Development of Trigger Control System for Beam Diagnostics at KOMAC

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1. Introduction

The KOMAC facility consists of low-energy component, including a 50-keV ion source, a low energy beam transport (LEBT), a 3-MeV radio-frequency quadrupole (RFQ), and a 20-MeV drift tube linac (DTL, as well as high-energy components, including seven DTL tanks for the 100-MeV proton beam. The KOMAC has been operating 20-MeV and 100-MeV proton beam lines to provide proton beams for various applications [1].

Each components of the pulsed operation mode has a timing trigger signal with precision synchronization. A timing system for beam extraction and for beam diagnostic components is required to provide precise pulse signals synchronized with a 300-MHz RF reference frequency. The KOMAC timing system was upgraded to a programmable event timing system that is synchronized with the reference signal such as RF and AC main frequency and is being used stably [2]. In the operating state of pulse mode, it is necessary to provide unlimited beam pulses within the RF operation repetition rate. The beam trigger control is implemented by commercial pulse delay generator BNC575 (B Berkeley Nucleonic Corporation) and sequence ram of timing system. The pulse delay generator is synchronized to the clock and trigger generated by the main timing system. In order to provide efficient beam pulses in the future, we plan to apply a control system that can automatically control the functions of beam pulses and beam counters.

2. Beam Pulse Control

The timing system was fabricated using a versa module eurocard (VME) system composed of an event generator (EVG-230) and event receiver (EVR-230RF) based on EPICS software. The EVG is responsible for generating and sending out event codes over 2-Gbits/s fiber optic links to an array of EVR, which is programmed to decode specific event codes. The EVR generates trigger pulses for the linac components, such as the beam diagnostics, high-power RF system, and high-voltage power supply through the fan-out board. Fig 1 shows a MRF timing system and a schematic layout of the timing system with a 300-MHz external reference signal is described in Fig 2. Two methods are used to generate beam triggers: The first is to use a pulse generator and the second is to add software to the timing system.

Fig 1. MRF timing system EVG EVR and fan-out

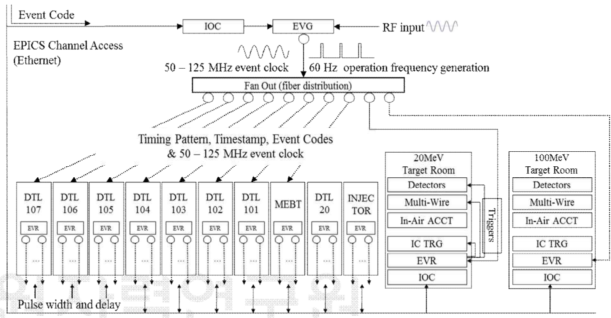

Fig 2. Schematic layout of the event timing system in the klystron galley and beam experiment hall.

2.1 Pulse Delay Generator for Beam Trigger

For beam extraction, timing was added to the beam injector with a BNC565 delay generator. The delay generator receives a 20 MHz clock and trigger signal from the EVR as described in Fig 3.

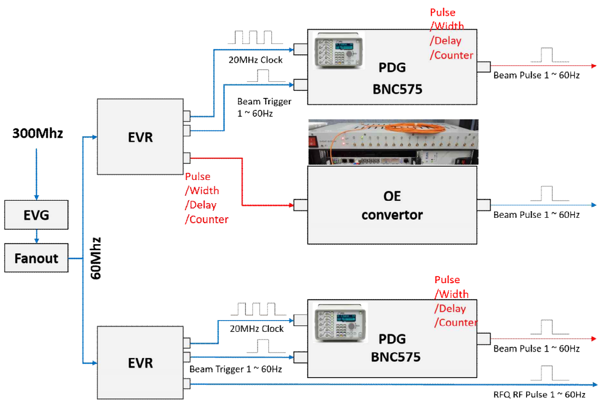

Fig 3. Schematic for providing beam triggers to an injector and beam target rooms using timing system and pulse delay generator.

The trigger signal determines the repetition rate for the beam service request, and the delay generator operates in burst mode to synchronize the external clock and the trigger and generate the trigger as requested pulses. The beam trigger is limited to a divisor of the RF repetition rate.

