Benha University

Prof . Mohamed Ahmed Ebrahim

Benha University
Faculty of Engineering at Shoubra
Electrical Engineering Dept.

Industrial Controls (1)

By

Associate Prof. / Mohamed Ahmed Ebrahim Mohamed

E-mail: mohamedahmed_en@yahoo.com

mohamed.mohamed@feng.bu.edu.eg

Web site: http://bu.edu.eg/staff/mohamedmohamed033

Lecture (1)

Historical Background

The **Hydramatic Division** of the **General Motors Corporation** specified the design criteria for the first programmable controller in **1968**

Their primary goal

To eliminate the high costs associated with inflexible, relay-controlled systems.

Historical Background

- The controller had to be designed in modular form, so that sub-assemblies could be removed easily for replacement or repair.

- The control system needed the capability to pass data collection to a central system.

- The system had to be reusable.

- The method used to program the controller had to be simple, so that it could be easily understood by plant personnel.

Programmable Controller Development

- 1968 — Programmable concept developed
- 1969 — Hardware CPU controller, with logic instructions, 1 K of memory and 128 I/O points
- 1974 — Use of several (multi) processors within a PLC - timers and counters; arithmetic operations; 12 K of memory and 1024 I/O points
- 1976 — Remote input/output systems introduced
- 1977 — Microprocessors - based PLC introduced

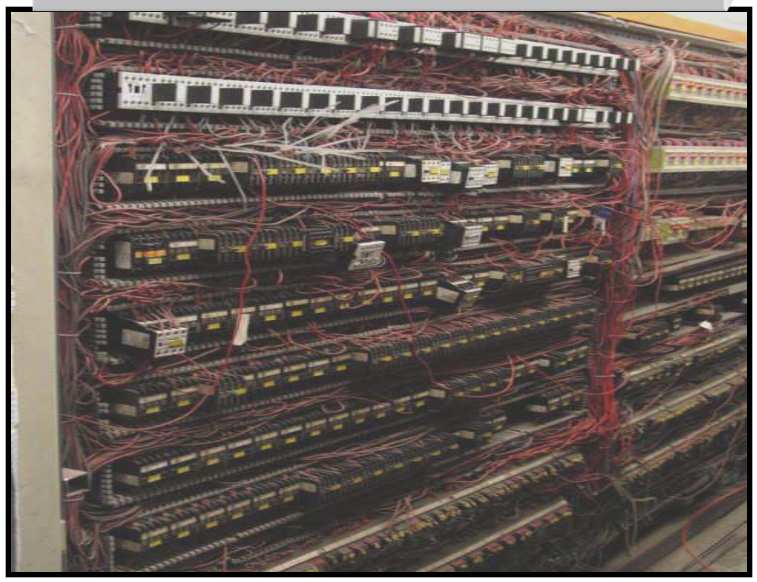
Programmable Controller Development

1980 – Intelligent I/O modules developed
Enhanced communications facilities
Enhanced software features
(e.g. documentation)
Use of personal microcomputers as programming aids

1983 – Low - cost small PLC's introduced

1985 on – Networking of all levels of PLC, computer and machine using SCADA software.

Exist



Desired

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Programmable Logic Controllers
(Definition according to NEMA standard ICS3-1978)

A digitally operating electronic apparatus which uses a programming memory for the internal storage of instructions for implementing specific functions such as logic, sequencing, timing, counting and arithmetic to control through digital or analog modules, various types of machines or process.

Detecting sensors
&
actuating elements

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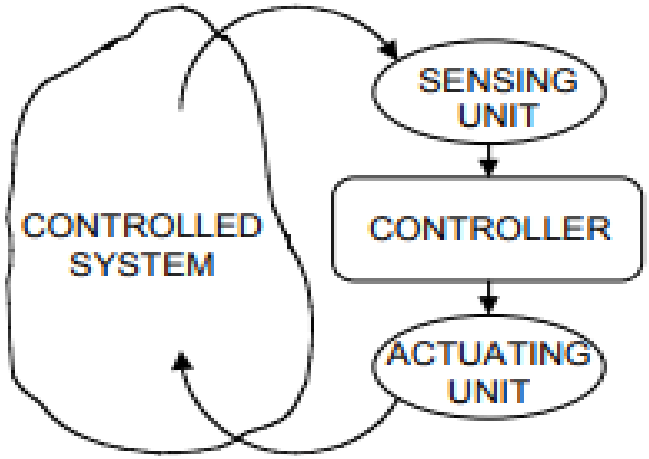
Introduction

- Sensors and actuators are two critical components of every closed loop control system. Such a system is also called a Mechatronics system.
- A typical control system as shown in figure consists of a sensing unit, a controller, and an actuating unit.



