TECHNICAL NOTE

A BALANCED COVERAGE OF A COURSE ON INSTRUMENTATION ENGINEERING

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ABSTRACT

Two different approaches of treating instrumentation engineering are known. Based on past experience, it is argued that outline of second approach is better from pedagogical point of view and a mix of the two approaches have been recommended for teaching the course in the Electrical Engineering Department of the Faculty of Technology, Addis Ababa University. A list of laboratory exercises have also been suggested which should go parallel with the lectures.

INTRODUCTION

Instrumentation Engineering is one of the most important senior courses in any electrical engineering curriculum. The coverage of the course, however, varies from one institution to another with an overall trend of improvement parallel to the technological achievements and new ideas. This paper is a reflection of an attempt to improve the current description of the course offered by the Department, based on the available varieties of course contents.

COMPARISON OF APPROACHES

There are two distinct approaches in treating the course at a degree or diploma level. They are identified by the sequence of the topics as shown below.

Approach 1	General Concepts
	Analog Instruments
	Comparison Type Instruments
	Digital Instruments
	Cathode Ray Oscilloscopes
	Test Sources
	Transducers (Sensors)
Approach 2	General Concepts
	Sensor Elements
	Signal Conditioning
	Signal Conversion
	Output Device

It is clear that the first approach emphasizes on instruments rather than instrumentation techniques and that makes it ideal for handbook preparation. From pedagogical point of view, it seems to be unsuitable for teaching purpose. The chapters are detached from one another and they seem to have nothing in common.

The second approach is based on a generalized instrumentation system which consists of four basic parts: the sensing element, the signal conditioning, the signal conversion, and the output presentation units. Thus it provides a unified treatment of the subject and appears to be more useful than the first one.

The sensor is the element which converts a possible nonelectrical quantity variation to electrical parameter (voltage, current, resistance, inductance, capacitance) variation suitable for the signal conditioning system which may be a combination of a bridge circuit, an amplifier, an oscillator and a filter circuit. Signal conversion (analog to digital or digital to analog conversion) is needed only when digital techniques are necessary. The output device which ranges from a simple d'Arsonval movement to a sophisticated recorder or an oscilloscope is the unit which provides measurement results.

In the system considered for the second approach, some blocks may be missing and others may occur more than once. For instance, the sensor element is not required for measurement of electrical quantities such as voltage and current. Also there is no signal conversion unit in a pure analog system. On the other hand, two or more amplifier or bridge sections may be cascaded as signal conditioning circuits.

There are quite a number of reference books which reflect the two approaches. Three representative books based on the first approach are listed in the

reference [1-3]. Another set of books with the second approach are also given [4-7]. Most of the reference books in the second group, however, do not concentrate on electrical-electronic aspects of instrumentation systems. Besides, the relatively new concepts of intelligent instrumentation and intelligent sensors are not also addressed sufficiently

A MIXED APPROACH

The optimum course outline adopted by the Department is a refinement of the second approach which reflects the essential elements of the first approach. Basic concepts of intelligent instrumentation are also introduced in addition to conventional instrumentation.

The new course outline requires a good understanding of analog and digital electronics, logic design, microprocessor fundamentals and communication systems.

With reference to the outline of the first approach, analog instruments, cathode ray oscilloscopes, and recorders are all treated under output unit. Principles of digital instruments are included in the signal conversion unit. Transducers (sensors), which are normally treated at the end, are covered at the beginning as they are the front-end elements of the general instrumentation system.

All the topics selected reflect only the measurement aspect of instrumentation. The control aspect is not treated in the course for there are already separate courses on control engineering. Thus, the course could also be titled Electronic Measurements.

Revised Outline

General Concepts
- Units and Standards
- Parts of a Measurement System
- Performance Characteristics

Conventional Instrumentation
- Sensor Elements
- Signal Conditioning
- Signal Conversion
- Output Device

Intelligent Instrumentation
- Microprocessor Applications
- Intelligent Sensor Concepts

The course has been offered according to the new outline during the present and last academic year and a good result has been obtained in terms of students' understanding and appreciation of the subject. A reading material, which can be easily converted into a teaching material, is already prepared as per the adopted style.

Laboratory exercises which can go parallel to the refined course content have also been felt necessary. Although there is no set-up to perform some of the exercises at present, the important practical exercises have been identified together with the number of weeks needed for the particular exercise as follows:

Laboratory Exercises

- *Calibration of Basic Electrical Instruments (3)*: DC and AC indicators for measurement of voltage, current and resistance
- *Simple DC Measurement System (2)*: A cascade of DC bridge and standard instrumentation amplifier with an indicator.
- *Chopper Stabilized Measurement System(2)*: A cascade of DC bridge and chopper-stabilized amplifier with an indicator.
- *AM Carrier Measurement System (2)*: A cascade of AC bridge, AC amplifier, and demodulator with an indicator.
- *FM Carrier Measurement System (2)*: A cascade of Controlled oscillator, AC amplifier and demodulator with an indicator.
- *Digital Measurement Techniques (2)*: Modules for measurement of time interval, phase-shift, frequency, and voltage using dual-slope technique
- *Intelligent Instrumentation (3)*: Familiarization with microprocessor / microcomputer based systems (logic analyzers, spectrum analyzers, and data acquisition systems).

Each of the exercises, except the first and the last two, can be carried out with selected passive, active, and digital sensors within a semester.

REFERENCE

[1] W.D Cooper, A.D. Helfrick, *Electronic Instrumentation and Measurement Techniques*, Prentice-Hall Inc., 1989.

[2] Hai Hung Chiang, *Electrical and Electronic Instrumentation*, John Wiley & Sons Inc., 1984.

[3] Bartholomew D., *Electrical Measurements and Instrumentation*, Allyn and Baden Inc., 1963.

[4] J.P. Bentley, *Principles of Measurement Systems*, Longman Scientific & Technical Ltd. 1988.

[5] A. Boros, *Electrical Measurements in Engineering*, Elsevier Science Publishing Co. Inc. 1985.

[6] R.H Cerni, L.E. Foster, *Instrumentation for Engineering Measurement*, John Wiley & Sons Inc, 1962.

[7] Barryo E. Jones, *Instrumentation Measurements and Feedback*, McGraw-Hill Book Company, 1988.