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Automation Module for Precision Irrigation Systems

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***Abstract*—In this paper is presented an improved design for an automation module which is dedicated for applications in irrigation systems used in precision agriculture. The architecture of the automation module relies on Arduino Uno development board containing the microcontroller ATmega328P which performs the majority of the control tasks required in the operation of the proposed system. The long-distance data transmission and remote monitoring of the important parameters of the system is realized with the connectivity ensured by SIM800L quad-band GSM/GPRS module. Also, the local connection between the automation module and a PC running a software control application is realized with the CH340G USB to USART converter which is integrated on the Arduino board. The automation module controls a precision irrigation system containing a set of sprinklers, a humidity sensor, a flow meter and a variable speed pump. By using a modern implementation approach, based on versatile ATmega328P microcontroller, together with the communication capabilities offered by the GSM/GPRS module SIM800L, the proposed design represents an efficient and cost-effective solution for implementing smart irrigation systems for modern agriculture industry.**

Keywords— automation, precision irrigation, microcontrollers.

I. Introduction

In the context of climatic changes and population growth, the use of modern electronic technologies in the agricultural domain for improving the efficiency of this industry has become almost mandatory. Precision agriculture based on electronic automation modules and distributed sensor networks represents a very efficient solution for solving many problems regarding the farming resources optimization. In the broad spectrum of applications that are specific to the precision agriculture, the irrigation systems occupy a very special place because the water is a key resource that can significantly influence the efficiency of the farming systems. Although the irrigation systems were constantly improved over the years, only in the late period was realized a real progress in the implementation of the complex control systems for agriculture, by using powerful informatic systems, microcontrollers and new transmission technologies for the sensors. Precision irrigation technology allows the implementation of a new management methods for the water resources to meet the need of the soil and plants. In this context, this paper presents the structure of an enhanced automation module for testing the concept of precision irrigation. The design is based on an Arduino Uno development board and GSM/GPRS module for long distance data transmission [1], [2].

II. Precision Irrigation Systems

Precision irrigation systems represents a technology applied in agricultural industry with the purpose to improve the utilization of the water and soil resources, without compromising the productions. A precision irrigation system must acquire and analyze data from a distributed network of sensors and, based on a predefined program and generate commands in a feedback loop for activating different types of control devices. The predefined program can contain elaborated algorithms that can operate in accordance with soil characteristics and with the local climatic conditions. Because usually the control algorithm of the precision irrigation system is implemented in software, it is obtained an enhanced flexibility and configurability. Also, a precision irrigation system can operate with multiple software models and algorithms that can be easily interchanged depending on the needs. This create conditions for a great reusability of the automation part of the system, including also the hardware elements [3].

In Fig. 1 is presented a typical structure of a precision irrigation system. As can be observed, the system is structured in multiple sections. The monitoring area is the first section of the system which comprise sensors for specific parameters (moisture, temperature etc.) and actuators for performing various commands like dripping activation, electro-valves control etc. The second section is represented by the local data acquisition and processing module that usually contains also wireless communication capability. Finally, the last section is composed by a gateway that connects all system to the Internet for additional data processing, adaptive control, decision support and cloud computing [4].

