Instrumentation II (III/I)

Course Code: EX–602
(Module#1)

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May 17, 2022

Chapter#1

Microprocessor based Instrumentation System

Class Outline

1. Course Evaluation
2. Basics of Instrumentation System
3. microprocessor based control system
4. Interfacing and address decoding

Course Evaluation

Theory (100)

I. Internal weight (20/100)
   - Assignments (in total 7/8) for each module [**10 marks**]
   - Class Activities and average of 3-ADT [**4+6=10 marks**]

II. External weight (80/100)
   - End Semester Exam by IOE, TU

Practical (25)

- Lab attendance (5)
- Lab report and Case Study (10+10 =20)

Basics of Instrumentation System

1. microprocessor
2. instrumentation
3. open loop control system
4. closed loop control system
5. interfacing with microprocessor
6. address decoding

Microprocessor

- basically, microprocessor is programmable, clock driven, register based electronic device.
- 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

Instrumentation System

- fundamentally, it is assembly of instruments and other components for the purposes: measure, analyze, control a process or physical quantities such as electrical, thermal or mechanical.

Microprocessor based Instrumentation 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.

merits of using microprocessor

- can be used in any system
- 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.

Features of microprocesor 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 equipments on time sharing basis.
- lot of processing capability with powerful microprocessor.

microprocessor based control system

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

Example of Open Loop Control System

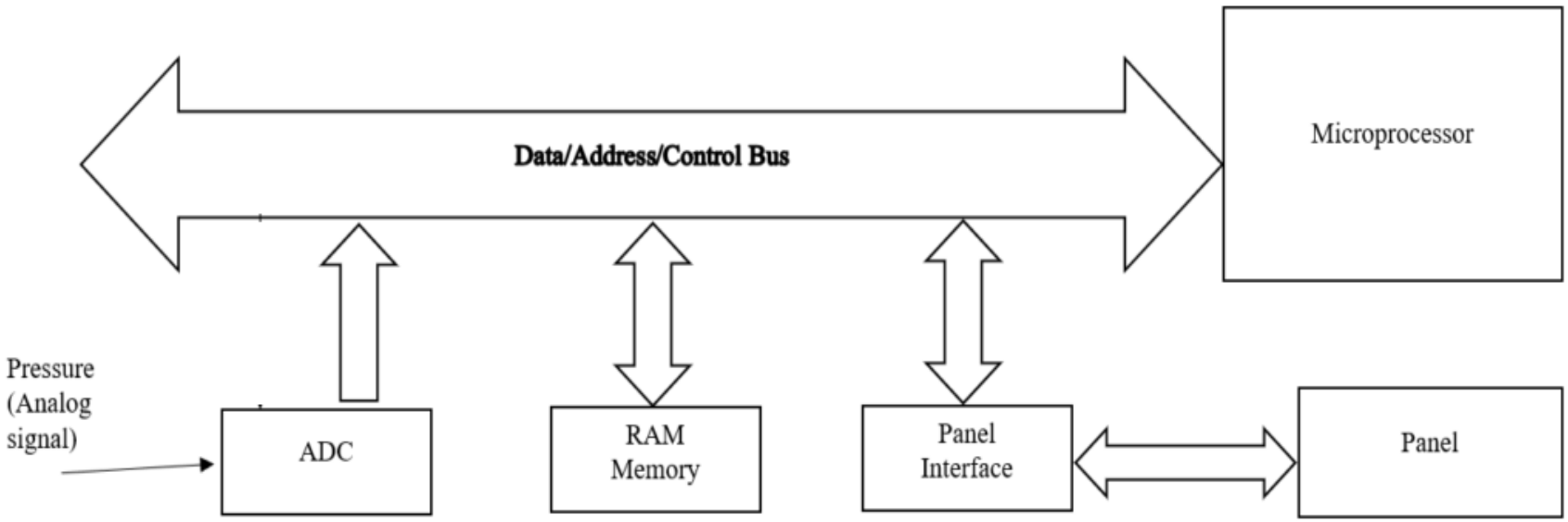
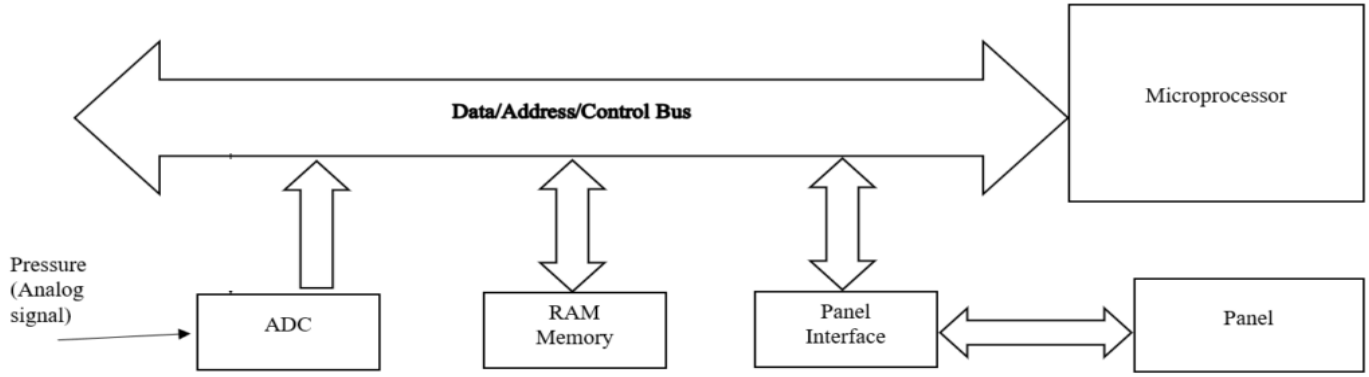


