



New Event-based Control System for Simultaneous Top-up Operation at KEKB and PF



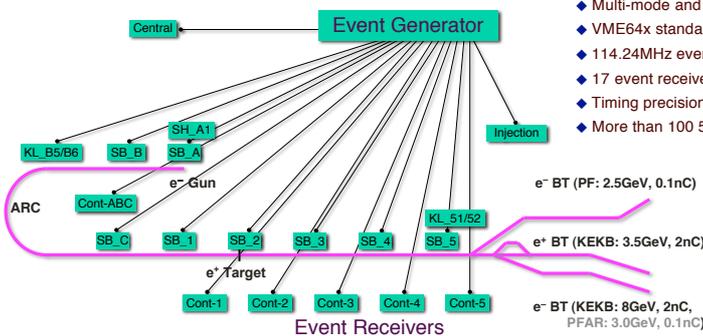
K. Furukawa, M. Satoh, T. Suwada, T.T. Nakamura - High Energy Accelerator Research Organization (KEK)
 T. Kudou, S. Kusano, T. Nakamura - Mitsubishi Electric System and Service (MELCO SC)
 Artem Kazakov - Graduate University for Advanced Studies (SOKENDAI)

The 8-GeV linac at KEK provides electrons and positrons to three ring accelerators of KEKB-HER, KEKB-LER and Photon Factory. Simultaneous top-up injections to those rings are carried for the ultimate experimental results at the both KEKB and PF facilities. An event-based fast control system was newly constructed overlapping the existent EPICS control system. The new system controls the distant equipment globally utilizing event modules from MRF and several other techniques. The event system enables fast controls from pico-second to milli-second range, and the conventional EPICS system

covers slower controls. More than 100 parameters are driven globally by the event system every 20ms pulse in order to generate beams with three-times different energies and 100-times different charges. And more than 500 parameters are observed synchronously to ensure the beam operation. The system enables the future accelerator complex such as SuperKEKB as well. This paper describes the detailed design of the hardware and software structures, beam operation experiences, and possible extensions towards the future.

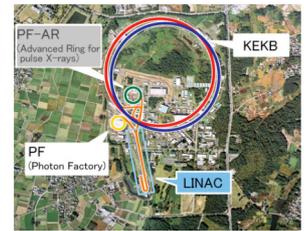
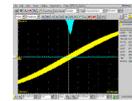
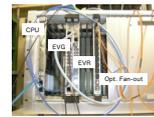
Global and Synchronous Controls for more than 100 Parameters at 50Hz and Successful Simultaneous Top-up Injections to Three Rings

Event System Configuration

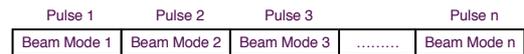


Event System

- ◆ MRF series-230 Event Generator / Receivers.
- ◆ Multi-mode and single-mode fibers.
- ◆ VME64x standard and VxWorks v5.5.1.
- ◆ 114.24MHz event rate, 50Hz fiducials.
- ◆ 17 event receivers for now.
- ◆ Timing precision is better than 10ps.
- ◆ More than 100 50-Hz Analog/Timing points



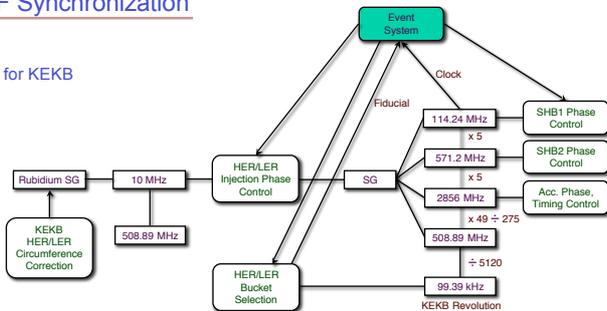
Beam Mode Pattern Generation



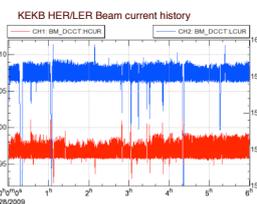
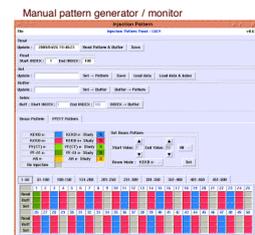
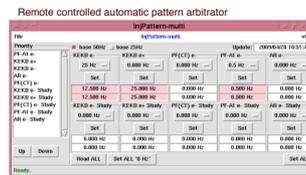
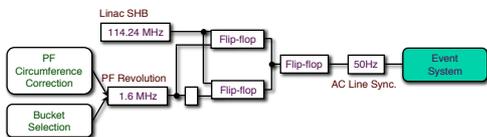
- ◆ Every pulse (every 20ms) corresponds to a beam mode.
- ◆ 10 different beam modes are defined (for KEKB e⁺, etc).
- ◆ One beam mode contains several event codes.
- ◆ Beam pattern buffer length (n) can be 2 to 500 (20ms x 500 = 10 seconds).
- ◆ A new pattern can be loaded at the end of the previous pattern.
- ◆ Otherwise, the pattern repeats forever.
- ◆ Pattern generator software arbitrates requests from downstream rings.
- ◆ There are many pattern rules due to pulse device features and limitations.

RF Synchronization

for KEKB

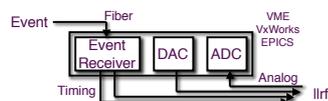


for PF



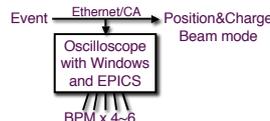
- ◆ Automatic injection program (or human operator) may change the beam mode pattern request several times a minutes
- ◆ Typical operations at April-June 2009 was
 - ◆ KEKB HER 0~12.5Hz
 - ◆ KEKB LER 0~25Hz
 - ◆ PF 0~0.5Hz
- ◆ As stable operation was achieved, the rates will be lower in the autorm run.

LLRF Controls



- ◆ Slow rf controls were replaced with fast event systems.
- ◆ Timing and analog signals are essential for absolute energy, energy spread, and dual-bunch energy equalization.
- ◆ Signals can be switched pulse-by-pulse at 50Hz.
- ◆ Driver klystrons (SB), energy tuner klystrons (KL), and sub-harmonic bunchers (SH) are managed.

Beam Instrumentation



- ◆ Tektronix DPO7104 with embedded EPICS can acquire data at 50Hz.
- ◆ Beam modes are recognized by events through network.
- ◆ Positions and charges are calculated with corresponding calibration factors.
- ◆ Clients can monitor data of an interested beam mode.
- ◆ 100 BPMs covered by 24 oscilloscopes are synchronized.

Summary

- ◆ The system successfully runs since summer 2008.
- ◆ Simultaneous injections are carried for 3 rings.
- ◆ Beam current stabilities (as of June 2009)
 - ◆ KEKB HER / LER : within ~1mA for 1100~1600mA (at 12.5 - 25Hz)
 - ◆ PF ring : within ~0.05mA for 450mA (at 0.5Hz)
- ◆ It helped luminosity tuning with crab cavities.
- ◆ It should be the basis of SuperKEKB design.
- ◆ Will be further improved
 - ◆ Integrity monitor system
 - ◆ Beam and equipment monitor system