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NEW INJECTION INFORMATION ARCHIVER FOR SuperKEKB

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Abstract

We developed the injection information archiver which records a variety of injection-related data for the SuperKEKB collider. The recorded data are utilized to understand the beam quality and the beam background at the interaction point. Even though the first version of the injection information archiver is working well, it cannot be operated with the maximum injection rate of 50 Hz. Therefore, we develop a new system that collects the injection data via the dedicated optical network. It is realized by expanding the Bucket Selection system. We installed one node which collects data from the network and records them into the archiver. The system worked without any problem and collected injection-related data in the 2019 spring run.

INTRODUCTION

The efficient and stable beam injection is important for the SuperKEKB collider [1]. It operates high current beams, like 2.6 A (positron ring) and 3.6 A (electron ring), to archive the large luminosity.

The detailed understandings of the injection operation and injected beam-pulse are important to discuss the beam quality, collision quality, and the beam background at the interaction point. For this purpose, the injection information archiver system is developed in 2018 [2]. It is successfully operated and the interesting results are evaluated from the recorded data.

However, this system has the issue that data acquisition can not be implemented in the injection rate >25 Hz. And such a high rate injection will be carried out in the future large current operation at SuperKEKB.

We developed the new injection information archiver system which can record the pulse-by-pulse data in 50 Hz. This system utilized the distributed shared memory network to collect the necessary injection related information.

INJECTION INFORMATION

The injection information archiver collects a variety of data. For example, the operation parameters of injector linac (LINAC) are collected and recorded. Besides, the following data are collected with the software process developed for this purpose.

Injected Current

The injected current, ΔI, is defined as follows:

$$\Delta I = I^{\mathrm{aft}}_{\mathrm{bunch}} - I^{\mathrm{bef}}_{\mathrm{bunch}}, \tag{1}$$

where $I^{\mathrm{bef}}_{\mathrm{bunch}}$ and $I^{\mathrm{aft}}_{\mathrm{bunch}}$ are the bunch current of RF-bucket which LINAC injects beam-pulse (Injection-bucket). It is recorded twice, before injection and after injection. The data of the appropriate channel of the bunch current monitor (BCM) is collected and recorded.

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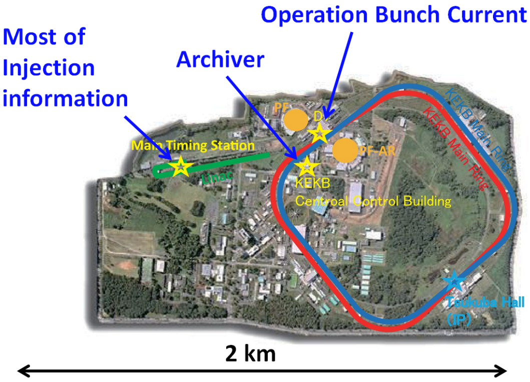

Figure 1: Accelerator layout at KEK and the location of injection-related data.

Operation Current Loss

There is the current loss of the storage bunches caused by the injection operation. The well-known loss is the injection kicker effect. The storage bunches around the Injection-bucket is kicked to approach the injection beam-pulse. This process makes storage bunches oscillating. Therefore, they emitted the synchrotron radiation and their bunch current is decreased.

We can determine and record this effect. The current loss is defined with Eq. (1). However, we change the measured bunch. In the SuperKEKB accelerator case, ±500 RF-buckets around Injection-bucket is affected by the injection kicker. The beam loss can be measured by applying the offset within this RF-bucket region.

Location of Information

The injection-information archiver collects a variety of data from the large beamlines. Figure 1 shows the location of the above information. They are spread on the SuperKEKB accelerator area.

The master IOC of Event Timing System has most of the injection-information since it manages the injection. There are the BCMs at the D7 hall. The master IOC of Bucket Selection located at the Central Control Building (CCB). It decides the next Injection-bucket.

DISTRIBUTED SHARED MEMORY NETWORK

We utilize the distributed shared memory to collect the injection information since their source is broadly spread. In this section, we introduce its module, network configuration, and the interruption functions.

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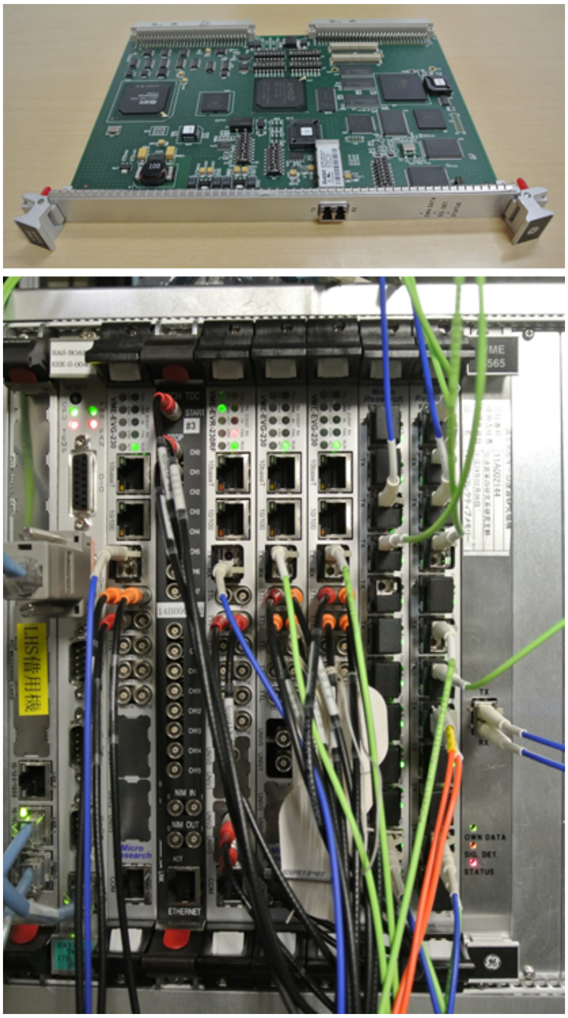

Figure 2: Pictures of VME-5565 (up) and the master IOC of Event Timing System in which the VME-5565 module is inserted (down).

