NSLS2 Injector Timing

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1 Overview

This document describes the proposed machine timing configuration and user controls for Booster commissioning.

2 Requirements

1. Support independant operation of Linac for testing at 1, 2, 5, and 10Hz.
2. Support independant testing of Booster timing.
3. Support Booster operating modes: 1Hz, 2Hz, and stacking.

2.1 Process Variables

The following are the minimum set of PVs which would be provided.

1. Provide a single timestamp for each booster cycle which can be used to simplify later retrieval.
2. Provide the timestamp of the previous cycle for diagnositics with long readout latency.
3. Provide the number of PSC clock ticks in the 1Hz and 2Hz cycle periods.
4. Allow operators to select Linac timing modes. This will consist of several individual controls
   (a) Select Linac Mode: Off, 1Hz, stacking, 2Hz, 5Hz, or 10Hz.
   (b) Select Booster Mode: Off, 1Hz, stacking, or 2Hz.
   (c) Load selected modes.

5. Provide status:

   (a) Currently running modes for Linac and Booster

   (b) Current modes compatible with injection of beam into booster.

   (c) If selected next modes can be loaded (based on current machine state).

   (d) Timing operation status (running, stopped).

   (e) Cycle counter.

3 Cycle Definition

For the purposes of configuration an injector cycle is viewed on a 1 second scale (see figure 2). Here 1 second is defined as as 127281000 ticks of the Timing System clock or equivalently 50912400 ticks of the ~500 MHz RF reference clock. This is broken down into two 500 ms periods (63640500 timing ticks) and further into 10 periods of 100 ms (12728100 timing ticks).

These numbers are selected to satisfy the constraints imposed by the necessity that the cycle periods should be multiples of several other clocks as shown in figure 1. The divider N gives the ~10Hz period. The constraints placed on N can be expressed as:

$$\begin{aligned} N &= 6 \cdot M \\ N &= \frac{14}{3} \cdot P \\ N &= 12540 \cdot Q \\ N &= \frac{25}{2} \cdot R \\ N &= \frac{5}{2} \cdot S \end{aligned}$$

Given that M, N, P, Q, R, and S must be integers, it can be seen that the first divider N which produces a frequency $\leq 10Hz$ is $N = 12728100$. The others parameters are then $M = 2121350$, $P = 2727450$, $Q = 1015$, $R = 1018248$, $S = 5091240$.

The number of 10 KHz PSC (Power Supply Controller) clock ticks during each 1 Hz cycle is thus 10150.

