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INFORMACIONE TEHNOLOGIJE

SADAŠNJOST I BUDUĆNOST

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SADRŽAJ

SISTEM ZA KONTROLU AMBIJENTA U STAKLENIKU
AMBIENT CONTROL SYSTEM IN GREENHOUSE

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Sadržaj: *Za postizanje dobrog rasta useva zasađenih u staklenik, neophodno je iskoristiti sva znanja o tome koje uslove moramo zadovoljiti da bi dobili očekuvanu žetvu. Nekoloko klimatskih faktora su važni da bi se razvio održlivi ambijenat unutar staklenika, a to su temperatura, vlažnost vazduha, vlažnost zemljišta, cirkulacija vazduha kao i njihov međusobni odnos. Ovaj rad objašnjava kako se savremena tehnologija može iskoristiti u jednom automatizovanom računarskom sistemu za kontrolu stanja u unutrašnjosti staklenika, upotrebljavajući određeni hardver (senzore, aktuatore, embeded upravljač i personalni računar za SCADA interfejs). Prikazano rešenje upravlja klimatskim faktorima na efikasan način, koristeći asinhroni komunikaciski protocol između LabVIEW bazirane SCADA na host straini i C bazirane akvizicije podataka i pokrenuti sistem na embedded PIC platformi.*

Abstract: *In order to achieve a good growth of crops planted in a greenhouse, it is essential to implement the knowledge concerning specific conditions that need to be fulfilled to support expected harvest. In general several climate factors are important to be developed for sustainable ambient inside a greenhouse - temperature, air humidity, soil moisture, air circulation and also the relations between these factors. This paper depicts how contemporary technologies can be employed in an application of an automatic computerized system for controlling a stable environment inside a greenhouse, using affordable hardware (sensors, actuators, embedded controller and personal computer for SCADA interface). The presented solution controls the climate factors in an efficient way using an asynchronous communication protocol between a LabVIEW based SCADA on the host side, and a C based data acquisition and actuation system running on an embedded PIC platform.*

1. INTRODUCTION

Greenhouses Environment Control Systems form an important part of the agriculture and horticulture sectors in our country as they can be used to grow plants under controlled climatic conditions for optimal harvest (production). Appropriate environmental conditions are necessary to support plant growth, improved crop yields, and efficient use of water and other resources. The soil moisture, the air temperature and humidity govern the plant growth [1], [2].

Automating the control of the named three parameters ensures a reliable environment avoiding constant presence of human factor. The automation of the process variables relies on data acquisition for constant monitoring of all three with sufficient frequency compatible to the real dynamics of their fluctuations over time or in cases of abrupt disturbances, as well as on the proper actuation of the control variables having impact on the environment.

The technical focus of this article is a simple, yet powerful solution for achieving the goal using an affordable PIC based process controller, equipped with cheap sensors for monitoring temperature and humidity, as well as affordable laptop/desktop host PC running a "homemade" LabVIEW based user interface in a form of SCADA, that is used to set the control variables and perform all necessary processing, calculations and logging of important data.

2. THE CONCEPT

The concept of the working solution is given in figure 1.

The process controller is a PIC, equipped with analog and digital I/O. Through its multiplexed A/D converter it acquires three sensors for monitoring the corresponding process variables (PVs) - the air temperature and humidity, and the soil moisture.

The PIC packs and transmits the acquired data for asynchronous serial communication with the SCADA host. It also listens for commands from the host for actuation of the control variables (CVs).

Through the D/A converters the PIC controls a pump for water irrigation; a motor for opening/closing a window for air conditioning against the outside temperature and humidity; a heater for increasing the inside temperature; and a ventilator for air circulation when humidity regulation (in combination with the window) is needed.

The SCADA host receives the acquired PVs via RS232 serial link, presents them in their user interface (UI) gages and indicators, calculates commands for the actuators to modify/sustain appropriate values of the corresponding CVs, and transmits them via the serial link to the embedded PIC.

