

INSTRUMENTATION (II/II)

Course Code: ENEX - 252
(Module#1)

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Course Evaluation

Theory (100)

- ❶ Internal weight (40/100)
 - Assignments (in total 7/8) for each module [**15**]
 - Class Attendance and class works [**10**]
 - Three - ADT Tests [**3 + 5 + 7 = 15**]
- ❷ External weight (60/100)
 - End Semester Exam by IOE, TU

Practical (25)

- Lab attendance [5] – 1 marks each Lab
- Lab report and Case Study [$2 \times 5 + (4 + 6) = 20$]

Note* - 6 marks for Case Study Report and 4 for Presentation

Final Exam Marks Distribution

Chapters	Hours	Marks Distribution*
1	2	4
2	6	5
3	8	6
4	14	12
5	6	6
6	4	4
7	6	6
8	6	6
9	3	5
10	5	6

*There may be minor deviation in marks distribution

CHAPTER#1

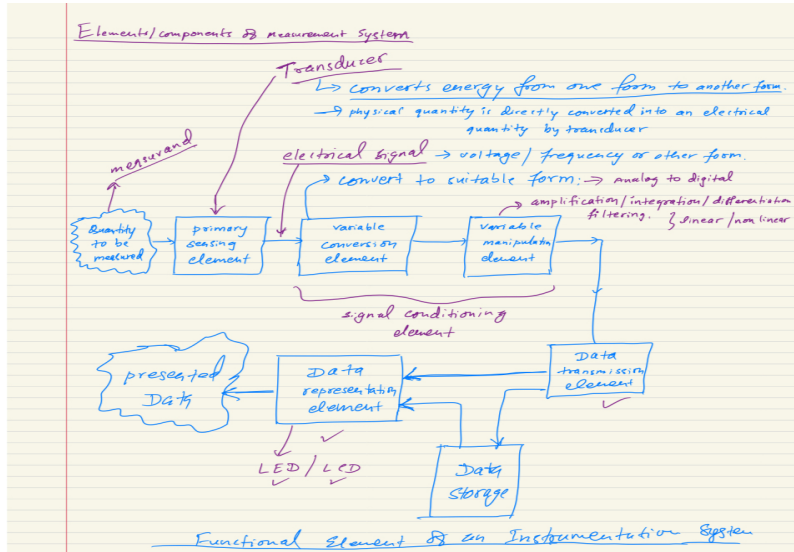
INTRODUCTION

✓ Class Outline

- 1 Introduction
- 2 Basics of Instrumentation System
- 3 Microprocessor based control system
- 4 Microcomputer on Instrumentation Design

Introduction

Analog and Digital Instrument



Introduction

Analog Instrument: | Analog and Digital Instrument

- An analog instrument displays measurement results either as a waveform or through the movement of a pointer across a scale.
- These instruments operate based on the principle of electromagnetic induction, involving a magnet (either permanent or electromagnet) and a current-carrying coil.
- The interaction between the magnetic field of the magnet and the field generated by the current causes a mechanical movement, typically observed as the deflection of a pointer on a calibrated scale.
- Common examples include analog multimeters, ammeters, voltmeters, and vehicle speedometers.

Introduction

Analog Instrument: | Analog and Digital Instrument

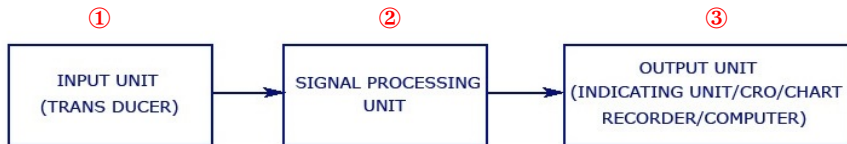


Fig. 1 Block Diagram of Analog Instrument

Introduction

Analog Instrument: | Analog and Digital Instrument

① Primary Element / Transducer

- The primary element, also known as the transducer, receives the physical quantity to be measured and converts it into a corresponding electrical signal—such as voltage, current, resistance, inductance, or capacitance.
- This altered electrical signal carries the information related to the original physical quantity.