Fig. 1 Block Diagram for Pressure monitoring system



Block Diagram for Pressure monitoring system

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

Example of Closed Loop Control System

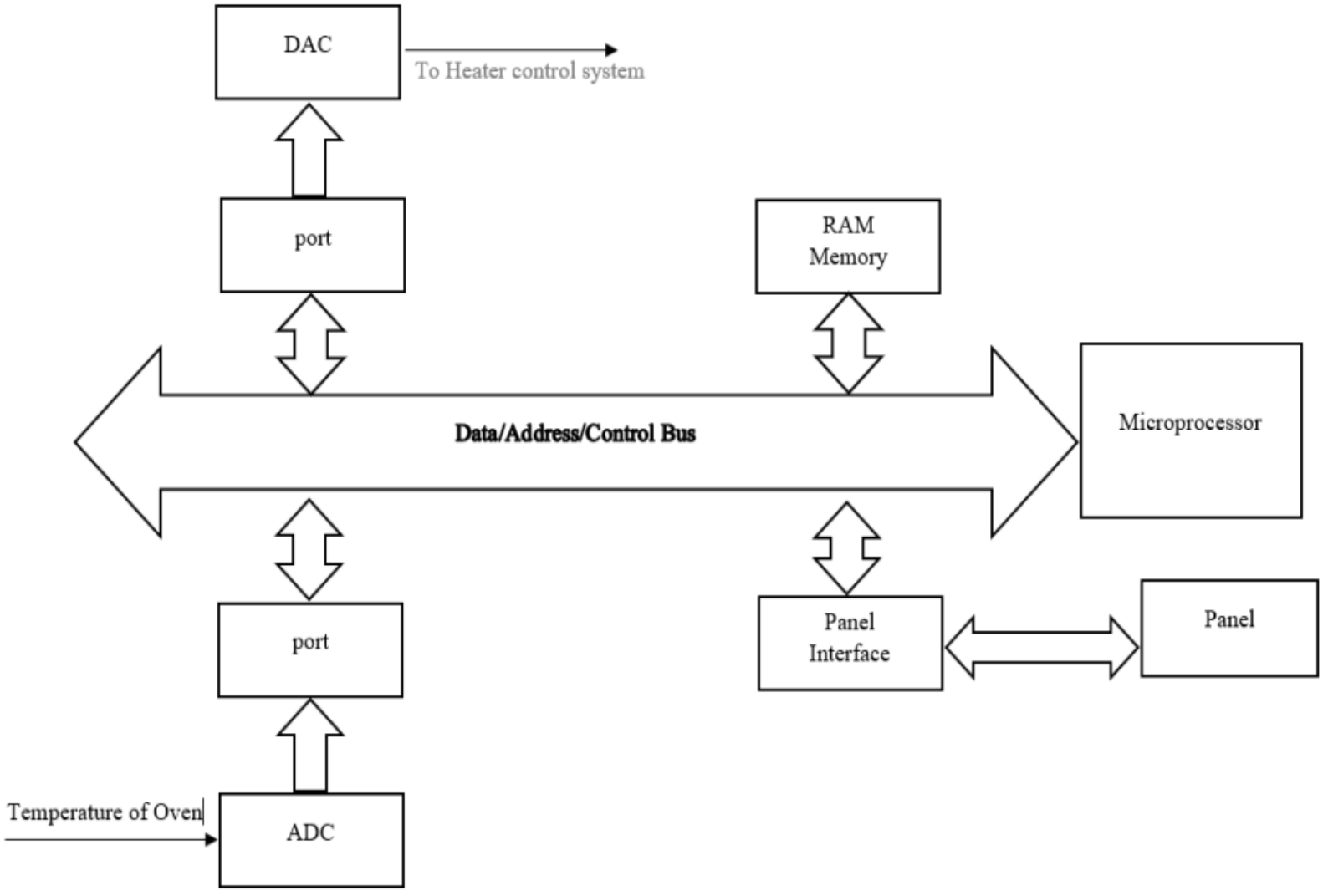


Fig. 2 Block Diagram for automatic temperature Control System

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.