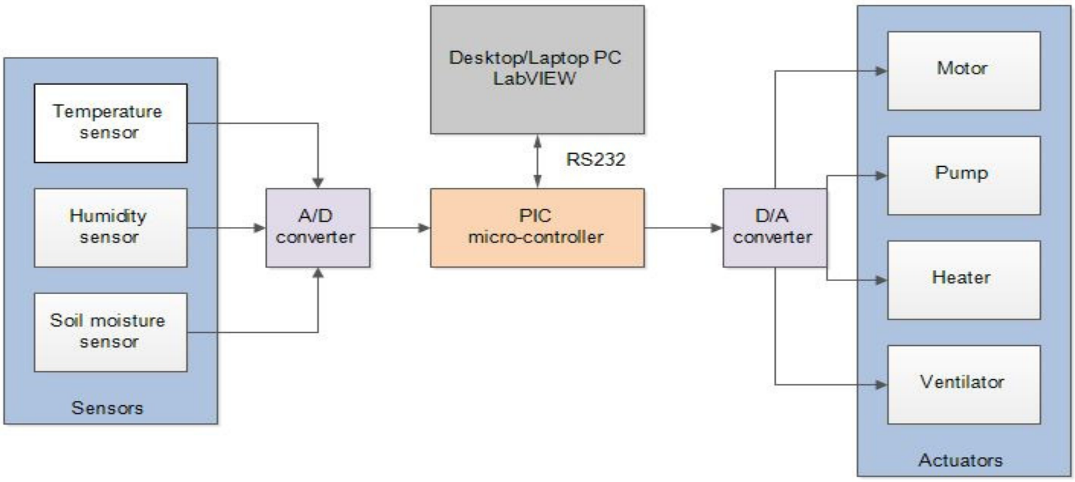

Figure 1: Block-diagram of the ambient control system in greenhouse

3. THE HARDWARE PLATFORM

The hardware platform organized around the embedded controller is given on figure 2.

The microprocessor is a low-cost 8-bit PIC16F877A equipped with 10-bit analog inputs multiplexed to a single ADC, digital I/O lines and an UART for serial communication.

The soil moisture sensor is SEN92355P, an affordable resistance based one (figure 3). The wetter the soil, the less resistive it is and the voltage transducer provides higher output. Being an analog sensor, it is connected to the A/D converter via the pin RA0/AN0.

The air temperature & humidity transducer DHT11 is also a low-cost combination of a thermistor and a capacitive humidity sensor [3]. It has its own ADC and outputs digital signal for both measurements. It is therefore connected to the bi-directional DIO pin RD2/PSP2.

All of the actuators are controlled in a ON/OFF manner, so they are connected to the digital outputs RB7/PGD (the irrigation pump), RB5 (the window motor), RB4 (the airflow ventilator) and RB2 (the air heater).

