# PRESENT STATUS OF CONTROL SYSTEM OF UVSOR-II

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## *Abstract*

This paper presents the overview of UVSOR-II control system and recent progress on the injector stabilization. In UVSOR-II, top-up user operation will start soon. For stable top-up operation, we were required to stabilize the injector of UVSOR-II and a slow feedback control system of an electric septum was introduced. The feedback system is working well and we succeeded in stabilizing the septum voltage with its voltage stability of less than 1%. And then stability of the injector was much improved. However, another source of fluctuation is still remained. The output power of klystron which drives a 15-MeV linear accelerator has large fluctuation and it causes unstable operation of the injector. The output power fluctuation will be compensated by another feedback system.

## ABOUT UVSOR-II

UVSOR-II [1] is a synchrotron light source based on a low emittance 750 MeV electron storage ring, which have been operated for more than 20 years and had been upgraded several times. Figure 1 shows the layout of the accelerators and beamlines. The UVSOR-II accelerator consists of the 750 MeV storage ring, a 750 MeV booster synchrotron and a 15 MeV linear accelerator. Now eight bending magnets and four insertion devices are available and the total number of operating beamlines is thirteen (9 is opened to outside users, and 4 is dedicated to users of our institute). From 2008, test run of top-up operation of the storage ring was started. User operation with top-up injection will be started from this October. For the operation, stable operation of the injector (the linear accelerator and booster synchrotron) is strongly required for keeping the stored current in the storage ring constant.

## CONTROL SYSTEM OVERVIEW

The storage ring components such as magnets and RF cavities and undulators are fully controlled by PCs. And some of the booster synchrotron components are controlled by PCs. And the rest parts of the booster and all components of the linear accelerator are still manually controlled. The control system was originally based on the VAX computers [2]. The VAX computers were replaced with Windows-PCs in 2005.

The typical configuration of control system is shown in Fig. 2. Control servers are connected with some Programmable Logic Controllers (PLCs) and Multi-Control Units (MCUs) based on TCP/IP protocol. The PLCs are directly connected with power supply of magnets for the storage ring and booster synchrotron. The MCUs are equipped a PCI interface board for CAMAC crate controller (CC/PCI Board in Fig. 1) and connected with CAMAC modules. The D/A and A/D converters are used to set and measure the hardware parameters. The control software for MCU-CAMAC system was developed using the JAVA Abeans libraries [3]. The control server PCs and control client PCs can communicate through CORBA technology [4].

