MICROPROCESSOR BASED HARDWARE-SOFTWARE COMPLEX FOR INVESTIGATING THE MAGNETIC SURFACES OF TORSATRON URAGAN-2M

S.P. Gubarev, G.G. Lesnyakov, G.P. Opaleva, A.N. Shapoval, V.S.Taran, M.I. Zolototrubova

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

This paper describes the microprocessor hardware and software complex designed to control the fluorescent rod scanning in the poloidal cross section of vacuum toroidal chamber in order to study the structure of magnetic surfacesin the torsatron "URAGAN-2M."

PACS: 52.55.Hc; 52.55.-s; 07.05.-t; 02.70.-c; 07.05.Pb; 52.70.Ds; 52.20.Dq; 06.60.Sx; 06.30.Bp; 07.05.Pj

INTRODUCTION

One of the methods of studying the structure of closed magnetic surfaces in stellarators / torsatrons is a method of scanning fluorescent rod [1-6]. This method has been used to study the torsatron with additional toroidal magnetic field of torsatron URAGAN-2M [4-7].

The experimental session in 2008 of the automation of this method was developed on hardware-software complex described in the article [7]. The hardware of the complex has been implemented on a personal computer and a special module L-783 by L-card. Software of the complex was written in the language Borland C++ Builder 6. To solve the problem of creation the stellarator-mirror magnetic system by switching off one toroidal coil in the torsatron URAGAN-2M described in [8, 9] it was need to conduct a new series of experiments to measure the magnetic surfaces. To perform this work a new safe, protected from the noise, portable device based on microcontroller, which completely replaced the personal computer and an expensive unit L-783 was created. The new complex has been successfully applied in a series of experiments in 2012.

This paper describes a new hardware-software control complex of the rod scanning motion in the chamber (Fig. 1) and presents some results of measuring (Fig. 2, Fig. 3) of the magnetic surfaces in the torsatron URAGAN-2M.

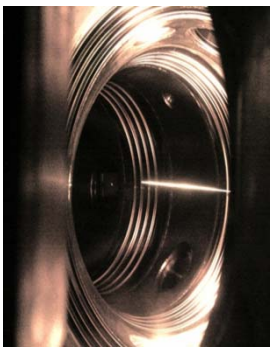

Fig. 1. Fluorescent rod in the URAGAN-2M chamber

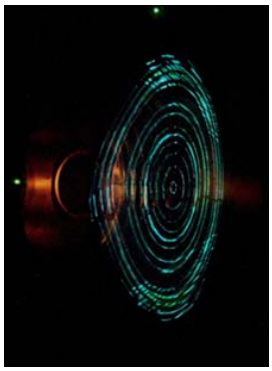

Fig. 2. The structure of the closed magnetic surfaces in the "Uragan-2M": mode Kφ=0.295; Bo=0.1 T; $<B_\perp/Bo>\approx$1.8% (the current in the solenoids corrective vertical magnetic field $I_{corr}\approx$175 A); the average radius of the last magnetic surface $\overline{a}$ ≈16.6 cm displacement of the magnetic axis from the geometrical axis of the torus $\Delta_{axis}\approx$-4.7 cm (the axis is located on the inner half of the torus). Two separate bright dots in the figure indicate the position of reference light-emitting diodes. Lateral reference LED is located on the inner half of the torus in the equatorial plane

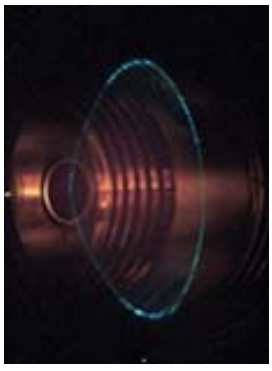

Fig. 3. Example of defining the last closed magnetic surface measurements on the hurricane-2M torsatron: mode Kφ=0.295; Bo=0.1 T; $<B_\perp/Bo>\approx$1.5% ($I_{corr}\approx$100 A); average radius $\overline{a}$ ≈17.3 см; $\Delta_{axis}\approx$-5.9

Newly developed control-measuring complex consists of 2 parts-hardware and software. The hardware is implemented on the basis of the complex integral

