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Control and Monitoring System Design Study for the UNK Experimental Setups

A. Ekimov, Yu. Ermolin, M. Matveev,
S. Ovcharov, V. Petrov, V. Vaniev.
Institute for High Energy Physics,
USSR 142284 Moscow region Protvino P.O.Box 35

Abstract

At present a number of experimental setups for the new UNK project are under construction. A common approach to the architecture of control/DAQ/trigger systems will be used in the development of electronics for all these detectors. The system analysis and design group has been formed for this purpose. The group activity is aimed at the development of such unified system. The group has started with control and monitoring system as one of the most important parts and the environment for the DAQ/trigger systems. The group activity status report is presented.

1. Introduction

The construction of several experimental setups is planned in the frame of the new UNK project at the Institute for High Energy Physics (Protvino) [1-4]. The size and complexity of these detectors is by an order of magnitude bigger as compared with those at the existing proton synchrotron. Table 1 shows the number of channels, event size and readout event rate for old and new (proposal) experiments.

TABLE 1

Exper.	Number of ch. $*10^3$	Event size (kbyte)	Event rate (Hz)
FODS-2	1	0.1	100
PROZA	1.5	0.5	250
SPHINX	25	1.5	100
VES	13	1	1000
NEPTUN	100	25-50	1000
GLUON	13	3	500
MPS	80	25-100	600
MMS	60	15-20	50-100

The general requirements to the electronics for the detectors have been formulated in the technical proposals. The electronics will be developed both at IHEP and at other institutes and organizations who take part in the detector preparation. The use of industry electronics is also foreseen. Such a distributed method of the development requires management and technical coordination when designing the electronics. A working group for the preliminary study of the design approaches and electronics architecture has been formed at IHEP.

2. Design Approach

At the beginning it was decided to choose the approach for the design of the electronics for different experimental setups, namely: to use specialized electronics designed for the specific experimental setups, or to use unified electronics adapted for a specific experimental setup. Both of them have well-known advantages and disadvantages. The choice is defined by the size and complexity of the detector, available funding and manpower, time schedule and so on. For the experimental setups at UNK it is possible to note the following points:

- experimental setups for the UNK are constructed practically at the same time,
- IHEP will participate in the design of the electronics for several (or all) experiments,
- the preliminary analysis of the electronics requirements for different experiments shows the existence of common functional elements.

With an account of the experience in using unified electronics for the experimental setups at the existing accelerator it seems reasonable to use the second approach for the electronics design at UNK.

As a second step the number of points to be studied at this preliminary stage have been defined with the aim to make some recommendation for the following investigations:

- standard modular unified architectures of the electronics for the experimental setups divided by the numbers of functional subsystems and levels with the definition of an unified interfaces,
- more detailed definition of this general architecture with the standard implementation of some parts of the system and possibilities of adapting these parts to the specific demands of the experimental setup,
- standard framework of the electronics development (tools, test setups management and so on),
- existing experience at IHEP in these areas.

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3. ARCHITECTURE

3.1 General

The discussion around the general architecture is based on the analysis of the technical proposals of the experimental setups and the outside experience in the field [5-8]. As a result it has been decided that all electronics can be split in several functionally independent parts, interacting during the operation:

- data acquisition system for the hierarchical data collection of the useful detector information,
- multi-level trigger system for the event rate reduction and useful event tagging,
- technological equipment of the experimental setup, such as high voltage, gas and power distribution, calibration and so on,
- control and monitoring system, which must provide supervision of all infrastructures of the experiment.

Such a separation with the definition of interfaces gives the possibilities of more or less further independent upgrading and modification of the electronics without redesigning the whole system.

The control and monitoring system of the experimental setup from this point of view is that frame where all the other functional subsystems are working. During the experiment run it should provide the status information and the remote access to all parts of the electronics. During the experiment preparation it may be used as a setup for the electronics debugging and testing. Due to this development of the control and monitoring system could be considered as a first step during the electronics design.

