Chapter 1

Microprocessor Based Instrumentation System

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Microprocessor

- Microprocessor is a multipurpose programmable clock driven register based electronic device that reads binary instructions from a storage device called memory accepts binary data as i/p and processes data according to those instructions and provides result as output

- Any instrumentation system centered around a microprocessor is called microprocessor based system

- Logical and computing power of microprocessor has entered the capabilities of many basic instruments improving accuracy and efficiency of use

- Microprocessor is a versatile device used in any instrumentation system. E.g. automatic washing machine fuel control, oven etc.

Microprocessor	Microcontroller
CPU is stand alone, RAM,ROM, I/O & timer are separate.	CPU, RAM,ROM, I/O & timer all are on single chip.
Designer can decide amount of RAM,ROM, & I/O ports.	Fixed amount of on-chip RAM,ROM, & I/O ports.
High processing power	Low processing power
High power consumption	Low power consumption
Typically 32/64 bit	8/16 bit
General purpose	Single purpose(control oriented)
Less reliable	Highly reliable
Eg.- 8086,8085	8051

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Instrumentation System

- The system which is defined as the assembly of various instruments and other components inter connected to measure analyze and control physical quantities such as electrical, thermal, mechanical etc.

Features of MBI systems

- Low cost
- Small size and low weight
- Low power consumption
- Versatile / Flexible
- Highly Reliable
- Easily maintainable
- Quick Response
- High throughput
- Real time
- Creation of distributed
- Safe
- Operational in harsh environment

Functions / purpose of MBI systems

- Data collection
- Data storage
- Data representation
- Data communication
- Data processing
- Monitoring
- Control
- Application specific user interface (UI)B

Benefits / advantages of MBI System

- Suitably programmed to automatically carry out the tasks of drift correction, noise reduction gain adjustments, automatic calibration etc.

- These instruments have signal conditioning and display which are compact, rugged and reliable and is suited for performing in wide condition such as industrial, consumer, military, automobile.

- There System can detect faults / errors only or detect and correct errors.

- Real time measurement, processing and display

- Lower cost, higher accuracy more flexible

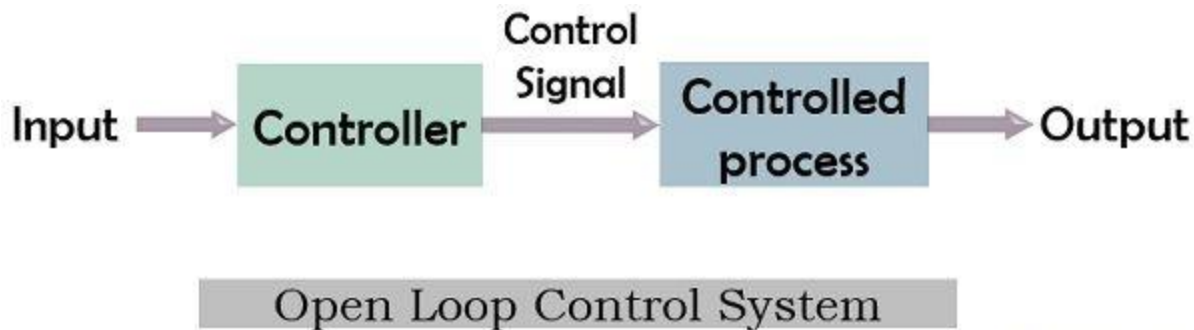# Disadvantages / Drawbacks of MBI system

- Cannot replace programmer / coder hardware designer and so cannot modify software / hardware by themselves
- Need processing data in digital form. And while converting from analog to digital ,inform is manipulated
- The system needs to update software periodically which involves time and expenses
- Prone to viruses problem, so may become in operation

Application of MBI system

- House hold devices: TV, toaster, microwave oven etc.
- Industry : Gasoline pumps, traffic light, control
- Transportation: Engine control navigation system
- Computer / Electronics : Gaming stations, printers
- Medical / Healthcare : x-ray machines, pacemaker
- Communications: n/w routers, bluetooth
- Banking and retail : ATM currency counter
- Home automation and security: Alarm system, CCTV
- Consumer electronics : cameras, smart phone
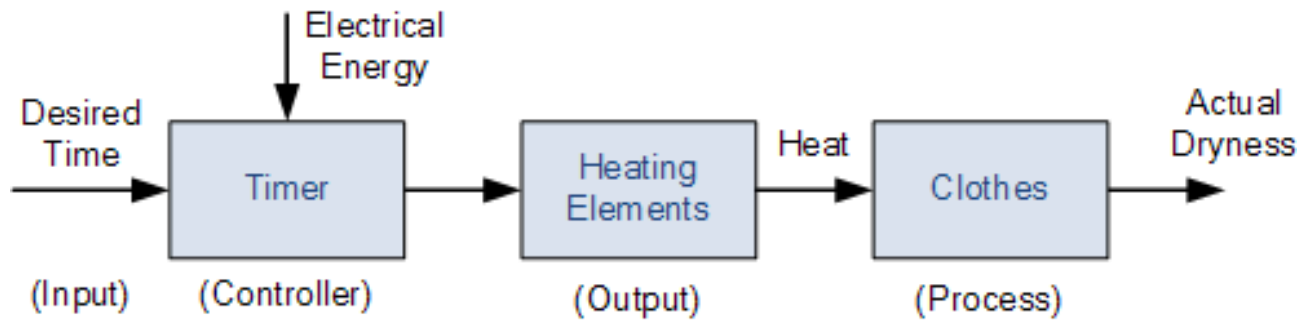- Measurement and instrumentation : Oscilloscope, function generator

