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IMPROVING RELIABILITY OF THE FAST EXTRACTION KICKER TIMING CONTROL AT THE AGS*

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Abstract

The fast extraction kicker system at AGS to RHIC transport line uses Stanford Research DG535 delay generators to time, synchronize, and trigger charging power supplies and high-level thyratron trigger pulse generators. This timing system has been upgraded to use an SRS DG645 instrument due to reliability issues with the aforementioned model and slow response time of GPIB buses. The new model provides the relative timing of the separate kicker modules of the assembly from a synchronized external trigger with the RF system. Specifications of the timing scheme, an algorithm to load settings synchronized with RHIC real-time events, and performance analysis of the software will be presented in the paper.

INTRODUCTION

The design principle of a fast extraction system is to give the circulating beam a deflection at the kicker position. The RF synchronized discharge trigger is distributed to the alternating gradient synchrotron (AGS) extraction fast kickers and the RHIC injection fast kicker system via fiber links [1].

Two DG535 pulse delay generators are used in each kicker system. The particles with initial conditions at the beginning of G10 are traced through the lattice and receive an appropriate kick at the kicker and an additional kick at the ejector. Extraction bump are produced using two supplies to create bumps centered on H10 septum and G10 kicker. Over time the control of kicker timing using the DG535 trigger generation system has been fallible.

Table 1: DG645 Specifications

Feature	Range
Channels	4 independent pulses controlled in position and width.
Range	0-2000s
Resolution	5 ps
Jitter	Ext Trigger to any output < 100 us

Reasons for Upgrade of Delay Generator

Multiple hardware upsets of DG535 during the run and need for AC resets resulted in a significant amount of down time of AGS operations. This was reported by the pulsed power group as a concern and an upgrade to modern pulse generator was proposed.

Upgrade Strategy

The SRS DG645 has been chosen to serve as a pulse generator. The new software developed for this device runs on Linux as opposed to a Front-End Computer in the case of DG535. Other than the chief benefit of improving reliability , there is also additional benefit of reduced cost of removal of network device used for communicating using a GPIB bus. As DG645 device is capable of communicating using the ethernet. The timing specifications [2] of this model provide a significant improvement in jitter and resolution as described in Table 1.

A new software Accelerator Device Object (ADO) [3] was created to control the DG645 physical device. The new ADO receives event activity from another ADO from a set called aelMon (AGS event link monitor), which is a reflected value of the real-time event generation system. These events are used to load new delay settings to the respective channels as configured for kicker timing. The AGS operation is PPM (Pulse to Pulse Modulation) based, that is, operation of that facility for multiple recipes, with characteristics of beam intensity, species, main magnet cycle, and certain other machine parameters which can vary on successive pulses. The ADO instance is also PPM based which means that there are different delay settings stored for a different profile of AGS operation [4]. These settings are automatically loaded at the change of AGS user occurs, as the software keeps track of the active users.

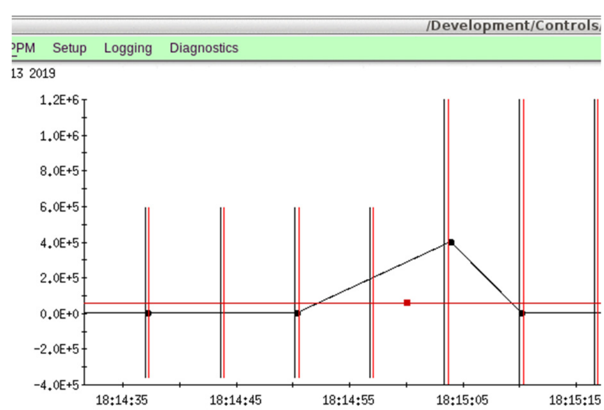

Figure 1: Execution time of new delay settings across seven AGS cycle.

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To maximize performance, software commands are pushed onto a queue and loaded to the device as one command. This helps to reduce the number of interactions with the hardware and to make sure operation is completed before a new AGS super cycle occurs. Supercycle refers to the overall repetitive sequence of the facility as a whole, while a Cycle is defined as the single, complete period of operation of a particular accelerator, usually associated with the sequence of the main magnet and/or rf system[5].

The time to load all the settings was tracked with respect to the AGS group end event. In Fig. 1, the red and black marker bars represent the AGS supercycle start and AGS group end event [6]. The red and black traces display the execution time of delay settings and delay value itself

One of the challenges of software upgrades is backward combability for software integration. For maintaining compatibility with archive servers, the naming scheme of the control parameters were kept consistent with old ADO. This also helped with retaining user interfaces and prevent any failure in external applications which were a client to the old ADO parameters.

RESULTS

The timing system upgrade of ATR beamline was successfully commissioned. The pulsed power supplies that need to be charged tor successful firing of kicker modules at extraction were fired appropriately (Fig. 2). The reliability of the system has been significantly improved as not a single incident of communication failure has been reported throughout the run.

The same software model will be adopted for the upgrade of F3 kickers for a booster to AGS (BTA) extraction and will be used in FY2020. Managing the timing for extraction in such cases is more challenging due to the inherently shorter nature of the Booster cycles.

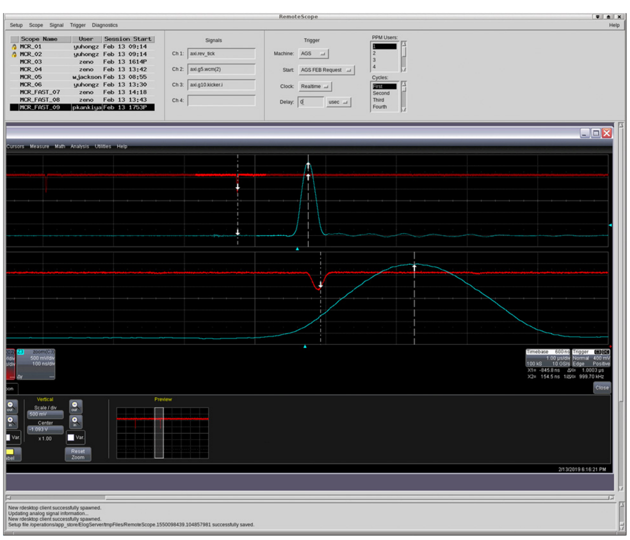

Figure 2: G10 kicker pulse viewed from a scope, captured at the AGS group end event.

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