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Remote Level Monitoring and Control Solution

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Abstract: This work presents a remote monitoring and control solution for a level measurement system. The level measurement system comprises two tanks in a closed loop water circuit, some level transducers, detectors and two actuators. The developed solution is based on microcontrollers and web services. The web interface allows the user to remotely interact with the level measurement and control system.

Keywords: Remote experiments, web interface, embedded system, level control, remote control.

1. INTRODUCTION

The increasing use of computer-based communications and mobile devices makes possible to offer online experimental activities. Remote experiments, being part of online experimentation (Restivo et al., 2013), remotely access a real set-up, which can be monitored and controlled at a distance, through the internet.

Despite the relevance of remote experiments in education (Villa-Lopez et al., 2013; Wenshan et al., 2013; De la Torre et al., 2016) and the remarkable increase of interest and reported works in the area (Heradio et al., 2016), as well as its significance for industrial, research and medical purposes, there still are different problems related with the remote labs features due to hardware and software solutions (Fabregas et al., 2011; Tawfik et al., 2013). At present, another important issue is preparing them for being easily accessed by mobile devices (Štefka et al., 2016; Papadopoulos et al., 2013).

In this context, the set-up described herein has been used not only as a system available for training the topic of level measurement and control but also to be open to the implementation of different solutions for remote access experiments.

In a first stage, a solution combining a PLC for controlling and LabVIEW software for developing the user interface was used. However, this was an expensive approach.

In the present work, an alternative solution based on embedded systems and web services is developed to provide the monitoring and control of the closed loop water tanks system and make it easily accessed by mobile devices.

Therefore, the present set-up for testing level transducers and detectors is a didactic test bench in both perspectives: as a training system and a basis for implementing new solutions for remote access. Different types of level transducers and detectors are available to put in evidence different working principles, characteristics and limitations, in a closed loop water circuit using two tanks and two actuators. The transducer selection has to take into account the adequate ranges for the present tank and to provide very distinct features to force different behaviours. In order to house all the transducers and detectors, the tank dimensions strongly compromise the system dynamics.

Therefore, the controller must be computationally light and also enable the remote control of the fluid level. A control policy based on the use of an on-off controller with dead zone and hysteresis was chosen. All parameters defining the dead zone and hysteresis functions may be selected by the user. The online experimentation of different parameter sets and the observation of their influence on system dynamic behaviour is thus made possible.

An embedded system based on PIC® microcontrollers was implemented for processing and web monitoring all signal information of sensing and actuating systems. The interface of Remote Level Monitoring and Control was made on Easy Javascript Simulations (EJsS) application (Christian et al., 2011) to be easily integrated in a Moodle platform. This integration requires to install EJSApp plug in (De la Torre et al., 2013), which can be combined with the EJSApp booking system resource.

This system is under use to give the students of the Instrumentation for Measurement course (2nd year, 2nd semester of Integrated Master in Mechanical Engineering, at the Faculty of Engineering of University of Porto), the opportunity to contact with an additional type of measurement, transducers characterization and an easy control strategy. During the Demo Session, results of the use of this remote experiment based on a sample of around 320 students will be available.

In the present work, Section 2 describes the workbench, comprising several level transducers and detectors. Section 3 presents the solution adopted for making the system remotely

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available. Section 4 provides details of the control algorithm implemented. Section 5 presents the user interface for remote access to the experiment.

2. THE WORKBENCH

One of the closed-loop water circuit tanks, the upper tank, is visible in Fig. 1. Different working principles of level transmitters (magnetostrictive, ultrasound and differential water level pressure) and detectors (conductive limit switch, vibrating limit switch), as shown in Fig. 1, can be perceived and their performance can be evaluated and compared in distinct perspectives. The transmitters' characteristics can be observed on Table 1, where the dead zones are setup geometry dependent. The detectors present different hysteresis (of the order of 3 and 4 mm) that can also be observed.

Table 1. Transmitter characteristics

Level transmitters	Sensitivity [µA/mm]	Nominal range [mm]	Dead Zone [mm]
Magnetostrictive	53.3	300	0 - 230
Ultrasound	36.3	60 - 500	0 - 44
Pressure	16.0	1000	—

Fig. 1. Level transmitters and detectors workbench.

The system also includes two electrical actuators: an on/off normally-closed (NC) outlet valve and a submersible circulation pump controlled by a DC motor. A flow transducer measures the pump water flow (range: 1.5 to 30 l/min).

3. IMPLEMENTED SOLUTION

The embedded system includes two microcontrollers, in order to achieve a modular solution for two well-defined and distinct functions. The goal is to reduce the development and debugging time, make the system run faster, permit an easy replacement of any of the modules, expedite the testing of other solutions (in both modules) and have a scalable solution for future developments. The acquisition and actuation module is associated to one of the microcontrollers and the web server module is performed by the second one. Synchronous serial communication in a master-slave mode is used between both microcontrollers, as shown in Fig. 3.

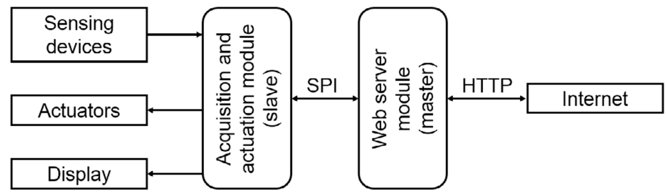

Fig. 3. Modular architecture of the implemented system.

3.1 Acquisition and actuation module

The acquisition and actuation module deals with signals acquisition, processing data from transmitters and detectors, as well as with the valve and pump actuations for controlling actions.

In this module, the microcontroller was selected considering the required number of analogue and digital I/Os, the range of the frequency pulse rate of the water flow transducer, the synchronous serial communication between both modules and the requirement of guarantying, at least, 1 mm resolution in the level measurement, with any of the transmitters.

3.2 Web server module

This module is responsible for the communications and the web page hosting. It includes a microcontroller with an Ethernet controller that meets all of the IEEE 802.3i specifications.

4. CONTROL ALGORITHM

A relay controller with dead zone and unequal pull-in and drop-out level error, with the general characteristic shown in Fig. 4, was chosen given its straightforwardness, its capability to control the process and its low computational load.

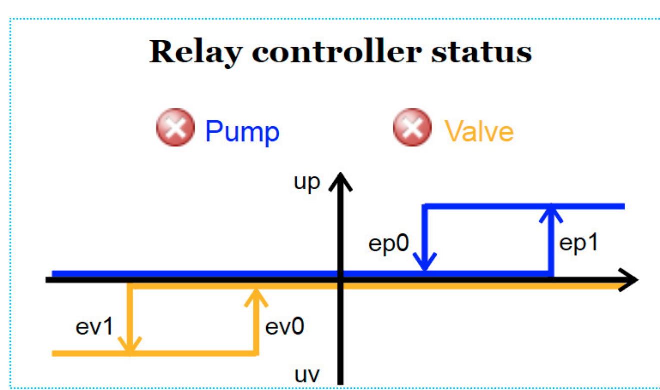

Fig. 4. Relay controller with dead zone and hysteresis