Open Loop MBI System

- Output of open-loop system has no effect on the input
- Output only depends upon the i/p parameters and calibration of system
- The basic elements in an open loop system are controller, connection unit, the process to be controlled
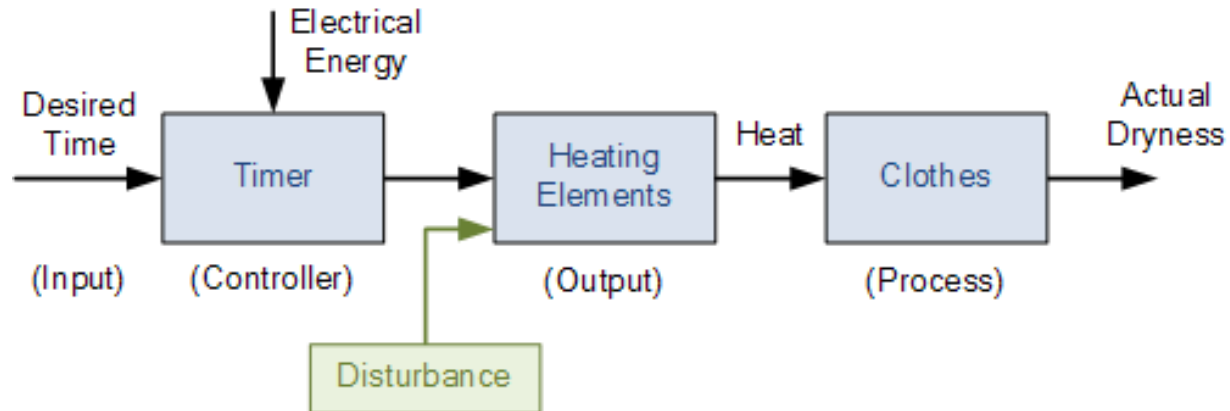

Open Loop Control System

Electronics Coach

-Controller : Determines the action to be take on I /p parameters

E.g. Open system example
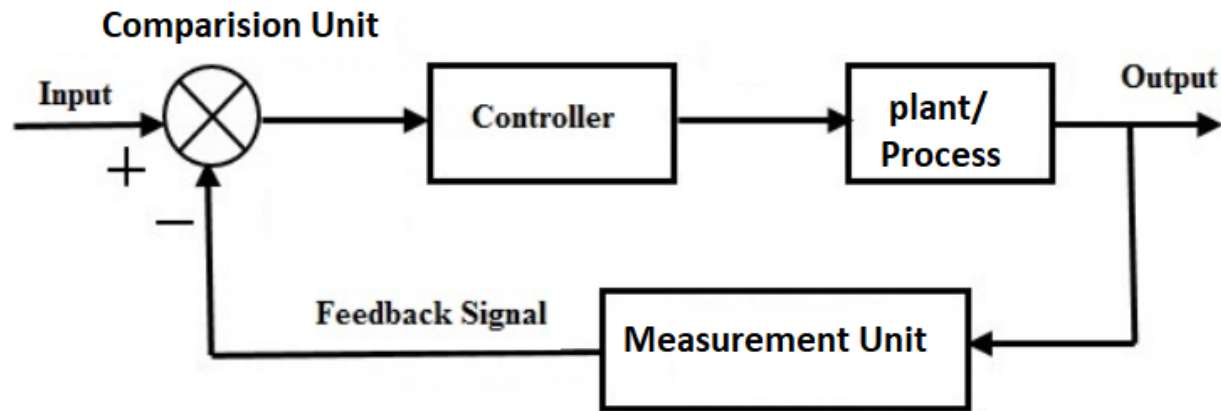

- **Advantages of Open Loop System**
  - Simple to construct
  - Convenient when 0 / p is difficult to measure
  - They are easy to maintain and economical
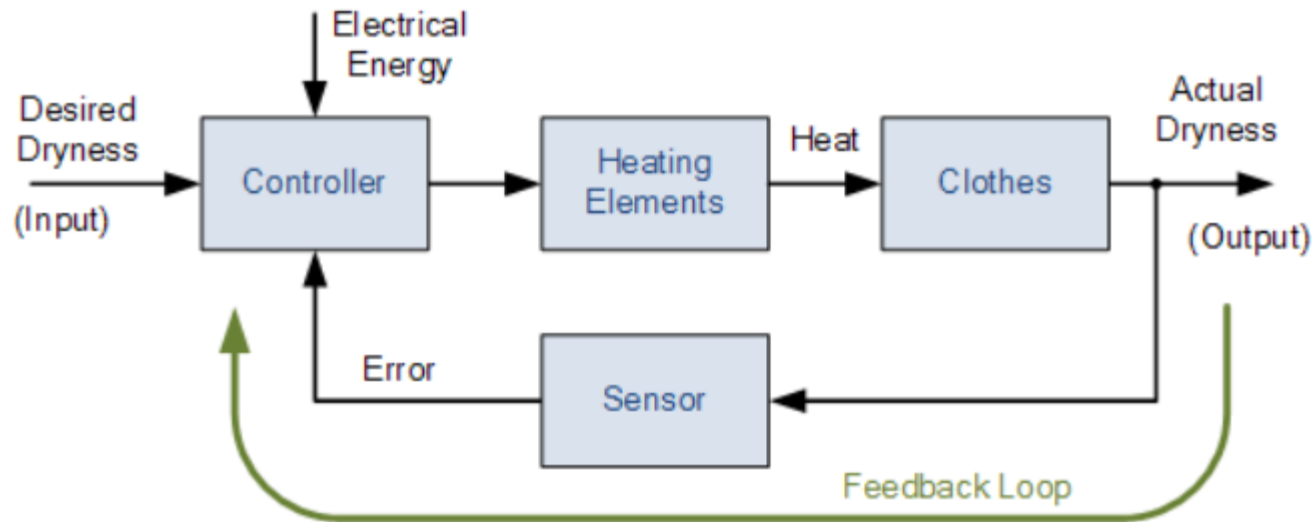
Disadvantages

- Cannot sense internal disturbances because there is no feedback path

- To maintain quality and accuracy these systems need to be regularly calibrated

Closed Loop System

- In these systems the output has an effect on the I/p.
- To create the dependency between i/p and o/p feedback path is needed.
- The basis elements needed to create a closed loop MBI system are as fallows
  - Control unit
  - Connection unit
  - Process/Plant
  - Measurement unit
  - Comparison unit

Comparision Unit

Block Diagram of closed loop system

Advantages

- Accuracy and reliability of these systems are high
- System is capable of sensing changes in the surrounding environment
- System produces reduced non-linearities / fluctuations.

