Buletinul Ştiinţific al Universităţii "Politehnica" din Timişoara

Seria ELECTRONICĂ şi TELECOMUNICAŢII
TRANSACTIONS on ELECTRONICS and COMMUNICATIONS

Tom 53(67), Fascicola 1, 2008

Central Units in Data Acquisition Systems for Engineering Education

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Abstract – The paper presents three central units (UCV-01, UCV-02, UCV-01XA) used both in experimental systems for engineering education and in data acquisition distributed systems in energetics. UCV-01 or UCV-02 is organised around a microcontroller from the 80C552 family, and UCV-01XA is configured around a P51XAS3 microcontroller (Philips Semiconductors). These central units are very flexible, with excellent control possibilities in various industrial applications. Two applications in engineering education and some experimental results are also summary presented in the paper.

Keywords: central unit, microcontroller, data acquisition system, sensor, measuring system.

I. INTRODUCTION

Central unit for local processing and communication is often configured around a microprocessor or microcontroller [1]. The main hardware resources are the processor, program memory and data memory. The processor is usually an 8-bit or 16-bit microprocessor or microcontroller because its data/address/control bus enables an easy connection of the necessary interfaces and other resources of the acquisition system. The microcontrollers are more versatile in practical applications; this is the reason for their frequent utilization in various data acquisition systems. An 8-bit or 16-bit microcontroller by Philips Semiconductors [2,3.4] contains the main hardware resources of the microcomputer (processor, data and code memory), process interfaces (for analogue and digital inputs/outputs) and communication interfaces. For example, XA-S3X microcontroller has the following specific features [3]:

- 16-bit data bus;
- 24-bit address bus;
- 32K bytes on chip EPROM/ROM program memory;
- two serial communication interfaces UART and one serial interface I^2C;
- 8-bit or 16-bit analog-to-digital converter, with 8 analogue input channels;
- digital input/output ports etc.

Program memory is an EPROM, and data memory is a SRAM. The storage capacity of these devices depends on application.

Some central units (UCV-01, UCV-02, UCV-01XA) are presented in this paper; they are used in experimental systems for engineering education (measuring system with rotary incremental encoder, experimental system for studying a force transducer, data acquisition equipment for studying some electrical circuits in c.a.) or in functional nodes of data acquisition distributed systems in energetics [5,6,7]. Two applications in engineering education are also summary presented in the paper.

II. CENTRAL UNITS FOR LOCAL PROCESSING

The development of various central units, interfaces etc. enables the resource optimization of data acquisition systems. This paper presents the features, some design aspects and applications of three central units for local processing: UCV-01, UCV-02 and UCV-01XA.

A. *UCV-01 and UCV-02 Modules*

Such central unit is configured around a microcontroller from the 80C552 family (Philips Semiconductors); this device is very flexible and versatile, with excellent control possibilities in various industrial applications.

The block diagram of UCV-01 central unit [8] is presented in Fig.1, where

- 80C552 – 16-bit microcontroller;
- BA – address bus;
- REG – memory register for A0 ... A7 bits of the multiplexed address/data bus;
- BUFFER – bi-directional bus buffer for accessing the internal data bus of the central unit;
- DEC – address demultiplexer; it forms selections for the ports that will be connected to the internal bus;
- RTC – real-time clock;

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- TXD and RXD – communication lines for RS-232;
- P1.0 ... P1.7, P4.0 ...P4.7 – digital input/output ports;
- P5.0 ... P5.7- analogue inputs;
- PWM0, PWM1 – width-modulated analogue outputs.

