Characteristics of RF Reference and Timing Signal Distribution for SPring-8

Hiromitsu Suzuki, Yoshitaka Kawashima, Yuji Ohashi, Hiroto Yonehara, Hiroyasu Ego,
Norio Tani , Teruyasu Nagafuchi, Toshihiko Hori, Takashi Oshima and Masahiro Hara
JAERI-RIKEN SPring-8 Project Team
JAERI, Tokai-mura, Naka-gun, Ibaraki-ken, 319-11, Japan

Abstract

The RF systems of the synchrotron and the storage ring is operated by the 508.58 MHz frequency of a master oscillator. Since the time width of each RF bucket is 2 nsec, the timing accuracy required for beam transfer from the linac to the synchrotron and from the synchrotron to the storage ring must be less than 100 psec to suppress the beam loss due to the synchrotron oscillation of the injected beam. The transfer line of the timing signal and the RF frequency consists of the optical fiber and the EO/OE transmitter and receiver which has low jitters and temperature dependence. For single-bunch beam-operation, a 508.58-MHz preset-counter was developed and tested.

1. INTRODUCTION

To operate the accelerator complex of the SPring-8 facilities, two systems for timing coordination are necessary. The first system is associated with beam transfer from the linac to the synchrotron. The second system is associated with beam transfer from the synchrotron to the storage ring. The RF systems of the synchrotron and the storage ring will be operated by the 508.58-MHz frequency of a master oscillator and the harmonic numbers of 672 and 2436, respectively. Since the time width of each RF bucket is 2 nsec, the timing accuracy required for the beam transfer from the linac to the synchrotron and from the synchrotron to the storage ring must be less than 100 psec to suppress the beam loss due to the synchrotron oscillation of the injected beam. For single-bunch beam-operation, it is necessary to select any one of the 2436 buckets as the single filled bucket in the storage ring into which the bunched beam from the synchrotron is transferred. Two concepts for the timing systems are being considered. One concept uses a synchronous timing table which has low jitters (lower than 100 psec) and the other utilizes is a phase control loop which has the accuracy of lower than 1 degree. The one or half kilometer transfer line of the timing signal and the RF frequency consists of the optical fiber and the EO/OE transmitter and receiver which has low jitters and temperature dependence.

The temperature dependence of the phase shifts in the transfer line was measured. The jitters of a short-pulsed beam were measured with the gun of the linac. And the 508.58-MHz preset-counter for the timing pulse generator was developed and tested.

2. Transfer Systems of the RF Frequency and the Timing Signal

A. Transfer System of the RF Frequency

There are four RF stations in the storage ring and one RF station in the synchrotron. The master oscillator is situated in the A-station. The transfer line from A-station to the other stations are one or half kilometer length.

The temperature dependence of the RF phase-shift was measured with the long optical fiber and the EO/OE transmitter and receiver. The fiber (DTS-M02) is made by Sumitomo Electric Industries. The EO/OE (model 3510A and 4510A) is made by ORTEL corporation. Figure 1 shows the block-diagram of the phase-shift measurement.

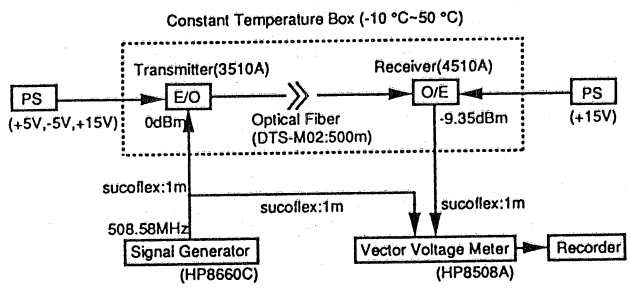

Figure 1 The block-diagram of the phase-shift measurement

Figure 2 shows the temperature dependence of two 500-m optical-fibers. Figure 3 shows the temperature dependence of the EO/OE. The phase shift of the optical fiber is lower than ±2 degree under the condition of 10 to 30 degree C. But EO/OE has the ratio of 0.2 degree per degree C. Therefore the optical fiber should be placed in the air-conditioned room, and the EO/OE must be placed in the constant temperature boxes.