Disadvantages

•System are more complex and expensive compared to open systems
•Due to feedback these systems are comparatively slower that open systems
•Because of larger no of units the maintenance cost becomes high.
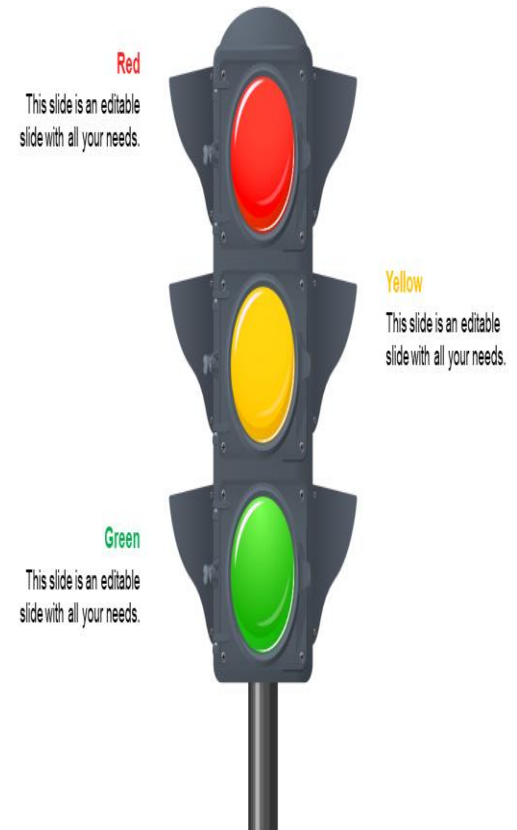
Traffic light powerpoint

- **Traffic Light System**
- Open Loop System vs Closed Loop System

Consideration : Timing (open system)
Timing + Control system(Density of Vehicles)
        Closed System

Red
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Yellow
This slide is an editable slide with all your needs.

Green
This slide is an editable slide with all your needs.

Micro-Computers

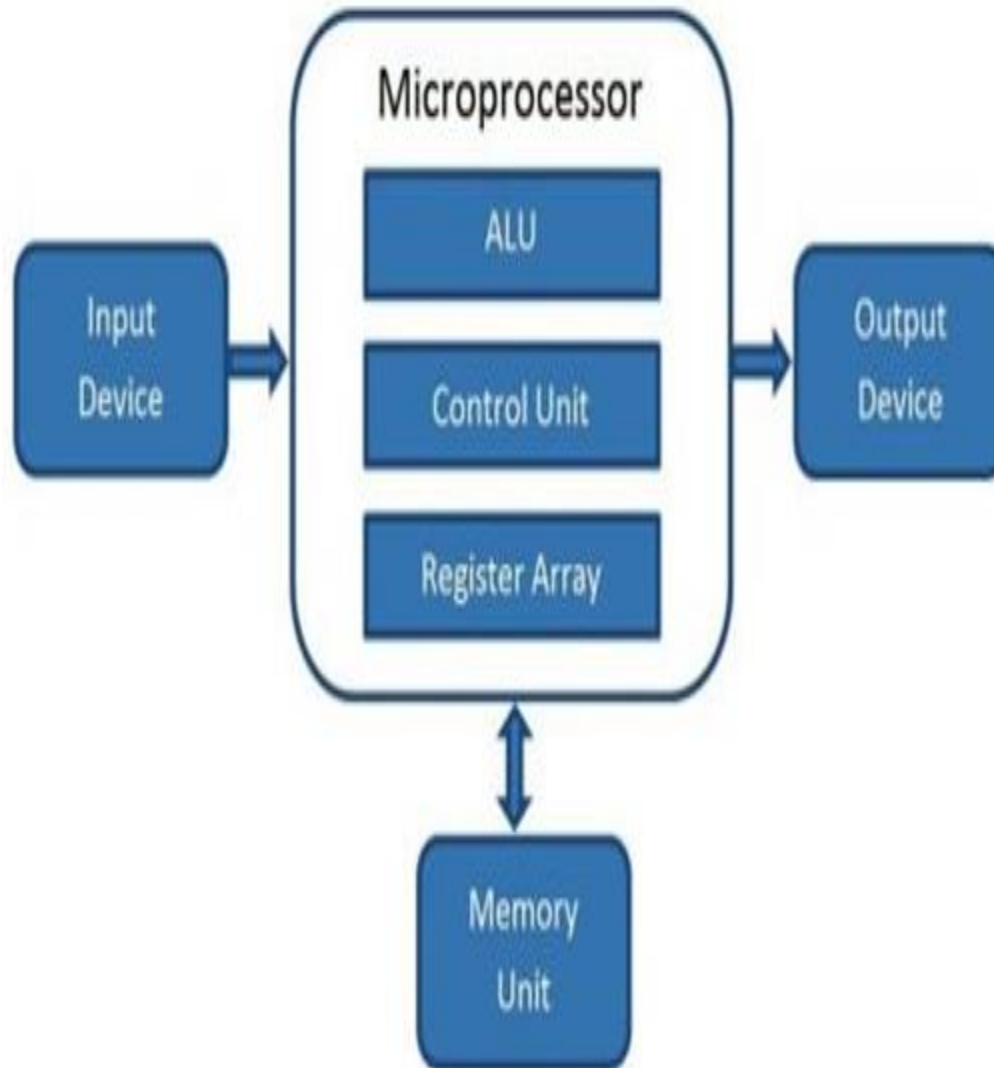- Microcomputer is known as personal computer like as small computer. Microcomputers are designed with **microprocessor** as well as it consists single chip that is CPU (Central Processing Unit), data memory (RAM, ROM), and I/O buses; these are connected on the **motherboard**.

