25Hz SYNCHRONIZED DATA COLLECTION SYSTEM IN J-PARC 3GeV RCS

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Abstract

Since the J-PARC 3GeV RCS is the 1MW high power proton accelerator, it should be enough taken into consideration to radiation by the beam loss.

Furthermore, two institutions of the Materials and Life Science Facility (MLF) and the 50GeVMR are injected the beam by 25Hz from the 3GeVRCS.

Therefore, all 25Hz beams need to be managed in beam operation.

In this realization, the design and manufacture of control system with PC (Linux) which mounted Reflective Memory is performed.

INTRODUCTION

For development of technologies and science utilizing a high intensity proton accelerator, JAERI and KEK are promoting a joint project "Japan Proton Accelerator Research Complex (J-PARC)". J-PARC consists of a linear accelerator (Linac), a rapid-cycling synchrotoron (3GeV RCS), and a 50GeV synchrotoron (50GeV MR). Each accelerator transports high intensity beam to the experimental facilities, a materials and life science facility (MLF), a nuclear and particle physics facility, and an accelerator-driven transmutation experimental facility.

Since the RCS is a proton synchrotron with an extreme high power of 1MW, a delicate care must be taken to suppress radiation due to beam loss.

The RCS injects each beam pulse of 25 Hz into the MLF and the 50GeV MR in a predefined order. Machine parameters should be set differently depending on the destination. Therefore, all 25Hz beams must be monitored and controlled separately in the RCS control system.

In this report, design and a prototype test of the data collection system synchronized in 25Hz are described.

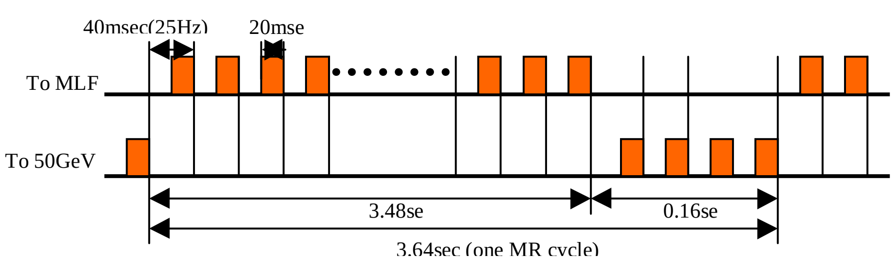

Figure 1: Example of Beam cycle of the RCS.

BEAM CYCLE OF 3GeV RCS

An example of a typical beam cycle of the RCS is shown in Fig. 1.

The RCS is operated in 25Hz (*i.e.* 40ms period), in which the beam acceleration time is 20ms. The operation cycle of J-PARC is defined as the operation cycle of the MR (MR cycle) of about 3.64sec. As shown in Fig. 1, the RCS accelerates 91 beam pulses per MR cycle, out of which 4 beam pulses in 0.16 sec are injected into the MR, and 87 beam pulses in 3.48 sec are injected into the MLF.

DATA COLLECTION SYSTEM

Since different beam control parameters are required for the MR and the MLF, monitoring and control must be made separately for each beam pulse, distinguishing the destination in the control system. In order to realize this demand, synchronicity of data is indispensable.

However, synchronicity of data cannot be secured with data received at the same time by a control PC with data transfer between apparatus and the PC via LAN. Also, the time when the PC has received the data can be different from the time when the apparatus has collected the data.

In the following, a data collection system with LAN which secures the synchronicity was examined.

System configuration of Beam Position Monitor (BPM)

The data collection scheme of beam position monitors (BPMs) which distinguishes whether the data is for the MLF or for the MR was examined.

A BPM system consists of a BPM and a BPM signal-processing unit. The signal-processing unit is composed on a VME crate. The unit consists of a CPU board and six signal-processing boards. Thereby, six BPMs are connected to a signal processing unit (Fig. 2). A signal processing unit calculates beam positions from signals of a BPM monitor every 1msec {(x1, y1), (x2, y2), -----(x20, y20)}, and records the coordinates on the registers of VME. Nine signal-processing units are

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installed in three rooms, each of which has three units.

