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A Low-cost Automatic Water Sampler Equipment

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Abstract: This work aims at presenting an automatic low cost water sampler prototype. Data provided by this equipment can be used in water resources management and control. Prototype has an electronic system which controls a peristaltic pump functioning, five solenoid valves and an ultrasonic sensor that provides water level measurement data. An interface with the user provided by a board and LCD display allows sampling parameters input and a report output when sampling is over. Hydraulic module uses a peristaltic 12V pump connected to five solenoid valves, which distribute sample and clean PVC tubes once each sampling is produced. Storage module contains four plastic bottles, 1.95 ℓ. Prototype structure is made of acrylic, 0.72 m height and 0.38 m diameter. Experimental laboratory runs have showed a successful performance.

***Keywords**:* water sampler; equipment; water quality

1. INTRODUCTION

Water management and control measures implementation usually involves systematic water resources monitoring (Coimbra, 1991). Indeed, monitoring systems are conceived to provide fundamental hydrologic and climatologic data to be used for control and management policies definition. Monitoring involves the acquisition of water resources system data by using a variety of measurement devices (Dick, 1996).

In general, water resources monitoring involves quantitative and qualitative dimensions. In a basin scale, quantitative monitoring involves a systematic fieldwork which may include stream cross section establishment and flow velocity measurement. In this case, the aim is to estimate water discharge in order to generate a database that can provide a discharge-water level relationship (Porto, 2008). Water quality monitoring usually involves a representative water sample collection by using a well accepted methodology. A punctual-based water sample usually involves the collection of a small amount of water that can be considered to represent instantaneously water body characteristics (CETESB, 1987). In general, water samplers can be classified as manual or automatic devices. During the last decade, automatic devices have had a great and revolutionary use, due to the advance of computation and automation sciences. The main advantage of these kinds of equipments is the possibility of program a previous water sample collection in accordance with the user needs. Furthermore, these equipments provide an interface with the user by using a keyboard or PC, where different sampling options, such as time, frequency sample size can be defined. Once sampling procedure is over, a data measurement report (such as water body level) can be provided.

It can be observed the importance of these kinds of equipments in a context of increasing water demands and pollution in developing countries, such as Brazil. Besides, one aspect of great importance is associated with the high cost.

This paper aims to present a prototype that automatically collects water sample from a water body. The equipment has an automated system which controls a peristaltic pump functioning along with an ultrasonic sensor that measures water body surface level. Water samples are stored in four 2-litres polyethylene bottles. A report is generated when sampling procedure is over, which contains water level and sample number as a function of time.

2. MATERIALS AND METHODS

Prototype was built by using a 6 mm thickness cylindrical acrylic structure 0.72 m (high) and 0.38 m (diameter). Equipment is composed by four internal compartments, which can be seen in Figure 1. The microprocessor and the other electronic components were installed at the automated control system, which was fixed at the upper compartment; into the compartment 2, a peristaltic pump, a 12-V battery, electric cables connection and pump tube. Into the compartment 3 it was installed a PVC tube distribution system, which connects the pump to five solenoid valves; their functioning provides both sample distribution and distribution system cleaning. The bottom compartment was designed to fix four plastic bottles used to store the samples. When sampling procedure is over, the access to the bottles can be made by handling the upper part of the structure (composed by the compartments 1, 2 and 3).

The basic equipment was conceived to provide an automatic water sample collection, previously defined by the user. For this purpose, a control system composed by two main components was developed: a) control system and data acquisition; b) sample collection and distribution system. Control system provides an interface with the user by using a keyboard and a LCD. Once sampling procedure is being made, an ultrasonic sensor provides the sampler water level data as a function of time.

Figure 1. Front view of the automatic water sampler.

Electric and hydraulic Connectors

The prototype offers serial communication with a PC, input for an ultrasonic sensor electric cable, input for the battery recharge and a power switch. The intake tube is installed to the equipment and uses a PVC strainer attached to the other end. Furthermore, an outlet tube is attached to the solenoid valve number 5, which is used to clean the distribution system immediately before the sampling procedure. At the bottom compartment, sample bottles are handled by acrylic pieces in order to keep them fixed.

Sampling Operation

The equipment was originally conceived in order to offer the option of programming the sampling operation, which must be established by the user. The equipment offers the following programming options: a) manual sampling operation by the user; b) automatic sampling operation, associated to the surface water level variation. Once sensor is installed, water level is measured and made reference. Water level measurement is made at a time interval established by the user. In an urban basin, the occurrence of storm flow associated by a precipitation event will make the sampling program start. At this moment, before the first sample is collected, pumped water stored into the sampler tube system is pumped out and the system is cleaned. The subsequent sampling times must be programmed by the user. c) automatic sampling operation, associated to a time interval program. In this case, the user must establish the date and time of sampling procedure. For every programming option, the equipment turns off immediately after the operation program.

