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The Improvement of TRISTAN Timing System

J.Urakawa and T.Kawamoto
KEK, National Laboratory for High Energy Physics
Oho 1-1, Tsukuba-shi, Ibaraki-ken 305, Japan

Abstract

The TRISTAN timing system is divided into fast and slow timing systems. In the fast timing system, the 50Ω coaxial cables for the timing signal transmission were replaced with special single-mode optical fiber cables. New fast timing signal transmission system achieved the timing accuracy within $11psec$ over the temperature range from 10 to $35°C$. In the slow timing system, a dedicated microprocessor(LSI-11) for the generation of slow timing signals was ejected and the software was rewritten and installed into one minicomputer in the computer network for the TRISTAN accelerator control. This modification gives more reliability and more flexibility. In this paper we describe the improvement of the TRISTAN timing system.

I. INTRODUCTION

The TRISTAN accelerator complex comprises four accelerators: a 200MeV electron linac for positron production, a 2.5GeV linac, an 8GeV accumulation ring(AR) and a 30GeV main ring(MR). The AR and MR are controlled by a highly computerized control system[1]. Twenty-five minicomputers are linked by optical-fiber cables to form an N-to-N token-ring network. The transmission speed through the cables is 10Mbits/sec. From each minicomputer, a CAMAC serial highway extends to the controlled equipment. The TRISTAN timing system is divided into fast and slow timing systems[2]. The fast timing system supplies timing signals(fast timing) for devices whose operation is synchronized with bunched beams from either the linac or the AR. These signals are also used in various beam monitors and beam feedback systems. The slow timing system generates trigger signals(slow timing) in order to achieve synchronization between the magnetic field and the rf accelerating voltage of the AR or MR. These triggers are also used for the automatic operation of machines. The slow timing system manages the operation mode of the AR and MR with both flexibility and extensibility.

For the precise timing signal transmission, a new optical fiber cable system was developed and installed between the 2.5GeV linac gun room and the TRISTAN control room, and their performance in transmitting the AR RF signal(508MHz) has been evaluated[3].

Triggers for changing the magnetic field are sent out by the slow timing system, which receives pulse signals which are transmitted at the end of the magnetic field change through a twisted-pair cable. The slow timing system distributes the trigger signals from the main control room to all subcontrol stations using MIL/STD-1553B with an 8-bit event code.

The slow timing signals are required for managing synchronization among the magnet system and the rf system as well as for automatic operation of the machines.

Each timing system was controlled through the CAMAC by minicomputers (HIDIC 80E or 80M) and a dedicated microprocessor (LSI-11). However, in order to simplify the software management and to increase the reliability and the flexibility, the LSI-11 was deserted.

In next section we describe the improvement of the fast timing transmission system with minimum transmission delay drift, and E/O, O/E converters. The improvement of the slow timing system is explained in section 3.

II. NEW OPTICAL FIBER TRANSMISSION SYSTEM

A. New Optical Fiber Cable

Optical fiber transmission system has advantages of low attenuation (0.35dB/km), wide bandwidth(more than 1GHz over dozens of kilometer) and immunity to electromagnetic interference. This fiber cable showed the reduced thermal transmission delay change less than 10psec/km in the temperature range from -20 to 30 $°C$, which is 100 times smaller than that of any other existing coaxial cables and conventional optical fiber cables.

B. E/O,O/E Converters

The E/O converter consists of a wide bandwidth laser diode module, a driver circuit, and an auto-power control circuit in order to stabilize the emitted power. The timing signal is fed to the driver circuit with 50Ω impedance and equalized to achieve the flat frequency response. The O/E converter consists of a PIN-AMP module and a commercially available low noise amplifier. The O/E and E/O converters achieved the timing accuracy within 11psec over the temperature range from 10 to 35 $°C$[4]. Another investigation about the timing jitter width clarified that the origin of the phase jitter is derived from the thermal noise in the optical receiver circuit. Hence, an appropriate bandpass filter should be used to improve the signal to noise ratio.

C. Improvement of Fast Timing Transmission System

The new optical fiber cable was installed from the linac gun room to the main control room of the TRISTAN AR

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in April 1989. The cable has 800m length and contains 6 fibers in it. 300 meter of the total cable was layed even in the underground from beam switching yard to the AR where the cable was subjected to the irradiation. Since the core material of this fiber is pure silica, this fiber cable is much resistant to irradiation than conventional fiber cables.

