# UPGRADE OF THE U-70 PROTON SYNCHROTRON EXTRACTED BEAM LINES CONTROL SYSTEM: MULTIPLE ACCESS AND DATA PRESENTATION

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*Abstract*

The U-70 extracted beam lines system includes about 130 magnet dipoles and quadrupoles, with power provided by 112 power supplies (PS). Each PS is controlled by an individual Analog Device's based controller. Since a number of used magnets may vary and exceeds the number of available PSs, the commutation is used. Controllers are connected to a front-end computer by means of four CAN field buses. The software for the controllers is tuned to a specific type of the PS and a specific inductive load of the magnet. The Dell PowerEdge T710 server is used for the PS control with multiple access from several client workstations which controls PSs for a particular beam line. All client workstations along with the server and front-end computer are connected together with a dedicated LAN.

The server grants different users a different permissions to control their own PSs only. Every four seconds the measured data are stored into an archive. Operating commands are archived as well to keep a history of all user's actions. The software is based on the National Instruments Developer Suite Core and MS Office Web Components packages.

## INTRODUCTION

The Extracted Beams on the Serpukhov 70 GeV Proton Synchrotron are spread for over 1 km. They include about 130 magnet dipoles and quadrupoles. The PSs (motor-generators, silicon rectifiers and thyristor rectifiers) are installed in the special building
500m away. The total number of PSs is only 112, so, as a result, the commutation is used. The PS are characterized with the following features:

- DC current stabilization time can be as long as several minutes;
- magnet hysteresis stipulates a special procedure of installation of current,
- imperfection of the PS feedback stabilization requires to adjust the DAC reference signal to get needed current of the magnet;
- current polarity can be changed.

Intel 8051 compatible custom PSs controllers (PLCs) are uploaded before a run with accordance to features of a specific "magnet-PS" couple [1]. The following data is uploaded;

- maximum value of current,
- DAC raising rate,
- matching delay,
- minimum making step,
- number of matching steps.

## CONTROL SYSTEM CONFIGURATION

A block diagram of the control system is shown in Fig.1. Front-end computer (FEC) is used as a master for PLCs. FEC acts as a CAN master and can gain the access to controllers through 4 segments of 2 CAN field buses. The total length of each bus is about 600 meters. The data transmission rate of 20 Kbit/s is used because of heavy noise conditions in order to reduce information losses down to acceptable level.

FEC reads data from PLCs periodically, one read cycle accounts for about 15 ms. Due to large number
(100-120) of PLCs the polling period is 2 seconds.

FEC is a client of the MS SQL-server 2008, that is located in the beam control room on the main archive server. Any computer inside the both industrial and public LAN could be a client of this server. Each client has its own permissions. There are 3 levels in client's permissions hierarchy:

- The lowest level is occupied by «observers», who can only view the data and does not take part in any control operations. The observers may belong to both the industrial and public LAN;
- The middle level is reserved for the operators of the physical experimental installations. They are observers too, but in addition they can also operate their own magnets;
- The full permissions level is given to the operators in the main beam control room and at the PS building. They can control any magnet of any channel. In addition, they can generate a list of magnets for the current run.

  Both the middle and high level operators consoles can belong to an industrial LAN only.

