The neutron monitor data acquisition system MARS-06 for cosmic ray stations

Evgeny Klepach *, **Valery Kartyshov** *, **Christos Sarlanis** †, **Alexander Shepetov** ‡
and Victor Yanke *

* *Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation RAS (IZMIRAN), Moscow, Russia*
†*Nuclear and Particle Physics Section, Physics Department, Athens University, Greece*
‡ *Tien-Shan Mountain Cosmic Ray Station, Almaty, Kazakhstan*

***Abstract*. The data acquisition system MARS06 is destined for recording the pulse intensity data of neutron monitor counters at the cosmic ray stations. The system in build on the basis of the industrial multi-purpose controller card** *Advantech PCI1780U* **which works in a simple scaling mode, where it possess a high operation speed. During the last years such systems have been installed at the cosmic ray stations in Almaty, Athens, Irkutsk, Magadan and Moscow, and also at the Antarctic station Mirny. The data registration may be held both under the Linux and Widows operation systems with an immediate dispatch of measurement results to the united database of the world-wide neutron monitor network (NMDB) in real time. The program package necessary for system installation may be down-loaded by ddress** *ftp://cr0.izmiran.rssi.ru/NMDB_doc/ RegistrationSystems_MARS/(PCI-1780)*.

***Keywords*: Neutron Monitor, Cosmic Ray Variations, Data Acquisition**

Fig. 1: The PCI-1780U card with its accessories.

I. INTRODUCTION

At present time, many firms, e.g. *Advantech, Adlink*, are manufacturing the digital multi-channel IO controller cards which may be used in I386-compatible computer system for automatic data acquisition at the cosmic ray stations. In creating of such measurement systems are met two different approaches. In the case, when together with a measurement of the signal intensity of cosmic ray detectors should be gained a more precise information, say, a distribution of the temporal lags between the signals must be studied [1], or some signal selection schemes should be realized [2], the experimental task presents a more strict demands both to the computer hardware, and to the complexity of the control program's algorithm. In the another, elementary case, a simple uninterruptable counting of the pulse detector signals is quite sufficient for the continuous monitoring of the intensity of cosmic rays. Such systems, which may be build on the base of the Advantech PCI-1780U or Adlink PCI-8554 type IO controller cards, have a good speed of operation (up to 20-50 MHz), because the count of input pulses is fully realized at the level of hardware card, without any use of the central processor's resources.
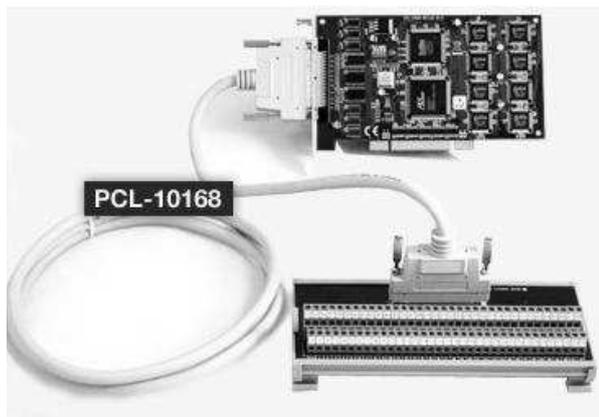
The subject of the present paper is the system for an automatic intensity monitoring of the pulse neutron counter signals, which is destined for using at the stations of the international cosmic ray network together with the neutron monitor installations of the type NM64, IGY, and the like. The system is build on the basis of the universal controller card PCI-1780U of Advantech production [3].

II. GENERAL DESCRIPTION OF THE HARDWARE

The PCI-1780U (see Fig 1) is a general purpose multi-channel counter/timer card with the PCI bus interface which uses the AM9513 programmable logic chip for implementation of its functions. The card provides eight 16-bit counter channels which feature 12 programmable counter modes, permitting to carry out the one shot and repeated pulse counting; the periodic interrupt output; the time-delay, the frequency, and the pulse width measurements. Together with PCI-1780U card it is recommended to use the PCL-10168 shielded cable for coupling of the input signals to its outer 68-pin connector. All the wires of the cable are twisted pairs, providing a minimal cross talk between signals and the best protection against the electromagnetic interferences.

When using the card for the counting of the pulse signals at a neutron monitor installation, the signals
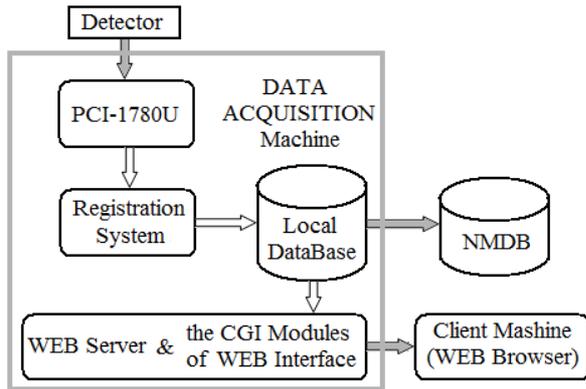
Fig. 2: The data flow chart of neutron monitor information. Hatched arrows correspond to a data exchange via the Internet.

from neutron detectors must be connected to the card's inputs $CLK0 - CLK7$ (pin numbers 1-7 of the 68-pin back-side connector). The neutron detector pulses must be previously shaped to have the TTL levels; the card can operate with digital pulses both of the positive and negative polarity. An analogue scheme designed at the Tien-Shan mountain station for the shaping of the output pulses of neutron-sensitive ionization counters used in neutron monitors is described in [4].