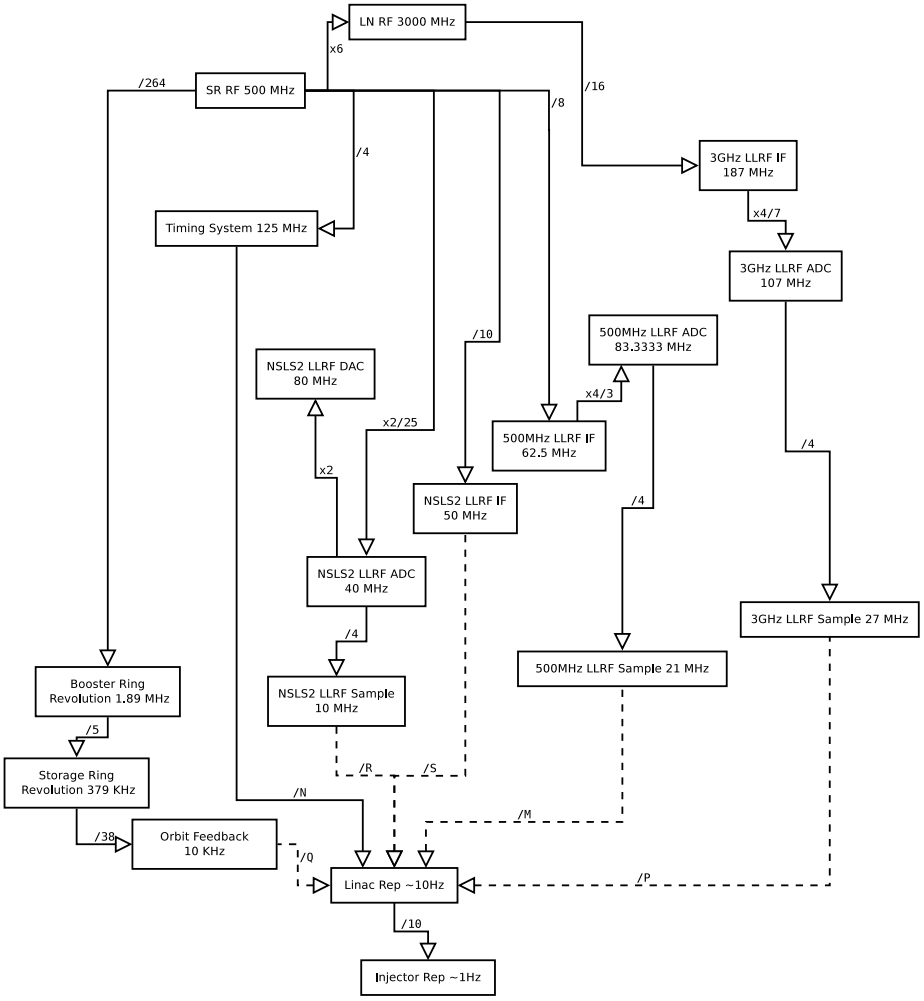
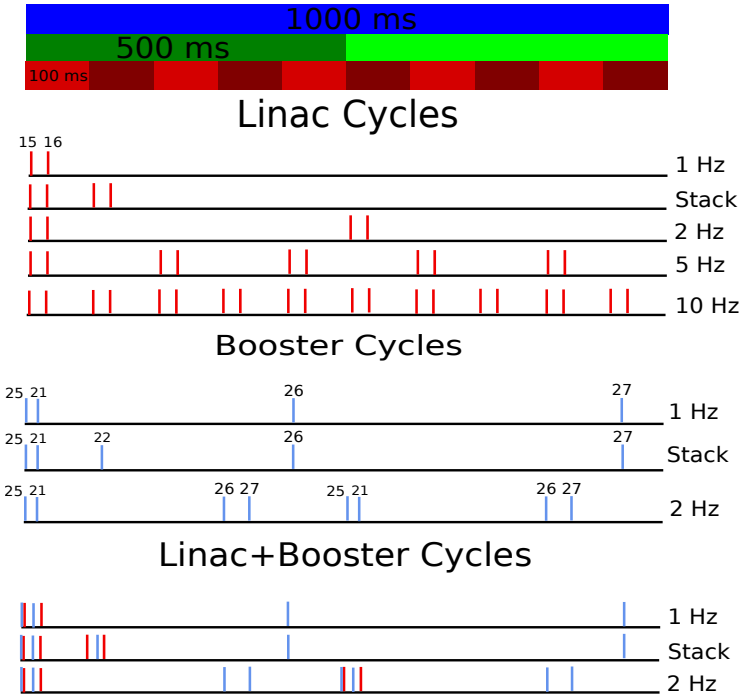


Figure 1: Constraints on the selection of the 10 Hz period



15 - LN T0
16 - LN EGun
25 - Injection T0
21 - BR fill 1
22 - BR fill 2
26 - BR Extract
27 - BR Extract Kicker Charge

Figure 2: Order and approximate time of injector events

4 Event Codes

4.1 Linac+Booster 1 Hz cycle

Event #	Delay Ticks	EGU	Function
25	0	0 ns	Starts PSCs and device cycle start time T_0
15	1	8 ns	Start Linac Cycle start
21	999360	8 ms	Booster injection #1.
16	1249201	10 ms	Linac Electron source trigger
23	14990400	120 ms	Ramp start (non-PSC)
26	49968000	400 ms	Booster Extraction
27	115051320	921 ms	Booster Extraction Kicker Charge