- A sensing unit can be as simple as a single sensor or can consist of additional components such as filters, amplifiers, modulators, and other signal conditioners.
- The controller accepts the information from the sensing unit, makes decisions based on the control algorithm, and outputs commands to the actuating unit.
- The actuating unit consists of an actuator and optionally a power supply and a coupling mechanism.

1. Detecting Sensors

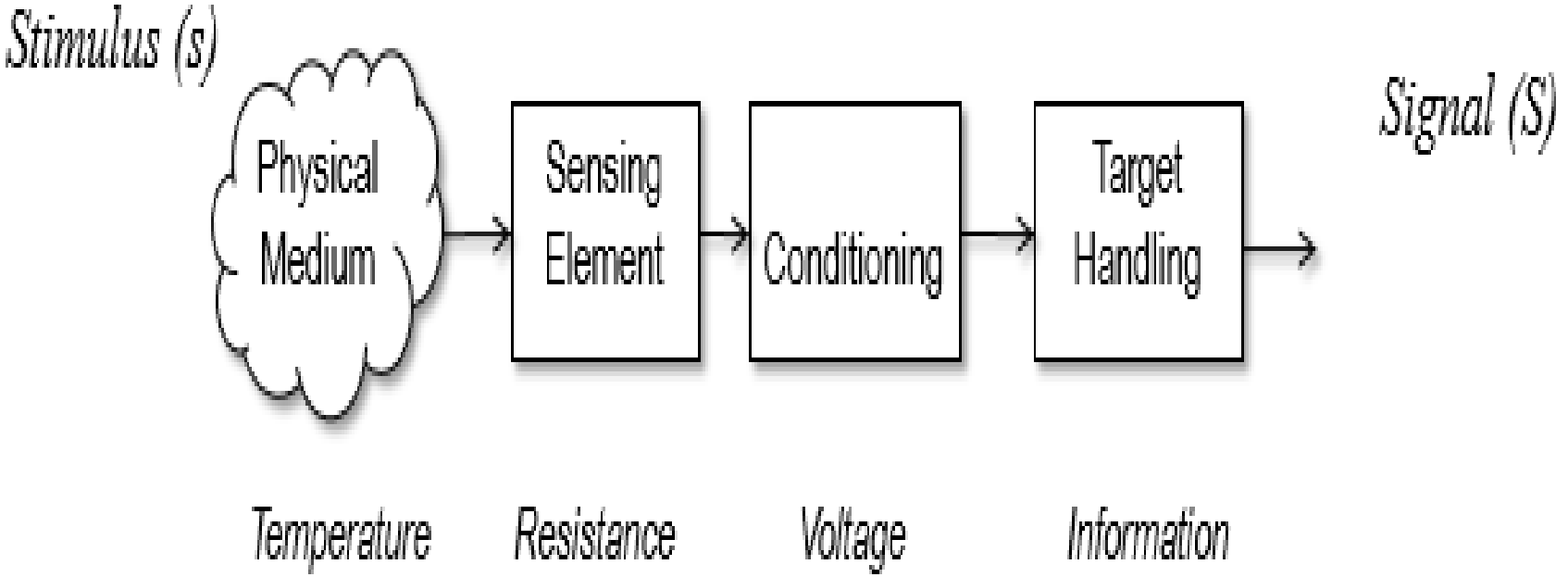
- Sensor is a device that when exposed to a physical phenomenon (temperature, displacement, force, etc.) produces a proportional output signal (electrical, mechanical, magnetic, etc.).

- The term transducer is often used synonymously with sensors. However, ideally, a sensor is a device that responds to a change in the physical phenomenon.

1. Detecting Sensors

- On the other hand, a transducer is a device that converts one form of energy into another form of energy.
- Sensors are transducers when they sense one form of energy input and output in a different form of energy.
- **Ex:** a thermocouple responds to a temperature change (thermal energy) and outputs a proportional change in electromotive force (electrical energy). Therefore, a thermocouple can be called a sensor and or transducer.

1. Detecting Sensors



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Basic Concepts of Sensors

- Sensors detect the presence of energy, changes in or the transfer of energy.
- Sensors detect by receiving a signal from a device such as a transducer, then responding to that signal by converting it into an output that can easily be read and understood.
- Typically sensors convert a recognized signal into an electrical analog or digital output that is readable.
- **EX:** The light bulb converts electrical energy into light and heat; however, it does not quantify how much light or heat. If the purpose of a device is to quantify an energy level, it is a sensor.