For better understanding of the control requirements for other parts of electronics some preliminary considerations of their structure and possible implementation have been made.

3.2 Data acquisition system

The architecture of the data acquisition system should allow us to easily scale and adapt to the experiment requirement, independent development of separate parts and further smooth upgrading. Natural parallelism of the event data and pipeline structure for high performance should be exploited. Proceeding from above supposition we propose to use three functional level data acquisition system:

- front end electronic,
- readout and event building,
- event processing and data storage.

The internal structure of subdetectors specialized front end electronics includes a number of basic components (analogue storage, converters, digital memory). The packing of the front end electronics depends on the technological possibilities at the moment of the system realization. At present we assume the crate implementation of the front end.

Possible implementation of the front end channels readout and event building electronics has several directions (shared bus, dual port memories, work on SCI). Dual port memory realization of the event building seems the most suitable for us due to the possibilities of realization and some experience we have. The hardware of this part of data acquisition is shared between front end and event processing crates connected by the cables.

Event processing will be done by the farm of commercial single board computers housed in the crates. Each node has input buffer, processor and output buffer, and processes all event data without passing them to other processors.

3.3 Multi-level trigger system

Event selection will be performed in three stages (or levels). Rough decision at the first level allow further conversion of the event data. A more precise second level decision tags the event for the readout. The third level performs full event processing (as a part of data acquisition).

Without going into details of different trigger processors implementation it is possible to note some control and monitoring requirements. In the case of analogue first level trigger processor implementation the control system should provide careful calibration and has no influence on the processor during the operation. For the second level processors (mostly digital), as for the data acquisition electronics, access to all internal registers for the test purpose seems essential.

3.4 Technological equipment

The general infrastructure of the experimental setup consists of several different technological subsystems. For the control and monitoring of such equipment specific electronics will be designed. It should give the possibilities for the access from the control system even in case of non-standard implementation.

4. CONTROL AND MONITORING SYSTEM

Following the above functional subsystems partitioning of the electronics, control and monitoring system may also be divided into the control nodes. The task for this control node is supervision of the allocated part of the electronics. It should provide the interface to the user of this subsystem and the interface to the whole system. Each of the nodes consists of three main parts:

- local computing power,
- interface to the controlled equipment,
- LAN between control nodes and the system.

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A local computer may be a personal computer or a single board computer, housed in a standard crate. It keeps all the information about allocated electronics (configuration, values of all parameters and so on). At present two possible implementations of such a local computer are under estimation: the AMS like crate with I8086 processor and VME crate with Motorola 68000 processor.

Interface to the equipment is defined by the implementation of the specific part of the electronics. Because of the lack of any final decision made about housing of different parts of the electronics, only some preliminary consideration may be fixed. We assume the crate implementation of the electronics. Inside the crate the control path may be physically separated from or joint with the data acquisition or trigger data path. Each crate for the control node is a station on the inter crate bus with the multi-register access and geographical addressing possibilities. The controlled crates are described by uniform table, accessible for the read/write operation.

For the communication between local nodes we plan to use commercial equipment like Ethernet or Token Ring.

Some experience of the development of such a separated control and monitoring system has gained during the development of the data acquisition and control system for the Big liquid ARgon Spectrometer (BARS) of the Tagged Neutrino Experiment (TNE) at IHEP. It consists of:

- I8086 based microcomputer housed in a CAMAC crate (analog of a control node), works under specialized operation system,
- interface to the controlled equipment, housed in a CAMAC crate, implemented as an auxiliary controller,
- star interconnection network to the main control computer (IBM PC).

The task for this control system is calibration of QDC cards, testing of digital modules and control of the data acquisition and triggers module during the experiment run. In a reduced configuration such a system is used for debugging and testing the electronics modules.

Several prototypes of special equipment for the user interface have been developed at IHEP.

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