A Sensors Kit for a Versatile Reconfigurable Measuring Platform

Y.I. YAKIMENKO, A.V. BOGDAN, A.I. ZAZERIN, A.T. ORLOV, V.M. SPIVAK
National Technical University of Ukraine "Kiev Polytechnic Institute", Kyiv, Ukraine

***Abstract* — A new flexible, low-cost measuring platform, containing lightweight, small size and low-power intelligent ad-hoc sensors has been presented. By a sensor platform we mean one employed in monitoring changes in its surroundings. This network was designed for use in a number of different applications, including environmental, chemical, biological and climatic monitoring.**

***Index Terms* — intelligent sensors, data logging, signals analysis, environment monitoring.**

I. INTRODUCTION

Design of capable of reconfiguration, customization and seamless integration into an educational, scientific and, in some cases, industrial area networks for ecological, biomedical, physical and climatic monitoring applications presents one of the most challenging tasks for system designers. To give answer to this challenge we propose a reconfigurable sensor platform featuring a wide set of intelligent sensors connecting to a low-power microcontroller, ADC and signal conditioning circuitry. To provide system's software flexibility we propose National Instruments development environment which allows one to create clear and transparent modifiable program structure. Another advantage of this approach is faster development time [1]. The core software manages communication, data logging, sensor addressing, identification and calibration, run-time error checking and diagnosis.

As the sensor network is employed in a variety of different places, some of these application areas cover a broad range of objectives. The applications range posed unique usability, functional and adaptability requirements which could not be met by existing measuring and monitoring platforms, and therefore motivated the design of new platform. The proposed solution promises a cost-effective, flexible platform that allows easy customization, updatability, run-time reconfiguration, energy- and performance-efficient communication, computation and signal processing. The distributed structure is introduced because the sensing abilities are realized in parallel. Data from all ad-hoc sensors are simultaneously transmitted to the central data acquisition and processing unit, providing a complex environment image comprising many parameters. The design allows tests that traditionally take several hours of laboratory time to be performed in minutes.

II. MEASURING PLATFORM COMPONENTS

Sensors are produced with MiniDIN8 consistent interface to a suitable data logging or network control system. Except the wired solution, one-dimensional sensor network may be connected via wireless using appropriate device (Fig. I). This feature allows user to experiment with premises located in different outlying places or, for example, to make experiments with sensors that are placed outdoors (this is primarily climatic, environmental, biomedical researches) [2]. Wireless data logger device operates in the unlicensed 434 MHz ISM frequency band and allow data acquisition from sensors at distances up to 300 meters of sight or through 1-2 concrete walls.

Fig. I. shows the functional diagram of measuring platform: 1 – array of sensors M_1-M_n,2 – data acquisition unit, 3 – data commutator, 4 – signal conditioning unit, 5 – transceivers.

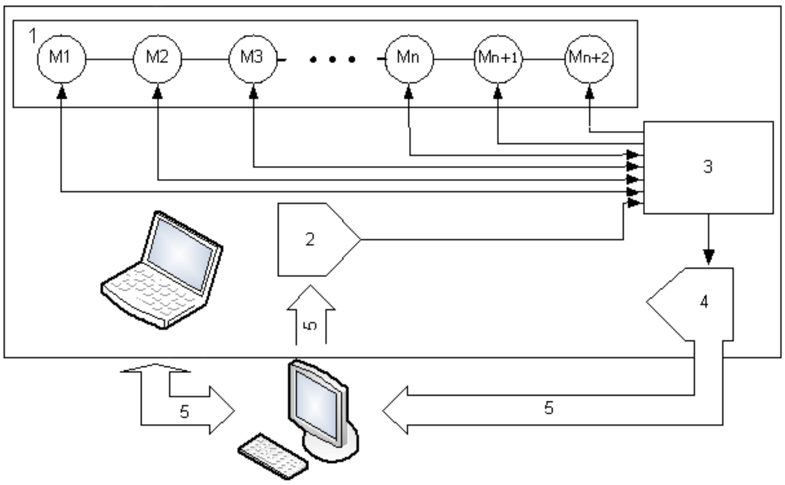


Fig.I. Operation principle.

TABLE I. SET OF SENSORS

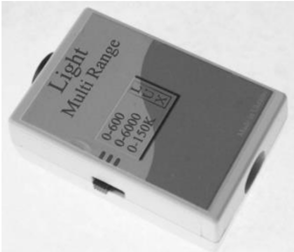
<table>
<tr>
<td>Light sensor DT009 (Fig. II)
A precision multi-purpose and multi-range light sensor with high-speed sensing element. Have three ranges of measurement: 0-600 lux, 0-6 Klux, 0-150 Klux. It was designed to work indoors and outdoors.


