SOME APPLICATIONS IN INTELLIGENT INSTRUMENTATION AND SENSORS – PART ONE

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Abstract

The development directions of the Technical University of Cluj-Napoca, stipulate the possibility of organizing post graduate courses, separate of the usual technical training, in specialties related to metrology and quality insurance. The appearance, five years ago, and the further development of the "Instrumentation and Measurement Techniques" (IMT), specialization tutored by our department, represents an important step in training future highly demanded specialists – mainly because the research, the process automation, practically everything is now based on data acquisition measure and processing.

An important support both moral and financial was received from the World Bank, which, during the last three years financed or co-financed various educational and research projects and contributed to the creation of an adequate infrastructure for the IMT specialization.

The paper presents some of the achievements which may be used either for educational as well as for industrial purposes.

1. Presentation

According to the White book for Education and Formation “Teaching and Knowledgement. To a Knowledgement Society” adopted by the European Commission in 1995, the permanent education and formation will have to insure the passage to a society based on the obtaining of knowledge where the teaching and learning are permanent, a society of knowledge. In this context the restructure and development plans of the Technical University of Cluj-Napoca foreseen an extension of the specialties from the university lists on one hand and the implementation of flexible educational systems such as the European credits transfer system ECTS.

Today, the industrialized nations grant between 3% and 6% of their GDP to the development of measurement techniques and equipment. It must be underlined the role of higher education in the field of training engineers who are capable to design and sew the new technologies in industry, in safety or in the protection of the environment. Consequently, for today society the IMT is an infrastructure and service element. Generic, it is a natural science, the basis of control and management of the technological process and progress in industry and biology, in transport or in communications.

We may say, the IMT is a key technology in future oriented branches of engineering (EPE). Only well training engineers in application oriented IMT technical sciences will be able to solve efficiently processing, automation and instrumentation problems on industrial and applied research projects.

In this idea, the education plan in higher technical schools maintain an innovative (modern teaching , experimental facilities) and cooperative (cooperation with the industry for the technology transfer) environment for IMT science.

All those are not possible without a strong financing program. That is why we consider so important the role of financing research contracts and implementing excellency research contracts.

As a late development we have to say that the IMT specialization was discussed at the Romanian Technical University Rectors Conference (September 2000) which approved the new academic curricula in the European integration context and the IMT specialization was authorized at the national level and is considered to have an on-growing demand. In our university the Electric Measurements Department tutors this branch.

We present several ideas of a technical higher education branch where the IMT has a leading role:

- the creation, by theoretical basis courses, of the fundamentals principles of IMT regarding its main levels : information management, information processing and automation, process field, supervisory and command systems of the process;
- the laboratory experiments are innovative teaching method : this, first to intensify the theoretically acquired knowledge in IMT and secondly, to analyze the interchanging influences of measuring system and the measuring process or object. We should analyze: the influence of location of the sensors to the rebelled of the measuring results; the optimization of the location of the sensors in the systems; the influence of the sensors on the dynamic and static characteristics of the process; the interconnection between the instrumentation and the process; the computerized signal processing of a real system instrumentation (computer aided modeling, simulation and analysis of different processes for instrumentation and servo-automation).

Some of the achievements of the co-financed program and also of using such an approach in our department are:

- the creation of an excellency laboratory for virtual instrumentation;
- the creation of a modern laboratory for computer based measurements both for electric and non-electric sizes;
- the elaboration of original software for electromagnetic and electrostatic field modeling;
- new laboratory works as well as ready to use virtual instruments for metrological calibration of A,V,W, type instruments and energy-meters

These achievements allow further developments for:

- application oriented project design courses, based on the basic level knowledgements and on the graduated lab exercises in IMT. Therefore, the student should get a deep insight in hardware and software of integrated IMT, process automation and controlling system as the basis for a project design;
- cooperation between industry and universities in the idea to optimize the teaching method for direct industrial applications;
- thesis for the master degree as the final level higher education in applied IMT science, oriented in two main directions : completing a development project in the laboratory to realize a major research project with application aspects;
- post-graduate courses focused on the latest technological news and interdisciplinary research.