Introduction

Analog Instrument: | Analog and Digital Instrument

② Secondary Element / Signal Processing Unit

- The electrical signal generated by the transducer is then sent to the signal processing unit.
- This section enhances the weak signal by amplifying it and may also filter or convert it into a form suitable for further interpretation.
- Components such as amplifiers, filters, and analog-to-digital converters are commonly found in this unit.

Introduction

Analog Instrument: | Analog and Digital Instrument

③ Final Element / Output Unit

- Finally, the processed signal is sent to the output unit, which presents the measured value in a readable format.
- The output can be displayed using various devices, such as analog indicators, cathode-ray oscilloscopes (CRO), or digital computers.

Introduction

Digital Instrument: | Analog and Digital Instrument

- A digital instrument is a type of measuring device that displays output as numerical values on a screen, typically using LCD or LED displays.
- It operates based on the binary number system, where two digits (0 and 1) are used to represent two distinct states.
- These instruments are built using **solid-state components** such as diodes, transistors, MOSFETs, and LEDs.
- Digital instruments offer high accuracy and are user-friendly, as their readings are straightforward to interpret.
- Common examples include digital multimeters, ammeters, voltmeters, energy meters, and speedometers.

Introduction

Digital Instrument: | Analog and Digital Instrument

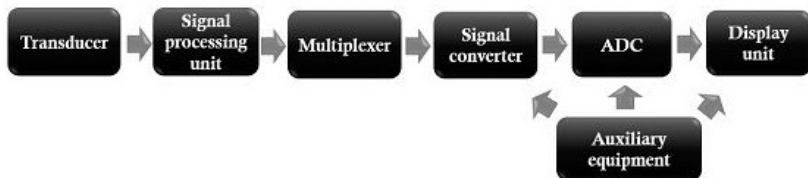


Fig. 2 Block Diagram of Digital Instrument

Introduction

Digital Instrument: | Analog and Digital Instrument

- ❶ **Transducer:** Converts physical quantities like temperature, pressure, or displacement into equivalent electrical signals.
- ❷ **Signal Processing Unit:** Enhances the transducer's output using amplifiers, calibration, and balancing circuits to make it suitable for further stages.
- ❸ **Multiplexer:** Combines multiple analog signals into a single output for streamlined processing.
- ❹ **Signal Converter:** Modifies the multiplexed signal into a form that can be processed by the next stages.

Introduction

Digital Instrument: | Analog and Digital Instrument

- ⑤ **Analog-to-Digital Converter (ADC):** Converts analog signals into digital format for processing and display.
- ⑥ **Display Unit:** Presents the final measured value numerically, using devices like CROs or monitors.
- ⑦ **Auxiliary Equipment:** Supports the entire system by ensuring linearity, performing limit comparisons, and maintaining overall functionality.

Introduction

Characteristics: | Analog and Digital Instrument

Characteristic	Analog System	Digital System
Signal Type	Continuous	Discrete
Data Representation	Varies smoothly over a range (e.g., voltage levels)	Represented in binary (0s and 1s)
Accuracy	Lower (susceptible to noise and distortion)	Higher (less prone to noise)
Precision	Limited by resolution of the device	High precision due to discrete levels
Noise Sensitivity	High (easily affected by noise)	Low (better noise immunity)
Complexity	Simpler in design	More complex due to logic circuits
Cost	Generally lower for basic systems	Higher due to advanced components
Speed	Fast (real-time, continuous response)	Slower due to conversion and processing delays
Storage	Difficult to store analog signals	Easy storage and retrieval in digital form
Processing	Harder to process and manipulate	Easy to process, compress, and transmit
Power Consumption	Usually lower	Generally higher
Examples	Analog voltmeter, thermometer, radio	Digital multimeter, computer, digital clock

