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Injection Timing System for PLS

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Abstract

The ultimate goal of the PLS timing system is to successfully inject a electron bunch to a predesigned bucket in the Storage Ring.

In the Linac, a pretrigger of 102.8 microseconds prior to the Gun trigger may be required to charge the pulsed divces properly and it should be precisely delayed to synchronize with beam pass at each accelerating column.

To inject the electron bunch, which fully acceleated in the Linac, into a target bucket of SR, the injection kicker magents must be energized to provide the appropriate magnetic field. For the sequential filling of the SR buckets, the appropriate timing delays throughout the entire timing system are programmably controlled by operator.

Introduction

The Pohang Light Source (PLS) consists of two individual particle accelerators all working in concert to ultimately produce the high brilliance X-ray to the experimenters: the Linac and the Storage Ring (SR). Both accelerators are composed of various transient devices like an electron gun, the booster and klystron modulators, injection magnets, and etc. In the Linac, an electron bunch is accelerated up to 2 GeV for full energy injection, while the SR accelerate the particle only to replenish any energy loss by synchrotron radiation.

The Linac rf system is composed of a booster station, 11 high-power klystron modulator and 10 pulse compressors. It's operating frequency is 2,856 MHz. In the booster station, the driving system provides the optimum condition of the drive signal for high-power klystron and the phasing system make the phase synchronization between the electron bunch and the accelerating wave. The function of these system is to get the maximum beam energy and minimum energy spread on the basis of a stable drive sytem and correctly phased high-power wave guide network. The typical output pulse length from the booster modulator is 4 usec. The high-power modulator supplies pulse voltage to the high-power Klystron. It can operate in two mode : an acceleration mode and a standby mode. In the acceleration mode, the output power is delivered to the accelerating column at the time synchronized to beam pass and then the beam is accelerated. In the standby mode, the output power is delayed with respect to the beam passage and has no effet on the beam. Typical specifications of the modulator are 60 pps pulse repetition rate, and 4.4 us flat top pulse width. Meanwhile, the klystron that utilized the pulse compressor require a phase reversal gate. So the PSK on the booster station is used to reverse the phase of 180°. All of these systems are operated very closely through the timing system.

Injection into the SR accomplishes via a Lamberson septum and the kicker magnets. Prior to injection, the storage ring closed orbit is bumped close to the end of the injection septum by four bump magnets. A pulse of electrons is then transported through the injection septum into the SR. After injection, the bump magnets are turned off in a time corresponding to about two orbits of the ring to prevent the stored beam from disturbunce of the kicker field. The newly injected beam then undergoes coherent betatron oscillation about the closed orbit-motion that is rapidly damped by means of synchrotron radiation damping. This process is repeated at the cycle rate of kicker magnet until the desired beam current is reached.

Timing Sequence

The timing sequence is shown in Fig.1,2 to illustrate that many events are initiated by a pretrigger. In this sequence all the transmission delay are neglected for simplicity. It is supposed also to be no delay for the beam from the gun to injection point, where injection point means the bucket into which the electron bunch is transferred. The time between consecutive buckets passsing a fixed point on the SR is 1.9996 nsec because the SR has 468 stable rf buckets into which a bunch of electrons can be injected. One periode of the rf is named a "tic" so a tic

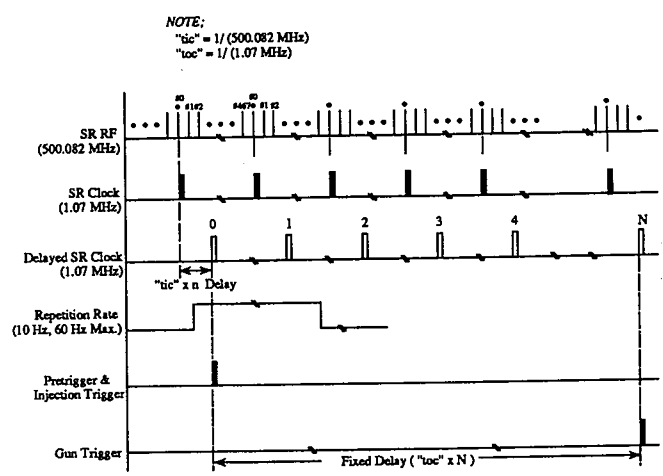

Fig.1 Timing Sequence (I)

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is equal to the time seperation between two adjacent rf buckets. When a arbitrary standard revolution clock is defined, each bucket can be uniquely identified by the time displacement of integer multiple of a tic from the standard revolution clock and can be named as bucket #0,#1,...#467. Actually the standard revolution clock is made dividing the rf frequency by the SR harmonics and then the physical bucket #0 is identified as the bucket which synchronized with standard revolution clock in the injection point. The physical bucket #0 is also defined as the bucket filling firstly for the ring operating cycle. To fill the next bucket, for example, as bucket #n the phase of standard revolution clock is shifted a degree of n times of a tic and then the gun trigger is fired at time when synchronizes with this delayed standard revolution clock. On the other hand, A pretrigger is provides 102.8 usec prior to gun grid trigger to properly charge the modulators. Basically, a trigger signal generated on the first edge of revolution frequency falling with a gate drived from the 120 Hz zero-crossing in the repetition rate generator produces a fiducial which is superimposed on the 1.07 MHz singal in the synchronizer is then transmitted on the timing local station and SR kicker station.

