E13-2018-55

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FIRE EXTINGUISHING SYSTEM DEVELOPMENT FOR THE SLOW CONTROL SYSTEM OF THE **TOF-MPD**

Submitted to “Particles and Nuclei, Letters”

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Дунин Н. и др. E13-2018-55

Внедрение устройств пожарной безопасности для системы медленного контроля времяпролетного многоцелевого детектора

В современном обществе безопасность человека стоит на первом месте. И не важно, где находятся люди — дома или на работе. Повсюду они должны оставаться в безопасности. Поэтому одной из основных задач является разработка системы, которая будет работать в координации с устройствами пожаротушения и сигнализации. Второстепенной задачей систем пожаротушения является сохранение имущества в целости. Система управления модулем пожаротушения, разработанная в этом проекте, работает в сочетании с автоматической системой газового пожаротушения и средствами оповещения, успешно решая эти задачи во время проведения физического эксперимента.

Работа выполнена в Лаборатории физики высоких энергий им. В. И. Векслера и А. М. Балдина ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна, 2018

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Fire Extinguishing System Development for the Slow Control System of the TOF-MPD

Human safety is considered a priority in modern society. No matter where people are, at home or at work, they must feel confident and secure. To ensure that, a fire protection system that would immediately send information to safety equipment is required. Therefore, one of the main functionalities is a design that would operate with alarm, fire extinguishing devices and data acquisition software. Modern fire alarm and fire fighting systems have been considered during the process.

The investigation has been performed at the Veksler and Baldin Laboratory of High Energy Physics, JINR.

Preprint of the Joint Institute for Nuclear Research. Dubna, 2018

INTRODUCTION

The development of a fire protection system for the Slow Control System of the Time-of-Flight Multi-Purpose Detector was set as a part of the modernization of the accelerator complex at the Veksler and Baldin Laboratory of High Energy Physics of the Joint Institute for Nuclear Research. The main goal of the system, as any other fire fighting apparatus, is to protect health and life of people and to preserve the equipment inside the rack.

Additionally, the system should be easy to set up and be as unnoticeable as possible during the normal operating conditions of the amenity. It should not cause additional hazards. It is desirable to be easy both to install and configure keeping the overall costs reasonable.

During this project, the data acquisition program for FRS-RACK extinguishing module has been designed and tested using the development environment LabVIEW 2016. The main two features of the program is reading data from the sensors of the Firesi FRS-RACK and the data visualization.

1. FIRESI FRS-RACK SYSTEM

FRS-RACK is a self-contained, fully automatic fire protection system designed for installation in 19″ rack cabinets. It offers very efficient solution applicable in various sites, for example, servers or telecommunication and control facilities. System FRS-RACK Master consists of fully equipped automatic system

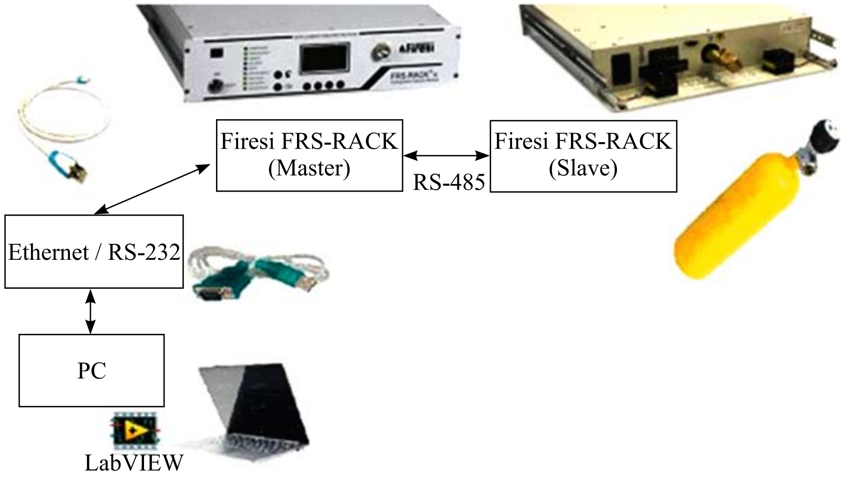

Fig. 1. Structure scheme of the fire extinguishing system [1]