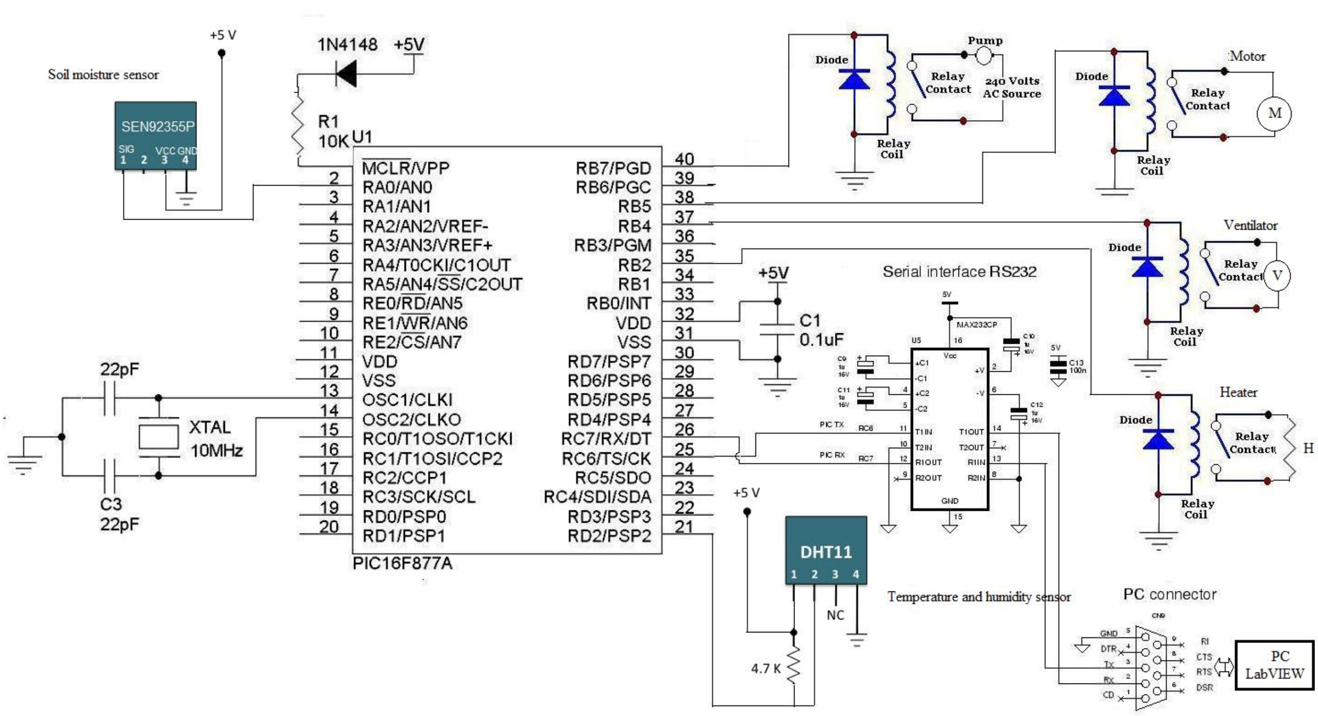

Figure 2: Circuit diagram of the ambient control system

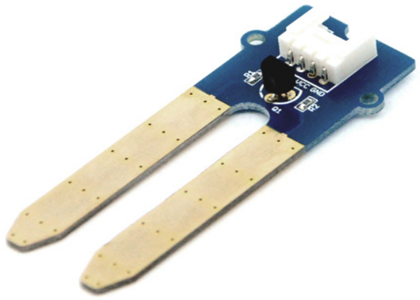

Figure 3: Soil moisture sensor (SEN92355P)

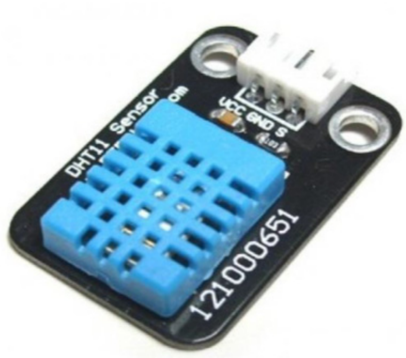

Figure 4: Temperature and humidity sensor (DHT11)

Understandable, all the digital outputs are conditioned toward the actuators via protective relays. The RS232 serial communication interface is realized with the MAX232 driver.

4. THE SOFTWARE SOLUTION

The SCADA concept based on an asynchronous serial communication protocol is given on figure 5.

It depicts the complete data loop formed by the on-field PIC based process controller and its supervising PC Host running the graphical user interface (GUI) of the SCADA.

The upper and lower parts of the block diagram show the C coded algorithm executing on the PIC. It performs continuous cyclic reading from and writing to the COM port. It reads the next ON/OFF statuses of the actuators, calculated by the process control algorithm on the Host. It writes the latest acquired values of the sensors for the Host to calculate next actuators' statuses.

The PIC executes as fast as possible. After receiving the new (ON/OFF) statuses for the actuators it immediately updates the corresponding digital outputs (DOs) with 1/0s accordingly.

After every read of the COM port buffer and update on its DOs it performs an acquisition of the current sensor values. The soil moisture sensor is acquired through its analog input (AI) in a form of 10bit integer (binary level representation), and the air temperature and humidity are read by a digital input (DI) to which their transducer is connected, in a form of two 8bit integers (one for each of the sensors).

