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STUDY OF SOLUTIONS FOR INTERFACING ILSF BEAM DIAGNOSTICS TOOLS TO CONTROL SYSTEM

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Abstract

There is an ongoing study at Iranian Light Source Facility (ILSF) aims to determine control solutions for a variety of diagnostics tools that will be placed at various locations around the facility. In this paper, an overview of the possible control solutions with a focus mostly on the low-level part of the control system is reported.

INTRUDUCTION

The ILSF synchrotron light source is under design and construction and now that the basic design phase of the diagnostics subsystems is finished, our job in the control and diagnostics group is to study and document the possible control solutions for each diagnostics tools. However, the study is still in progress and our choices are not finalized yet. The diagnostics tools we will discuss in this paper are Fluorescent Screen (FS) and Optical Transition Radiation (OTR) systems, Beam Loss Monitors (BLM), Fast Current Transformer (FCT), Integrating Current Transformer (ICT), Faraday Cup (FC), and Direct Current Transformer (DCCT). These tools are categorized into three sections and the control solution is discussed for each one.

CAMERA BASED DIAGNOSTICS TOOLS

Camera based diagnostics tools have applications in measuring the size and profile of the beam. There are several FS/OTR and SRM stations at various locations around the facility. Table 1 summarizes the location and controllable components for each of these tools.

Table 1: Camera Based Diagnostics Tools and their Controllable Components

Tool	Location	Qty.	Controllable Component
FS/ OTR	Linac Diagnostics line, LTB, Booster, BTS, Storage ring	20	Stepper Motors, CCD Cameras, Single-Board Computers
SRM	LTB, Booster, BTS, Storage ring, Diagnostics beamline	9	Streak Camera, CCD Cameras

The standard we choose to transfer the image data from the camera to the IOC depends on the required frame rate and the image quality. For a typical 2-4-megapixel camera that we will use in FS/OTR systems, we presume that the required speed demand will not exceed 1000 Mbps. This makes the GigE solution a good choice in terms of much longer cable it supports compared to the Firewire, and also, its simplicity and much lower cost compared to other non-Ethernet based standards.

For the Streak camera, with a high bandwidth demand of about 2 Gbps, we will use CoaXPress (CXP) interface to send data from the camera to a frame grabber that is installed on a PC workstation. In the future, depending on the community support and commercial availability of the required equipment, other network-based solutions like 10 GigE might be used as well. Table 2 gives a summary of camera based diagnostics tools control specification and its IOC platform.

Table 2: Control Requirements and IOC Platform for the Camera Systems

Camera	Interface	Data Rate	Frame Grabber	IOC
CCD Camera	GigE	320 Mbps	No	PC
Streak Camera	CXP	2000 Mbps	Yes	PC

All camera systems have PC-based IOCs. This PC runs the camera EPICS IOC, areaDetector modules [1], and applications such as ImageJ to calculate some parameters and visualize the image data.

A simplified layout of the control interface of the camera based diagnostics tools at ILSF is shown in Fig. 1. There will be one workstation PC in the instrumentation area that is used as the EPICS IOC for FS/OTR and SRM cameras. Another workstation PC that hosts the CXP frame grabber is used as the EPICS IOC of the streak camera and SRMs that are located in the diagnostics beamline. The latest one will be located somewhere near the beamline instrumentation area to ease the access of the engineers to it.

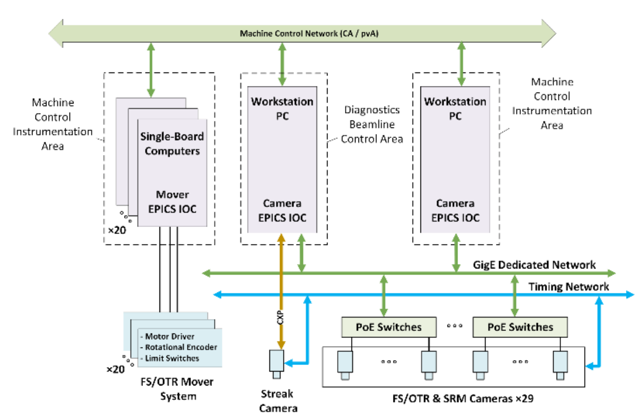

Figure 1: An example of the possible control solution for camera based diagnostics tools.

Each FS/OTR stations has a mover system that is controlled by a single-board computer (e.g. BeagleBone Black). The board runs soft IOCs to interface the mover

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system with the EPICS channel Access. Similar solution is proposed for the scraper mover system.

BEAM LOSS MONITORS

Bergoz single-ended type BLMs will be installed outside of the BR and SR vacuum chambers, mostly near the possible loss locations (e.g. near dipole magnets, insertion devices, scrapers, collimators, and downstream of RF cavities; see Table 3). The output of each sensor is a 50-ohm positive TTL pulse which can be sent through a coaxial cable to a counter unit.

A complete solution to interface BLM sensors to the control system is presented by Cosylab [2]; in which, a central unit runs the EPICS IOC and the BLM sensors can be connected to the central unit, either directly, or in a daisy chain, through signal conditioner (BSC) units. Another option for us is to use MTCA based solution, in which, the existing MicroTCA crates of the BPM system hosts the scaler AMC boards in order to receive BLM signals. This way, the timing AMC as well as other resources in the MTCA crate can be shared between multiple diagnostics systems and it might bring us better performance.

