NSLS-II BOOSTER TIMING SYSTEM

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Abstract

NSLS-II light source includes the main storage ring with beam lines and injection part consisting of 200 MeV linac, a full-energy 3 GeV booster synchrotron and two transport lines.

The booster timing system is a part of NSLS-II timing system which uses hardware from MicroResearch Finland: Event Generator (EVG) [1] and Event Receivers (EVRs) [2,3]. The booster timing is based on the events coming from NSLS-II EVG: "Pre-Injection", "Injection", "Pre-Extraction", "Extraction". These events are referenced to the selected RF bucket of the storage ring and correspond to the first RF bucket of the booster.

EVRs provide triggers both for the injection and the extraction pulse devices. EVRs also provide the timing of booster cycle operation and generation of events for cycle-to-cycle updates of pulsed and ramping parameters, and synchronization of the booster beam instrumentation devices.

This paper describes the final design of the booster timing system. The timing system functional diagrams and block diagram are presented.

INTRODUCTION

The NSLS-II timing system is based on solutions and experience of the Diamond Light Source timing system [4,5] and uses events coming through fiber optic from the central EVG. The feature that simplifies the booster timing and beam injection from the booster to the storage ring is the fact that ratio of their perimeters is 5. It allows the use of two groups of events referenced to one selected RF bucket of the storage ring. The first group ("Pre-Injection" and "Injection") provides injection of the beam into the booster. "Pre-Injection" event sets the first RF bucket for the booster. All other events coming from the EVG are referenced to this bucket automatically. The second group of events coming in 300 ms after the first group ("Pre-Extraction", "Extraction") provides extraction of the accelerated beam from the booster and injection to the storage ring.

With a help of EVRs, each group of events initiates a set of triggers for triggering of pulsed devices, control and measuring electronics, and beam diagnostics systems. EVRs provide two scales for triggering. The first scale is for triggering the pulsed septums and the bump magnets in millisecond range and uses TTL outputs of EVRs. The second scale corresponds to triggering of the kickers in microsecond range and uses CML outputs. Also EVRs provide revolution frequency and 10 kHz clocks for control and measurement equipment.

BOOSTER TIMING SYSTEM STRUCTURE

A block diagram of the booster timing system is presented in Fig.1. The booster timing system receives events from the central EVG. These events are distributed over fiber optic links (blue lines) and fan-out modules to EVRs.

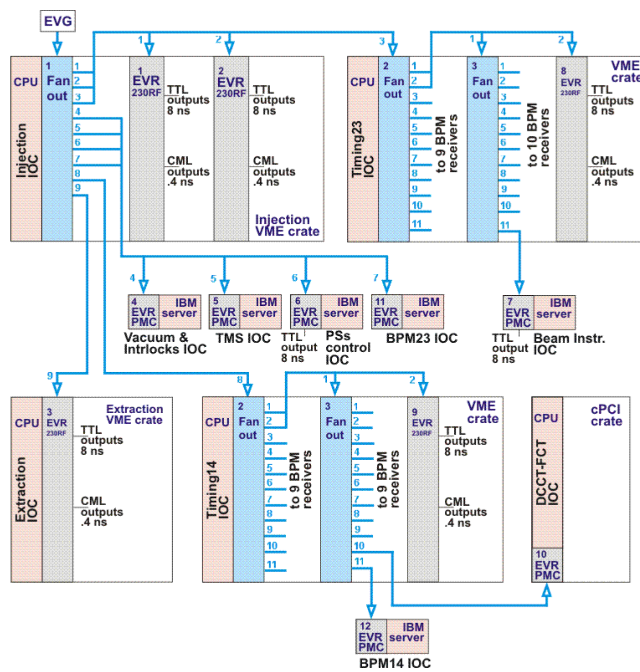

Figure 1: Block-diagram of the booster timing system.

Three EVR-230RF are located in two VME crates: two EVRs are used for injection and one - for extraction. These EVRs provide hardware triggers for injection and extraction equipment.

Also two EVR-230RF are used for synchronization of BPM receivers and other beam diagnostics equipment. These EVRs are placed in VME crates in diagnostic racks and are used for generation of the booster revolution frequency signal and 10 kHz signal for clocking of power supply controllers (PSCs). One EVR generates triggers for cameras in order to provide synchronization with the beam passing.

Six PMC EVRs are placed in six IBM servers. One PMC EVR generates triggers for three chassis with PSCs for providing a synchronous start of the ramp power supplies.

One PMC EVR is placed in cPCI controller for triggering beam diagnostics ADCs which are placed in cPCI crate.

