Abstract: The authors want to present the way in which a mechatronic system of measurement, acquisition and processing of results aimed at characterizing the soil agro-productive parameters in real time is modelled, designed and implemented. The authors measured the soil electric conductivity, humidity and temperature. The electric conductivity of the soil, was measured by the direct contact method. The measurements result in establishing parameters of the mechatronic system are drawn on maps. These parameters are used in GPS systems, acquisition and data processing. These maps are transmitted to the experts in agriculture in real time in order to do measurements that depend on the optimization of agrotechnic programmes of plants crop. The aim is to obtain crops through low costs. Keywords: agricultural mechatronics, sensors, actuators, GPS.

1. INTRODUCTION

In these days the field of electronics continues to change and evolve rapidly. Electronics are increasingly being used to collect and process all types of data, transfer information, make decisions provide automation and control functions. Modern microcontrollers and semiconductor components offer many advantages and ease of use in designing custom measurement and control systems. The manual collection of field and laboratory data can be time- and labour-intensive. This constrains result in data often being collected at irregular or infrequent intervals. Automating the data collection process can provide more information at regular and frequent intervals, and reduce labour requirements and costs. Advances in electronics and the availability and ease of use of electronic devices and components have made it easier and more affordable to automate many control and data collection processes. The Department of Fine Mechanics and Mechatronics from Transilvania University of Brasov in collaboration with the Research and Development Institute for Potatoes and Beetroots of Brasov - I.C.D.C.S.Z Brasov - has had intense preoccupations in the field of mechatronics applied in agriculture [1]:

• computer-aided installation for measuring the starch and dry substance content in potatoes tubers;
• installation for automated dosage of chemical liquids used as fertilizers;
• research and experiment of a mobile laboratory and of the automated system of acquisition and processing of phytoclimatic data in the potatoes growing.

The precision agriculture, which comprises the agriculture as an application of mechatronics, enhances a new methodology (that aims at a new agricultural system) that could be the key to many current problems [3]. The opportunities that have favoured the development of precision agriculture are [2]:

• capacity to understand the complexity of agricultural systems – systemic and holistic approach;
• capacity to monitor the phenomena and processes – computer - controlled data acquisition;
achievements in computing techniques – hardware, software, fineware and data bases;
• improvement of interpretation and computing methods – statistics, modelling, simulation, decision support systems – DSS;
• development of geographic informational systems – GIS;
• occurrence and development of spatial analysis and statistics – Geostatistics;
• progresses of spatial technique – teledetection, GPS;
• technical achievements in automating and improving agricultural machines – agricultural mechatronics.

Improvement of crop quality and yields is a demand in modern aquaculture closed-systems. An important requirement for production costs is to be kept as low as possible to guarantee market competitiveness. The achievement of these goals implies the use of complex management and control systems to regulate, in an efficient way, a large amount of interactive physical variables.

Recent developments in hardware and software tools namely microprocessors and microcontrollers, lead to the integration of complex control and management tasks in agricultural exploitations.

2. THE SYSTEM FOR MEASURING THE SOIL ELECTRICAL CONDUCTIVITY

Soil electrical conductivity (EC) in agriculture is a property of soil that is determined by standardized means. Soil’s electrical conductivity is produced in the water layer that covers the pores among soil particles. The electrical conductivity is influenced by a series of the soil properties:

• **Porosity** – the greater the porosity the greater the electrical conductivity (the clayey soils have greater porosity as compared to sandy soils);
• **Water content** – the electrical conductivity gets greater as the soil gets more humid;
• **Salinity level** - the electrical conductivity is strongly influenced by the solution concentration in electrolytes, being directly proportional with it;
• **Cations exchange capacity** influences the soil electrical conductivity through its content in positive ions of Ca, Mg, Na, NH₄ or H, which is held especially in soils with increased clay humus and minerals level;
• **The temperature** influences the soil electrical conductivity, being in relation of direct proportionality.

In order to measure soil conductivity we used four-terminal method (figure 1 – block diagram for measurements). The measuring principle consists in injecting a current with known value trough two external terminals and in measuring the voltage between the inner terminals. Taking into account the mechanical parameters, h the depth of terminals in the soil, and the distance between electrodes we can calculate soil conductivity [^1].

![Fig. 1. Block diagram for measurements](image)

We designed and created a signal generator with various types of signals. Signal generator can supply three types of signals: sinusoidal, triangular and rectangle forms in three decades from 25 to 25000 Hz. The signals are amplified in a low distortion power amplifier.
3. THE VIRTUAL INSTRUMENT

We developed a virtual instrument able to display computed values for the electrical conductivity of the soil, and to map the measured area in 3D representation [3]. We used the graphic language LabView 7.1 software and the data acquisition equipment, Labjack U12.

First, we generated measured points and after we collect data from the LabjackU12 board. For the automatic generation of the measuring point position, the panel shows two numeric controls, figure 2, called: number of measuring / row and number of rows and two numeric indicators X and Y, the obtained pairs of values corresponding to the soil measuring points. The Diagram window contains a repetitive programming structure FOR – LOOP, having \( N \) iterations corresponding to the number of measuring points / row. It generates a 1D Array which elements vary for 1 to the setup number.

![Fig. 2. The automatic generation of the measuring points](image)

The same FOR structure generates the second 1D Array which elements varies for the setup number to 1 (All Functions, Array, Reverse 1D Array). The two 1D Arrays are concatenated by the function Build Array. The same structure allows also the generation of another 1D Array, containing the current measuring row (starting from 0).

