ENERGY RAMPING SYSTEM IN PLS STORAGE RING

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Abstract

New energy ramping control system is developed to make raise beam energy in the PLS storage ring. The new control system shows faster ramping and more stable beam features than a previous energy ramping control system that was consisted of OIC(operator interface workstation), SCC(subsystem control computer) and MIU(machine interface units). The system controls current settings of the magnet power supplies in multiple steps with different energy increment rate in ramping energy. Newly developed energy ramping system controls synchronously the magnet power supplies with the constant energy increment rate in ramping energy. We present the new energy ramping control system and its performance on operation.

1 INTRODUCTION

The PLS consists of 2.0 GeV linac, beam transport line and a storage ring that beam energy can be raised to 2.5 GeV. 2 GeV electron beam is injected from the linac to the storage ring. Then storage ring needs ramping process to increase the beam energy to 2.5 GeV. PLS has provided 2.5 GeV electron beam to users of beam lines since 2000. It is required to increase the beam energy rapidly by increasing currents of the magnet power supplies. It is possible to influence the beam dimesnsion, coherent collective and the lifetime effects during the ramping. Then it is important to store the beam stably during the energy ramping. Accordingly it is required to maintain the beam parameters and lattice parameters. We present control system structure, synchronization and control software of the new energy ramping control system in the PLS storage ring.

PLS stoarge has symmetry structure of 12 superperiods. Each of the 12 superperiods has three bendings, 12 quadrupoles (Q1,Q2,Q3,Q4,Q5 and Q6 in pairs), two pairs of sextupoles (SD and SF), which are necessary to keep the storage ring optics unchanged in the ramping process. All bending, Q4,Q5,Q6,SD and SF magnets in the ring are connected in series to their single power supplies respectively. On the other hand, 24 quadrupoles of Q1, Q2, A3 are connected to 12 power supplies in pairs respectively.

In order to keep the storage ring optics [**?**], the previous ramping system in the storage ring compensated for the deviations of the magnets field-to-current relation from the linearity by simply giving varying step sizes to bending and Q2 power supplies in the process of the ramping. The ramping system consists of the three-layered control system; the operator interface computer (OIC) layer, the SCC layer and the MIY layer. Both SCC layer and MIU layer are based on VMEbus standard with OS-9 real-time operating system. The OIC layer is linked with the MIU layer through MIL-1553B. The OIC does nothing but simply sending ramping start command to the lower layers. Then 12 MIUs control current settings of the magnet power supplies in multiple synchronous steps. The SCC generates the necessary synchronization signals. In the operation under the previous ramping control system, betatron tune variations during the ramping were quite large and sometimes the beams were lost due to third betaron resonance during the ramping. It took four to six minutes for the energy ramping from 2 GeV to 2.5 GeV.

2 ENERGY RAMPING CONTROL SYSTEM

The synchronization of ramping system is required for the fast and reliable energy ramping. Beam can become unstable when excessive MPS currents are supplied or MPS currents are fully not synchronized. Fig.1 shows structure of the PLS energy ramping control system. In the previous control system. when command is sent to SCC by unix workstation in the control room, the command is transferred to MIU in control shed through MIL-1553B NET. Then the command in MIU is transferred to MPS through RS422 serial port. The energy ramping was performed on software by OS-9 task in MIU. This method to synchronize the signal by software have showed delay in ramping time and defect in synchronization of the signal in 42 MPS(magnet power supplies). In order to solve the timing delay and to improve the synchronization, energy ramping controller (ERC) is installed between MIU and MPS, and 42 MPS are connected in serial by optical fiber. TCP/IP MODBUS is used to monitor the MPS data through eternet. Energy trigger master (ETM) reads values of the bending MPS through RS422 port and calculates the beam energy and sends the data to 42 MPS by optical fiber. Because ETM has to do TCP/IP communication with control room, embedded linux system is used due to its stability in network communication. The ERC has to perform three kinds of function: 1) ERC has to send to control room values of MPS that come from VME on operatin. 2) ERC has to increase the beam energy fastly, minimizing the variations of beam orbit and betatron tune. 3)ERC has to monitor MPS data through eternet exactly and fastly.

Fig.2 shows the structure in connections of optical fiber and network that are installed in the storage ring and MPS building. All 42 MPS are connected in parallel to make send step signal and energy signal that are requird for ramping to optical fiber. In ramping mode, master controller is controlled in control room through ethernet and ERC performs the ramping independently on the VME. On the other hand, ERC receives data from VME and sends to MPS and vice versa, in the case of normal mode.

Fig.3 shows structure of trigger master and ERC. Embedded linux CPU board receives the command through ethernet from the control room and sends the command by serial port to trigger master. Trigger master board analyzes the command that comes by serial and sends ramping information through optical fiber. ERC receives values of 42 MPS through optical fiber from trigger master and controls the ramping currents of MPS. Fig.4 shows the structure of control board in the new energy ramping controller.

2.1 Energy increment rate

The energy increment in the ramping determines the speed of the ramping procedure and is limited by the beam stability. Larger energy increment results in shorter ramping time, but more unstable ramping procedure. Fig.5 shows relationship between beam energy and energy increment rate in the previous ramping system. We note that the energy increment rate in bending and Q2 power supplies vary as the beam energy increases. This is because the relation of the magnet field strength to the MPS current is not linear but needs a polynomial expression. But, energy increment rate in the new ramping system is constant during the ramping: 0.32% for bending and 0.31% for another magnets It means that new ramping control system gives better synchronization than the previous ramping control system. In addition to energy ramping, the new ramping control system can decrease the beam energy from 2.5 GeV to 2.0 GeV, keeping the beam parameters.

