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DATA COLLECTION, ARCHIVING AND MONITORING SYSTEM FOR U70 SYNCHROTRON

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Abstract

This paper describes a data collection, archiving and monitoring system for U70 synchrotron. The system is designed to monitor the operation of the U-70 accelerator and is responsible for the collection of low-frequency (less than 2 kHz) analog signals from the U-70 technological systems, their processing and subsequent sending to the database using the Data Socket technology. The developed complex block diagram is presented. The hardware and its characteristics (number of channels, resolution, bandwidth) and the interface and functionality of the software are described. The results of using this system at the U-70 accelerator complex are presented.

INTRODUCTION

U-70 personnel need to control a large number (more than 100) parameters when controlling the accelerator complex, most of which are represented in the form of low-frequency (frequencies less than 2 kHz) analog signals. To quickly identify malfunctions and improve the efficiency of the accelerator complex, it was decided to create a system for monitoring and archiving low-frequency signals.

HARDWARE

The block diagram of the data collection, archiving and monitoring system for U70 synchrotron is shown in Fig. 1. It includes analog-to-digital converters (ADC), local servers and a database server.

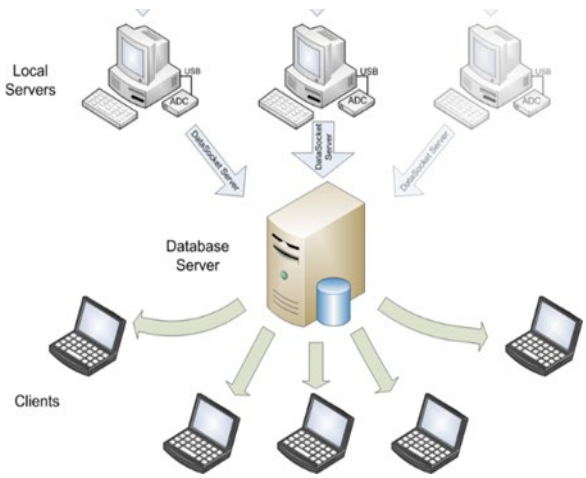

Figure 1: The block diagram of the data collection, archiving and monitoring system for U70 synchrotron.

An analog-to-digital converter (ADC) E-14-140-M is used to digitize the signals. Its characteristics are presented in Table 1. The ADC is connected to the Local server (a PC running the WINDOWS 7 32bit operating system) by a USB cable. The HP proliant dl160 running the Debian 8 operating system is used as a database server (Database server).

Table 1: Characteristics of the ADC E-14-140-M

Number of channels	32 with "common ground"
Resolution	14 bits
Input signal range	±10 V
Conversion frequency	100 kHz

Each ADC operates in the mode of 32 analog channels and 8 digital channels.

The analog inputs of the ADC are supplied with 31 signals from the control outputs of various sources (induction sensor, total voltage of the electric field RF, magnetic field corrections, etc.) (Data Sources) and one synchronization signal (common for all ADCs). The synchronization signal represents two pulses of different amplitudes (8V and 3V). The pulses are linked to the supercycle of the U-70 accelerator with a duration of 8-10s.

The digital channels receive the following signals from the synchronization system [1]:

- NC (start of the accelerating cycle);
- B1 (technological pulse generated on the falling part of the magnetic field of the previous magnetic cycle);
- B2 (the beginning of magnetic field booster plateau stabilization pulse);
- KS1 (end of the booster plateau);
- T0 (the beginning of magnetic field main plateau stabilization pulse);
- KS2 (end of the main magnetic field plateau);
- Reset (service pulse delayed in time relative to the NC pulse);
- Two backup channels of the U-70 timer system.

The parameters of the magnetic cycle are monitored using digital signals.

SOFTWARE

The software is created in LABVIEW and consists of the server and client parts.

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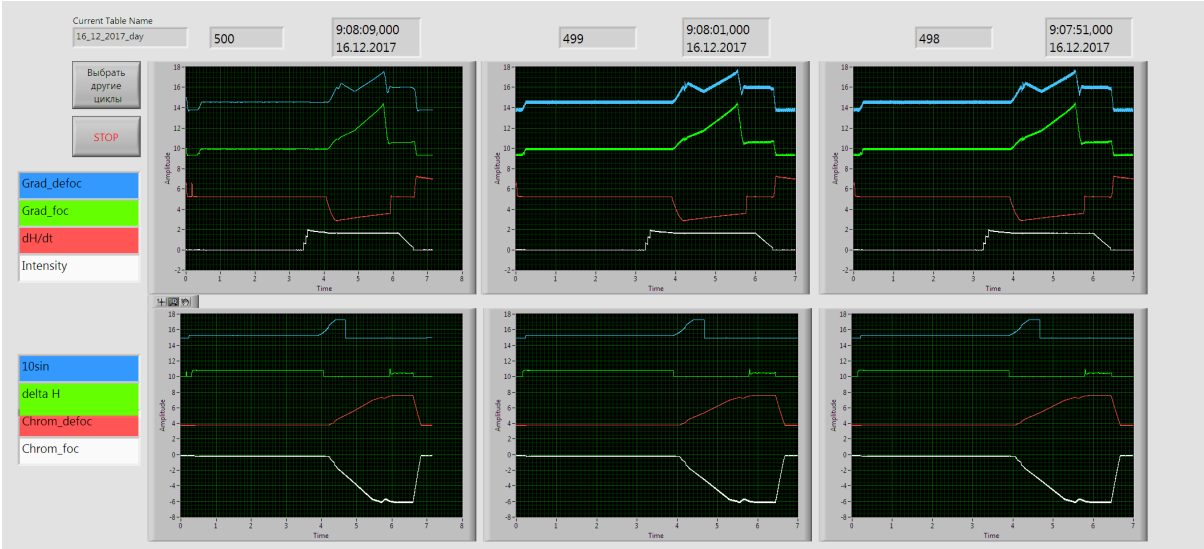

Figure 2: Three cycle monitoring program interface.