Benefits of Microprocessor based 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

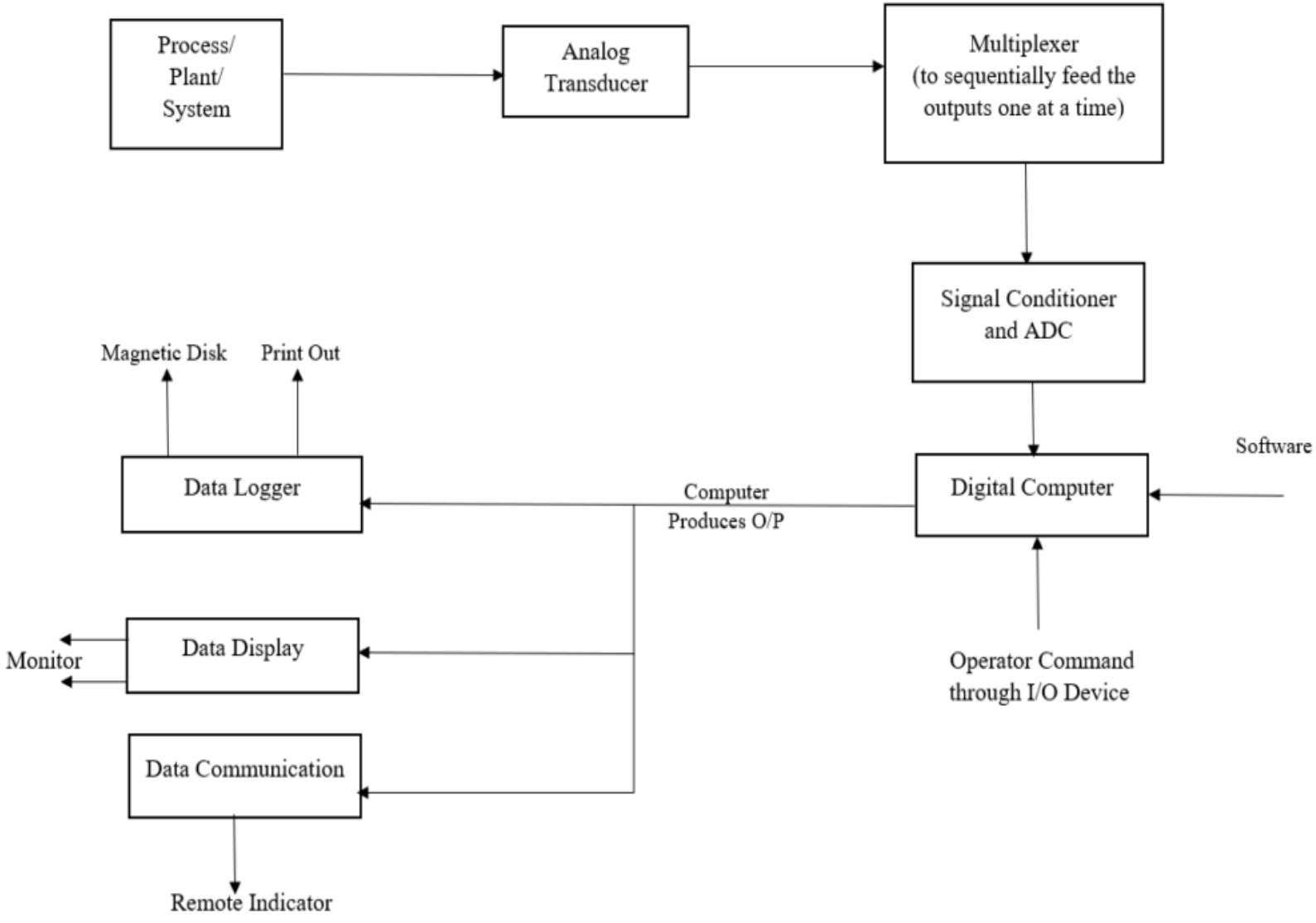


Fig. 3 Typical Computer based Instrumentation System

Microcomputer on Instrumentation Design

- 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

Advantage

- 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 detection and correction.
- capable of real time measurement, processing and display.
- lower cost, higher accuracy, and more flexible.

Disadvantage

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

Interfacing and address decoding

Interfacing with Microprocessor

- primarily, a microprocessor has the functions:
  - accept data from input devices
  - read instruction from memory
  - process data according to the instructions.
  - send results to output devices.
- input devices : keyboard, A/D converters
- output devices : LEDs, Printers, Video monitors.
- these input devices/output devices are peripherals or I/Os

Interfacing and address decoding

Interfacing with Microprocessor

- designing logic circuits and writing instructions to enable the microprocessor to communicate with these peripherals is called interfacing.
- these logic circuits are called I/O ports of interfacing devices.

PC Interfacing Techniques

- PC compatible devices can be interfaced through I/O BUS (internal expansion slot), parallel or serial ports, USB ports

PC Interfacing techniques

I/O BUS

- I/O BUS is also known as expansion slot (expand system bus to external devices for direct connection)
- external devices such as video card, sound card or network card can be interfaced through I/O buses to motherboard.

Parallel and Serial Ports

- PC includes one parallel port (LPT1 - 25pins) and two serial ports com1 and com2.
- LPT1 (line printer terminal) is basically for printer interfacing.
- serial ports are used for long distance communications ie for remote data acquisition, serial ports (COM1 - 9pins, COM2 -25pins) are used.

PC Interfacing techniques

USB ports:

- printer, scanner, digital cameras, and pendrives are connected to PC using USB ports
- comparatively faster than traditional serial and parallel ports.

