VIRTUAL INSTRUMENTATION AND RECONFIGURABLE TECHNOLOGY ON WATER QUALITY SENSOR CALIBRATION SYSTEM

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Abstract

This paper presents an application of LabVIEW graphical programming and FPGA technology in the area of sensor calibration. A water quality sensor calibrator based on compact reconfigurable FPGA core that works under a real-time controller is described. The system provides automatic calibration of stand alone sensors such as turbidity, pH or conductivity using different calibration solutions that are injected in the calibration vessels using a set of pumps and electro valves. The control of the system actuators, data acquisition, primary filtering of the acquired signals and sensor modelling is implemented using the FPGA core included in the compact reconfigurable I/O system. To programme the FPGA the LabVIEW FPGA Module that extends LabVIEW graphical development to reconfigurable FPGAs on National (NI) Reconfigurable I/O (RIO) hardware was used. Parts of data processing, data logging, and data communication are embedded on the real time controller that is connected to the FPGA core through a PCI interface.

1. Introduction

Water is essential to human life and to the health of the environment. Water quality (WQ) is commonly defined by its physical, chemical, biological and aesthetic (appearance and smell) characteristics.
In order to perform the water quality monitoring, different measuring systems including WQ sensors associated with the physical, chemical or biological characteristics have been designed and implemented [1-3]. These environmental sensors require frequent calibrations, which imply the development of field calibration units. The present paper presents a water quality sensor calibrator based on a Field Programmable Gate Array (FPGA) to control the calibration procedures. The FPGA unit is able to communicate with a real-time controller (cRIO-9002) that reliably and deterministically executes the LabVIEW real-time software.

2. WQ Sensor Calibration System

The block diagram of the WQ sensors calibration reconfigurable system is presented in Fig.1.

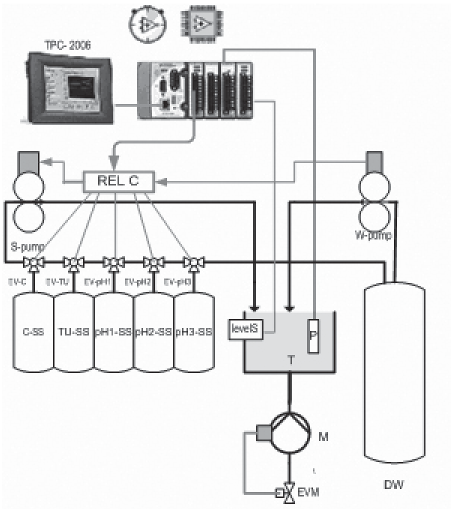

Fig. 1. WQ sensor calibration system block diagram:
C-SS, TU-SS, pH1-SS, pH2-SS, pH3-SS: conductivity, turbidity and pH standard solution vessels; DW: deionised water vessel; S-pump: testing solution peristaltic pump; W-pump: peristaltic pump for deionised water; M: mixer centrifugal pump; EVM: output electrovalve; EV-C: conductivity electrovalve; EV-TU: turbidity electrovalve; EV-pH1, EV-pH2, EV-pH3: pH electrovalves; levels: level detector; P: sensor under test; REL C: relay switching scheme; T: testing cuvette; TPC 2006: touch screen.

The system comprises a set of pumps and electrovalves that permit to perform different tasks such as: (1) realization of the calibration solutions using a mixing procedure; (2) vessels cleaning; (3) used solution storage and (4) continuous injection of the water under test.
The application considers the calibration of pH, conductivity and turbidity sensors (Global water WQ201 WQ301 and WQ770). Two mixing peristaltic pumps (Watson Marlow 102R, S-pump and W-pump) are used to obtain the calibration solution by mixing the concentrated buffer solution with de-ionized water. To inject the calibration solution 3-way electrovalves (Burkert 6014) are used. On the turbidity sensor calibration case a formazine buffer of 4000 NTU is used and for the conductivity sensors a 10 mS/cm KCl conductivity buffer.
Indications of the pumps or electrovalves state or the level sensor output state are acquired using a 8-channel digital input module (CompactRIO cRIO-9423) that also works under the programmed FPGA core control.

2. Calibrator Software

The system software developed in LabVIEW graphical programming language comprises two modules, one to control the hardware and the other to interface with the user using the HMI touch screen TPC-2006. The module to control the hardware includes one application to program the FPGA core and another that controls the Compact Reconfigurable I/O system (cRIO).
The embedded FPGA software is developed using the LabVIEW FPGA module and is responsible for the following tasks: actuators (electrovalves and pumps) control, voltage acquisition, digital filtering of the acquired voltage and water quality measuring channel modelling.
The real time controller software (RTCS) that controls the Compact Reconfigurable I/O system permits: (1) to communicate with the FPGA software component, (2) to perform the conversion of ADC digital codes to voltage values expressed in physical units, (3) to perform data logging and data processing associated with sensor calibration curves, and (4) to transmit calibration data to the HMI included in the system or to a PC.

