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Data Acquisition and Control in a User-Mode Real-Time System for Electrochemical Equipment Automation

The paper considers the characteristics of the user mode real-time system that was implemented in a series of programs for electrochemical equipment automation. This simple real-time system uses efficiently the potential of ISA-bus data acquisition and control boards and conciliates the requirements of time-critical and slow stages in time resources in the computerized electrochemical experiment.

INTRODUCTION

There are fairly different situations in the automation that contrast in the relation of the main object of the automation with other tasks controlled in the system. A great number of the automated processes require both real-time support and accurate coordination of various simultaneously running tasks. That is the case for using Windows NT with real-time extensions [1]. There is also quite a few applications of the automation that require real-time control with moderate demands to the multitasking characteristics of the operating system. A typical example of the latter is the majority of the computer-controlled equipment in a chemical or physical research and educational laboratory. Windows 95 (98) is a sufficient solution in the case of a single instrument control, provided that a user program employs properly implicit real-time control capacities of this operating system.

USER-MODE-REAL-TIME SYSTEMS

Windows 9X is not a real-time operating system, however, it can grant the user program a power to control major time resources in the computer. In the case of a single real-time task the real-time control provided in the user mode may be a better solution then the employment of the operating system that controls time resources itself, because of the elimination of a lot of time-consuming steps. Though a limited number of functions can be implemented in the real-time system created in the user mode, this approach is sufficient to fulfil usual tasks of data acquisition and control in the laboratory equipment automation.

In this communication we consider the characteristics of the user mode real-time system that was implemented in a series of programs for electrochemical equipment automation. Electrochemistry has modest requirements to the speed of data acquisition and control, usually limited to the support of sound frequency range, but the program must be flexible enough to provide various combinations of data acquisition, processing and control, in order to meet the requirements of new fields of electrochemistry such as

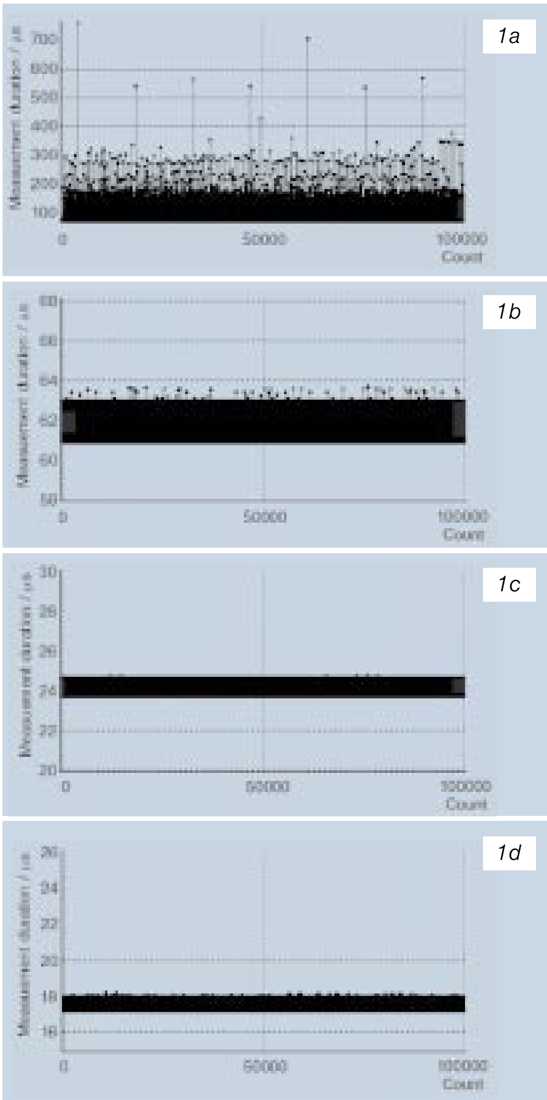

Figure 1. Fluctuations of the measurement duration using (a)-(c) CIO-DAS08/Jr-AO and (d) ADC100K12-8 boards.
(a) Universal Library in a usual mode in Windows;
(b) Universal Library in the real-time mode;
(c), (d) low-level data acquisition optimized for Intel Pentium in the real-time mode.

