TRIGGER GENERATOR FOR THE SUPERCONDUCTING LINEAR ACCELERATOR ELBE

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Abstract

The Center for High-Power Radiation Sources ELBE at Helmholtz-Zentrum Dresden-Rossendorf (HZDR) runs a superconducting linear electron accelerator for research applications. A recent machine upgrade enabled new time resolved experiments and made a replacement of the current trigger and clock generation system necessary. The requirements include centralization of trigger generation, improvement of trigger quality, and trigger pattern versatility. To address these needs digital delay generators, developed by Bergmann Messgeräte Entwicklung (BME), have been evaluated. These field programmable gate array (FPGA) based PCI boards have 6 independent trigger channels. Individual PCI modules can be connected by a dedicated trigger bus to extend channel count on demand. The boards are installed in an industrial personal computer (IPC) running Windows 7. Trigger generation runs stand-alone in the FPGA making it independent of operating system timing and ensuring stable phase relation between individual channels. Delay control is possible via C and LabVIEW libraries. A LabVIEW application will offer a graphical user interface (GUI) for local control and an OPC UA interface for control system integration.

INTRODUCTION

The ELBE accelerator is capable of CW operation with a frequency of up to 26 MHz. All timing signals for thermionic injector and superconducting radio-frequency photoinjector (SRF) [1], buncher resonators, macro pulser generator and so on are derived from a 13 MHz master clock oscillator. Currently these signals are generated independent hardware components. A new structure for the ELBE timing system was proposed that can be seen in Figure 1. This was motivated by:

- a transition to an up to date hardware that is much easier to extend and to maintain,
- an inherent synchronization of all delay channels,
- a precise adjustment of delay channels in reference to each other,
- an increased flexibility of pulse train pattern definition,
- a reduced jitter.

This paper gives an overview of the hard and software structure of the central trigger system currently under development.

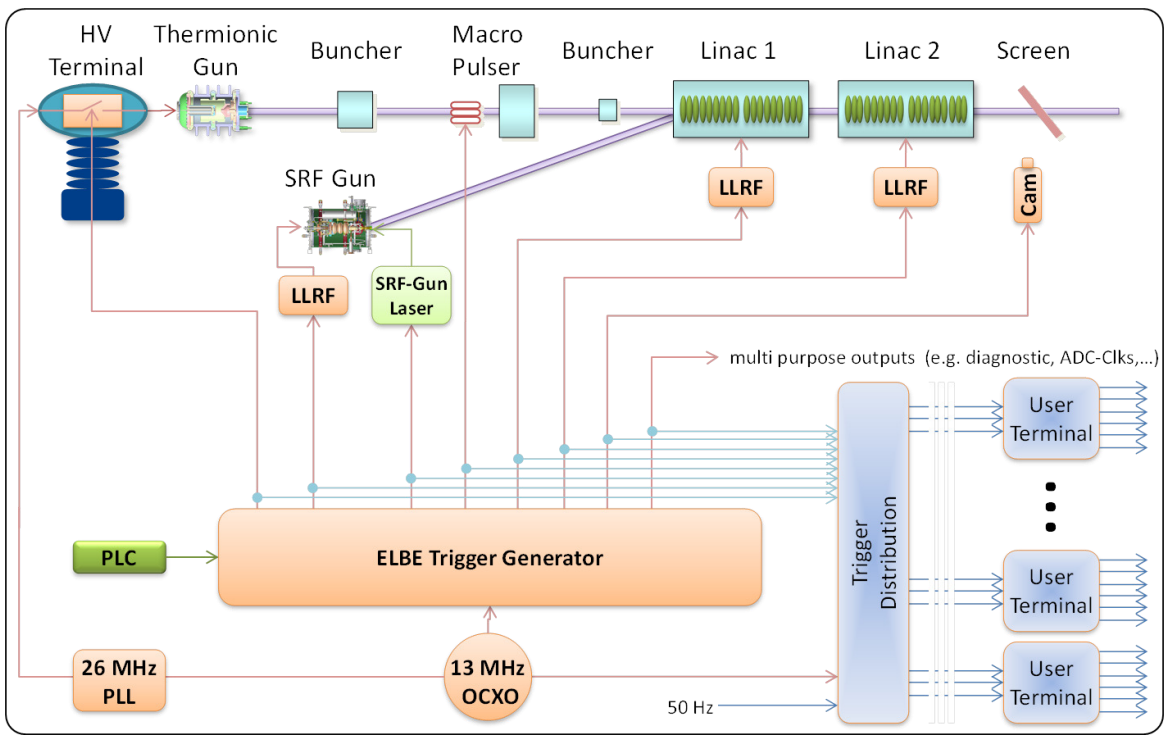

Figure 1: Projected structure of ELBE trigger distribution with central trigger generator. [2]

ISBN 978-3-95450-176-2

DELAY GENERATOR HARDWARE

Delay Generator Modules

BME offers a range of FPGA based digital delay generators. Type BME_SG08p [3] has been selected for the central trigger generator. These PCI modules provide 6 TTL outputs with a delay range from 50 ns to 429 s and a resolution of 25 ps. Trigger repetition rates between 0.002 Hz and 15 MHz are possible. Additionally channels can be pairwise combined by logical OR, XOR or AND operations. This feature is illustrated in Figure 2 where a 26 MHz trigger signal is generated by the disjunction of two 13 MHz signals. In this way it is possible to overcome the 15 MHz repetition limit and to produce the fastest trigger signal needed for the ELBE accelerator.

