

CONTROL INTERFACE OF PULSE MAGNET POWER SUPPLY FOR TPS PROJECT

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Abstract

The TPS (Taiwan Photon Source) is low emittance 3 GeV synchrotron light source. The design and implementation of a pulse magnet power supply control system for beam injection and extraction were done. The EPICS embedded programmable logic controller (PLC) was applied to control pulse magnet power supply. The system comprises various input/output modules and a CPU module with built-in Ethernet interface. The control information (status of the power supply, ON, OFF, warn up, reset, reading/setting voltage, etc.) can be accessed remotely using EPICS client tools. The TPS timing system provide trigger signals for pulse magnet power supplies. The Ethernet-based oscilloscope is employed to observe current waveform of pulse magnet power supply with EPICS support. This paper describes control interface and operation GUI for the TPS pulse magnet power supply.

INTRODUCTION

The TPS [1] is a latest generation of high brightness synchrotron light source which has been under construction at the National Synchrotron Radiation Research Center (NSRRC) in Taiwan since February 2010. The civil construction works are finished in early 2014. The TPS pulse magnets consist of booster injection septum and kicker, booster extraction septums and kickers, storage ring injection septum and kickers, and storage ring diagnostic kickers (pingers). The pulse magnets installation and system integration were done soon after site available. The pulse magnets power supplies functionalities and performance were successfully verified with beam commissioning [2].

Table 1 lists main parameters of TPS kickers and septa pulse magnets. The EPICS IOC embedded PLC, F3RP61-2L IOC, was adopted for the pulse magnet power supply control. The F3RP61-2L IOC is compact, easy troubleshooting, and cost effective for pulse magnet power supply control. The pulse magnet power supply (pulser) requires small amount of I/O points, therefore, the F3RP61-2L IOC is more suitable compared with the applications of the TPS standard 6U CompactPCI platform with high I/O density.

The EPICS [3] was adopted as the TPS control system framework. A typical PLC in control environment is supervised by a remote IOC through serial link or Ethernet connections. It needs more work for developing both side of control software compared with using F3RP61-2L IOC. This report will summarize the pulse magnets power supplies related control environment, functionalities and measurement.

Table 1: Main Parameters of TPS Pulse Magnets

Magnet Type	Type	Operating Current (A)	Pulse Duration (μ s)	Quantity
Booster Injection Kicker	PFN	~250	~1	1
Booster Extraction Kicker	PFN	~350	~1	2
Storage Ring Injection Kicker	Half-sine	~1100	~5	4
Storage Ring Pinger	Half-sine	-	~3	2
Booster Injection Septum	Half-sine	~2300	~400	1
Booster Extraction Septum	Half-sine	~10000	~400	2
Storage Ring Injection Septum	Half-sine	~10000	~400	2

SYSTEM CONFIGURATION

The control environment for TPS pulse magnets power supplies is shown in Fig. 1. The F3RP61-2L IOC is used to monitor status and control the pulse magnets power supplies. To support remote access of the current waveforms, oscilloscopes are managed by one dedicated EPICS IOC. To capture current transformer waveform of pulse magnets power supplies, the LAN extension for Instrumentation (LXI) or Ethernet-base oscilloscopes are connected to EPICS IOC via Ethernet interface.

Event based timing system is implemented to support commissioning and operation for the TPS [4-5]. The timing system is based on the events coming from event generator (EVG). EVG handles the accelerator synchronization and trigger the injection and the extraction pulse device. The timing IOC equipped with event receiver (EVR) will distribute trigger signal of the pulse magnets power supplies to synchronize the operation of the accelerator system. The TPS pulse magnets power supplies will be operated in 3 Hz repetition rate.

The I/O modules configuration of Yokogawa F3RP61-2L IOC is shown in Fig. 2. It includes power supply module, 16 bit digital input module, 16 bit digital output module, 8 channel analog input module (16 bit ADC) and 8 channel analog output module (16 bit DAC). The I/O modules are mastered by F3RP61-2L CPU module. The interlock function of pulse magnet power supply is handled by local hardware circuits. It uses relay and timer

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relay to implement interlock logic and warm up procedure. Fig. 3 shows TPS pulse magnets power supplies rack and EPICS IOCs in the equipment area.

