REMOTE CONTROL AND DATA TRANSMISSION SYSTEM FOR MEASUREMENTS IN SEVERE RADIATION ENVIRONMENT

V.G. Batiy*[1]*, N.A. Kochnev*[2]*, V.V. Selyukova*[2]*,
***D.V. Fedorchenko*[2]*, M.A. Khazhmuradov*[2*]**

[1]*Institute for Safety Problems of NPP NAN, Chornobyl, Ukraine*

[2]*National Science Center "Kharkov Institute of Physics and Technology", 61108, Kharkov, Ukraine*

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Remote control and data transmission module for in-situ γ-radiation measurements system under severe radiation conditions was developed. Testing showed reliability of wired controlled system for short distances and radio controlled system for long distances for real measurements.

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1. INTRODUCTION

The problem of remote control and data transmission often occurs during research activities in a complex radiative environment. The typical examples are "Shelter" object of Chernobyl Nuclear power plant (NPP), NPP power units in the process of their decommissioning, operating nuclear power facilities, storages of radioactive waste and spent nuclear fuel, etc.

In particular, during design and implementation of projects to strengthen "Shelter" building structures a large amount of radiation environment studies were carried out to ensure the required level of personnel radiation protection. The necessary equipment for measurements of angular and energy characteristics of the gamma-fields and surface beta contamination under strong gamma-ray background was designed by ISP NPP together with NSC KIPT [1,2]. It includes a series of collimated dosimeters, collimated gamma-ray spectrometers SEG-04K based on CsJ scintillation detector and KGS-01 based on CdZnTe semiconductor detector, collimated beta dosimeter based on Si-detector. Also, currently multi-detector facility ShD is upgraded from thermoluminescent detectors to Geiger counters.

Research experience for the severe radiation environment pointed to the need for remote control and data transfer. This will allow personnel to provide measurements behind biological shielding and will reduce the dose rates substantially. Also measurement time could be extended to improve accuracy and reliability. Remote data transmission system will enable to carry out data processing in the laboratory and to provide necessary measurement process adjustments. This will improve the efficiency of measurements and will additionally reduce the dose rates.

Another benefit of remote control system is possibility of measurements at hard-to-reach zones, delivering equipment to the measurement point using lifting gear (crane), or remote-controlled devices (robots). The first will be required during installation, sliding and operation of the new safe confinement arc, while the second - during later stages of the "Shelter" transformation for the project design of fuel containing materials extraction.

The existing experience showed the necessity of additional equipment: global positioning system (GPS), orientation system, remote control and data transmission system, closed circuit television (CCTV), autonomous data storage, temperature sensor, etc. It was therefore decided to create a modular system for field measurements management. Such system will provide measurements of different types on wide range of radiation-hazardous facilities. The proposed design allows construction of a complex system containing up to 127 modules. In this paper, we describe remote control and data transmission system.

2. GENERAL DESIGN PRINCIPLES

Firstly we have worked out the main requirements for a remote control and data transmission system:

- minimal measurements impact;
- distance to the measurements site varies from several meters to several hundred meters depending on site conditions (for example, measurements using crane on the "Shelter" roof and inside);
- lossless data transmission;

*Corresponding author E-mail address: khazhm@kipt.kharkov.ua

- low off-line mode power consumption.

The following solutions on minimization of remote control and data transmission system impact were suggested:

- optical insulation of measurement board and interface board;

- time gap between measurement and data transmission;

- independent power supply for measurement board and interface board.

Depending on the required distance for remote control and data transmission the following design solutions are feasible:

- wired connection at distances up to 10 meters or when wireless communication is hampered. The main drawbacks are necessity of wire winding / unwinding with consequent decontamination in the case of contaminated site surfaces;

- radio communication. Operation range for this case is up to 600 m for unlicensed frequencies 433 and 866 MHz and depends on the environment (metal and concrete obstacles, etc);

- cellular network communication. For this case cellular network must be present at measurement site. The cellular network could be used in the following ways:
  - dial-up networking;
  - SMS messaging;
  - GPRS networking.

To avoid data losses during the measurement process following solutions are provided:

- checksum verification when transmitting / receiving;

- data receive acknowledgment;

- data storage in nonvolatile memory;

- autonomous operation mode.

3. CONTROL SYSTEM DESIGN AND TESTING

We have developed (Fig.1) and constructed (Fig.2) universal board, which consists of microcontroller (1), 433 MHz transceiver (based on TRC102 chip) (2), non-volatile memory measurements and stack commands storage (3,4), LiIon (LiPo) battery charger (5), power load switch (6).

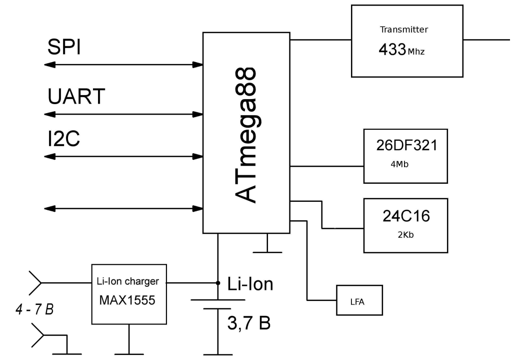

Fig.1. *Universal board basic circuit*

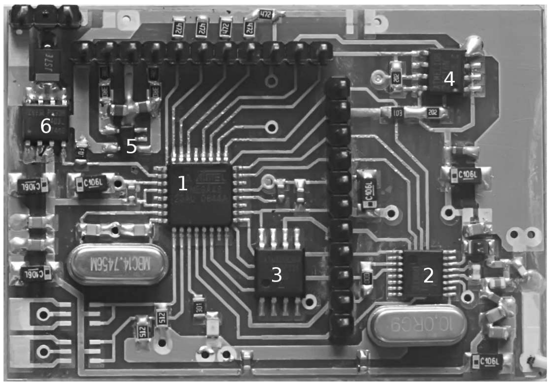

Fig.2. *Universal board design*

For communication with external devices, the scheme can use the SPI, I2C and UART hardware interfaces. The following devices can be connected to the scheme via those interfaces:

- accelerometer;
- temperature sensor;
- camcorder;
- additional memory modules;
- PC;
- GSM module;
- other sensors and modules.

