Universal Opto-electronic Measuring Modules in Distributed Measuring Systems

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Abstract - **Large or long objects require measuring systems as a combination of more than one measuring instrument. In this case the combination of instruments is a network system consists from several measuring modules and one central module.**

Measuring modules make the preliminary computation of measuring information and translate it to the central module for final computation of measuring parameters. The central module also makes statistics of measuring and archive of information. Some tasks require the noncontact methods of measuring angular and linear coordinates of objects or places.

The opto-electronic measuring devices (OEMD) are ideal for these purposes. These devices also have other advantages like great precision, calibration and adaptation. In this article variants of the distributed measuring systems are described. The basic attention is given to the description of the unified opto-electronic modules for measurement of angular and linear coordinates.

Keywords – **Opto-electronic measuring system, distributed measuring system.**

I. Introduction

Large or long objects require measuring systems as a combination of more than one measuring instrument. In this case combination of instruments is a network system consists from several measuring modules and one central module. Measuring modules make the preliminary computation of measuring information and translates it to the central module for final computation of measuring parameters. The central module also makes statistics of measuring and archive of information.

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II. Statement of the Task

The solving of several problems is required for creation of the distributed measuring system:

- The information from all modules should be unified and submitted to the uniform communication protocol,
- The volume of the data transmitted through the interface should be minimal,
- Measuring modules, if possible, should be unified, interchangeable and easily adjusted,
- General synchronization of measuring modules should be in measuring system,
- The central module should carry out calibration and adjustment of measuring modules and all system,
- Reliability of system should be provided with reservation of elements of system and use of alternative circuits of measurement,

The task can be solved by the analysis of block diagrams of measuring systems, and also their separate measuring modules constructed on principles of opto-electronic instrument making.

III. Block Diagrams of Distributed Opto-Electronic Measuring Systems

The generalized block diagram of two-level distributed opto-electronic measuring system is present on fig. 1. The system consists from N measuring modules connected to the central measuring module by the general communication interface. In this case each module working independently, carrying out measurements according to purpose of each separate module. Results of these measurements are sending to the central measuring module which makes general processing of the measuring information.

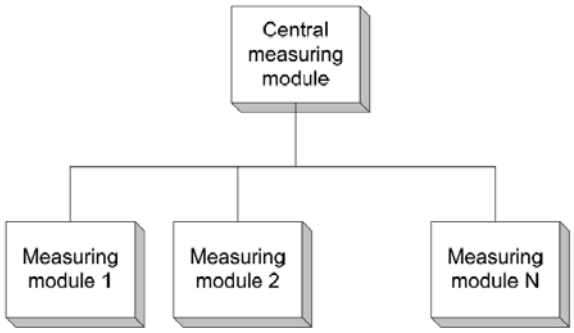

Fig.1. Block diagram of simple distributed opto-electronic measuring system

This structure of distributed measuring systems is the most simple and prevalent. But it has some lacks which limit its application:
- There are no local connections between separate measuring modules,
- Modules of only one type are used,
- There are no auxiliary modules for supporting process of measurement.

Block diagram shown on fig. 2 is more complex, but it provides more flexibility. Measuring modules according to this diagram can be of several types which provide different functionalities, accuracy or speed. Some modules can provide local measurement tasks by using local interface. There are auxiliary modules for supporting measuring process.

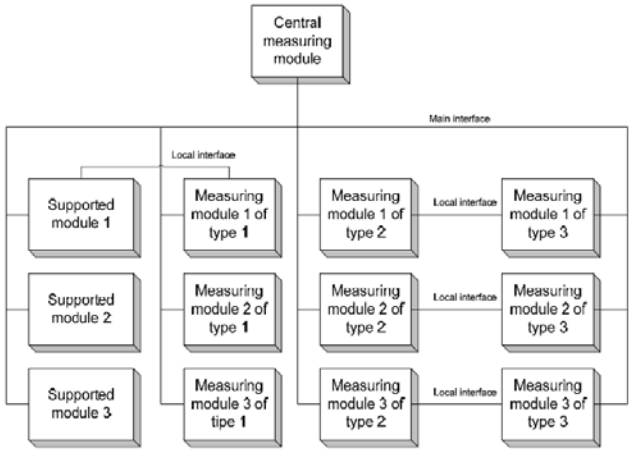

Fig.2. Block diagram of advanced distributed measuring system

IV. Structure of the System

The family of the unified measuring modules is developed for the distributed measuring systems at Department of optoelectronic devices and systems.

The modules which are included in distributed opto-electronic measuring system are divided into three basic types:
- Two-coordinate measuring modules based on a matrix photo sensor,
- One-coordinate modules based on linear photo sensor,
- Auxiliary modules for management of brightness of sources and working of executive devices.

All these devices have RS-485 interface. It allows to construct the system consisting of 32 addressing devices with expansion up to 256 devices with length of interface up to 1200 meters. The block diagram of the two-coordinate module is present on fig. 3.

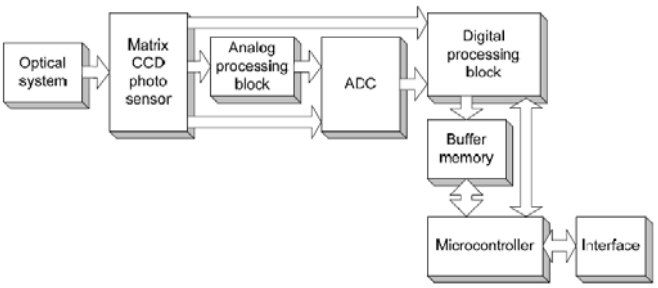

Fig. 3. Block diagram of the two-coordinate module.