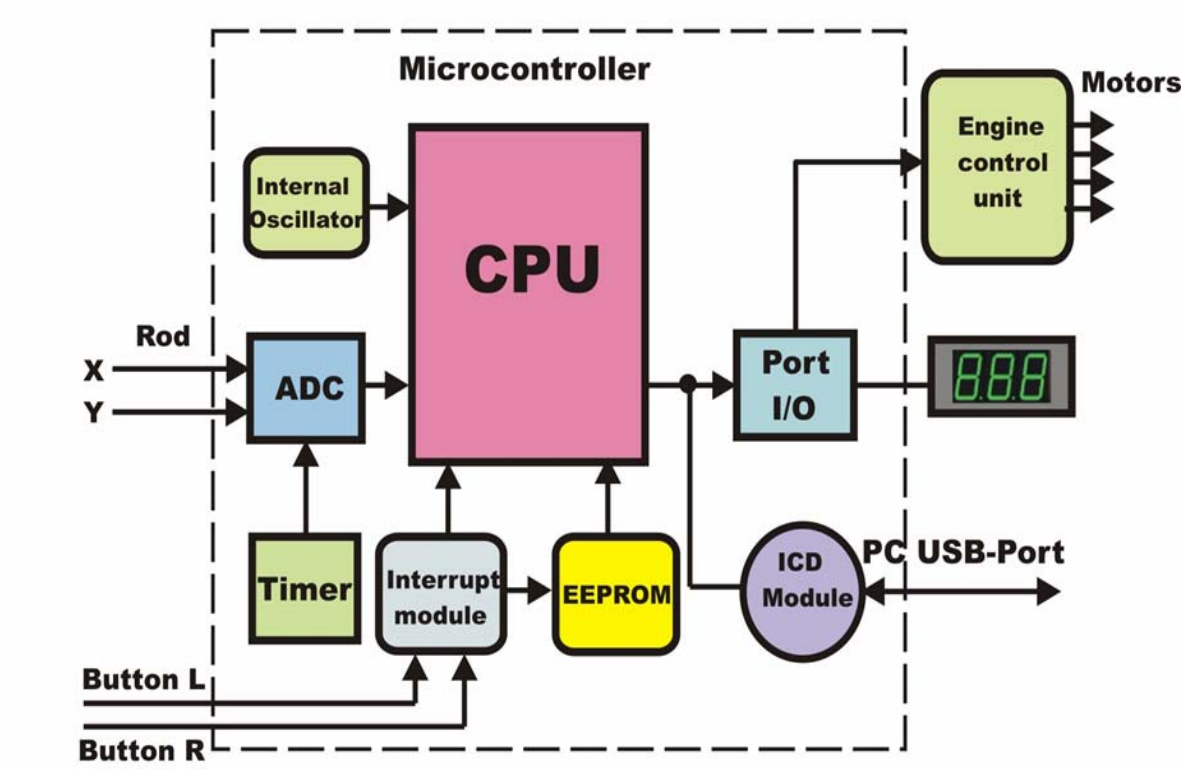

Fig. 4.Structural block scheme

PIC18F2620 microcontroller manufactured by Microchip Technology Inc., which is a market leader in the class of 8-bit microcontrollers with RISK architecture. Block scheme of the complex is shown in Fig. 4. PIC18F2620 is an integrated circuit that combines high performance 8-bit microprocessor, the various memory modules, timer modules, internal and external clocking, analog and digital input-output ports, communication ports, interrupting and comparing modules, PWM modules, diagnostics and power management, energy consumption, etc.[4-7].

Device includes microcontroller, a communication device with the object, the control device, LCD display and developed software, which is loaded into the electronic memory of the microcontroller.

The controller provides the choice of scanning chamber modes, receiving and converting analog signals from the sensors of the fluorescent rod, controlling motor signals of the rod according to the programmed algorithm for each of the selected scanning modes.

The results of measurements, the state of nodes, mode indication are shown on the LCD display.

All software modules are created in the environment of development MPLAB IDE in a specialized language C18, designed for the programming microcontrollers of the 18-th series. The program provides the opportunity to choose one of 3 modes of scanning chamber in torsatron URAGAN-2M. (Fig. 5).During performing each mode the end of the rod is moving along different trajectories and scans various regions of the chamber. The trajectories of the rod movement for each mode are given by X and Y coordinates sets, every set is written in nonvolatile memory EEPROM of microcontroller PIC18F2620.

Fig. 5. Selection of scanning mode

For the safety of the experiment in the program there is a possibility to stop the rod movement by pressing the button, further action can either continue performance of the previous mode or exit to main menu (Fig. 6) .

