Overview of field gamma spectrometries based on Si-photomultiplier

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ABSTRACT

Design of optical-electronic devices and systems involves the selection of such technical patterns that under given initial requirements and conditions are optimal according to certain criteria. The original characteristic of the OES for any purpose, defining its most important feature ability is a threshold detection. Based on this property, will be achieved the required functional quality of the device or system. Therefore, the original criteria and optimization methods have to subordinate to the idea of a better detectability. Generally reduces to the problem of optimal selection of the expected (predetermined) signals in the predetermined observation conditions. Thus the main purpose of optimization of the system when calculating its detectability is the choice of circuits and components that provide the most effective selection of a target.

Keywords: measuring systems, SiPM, scintillator, gamma ray

1. INTRODUCTION

Geophysical measurements can be considered as one of the most conservative types of measurements. Many years of experience in the research of geophysical fields were subdued in the first place, the requirements of high accuracy and adequacy of the measurement results (matching the real picture of the physical world). These requirements largely provide continuity measurement technology. As a result, the range of devices, their functionality, methodological and metrological support remained unchanged for decades. It must be admitted that many users are quite satisfied with this state of affairs: the use of the same devices for tens of years ensures continuity of measurement technology, processing and interpretation of data. A single instrument platform is a tool which allows you to use to provide a number of advantages such as consumer devices and systems, and their developers.[1,2] The consumer receives a group of field devices that solve different problems, but united by several common traits: a functional and ergonomic principles, a single field computer, unified command system, unified data exchange and formats of protocols, common methods of navigation, the use of wireless communication, operational communication with remote users. In this case, there is an additional possibility of combining multiple devices into a single measurement system. This allows, for example, to simultaneously measure various physical fields, such as radiation and magnetic fields. The costs of measurements are reduced almost twice. In this case the results of measurements of different physical fields are aligned in time and space, which gives new possibilities for the analysis of the nature of the anomalies, increasing the quality of data interpretation. In turn, the developer is able to use the same carefully planned solutions for all devices of the group. For example, the software controller will be used regardless of the destination device, the development of specialized modules will be carried out within a single technology for integration with a single core. Add to this the unification of

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Table 1. Average specification

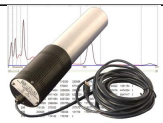
	Parameter	Requirement	Notes
1	Type of PM	Si-PM	–
2	Time of continuous work	16 h >	To satisfy the requirements of autonomous operation can be used in standardized batteries, or integrated into the TB batteries
3	Weight of the device	> 2 kg	Wearable devices must have minimal weight and size
4	Operating temperature	$-40°C < T < 60°C$	-
5	Protection against magnetic interference	Required	Shielding of sensitive elements
6	The indicator	Required	Displays measurements, mode of measurements, interface interaction of the operator, the ability to disable the screen to save power consumption
7	Technological requirements	-	In the manufacture of TB needs to be associated with standard technological tools and equipment
8	View performance	-	Modular. For the implementation of the platform concept and measurement of geological assumes the separation apparatus to the unit with the sensing element and the processing unit and display
9	Positioning	GLONASS, GPS, Beidou	Using modules positioning using satellite systems GLONASS, GPS and Beidou
10	Materials	-	The use of heat-resistant lightweight and durable materials
11	moisture protection	IP67	Protection from moisture, as well as disinfection and decontamination substances
12	Portability	Wearable equipment	Low weight, small dimensions, easy mounting and carrying means

technology of preparation of documentation, implementation service, simultaneous transition of all the family to the new version of the software. The requirements for basic functionality of the field of gamma-spectrometer based on solid-state silicon photomultiplier are laid down in the specifications on the prototype development, almost completely coincide with the requirements of modern geophysical measuring instruments. This allows you to extend the principles of the unified architecture, laid down in the development of the EA field gamma-ray spectrometer and other measuring geophysical instruments.[3,4] Among the specialized software and hardware components, the development of which is beyond the scope of standard solutions a single platform, and probably will not be transferred to other measuring geophysical instruments which are necessary to carry a measuring channel comprising a scintillator, solid state silicon photomultiplier and additional matching the optical and / or structural components, as well as specialized software application to be developed as part of the prototype gamma spectrometer.

Table 2: Market review

	View	Model	Site	Country

1		The spectrometer MKS-6102	link	Russia
2		The spectrometer MKS-6101D	link	Russia
3		spectrometer Eco PAK	link	Russia
4		Portable spectrometer IdentiFinder	link	Russia
5		MKGB-01	link	Russia
6		Insitu gamma-spectrometer	link	Russia
7		SKS-99 "SPUTNIK"	link	Russia
8		MKS-01A "Multirad-M"	link	Russia
9		Flagman-Gamma	link	Russia
10		InSpector 1000	link	USA
11		TransSpec-100	link	USA
12		RS-125; RS-120	link	Australia
13	-	Identifinder - N	link	UK
14		Portable / Mobile Gamma-Ray Spectrometry	link	Canada

15		Portable / Mobile Gamma-Ray Spectrometry	link	Canada
16		MICROSPEC GAMMA PROBES	link	USA

Thus the results of the analysis of the requirements,[5,6] you can determine the specifications of the device:

- the use of solid state photomultiplier enables the use of more rigid load-bearing elements, as it is not necessary to demirovici tube element, and the ability to use the device in more harsh environments and transportation. In addition, the diagram will be missing the high voltage source to power the lamps, which allows you to make paths more compact;
- work in a wide temperature range involves the use of construction metals or heat resistant plastics, and given the mobile usage of the device in the field, the device must have minimum mass;
- battery life depends on the amount of battery time increase leads to an increase in the size of used supply items, and as a consequence, leads to an increase in size and weight;
- given the requirements for immunity to magnetic interference, the design must be elements of shielding of the sensitive element of magneto-soft materials such as permalloy;
- use of the device in the field imposes the requirements of functioning in the open sun and in the pouring rain, in addition, it is possible to measure in the aquatic environment, therefore the device should be hermetically sealed with protection degree IP67 is not below. This requirement also imposes a limitation on the choice of connectors, they must be sealed;
- the materials used for the manufacture of the device needs to have small reactions to aggressive agents, which are using for disinfection and measuring instruments in polluted areas;
- the use of satellite navigation and wireless interfaces transmitting information force the use of radio-transparent materials when constructing a housing;
- to display different information in all modes of operation of the device requires the use of screens with a diagonal of at least 6-7 cm. Increase in screen diagonal of more than 20-24 cm increases the weight and dimensions of the device. Screen type should be chosen from the conditions of its basic properties (viewing angle, resolution, power consumption, etc.), it is necessary not to forget to the information on it was visible under natural sunlight;
- the performance of a device within a platform concept, there should be a block, with split function;
- execution of the blocks in turn should have a modular type of organization functionality, with the possibility of increasing function;
- for multiple applications of the devices (fixed, field, field), enclosures shall be provided fastening elements, giving the possibility of using additional staff or retaining funds to make use of the devices most convenient for the operator;

- at the stage of design, development and testing to accelerate the process may be used in the circuitry of both Russian and foreign production. At the stage of serial production, in the framework of import substitution and reduce the risk of sanctions, should be the most used element base of domestic production;
- in the manufacture, set up and operate devices must use standard tools and equipment, methods of processing materials. Devices must not require special tools. Analysis of the above requirements, describing the appearance of the devices and EO, in particular, gives an idea of the preferred design implementation of the EO.

2. RESULTS

Based on the requirements to the EA and analysis of constructive decisions of devices produced nowadays,[7–11] and also taking into account the concept of a single platform measuring instruments, design implementation of TB PGS should be based on the following principles:

- TB constructively should be two separate unit, with division of functions; sensor must be a block with sensor database (sensor unit), which must perform the functions of measurement and processing of measurements;
- processing unit, with display control and other advanced functions BO (processing unit), must implement the entire list of tasks required for the operator.
- unit DB should be a sealed cylinder (or close to it form) with fixing elements and connectors for connection with BO. The material can be used light metals (e.g. aluminium and its alloys), or durable plastics and polyamides. The materials used must have the capability of machining;
- unit DB should have a solid supporting frame for the mounting of the measuring path;
- unit DB should have a weight not exceeding 1 kg;
- dimensions of the database should not exceed $100 \times 100 \times 350$ mm;
- the external surfaces of the DB should be smooth, sharp corners and edges dulled;
- design database needs to be collapsible;
- to build the database needs to use the standard types of fasteners and tools;
- the design of the database should be provided by the shielding elements sensitive element and the measuring path;
- must be elements, signaling the unauthorized opening of a design database;
- block BO needs to submit a sealed box (or close to it form) with fixing elements and connectors for connection with database and PC. The material can be used light metals (e.g. aluminium and its alloys), or durable plastics and polyamides. In the place of installation of the emitted and host modules that should be used only electrically transparent materials. The materials used must have the capability of machining;
- block BO should have a solid supporting framework for attachment of the modular elements of filling;
- block BO should have a weight not exceeding 1 kg;
- size BO should not exceed $250 \times 200 \times 100$ mm;
- the outer surface of the BO should be smooth, sharp corners and edges dulled;
- the design of the BO must be collapsible;
- to build BO needs to use the standard types of fasteners and tools;
- must be provided by the elements, indicating the attempt of unauthorized opening design BO;

- block BO must be equipped with a screen diagonal of at least 10 cm;
- in the block BO, must be the elements to protect the screen against external mechanical impacts;
- block BO should have controls that are sufficient for measurements, settings and calibration of the device, the solution of the assigned tasks by the operator.

Selected design implementation EA is preferred in the following factors:

- block division EO gives the possibility of separating the functions, and as a result the design and implementation of components of a product;
- the ability to use for each part its optimal design solution;
- design developed in the design of EO can be used in the further development of the instrument, the concept of a single instrument platform;
- there is a possibility of modernization of the unit;
- design implementation of BO, entailing modular content allows you to combine and increase function, upgrade circuit solutions, to translate the instrument to new components, which were deprived of the design of old products;
- reviews of geologists conducting field work, indicate the current habit of using devices made of blocks that will avoid having to change familiar methods of monitoring and reconnaissance.
- the use of these materials allows to make the construction light and durable;
- having fastening elements, enables the use of restraints, the use of which is optimized for solving tasks (laboratory studies, local monitoring, field work);
- means of displays and controls located in BO, enable one device to control the operation of the whole device;
- manufacturability units takes into account the possibility of serial production, which in turn reduces the cost, and thus the price for the final consumer.

3. CONCLUSION

Analysis of the devices offered on the market today, shows that the above design requirements actual. For mobile and wearable measuring devices relevant issue is the weight of the fixture to hold the nodes, which includes sensing element, in the operating direction, and the means of indication and control. Widespread transition to the use of as an indicator of the LCD matrices, in addition to the convenience, exact a just measure to protect the screen from external influences. Also there is a clear tendency of divisions of the instrument into its component parts:

- unit of measurement, with the sensor element;
- unit display, processing, recording and storage of measurement results;
- restraints.

Monoblock constructs a rather bulky and is not suitable for field work, they are more relevant for local measurements and monitoring. The use of block separation allows the manufacture of devices based on different principles and using different materials. The part containing the sensitive elements, usually made of meta,l, the units with controls and display, most of them are plastic housing with a film keyboard and screen display.

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