THE ACQUISITION SYSTEM OF EXPERIMENTAL DATA FOR URAGAN-2M

S.P. Gubarev, G.P. Opaleva, V.S. Taran, M.I. Zolototrubova

Institute of Plasma Physics, NSC "Kharkov Institute of Physics and Technology", Kharkov, Ukraine

The data acquisition system for controlling the real-time parameters of high-temperature plasma for Uragan-2M device has been presented. Its development is carried out in Kharkov Institute of Plasma Physics of NSC KIPT. This system provides synchronous multi-channel high-speed measurement of electrical signals coming from installed sensors and diagnostic equipment as well as collecting and displaying information, archiving it on a server and electronic data depository allowing users to access files with recorded data.
PACS: 52.70.-m

1. INTRODUCTION

According to increasing search for alternative energy sources, experiments of studying the problem of controlled thermonuclear fusion (CTF) carried out on experimental physical devices such as stellarators and tokamaks are becoming increasingly important in the world's major research centers throughout the world. An integral part of these works is development of automated systems for collecting experimental data. Traditionally, much attention is paid to the development of such systems in Russia, in particular - Institute of Nuclear Fusion, Russian Research Centre "Kurchatov Institute" (tokamak T-10) [1], Troitsk Institute for Innovation and Fusion Research (tokamak FTU) [2], Tomsk Polytechnic University (tokamak KTM) [3].

Similar research work on the automation of physical experiments is carried out for torsatron Uragan-2M at the Institute of Plasma Physics (IPP) of the National Science Centre "Kharkov Institute of Physics and Technology". Data acquisition system is an important device due to the following requirements: significant energy consumption of the device and auxiliary systems, large amount of information, pulsing unit (operating pulse – 100 ms, pulse pause – several minutes), the need to send signals over long distances from the installation (in accordance with safety requirements), on-line processing of recorded information and its visualization and storage.

The main aim of the present activity was to optimize the time necessary to collect maximum amount of information, presentation of results and modernization of data processing algorithms for data acquisition system.

2. EXPERIMENTAL EQUIPMENT AND SOFTWARE

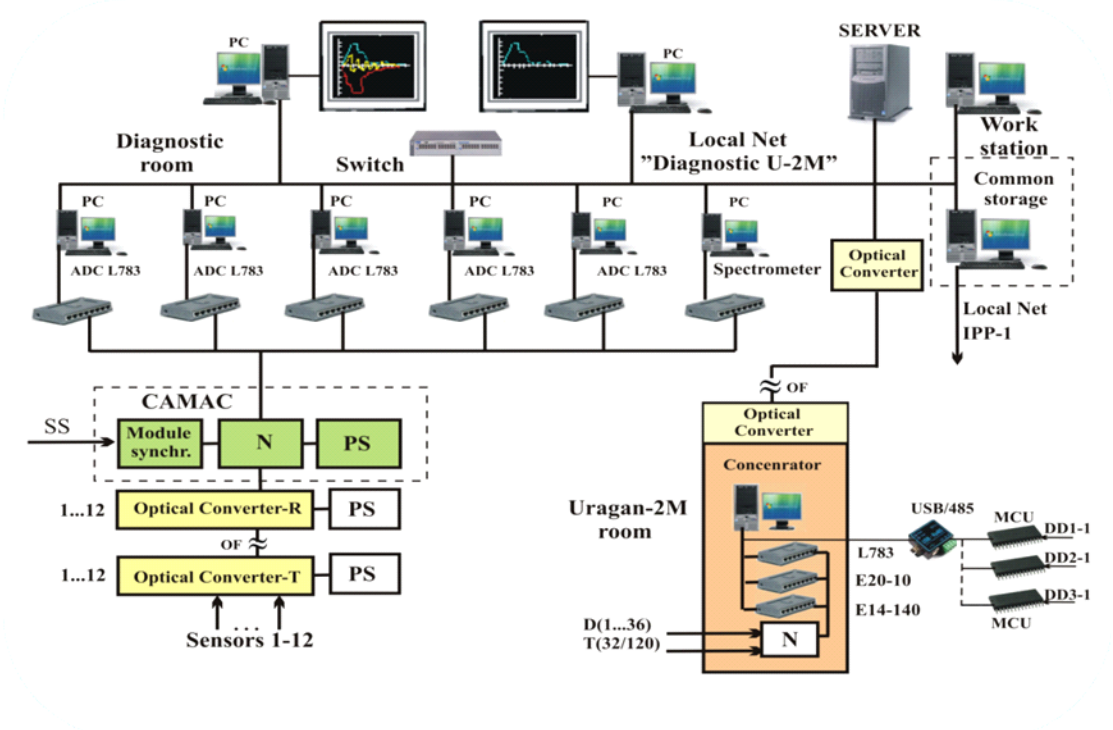
Uragan-2M experimental thermonuclear device is a huge and complicated electro-technical device used for investigation of high-temperature plasma. The input power rate riches about 1 MW and magnetic field is up to 2 T, current in the windings of the magnetic system is up to several thousands amperes. Diagnostic equipment operates in conditions of high electric, magnetic and high-frequency fields. On the Uragan-2M the following basic methods of plasma diagnostics are used:

