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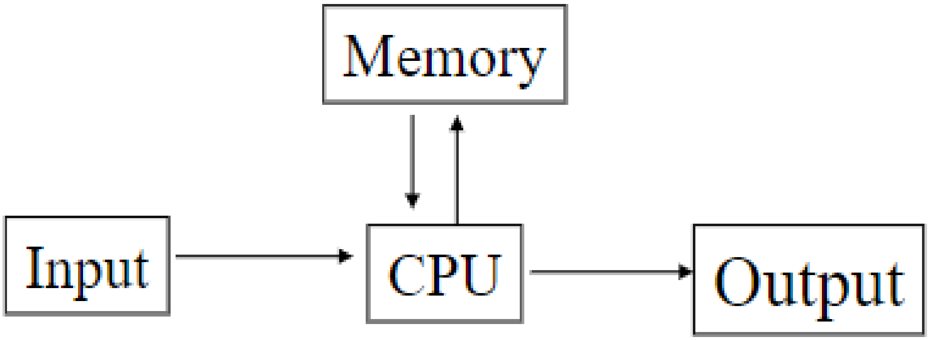
Where leaders are created

Lecture-1
Introduction to Microprocessors and Microcomputer based applications

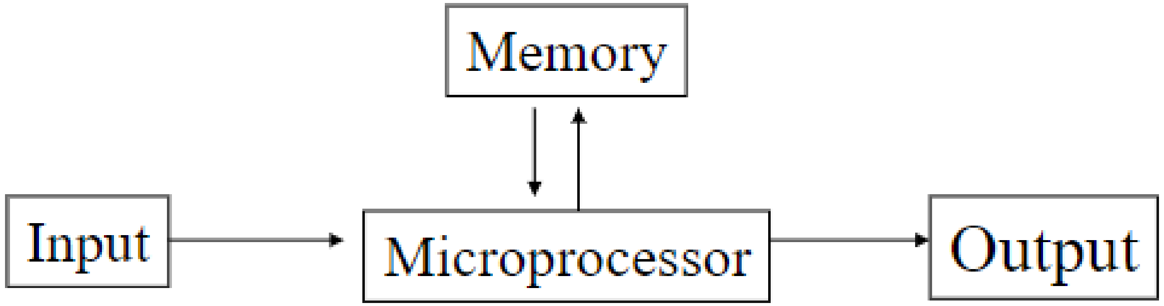
Department of EEE

What is a microcomputer systems

- Block Diagram of a digital computer



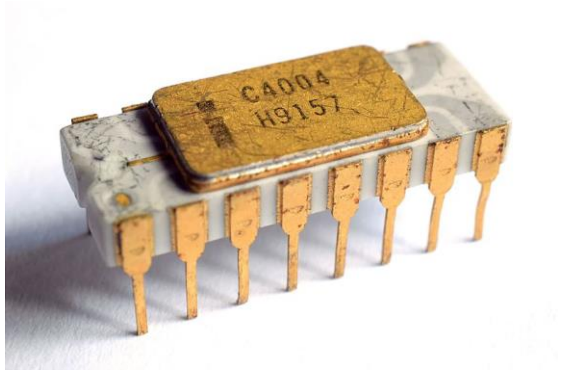
- Block Diagram of a microcomputer system



Microprocessor is an integrated circuit that contains all the functions of a central processing unit of a computer.

Evolution of Microprocessor

- Intel 4004 (4-bit)
  - 4 bit microprocessor
  - Able to address 4096 4-bit wide memory
  - Instruction set contained 45 instructions
  - It was fabricated by PMOS technology
  - Instruction execution rate was 50 KIPs.
- Intel 4040 (4-bit)
  - Updated version of 4004
  - Use: microwave systems, small control system and calculator



Intel 4004

Evolution of Microprocessor(8-bit)

- Intel 8008
  - 8 bit microprocessor
  - 16 K bytes memory
  - 48 instructions
- Intel 8080
  - 500,000 IPS
  - 64K bytes memory
- Intel 8085
  - In 1977, Intel Corporation introduced the last 8 bit microprocessor.
  - Execution rate 769,230 per seconds
  - Main advantage was internal clock and higher clock frequency.

