Chapter 6 Timing System

In this chapter, we describe the conceptual design of the timing system.

The LINAC, RCS and MR are operated at the repetition rate of 50 Hz, 25 Hz, 1/3.64 Hz (40 GeV MR operation in phase I) or 1/3.52 Hz (50 GeV operation), respectively. In each pulse, the LINAC and the RCS have the different destination of the beam as following:

- (LINAC) One pulse for the RCS injection and one pulse for the accelerator-driven nuclear transmutation (ADS)
- (RCS) 4 pulses in the 91 (or 88) pulses in the MR cycle for the MR injection and the others for the 3 GeV beam-users

Hence, the LINAC and the RCS must be operated in different modes in each pulse. This leads that the devices in them run in the *different timing* by pulse-to-pulse.

Since the power supplies for the lattice magnets if the RCS and MR are operated independently from the AC line frequency, the timing system does not need to synchronize with the AC line-frequency. The whole timing system is based on the *master clock* generated by a high-stability synthesizer. The system clock is chosen to be 12 MHz, which has a integer ratio to the LINAC acceleration frequency 324 MHz.

6.1 Basic design

Most devices run with the scheduled timing, which is defined by a delay determined in advance from the 50 Hz *trigger clock*. Before the trigger clock is sent from the central timing-control room, a control word (so-called "*type*" which presents the operation type of the accelerator during the next 50 Hz period) is sent to the receiver-modules for the target devices in the power-supply rooms. The transmitter module sent the type one-by-one from the type-memory in the module with every trigger clock. The receiver module picks up the delay word from a lookup-table (LUT) in the module by using the type. The LUT is programmed from the remote work-stations. Upon receiving the trigger clock, the receiver module starts an internal delay counter and outputs a delayed-pulse on the scheduled delay timing. The delay word width is to be 24-bit and the delay counter runs at the clock of 96 MHz, which is generated by the 12 MHz master clock by a PLL. Hence, the module can count up to 170 msec. By setting the control-bits in the LUT, the module can count across the trigger clock. The system jitter is to be below 1 nsec.

The following signals sent from the central timing-control room is related to the scheduled timing. The signals are distributed to the receiver modules for the target devices through optical cables and fan-out modules.

- The master clock (MC): 12MHz high stability synthesizer.
- Trigger clocks: 50Hz clock are generated by counting down the MC of 12 MHz.
- "Type": This defines the accelerator operation in the next 20 msec period.

There are timings which cannot be programmed in advance as following:

- The timing of the beam chopper in the LINAC; this must be perfectly synchronized with the RCS RF system.
- The timing of the RCS extraction kickers and the MR injection kickers; they must be fired by a trigger generated by the RCS-MR RF synchronization system.

The dedicated modules and cablings for these special timing system are to be built separately from the scheduled timing system.

