HINS Clock Event Definitions and Initial Set-up

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Introduction

There are three fundamental timing rates important to HINS Linac systems operations.

1) The ion source rate, which needs to be steady and constant for stable ion source operating temperatures
2) The RF system pulse rate, which should be equal to or a sub-harmonic of the ion source rate
3) The accelerated beam rate, which should be equal to or a sub-harmonic of the RF rate

Each of these three fundamental system rates is identified with an associated clock event. The rates shall be independently selectable and the respective events shall each have an adjustable delay from the fundamental 10 Hz event of the clock system. The philosophy is to provide common and adjustable event references for systems linked to each of the fundamental rates.

Planned Clock System Implementation

The HINS accelerator in Meson will initially operate with ten clock events. Seven events, $A9-$AF, are triggered directly by the Rep Rate Generator hardware; of these, four are fixed rate and two variable rate events. These six events are synchronized with the fundamental 10 Hz rate of the clock system (power line frequency divided by six) and each occurs at its respective rate within microseconds of the corresponding 10 Hz event. Event $A8 is triggered by the Ion Source Pulse Shifter output pulse that is ultimately referenced to one of the $A9-$AF events. Events $A6 and $A7 are triggered by individual programmable delay timers referenced to one of the $A9-$AF events.

Event Definitions

The event definitions are:

$AF – 10 Hz Event
- fixed 10 Hz line-locked clock event (one-sixth of power line frequency)
- triggered by GPIP Clock Generator

$AE – 5 Hz Event
- fixed 5 Hz clock event
- triggered by Rep Rate Generator hardware 2 μs after corresponding $AF

$AD – 2.5 Hz Event
- fixed 2.5 Hz clock event
- triggered by Rep Rate Generator hardware 4 μs after corresponding $AF

$AC – “Rate M” Event
- selectable rate event set to 0.2, 0.5, 1, 2, 2.5, 5, or 10Hz by the “Rate M” switch on Rep Rate Generator
- triggered by Rep Rate Generator hardware 6 µs after corresponding $AF

$AB – “Rate N” Event
- selectable rate event set to 0.2, 0.5, 1, 2, 2.5, 5, or 10Hz by the “Rate N” switch on Rep Rate Generator
- *optionally locked to “RATE M” divided by 1, 2, 4, 5, 10, 20, 50 or 100 via switches on Rep Rate Generator; locked/independent mode switch is on Rep Rate Generator rear panel; mode indicator light is on front panel*
- triggered by Rep Rate Generator 8 µs after corresponding $AF

$AA – 1 Hz Event
- fixed 1 Hz clock event
- triggered by Rep Rate Generator hardware 10 µs after corresponding $AF

$A9 – 0.1 Hz Event
- fixed 0.1 Hz clock event
- triggered by Rep Rate Generator hardware 12 µs after corresponding $AF

$A8 – Ion Source Event
- triggered by the ion source pulse shifter output subject to logic conditions when the Ion Source Event Trigger pulse is received
- referenced to any Rep Rate Generator hardware triggered event

$A7 – RF Event
- triggered by RF Event Trigger timer channel
- referenced to any Rep Rate Generator hardware triggered event

$A6 – Beam Acceleration Event
- triggered by Beam Acceleration Event Trigger timer channel
- referenced to Rep Rate Generator hardware triggered event

The $A8 Ion Source Event shall be referenced the 10, 5, 2.5, or 1 Hz event ($AF-$AD and $AA respectively), the $A7 RF event referenced to the $AC “Rate M” Event, and the $A6 Beam Acceleration Event referenced to the $AB “Rate N” Event.

Ion source referenced systems shall be timed relative to the $A8 event, RF referenced systems relative to the $A7 event, and accelerated beam referenced systems relative to the $A6 event.

Ion Source Pulse Shifter Module

The Ion Source Pulse Shifter module is an integral component of the beam timing and beam enable system. The Pulse Shifter processes a “shifter input” pulse and multiple logic signals to generate a “shifter output” pulse.

The Ion Source Event Trigger timer, referenced to the appropriate fixed rate clock event for the desired ion source rate, provides the “shifter input” pulse. When the “shifter

input" pulse appears, the Pulse Shifter module samples the logic signal states. If conditions are satisfactory, the Pulse Shifter asserts a prompt "shifter output" pulse with only logic gate delays. If conditions are not satisfactory, the Pulse Shifter asserts the "shifter output" pulse with a five-millisecond delay. The "shifter output" pulse is the trigger for the $A8 Ion Source Event. This event 'bounces' by five milliseconds relative to the Ion Source Event Trigger depending on the result of the Phase Shifter logic test. Referencing all ion source device triggers to the $A8 event fixes the relative timing within the ion source system independent of any $A8 trigger delay.

Timing of accelerator systems other than the ion source shall be set to accept beam delivered by the prompt, not the delayed, $A8 Ion Source Event. Ion source beam delivered on delayed $A8 events will appear too late to see any RF in the RFQ and will not accelerate.

The nominal accelerated beam rate is set by the Beam Request timer, the output of which is connected as one of the logic input signals to the Pulse Shifter module. Since the Pulse Shifter requires all logic inputs to be valid for creating a prompt "shifter output" pulse, and therefore for proper beam timing for acceleration, the Beam Request controls the nominal accelerated beam rate. The Beam Request timing channel shall be referenced to the $AB "Rate N" Event as is the $A6 Beam Acceleration Event trigger.

