

## STATUS OF THE PAL-XFEL CONTROL SYSTEM

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### Abstract

Pohang accelerator laboratory (PAL) started an x-ray free electron laser project (PAL-XFEL) in 2011 [1]. In the PAL-XFEL, an electron beam with 200 pC will be generated from a photocathode RF gun and will be accelerated to 10 GeV by using a linear accelerator. The electron beam will pass through undulator section to produce hard x-ray radiation. In 2015, we will finish the installation and will start a commissioning of the PAL-XFEL. In this paper, we introduce the PAL-XFEL and explain present status of it. Details of the control system will be described including a network system, a timing system, hardware control systems and a machine interlock system.

### PAL-XFEL

Figure 1 shows a bird eye’s view of the PAL facilities which is taken in the April 2015. A circular building in right hand side is the storage ring of the Pohang Light Source (PLS-II) and a new long building on the left hand side is the PAL-XFEL. The building construction was started in 2012 and it was finished at the end of 2014.

The length of the PAL-XFEL building is 1.11km which is consist of a 700 m long linear accelerator, a 250 m long undulator hall, and another 60 m long beam line hall. 10 GeV electron beam can be obtained from the 700 m long linear accelerator and 0.1 nm wavelength hard x-ray can be generated from the electron beam by using the self amplification of the spontaneous emission (SASE).

The total budget is 400 million US dollar and the project period is from 2011 to 2015. Installation of the components of the accelerator was started from the beginning of 2015.

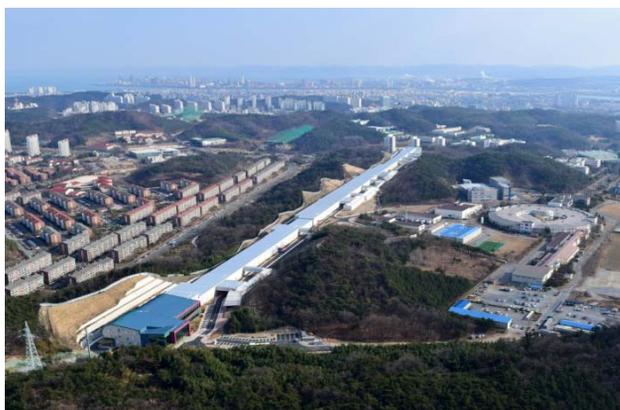


Figure 1: Pohang Accelerator Laboratory.



Figure 2: Pohang Accelerator Laboratory.



Figure 3: Pohang Accelerator Laboratory.

Figures 2 and 3 show the klystron and modulator gallery and inside of the linear accelerator tunnel, respectively. 51 klystrons and modulators and 174 accelerating columns will be installed up to end of 2015.

### CONTROL SYSTEM

The PAL-XFEL control covers a large range of hardware and software. An Experimental Physics and Industrial Control System (EPICS) will be used for the control system of the PAL-XFEL. A powerful network system was installed and a large number of Input Output Controllers (IOCs), for example about 700 magnet power supplies, will be connected to a high level control system. An event timing system will be used to send trigger signals to all the equipment and RF distribution system will be ready to supply the 2856 MHz RF signal for S-band RF stations. In addition, a machine interlock system will be prepared to protect important equipment.

Figure 4 shows the network system layout and core switches with Fiber Distribution Frames (FDFs). Duplicated core switches were installed for safety and local switches were connected to them by using 1 Gigabit or 10 Gigabit bandwidth optical fiber.

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Figure 4: Network core switches and FDFs.

An event timing system will be used to generate the trigger signal. Figures 5 and 6 show layout of the event timing system and the event generator, respectively. 476 MHz signal from RF distribution system and 360 Hz signal from AC power are provided to a VMTG to make 119 MHz which is synchronized with AC power. 119 MHz and 360 Hz signal go to the event generator to produce 60 Hz trigger signal.