Fig. 6. Selection of next action

CONCLUSIONS

This paper presents a low-cost and compact solution for the automated measurement of the magnetic surfaces in the stellarator URAGAN-2M. This measuring system would greatly facilitate the experiment in real time, as well as improve the reliability and validity of the measurement of the magnetic surfaces

REFERENCES

1. H. Hailer, J. Massig, F. Schuler et al. // *Contributed Papers of 14 EPS Conf. on Contr. Fusion and Plasma Phys*., Madrid.1987, v.11 D, part. I, p. 423-426.
2. V.E. Bykov, V.S. Voitsenya, E.D. Volkov, et al. *Study of the modified Uragan-3M torsatron magnetic configuration*. // *Vopr. Atomn. Nauki i Tekhn., Ser. "Termoyad. Sintez"*. 1990, **№**3, p.12 – 31(in Russian).
3. G.G. Lesnyakov, E.D. Volkov, A.V. Georgievskij, et al. *// Nuclear Fusion*. 1992, v. 32, p. 2157-2176.
4. G.G. Lesnyakov, D.P. Pogozhev, Yu.K. Kuznetsov et al. // *Contributed Papers of 23rd EPS Conf. on Contr. Fusion and Plasma Phys*., Kiev, 1996, v. 20C, part. II (b025), p. 547-550.
5. A.A. Beletskii, V.L. Berezhnyj, P.Ya. Burchenko, et al. // *Problems of Atomic Science and Technology*. 2008, № 6 (58). *Series «Plasma Physics»* (14), p. 13-15.
6. V. I. Tereshin, A. A. Beletskii, V. L. Berezhnyj, et al. // *35th EPS Conference on Plasma Phys. Hersonissos,* 9-13 June 2008. ECA, v. 32, p-1.061 (2008).
7. S.P. Gubarev, E.B. Ermakov, G.G. Lesnyakov et al. // *Problems of Atomic Science and Technology. Series «Plasma Physics»* (15), 2009, № 1 (59), p. 177-179.
8. V.E. Moiseenko, K. Noack, O. Ågren "Stellarator-mirror based fusion driven fission reactor" *// J Fusion Energy*. 2010, 29, p. 65–69.
9. V.G. Kotenko, V.E. Moiseenko. Influence of the value of a single magnetic field ripple on the torsatron magnetic surfaces *// VANT. "Termoyad. Sintez"*. 2011, **№** 3, p. 74-80 (in Russian).
10. http://microchip.com.

Article received 10.10.12

АППАРАТНО-ПРОГРАММНЫЙ МИКРОПРОЦЕССОРНЫЙ КОМПЛЕКС ДЛЯ ИССЛЕДОВАНИЯ МАГНИТНЫХ ПОВЕРХНОСТЕЙ В ТОРСАТРОНЕ УРАГАН-2М

С.П. Губарев, Г.Г. Лесняков, Г.П. Опалева, А.Н. Шаповал, В.С. Таран, М.И. Золототрубова

Описывается разработанный в Институте физики плазмы ННЦ ХФТИ аппаратно-программный комплекс, предназначенный для управления люминесцентным стержнем при сканировании в полоидальном сечении вакуумной тороидальной камеры с целью изучения структуры магнитных поверхностей в торсатроне Ураган-2М. Аппаратная часть комплекса построена на базе микроконтроллера PIC18F2620 Microchip Technology Inc. Контроллер обеспечивает выбор режимов сканирования камеры, прием и преобразование аналоговых сигналов от датчиков положения флуоресцентного стержня, управление двигателями привода стержня в соответствии с запрограммированным алгоритмом для каждого из выбранных режимов сканирования. Программное обеспечение создано и отлажено в среде разработки MPLAB IDE на специализированном языке C18, предназначенном для программирования микроконтроллеров 18-й серии Microchip Technology Inc.

АПАРАТНО-ПРОГРАМНИЙ МІКРОПРОЦЕСОРНИЙ КОМПЛЕКС ДЛЯ ДОСЛІДЖЕННЯ МАГНІТНИХ ПОВЕРХОНЬ В ТОРСАТРОНІ УРАГАН-2М

С.П. Губарєв, Г.Г. Лєсняков, Г.П. Опалєва, А.Н. Шаповал, В.С. Таран, М.І. Золототрубова

Описується розроблений в Інституті фізики плазми ННЦ ХФТІ апаратно-програмний мікропроцесорний комплекс, призначений для управління люмінесцентним стрижнем при скануванні в полоідальному перетині вакуумної тороїдальної камери з метою вивчення структури магнітних поверхонь у торсатроні Ураган-2М. Апаратна частина комплексу побудована на базі мікроконтролера PIC18F2620 Microchip Technology Inc. Контролер забезпечує вибір режимів сканування камери, прийом і перетворення аналогових сигналів від датчиків положення флуоресцентного стрижня, управління двигунами приводу стрижня згідно із запрограмованим алгоритмом для кожного з обраних режимів сканування. Програмне забезпечення створено та налагоджено в середовищі розробки MPLAB IDE спеціалізованою мовою C18, призначеною для програмування мікроконтролерів 18-ї серії Microchip Technology Inc.