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DESIGN PROJECT OF A SYSTEM OF WIRELESS SENSORS NETWORK SUPPORTING THE FIELDS IRRIGATION PROCESS

Summary

The aim of this work is to present a project of a network of wireless sensors for the monitoring of plantations in agriculture. The developed project can be used to automate the field irrigation process. The design of the field moisture control system was based on the WSN (Wireless Sensor Network) technology. A measuring element with necessary sensors was also designed for the project. The methodological part of the work includes the network design and the development of the concept of measuring device construction. The Advantech ADAM 2000Z series components were used for the wireless sensor network project.
Key words: *WSN, irrigation of fields, wireless sensor network*

PROJEKT SYSTEMU SIECI BEZPRZEWODOWYCH CZUJNIKÓW WSPIERAJĄCY PROCES NAWADNIANIA PÓL

Streszczenie

Celem niniejszej pracy jest prezentacja projektu sieci bezprzewodowych czujników dla potrzeb monitoringu plantacji w rolnictwie. Opracowany projekt może być wykorzystywany do automatyzacji procesu nawadniania pól. Projekt systemu kontroli stopnia uwilgotnienia pola został wykonany na podstawie technologii WSN (ang. Wireless Sensor Network). Na potrzeby projektu został również zaprojektowany element pomiarowy wraz z niezbędnymi czujnikami. Cześć metodyczna pracy obejmuje projekt sieci, oraz opracowanie koncepcji budowy urządzenia pomiarowego. Do projektu bezprzewodowej sieci czujników użyto komponentów firmy Advantech ADAM seria 2000Z.
Słowa kluczowe*: WSN, nawadnianie pól, sieć czujników bezprzewodowych*

1. Introduction

The crop irrigation sector is one of the most popular directions of using wireless sensor networks in agriculture. This system is gaining popularity due to limited time needed for the service of such a system as well as the possibility of real-time preview of the situation that is found on the growing surface. These systems have a number of advantages and one of them consists in an uncomplicated construction that is not based on the placement of physical cabling. Another advantage is connected with the waterproof construction which allows the system to work in difficult conditions. The process control is irrigated, and mainly the view of the conditions prevailing in the field, i.e. the degree of humidity, and the temperature of the soil can help us with the decision regarding the watering process itself, i.e. its appropriateness under the prevailing conditions.

The main purpose of WSN (Wireless Sensor Network) wireless sensor networks is to collect information from wireless devices spread over wide areas. These devices can collect information on temperature (soil, air), humidity and many more. This is conditioned mainly in the set of sensors we have at our disposal. Sensor networks are built from communication nodes. The nodes contain sensors, i.e. a measuring element, a communication module, and power supply [1-3].
During the design process, an important stage of action consists in the selection of appropriate components, and transmission protocols that ensure long network operation on the battery. Behind the concept of good transmission protocols there are the dependences that put the sensors in most of the time in sleep mode with minimal power consumption, it is only triggered when information is collected and data are transmitted. Sensor networks, in the basic variant, consist of sensors or a sensor, collective elements, i.e. a gateway and a receiving station in the sense of the network. This architecture enables the creation of a measuring system, the purpose of which is to collect measurable values and data transmission from the examined space. The measuring system also includes measuring transducers and A / C converters, microprocessor controllers or a computer for visualizing measurement results or an external memory for recording measurements [4-6] For the purposes of the project, the Standard IEEE 802.15.4 was used. This standard was created to provide wireless connectivity in sensor networks, in measurement and control systems, etc. Their main features are: low cost of manufacturing devices, high compatibility with other devices and low power consumption. Unfortunately, these features are associated with low speeds. However, it is acceptable for control and measurement applications [7].

2. Material and research methods

Advantech devices of the 2000 series were used for the construction of measuring elements. The ADAM-201Z (Fig. 1) devices are responsible for the measuring elements together with the network elements. The signals from the sensors are sent to the transmission element by means of an analog-digital converter, because the Advantech devices have digital connectors. The device is characterized by:

- 6 analog inputs
- Support for IEEE 802.15.4 standard and work in the 2.4 GHz band
- DSSS modulation (OQPSK)
- Built-in 2 dBi antenna
- Range up to 110 meters
- Operating at -20°C to 70°C with external power supply
- 2xAA battery power supply.