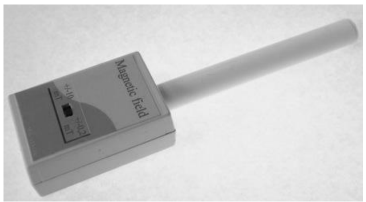
Fig. II. Multirange light sensor</td>
<td>Magnetic field sensor DT156 (Fig. III)
The sensor has two ranges of measurements. Range with low sensitivity is designed for measuring of magnetic fields of solenoids and permanent magnets. A range with high sensitivity designed for Earth’s magnetic field explorations.


Fig. III. Magnetic field sensor</td>
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<td>Distance sensor DT020 (Fig. IV)
It measures distance from the sensor installation to the object. Data logging speed of this device can reach 50 measurements per second, which allows to use it in monitoring moving objects.

Fig. IV. Distance sensor</td>
<td>Temperature sensor DT029 (Fig. V)
This simple and reliable sensor is designed to measure the temperature of water and other chemical solutions with an accuracy of ±1 ºC. The sensitive element has a protective cover. Measurement range -25..+110 ºC.

Fig. V. Temperature sensor</td>
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<td>Temperature sensor DT025 (Fig. VI)
It is a sensor with K-type thermocouple is used as a sensitive element with measurement range 0-1200 ºC. This is extremely sensitive sensor that has an error less than 2% on the entire range of measurement. It is used primarily for measuring high temperatures, simple monitoring od drying cabinets etc. High accuracy and reliability of this sensor aloows to use it in industrial and scientific applications.

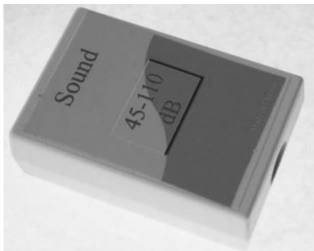

Fig. VI. Temperature sensor</td>
<td>Sound level sensor DT320 (Fig. VII)
Sound level sensor measures the amount of audible noise in decibel in range of 45-100 dB. It is ideal for measuring the level of surrounding noise and acoustic characteristics of the room. The sensor contains a special filter for filtering electrical voltage interference from the supplying circuit. It has three ranges of amplification, which switches automatically, providing convenience and flexibility of use.


Fig. VII. Sound level sensor</td>
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Voltage sensors DT001-DT003 (Fig. IIX)
This differential type sensor is capable of measuring voltage at any current direction. It was placed in a plastic body and equipped with two solid plugs that simplify a connection to an electric circuit. Sensor has a symmetrical input and, therefore any number of voltage sensors can be connected to a circuit without causing a short circuit condition.

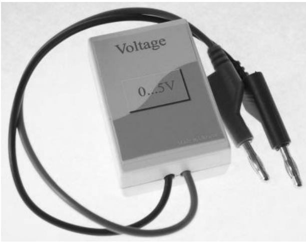

Fig. IIX. Voltage sensor

Current sensor DT005-006 (Fig. IX)
Sensor is designed to measure amperage. It's a differential type sensor capable of measuring the current flowing through it in any direction. Sensor placed in a plastic body and equipped with two solid plugs that simplify a connection to an electric circuit. It has no grounding.

Fig. IX. Current sensor

Microphone sensor DT008 (Fig. X)
This sound sensor is designed to measure sound wave oscillations in 35-10000 Hz frequency range. It is placed in plastic body and not intended to control the sound level.

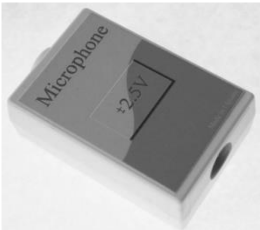

Fig. X. Microphone sensor

Pressure sensor DT015 (Fig. XI)
Pressure sensor is designed to measure absolute pressure of gases. It is usually used for environment monitoring or, for example to study gas laws. Measurement range 0-700 kPa.

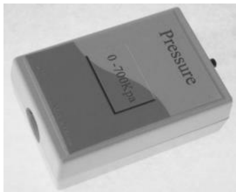

Fig. XI. Pressure sensor

Humidity sensor DT014 (Fig. XII)
The sensor is designed to measure relative humidity. It is placed in plastic body and has adjusting screw for zero seting. Measurement range 0-100%.

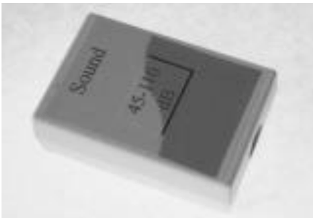

Fig. XII. Humidity sensor

Force sensor DT272 (Fig. XIII)
The sensor is designed to measure applied force. It must be mounted on tripod or moving cart. User can also use it as a hand-held spring scale. It has two measurement ranges: ± 10 N and ± 50 N.