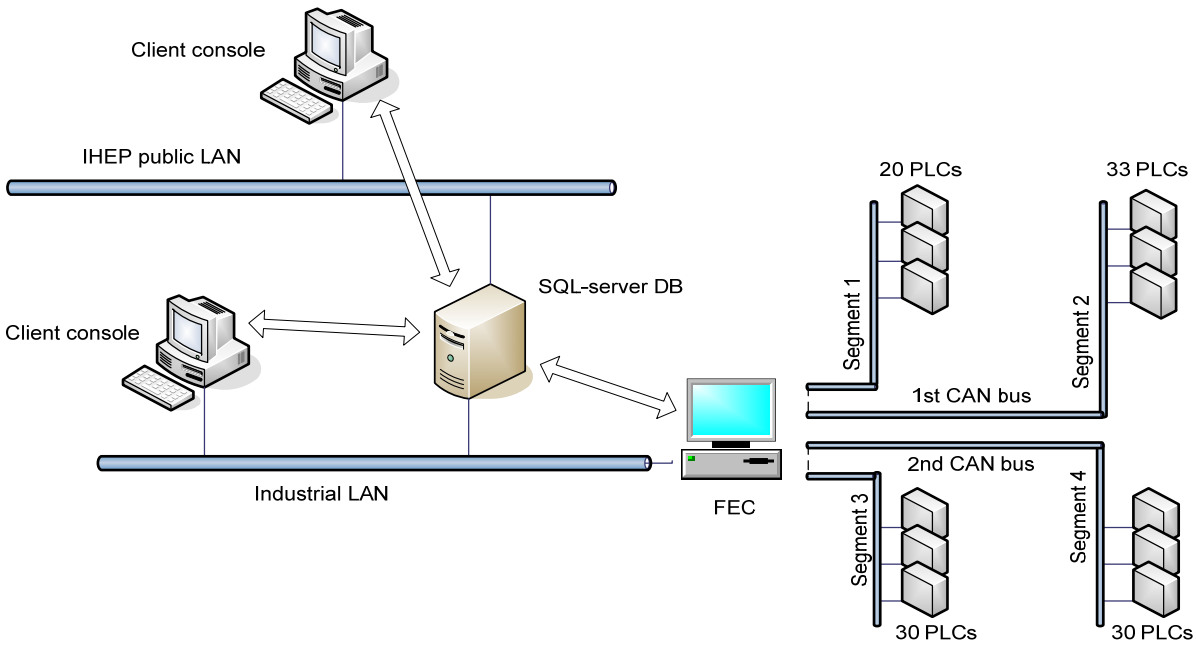


Figure 1: Control System of the Beam Lines

## USER OPTIONS

The ODBC protocol is used for gaining access to SQL-server stored procedures and queries. The independence and uniformity of ODBC simplify the development of control system applications. Fig.2 and 3 show examples of web clients for selection of the channel and control operation, respectively. Internet explorer is used.

Similar examples of windows for control operations, created with the National Instruments LabVIEW environment are shown in Figures 4 and 5. Having many useful and powerful possibilities, LabVIEW is a perfect instrument for developing of control system applications.

## ARCHIVING

To deal with archive data the two types of software were developed - web-pages and LabVIEW programs. Both types of applications give an opportunity to supervising (viewing) data in tabular and graphical styles as well. With any archive viewing way the operator can make data selections using different criteria.

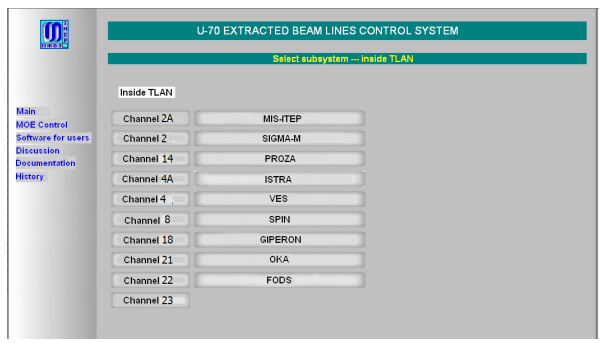


Figure 2: Web-client for channel selection. Each button corresponds one of the magnet sets – beamline or installation.

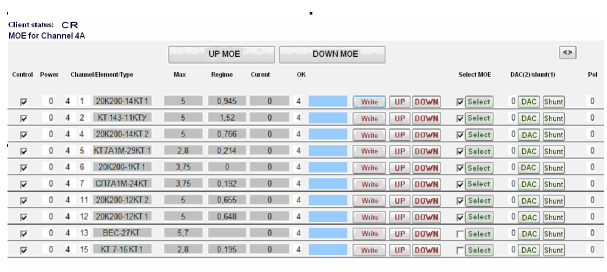


Figure 3: Web-client for magnet control operations. For every magnet the set of several operations is provided (red and green buttons)

The archiving gives powerful possibility for making periodical evaluation of PLC current state with the aim to find malfunctioning PLCs or feedback stabilization systems. Fig.6 shows an example of using the archive data for monitoring of the PLC efficiency.