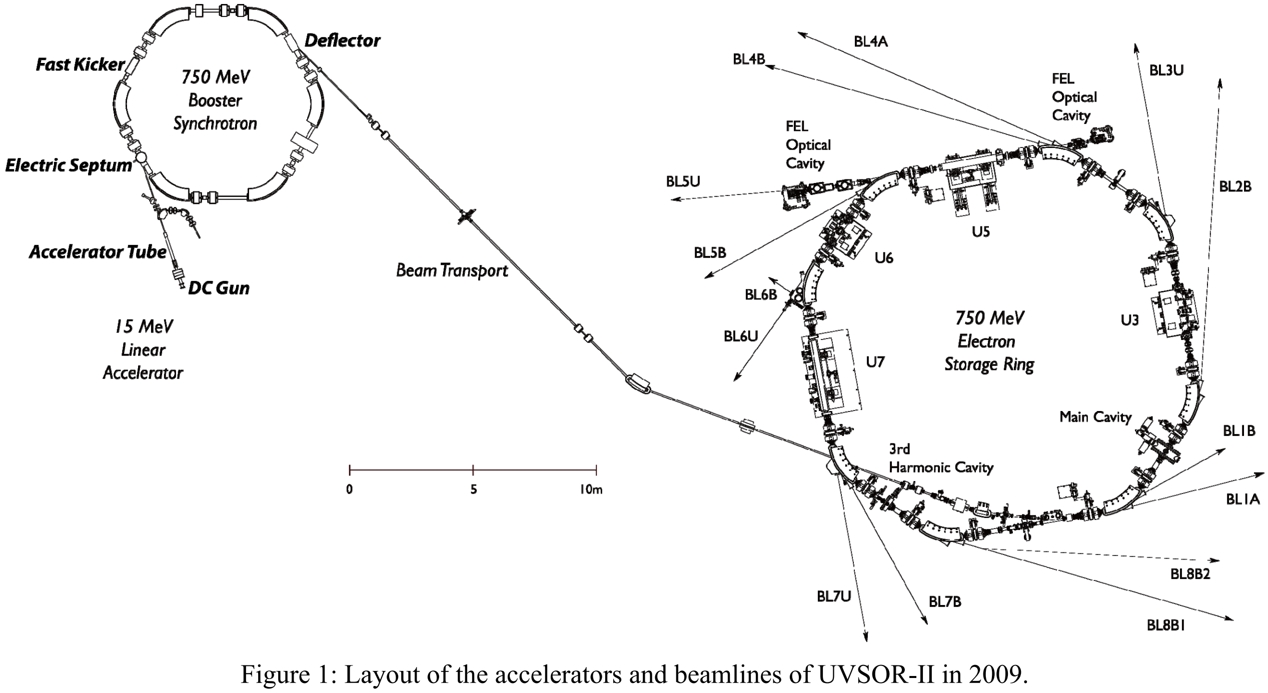

Figure 1: Layout of the accelerators and beamlines of UVSOR-II in 2009.

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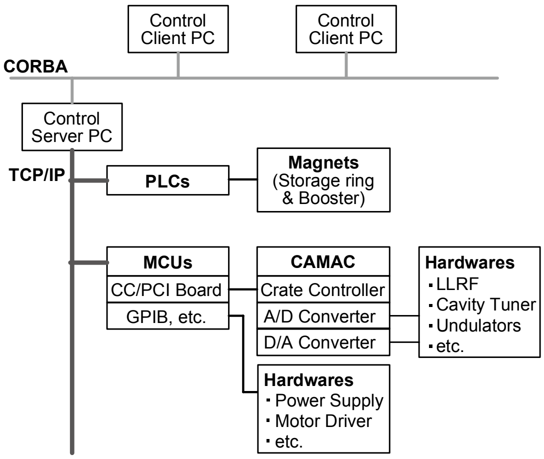

Figure 2: Configuration of control system in UVSOR-II.

## DEVELOPMENT OF SLOW FEEDBACK CONTROL OF ELECTRIC SEPTUM

### Motivation

Results of half year trial of top-up operation (Oct. 2008 – Apr. 2009) are good and we have succeeded in keeping the beam current around 300 mA in multi-bunch user operation more than 10 hours. However, sometimes the stored beam current gets lower than 300 mA (see Fig. 3), due to the long term fluctuation of the accelerated charge in the booster synchrotron (we call it as synchrotron charge). As one reason of the fluctuation, we found that the slow voltage drift of the electric septum which used to inject 15 MeV electron beam into the booster synchrotron (see Fig. 1). Fortunately, the electric septum can be controlled by the PC control shown in previous section. We decided to introduce a slow feedback control system to reduce the voltage drift.

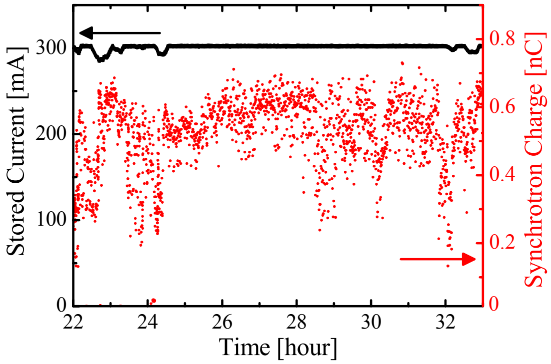

Figure 3: A temporal evolution of stored current and accelerated charge in the booster synchrotron during an eleven-hour top-up operation.

### Feedback System

Figure 4 shows the schematic diagram of the feedback system. The voltage waveform of the septum is measured by an oscilloscope. The measured waveform was sent to a client PC. On the client PC, a software PID control given by the LabView is used to determine the set value fed to high voltage power supply through the server PC, MCU and CAMAC.

The proportional gain, integral time and derivative time of the PID software were set to 20, 0.01 min. and 0.01 min. The parameters are tuned to have moderate rise/fall time and keep the voltage fluctuation less than 1%.

