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A TWO YEARS EXPERIENCE FROM THE INTERNATIONAL SUMMER SCHOOL ON DATA ACQUISITION SYSTEMS

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Abstract − The International Summer School for Master of Science (MS) and PhD students is aimed to give expertise for designing and testing Data Acquisition (DAQ) systems. The students became familiar with various aspects concerning (i) interfaces for measurement instrumentation, (ii) different programming environments for DAQ system software development, and (iii) DAQ system control in the integrated communication and computer networks. Obtained skills allow the student the implementation of design and test methods in any European enterprise with regards to the common standards and products available on the market. The paper presents the two years experiences achieved at organizing the Summer School held in 2001 and 2002, and programmed in 2003, supported by the European SOCRATES/ERASMUS Programme, the IMEKO Working Group on ADC&DAC Metrology, the University partners, and other Institutions.

Keywords: Education, training, DAQ systems.

1. INTRODUCTION

The assembling of modern systems based on the computer processing of the digitalised information coming from sensors requires deep knowledge of technology and metrological properties of the interfacing blocks.

The interfacing blocks, including Analogue-to-Digital (ADC) and Digital-to-Analogue Converters (DAC), influence the performance of Data Acquisition (DAQ) systems. In particular, the possibility of integrating ADC and Digital Signal Processor (DSP) in one chip has enhanced their application field. Therefore, a deeper insight into the ADC and DAC characteristics is needed and fundamental in order to evaluate their influence on the digital processing architecture. Moreover, the demand for building DAQ systems for the monitoring and controlling over wide geographical areas requires competence in programming in environments for the development of distributed software systems.

Particular topics related with this actual area are taught in separated courses of Electronic Measurements, Electronics, Signal Processing, and Software Programming within the MS and PhD courses.

The International Summer School framework seems to be a very convenient and acceptable way to integrate and expand the knowledge of the students in the DAQ system area. The developed intensive course reflected the requirements of industrial partners for graduates with advanced skills in the field of design and testing of the DAQ systems integrated with the information environment for the Total Quality Management. Moreover, the Summer School tried to meet the main goal of the European policy to enhance resources of highly qualified graduates, able to work in a multinational team [1].

2. OBJECTIVES OF THE SUMMER SCHOOL

The objectives of the intensive training course were:

1. To provide a two weeks long intensive course of "Data Acquisition Systems" for MS and PhD students covering actual topics, so far taught separately in various optional courses.
2. To write a student's handbook for the developed course of "Data Acquisition Systems" containing the basic ideas necessary to understand the background of this discipline. The handbook was prepared in form of a guideline for participating students. It includes (i) the explained topics, (ii) references to recommended study literature, and (iii) data sheets of components of DAQ systems.
3. To prepare a list of case studies for course participants. The students solved the problems during the experimental activities in the laboratory under the supervision of the teachers. The solved problems were part of the final teaching materials.

3. ORGANISATION OF THE SUMMER SCHOOL

The organisation of such international training courses needs to fulfil the following four necessary, mutually linked, conditions:

1. To build an university partnership which results in:
   a. Establishing a group of teachers, with high level of skill and competence, willing to participate to the course.
   b. Establishing the international organisation committee.
   c. Choosing the hosting and coordinating University willing and capable to provide teaching support (lecture rooms, didactic technology, experimental laboratory and equipment, etc.) and boarding (accommodation for students, etc.).
   d. Appointing the responsible person at each partner University to recruit the students interested in attending to the course.
2. To establish the national organisation group at hosting University that is able and willing to arrange all needs linked with the course according to the point 1c.
3. To prepare and schedule the course programme including the practical exercises and the individual case studies.
4. To find the financial support for the course.

3.1. Partnership

The established Universities' partnership was based on personal contacts and previous mutual research/educational activities gained within the *IMEKO TC-4 Working Group on Analogue-to-Digital & Digital-to-Analogue Converter Metrology*. The Working Group was formally established during the IMEKO World Congress held in Tampere, Finland, 1997 [2].

The Universities involved into the Summer School project were: Technical University of Košice, Slovak Republic; University of Sannio, Benevento, Italy; University of Calabria, Cosenza, Italy; and Czech Technical University, Prague, Czech Republic.