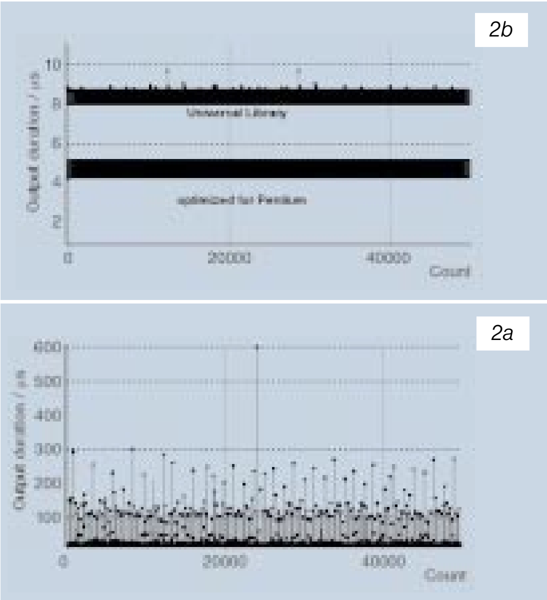

Figure 2. Fluctuations of the output duration on CIO-DAS08/Jr-AO
(a) Universal Library in a usual mode in Windows;
(b) Universal Library and low-level control (optimized for Pentium) in the real-time mode.

the electrochemistry of nanostructures.

Figs. 1 (a-c) show the results of the tests of the time required for data acquisition with an ISA-bus board CIO-DAS08/Jr-AO (Computerboards) using (a) the Universal Library of Combuterbords, (b) the Universal Library applied in the real-time system created in the user mode in Windows, (c) low-level data acquisition optimized for Intel Pentium in the same real-time system. Fig. 1(d) shows the results obtained in the same conditions as in Fig.1(c) for another ISA-board (ADC100K12-8, Spetcpribor) that has an approx. twice shorter analog-to-digital conversion time. The measurement duration in Fig.1 comprises of the time required for data acquisition with a time coordinate for every point. High-resolution performance counter was used with Universal Library in the mode with Windows control of time resources, while the Intel Pentium specific time stamp counter [2] was applied in the measurements using real-time mode. In the conditions of the experiment the duration of the ADC stage in data acquisition was 18 ms for CIO-DAS08/Jr-AO and 8 ms for ADC100K12-8. The tests were run using Intel Pentium 100 MHz processor with 32 Mb RAM (that is a minimal sufficient computer configuration for the efficient usage of the ISA-bus boards). Fig. 2 shows the similar set of tests for the control function (analog output) of CIO-DAS08/Jr-AO board.

CONCLUSIONS

Several conclusions may be drawn from Figs. 1 and 2. First, the user mode real-time system realizes the potential of ISA-bus data acquisition and control boards. The fluctuation band shown in Figs. 1(c) and 1(d) is almost independent on the ADC time of the boards. Reading of data requires multiple addressing to the board using a bus that is much slower than the processor, which results in the fluctuation bandwidth of approx. 1 ms. Low-level optimization of data acquisition for Pentium results in more then a twofold reduction in the measurement duration and its fluctuation bandwidth compared to the Universal Library, though data acquisition with the Universal Library also shows quite good stability in the real-time mode. The similar tendency was observed for the output duration (Fig.2).

The actual time resolution of the automated equipment combines I/O duration with the time required for the real-time part of data analysis and also depends on the speed of the equipment. Fig.3 shows an exam-

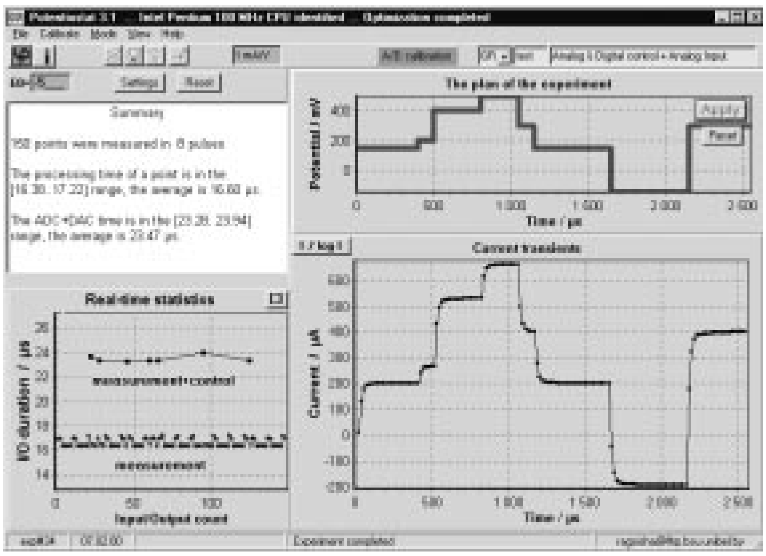

Figure 3. Potentiostat program in the pulse potentiostatic mode.