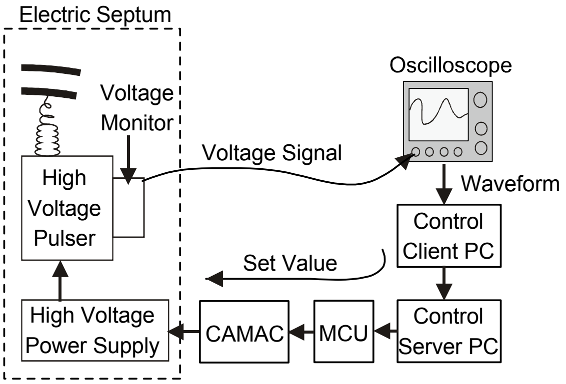

Figure 4: Schematic diagram of voltage feedback system for electric septum.

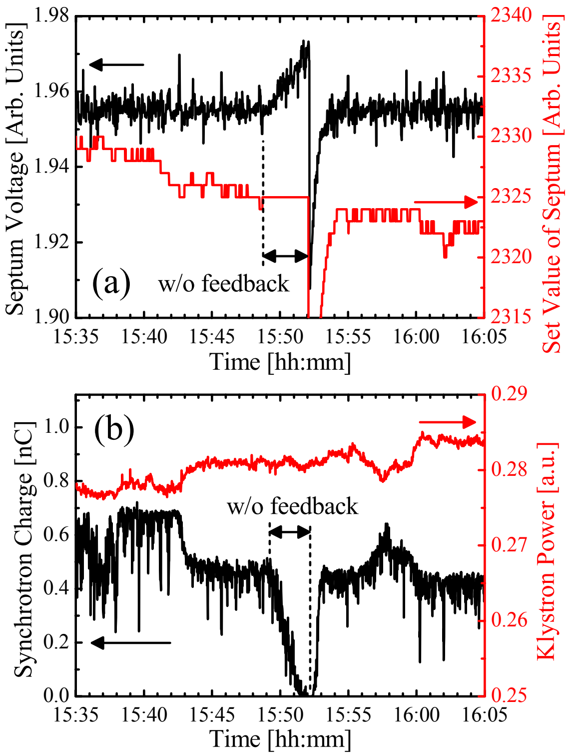

Figure 5: Operation results with and without the feedback of electric septum. (a) Septum voltage (left axis) and its control value (right axis). (b) Charge circulating in the booster synchrotron (left axis) and output power of klystron (right axis) which drives the 15-MeV linear accelerator.

### *Results*

Temporal evolutions of the septum voltage, set value of septum, synchrotron charge and the output power of klystron are recorded. The results are shown in Fig. 5. As one can see in the Fig. 5 (a), when the feedback control was working, the septum voltage was kept constant with the fluctuation of less than 1%. On the other hand, when the feedback control is turned off, large drift of the septum voltage was observed. The drift leaded to decrease of the synchrotron charge (see Fig. 5 (b)). The feedback is turned on at 15:52 in the Fig. 5, and then the synchrotron charge got recovered.

The drift of septum voltage was successfully suppressed by the feedback control. After that, we found that we suffered from the drift of klystron output power. As shown in Fig. 5 (b), one can obviously see the large fluctuation of klystron power and the strong correlation between the klystron output power and the synchrotron charge. Therefore, now introduction of feedback compensation for the fluctuation of klystron output power is being planned. The feedback will increase the stability of our injector and allow us much more stable top-up operation.

## SUMMARY

The overview of present control system and recent progress are reported in this paper. Magnets for the booster synchrotron and storage ring are controlled by PLCs and other PC-based control system is using combination of MCUs and CAMAC. Some part of the booster synchrotron and all component of 15-MeV linac are still manually controlled.

The feedback compensation system was introduced to stabilize the voltage of electric septum. The system worked well and the voltage stability is much increased. After that another source of the injector fluctuation, fluctuation of the klystron output power, was revealed. Introduction of another feedback system is being planned to compensate the klystron fluctuation.

## REFERENCES

[1] http://www.uvsor.ims.ac.jp/defaultE.html.

[2] N. Kanaya et al., “Gracefully-degraded operationable control system for the UVSOR synchrotron radiation source and its operational experience,” Nucl. Instr. and Meth. A 352, pp. 166-169 (1994).

[3] I. Kriznar et al., “Beyond Abeans,” Proceedings of ICALEPCS07, Knoxville, Tennessee, USA, pp. 141-143 (2008).

[4] http://www.corba.org.