THE PC BASED CONTROL AND DATA ACQUISITION SYSTEM OF LEPTA

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Abstract

The Low Energy Positron Toroidal Accumulator (LEPTA) is expected to provide experiments with an intense flux of positronium. The control and data acquisition system consists of PCs connected other to each and with the institute computers via an Ethernet network. They are grouped in accordance with the functions of the LEPTA equipment and the beam instrumentation. Device control and data acquisition are performed via CAMAC, GPIB and special designed microcontroller interfaces.

1 INTRODUCTION

The storage ring LEPTA [1] is composed of a cyclic system of solenoids surrounded by common magnetic shielding. The vacuum chamber of the ring is located inside the solenoids. The positron injector has its own magnetic and vacuum system and connects with the ring at the straight section.

LEPTA consists of the following general elements:

1) a septum solenoid dedicated to injection of the positron beam and superposition and separation of the beams in the horizontal plane. In the section inside the solenoid in the longitudinal field region the following devices are placed:

- two septum coils producing transverse magnetic fields and placed symmetrically below and under the equilibrium orbit,
- kicker coils for injection and extraction of the circulating positron beam,
- the gun of the electron cooling system;

2) two toroidal solenoids bend the beams by an angle of 180^0 – here the superposition and separation of the beams occur in the vertical plane;

3) an electron cooling section for the positrons, which includes also:

- pick-up stations of the diagnostic system,
- an RF cavity using for bunching of the positron beam,
- also to investigate the possibility of betatron acceleration of the particles we plan to install a betatron yoke in this section;

4) the electron collector, which is placed outside the magnetic shielding near the solenoid septum;

5) the injector of the low energy positrons including the beam instrumentation system at the entrance of the ring.

2 CONTROL SYSTEM CONFIGURATION

The control system of LEPTA is based to the compatible with IBM personal computers. With the development of the LEPTA complex the number of PCs will be increased. The choice of operating system is MS Windows 98. It easily allows multithread software applications. Also it has good enough network and access possibilities. The speed of the operating system is sufficient too, because LEPTA doesn’t require real-time control operations.

The main function of the control system is the acquisition and the storage of data from all signals, the comparison with preventative and alarms levels and the graphical presentation of general status and the history of selected signals. The PC provides the warning alerts if a signal value exceeds the alarm level. If nothing is done is switched OFF automatically. An algorithm of the alarm turn off LEPTA is prepared together with experimenters in details.

The control system has two main parts: hardware and software.

2.1 Hardware

The LEPTA control system is divided into two levels (Fig.1). The upper level consists of IBM compatible PCs. They communicate with each to other via a local area network. This net uses the Institute Ethernet cable communication. The lower level consists of engineering, experimental and test facilities, and also beam diagnostic instrumentation. At present the total number of signals to be controlled and monitored is about 200. The lower level is all the control subsystems with CAMAC hardware and special measurement equipment for the I/O data acquisition and control. CAMAC hardware can be connected to any computer with 1 MBaud serial links. There will be measurement equipment, which will be connected to PC’s with GPIB links.

There are about twenty signals, which should be measured precisely to have stable operation of LEPTA. This is especially true for current values of some magnet elements, for the electron beam energy and for kicker pulse amplitudes. Precision measurement with resolution 20 and 24 bits requires about 200 ms or more. To minimize the duration of measurement processes special measurement cards [2] with on-board microcontrollers have been designed. The AT90S2313 and AT90S4414 chips from Atmel provide local control of the AD7714 chips from Analog Devices, previous data analysis and communication with PCs.

To minimize the number of CAMAC crates for the measurement of several signals, which are under different high voltage potentials nearly identical measurement cards are used. Connection to PCs is performed via a high-voltage optical couple.

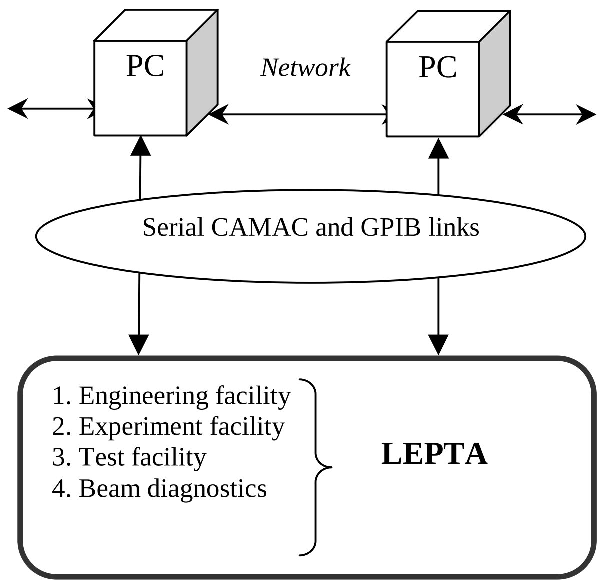

Figure 1: Hardware configuration.

2.2 Software

Software programs are written using C++ Builder. The control system software architecture is hierarchical with four functional layers: equipment control, accumulator devices, service and operator interface (Fig.2). Each of the four layers performs specific functions, with well-defined interfaces to the layers immediately above and below it. The software interface between layers is realised through procedure calls that may involve communication over local area networks. Standardised remote procedure call protocols are used between the software processes that operate on the different computers of the control system. An object-oriented approach is taken throughout the software development.

2.2.1 Equipment Control

There is only one equipment control layer which directly performs I/O to external devices and handles signals for events. All control and data acquisition transactions with LEPTA equipment takes place in this layer or in the equipment itself. The equipment control layer receives standardized messages from an accumulator device object (ADO) layer which contains commands and set points for the equipment or requests for data. The equipment control layer is responsible for translating a standard data representation in the control system to a suitable format for devices and device control modules. It performs the necessary conversions where analog control is required by equipment. For equipment with a digital interface, this layer is responsible for presenting data to the equipment in proper digital form.