Figure 7 shows layout of the RF distribution system. To generate RF power from 51 klystrons and modulators, 2856 MHz signal should be provided to them, however, such a high frequency can have serious loss in a long RF coaxial cable, so that 479 MHz signal will be generated from a Dielectric Resonator Oscillator (DRO) and sent along the linear accelerator by using a RF coaxial cable.

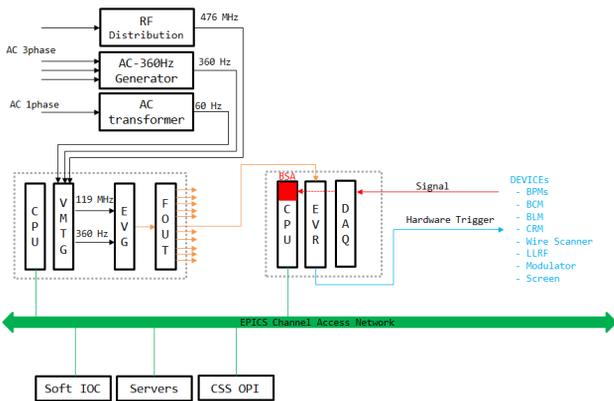


Figure 5: Event timing layout.

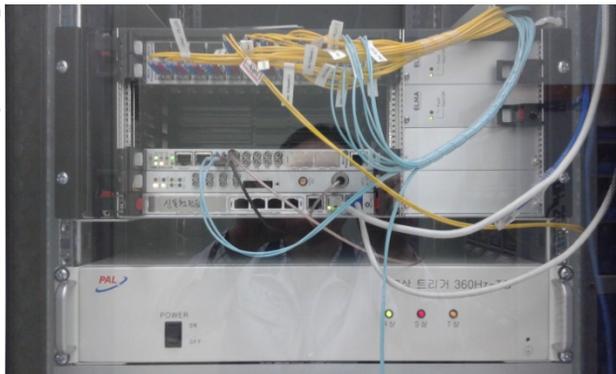


Figure 6: PAL-XFEL event generator.

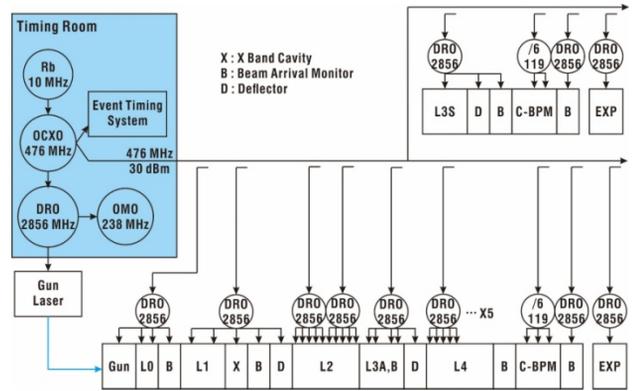


Figure 7: RF distribution system.

The RF coaxial cable will be installed inside the temperature controlled box on a tray along the linear accelerator.

Figure 8 shows modulator with its controller. Yokuga-wa Programmable Logic Controllers (PLCs) are used for modulator control and an EPICS module is installed to make an EPICS IOC.

Figure 9 and 10 show installed undulators inside the undulator hall and its control layout, respectively. A Microsoft Windows based, real time capability, embedded pc controller is connected by using an EtherCAT network to a server motor driver which moves motors of the undulator.



Figure 8: Modulator and its control system.



Figure 9: Installed undulator in undulator hall.

