Signal Conditioning

By

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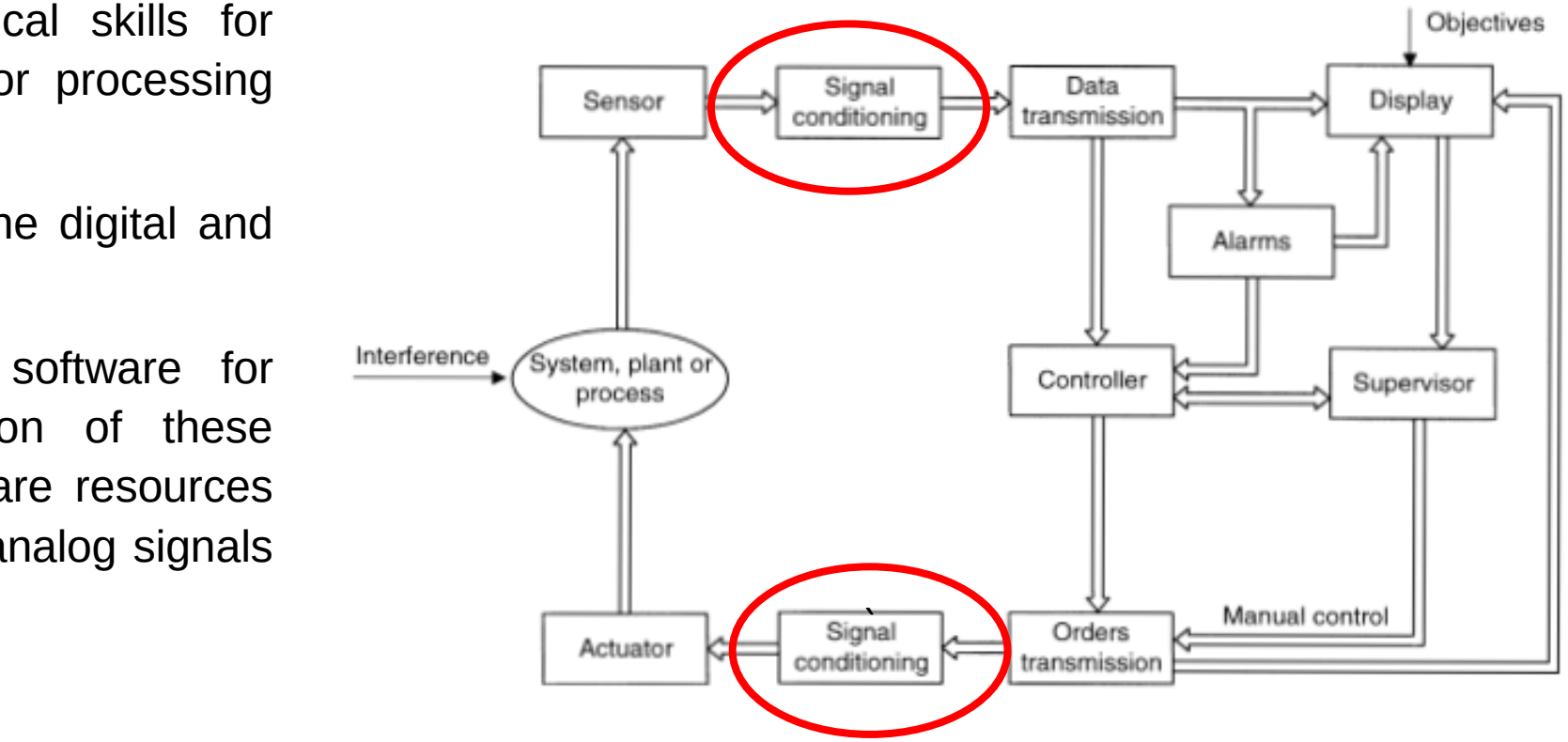
Course Objectives

- Get basic theoretical and practical skills for design of the interface circuits for processing signals from/to sensors/actuators.
- The treatment of the data from the digital and smart sensors.
- Get practical experience with software for theoretical design and simulation of these circuits, and hardware and software resources for processing and digitization of analog signals from sensors.