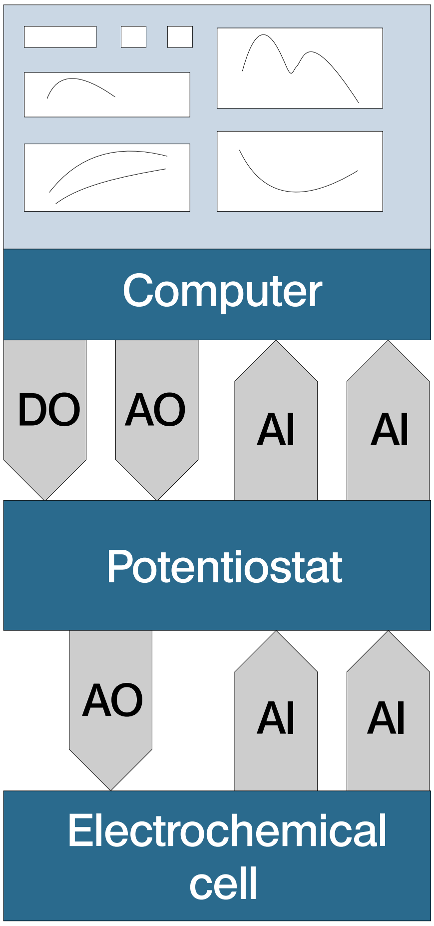

Figure 4. Schematic diagram of the electrochemicalcomplex.

ple of the application of the user mode real-time system in the electrochemical equipment automation. The schematic diagram of the electrochemical complex is shown in Fig. 4. A potentiostat (the instrument for investigation of the electrochemical processes by measuring the current in the electrochemical cell at the electrode potential controlled versus the reference electrode) is driven by a computer through analog and digital interfaces. The real-time subsystem of the Potentiostat program communicates with the equipment using the analog channels, while slower electromechanical switches are controlled through a digital interface in a usual Windows mode. A screenshot in Fig.3 illustrates the behaviour of the Potentiostat program in the pulse potentiostatic mode. The program supports also potentiodynamic, galvanostatic, galvanodynamic modes and a set of special techniques for investigation of the nonequilibrium systems. The application of the user mode real-time system provides flexibility of the equipment control in all those modes due to a combination of a fast data acquisition and control that is non-perturbed by Windows with the advantages of Windows API. The switching between real-time and Windows control mode usually takes few microseconds, therefore a simple structuring of the program with a separation of time-critical and slow stages conciliates their requirements to the operation mode ■

I graduated from the Chemistry Department of Belarusian State University in 1978. My doctoral thesis (1982) was on the photochemical information recording on thin film semiconductor heterostructures. In the 80's I published a series of papers, a book and got 6 authors certificates (patents) of the USSR on the photochemical information recording. In the 90's the nonlinear phenomena in chemical systems and electrochemistry of nanostructures became my main scientific interests. The results of my work in those fields were published in numerous scientific papers and presented on various international scientific conferences, including the Joint Electrochemical Societies meeting in Paris (1997), the Electrochemical Society meeting in Miami (1994), Micro- and Nanoengineering conference in Davos (1994), etc.
There were several motivations to combine this work with computer programming. First, my chemical research was always connected with the information recording, processing and computer modeling of chemical phenomena. Second, the available computerized systems for chemical experiment did not always satisfy me in their functionality or were inappropriately expensive. The research work in the new fields of science usually requires more control of the experiment then it is provided by common equipment and programs.
I have been working in the Institute of Physico-chemical Problems since the graduation from the university with the exception of short periods of foreign fellowships. My official position is a Seniour Research Scientist. Besides, I read a course on the information technologies in chemistry for the undergraduates in Belarusian State University.

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1. Martin Timmerman. Real-Time Magazine. 1997, Quarter 2, 14.
2. Pentium Processor Family Developer's Manual. Volume 3: Architecture and Programming Manual. Intel Corporation. 1995.