Proceedings of the 10th WSEAS International Conference on CIRCUITS, Vouliagmeni, Athens, Greece, July 10-12, 2006 (pp314-317)

Portable seven sensor soil analyser

N.I.KORNILIOS, I. MINADAKIS, A. TOUTOUNTZIS, and G. PAPAIOANNOU
Electrical Engineering Department
Technological Educational Institute of Crete
Estauromenos Heraclion Crete 71040
GREECE

Abstract: Last years a dynamic growth of sensors and their applications is observed. Recent ideas and developments have been added in this area inducing a progress of sensors technologies like the semiconductors sensors the MEMS (micro-electro-mechanical systems) and the MEOEMS (micro-electro-opto-mechanical systems). A lot of research laboratories aim via programs apart from the discovery of new sensors in the enlargement of their applications simplifying methodologies and creating more and more applications of small cost. In the framework of the researching program Archimedes, which is financed by the European Union through the programs EPEAEK of Greek Minister of Education (YP.E.P.TH) we implement a work of dia-institutional character and concern the manufacture of a portable seven sensor soil analyser.

***Key Words*:** Sensors, Portable device, Soil analyser.

1 Introduction

The creation field of sensors and their applications presents dynamic growth the last years in global level, since it is constitutive part of the most advanced technologies in industry, medicine, and biotechnology. The growth of sensors and generally their applications take place at the same time with the progress that is made in Physics, Chemistry, Microelectronics, Chemical Technology, Informatics and Telecommunications. In the last years the wide use of microcontrollers brought highly sophisticated instruments and devices. The demand for sensors is high enough, thus it is calculated that only in the European market exist roughly 15.000 different sensors that are manufactured by approximately 1.000 manufactures.

In the framework of the researching program Archimedes that is financed by the European Union the laboratory of electronic manufactures of the Electrology department of T.E.I Crete, the laboratory of analytical chemistry and growth of chemical sensors of the Chemical department of the University of Crete and the laboratory of Microelectronics of the Institution of Technology and Research, proposes the manufacture of a portable seven sensors soil analyser. The usefulness of the portable soil analyser is obvious for agricultural use and also for environmental measurements. The initial specifications of planning (measurements of pH, conductivity, Potassium, Calcium, Nitric, chlorine) serve these uses [1], [2], [3]. A permanent infrastructure with a prospect capable of composing researching results with the aim of the manufacture of measuring provisions is created in the long run. The above collaboration has exceptionally high importance for the growth of systematic completed vertical researching activity in the wider region of Crete with prospect.

2 Methodologies

The sensors that were used for the implementation of the above device are self-excited sensors, that is to say they do not need exterior provision of supply in order to function. Their manufacture took place in the laboratory of sensors of the Chemical department of University of Crete. The calibration of sensors was conducted according to certain specifications that are reported in the bibliography that is given in the end of the project. The concept of the function of the sensors apart from the sensor of conductivity is same. We measure the voltage that is created selectively on an electrode related to the ground. In order for the above to occur the electrode is covered with a selective membrane. The sensor of conductivity functions completely differently since it measures the conductivity between two electrodes that are wetted by the land

solution. The measurement is performed via a bridge, which is supplied with voltage AC of frequency about 1 KHz.
The sensors that we used, because they produce very small power in their output, require pre-treatment and amplification of their signal in measurable levels. For the growth of the device, suitable software and hardware were designed and implemented such as:

2.1 Software

The program of collection of elaboration and presentation of data has been created with the graphic language of programming Lab View version 6.1. The above version creates executable files that are executed in Windows 2000 environment and XP, but can also be executed in other operating systems like MAC OS, Linux and HP UNIX.