3. Results and Discussion

Using the above mentioned WQ sensor calibration system and the associated software components, several tests were carried out.
In the case of a five-point calibration of the conductivity sensor (WQ301), the obtained calibration curve is depicted in Fig. 2. Calibration solutions were obtained mixing the concentrated test solution CS (12.856 mS/cm that corresponds to 7.456 g KCl for 1L of solution) with de-ionizer water. Thus and for example, the 1408 µS/cm calibration value is obtained mixing 20 ml of CS with 380 ml of de-ionized water. The pumps and electrovalves are actuated during 3.4 s (S-pump) and 65.4 s (W-pump).

For the turbidity sensor WQ770 (TU sensor), the results are presented in Fig.3.

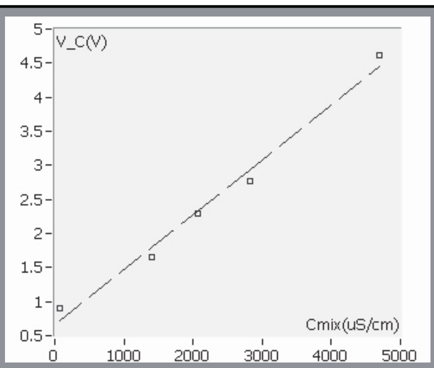

Fig. 2. Calibration curve for WQ301 sensor at 25ºC.

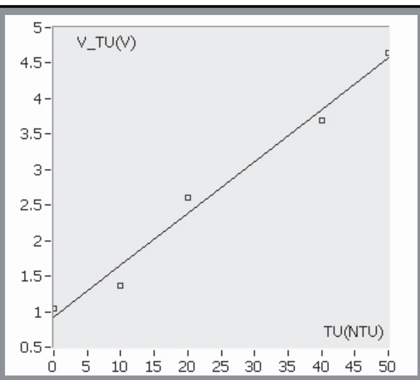

Fig 3. The WQ770 turbidity sensor calibration curve for a set of 5 calibration formazine solutions

5. Conclusion

The sensor calibration system presents a user-friendly interfaced based on a HMI touch screen that is connected to the Ethernet port of real time controller.

FPGA based implementation permits the different tasks (actions) associated with the calibration system to be performed in parallel mode, which implies shorter processing times and accurate. The FPGA core added to a real time controller permits the implementation of advanced processing techniques and data communication tasks not possible with conventional processing devices.

The water quality sensor calibration system has reduced power consumption due to the use of low power electrovalves and peristaltic pumps.

The results obtained show that the sensor test/calibration system is a good solution for water quality sensor field calibration procedures

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A PRACTICAL APPROACH ON WATER QUALITY MONITORING BASED ON DISTRIBUTED MEASUREMENT SYSTEM AND INTELLIGENT SIGNAL PROCESSING

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1. Introduction

This paper presents a set of distributed measurement systems for water quality (WQ) monitoring characterized by different communication protocols (e.g. IEEE802.11b/g, SDI-12). Special attention is granted to the advanced processing of the data acquired from the measurement channels in order to offer best metrology performances for a given hardware using intelligent processing architectures based on neural networks, adaptive neuro-fuzzy inference system and Kohonen maps.

2. Distributed Measuring System

Different distributed measuring systems for water quality monitoring were developed in order to assure higher flexibility, accuracy and mobility. Communication interfaces associated with IEEE802.3, IEEE803.11b/g or SDI-12 were included on the water quality monitoring nodes (RTP1, RTP2) that are connected to the advanced data processing and data logging units expressed by a host computer. Different architecture were designed and implemented on of them presented in Fig. 1.

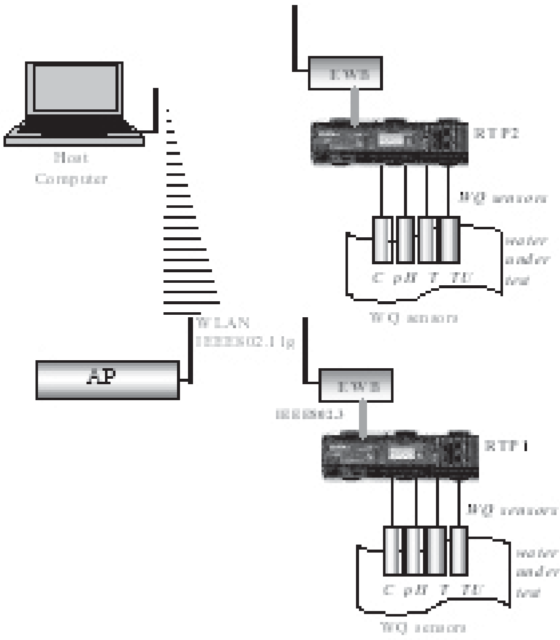

Figure 1. Distributed Measurement Systems for Water Quality Monitoring based on real-time processing unit and IEEE 802.3 and IEEE 802.1g communication protocols (AP-access point E WB-wireless bridge)