CONTROL SYSTEM FOR IC-100 CYCLOTRON

Aleinikov V.V., Bondarenko P.G,. Krylov A.I., Nikiforov A S., Pashchenko S.V

JINR, FLNR, Dubna, RUSSIA

Abstract

The control system for IC-100 cyclotron has been designed and developed at the Flerov’s Laboratory of Nuclear Reactions. The control of the accelerator is realized from a remote machine through the local area network. The software for the QNX operating system and SCADA FLEX CONTROL is developed. The application of the universal controller produced a flexible and simple system that has shown high operational characteristics. The structure of the control system and its specialized modules are described in present article.

INTRODUCTION

As we begin to apply totally integrated automation solutions from industry automation [1] to the control of accelerators, we are faced the question of procurement and development of specialized modules. For example, the development of filtering modules of current signal with current magnitude as little as one micro Ampere and the modules for the control and management of high frequency signals presents in our tasks. The development and manufacturing of control systems with a mixture of standard and custom made modules was acknowledged by us to be a wrong approach. The main reason of this is the induced difficulty in operation and repair of the equipment. A collection of integrated controllers of SMARTBOX series along with all the necessary specialized modules was developed in the Laboratory of Nuclear Reactions. The new system have already used in the control of accelerators DC-72, EA10-10, and IC-100. Works to modernize control systems of U-400 and MC-400 are being carried out. The present article describes the control system of IC-100.

CONTROL SYSTEM

The structure of control system is shown in figure 1. The control system is mounted in five 19" racks. Management of all equipment is carried out through serial communication channels. The system deploys RS-232, RS-422, RS-485, IEEE 802 protocols and universal controllers of type SMARTBOX-4. 14 controllers are used in the system. Management of controllers is executed through a serial interface RS-485. The protocol of exchange with the computer is PROFIBUS. Each controller has the unique address, which is defined, by its installation site in the system by means of crosspieces on the plug in crate. A controller address is determined once the power is switched on.

Management of all equipment is carried out in the following way. An Industrial 4 port RS-232/RS-422/RS-485 of the serial board produced by Moxa Technologies is used for management on communication channels in a personal computer. The interface IEEE 802 is used for remote control of the accelerator and for other operational needs.

For the management of the equipment that takes place under potential ECR source (up to 30 kV); two converters RS-485 are installed to fiber optic, providing isolation of the controller on communication line RS-485.

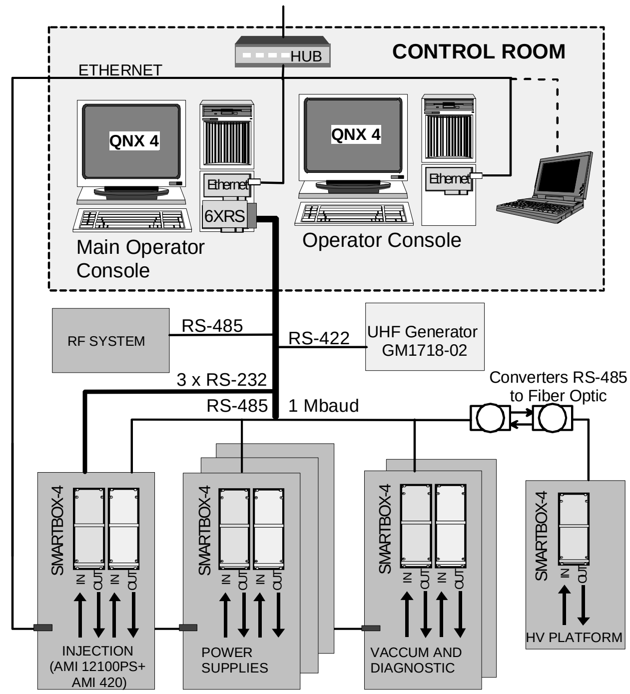

Fig. 1: The structure of control system.

For the management of magnetic elements of beam lines current sources of series ES, SM firms DELTA ELEKTRONIKA BV, Netherlands with 10V analog interface are used.

A collection of current-to-voltage transformers is developed to measure signals from current samplers. All converters are constructed under the three-cascade circuit inverting «current to voltage» with input protection, the active low frequency filter of the second order with Кu = 1, the inverting cascade with Кu = 10.