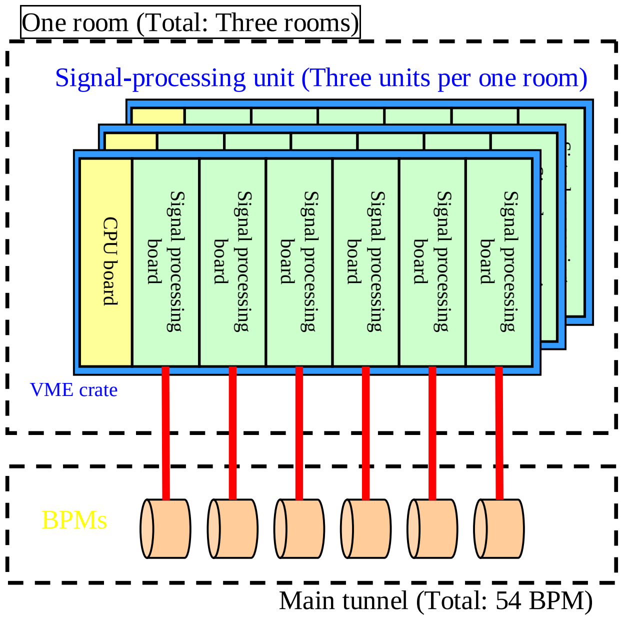


Figure 2: Outline of BPM system configuration.

Data collection system using LAN

Let us consider the case when the data from a BPM signal processing unit is read by a control PC via LAN. As mentioned above, the synchronicity of data cannot be secured via LAN. Therefore, in the environment where three signal processing units are installed in each of three distant rooms, it is hard to collect synchronous BPM data in every beam pulse. It means that data for the MLF and data for the MR cannot be distinguished. Operation based on unsynchronized data may cause a problem.

To resolve this problem, we introduce a beam tag (beam count) and readout time information of each BPM data. The beam count is defined as a trigger count (timing signal) which starts data processing. Time information is defined as the time (msec) when the trigger signals generated, which is measured by the CPU board of a signal processing unit. The signal-processing unit attaches the two information to BPM position data. The BPM position data for several seconds is recorded on the registers in a signal processing unit.

Then, the data collection PC collects BPM position data from different signal processing units, and synchronizes the data from different units referring beam tags.

Thus, synchronized data is obtained. Further check of time information makes the data more reliable data. The concept of the above data arrangement is shown in Fig. 3. Before arrangement, BPM position data from different units has a mismatch in beam tags, due to different delay to transfer data via LAN. After being arranged using beam tags (based on BPM1), the data is synchronized.

Using Reflective Memory

We classify the BPM position data in (1) BPM number, (BPM 1 to 54), in (2) acceleration time (1msec to 20msec) and in (3) MR cycle number (Fig. 4).

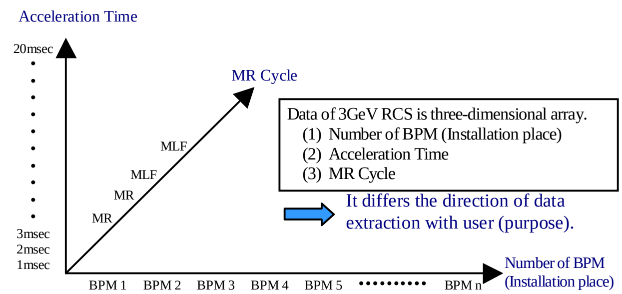


Figure 4: Data of 3GeV RCS (*in the case of BPM*).

Therefore, it is inadequate to arrange data only using the beam tag. In order to divide the data in the above (2) and (3) directions, further processing of data is needed after data collection. Then, the data acquisition system which could fulfil the demand to distinguish the data in the (1) to (3) directions, and real-time data handling by using a Reflective Memory was designed and examined.

The Reflective Memory is hardware suitable for constructing a high-speed data-communication network. In the network of a Reflective Memory, any computers (PC, VME, etc.) connected to the same network can share the common memory space. Therefore, when some nodes (PC, VME, etc.) linked to memory space have updated data, the data of memory space seen from the other nodes connected to the same Reflective Memory network will also be updated. The capability of Reflective Memory was utilized and the data collection system which synchronized in 25Hz was designed.

Data collection system using Reflective Memory

A Reflective Memory network consists of a signal processing unit (VME) of BPM 1 to 54, and a PC for data collection.

First, since the data distinction by the beam tag in MR cycle is required, in

Collection Data using LAN
- Data without synchronicity
Displayed Data

BPM 1			BPM 2			BPM n		
tag	time	value	tag	time	value	tag	time	value
3	01.920	1.1	4	01.965	1.5	2	01.870	0.7
4	01.960	1.2	5	02.005	1.6	3	01.910	0.8
5	02.000	1.3	6	02.045	1.7	4	01.950	0.9

Data is arranged based on beam tag.

