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Title :

TOPOLOGY OF THE SESAME TIMING SYSTEM

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1	*19/1//2009*	*T. Ali Khan, A. Kaftoosian*	*This report is the first technical note on SESAME timing system, the contents have been presented in TAC, 2nd November 2008*
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TOPOLOGY OF THE SESAME TIMING SYSTEM

Tasaddaq Ali Khan, Arash Kaftoosian

Abstract

Timing system generates and distributes hardware trigger signals and synchronization clocks around the accelerator facility to control the injection and acceleration. The proposed Timing System of SESAME will be discussed in this paper. Basic timing requirements, instruments to be timed, and communication of timing system with the control system will also be explained. This paper will also cover timing diagrams.

Introduction

SESAME accelerator complex consists of 22.5 MeV Microtron, 800 MeV Booster, and 2.5 GeV main Storage Ring. SESAME machine parameters and timing information is as follows:

RF Frequency	499.654 MHz
Injection Repetition Rate	1 Hz
Storage Ring Circumference	133.2 m
Harmonic Number of Storage Ring	222
Storage Ring Revolution Frequency	2.25 MHz
Booster Ring Circumference	38.4 m
Harmonic Number of Booster	64
Booster Revolution Frequency	7.807 MHz
Coincidence Frequency[1]	70.334 kHz

Table 1: SESAME Timing System Design Parameters

The task of the timing system is to synchronize different components of an accelerator complex [1]. One part of the task is to trigger the particle source (electron gun), triggering injection and extraction pulsed magnets, and to trigger the beam diagnostics components like BPMs and current monitors etc. These tasks are often termed as ***Fast Timing***. High precision is required to complete these tasks. Second kind is called ***Slow Timing*** and is related to synchronize components where the resolution requirement is more relaxed like triggering of magnets for acceleration ramp and phasing of dipole/quadrupole power supplies. Number of components synchronized by the slow timing is usually large. In general, slow timing takes care of synchronization that is in the timescale of one Storage Ring revolution and the fast timing up to a single bunch level. Following table shows the devices under slow and fast timing categories:

[1] The rate of having two marked buckets (one in Booster and one in SR) both in specific positions in Booster and SR

Table 2: Slow and Fast Timing Devices

Fast Timing Devices	***Slow Timing Devices***
Electron Gun & Magnetron Triggering	RF Ramp Trigger
Booster Injection Kicker	Booster Magnet Ramp Trigger
Booster Extraction Kicker	Booster Injection Septum
Storage Ring Injection Kicker	Booster Extraction Septum
Diagnostics (BPMs)	Storage Ring Injection Septum
	Steerer Magnet

Distributed vs. Centralized Timing System

Timing system can be distributed or centralized. In distributed timing system, triggering signals that control the devices are generated locally while machine cycle events that determine the order and flavor of each machine cycle are generated at a central location [2]. In the central timing system each timing signal is distributed by its own dedicated wire. There are following advantages of using distributed event system over centralized gate generator:

- Reduced cable plant
- Modularity
- large number of timing gates

Advantages of using centralized timing system over the distributed timing system:

- Synchronizing multiple gate instances
- Two events can occupy same time slot as compared to the serial line of event distributed system

Requirement

Basic requirements of the SESAME timing system are:

- To control injection process by providing highly stable reference (clocks) and timing signals to subsystems via distributed network
- To use RF-clock as reference signal to synchronize accelerator cycle control and recovery of the RF-clock at destination points (event-receiver site)
- To synchronize different equipments used for monitoring like BPMs and current monitors, gated cameras etc.,
- To support injection control for various operating modes (like single bunch, multi-bunch, etc.,)

Filling Scheme

The repetition rate of the injection is 1 Hz, so during one cycle the Booster will operate for 0.9 sec while 0.1 sec is the rest time of the dipole magnet power supplies. The electrons will be generated from the Microtron electron gun and the pulse width of these electrons will be 2 µs. RF Cavity of 3 GHz will bunch these electrons in the Microtron. Electrons will be accelerated by the Microtron to attain the energy level of 22.5 MeV and after 1 µs these electrons will reach at the boundary of injection septum of the Booster. The electrons will be again re-bunched in the Booster by the RF Cavity of 499.654 MHz. Total 64 buckets of the Booster (128 ns) will be filled during ~2 µs in one injection repetition cycle. The electrons will revolve in the Booster to attain the energy of 800 MeV. The revolution period of Booster is 128 ns.

After attaining the energy of 800 MeV in the Booster, electrons are ready for extraction from the Booster and injection into the Storage Ring. In the Storage Ring electrons will take several turns before attaining the energy level of 2.5 GeV. The revolution period of Storage Ring is 444ns (i.e. 222 buckets with 2ns RF period).
Timing scheme of the SESAME injection process is shown in figure 1 (times are not in scale).