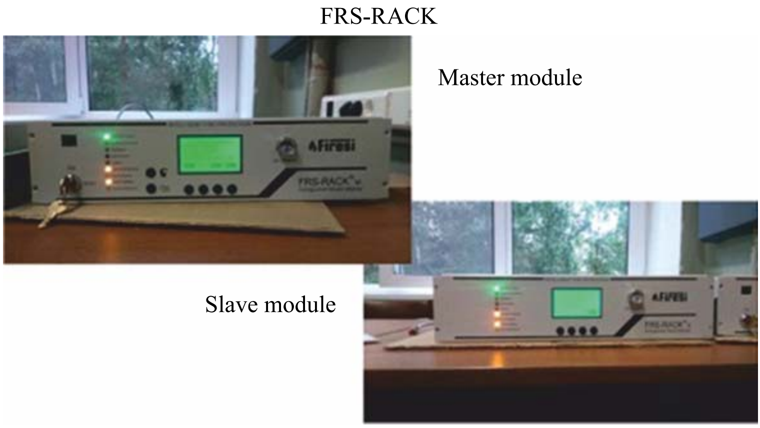

Fig. 2. Front panels of FRS-RACK Master and Slave units

of fire detection, control, evaluation, communication and extinguishing units. Larger-sized server racks and adjacent cabinet units can be protected by additional auxiliary FRS-RACK Slave units comprising detection elements, communication and fire extinguishing units. The slave units must always be connected to the FRS-RACK Master control unit (see Fig. 1). One Master unit allows to connect up to four Slave units, each via its own dedicated RS-485 communication line and within a single fire compartment. Upon a fire onset, all units are actuated simultaneously. The system can be used with electrical equipment supplied with a nominal voltage up to 1000 V. Moreover, it causes no damage to the data stored within the rack, since the extinguishing agent is electrically nonconductive and does not contribute to corrosion.

The fire detection is implemented through optical smoke detectors, which — in order to eliminate false alarms — are related in a double-loop dependency and connected to the evaluation and control units. The integrated control unit with LEDs and embedded display indicates the current status of the system, controls and evaluates the actuation of the extinguishing unit (see Fig. 2).

Description of FRS-RACK current status:

1. Operation — green LED is lit when the system is fully operational.

2. Fault processor — yellow LED is lit when the processor and hence the complete system fail critically. This is the only LED on the front panel not controlled by the processor.

3. Emergency switch-off — this yellow LED is lit when extinguishing process is blocked, e.g., by opening the door contact switch.

4. Pre-alarm 1 or 2 — these red LEDs are lit when loop 1 (detector) or loop 2 (detector 2) reports alarm. Loop of external acoustic signalization and loops blocking technology and HVAC are active.

5. Alarm — red LED blinks slowly and the extinguishing agent will be discharged.

6. Fault — summary fault when yellow LED of specific fault lights up.

7. Fault power supply — this yellow LED is lit when the main (230 V) power supply fails.

8. Fault accumulator — this yellow LED is lit when backup power supply source is disconnected or fails. The LED blinks when the accumulator is being charged.

9. Fault pressure — this yellow LED is lit when loop to storage cylinders experiences short circuit or becomes disconnected. When pressure in storage cylinders drops below allowed limit, this LED will blink.

10. Key switch Operation / Test — in Test position the system performs all operations and functions as in the Operation status — only the function of powering the solenoid valve, i.e., allowing the extinguishing agent to discharge, is disabled. Status Operation is a fully monitoring condition. Upon switching to this status, the system automatically tests all loops, testing takes roughly 30 s. Alarm status can be reset after the solenoid valve is opened by turning the key switch to Test position and pressing the Reset pushbutton. All LEDs on the front panel will light up for 1 s and simultaneously the internal acoustic signalization inside the unit will sound.

The Master enables communication with the fire alarm control panel (FACP) of the building and reports the following statuses: pre-alarm, alarm, and extinguishing [2]. When one of the two detectors in pair detects fire, the unit triggers a pre-alarm and acoustic and visual signalization activates. In case of a simultaneous detection of smoke by both detectors, the alarm status is set. That results in an automatic activation of the output contact controlling the extinguishing unit, and the acoustic and visual signalization is switched on as in the pre-alarm status. After a pre-determined time delay the solenoid valves open and the rack is flooded by the extinguishing agent from storage cylinders. The system also allows a manual actuation with a physical Start button.

