MEASURING - CONTROLLING COMPLEX FOR INVESTIGATING THE MAGNETIC SURFACES OF THE URAGAN-2M TORSATRON

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Created hardware - software complex, intended for scan controlling with luminescent rod of magnetic surfaces in the poloidal cross-section of the torus (in the toroidal vacuum chamber), and investigating the structure of these surfaces in the URAGAN-2M torsatron are described.

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INTRODUCTION

For the study of the closed magnetic surfaces structure in the URAGAN-2M torsatron (U-2M) [1] an automated system was created, providing autocontrol of the movement of a luminescent rod and as the result – the measurements of the closed magnetic surfaces was carried out. Measuring-controlling complex has allowed using modern, demonstrative method of scanning luminescent rod [2-4], which passed the approbation on the URAGAN-3M torsatron [3, 4] earlier and has been already used on the U-2M torsatron [1]. In persisting investigations of the vacuum structure of elliptical form of the magnetic surfaces a remote control of a rod movement was realized by means of computer and L-783 special module of the company L-card connected to computer and an executed complex software on the base of the object-oriented programming C++Builder 6.

METHOD AND PERFORMING THE MEASUREMENTS OF THE MAGNETIC SURFACES

Coated by a saturated solution of luminophore, grounded a stainless steel rod with a diameter of 2 mm, (Fig.1, pos. 4) was consolidated on a movable rod with linear gear in device of the movement and was placed in the poloidal cross-section of the toroidal vacuum chamber of U-2M (Fig.1, pos.3 and Fig.2), between solenoids of the toroidal magnetic field. For full scanning with a rod (Fig.1, pos.4) of the elliptical cross-section of a vertically located magnetic surface in the regimes of the magnetic configurations with different vertical magnetic field a rod must execute some complex two-dimensional movement (scanning) - angular (azimuthal) travel with simultaneous movement along the major radius R of the torus, see Fig.1. Methodically, when the diameter of the vacuum chamber equals of 0.68 m and the length of a rod is of 0.44 m, the movement program of the rod was built so that the main part of it movement formed the angular scanning. For execution of such movement in toroidal vacuum chamber with a high vacuum the complex mechanical in-plane displacement device was created (the drawing RS.1003 AD, Institute of Plasma Physics, NSC KIPT) with two micro electric motors - the UAM-74 motor (the alternating voltage is 127 V, the power is 30 W) with the reductor of the RM-09 motor and the RM-09 motor (the alternating voltage - 127 V, the power – 10 W), and two potentiometers for determination of the location coordinates of the rod (the operation voltage is 5 V). This device can be seen on Fig.3. Movement of the rod was held by means of the program, installed on computer, which could switch contact pairs – closed electrical feed circuit by reed relay in power supply unit of micro motor and controlled movement of the rod. The scheme of scaling the sizes on an image consisted of 2 LEDs (Fig.1, pos.5) with the distance between them of 414 mm.

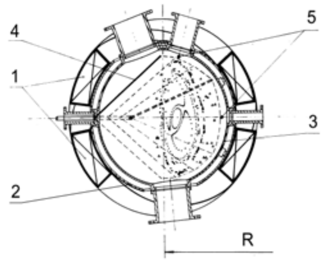

Fig. 1. The poloidal cross-section of the U-2M torsatron and the cross-section of one of variants of calculated magnetic surfaces of the regime of magnetic configuration in the place of carrying out of the magnetic surface measurements: 1 - two half poles of helical winding; 2 - toroidal carrying skeleton, on which the helical winding is put; 3 - the toroidal vacuum chamber; 4 – the scanning rod coated luminophore; 5 - two LEDs, which define the scale of the measurements

The LEDs were installed in the centre of ports on the minor radius of the vacuum chamber in the cross-section of the measurements on internal half of torus. The luminescence of the rod under bunch of electrons visualized the magnetic surfaces and traced separate turns of the bunch. Each magnetic surface was recorded with a CCD camera on one image, unlike the same thing by means of Polaroid. The image with good scene of the magnetic surface was got every time, when rod scanned the cross-section of the vacuum chamber from top to bottom. Scanning time for cross-section measurement was within 92…120 s. It depended on positions of the magnetic axis along R for a chosen regime of magnetic configuration measurement. The capture images of the magnetic surfaces were registered under changing the radial positions of the e-gun, in 10-24 points along minor radius. The superimposing the magnetic surface images recorded at the different minor radii on one drawing has allowed to get the structure of the nested magnetic surfaces.

