Measurement and Instrumentation in Mechatronics Engineering Education

Conference Paper · June 2007

5 authors, including:

Abdulgani Albagul
College Of Electronics Technology

Tarig Faisal
Higher Colleges of Technology

Momoh Salami
International Islamic University Malaysia

Othman O. Khalifa
International Islamic University Malaysia

Measurement and Instrumentation in Mechatronics Engineering Education

A. Albagul [1], Tarig Faisal Ibrahim [2], M. J. Salami[2], O. Khalifa[2], M. Hrairi[2]

[1]The Higher Institute of Electronics, Control Engineering, Baniwalid, Libya
[2]Faculty of Engineering, International Islamic University Malaysia, Kuala Lumpur, Malaysia

ABSTRACT: Instrumentation and measurement technology has served as the backbone of modern industry. It is very important that engineering graduate should be equipped with the comprehensive knowledge about instrumentation and measurement techniques. This will help them to cope with various industrial sectors. Industrials are eager to get highly educated engineers who can deal with their equipment easily with no extra training. Since industry is continuously upgrading with new generation equipment, it is essential that engineering students should be trained in all major groups of instrumentation including analog technology, digital technology and computer base instrumental. However, there is no any module or references include this three part. Most references are discussing the instrumentation and measurement technology in general or separately. Consequently, the proposition of work is to come up with a one module which will include all instrumentation and measurement technology syllabus specially designed for engineering student to cover the whole aspects. However, the concentration will be devoted to mechatronics engineering.

1. INTRODUCTION

In many cases the Mechanical and the Electronic Design division of one company may even be in different cities or even countries. Even, if they are in the same building then they do not tend to communicate with each other with an expected effect on product design. Actually, the mechanical engineers design a machine; when finished they handover to the electric and electronic engineers to design and fit the control systems and they, in turn, handover to the software engineers to write the control programs. In order, to find one engineering that is able to perform the above mention tasks, Mechatronics engineering approach was introduced by senior engineer of a Japanese company; Yaskawa, in 1969.

Mechatronics has been defined in several ways. In fact there are as many definitions. It is arguable that the semantics of the definition are unimportant. A familiar agreement would be to describe *mechatronics* as an integrative discipline utilizing the technologies of mechanics, electronics and information technology to provide enhanced products, processes and systems. It integrates the classical fields of mechanical engineering, electronic engineering and computer science information technology at the design stage of a product or a system. Mechatronics is therefore not a new division of engineering, but a newly developed concept that underlines the necessity for integration and intensive interaction between different branches of engineering. The core disciplines of the mechatronics are certainly set by the name, i.e., *mechanics* and *electronics*. This should not be taken literally as fixing the boundaries of mechatronics; *mecha* should be understood as the widest aspects of the physical embodiments of mechanical engineering, including optical elements, whilst *tronics* should be understood to embrace all aspects of microelectronics and information technology including control. Mechatronics systems are becoming common in any engineering discipline dealing with the modulation of physical power. Mechatronics is the totality of fundamentals, procedures and techniques for the service, production and development of future-oriented machines, devices and installations. Mechatronics is thus an interdisciplinary technical discipline, built upon the basis of classical mechanical, electrical and electronic engineering, binding these sciences not only with one another, but also with computer science and software engineering as it shown in figure 1. Hardware and software need to be effectively integrated in order to get maximum performance.

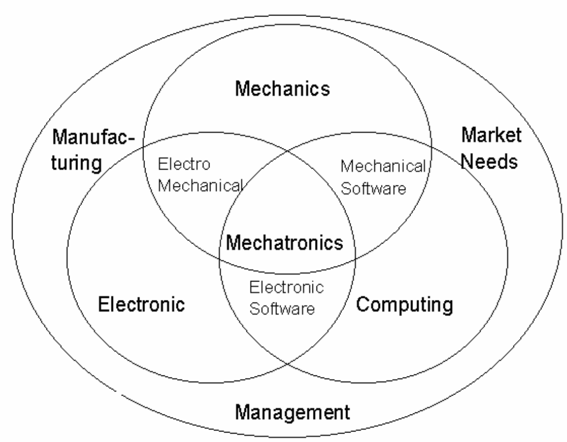

Figure 1 Mechatronics combination

The result is that a wide range of detailed, expert skills are required to realize these new generations of products that actually deliver small size and high accuracy. What's needed is an engineer with both expert knowledge and training in a systematic approach. The most essential skill for engineers on the job is problem solving. Engineers spend their days analyzing the current status of processes, identifying issues to be resolved, determining the plans of action needed to solve them, and then finally finding solutions. However, due to the complexity of modern technologies, identifying real issues has become more difficult. Advanced skills are required to plan and carry out the good measurements crucial for identifying the key issues. On-the-job training for engineers is an ongoing challenge. Analog and digital and computer base elements needed to implement them the basic education of engineers is very important. Added to those complexities and details are the system, hardware, and software tradeoffs that must be made.