During the past years, through several scientific research contracts, co-financed by the Romanian Government and the World Bank we created a research center with a solid infrastructure (computer networks, data acquisition and processing systems, transducers) suitable for both electric and non-electric measurements in either classical measurements as well as in the virtual instrumentation domains.

Figure 1 Research center – nonelectrical sizes measurements department

The research center (see figure 1) has a solid infrastructure composed of computer networks with adequate software, data acquisition boards, data conditioning and processing modules for transducers, measuring signals generator board, oscilloscope multimeter and signal generator boards, performant transducers for electric and non-electric sizes.

This infrastructure allows researches in the following domains:

- non-electrical sizes measurements suitable in industrial automation and robotics;
- electromagnetic and electrostatic field modeling for inductive and capacitive transducers for performance increase and optimize;
- measuring and design methodology for intelligent transducers measuring and design methodology for intelligent transducers;
- measuring circuits and equipment overall performance increase (low errors, increased reliability, …).

The main objectives of the research center from our department are:

- to implement a inter-university collaboration framework and to insure good integration of our research in the European educational system;
- to create a research infrastructure in the intelligent sensors and instrumentation domain so that the modern applications, collaboration and achievements allow a future development of the research frame contract.

2. Research results

We consider that any idea on either the structure of the curricula of a high technical education system must be supported by achievements which should on some extent prove a certain approach. This is the reason why this chapter briefly presents some of our results:

- Original software design for electromagnetic field distribution based on the 2nd order finite element method, for measuring instruments and inductive transducers:
- measuring instruments (see figure 2);

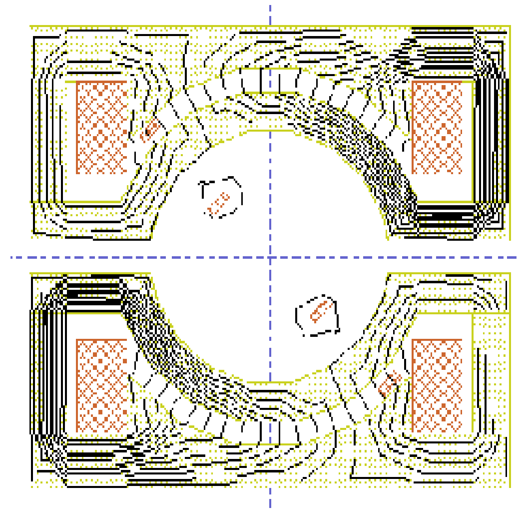


Figure 2 EM field distribution

- turn transformer type inductive transducer (see figure 3); e.g.: Range extension form ±20% to ±40%with a cvasi-linear characteristic.

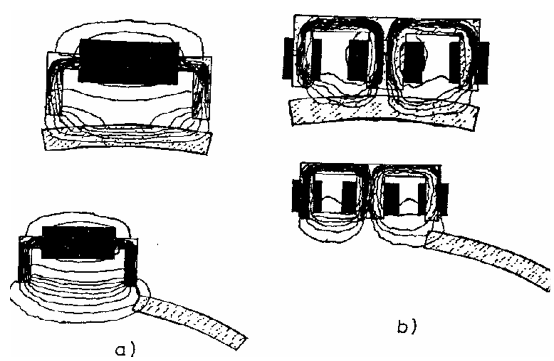


Figure 3 Turn transformer transducers field distribution in two variants

- The roughness measurement is based on the autofocus laser method. Because of the system's enhancements in order to perform surface mapping and boundary following the transducer has the configuration as shown in figure 4.

