

SYSTEM FOR ONLINE MEASUREMENT OF MECHANICAL PARAMETERS

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Online measurement of mechanical parameters is often used in laboratories and technical applications and it is an essential development field for measurement applications. Only through online measurement the user can obtain the real-time signals and can control the process.

In this work we present an approach, designed to increase the effectiveness of basic experiments in areas such as instrumentation, material science and mechatronics and to bring into the curriculum the modern data acquisition methods and virtual instrumentation approaches. To be more specific, the study of basic material properties under uniaxial stress-strain measurements, within the elastic and plastic regimes is presented to illustrate the benefits and efficiency gained by the use of graphical programming environments.

Keywords: Online measurement, virtual instrumentation, LabVIEW, data acquisition, analog microcontroller.

1. Introduction

The understanding of the basic physical and engineering principles requires complex experimental demonstrations, which are often accompanied with extensive online measurements. Often the experiments' objectives are hindered, by the complex data collection process. The student's comprehension can be enhanced with the use of modern data acquisition systems.

Online measurement of mechanical parameters is a frequent issue in laboratories and the industry and is an essential development field for the measurement applications. Only through online measurement the user can get the real-time signals and can control the process by feedback system. With the development of the computer technology, the research of online measurement using virtual instrumentation is constantly developing. It has many advantages, which the traditional methods do not have. Only with sensors, A/D converter, software and PC we are able to easily and efficiently define many different measurement systems in which the software is the main part.

Programming environments like LabVIEW are proven to be a powerful computational package for the automated monitoring and analysis of diverse experiments. The use of such a computational environment with modern digital instrumentation and high resolution measurement modules has enabled us to provide the student and researchers with a more complete hands-on experience, which is a

significant aspect for the students' training. More complex experiments can be scheduled within the normal laboratory periods. The user-friendly nature of these programs makes both, the collection of the data and their analysis, to become a straight-forward process.

A number of experiments in different areas of instrumentation, mechanical engineering and mechatronics at the Department of Electronics of TU Sofia in cooperation with the Department of Mechatronics, Optics and Instrumentation Technology of the TU Budapest have been revisited to improve the experiments' scope and their educational value.

In our particular case, the study of basic materials properties under mechanical tensile stress, within the elastic and plastic regimes is presented to illustrate the benefits and efficiency gained by the use of modern data acquisition programs.

2. Tensile Stress-Strain Analysis of Materials

In this experiment the students study the mechanical properties of different metals which, loaded under tension, are deformed within the elastic and plastic regimes, up to failure. This classical and basic experiment of materials engineering is considerably valuable for the students to better understand the various concepts and principles governing the mechanical behavior of materials, and also for researchers when working on particular problems from real life.

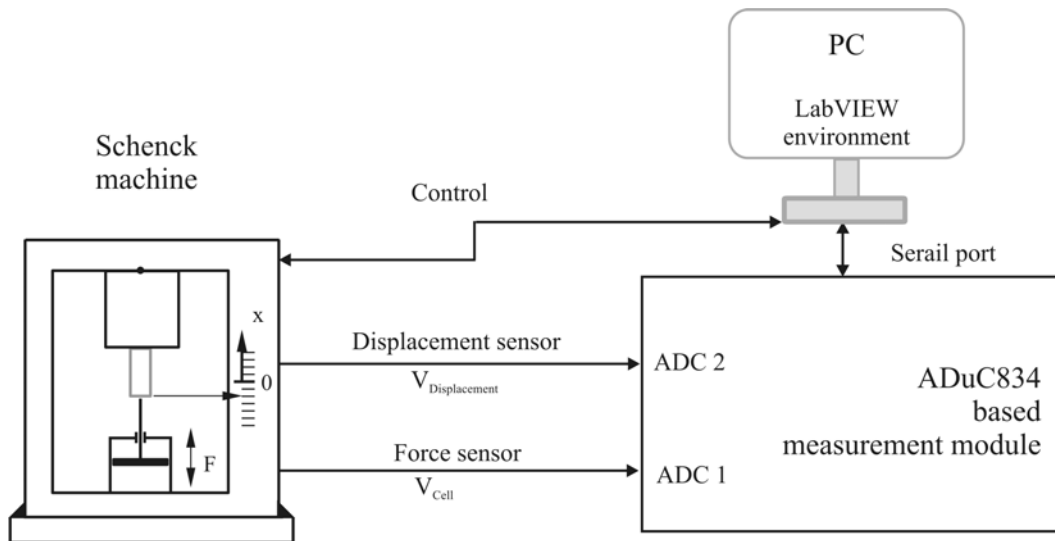


Figure 1. Experimental set-up

These experiments are carried out on a Schenck (Instron) materials testing machine where load cycles and load rates can be set at different magnitudes. The output voltages from a load cell and a displacement sensor (extensometer) are monitored with a measurement module, equipped with a serial communication port. The high resolution voltage measurement of this module allows the monitoring of output voltages from load cell and extensometer, with remarkable precision. Various