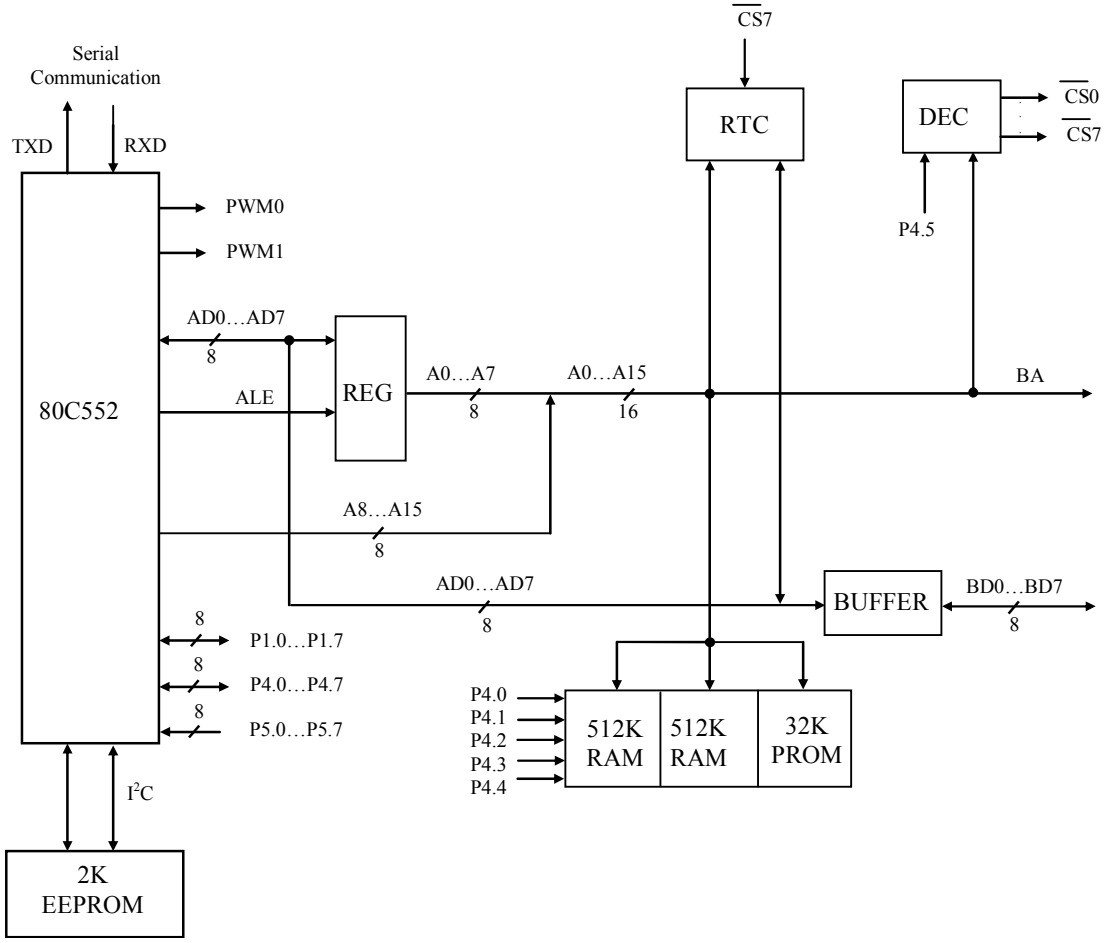

Fig. 1. Block diagram of UCV-01

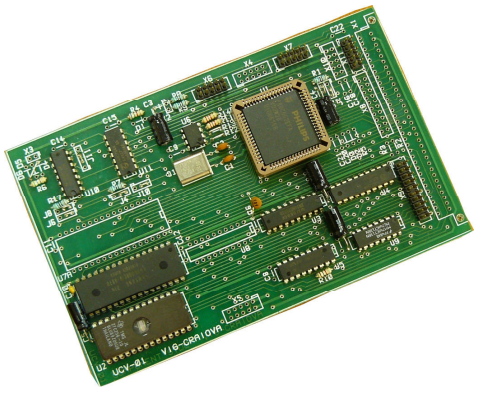

Fig. 2. Central unit UCV-01

The main features of UCV-01 central unit (Fig.2) are the following:
- microcontroller frequency: 11.0592MHz;
- maximum 1Mbyte external data memory (RAM);
- 32K bytes external program memory (EPROM);
- EEPROM memory (24C16), connected to I^2C serial line;
- real-time clock – RTC 72421.

