CURRENT STATUS OF THE CONTROL SYSTEM FOR J-PARC ACCELERATOR COMPLEX

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Abstract

J-PARC is a large scale facility of the proton accelerators for the multi-purpose of scientific researches in Japan. This facility consists of three accelerators and three experimental stations. Now, J-PARC is under construction, and LINAC is operated for one year, 3GeV synchrotron has just started the commissioning in this October the 1st. The completion of this facility will be next summer.

The control system of accelerators established fundamental performance for the initial commissioning of LINAC and RCS. The most important requirement to the control system of this facility is to minimize the activation of accelerator devices. In this paper, we show that the performances of each layer of this control system have been achieved in the initial stage.

OVERVIEW OF FACILITY

The H^-beam is generated at the Ion source of LINAC, and accelerated up to 181MeV, 5mA, 500us, 25Hz. Next, the beam goes through charge exchanger foil at the injection part of 3GeV-RCS (Rapid Cycle Synchrotron) and the proton beam is accelerated to 3GeV in 20ms. Most of the output beam of RCS are carried to MLF (Material and Life Science Facility, neutron beam experiments station), but four pulses switch to 50GeV-MR(Main Ring) in each 3.5sec cycle.

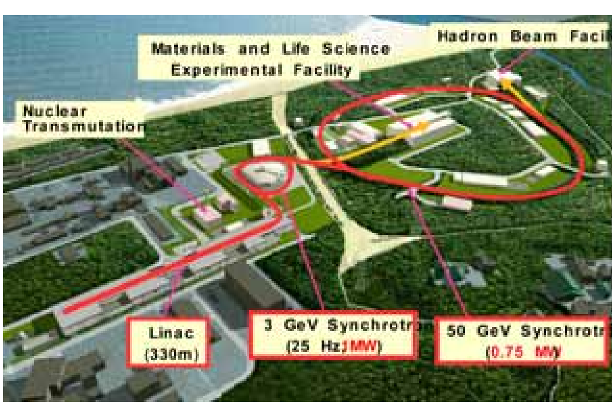

Fig.1 Overview of J-PARC site

MLF receives the proton beam at the liquid mercury target, and several mechanical shutters for the neutron beam are operated with synchronization of the beam repetition. In future, 23 neutron beam lines will be settled for many kind of experiment. MR provides accelerated proton beam to two facilities. One is Hadron Beam Facility for the elementary particle physics, and the other is neutrino experimental station. In the 2nd phase of this project, LINAC provides the extra-high power beam to ADS (Accelerator Driven Spallation Source).

SAFETY SYSTEM ARCHITECTURE

High power proton beam handling should be cared with minimization of beam loss for reducing activation. For this purpose, four layers work in each function. The radiation measurement system always checks radiation level at static points, and the quantity of personnel contamination is managed. The second layer is PPS (Personnel Protection System). PPS makes the boundary condition of the closed space which is allowed the existence of the beam. The third layer is MPS (Machine Protection System). MPS senses device errors, and works to stop the beam immediately. Input signals of MPS are not only device errors but the threshold of the beam loss monitors. The top layer is computer control system. The parameter database of this layer must be matured for intellectual check of the range of suitable parameters of all devices.

PPS

PPS hardware has full dual configuration, and even if the single device error occurs, fundamental function can be unaffected. The spacial area is defined to each operation mode, and changing mode is established without interruption of the beam operation. PPS adopts the two methods of intercepting beam by the difference between the operation condition of the high-power equipment and the boundary condition of a human safety viewpoint. When the hard blocking activates, it is not considered to need the start up time, and the power supply of a high voltage is compulsorily intercepted. The soft blocking activates at the logic error of condition that doesn’t influence human safety. After the faraday cup is inserted, the pulse timing is moved and operation is restarted so that the heat load of the equipment should not be changed. PPS also carries out the function to manage the person’s going in and out. It operates correspond to the radiation safety system, and the person who goes in and out should pass the confirmation of both systems.

In this summer, the covering area of PPS had been extended adding RCS area to LINAC area. Under the beam operation of LINAC, same logical configuration of PLCs was built offline, and tested to merging area. There was only one system error caused of a loose connection of the built-in key switch (this is not dual) in a door after the accelerator operation had started.

