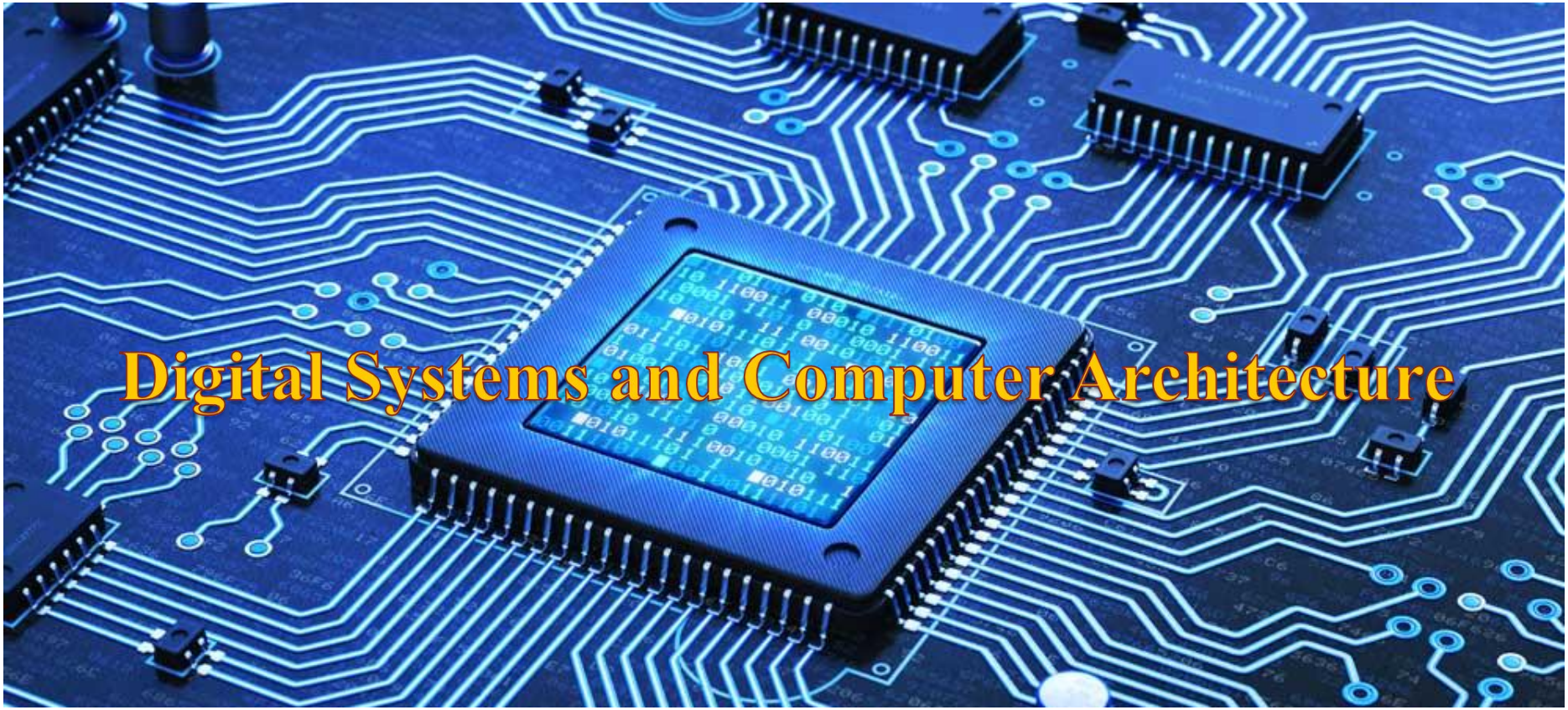


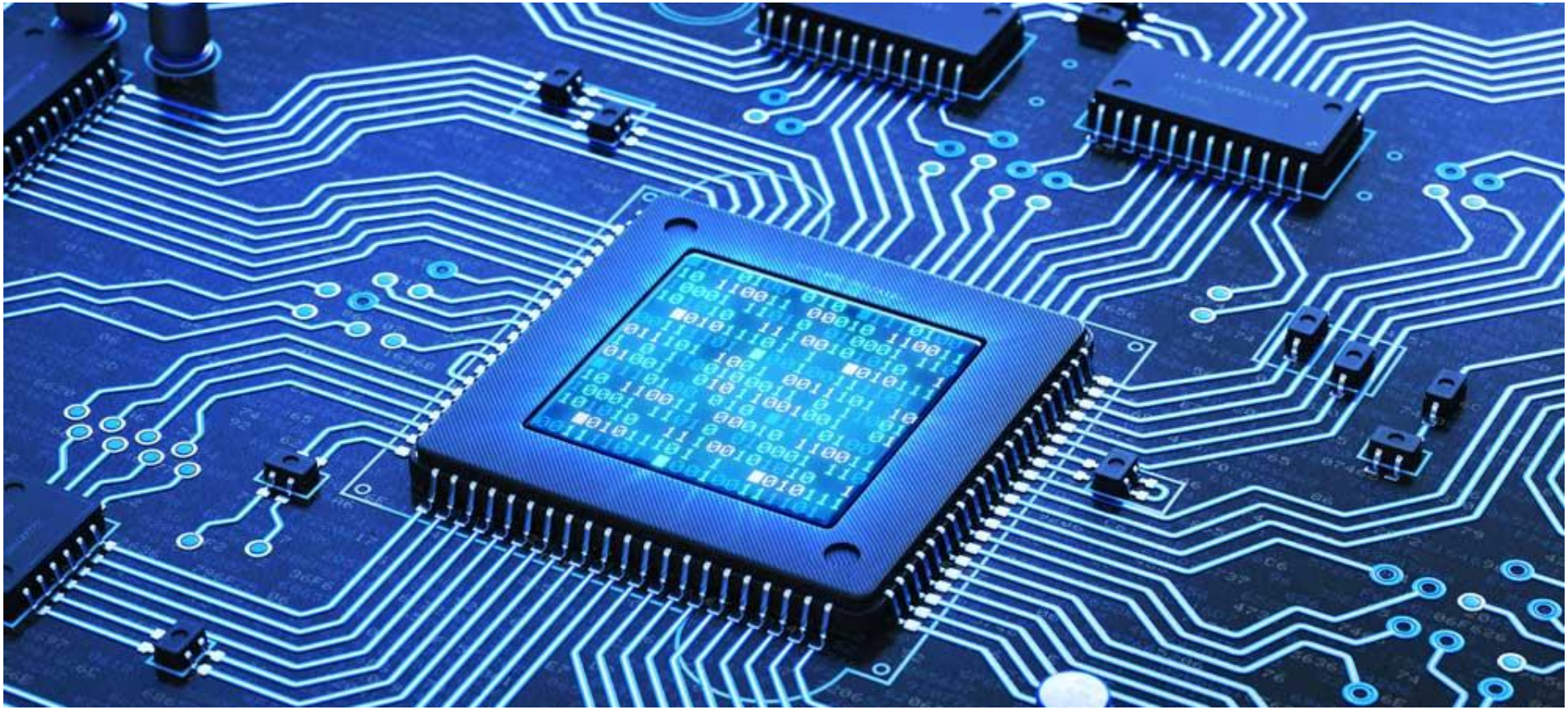
Digital Systems and Computer Architecture

Session 1.2

Module 1a: Sensors, Active/Passive Elements

Session 1.2: Focus

- Introduction to Sensors
  - Types of Sensors
  - Use of Resistors in Sensors
- Quiz
- Simple Circuit Elements
  - Active and Passive Elements
- Independent Voltage Source
- Independent Current Source
- Problem 1