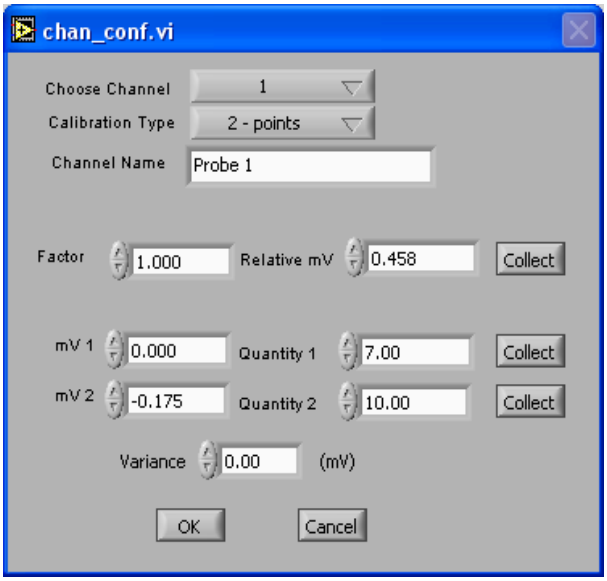

Fig.1: Channels and others parameters

The program can receive and portray up to nine (9) channels of data from external sensors, by means of the collection device. The input channels of the sensors of the device as well as various parameters that can be regulated from the user during the recording of the measurements are pictured in Fig.1.
The biggest sampling that it supports is 1 sample a second per channel (1 sample/second/ channel). The communication of program with the device is actualized via serial interconnection and follows the rules of protocol RS-232C. In Table 1 appear the typical values of serial communication characteristics.

Baud Rate	9600
Stop Bits	1
Handshaking	None
Data Bits	8
Start Bits	1

Table1: Communication characteristics

The program consists of three phases:

- □ the initialization
- □ the main loop
- □ the termination

In the phase of initialization the program receives all the essential data from the registration of Windows (Registry). These data are reported in the parameters of the function of the serial door, in the state of the channels and in the parameters of sampling (e.g. rhythm). With these data the serial door is initialised and opens a channel of communication of the program with the collection device. In the phase of the main loop the main functions of the program that include the collection of data from the exterior device, the transformation of them from hexadecimal form to units of the measurable size, the storage of parameters but also values in files for further elaboration and study are executed. The user has the ability to change the parameters of the serial communication, the parameters of sampling from the exterior device, the parameters of the channels that are being sampled (slope, offset, multiplier) and to appoint the beginning of the communication. A picture of the central loop appears in the following Fig.2.

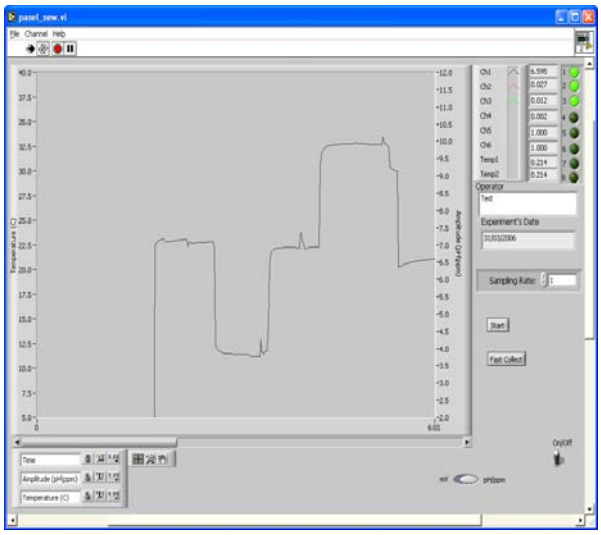

Fig.2: Experimental results for each channel.

In the phase of closure, the program restores the PC to the situation that it was before the beginning of the program, erasing files that by any chance were created during the execution of the program and closing the serial door that was used by the program, sending at the same time a termination command of the dispatch of data to the device.

2.2 Hardware

It has been designed for use in combination with a line of sensors of chemical elements. The particularly electric characteristics of these sensors also dictated the characteristics of individual departments of the device. It includes six inputs for equal sensors in number and one input for the measurement of temperature with the use of a special sensor that has been placed in a metal waterproof executive. The device has been designed with totally 9 channels of input. The output of the device is the measurements of inputs in digital form. A micro controller that brings the suitable software executes all the functions.

