IMPLEMENTATION OF THE CONTROL SYSTEM FOR A POLARIZED GAS TARGET WITH THE INDUSTRIAL SCADA SYSTEM WINCC ON A WINDOWS/PC PLATFORM

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Abstract

For the ANKE experiment at the medium-energy storage ring COSY at Forschungszentrum Jülich, a hydrogen/ deuterium internal gas target, the Atomic Beam Source (ABS), was built. The total amount of process signals of the heterogeneous front-end equipment of this target is about 700. The interlock system has been implemented with Siemens S7 PLCs. A PC with Windows NT serves as controlling computer. The process control software was implemented on this PC on the base of the SCADA system WinCC from Siemens.

Basic design decisions and structure of the control system are presented. WinCC features, implementation issues and experiences are reported.

1 INTRODUCTION

For the study of proton-proton reactions as well as proton induced deuteron break-up at a polarized beam, an ABS (atomic beam source) has been developed at the magnetic spectrometer ANKE in the COSY proton storage ring in Jülich [1]. The ABS is an internal Hydrogen/Deuterium polarized gas target following the Stern/Gerlach principle: A dissociator inside a vacuum vessel produces a hydrogen plasma discharge, in which hydrogen molecules are dissociating. Two RF transition units are used to polarise the atomic beam, which will feed a storage cell. Additional diagnostic subsystems have been developed for measurement of absolute beam intensity, degree of dissociation and the degree of polarisation.

Major attention has been directed to the control system, which should support the routine operation of the ABS as well as experimental tests of the ABS itself. The guiding principles for the control system were stable and reliable operation as well as maximum degree of flexibility and development productivity. So it was possible to have a working control system also in the early development stages of the ABS, that evolved with the construction of the ABS itself and allowed measurements and optimisation of key parameters during the construction phase [2].

The necessary front-end equipment of the control system consists of more than 100 components, including a variety of vacuum pumps, vacuum gauges, RF generators, valves, leak detectors, temperature sensors, stepping motor controllers, PID controllers, flow controllers, power supplies etc. from different vendors. With regard to control, it is a medium sized but extremely heterogeneous system with about 700 process signals and about 20 serial interfaces to more complex devices

2 CONTROL SYSTEM DESIGN ISSUES

Our central design decisions were motivated by the requirement to a achieve a reliable operation and to minimize development effort. So we decided to base the system on industrial automation technology as much as possible, expecting to benefit from

- the inherent robustness,
- long term availability and support from manufacturer,
- powerful development tools.
- low prices induced by mass market,

Following the approach of industrial control systems, we decided to attach all front end equipment to PLCs, where all interlocks and control algorithms are implemented. We chose PLCs from the Siemens S7-300 series, because it dominates the European market.

The moderate size of the system allowed the implementation of operator interface and databases for setup and process data on one single computer. Here we selected a PC with Windows NT, because industrial solutions are almost exclusively Windows-based.

A main factor increasing productivity and supporting the implementation of intermediate systems during the construction and test phase, was the selection of a powerful Windows-based SCADA (supervisory control and data acquisition, [3]) tool for the creation of the process control computer software. Because of the inherent support of S7 PLCs we chose the Siemens product WinCC, which implements the operator interface, the alarm system and the process data base.

A further key component of the system is the use of PROFIBUS DP (EN 50170) which connects all PLCs and other front end devices to the PC. It is also used as a subordinate bus connecting front end components to PLCs. PROFIBUS DP is the dominating fieldbus in Europe and is naturally supported by WinCC, S7 PLCs and many other devices. A major reason for its success is the technological and functional scalability based on a common core as well as the programming model which easily maps to PLC operation[4].