2. INSTRUMENTATION AND MEASUREMENT TECHNOLOGY

For engineers, standards and specifications are the rules that behavior. However, we are now at a crossroads. Guide both product development and manufacturing. Engineers must devote most of their time and effort to performing tests and data analysis. The level of effort varies, depending on whether it is for quality control on a manufacturing line or for the design and qualification of new products and processes. However, patient dedication to such tedious work has successfully produced high-quality industrial products. The foundation of quality in manufacturing and design is instrumentation and measurement. That is, instrumentation and measurement provides the foundation for modem industry. Instrumentation Technology is one of the most dynamic high-tech fields in industry today. Instrumentation technologists are responsible for installing, calibrating and troubleshooting individual process instruments as well as complete control systems. On the other hand, measurement may be considered as a sequence of elementary operations that are organized to accomplish the desired processing of the measurement signal. In terms of information theory (using the concepts of system, signal, and information), one can define measurement as the procedure for extracting desired information from a signal, called the measurement signal, and presenting it in a useful form, called the result of measurement. Instrumentation-and-measurement (I&M) education is of interest to a number of stakeholders. Measurement standards provide the foundation for commerce. Equipment I companies need fresh ideas in order to innovate and produce improved instrumentation products.

3. INSTRUMENTATION AND MEASUREMENT SYLLABUS

The field of instrumentation and measurement has been changed dramatically over the last two decades as the microelectronics, computers, and sensors' integration offered an almost different, new, meaning to the terms "instrumentation" and "measurement". The old measurement and instrumentation symbol, is no longer the first thing that one is thinking when asked to identify the Instrumentation and Measurement field nowadays. This situation has certainly affected the teaching Instrumentation and Measurement related courses worldwide especially in Mechatronics field. Instrumentation and measurement technology syllabus cover three area, analog, digital and computer base Instrumentation and measurement technology. Most of the references in the universities for Instrumentation and measurement just cover certain part according to the specific department, for example mechanical department or electrical department. As the available "instruments" necessarily a drawback; each book is written to serve the educational process in a given situation (a certain kind of students) and it is only natural that there is no such thing as the ideal textbook. Therefore, this paper discussed the proposition for the new module of Instrumentation and measurement technology to cover the whole aspect. Next section will summarize the main feature of the book.

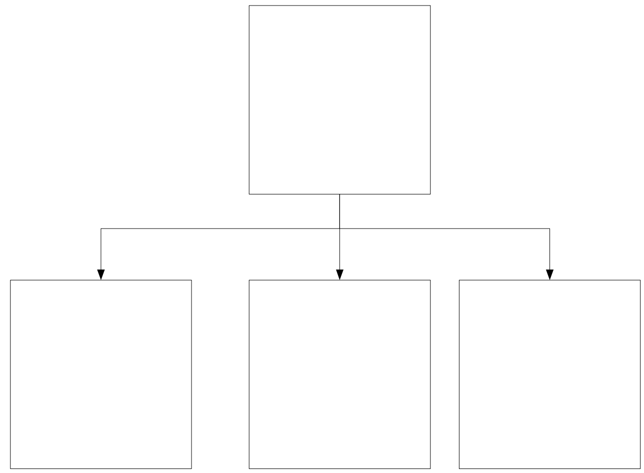

Figure 2 Instrumentation and Measurements Reference Module

3.1 First part analog instrument

The first part of Instrumentation and measurement technology volume is the general preparation and explanation of what measurement is in terms of mathematics (mapping some aspects or characteristics of the empirical world into sets of numbers) in parallel with a more practical description of measurement in instrumental terms. This part prepare the student are to be able to choose the proper measurement methods and equipment, carry out the measurements, and interpret the results. Consequently, this part start with introducing of the fundamental of the system units and the system international electrical unites. The definition of electrical methods of measurement for various electrical and non-electrical quantities is the basic element as being the most important today among existing possibilities. Therefore, the explanation of the principle of the force, work, energy and power is exposed. Moreover, the basic electronics component is introduced in details and Examples of measurements of selected quantities such as resistance, capacitance, and inductance (including the measuring-bridge principle). In order to interpret the results from the measurement, error analysis and types of error is been clarified. Last part deals with conventional Electromechanical Instruments (analog system) including (DC Ammeters, Multi-range Ammeters, DC Voltmeters, Multi-range voltmeters, Series-type Ohmmeters, Shunt-type ohmmeter). The design of the instrument and the application and how it can be used is clarified is this part as well as simplified be some examples. For many years, the use of various forms of bridges has been applied to determine the precision measurement of components values. Therefore, all types of bridges are clarified in the following this part. The comparison of the given instrument against a standard instrument is used to determine its accuracy. Therefore, the Calibrating of dc instruments is shown specially the Calibration of dc voltmeter, the ohmmeter, and the dc ammeter. Finally, all methods to record the data including Strip chart recorder , Galvanometric strip chart recorder, Potentiometer strip chart recorders, X- Y recorder, Magnetic recorders and Watt-hour meter is explained.