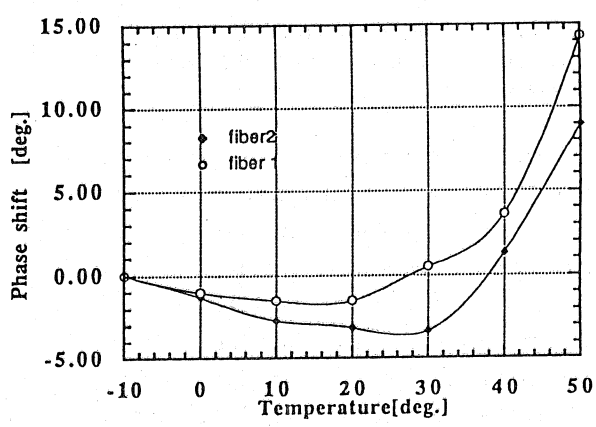

Figure 2. The temperature dependence of two 500-m optical-fibers

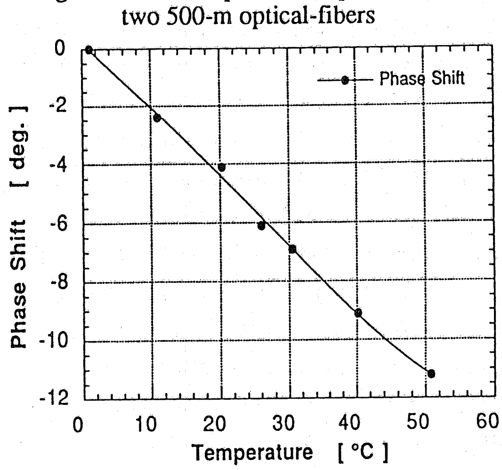

Figure 3. The temperature dependence of the EO/OE

B. Transfer System of the Timing Signal

The timing signal generator for the gun trigger is situated in the control station of the synchrotron. The transfer line from the synchrotron to the gun is about 200 m length. The jitters of the timing signal is required to be less than ±100 psec for the single-bunch beam-operation. The same system of the optical fiber and the EO/OE which is used for the RF frequency. The optical fiber and the EO/OE as the transfer line of the RF frequency is used for the timing signal.

The jitters between the trigger signal and the electron beam emitted from the gun following the signal were measured with using of the old and new timing systems. Figure 4 shows the jitters of the old timing system. One standard deviation of the jitters is 170 psec. Figure 5 shows the block-diagram of the new timing system. The optical fiber and the EO/OE is the same system used for the transfer system of the RF frequency. To reduce the jitters caused by the deference of the pulse height, the constant fraction discriminator (ORTEC model 935) is used after the O/E receiver. After this signal is amplified to the level of 9 V, the 9-V signal is used for the trigger of the grid pulser of the gun. The electron beam from the gun is measured by the wall-current monitor. Figure 6 shows the jitters of the beam current waveform for the trigger signal. One standard deviation of the jitters is 30 psec. This value meets the specification of the transfer line.