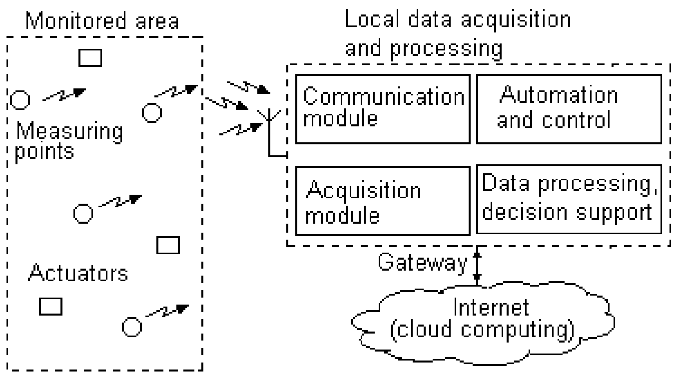

Fig. 1. Typical structure of a precision irrigation system

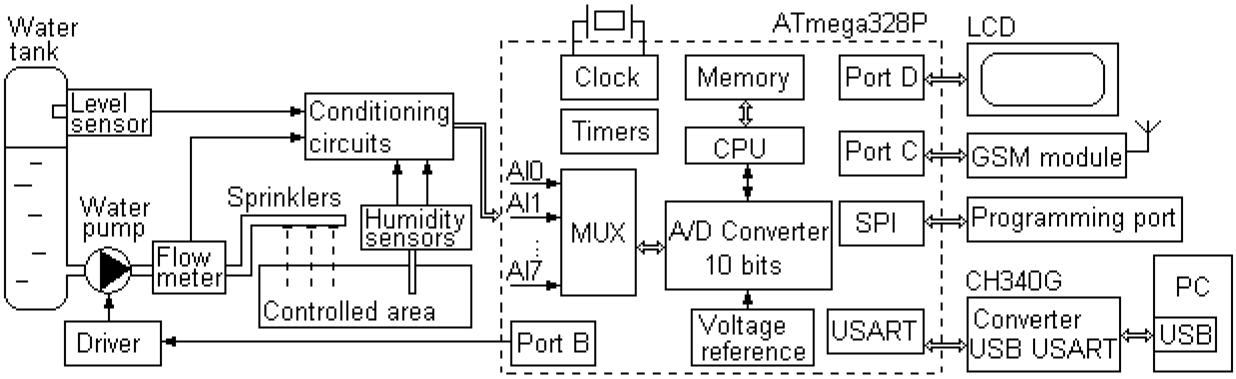

Fig. 2. The block diagram of the automation module used for the implementation of the precision irrigation systems.

III. The Structure of the Automation Module

The simplified block diagram of the proposed system is presented in Fig. 2. The proposed design contains a section of automation and control, realized with the microcontroller ATmega328P, a section containing the sensors and the execution elements, and a section responsible with the transmission of the acquired data. Dedicated sensors are used for measure the humidity in the soil and the water quantity that is provided to the sprinklers. As can be observed in Fig.2, the system uses a water tank as buffer for alleviating the variable character of the supply sources that are existent in the site where the system is installed [5]. The level of water in the tank is permanently monitored and the information is sent to the automation module through a conditioning circuity. A key parameter that is used by the automation module in the process of decision-making process is soil and air humidity. In this case, both parameters are constantly monitored and the acquired information is sent to the microcontroller through a set of conditioning circuits that are connected to its analog inputs (AI0-AI7). The water quantity that is sent to the irrigation system is accurately measured with a flowmeter based on turbine principle. The output signal of the flowmeter is a train of impulses with the frequency proportional with the volume of the water that passthrough the flowmeter. In order to accommodate the impulses from the flowmeter with the logical levels of the microcontroller, a dedicated circuit is used. The same circuit realizes also the galvanic insulation between the internal circuit of the flowmeter and the board containing microcontroller. Observing the Fig.2 can be seen that the GSM/GPRS SIM800L communication module and the local display are connected with the ATmega328P microcontroller through the digital ports denoted C and D respectively. For ensuring the local connection between the automation module and a PC is used the internal USART block of the ATmega328P microcontroller and the circuit CH340G which operates as a bidirectional USART to USB to converter. The operation of the software application that was programmed into the memory of the ATmega328P microcontroller can be analyzed by looking to the simplified state diagram presented in Fig. 3. As can be observed this figure, the program starts with a general initialization of microcontroller's internal variables and registers. In the next step are read the outputs of the sensors and a user menu displayed on the local LCD. Subsequently, this data will also be sent to a remote location via the GSM module. If the user wants to establish new threshold values for parameters of the automation module then the application enters in a specific loop that allows to realize this procedure [6], [7].