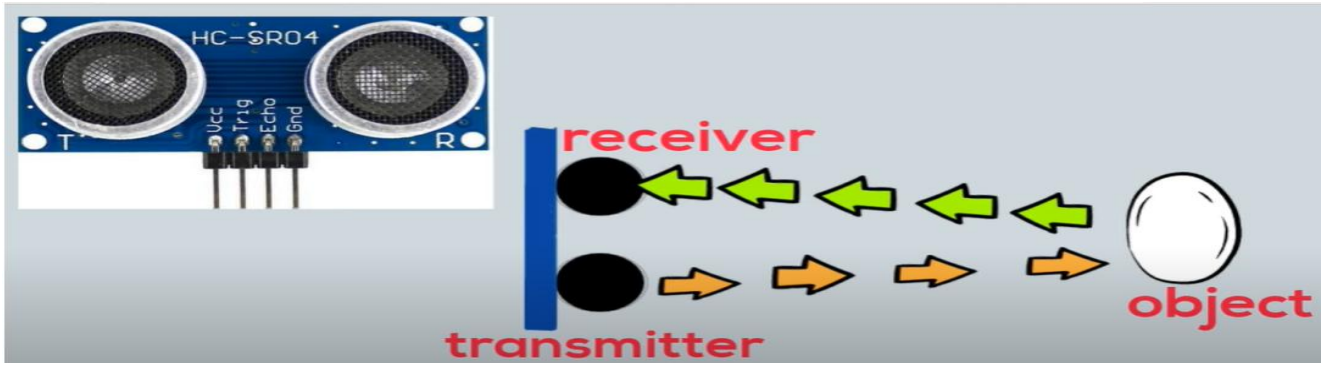


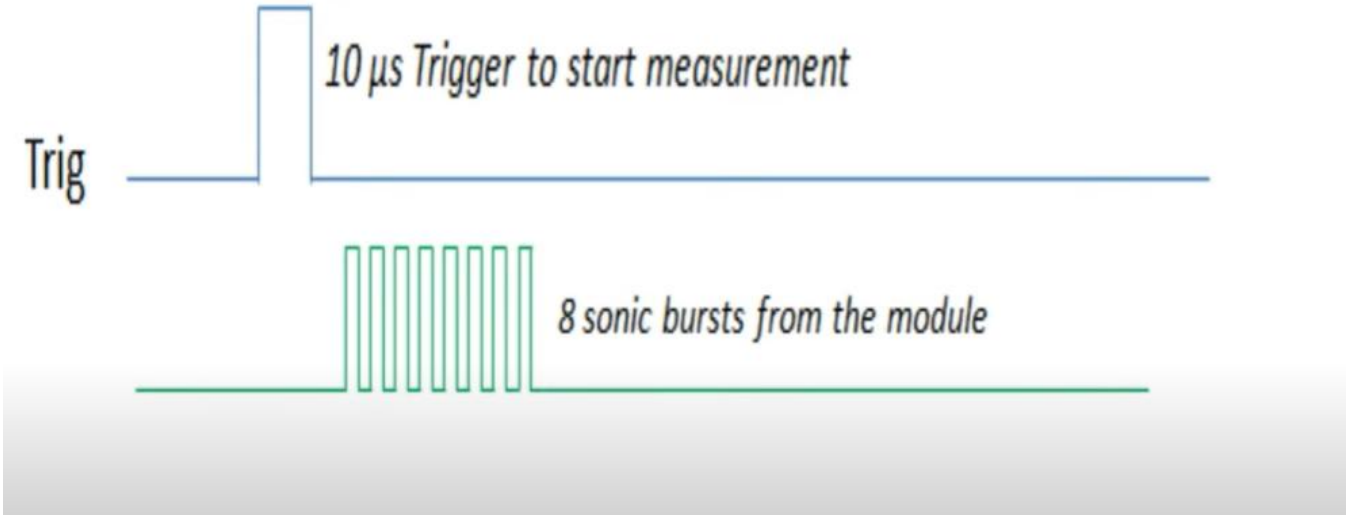
Sensors

Introduction to Sensors

- We live in analog world and we try to sense and control it using digital computers and products.
- We need some mechanism to convert analog signals into electrical signals which we can process using computers
- Sensor is a device that provides usable output in response to a specified quantity which is being measured.
- Sensors detect changes to the physical stimulus provided to it and gives out corresponding output signal that can be measured and/or recorded for further processing.

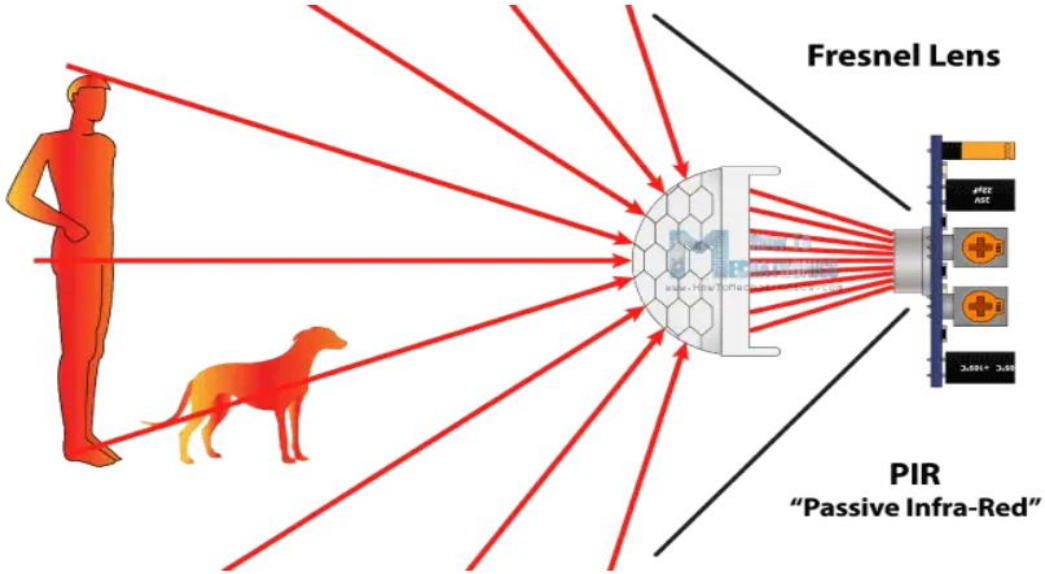
Ultrasonic sensor

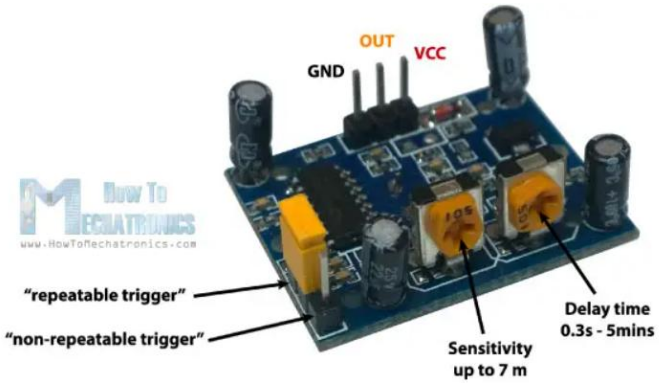


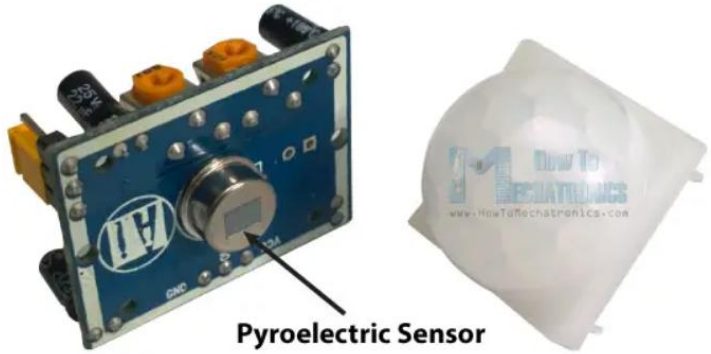


Distance = Time X Speed of Sound /2

PIR Sensor


Fresnel Lens
PIR
"Passive Infra-Red"


OUT
VCC
GND
"repeatable trigger"
"non-repeatable trigger"
Sensitivity
up to 7 m
Delay time
0.3s - 5mins


Pyroelectric Sensor

Types of Sensors

- Thermal or Temperature Sensors:
  - It senses the amount of heat energy or coldness that is generated by an object or a system.
  - **Sensors**: Thermistor, Bi-metallic Thermostat, etc
- Acoustic Pressure Sensors:
  - Because acoustic waves are mechanical pressure waves, acoustic sensors measure the pressure to generate output.
  - **Sensors**: Resistive and Piezoelectric types
  - **Product**: Microphone