The Technical University of Košice was chosen to be the course hosting University. The course lecturers came from all the cooperating Universities.

Fig.1. CD-Rom including theoretical lectures, experimental exercises, and practical case studies developed during the 2nd Summer School.

The MS and PhD students were selected from the Universities participating to the project, approximately 3-5 students from each University. The contact person from each University carried out the selection of participating students. The required theoretical students' knowledge included the disciplines: Electronic Measurements and Instrumentation, Electronics, Computer Systems, Telecommunications, Digital Signal Processing and Software Programming. Moreover, good knowledge of English language was also required.

3.2. Course programme and schedule

The course programme and the time schedule were prepared according to the partner suggestions. The final course programme was approved on the basis of the project agreement signed by the cooperating Institutions.

The English language was chosen as offical language for teaching.

The Summer School schedule included morning and afternoon meetings with lunch break. The official program was completed by the official social events – sightseeing tours with lunch on Sundays, and by informal meetings and daily events in the evenings.

For the Summer School edition held in 2002, in the last three days technical visits to the Measurements and Instrumentation Laboratories of Czech Technical University in Prague were organised.

Besides the possibility of visiting qualified laboratories, the course participants attended tutorial lectures in the framework of ADDA&EWADC Workshop organised in the same time in Prague [3].

The Workshop is the annual scientific event organised by the *IMEKO Working Group on ADC & DAC Metrology* and involves several international research centres dealing with DAQ systems.

The participants valorised this occasion for meetings with other European experts working in this area and to get acquainted with new trends in DAQ system area.

3.3. Financial support

There are four possible financial sources, which can be mutually combined:

1. European Union programmes such as the SOCRATES/ERASMUS [1].
2. Support of cooperating Universities.
3. Individual sources from involved students.
4. Sponsoring of industries and other institutions and bodies.

The most convenient source for financing an International Summer School such as on DAQ systems seems to be the European SOCRATES/ERASMUS Programme [1].

An Intensive Programme (IP) of the SOCRATES/ERASMUS Programme is a short programme of study (from 10 days to 3 months) which brings the students and the staff, from Universities of different participating Countries, together with non-academic experts, in any field of study.

The SOCRATES/ERASMUS Programme may cover the implementation of an IP during one, two or three successive

years, including travel and subsistence costs for participants. The support is given to the coordinating Institution within its Institutional Contract [1].

According to the proposal, the financial support from the SOCRATES/ERASMUS Programme covered travel expenses of participants and lecturers, preparation of study materials and administrative costs.

4. TEACHING METHODS AND GOALS

The main features of the prepared teaching materials were [4], [5]:

1. the taught topics, which have to show theoretical background based on the following disciplines: Electronic Measurements and Instrumentation, Electronics, Computer Systems, DAQ Systems, Telecommunications, and Software Programming.
2. the definition of most important parameters and metrological characteristics including the ways of their determination and testing.
3. the explanation of the ways for the metrological property improvement of the developed systems.
4. the design methodology based on the combination and integration of modern components available on the market.

The course programme, whose short general content from the last course held in 2002 is listed in Table 1, consisted of three main components differing by teaching methods:

1. Theoretical lectures, given by the internationally recognised experts from all involved Universities, explained the theoretical topics. The lectures were focused on (i) main principals, (ii) components of DAQ systems including local and distance communications, (iii) metrological characterisation of main components, and (iv) their testing. The short list of theoretical lectures is given in Table 1.
2. Experimental exercises performed on ready-to-run settings. The main goals of these exercises were (i) to make students familiar with basic components of DAQ systems, available on the market, and (ii) to inform the students about some, among the most common, software programming environments for DAQ systems. The stands were presented by the teachers, and the students were asked to explain some questions and problems according to the theoretical knowledge acquired from lectures. The short list of the experimental tasks is shown in Table 1.
3. Practical case studies, tutored by teachers, were based on the theoretical knowledge and on the student experience gained within the previous theoretical and experimental parts of the course. The student task within the case studies was to develop an own control and test software for ready-to-run DAQ system hardware. Students worked in international groups of 2-3 persons. The tasks were adapted according to the actual individual knowledge and interests of students. The outcomes of these activities were presented by the authors at the end of the course to audience of the

TABLE 1. Time schedule and list of theoretical lectures and experimental exercises from the 2002 Summer School edition.