Types of Micro Computer — Notebook, Smartphone, Laptop, Desktop Computer

Simplified Block Diagram of Micro computers

Micro computer on Instrumentation Design

A computer based measurements system has the capability of processing all inputs (such as pressure, temperature, velocity, viscosity, flow rate etc) and present the data in real time.

Factors to consider while selecting a processor

1.Features Set :
a)   Does the processor support the peripherals required by your application
b)   Does the processor support the enough no of timers, counters and interrupts
c)   Does the processor support the hardware for ADC/DAC
d)   Does the processor provide the performance?

2. Speed of operation
 a. The no of clock cycle required to complete the execution of an instruction

3. Development Support
a.   Does the vendor / manufacturer provide development tool
b.   Does the vendor provide prototypes
c.   Does the vendor provide third party tool
d.   Does the vendor provide enough document (user - manual)

4. Availability
a.   How popular is the processor
b.   How long does it take between purchase order and supply of devices.

5. Cost
a.   The cost should be reasonable so that customers can purchase them.

6. Power Consumptions

   a. Power consumption should be minimal

   b. Large power consumption requires cooling which adds complexity and cost in the design

7. Reliability

   - should provides correct result

8. Safety

9. Easy to use

10. Internal memory space

11. Flexibility

   - Does the device support multiple applications.

Interfacing with Microprocessor

Interfacing refers to connection between one or more devices for data transfer

Factors to be considered while Interfacing
a. Electrical and Mechanical compatibility
b. Data compatibility
c. Timing Compatibility

The primary function of microprocessor is to accept data from input devices such as keyboard and A/D converters, read instructions from memory, process data accordingly to the instructions, and send the results to output devices such as LEDs, printers and video monitors. These input and output devices are called peripherals or I/Os. Designing the logic circuits (hardware) and writing instructions (software) to enable the microprocessor to communicate with these peripherals is called interfacing, and the logic circuits are called I/O ports of interfacing devices.

PC Interfacing Techniques

1)   **I/O Buses**

PC brings out the system bus signals through expansion slots known as I/O buses on the motherboard that is an I/O bus interfaces an external device directly to the system bus. Video card, sound card, network card etc. are inserted into the slots for various applications.

2)   **Parallel and Serial Ports**

Basic PC configuration includes one parallel port (LPT1) and two serial ports (COM1 and COM2). However, additional ports can be created by adding expansion cards. For industrial measurement and control operations, remote data acquisition system compatible for serial port are used.

3)   **USB ports**

Universal serial bus used for connecting number of peripheral devices such as printer, scanner, digital cameras, and pen drives etc. It is faster compared to traditional parallel and serial ports.

Review of Address Decoding

The R/W memory is made of registers and each register has a group of flip flops or field-effect transistors that store bits of information; these flip flops are called memory cells. The number of bits stored in a register is called a memory word.

In a memory chip, all registers are arranged in a sequence and identified by binary numbers called memory address.

To communicate with memory, the MPU should be able to:
- Select the chip
- Identify the register
- Read from or write into the register

- Address decoding is the technique of selecting the correct I/O device or the correct memory location within the correct memory chip unit the bits on the address lines.

- Depending upon the no of address lines used to generate chip select signal ($\overline{CS}$) for the device, the address decoding is classified under

a) **I/O mapped I/O**

In this method, a device is identified with an 8 bit address and operated by I/O related functions IN and OUT for that IO/M' = 1. Since only 8bit address is used, at most 256 bytes can be identified uniquely. Generally low order address bits A_0-A_7 are used and upper bits A_8-A_{15} are considered don't care. Usually I/O mapped I/O is used to map devices like 8255A, 8251A etc.

b) **Memory mapped I/O**

In this method, a device is identified with 16 bit address and enabled memory related functions such as STA, LDA for which IO/M' = 0, here chip select signal of each device is derived from 16 bit address lines thus total addressing capability is 64K bytes. Usually memory mapped I/O is used to map memories like RAM, ROM etc.

Depending on the address that are allocated to the device the address decoding are categorized in the following two groups.

a) Unique Address Decoding:

If all the address lines on that mapping mode are used for address decoding then that decoding is called unique address decoding. It means all 8-lines in I/O mapped I/O and all 16 lines in memory mapped I/O are used to derive $\overline{CS}$ signal. It is expensive and complicated but fault proof in all cases.
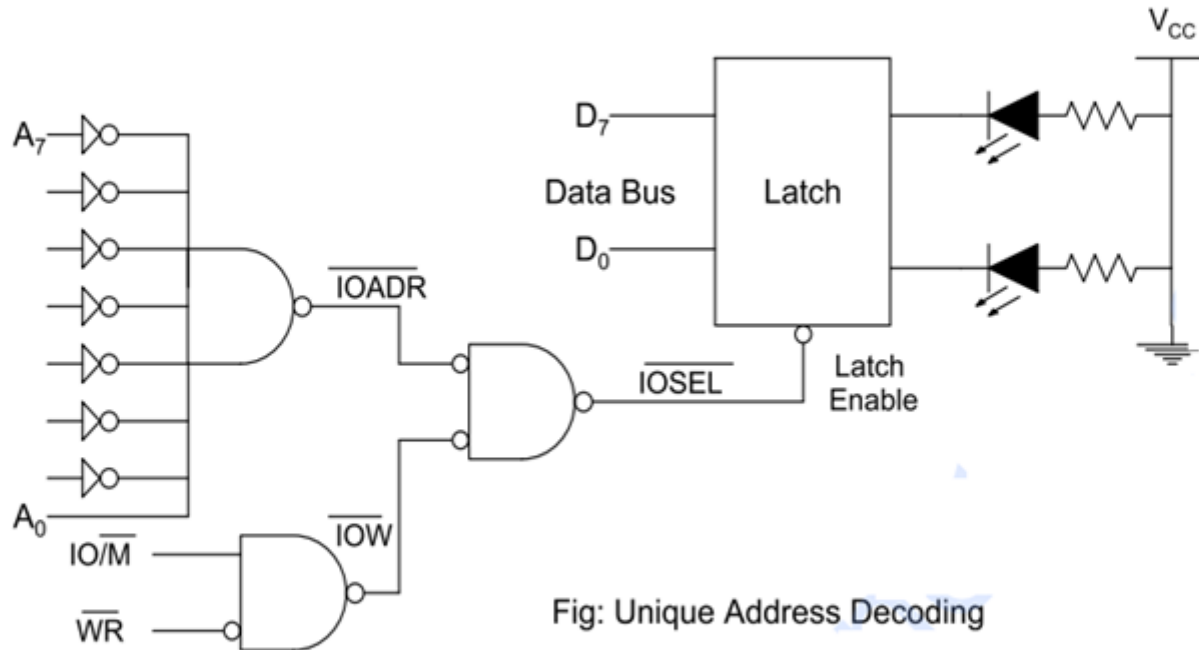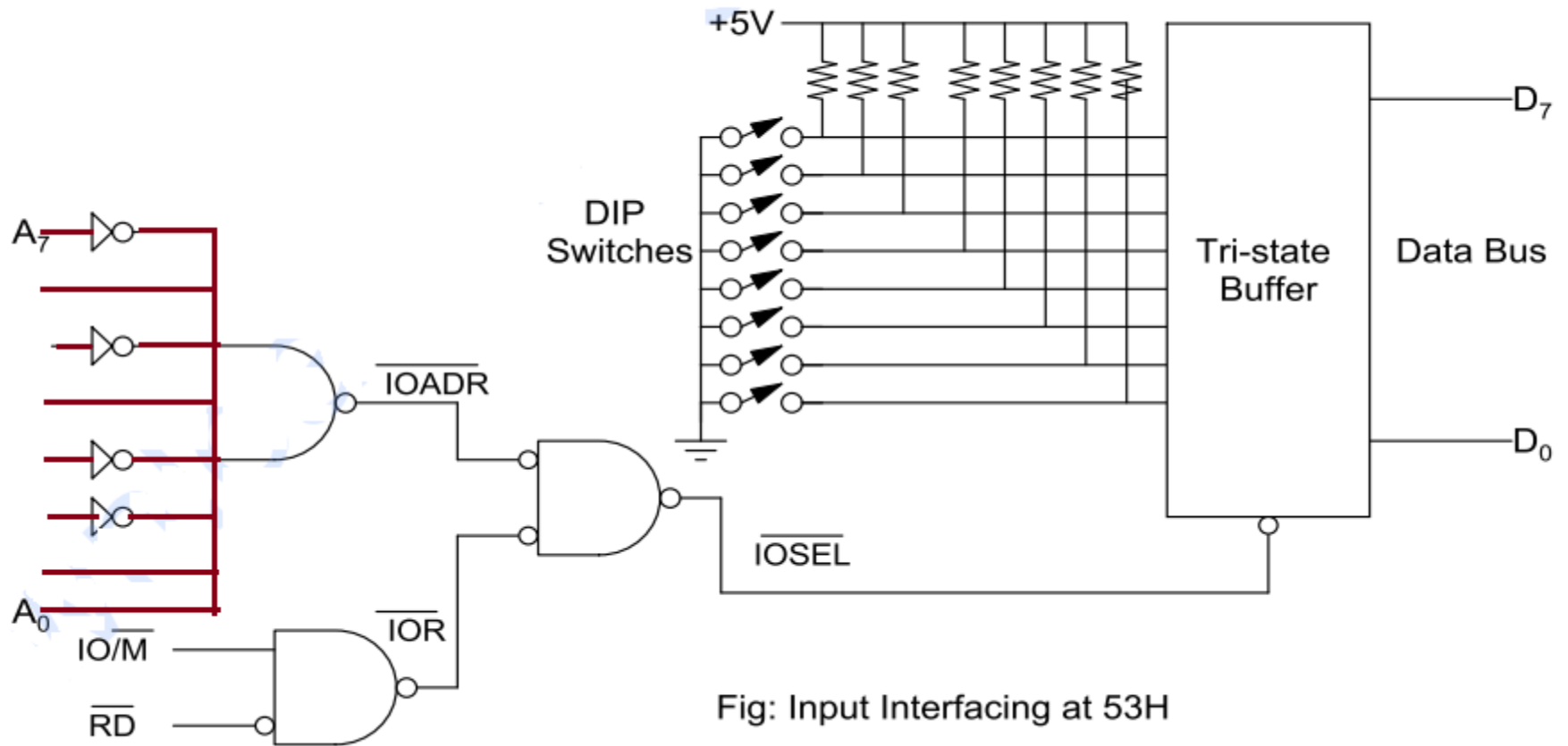

Fig: Unique Address Decoding

➢ If A_0 is high and A_1- A_7 are low and if $\overline{IOW}$ becomes low, the latch gets enabled.
➢ The data to the LED can be transferred in only one case and hence the device has unique address of 01H