Course Syllabus

Lecture #	Topics
1	Introduction • Signal Conditioning [What – Why – How]. • Overview of Basic Electrical Components and Signals
2	Overview of Proteus (Electronic Design Automation Software) Overview of Operational Amplifier Basics #1 • Amplifier - Comparator - Follower
3	Overview of Operational Amplifier Basics #2 • Summing - Integration - Differentiation - Voltage/Current conversion - Instrumentation Amplifier
4	Tasks to be done by Signal Conditioning Circuits #1 • Signal Amplification [Level Shifter – Buffer] • Filtering [Analog]
5	Tasks to be done by Signal Conditioning Circuits #2 • Filtering [Digital]. • Isolation - Protection - Linearization – Excitation - Impedance Changing
6	Tasks to be done by Signal Conditioning Circuits #3 • Clipping – Clamping – Multiplexing • Interfacing with µP (ADC)

Course Syllabus

Lecture #	Topics
7	Applications for Sensors and Actuators Interfacing #1 Signal Conditioning for: • Resistive Sensors - Reactance Variation Sensors
8	Applications for Sensors and Actuators Interfacing #2 Signal Conditioning for: • Self-Generating Sensors - Digital Sensors
9	Applications for Sensors and Actuators Interfacing #3 Signal Conditioning for: • Intelligent (Smart) Sensors - Loads Requiring AC Switching or Large Current Flow
10	Experimental Issues • Error compensation - Grounding in mixed-signal systems • Preventing RFI rectification – Shielding – Electrostatic Discharge
11	Data Acquisition • Signal Sources and Measurement Systems - Analog input (A/D) boards • Analog output (D/A) boards - Digital I/O boards - Counter/timer I/O boards
12	Project

Learning Activities and Teaching Methods

- Lectures
- Student Presentations
- Assignments
- Software laboratories
- Project

Assessment methods

- Up to 40 % for the student activities:
  - Assignments ➔ Ensure your understanding of lecture content
  - Presentations ➔ Enhance your research and presentation skills
  - Project ➔ Achieve course aims (Enlighten your Design, Analysis, Simulation, Implementation Skills)
- Up to 60 % for the written exam.

Recommended reading [References]

1. SHEINGOLD, D. H. Transducer Interfacing Handbook - A Guide to Analog Signal Conditioning. Analog Device, Inc., USA, First edition, March 1980. 231 p. ISBN 0 916550-05-2. (EN)
2. KITCHON CH., COUNTS, L. A Designer's Guide to Instrumentation Amplifiers. Analog Devices, Inc., USA, Second Edition, 2004. 108 p.(EN)
3. PALLÁS-ARENY, R., WEBSTER, J. G. Sensors and Signal Conditioning. John Wiley & Sons, Inc., USA, Second edition, 2000. 587 p. ISBN 0 471-33232-1. (EN)
4. HOROWITZ, P., HILL, W. The art of electronics. Cambridge University Press, UK, Second Edition, 1989 (2001). 1125 p. ISBN 0 521-37095-7. (EN)
5. Data Acquisition and Signal Conditioning Course Manual From NI
6. Gómes, C. "An experimental apparatus for signal conditioning circuits development and testing: a teaching experience." (1970).
7. Kester, Walt, ed. *Practical design techniques for sensor signal conditioning*. Analog devices, 1999.
8. Jackson, Leland B. *Digital Filters and Signal Processing: With MATLAB® Exercises*. Springer Science & Business Media, 2013.
9. Fernýndez, Juana, et al. "Digital filter design with Arduino DUE and Matlab." *Information Processing and Control (RPIC), 2015 XVI Workshop on*. IEEE, 2015.

Lecture 1

Introduction

- Signal Conditioning [What – Why – How]
- Overview of Basic Electrical Components and Signals