Day	Morning	Afternoon
1	Theoretical background, instrumentation and uncertainty theory. Error and EM interference. Sampling theory and quantisation, quantisation noise, information capacity.	Metrological aspects of DAQ systems. ADC and DAC characteristics. ADC and DAC terminology. DAQ components available on the market.
2	Main circuits for general A/D and D/A conversion. Pre-processing circuits.	Component representation of FDC, TDC and VCO. DAQ boards. Integrated signal conditioners.
3	Software for DAQ system programming. SCPI language. Integrated software development system; LabWindows/CVI, LabVIEW, JAVA programming, Virtual Instruments.	Experimental exercises: - design of digital filters for DAQ application, error evaluation; - example of DAQ system controlled by means of Internet.
4	Improved digital signal processing for error reduction ADC modelling. Signal recovering and interpolation. DAQ system error budget. Stochastic and systematic error correction. Testing of converters and DAQ systems. Static testing methods according to IEEE 1057 Std. and IEEE 1241 Std.	Experimental exercises: static and dynamic testing of multifunction DAQ cards and sound cards.
5	Dynamic testing methods according to IEEE 1057 Std. and IEEE 1241 Std. Internetworking basics. Communication theory. Mobile agent approach. Automated laboratories. Distributed monitoring systems over a wide area.	Tutored case study.
6	Saturday - Tutored case study	
7	Sunday – free day, social program	
8	Signal conditioning modules. Centralised DAQ systems with plug-in modules; ISA Bus, PCI Bus, PC Card, CardBus, Compact PCI, VXI, PXI.	Tutored case study.
9	Tutored case study.	Presentation and assessment of individual case study results.
10	Travelling to Prague	
11	EMC aspects of DAQ systems. Sources of external and internal disturbances. Advanced method for ADC testing. Oversampling principle. Practical problems. Matlab tools for ADC testing.	Visit to the DAQ system laboratory. Visit to the laboratory for ADC and DAC testing. Questionnaire and comments related with organisation of the 2nd Summer School.
12	Attendance to the ADDA & EWADC scientific events	
13		
14	Sunday – free day, social program	

TABLE 2. List of case studies solved by the students in the international working teams in the 2002 Summer School edition.

Interfacing PC and measurement instrument using GPIB
Simple DAQ system based on ADuC 812 kit (Analog Devices)
Remote monitoring of temperature using AM modulation
Virtual Instrument based on Agilent 34970A
Data acquisition from PC sound card

lecturers and the students. The list of activities carried out by students is given in Table 2.

Working in the international teams enabled the lecturers and the students to achieve two goals simultaneously:

1. The first one is the practice with the modern tools and components for implementation of DAQ systems within measurement and monitoring of the industrial processes.
2. The second goal is represented by training the students to work in international working teams. This task was more complex and allowed the students to obtain skills in the multinational teamwork methodology under supervision of internationally recognised experts. Furthermore, the students were informed about the European standardisation in the DAQ system field and the progress in the approximation of the national legislation in the Associated Countries to the common European legislation. It allowed preparing the young researchers experienced in the use of the ordinary testing procedures according to the European standards.

The performed course improves "common language" of the participants of the various European countries. On the other hand, the variety of the studied topics and the achieved results represented the knowledge potential. This is based on (i) research activities, (ii) results, and (iii) approach methods of the European researches, as well as similarly occurs in USA and Japan.

5. CONCLUSIONS

The experience gained by the organisers from the International Summer School on "Data Acquisition Systems" indicates that:

1. the organisation of the international meeting of teachers and students in the framework of Summer School is very meaningful and useful for all participants – students as well as lecturers. The authors strongly recommend to organise such events on various topics.
2. the organisation and management of this event needs a relevant organisation work early in advance. The necessary condition is to establish the cooperation between teachers and organizing committee.
3. Getting an adequate financial support is the next imperative condition. The organisers have to look for all possible sources: international project, local sources, industrial sponsors.

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