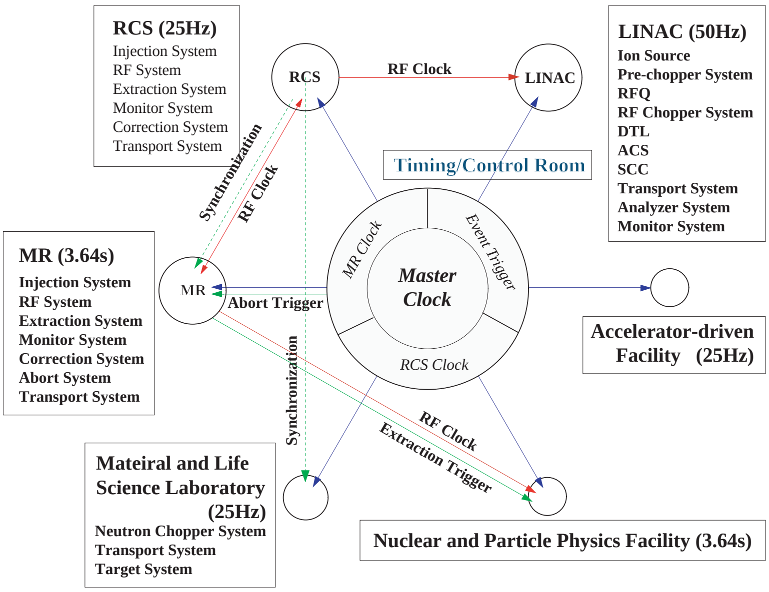

Figure 6.1.1: Basic timing block diagram for the JKJ accelerator complex

6.2 Timing chart of each accelerator

The trigger clock is generated by counting down from the master clock of 12MHz (figure 6.2.1). During 1 cycle of the MR, there are 91 RCS cycles (in the case of 40 GeV MR operation, for instance) of the 3GeV RCS. Timings for one cycle of 3GeV RCS is charted schematically in figure 6.2.3. All systems related to RCS must be based on this. After receiving the trigger clock, all systems start their operation as programmed. Timing of main components of the LINAC is shown in figure 6.2.2. For example, the power supplies of the DTL-Q have the rise time of about 10 msec and start first. All components of the LINAC are operated sequentially. Output beams from the LINAC are injected into the 3GeV RCS. Each timing clock from injection to extraction of the 3 GeV RCS is shown in figure 6.2.3. The 50GeV MR has fast and slow extraction modes. Time marks from P_0 (=P_5) to P_4 shown in figure 6.2.4 indicate start of MR injection, start of MR acceleration, end of MR acceleration and MR deceleration for the next cycle, respectively.

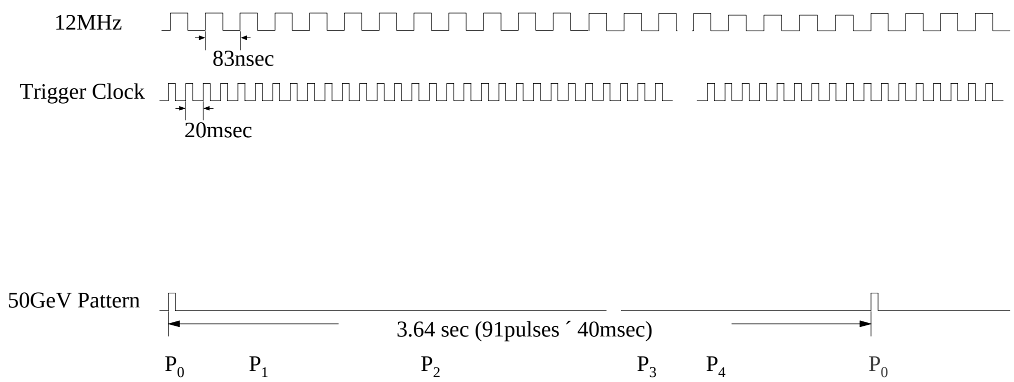

Figure 6.2.1: Timing clocks

The fundamental clocks, timing/triggers, control signals and gated signals are summarized in Table 6.2.1 ~ 6.2.3, and are distributed from the Timing/Control Room to all other facilities and the related power supply buildings as shown in Figure 6.1.1.