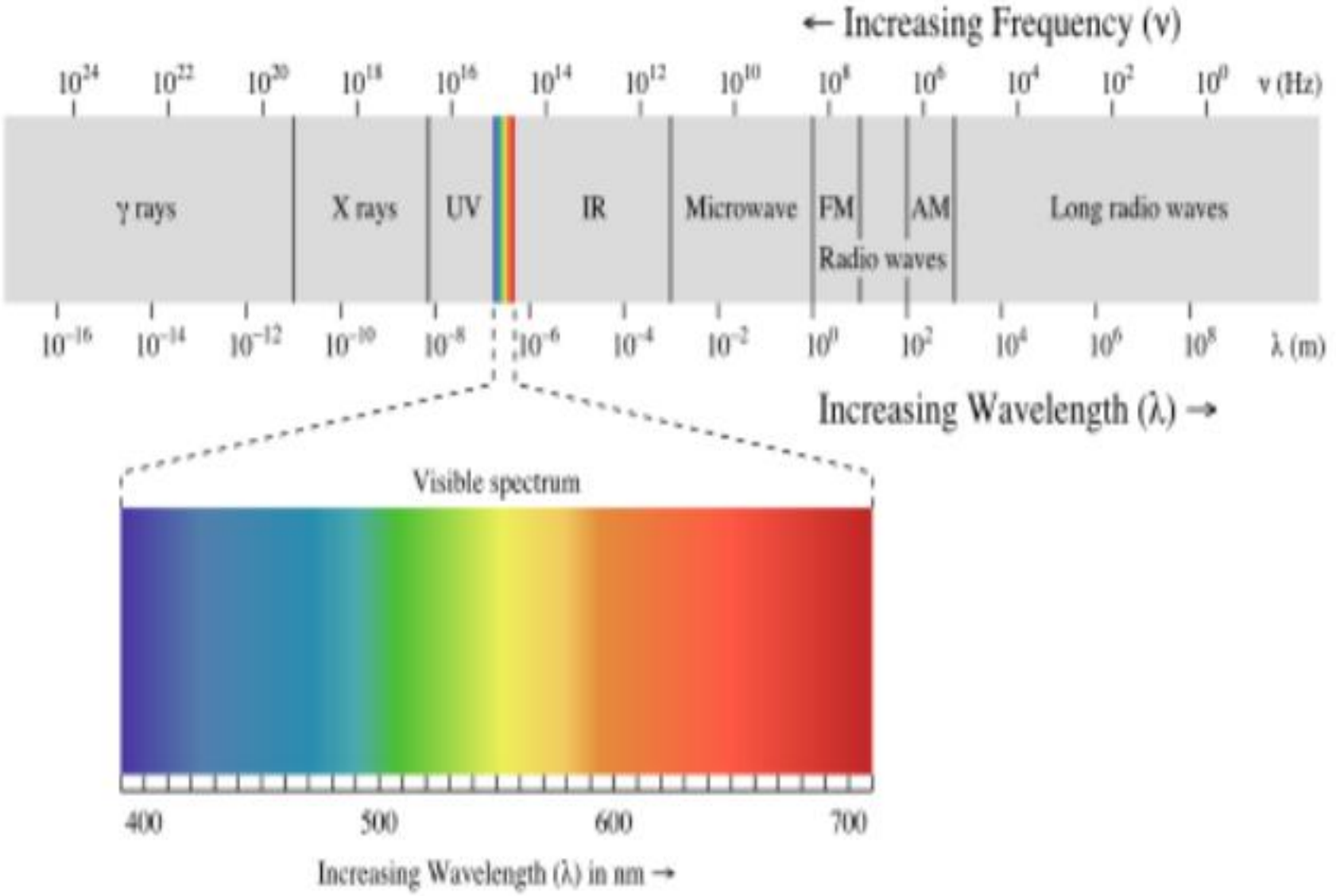
Thermometers

Types of Sensors … contd.

- Optical Sensors:
  - Optical sensors convert light rays into an electric signal, which measures quantity of light falling on it.
  - **Example**: Photovoltaic cells, Photodiodes, Solar panels, etc.
  - **Products**: Solar cells, X-Rays and radiation detectors, etc.

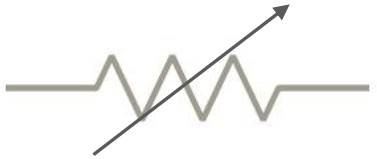
- Electrical Current Sensors:
  - It measures current passing through a small, sense resistor, generating a equivalent voltage.
  - **Example**: Sense resistor
  - **Products**: Ammeter, Multi-meter, etc

Sense resistor: A small resistor (milliohm) through which current passes generating a small voltage drop which is measured to get the current value.

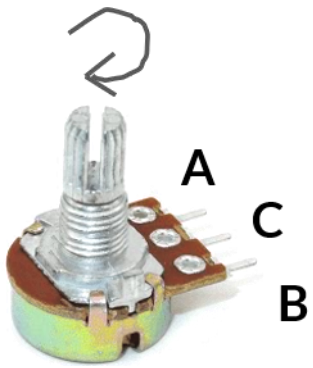

← Increasing Frequency (ν)
10^{24} 10^{22} 10^{20} 10^{18} 10^{16} 10^{14} 10^{12} 10^{10} 10^{8} 10^{6} 10^{4} 10^{2} 10^{0} ν (Hz)
γ rays
X rays
UV
IR
Microwave
FM
AM
Radio waves
Long radio waves
10^{-16} 10^{-14} 10^{-12} 10^{-10} 10^{-8} 10^{-6} 10^{-4} 10^{-2} 10^{0} 10^{2} 10^{4} 10^{6} 10^{8} λ (m)
Increasing Wavelength (λ) →
Visible spectrum
400
500
600
700
Increasing Wavelength (λ) in nm →

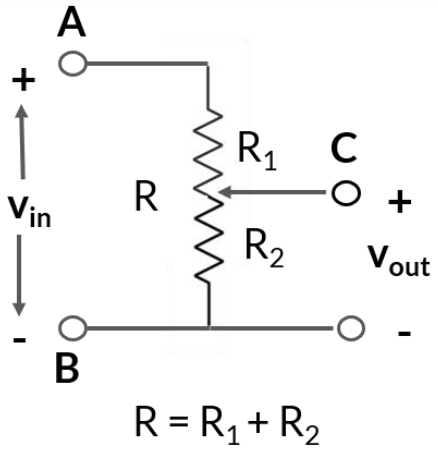
Resistors in Sensors

- There are sensors whose resistance value changes with the physical signals being measured.
- The symbol used to depict a varying resistor is given here.
- Resistance value of the sensor could either increase or decrease with respect to the physical quantity being measured.
  - **Thermistor**: Resistance decreases with the increase in Temperature.
  - **Potentiometer** or Rheostat: Resistance varies with the position.
  - **Pressure gauge**: Resistance decreases with the increase in Pressure.