One of the six fibers in the cable was connected to the E/O and O/E converters at both ends to replace the existing coaxial system of transmitting 508MHz RF timing signal. This coaxial cable, although it had been designed to have a thermally stabilized electrical length, required phase adjusting several times a year. On the contrary, the new optical fiber cable system has been operating without any phase delay adjusting to April 1991. The characteristics of this system has not been degraded during the last two years. The superiority of the new system is demonstrated.

The confirmed high stability suggests that the use of this cable system will effectively simplify and improve the "main drive lines" in the acceleration systems, where large diameter coaxial cables are used in the special conduit with sophisticated temperature control.

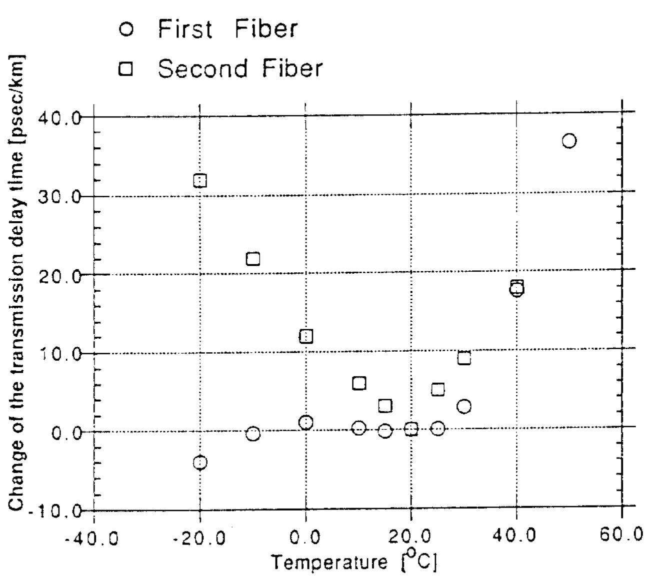

Fig.1 Measured transmission delay time change against temperature.

Since precise bunch oscillation and beam profile monitors require the precise synchronization signals for bunched beam, the synchronization signals will be transmitted to 4 site buildings through the optical fiber cables from the main control room in this summer. Figure 1 shows the temperature dependence of the transmission delay time of the fibers which was used before and will be used. The difference is due to the variations in the process of manufacture. The thermal coefficient for delay of less than 0.5ppm/$^\circ C$ is guaranteed.

III. IMPROVEMENT OF THE SLOW TIMING SYSTEM

This system supplies the timing for devices which are operated in synchronization with the magnetic field of the AR or MR. Since there are many kinds of operation modes for TRISTAN, it must be easy to change the timing for the operation mode and to extend the system. It is also required that the timing signals be transmitted to many points distributed over the large area of the accelerator sites. The generation, transmission and receiving of timing signals are carried out through the CAMAC system by means of a serial bus using Manchester II code, based on the standard MIL/STD-1553B.

Since the Manchester II code (biphase level code) is transmitted as a bipolar signal, low noise susceptibility can be realized by using transformer-coupled transmission lines, which allow half-duplex transmission and transmission of information from numerous sources through one cable. The non-word format of the MIL/STD-1553B consists of a twenty-bit field for data or command and one bit for parity. The discrimination of the synchronization signal polarity distinguishes two kinds of word formats: command words and data words. These words are utilized to transmit both clock and event signals, respectively.

There are three kinds of slow timing signals for the TRISTAN control:

(1) a 100Hz clock signal;

(2) 255 event signals coded by eight bits with a dummy identification bit, meaning that the event is not in operation;

(3) time code signals of year, month, day, hour, minute and second.

These signals are converted to the Manchester II code and transmitted to CAMAC timing modules on serial multidrop buses through coaxial cables and repeaters. The command synchronization of the 1553B bus code is used as the clock signal, and the time-code data are divided into three command words. The event signal is attached to the data word. The next clock following an event code gives its exact time.

As old slow timing system which was controlled by the dedicated microprocessor (LSI-11) was described in ref.[2], we explain the reason which the LSI-11 was deserted and new slow timing system. In the old timing system, we must manage two software system and maintain the communication system between the HIDIC 80E and the LSI-11. We think that the unification of the software system and the simplification of the hardware system are important. Though the response speed for the event request is degraded, one of the new timing system is enough for the accelerator operation. We decided to eject the LSI-11 for reliability, flexibility and maintainability. Figure 2 shows the relationships between the software modules and the hardware modules which they control in new slow timing system. In the main control room there is a CAMAC crate with the timing master generator module for generating and transmitting the slow timing signal.