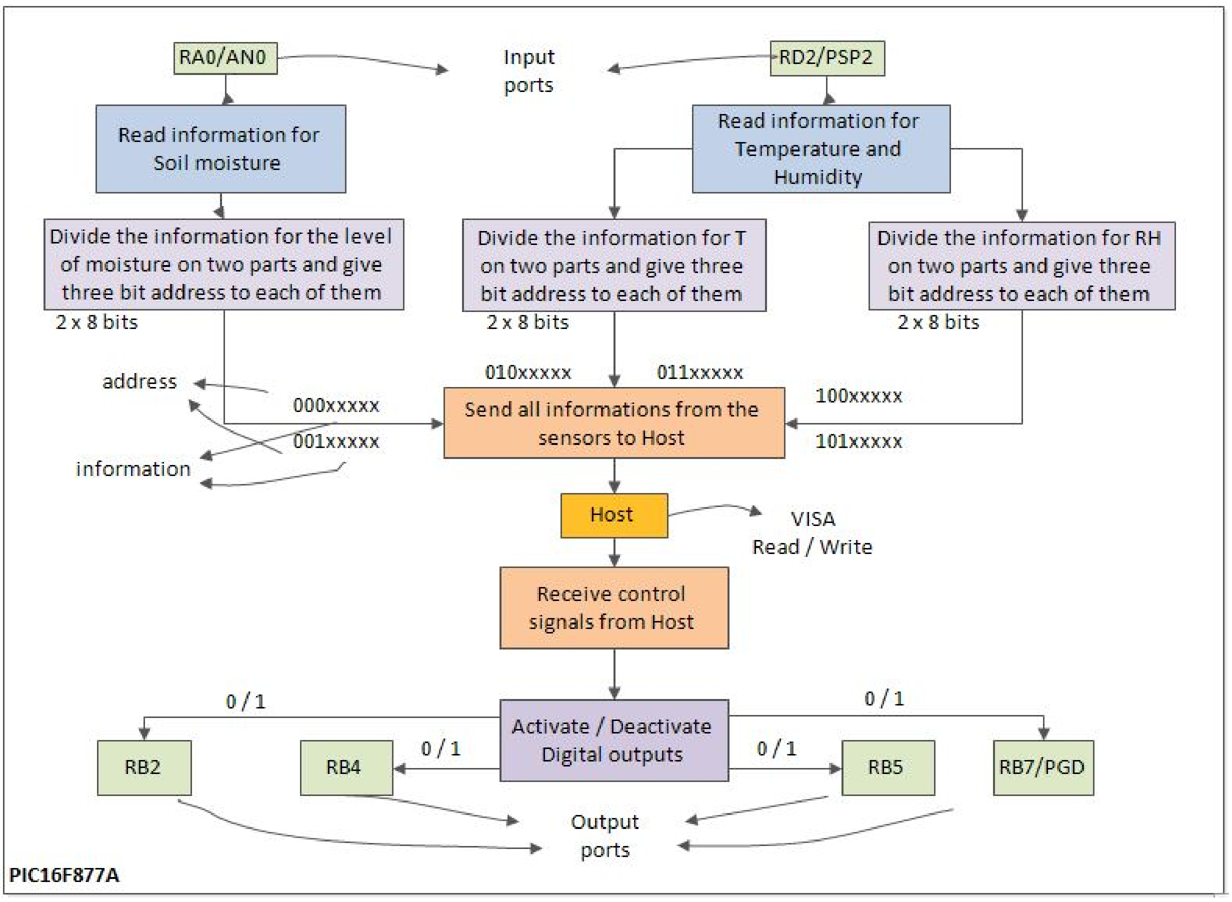

Figure 5: The SCADA concept

After all three sensors are read they are packed for sending to the Host. Due to the nature of the asynchronous protocol (no handshaking) the packing process assures the correct order for receiving on the Host side by the following framing scheme:

- divide the soil moisture 10bit integer into two halves
- frame the upper 5 bits with 000 in front into the MSB1 (00=1st sensor + 0=MSB)
- frame the lower 5 bits with 001 in front into the LSB1 (00=1st sensor + 1=LSB)
- divide the air temperature 8bit integer into 3+5 bits
- frame the upper 3 bits with 01000 in front into the MSB2 (01=2nd sensor + 0=MSB + 00 as data)
- frame the lower 5 bits with 011 in front into the LSB2 (01=2nd sensor + 1=LSB)
- frame the upper 3 bits with 10000 in front into the MSB3 (10=3rd sensor + 0=MSB + 00 as data)
- frame the lower 5 bits with 101 in front into the LSB3 (10=3rd sensor + 1=LSB)

After all data is packed for sending (string of 6 bytes), it is sent to the COM port FIFO buffer.