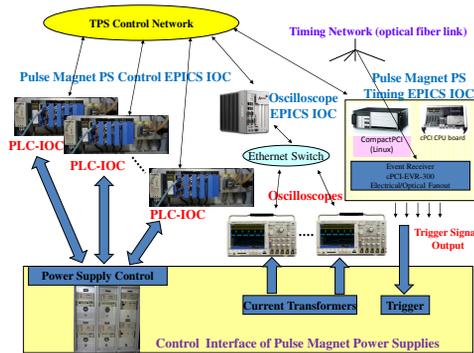


Figure 1: Control environment of TPS pulse magnets power supplies.

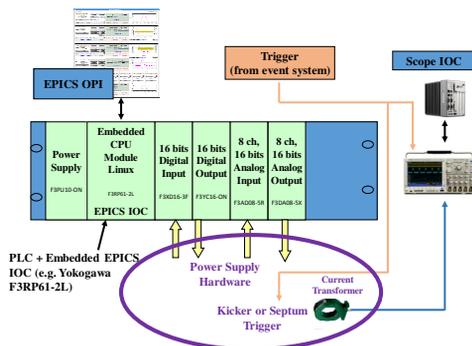


Figure 2: EPICS IOC layout for TPS pulse magnet power supply control.



Figure 3: TPS pulse magnets power supplies rack and EPICS IOCs rack.

SOFTWARE ENVIRONMENT

The F3RP61-based IOCs were adopted for the control systems of KEKB, J-PARC and RIKEN RI Beam Factory [6-7] successfully. The Yokogawa F3RP61-2L CPU complies with FA-M3R form factor and EPICS installed. I/O modules could be accessed by the F3RP61-2L CPU module running Linux. The Yokogawa company provides Embedded Linux Development Kit (ELDK) and Board Support Package (BSP) for F3RP61-2L module. The development server with the RHEL 5.x operation system is used to develop the F3RP61-based EPICS IOC.

The dedicated Linux system is installed in the Flash memory of CPU module. The cross-compile libraries for

the EPICS programs are placed on the development server for developing IOC-related control applications easily. The F3RP61-2L IOC downloads the executable file of iocCore after the boot up by use of the Network File System (NFS) from the development server.

OPERATION INTERFACE

At the commissioning phase, the TPS control system adopts the EDM (Extensible Display Manager) toolkit to develop graphical operation interface. The EDM based GUIs of pulse magnets power supplies are executed for the control consoles via the NFS service and are shown in Fig. 4-6. All control pages are launched from the TPS main page. These control pages show critical information for observing status clearly, and major operation functions are also executed from these pages. The related timing parameters (trigger enable and delay value) and pulse magnet current waveform are also located at the same page for tuning easily as shown in middle and right side of Figs. 4-6.

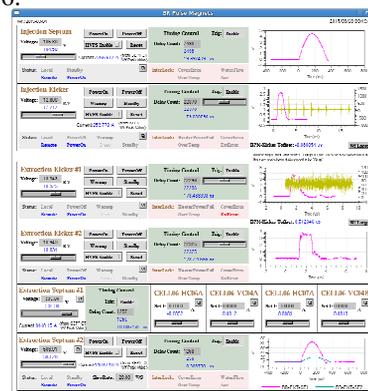


Figure 4: TPS BR injection/extraction kickers and septa power supplies control page.

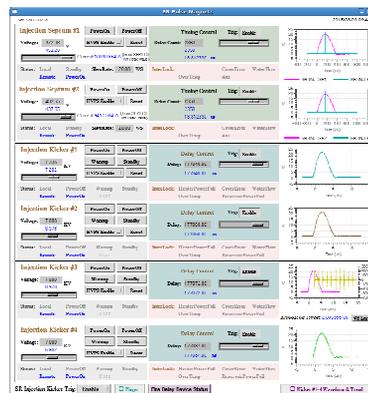


Figure 5: TPS SR injection/extraction kickers and septa power supplies control page.