4.2 Linac+Booster 2 Hz cycle

Event #	Delay Ticks	EGU	Function
25	0	0 ns	Starts PSCs and device cycle start time T_0
15	1	8 ns	Start Linac Cycle start
21	999360	8 ms	Booster injection #1.
16	1249201	10 ms	Linac Electron source trigger
23	14990400	120 ms	Ramp start (non-PSC)
26	37476000	300 ms	Booster Extraction
27	40099320	321 ms	Booster Extraction Kicker Charge

4.3 Linac+Booster stacking cycle

Event #	Delay Ticks	EGU	Function
25	0	0 ns	Starts PSCs and device cycle start time T_0
15	1	8 ns	Start Linac Cycle start
21	999360	8 ms	Booster injection #1.
16	1249201	10 ms	Linac Electron source trigger
15	12728101	100 ms	2nd Linac Cycle start
22	13727460	108 ms	Booster injection #2
16	13977301	110 ms	2nd Linac Electron source trigger
23	14990400	120 ms	Ramp start (non-PSC)
26	49968000	400 ms	Booster Extraction
27	115051320	921 ms	Booster Extraction Kicker Charge

4.4 Booster PSC Update Event (#27)

This is a special software (asynchronous) event to signals all Booster PSCs to switch their ramp tables at the next start trigger. This event may not be sent for every cycle.

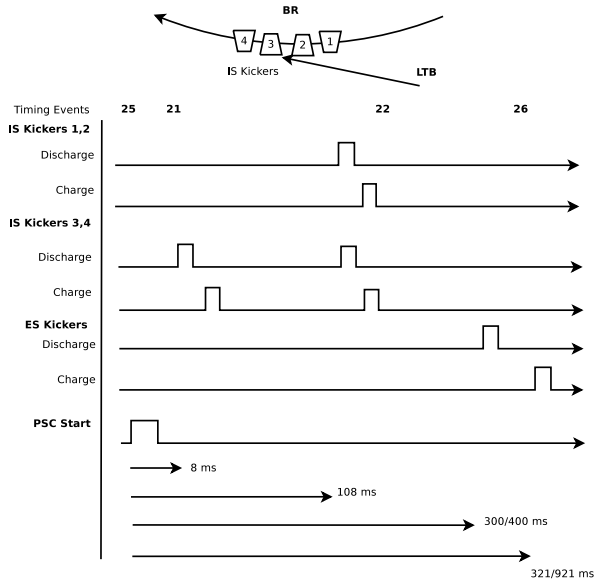


Figure 3: Electrial trigger signals for kicker PS types in stacking mode

4.5 Booster startup pre-trigger (#24)

When the booster has been idle for >1 sec this event will be sent ~500ms before the next T_0 event to prepare the booster. At present only requirement is to start charging of the kicker magnet power supplies.

5 Device Timing

5.1 Booster Kickers

The Booster kicker power supplies expect two electrial trigger inputs. One trigger begins the charging process, the second triggers a discharge. The timing for these signals in the CW operating modes is shown in figure 3. The PSC start trigger is also shown for reference.

The discharge triggers for IS kickers 1 and 2 are mapped to event 22 only. IS kickers 3 and 4 are mapped to both events 21 and 22. The XS kickers are mapped only to event 26.

The charge triggers for all kickers are mapped to the special startup event 24. In addition each injection kicker is also mapped to the same events as the

corresponding discharge trigger with a longer delay. The extraction kickers have a seperate event to trigger charging.

An example configuration for the EVent Receiver (EVR) channels would be

Name	Event(s)	Delay from Event	Pulse Width
IS 3,4 Discharge	21,22	2 ms	20 us
IS 3,4 Charge	21,22,24	4 ms	20 us
IS 1,2 Discharge	22	2 ms	20 us
IS 1,2 Charge	22,24	4 ms	20 us
XS Discharge	26	2 ms	20 us
XS Charge	27,24	0 ms	20 us

6 Process Variables

In order to satisfy the requirements stated in section 1 the following PVs are provided.

All injector EVRs will be loaded with local counter PVs to provide Booster and Linac timestamps with minimum delivery latency.