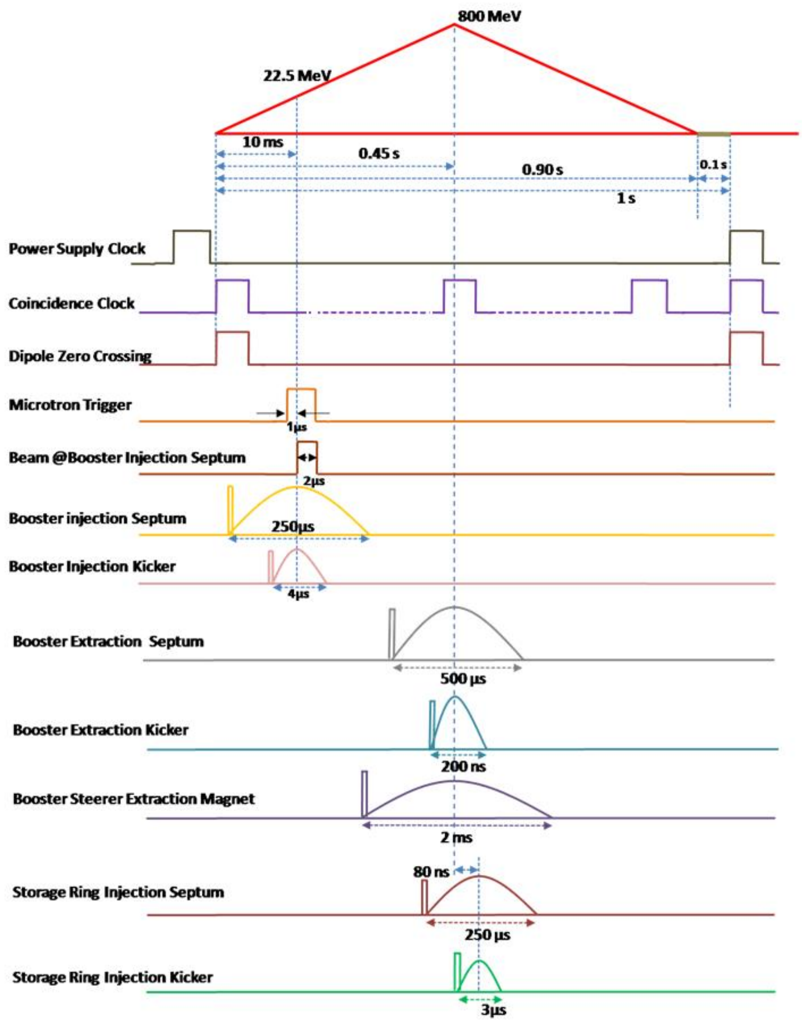

Figure 1: Timing diagram and event scheme of the SESAME injection process

System Overview

SESAME timing system will be based on event distribution system which is one of the most popular schemes in light sources now-a-days to distribute the timing signals. In this scheme, a Master/Event Generator Card communicates with many local/Event Receiver Cards globally via dedicated fiber optics. Master broadcasts the events over dedicated network to locals that generates hardware signals to the proper device/instrument. All the timing signals are generated relative to the main clock that is called Master Clock (499.654 MHz). The main AC of 50 Hz will be converted to 1 Hz that is the injection repetition rate. This down converted AC of 1 Hz along with main frequency (499.654 MHz) will be fed to the Master that will generate the machine fiducial accordingly. Since, SESAME will use the event based scheme so the Master will generate the events and send to the locals via dedicated fiber optics. After receiving these events local boards will generate the trigger signals to instruments/devices to be timed. Events and delays are user configurable for each output [3]. Machine fiducial and bucket selection is done at the master board while the delay signals are generated locally. Control system will access and control master and local boards through local network (Ethernet). The hardware architecture of the SESAME timing system will look like:

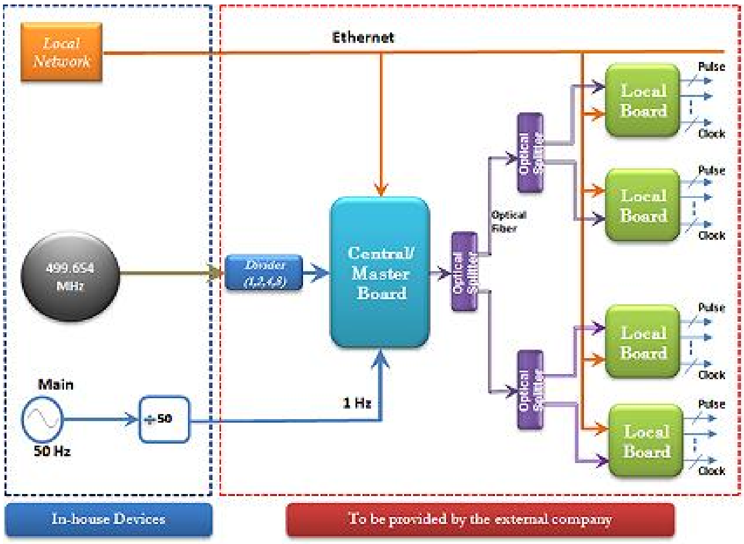

Figure2: Hardware architecture of proposed timing system

References:

[1] T. Korhonen "Review of Accelerator Timing System", ICALEPCS'99, Trieste, Italy

[2] E. Bjorklund, "The LANSCE Timing System Upgrade", ICALEPCS'07, Knoxville, Tennessee, USA

[3] JP Ricaud, Betinelli-Deck, L. Cassinari, JM Filhol, B. Gagey, F. Langlois, A .Loulergue, "Synchronization System of Synchrotron SOLEIL", ICALEPCS'07, Knoxville, Tennessee, USA