Using a laser diode, a laser beam is send to the measured surface; the beam is reflected by the surface and through the

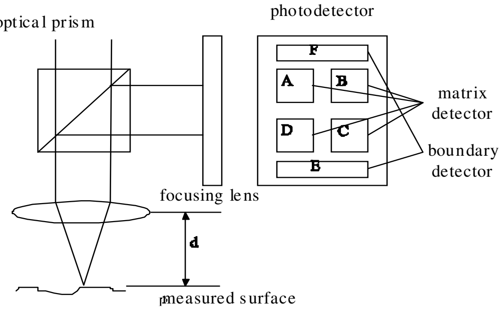


Figure 4 Sensor for roughness measurement

optical prism is sent to a matrix type photodetector. The output currents of the photodetector give sufficient data both to determine the size and sense of the defocalisation of the laser beam for the studied surface point and to determine if the point is or not a boundary point. The roughness is determined performing the autofocus operation and is equal with the distance the focusing lens is moved.

As a particular aspect of this method the acquisition of these currents is not made by a specialized DAQ board but via the analogic input channels of a DC motor drive board. This solution had been chosen in order to reduce as much as possible the system's hardware. Once the currents acquisition made the whole system is controlled by a virtual instrument made for this application. The instrument controls not only the roughness measurement part but also, with a special program, the movements of the optical head if a surface mapping or a boundary following is necessary. A block diagram of the system is presented in figure 5.

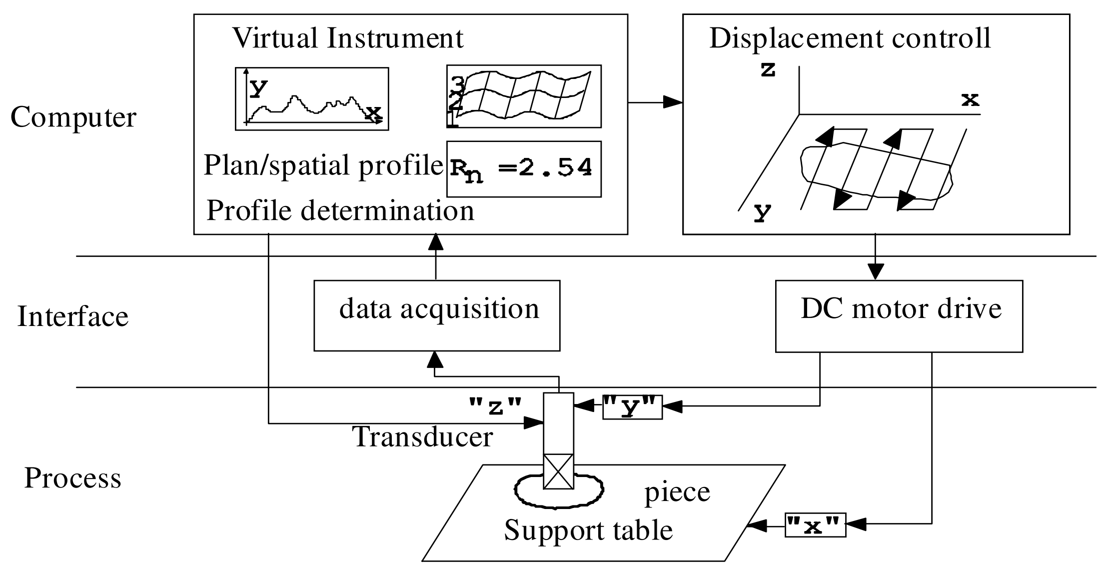


Figure 5 Roughness measurement system – block diagram

The displacement control is made in different ways for the different types of measurements. For roughness measurement three different movements: the optical head (transducer) along the *"y"* axis, the support table along the *"x"* axis and a movement performed either by the entire optical head – if the surface is not planar and a proximity sensor is used – or only by the focusing lens inside the transducer along the *"z"* axis (this last one in order to keep the system permanently focused).

If we consider a planar surface for the measurement of only the roughness (no proximity sensor added) the logical diagram the system is based on, isshown in figure 6.