Commonly adopted for this kind of equipment, peristaltic pump operation is provided by a 12-V electric engine. Suction is made possible when a silicon tube is pressed by two dots in a rotational movement.

The equipment was designed to use five solenoid valves attached to a PVC tube system. Four valves provide sample distribution through the system to the bottles. The fifth valve is used to clean the tube before each sampling collection. Water level records supplied by the ultrasonic sensor can be transferred to an automatic control system and be stored in a datalloger as well as sampling time and date.

Hardware

The hardware of the equipment is composed by the following components, installed in a plate circuit: (a) microcontroller; (b) storage mechanism; (c) clock; (d) ril; (e) command interface; (f) serial communication interface; (g) sensor-controller communication interface. A basic scheme of the plate circuit can be seen on Figure 3.

Ultrasonic sensor

It is composed by a sensor and a circuit installed in a PVC tube (40 mm diameter, 0.2 m length), covered with PVC caps on both ends. The sensor was fixed at one end, while the other end the cable was attached. The sensor must be installed over the water surface at a distance between 1 and 2 m, with its face pointed to the water surface. Sensor is connected to the data acquisition system by using an 8-m length parallel 4-wire cable.

Software

Software development took into account a variety of operation options. Software was developed in C++ language, which allows its operation by Windows platform.

Sample intake mechanism

Sampling procedure is made by using a rubber tube, ½” diameter, 4.6 m length. At one end it was attached a retention valve and a strainer, which aims to prevent solid matter admission larger than 1 cm diameter. Strainer was built using a PVC tube, ¾” diameter, 0.22 m length, punched.

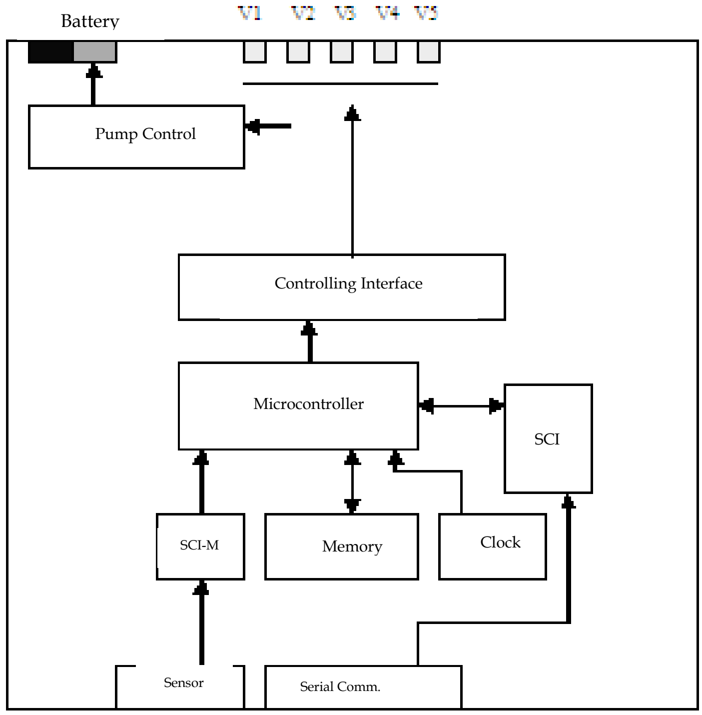

Figure 3. Basic scheme of the plate circuit equipment hardware.

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User-equipment communication interface

Communication interface is an aspect of great importance for automatic equipments. An appropriate interface allows the user a good communication, user visualization and easy operational sampling programming. User-equipment was designed to operate with two mechanisms: (a) membrane keyboard (12 keys, fixed at the top cover); (b) LCD display. Keyboard and LCD display allows accessing the programming menu and defining sampling option. Once sampling operation has been concluded, equipment generates a report containing date, time and bottle number. This file has a text format and can be downloaded to a PC.

CONCLUSIONS

The prototype has been subjected to laboratory experimental runs in order to test its hydraulic and sampling operational efficiency. The purpose is testing its capacity on making the programming tasks. Some adjustments and improvements have proved to be of great concern. One of them refers to an easy exchange of the silicon tube by the user. The cost of the materials used on the prototype development was estimated to be 1,620 american dollars.

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