Address Decoding

- memory cell consists of registers - which are group of flip flops to store bits of information.
- the number of bits stored in a register is called memory word.
- in memory chip, these registers are arranged in sequence which are identified by binary sequence - memory address.
- to communicate with memory, microprocessor unit should:
  - select the chip
  - identify the register
  - carry read/write operation over register.
- the address decoding circuit makes microprocessor unit(MPU) to select particular sequences of register indicated by address within memory chip or I/O chip.
- Once the sequence is selected, read/write operation is executed using data bus.

Address Decoding

- operation should avoid data contention or collision using proper addressing.
- microprocessor is connected with memory and I/O devices through common address and data bus.
- Only one device can send data at a time, and other devices can only receive the data.
- if more than one device sends data at the same time, the data could get collision.
- to avoid the collision, proper device should get addressed at the proper time.

Address Decoding

- in method of address decoding, all devices (memory blocks, I/O units) are assigned with specific address.
- the address of the devices is determined from the way suitable to select particular device using chip selection ($\overline{CS}$) signal.
- for read/write operation, $\overline{CS}$ signal to that device should be enabled.
- it is to be ensured ($\overline{CS}$) signal to other devices are not activated.

Address Decoding

Address decoding method can be classified depending up on the no. of address line used to generate $\overline{CS}$.

1. I/O mapped I/O
2. memory mapped I/O

Address Decoding

I/O mapped I/O

- a device is identified with 8-bit address
- being 8-bit for addressing, 256 bytes can be identified uniquely.
- I/O related functions IN and OUT are used for the read/write operation.
- generally, lower order address bits ($A_0 - A_7$) are used for addressing.
- upper bits $A_8 - A_{15}$ are considered don't care.
- I/O mapped I/O is used to map devices like 8255A, 8251A etc.

Address Decoding

memory mapped I/O

- a device is identified with 16-bit address.
- memory related functions STA, LDA are used for the read/write operation.
- chip select $\overline{CS}$ signal for each device can be generated from 16 bit address lines; therefore, addressing capability is 64K bytes.
- generally, RAM, ROM etc are mapped using this kind of address decoding.

Address Decoding

Based on the address allocated to the device, address decoding are classified as:

1. Unique address decoding
2. Non-unique address decoding

Unique Address Decoding

- all address lines are used for address decoding
- in I/O mapped I/O
  - all 8-bits are used for addressing.
- in memory mapped I/O
  - all 16-bits are used to generate $\overline{CS}$ signal.
- it is expensive and complicated.