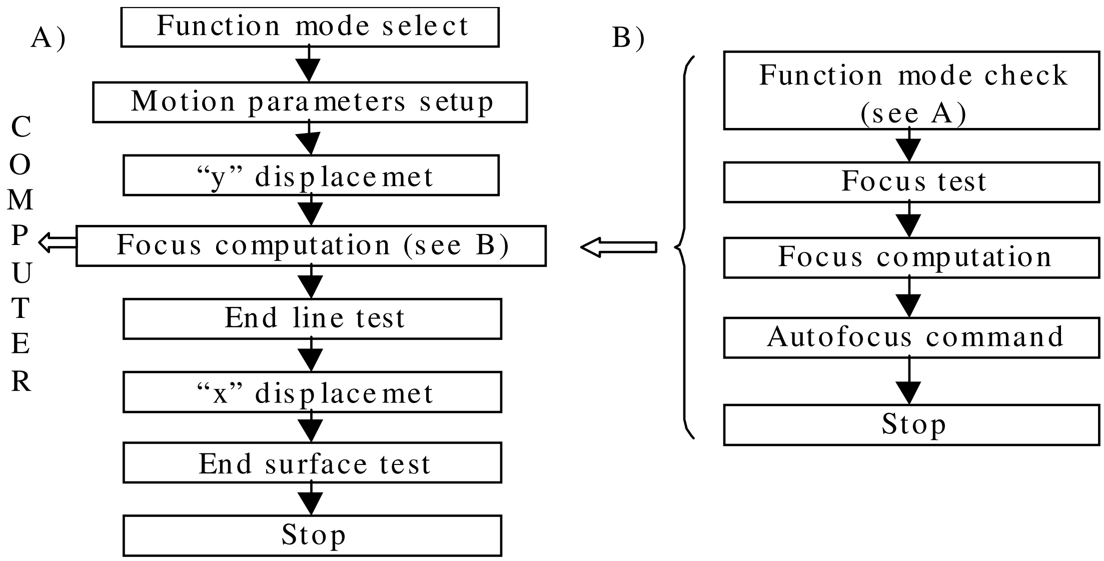
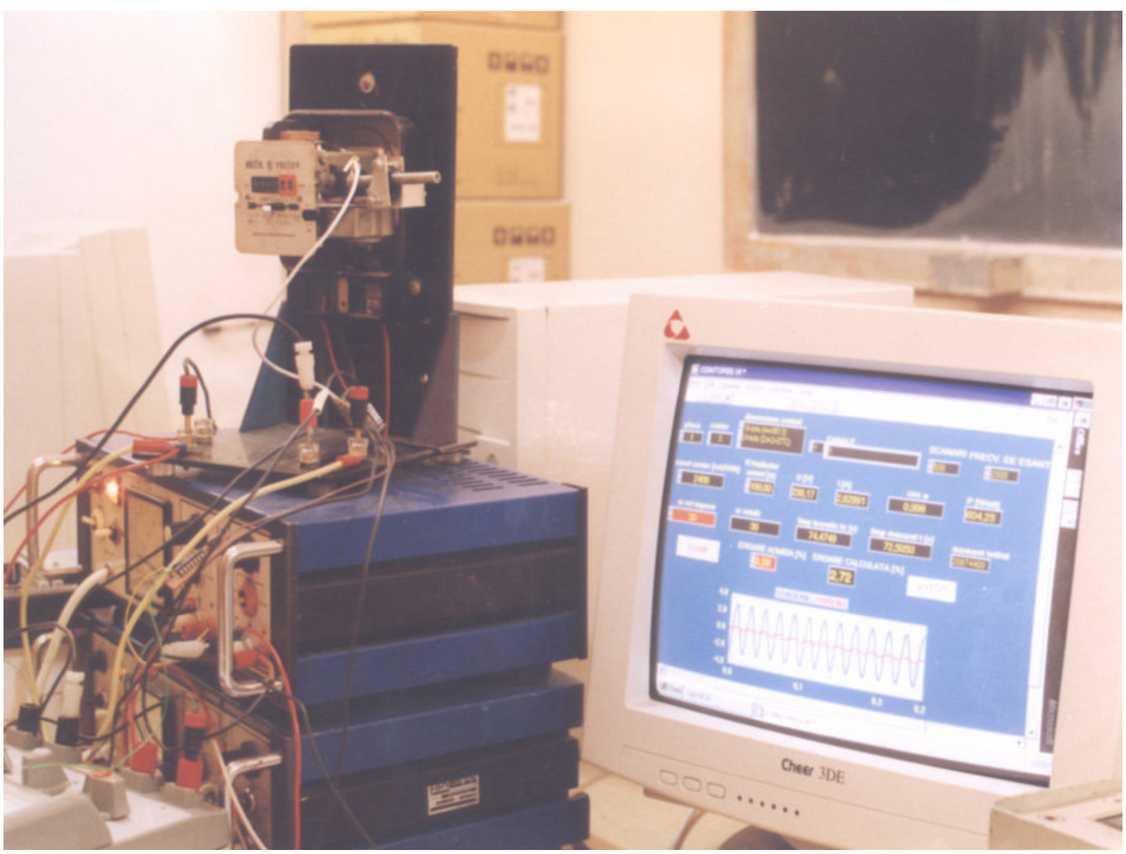