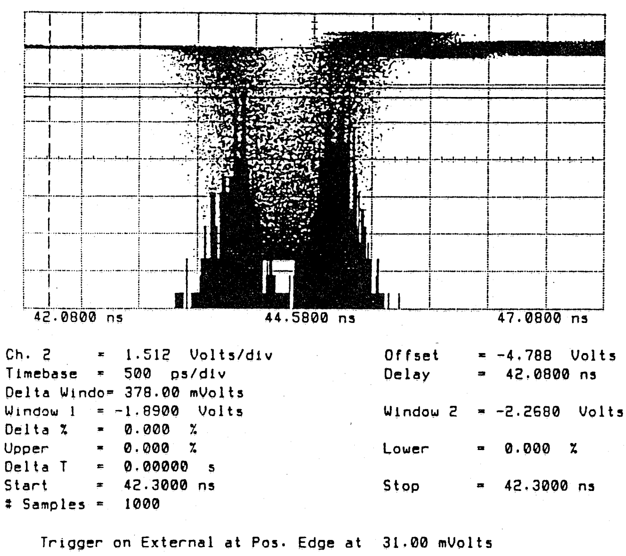

Figure 4. The jitters of the old timing system

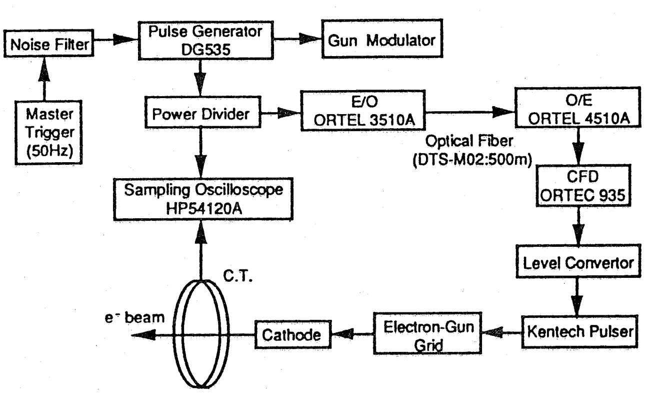

Figure 5. The block-diagram of the new timing system

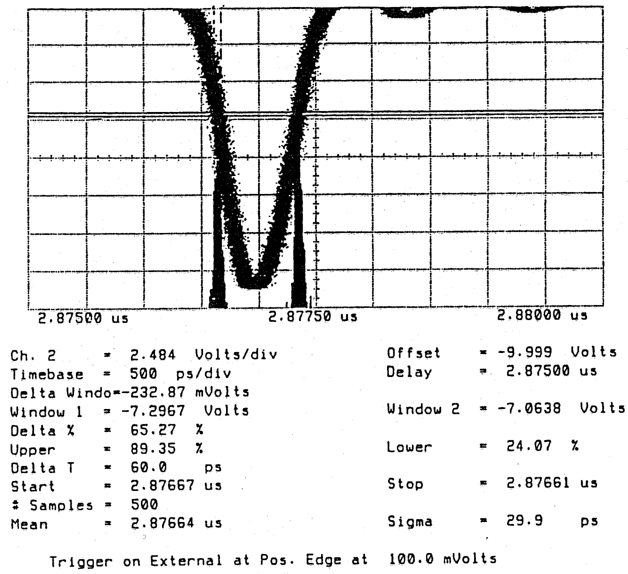

Figure 6. The jitters of the new timing system

3. 508.58-MHz Preset-counter

To generate the master pulse for a single-bunch beam-operation, 508.58-MHz preset-counter is tried to be manufactured and the quality is measured. Figure 7 shows the block-diagram of the measurement system. The RF signal of 254.29 MHz is entered into one preset-counter and the RF signal of 508.58 MHz is entered into the other preset-counter. These preset-counters count 1218 pulses and 2436 pulses, respectively, and make out one pulse. The duration of the pulses are constant (4.79 μsec) and the delay between two pulses is also constant, if the preset-counters do not miscount the RF signals. Figure 8 shows the waveform at start. Figure 9 shows the waveform after 22 hours. Because the delay between two pulses is not changed, the preset-counters do not miscount the RF signal.

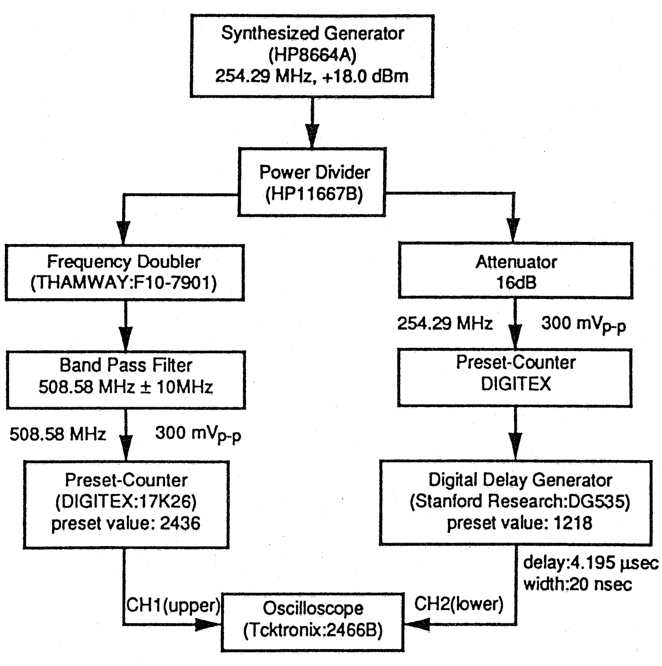

Figure 7. The block-diagram of the preset-counter measurement system

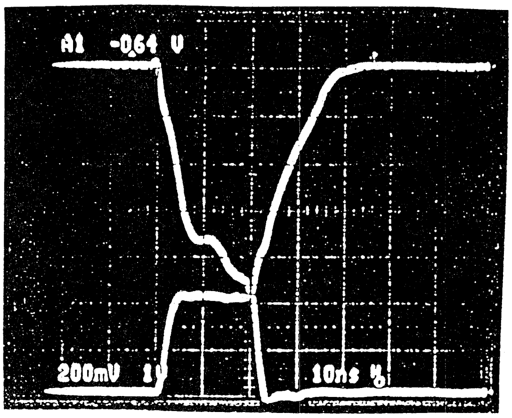

Figure 8. The waveform at start

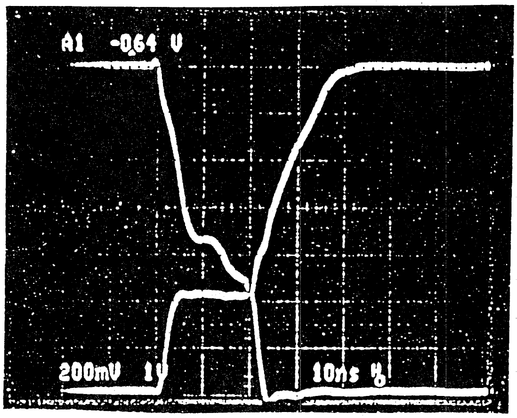

Figure 9. The waveform after 22 hours

4. CONCLUSION

The optical fiber, the EO/OE and the 508.58 MHz preset-counter for the transfer line of RF frequency and the timing signal were tested and it probed that the components meet the specification of the RF and timing system.