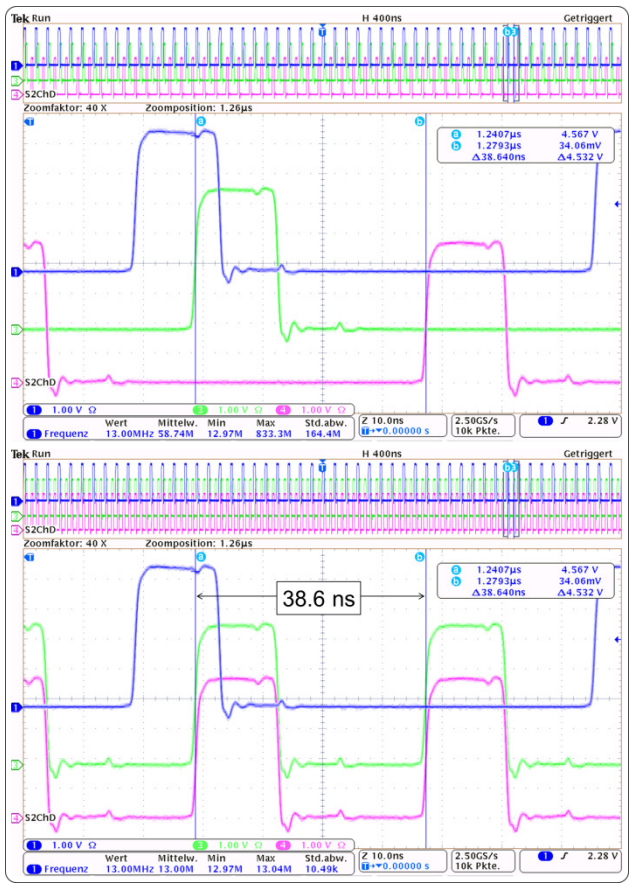

Figure 2: Disjunction of two 13 MHz delay channels (top) to produce a 26 MHz delay signal (bottom).

To increase the number of synchronized delay channels BME_SG08p modules can be connected with a Master/Slave bus cable.

In order to generate asymmetric pulse train patterns it is possible to load delay parameters into FPGA memory tables. These parameters are then cyclically or burst wise transferred into the delay registers after occurrence of selectable trigger events. Any parameter changes are synchronously activated on all delay channels, where any delay channel can be defined as synchronization source, i.e. the trigger for the parameter activation.

Besides standalone control software for Windows operating systems, libraries for C and LabVIEW programming are available.

Hardware Configuration

The PCI delay modules are installed in an IPC with redundant power supplies, high cooling capacity and 20 PCI slots. 18 of these slots are available for delay generators, allowing for up to 108 output channels.

The current system setup comprises five BME_SG08p delay generators. It is used in a laboratory setup (see Figure 3) for further tests and software development.

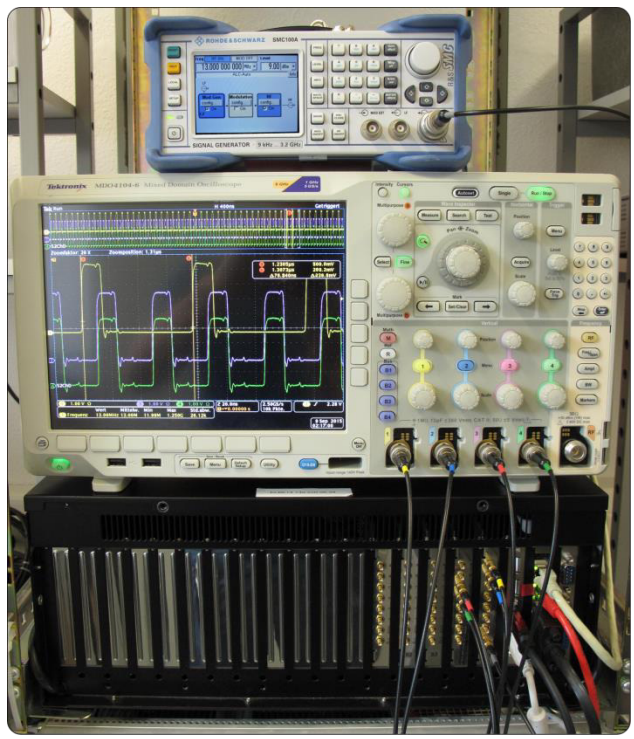

Figure 3: Trigger generator laboratory setup.