So let's take a look at a sensor that should be familiar to everyone(a temperature sensor)

- A thermometer senses and converts temperature into a readable output, thus it is a sensor. This output can be direct or indirect.
- A digital readout thermometer is an indirect output. For a digital readout thermometer, a converter is used to convert the output of the temperature transducer to an input for the digital display.
- The measured temperature is displayed on a monitor. The thermometer is both a transducer and a sensor (quantifies the transducer output with a readable format).

Types of sensors which are classified by the type of energy they detect

A. Thermal Sensors.
B. Mechanical Sensors.
C. Electrical Sensors.
D. Chemical Sensors.
E. Other sensors.

A. Thermal Sensors

1. Thermometer:

- measures absolute temperature.

2. Thermocouple gauge:

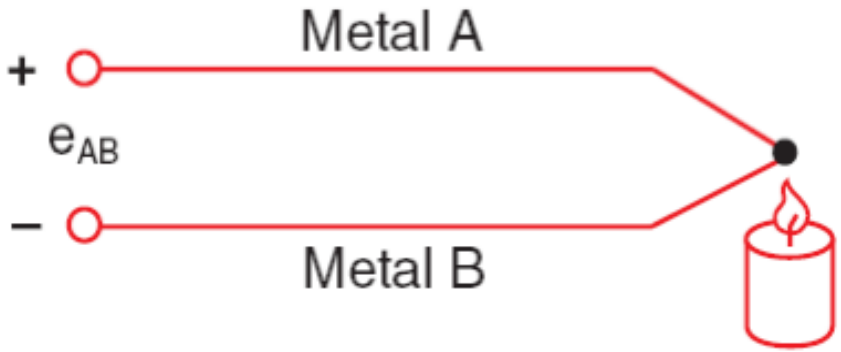
- measures temperature by its affect on two dissimilar metals.

3. Calorimeter

- measures the heat of chemical reactions or physical changes and heat capacity

A. Theory of Operation

- A thermocouple is a device that directly converts thermal energy into electrical energy.
- When two dissimilar metal wires are connected at one end forming a junction, and that junction is heated, a voltage is generated across the junction.
- If the opposite ends of the wires are connected to a meter, the amount of generated voltage can be measured.
- The voltage created in this situation is proportional to the temperature of the junction.

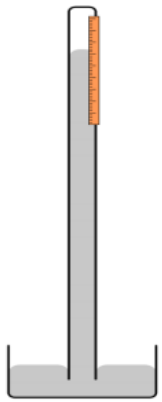


B. Mechanical Sensors

1. Pressure sensor: measures pressure.
2. Barometer: measures atmospheric pressure.
3. Altimeter: measures the altitude of an object above a fixed level.
4. Liquid flow sensor: measures liquid flow rate.
5. Gas flow sensor: measures velocity, direction, and/or flow rate of a gas.
6. Accelerometer: measures acceleration

Theory of Operation

- Mercury Barometers determine the level of atmospheric pressure.
- A tube is initially filled with mercury and then inverted into a dish.
- Some of the mercury from the tube flows into the dish (reservoir) creating a vacuum in the upper portion of the tube.
- The flow stops when equilibrium is reached between the pressures on the surfaces inside the tube and in the reservoir.
- When the atmospheric pressure increases, the level of the mercury in the tube rises. This is due to an increase in pressure on the mercury's surface in the reservoir.
- A decrease in the level of mercury in the tube is seen when the atmospheric pressure drops.



Schematic of a mercury barometer

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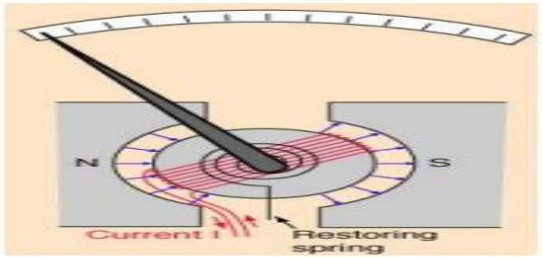
C. Electrical Sensors

1. Ohmmeter: measures resistance.
2. Voltmeter: measures voltage.
3. Galvanometer: measures current.
4. Watt-hour meter: measures the amount of electrical energy supplied to and used by a residence or business.