Basics of Instrumentation System

Microprocessor

- A microprocessor is an integrated circuit (IC) that serves as the central processing unit(CPU) of a computer/electronic device.
- It is essentially a programmable, **clock driven** electronic device that can perform arithmetic, logic, control and input/output operations according to the instructions stored in its memory.
- Components of microprocessor:
 - ✓ Arithmetic Logic Unit (ALU)
 - ✓ Control Unit (CU)
 - ✓ Register
 - ✓ Instruction Set Architecture (ISA)
 - ✓ Clock
 - ✓ Cache Memory
 - ✓ Bus Interface

Basics of Instrumentation System

Class#Work:

- 👉 What is micro-controller? Differentiate microprocessor and micro-controller.

Microprocessor

- Fabricated from SSI (Small Scale Integration) to VLSI (Very Large Scale Integration)
 - ✓ SSI – up to 10 Transistor (12 gates),
 - ✓ MSI – up to 500 transistors (99 gates),
 - ✓ LSI – up to 20,000 Transistors (9,999 gates),
 - ✓ VLSI – greater than 20,000 Transistors
- Reads binary instruction from storage device (memory)
- Accepts binary input data and process according to instruction.
- Provides results as output for corresponding input

Basics of Instrumentation System

Merits of using microprocessor

- can be used in any system, **simplifies design** and minimizes cost.
- applicable in any specific design and applications
- Accuracy and efficiency of the system can be enhanced because of logical (algorithm) and computational power of microprocessor.

Demerits of using microprocessor

- complex interfacing introduces system complexity.
- needs machine level programming language knowledge.
- microprocessor development process itself is expensive.

Basics of Instrumentation System

Instrumentation System

- fundamentally, it is assembly of instruments and other components (devices , sensors) for the purposes:
 - ✓ measure,
 - ✓ analyze,
 - ✓ control

↳ a process or physical quantities such as electrical, thermal or mechanical.
- Some of the components of Instrumentation Systems:
 - ✓ Sensors/Transducers, ✓ Signal Conditioning,
 - ✓ Data Acquisition System (DAS), ✓ Control Units,
 - ✓ Communication, and ✓ Data Display and Analysis.

Basics of Instrumentation System

What is next?

Explore more on:

- ✓ What are the major components of MBI system ?
- ✓ What are the major components of microprocessor based control system (open & closed)?
- ✓ Write block diagram of automatic heat control system.
- ✓ Explore feature and applications of microprocessor based system in instrumentation design.

Basics of Instrumentation System

Microprocessor based Instrumentation (MBI) System

- Microprocessor is core component in the system
- programmability adds the improved logical and computing capabilities, and improved accuracy and efficiency because computing power is function of algorithm too.