Address Decoding

Unique Address Decoding

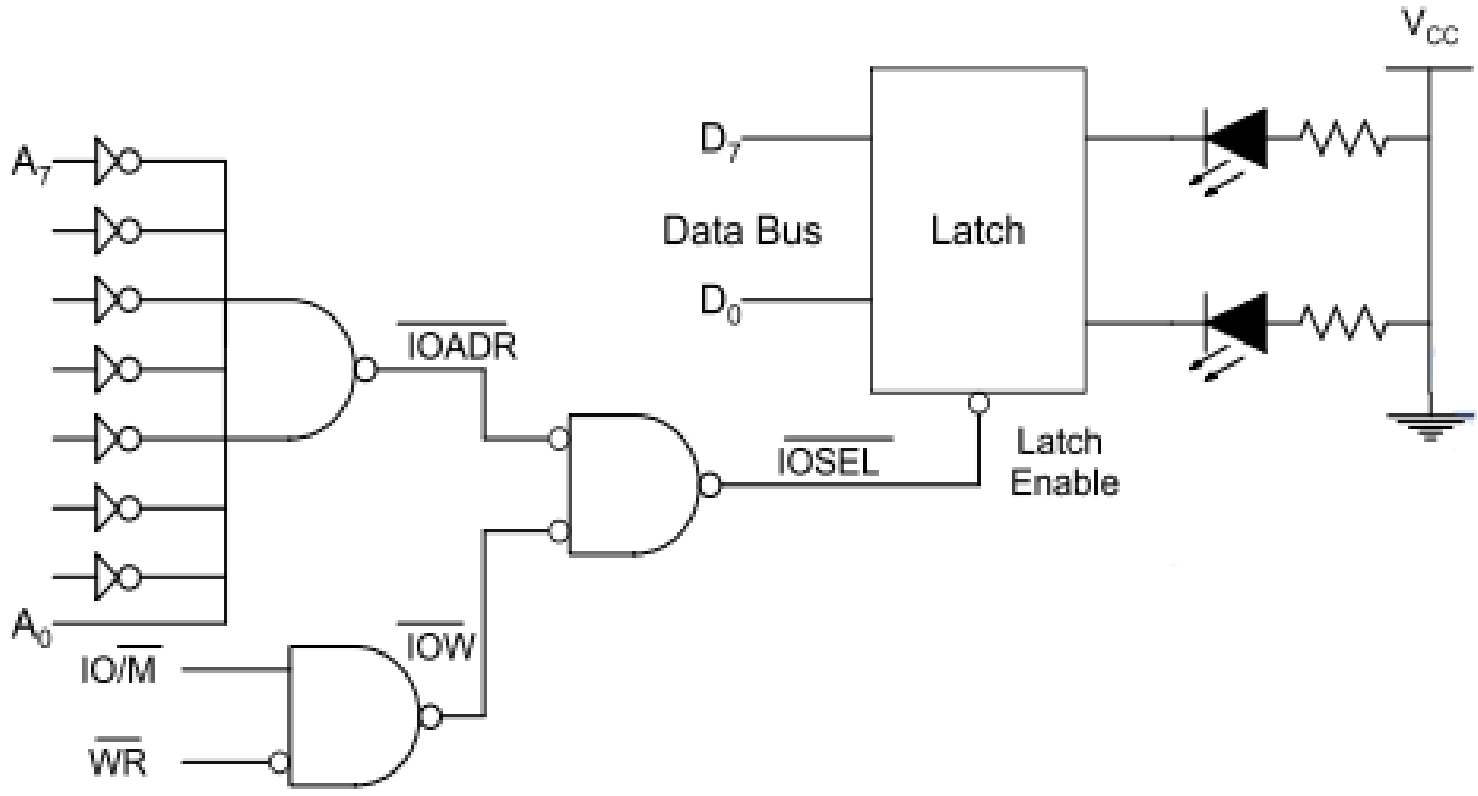


Fig. 4 Unique Address Decoding

Address Decoding

Unique Address Decoding

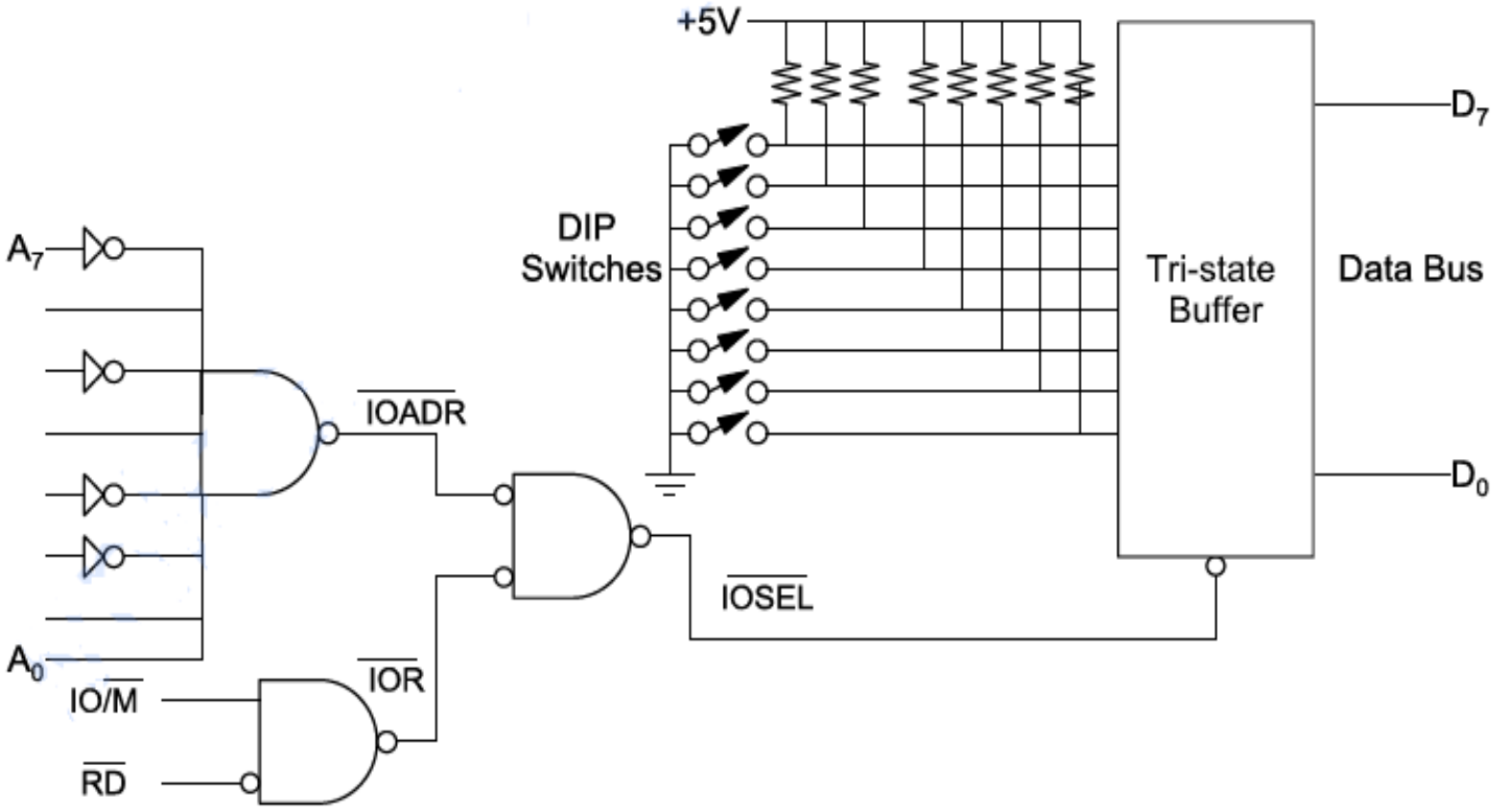


Fig. 5 Input Interfacing at 35H

Address Decoding

Non-Unique Address Decoding

- if all the address lines are not used in address decoding then that decoding is called non-unique address decoding.
- cheaper technique but higher chance of address conflict.