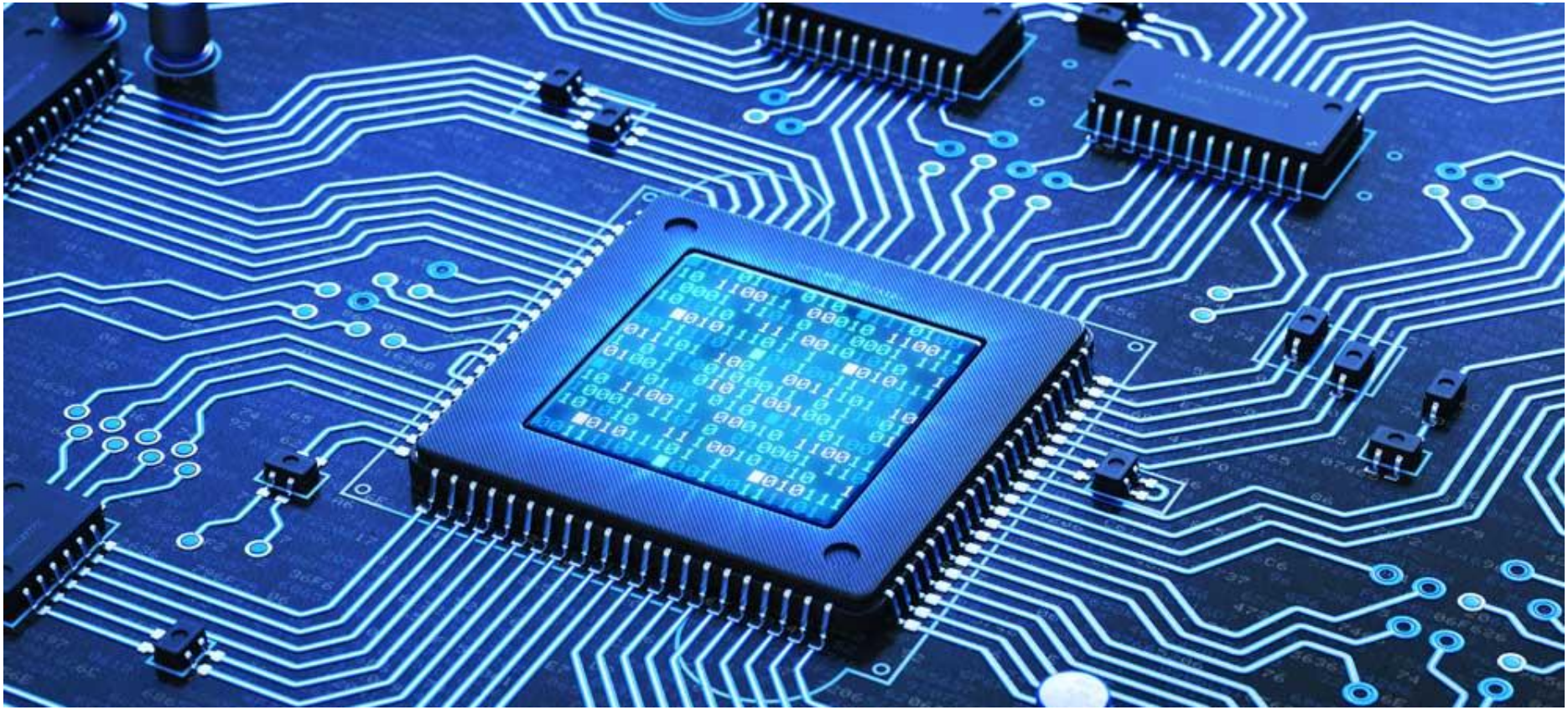


Potentiometers



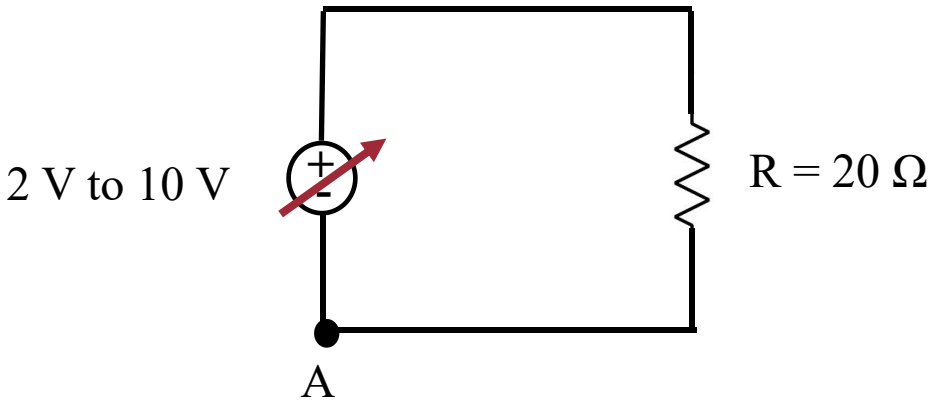


- A potentiometer is a three-terminal device with a rotating contact that forms an adjustable voltage divider.
- The resistance value across the terminals A and B always remains constant.
- The terminal C moves as the potentiometer is rotated, which is results in change in the resistance across C and B.
- Example:
  - A 100k Ω potentiometer will have 100k of resistance across A and B.
  - Resistance across C and B may vary from 0 to 100 k ohms, based on the position of the shaft



Quiz

Quiz 1

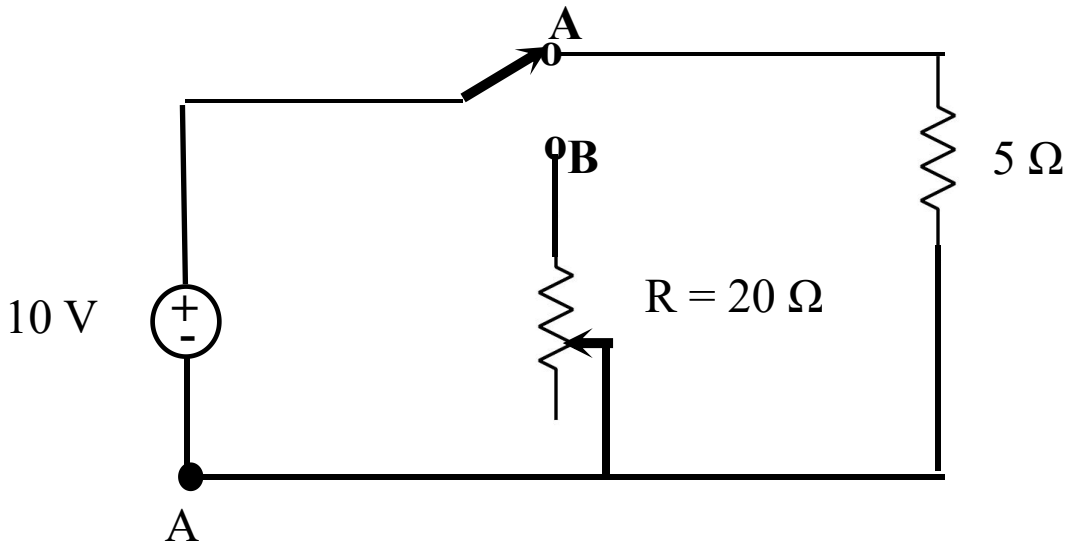


Max power dissipated by R $= V^2 / R$
$= 10^2 / 20$
$= 5$ W

- Choose all the resistor (R) values with suitable power rating for the circuit above.
  - A. 20 Ω with a power rating of 1 W
  - B. 20 Ω with a power rating of 2 W
  - C. 20 Ω with a power rating of 3 W
  - D. None of the above

ANS: D

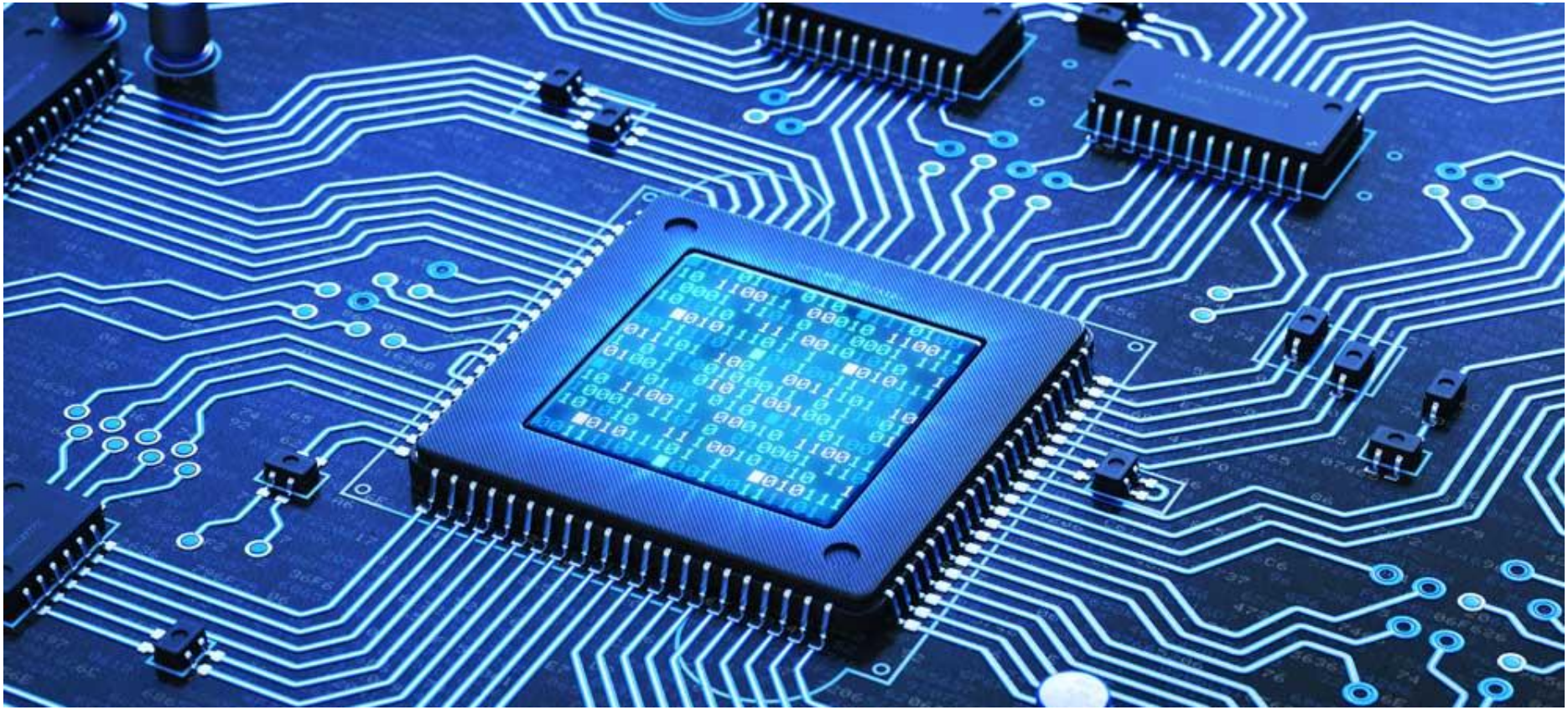
Quiz 2



- Should this power supply have a short circuit protection or not?
  - Assume that the switch can be either in the position A or B.