In the Linac, a pretrigger is delayed according to the timing requirement of each pulsed devices. Their events are as follow :

1. Gun Trigger ; This signal is used as the reference for all of the other events. The occurence of this signal is determined by the entire timing system and is synchronized to the SR rf.
2. Early Modulator Tirgger ; The high-power modulators must begin charging before any other events.
3. Thyratron Trigger ; This event enable the klystrons. After the modulator rise time, rf begin filling the accelerating waveguides and the pulse compressor cavities.
4. Booster Modulator Trigger ; This event enable the booster modulation amplifier.
5. PSK trigger ; The klystrons used the pulsed compressor need a phase reversal gate. This starts at 0.86 usec prior to the gun trigger signal.

Timing System Description

The PLS timing system consists of a master oscillator, a bucket selector, two rf drive stations, a kicker drive station and other miscellaneous modules. A block diagram of the system description of PLS timing is shown in Fig. 3. The 500.082 MHz rf reference signal is provided to each component via a temperature stabilized line from the main oscillator located in the rf room.

In the bucket selector, the synchronizer generates the pretrigger and a gun trigger, which are synchronized with the SR rf. A gun trigger singal is transmitted to the gun grid pulser without extra delay, in order to reduce the jitter of beam with respect to the ring rf. The pretrigger is split and delayed individually by three kinds of delay circuits to adjust the timing of each modulator.

The repetition rate generator decides an operating cycle to the pulsed devices. Although the pulse repetition rate is limited by the hardware constraint of the power supply of kicker magnet, the repetition rate is variable up to 120 Hz.

Bucket Selector

The function of bucket selector is to make the Linac triggers synchronize with ring rf and to facilitate the selection of an arbitrary bucket. The bucket selector is composed of a ring revolution frequency generator, a synchronizer and a fine delay module.

Fig.4 shows the schematic layout of the bucket selector. Firstly, the standard revolution clock is obtained as divding the ring rf frequency by the ring harmonics. The next, the standard revolution clock is delayed and then the fine delay module is used as a revolution frequency phase shifter. Threrfore we can select an arbitrary bucket by the setting of a preset value corresponding to time displacment of a target bucket. The synchronizer generates two kinds of synchronized triggers : the injection trigger

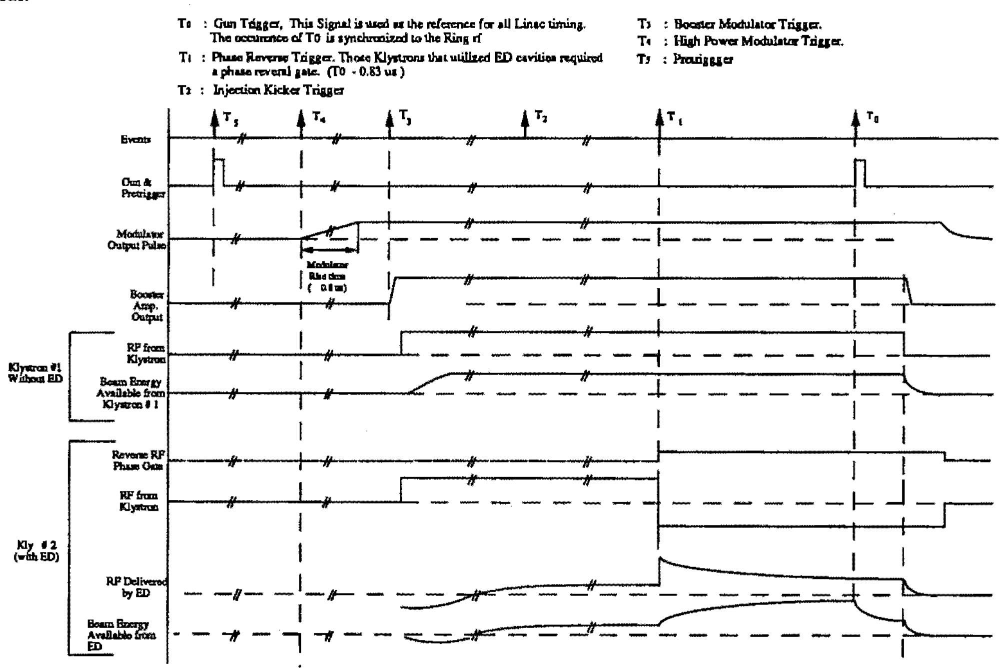

Fig.2 Timing Sequence (II)