Each PCI-1780U card has 8 separate counter channels; in a single computer box may be placed simultaneously up to 16 cards (this amount is mostly limited by a number of the empty PCI slots in computer's motherboard). Hence, 2-3 cards are usually sufficient to build the data acquisition system for a typical neutron monitor installation with its 12-24 neutron detectors.

III. SOFTWARE TOOLS

A. Technical requirements

A specific feature of the considered system is, that the whole operation of the input signals succeeds exclusively by the internal electronics of the PCI-1780U card, and the computational capability of the control computer remains almost absolutely free from the task of primary data registration. This permits to build a complete information system (the registration program itself + the database for keeping the measurement results + the access means to the latter) with a possibility of a distant control via the Internet on the basis of the same machine, which fulfils the registration of neutron intensities. The latter circumstance is of a much importance because of the distant disposition of the many neutron monitor sites (mountains, sea bays, mobile installations etc) and the difficulties with the permanent presence of a qualified maintenance staff in a majority of such places.

A much interest in the last time is paid to the physics of the Sun-Earth connections, to the transient phenomena at the Sun and in the interplanetary space, to the forecast of radiation safety in the near-Earth envi-

ronment ("the cosmic weather"), and to other scientific problems, both fundamental and applied, which demand an immediate access to the data of the whole world-wide neutron monitor network. With this purpose, a united neutron monitor network database NMDB [5] is now under creation, where the data from the all monitor installations must be kept in a common format and with a temporal resolution sufficient for the mentioned tasks (not worse than 1 min). The system of data acquisition operating at a separate neutron monitor installation should be capable to regularly dispatch the results of its measurements to NMDB in automatic mode.

It is convenient to satisfy the above requirements when building the neutron monitor data acquisition complex on the basis of the Linux operational system. Advantages of this system are: (1) the possibility of a fully automatic start-up after turning on of the power supply and a high operation reliability, both of which practically does not demand the presence of a qualified personal for system exploitation; (2) the existence of a powerful networking subsystem, which permits to create the distributed, reliably operating network applications, necessary, in particular, for information exchange with a distant data center; (3) the availability for this system of the standard, well tested, free software for the tasks mentioned above: there exist the database server (in fact, just a number of them) to keep the measurement information, and the web server for organization of the access to these data, both locally and distantly.

B. Description of the program complex

A scheme of the information flows in the considered neutron monitor control system is presented in the figure Fig 2. The basic program components of this system are the following:

1. The registration program, which interacts immediately with the control registers of the PCI-1780U card and accomplishes a measurement process. The program synchronizes its operation with the computer's clock timer, and on expiry of the each current minute is selects the pulse numbers stored in the internal counters of PCI-1780U card, simultaneously resetting them and starting an exposition of the next minute. Besides, this program grants some means for control of the measurements: if necessary, it prints the current results on the computer's console, permits to start or stop registration process, to change the duration of exposition timeout etc. Also, the registration program keeps check of atmospheric pressure at the neutron monitor site location (by means of a digital barograph), which is necessary for analyzing of the neutron intensity data.

2. A local database, where the registration program puts the results of its operation: the date, time, and neutron pulse numbers for the each 1-min long time interval. In the current version of data acquisition system the local database is build on the basis of the free database server Postgres, the standard distribution of which is supplemented by a number of scripts necessary,
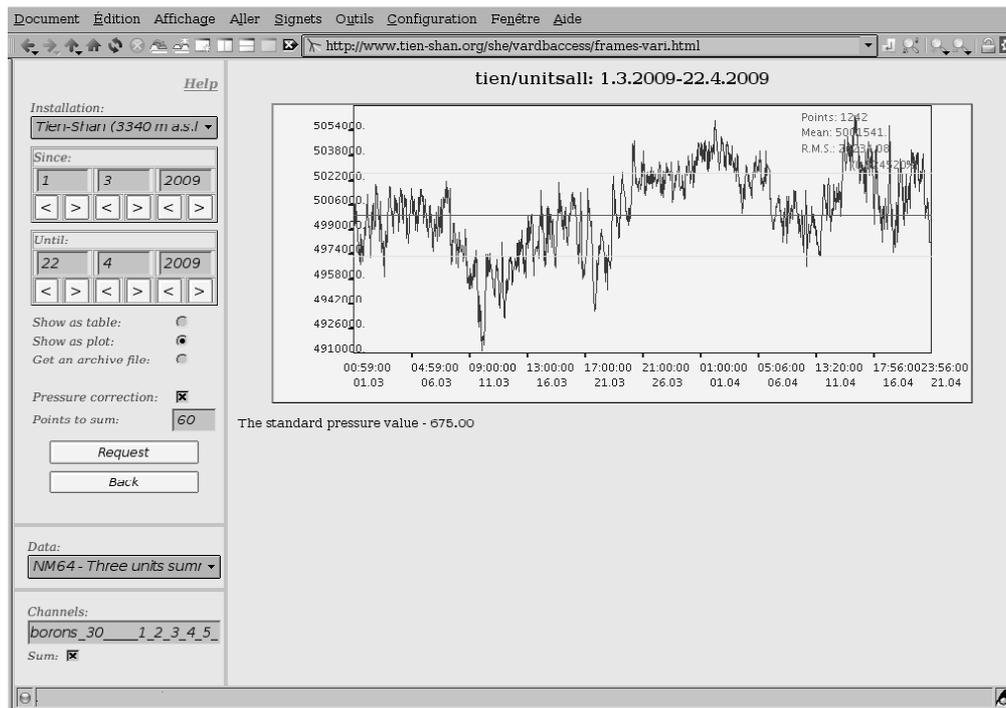
Fig. 3: Review of the neutron monitor database contents through the web interface.