3.2 Digital instrument

The impact of innovations directly attributable to digital technology has been substantial. Measurement sophistication can be built into the most basic of instruments. Moreover, all the disadvantages and the limitation of the analog instrumentation have been avoided by using the digital instrumentation. Therefore, part two of the book is dealing with digital instrumentation for example, Electronic Multi-meter, Resistance Ranges, AC Voltmeter using Rectifiers, Ramp-Type DVM and Successive-Approximation. The explanations about how its work, the specification and the classifications are briefly explain as well as how it can be used. Transducer is a devise or apparatus that converts energy from one fore to another. For electrical measuring system, the transducer converts non-electrical physical parameters into electrical signal, (i.e. voltage or current), which is proportional to the value of that physical parameter. Consequently, The Classification of Transducers and the selection of the Transducers are covered in this part. All types of transducer mechanical and electrical types will be discus in details. Other devices which will converts non-electrical physical parameters into electrical signal are shown and explain in details for example thermocouple, Photodiode. Last devise is Analog-to-digital. Analog-to-digital Converter is the process of converting analog signals to an equivalent signal in digital. All types' classification and some all the application of analog-to-digital (A/D) is shown. The last part of this part is the explanation of most popular system which is used to evaluate the system characteristics, for example Wave Analyzer, Spectrum Analyzer and Harmonic Distortion Analyzer.

3.3 Computer base Instrumentation and measurement technology

Software written for instrumentation does not live isolated on a computer. It measures, stimulates, and interprets the real world. For instrumentation work, the engineering should be able to relate to the physical nature of the data. Therefore, in this part computer base Instrumentation and measurement technology is considered by explain the use of Matlab and Labview software. MATLAB stands for Matrix Laboratory. It is a high-performance numerical computation and visualization software. MATLAB integrates matrix computation, numerical analysis, signal processing, data analysis, and graphics in an easy to use environment where problems and solutions are expressed just as they are written mathematically -- without traditional programming. National Instruments LabVIEW is an industry-leading software tool for designing test, measurement, and control systems. For 20 years, LabVIEW graphical development has revolutionized the way thousands of engineers and scientists work, providing improved product quality, shorter time to market, and greater engineering and manufacturing efficiency. By using the integrated Labview environment to interface with real-world signals, analyze data for meaningful information, and share results, you can boost productivity throughout your organization. The basic functions for Matlab and Labview software is shown as well as how to relate Matlab and Labview software to measuring and simulate the systems. Some application has demonstrated the modeling and the simulation of the real time system by using Matlab and Labview software. Data acquisition card it is a basic A/D converter coupled with an interface that allows a personal computer to control the actions of the A/D, as well as to capture the digital output information from a conversion. A data acquisition card plugs directly into a personal computer's bus. All the power required for the A/D converter and associated interface components on the data acquisition card is obtained directly from the PC bus. Therefore, last part dealing with the data acquisition card. First, common data acquisition terms are explain which are, Analog-to-digital converter (ADC), Digital-to-Analog Converter (D/A), Digital Input/Output (DIO), Differential Input, General Purpose Interface Bus (GPIB), Resolution, RS232, RS485, Sample Rate and Single-ended Input (SE). Finally, four types of Data Acquisitions Systems, which are Serial Communication Data Acquisition Systems, USB Data Acquisition Systems, Data Acquisition Plug-in Boards and Parallel Port Data Acquisition Systems, is shown and explain.

4. CONCLUSIONS

Instrumentation and measurement technology may not be ready-ever-for status as a separate engineering discipline because it is intertwined with so many diverse fields. However, it is time to improve the formalism of Instrumentation and measurement technology and improve the level of support to the broader community of engineers, scholars, and others who work in this area. Therefore, the new module of Instrumentation and measurement technology to cover the whole aspect especially Mechatronics field, is required. Therefore, This paper discussed the summarize of the new book for Instrumentation and measurement technology which is cover the three elements analog, digital and computer Instrumentation and measurement.

5. REFERENCES

1. Kenzo Watanabe, Instrumentation Education in Japan, IEEE Instrumentation & Measurement Magazine, www.ieee.org, 1999.
2. Theodore Laopoulos, Teaching instrumentation and measurement in the complex system, IEEE instrumentation & Measurement Magazine, www.ieee.org, 2000.
3. John L. Schmalzel, I&M Education For the New Millennium: A USA prospective, 36-42, 1999.
4. Ancirzej Barwicz and Roman . Morawski, Teaching Measurement Systems Beyond the Year 2000, IEEE Instrumentation & Measurement Magazine, www.ieee.org, 1999.
5. M. A. Jarrah, Teaching Mechatronics Design for Engineers, 2005 IEEE Workshop on Advanced Robotics and its Social Impacts, 97-103, 2005.
6. R.Thorn, Measurement science versus measurement technology in the engineering curriculum, Engineering Science and Education Journal, 133-119, 1997.
7. John L. Schmalzel, Improving Instrumentation and Measurement Education, IEEE lnsirumentation & Measurement Magazine, www.ieee.org, 1999.
8. Shuvra Das, Mohan Krishnan, and Sandra A. Yost, "Work in Progress - The Outgrowth of Mechatronics Curriculum Development Efforts: An Undergraduate Concentration in Mechatronics", 35th ASEE/IEEE Frontiers in Education Conference.