The board allows to implement wired and wireless remote control, data transmission, data storage up to 4 *Mb*, LiIon (LiPo) battery charging and control, etc. Remote control and data transmission system is operated using the instruction set developed, which allows flexible management of all modules installed. Computer codes were developed for PC and microcontrollers for universal board and spectrometer board. Laboratory tests were performed both for radio control and wired control systems. Two variants of wired control system were tested: with UART and RS485 interfaces.

For UART interface, depending on the cable used, the data transmission distance was from 1.5 meters (for unshielded flat or round cable) to 15 meters (shielded twisted pair) at 115200 bps. To overcome this limitation one can use converters UART - RS485 (with full software compatibility). In this case distance can be increased up to 1 km at a speed of 9600 bps. The disadvantages of the RS485 interface are complicated construction (two converters and an additional battery for converter power supply). RS485 interface was implemented using two UART - RS485 converters on MAX13485 chips. With galvanic coupling of spectrometer board and PC spectrum measurements are hampered by significant increase of noise level. Connection via optical insulators based on 6N137 chips lowers noise to inessential level. Therefore, for all subsequent measurements, data transmission was always carried out only through optical insulator located in close to microcontroller board (to reduce the antenna effect of the connecting wires).

Data transmission via UART interface was performed at speed of 115, 200 bits per second over a distance of 2 meters and via RS485 interface at the same speed over a distance of 15 meters. Data was transmitted by 512 byte packets every 2 seconds. After 30...60 minutes of operation data transmission failure usually occurred. To handle the problem we have modified the PC program used. In the case of wrong data packet received data transmission request was repeated 10 times. This modification have completely eliminated data transmission failures.

Wireless data and instructions set transmission was tested at $433\,MHz$. The transmission was carried out at a speed of 2400 bps by 64 byte packets with 2 checksum bytes. Inside the building stable lossless data transmission range achieved was about 30 meters, through the window frame – up to 100 meters. According to the TRC102 chip developer tests for transmitter at a height of 3 meters and receiver at a height of 1.5 meters above the ground level the achievable direct view transmission range is 675 meters.

4. CONCLUSIONS

The research have shown that it is expedient to design and create universal remote control and data transmission unit to improve measurement quality and accuracy. It could be used with a number of setups: dosimeters, spectrometers (including collimated spectrometers), multi-detector facilities, gamma-vision facilities, etc. The possible fields of application include contaminated areas, radiation hazardous objects, hard-to-reach spots in radiation environment. Such a unit should have a modular structure and consist of a number of different modules depending on the current application.

Remote control and data transmission module is one of the most important constituents of modular system. Our research showed for distances up to 15 meters wired communication based on UART of RS485 interface is the most efficient. For long distances (about $600\,m$ for open areas) $433\,MHz$ radio communication is more suitable. It could be implemented using Trc102 chip.

References

1. V. Batiy, V. Yegorov, A. Pravdivyi. Development of a radiation environment studies for object "Shelter" construction site //*Safety problems for nuclear power plants and Chornobyl.* 2008, N10, p.155-164 (in Russian).

2. V. Batiy, A. Pravdivyi, I. Kopanets. Multidetector device for gamma-radiation angular distribution measurements IN severe radiation environment // *Safety problems for nuclear power plants and Chornobyl.* 2009, N11, p.104-108 (in Russian).

СИСТЕМА ДИСТАНЦИОННОГО УПРАВЛЕНИЯ И ПЕРЕДАЧИ ДАННЫХ ДЛЯ ПРОВЕДЕНИЯ ИЗМЕРЕНИЙ В СЛОЖНЫХ РАДИАЦИОННЫХ УСЛОВИЯХ

В.Г. Батий, Н.А. Кочнев, В.В. Селюкова, Д.В. Федорченко, М.А. Хажмурадов

Разработана система дистанционного управления и передачи данных (СДУПД), которая является модулем общей системы проведения полевых измерений в сложных радиационных условиях. Проведенные испытания подтвердили надежную передачу данных через проводную линию на небольших расстояниях и посредством радиосвязи на больших расстояних в полевых условиях.

СИСТЕМА ДИСТАНЦІЙНОГО УПРАВЛІННЯ ТА ПЕРЕДАЧІ ДАНИХ ДЛЯ ПРОВЕДЕННЯ ВИМІРЮВАНЬ У СКЛАДНИХ РАДІАЦІЙНИХ УМОВАХ

В.Г. Батій, М.А. Кочнев, В.В. Селюкова, Д.В. Федорченко, М.А. Хажмурадов

Розроблена система дистанційного управління та передавання даних (СДУПД), яка є модулем загальної системи проведення польових вимірювань у складних радіаційних умовах. Проведені випробування підтвердили надійне передавання даних крізь дротову лінію на невеликих відстанях та з використанням радіозв'язку на великих відстанях у польових умовах.