ANS: **Yes. Can you give a reason for it?**

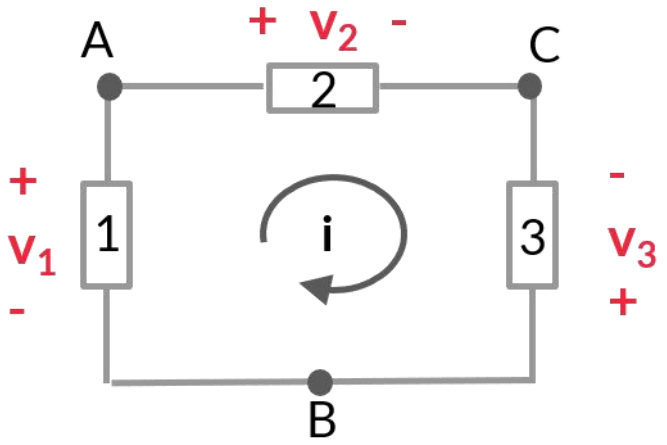
Reason: It is possible to make the total resistance across the potentiometer to zero when the switch is in the position B, then the voltage source will be short circuited. So, short circuit protection, especially in this circuit, is a must.



Simple Circuit Elements

Simple Circuit Elements

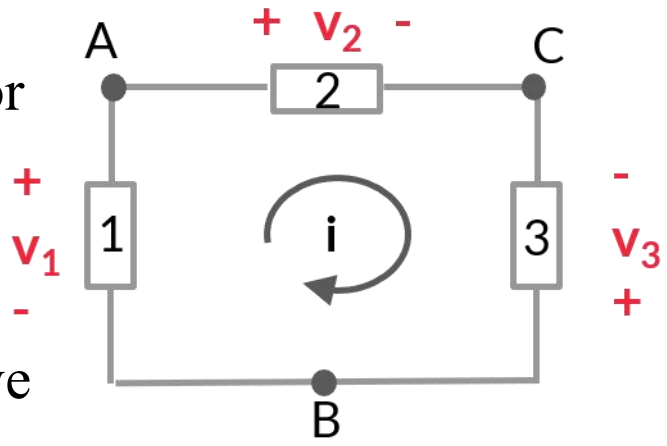
- A simple circuit element is a mathematical model of a two-terminal electrical device.
- Particular model of a real device is derived based on the experimental data or experience.
- Circuit elements are completely characterized by its voltage-current (V-I) relationship.
- Such simple elements cannot be subdivided further into other two-terminal devices.

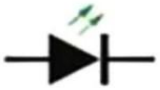
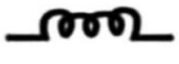
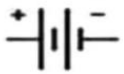


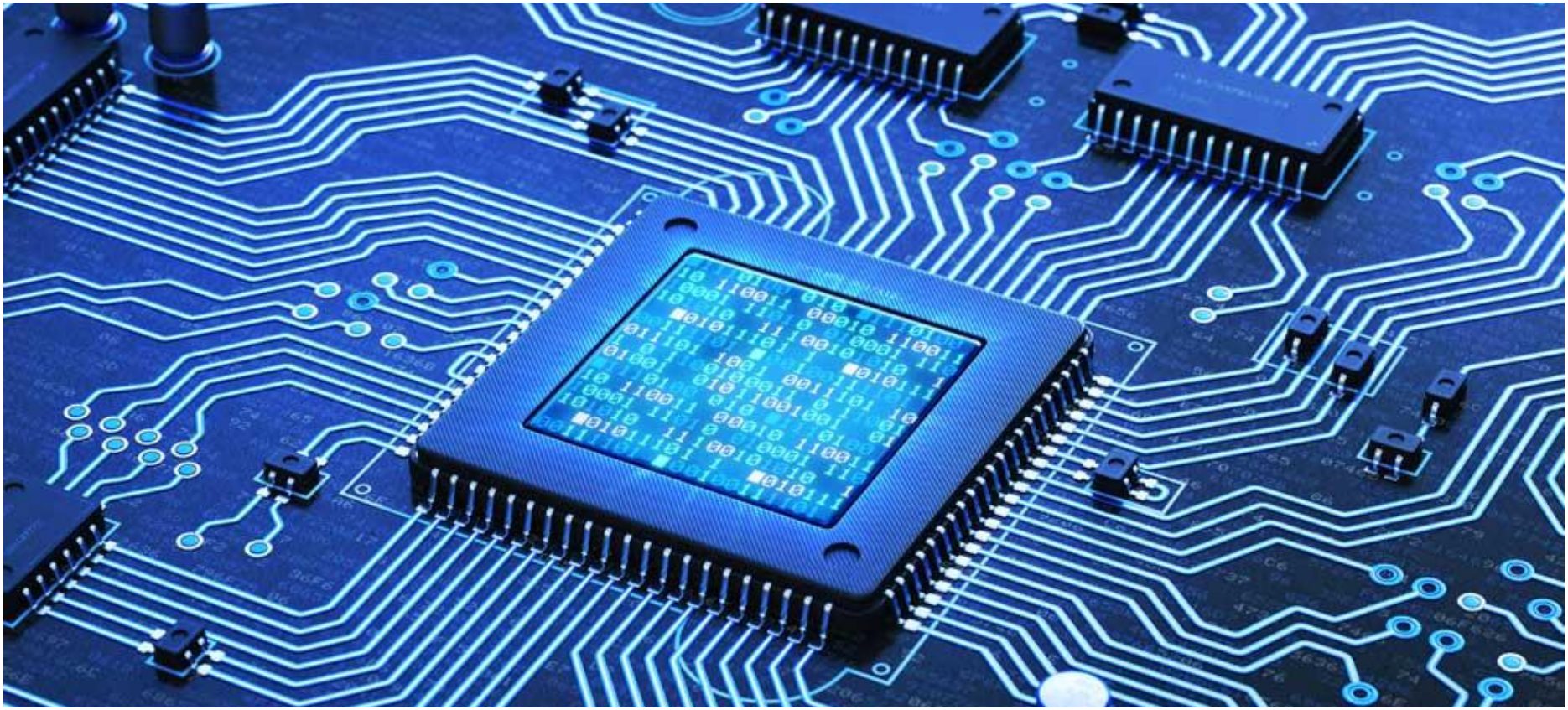
Make a note of the signs
across the elements

Active and Passive Elements: Example

- There are two main types of circuit elements.
  - Active and passive elements.
- Active elements or components that supply energy to an electric circuit.
- Passive elements can only receive or dissipate or absorb energy, but it cannot generate energy.
- As per **passive sign convention**, current flows into the +ve terminal of passive elements, whereas current leaves the +ve terminal of active elements.
- In the circuit here, based on the direction of the current i, identify the passive and active elements.
  - **Active elements**:1 and 3 **Passive element**: 2



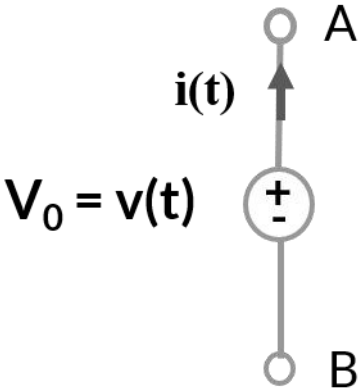
ACTIVE			PASSIVE		
Transistor			Resistor		
Diode			LDR		
LED			Thermistor		
Photodiode			Capacitor		
Integrated Circuit		-	Inductor		
Operational Amplifier			Switch		
Seven Segment Display			Variable Resistor		
Battery			Transformer		

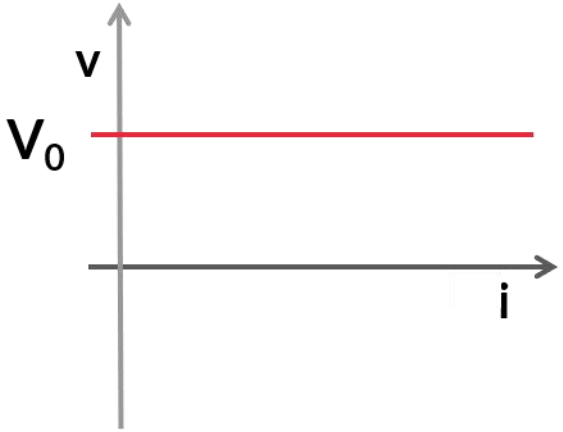


Independent Voltage Sources

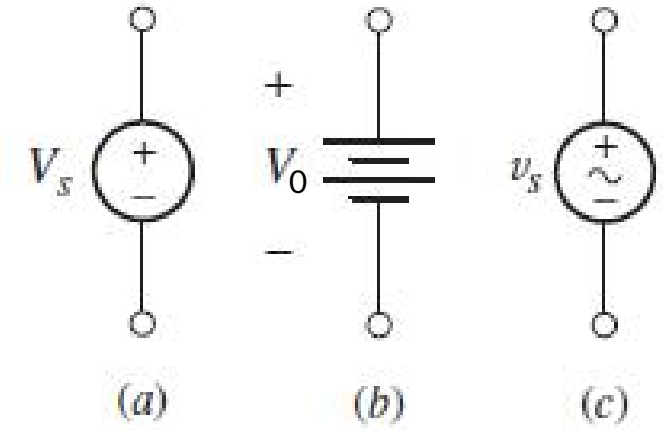
Independent Voltage Sources

- An independent voltage source is characterized by a terminal voltage which is completely independent of the current or power supplied by it.
- An independent voltage source is an ideal source and it does not represent exactly any real physical device.