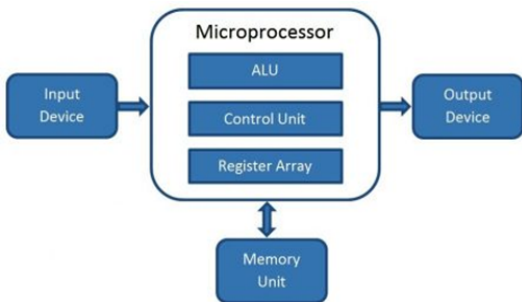


Fig. 3 Microprocessor Based System

Basics of Instrumentation System

Microprocessor based Instrumentation (MBI) System

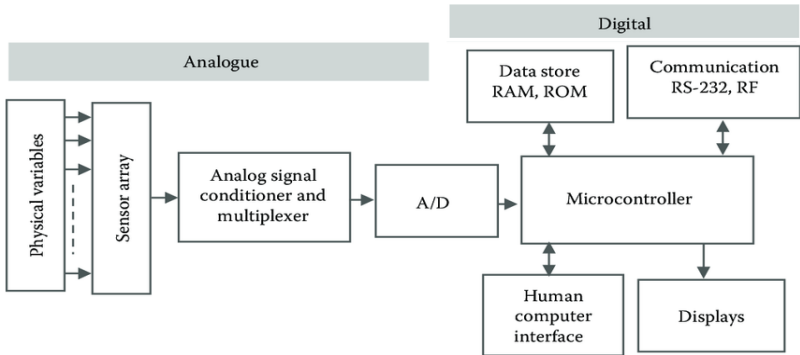


Fig. 4 A Typical Microprocessor Based Instrumentation System

Features of microprocessor based system

- major components:
 - ✓ Microprocessor,
 - ✓ I/O devices, and
 - ✓ Memory.
- decision making power based on set value.
- user friendly with signal levels or information.
- parallel processing; multiprocessing with time sharing.
- data storage, retrieval and transmission.
- effective control of multiple equipment on time sharing basis.
- lot of processing capability with powerful microprocessor.

Microprocessor based control system

Microprocessor Based Instrumentation System can be of two types:

- ① Open Loop control system
- ② Closed Loop control system

Open Loop Control System

- Depending up on the control output from microprocessor, operator makes the changes to control input.
- output quantity from the microprocessor could be displayed or presented in readable form for the operators.

Closed Loop Control System

- continuous monitoring of process variables
- output signal to control system or units

Microprocessor based control system

Example of Open Loop Control System:

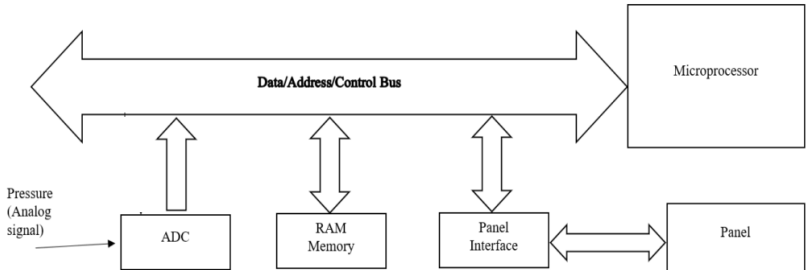
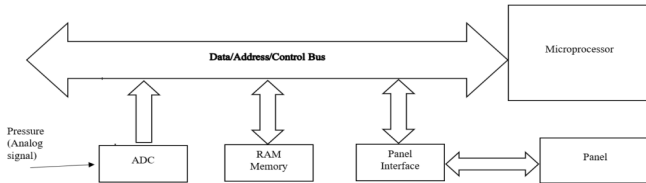


Fig. 5 Block Diagram for Pressure monitoring system

- Simple, low cost and used for non-critical feedback.
- Upper and lower limit of desired pressure is set by operator.

Microprocessor based control system



Block Diagram for Pressure monitoring system

- Analog (pressure) signal is converted to digital form and fed to microprocessor.
- Microprocessor compares the sample measurement with present pressure limits.
- If the sample is beyond limits, the microprocessor indicates in the form of some alarm or light.
- According to output signal, operator makes necessary changes.

Microprocessor based control system

Example of Closed Loop Control System:

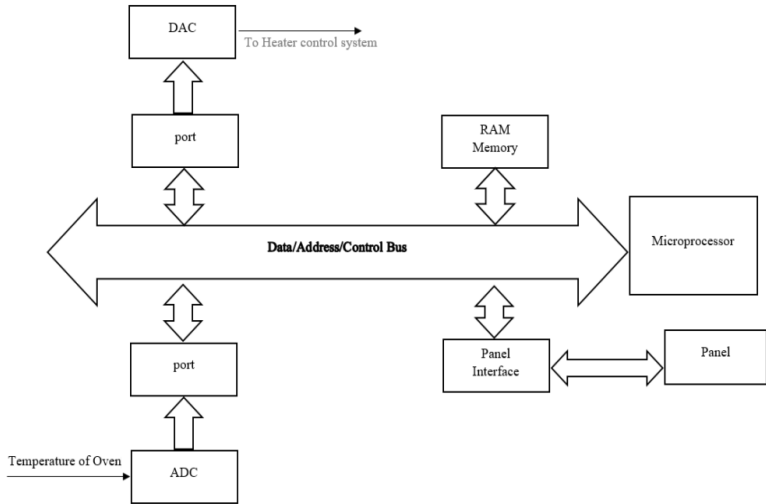


Fig. 6 Block Diagram for automatic temperature Control System

Microprocessor Based Control System

Automatic Temperature control system

- For accurate and adaptive monitoring
- no human interference or operator is not required
- Upper or lower limits of temperature are set by operator.
- each sample of temperature is compared to predefined value by the processor.
- If the temperature exceeds the upper limit, microprocessor transmits an output signal to control system which turn off (generally) the supply to some of the heating elements.
- if temperature is less than preset lower limit, the microprocessor transmits signal to control system so that it turns on the supply to some heating elements.

Microprocessor Based Instrumentation System

Benefits: | Microprocessor Based Instrumentation System

- Complete automation and intelligence to some extend.
- Redesign flexibility due to programmability.
- Economic and reduced complexity.
- reduced operating costs.
- Higher accuracy of control enforcement
- timely and accurate information enables operators for efficient plant running.
- Information exchange with other plant system with relational database management.

Microcomputer on Instrumentation Design

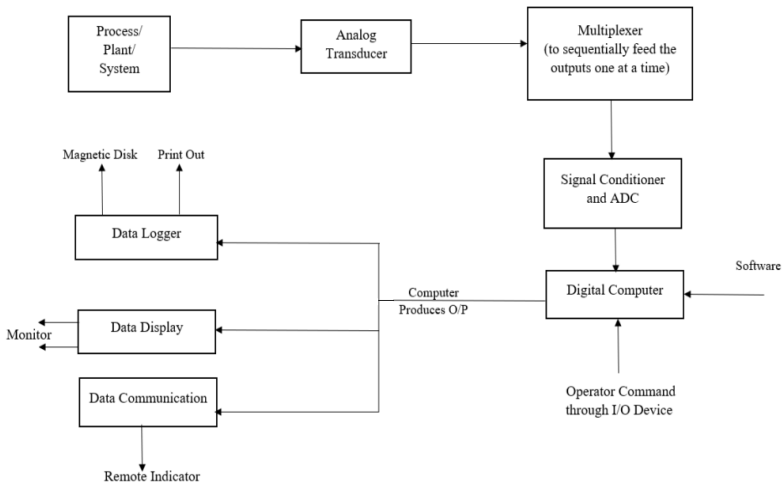


Fig. 7 Typical Computer based Instrumentation System

Microcomputer on Instrumentation Design

Microcomputer on Instrumentation System

- A process or plant may have to measure multiple variables simultaneously:
 - ✓ pressure, ✓ temperature, ✓ velocity,
 - ✓ viscosity, ✓ flow rate etc.
- computer based system can process all inputs or variables in real time simultaneously.
- computer or microprocessor is fed with a sequence of **instructions** known as computer program for processing or manipulation of data.

Microcomputer on Instrumentation Design

Advantages: | Microcomputer on Instrumentation System

- programmed to carry out the task such as noise reduction, gain adjustment etc automatically.
- It contains signal conditioning and display system suitable to work in wide range of conditions like industrial, consumer etc.
- diagnostic subroutines can be integrated for (fault) detection and correction.
- capable of real time measurement, processing and display.
- lower cost, higher accuracy, and more flexible.

Microcomputer on Instrumentation Design

Disadvantages: | Microcomputer on Instrumentation System

- pedestrian can not replace the program themselves.
- updating software is not easy relatively.
- prone to virus problem, so dysfunctional probability.

As you go Assignment

Assignment Module#1 is available at MS-Team.

Submission Deadline: 17th May 2025 (*Before 3:00 PM*)