MOPGF035

Control System Status of SuperKEKB Injector Linac

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Introduction

The KEKB project has completed in the June of 2010. The Super KEKB project has started for aiming at the peak luminosity of 40 times higher than that of former KEKB project. The electron/positron injector linac upgrade is going on for increasing the intensity of bunched charge with keeping the small emittance. In this linac upgrade, main issues are the construction of positron damping ring, the development of a new positron capture system based on the flux concentrator and large aperture S-band accelerating structure for increasing the positron charge of four times previous project, and the operation of a low emittance photo-cathode rf electron gun. Linac beam commissioning started in the Oct. of 2013. For accelerating and enhancing the beam commissioning efficiency, the whole control system performance is getting important more and more.

Required Parameters for SuperKEKB Injector Linac

e- beam parameters

	SuperKEKB	KEKB
Energy (GeV)	7.0	8.0
HER stored current (A)	2.6	1.1
HER beam lifetime (min.)	6	200
Maximum beam repetition (Hz)	50	50
Max. # of bunch in an rf pulse	2	2
Emittance (mm·mrad)	50/20 (Hor./Ver.)	310
Charge (nC)	5	1
Energy spread (%)	0.1	0.05
Bunch length σz (mm)	1.3	1.3
Damping ring	-	-
Simultaneous top-up injection	4 rings (SuperKEKB e-/e+, PF, PF-AR)	3 rings (KEKB e-/e+, PF)

e+ beam parameters

	SuperKEKB	KEKB
Energy (GeV)	4	3.5
LER stored current (A)	3.6	1.6
LER beam lifetime (min.)	6	133
Maximum beam repetition (Hz)	50	50
Max. # of bunch in an rf pulse	2	2
Emittance (mm·mrad)	100/20 (Hor./Ver.)	1400
Charge (nC)	4	1
Energy spread (%)	0.07	0.125
Bunch length σz (mm)	0.7	2.6
Damping ring	○	-
Simultaneous top-up injection	4 rings (SuperKEKB e-/e+, PF, PF-AR)	3 rings (KEKB e-/e+, PF)

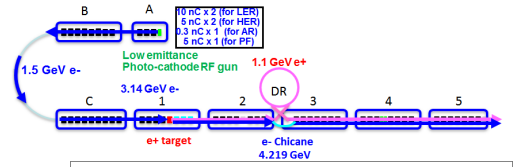


FIG. 1: Schematic drawing of SuperKEKB injector linac.

Control System Overview

- EPICS based Control System
  - Base R3.14.9, R3.14.12.X
  - EPICS Archiver, EPICS CSS Archiver
  - EPICS CSS Alarm
- Server machines (x17)
  - CentOS 5.11 (x86_64)
  - HP blade BL460c G1, BL680c G5, 1U/2U server
- Storage: NetApp FAS3220, FAS2040, FAS2020
- Operation terminal machines (x10)
  - PC (Windows 7/CentOS 5.11)
- HLA development
  - Python, SAD, MEDM, CSS
- Network
  - Core: C3750-X (x6) for
  - Edge: C2960S (x48), Buffalo BS-G2024MR (x14)

- Three large LCDs (55") show alarm status, operation status, and safety status.
- Sixteen LCDs (27") are used for the beam operation and software development.
- Four LCDs (19") are used for the X-band accelerating stand statuses.

FIG. 2: Linac control room.

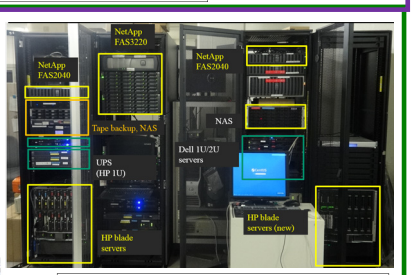
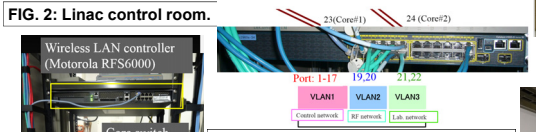


FIG. 3: Photograph of Linac server racks.



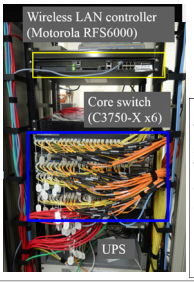


FIG. 4: Photograph of core switch and wireless LAN controller.

FIG. 5: Edge switches using port VLANs are connected to the core switch via optical fiber (1 Gbps). The Virtual Switching SystemTtrechnology enables the redundant network connections (active-active operation). Edge switch and local controller (like PLC) are connected via 100 Mbps (FXC media converter).