Lecture 1

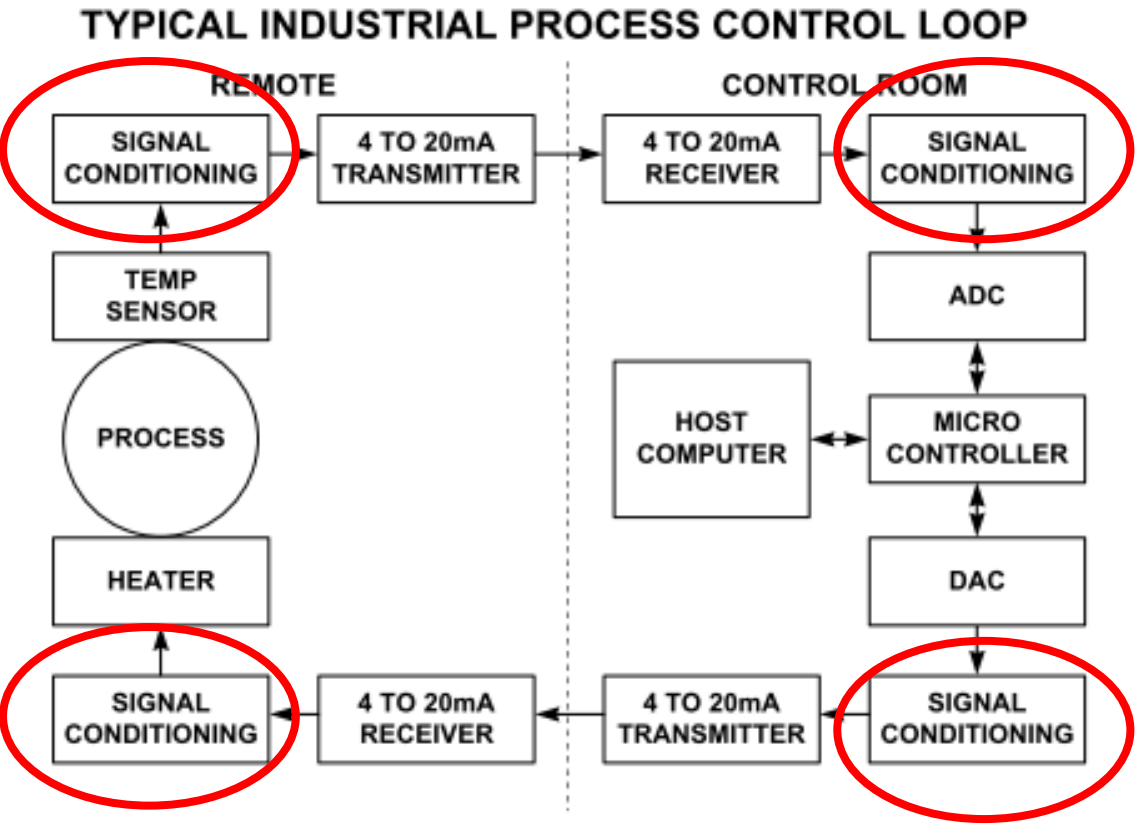
Introduction

- Signal Conditioning [What – Why – How]
- Overview of Basic Electrical Components and Signals

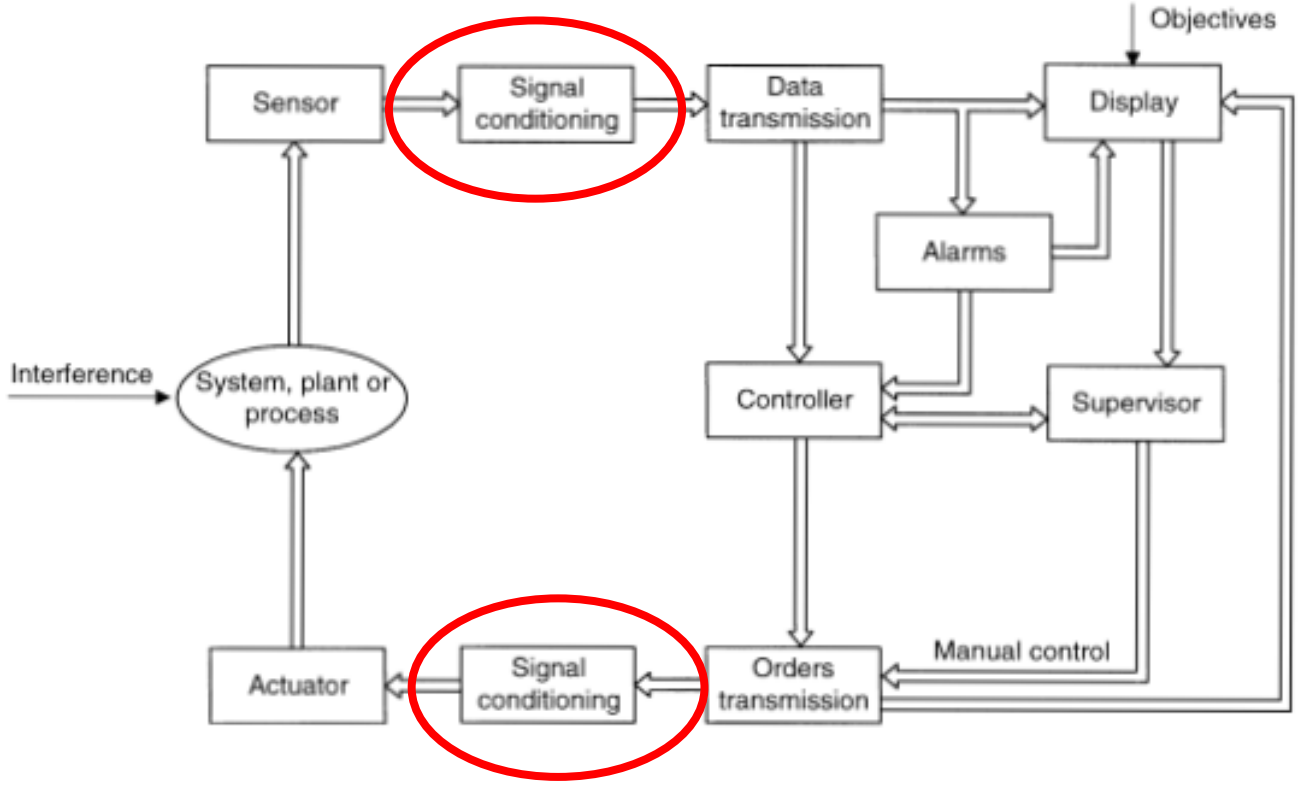
What is “Signal Conditioning”?