Theory of operation

- A Galvanometer is a specific type of ammeter used for sensing an electrical current.
- Current flows through a coil (the red wire wound around a metal cylinder) creating a magnetic field. Permanent magnets surround the coil.
- The interaction of these two magnetic fields causes the coil/cylinder combination to pivot around its central axis.
- The amount and direction of the pivot moves the needle on a readout (right image) left or right, indicating the level of current and its polarity (negative or positive, respectively).
- This device uses two energy conversions to sense and quantify an electric current: electrical to magnetic and magnetic to mechanical rotation.

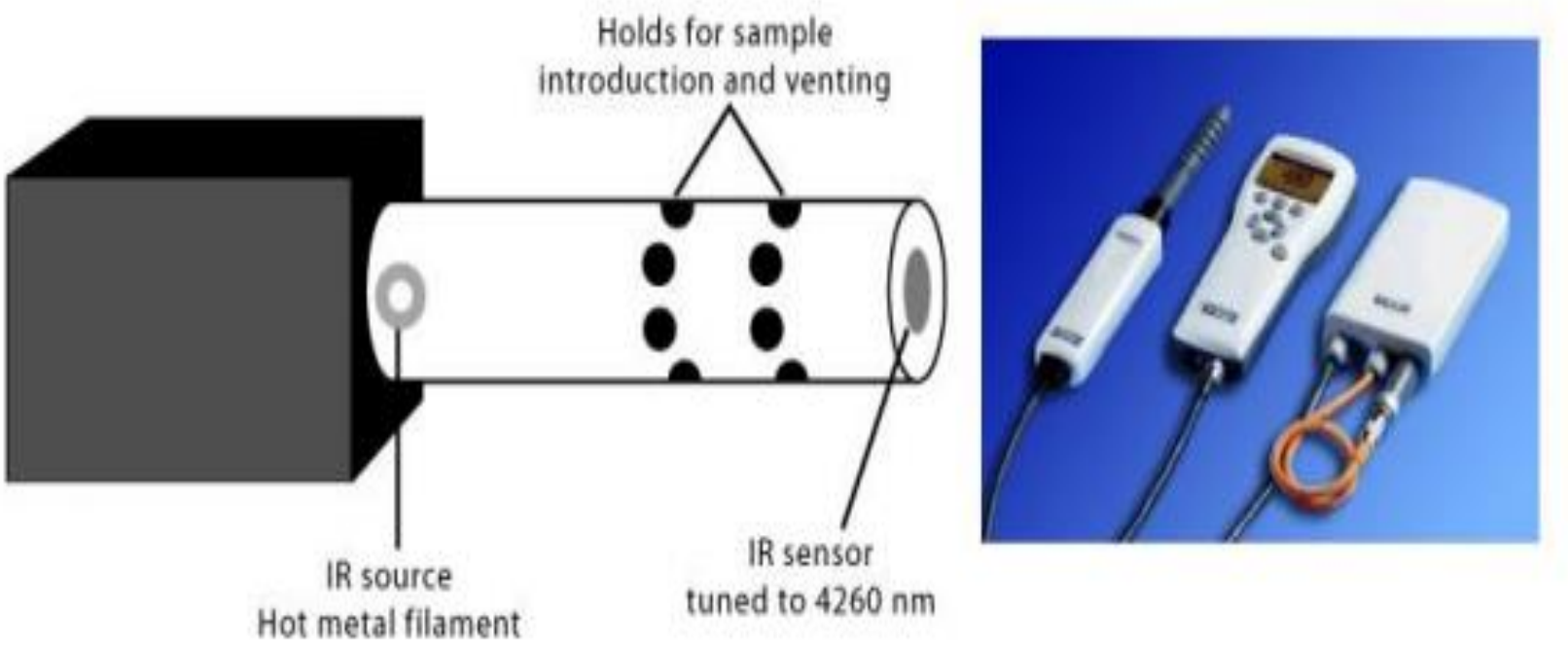


Schematic and photograph of a Galvanometer used for sensing electrical currents

D. Chemical Sensors

- Chemical sensors detect the presence of certain chemicals or classes of chemicals and quantify the amount and/or type of chemical detected.

1. Oxygen sensor: measures the percentage of oxygen in a gas or liquid being analyzed.
2. Carbon dioxide detector: detects the presence of CO_2



(Schematic and Photo of a Carbon Dioxide Sensor)

D. Other types of Sensors

1. **Optical**

- Light sensors (photodetectors):detects light and electromagnetic energy.
- Photocells (photoresistor): a variable resistor affected by intensity changes in ambient light.
- Infra-red sensor: detects infra-red radiation.

2. **Other**

- Motion: detects motion.
- Speedometer: measures speed.
- Biological: monitors human cells

Thank You For Your Attention

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