Arranged Data based on beam tag
- Data with synchronicity

BPM 1			BPM 2			BPM n		
tag	time	value	tag	time	value	tag	time	value
3	01.920	1.1	3	01.925	1.4	3	01.910	0.8
4	01.960	1.2	4	01.965	1.5	4	01.950	0.9
5	02.000	1.3	5	02.005	1.6	5	01.990	1.0

Figure 3: Concept of data arrangement.

addition to the data information on 3.1, a MR cycle tag is also appended. And Reflective Memory space is used as a ring buffer and BPM position data is recorded according to the MR cycle tag. Thereby, data distinction with MR cycle tag is also attained. Furthermore, with the data classification in acceleration time, it becomes easy to treat BPM position data.

Moreover, the data collection which distinguished BPM 1 to 54 is attained by assigning data area to Reflective Memory space for every BPM.

The outline of Reflective Memory space is shown in Fig. 5.

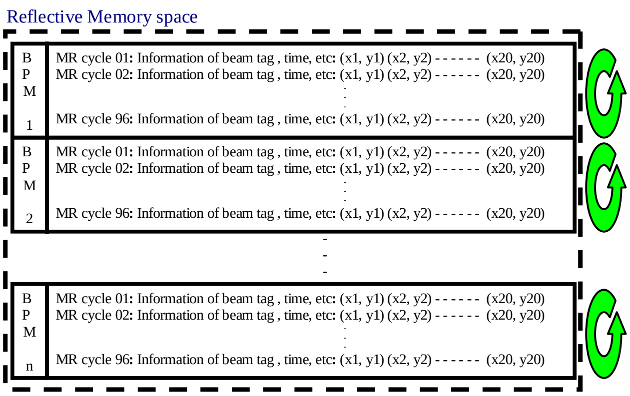


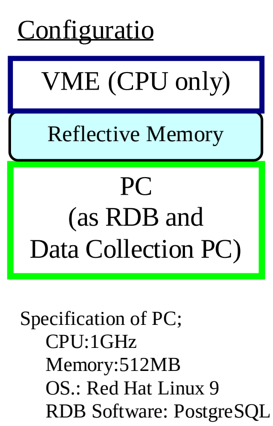
Figure 5: Outline of Reflective Memory space.

A MR cycle is about 3.6 seconds. Therefore, PC carries out data collection in a constant cycle (every sec), and 25Hz data which is synchronized is obtained by arranging it with the beam tag.

SYSTEM CONFIGURATION AND BENCH TEST

The outline of the BPM position data collection system configuration based on the Reflective Memory is shown in Fig. 6. This system consists of the BPM signal-processing unit (VME), the computer for Database (RDB PC), the computer for data collection (Data Collection PC) and the computer for data monitoring (Monitoring PC).

BPM signal-processing unit always holds 96 25Hz BPM position pulse data (corresponding to the number of beams in MR cycle) per BPM on Reflective Memory space.



RDB arranges a beam tag as a key and inserts BPM position data. Moreover, RDB hands over the BPM position data of a data format according to a demand to Monitoring PC.

Data Collection PC carries out data collection in a constant cycle. Furthermore, Data

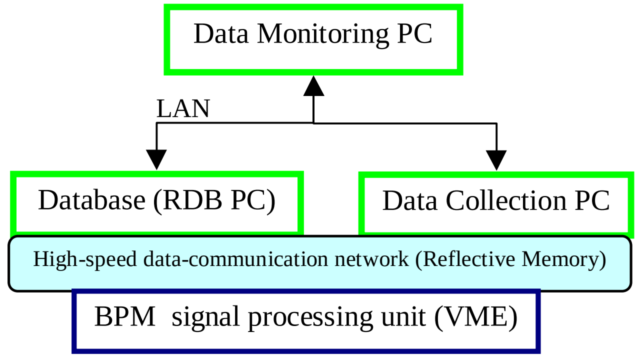


Figure 6: Outline of BPM position data collection system.

Collection PC cuts down the data near the real time, according to a demand (3.2 (1) to (3)) from Reflective Memory space, and hands it over to Monitoring PC. Since not only a beam tag but also time, a MR cycle tag, and so on are attached to BPM position data, it is possible to respond to various demands, for example, to retrieve the data around the beam provided to 50GeV MR.

