The source frequency is swept from 48 to 72 GHz and the step size is 1 GHz with 20 ms duration in this plasma discharge. Figure 2 shows the frequency spectrum of the hopping reflectometer signal. We can see continuous coherent frequency components of about 120 kHz in the finite launching frequency range. The toroidal mode number of this coherent fluctuation n=1. The radial fluctuation profile of the frequency components of 110-130 kHz is shown in Fig. 3. It can be obatined that this mode is large around at ρ=0.3.

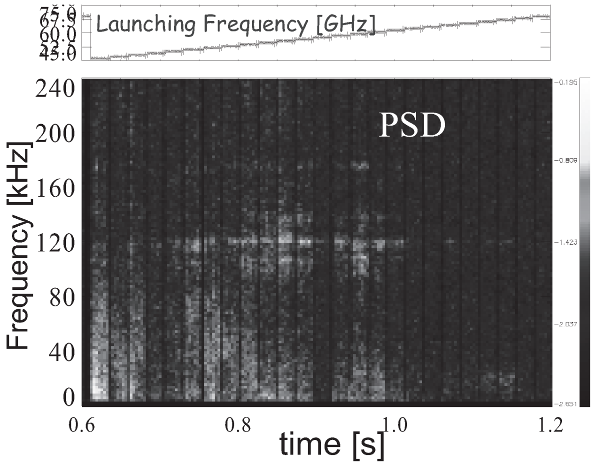

Fig. 2. Time evolution of the launching frequency and the frequency spectrogram.

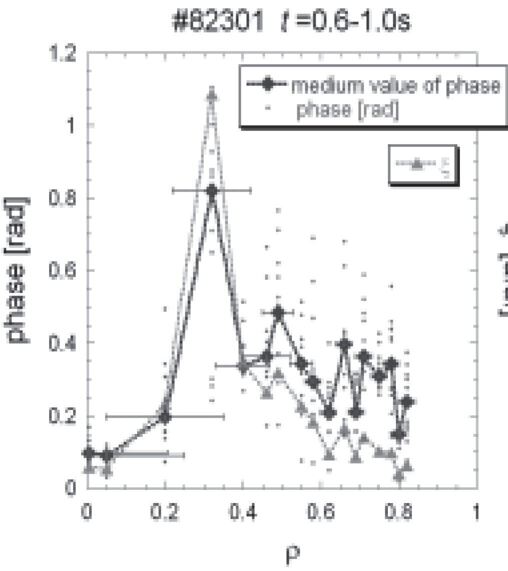

Fig. 3. Radial profiles of the amplitude of phase fluctuation (dots), which frequency components of 110-130 kHz, and medium value at each radial position (thick line with diamond) and calculated radial displacement (thin line with triangle).