TIMING EVENTS

The time of the booster operation cycle is 1 sec. Two beam injections with a 100-msec interval are proposed to increase the accelerated beam current. The ramp time is 300 msec. A simplified diagram of the booster operational cycle and timing events is presented in Fig. 2. The red curve shows a current value in the bending magnets.

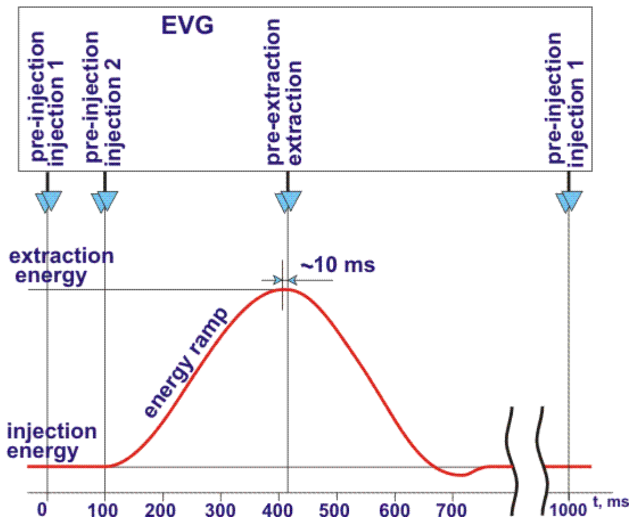

Figure 2: Simplified timing diagram of the booster cycle.

The EVG will provide six events referenced to the selected RF bucket of the storage ring for reference of the booster control timing to the NSLS-II beam:

- Two “Pre-Injection” events spaced 100 msec apart.
- Two "Injection" events coming after 50 turns in the storage ring (132 μs) after "Pre-Injection".
- "Pre-Extraction" event coming in 300 msec after “Pre-Injection” event.
- "Extraction" event coming after 350 turns in the storage ring (925 μs) after "Pre-Extraction" event.

The set of the events listed above provides synchronization between the booster and storage ring bunches.

BEAM INJECTION TIMING

Injection from the linac to the booster is repeated twice with a 100-msec interval in each cycle. A detailed diagram of injection triggering signals from EVRs is shown in Fig. 3.

The following triggering signals are required to control the injection pulsed devices:

- BIT1 (Booster Injection Trigger) - start of the table processing in all Power Supply Controllers (PSCs) [6] (EVR TTL output).
- BIT2 – start of volt-second digitizer for measurement of a pulsed magnetic field value (EVR TTL output).
- BIT3 – start of injection septum current wave form digitizer for digitizing the injection septum pulse current shape (EVR TTL output).
- BIT4 - start of the injection septum (EVR TTL output).
- BIT5-BIT8 – start of injection kickers (EVR CML outputs).
- BIT9 – start of injection kickers current wave form digitizer for digitizing the injection kicker pulse current shape (EVR TTL output).
- BIT10 - stop of the volt-second digitizer (EVR TTL output).

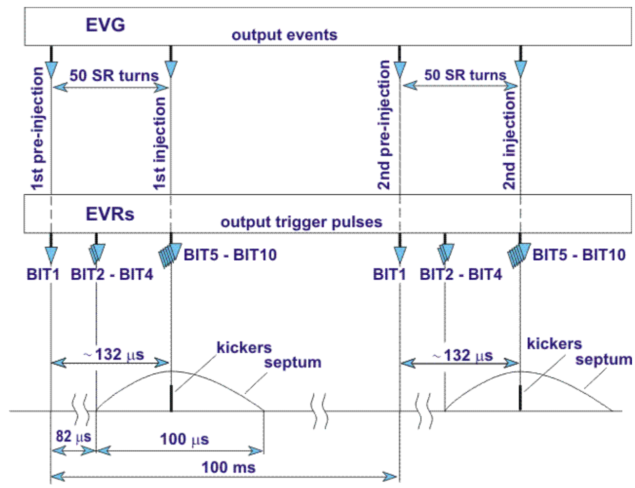

Figure 3: Injection timing diagram.

Both injections use the same triggering signals, but some signals (BIT2, BIT3, BIT9, BIT10) come from different EVR TTL outputs: one output is used for the first injection, another - for the second injection. This allows us to divide measurement channels for the first and the second injections.

Also 10 kHz frequency will be provided from EVR for clocking of PSCs. This signal will be sent from EVR to all PSCs via CML fan-out modules.

BEAM EXTRACTION TIMING

Extraction from the booster is initialized by "Pre-Extraction" event coming 300 msec after “Pre-injection” event. At this moment the beam is accelerated up to 3 GeV and is at the energy flat to provide stabilization of beam parameters during 10 msec. After coming of "Pre-Extraction" event, pulsed bump magnets deflect the beam orbit close to the extraction septum, then, at the moment of maximum deflection, the septum PSs and kicker PSs start. The diagram of extraction procedure is shown in Fig. 4.