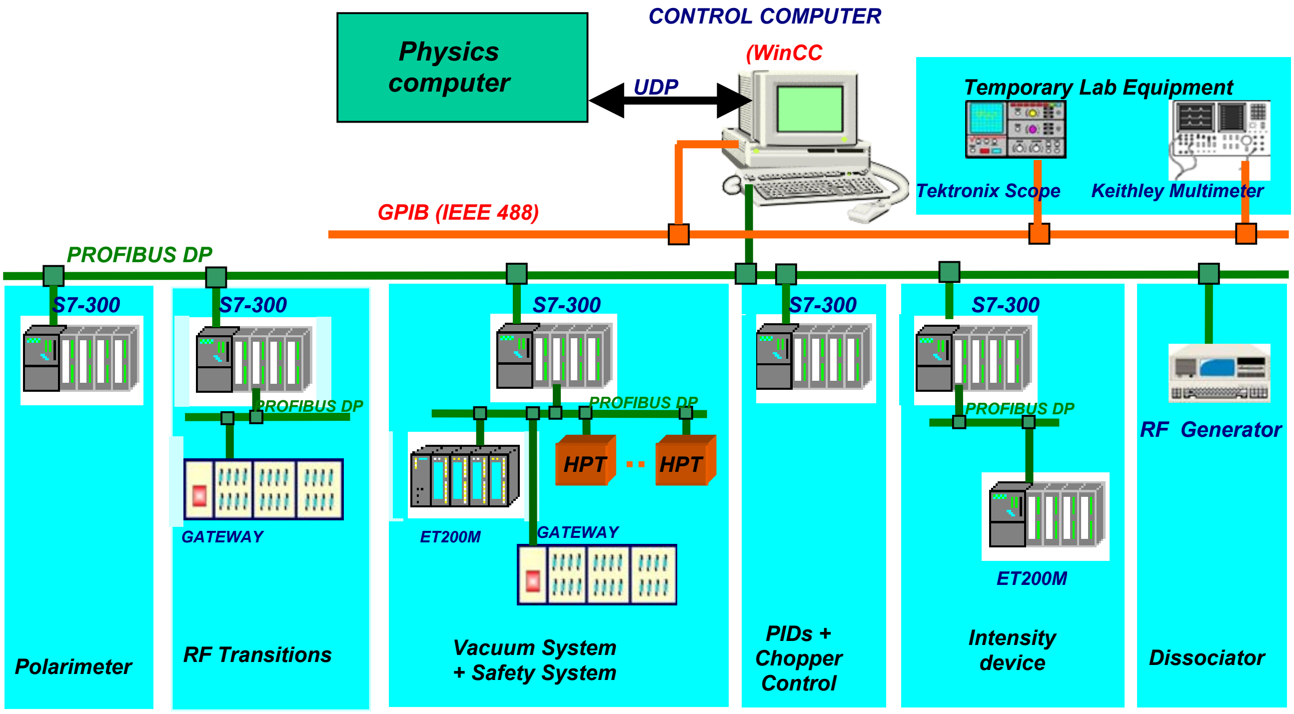

Figure 1: Structure of the ABS control system

3 CONTROL SYSTEM ARCHITECTURE

3.1 Logical Control System Structure

Conceptually the ABS control system can be structured into the following subsystems:

Vacuum system: A powerful differential pumping system consists of turbomolecular pumps, diaphragm pumps and cryo pumps. Valves can control several bypasses between the four stages of the vacuum vessel.

Atomic beam formation system: The dissociator includes an industrial RF generator for the plasma discharge as well as flow controllers for Hydrogen/Deuterium and Oxygen gas supply. The dissociator nozzle is cooled down to 40 K. Heaters which are controlled by individual PID loops are responsible for the temperature stabilisation of cold head and nozzle.

RF transition units: Desired polarisation is achieved by three RF transitions. Front end equipment includes power supplies, function generators and RF amplifiers.

Security Subsystem: Cooling system consists of water cooling of cryo pumps, turbo pumps, RF generator and two separate closed circuit Lauda cooling devices for the dissociator. Equipment includes leak detectors, valves as well as sensors for pressure, temperature and flow. Additional equipment includes special safety detectors for hydrogen and a UPS for the control system electronics.

Unpolarized gas supply system: For absolute intensity measurements of the beam, a special unit was implemented that includes compression tube, compression volume and unpolarized gas supply system for calibration [5].