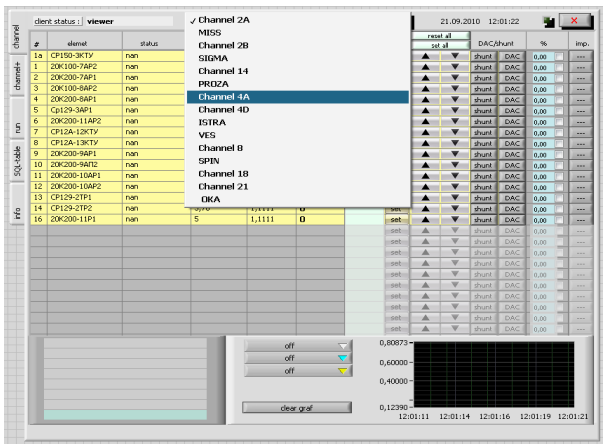

Figure 4: LabVIEW-based client for control operations

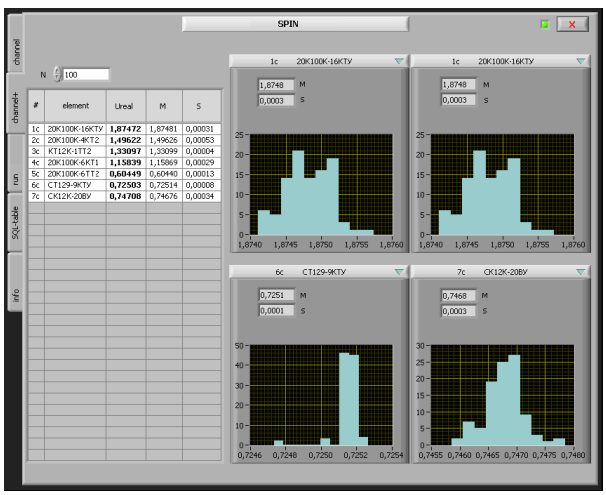

Figure 5: LabVIEW-based client for control operations

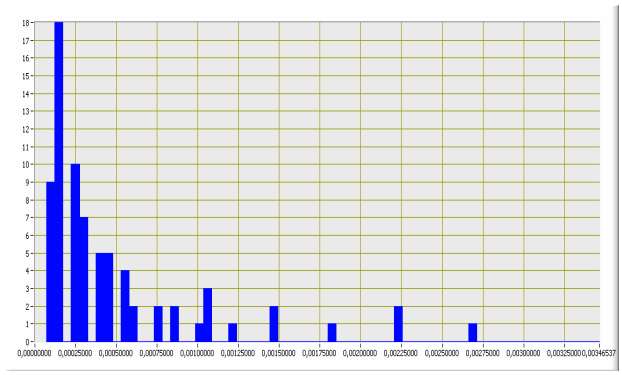

Fig 6. Histogram of the PLC distribution of self noise levels

## CONCLUSIONS

The control system of the extracted beam lines at the IHEP U-70 proton synchrotron has been in operation since 2001. It provides: multiple access for different clients with different rights; data storage for quality control of the PLCs and PS stabilization system; convenient methods of data presentation. The system can be easily expanded by adding more PLCs and more clients. We plan to make the PLC polling faster by increasing the CAN bus rate and with parallel access to two independent CAN buses.

## REFERENCES

[1] V. Alferov, Y.Bordanovski, S.Klimov, V.Ilukin, V.Kuznetsov, O.Radin, A.Shalunov, A.Sytin, P.Vetrov, V.Yaryguine, V.Zapolski, V.Zaruche U-70 Proton Synchrotron Extracted Beam Lines Control System Modernization. Proceedings of the 2001 International Conference on Accelerator and Large Experiment Control Systems. Los Angeles, USA, 2001.

[2] http://icalepcs2001.slac.stanford.edu; http://can.marathon.ru/