The following triggering signals are used for extraction procedure:

- BET1 (Booster Extraction Trigger) - start of extraction Volt-Second Digitizer (VSD) for measurement of bump and septum pulsed magnetic field values at the extraction moment (EVR TTL output).
- BET2 – start of extraction current Wave Form Digitizers (WFD) for digitizing the extraction bump

and septum magnets pulse current shapes (EVR TTL output).

- BET3 – start of bump magnets (EVR TTL output).
- BET4 - start of the extraction septum (EVR TTL output).
- BET5, BET6 – start of extraction kickers (EVR CML outputs).
- BET7 – start of extraction kicker current fast Wave Form Digitizer (EVR TTL output).
- BET8 - stop of the volt-second digitizer (EVR TTL output).

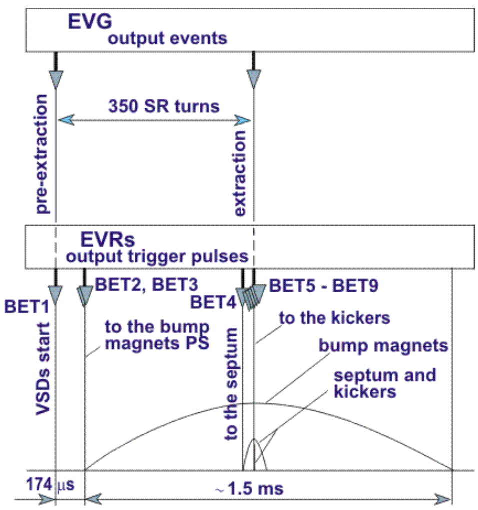

Figure 4: An extraction timing diagram.

BEAM INSTRUMENTATION TIMING

Several triggers are required for the beam instrumentation timing:

- BDT1 (Booster Diagnostics Trigger) - start of high speed digitizer DC222 for FCT (EVR TTL output).
- BDT2 – start of a high resolution digitizer for measurement of signal from DCCT (EVR TTL output).
- BDT3 – start of Tune Measurement System (TMS) controller (EVR TTL output).
- BDT4-BDT9 - start of beam flag cameras (EVR TTL outputs).
- BDT10, BDT11 – start of SR Monitor (SLM) cameras (EVR TTL outputs).

The first “Pre-Injection” event will be used for triggering of on-board EVRs in each of 37 BPM receivers. For this purpose four fan-outs are used in two VME crates (see Fig. 1).

The booster revolution frequency signal will be provided from EVR for Beam Position Monitor receivers and TMS clocking. These signals will be sent from EVR via CML fan-outs.

SOFTWARE

The timing system is integrated into the EPICS based control system through EPICS records. The EVR .db records configure next parameters of the EVR: pulse delay, pulse width, pulse polarity, output assignment, etc. An example of application proposed to be used for control of test stand timing is built with the use of CSS (see the application screen in Fig. 5).

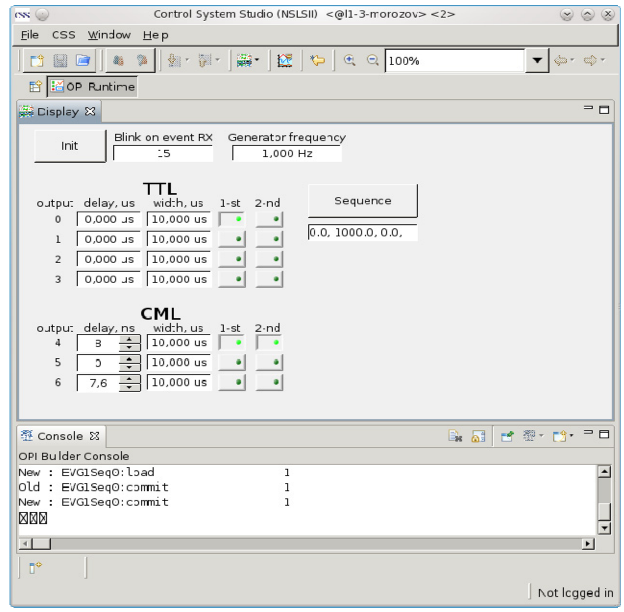

Figure 5: Screen for the EVR control.

SUMMARY

The detailed design of the NSLS-II booster timing system is finished.

The timing system based on the standard equipment provides all required triggers and signals for the booster PSs and electronics.

Some part of electronics now is being used at power supplies test stand.

Software is based on EPICS, now it is under development, its completion is planned before the start of the booster commissioning in October, 2012.

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