§5. Development of a Real-time Plasma Image Data Acquisition System for LHD

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Charge Coupled Device (CCD) cameras have widely been used for observing plasma dynamic behavior, impurity radiation profiles and plasma-wall interactions, etc. The image data taken by the cameras give much useful information. However, huge data storage system is needed because of the output signal from many pixels on the CCD arrays. When we used a standard video camera (NTSC), a video data stream (~100 Mbps) is generated, corresponding to (125 Mbytes/shot) when the camera monitor plasma discharge for 10 seconds. Video Tape Recorders (VTR) have been used for image data acquisition. This analog recording system has some disadvantages, i.e. the recorded images deteriorate compared to the original images and tracking noise is inevitable. Furthermore, we cannot access the data at random, which is inconvenient for flexible data analysis and efficient plasma experiments.

Recently, image data compression technique such as JPEG and MPEG has been developed. We applied the compression technique to the data acquisition of plasma images. In plasma discharge experiments in LHD, tangential viewing CCD cameras have been used for monitoring plasmas. Four cameras with interference filters are installed in a tangential port (6-T). We can choose four interference filters from six ones (OII:442.5nm, CIII:465.4nm, CII:426.7nm, HeI:587.8nm, HeII:468.6nm and Hα:656.6nm). The video signals from the cameras are integrated with a video multiplexer. The video signal is converted to an optical signal with a converter for avoiding electric noises. We have stored the video signal by a video tape recorder. To overcome the defects of this analog recording, we newly introduced a Video On Demand (VOD) system during the third experimental campaign. Figure 1 shows the configuration of the VOD system. The video signal is received by an MPEG-2 encoder board installed in a VOD encoder server. The sequential video image is compressed by the data compression technique (MPEG-2), and the image data are stored in hard disks. This system has been useful for controlling the gas fueling rate in long-pulse discharge experiments. Our final goal is to sustain plasmas for several hours, requiring the real-time data acquisition, unless huge buffer memories for storing the image data are necessary. The system can encode and store the data in real-time, contributing to efficient data acquisition at a reasonable cost.

Before applying the compression technique (MPEG-2) to plasma image data acquisition, we optimized the video streaming bit rate acquired in the VOD system. Figure 2 shows the time evolution of the impurity line emission profile. Figure 2 (a), (b) and (c) are the images in a video bit rate of 0.58, 2.31 and 5.77 Mbps, respectively. Block noises appear in the first frame in the lowest video bit rate. The noise diminishes as the progress of frames, which is ascribed to the fact that the plasma shape becomes steady as the progress of time. The accuracy of the prediction of the images becomes higher in the compression scheme in MPEG, leading the reduction of the noises under the limitation of a specified video bit rate. Considering the quality of the plasma images in the plasma start-up phase and comparing with the video images recorded in the VTR, we set the optimized video bit rate to be 5.77 Mbps. Consequently, we have succeeded in compressing the video image data into a reasonable size which is as small as about 1/17 in the case without any compression techniques.

![Fig. 1. Configuration of the VOD system for monitoring LHD plasmas.](image_url)

![Fig. 2. Plasma images in various video streaming bit rates: (a) 0.58, (b) 2.31, (c) 5.77 Mbps, respectively.](image_url)

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