A simple examination of the proposed BPM position data collection system was performed. The test bench configuration is shown in Fig. 7. In this configuration, VME generates same fake data which simulates data from a BPM signal processing unit, and the PC serves both as a RDB PC and a Data Collection PC.

In this test, fake data of a BPM with the position information in 20msec {(x1, y1), (x2, y2), -----(x20, y20)} with additional information such as a beam tag was generated. The data size of a BPM per beam is about 200 byte. The number of BPM is taken to be 80.

With the 80 BPM data, the following examinations were performed.

Case 1: Insert each shot of beam data into RDB in 40msec cycles

Case 2: Insert beam data for 1 second interval corresponding to the data of 50 shots of beams as one data block into RDB

Case 3: Write one shot of beam data to a file in 40msec cycles

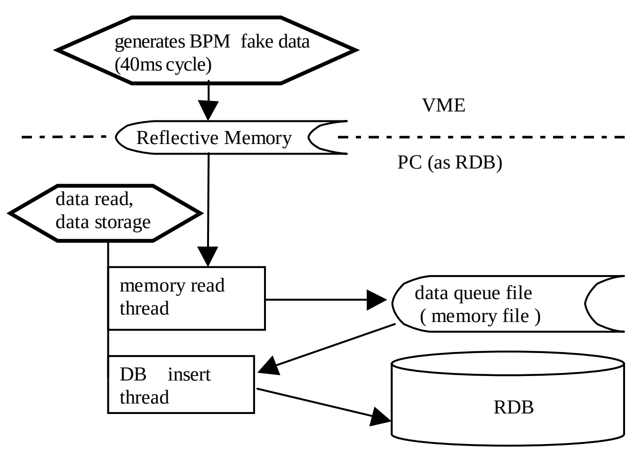


Figure 7: Test bench configuration.

Case 4: Write beam data for 1 second corresponding to 50 shots a file as one data block.

The specifications of the PC is; CPU:1GHz, Memory:512MB, OS.: Red Hat Linux 9 and RDB Software: PostgreSQL.

A result is shown in Table 1.

Table 1: Result of Reflective Memory test bench

	Cycle of RDB Data Insert (msec)	Time of RDB Data Insert (msec)	Cycle of Data File Output (msec)	Time of Data FIle Output (msec)
case1	40	84.4	–	–
case2	1000	154.5	–	–
case3	–	–	40	3.04
case4	–	–	1000	60.80

In Case 1 when inserting each short of 40msec into RDB, it turns out that data insert time takes longer time than the 40msec, and data collection does not meet the requirement.

In Case 2 when inserting a bulk data into RDB in every second, it turns out that data collection is fast enough.

In Case 3 and Case 4 when writing to a file, it turns out that data collection is much faster than with RDB, and there is no problem to record the data.

From the test results of Case 2 with the actual amount of data, the data collection is successful in the system configuration with RDB with the cycles of several seconds (MR cycle is taken into consideration and it is 1sec to 3sec). It becomes possible from this RDB to read the data arranged by the beam number. On the other hand, in the case of the file output of case3 and case4, it turns out that data collection is very fast. Therefore, it may be possible by combining these methods to collect all data, even when the 25Hz data collection becomes difficult in the method of case2. However, in this case an examination how to arrange the data with the beam tag is necessary.

CONCLUSION

A possibility that the 25Hz synchronized data collection could be carried out by the system with the Reflective Memory was shown, in the methods (1) to insert into RDB in a cycle of 1 second, (2) to write in a file in 40msec cycles and (3) to write in a file in a cycle of 1 second.

This report described only the case of BPM. In the next step, the actual amount of data will be computed from the data of other monitors and from the output waveform data of a pattern power supply, which may have significant amount of data. And hardware configuration of a data collection system should be improved based on amount of data. Simultaneously, examination and verification of the optimal data collection system should be performed. Probably, on RDB, examination of the table configuration is also needed.

Furthermore, examination and a design of the system which send and receive the data on a Reflective Memory space by LAN to Monitoring PC will be performed.

In summer of 2005, the examination using the actual BPM processing unit will be performed. Based on this result, the optimal data collection system will be designed, and optimal 3GeVRCS control system will be designed.

REFERENCES

[1] F.Tamura, et al.,. “J-PARC TIMING SYSTEM”, Proceedings of ICALEPCS2003 in Korea. URL: http://icalepcs2003.postech.ac.kr