The structure of the device includes the optical system focusing the image of measured object on a photosensitive surface matrix CCD photo sensor, the block of analog processing of video signal, ADC, the block of digital processing, buffer memory, the microcontroller and the interface of communication.

The block of digital processing based on programmable logic matrix. Buffer memory is a static RAM. Its volume corresponds to one field or frame of the television image. The microcontroller provides data processing and communication with the central module by means of the interface of communication. Measurements of angular and linear coordinates are made as an estimation of small size image's position in module's instrumental coordinate system. The central measuring module provides subsequent recalculation to the general system of coordinates.

The basic algorithm of coordinate's calculation of small size objects is the weighing method. Calculations of coordinates can be carried out by either the digital processing block or the microcontroller. The calculation by the block of digital processing can be made in real time according to the frame rate. The block diagram of other variant of the two-coordinate module is present on fig. 4.

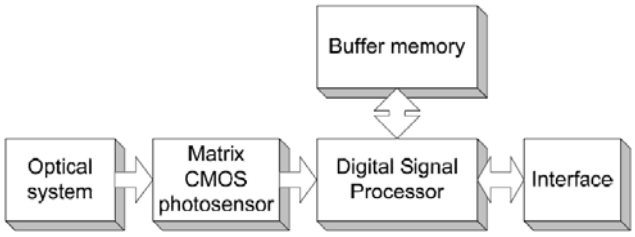

Fig.4. Block diagram of the two-coordinate module, based on CMOS photosensor.

This module use CMOS matrix photo sensor. The block of analog processing of video signal and ADC are integrated into a crystal of the CMOS photo sensor. As the embedded controller the high-speed digital signal processor with the integrated video port is used. In this case separate buffer memory and the block of digital processing are not required. Integrated peripheral devices of digital signal processor perform these functions. The module corresponding to this diagram has several advantages:
- CMOS photo sensor has higher resolution in comparison with CCD (up to 8 MPixels),
- Digital signal processor has higher speed in tasks of processing of a signal, in particular, video signal. In this case it is possible to use more perfect algorithms of coordinates measuring, for example, a least squares method,
- use of adaptive methods of searching and tracking images of objects due to advantages of embedded peripheral devices of CMOS photo sensor and digital signal processor.

The block diagram of the one-coordinate module presents on fig. 5.

The main part of this module is a linear CCD with analog output, connected to ADC. Digital signal is read by microcontroller and is put into the buffer memory. One-coordinate task is simpler. In this case, microcontroller provides calculation of coordinates and interface function.

Sample rate in the one-coordinate module is higher, than in two coordinate module. Coordinate accuracy is higher due to large format of linear CCD (about 10400 pixels).

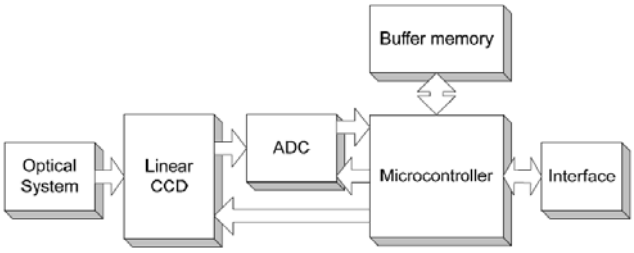

Fig. 5. Block diagram of the one-coordinate module.

There are two types of supported modules designed for distributed measuring systems. One of these modules is a module for management of brightness of sources, such as LED. Block diagram of this module presents in fig.6a. Microcontroller provides interfaces functions and controls built-in pulse-width modulator. Another module, presented in fig. 6b, provides the work of up to three stepping motors.

V. Operation Modes of Distributed Measuring Systems

The considered systems have several operating modes for message transfer on the communication interface:
- Mode of calibration and adjustment. In this mode the full frame or line transmits to the main module,
- Mode of capture of realization and the measurements in internal system of coordinates,
- Mode of transfer of the results of measurements,
- Mode of synchronous capture of realizations and the subsequent measurements.

All modes, except for the last, use the address reference to each module. The last mode uses commands for all modules simultaneously.

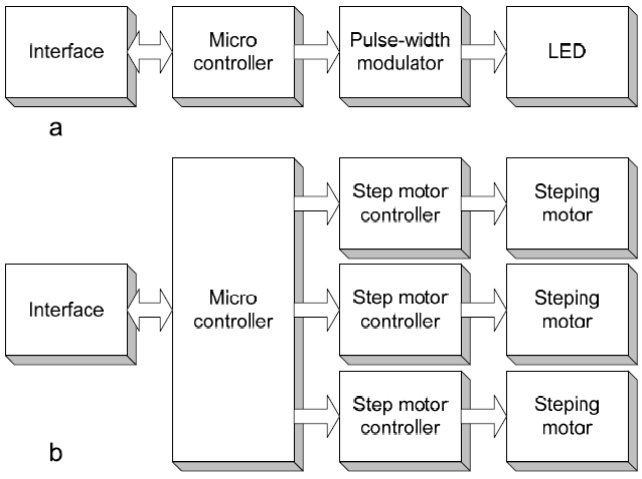

Fig.6. Block diagrams of supported modules.

V. Examples of Distributed Measuring Systems

The distributed systems are intended for solving of metrological tasks of large and long objects. These objects demand constant or periodic measurements of linear or angular positions of control points. And these points make a uniform measuring circuit.

The following applications are investigated at the Department of opto-electronic devices and systems:
- The control of position in large-sized shaft of turbines in power engineering,
- Measurements of a deflection of dimensions of large ships at their repair in docks,
- Measurements of deviation of a rail way of railroad tracks,
- Measurements of position of elements of the antenna of a large radio telescope.

In all listed applications increasing of efficiency of measurement is achieved. Accuracy of the angular and linear measurements made by opto-electronic methods is increased.

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