- radiometry (6 channels);
- 1 mm interferometer (3 channels);
- 8–16 mm interferometer - reflectometer (4 channels);
- analyzer of neutral charge (2 channels);
- bolometer (6 channels);
- grid analyzer (32 channels),;
- Langmuir probes (8 channels);
- diamagnetic diagnostics (4 channels);
- RF probes (4 channels);
- capacitive probes (4 channels).

Each diagnostics includes measuring channels contained sensors, electronic components, signal transmission path from corresponding diagnostics to individual workplace. One should solve several problems connected with amplification, normalization and protection from strong electric, magnetic and high frequency noise source signals as well as recording signals bearing information on plasma parameters in the installation and operation modes of different systems. The distance between the diagnostic sensors mounted on the diagnostic equipment installation and the measuring room is 100 m.

The automation system is built in the form of a distributed local area network (LAN) - based hardware-software complex contained a number of personal computers equipped with multifunction I/O devices of the analog and digital signals (see Figure below). The collection system components are located on several floors of the IPP, including the premises of the diagnostical hall, experimental hall "Uragan-2M", server and storage rooms.

The hardware part of the complex consists of boards L-783, E20-10 and E14-140 modules of L-Card production, with the Lgraph2 software, which allows the input-output information on the analog channels in various modes [4], as well as microcontrollers PIC18F2550 (PIC-Programmable Interface Controller) of Microchip Inc. company [5], integrated into the overall system via USB and RS-485. Multi-board L-783 can also perform certain management functions, providing multi-output of digital and analog signals in accordance with design software.



Data acquisition system for Uragan-2M

This feature is implemented by the authors on the Uragan-2M by remote control drives of the measuring probe [6].

Automated system for collecting diagnostic information (see the Figure) consists of server and seven client stations, six of which are equipped with universal I/O boards L-Card L-783 (3 MHz, 32 channels, PCI), and one - with the additional modules E20-10 (10 MHz, 4 channels, USB), E14-140 (100 kHz, 32 channels, USB) and PIC18F2550 microcontrollers for converting analog input signals, their memorization and analysis at the local work place of a diagnostician.

The system which is a local area network "Diagnostics U-2M" also includes computers and monitors to ensure rapid graphical representation of the recorded experimental data, the workstation of an administrator, remote (issued in the experimental hall) stand - the hub and the data depository. The latter allows access for users of IPP (Institute of Plasma Physics) local network to archive recorded experimental data. Stand-hub includes a computer equipped with boards and modules of the signals input-output. It is possible to increase the number of connected channels.

All electrical signals from sensors installed are going through pre-amplification, normalization (N) and harmonization. These operations are carried out by so-called communication devices with the object (CDO), made in the form of modules in the CAMAC standard and constructively placed in crates or in a rack. The problem of high electrical isolation between the electrical signals from the plant and input circuits of the recording equipment of automated collection system is solved by using an optical transmission medium of information through the use of fiber - optic communication lines (OF), optical converters and optic-isolation of individual devices. This ensures a high level of accuracy and noise immunity which is especially important when using equipment with remote sensors and extended lines of communication. The synchronization module ensures the simultaneous launch of the analog-digital converters on all diagnostic computers on the arrival of sync pulse (SS) from the synchronization system of the installation.