mechanical parameters of the investigated specimens can be obtained from the measured stress-strain (σ - ϵ)-diagram. These diagrams are established from the raw data (i.e., $V_{\text{Cell}}-V_{\text{Displacement}}$ -diagrams) collected from those sensors.

The control of the Schenk machine, the measurement process, visualization and computation of data is done in the LabVIEW environment (fig. 1).

3. Hardware Implementation of the Data Acquisition System

Analog microcontrollers' development is one of the fastest growing segments of engineering, and will continue to be for the foreseeable future as consumers demand smarter cars, appliances, intelligent sensors, and so on. The evolution of these commercial technologies will propel virtual instrumentation into being more applicable to a growing number of applications. The analog microcontrollers combine precision analog functions, such as high resolution ADCs, DACs, voltage and current references, with an industry-standard microcontroller and embedded flash memory. With their mixed-signal IC architecture, they supply the needs of today's sensor and measurement systems designers. Using their functionality it is possible to significantly increase the performance and significantly cut the development time of data acquisition systems.

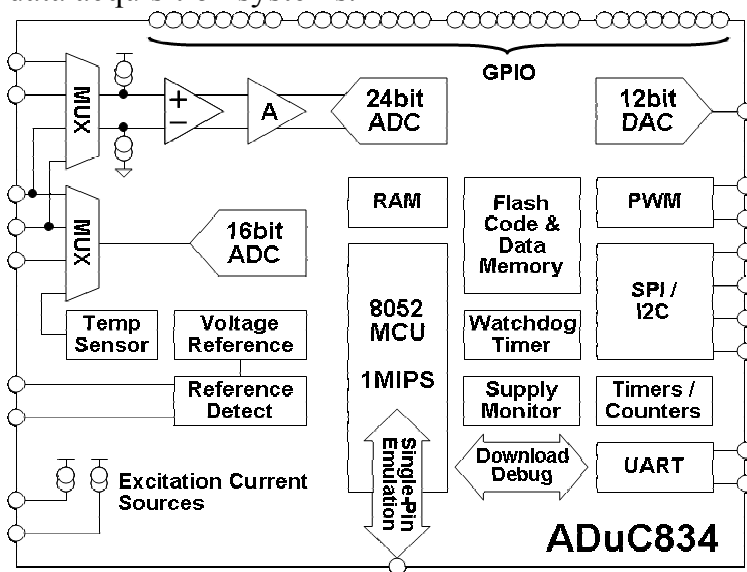


Figure 2. The building blocks of analog microcontroller

Serial download capability allows developers to re-program the part while it is soldered directly onto the target system avoiding the need for an external device programmer. Serial download also opens the possibility of system upgrades in the field.

In present paper the approach of integrating these advanced technologies in one environment is proposed [3].

The base building blocks of typical analog microcontroller (Analog Devices Σ - Δ -Micro-Converter ADuC834 Products) are shown on fig. 2. By reconfigurations and reprogramming of these blocks the developer can compose a multitude of measurement configurations. One of the features of the analog microcontrollers is the ability of the device to download code to its on-chip program memory [1]. This in-circuit code download feature is usually conducted over the device serial port. Serial

4. Software Implementation

Keil μ Vision compiler is used for software realization of the analog microcontroller based module. This compiler supports programming in Assembler and 'C' languages and generates HEX files.

As mentioned earlier, the modification of the various undergraduate experiments focuses on the implementation of simple data acquisition programs which the student can easily work with, and the instructor can readily customize to the particular objectives of each experiment. The high level graphical programming environments have been found to be rather attractive tools in the accomplishment of the revision's goals, which include the time optimization and the enhancement of the quality and clarity of the experiments.

The programming environment LabVIEW is a data acquisition, process control and analysis system, which has full advantages of the features and the graphical interface provided by Microsoft Windows. Using LabVIEW, a measuring and process control, or simulation task can be set up directly on the screen by selecting and connecting instrument modules that can then be freely arranged according to the purposes of measurement.