Only one difference exists between UCV-01 and UCV-02 (shown in Fig.3): the first central unit contains 1Mbyte external data memory, and the second contains only 32K bytes.

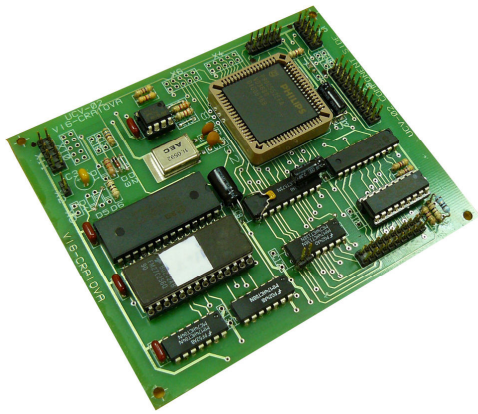

Fig. 3. Central unit UCV-02

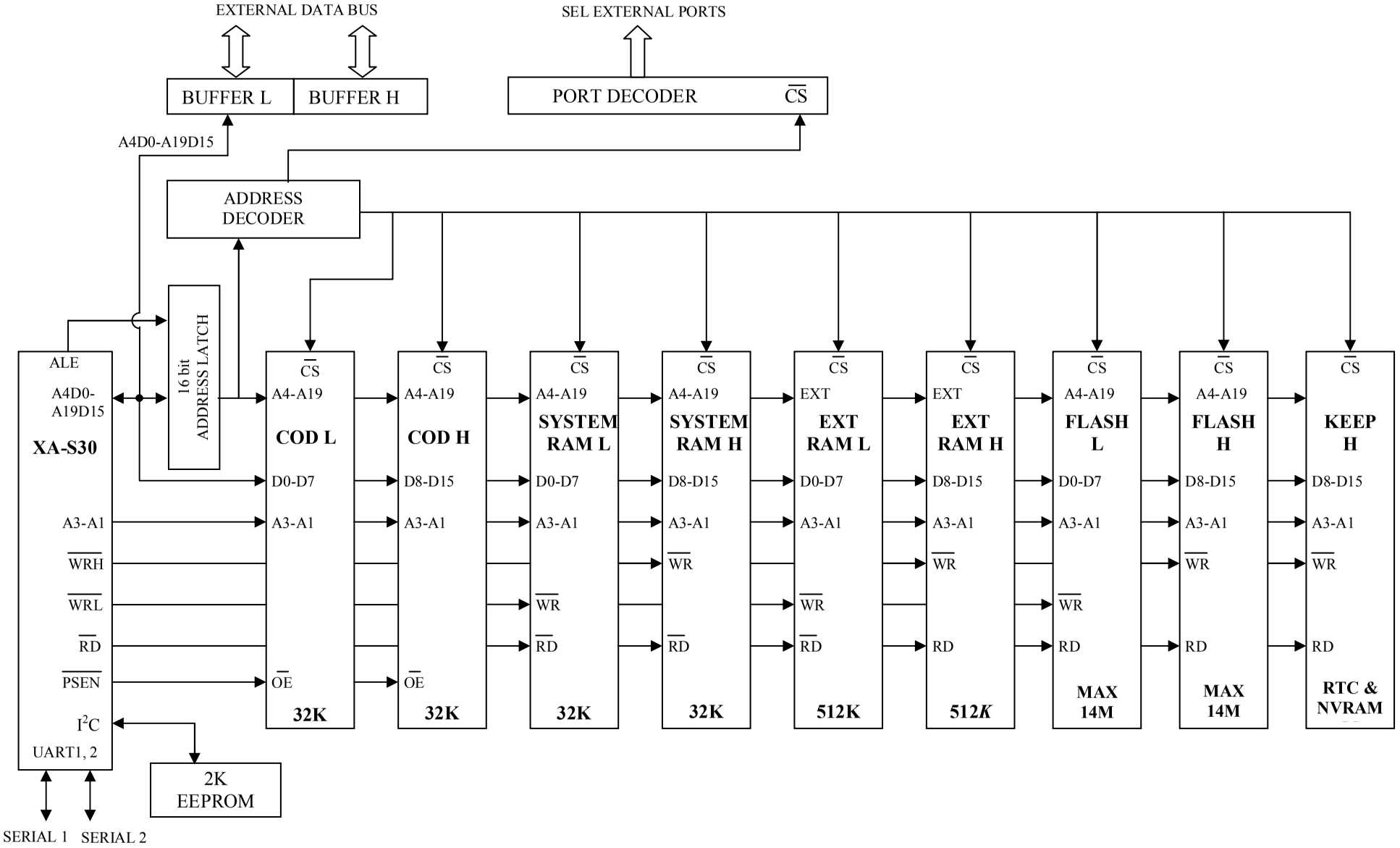

Fig. 4. Block diagram of UCV-01XA

B. *UCV-01XA Module*

This central unit is configured around a P51XAS3 microcontroller Philips Semiconductors. The XA (eXtended Architecture) family of 16-bit single-chip microcontroller is powerful enough to easily handle the requirements of high performance embedded applications.
The block diagram of UCV-01XA is presented in Fig.4.
The XA architecture [3] supports:

- upward compatibility with the 80C51 architecture;
- 16-bit full static CPU with a 24-bit program and data address range;
- eight 16-bit CPU registers, each capable of performing all arithmetic and logic operations as well as acting as memory pointers; operations may also be performed directly to memory;
- both 8-bit and 16-bit CPU registers, each capable of performing all arithmetic and logic operations;
- an enhanced instruction set that includes bit intensive logic operations and fast signed or unsigned 16x16 multiply and 32/16 divide;
- instruction set tailored for high-level language support;
- multi-tasking and real-time executives that include up to 32 vectored interrupts, 16 software traps, segmented data memory and banked registers to support context switching;