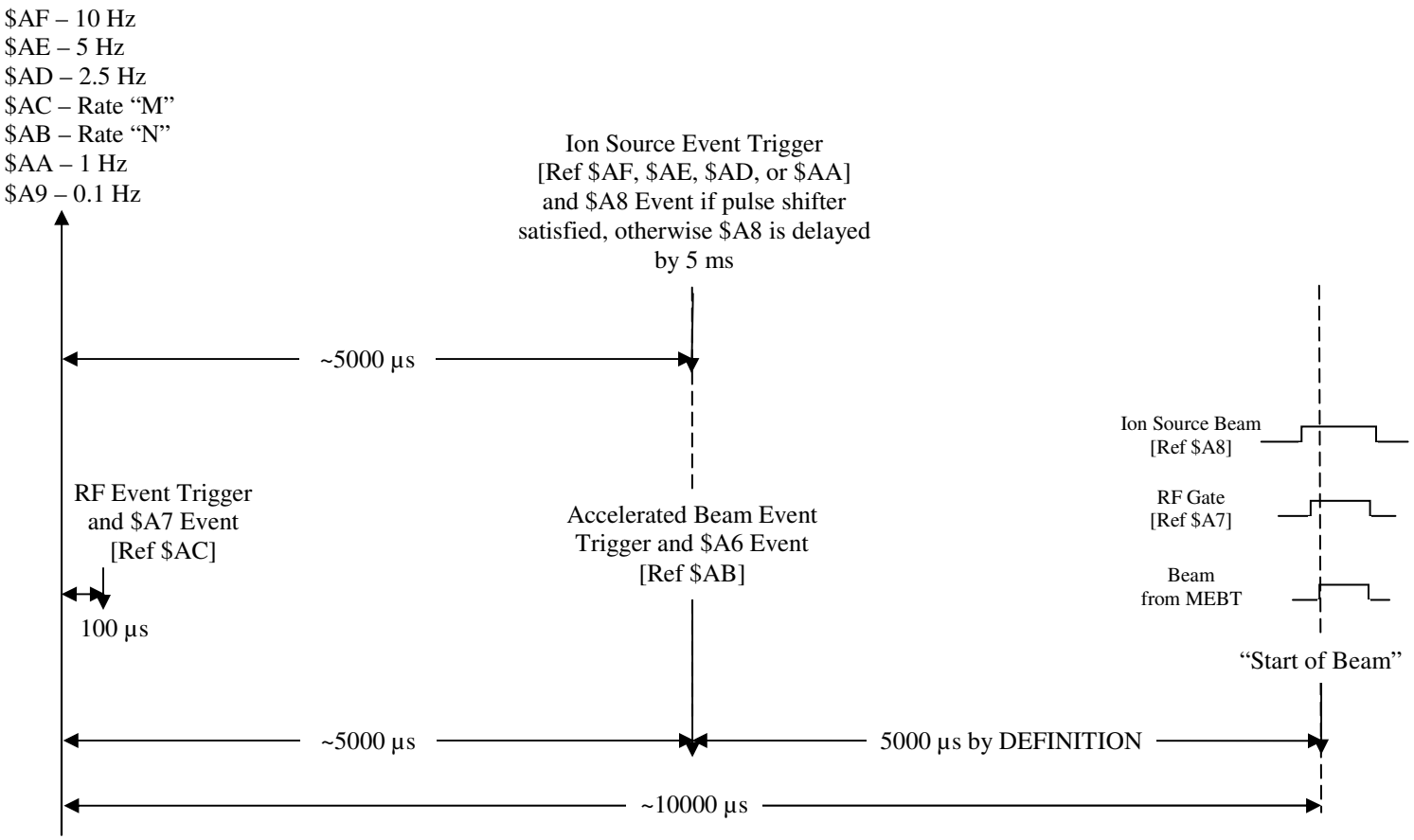
"Start of Beam" Definition and Event Setup

The klystron modulator(s), ion source, LLRF, and other systems require triggers as much as several milliseconds in advance of beam time. To accommodate these requirements, the nominal time of beam shall be approximately 10 ms after the $AF 10 Hz Event on the respective 10 Hz clock cycle.

The $A6 Beam Acceleration Event is established so that all systems monitoring clock events can know precisely when to expect beam. "Start of Beam" is defined as that time at which the front edge of the beam pulse exits the Medium Energy Beam Transfer line. By definition, the $A6 event shall be set to occur exactly 5000 microseconds (μs) in advance of "Start of Beam". This implies that the nominal time of the $A6 Beam Acceleration Event is about 5000 μs after the corresponding $AF 10 Hz Event.

Delays for the $A8 Ion Source and the $A7 RF event triggers are somewhat arbitrary, since most individual device triggers have subsequent programmable delays from their respective event. The $A8 and $A7 Event Trigger delays should be ≥100 μs so that these events are well separated from the fixed rate events. The low level RF system requires nearly ten millisecond advance triggering; this indicates that the $A7 event trigger be set to a small value, like 100 μs. Ion source systems require somewhat less advance triggering. To allow beam diagnostic triggers to switch between $A8 or $A6 event references without the need for corresponding delay adjustment, the $A8 Ion Source Event Trigger delay shall be set to the same value as the $A6 Beam Event Trigger delay.

HINS Timing Diagram



"Start of Beam" is defined as the time at which the front edge of the beam pulse exits the MEBT. The start of ion source beam and the RF Gate will precede this time by perhaps tens of microseconds. The RF system ($A7) event rate should be equal to or a sub-harmonic of the ion source ($A8) event rate and the accelerated beam ($A6) event rate should be equal to or a sub-harmonic of the RF event rate.