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FERTIGATION CONTROLLER WITH IoT GATEWAY FUNCTIONALITY

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Abstract

A command and control unit of an irrigation system, fertilization and plants treatment, very compact, which has the hardware and software resources to ensure the communication in a network of sensors and in the IoT cloud platform is presented. This fertigation controller – called here UCCSI is an element of IT infrastructure for precision farming, "visible" on the Internet, with the user interface in cloud. The use of this command and control unit leads to savings in materials and workmanship in a notable degree.

Key words: *fertigation controller, sensor network, IoT cloud platform, Ethernet controller.*

INTRODUCTION

In the internet world and ubiquitous computer, the control, monitoring, remote supervision became accessible both in terms of technology and price. The new technologies developed M2M and IoT have found their place rapidly in all activities, from industry and agriculture to transport and health.

In the context in which agriculture benefits from incorporation of technological advances primarily developed for other industries (Naiqian et al., 2012) was developed this command unit UCCSI, the central element of a system of irrigation, fertilization and plants protection - fertigation, for small and medium vegetable farms with a maximum area of 50,000 square meters. The command and control unit - UCCSI meets at the same time the requirements of the control and monitoring of a system for irrigation, fertilization and treatment and those imposed by the communication on the IoT cloud platform and a network of sensors in the 2.4GHz ISM band. UCCSI has a compact structure that includes specific process interfaces, a communication interface into wireless sensors network and an Ethernet interface. Thus UCCSI appears as fertigation controller with IoT gateway functionality.

Communication capacity on a IoT cloud platform allows the virtualization of user interface. This leads to simplification of UCCSI hardware structure embodied by the disappearance of display (or any other displaying device) and of keyboard. This leads to notable savings in materials and workmanship, given by the fact that the application requires a high degree of protection - IP65.

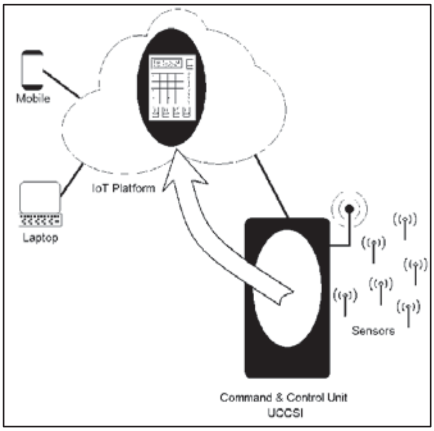

Figure 1. The User Interface of UCCSI is in cloud

The command and control unit for ferigation system - UCCSI has the hardware and software resources to assure:

a- the acquisition and processing of signals from sensors that control the operation of the irrigation system (pressure sensors, flow, level);
b- the acquisition and processing of signals from sensors measuring of soil parameters (humidity, temperature, pH, conductivity) and of environmental parameters (tem-

perature, relative humidity, light intensity, atmospheric pressure);

c- the connectivity in a wireless sensor network;

d- the implementation of algorithms irrigation, nutrient and pesticide management;

e- the command of execution elements of the system (solenoid valves, pumps, dispensers);

f- the communication on a IoT cloud platform;

g- the virtualization of user interface.

The functions from a. to f. are specific functions of a irrigation/fertigation/treatment plants controller while functions g. and h. are specific to a IoT gateway.

MATERIALS AND METHODS

The hardware structure of command and control unit for fertigation system - UCCSI is shown in figure 2.

A. Processor block

Processor block 1 (Figure 2), consists of 32 bits microcontroller – MCU, with (Vasilescu et al., 2009) 256KB Flash memory read/program/erase over full operating voltage and temperature, 32KB static random access memory - SRAM, security circuitry to prevent unauthorized access to SRAM and flash contents, A/D converter with 12-bit successive approximations and asynchronous clock source for lower noise operation - 12-bit ADC, 2 full-duplex serial communications interfaces - SCI1, SCI2, 2 serial peripheral interfaces – SPI1, SPI2, inter-integrated circuit interface compatible with IIC bus standard - I2C, interface for debugging and programming on a single wire BDM and 69- input/output port line for general use.

B. Analog inputs block

The block of analog inputs 2 (Figure 2), receives signals from transducers and sensors connected by wires. The output of these transducers and sensors can be in unified or differential signal. This block has 8 analog inputs of which 6 entries for unified signal and 2 entries for differential signal. Unified signal inputs are provided with operational amplifiers with unitary gain and the differential signal inputs with operational amplifiers with digital programmable gain. The sensors with 4...20 mA output and the sensors with differential output are connected to terminal block of analog inputs.