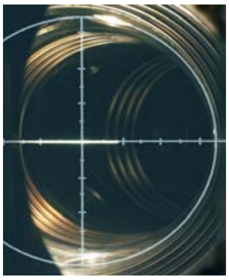

Fig. 2. Photography of a scanning rod and internal wall of the toroidal vacuum chamber in the measurement cross-section, executed through a glass window of the tangential port

Fig. 3. The movement device of a luminescent rod

THE PROGRAM CONTROLLING MOVEMENT OF A ROD

The composition of a hardware part of the complex (Fig. 4) was selected, coming from requirements of the task. Controlling movement of the rod was realized by means of computer, equipped by L -783 module of the company L-CARD. The module L-783 is intended for building multichannel measuring systems, collecting analog data, as well as digital control and checking the condition of external devices. Conceptually L-783 is faster PCI Bus Master Module, which has got the new functional possibilities. The base functions of L-783 are: multichannel analog-to-digital converter (ADC) with multiplexing channels; digital asynchronous entering-output and synchronous entering. Multichannel 14 bit ADC of module L-783 allows the work with 16 differential or 32 channels with the general ground connection. Each of analog channels is connected to ADC through software operated attenuator, allowing assign one of eight the measurement ranges of the voltage. The Module L-783 provides the unceasing collection of analog data given on sampling rate ADC from 0.005 Hz to 2857 kHz. Presence of the special input of synchronizing allows to hardware synchronization moments of the starting ADC with the help of hardware.

Digital entering-output is presented as 16 input and 16 output digital (transistor-transistor logic) TTL - compatible lines. The digital findings, as to user's will, can be transmitted to the third condition. Dual-link 12 bit digital-to-analog converter (DAC) allows supplying with the constant voltage of two independent channels.

So the program, controlling motion of a rod, works, both with digital, and analog channels. The digital channels were used for switching the direction of the rod movement (upwards, downwards, inward and outward). But analog channels measured the voltage while moving rod.

The program, controlling motion of a rod written on base of the system of object-oriented programming C++ Builder 6, works in Windows XP and executes 2 main functions:

1) calibrating, under which the factors are defined, used for controlling movement of the rod by UAM-74 and RM-09 micro motors (Fig. 5);

2) scanning the poloidal cross-section of the toroidal vacuum chamber of the U-2M torsatron is produced on chosen paths (one of three), to provide processing of greatly available area of the cross-section of the chamber.

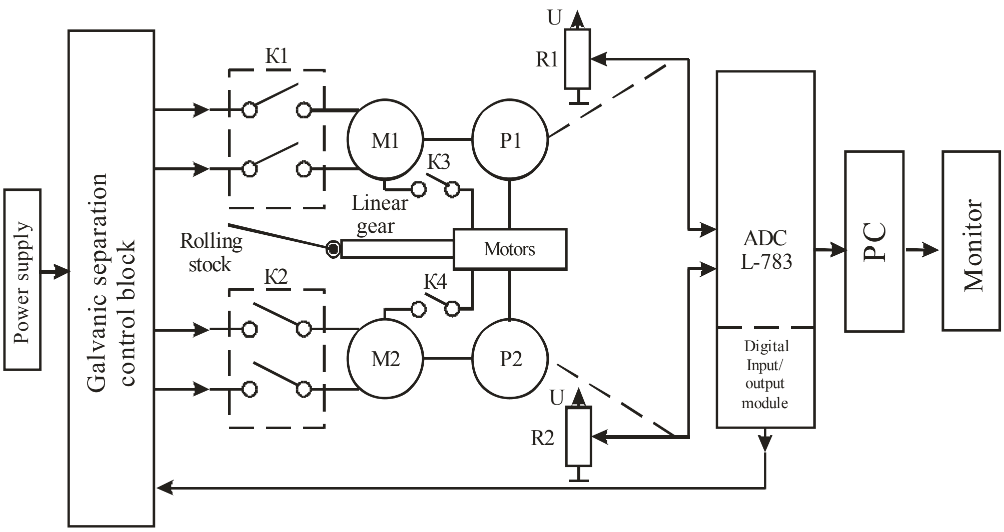

Fig. 4. Complex hardware scheme: K1, K2 – airtight contacts; K3, K4 – limit switches; R1, R2 - potentiometers; M1, M2 – micro motors; P1, P2 – reductors; U – voltage reference