Modules are 7TE, 6HE Euro-19″ size. Input : 24 VDC.

CVC-01. Module is designed for converting profile meter current signal in range of 1 mkA to voltage 10 V. Number of input channels - 32.

CVC-02. Module is designed for converting aperture diaphragms current signal in range of 20 mkA to voltage 10 V. Number of input channels - 12. A range of controllable resistance of a source of a signal 50 whom – 5 MOhм

CVC-03. Module is designed for converting Faraday cup current signal in ranges of 1 mkA, 10 mkA, 100 mkA, 1000 mkA to voltage 10 V. Number of input channels – 16, output channel - 1 A range of controllable resistance of a source signal 10 kOhm – 100 MOhм

SMARTBOX-4.

The functional diagram of SMARTBOX-4 module is shown in figure 2.

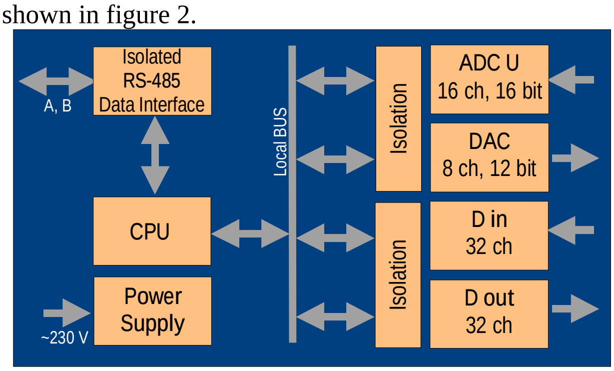

Fig. 2: The SMARTBOX-4 functional diagram

The SMARTBOX series microprocessor controlled device is designed as fully enclosed data acquisition module with built-in industrial bus interface. Mechanically modules can be integrated into a system by way of a crate.

SMARTBOX-4 technical data is shown in table 1.

Table. 1. SMARTBOX 4 technical data

CPU	Type	MSC-51
Communication	Type	EIA RS-485
	Communication speed	921600 baud
Power	Power supply type	Built-in, Analog
	Input voltage	~230 V, 12VA
Construction	Type	Euro 19", crate mount
	Dimension	6U, 10HE, 188mm
	Operational humidity	From 65% ±15% at 25°C
Analog INPUT	ADC type	Σ-Δ ADC
	Voltage Channels	16 channels, 16 bit
	Voltage Range	±10 V
Analog OUTPUT	Channels	8 channels, 12bit
	Output Range	0 – 10V
	Output Current	±5 mA
Digital INPUT	Channels	32 (4*8) Isolated channel
	Logic level 0	0 – 5 V
	Logic level 1	10 – 24 V
	Isolation voltage	250 V AC
Digital OUTPUT	Channels	32 (8*4) Isolated channel
	Open collector	To 30 V max.
	Output current	200 mA per channel
	Isolation voltage	250 V AC

SOFTWARE

The control system for IC-100 cyclotron uses commercial SCADA FlexControl running under RTOS QNX 4 [2]. QNX is UNIX-style scalable, multi-user, multi-tasking, real-time, network and POSIX-compliant operating system. FlexControl [3] is a process control system for the automation of technological processes. It is modular and scalable. We have developed a library of functions, which we have built into application to control the screen and the keyboard. It uses Photon Application Builder as graphical editor, object configurator and application compiler. In order to manage message queues for HMI client in the network we have developed Visualization Server. HMI allows analyze process data in real-time trend, store and retrieve a set of variables to repeat important system modes. Alarm server controls faulty operations and signalizes by means of ringing bell, message and/or printing. Reports can be hard copied and exported in text file.

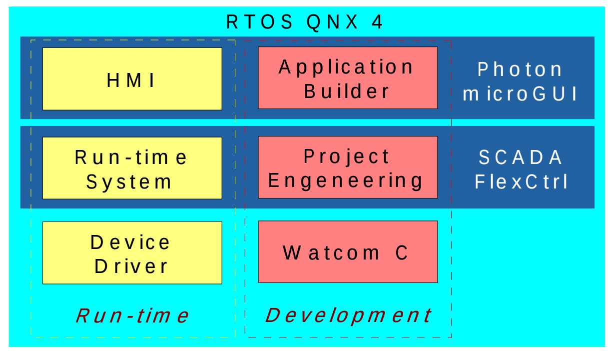

Fig. 3: Basic structure of the software development

It was developed device drivers for 3rd party equipment with unique remote control protocols (via RS-232):

- UHF synthesizer GM1718-02,
- UHF Power amplifier Neptun-18,
- Power supplies AMI-420 for superconductive magnets.