Figure 6: TPS storage ring pinger power supplies control page.

WAVEFORM ACQUISITION OF PULSE MAGNETS

The standalone fanless PC-based platform which runs the Linux operation system had been set up as the dedicated soft-IOC to connect with oscilloscopes via Ethernet interface. The IOC uses the VXI-11 or TCP protocol to communicate with the LXI/Ethernet-based oscilloscopes. The control console can observe the waveform data by using specific OPI toolkits (EDM, MATLAB and CS-Studio) through EPICS PVs channel access [8].

To implement the EPICS support of LXI/Ethernet-based oscilloscopes, the device support was built to communicate with the device driver through the asynDriver module [9]. The related record support was created with link to the device support. Two types of oscilloscopes had been used for TPS pulse magnet as shown in Table 2. Remote access current transformer (CT) of pulse magnets power supplies from oscilloscopes were implemented to eliminate requirements of long distance cabling and to improve signal quality.

Table 2: Oscilloscopes for TPS Pulse Magnet

Device	Waveform Length	Purpose
Tektronix DPO4000	10K	BR Septum CT, BR Kicker CT SR Septum CT, SR Pinger CT
Agilent DSO9000H	20K	SR Injection kicker CT

The DPO4000 are used for observing current transformer waveform of pulse magnets power supplies. Specially the DSO9000H is higher resolution oscilloscope and used for observing and analysing waveform of storage ring injection kickers current transformer in detail at every shot as shown in Fig. 7.

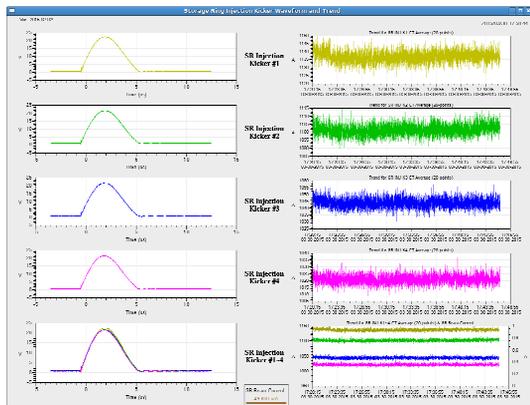


Figure 7: Long-term parameters trend display of storage ring injection kickers and comparison with kickers.

The benefits of EPICS waveform supports is that oscilloscopes waveform can be displayed remotely and users can easily to analyse the acquired waveform data by using EPICS CA Clients (C, MATLAB, Java, Python, LabVIEW ...) on the control consoles. The MATLAB script is used to calculate peak value of acquired

waveform data of pulse magnet power supplies and publish PV in every shot. These PVs are helpful to roughly check stability of pulse magnet power supply. Fig. 8 shows long-term stability trend display for extraction kickers and septa of booster synchrotron.

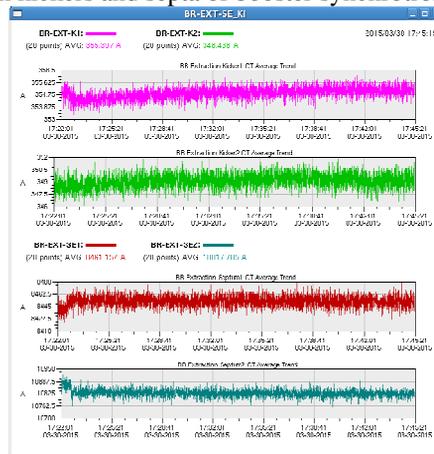


Figure 8: Long-term stability trend display for extraction kickers and septa of booster synchrotron.

SUMMARY

The TPS control system adopts the EPICS framework as control infrastructure. The embedded EPICS IOCs of pulse magnets power supplies were set up. Operating supports of pulse magnets power supplies are also developed and used to commission with beam. Functionalities and performance of the control environments have been proved and satisfied the design goals.

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