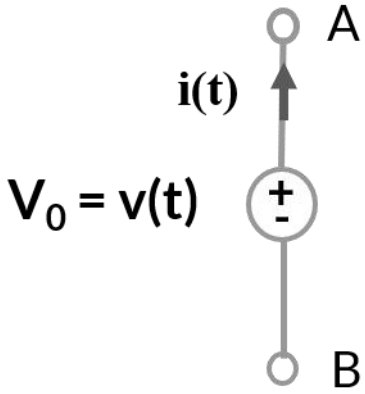


Independent Voltage Sources: Symbols



a) DC Voltage source
b) A Battery
c) AC Voltage source

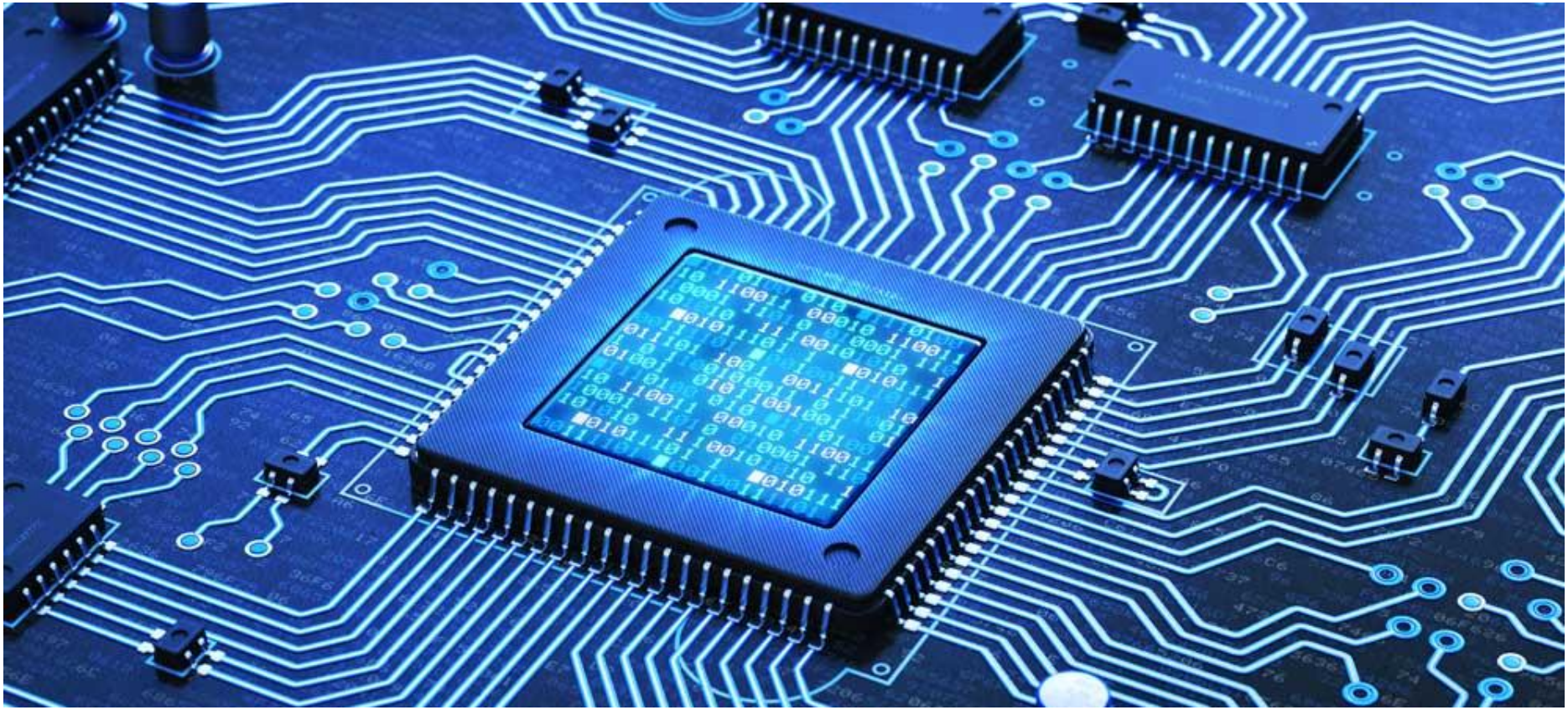
Current Supplied by a Voltage Source



1.5A rating

5A rating

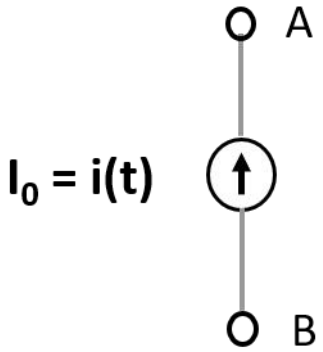
- Current drawn from a voltage source depends on the load connected to it.
- Practical voltage source cannot supply infinite current like an ideal voltage source
- The voltage sources are designed for a maximum current that it can supply

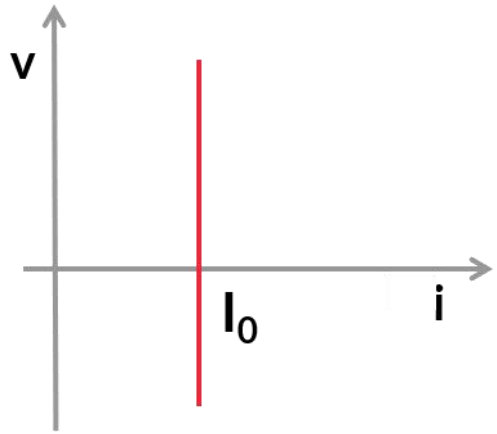


Independent Current Sources

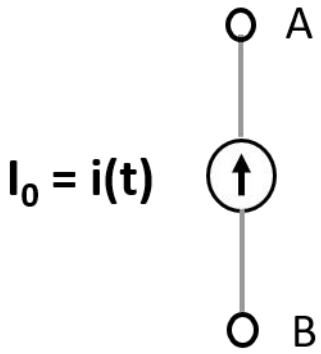
Independent Current Source

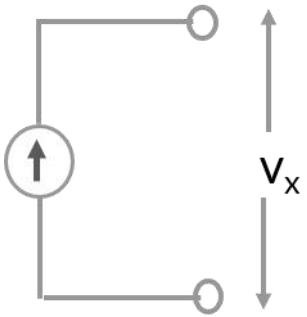
- An independent current source is characterized by a terminal current which is completely independent of the voltage across it.
- An independent current source is an ideal source and does not represent exactly any real physical device.





Voltage Across Independent Current Source

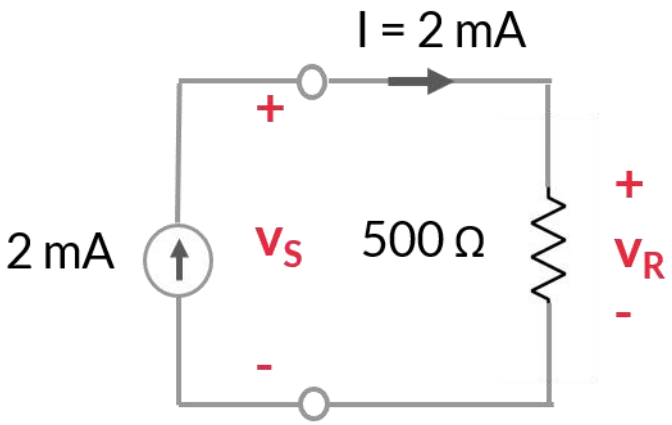




- It is a common mistake to view an independent current source as having zero voltage across its terminals while it provides a fixed current.
- In fact, we do not know a priori what the voltage across a current source would be.
  - It depends entirely on the circuit to which it is connected to.