In order to repeat the described sequence, for a setup number of iterations, using the Number of rows control, we used another external FOR – LOOP structure. This allowed us the obtaining of two 1D Arrays, one for \( X \) and the other for \( Y \), placed on the Panel as output 1D Array elements.

To simultaneously read two voltage levels, we used a FOR structure placed in a repetitive WHILE – LOOP structure. It permitted to the user to pass to a new reading conditioned by the ordering of the virtual switcher on the panel, figure 3.

In the Diagram, in this FOR structure, we have placed the two specific EAnalog Input.vi for the data acquisition, using the acquisition board LabJack U12. For each of the two acquisition functions we defined a Ring Control for the acquisition channel setting. This first control was named Channel Voltage Setting and the second was named Channel Amperage Setting.

The panel contains also a numeric Control, called Shunt. The user can read from two virtual apparatus, the voltage level – in [V] and the amperage in [A]. This program sequence computes the electrical resistance value, expressed in [\( \Omega \)].
On the Panel there is placed a Numeric Control, called **Distance between electrodes**, where the user sets the distance in [mm] program transforming it in [m] by the dividing with 1000.

For the data transfer into ASCII file we defined the function **Write to Spreadsheet File**.

In the figure 6 there is presented the panel and the diagram of the described virtual instrument.

Fig. 4. Establishing the distance between electrodes

The electrical resistivity in the current measuring point is calculated due to the function **Compound Arithmetic**.

The measured values for the 44 points are graphically represented by the using of the **3D Surface Graph** Indicator. The three obtained 1D Arrays for X, Y and conductivity were connected to **Invoke Node** function of the graphic indicator. After the connecting we have choose the **Plot 3D Mesh**.

In the figure 5 it is presented the physical connection of the electrodes to the LabJack data acquisition board.

Fig. 5. The electrodes coupled to Labjack U12 board

In the figure 7 we present the generated map of the soil electrical conductivity.

Fig. 7. Generated map of the soil electrical conductivity

The virtual instrument allows, through the connecting-up to a portable system, the acquisition of the measured values for the electrical conductivity of the soil. They will be computed and mapped in real time. The automatic generating of electrical conductivity of the soil maps is the first advantage of this virtual instrument, for large surfaces. The virtual instrument will
have as input collected data from a Global Position System and from the Labjack U12 board. The collected values will be processed by a computer which will plot the map in real time, figure 8. The virtual instrument will be integrated in a mobile system.

Fig. 8. The electrical conductivity experimental set up

4. THE EXPERIMENTAL RESULTS

Laboratory experiments were made in order to obtain the influence of: distance between electrodes, temperature, signal frequency and humidity on the conductivity. In the figure 9 is presented the influence of the signal frequency at 30 cm distance between electrodes. We concluded that optimum field frequency, for which the conductivity stay almost constant is [50-400] Hz. To avoid the 50Hz noise, in literature it is recommended 400 Hz frequency.

In the figure 9, is presented the frequency influence on soil conductivity at constant temperature (18.7 °C), distance (30 cm) and constant humidity. The experiments were carried out on the areas belonging to I.C.D.C.S.Z Brasov on chernozemic cambic soil, characteristic of about 5% of the agricultural fields in the county and 15% of the agricultural fields in the depression of Barsa. The depression of Barsa, where the Institute of Brasov (I.C.D.C.S.Z) is located, belongs to the intramountainous plain naturally drained, situated in Tara Barsei and formed through deposit, stratified and carbonated.

5. FURTHER DEVELOPMENTS

In figure 10 there is presented the continuous soil conductivity measurement that will be further designed and realized by our team. The device will be attached to the vehicle especially designed for this purpose. Measurement electrodes, disk-shaped, assure the continuous measurement in soil.

Fig. 9. The influence of the signal frequency

Fig. 10. Continuous soil conductivity measurement device
The disks are rolling at the displacement of the device. The measurement device and the computer which routes the soil conductivity map, according to the block diagram in figure 1, are placed on the vehicle.

6. CONCLUSIONS

Results of the laboratory experiments confirmed us the modality of the designing the entire system for the measurement of an important properties of the soil: conductivity. The agriculture researchers will use this data to optimum crop growth. The final result will be an integrated system able to measure, to acquire and to map the soil conductivity chart. This will give the opportunity to agriculture engineers to plan and obtain enhanced quality and quantity yields per hectares.

5. REFERENCES

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6. ADDITIONAL DATA ABOUT AUTHORS

1) Author names: Olteanu Ciprian prof.dr.eng., „Transilvania” University of Brașov, Precision Mechanics and Mechatronics Dept., Title of manuscript: Mechatronic system for measuring and tracing of maps concerning soil agro-productive parameters Full address: 50036 Brașov, B-dul Eroilor 29, e-mail: oltcip@unitbv.ro, Tel. +40268 416352;
2) Author names: Turcu Catalina Full address: Rozelor, No. 37, Ap. 2, Brasov, e-mail: cturcu2000@yahoo.com ;
3) Author names: Olteanu Felicia prof.dr.eng., „Transilvania” University of Brașov, Descriptive Geometry and Computer Graphics Dept., 500036 Brașov, B-dul Eroilor 29, e-mail: oltna@unitbv.ro, Tel. +40268412921.
4) Author names: Zamfira Sorin prof.dr.phys., „Transilvania” University of Brașov, Precision Mechanics and Mechatronics Dept., 50036 Brașov, B-dul Eroilor 29, e-mail: zamfira@unitbv.ro, Tel. +40268416352;
5) Author names: Oltean Gheorghe scientific manager at Potatos Research and Production Institute Brasov, 2 Fundăturii Street,e-mail: olgeo@potato.ro, Tel.+40268476795.