NATIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF MECHANICAL ENGINEERING
MECHANICAL-ELECTRICAL ENGINEERING PROGRAM

ML313 – ELECTRICAL MEASUREMENTS

I. GENERAL INFORMATION

CODE	: ML313 Electrical Measurements
SEMESTER	: 7
CREDITS	: 2
HOURS PER WEEK	: 4 (1 Theory– 1 Practice - 2 Labs)
PREREQUISITES	: MC512-ML115
CONDITION	: Mandatory

II. COURSE SUMMARY

The course prepares the student in the application of the concepts, methods and techniques of descriptive and differential statistics to describe and analyze groups of data and variables through their relevant statistical parameters. Probability concepts are presented and applied to predict expected future values of random variables. Regression techniques are applied to construct models that relate variables of a system or process through the processing of representative data. Problems of application in engineering are developed and use is made of specialized software.

III. COURSE OUTCOMES

The student:

1. Constructs linear regression models to represent the relationship between the representative parameters of a data set.
2. Identifies the sources of error in the measurements.
3. Explains the principle of operation of analogue instruments.
4. Explains the principle of operation of digital instruments.
5. Selects measurement and protection transformers..
6. Measures soil resistivity and measures the resistance of an artificial grounding electrode.

IV. LEARNING UNITS

1. MEASUREMENT AND TEST, FUNCTIONAL CHARACTERISTICS / 2 HOURS

Introduction. Measurement Methods. Test. Error. Error Sources. Estimation and Reduction of Errors. Probable Error. Sum of Errors. Best Straight Line. Functional Features. Specifications. Decibels. Standard Specifications. Quality Standards.

2. SOURCES OF ERROR, UNITS AND PATTERNS / 2 HOURS

Introduction. Load. Charging of a potentiometer. Noise. Random noise. Noise Generators. Signal to Noise Ratio. Noise Factor. Interferences. Rejection of Noise. Intelligent Instruments. Units. Electrical Patterns. Referability.

3. DIGITAL METERS, OSCILLOSCOPES / 2 HOURS

Introduction- The Digital Voltmeter. Analog / Digital Conversion. A / D converters. Features of Digital Voltmeters and Multimeters. The basic oscilloscope. The Cathode Ray Tube. Vertical Deflection Subsystem. Horizontal Deflection Subsystem. Oscilloscope probes. Two Input Oscilloscope. Sampling oscilloscope. Memory Oscilloscope. Digital Memory Oscilloscope. Measurements with Oscilloscopes.

4. ANALOG METERS, RECORDERS / 2 HOURS

Introduction. Functional Criteria. Mobile Coil Meter. Beginning. Scale Extension. Effect of Temperature. Sensitivity. Measures in c.a. Benefits. Ohmetro. Multimeter. Mobile Iron Meter. Principles. Scale Extension. Benefits. Thermal or Dilatable Wire Meter. Thermocouple meter. Electrostatic meter. Electrodynamometer. Direct Reading Recorders. Galvanometer recorders. Ultraviolet Galvanometer Recorders. Dynamic behavior of Galvanometric recorders. Potentiometric recorders. X-Y recorders. Magnetic Tape Recorders. Magnetic Disks.

5. COMPONENT MEASUREMENT / 2 HOURS

Introduction. Ammeter-Voltmeter Method for Resistors. Wheatstone Bridge, Balanced, Output Voltage, Compensation. Double Kelvin Bridge. High Resistance Bridge. C.a. bridge Equivalent Circuits for R, L and C. Maxwell-Wien Bridge. Hay Bridge. Owen Bridge. Capacity Bridge Series. Parallel Capability Bridge. Bridge of Wien. Schering Bridge. Parasite Impedances with c.a. Transformers Bridges. Q meter. Potentiometric Measurement System. Automatic Bridges.

6. COUNTERS, SIGNAL SOURCES / 2 HOURS

The Basic Counter. Measurement Modes. Measurement Errors. Signal sources. Output Impedance. Oscillators. Impulse and Square Wave Generators. Sweep Frequency Generator. Frequency Synthesizer. Function Generators.

7. MEASUREMENT TRANSFORMERS / 2 HOURS

Definitions. Classical theory: Potential Transformer, Current Transformer. Transformers for Measurement.

8. MEASUREMENT OF THE RESISTIVITY OF THE GROUND / 2 HOURS

Land Resistivity Measurement: Four Electrode Method, Wenner Method. Schlumberger method.

9. MEASUREMENT OF EARTH RESISTANCE / 2 HOURS

Method of voltage drop, Measurement of the Resistance of a Point Ground.

10. POWER AND ENERGY MEASUREMENT / 2 HOURS

Introduction. Monophase Wattmeter. Measurement of Power Factor. Electronic Wattmeter. Three Phase Wattmeter. Watt-Hour Meter.

11. INSULATION RESISTANCE / 2 HOURS

Insulation resistance. Short Circuit or Ground in Long Lines: Short Circuit, Ground Leak, Wire Bridge. Connections of Electrical circuits in Residences and Small Shops.

12. SIGNAL ANALYSIS / 2 HOURS

Signal Analysis. Fourier theorem. Wave Analyzer. Noise Measures.

13. AUTOMATIC INSTRUMENTS / 2 HOURS

Introduction. Basic Auto Tester. Data transfer. Standard Buses. I / O interface. The programmable voltmeter.

14. INSTRUMENTATION SYSTEMS / 2 HOURS

Introduction. Electrical Transducers. Transducers. Signal Conditioning and Processing. Operational Amplifier.

V. LABORATORIES AND PRACTICAL EXPERIENCES

Lab 1: Frequencies Measurement.
Lab 2: Differential protection.
Lab 3: Grounding resistance.
Lab 4: Determination of loss angle and loss factor of a capacitor.
Lab 5: Insulation resistance.
Lab 6: Measurement of ground resistivity.

VI. METHODOLOGY

The course is developed in sessions of theories and laboratories of electricity. In theory sessions, the teacher presents concepts and applications. In the laboratory sessions electrical circuits are constructed to analyze and to experiment the technical principle of the method of measurement or electrical protection. In all the sessions the active participation of the student is promoted.

VII. EVALUATION FORMULA

Evaluation System "D". Calculation of Final Average:

$$FA = \frac{1}{3}\left[\frac{2Q1+\frac{L1+L2}{2}}{3}\right] + \frac{1}{3}\left[\frac{2Q2+\frac{L3+L4}{2}}{3}\right] + \frac{1}{3}\left[\frac{2Q3+\frac{L5+L6}{2}}{3}\right]$$

Q1: Quiz 1, Q2: Quiz 2, Q3: Quiz 3, L1: Lab 1, L2: Lab 2, L3: Lab 3, L4: Lab 4, L5: Lab 5, L6: Lab 6.

VIII. BIBLIOGRAPHY

1. W. Bolton. Mediciones y Pruebas Eléctricas y Electrónicas. Marcombo S.A., Barcelona, España, 1995
2. Stanley Wolf, Richard F.M. Smith. Guía Para Mediciones Electrónicas y prácticas de Laboratorio. Prentice-Hall Hispanoamericana, S.A., 1992.
3. R. Garcia M. La Puesta a Tierra de Instalaciones Eléctricas. Marcombo S.A. Barcelona España, 1999.