EAS 200
EE Concepts - non-Majors

Introduction I
Overview of Electrical Engineering

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or by appointment
Text Book

Electrical Engineering
Principles and Applications

Allan R. Hambley

# EAS 200 - EE Concepts - non-Majors

## Two Parts

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EAS 200 Website

http://www.eng.buffalo.edu/~etemadi/eas200/index.html
1- Major Objective of Electrical Engineers

2- Electrical Instrumentation
   - Examples
   - A Typical Instrumentation System
   - Instrumentation Issues

3- Outline of EAS200

4- Website of EAS200
Major objectives of electrical engineers

- To collect, store, process, transport, and present information

- To distribute and convert energy between various forms
EE Subdivisions

Institute of Electrical and Electronics Engineers

(IEEE) Societies/Councils by Division

• Communication Systems
• Computer Systems
• Control Systems
• Electromagnetics
• Electronics
• Photonics
• Power Systems
• Signal Processing
Communications/Signal Processing

Example:
- Cellular Phones, Radios, Satellites, Internet

- Transmission of information electrically and optically
- Modification of signals
  - enhancement
  - compression
  - noise reduction
  - filtering
Computer Systems

Example: Computers in car, railroads, chemical plants, …

• Digital (ones and zeros) signals and hardware
• Computer architectures
• Embedded computer systems
  – Microprocessors
  – Microcontrollers
  – Digital Signal Processors (DSP) chips
Control Systems

Examples:
- In tall building to reduce their movement due to the wind
-- Temperature control in Furnace

• Changing system inputs to obtain desired outputs
• Feedback
• Stability
Electromagnetics

Examples:
- Microwave Oven
-- Antennas

• Propagation of electromagnetic energy
• Very high frequency signals
• Fiber optics
Solid State
(Electronics & Photonics)

Examples:
   Pacemaker, DVD disk reader, optical signal processor

• Devices
  – Transistors
  – Diodes (LED’s, Laser diodes)
  – Photodetectors

• Miniaturization of electrical devices
• Integration of many devices on a single chip
Power Systems

Example: motors, Capacitors, Power Interrupters

- Generation of electrical energy
- Storage of electrical energy
- Distribution of electrical energy
- Rotating machinery-generators
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Electrical instrumentation is the process of acquiring data about one or more physical quantities of interest using electrical sensors and instruments.

This data may be used for diagnostics, analysis, design, or to control a system.
Strain Measurements
Non-destructive Testing

Ultrasound transducer
Automotive Sensors

- Accelerometer
- Oxygen Sensor
- Airflow Sensor
- CO Sensor
- Oil Pressure
- Water Temperature
Biomedical

Ultrasound Transducer
Outline

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A Typical Instrumentation System

Sensor → Amplifier → A/D Converter → Computer

Output:
- Voltage or current (temperature, pressure)
- Resistance (strain gauge)
- Frequency (accelerometer)

Output:
- "Conditions" Analog Signal
- digital Processing

Two Operations:
- Sampling: measuring the voltage signal at equally spaced points in time.
- Quantization: approximating a voltage using 8 or 16 bits.

The gain of the amplifier is set so that the voltage falls between lower and upper limits (for example, -10V to 10V).
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Instrumentation Issues

- Noise
- Signal bandwidth
- Sampling
- Amplifier characteristics
- Feedback
- Real-time processing
- Control systems
Sources of Noise

- *Thermal noise* caused by the random motion of charged particles in the sensor and the amplifier.
- *Electromagnetic noise* from electrical equipment (e.g. computers) or communication devices.
- *Shot noise* from quantum mechanical events.
Effects of Noise

- Reduces accuracy and repeatability of measurements.
- Introduces distortion in sound signals.
- Introduces errors in control systems.
What to Do?

How can we eliminate or reduce the undesirable effects of noise?

• Grounding/shielding electrical connections
• Filtering (smoothing)
• Averaging several measurements
Signal Bandwidth

Conceptually, bandwidth is related to the rate at which a signal changes:

High BW

Low BW
Bandwidth and Sampling

A higher bandwidth requires more samples/second:

High BW

Low BW
Bandwidth Limitations

Every component in the instrumentation system has bandwidth limitations:

• Sensors do not respond immediately to changes in the environment.
• The amplifier output does not change immediately in response to changes in the input.
• The A/D converter sampling rate is limited.
Effects of BW Limitations

Sensor Output

Amplifier Output
Amplifier Characteristics

Amplifiers are characterized in terms of attributes such as:

• Gain
• Bandwidth and/or frequency response
• Linearity
• Harmonic distortion
• Input and output impedance
Operational Amplifiers (OP AMP)
A commonly used type of amplifier

- They have differential inputs: output voltage is the amplified difference of two input voltages.
- They have very large gains (>10³).

Their circuits can be designed to:
- Provide voltage gain or attenuation.
- Convert current to voltage.
- Integrate or differentiate.
- Filter out noise or interference.
Feedback

When sensor output is used to control the system in a desired manner.

Example: Industrial Process Control

In many manufacturing processes (integrated circuits, for example) temperatures must be closely controlled. Feedback can be used to maintain a constant temperature.
The Control System sets the current supplied to the heating elements in the furnace to keep the material temperature at the desired value.
A car cruise control is a feedback system. How does it work?
Benefits of Feedback

• Provides stability with respect to changes in system parameter values.
• Helps to obtain a (nearly) linear response from non-linear components.
• Can be used to change the characteristics of a system under control.
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Part I - Circuits
(Resistive, Capacitive and Inductive Circuits; Transients, Steady-State Sinusoidal Analysis, Frequency Response, Resonance, ...)

Part II - Digital Systems
Logic Circuits, Microcomputers and Computer-Based Instrumentation Systems

Part III - Electronics
Diodes, Transistors and Amplifiers

Part IV - Electromechanics
Magnetic Circuits, Transformers, DC Machines and AC Machines
1- Introduction

2- Resistive Circuits

3- Capacitive and Inductive Circuits

4- Transients

5- Steady-State Sinusoidal Analysis

6- Frequency Response, Bode Plots and Resonance
What is Electrical Circuits?

A collection of circuit elements, connected in closed paths by conductors

Current, Voltage, Power, energy, Sign Convention, Active and Passive Circuit Elements, Kirchoff’s Laws and Basic Circuits elements
Chapter 2 - Resistive Circuits

Solve Circuits by combining resistance in series and Parallel

Solve circuits by the node-voltage technique

Solve circuits by the mesh-current technique

Thevenin and Norton Equivalent Circuits
Chapter 3 - Capacitive and Inductive Circuits

- What is Capacitor and Inductors

- Circuits with Capacitors and Inductors

- Circuit models for Capacitors and Inductors
Chapter 4 - Transients

Resistors, Capacitors, and Inductors

Source

The time-varying currents and voltages resulting from sudden application of sources, usually due to switching, are called transient

\[ V_x = ? \]

\[ R_2 = 5\Omega \]

\[ V_x = ? \]
Chapter 5 - Steady-State Sinusoidal Analysis

Circuit Analysis with Phasors and Complex Impedance

\[ V_s(t) = 10 \sin(1000t) \]

\[ R = 100 \Omega \]

\[ F \]

\[ L = 0.1 \text{H} \]

\[ C = 10 \mu \text{F} \]
Nonsinosoidal Source

Fourier Analysis:
All real-world signals are composed of sinusoidal components

Filters

Resonant Circuits
Outline

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