Eight I/P switch interfacing at 53H. (01010011)

Fig: Input Interfacing at 53H

b) Non Unique Address decoding:

If all the address lines available on that mode are not used in address decoding then that decoding is called non unique address decoding. Though it is cheaper there may be a chance of address conflict.
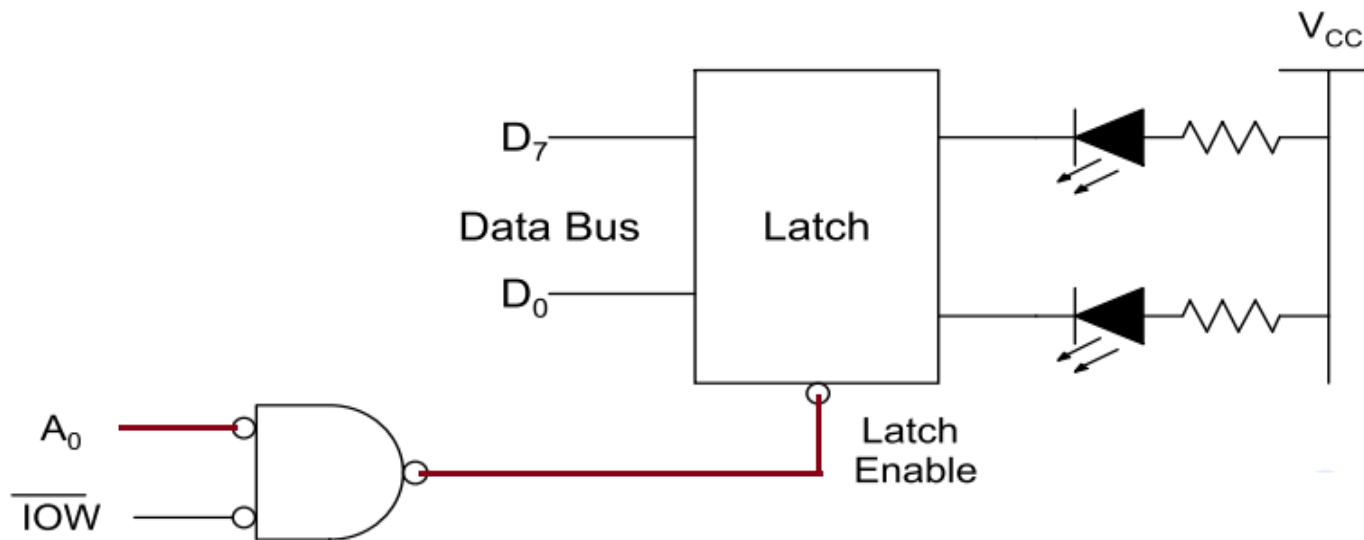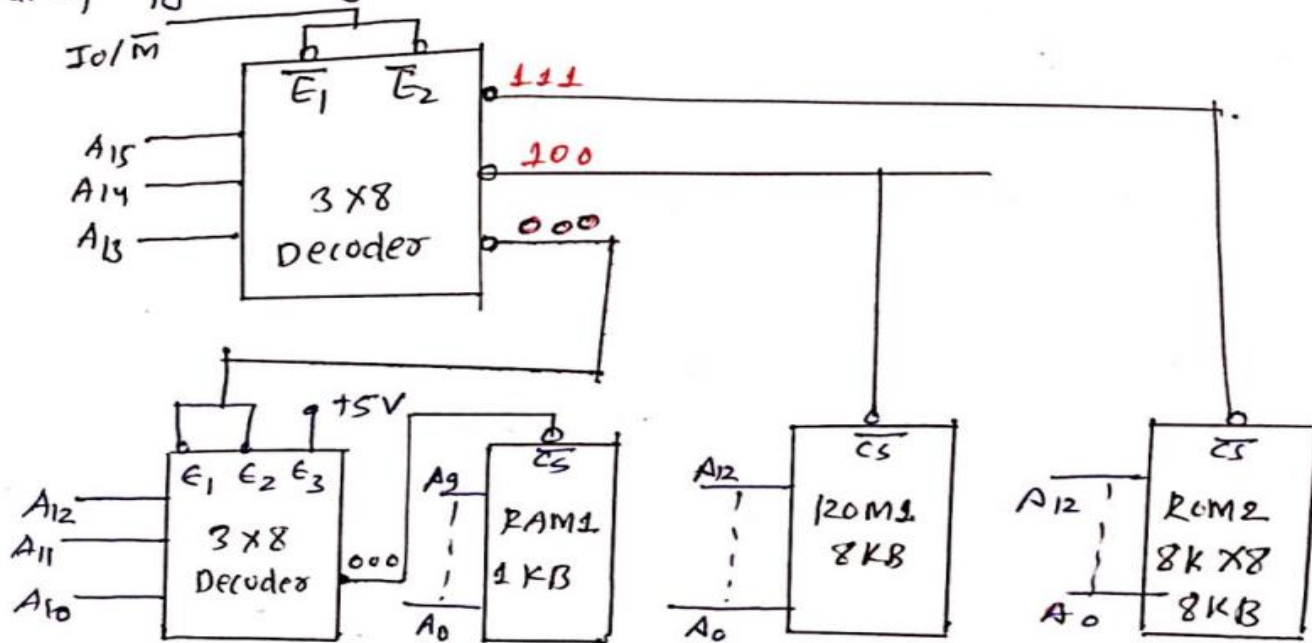

Fig: Non unique Address Decoding

- If A_0 is low and $\overline{IOW}$ is low. Then latch gets enabled.
- Here A_1-A_7 is neglected that is any even address can enable the latch.

specify memory address for RAM & ROM.