- low power operation, which is intrinsic to the XA architecture, includes power-down and idle modes.

XA-S3 is a derivative of 16-bit microcontroller XA family by Philips Semiconductors. More peripheral devices are integrated in only one XA-S3 circuit: analog-to-digital converter, timers/counters, watchdog, programmable counters (PCA), I^2C interface, dual UART, many I/O ports.
UCV-01XA central unit provides the necessary resources for the data acquisition distributed systems. This central unit contains the following blocks:

- XA-S30 – 16-bit microcontroller;
- Address Latch – memorises the current address (from the multiplexed address/data bus) during the processor machine cycles;
- COD L, COD H – code memory (EPROM or EXTERNAL FLASH);
- SYSTEM RAM (L, H) – extensible system SRAM memory;
- EXT RAM (L, H) – extended SRAM memory, often used as temporally data memory;
- FLASH (L, H) – external FLASH memory, for non-volatile storage of data;
- BUFFER (L, H) – bi-directional buffers for external data bus allocated to input/output ports;
- PORT DECODER – decoder that generates the port selections (16x8 bit selections or 8x16 bit selections);
- EEPROM – serial EEPROM memory;
- SERIAL 1, SERIAL 2 – two serial interfaces;
- KEEP H – NVSRAM memory and real-time clock.

UCV-01XA (Fig.5) provides high versatility in applications, both in data acquisition and processing and in communication with other components of the distributed systems.

