§16. Ultra-Short Microwave Pulse for Plasma Diagnostics

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Ultrashort-pulse reflectometer (USRM) is one of the promising methods to measure electron density profile without perturbing plasma. The frequency source is replaced by an ultrashort-pulse which pulse width is less than 100ps. The density profiles can be reconstructed by collecting time-of-flight (TOF) signal of each frequency component of an impulse reflected from each cutoff layer.

The detail of the USRM system was shown last year. Remote control system using super science information network (super-SINET) has been introduced to the USRM system since 2003. Bandwidth of the main backbone and branch line is 10 Gbps and 1 Gbps, respectively. The control client can operate the control server by using this network. The general purpose interface bus (GPIB) card is installed in the control server. The remote console, which has graphical user interface (GUI) as shown in Fig. 1, is prepared to control the instruments of USRM via GPIB. The operations such as adjustment of supply voltage fed to amplifiers and the doubler, timing control of the impulse, data acquisition and monitoring can be performed from the remote site (Kyushu University).

Figure 2 shows reflectometer signals observed by a sampling scope together with the time evolution of stored energy and line-averaged density of LHD plasma. The plasma is generated from 0.5 s, and density reaches 1.5×10^{19} m^{-3} at 2.0 s, which corresponds to the cutoff frequency of 35 GHz. We can confirm the reflected wave from the diagonal vacuum vessel from 186 ns to 187 ns when the plasma does not exist. Bandpass-filtered signals by 2nd order digital Butterworth filter are shown in Fig. 2 (b)-(d). Noise level (in raw signals) increases obviously compared to (a). This noise is considered to be detected due to interference of other microwave diagnostic systems and electron cyclotron emission. By using the bandpass filter, we can confirm reflection from the plasma as shown in trace (c). The signal received around 178 ns is attributed to the reflection from the plasma since the detection time is 10 ns former than that from the vacuum wall. However, we cannot observe any obvious reflection when the measuring time corresponds to t2 and t4.as shown in (b) and (d), even though the value of the plasma density are almost same. It takes 10 ms to acquire a trace of data by using the sampling scope. Therefore, the cutoff layer should freeze during 10 ms in order to measure the reflected wave keeping its phase information. Plasma density at t2 and t4 changes rapidly during the measurement. We cannot observe the obvious reflected waves since the cutoff layer moves back and forth. While, we can observe at t3 since the cutoff layer seems to freeze during the measurement.

In the present experiment, it is difficult to acquire the data in good signal to noise ratio. We plan to improve this USRM system more reliable diagnostics by optimizing direction of the antenna, and applying more high repetition rate of the incident impulse, and also applying a notch filter for rejection of other diagnostics signals. The signal will be detected in good signal to noise ratio even when the cutoff layer moves rapidly by such improvements.

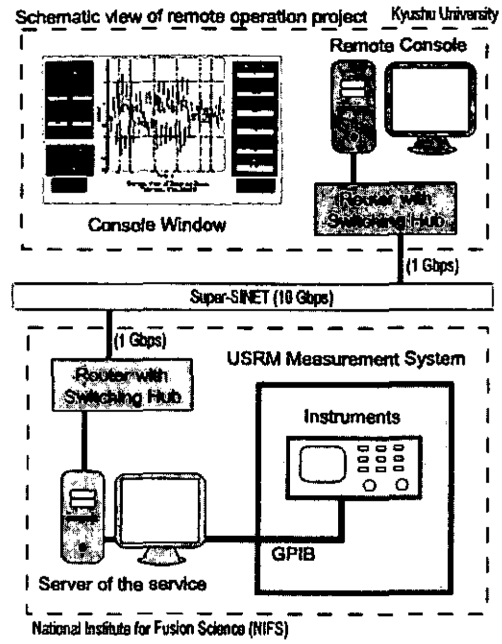

Fig. 1. Remote operation system utilizing super-SINET.

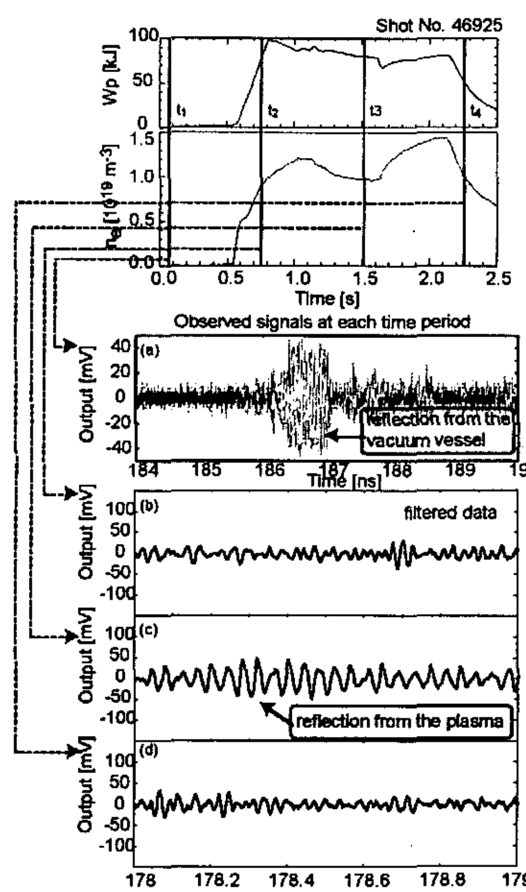

Fig. 2. Reflectometer signal at various times.