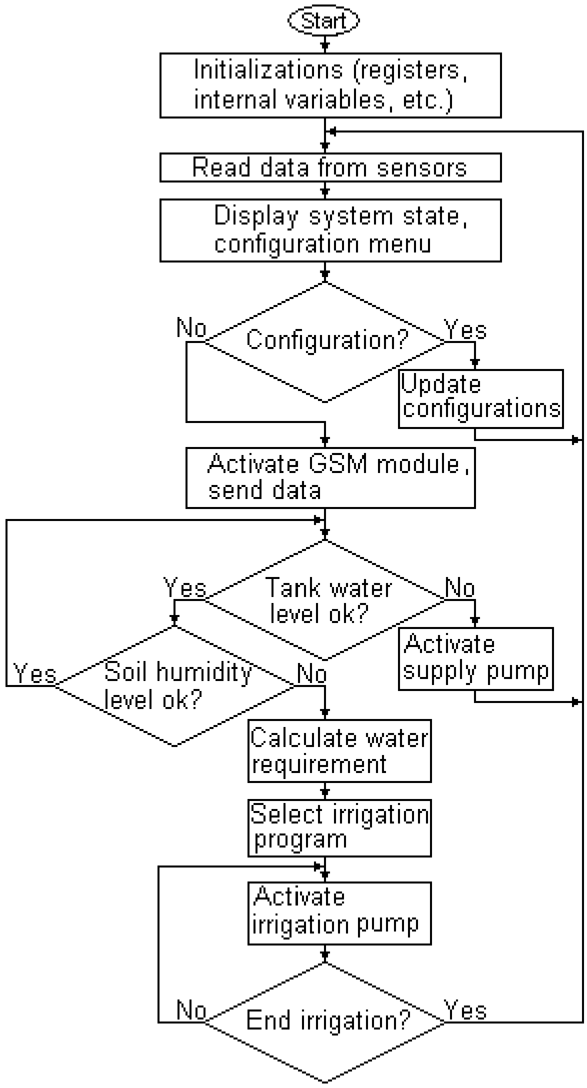

Fig. 3. The simplified state diagram of the software application for the automation module.

IV. Implementation and Results

For verifying the correct operation of the proposed automation module, a small-scale precision irrigation system was implemented. The electrical diagram of the board containing the Atmega328P microcontroller, the local LCD and the interface circuits for sensors is detailed in Fig. 4. The air humidity was measured with H25k5A resistive sensor that is capable to operate in a range of 20-90% relative humidity, has a relatively small hysteresis of only 3% at full-scale and can realize accurate determination in the temperature domain 0-60ºC. The moisture in the soil was measured with SEN-13637 sensor [8]. This device consists of two pads that operate as a variable resistor, depending on the conductivity of the soil, which in turn is proportional with the water content in the soil. The water volume transferred from the local tank to the irrigation system is monitored by the PRZ-1800/L flowmeter which has a precision of 2% and can operate with liquids having a maximum temperature of 65ºC. The measurement resolution of the flowmeter is of 1880 impulses/liter [9].

The data transmission from the automation system to a remote PC is realized through the SIM800L quad-band GSM/GPRS module. The device is integrated in a dedicated extension board (shield) for the Arduino Uno development system contains the ATmega328P microcontroller. The wireless transmission is made at a relatively low speed of 85,6kbps, according to General Packet Radio Service (GPRS), but taking into account the extended availability of the mobile network, the automation module can be monitored virtually from everywhere. In Fig. 5 is presented the practical realization of the experimental prototype of the automation module and the reduced scale irrigation system. After tests realized with this reduced scale model it was found that the implemented system operates in accordance with the designated parameters. The flexibility in operation, scalability and the rapid reconfiguration offered by the proposed design is also due to the software application used to control the automation module. These characteristics represents major advantages of the proposed design. [10], [11].