The following programs have been developed.

(1). A Management program to produce slow timing signals runs on the HIDIC 80E (GP0). This program (TRLSI) has the data-table for timing event codes.

(2). A program which is activated by a LAM directly produced from several hardwares requests slow timing signals to TRLSI. This program (EVSIL) runs on the GP0.

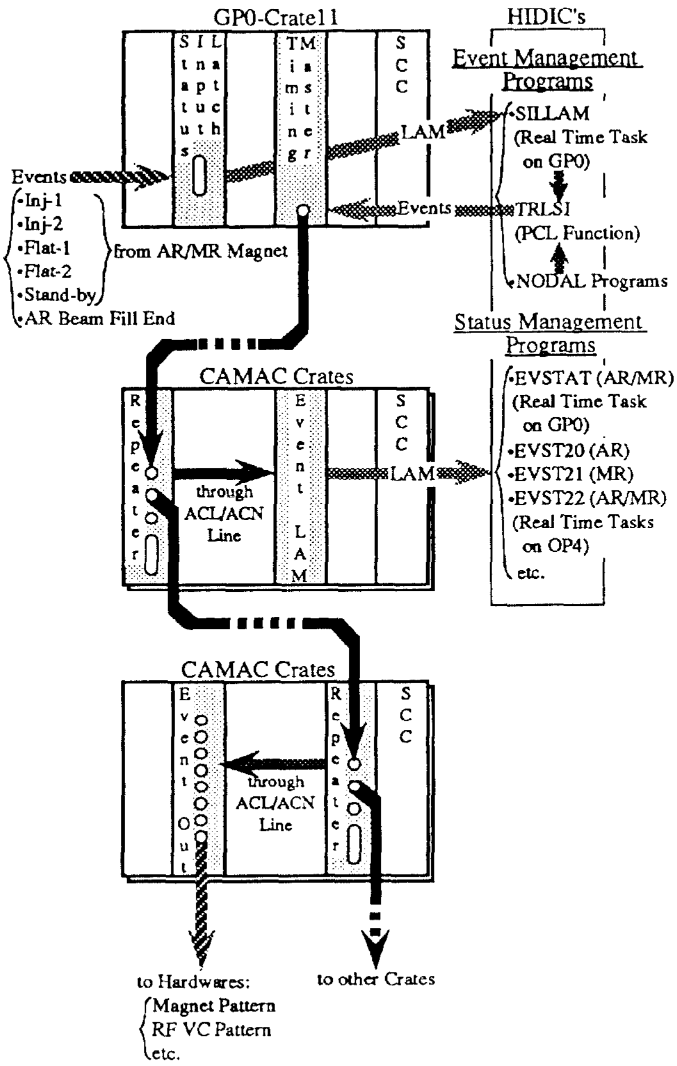

Fig.2 The relationships between the software modules and the hardware modules which they control in new slow timing system.

(3). Programs which are activated by LAM produced by timing modules using a code of slow timing signals run on several HIDIC minicomputers to display the timing status and to activate other programs.(EVSTAT, EVST20, etc.)

(4). A program which manages the bunched beam transfer runs on the GP0. (EVBMC)

(5). Program for setting data into the timing modules run on HIDIC 80's.

(6). Many function programs for the timing system.

(7). A cheking program for the slow timing system.

Program(1) attaches the event signal to the slow timing signal through the timing master module by a CAMAC command.

The slow timing system manages the operation mode of the accelerators. The HIDIC-80E (GP0, OP4) can monitor the operation mode through the operation-mode events of the slow timing signal, using the event LAM module. If one wants to activate a program following the operation mode, the program is queued by a timing event registered in the GP0. This program is either initiated after the operation mode, or activated by the event management program on the HIDIC-80.

IV. SUMMARY

A new optical fiber cable with highly stabilized transmission delay time and improved resistivity against irradiation was installed for the transmission of 508MHz timing signal between the linac gun room and the TRISTAN AR. The new optical system eliminated the frequent phase adjusting in the former coaxial transmission system required from the temperature change in a year. The use of this phase stabilized optical fiber system will be effective in the precise transmission of timing signals in the acceleration systems.

The new slow timing system has managed the operation since January 1990. It gives more reliability and more flexibility. In order to increase the response speed for the event request, we are preparing for the replace of the HIDIC-80E to a 32-bit computer.

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