Table 3: Location of BLM Sensors and Their IOC Platform

Location	Qty.	IOC
Near to the booster dipole magnets	55	MTCA
Near the storage ring dipole magnets	100	MTCA
Downstream of the RF cavities	6	MTCA
Near to the insertion devices	7	MTCA
Next to the collimators and scrapers	4	MTCA

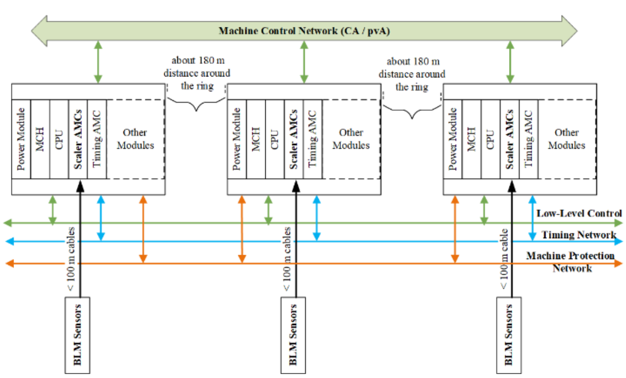

Figure 2: An example of the possible solution for interfacing the BLM system to the control system.

The circumference of the ILSF storage ring is 528 m and the crates will be placed in the control instrumentation areas around the storage ring. As shown in Fig. 2, BLM signals will be distributed between three MTCA crates in a way that the length of the cabling between a particular sensor and its associated AMC does not exceed 100 m. This way we do not have to amplify the sensors signal.

ANALOG DIAGNOSTICS TOOLS

Some diagnostics tools like FCTs, ICTs, and the Faraday Cups have analog output signals. For now, it is not decided to use these signals as input for feedback system. However, we need to visualize the signal, calculate some parameters, and send the data in form of PVs to the EPICS control network. For the sake of simplicity and ease of signal visualization, we employ a couple of oscilloscopes to view and digitize the output signal of these diagnostics tools (see Table 4).

Most modern oscilloscopes have USB or Ethernet port to communicate with a PC. This can PC host a proper EPICS hardware supports for the oscilloscopes and runs the EPICS IOC to interface oscilloscopes to the channel access or pvA network (see Fig. 3). It also runs applications such as Matlab, LabVIEW, etc. to calculate the required parameters and send them over the control network so that other EPICS clients can access or monitor them. Depending on the control demand in the future, we might use PXI or PCI digitizer cards for this purpose as well.

Table 4: Analog Diagnostics Tools and Their Controllable Components and IOC Platform

Tool	Location	Qty.	Controllable Component	IOC
FCT	Linac, LTB, BTS,Storage Ring	9	Oscilloscope 4GSa/s, 1GHz	PC
ICT	LTB	2	Oscilloscope 2GSa/s, 1GHz	PC
FC	Linac Diagnostics line	1	Oscilloscope 2GSa/s, 200MHz	PC
DCCT	Booster, Storage Ring	2	18bit Digital Multimeter	PC

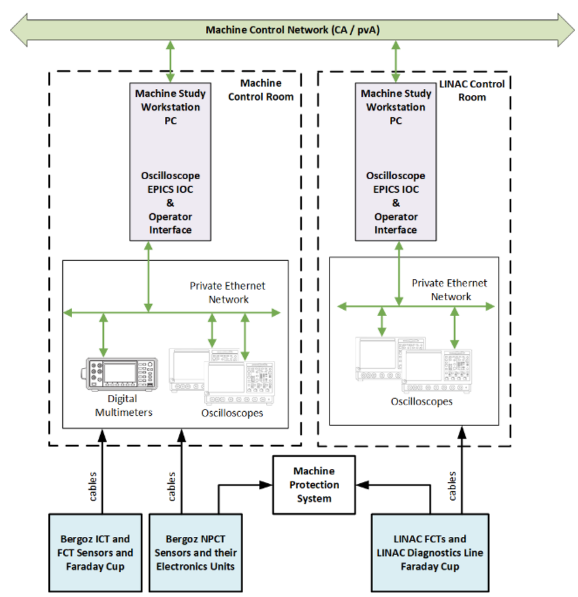

Figure 3: An example of the possible solution for interfacing analog diagnostics tools to the control system.

DCCTs are other diagnostic tools with analog output signal. Both of the storage ring and the booster ring will be equipped with a DCCT (Bergoz NPCT) together with its

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associated electronics that provide the analog output proportional to the average beam current that flow through it. Similarly, the output signals of DCCTs can be connected to digital Multimeters that communicates with the EPICS IOC PC via Ethernet. The digital Multimeters may have at least 18-bit resolution in order to have good accuracy in calculating the beam lifetime. As it is shown in the Fig. 3, the same PC as the one used for FCTs, ICTs, and Faraday Cup will be used for this purpose. This PC is responsible for calculating machine parameters and serving the EPICS clients too. To check the interlock thresholds related to the beam current, the output signals of the Faraday Cup and the DCCTs will be delivered to the machine protection system as well.

SUMMARY

We presented our progress in the ongoing phase of the study of possible control solutions for some of the ILSF diagnostics tools. We presented simplified layouts of control solutions for camera based diagnostics tools, mover systems of FS/OTR and scrapers, BLM system, and analog diagnostics tools. The next step is to choose between the solutions studied, and build prototypes and test benches accordingly.

REFERENCES

[1] https://epics-controls.org/resources-and-support/modules/soft-support/.

[2] M. Kobal, J. F. Bergoz, J. Dedic, and R. Stefanic, "A Complete Solution for Beam Loss Monitoring", in *Proc. 11th European Particle Accelerator Conf. (EPAC'08)*, Genoa, Italy, Jun. 2008, paper TUPC050, pp. 1170-1172.