α-device: This diagnostic instrument measures the degree of dissociation. Equipment includes a chopper and a crossbeam quadrupole mass spectrometer [6].

Lamb-Shift Polarimeter: This diagnostic instrument analyses the degree of polarisation. It is based on measuring the ratios of Lyman-α transition intensities after stark quenching of Spinfilter selected Zeeman hyperfine states [7]. Equipment includes a seperate vacuum system and a multitude of power supplies.

3.2 Physical Control System Structure

According to Fig. 1, there is one central control computer, a PC running Windows NT with WinCC, that contains process data base and operator interface. All process I/O is connected via PROFIBUS DP. Temporarily, some “laboratory type equipment” is attached via GPIB. For the connection to ANKE DAQ, a simple protocol based on XDR and UDP has been implemented, that allows the transparent access to internal WinCC tags via Ethernet. Thus ANKE DAQ can download setups to the ABS and continuously read back its status for inclusion in the data stream. The same protocol is used by a physics workstation for experimental tests of the ABS itself.

Process equipment includes five S7-300 PLCs. As indicated in the Fig. 1 the application is structured in very modular way by allocating each functional subsystem to one PLC. The PLC responsible for the vacuum and security subsystem is by far the most complex one. It is responsible for overall system start up and shutdown, thus controlling also the other PLCs. Most process signals are directly connected to these PLCs. Additional subordinate

PROFIBUS segments reduce cabling by accessing process signals via ET200M decentral periphery. Also Pfeiffer vaccuum gauges are connected via subordinate PROFIBUS segments. Gateways between PROFIBUS and RS232/RS485 are used to connect a variety of intelligent devices to the PC, at the moment. After a test phase these gateways will be connected via subordinate PROFIBUS segments to PLCs, as indicated in Fig. 1.

4 WINCC IMPLEMENTATION ISSUES

WinCC is a PC based system that runs only under Windows NT/2000 and offers most of the "open" interfaces (ODBC, OPC, DDE, OLE,...) found in a Microsoft environment. It is scalable by supporting multi-client/multi-server configurations. Main components of WinCC are

- Graphical editor: Process pictures can be drawn comfortably and the attributes of graphical objects can be connected to process variables transparently
- Data base: WinCC integrates Sybase SQL Anywhere for the storage of process values and alarms.
- Alarm system
- Variety of channel DLLs to support a lot of industrial networks and PLC types
- ANSI C as integrated script language: The script language allows modification of dynamic actions during runtime, thus increasing development productivity. The use of ANSI C allows a simple port of code between script modules and conventionally implemented modules. Scripts can directly call functions and access variables in Windows DLLs.

Development focused on the drawing of process pictures and connecting dynamic attributes of graphical objects to process variables. Additional actions on script level handled more complex tasks and operations like format conversions or scaling of process data.

Many control algorithms were first tested as script modules and then implemented on the PLC or even the gateway. This approach could only be used for very slow tasks, because the process variable updates as well as the maximum calling frequency of script actions are limited by WinCC to 4 Hz. Faster operations could be implemented by DDE Servers, using WinCCs DDE channel.

5 CONCLUSIONS

The overall experiences justified our basic design decisions. The operation of the PLC-based process periphery as well as the Windows-based controlling PC was robust and reliable. The system proved to be flexible and extendible. Especially the selection of PROFIBUS DP made integration of new components very simple. The main increase of productivity was caused by WinCC, which allowed easy extensions and modifications of process pictures. Transparent access to the process periphery via PROFIBUS DP, the predefined alarm system and the integrated database were key benefits. But the base system should have more predefined operator controls. WinCCs inherent limitation of process variable updates to 4 Hz restricts its functionality to pure operator interface and process data base.

The ABS is now in a test and optimisation phase. Operation in the COSY ring is expected at the end of 2003. Future plans for the control system cover the inclusion of a webserver as well as a mechanism to access the process data base also from Linux systems.

6 REFERENCES

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