The connection of each sensor that produce a very small power signal with the device is essential to be performed via one stage of input of very high resistance of the order 10^{12} Ω. (E1 τo E6 in the figure1) Each stage is constituted by an operational amplifier with unitary gain (buffer). For the complete isolation of the inputs it is enough each stage of input to be supplied with autonomous power so that there isn't a common reference point. In the running implementation all the inputs have a common reference point. The selector of input is checked by the microcontroller and connects the each time-selected input with the circuits of adaptation and amplification. The isolation of the inputs is complete (differential connection). The adapter is a sliding of the level of the input voltage and converts the symmetric signal of input (± 1,0 Volts) into dc signal (0 - 2,0 Volts). The amplifier converts the input signal into a signal 0 – 2,5 Volts so as to match with the region of measurement of the converter and to create the maximum possible discretion. The stage of production of reference voltage for the converter includes circuit of temperature compensation in order the reference voltage that is produced to be as constant as possible, and the measurement more precise. Electrical signal from the sensors are fed into a multiplexer. Its function is to connect sensors one at a time to an AD converter. The connected computer controls the multiplexer and the AD converter for the appropriate timing.

The converter of analogue signal to digital has analysis of 16 digits, as a result the smallest voltage difference that can be measured is 2,50 Volts/ 65536 = 0,038 mV. The serial communication with a personal computer arises at a rate of 9.600 bps with stop bit without parity bit.

With the supply of a suitable adapter the transmission might take place via USB connection. The development of the software of the microprocessor was materialised in language C. The design and the choice of individual stages were carried out with criterion the avoidance of undesirable electric noise and the precision of measurements independent from factors like the temperature. During the period of experimental function the performance of the provision was very good, with minimal fault in the measurements and very good segregation of inputs. The device contains some peripherals and a number of components, which are not shown in the block diagram of Fig.3.

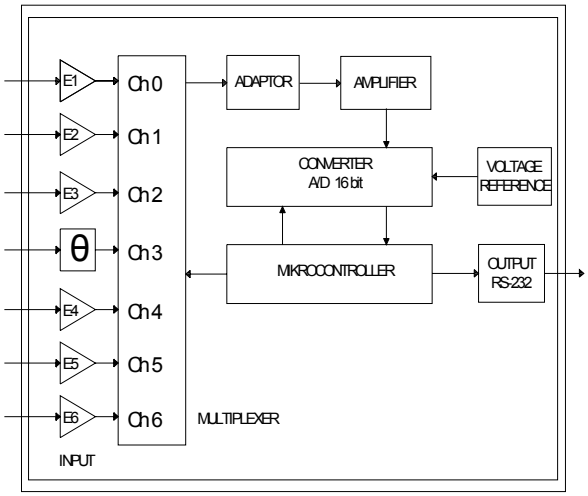

Fig.3: Block diagram of stages

3 Conclusions

We presented some of the elements that determine the function of a portable soil analyser with six channels of input. It allows the connection with six chemical sensors and offers equal in number land analyses, pH, conductivity, potassium, calcium, nitric ions and ions of chlorine with applications unlimited in agriculture but also in environmental measurements. This instrument can perform both in-situ soil analysis taking measurements directly from the area under examination and ex-situ soil analysis analysing prepared soil samples. With this

analyser it is possible to monitor the soil composition in order to evaluate the needs of elements for specific implantation and also evaluate in situ soil composition and over fertilisation phenomena that's induce soil pollution. Moreover, it is possible to evaluate soil composition near rubbish dump area and prevent the near water pollution and the over chlorine of soils near seas area.

4 Acknowledgements

We thank the team of Professor N. Chaniotakis of the laboratory of analytical chemistry of Chemical Department of the University of Crete that supplied us with the sensors and participated in the controls as well as in the test of the measurements making the implementation of the manufacture possible. We also thank the European Union and the researching programs Archimedes, which is financed by the programs EPEAEK of Greek Minister of Education YPEPTH through the E.U. **"The Project is co-funded by the European Social Fund and National Resources"**

References

[1] K. Perdikaki, J.K. Tsagatakis, and N. A. Chaniotakis (2001), A new Chloride-Selective Carrier and its Evaluation in Ion-Selective Electrodes, *Mikrochimica Acta* 136, pp.217-221

[2] E.Geniatakis, M.Fouskaki, and N.A.Chaniotakis (2003), Direct Potentiometric Measurement of Nitrate in Seeds and Produce, *Communications in soil science and plant analysis* Vol.34, Nos. 3& 4, pp. 571-579

[3] E. A.Moschou, N.A.Chaniotakis (2001), Potassium selective CHEMFET based on an ion-partitioning membrane, 445, pp.183-190