HYPERION NET – A DISTRIBUTED MEASUREMENT SYSTEM FOR MONITORING BACKGROUND IONIZING RADIATION

by

Djorde ŠAPONJIĆ, Aleksandar ŽIGIĆ, and Vojislav ARANDJELOVIĆ

Received on June 28, 2003; accepted in revised form on September 8, 2003

The distributed measurement system – HYPERION NET, based on the concept of FieldBus technology, has been developed, implemented, and tested as a pilot project, the first WEB enabled on-line networked ionizing radiation monitoring and measurement system. The Net has layered the structure, tree topology, and is based on the Internet infrastructure and TCP/IP communication protocol. The Net’s core element is an intelligent GM transmitter, based on GM tube, used for measuring the absorbed dose in air, in the range of 0.1 to 720 μGy/h. The transmitter makes use of an advanced count rate measurement algorithm capable of suppressing the statistical fluctuations of the measured quantity, which significantly improves its measurement performance making it suitable for environmental radiation measurements.

Key words: radiation monitoring, distributed measurement system, nuclear instrumentation

INTRODUCTION

The modern information technology approach to the measurement of physical quantities, control of technological processes, environmental/object monitoring aimed at protection of humans and environment requires the execution of multiple measurements at many remote sites. A measuring system organized in this way is called a distributed measuring system.

So far, a number of stand-alone (wall-mounted, benchtop, portable, etc.) nuclear measuring instruments have been developed and produced in large series in the Electronics Department of the VINCA Institute of Nuclear Sciences. The first PC based radiation monitoring system having network connectivity was developed in 2000 [1], but it had some restrictions as pilot project: concept “Client-Server” was implemented in the way contrary to the usual implementation, the supporting software required installation at each PC user, the probes were intended for indoor use only, etc. The emerging trend of networking and WEB enabling of instrumentation has given rise to the development of HYPERION NET. The implementation and functional testing of the pilot project was carried out in 2003. HYPERION NET represents a versatile system primarily meant for environmental monitoring and human protection in the vicinity of nuclear machines, technological processes using radioactive materials, and areas with high risks of radiation pollution. It is a rugged and robust ionizing radiation monitoring system, used for in-building, near-building, and field measurements operating under exceptional working conditions. In order to meet its purposes, the HYPERION NET had to obey specific international standards and regulations [2-5].

THE ARCHITECTURE AND ORGANIZATION

The distributed measurement system HYPERION consists of three hierarchical layers. Each individual layer performs its task in the process of measurement, acquisition, and processing of the measured data.

The lowest layer of the system is the net of transmitters (intelligent sensors), in the FieldBus terminology denoted as “Device Network” [6, 7].
A constituent part of the device net is an intelligent GM transmitter (IGMT); it measures the layer of ionizing radiation, performs local processing of the measured data, and, on request, and forwards the data to the local node $C_1$ using standard digital communication interface. Within the device net the master-slave relation is clearly defined in that the local node $C_1$ is a master and all IGMT in the net are slaves.

The data collected by the local node are processed and stored in the local database, they are available on a PC display to the operator, and, in the form of packages, they are exchanged with the higher hierarchical layer – the central node $C$. The hierarchical layer higher to the Device Network is called Field Network. It consists of local control nodes $C_1$ to $C_m$ and the central control node $C$. The exchange of data between any local node $C_i$ ($i = 1, m$) and the central node $C$ is carried out by using standard digital TCP/IP protocol via Ethernet or Internet.

The data collected from local nodes $C_1, C_2, ..., C_m$ are processed by the central node $C$, stored in the central database of the HYPERION net, displayed to the operator in the central node, and organized in a WEB site, in HTML document format, for the purpose of further vertical connection to the higher hierarchical layer (Management Network) or public information services.

**DESCRIPTION OF THE INTELLIGENT GM TRANSMITTER**

The basic measuring element in the distributed measuring system HYPERION is an IGMT. It performs the following tasks: measurement of the levels of ionizing radiation, processing of the measured data, self-testing for the purpose of identifying the state of the transmitter, and communication to the higher hierarchical layer, local node $C_1$. Block diagram of the IGMT is shown in fig. 1.

The IGMT is based on two SI-8B GM tubes supplied by a 400 V d. c. power supply [8]. The selected GM tube has sensitivity of 114 imp/s at 10 μGy/s for 40Co, which was sufficient for this type of measurement. The pulses from the two detectors are collected and processed by the microcontroller subsystem. The speed and accuracy of the applied preset count measurement method have been improved by implementation of a new algorithm for suppressing statistical fluctuations of measured data [9]. The new implemented algorithm significantly improves measurement performance of an IGMT, makes it suitable for environmental radiation measurements. The microcontroller subsystem [10] also performs the autotest of the IGMT functions, e.g., control of the high voltage supply, operating temper-
(1) The process of reading measured data from IGMT
   - The protocol is cyclic, i.e. the local node polls IGMTs in the device net, point-to-multipoint.
   - The communication is initiated by the master, the local node C1, which sends two bytes formatted SYNC + ADR (SYNC = 7Eh, ADR – IGMT address) to identify the IGMT requested to send its measured data.
   - The identified IGMT returns measured data to the master, the local node C1, seven bytes formatted ALARM + DATA + CHECK_SUM (ALARM – autotest status, one byte, DATA – mean time between successive pulses, four bytes, CHECK_SUM – general parity check).

(2) The process of parametrization of IGMT table
   - The protocol implies point-to-point communication of the configuring PC and IGMT.
   - The communication is initiated by the master, the configuring PC, which sends one byte CALW (CALW = 2Ah).
   - Upon receipt of the CALW byte, IGMT is ready to receive the configuring data. The data contain the identification, measurement, and calibration parameters.