Modules

The reflective memory modules [3], VME-5565 and PCIe-5565PIORC, are utilized to configure the network.

Figure 2 is pictures of VME-5565 (up) and the VME IOC in which the reflective memory is inserted (down). This node is placed at LINAC and the master IOC of Event Timing System. Therefore, the reflective memory and Event Timing modules are inserted in the same VME-bus.

Figure 3 is pictures of PCI-5565PIORC and the archiver node (right). The PCIexpress card of the reflective memory is inserted in the rack-mount server which the archiver software is running.

Configuration of Network

Figure 4 is the schematic view of the reflective memory network. We configure the loop topology network with the four reflective memory nodes. Three of them are the VME nodes and the remaining one is the PCIexpress node. Actually, the three VME nodes are developed as the Bucket Selection system [4]. We expand the Bucket Selection network and, additionally, install the PCIexpress card of the reflective memory and the server as the archiver node.

We call the VME nodes at LINAC and the D7 hall as the “LINAC” and “D7” nodes, respectively. And for two nodes at CCB, the VME node is called the “CCB-1” node, while the PCIexpress node is called the “CCB-2” node.

Network Interruption

The reflect memory modules have network interruption functions. Each node can send the interruption signal to the other node. Then, the node received the interruption signal launches the interruption to its own CPU.

The process starts with the LINAC node. It interrupts the CCB-1 node. The CCB-1 node decides the next Injection-bucket. In this process, the bunch current information which is provided by the D7 node is referred. The operation timing of LINAC is calculated for implementing the injection towards the selected RF-bucket. They are written on the reflective memory. Then, the CCB-1 node launches the network interruption to the LINAC node. This function is utilized in the Bucket Selection system.

At the end of the above process, we define the new network interruption from the CCB-1 node to the CCB-2 node. The CCB-2 node implements the following injection archiver process.

INJECTION ARCHIVER PROCESS

The CCB-2 node collects the injection information from the reflective memory. Firstly, the next Injection-bucket is checked on the reflective memory. It is written by the CCB-1 node. Then, the bunch current of Next-bucket is collected. This becomes $I_{\text{bunch}}^{\text{bef}}$. Other injection information is collected from the reflective memory. The Next-bucket data is buffered until the next interruption process. Then the bunch current of the same channel is collected again. It becomes $I_{\text{bunch}}^{\text{aft}}$.

For recording the collected data, the EPICS Archiver Appliance [5] is operating on the server.

CONCLUSION

The injection information archiver system is important to understanding the beam quality, collision quality, and beam background at the interaction point of the SuperKEKB accelerator. It records a variety of injection-related data. We developed and operated the first version of the injection information archiver in 2018, successfully.

We developed the new injection archiver system which can collect and record the injection information in 50 Hz. It utilizes the distributed shared memory network so that the fast and robust transferring of data is realized. The Bucket Selection network is expanded for this purpose. We installed the archiver node which consists of the PCIexpress card of the reflective memory and rack-mount server. The EPICS Archiver Appliance is running on this server to record the injection-related data.

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Figure 3: Pictures of PCIe-5565PIORC (left) and the server (right). The upper server in the left picture is the server for the archiver node. The EPICS Archiver Appliance is running on this server and recording the collected data. The PCIexpress card is inserted in the back panel.

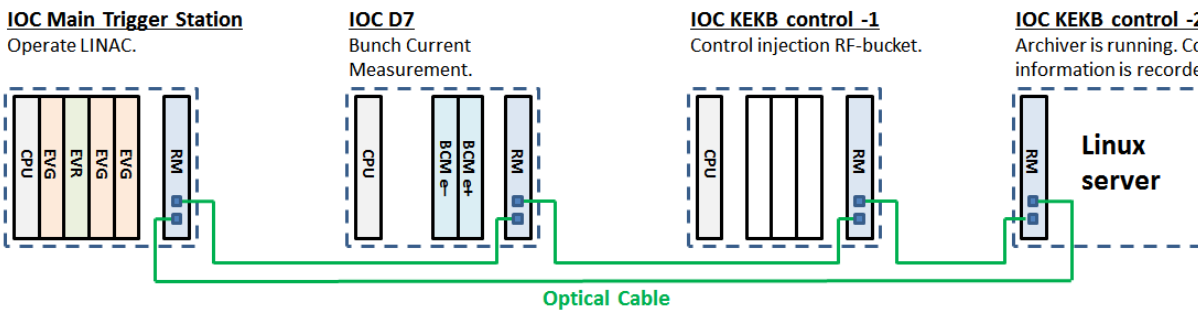

Figure 4: Schematic view of the reflective memory network. It is configured with four reflective memory nodes. Three nodes are developed with the VME module. They are the Bucket Selection network modules. The PCIexpress node is installed into this network as the archiver node.

This system works correctly in the 2019 spring run without any problem. We recorded the injection data successfully. We hope the understanding of beam is advanced by deeply analyzing these data.

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