THE CONTROLLER FOR THE POWER SUPPLY OF PULSE MAGNETS WITH OUTPUT CURRENT UP TO 10 KA

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Abstract

As part of the construction of the NIKA project [1], implemented at JINR (Dubna), the Budker-Nuclotron transport channel is facing the Budker Institute of Nuclear Physics. For him, BINP, in particular, develops, manufactures and supplies a number of high-voltage power supplies of dipole and septum magnets.

As the development of accelerator technology, the issue of automation of scientific complexes and industrial accelerators is becoming ever more acute. With increasing beam energy, the necessary accuracy of maintaining the parameters of the accelerator grows. All this imposes new demands on the automation system of the accelerator complex. In addition, for power supplies with powerful drives for high energy, the issue of safe operation was always acute. It is necessary not only to monitor the load parameters, but also to ensure safety during routine maintenance and service operations.

The presented article contains a description of the controller for switching power supplies. A distinctive feature of the controller is the combination in one device, several, logically connected with each other. Realization within the controller of the fast protection device allowed to realize a qualitative analysis of the behavior of the power system by changing the voltage and current of the load, which is very important for determining future possible problems and not regular situations. The control is carried out via Ethernet, as well as manual control by means of a touch screen located on the front panel of the power supply. As the core, a digital signal processor is used, which makes it possible to implement the execution of local work scenarios by maintaining part of the autonomous functions.

This article describes the controller itself, its properties and the main application.

INTRODUCTION

As part of the construction of the NIKA project, implemented at JINR (Dubna), INP designs, manufactures and supplies a number of high-voltage power supplies for dipole and septum magnets of the Buster-Nuclotron transport channel [2]. The work of magnets is carried out in a pulsed mode. The source is made according to the scheme of a powerful capacitive energy storage device that is switched at the right time to the magnet windings. For the correct operation of the bypass channel, it is required to maintain the accuracy of the current in the winding when the beam passes no worse than 10^{-3} and the possibility of realizing the accuracy of the magnetic field by external feedback is no worse than 10^{-4}. Due to the fact that the power source contains an energy storage device with a stored energy of the order of 10 MJ, it is necessary to implement all safety measures when working with a high-energy installation in order to exclude the occurrence of a situation of a non-standard discharge of energy accumulated in the capacity when operating the sources.

To solve these problems, the described controller was developed, which combines both the functions of the interface and control unit and the functionality of the fast protection unit.

CONTROLLER

As already mentioned, the controller carries out a full set of control, measurement and lock communication functions. The controller controls the charging source by specifying the required voltage on the capacitance, and the output thyristors bridge is controlled via the fiber. As the main protective function, a powerful mechanized discharge key is controlled. At the end of the operation of the source, in the event of an abnormal situation associated with the danger of unauthorized discharging of the storage tank, or if a source of suspected malfunctioning of the power components of the source is suspected, the drive is first discharged with a powerful discharge resistor and then tightly closed with an electric key. If the drive is malfunctioning, the capacitance is shortened by means of a backup high-power discharge resistance.

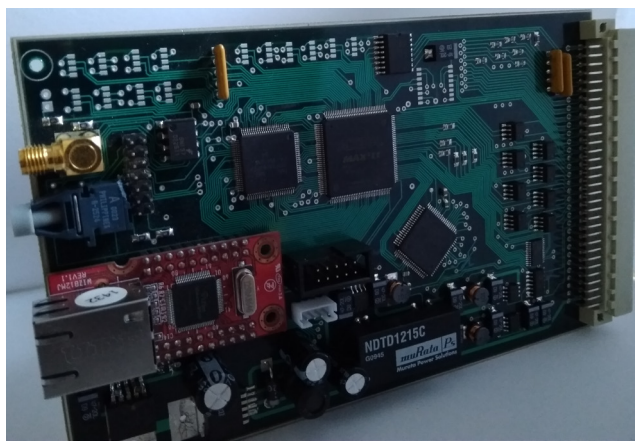

Figure 1: Controller.

As a consequence, it requires both a precision DAC interface and an ADC, as well as many binary I / O channels, to interrogate locks and control external devices. At the same time, a modular approach to device development was used, which allowed us to design a controller as a universal module (Fig. 1), which can be used in various applications.

ISBN 978-3-95450-197-7

The architecture of the device is typical for similar applications and is shown in Fig. 2.

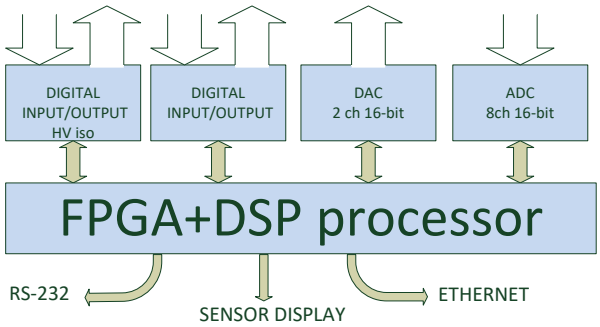

Figure 2: The structure of controller.

DAC and ADC

As a DAC, the AD5754 chip is used - 16-bit DAC (Analog Devices) in the inclusion circuit recommended by the manufacturer. The parameters of this chip allow to completely satisfy the requirements of the source specification. For this application, two channels of four are involved.

As an ADC, a 16-bit, 16-channel AD7616 ADC is used, with an input voltage of +/- 10.5V, a programmable gain and a first-order filter located on a single chip. The chip provides a maximum noise level of 90.5 dB SNR at a sampling rate of 1 MSPS.

For this application, only 8 measurement channels are used. This number of channels allows you to monitor all analog parameters of the source.

To implement voltage protection and measure fast values and reserve critical measurements, 3 out of 8 channels in parallel measure 12 bits of the ADC of the signal processor.

I/O Registers

Galvanically isolated input / output digital registers are divided into 2 types. To communicate with other devices located in the source, a decoupling via optocouplers is used. The second type is implemented on high-speed digital galvanic isolations of the ADUM family and is used in the system of interlocks and control from external control devices. Asynchronous logic inside the FPGA matrix is used to handle all locks. This avoids cases of incorrect operation when the clock elements fail or in the presence of high-power impulse noise. All-important security functions are implemented taking into account that work is not performed when any of the protection elements fail.

Core

The implementation of a controller with an FPGA matrix in the center, allows for quick reconfiguration of the controller for the required task. Using the C2000 (TI) Piccolo family processor allows to implement a wide range of tasks. Control by means of external synchronization allows, how to start a process by external impulse, and synchronize work with other devices.

To implement the manual control function and output parameters to the front panel, it is possible to connect the touch screen via one of the RS-232 interfaces. The touch screen provides the full range of local control options, including settings and saving parameters. The use of the sensor allows for a more flexible approach to tuning and the use of universal modules in different devices, changing if necessary only their software part.

Figure 3: WEB server.

To communicate with the control system of the accelerator complex, an Ethernet interface is used with the MODBUS TCP protocol. In addition, the controller implements a diagnostic WEB server (Fig. 3), through which it is also possible to manage and configure and store parameters.

CONCLUSION

The result is a universal controller that combines many previously independent devices. The controller, thanks to the distributed architecture and flexible circuitry, makes it easy to adapt it to the required tasks and covers most of the needs for controllers for high-voltage sources.

REFERENCES

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ISBN 978-3-95450-197-7