2.2 Ramping control software

Program loop consists of main loop and ramping loop. Main loop receives command through RS242 from VME and transfers the command to MPS. Main loop also sends data of MPS to VME within 30 ms when VME asks the data and monitors it every 2.5 secc. Ramping loop increases currents of MPS when there is command from trigger master. MPS has not to be affected even if the ramping controller is reset. Fig.6 shows the flow chart of software in ramping controller. It has structure of soft cooperative multi tasking. Control structure is divided by three kinds of task. MPS task reads status and currents of MPS and can keep information of MPS. Main task is divided by TCP/IP socket service, ramping task and VME task. Interrupt task is also given. Fig.7 show the processes of ramping and deramping that are monitored by using Epics extension tool of MEDM. Used instrument for this monitoring is HP34401.

The procedures used in PLS are such as to 1) provide the necessary synchronization of the magnetic fields, 2) allow to control, monitor, recorder and adjust currents of MPS, beam parameters during the ramping process.

3 CONCLUSION

Energy ramping in the previous control system was performed by software on VME. It took 4-6 minutes for energy ramping from 2 GeV to 2.5 GeV. In the new control system, MPS currents are synchronized through ERC hardware that is controlled by using network of optical fiber. We could get improvement in synchronizatin and thus constant energy increment rate during the ramping could be used on operation. Energy de-ramping as well as energy ramping have been applied in normal operation of PLS storage ring. Available beam time on operation could be increased by using of the new ramping control system. Energy ramping from 2 GeV to 2.5 GeV takes 1.5 minutes in the new energy ramping system. We also presented optical fiber, network for monitoring and energy ramping controller in the new energy ramping control system.

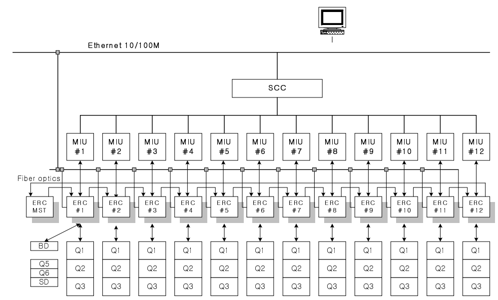

Figure 1: System structure of the PLS energy ramping control system..

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[1] I.S. Ko and et. al., IEEE trans. Nucl. Sci., vol. 45, p.2012, 1998.

[2] K. Ha and et.al. PAL-PUB 2001-006 (in Korean), 2001.

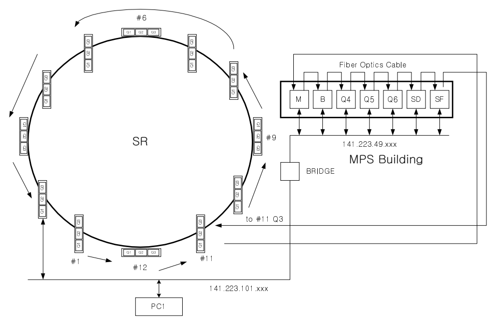

Figure 2: Connection of network and optical fiber.

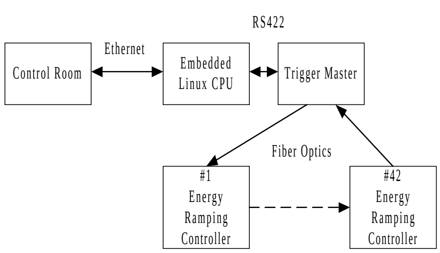

Figure 3: Trigger master and energy ramping controller.

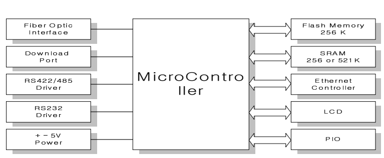

Figure 4: Structure of control borad.

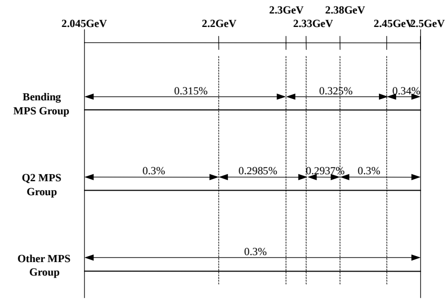

Figure 5: Relationship between beam energy and energy increment rate in the previous energy ramping system.

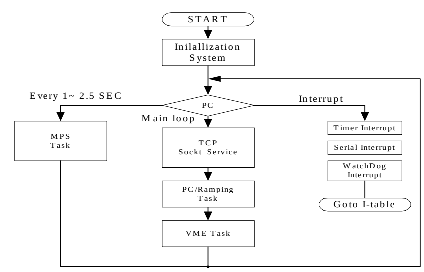

Figure 6: Structure of the control software.

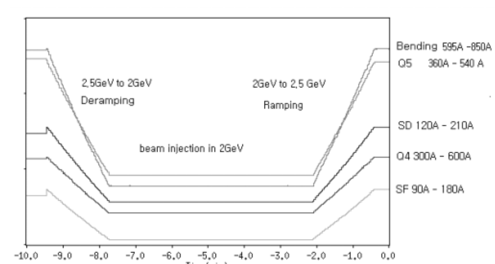

Figure 7: shows variations of the currents in MPS during energy ramping and energy de-ramping.