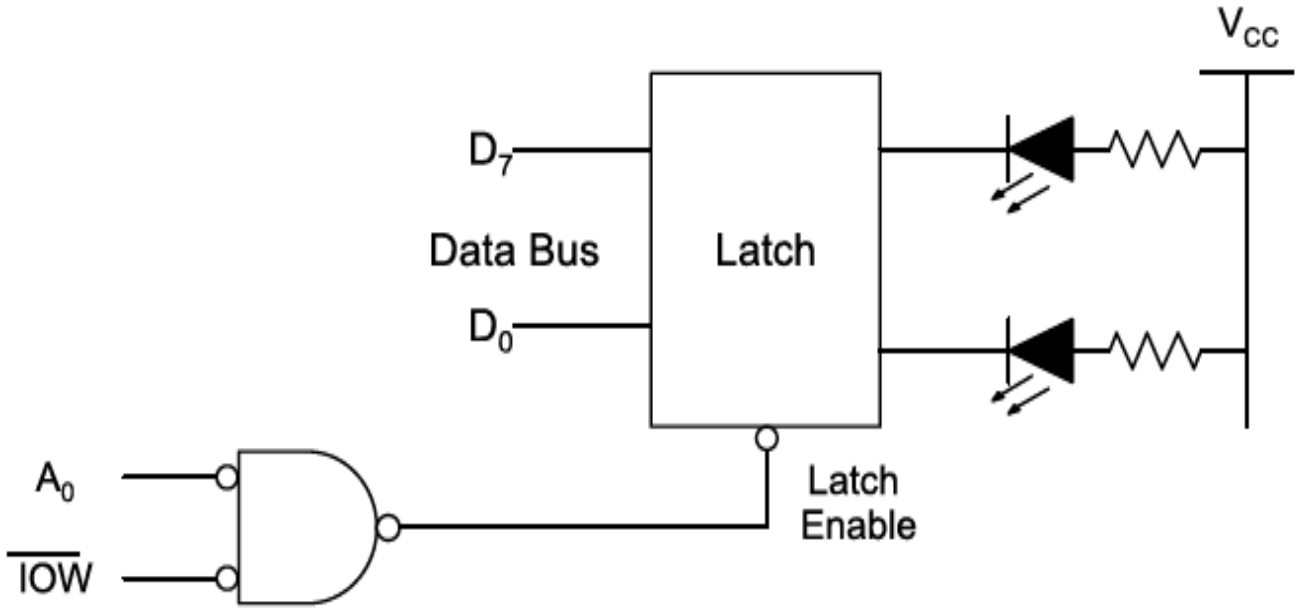
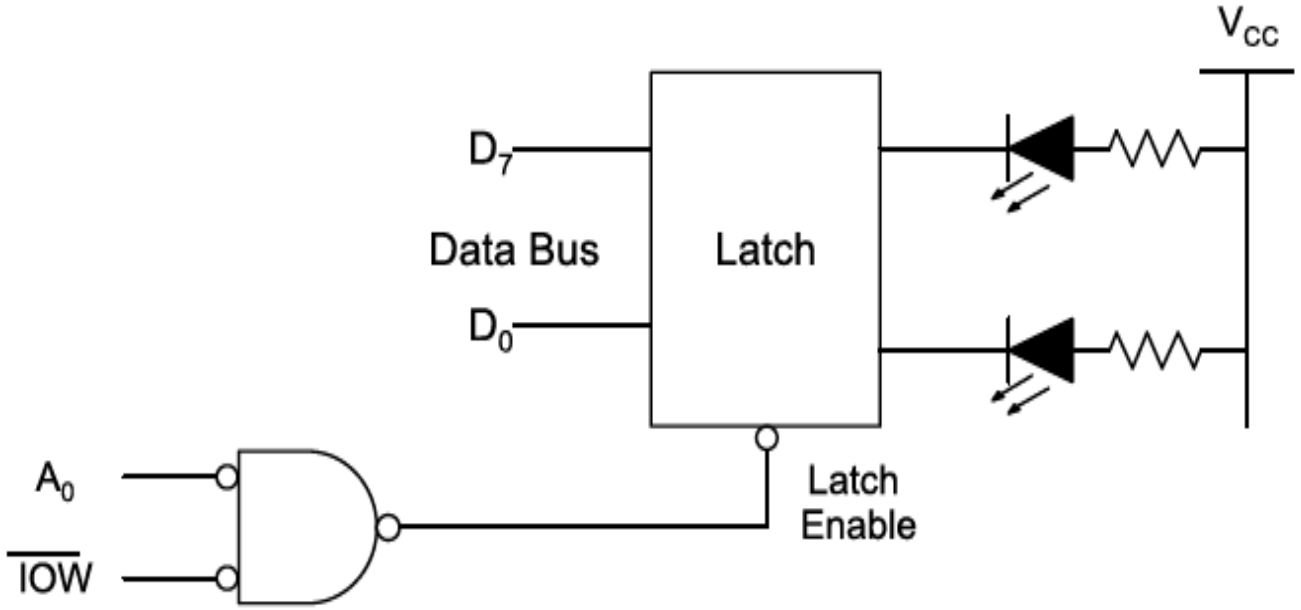


Fig. 6 Non-Unique Address Decoding

Address Decoding

Non-Unique Address Decoding



Non-Unique Address Decoding

- if A_0 and $\overline{IOW}$ is low, latch get enabled.
- higher address lines ($A_1 - A_7$) are neglected.
  - that is any even address (..0H, ..2H, ...) can enable the latch.