Extinguishing unit consists of cylinder-shaped metal storage cylinders filled with extinguishing mixture. Cylinders are gas-tightly sealed by collection fittings providing connection to filling device and pressure gauge allowing visual checking. The unit also contains solenoid valve and electronic pressure checking sensor. Extinguishing agent is expelled through special rising pipe via collecting pipe, solenoid valve, and through discharge nozzle it is distributed and directed into the protected space. Collecting fitting is made of zinc-galvanized steel equipped with sealing rubber O-ring. Storage cylinders are marked by individual production numbers and all relevant data are recorded in the assembly sheet of the extinguishing unit collecting fitting together with records of the checks performed during assembly.

2. UDP PROTOCOL

The default Firesi FRS software has a few aspects like:

1. The data acquisition software works only with 2 ports at the same time — RS-232 and Ethernet.

2. It uses a text log file for the data collected from sensors, whereas a graphical representation would significantly improve the user experience.

3. The RS-232 interface has a physical limit of a communication cable length — 15 m (whereas the Ethernet interface limit for length is about 450 m [3]).

For these reasons, the Multi-Purpose Detector department commissioned development of a data acquisition software that works only with the Ethernet. If compared with TCP/IP, UDP has advantages like higher speed, narrower load network bandwidth, and a topological broadcast on multiple interfaces [4]. Data sending between FRS-RACK device and PC via UDP protocol is represented by hexadecimal bytes (see Fig. 3). Therefore, integer numbers from the device sensors are hexadecimal bytes too.

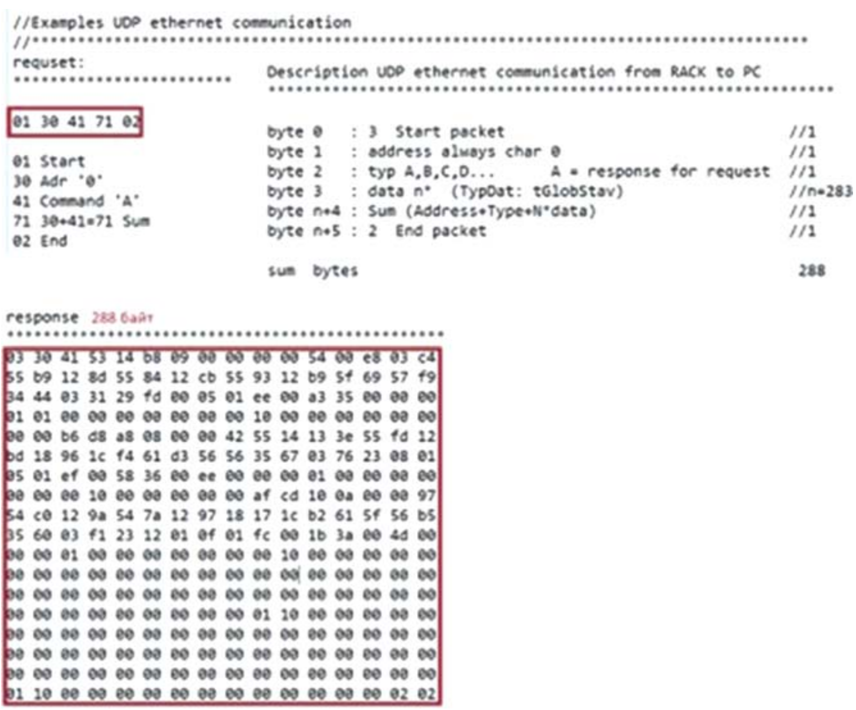

Fig. 3. Typical byte request and response for Master FRS-RACK module [5]

To convert hexadecimal bytes to integer data representation, the following steps should be performed:

1. Cut bytes from 15 to 30;
2. Swap two consecutive bytes (1 and 2, 3 and 4, etc.);
3. Convert bytes from ASCII to HEX/INT representation.