Figure 6 Roughness measurement system – logical diagram

- The design of a metrological equipment (virtual technique-LabVIEW platform) for single phased energy meters calibration(see figure 7). The calibration stand is equipped with AT-MIO-16E-10 DAQ boards and it works at a 16 bits resolution. This equipment is part of the research for a Ph.D. thesis and in process of implementation in the metrology laboratories in our area.



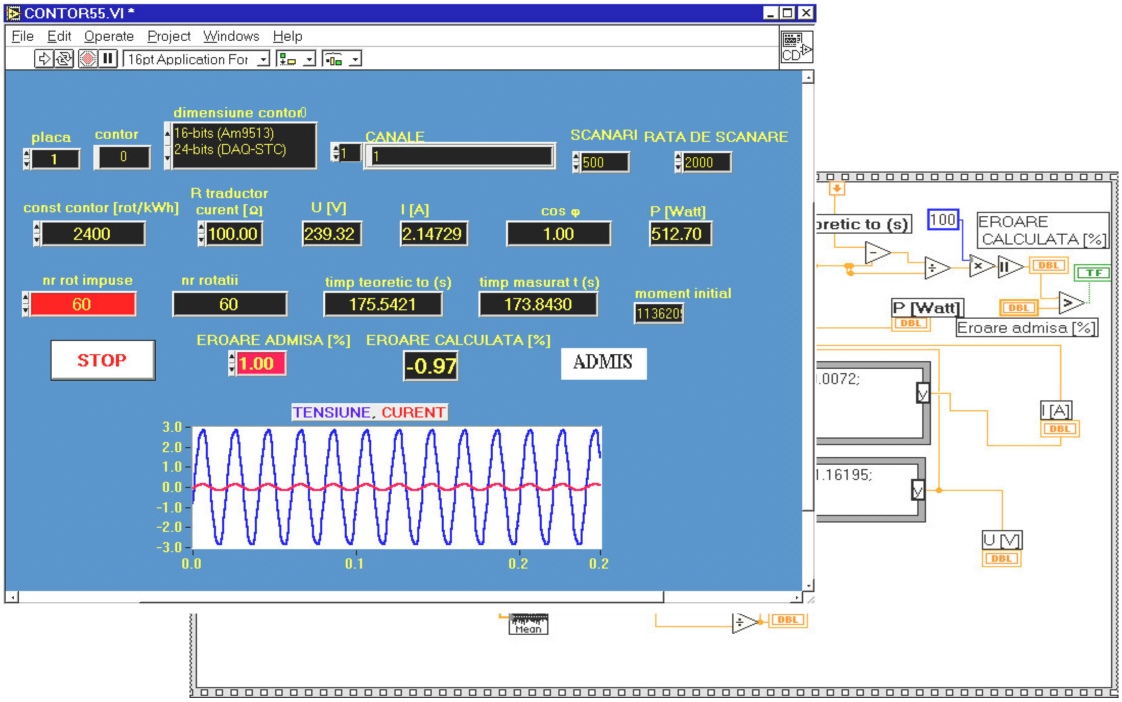


Figure 7 Virtual stand for single phased energy meters, LabVIEW program front panel and diagram

• The design of a virtual ferrotester (see figure 8) fully automated for the B(H) functions plotting and characteristic values computation. The equipment works at a 0.5% precision.

