

COURSE CODE:	<i>ELE 407</i>
COURSE TITLE:	<i>Electrical Measurements and Instrumentation</i>
NUMBER OF UNITS:	<i>3 Units</i>
COURSE DURATION:	<i>Three hours per week</i>

COURSE DETAILS:

Course Coordinator:	OPEODU F.A
Email:	opeodufa@unaab.edu.ng
Office Location:	Civil Engineering Building
Other Lecturers:	None

COURSE CONTENT:

Principles of measurements: errors and accuracy – units of measurements standard symbols for electrical measuring instruments and electrical standards. Basic meter in DC measurement of current and voltage – moving coil, moving iron, electrodynamic and electrostatic measuring instruments. DC and AC bridges and their applications. Measurement of electrical energy , power, power factor and frequency. Measurement of magnetic field strength. Electronic instruments for the measurement of voltage, current, resistance and other circuit parameters. Principle of the cathode-ray oscilloscope.

COURSE REQUIREMENTS:

This is a compulsory course for all 400 level students in the College of Engineering. In view of this, students are expected to participate in all the course activities and have minimum of 75% attendance to be able to write the final examination.

READING LIST:

LECTURE NOTES

Measurement and instrumentation

Scientific and technical instruments are devices used in observing, measuring, controlling, computing or communication. Instruments and instrument systems refine, extend or supplement human facilities and abilities to sense, perceive, communicate, remember, calculate or reason.

Before describing any instrument in detail it is desirable to consider the following questions before making any measurement.

- What is the most suitable method of performing the measurement?
- How should the result be displayed?
- What tolerance on the measured value is acceptable?
- How will the presence of the instrument affect the signal?
- How will the signal wave-shape affect the instrument's performance?
- Over what range of frequencies does the instrument perform correctly?
- Will the result obtained be affected by external influence?

In solving any engineering problem, a compromise between the ideal and the real provides the solution, especially where there are limitations of availability in practice, when it comes to selecting an instrument without restrictions.

Methods of Measurement

Appreciation of the methods used in instrumentation and measurements can be assisted by categorising them into broad groups under the headings of analogue, comparison and digital methods.

Analogue techniques

Analogue measurements are those involved in continuously monitoring the magnitude of a signal or measurand.

A large number of analogue instruments are electromechanical in nature, electromechanical instruments are used to obtain the deflection of a pointer: (a) by the interaction of magnetic field around a coil with a permanent magnet; (b) between ferromagnetic vanes in the coil's magnetic field; or (c) through the interaction of magnetic fields produced by a number of coils. Constraining these forces to form a turning moment produces a deflecting torque $T_d = G\theta$ Nm, which is a function of the current in the instrument's coil and the geometry and type of

coil system. To obtain a stable display it is necessary to equate the deflection torque with a n opposing or control torque.

Since the movable parts are attached to a control spring they combine to form a mass-spring system and in order to prevent excessive oscillations when the magnitude of the electrical input is change, a damping torque ($Dd\theta/dt$ Nm) must be provided that will only act if the movable parts are in motion. The methods by which this damping torque may be applied are:

- (a) Eddy- current
- (b) Pneumatic
- (c) Electromagnetic

Accuracy

Definition- The accuracy of a measuring instrument is the quality which characterises the ability to the true values of the quantity to be measured.

True Values & Uncertainty

True Value

It is impossible to determine exactly the true values of any quantity; the value assigned to a quantity will always have a tolerance or uncertainty associated with it. In some instances this tolerance is very small, say 1 part in 10^9 , and the true value is approached but it can never be determined exactly.

Nominal Value

This is the value of a component given by a manufacturer for example, a $10k\Omega$ resistor. Such a value must be accompanied by a tolerance, say $\pm 1\%$ and the interpretation of the complete statement is that the true value of the resistor is between $9.9 k\Omega$ and $10.1k\Omega$.

Measured value

This is the value indicated by an instrument or determined by a measurement process.

Tolerance & uncertainty

The accuracy of a measurement is quoted as tolerance or uncertainty in measurement. For example, if a measurement on a particular resistor gave the result $102.5k\Omega \pm 0.2 \Omega$. the uncertainty in the measurement would be $\pm 0.2\Omega$. and the true value of the resistor is $102.6k\Omega$ and $102.7k\Omega$. it is therefore possible to estimate or postulate that the true value of the resistor is $102.5k\Omega \pm 0.05 \Omega$

Errors

The error in a measurement is the algebraic difference between the indicated value (or measurand) and the conventional true value. The conventional true value is the value the measurand can be realistically accepted as having

Sources of Error

1. Construction effect
2. Determination Error
3. Approximation of expressions
4. Calculation error
5. Environmental effects
6. Ageing effects
7. Strays and residuals
8. In section errors

Summation of Errors

Measuring Errors

We distinguish between the absolute error F and the relative error F (per cent error)

The absolute error is the difference between the value indicated by the measuring instrument A and the true Value W

$$F = A - W$$

The relative error is calculated by expressing the absolute error as a function of the true vlue

$$\text{Relative error } F = \frac{\text{Absolute error } F}{\text{True value}}$$

Errors inherent in the design of measuring instruments are indicated by their Accuracy class.

Accuracy class expresses the potential absolute error as percentage of full-scale value.