MPS

MPS works to protect the material of devices from the damage of the high power beam. It is necessary to stop the beam before the beam orbit comes off because of the breakdown of any equipment causes the error of the electromagnetic field. In other word, it is the principle that the beam is stopped when something happens. Actually, the radiations are previously detected earlier than the breakdown of the equipment. MPS received the integrated signal of the beam loss monitors. Especially in the low energy region of LINAC, the tolerable quantity in which a plastic deformation of copper is severe, and this limitation defines the design value of the response time of MPS. The signal which is connected fast circuit module of LINAC MPS causes the beam stop in a few micro-seconds. And MPS event in the RCS area stops the LINAC beam in less than 10 micro-seconds. We desired co-existing the high-speed response and the endurance with noise. The optimization of circuit isolation on the board of MPS input module achieved enough to endure the breakdown of the high voltage power supply for klystrons. At the beginning of RCS commissioning, there were some error event caused by pulse noise of bump magnet. We had met the weakness of the O/E element, and adding a filter is limiting the response time.

MPS handles the information of the beam loss monitor, and MPS GUI shows the distribution of beam loss measured by BLM. This information is very useful for the commissioning of course.

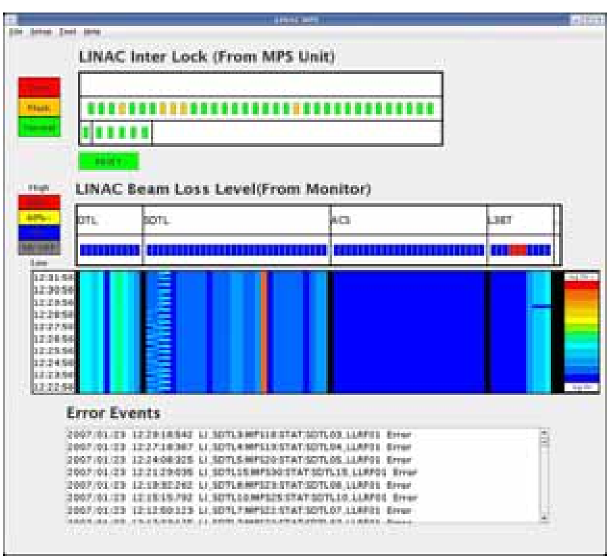

Fig.2 Trend of Beam Loss Distribution shown in MPS Window.

NETWORK

For the distributed control system, network architecture is very important as a key infrastructure which dominates total performance of the system. The number of network clients is not so much compared with large scale intranet of a large company. But this TCP/IP network is used for the control system. And we defined the design specification that TCP connection does not break even if the network device or transfer line makes a problem. We considered that the specification enable to separate software problems to network problems. The model of our design is the renewal network of FUJI-TV broadcasting company which was just completed at that time. Standard protocol can not realize our requirement. Especially, it was necessary to adopt a vender dependent protocol to make it for no spread of the problems to other parts when the cutting circuit returned soon. We tested some protocols and selected combined configuration of EAPS and ESRP of Extreme.

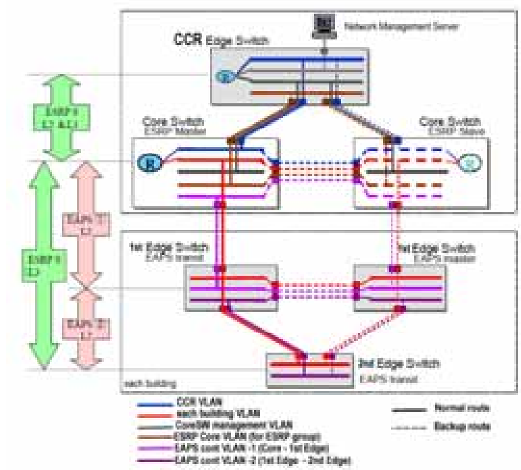

Fig.3 Protocol Configuration for Redundancy of network

By the redundancy of network, even if the optical fiber disconnection appears, the user does not notice the pass change. It takes about less than two seconds from the occurrence of the disconnection to securing the substitution route.

Initial phase of LINAC commissioning, we met a problem by the multi-cast packets of the network camera. We prepared to suppress the traffic load of it by QoS, and fixed the bug of the operating system of switches.

