Analog Measurement Technology

DBF

ACADEMY FOR APPLYIED ENGINEERING

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DBF Academy for Applied Engineering

“Where Engineering Meets Real-World Application”

Course Format

Type: Block Lecture
Duration: 5 Lecture Days + 1 Exam Day
Daily Schedule: 6 hours per day
Delivery Mode: In-person or online
Assessment: Final exam (written or oral, to be discussed with host university)
Suggested Credit: approx. 2 ECTS (based on student workload; final decision to be coordinated with the university)

Target Audience

Bachelor students in: Electrical Engineering, Mechatronics, Energy Technology, Industrial Engineering and Mechanical Engineering

Course Outcome

Students will learn the fundamentals of analog measurement systems, sensor integration, and signal processing. The course includes real-world applications and introduces emerging technologies like MEMS and wireless sensors.

Day 1: Fundamentals of Measurement

Measurement principles and accuracy

Understand what measurement means in an engineering context. Learn how accuracy, precision, resolution, and repeatability define the quality of measurements, and why they are critical in analog systems.

Error Analysis and Uncertainty

Explore different types of errors (systematic vs. random), how they arise, and how they can be quantified. Learn methods to calculate uncertainty and how to present results with confidence intervals.

Standards and Calibration

Understand the importance of reference standards, calibration procedures, and traceability in measurement systems. Learn how calibration ensures reliable results and complies with international norms (e.g., ISO 17025).

By the end of this session, students will be able to:

Explain basic measurement principles
Understand the role of accuracy and precision
Analyze measurement errors and calibrations

Day 2: Sensors and Transducers

Types of Sensors
Gain an overview of common analog sensors used in industrial and automotive applications. Learn how thermocouples, RTDs, strain gauges, pressure sensors, accelerometers and displacement transducers function.

Signal Conditioning
Understand the need to amplify, filter, and linearize sensor signals. Learn how analog signal chains are designed to ensure clean, usable outputs suitable for acquisition and analysis.

Sensor Characteristics and Selection
Explore key parameters like sensitivity, response time, hysteresis and range. Learn how to select the appropriate sensor for a given application based on performance and environmental constraints.

By the end of this session, students will be able to

Differentiate between various types of analog sensors
Understand signal conditioning methods
Select sensors based on application-specific criteria

Day 3: Analog Signal Processing

Operational Amplifiers and Analog Filters

Learn how op-amps are used to build amplifiers, integrators, and filters in analog front-ends. Understand active filter topologies like low-pass, high-pass, and band-pass filters.

Data Acquisition Systems

Get introduced to analog-to-digital conversion (ADC), sampling theory, and signal digitization. Learn how DAQ systems interface with sensors and what specs (e.g., resolution, speed) matter.

Noise Reduction Techniques

Explore analog methods (e.g. filtering, shielding, grounding) and layout techniques to minimize electrical noise in measurement systems, improving signal integrity and measurement reliability.

By the end of this session, students will be able to:

Describe the role of op-amps in signal processing
Design basic analog filters
Understand signal acquisition and noise reduction techniques

Day 4: System Design & Communication Interfaces

Design of Measurement Systems

Learn how to design a complete analog measurement chain: from sensor to DAQ to output. Understand system-level considerations including isolation, channel scaling and modularity.

Interface and Communication Protocols

Explore interfaces such as CAN, RS232, SPI, and I²C used for data transfer between analog modules and control units. Understand bandwidth, latency and real-time communication needs.

Case Studies in Industrial Applications

Review real-world examples from automotive, energy, and industrial automation sectors. Analyze how analog measurement systems are deployed, monitored and validated in practice.

By the end of this session, students will be able to:

Design an integrated measurement system
Describe key communication protocols
Analyze real-world industrial case studies

Day 5: Advanced Topics

Wireless Sensor Networks

Understand how wireless systems are used for remote sensing. Learn about power constraints, signal reliability and common protocols (e.g., ZigBee, BLE, LoRaWAN) in sensor networks.

Microelectromechanical Systems (MEMS)

Dive into MEMS-based sensors for acceleration, pressure, and orientation. Understand their advantages, limitations and use in compact and low-cost measurement systems.

Future Trends in Analog Measurement

Explore innovations like AI-assisted signal evaluation, embedded analytics, energy harvesting sensors and the role of analog front-ends in high-speed or low-power applications.

By the end of this session, students will be able to:

Explain the principles of wireless sensor networks
Understand the role of MEMS in modern systems
Identify emerging trends in analog measurement technology

Day 6: Examination

The final exam format (written or oral) will be discussed and agreed upon with the host university. Regardless of the format, the evaluation will cover:

- Theoretical understanding of key concepts
- Application of measurement techniques to practical problems
- Critical thinking and interpretation of measurement data