firstly, for an interaction with registration program, and, secondly, for a regular dispatch of neutron intensity data via Internet to the distant data center (currently, to NMDB).

3. The visualization means of the measurement result data. As such, it was decided to use a web-interface to local database, which gives a possibility of an unified access to neutron data both from the same computer where the measurement process is going on, and from everywhere in the world via Internet. In considered system this interface consists of: (1) the standard web server Apache; (2) a set of the html-documents constituting a local internet site of the neutron monitor station; (3) a number of scripts for information exchange between the local database and client machine's internet browser, which interact with the Apache server by the means of Common Gateway Interface (CGI). An example of the neutron monitor database session is shown in Fig 3.

Some other tasks concerning maintenance of the measurement process at a neutron monitor installation (e.g., the synchronization of the control machine's internal clock either via the NTP Internet protocol, or by the means of GPS service; the timely start of the data exchange with NMDB; the proper keeping of the disk space etc) are solved by the means of the standard utilities of the Linux operational system.

C. The Windows version of registration system

Besides the above-described data acquisition complex which works under the Linux operational system, it has been designed the version of registration program to operate under the control of Windows. In this program

a special attention was paid to generation of exposition timeouts with an accuracy, necessary for our perpoise. The PCI-1780U card has a possibility both of an external temporal synchronization, and an synchronization with the use of its internal standard timer. In the last case the time intervals are counted with an accuracy about $50 - 60$ ms, which, in addition, depends strongly on the current stage of computer utilization. Nevertheless, the using of the high-speed multimedia timers [6] gives a possibility to improve an accuracy of time intervals up to 1 ms, which is quite sufficient for our tasks, and to avoid an influence of the computer's payload.

The Windows-based data registration system is developed in Delphi environment, its basic structure corresponding to the figure Fig 2. Results of the minutely measurements are written by registration program in a disk file; afterwards this information is placed into a database by a special additional application. The program complex has a module-like structure which permits to change easily its configuration in accordance with a current experimental task. The registration program (see the figure Fig 4) may be operating in a two modes: Online, corresponding to the normal neutron intensity registration; and Offline, used in methodic measurements. Both the program and documentation are accessible at [7] for a free use.

IV. CONCLUSION

On the basis of the industrial counter/timer card Advantech PCI-1780U and the modern software toolsis created a data acquisition system to be used at the installations of the world-wide neutron monitor network.
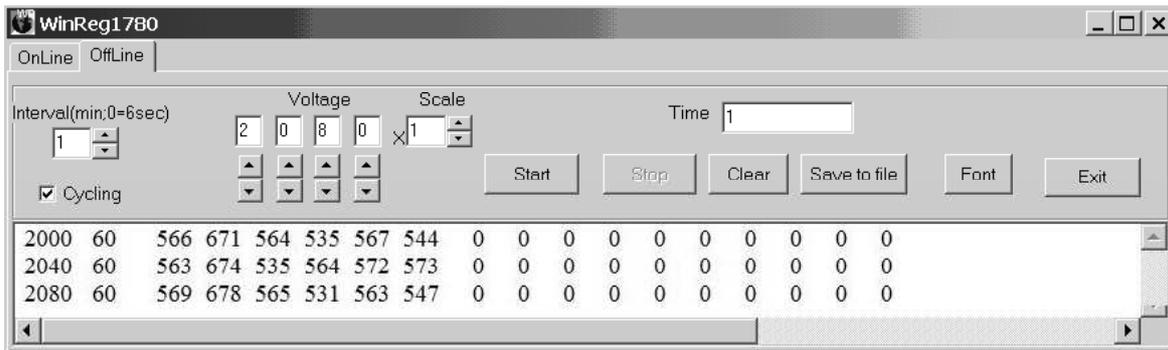
Fig. 4: The Windows version of registration program in an offline mode.

The system give a possibility of continuous neutron intensity measurements with a high temporal resolution, of a distant control for the measurement process, and of an automatic real-time output of measurement data to the world data center. At the present time, the systems of this type are installed and operating at the cosmic ray stations in Almaty, Athens, Irkutsk, Magadan and Moscow, and also at the Antarctic station Mirny.

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