STATUS OF TIMING SYSTEM AND ITS UPGRADE FOR THE PLS STORAGE RING

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Abstract

The timing system for the Pohang Light Source(PLS) storage ring consists of a trigger synchronize module, a fine delay module, a repetition rate pulse generator module, and so on. All the timing modules are installed in the VXI crate and controlled by the 32 bit microprocessors with the host computer. Although the timing system has been operated without any serious problems since commissioning in 1994, there were some minor troubles, and the performances were not so excellent. Therefore, upgrade of the timing system is progressing with a synchronous universal counter and other commercial modules of NIM type for increasing of a reliability, easy maintenance, low timing jitters, and all types of beam filling pattern.

1 INTRODUCTION

The Pohang Light Source (PLS) is a 2.0 to 2.5 GeV, the third generation synchrotron radiation source, which has a full energy linac and a storage ring. The PLS is usually operating at 180 mA storage currents of 2.5 GeV full energy injection with 400 multi-bunch mode[1]. The function of the timing system is to provide the synchronized trigger signals for the linac, the kicker magnet of the injection system, so that a bunch will be fully accelerated in the linac and transported to the injection point at the right time, and injected into the storage ring properly. The PLS timing system was capable of producing trigger pulses for all the pulsed devices that are an electron gun, klystron modulators as well as a kicker[2].

Parameters of present timing system are shown in table 1.

Table 1. Parameters of Present Timing System

Storage Ring RF Frequency	500.082 MHz
Harmonic Number	468
Revolution Frequency	1.068 MHz
Linac RF Frequency	2856 MHz
Repetition rate of Gun	10 Hz
Repetition rate of Modulators	30 Hz
No. of Modulators	12 set
Adjusting Delay range	5 ps to 2 sec
General Delay for Kicker	42.09 us
Jitter between SR and Linac	~200 ps (rms)

2 PRESENT TIMING SYSTEM

The main requirements of timing system is to fill up the required storage ring buckets as well as partial buckets in any pattern and have the small timing jitter so that the beam quality and the transfer efficiency are maintained. For the successful injection, the timing system should provide accurate trigger signals for the gun, klystron modulator in the linac, and injection kicker magnet in the storage ring. For high flexibility and reliability of the timing system, all timing modules are installed in a VXI crate, and fully controlled through the communication network from the upper level computers. The timing trigger pulses are generated with the main modules, such as a trigger synchronizer module(TSM), a repetition rate pulse generator(RRG) and a fine delay module(FDM). Figure 1 shows a block diagram of the present timing system for the PLS storage ring and linac.

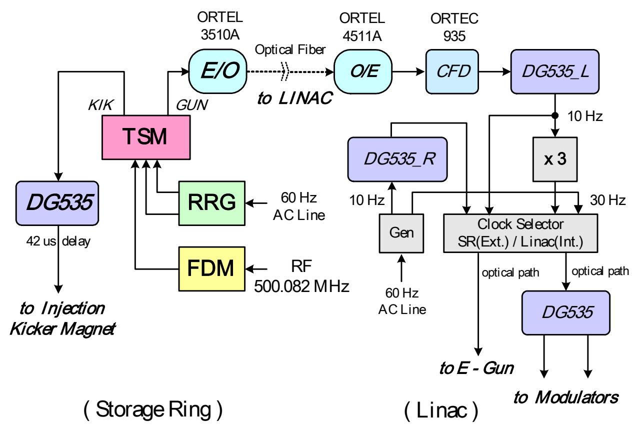

Figure 1 : Block Diagram of Present Timing System

The FDM has two function of dividing the rf frequency by harmonic number and delaying with 2 nanosecond each by the a programmable delay through the computer program. The outputs of the FDM are a storage ring clock and a delayed ring clock of 1.068 MHz revolution frequency. The RRG gives the electron gun and klystron modulators the repetition rate pulse which is synchronized by AC power line. Synchronizing the timing signals to the AC mains is important to minimize the effects of magnet and klystron modulator power supply ripples on the beam [3] The repetition rate pulse is 10 Hz for the gun and kicker, and 30 Hz for the klystron modulators in order to stable operation. The TSM generates timing signals for a gun, modulators and a kicker, which are synchronized on the 500.082 MHz storage ring rf and 1.068 MHz revolution frequency, as well as 60 Hz AC mains.

