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Contemporary Methods and Devices for Automatic Measurement*

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A problem of the automatic measurement

In scientific and development work, during laboratory research and design of technological processes control systems, are already widely used computer based systems for automatic measurement. These types of systems realize data acquisition, data processing, and representation of the measurement results. It's very difficult to imagine the contemporary system for automatic measurement, without been equipped with computer devices. It's offered a great variety of measurement systems, which have the potential to store information or have standard interface for connection to PC, giving options for transfer and storage of data arrays.

Modern technologies allow creation of multifunctional measurement systems, built and based on personal computers and additional input-output transfer devices, conditioning and signals processing. For last years, more and more companies, developing measurement products and equipment, like National Instruments, Analog Devices, Texas Instruments and many others, orient to design and production of specialized measurement modules for entirely or partly integration in PCs. Some of the described above companies offered software and hardware resources for automatic measurement, modeling and control find wide application in different industrial areas, scientific research works and education.

Used hardware devices include also practically all types of components of modern measurement - control systems: universal modules for data acquisition; displaying of analog and digital signals; multimeters; generators; measurement controllers; PCI, USB or Ethernet bus compatible devices and so on.

Used in practice concept of virtual devices allow significant extension of function designed measurement systems, combined at the same time with simultaneous reducing of the degree of labour-consumption of their development .

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Each problem, relevant to measurement, can be considered as a sequence of logical operations (Fig. 1): DATA ACQUISITION DATA PROCESSING RESULTS PRESENTATION.

Each task relevant to measurement includes multiple operations, whose automation significantly simplifies and optimizes the measurement process.

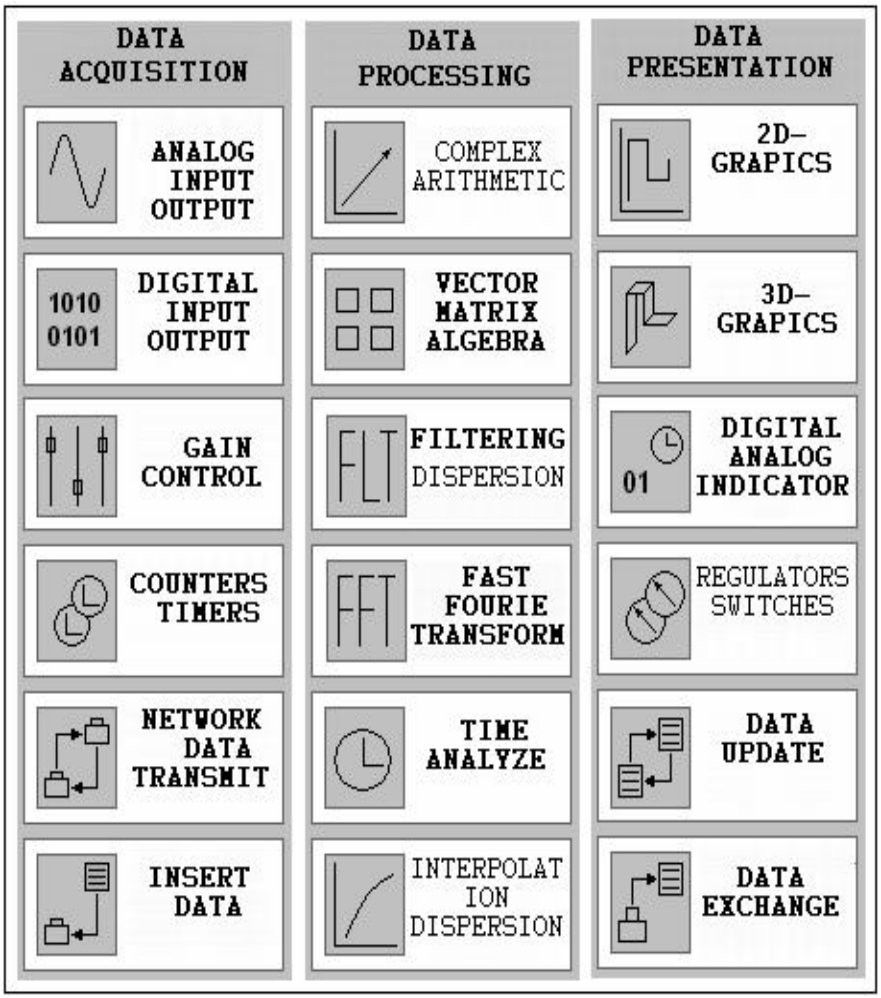

Fig. 1. Schematic structure of the tasks of measurement

Variety in solutions of problems, relevant to measurement

About solution of standard tasks, relevant to electric signal parameters measurement it is used amount of programmable devices: voltmeters, oscillographs, generators, spectral processing software, recording devices and others.