Address Decoding

Memory Interfacing

- address lines are used to identify memory register in a memory chip.
- if there are n address lines, 2^n number of registers can be recognized.
- Chip Select ($\overline{CS}$) signal enable the memory chip.
- the address lines (remaining) from the microprocessor can be used to connect $\overline{CS}$ line through the interfacing logic.
- all the address lines are responsible to select a specific register within a memory chip.

Programmed I/O, Interrupt Driven I/O, Direct Memory Access(DMA)

Programmed I/O

- microprocessor is programmed for loop to check if data are available.
- to read data from input keyboard, microprocessor can keep polling the port until a key is pressed.

Programmed I/O, Interrupt Driven I/O, Direct Memory Access(DMA)

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 peripherals and then returns to the program.

Programmed I/O, Interrupt Driven I/O, Direct Memory Access(DMA)

Direct Memory Access

- this type of data transfer is used for faster peripherals than microprocessor.
- DMA controller sends a HOLD signal to the microprocessor and microprocessor releases its data bus and address bus to the DMA and microprocessor continues its tasks.

A decoder design problem

Memory Interfacing

design an address decoding circuit for two RAM chips each of 4K X 8 at address 2050H

Momory Block	Address	A15	A14	A13	A12	A11	A10	…	…	…	A4	A3	A2	A1	A0
Start Address	2050H	0	0	1	0	0	0				1	0	0	0	0
RAM#1															
End Address	304FH	0	0	1	1	0	0				0	1	1	1	1
Start Address	3050H	0	0	1	1	0	0				1	0	0	0	0
RAM#2															
End Address	404FH	0	1	0	0	0	0				0	1	1	1	1

A decoder design problem

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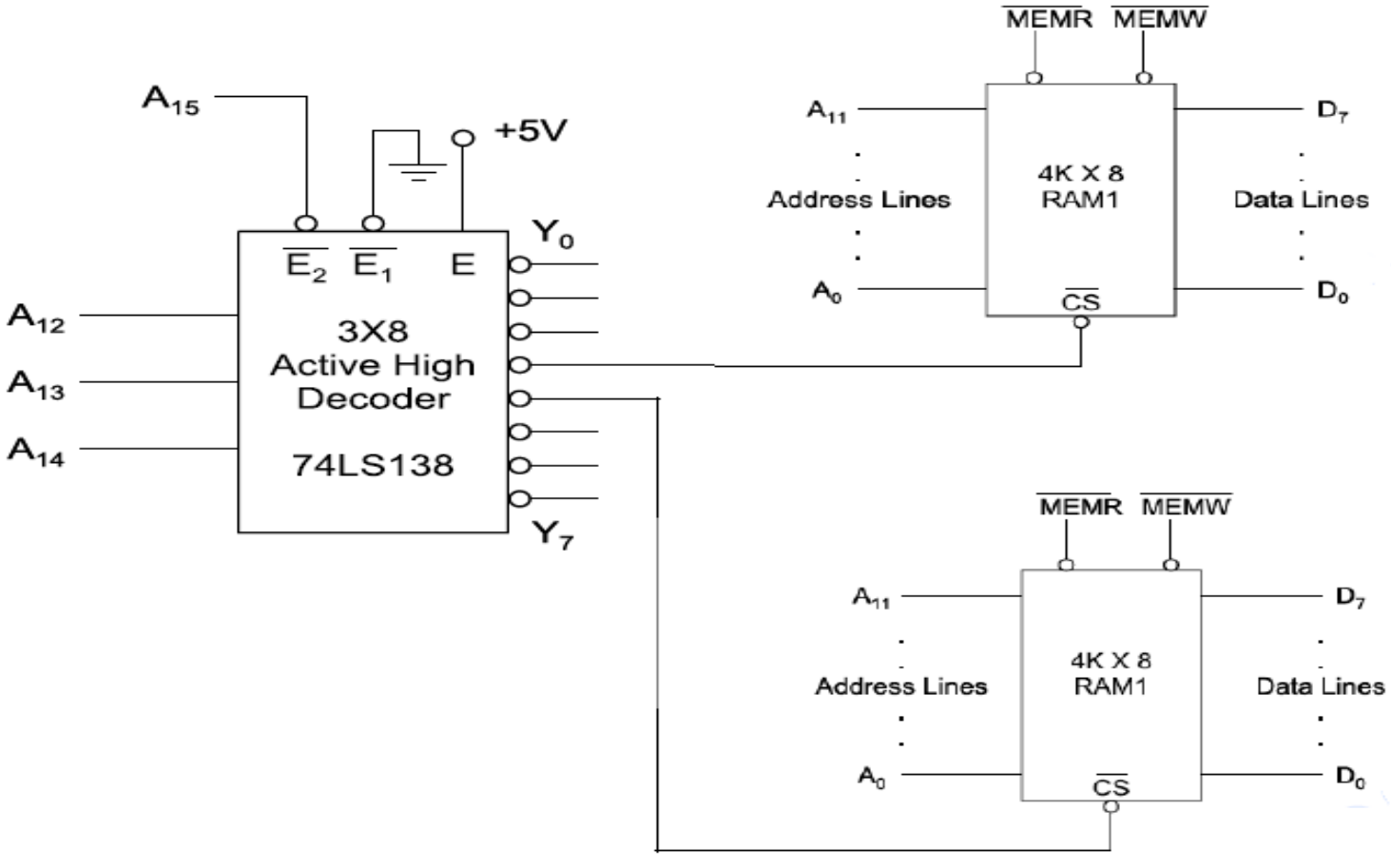