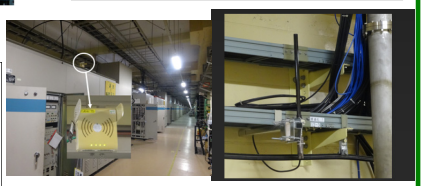


FIG. 6: Photograph of Access point for klystron gallery. Aruba-AP65.

FIG. 7: Photograph of collinear antenna for Wireless LAN in the linac tunnel. 10

Local Controllers and EPICS IOCs

TABLE1 : # of local controller.

Devices	Accelerator components (# of components)	# of controllers (385)
VME64x	Event-based timing system (MRF EVG-230, EVR-230RF)	25
PLC	Magnet (363)	59
	Vacuum (333)	26
	Klystron (5)	5
	Charge integration interlock	3
Network attached power supply	Magnet (105)	105
Linux-based PLC	Profile monitor (100)	30
Embedded Linux	Klystron (66)	66
Data logger (CHINO)	Temperature (690)	28
	Timing watchdog (15)	15
Oscilloscope	BPM (90)	23

TABLE 2 : # of EPICS IOC.

Group	# of IOCs (153)
Safety	2
Monitor	48
RF	57
Magnet	19
Vacuum	1
Operation	3
Timing	21
Temperature	2

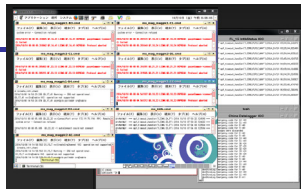


FIG. 8: EPICS IOCs and CA gateways are running inside VNC. For more efficient management, other methods to manage them like casave, procServ, and etc. are now under consideration.

- Many ladder PLC and VME based modules are utilized as the local controllers. EPICS IOCs for them are running on the blade based servers. Different IOCs are running inside the different vncservers of same blade servers. Some embedded devices (like Linux-based PLCs, oscilloscopes, and Embedded Linux Armadillo) , IOCs are directly running on them. Towards SuperKEKB operation, # of IOCs will be increased, and the efficient managements of them could be important issues for the robust beam operations.

High Level Applications

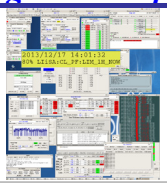


FIG. 9: Display example of operator console. Almost all HLA panels were developed by Python scripting language.

FIG. 10: Linac alarm display based on Python. CSS alarm (Ver. 3.0.0) and PostgreSQL (Ver. 9.1.4).

FIG. 11: Web-based linac operation status.

FIG. 12: Web-based linac operation eLog. The eLog was implemented by using Flex Ver. 4.5.1 and PostgreSQL Ver. 9.4.0. Sequence operation like changing the beam repetition can be automatically recorded. The pictures of beam orbit panel and beam profile can be embedded.

Archiver System

- EPICS channel and CSS archivers (CSS Ver. 3.2.1 and PostgreSQL Ver. 9.1.4/9.3.3) are available.
- # of registered PVs: 44063
- Required disk space: 2 GB/day (channel archiver), 4.5 GB/day (CSS archiver).
- Channel archiver
  - Archiver viewer is Java based one.
- CSS archiver
  - Archiver viewer is Web-based one developed in-house (Flex Ver. 4.6, PHP Ver. 5.3.6, and Amfphp Ver. 1.9)
    - Easy to access logging data via any kinds of Web browsers.
    - Correlation plot, multi vertical axes, PV name search/autocomplete functionalities.
    - pg_reorg option of PostgreSQL is effective for increasing the read speed performance and reducing the required disk space (2/3).
- CSS archiver issues
  - Performance improvement (data retrieve speed)
    - NoSQL backend like Casandra is now being evaluated.
  - CSS archiver sometimes stop running w/o any error.
  - CSS archiver sometimes includes null data.

TABLE 3: List of PVs registered for channel/CSS archivers.

Group	# of PVs
Klystron	1838
Vacuume	405
Temperature	694
Environment	324
Magnet	5410
PF ring	70
RF phase monitor	808
Safety	690
Operation	45
Event based timing system	6245
Timing	84
Alignment	151
Slow positron facility	30
Test	5
Beam position monitor	27180
Injector (rf gun related)	84
Total #	44063

FIG. 13: EPCIS CSS archiver viewer is accessible via Web browser.

Summary and Future Plan

•Since the middle phase of KEKB operation, the linac beam control system has been gradually transferred from the in-house system based on RPC to EPICS based one. Towards SuperKEKB project, the injector linac upgrade and commissioning is now on going for aiming at the 4 ring simultaneous top-up operation.

•For accelerating the beam commissioning, the rapid development of effective commissioning tools and management them are getting important more and more.