GENERAL ASPECTS OF THE BASIC STRUCTURAL DESIGN OF GENERAL-PURPOSE AUTOMATED SENSOR SYSTEMS

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Problems in the design and development of general-purpose automated sensor systems are reviewed.

The development of general-purpose automated sensor (GPAS) systems for measurement, monitoring, and control is paralleled by increasing requirements on present-day hardware facilities. Existing methods for the design of sensor systems are aimed at specific measurement/monitoring/control objects* and therefore tend to create overly complex, not very reliable systems that cost too much and rapidly obsolesce.

The class of general-purpose systems includes the very familiar measurement computing systems [1, 2]. Despite the emergence of fairly successful systems of this subclass (e.g., the IVK-L70 and K1759 systems), it can be concluded on the whole that the majority of recommended measurement computing systems are technically imperfect, and the metrology of the design of aggregate systems for the solution of monitoring and control problems needs to change.

As in Russia, foreign sensor systems for measurement, monitoring, and control are most often tailored to a specific object, although general-purpose aggregation techniques do exist within individual groups of sensors and final control mechanisms (actuators), for example, thermoelectric transducers [3, 4], etc.

The main trends in the development of GPAS systems have taken shape in several scientific papers [5-7] and include: room for potential expansion of the available functions and adaptability to changes in the object parameters; modular structure; decentralization of executed tasks; automation of all types of monitoring and control; the liberal use of standard network structures; the application of powerful computer facilities to support real-time modes of operation, artificial intelligence, and expert-evaluation systems. These trends need to be expanded (among other reasons, to implement the foregoing) with the introduction of hardware and software production facilities among the world's major industries, and entry of the development, manufacture, and utilization of sensor systems into an integrated world market.

The solution of the problem of GPAS system development will set the stage for: a unified engineering policy in the area of sensor systems, compatible with frontline foreign industry; the development of individual, competitive elements of such systems; the creation of an environment for refinement of the technology of measurement, monitoring, and control of processes in industry and the testing, development, operation, calibration, and checking of measuring devices.

The structure of the typical measurement, monitoring, and control sensor system has been thoroughly investigated in the scientific and engineering literature and corresponds more or less, depending on the degree of sophistication, to the diagram in Fig. 1, which includes: 1) the original part; 2) a first interface; 3) the general-purpose part; 4) a second interface.

According to this plan, the GPAS system is an assemblage of modules designed as a basis for the construction of active sensor systems for the monitoring and control of specific objects. The GPAS system is essentially the "latest" aggregate system utilizing electrical signals, which incorporates next-generation computer facilities, interfaces, and software. GPAS systems are considered to differ from existing counterparts in their broader compass of measurement, monitoring, and control problems, the use of new hardware and software facilities, and recourse to data processing and compilation methods.

*In Russian, object is a generic term connoting a physical quantity, phenomenon, process, plant, or controlled system — Translator.]

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The interface embodies six groups: group 1) digital object-control systems; group 2) analog (usually electrical or radio) signals needed for object monitoring and control; group 3) S/A analog signals transmitted from sensors (S) to actuators (A); group 4) A/S (actuator-to-sensor) digital signals; group 5) analog signals from or to transducers/converters; group 6) digital signals from or to transducers/converters. A specific system can be any combination of these signals.

Group 1 is designed to control the operating regimes of the object and the retrieval of data on its parameters and state. With this purpose in mind, the existence of functionally complete digital control in the object makes it possible to exclude from the GPAS system all components except the second interface; aspects of the solution of this problem will be discussed below. On the other hand, it is obvious that a built-in measurement, monitoring, and control system cannot exist without sensors and actuators located at various points of the object. In the presence of sensors, actuators, and other electrical analog signals this information must be digitized, accessed, selected, and processed. Consequently, all components of the GPAS system are operative, and built-in functionally complete systems, being a special case of GPAS systems, cannot be treated separately. If digital control does not encompass all operating regimes of the object and if additional sensors, etc., are required, protocol and interfacing are best confined to one of the standard interfaces used for signals of group 4 or 6 to maintain a high level of unification in the internal design of the GPAS system. Nowadays the digital control of an object is not usually functionally complete and is implemented by extremely diverse methods ranging from computer bus interfaces (MPI, Q-bus) to the most elementary forms (IRPR, IRPS).

Group 2 comprises input signals for determining the state of the object and output signals for the generation of drivers, reference values, etc. The majority of objects have a set of check points at which measurements are performed to obtain a certain volume of information about the object, for example, the parameters of channels and electrical networks, frequency and time characteristics, etc. Not to be overlooked is the use of normalized analog signals generated within the GPAS system. They are usually radio signals simulating the external environment. A detailed analysis of the inventory of analog signals of group 2 or their ranges and error limits, based on an investigation of all objects, is not required, because it would merely corroborate the obvious result: GPAS systems must be used in conjunction with different types of measuring devices. Measurement techniques can have two alternative modes of execution within the scope of GPAS systems (including switches): remote-controlled stand-alone instruments using the world's most popular interface HP-IB (IEEE-488) or instruments using computer printed-circuit boards (cards, modules).

Switching hardware is the only topic of discussion pertinent to the first alternative, since this area is encumbered with a host of factors that diminish the technical specifications of the system, viz.: degradation of the metrological characteristics due to the onset of additional errors in the measurement channel; degradation of the operational parameters (especially reliability) due to the short service life, rapid aging, and wear of mechanical relays; increased complexity of measurement, monitoring, and control algorithms because of the need to allow for signal attenuation processes in the switching elements and readjustment of the switches prior to each new measurement; reduction of efficiency on the part of the system by a factor equal to the number of switch channels. The most promising approach, therefore, is to minimize the number of stand-alone and single-card switches in the GPAS system by constructing multichannel instruments and (or) implementing the "contact-making tester" concept.

Single-card instruments (the second alternative) are used extensively in Russia and in other countries. For example, a set of modules in the interface Multibus [1], Lomikont [9], MicroDAT [10], etc., are manufactured on the basis of CAMAC (Computer Application to Measurement and Control), KASAK [8], and KARAT. The Recording Systems Division of Gould, Inc., manufactures 13 modules for IBM PC AT/XT [11].

The advancement of this direction in measurement engineering is under constant criticism [12], yet constantly moves ahead. For example, a new analog-to-digital converter (ADC) card with self-calibration software is available. Adjustable components using an ADC card no longer exist [13]. The expansion of the assortment of different auxiliary circuit boards at a cost of $400 to $1000 for computers supports the tendency to use personal computers in industry (shops, etc.) [14]. Data-

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Fig. 1