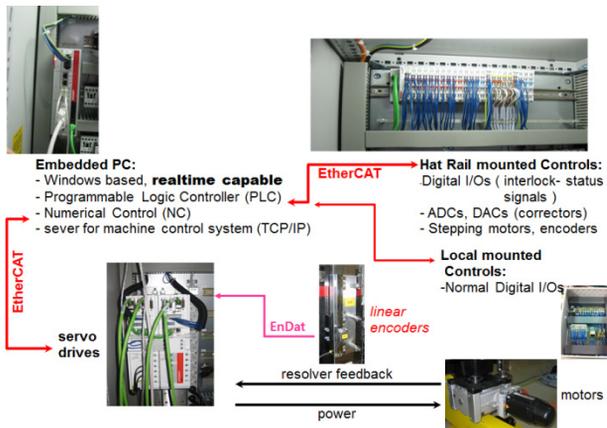


Figure 10: Undualtor control layout.

Figure 11 shows an uTCA based Beam-Position-Monitor (BPM) electronics. The BPM electronics consist of a chassis, a central processing unit, a channel manager, a network card, an event receiver, and analogue digital converters with rear transition modules. BPM electronics can measure the beam position with a time stamp which is generated by event timing system to make a beam synchronous acquisition.



Figure 11: uTCA based BPM electronics.

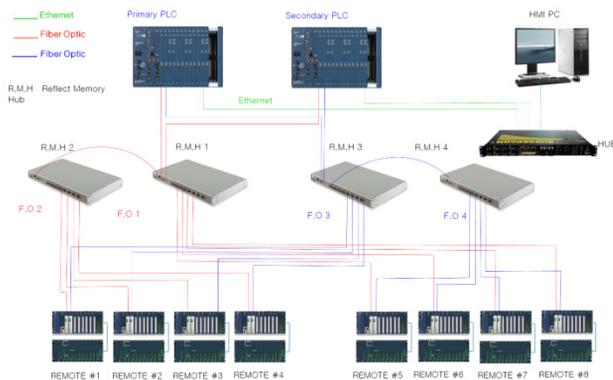


Figure 12: Machine interlock system layout

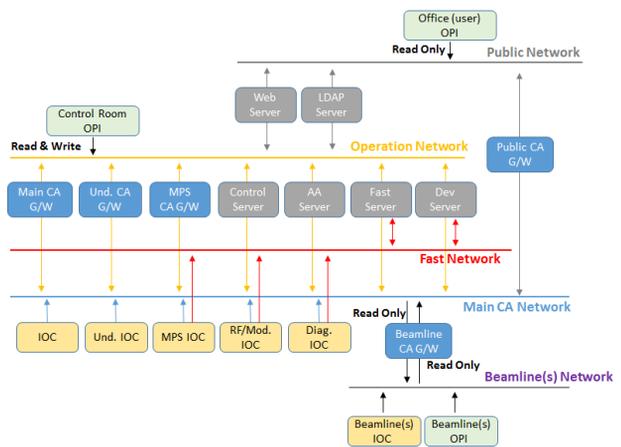


Figure 13: Control server connection.

Figure 12 shows layout of the machine interlock system. The machine interlock system will make interlock signal to protect critical component such as permanent magnets of an undulator which should be protected from a high energy electron beam. The machine interlock system will have duplicated main PLCs and local PLCs which are connected by optical fiber to reduce the communication time.

Figure 13 shows control servers and their network connections. There will be a public, an operation, a main channel access, a fast data, and a beamline network. Operation status can be monitored by using a web server and outside access will be controlled by a public gate way in the public network. Operation interfaces in the control room will be connected to control servers and gateways by using the control network. Local IOCs will be connected by main channel access network and protected by gateways from direct access of operators or outside users. The fast data network will be prepared for 60 Hz real time data transfer between IOCs and the fast data server.

### SUMMARY

The PAL-XFEL will be installed until the end of 2015 and start commissioning in the beginning of 2016. After 1 year of commissioning it will be opened to public for user experiments. From the network system to the various kinds of servers, the control system of the PAL-XFEL is under construction and will be ready for the successful commissioning of the PAL-XFEL.

### ACKNOWLEDGMENT

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### REFERENCES

[1] H.-S. Kang et al., "Status of the PAL-XFEL Construction", in proceedings of IPAC2015, Richmond, VA, USA (2015), p 2439.