About solution of problems, relevant to concrete measurement requirements, companies offer development works, which allow the building of multifunctional

programmable measurement systems. In fact those development works represent systems, which respond to the requirements, connected with the concrete specific measurements. Such a measurement system realizes information acquisition and processing, as well as presentation of the measurement results.

Using specialized software (LabVIEW, ZETLab-Studio and others.) it can be created programs for data acquisition, processing and control of peripheral devices. Programming can be realized by the specialized graphic user interface software as well as object oriented programming languages – Visual Basic, Visual C^{++}, Delphi, implementing application modules and library files. It is offered many software modules, component and libraries, which users can implement in their concrete applications. Each software module is based on the concept of simultaneous work of many programs and their optimal use.

Automatic measurement system development

The development of the automatic measurement system is advisable to be realized on base of a certain company software packet, offering all necessary resources, integrated by automatic measurement systems universal methodology. Many different programs are being offered for virtual devices realization (devices-software modules) with common purpose: voltmeters, frequency meters, oscillographs, recording devices, analyzers, correlation modules, function generators, low-pass and high-pass filters, nonlinear distortions meters, amplitude phase-frequency characteristics, lock-loop generators and others. Measuring and test stend are designed on base of these devices. All virtual devices-software modules can work in real time as well as beforehand stored data files processing.

Signal registration and replaying devices allow a defined signal to be processed using different types of algorithms. This significantly reduces development and test time period. Some different input-output devices can be used on a personal computer. In this way, multi-channel ADC can be used for slowly changing signals and highly productive ADC – for fast changing signals. By connecting few computers in a local area network it's possible for them to work simultaneously to a measurement tract.

All virtual devices can store measured values in file for post processing and analyze. The user has many possibilities to manipulate data – read from and write to disk, transmit via network, printing and plotting. The final results can be easily and quickly edited by Microsoft Office software.

Some of the possible resources, on which base can be designed automation measuring system, are shown on Fig. 2.

They can be: desktop computer systems; portable data assistants (PDA); portable computers (Laptops), free programmable gate areas devices (FPGA); intelligent industrial "man-machine" integrating interface touch panels; compact module structures – programmable logic controllers or standard interface controlled stand-alone measuring modules – CompactPCI, CompactRIO, CompactDAQ and others. Measurement controlling specialized software packet communicates with described devices by relevant software drivers.