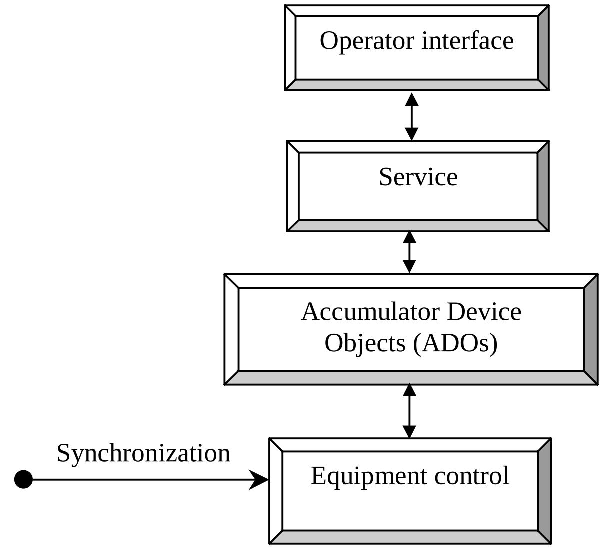

Figure 2: Software configuration.

2.2.2 Accumulator Devices Objects (ADO's)

The ADOs layer comprises a set of ADOs that provide an object-oriented image of the LEPTA equipment in the application environment. This image is independent of details of the equipment control layer or equipment itself. ADOs will be implemented as C++ classes that contain a software data structure and the full set of actions or methods that are needed to control and monitor the LEPTA devices. The application interface to the ADO consists of standardized I/O operations of *get*, *set* and so on. When the ADO layer responds to a request from the computer services layer, data is transformed and formatted as necessary. These operations may include sequenced state transitions, conversion to/from engineering or physics units and filtering of status information for equipment monitoring. The standard interface to the ADO layer is uniform for all subsystems. ADOs in the control system will be named correspondingly the LEPTA devices or subsystems.

2.2.3 Service

The functions provided by the Services layer include those usually provided by any interactive, networked computer system, plus special functions that are needed by control systems. Usual control system functions, which will be provided, include:

- communication protocol support,
- computer security,
- network management tools,

- remote login,
- network file systems,
- printer support.

The communication is based on Windows Socket and uses the TCP/IP protocol.

In addition to generic functions and custom applications programs, the following control system functions will be supported at this layer:

- data analysis and viewing,
- message support,
- relational database management,
- archiving and restoring of accelerator objects.

Data analysis process is performed under clear algorithms. That will guarantee stable operation of LEPTA. Analyzed data is viewed as graphical objects, which helps an operator to access the cause of an alarm case. For instance, if a parameter has a range of normal work and its value is inside this frame, the color of graphical object is green. In case the value is near an alarm border the color changes to yellow and if it is out the normal range – red.

Any action of an operator, which can lead the changing of any parameter, is accompanied by warning messages.

All data is recorded into a temporary buffer, which contains the last values of all signals, and into the temporary data archive, where all values of all parameters are saved for the last half hour. In the case of an alarm, an operator can recall the data from the temporary data archive to the data archive of alarm conditions. It helps to analyze the history of the alarm appearance to eliminate such situations in the future. The structure of archives is compatible with the structure of commercial relational databases. The mechanism of the data recording is illustrated in Fig.3.

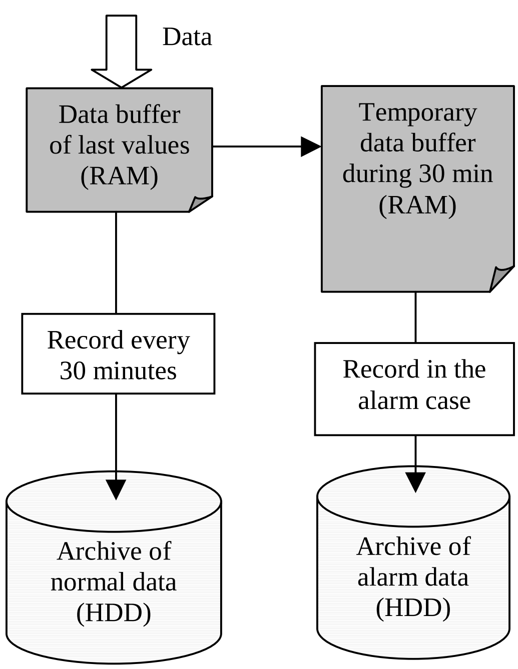

Figure 3: Mechanism of data recording.

2.2.4 *Operator Interface*

The user interface layer provides the man-machine interface for the control of LEPTA. It supports an interactive graphical user interface, as well as passive graphical and text displays and files for operation and analysis. This interface contains modern, user-friendly graphical input and output objects, such as pull-down and pop-up menus, menu bars, buttons, check lists, forms, text and graphical output, etc.

3 CONCLUSIONS

At present now the total number of measured and controlled signals of LEPTA is about 200. For operation of the implemented and ready to work equipment only two computers are used. Specially designed measurement boards with microcontrollers AT90S2313 and AT90S4414 from Atmel economise the PC's processor time and minimise the total number of CAMAC crates. The writing of software with a C++ Builder allowed a control system with a modern man-machine interface.

4 ACKNOWLEDGEMENTS

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5 REFERENCES

[1] I.Meshkov, et al., "Design and construction of LEPTA", to be published.
[2] Yu.Korotaev, "Measurement board based on the microcontroller", to be published.