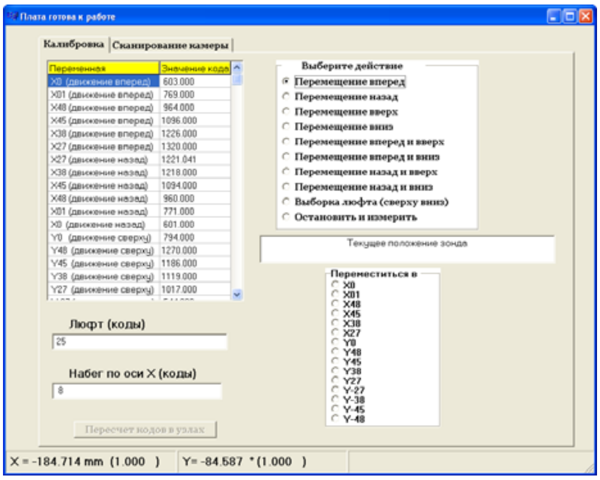

Fig. 5. Window of the calibration subprogram

Window of the scanning subprogram has the options: scanning mode; start coordinates of the rod tip; scanning mode come to the end; time of the scanning.

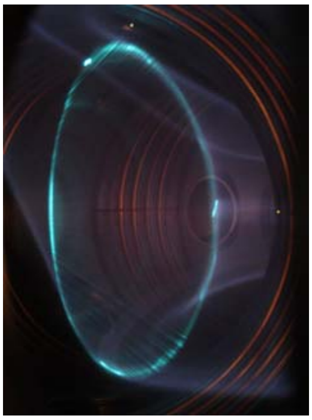

Fig. 6

The given program uses the subroutines, falling into staff software, delivered in the kit with a board L-783 of the company L-CARD. These subroutines realize controlling multichannel ADC with multiplexing channels and transmitting the data to digital of the board L-783.

CONCLUSIONS

The presented measuring complex has allowed much to relieve the experiment in the mode of real time, to conduct it in the mode of remote access, as well as raise reliability and validity of the results of measuring the magnetic surfaces.

As result, one can see in Fig.6 an example of the measurement of the closed magnetic surface, which has average minor radius 0.2 m (the regime of the magnetic configuration in U-2M has the operation parameter $K\varphi$=0.31 [1]; the shift of the magnetic axis inward from the circular minor axis of the torus is 5.7 cm).

REFERENCES

1. 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. 20 C, Part II (b025), p. 547-550.
2. 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.
3. V.E. Bykov, V.S. Voitsenya, E.D. Volkov et al. Study of the modified Uragan-3M torsatron magnetic configuration//*Vopr. Atom. Nauki i Tekh., Ser. "Termoyad. Sintez"*. 1990, N 3, p.12 (in Russian).
4. G.G. Lesnyakov, E.D. Volkov, A.V. Georgievskij et al// *Nuclear Fusion*. 1992, v. 32, p. 2157-2176.

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ИЗМЕРИТЕЛЬНО-УПРАВЛЯЮЩИЙ КОМПЛЕКС ДЛЯ ИССЛЕДОВАНИЯ МАГНИТНЫХ ПОВЕРХНОСТЕЙ НА ТОРСАТРОНЕ "УРАГАН-2М"

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Описывается созданный аппаратно-программный комплекс, предназначенный для управления сканированием люминесцентным стержнем магнитных поверхностей в полоидальном сечении тора (в тороидальной вакуумной камере) и исследования структуры этих поверхностей в торсатроне "Ураган-2М".

ВИМІРЮВАЛЬНО-КЕРУЮЧИЙ КОМПЛЕКС ДЛЯ ДОСЛІДЖЕННЯ МАГНІТНИХ ПОВЕРХОНЬ НА ТОРСАТРОНІ "УРАГАН-2М"

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Розглядається створений апаратно-програмний комплекс, який був застосований для керування скануванням люмінесцентним стрижнем магнітних поверхонь в полоідальному перетині тора (в тороїдальній вакуумній камері) і дослідження структури цих поверхонь в торсатроні "Ураган-2М".