- There are many factors which may prevent a signal produced by one device or circuit from being usable by another device or circuit, requiring some intermediate circuitry to bridge the gap.
- This kind of “bridging” function is doing what we call “signal conditioning”.
- Often, the signals outputted by the sensors are not adequate for data acquisition.
- In addition, some sensors required an external excitation or bridge completation to operate.
- The function of the signal conditioning circuits include the following items:
  - Signal amplification
  - Filtering
  - Protection – Linearization
  - Current – voltage change circuits
  - Resistance change circuits
  - Error compensation
  - Interfacing with µP (ADC)

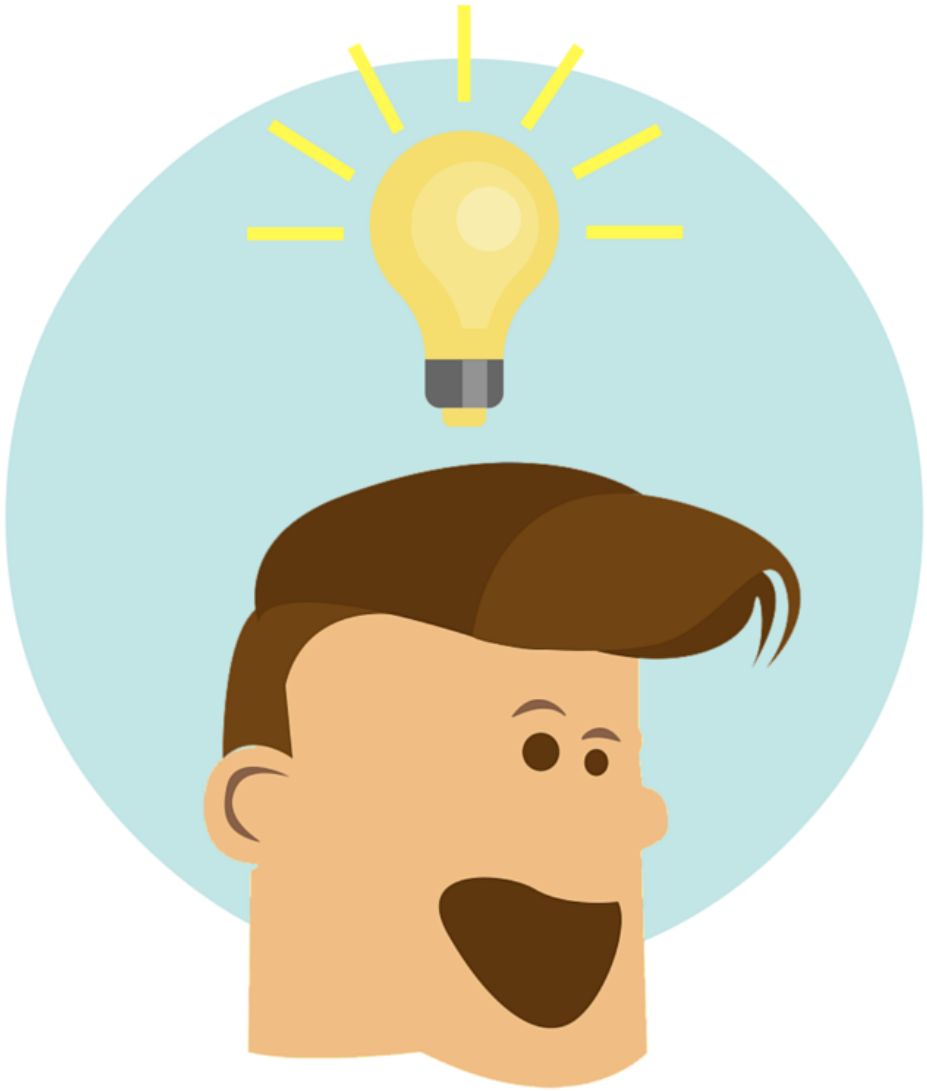
Examples of Real Applications Of SC



Example #1



Example #2



Learning Moments

PEC [] – Signal Conditioning

Course Specification

Aims:

The main aim of the course is to get basic theoretical and practical skills for design of the interface circuits for processing signals from/to sensors/actuators and for the treatment of the data from the digital and smart sensors. Get practical experience with software for theoretical design and simulation of these circuits, and hardware and software resources for processing and digitization of analog signals from sensors.

Course curriculum:

1. Introduction to Signal Conditioning [What – Why – How].
2. Overview of Basic Electrical Components and Signals.
3. Overview of Operational Amplifiers Basics [Amplifier – Comparator – Follower – Summing – Integration – Differentiation – Voltage/Current conversion - Instrumentation Amplifier].
4. Signal Amplification [Level Shifter – Buffer].
5. Filtering [Analog – Digital].
6. Isolation – Protection – Linearization – Excitation – Impedance Changing – Clipping – Clamping – Multiplexing.
7. Interfacing with µP (ADC).
8. Signal Conditioning for Resistive Sensors.
9. Signal Conditioning for Reactance Variation Sensors.
10. Signal Conditioning for Self-Generating Sensors.
11. Signal Conditioning for Digital and Intelligent Sensors.
12. Signal Conditioning for Loads Requiring AC Switching or Large Current Flow.
13. Experimental Issues [error compensation - Grounding in mixed-signal systems – preventing RFI rectification – Shielding – Electrostatic Discharge].
14. Data Acquisition [Signal Sources and Measurement Systems - Analog input (A/D) boards - Analog output (D/A) boards - Digital I/O boards - Counter/timer I/O boards].
15. Software for design, analysis, simulation, and implementation of the signal conditioning circuits: MATLAB - Proteus (Electronic Design Automation).

Course Schedule:

#	Topic	Hours
1	Introduction • Signal Conditioning [What – Why – How]. • Overview of Basic Electrical Components and Signals • Overview of Proteus (Electronic Design Automation Software)	3

2	Overview of Operational Amplifier Basics • Amplifier • Comparator • Follower • Summing • Integration • Differentiation • Voltage/Current conversion • Instrumentation Amplifier.	2
3	Tasks to be done by Signal Conditioning Circuits #1 • Signal Amplification [Level Shifter – Buffer]. • Filtering [Analog – Digital].	2
4	Tasks to be done by Signal Conditioning Circuits #2 • Isolation • Protection • Linearization • Excitation • Impedance Changing • Clipping • Clamping • Multiplexing. • Interfacing with µP (ADC).	2
5	Applications for Sensors and Actuators Interfacing #1. Signal Conditioning for: • Resistive Sensors. • Reactance Variation Sensors. • Self-Generating Sensors.	2
6	Applications for Sensors and Actuators Interfacing #2. Signal Conditioning for: • Digital and Intelligent Sensors. • Loads Requiring AC Switching or Large Current Flow.	2

7	• Experimental Issues [error compensation - Grounding in mixed-signal systems – preventing RFI rectification – Shielding – Electrostatic Discharge].	1
8	• Data Acquisition [Signal Sources and Measurement Systems - Analog input (A/D) boards - Analog output (D/A) boards - Digital I/O boards - Counter/timer I/O boards].	2

Total Hours: 16

Recommended reading [References]:

1. SHEINGOLD, D. H. Transducer Interfacing Handbook - A Guide to Analog Signal Conditioning. Analog Device, Inc., USA, First edition, March 1980. 231 p. ISBN 0 916550-05-2. (EN)
2. KITCHON CH., COUNTS, L. A Designer's Guide to Instrumentation Amplifiers. Analog Devices, Inc., USA, Second Edition, 2004. 108 p.(EN)
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Planned learning activities and teaching methods:

Teaching methods include: lectures, Student Presentations and Software laboratories.

Assessment methods and criteria linked to learning outcomes: [Proposed]

Up to 40 % for the student activities: Lectures Assignments - Experimental Project.

Up to 60 % for the written exam.

Language of instruction:

English