Solution:-

RAM $(1KB \Rightarrow 2^n = 2^{10} \Rightarrow n = 10)$

	A_{15}	A_{14}	A_{13}	A_{12}	A_{11}	A_{10}	A_9	A_8	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0
start (0000H)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final (03FFH)	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1

ROM1 $(8KB \Rightarrow 2^n = 2^{10} \times 2^3 \Rightarrow \underline{n = 13})$

	A_{15}	A_{14}	A_{13}	A_{12}	A_{11}	A_{10}	A_9	A_8	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0
start (8000H)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
End (9FFFH)	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1

Rom2 (8 KB ⇒ $n=13$)

	A_{15}	A_{14}	A_{13}	A_{12}	A_{11}	A_{10}	A_9	A_8	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0
start (E000H)	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
end (FFFFH)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Design an address decoding circuit to interface two RAM and ROM Block of each 4KB starting address at 4000H.

step1 calculate address pin

$$4KB = (4 \times 1KB) = (2^2 \times 2^{10}) = 2^{12}$$

4KB requires 12 address lines.

step2 memory mapping

memory	Address	A_{15} A_{14} A_{13} A_{12}	A_{11} A_{10} A_9 A_8	A_7 A_6 A_5 A_4	A_3 A_2 A_1 A_0
RAM1	start: 4000H	0 1 0 0	0 0 0 0	0 0 0 0	0 0 0 0
	end: 4FFFH	0 1 0 0	1 1 1 1	1 1 1 1	1 1 1 1
RAM2	start: 5000H	0 1 0 1	0 0 0 0	0 0 0 0	0 0 0 0
	End: 5FFFH	0 1 0 1	1 1 1 1	1 1 1 1	1 1 1 1
ROM	start: 6000H	0 1 1 0	0 0 0 0	0 0 0 0	0 0 0 0
	End: 6FFFH	0 1 1 0	1 1 1 1	1 1 1 1	1 1 1 1

calculation: 12 address lines : 1111 1111 1111 = FFFH

RAM1: start 4000H + FFFH = 4FFFH = End address

RAM2: start add = 4FFF + 01H = 0100 1111 1111 1111

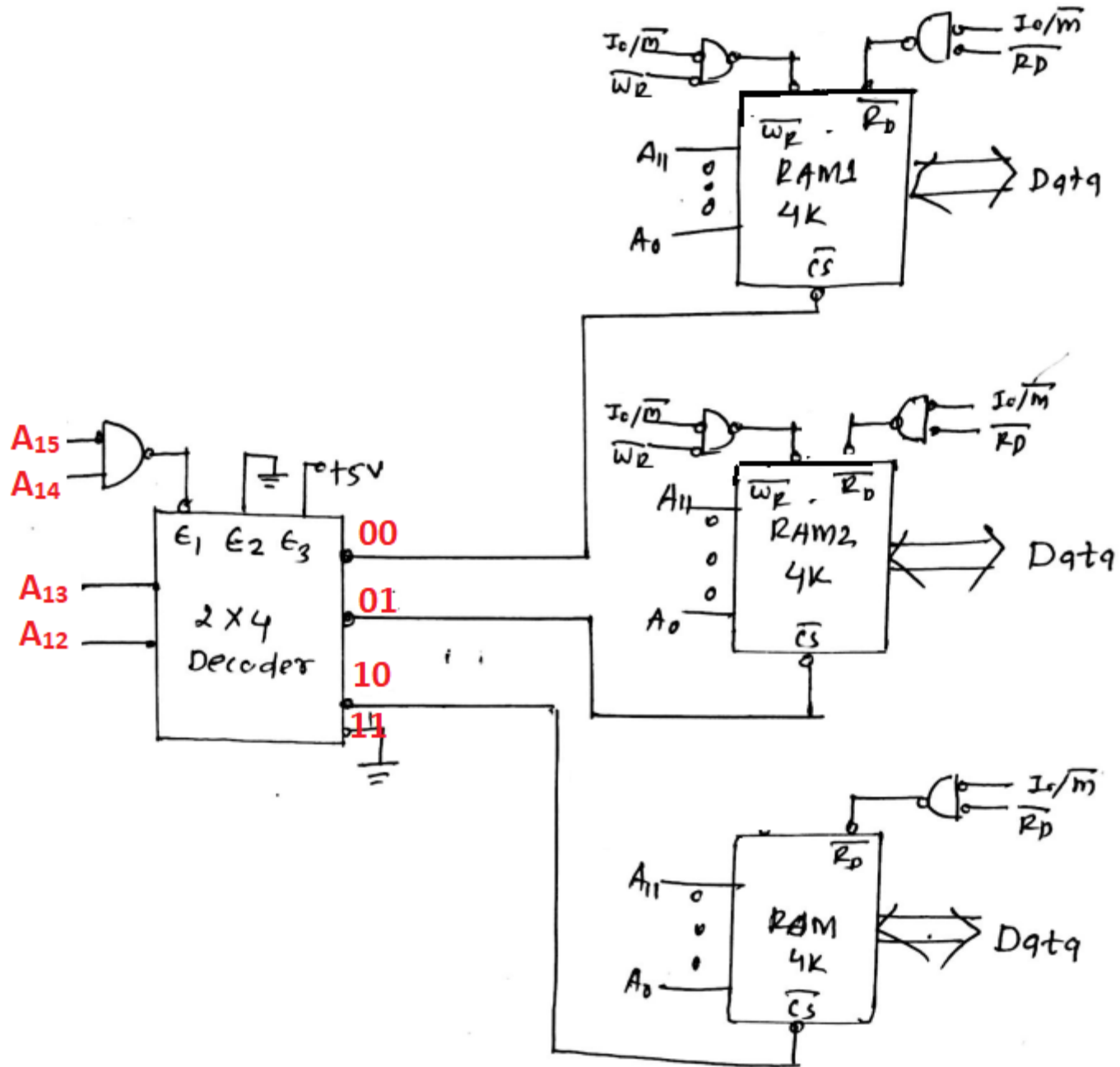0000 0001

0000 0000 0000 0000

5000H

Step 3

Decide pins for decoder.