DELAY GENERATOR SOFTWARE

Control Application

A control application is under development that will be used to configure the trigger generator according to the ELBE operation requirements. On the one hand this includes configuration of delay generator hardware during setup and system start-up, on the other hand delay channel parameterization for different operating modes. The development environment is NI LabVIEW running on Microsoft Windows 7 64 Bit. Since all time critical operations are executed on the FPGAs of the delay modules, the trigger generation is independent of operating system and software timing issues. The application will run on the IPC and will be available for experts via remote desktop protocol inside the ELBE Ethernet network.

ISBN 978-3-95450-176-2

Only a reduced set of parameters has to be exchanged between the trigger generator and the ELBE control system. The data interface for these parameters is described in the following section.

Control System Integration

The ELBE control system is built with Siemens S7-300 and S7-400 programmable logic controllers (PLCs) [4] and WinCC supervisory control and data acquisition (SCADA). Since the machine interlock system (MIS) is parameterized on PLC level, depending on the machine operation mode, it is desirable to have a direct data connection between the trigger generator and the PLCs.

The LabVIEW Datalogging and Supervisory Control (DSC) Module [5] supports the upcoming OPC UA protocol [6]. Because of its interoperability and platform independence it has been chosen as a candidate for implementing the control system interface of the trigger system.

Although S7 PLCs do not directly support OPC UA, there are ready to use products closing this gap. The OPC UA gateway IBH Link UA [7] from IBH softec has been evaluated. This gateway is acting as OPC UA server, publishing data from Simatic S7 PLCs. At the same time it is an OPC UA client allowing to connect PLCs and external OPC UA servers. The OPC UA address space for PLC data can easily be set up and maintained based on the symbolic data from the according S7 PLC project. With the help of the IBH link UA it was possible to exchange control data between a S7 PLC and a LabVIEW application running on the trigger generator IPC.

Figure 4 gives an overview of the software and communication scheme.

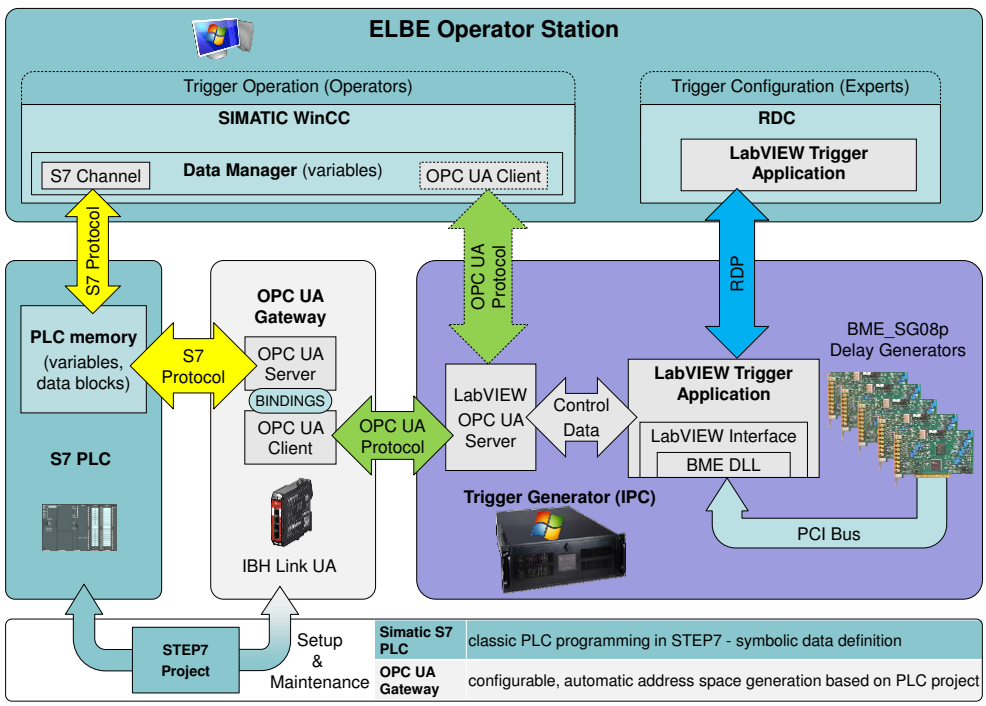

Figure 4:software structure and control system integration.

CONCLUSION AND OUTLOOK

All hardware components for the upgraded trigger system have been selected and evaluated. The trigger generator hardware is ready to use in a laboratory setup. A LabVIEW application to configure and control the trigger generators is under development. OPC UA technology has been successfully tested as an interface to the ELBE control system.

It is planned to finalize development of the trigger control application by end of this year. The trigger generator will then be installed in parallel to the current system to validate operation with the accelerator. After that the final step will be to establish the control system connection and make the trigger generator available for standard machine operation.

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