The software is implemented in the language of object-oriented programming such as C^{++} Builder 6 and C18 language and provides collecting, displaying and archiving of the experimental data on a remote server. An automated system of open architecture allows to extend the LAN client stations. The software (SW) has a modular structure and based on high-level C^{++} Builder 6 and C18 languages. The last one is a special version of the C language for programming microcontrollers of PIC18 series. This software comprises of autonomous modules united by joint-manager and general data files. Such a structure of package provides a complete separation of functions between the modules which is convenient for editing and replacement of individual modules. The program modules are running under Windows XP operating system and management of this system as a whole is possible due to Windows Server 2003 specialized software on the server. Up to 1GB of data can be transferred on one workplace per shift depending on number of connected channels, time of measurement and sampling frequency. Multiplayer mode is achieved by using several parallel processes with full synchronization of all client stations and server. Parallel processing of multiple information streams provided real-time data controlling and viewing with their following storage on a hard disk.

3. CONCLUSIONS

The data acquisition system for Uragan-2M allowed to increase data collection, accuracy and reliability of the experiment. Using the parallel processes with full synchronization of all customers reduces the time necessary for data collection and also ensures the objectivity and reliability of the performed measurements. Implementation of this system into practice of physical experiments on the Uragan-2M provided technical possibility to gain remote access to equipment located at a certain safe distance from the researcher providing protection from high electric, magnetic and RF fields. Minimization of distortion of transmitted signals became possible due to reducing the distance between the signal source and conversion devices by integrating low-cost microcontrollers into the system.

REFERENCES

1. G.B. Igonkina, I.Yu. Koutcherenko, D.N. Nurov, M.M. Sokolov. New system for tokamak T-10 experimental data acquisition, data handling and remote access // *Plasma and Fusion Science: 17th IAEA Technical Meeting on Research Using Small Fusion Devices*./ AIP Conf. Proc. April 7, 2008, v. 996, p. 269.
2. L. Bertalot, B. Esposito, Yu.A. Kaschuck, D.V. Portnov. A diagnostic system for neutron and gamma-ray spectrometry on FTU tokamak// www.fpl.gpi.ru/Zvenigorod/XXVI/magud.htm.
3. K.I. Baystrukov, Y.N. Golobokov, S.V. Merkulov, et al. Control And Data Acquisition System Of Tokamak KTM// *Plasma and Fusion Science: 17th IAEA Technical Meeting on Research Using Small Fusion Devices* / AIP Conference Proceedings. 2008, v. 996, p. 297-306.
4. V. Butkevich, V. Nevzorov. L-CARD poducts: domestic cards ADC/DAC with signal processor// *Electronics NTB.* 1999, p. 3, p. 32-33.
5. Myke Predko. *PICmicro Microcontroller Pocket Reference.* McGraw-Hill, 2000.
6. S.P. Gubarev, E.B. Ermakov, G.G. Lesnyakov, et al. Measuring-controlling complex for investigating the magnetic surfaces of torsatron "Uragan-2M"// *Problems of Atomic Science and Technology. Series "Plasma Physics" (15).* 2009, N 1, p. 177-179.

Article received 25.10.10

СИСТЕМА СБОРА ЭКСПЕРИМЕНТАЛЬНЫХ ДАННЫХ НА УСТАНОВКЕ УРАГАН – 2М

С.П. Губарев, Г.П. Опалева, В.С. Таран, М.И. Золототрубова

Рассматривается созданная в Институте физики плазмы ННЦ ХФТИ система автоматизированного сбора диагностической информации, отображающая параметры высокотемпературной плазмы в реальном масштабе времени на экспериментальной физической установке Ураган-2М. Эта система обеспечивает синхронное многоканальное высокоскоростное измерение электрических сигналов, поступающих от датчиков установки и диагностического оборудования, сбор и графическое отображение информации, архивирование ее на сервере и в электронном хранилище данных, что предоставляет пользователям возможность доступа к файлам с зарегистрированной диагностической информацией.

СИСТЕМА ЗБОРУ ЕКСПЕРИМЕНТАЛЬНИХ ДАНИХ НА УСТАНОВЦІ УРАГАН – 2М

С.П. Губарєв, Г.П. Опалєва, В.С. Таран, М.І. Золототрубова

Розглядається створена в Інституті фізики плазми ННЦ ХФТІ система автоматизованого збору діагностичної інформації, що відображає параметри високотемпературної плазми в реальному масштабі часу на експериментальній фізичній установці Ураган-2М. Ця система забезпечує синхронне багатоканальне високошвидкісне вимірювання електричних сигналів, що надходять від датчиків установки та діагностичного устаткування, збір і графічне відображення інформації, архівування її на сервері і в електронному сховищі даних, що надає користувачам можливість доступу до файлів із зареєстрованою діагностичною інформацією.