These steps are important because the FRS-RACK system sends data to PC in a form of unprocessed HEX characters. For example, 25 °C from an external sensor will be represented as “19” in a hexadecimal representation. In turn, “1E” in hexadecimal will be represented as 30 °C in decimal system. When the Master FRS-RACK sends data to a PC or a different electronic device with communication interfaces, the information looks like undivided random numbers and characters like “0330415C70FE0500004C014B01E803AE55A512A7555A13B055CB121C597F”. The FRS-RACK device collects 25 or more values from sensors depending on the number of slave devices plugged to the master.

The main reason why the bytes from 15 to 30 of the UDP are cut is due to the data contained within them. Bytes at the beginning of the log file are used to display the device id and service constants which is an insignificant information, from our point of view (see Fig. 4).

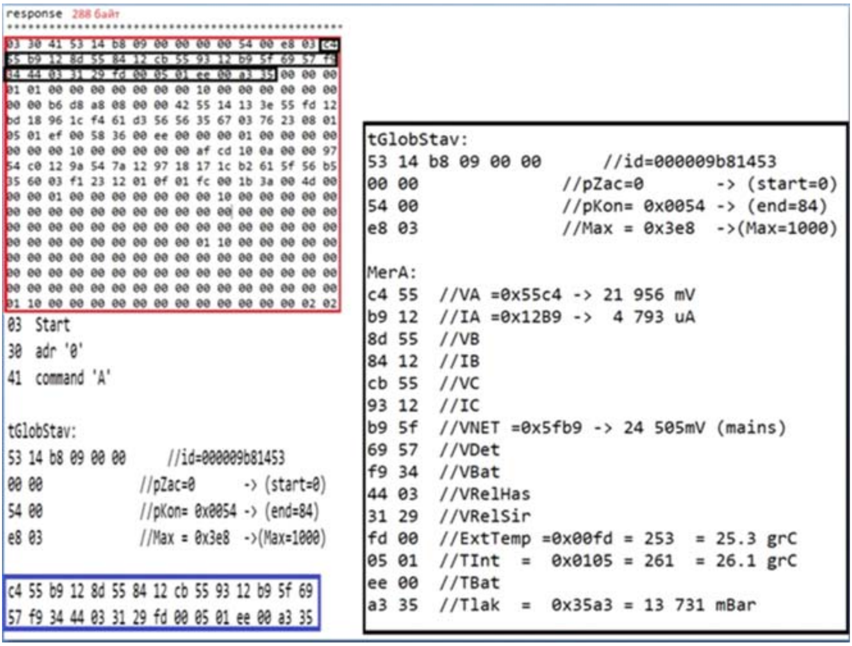

Fig. 4. The conversion of the FRS-RACK Master response containing all the data from sensors

The second step is used because of the FRS-RACK firmware. For example, the HEX representation of 21956(DEC) is 0x55C4 [6] that will be present in the FRS-Master UDP transfer “C455”.

The third step, the conversion to HEX, is also of high significance. When working with ASCII encoded data, the main program and subprograms would display an encoding failure and measurement errors.

3. DATA ACQUISITION SOFTWARE

In this project, the development environment LabVIEW 2016 with preinstalled UDP protocol libraries and drivers for RS-485 and RS-232 [7] was used. The main algorithm of the program works in an endless loop [8] (see Fig. 5). At first, the UDP protocol is initialized. Next, 5 bytes are sent via Ethernet to FRS-RACK Master as a request [9]. Requests are composed according to the following scheme: 01 30 41 71 02; 01 is START byte [10]; 30 is a command “0” for microcontroller in the FRS-RACK Master device; 41 is a command “A” for registers in microcontroller; 71 is a checksum [10]; 02 is a STOP byte [10].

Subsequently, the main program receives a response (288 bytes). Raw bytes with sensor data are obtained with string processing functions. The next step is the conversion of ASCII bytes to hexadecimal. And at the final step hexadecimal data representation is converted to sensor parameters like external/internal temperature, pressure, voltage, current and battery temperature (see Fig. 6).