On the Host side the LabVIEW based control algorithm [4] constantly listens for incoming data on the COM port, whenever possible, while not processing sensors data and calculating next actuators statuses. The processing loop reads every incoming byte, looking at its first three bits, searching for the combination 000 (MSB1) and the next five bytes up to LSB3 (figure 6).

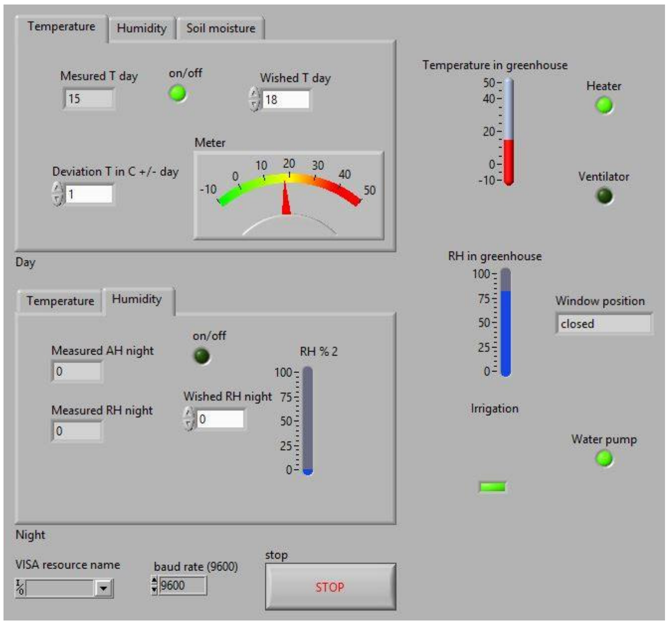

Figure 7: The SCADA GUI

for solving real life problems and challenges. It depicts a straight forward implementation of a simple SCADA for automated control of a greenhouse inside climate, using conventional strategy for process variables comparison to their respective set points, and actuating the control variables by the means of standard motors, heaters, irrigation pumps. It also employs some affordable electronics (the embedded PIC), and "proprietary" serial communication protocol between the PIC and the PC based Host.

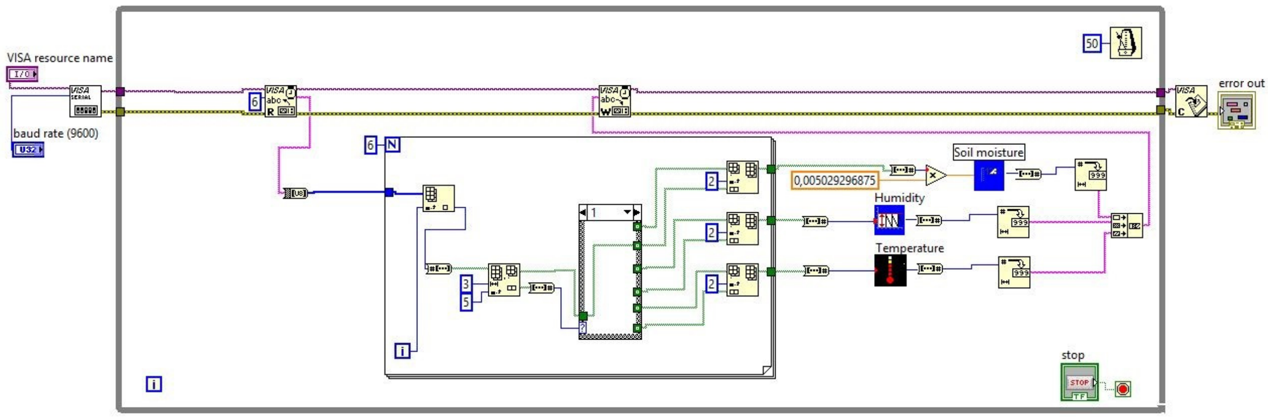

Figure 6: The main control loop coded in LabVIEW

After sensors data is consolidated it is used by SCADA's control algorithm to compare PVs values against the corresponding set points (SPs) and determine new statuses for each of the actuators, having in mind their hysteresis.

Figure 7 shows the GUI panel where the user/operator can adjust all the environmental set points that define the greenhouse ambient.

5. CONCLUSION

This paper is a prominent example of how modern technologies can easily and affordably be employed in-house

Exploitation is expected to show increased productivity!

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