Data flow diagram [5] is shown on fig. 4.

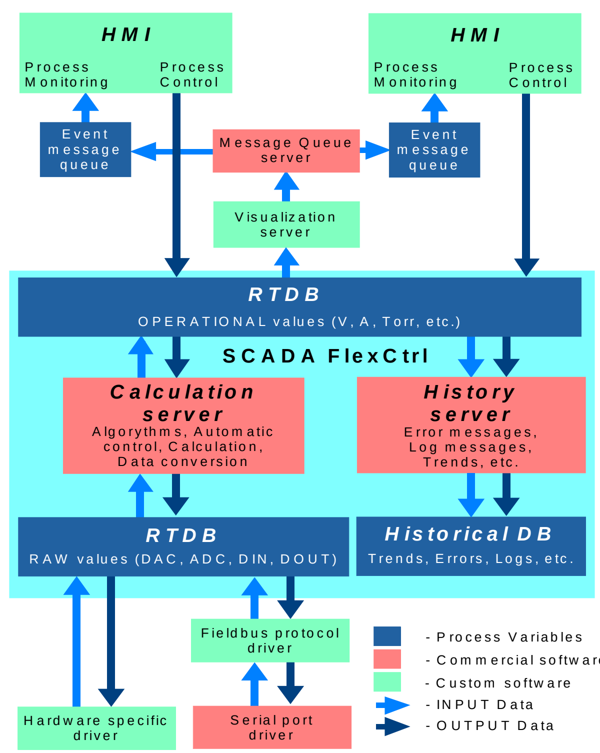

Fig. 4: Data flow

Basic structure of the software development [4] is shown on fig. 3. HMI for IC-100 cyclotron systems were designed as follows:

- Vacuum system (axial injection, see fig. 5, cyclotron, extraction and beam line)
- Beam transport magnets and beam diagnostics system
- ECR source and superconductive magnets diagnostics
- RF system
- Cooling system

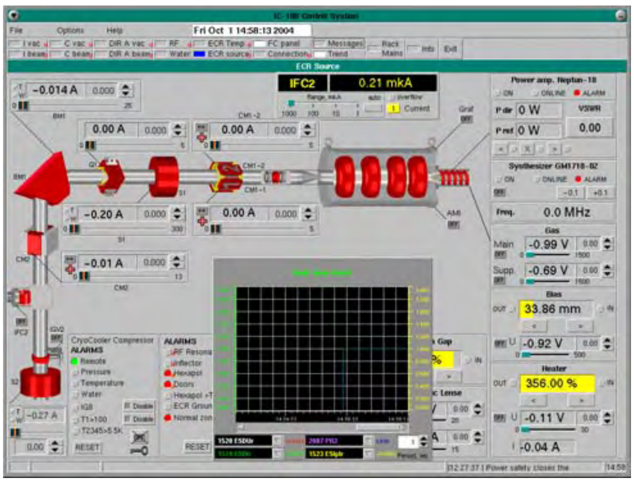

Fig. 5: IC-100 Axial injection HMI

Using commercial SCADA for a control system decreases total project development time, unifies data processing and allows concentrating more on visualization and automation algorithms. It also increases reliability and endurance of the software since the core of the system is well optimized and tested.

REFERENCES

[1] SIMATIC Controllers. http://www.ad.siemens.com

[2] Rob Krten, “Getting started with QNX 4. A Guide for Realtime Programmers”. PARSE Software Devices, 1998.

[3] FlexControl - System Architecture Manual. BitCtrl GmbH. October 1998.

[4] V. Aleinikov, S. Paschenko, “Using commercial SCADA in control system for ECR CyLab.” PCaPAC 2000. Hamburg.

[5] V. Aleinikov, A. Nikiforov, “Integtrating custom software and commercial SCADA.” NEC 2003. Varna