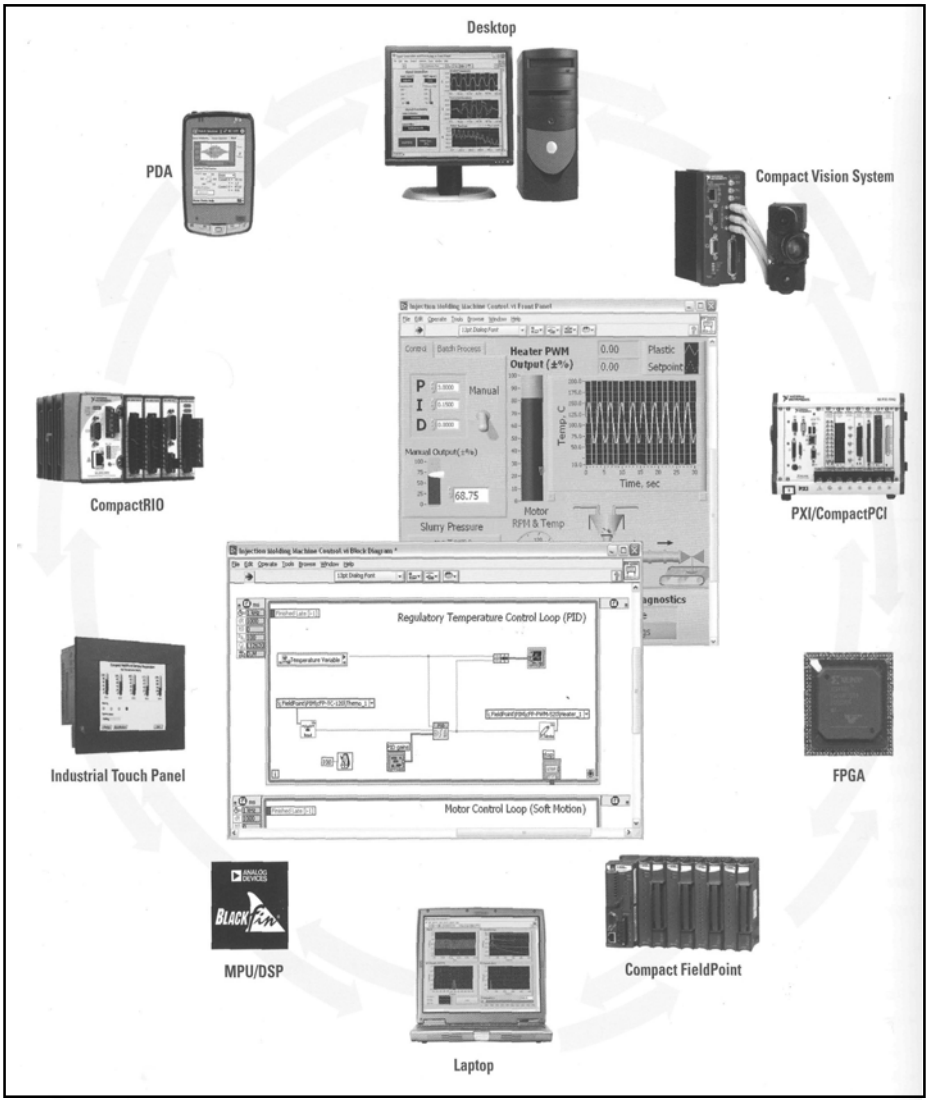

Fig. 2. Building devices for automatic measurement system

Virtual device design

Through the medium of companies' software packets, it's possible to create a virtual device program on its own, using some of the famous graphic or object – oriented programming languages. In the user's program can built in different software components, corresponding to:

- Input-output analog and digital data;
- 2D and 3D graphical visualization;
- X-Y graphics;

- Polar coordinates graphics;
- Integral equations;
- Digital indicators.

In the user program can implemented also standard object oriented programming language components like: buttons, text blocks and many others. Executable code of the program is received after compilation using full performance of the computer and giving possibilities to distribute executable files without reveal source code of the program. The final software product can have individual graphic interface and can use it equally with main software packets.

It is possible user's applications, which are controlled and helping data acquisition by virtual devices to be realized. In this case, metrological attestation of the described designed measuring system is significantly optimized. A control and automation module is used for creating of its own applications and for existing programs control.

An example of multi-channel data acquisition module development

The design principle is going to be described by an illustrative solution, which represents design of a specialized multichannel module for measurement up to 10 analog inputs, intended for PC-based data acquisition system integration. Signal processing specialized electronic modules outputs from primary sensors are associated to module inputs by external passive terminal block.

Described technological solution uses common analog-to-digital converter (ADC) and input channels multiplexing. In this case, each channel measurement speed is reverse to the measured channels number.

Channel measurement speed is basically defined by ADC time convert. The smaller measurement time can give more measured values of the input signals and possibility of more accurately representing, visualize and mathematical processing.

The analog inputs cover standard measuring voltage and current ranges. During the experiments it is not expect active intervention and control from the module and because of that is not realized analog functional outputs. Additional discrete inputs are added to synchronize the measurement process to externally doings and signals. Standard PC interfaces and functions can be used for additional communications.

The measurement module is not provided with additional functional inputs and outputs (frequency, counters, timers and others).

Main module technical characteristics are:

– analog inputs – 10 differential, ranges – 0/+10 V; 0/–10 V; –10 V/+10 V; 0–20 mA;

– accuracy convert – 12 bits (including sign bit);

– converting time – 200 ms per input point;

– discrete inputs – 4 (12 V max, opto-insulated)

Base measurement module connection block-scheme with additional external modules is shown on Fig. 3.

The measurement module (1) presents ISA-based PC extension board. It consists 12-bits analog-to-digital converter (ANALOG DEVICES) with incorporate precise stable voltage source; 16-channel input multiplexer for switching over input signals; precise operational amplifiers; "simple and hold" – integrated circuit; fast optocouple for galvanic insulation from CPU mother board; interface buffers for address and

data buses and ISA control signals. By an external passive terminal board (2) the outputs of sensor signal conditioning modules can be assigning. There is possibility for hardware configuration of the inputs like voltage or current as well as differential or nonsymmetrical.