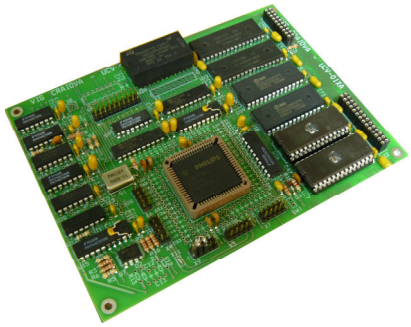

Fig. 5. Central unit UCV-01XA

The architectural features of UCV-01XA provide higher performances comparatively with UCV-01:

- 16-bit data bus assures a higher speed of data movement;
- 24-bit address range enables maximum 16Mbyte program memory and up to 16Mbyte data memory;
- the central unit is endowed with a special connector (configured depending on the available signals) that enables the simplicity of connection with various data memory modules; this features assures higher flexibility in applications that require SRAM or FLASH memory;
- many communication interfaces (two UARTs and one I^2C) enable more accessible integration in a data acquisition distributed system;
- 16-bit external bus connector assures faster data running between central unit and I/O ports.

III. APPLICATIONS

Two measuring systems based on central unit UCV-02 are summary presented in this paper. These experimental systems are very useful in higher education and research activities because they illustrate how the same sensor can measure different physical variables, they enable the application of different knowledge about sensors, signal conditioning and processing, microcontrollers, computers, analogue and digital circuits, motors and their electric control etc., and industrial applications of some sensors can be studied step by step.

A. *Experimental measuring system with rotary incremental encoder*

This experimental system [9] contains a rotary incremental encoder [10,11], a mechanical subsystem, a driving module, an intelligent interface (UCV-02) and an IBM-PC compatible computer (Fig.6). The encoder under test is of SUMTAK origin.

Fig. 6. Overview of experimental measuring system with rotary incremental encoder

The measuring system has many advantages:

- it illustrates how the same device can measure different physical variables;
- a soft method for resolution improvement and sense discrimination [12] can be studied and verified;
- the hard and soft previous knowledge about microcontroller can be applied;
- an industrial application of the rotary incremental encoder can be studied [13].

Hardware resources of the interface enable the engendering of some digital or analogue commands (for the motion control or sensor supply) and the acquisition of many digital or analogue signals necessary for computing some motion variables or technological parameters. The interface is endowed with adequate software resources for connecting the rotary incremental encoder, for improvement its resolution, for computing motion variables. A soft interaction exists between the interface and computer. The intelligent interface is serial connected to IBM-PC compatible computer that

- assures the final data processing,
- displays the measured variables and computed parameters,
- assures a simple dialogue with the user.

Program modules (both intelligent interface level and computer level) enable the study of encoder and its application. The program modules at the intelligent interface are written in the assembly language and C for 80C552 microcontroller; each program module implements an elementary function (serial dialogue with the computer, control of the mechanical subsystem, acquisition of the analogue and digital signals etc.).

The procedure for studying the rotary incremental encoder and its application enables

- displacement measurement, with 0.09deg. resolution,
- mean rotational speed measurement, with 0.015 r.p.m. resolution,
- sense discrimination,
- simulation of one industrial application.

During the measuring process, the mean value of the rotational speed (in r.p.m.), angular displacement (in deg.) and displacement sense (positive or negative) are displayed (Fig.7). The vector position reflects the measured angular displacement; the vector moves in counter-clockwise when the motion sense is positive.

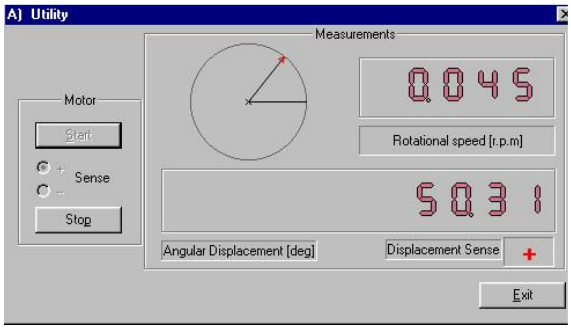

Fig. 7. Measurements for positive motion sense

The intelligent interface of this experimental system can be used for the study of many other sensors and various measuring methods [8].