TIMING SYSTEM

Timing distribution system is able not only to inform the entire facilities of time but also to inform of the operation mode on real time. The trigger of 25Hz counted to the clock and the clock of 12MHz and the type code in 32 bits for each trigger are notified from the sending module to the receiving modules in each place in facilities through the optical fiber lines. LUT consists of a set value for delay of eight channels with the type code in eight bits. When the delay value should be changed, we choose the way of changing type code of rewriting the LUT. The type code is defined in common one, and is meaning the operation mode of facilities. Although LUT can be changed through the network, it is required to change simultaneously set value of many channels. The type code was decided to maintain a comprehensible composition, and the set value change of selected equipments was decided not to use it. We mounted reflective memories on each CPU for the receiving modules, and simultaneous change of delay values of equipment without stopping the beam was enabled. Before installing the reflective memories the direction of information flow was one way, but trigger counter system to confirm receiving information of the timing system was set up by using the reflective memories.

DATA ACQUISITON

J-PARC control system based on the EPICS. Stochastic data can be acquired easy by EPICS scheme, but RCS commissioning demands to make the simultaneous data of each shot. The timing system and the trigger counter enabled to assign the shot number and to trigger the monitor devices at the same time. The left problem is how to negotiate the trade-off between the bulk data size and the collection cycle. To store the all waveform data was requested, but time resolution of the waveform data is important too. We brought the concept of data selection in the acquisition. WER (Wave Endless Recorder) was developed to observe the stability of the system. WER is checking fluctuation of signals, and when the event is sensed WER keeps the high resolution waveform data for maximum 20 seconds stepping back. Many WER can operates cooperatively with the trigger counter, and a lot of data can be preserved synchronously.

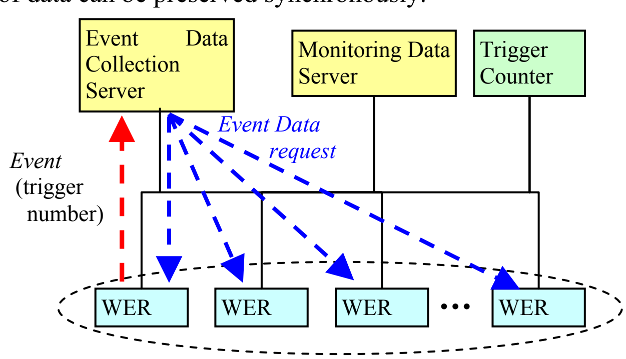

Fig.4 Configuration of WER Acquisition

APPLICATION SOFTWARE

Basic function of this control system has been achieved by EPICS. Fundamental application of LINAC and RCS was developed in java. The GUI of the generalization of information on the LINAC, MPS, TS and launchers of individual equipment GUI have been completed and are operating. Beam optics parameters which are measured by current transformers, position monitors, wire-scanners are shown in the viewgraph on real time[1]. Both of WER data and EPICS monitors archives to the database. Histories of data can be seen on the web-based GUI[2].

High Level Application is developed now, and the situation about HLA is a little bit complicated. We had a big resource of SAD in KEK. Many staff (they are users) want to use SAD for the commissioning, but it is very difficult to modify and to adopt to new facilities at the viewpoint of programming. KEK-B is working, and SAD staff can not be moved to J-PARC. Then we separated SAD to SAD core (means simulation engine) and SAD script (means function of integrated operation environment), and analyzed SAD codes which are written by commissioning team. We knew that it is not necessary to support all statements of SAD script, and the code of 95% or more can be replaced with the code written in java native. The APIs for SAD core were written in java, and our integrated operation environment can connect some kind of simulations transparently. Writing in java enables our IOE to merge with XAL easily, and the initial commissioning of LINAC was done with XAL consequently[3]. RCS commissioning started by using SAD, and other simulation codes, tools of other IOE will be used in near future.

SUMMARY

The details of the important part of high level application are shown in the presentation of references. J-PARC accelerators just started the long way trip to the goal of the mega-watt beam. The software sophistication owes the time length of commissioning. Fundamental function of infrastructure preparing three to five years future has been established. Technical and political strategy for software production will be discussed in else where.

REFERENCES

[1] 1418 in this conference. Hiroyuki Sako, et al. “Beam Commissioning Software and Database for J-PARC LINAC”.
[2] RPPA in this conference. Hiroki Takahashi, et al. “Database for Control System of J-PARC 3GeV RCS”
[3] 1534 in this conference. Chris Allen, “XAL Online Model Enhancements for J-PARC Commissioning and Operation”.