Source: / Źródło: www.s-connect.dk/zeige_produkt.php?produkt_id=3241/

Fig. 1. The ADAM-2051Z device
Rys. 1. Urządzenie ADAM-2051Z

The measuring element includes the ADAM-2017Z device with two sensors. The first of the sensors is responsible for the measurement of moisture; for this purpose Irrometer Watermark sensor (Fig. 2) of Irrometer Company was used. This sensor measures the suction value of the soil. Measurements are taken on a scale from 0 to 200 centibars (1 centibar = 1 kPa). The sensor is frost-proof and resistant to variable salinity of the soil solution.

The second sensor is Davis Instrument 6470 (Fig. 2) responsible for measuring the soil temperature. The sensor consists of a platinum thermistor immersed in an epoxy resin enclosed in stainless steel. A platinum thermistor is the measuring element. The reaction time for the temperature change in the air - 100 seconds, while in the liquid - 28 seconds.

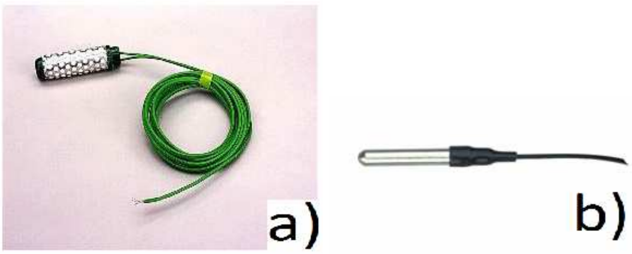

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Fig. 2. a) irrometer Watermark Soil moisture sensor, b) Davis Instruments 6470 Temperature sensor
Rys. 2. a) czujnik wilgotności gleby Irrometer Watermark, b) czujnik temperatury Davis Instruments 6470

Table 1. Comparative table of sensors
Tab. 1. Tabela porównawcza czujników

Name		**Irrometer Watermark**	**Davis Instruments 6470**
Model		Soil moisture sensor	Temperature sensor
Type		Resistance	Platinum Thermistor
Cable length		4.6 m (maximum 300 m)	4.6 m (maximum 242 m)
Dimensions	Lenght	76 mm	64 mm
	Diameter	22 mm	8 mm
Weight		103 g	128 g

Source: own working / Źródło: opracowanie własne

3. Results and conclusions

The aim of the work is to present two projects. The first of them assumed the design of the measuring element, while the second - the arrangement of the network elements. Initial assumptions made before the measuring element are connected with the possibility of using it in hard field conditions. The information to collect is the value of moisture, and the temperature of the soil. Values are obtained from the price point of view, the operator irrigation too high because the soil temperature in the process of irrigation may cause plugging [8]. However, the humidity value tells us about the need for quantitative water for watering. The device must be resistant to contact with water, chemicals and fertilizers needed for the protection and fertilization of plants. In response to the assumptions, the measuring element has been designed, including the enclosure that protects it. The design includes the height of the measuring element that can not exceed 40 cm, because the larger one would interfere with the performance of agrotechnical procedures (Fig. 3).

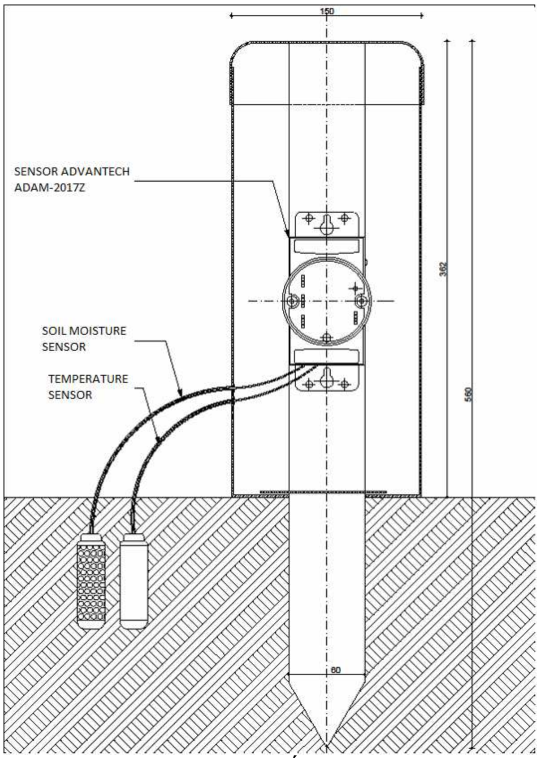

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Fig. 3. Design of the measuring element
Rys. 3. Projekt elementu pomiarowego