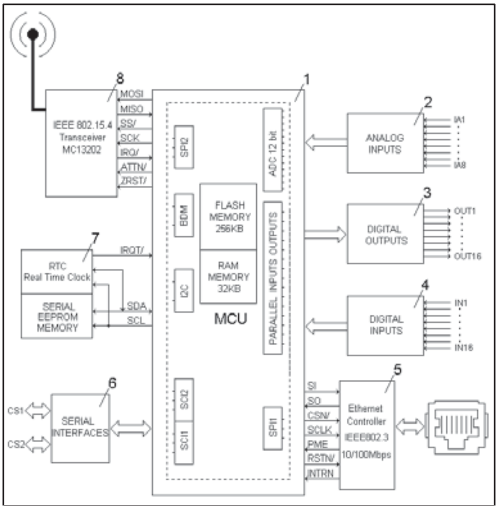

Figure 2. Block diagram of Command and Control Unit UCCSI

C. Digital outputs block

The block of digital outputs, 3 (Figure 2) ensure the transmission of commands in process. This block consists of 16 digital outputs with Single Pole Double Throw (SPDT) relay, identical in terms of electrical schematics. To give full freedom to connect in the process is output from the terminal, for all 16 outputs, besides that switch contact COM and the normally closed contact (NC) and normally open contact (NO). Thus each digital outputs correspond three terminals marked NOi, COMi and NCi (i = 1 ... 16). The control circuits of motors and solenoid valves are connected to terminal block of digital outputs.

D. Digital inputs block

The block of digital inputs 4 (Figure 2), receives status signals of the process signals in frequency or pulse train. This block consists of 16 digital inputs, identical in terms of electrical schematics, isolated from the process by optocouplers. The level sensors of buffer tank, the clogging detectors for water filters and the rain sensor (wired RainSensor - Irritrol) are connected to terminal block of digital inputs.

E. Ethernet interface block

Ethernet interface block 5 (Figure 2), ensures the connection and communication in an Ethernet network. This block consists of a specialized controller (MCF51AC256

ColdFire® Integrated Microcontroller Reference Manual, 2011) with Auto MDIX feature and self- diagnosis communication cable, a serial EEPROM memory and an Ethernet connector with transformer and two LED indicators incurporated. The specialized controller communicates with the microcontroller MCU through full-duplex synchronous serial peripheral interface SPI1 and port lines: PME – power management event, RSTN/ - reset signal of controller specialized and INTRN - interrupt signal to host MCU.

F. Serial Comunication block

The block of serial communication interfaces 6 (Figure 2), consists of two serial channels, independent, identical in terms of electrical schematics, CS1 and CS2 using asynchronous serial ports SCI1, SCI2 and two lines port of MCU for switching between reception/ transmission. These two serial channels ensure direct connection of UCCSI to a computer, a programming console or modem.

G. RTC and serial EEPROM block

The block RTC and serial EEPROM 7 (Figure 2), consists of circuit RTC - Real Time Clock, with automatic backup supply using a non-rechargeable battery and 16KB serial EEPROM memory. Real time clock circuit and serial EEPROM memory communicate with the microcontroller MCU through semi-duplex synchronous serial interface I2C and the line port IRQT/- interrupt signal to host MCU.

H. IEEE® 802.15.4 standard communication block

The block IEEE® 802.15.4 standard communication interface, denoted by 8 in Figure 2, consists of a specialized controller (KSZ8851SNL/SNLI Single-port Ethernet Controller with SPI Interface, 2009) and a single mode adaptive antenna circuit. Specialized controller communicates with the microcontroller MCU through full-duplex synchronous serial peripheral interface SPI2 and port lines ATTN/ - command signal for specialized controller, ZRST/ - reset signal of specialized controller and IRQ/ - interrupt signal to host MCU. This block provides the necessary hardware resources to communication in a wireless sensor network in the 2.4GHz ISM band.

Beside the hardware the UCSSI unit is provided with a specific software.

The program written in non-volatile memory of the microcontroller controls, in real-time, the hardware resources of the command and control unit - UCCSI, ensures its functionality in the irrigation/fertilization/treat application and the communication in a wireless sensor network in the 2.4GHz ISM band and on a IoT cloud platform via the Ethernet interface. This software is developed around an In-House real-time operating system – RTOS, described in (MC13202 2.4 GHz Low Power Tranceiver for the IEEE®802.15.4 Standard Reference Manual, 2010).

The flowchart of the UCCCSI functionality is showed in Figure 3.