(3) The process of reading the identification, measurement, and calibration parameters from IGMT table
   - The protocol is not cyclic, i.e. the local node reads the table of parameters of the IGMT in the device net upon request by the operator, the configuration is point-to-multipoint.
   - The communication is initiated by the master, the local node C1, which sends two bytes formatted CALR + ADR (CALR = 2Dh, ADR – IGMT address) for identification of the IGMT requested to send its parameter table.
   - The identified IGMT returns 28 bytes from its EEPROM table and, for the purpose of ensuring the synchronization master-slave, upon receipt of each byte the local node C1 returns one ACK byte for confirmation (ACK = 2Eh).

DESCRIPTION OF THE LOCAL NODE AND THE CONCEPT OF VIRTUAL MEASURING POINT

The local node, as the central point of the lowest hierarchical layer of the distributed HYPERION system, i.e. of the Device Network, is designed on the basis of the concept of virtual measuring multi-probe instrument [14]. The functions of the local node are: acquisition of data from IGMTs, processing of these data, storing the processed data in a local database, displaying locally the measured data, generation of reports on the measurements carried out by the portion of the device net it controls, and forwarding the acquired data to the higher hierarchical layer, the central node C.

A general purpose PC can be used as the local node C1. The necessary adjustment required for connecting the PC to the device net is the use of the adapter EIA RS-232 to EIA RS-485 full duplex with a +5 V supply for the bus. The adapter allows two-way communication with the device net at the speed of 9600 baud at distances up to 1200 m without repeaters. The local node is equipped with an autonomous power supply (UPS).

The data acquired by the device net are forwarded to the higher hierarchical layer, central node C, by the standard digital protocol TCP/IP [15].

INTERCONNECTION OF THE LOCAL NODES WITH THE CENTRAL NODE AND THE CONTROLLER NET

The local nodes, Ci (i = 1, 2, ..., m), are connected to the central node C, by using net topologies of Ethernet (LAN or MAN) or by Internet, and constitute a net of controllers. The communication between a local node Ci and the central node C is realized by using the standard digital protocol TCP/IP. Figure 3 shows a block diagram of the interconnections of local nodes Ci with the central node C.

The use of the standard digital protocol TCP/IP ensures the integrity of data sent from local
nodes \( C_i \) to the central node \( C \). The distributed measuring system HYPERION allows the possibility that the local nodes could be statically or dynamically IP addressed, whereas the central node \( C \) must have a fixed IP address.

**DESCRIPTION OF THE CENTRAL NODE C AND THE ORGANIZATION OF SOFTWARE**

The central node \( C \) is the central point of the Field Network of the HYPERION system i.e. the net of controllers. The functions of the central node are: collection of the measured data from the local nodes, processing and storing the processed data in the central database, displaying of the status of the measuring system and displaying of the measured data to the operator, generation of reports on the measurements carried out by the complete HYPERION Network, presentation of the collected data by WEB technology using HTML data format [16] in the manner that they are accessible to the higher hierarchical layers (Management Networks or public information services) using standard WEB browsers.

A general purpose PC can be used for the realization of the central node \( C \) of the minimum configuration of HYPERION measurement system. If needed, the performance and reliability of the system could be increased by using two separate servers for the database application (database server) and a WEB access application (WEB server). The central node is equipped with UPS in order to ensure the autonomy of the power supply.

The software of the central node comprises: the application for acquisition of data from the local nodes based on TCP/IP, the application database, and the application WEB server. The Apache server is used as the WEB server application. Configuring the Apache server is carried out locally by the operator of the central node.

**CONCLUDING REMARKS**

The distributed measurement system HYPERION NET follows the modern concept of Field-Bus technology. The system has been developed, implemented and tested as a pilot project. It represents the first WEB enabled on-line networked ionizing radiation monitoring and measurement system realized in the Electronics Department of the VINCA Institute. The Net has a three-layer structure, tree topology, and is based on the Ethernet or Internet infrastructure. For increased data integrity and reliability, it uses the TCP/IP communication protocol. For measurement of the absorbed dose in air in the range of 0.087 to 720 \( \mu \)Gy/h an intelligent GM transmitter is used. The transmitter makes use of an advanced count rate measurement algorithm capable of suppressing the statistical fluctuations of the measured quantity which significantly improves its measurement performance making it suitable for environmental radiation measurements.

The developed, implemented and tested, distributed, Internet-based, monitoring measurement system is shown to represent a suitable low-cost solution for Government institutions, interested scientific community and the public in order to be on-line and accurately informed on the level of background ionizing radiation.

**REFERENCES**


puter Based Systems and Software Aspects, IEC, December 1998


Ђорђе ШАПОЊИЋ, Александар ЖИГИЋ, Војислав АРАНЂЕЛОВИЋ

HYPERION NET – ДИСТРИБУИРАНИ МЕРНИ СИСТЕМ ЗА МОНИТОРИНГ НИВОА ПОЗАДИНСКОГ ЈОНИЗУЈУЋЕГ ЗРАЧЕЊА

Развијен је примењен и тестиран дистрибуиран мерни систем – HYPERION мрежа заснована на FieldBus технологији као први WEB умрежени интерактивни мерни систем за праћење радиоактивног зрачења. Мрежа има хијерархиску структуру, топологију дрвета и заснована је на Интернет инфраструктуре и TCP/IP комуникационом протоколу. Основни елемент мреже је интелигентни Гајгер-Миллеров трансмитер, заснован на Гајгер-Миллеровом бројачу, који мери аспербовану дозу у ваздуху у опсегу од 0.087 до 720 μGy/h. У трансмитеру је примењен усовршен алгоритам за праћење средње брзине бројања који потискује статистичке флуктуације мерене величине што значајно побољшава перформанс мерења тако да је систем погодан за мерење основног гама зрачења из природе.