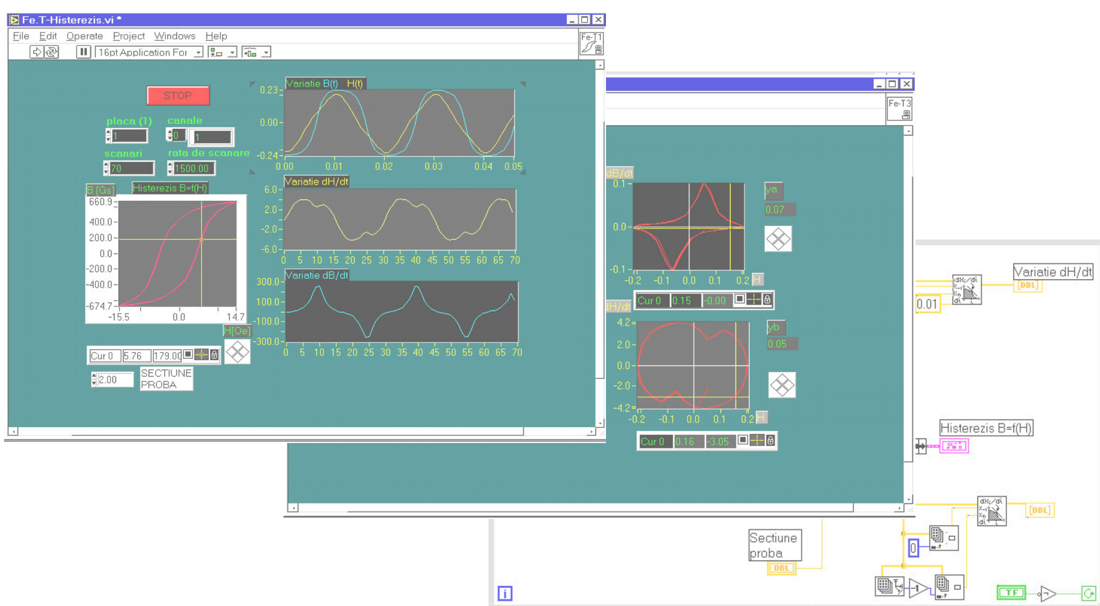


Figure 8 Virtual ferrotester – front panels and diagram

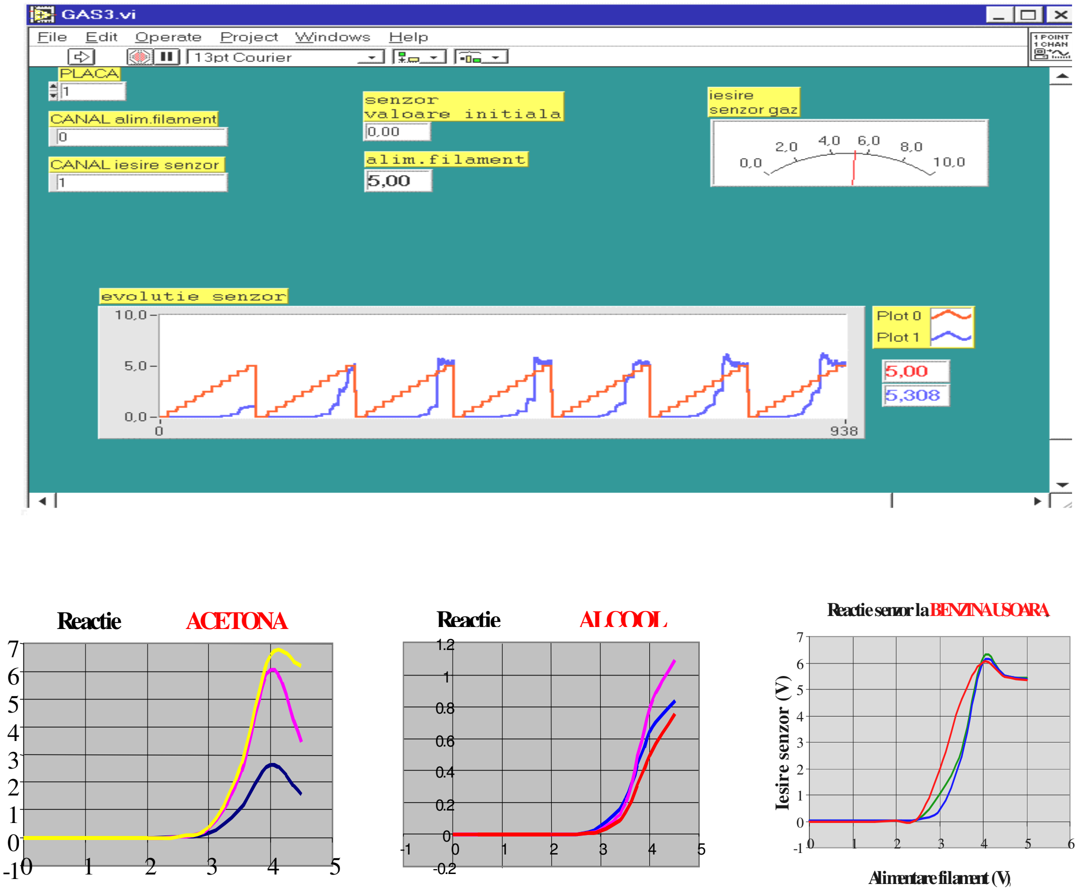