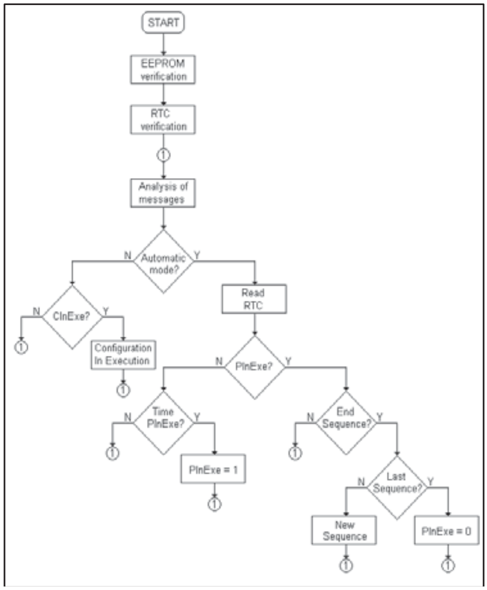

Figure 3. The flowchart of the UCCSI functionality

For irrigation, fertilization and plants treatment the farmer uses different recipes depending on the culture and values of certain parameters measured. These recipes are applied at some moment of time or a certain periodicity and are translated into a sequence of digital output configurations - sequences with a predetermined duration. Recipes and their moment of applications are configurable information stored in the EEPROM memory of the UCCSI.

The UCCSI controller has two working modes: **automatic** and **configuration**, respectively. Setting time recipes and timing of their application can be made only in the configuration mode - **Configuration In Execution** block Figure 3, through the Ethernet interface or one of the two serial communication channels CS1, CS2. Configuration of the command and control unit UCCSI is done from a computer or a programming console remotely connected via an IoT platform or by direct connection.

At power on, **START** in Figure 3, the controller are initialized hardware and software resources, then it is checked EEPROM memory - **EEPROM verification** block and function of the real time clock RTC - **RTC verification** block. EEPROM memory is checked to determine if are stored recipes and timing of their application.

Point **1** in Figure 3. marks the entrance to the main loop of application software. Within it are received and interpreted the messages received via Ethernet interface, the wireless sensor network and CS1 and CS2 serial channels - the block of **Analysis** of **messages**. Then, it executes, as appropriate, the configuration mode or automatic – the decisional block **Automatic mode** (Figure 3).

UCCSI it is found in configuration mode - the negative branch of the decisional block **Automatic mode**, when in EEPROM memory not are stored recipes, if the real time clock is not running or after receiving of a configuration message by communication (Ethernet interface and one serial communication channels CS1, CS2.). In configuration mode it check if received a configuration message – the decision block **CInEx**. If YES is running through the block **Configuration In Execution** then resumes the main loop - it returns in the point noted **1**. If it doesn't received a configuration message resumes the main loop.

In automatic mode it reads the real time clock - the **Read RTC** block and it checks if are running a recipe for irrigation, fertilization and treat plants - **PInExe** decisional block - **P**rogram **In Exe**cution. The negative branch compares the real time clock with the time when the recipe must be applied – the decisional block **Time PInExe**. In case coincide, the affirmative branch, is initiated the recipe - block **PInExe = 1**, and then, the main loop it resumes. The negative branch directly leads to the resumption of the main loop. The affirmative branch of decision block **PInExe**, in which the execution of recipes irrigation, fertilization and treat plants is underway, it checks if is the end of a sequence - the decisional block **End Sequence**. If **Y**es, it check whether is the last sequence – the decisional block **Last Sequence**. If is the last sequence, the affirmative branch, is marked the end of the recipe - **PInExe = 0**. If is not the last sequence it execute the following sequence – the block **New Sequence**.

After all these actions resumes the main loop - it returns in the point noted **1**.

CONCLUSIONS

The command and control unit UCCSI, providing hardware and software resources specific to the fertigation controller but also the necessary communication in a wireless sensor network and an IoT cloud Platforms, assure a new perspective to the control and monitoring of irrigation, fertilization and plants treatments. UCCSI is an element of IT infrastructure for precision farming, "visible" on the Internet, with the user interface in cloud.

The use of the ferigation controller UCCSI has to the following advantages:

- Increased reliability in terms of reduced consumption due to the compact structure and of the user interface's disappearance;
- Low effort and cost of installation and operation due to the use of wireless sensors;
- Easy access, minimal effort and cost effective control, monitoring and reconfiguration of application due to a connection via Ethernet Interface to an IoT cloud platform.

ACKNOWLEDGEMENTS

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