Problem 1

- Compute v_R and voltage across the current source (v_S):



$v_R = (2\ mA * 500) = 1\ V$

$v_S = v_R = 1\ V$

Ans: 1 V

Session 1.2: Summary

- Introduction to Sensors
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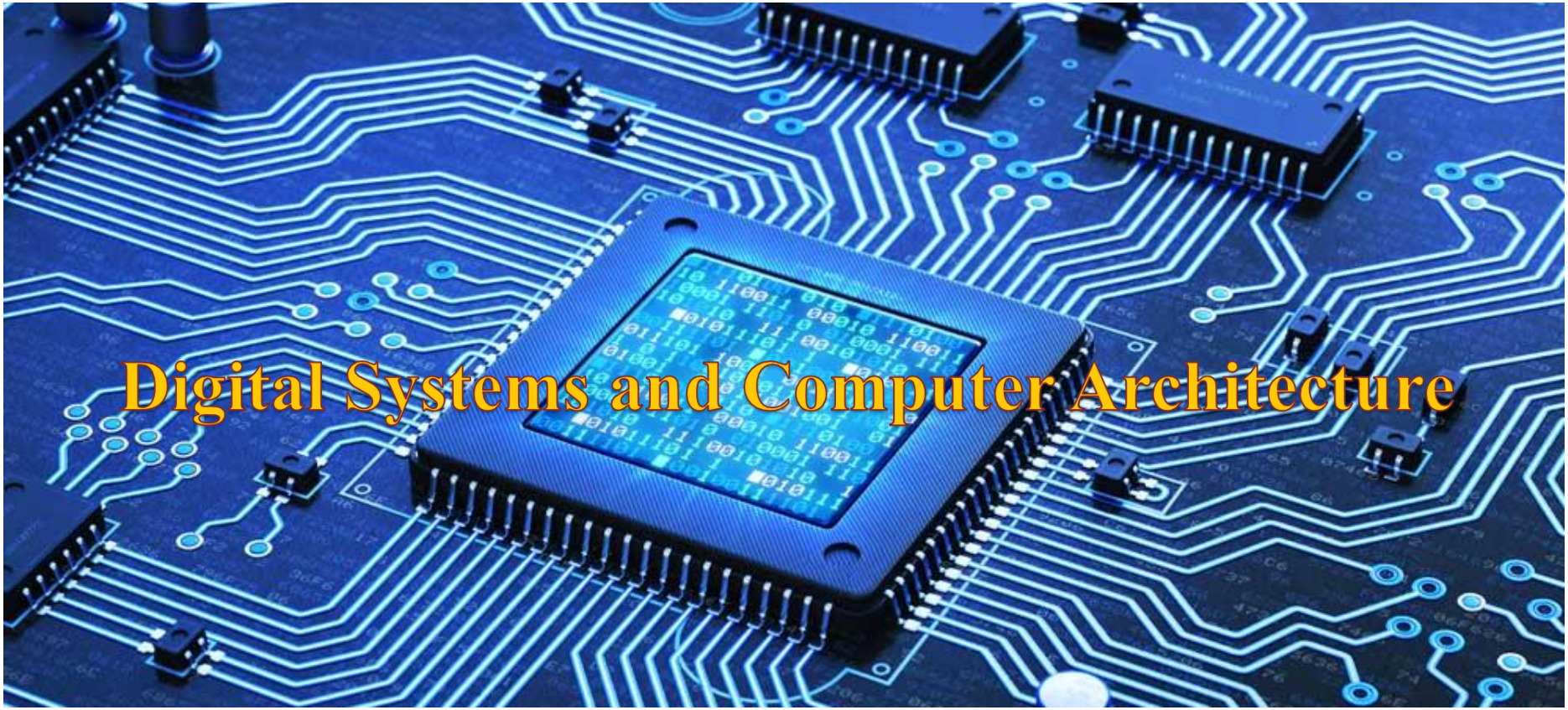
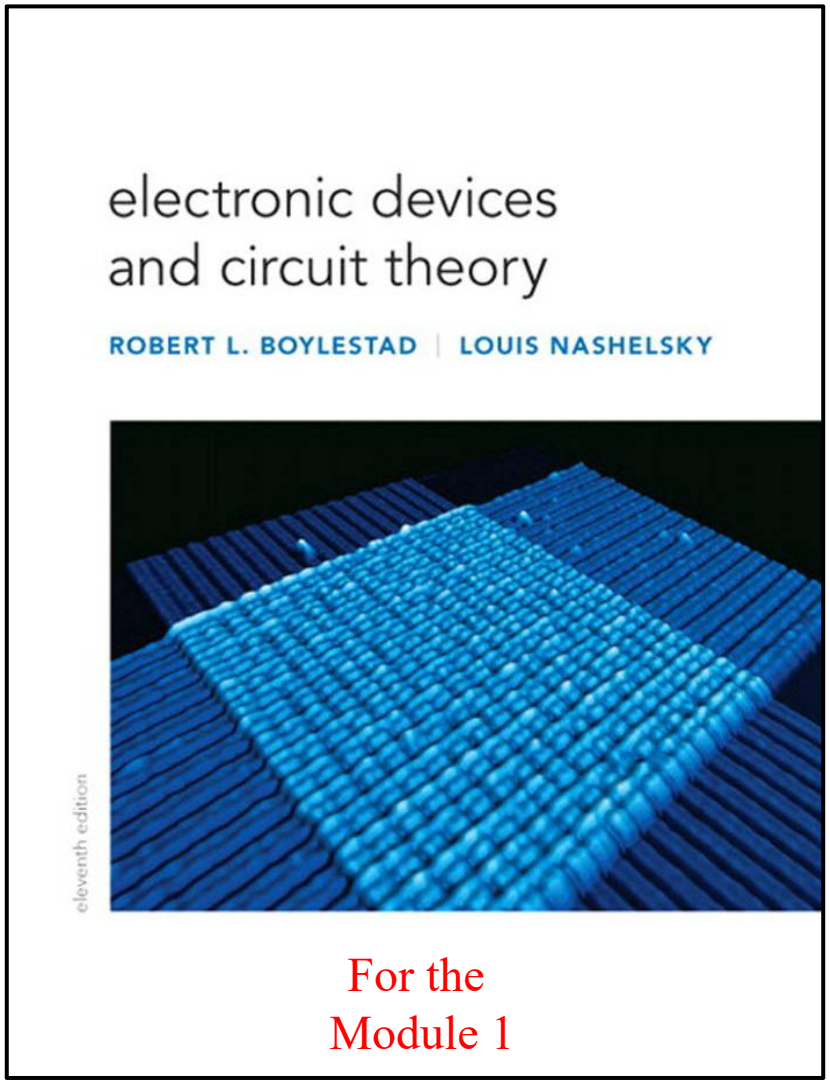
- Quiz
- Simple Circuit Elements
  - Active and Passive Elements
- Independent Voltage Source
- Independent Current Source
- Problem 1