A decoder design problem

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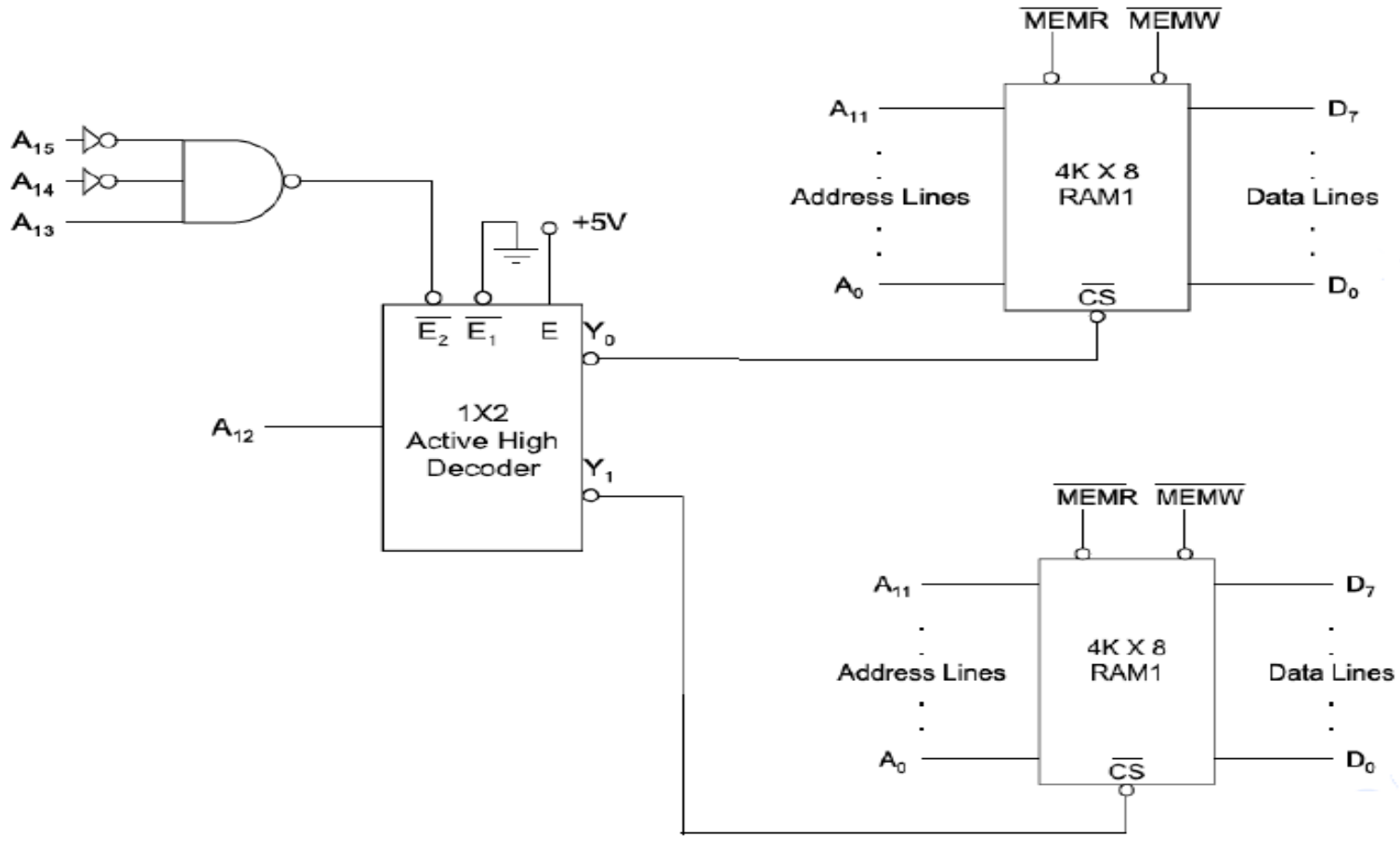

As you go
Assignment

Assignment Module#1 is available at MS-Team.

Submission Deadline: May 27, 2022 (*Before 3:00 PM*)