Synchronization scheme for the KEKB accelerator

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Abstract

The design of the synchronization system of the KEKB accelerator is described. The synchronization system is classified into 1)fast timing and 2)software timing. The fast timing signals including rf frequency will be distributed by a optical transfer system with a phase stabilized optical fiber. The performance has been evaluated. A scheme of synchronization for multi-CPU control is proposed as the software timing signal generation and distribution. More than several tens of crates of VME and CAMAC will be used in the control system. Each CPU will be located at each station along the linac, the Beam Transport Line and the Rings and will be connected with Ethernet each other. The synchronization of the hardware under the different CPUs is essential for the precise control and measurement.

1 Introduction

The KEKB accelerator complex consists of a linac, the Beam Transport, the 8GeV High Energy Ring(HER) for electron beam storage and the 3.5GeV Low Energy Ring(LER) for positron beam storage. The control system is based on EPICS(Experimental Physics and Industrial Control System) tool kits and uses large number of IOCs(Input/Output Controllers) which are distributed to each local station.[1]

The timing system is classified into fast timing signals and software timing signals. The fast timing means the synchronized signal which is created by the hardware directly, for example, rf(508MHz), revolution(100kHz), injection(50Hz), etc.. There will be used many kinds of diagnostics tools and feedback systems in the KEKB accelerator, for example, bunch by bunch beam feedback, laser wire, streak camera, wire scanner, single shot BPMs, rf feedback, etc.. The diagnostics tools and the feedback systems need to the beam timing at each location. The fast timing signals are created at the Center Control Room(CCR) and the linac control room. The signals have to be distributed to all of the local stations with high stability.

The software timing means the synchronized signal which is created by the software. The timing signals are used for synchronizing each device under the different IOCs. The timing signals are required to resolve the injection timing(linac and BT) or the revolution timing(rings). Many kind of the software timing are required. Several tasks are already reserved. In order to