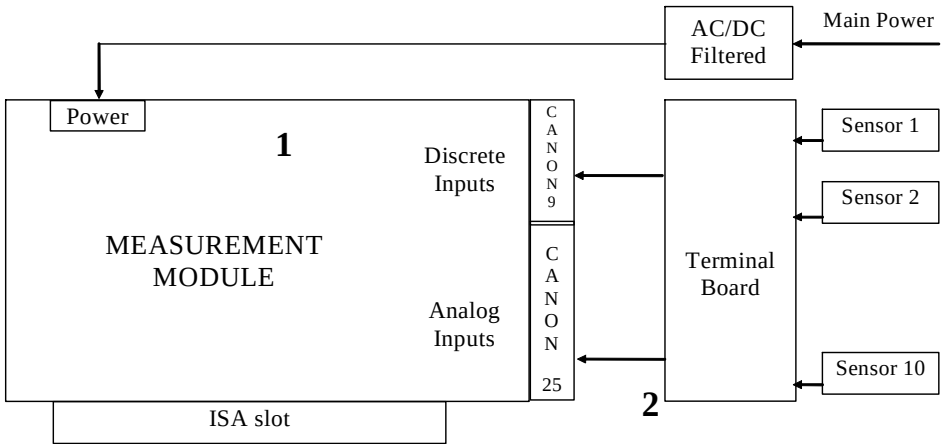

Fig. 3. PC-based measurement module block-scheme

Module configuration settings and control is described below. By premeditated configuration, conformable to concrete measurement process, it can be ensured flexible module control by software. All type of measurement and parameters can be described in text initialization file. All configuration parameters can be differentiated in two groups – common and own of the inputs.

Main setting parameters are:

– *data file* - DATAFILE.DAT, used to store the measurement data;

– *Total Measuring Time* (TMT) and *Total Waiting Time* (TWT). Total Measuring and Waiting Time intervals are up to 5 (respectively TMT1,...TMT5 and TWT1, ... TWT5) and describe up to 5 consecutive measurement "cycles". Total measuring intervals have to be considered with quantity of data to be stored for all measurement process and available computer memory.

– *Scan Time* (ST), is defined by multiplying the number of measured inputs and channel measurement time.

Fig. 4 shows the described time intervals.

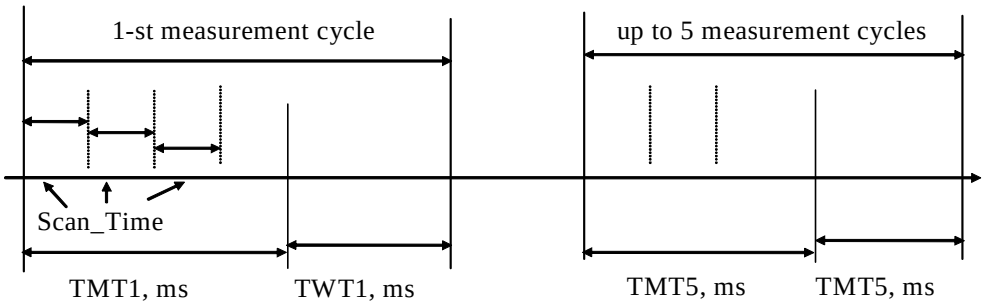

Fig. 4. Temporary time intervals scanning illustration

In configuration text file, each one of the ten channels has its own setting sequence. Variables are described below by the order of their assignment:

Point Number (PN) is a value between 0 and 9, describing the point number, which is referred to the setting sequence.

Group Number (GN) is a value between 1 and 10, describing which group the relevant input points had been associated with. This configuration parameter is used in order to measurement of some of the points to start at such measurement conditions, different from others points ones.

State Measure (SM), is used to permit/ forbid the relevant point scanning.

State Trigger (ST), is used to permit/ forbid relevant point triggering. Its level is described by additional parameter.

State Graph (SG), is used to permit/ forbid the relevant point visualization by a graphic visualization program.

Trigger Value (TV) is a value, considered with the relevant selected measurement range, describing the signal level, at which to start measurement .

Trigger Mode (TM) is a flag indicating what type of edge will be examined reaching the triggering level.

Trigger Function (TF), is used to describe the type of logical sequence a certain group points triggering conditions are combined.

Pretrigger Time (PreTT) is a parameter, describing the time interval, before trigger moment, about recording the relevant point signal pre-history.

Posttrigger Time (PostTT) is a parameter, describing a recording time interval, after the trigger moment.

Input Measuring Time (IMT) is a parameter, describing the relevant point measurement duration, after which the trigger condition had been set in.

Point measurement time interval must be considered with total measurement time intervals, which have greater limit priority.

Letter Physical Phenomena (LPP) – a text, describing the type of physical signal, measured at the relevant point.

Dimension – a text, describing measurement unit on the graphical visualization of the stored data, for example: [V], [A].

Signal Conditioning (Coef) is coefficient, used to recalculate the measured point signal values before their storage as data in referred data file. This parameter is used, also in order to additional setting the coefficient of the full input signal tract.

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Современные методы и средства автоматизированного измерения

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(Р е з ю м е)

Описываются современные методы для автоматизации измерительных процессов на базе персональных компьютеров и дополнительных устройств ввода-вывода сигналов. Приведены примеры построения виртуальных устройств и компьютерной системы автоматизиранного измерения, реализирующая сбор данных, обработку сигналов и представление результатов.