- $(SYS)-TS{EVR:$(EVR)}Cnt:BR-I
- $(SYS)-TS{EVR:$(EVR)}Cnt:BRPrev-I

The relation between the ~10 KHz orbit feedback clock period (used for all PSCs) and the injector repetition clock periods are given availible. The values of the first two PVs will remain unchanged unless the timing config is updated. The third will change to reflect the current Booster timing mode.

- BR-TS{}Ratio:10Kto1-I
- BR-TS{}Ratio:10Kto2-I
- BR-TS{}Ratio:10K-I

7 User Interface

The current operator (figure 4) and expert (figure 5) control panels.

The operator panel shows the current timing modes in the right pane. The left pane allows a new timing configuration to be prepared and applied (two seperate steps). To do this a user selects from the possible modes for the Linac and Booster. The 'Apply' button will write the new configuration to the Event Generator.

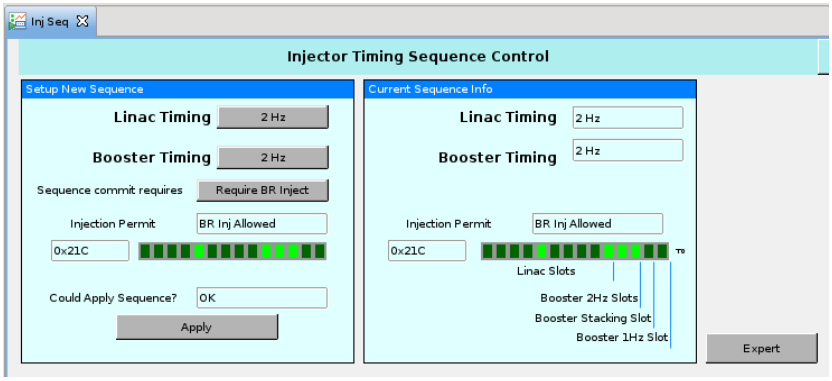


Figure 4: Operator Injector Timing Panel

The 'Sequence commit requires' selection allows the modes which can be used to restrict the selectable modes. Currently selections are 'Allow any' and 'Require BR Inject'. The second allows only modes which a compatible with injection from Linac to Booster. If an invalid selection is made then clicking the 'Apply' button has no effect.

The expert display contains some diagnostic information and two bit masks which can be used to prevent certain modes from being selected.

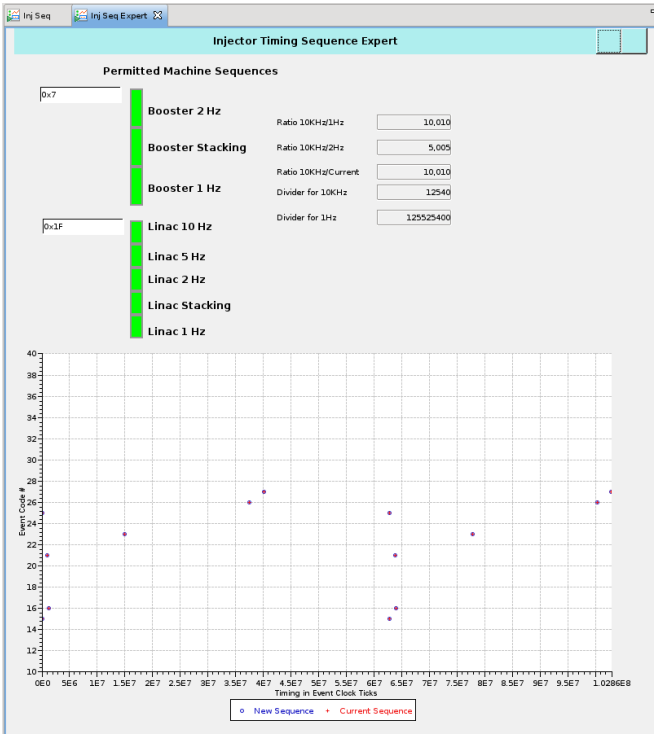


Figure 5: Expert Injector timing display