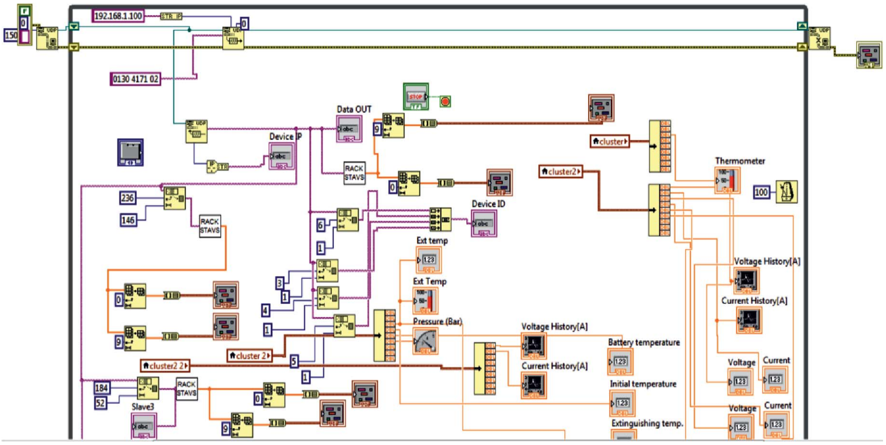

Fig. 5. The first part of the main block diagram written in G language using the LabVIEW 2016 environment

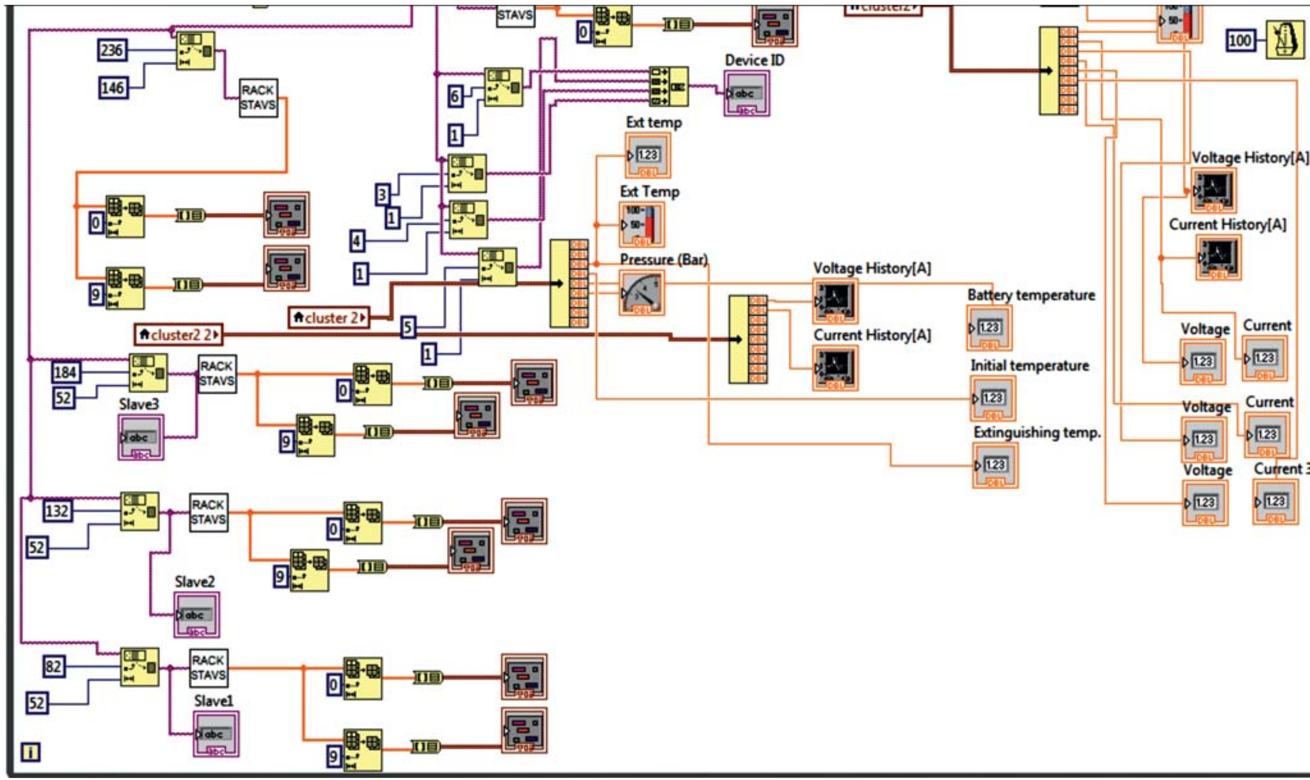

Fig. 6. The second part of main block diagram written in G language using the LabVIEW 2016 environment