The DG535 of the Stanford Research Systems(SRS) is a very precise delay and pulse generator providing four precision delays or two independent pulses with 5 picoseconds resolution. The E/O module of the ORTEL is to transfer the timing pulse from electrical signal to optical signal in order to transmit with low jitter to the linac.

3 FUNCTIONS & REQUIREMENTS

The timing system was designed, developed and fabricated in 1994 for the PLS with reference to KEK timing system[2]. The timing system modules was fabricated with VXI standard modules. So far, there were some minor changes to improved the function of the timing system such as the FDM, RRG, TSM, control programming, and optical fibers including linac timing distribution system.

Although the present timing system has been operated without any serious problems since commissioning in 1994, there were some minor troubles, such as a single mode operation, unstable klystron modulators operation with 30 Hz timing pulses, and fan-out signals for diagonasis system. Also there are not sufficient spare parts of the modules to maintenace, and it is difficault to make and improve the modules because of shortage of manpower. Therefore, upgrade of the timing system is progressing with a synchronous universal counter(SUC) [3] and other commercial modules of NIM(Nuclear Instrumentation Module) type for increasing of a reliability, easy maintenance, low timing jitters, and all types of beam filling pattern to users.

There are five important requirements for the upgrade of the present timing system.

First of all, the first is to stable the beam operation for increasing of a reliability with upgrade timing system including klystron modulators operation. The second is to synchronize the 500.082 MHz rf phase between the storage ring and timing signals to control precisely the various beam filling patterns even though to make any arbitrary filling patterns. The third is to decrease the timing jitter as small as possible less than 100 ps especially between the electron gun trigger with respect to the storage ring rf. The fourth is to add the flexibility with bunch by bunch filling for the advanced operation, such as 2.5 GeV top-up mode operations. The fifth is to consider the easy maintenance, modification, expansion with many fan outs, and so on.

To satisfy the requirements with the higher precision, the upgrade will be used the SUC module and commercial modules of NIM which are already proven good qualities.

4 UPGRADED TIMING SYSTEM

The most important module of the upgraded timing system is an SUC which was designed, developed, and operated very well at the SPring-8 in Japan. The SUC works from 450 to 550 MHz rf frequency and has a 30 bit width. Its two main features are a dividing function with an arbitrary positive integer and a digital delay function with a time interval from 2 ns to 2 s. The circuit block diagram is shown in figure 2. The SUC counts the rf bucket number corresponding to the harmonic number (N=468) of the storage ring, and then it provides a pulse corresponding to the revolution frequency of storage ring from '1/N' output. And the output 'M' corresponds to the particular rf bucket within a revolution. Beams from the linac are injected into the addressed rf bucket by setting the number 'M' with control program externally as desired beam filling pattern[4]. The block diagram of the SUC is shown in figure 3.

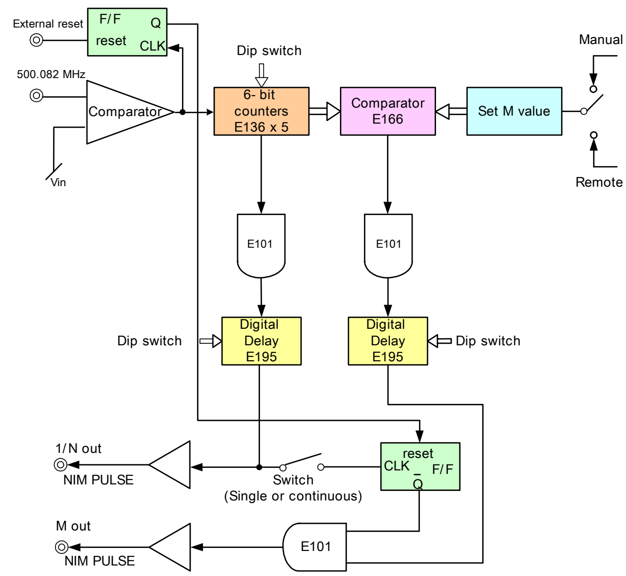

Figure 2 : Block Diagram of the SUC

The block diagram of the upgraded timing system is shown in figure 3.