B. *Experimental system for studying a force transducer*

This experimental system consists of the force sensor, data acquisition equipment, and IBM-PC computer. The overall structure of this measuring system is presented in Fig.8. The strain gages [10,11] inside the force sensor are connected into a Wheatstone bridge configuration in order to convert the very small change in resistance into a usable electrical signal. This circuit ensures large output of strain gage sensor and improves temperature compensation as well as eliminates strain components other than the target strain. Most such force sensors have four wires coming out of them: +OUTPUT, -OUTPUT, +POWER, -POWER. The measured force is F[N].

Data acquisition equipment is organized around a central unit UCV-02; it also contains

- at input – an instrumentation amplifier (IA) and a signal conditioning circuit (SCC),
- at output – a RS-232 adapter.

The central unit is serial connected to IBM-PC compatible computer, using a RS-232 adapter. The computer assures a simple dialogue with the user and data processing, and it also computes and displays many variables and characteristics.

The procedure for studying the force sensor

- enables the fixing of measurement points $P_i(G_i,U_{Oi})$, where G_i is the gravitation force and U_{Oi} is the input voltage of UCV-02 (see Fig.9),
- displays the measurement points in the plane (G,U_O),
- ensures the linearization of the transfer characteristic $U_O=f(G)$,
- computes and displays the zero error and sensitivity based on the linearized transfer characteristic,

- compensates the zero error,
- measures and displays the weight of some objects.