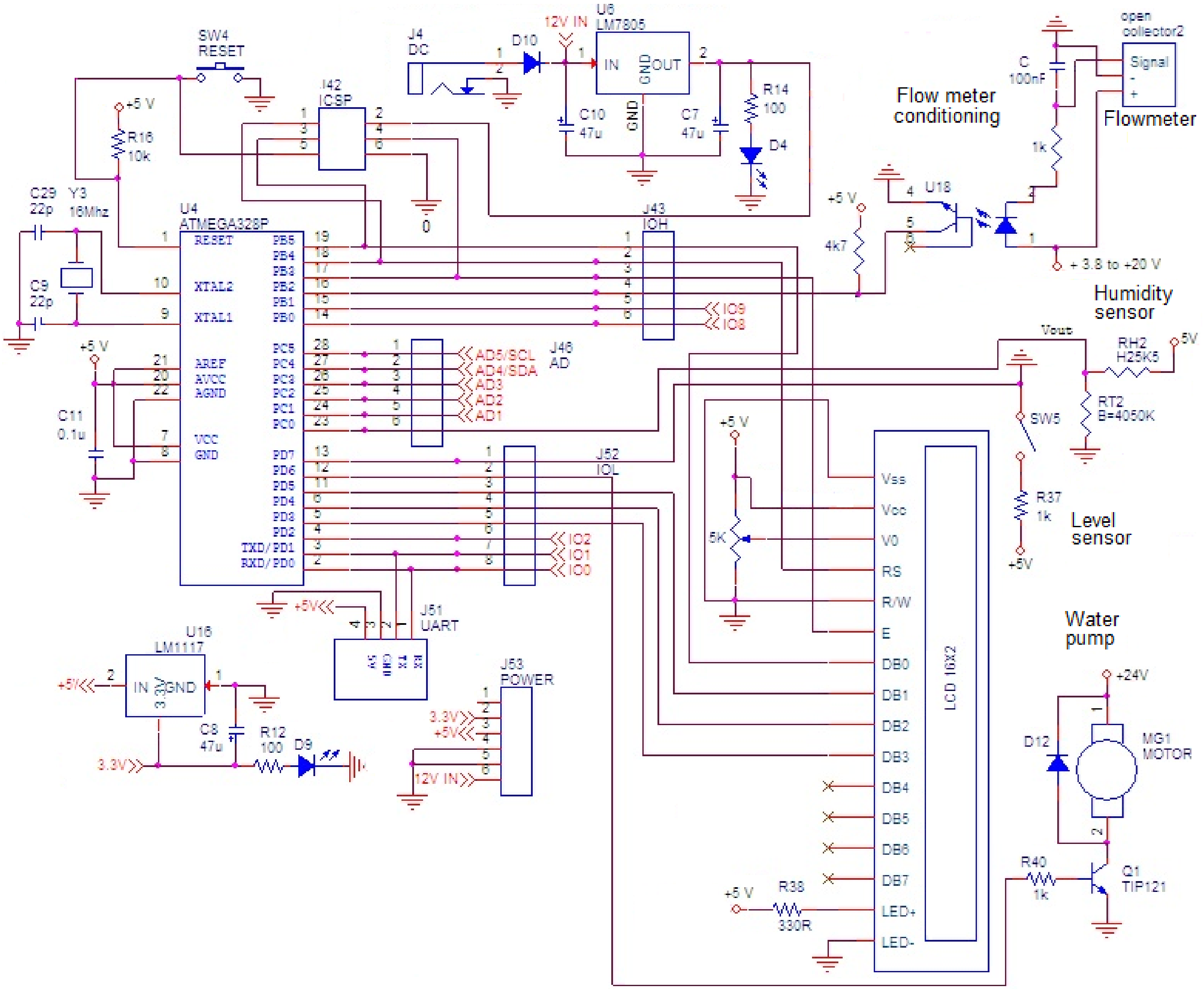

Fig. 4. The electronic schematic of the main board of the automation module for precision irrigation systems.

Fig. 5. Small-scale experimental setup, containing the automation module for irrigation systems used in precision agriculture.

V. Conclusions

Although it has always been an important issue, the management of water resources has now become, in the context of climate change, of vital importance for the development of a modern, much more efficient agriculture. Precision irrigation systems are a modern solution for optimizing the use of water in agriculture. Although the technology has many advantages, it is not widely adopted due to the initial development costs that are required for implementation and at the same time due to the requirements for the use of qualified personnel to operate the systems. This paper presented an enhanced design for implementing a reliable and efficient automation module for precision irrigation systems. Because is based on microcontroller and software programming, the proposed module is suitable for adaptive control and can be integrated in a larger system due to its communication capability using GSM network. Also, due to the implementation of the control algorithm in software, the proposed module has intrinsic flexibility in operation, scalability and allows rapid reconfiguration to suit any specific application. Tests realized with the reduced scale model of the automation module revealed that the implemented system operates in accordance with the designated parameters.

Acknowledgment

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