References

Reference 1: DS & CA

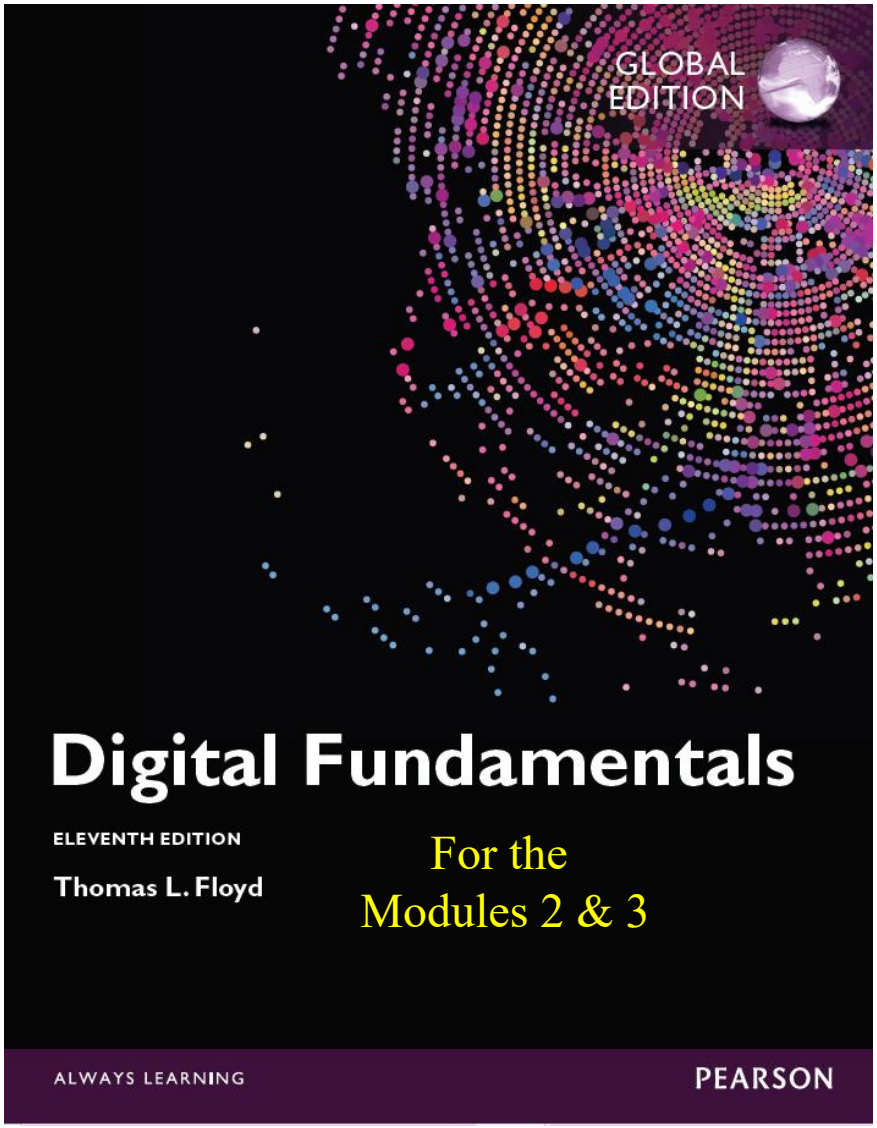
Ref 1



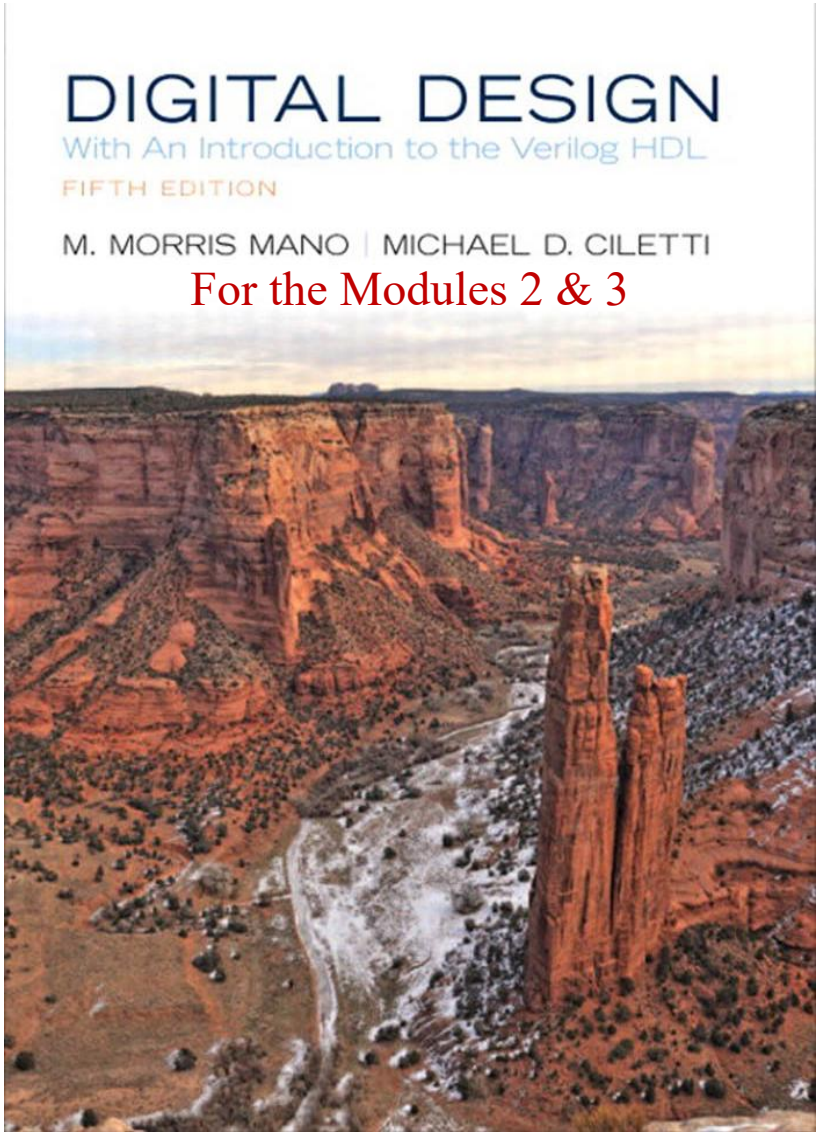
For the
Module 1

References 2 & 3: DS & CA

Ref 2

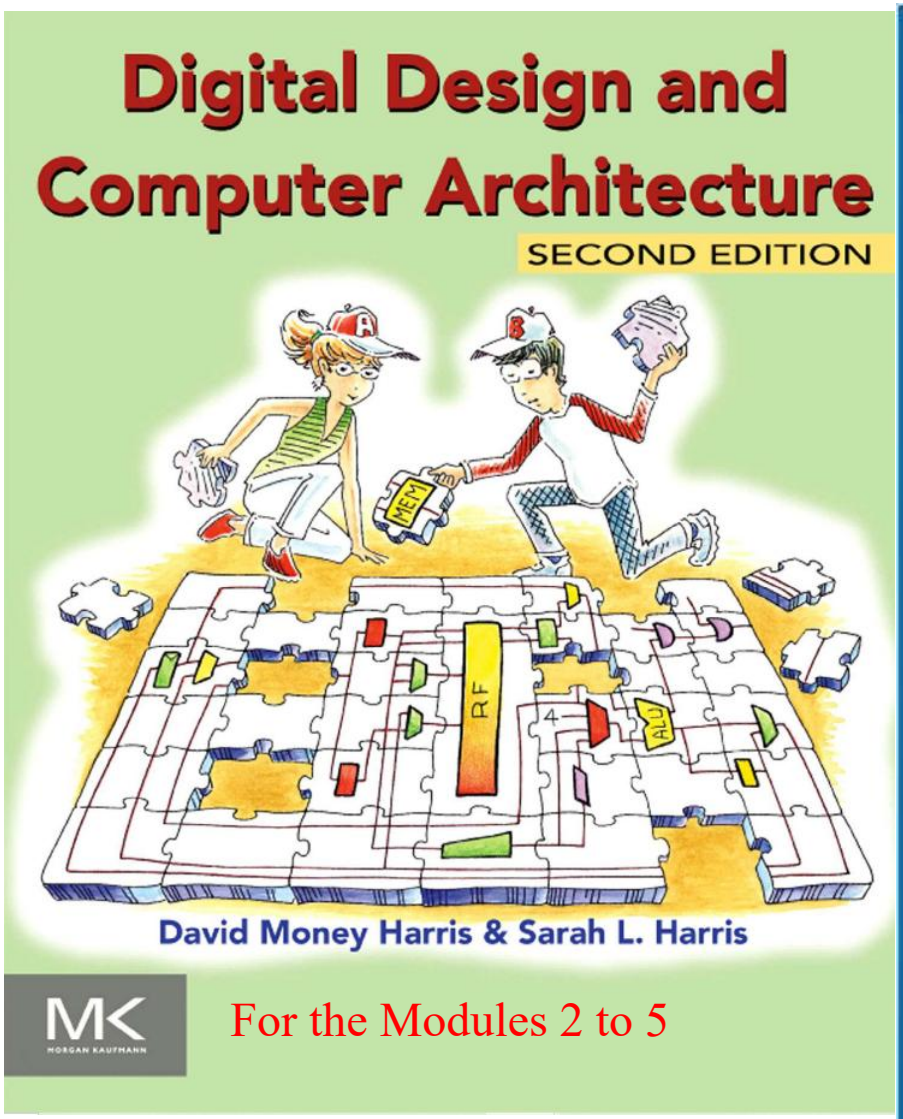


Ref 3



References 4 & 5: DS and CA

Ref 4



For the Modules 2 to 5

Ref 5