A_{12} A_{13} → used for 2 RAM and ROM selection

A_{14} A_{15} → used to enable the device

Remaining A_0 - A_{11} → Given to ID for RAM & ROM

Step 4:

Address Decoding Design

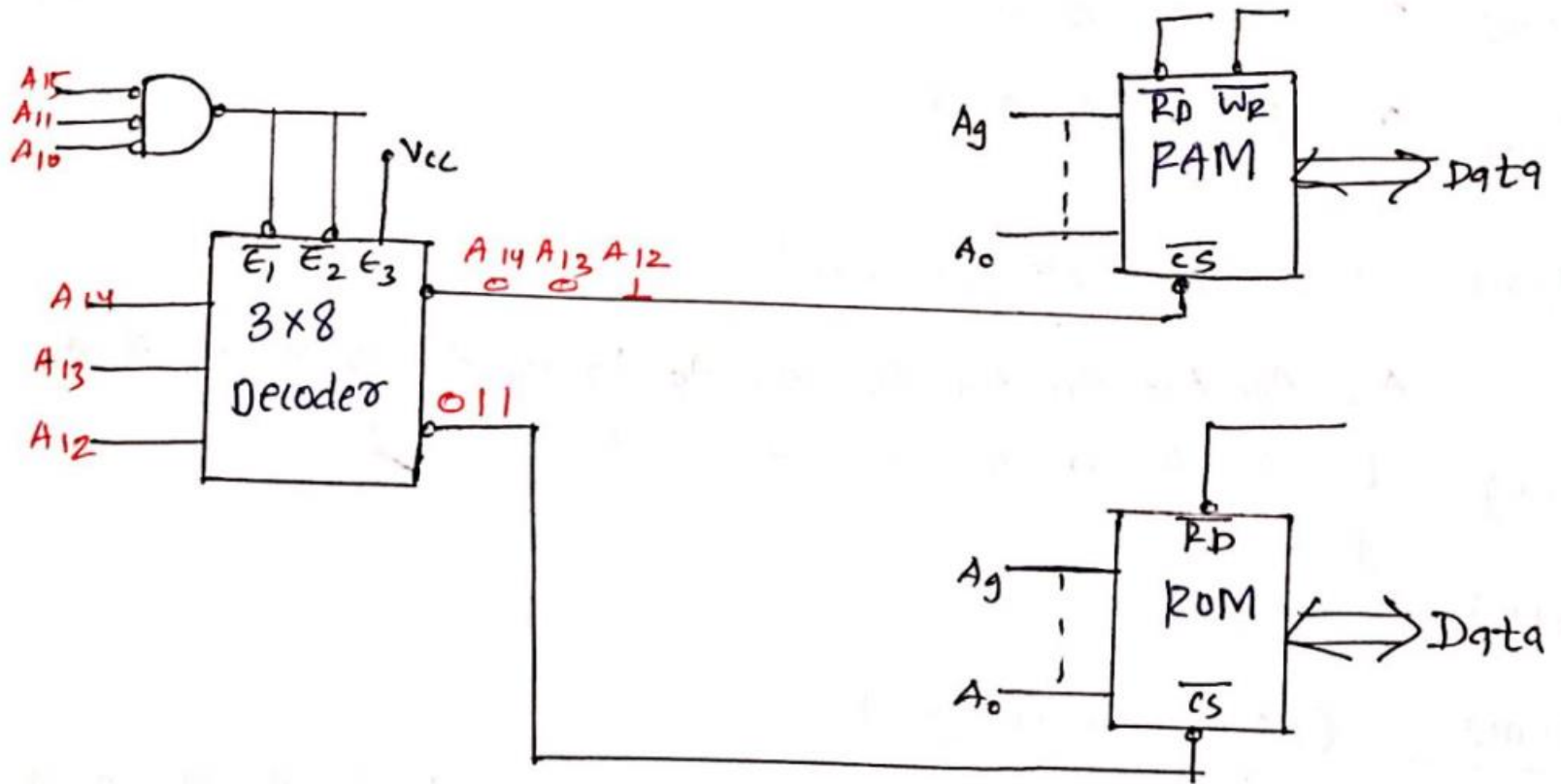1. Design an address decoding ckt to map 1k RAM at base address 1000H and a 1k ROM at base address 3000H

Now,

	Start address	End Address
RAM	1000H	0001 00 1111111111 (13FFH)
ROM	3000H	0011 00 1111111111 (33FFH)

RAM:

	A_{15}	A_{14}	A_{13}	A_{12}	A_{11}	A_{10}	A_9	A_8	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0
Start :	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
End :	0	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1

ROM:

Start :	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
End :	0	0	1	1	0	0	1	1	1	1	1	1	1	1	1	1

Programmed I/0 , Interrupt driven I/0 and Direct Memory Access (DMA)

Programmed I/O or Polling:

The microprocessor is kept in a loop (programmed) to check whether data are available. For example to read a data from an input keyboard in a single board microcomputer, the microprocessor can keep polling the port until a key is pressed.

Interrupt Driven I/O:

When a peripheral is ready to transfer data, it sends an interrupt signal to the microprocessor. The microprocessor stops the execution of the current program, accepts the data from the peripheral and then returns to the program. The processor is free to perform other tasks rather than being hold in a polling loop.

Direct Memory Access (DMA):

This type of data transfer is employed when the peripheral is much faster than the microprocessor. The DMA controller sends a HOLD signal to the microprocessor, the microprocessor releases its data bus and the address bus to the DMA controller, and data are transferred at high speed without the intervention of the microprocessor.

Thank You