The housing has been designed in stainless steel. Black has been chosen as the housing color, while the lid is orange. The orange color has been specially selected for better visibility of the element on the field. The fastening rod is the shape of a cylinder ending in a stainless steel cone. The wires coming from the sensors have been secured by placing them in a notched flexible tube. This construction allows you to drive the device into the soil without damaging the sensor thanks to the casing made of stainless steel. The housing also allows you to eject the device to replace the battery or other tasks related to the operation of the device. The proposed sensor consists of the ADAM-2017Z device (previously described) and two sensors: the soil moisture sensor Irrometer Watermark and the soil temperature sensor Davis Instruments 6470. The placed sensors have been designed to read the values at the plant roots, which will best reflect conditions on the surface of the field.

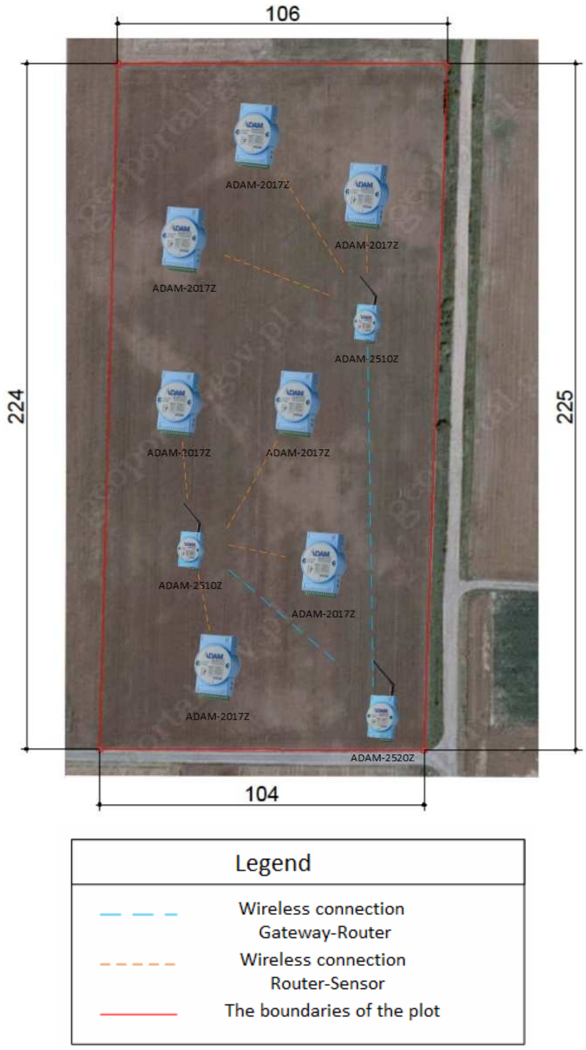

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Fig. 4. An overview of the network topology
Rys. 4. Poglądowa topologia sieci

Choice of the right topology can guarantee us less energy. As part of the WSN network project presented, a tree topology was selected which, according to the manufacturer's data, guarantees battery consumption at an average level [9]. Components of the system include the ADAM-2510Z Router with a range of up to 1000 m and operation in the 2.4 GHz band, compliant with the IEEE 802.15.4 standard. used to retrieve information from individual work elements, that is from the ADAM-2017Z device with sensors. The roles of the collective element will be performed by the ADAM-2520Z central gate, whose technical parameters are the same as the ADAM-2510Z Router. The ADAM-2520Z central gateway supports the Modbus / RTU data communication protocol which enables communication with a computer. Presentations of the arrangement of individual elements together with their connection will be shown in an example experimental field with dimensions of 106 m wide by 225 m as shown in Fig. 4. The measuring device at the end of the field communicates with the central gate using a router. This is a necessary element, because the range of the measuring device of 110 m would prevent it from communicating directly with the central gate.

The proposed project of wireless sensor network combined with sprinklers would automate the whole irrigation process which, according to previous research, in the dimension of an agricultural holding means large savings of resources, especially time, people and money. In the near future, along with the progress of technology and the requirements for plant production, the measurement part of this project should be extended to include solar radiation sensors, which include help to prevent soil sealing during irrigation. In the evolution of the system, it will be adapted to mobile phones and tablets, which will increase the convenience of use.

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