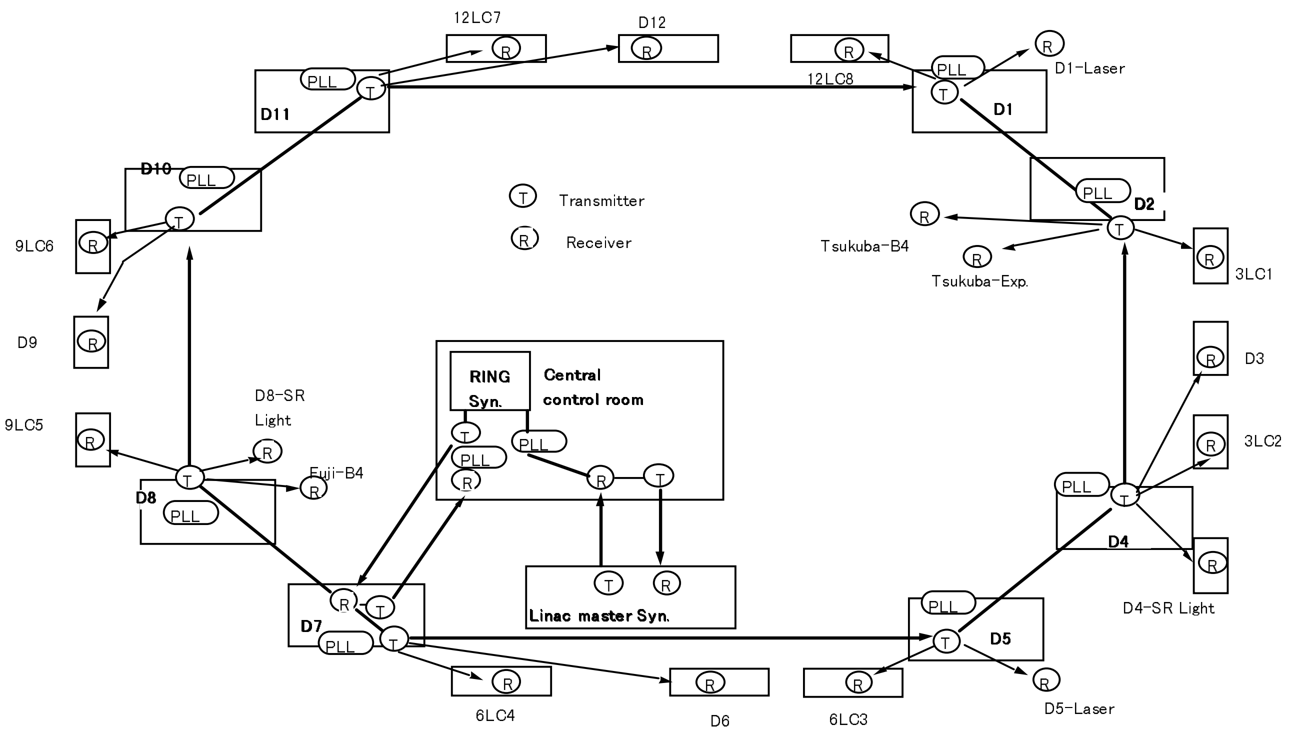

Fig.1 Timing signal distribution of the KEKB accelerator

reduce the hardware cost, the signal is submitted as the code and decoded the code at each station. There are over 20 local control stations which are located around the 3 km circumference ring.

2 Hardware of the fast timing signal

The fast timing signal means hardware driven signals including the rf(508MHz) reference signal. The fast timing signals are classified the high precision signals and the other signals. The phase stability of the high precision timing needs to be less than 30ps and the other timing signals are required to resolve the revolution period, into less than 10micro-sec.

2.1 Distribution of the high precision timing signals

In order to resolve bunch by bunch beam timing, following four signals are required at each local control station, 1)rf(508MHz), 2)revolution(100kHz), 3)injection timing of the electron beam(50Hz or lower rate) and 4)injection timing of the positron beam(50Hz or lower rate). The phase stability of the signal needs to be ~30ps at the temperature range of 0 to 30 ^{o}C. An optical transfer system with phase stabilized optical fiber(PSOF) will be used to distribute these signals. The optical fiber (SUMITOMO DTS) has a very low temperature coefficient(0.04ppm/ ^{o}C). At the station in the short distance, 200m or less, the PSOF can keep the phase stability without feedback. The distribution line and each station are shown in Fig.1. The E/O and O/E were evaluated at 3510A(transmitter) and 4512A(receiver) (Ortel Co.) which have the temperature coefficients 0.45ps/ ^{o}C and 0.85ps/ ^{o}C, respectively. The short time jitter of the optical transfer system, when 100m fiber cable was used, was 1.1ps for 508MHz. The measurement set up and result are shown in Fig.2. The total performance of the PSOF was confirmed at ATF.[2]

It is difficult to keep the phase stability without the feedback system at the all location even if the PSOF is used. The longest distance from the CCR to the station is about 2 km. Eight of the rf stations(D1~D11) have the phase locked loop feedback system with coaxial cables and the phase stability keeps ~5ps. The coaxial cable will be replaced by the PSOF with the feedback. The feedback system is now under testing. [3]

For the other signals except for rf, the phase stability and the time delay between the stations are adjusted by the synchronous delay counter module(called TD2) developed at TRISTAN timing system. The time delay is adjustable when 2ns step at 508MHz clock is used. The improved version can count up to 1.4GHz and the time jitter is ~5.8ps(σ) at 508MHz clock.[4]

2.2 Distribution of the other timing signals

Some devices are required to transmit/receive the special timing signals. These signals are vertical kicker timing, beam feedback request/status, beam abort request/status, beam loss status, etc.. The timing signals are required to resolve the revolution period into less than 10micro-sec. These signals are distributed by a simple fiber optic link. These signals are required to guarantee the time deviation from the source to the destination.