4. SUMMARY

As a result, the software and hardware acquisition system of the fire protection Firesi module was designed to connect slave devices, read their operating parameters, and display them on a PC (see Fig. 7). During this project, the following tasks were solved:

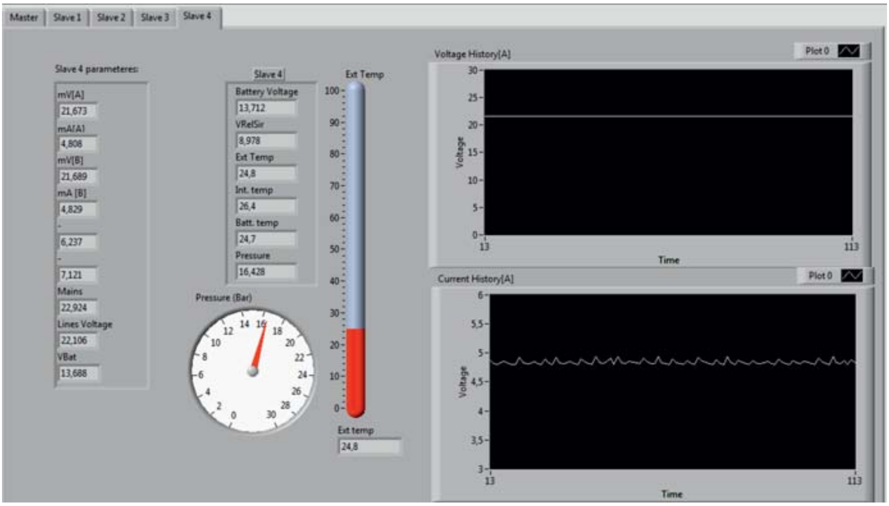

Fig. 7. User interface for Slave module

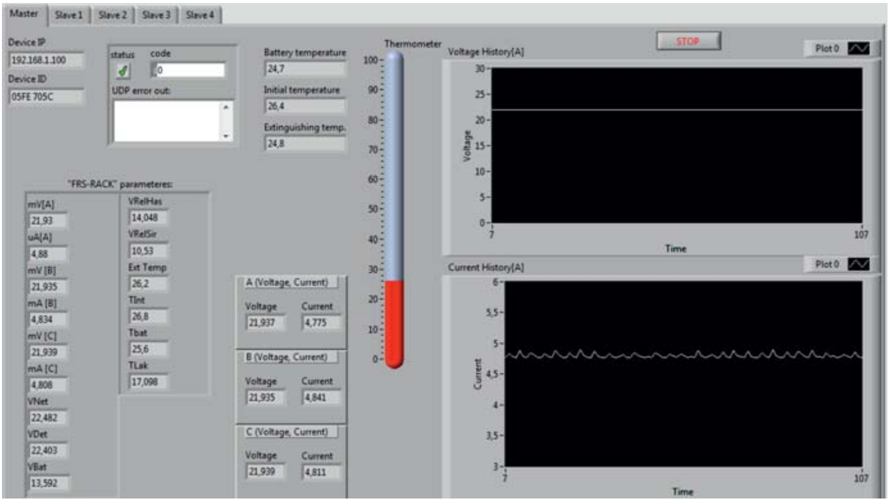

Fig. 8. User interface for Master module

1. Configuration of Ethernet and RS-232 protocols;
2. Assembly of the system in a block;
3. Development of algorithms for the data acquisition;
4. Development of the software for data visualization and monitoring;
5. Testing and debugging;
6. Preparation of documentation.

The result of the system designing is the possibility of using cables up to 500 m. Second, using three temperature sensors (internal, external and temperature sensor for battery) inside Firesi device. Third, measuring of pressure gauge and using of visualization tools in the form of indicators and graphs (see Fig. 8).

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Received on October 2, 2018.

Редактор *Е. И. Крупко*

Подписано в печать 09.11.2018.
Формат 60 × 90/16. Бумага офсетная. Печать офсетная.
Усл. печ. л. 0,75. Уч.-изд. л. 0,84. Тираж 215 экз. Заказ № 59542.

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