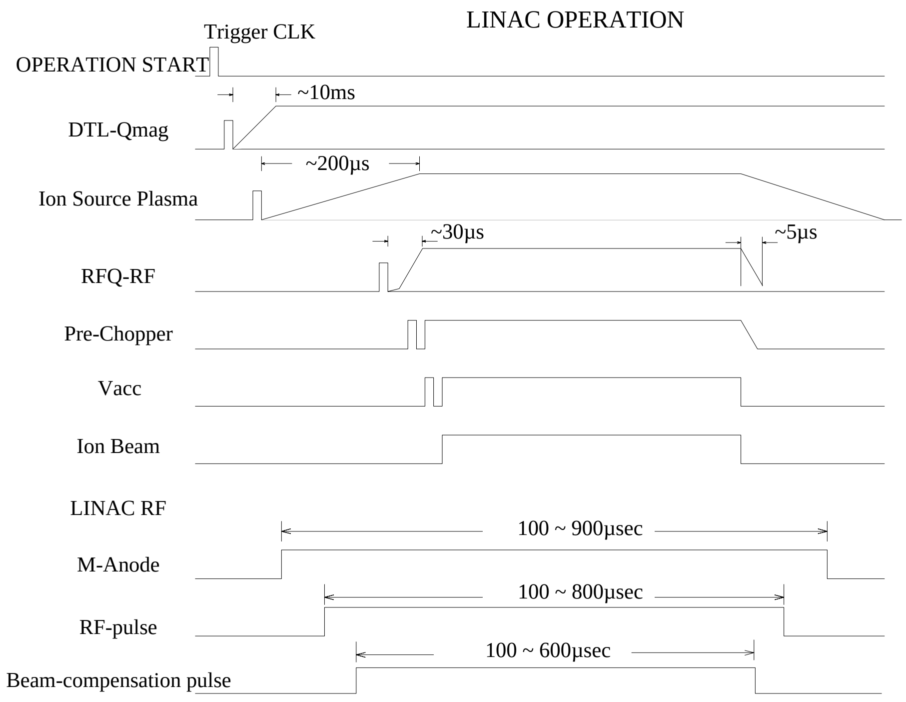

Figure 6.2.2: Timing details for LINAC

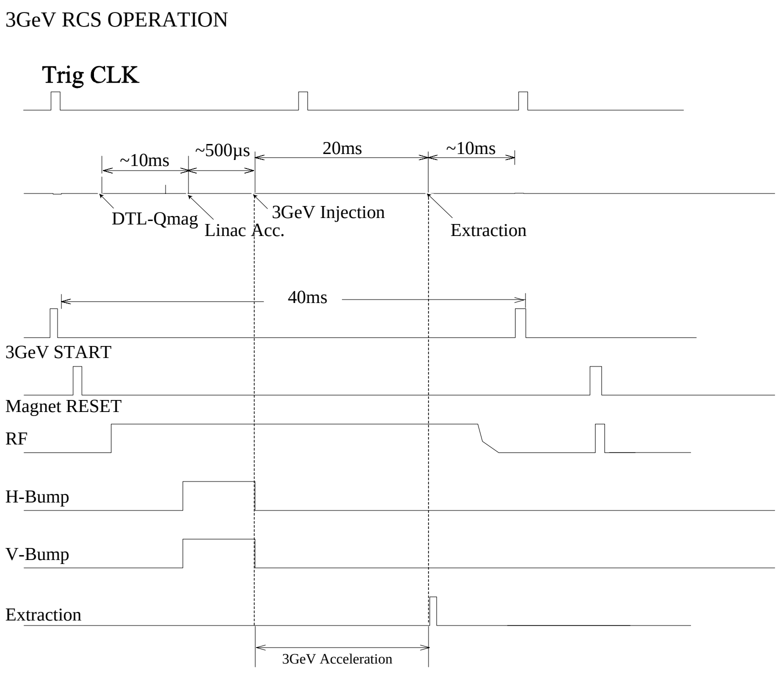

Figure 6.2.3: Timing chart for RCS cycle

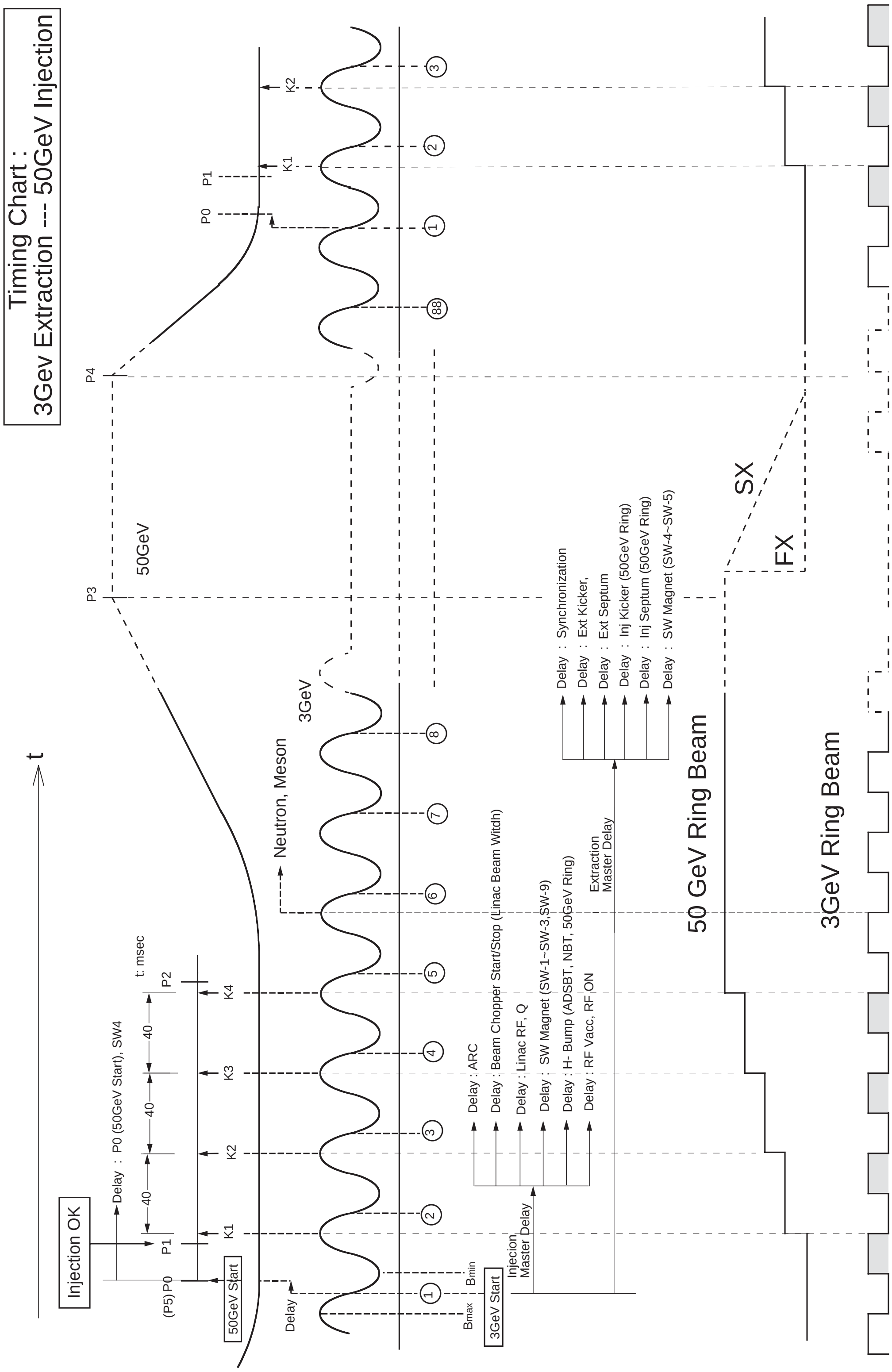

Figure 6.2.4: Timing chart for MR cycle

Table 6.2.1 Clocks and RF signals

Name	Category	Description	Source	Destination/distribution
12MHz Master clock	Clock	The periods of the 50GeV main ring and 3GeV RCS cycles are based on this master clock. All delayed timing and other clocks are also based on this.	Timing/ control room	All other facilities and the power supply buildings
324MHz RF signal	RF	This is the radio-frequency signal for RFQ, DTL and SDTL	LINAC control room	RFQ, DTL and SDTL Klystron's galleries
972MHz RF signal	RF	This is the radio-frequency signal for ACS and SSC	LINAC control room	ACS and SCC Klystron's galleries
36 MHz DDS System Clock	Clock	System clocks for DDS based RF generator modules of both the RCS and MR Ring RF systems. This is multiplied the master clock of 12MHz by 3.	RCS RF control room located in the power supply room	LINAC RF control room, MR RF control room
Trigger Clock	Clock / Trigger	50 Hz trigger, all delayed timing are defined as the delay from this trigger	Timing/ control room	All other facilities and the power supply buildings
BCLOCK1	Clock	The gauss clock of the RCS dipole magnet is considered 0.01 gauss clock or less	RCS magnet power supply room	All other facilities and the power supply buildings
BCLOCK2	Clock	The gauss clock of the MR dipole magnet is considered 0.01 gauss clock or less.	MR magnet power supply room	All other facilities and the power supply buildings

Table 6.2.2 Triggers:

Name	Category	Description	Source	Destination/distribution
Trigger Clock	Clock / Trigger	50 Hz trigger, all delayed timing are defined as the delay from this trigger	Timing/ control room	All other facilities and the power supply buildings
S	Trigger	This trigger is sent every 3 second period just before the MR machine cycle is started. through the same line as the line of “type” words. The receiver module is reset the all counters with this trigger.	Timing/ control room	All other facilities and the power supply buildings
B_{min}	Trigger	RCS magnet power supply gives the timing when the magnet field reaches at minimum. Not very accurate, but indispensable for the monitor, and not synchronized with 12MHz master clock.	RCS magnet power supply room	All other facilities and the power supply buildings
B_{max}	Trigger	RCS magnet power supply gives the timing when the magnet field reaches at minimum. Not very accurate, but indispensable for the monitor, and not synchronized with 12MHz master clock.	RCS magnet power supply room	All other facilities and the power supply buildings

Table 6.2.3: Control signals and gate pulses:

Name	Category	Description	Source	Destination/distribution
Mode pattern	Digital	Specific operation of the accelerator complex is distinguished with this pattern code.	Timing/ control room	All other facilities and the power supply buildings
Chopping duty	Gate pulse	Control signal to set a chopping duty factor for LINAC macro-pulse.	Timing/ control room	All other facilities and the power supply buildings
Beam request	Gate pulse	Beam inhibit signal based on PPS and MPS policies.	Timing/ control room	All other facilities and the power supply buildings