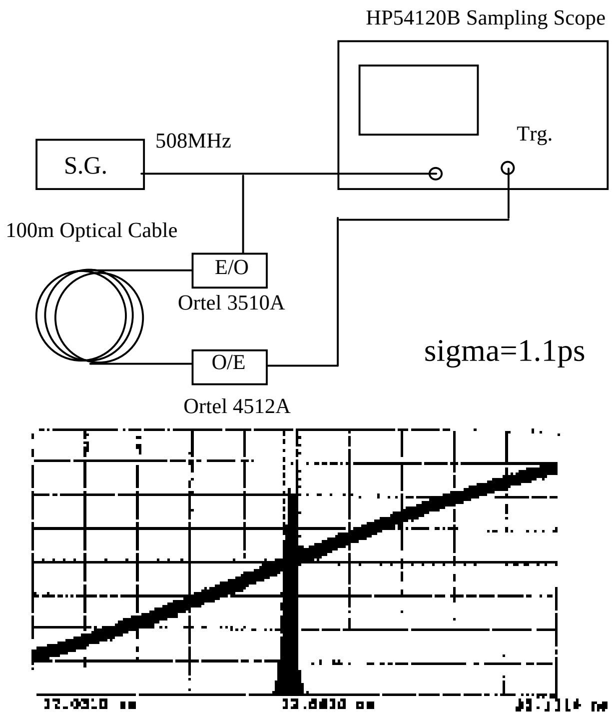

Fig. 2 Measurement of the short time jitter of the E/O, O/E system

3 Software timing signal

The software driven timing signals are required for multi-CPU control system like the KEKB. The data acquisition and the controls are required to synchronize the injection timing or the revolution timing. The command through the network can not guarantee the timing. One network command or channel access requires 5~10ms even if there is no traffic. At the case of the turn by turn beam position monitor(BPM), the IOCs located in 20 different buildings which acquire the same turn of the signals. It is required to have the hardware which guarantees the synchronized timing with the injection(50Hz) or the revolution(10micro-sec). This system will be used at 1)synchronized data setting of the steer magnets for the orbit change, 2)synchronized data acquisition of the BPM at the linac and BT, 3)synchronized data acquisition of the turn-by-turn BPM at HER/LER and so on.

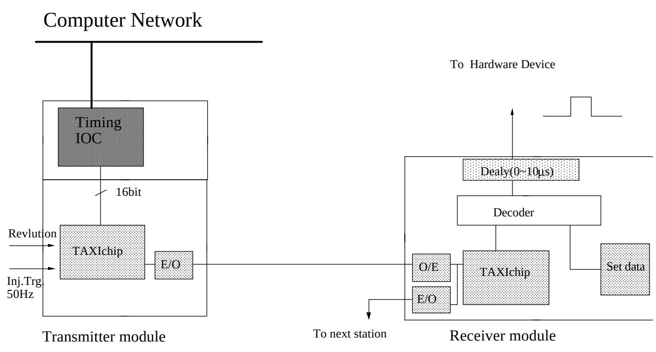

Fig. 3 Software timing generation sheme

3.1 Generation of the software driven timing signal

The configuration is shown in Fig.2. In order to reduce the cost of the transfer line, the signal is submitted as the 16 bit code. The transfer line is connected with an optical fiber link. The submitted timing is synchronized with the injection timing or the revolution timing. Each task has own code and the signal is recognized at each location with comparing the code and the device ID value. The software sequence is following, 1)the manager IOC of the hardware checks the status of each IOC, 2)the manager IOC requests the timing signal to the timing IOC when all IOCs are ready, 3)the timing IOC writes the code to the register of the transfer module, 4)the code is transferred to all of the location and recognized at the required station, 5)the code is converted to a pulse and used as the timing signal after adjusting the cable delay. The number of the code is extended easily for flexible use.

3.2 Hardware of the transmitter/receiver module

A pair of TAXIchip(Transparent Asynchronous Xmitter - receiver Interface, Am7968(transmitter)/Am7969(receiver)) is used for the parallel to serial conversion and serial to parallel conversion. Two Am7968s are used in the transmitter for switching the transfer data of the injection timing and the revolution timing, alternatively. The specified transfer rate is 4Mbyte/sec to 12.5Mbyte/sec. There is a time jitter coming from the asynchronous communication which is 10ns to 25ns. It is correspond to less than 1% of the revolution period. The performance is under testing with the proto-type module.

4 Summary

The timing system of the KEKB accelerator has been presented. The PSOF system will be achieved by the requirement of the stability for the fast timing. The software timing with inexpensive and flexible system has been designed. The confirmation of the performance and the development of the control software are in progress.

5 Acknowledgments

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