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Commissioning of textorCC, the new TEXTOR control system and first operating experiences

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Abstract

The old TEXTOR control systems have successfully been updated. The machine control has replaced by textorCC, a solution based on the software package WinCC produced by Siemens. WinCC, and therefore textorCC, can be easily integrated with the already available Siemens S5/S7 hardware components. This new system has the advantage that it is based on industrial soft- and hardware components.Therefore, the lifetime of the control system is extended and the maintenance effort is reduced. The installation and commissioning of the new control system was done in parallel to TEXTOR operation. During this time each function was tested and compared with the actual TEXTOR data. All functionality of the former control system was step-by-step replaced. Special attention was given to the visualization, data and error logging. The machine control timing system has been replaced by an in house development in partnership with Siemens. It consists of transmitters and receivers based on PROFIBUS modules and is fully compatible with the pre-existing timing infrastructure. The old programmable function generator (PFG) has been replaced by compact RIO modules, controlled and programmed by Labview. This new PFG system allows to program up to 84 different time dependent signals. In this paper we intent to present a more detailed overview of our, on WinCC-based work, and a first status report on this new control system for TEXTOR.

Keywords: Fusion research; Control system; Data acquisition; Data management; Remote data access; Remote participation; Platform independent; Web technology

1. Introduction

Textor is the fusion research tokamak of the Research Center Jülich. It is operated by an international community: the Trilateral Euregio Cluster (TEC) consisting of Forschungszentrum Jülich (Germany), FOM-Rijnhuizen (The Netherlands) and ERM-Brussels (Belgium). The DEC-VAX (VMS) [10] and CAMAC-based machine control system of TEXTOR was designed 25 years ago[1][2]. It was twice adapted to the technical requirements of TEXTOR in 1985 [3][4] and 1990 [5][6] when the Simatic S5/S7 programable logical controller (PLC) was added. Meanwhile the system has reached its technical limits. Most of the hardware components are not anymore available and know-how for the technical support is missing. Therefore, a new solution has been developed to replace the old existing control system. The new control system should fulfil the following requirements:

- The control system should be based on commercially available software.
- Similarly, the software should run on commercially available industrial PC's.
- The components and software packages should be actively developed and supported.
- The technical staff should be able to develop its own applications fulfilling the needs of the TEXTOR operation.

2. Replacement of critical items

A solution was found in the software package WinCC, produced by Siemens,[7] which can be easily integrated with the already available Siemens PLC S5/S7 hardware components. It is scalable and based on Microsoft-Windows technology. The interface fulfils the requirements for the integration within the TEXTOR data distribution system (TEC Web-Umbrella). The

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installation and commissioning of the new control system could be done in parallel to TEXTOR operation and guarantees smooth transfer from the old to the new system.

Our analysis found the following critical items:

- Implementation of existing S3 PLC components
- The programmable function generator (PFG) for the nominal value programming
- The TEXTOR timing based on CAMAC units

Before the start of the new control system the above hardware had to be replaced because these are not supported by WinCC in their existing state.

2.1. Old S3 PLC-components

The migration of the remaining four S3-/CAMAC systems was done in parallel to TEXTOR operation in 2005. The digital and analog I/O channels recorded in the past by CAMAC are now redirected to one S7 PLC. The connection was done by ethernet using the Sinec H1 protocol to match the requirements of the standard S5 PLCs. In autumn 2005 the migration was finished and all old CAMAC system were switched off.

2.2. Programmable function generator

The old PFG consisted of a μ Vax and two CAMAC crates with 16 and 8 channels, respectively. In a collaboration with an external company all old hardware was replaced. We decided to use industrial available components and software in our case, from National Instruments, which are programmable in Labview Real-Time (ETS). The resulting system is modular and can easily upgraded with additional crates and channels to fulfil future requirements at TEXTOR.

- Embedded Realtime-Controller Compact Rio cRIO-9002 (Fast-Ethernet, FTP- and WEB-Server)[8]
- 8 Slot-Chassis cRIO-9102(8 Slot, 82 kB, 40 MHz)
- C Series Digital Input (DI) and Counter/Timer Modules NI9411 (6 Channels, 500 ns, $\pm$ 5 to $\pm$24 V)
- C Series Analog Output Modules NI9263 (4 Channels, 16 Bits, 100 kS/s/ch, $\pm$10 V)

At TEXTOR the crates are spatial distributed. Each crate has room for 28 analog channels. The three installed crates can record up to 84 channels. At the moment, one crate with 20 channels is used for the control of the rectifier. The second one with 12 channels manages the feedback control of the gas inlet systems. The last one is a spare one reserved for future applications and tests. For the timing of the discharge each crate needs three digital inputs (plasma preparation $t_0 - 20$ s, plasma start $t_0 - 1$ s and plasma stop $t_0 + 10$ s).

The graphical user interface (GUI) is also programmed in Labview V7.x together with an external company. Within the GUI all crates and modules can be separately addressed. The channel units and descriptions and the time interval of all channels are programmable. The data are stored pulse oriented. The pulse number is read by the TEC-Web-Umbrella (TWU). The complete dataset is stored in common storage facility (CSF). Each data set can be uploaded into the PFG as a whole or for special channels only. (http://ipptwu.ipp.kfa-juelich.de/follow: textor → last shot → PFG).

During commissioning of the new PFG systems, irregular failures occured in the communication between the controlling PC and the cRIO stations. This was traced back to Multicast- and Broadcast-storms in the local network backbone. To improve the reliability of these systems, we had to provide a private subnet to the cRIO stations and a 2nd network port on the computer.

2.3. Timing

The new timing system was developed in co-operation with the "Siemens" company. The new timing-modules can be used in all TEXTOR areas, thanks to their rail-mounted, metal casings. The triggers are generated in a way, compatible with the timing modules in use by the TEXTOR diagnostic data-acquisition systems.

2.3.1. Code generation

The modulation of the trigger marks is implemented with a Bi-Phase (Manchester) coding using a 10 bit frame. These 10 bits contain a start-bit, a 7 bit trigger-code, a parity and a stop-bit. Without trigger modulation, the timing-transmitter continuously sends a logical "1". The timing-code starts with the start-bit, a logical "0", followed by the 7 bit code for the trigger, least significant bit first. The parity bit ensures that the 7 data bits and the parity bit contain an even number of logical ones. The sequence ends with the stop-bit, always a logical "1". Of the 128 possible codes, only 16 are used for timing code points.

2.3.2. Modules

Two types of timing modules have been developed: a transmitter and a receiver. Both require a supply of 24 V DC and have a four-pole configuration DIP-switch to select the basic functionality at power-up. The firmware is coded in a flash-memory, to allow future changes. The modules receive their configurations data via a PROFIBUS (DP-bus)[9]. An optical bus connection can be used via a DP-bus medium-switch. The timing bus is accessible as a TTL signal (on a co-axial Lemo connector) or as an optical signal (on a glass–fibre, FSMA-connector, 50, 62.5, 100, 200 μm, compatible with the old timing bus). This allows connections with and without galvanic separation.

Transmitter:

- 16 Trigger-Inputs (TTL or 24 DC Optocoupler)
- 2 Status Led's (Trigger received, Gatepulse active)/per Channel
- 4 Status Led's, 4 Fault Led's
- Timing Code-Bus 1 MHz (optical 1 Input 4 Output, TTL 1 Output)