Fig. XIII. Force sensor

Rotation angle sensor DT148A (Fig. XIV)
The sensor is designed to measure various displacements of registered objects. It measures the angular deviation from the desired direction.

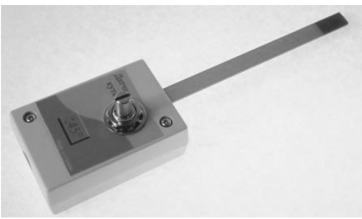

Fig. XIV. Rotation angle sensor

Photo-gate sensor DT137 (Fig. XV)
This sensor is designed to measure the passage time of moving objects. It can be used in a variety of applications.

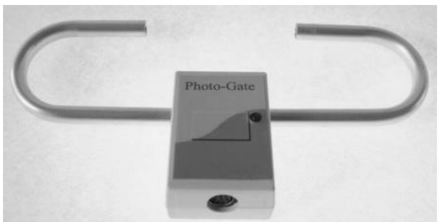

Fig. XV. Photo-gate sensor

A table above contains a short enumeration of constituent components of measurement platform, which allows the user to create any combination of physical quantities meters. All components are characterized by a small size, low electric power consumption when powered from USB interface, low transmitter power (10mW) and high receiver sensitivity – less than -110 dBm, allowing the acquisition of data at distances up to 100 meters.

Fig. XVI. shows data logger. This is simple device, that has four inputs expandable up to eight inputs with analog multiplexer connected to analog-to-digital converter. Connection to a PC is provided via USB 2.0, no need for additional power supply. Sampling resolution of data logger is 12 bit, analog sampling rate is 20 kHz.

Fig. XVI. Data logging unit

As the primary transducers of physical values smart sensors the developed at the Microelectronics Department of NTUU “KPI” MEMS sensors on silicon membranes have been used [3], and as a means of self-calibration and normalization of the signal- SoC from various IC producers.

Received data is displayed in a specialized software DOSLID (FIG. XVII), which provides a variety of functions including data acquisition management, displaying system status and parameters, functional and mathematical processing of captured data, saving and transferring results to other applications for further processing [4].

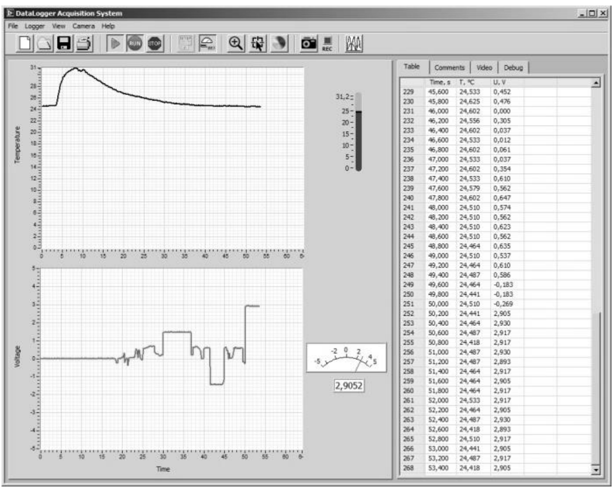

Fig. XVII. Data acquisition software

III. CONCLUSIONS

Due to the large number of different sensors of physical quantities, it is a sort of constructor that allows assembling any combination of required sensors, and therefore applying the system in a variety of areas: starting from education and finishing by industry.

In particular, the presented measurement platform provides the possibility of creation a flexible, distributed and versatile environment monitoring network. The features of hardware architecture and software environment make this platform an extremely flexible and easily customizable.

Using of integrated primary transducers and modern electronic components for our sensors also allows us to offer cost-effective solution for the modernization and creation of new laboratory equipment.

Developed system was successfully tested in Industrial and Economic College of National Aviation University with support of Institute of Information and content of education, Ministry of Education, Science, Youth and Sports (new series of laboratory courses in Health Administration), the Institute for Energy Saving and Energy Management (IEE) within the National Technical University of Ukraine “Kiev Polytechnic Institute” (upgrade of the laboratory courses).

IV. PROSPECTS FOR IMPLEMENTATION AND DEVELOPMENT

It is planned to implement the presented solution in a number of universities with I-IV accreditation levels and Junior Academy of Sciences of Ukraine.

Prospect of development include extension of number of biomedical, climatic and electrical sensors, development of new data processing and analysis functions, implementation of connection with mobile telecommunication and computing devices such as iPhone, iPad etc [5]. Another side is the development of features for adding new sensors, their communication algorithms and data processing functions without being tied to cumbersome and complicated software development environment. For example, it can be implemented by using a special subroutine or an external file with parameters.

ACKNOLEDGEMENT

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