Figure 9 Virtual gas analyser – front panels and diagrams

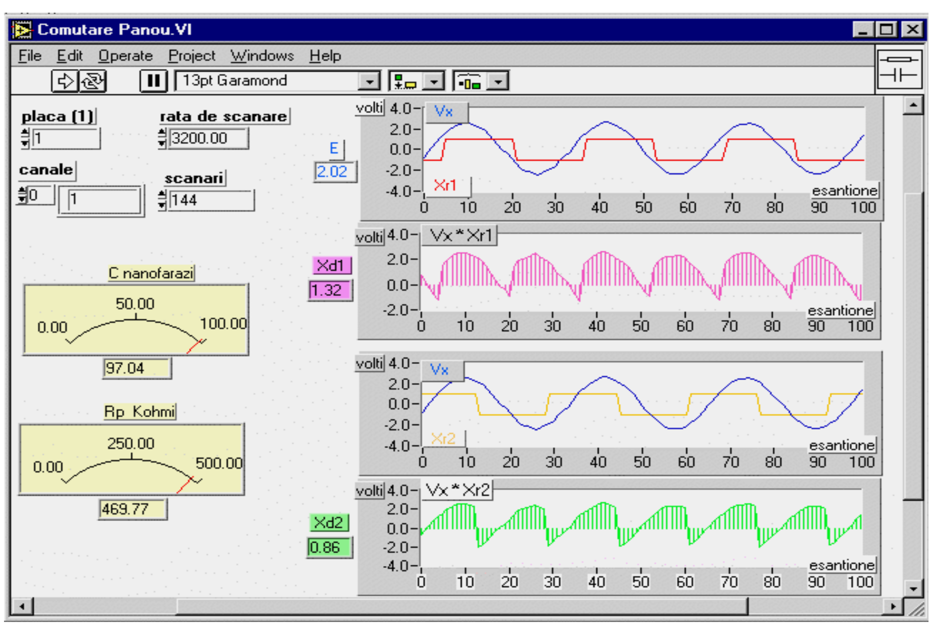


Figure 10 Virtual impedance meter – front panel