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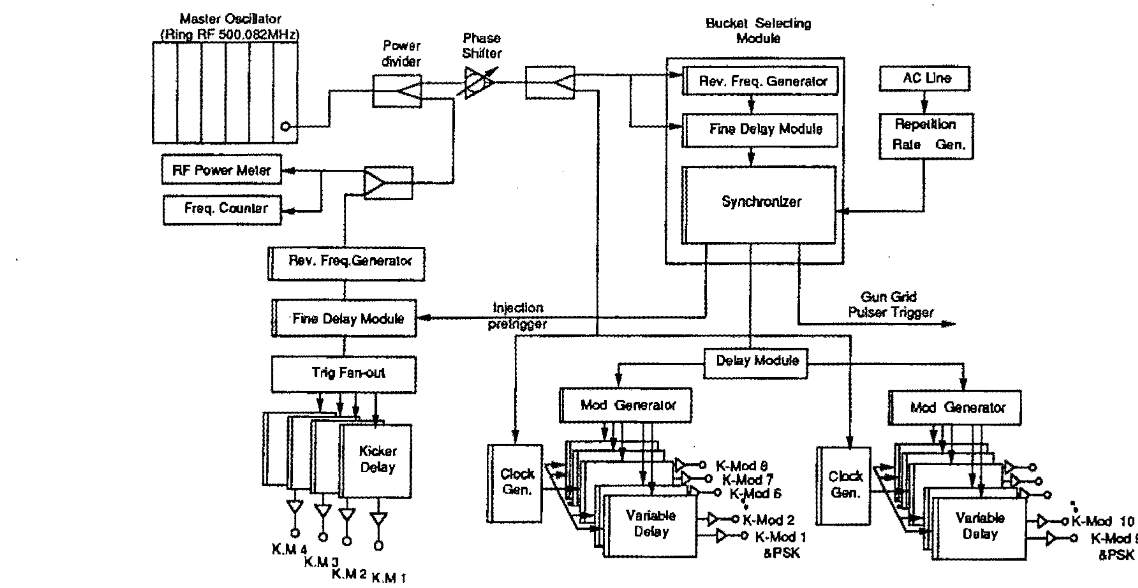

Fig. 3 Schematic Diagram of the PLS Timing System

and gun grid trigger. The jitter of the gun grid trigger output of the synchronizer is less than 100 psec with respect to the SR rf.

RF Drive Station

The rf drive station is designed to adjust individually the trigger timing of each Klystron modulator and a booster modulaor, and to select the trigger mode of each Klystron modulator. At each station it provides 6 mode-selected Klystron modulator trigger signals delayed individually. Each unit of the local station consists of a trigger mode selector, six 10 us/step variable delay modules and a clock generator. The input trigger generates two type of signal : an acceleration mode trigger and a standby mode trigger. Both are fed to the variable delay module for the one of them selected by the mode selector is fed to each Klystron variable delay module.

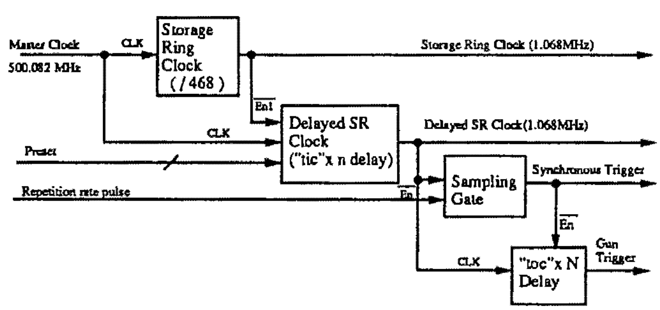

Fig. 4 Schematic Diagram of the Bucket Selector

Kicker Drive Station

To inject the bunch into the SR, the injection kicker magnet must be energized to provide the appropriate magnetic field. The power supply of PLS injection kicker magnet is specified to provide a half sine wave with a base width of 4 usec. Since magnet field must be stable when the bunch arrives, the magnet should nominally be triggered at 2 usec prior to the arrival of bunch at injection point. The kicker drive station is composed of a fixed and some variable delay modules and supplies the pulsed magnets with the delayed trigger pulses according to delay time of each pulsed manget. The lengths and heights of a delayed pulse should be adjusted to drive the pulse magnet.

Control of Timing System

For the high flexibility and reliability of the timing control, VMEbus based computer are introduced and all the timing modules are installed in VME crates. Overall control sytem for the PLS timing is composed of a master and 3 distributed slave system. The master VME system consist of a motorola 32-bit microprocessor, local memories, a Ethernet controller, some I/O controller. The real-time opeating system such as OS-9 is installed and all of the timing data is set and recorded.

References

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