2.2 Timing System for Beam Trigger

To control pulse repetition rate and beam pulse counter, sequence random access memory of the EVG is applied and beam pulse counter control is implemented using Sequencer. Event sequencers provide a method of transmitting sequences of events stored in random access memory with defined timing. The 8-bit event codes are stored in a RAM table each attached with a 32-bit timestamp relative to the start of sequence. Fig 4 shows the timing pattern for accelerator operation. The EVG creates an array of timestamps and delays in the sequence ram and passes event codes to the EVR.

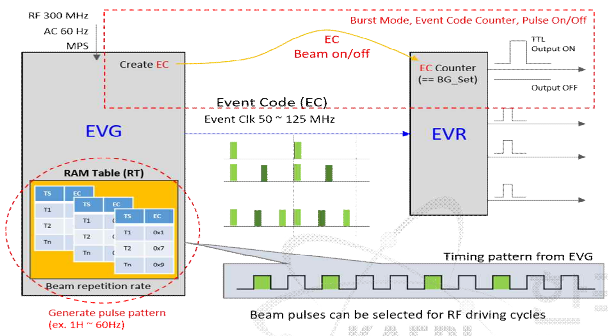

Fig 4. Timing patterns for accelerator operation are generated using sequence ram of EVG and transmitted to EVR

The beam pulse control depends on the beam fluence in the beam target room. When the accumulated beam fluence is reached, the beam pulse should be stopped. The sequencer is used to control the beam pulse using an event code in the EVR that could count the number of beam pulses. Fig 5 shows a user interface for beam gate and event sequence control the EVR sequencer. The EVR database includes an analog out BGCnt-Set record for number of beam pulse set value, fanout BGFout record for enable/disable control for output pulse.

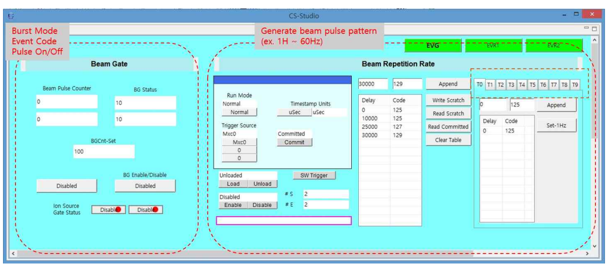

Fig 5. User interface to control beam gate using EvCode and Timestamp in EVG sequencer.

3. New Beam Trigger Control System

Separation of hardware and software for beam triggering is required for more stable system operation. Therefore, the development of the beam trigger system is in progress. Fig 6 shows a schematic diagram of the beam counter system. The input signals consists of an electrical signal, an optical signal and an interlock signal, and the output signal consists of a TTL signal of LEMO type.

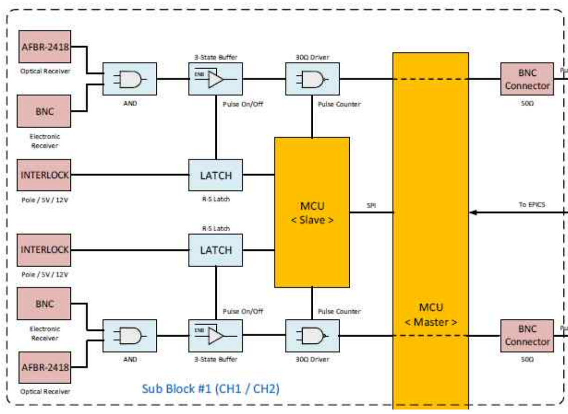

Fig 6. Schematic diagram of beam counter system

The new beam trigger system include the ability to convert trigger signals and the pulse counter function. The MCU is built in to enable remote control and monitoring using EPICS [3].

4. Conclusion

It was possible to provide beam pulse signal using timing system and pulse generator. The new beam trigger system will have independent functions and will be able to provide a more stable beam trigger. The beam trigger system currently under development will incorporate a MCU for external control and monitoring. In particular, depending on the conditions of accelerator operation, the beam trigger will be controlled by an external signal, such as an interlock. It is expected that this will provide more efficient beam service.

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