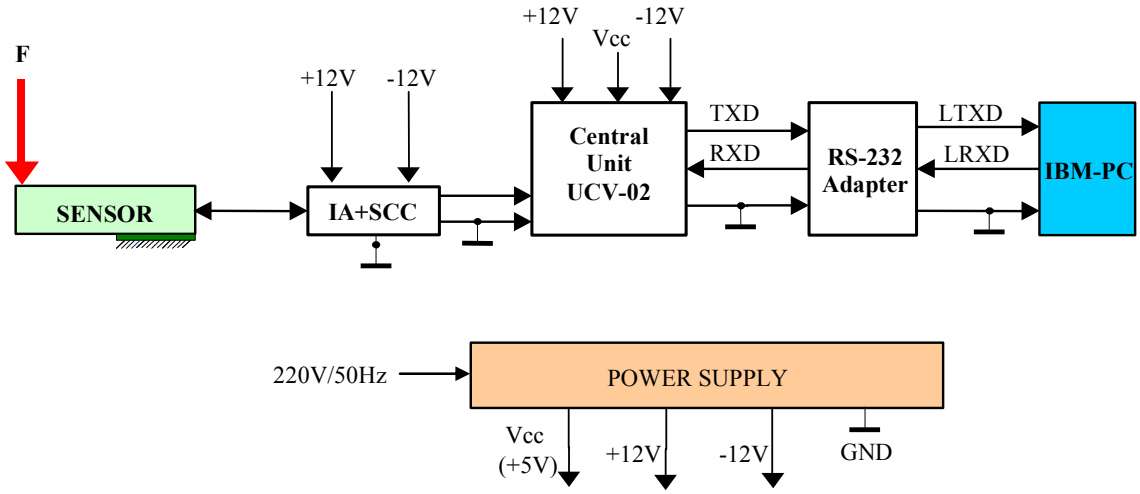

Fig. 8. Experimental system for studying a force transducer - Overall structure

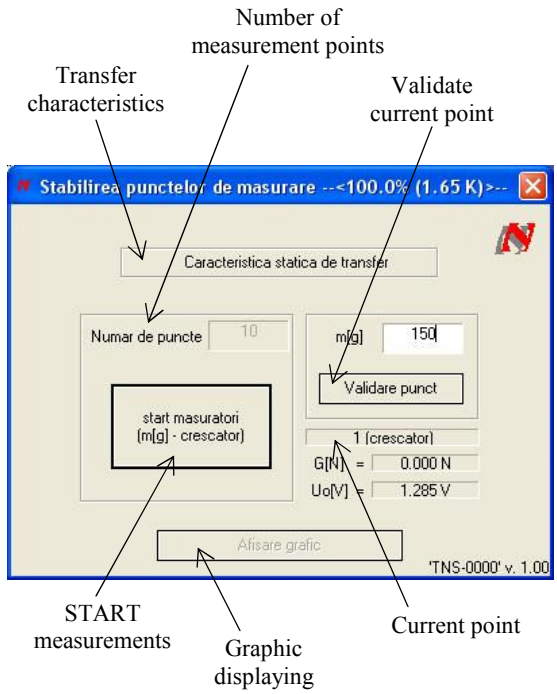

Fig. 9. Measurement points establishment

The transfer characteristic is depicted based on many measurement points, fixed by user. Their number and the weight associated with each point are also introduced (Fig.9).

IV. CONCLUSION

The paper presents three central units: UCV-01, UCV-02, UCV-01XA. Each module is configured around a microcontroller and provides high versatility in applications. Such central units are used in data acquisition distributed systems in energetics or in experimental systems for higher education and research activities. Two applications in engineering education (measuring system with rotary incremental encoder and experimental system for studying a force transducer) are also summary presented in this paper.

REFERENCES

[1] V. C. Petre, "The Technician's Point of View in Microcontroller Based Measurements", *WSEAS Transactions on Advances in Engineering Education,* Issue 8, Volume 3, 2006, pp. 779-782.

[2] *80C51-Based 8-Bit Microcontrollers*. Data Handbook, Philips Semiconductors, 1993.

[3] *Integrated Circuits. XA 16-bit microcontroller family.* Philips Semiconductor Data Sheet, 2001.

[4] Philips Semiconductor Data Sheet, *Integrated Circuits. XA 16-bit Microcontroller Family,* 2001.

[5] S. Iordache, M. Nedelcu, I. Purcaru, V. Țăpârdea, "Sisteme de surveillance des grandeurs électriques et dépistage des défauts dans une station électriques", *Proceedings of The International Symposium on Systems Theory, Robotics, Computers, Process Informatics (SINTES 8), 1996, Craiova (Romania), Section Computer Science & Engineering,* pp.105-112.

[6] A. Vasilievici, *Implementarea echipamentelor digitale de protecție și comandă pentru rețelele electrice,* Ed. Tehnică, București, 2000.

[7] C. Vlaicu, *Sisteme de măsurare informatizate,* Ed. ICPE, București, 2000.

[8] I. Purcaru, D.M. Purcaru, "Intelligent interface for studying different sensors", *Proceedings of The International Symposium on Systems Theory, Automation, Robotics, Computers, Informatics, Electronics and Instrumentation (SINTES 10),* 2000, Craiova (Romania), pp. E75-E78.

[9] Purcaru, D., Niculescu, E., Purcaru, I., "Experimental Measuring System with Rotary Incremental Encoder", *WSEAS Transactions on Advances in Engineering Education,* Issue 9, Vol. 4, 2007, pp. 180-186.

[10] I. R. Sinclair, *Sensors and Transducers,* Third Edition, Newness, 2001.

[11] H. K. Tönshoff, I. Inasaki (Editors), *Sensors Applications. Vol.1 (Sensors in Manufacturing),* Wiley-VCH Verlag GmbH, 2001.

[12] D.M. Purcaru, E. Niculescu, I. Purcaru, "Measuring Method for Computerized Study of Rotary Incremental Encoders", *WSEAS Transactions on Electronics,* Vol. 3, 2006, pp. 349-355.

[13] Purcaru, D.M., Niculescu, E., Nedelcuț S.D., "A Possible Method for Measuring Some Technological parameters", *Proceedings of the 11th WSEAS International Multiconference on Circuits, Systems, Communications and Computers, (CSCC'07),* Crete (Greece), 2007, Volume 1, 2007, pp. 77–81.