As with LabVIEW, engineers interface with real-world signals, analyze data for meaningful information, and share results and applications, than in the implemented software environment can be seen that it has been composed of three basic parts. The first one is for data acquisition, second for data manipulation and analyzing, and the last one for data presentation and publishing [3]. Following this division the implemented software is divided in three parts:

1. Library consisting of number of programs and functions for control of the load cycles and rates of the Schenck machine and for the data acquisition process;
2. Library consisting of created and built-in Virtual Instruments (VIs) and subVI for data manipulation and
3. Number of programs of top level VIs for data representation.

The first part consists of number of Virtual Instruments (VI) defined for the acquisition of data from the load cell and displacement sensor. These VIs enable students:

- (1) To interactively enter information of the test, materials, and name of the file where the raw data is to be saved for later use.
- (2) To calibrate both, the load cell and the displacement sensor before the actual tests, or enter the transducers sensitivity values.
- (3) To record the zero-load voltages from the load cell and displacement sensor.
- (4) To acquire data from the sensors within the linear portion of the stress-strain diagram, prompting the user to cycle the load several times.
- (5) To acquire the load cell and displacement data when the specimens are plastically deformed, up to the fracture point and

- (6) To save in one file the experiment's data, along with the sensitivity values of the sensors.

The second part consists of VIs, which allow students and researcher to analyze the data and determine the parameters of interest.

The implemented algorithms convert the raw data into loads and strains and analyze these variables in the elastic region through the use of built-in mathematical functions, available in the LabVIEW environment to determine E and modulus of resilience, σ_y , σ_{max} , ϵ_{max} , and modulus of toughness of the material.

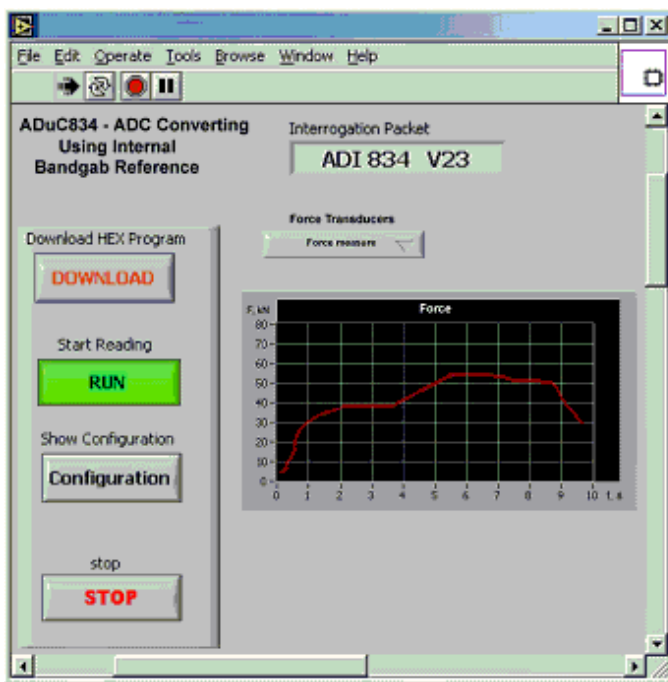


Figure 3. Virtual instrument front panel with part of stress-strain diagram

“Download” is used to download and start program. “Run” serves data acquisition and properly manipulation for desired result representation. The “Configuration” button activates additional window with system configuration. “Stop” breaks the program executing.

4. Conclusion

In this paper we describe some of the current efforts to upgrade the experimental laboratory courses in various engineering areas in order to improve the scope and the educational value of experiments. In our case the implementation of a System for online measurement of mechanical parameters, based on analog microcontroller and PC with LabVIEW environment is developed. We efficiently integrate a flexible and reliable toolkit using virtual instrumentation technology and significantly reduced time by efficiently collecting, logging, and further processing multiple signal sources.

One of the key aspects contemplated in the re-structuring process of the different experiments has been the inclusion of modern data acquisition principles and virtual

instrumentation that would allow the implementation of complete experimental exercises. All experiments are being re-designed to have an interactive environment for the acquisition of data and so both instructors and students can benefit of the friendly nature of the graphical programming packages which, with data-acquisition add-ins, become a rather complete environment for the hardware control, acquisition of data, analysis and file administration.

Efforts will continue to upgrade other experiments in the areas of measurement instrumentation, smart sensors and actuators, systems and controls.

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