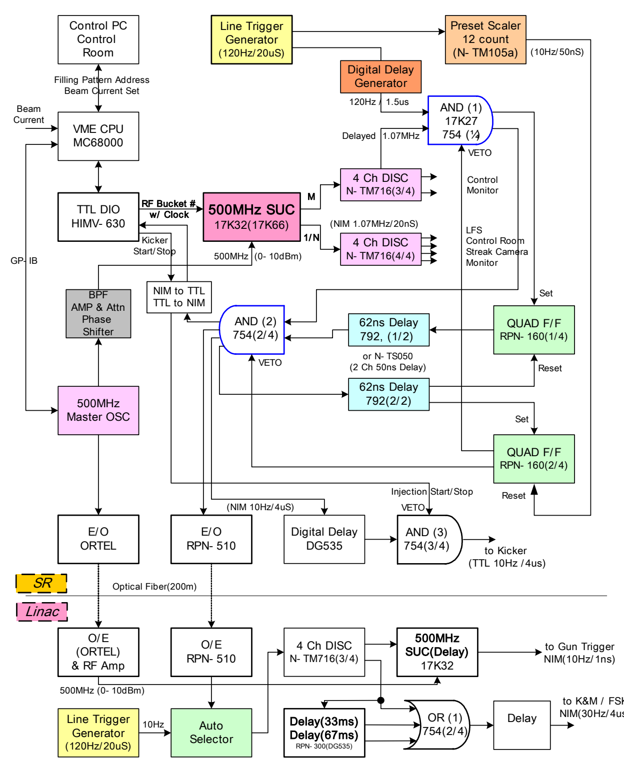

Figure 3 : Block Diagram of Upgraded Timing System

Injection commands with filling pattern are delivered from the central control room via a VME and a computer network. At first address of the rf bucket according to the filling pattern is written on the SUC. The SUC makes '1/N' revolution clock and delayed 'M' revolution clock.

And then, the revolution clock goes to the discriminator for shaping the pulse and adding the fan-outs.

There are two AND gate modules which have two inputs and one veto. An output signal of the AND(1) gate is produced one or two revolution clock about 1 ns period during 10 Hz with about 1.5 us width. Simple coincidence between 1.068 MHz revolution frequency and the 60 Hz AC line may cause an ambiguous output timing depending on the relative timing of the two inputs. Therefore, to avoid the situation of determining the timing by the 60 Hz line pulse, the second coincidence output must be used by ignoring the first output. The AND(1) output enters to AND(2) and a gate generator of the QUAD F/F. The first pulse of AND(1) never triggers the output pulse of AND(2), and the second pulse triggers it because of the veto function with two 62 ns delay modules. A preset scaler counts the 120 Hz by 12 division and produces a reset trigger of the QUAD F/F(2) after every 10 Hz period. And then, AND(1) and AND(2) are reset again for a next new trigger signal of 10 Hz[5].

The 10 Hz gun trigger timing pulse transmit to linac through the E/O (Electrical to Optical translator) and O/E (Optical to Electrical translator) modules to suppress noises and to improve the jitter. At the linac timing system, 30 Hz pulse for the klystron modulators is generated by 10 Hz with delay modules.

Some modules such as line trigger generator and auto trigger selector are developed at a domestic company with ECL technology. A line trigger generator has a function to synchronize with 60 Hz AC line, and to divide input trigger on two stages.

5 SUMMARY

The status of present timing system and its upgrade for the PLS storage ring has been described. The present timing system is usually operating for 400 multi-bunch filling pattern without any serious problems. The upgraded timing system was tested at the laboratory with some NIMs including the SUC, and will be installed this year. Also control group members are developing the control programming by new EPICS with present VME for the better operation of the upgraded timing system. After successfully commissioned, bunch by bunch injection operation to fill same storage current at each buckets will be considered for the top-up injection in the future.

6 ACKNOWLEDGEMENTS

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7 REFERENCES

[1] E.S. Kim et al. "Operation Performance in 2.5 GeV Full Energy Injection at PLS", Proc. of in this conference.

[2] S.S. Chang et al. "Timing System for PLS", Proc. of 4th Asia-Pacific Physics (1992).

[3] S. Marques et al. "Upgrade of the LNLS Synchrotron Light Source Timing System", Proc. of PAC'01, Chicago, USA (2001).

[4] H. Suzuki et al. "508.58 MHz Synchronous Universal Counter for Beam Control System of SPring-8", Nuclear Instruments and Methods in Physics Research A 431 (1999) p294-305.

[5] Y. Kawashima. "Timing System at SPring-8", Proc. of 13th Symposium on Accelerator Science and Technology, Japan (2001).