The Server Part

When the local server program receives a 3V synchronization pulse (the beginning of the U-70 magnetic cycle booster plateau), it collects data from the ADC until an 8V synchronization pulse is received (the end of the U-70 magnetic cycle main plateau). Then it displays the collected data on the graph and transmits it via DataSocket Transfer Protocol [2] to the Database server.

The database server program receives data from all local servers via the DataSocket Transfer Protocol and writes it to the database. MariaDB 10.2 is used as a database [3].

Each session creates a new database consisting of tables. Tables are created automatically twice a day (the beginning of the shift at 8:00 and the end of the shift at 20:00). Each table contains the following columns: cycle number (from the shift beginning); date and time of data receipt; columns of data from local servers, a column with digital channel data (time intervals between U-70 timer system pulses). To save space, the database stores complete information only for the last seven days. The remaining tables contain data for every tenth cycle and cycles with certain parameters (the work of fast output, the work of a certain physical installation).

The Client Part

Three client programs have been developed: monitoring of the last three cycles, working with the archive and an emergency alerts program (SPY).

Monitoring of 3 cycles The program continuously outputs the last 3 cycles for the 8 selected channels. The cycle number and the date of data receipt are displayed at the top of the screen. The user can change the sensitivity of the signals and their offset relative to each other. It is also possible to bind the signals to one of the pulses on the digital channels. Three cycle monitoring program interface is shown in Fig. 2.

Working with the archive The user can display up to 10 signals from the database. To do this, you need to select the signals of interest and the date when the data was received. The search for a cycle is carried out using the slider on the statistics graph. If the requested data is not found in the database, the message "Table not found" will be displayed. The user can use cursors to measure the time and amplitude characteristics of signals. The cursor color matches the color of the channel whose characteristics the cursor measures. The corresponding fields display measurements of both absolute values (relative to the zero signal level) and the difference values between the cursors.

For more convenient search, buttons (arrows) are organized to scroll the cycles forward and backward with a given step. The user can display the signals of the last cycle recorded in the database on the graph.

The program allows to save the current settings (selected signals, sensitivity, position of signals on the graph, binding to synchronization pulses, cursor selection), the graph (in .png, .jpeg, .bmp formats) and the selected signals in .csv format. The program interface for working with the archive is shown in Fig. 3.

Emergency Alerts Program (SPY). The emergency alerts program signals the occurrence of emergency situations through visual and audible alerts. The program will respond to the following emergency situations:

- The intensity is below the threshold. The source of the intensity signal is the signal of the induction sensor U-70. The threshold is set on the statistics graph (Fig. 4) using the horizontal cursor (intensity threshold).
- Acceleration losses. The difference between the accumulated and accelerated intensity is determined. The accumulated intensity is determined by the pulse T0, the accelerated intensity is determined by the pulse KC2.

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Figure 3: The program interface for working with the archive.

- Insufficient intensity for the work of internal targets. In total, three targets are controlled (24, 27 and 35). The user has the opportunity to choose controlled targets. The shortage of intensity is determined by the nature of the current flowing in the additional windings of the blocks of the U-70 ring electromagnet (bumpers), which create a local distortion of the orbit. If the intensity is insufficient, the feedback increases the bump current to the maximum value (Fig. 5). The program monitors a sharp (no more than 10 ms) increase in the current signal to the maximum.
- The remaining intensity in U70 is higher than the set value. The remaining intensity is controlled using the FEP bump.
- The disappearance of the magnetic cycle U-70 is determined by the signal Ḣ. In this case, the program only issues a sound notification.

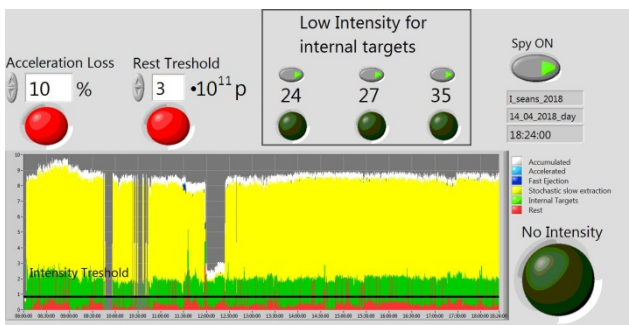

Figure 4: Emergency Alerts Program interface.

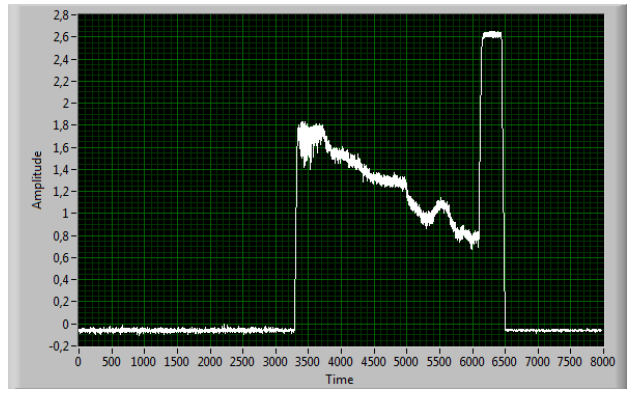

Figure 5: Bump current with insufficient intensity for target operation.

CONCLUSION

A data collection, archiving and monitoring system for U70 synchrotron has been developed. The system was tested on the U-70 accelerator in the first run of 2018. It is planned to increase the number of signals recorded in the database, expand the list of emergency warnings and expand the functionality of client programs (measurement of betatron and synchrotron frequencies).

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