Evolution of Microprocessor(16-bit)

- 8086/8088
  - 2.5 MIPs
  - 1 M byte memory
  - 6 byte instruction cache or queue that pre-fetch a few instructions before execution.
- 80286
  - 4 MIPs
  - 16 Mbyte memory
  - Almost identical to 8086

Evolution of Microprocessor(32-bit)

- 80386
  - First 32 bit microprocessor
  - 32 bit data and 32 bit memory address
  - 4 G bytes memory
  - It included hardware circuitry for memory management
- 80486
  - 8K byte cache memory
  - Half cycle instruction execution

Evolution of Microprocessor (contd…)

- Pentium
  - 4 G byte memory, 8 K byte data cache and 8K byte instruction cache
  - Data bus 64 bit
  - Multimedia execution instructions or MMX
  - Dual integer processors
  - The Pentium simultaneously executes two independent instructions using superscalar technology.
  - Jump prediction technology of Pentium, speeds the execution of programs that includes loop.
  - Floating point processor process floating point data.

Evolution of Microprocessor (contd…)

- Pentium Pro
  - 21 million transistors, 3 integer units, one floating point unit.
  - 16 K byte level 1 cache (8K byte for data and 8K byte for instructions) and 256 K level 2 caches
  - 3 execution engines can be configured for 64 G byte memory and it is used with windows NT operating systems for server applications.

Types of Computer

- Mainframe
  - The largest and most powerful computer
  - They are designed to work at a very high speed
  - Large data words, typically 64 bits or greater
  - They have massive amount of memory
  - Used in military defense control, business data processing, computer graphic display.
  - Example : IBM 4381
- Super Computer
  - The fastest and more powerful mainframes are called Super Computer.
  - Example: Cray Y-MP/832
  - Used by largest firms, government agencies and universities

Types of Computer(Cont...)

- Mini Computer
  - Scaled-down version of mainframe computer
  - Runs slowly, works with smaller data word
  - Does not have as much memory as mainframe
  - Used in scientific research and industrial control
- Micro Computer
  - Small Computer
  - CPU is usually a single microprocessor
  - Example : Desktop, Laptop, Palmtop

Microprocessor Data Type

- Unsigned and Signed Binary Integers
- BCD Numbers(Binary Coded Decimal)
- ASCII(American standard code for information interchange)
- Floating point Numbers

Microprocessor Data Type

- Unsigned and Signed Binary Integers
  - An unsigned binary integer has no arithmetic sign
  - Example of unsigned integer is memory address
  - Signed integer is represented in true form for a positive number and in two's compliment form for a negative number.

Microprocessor Data Type (Cont..)

- BCD Numbers
  - Microprocessor stores BCD numbers in two forms, packed and unpacked.
  - The unpacked BCD number represents each BCD digit as a byte
  - The packed BCD number represents two BCD digits in a byte
- ASCII
  - This Code represents alphanumeric in a microprocessor’s memory
  - It also represents special symbol.

Microprocessor Data Type

- Floating Point Number (IEEE-754 single precision)
  - Floating point numbers contains three components – sign, exponent and mantissa.
  - For the decimal value -2.5$\times 10^{-2}$, sign is negative, exponent is -2 and mantissa is 2.5.
  - A binary floating point number is represented as a normalized binary fraction raised to a power of 2.
  - Binary number is converted to a 32 bit floating point format.
  - Most significant bit is sign bit which is **0 for positive number** and **1 for negative number.**
  - The next 8 bits contains the bias exponent i.e. $(7F)_{16}$ or $(127)_{10}$ is added to the new exponent.
  - Minimum value of exponent is $(0)_{10}$ and maximum value is $(255)_{10}$
  - Remaining 23 bit represents the fractional part of the number.

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Microprocessor Data Type

- Example: Convert decimal number $(10)_{10}$ to standard floating point format.
  - Step-1: Convert the given number to binary. [Note: Any number given in any format should be converted to binary first]

$$(10)_{10} = (1010)_2$$

  - Step 2: Bring a decimal to the right of the first '1'.

sign

$$1010 = 1010.0\times2^0 = 101.0\times2^1 = 10.10\times2^2 = \square 1.010 \times 2^3 = \cancel{0.1010 \times 2^4}$$

mantissa

  - Step 3: Look for the sign of the given number. Here the number is $(10)_{10}$, this number is positive therefore

sign s= 0 for positive [Note: s=1 for negative]

This is the first bit of the 32 bit floating point format.

  - Step 4: Bias the exponent of the number, means adding decimal $(127)_{10}$with the exponent or adding hexadecimal $(7F)_{16}$ with the exponent. Since the exponent is always in decimal, it is better to add $(127)_{10}$ with the exponent.

Microprocessor Data Type

Biasing exponent = $(127)_{10} + (3)_{10} = (130)_{10}$

Then convert the biasing exponent to binary which will always be **8 bit**.

$(130)_{10} = (1000\ 0010)_2$

- Step-5: The next 23 bit represents the fractional part of the number.

23 bit fraction = 0100 0000 0000 0000 0000 000

- Step 6: The floating point equivalent of (10)10is:

S	Biased Exponent	Fraction
0	1000 0010	0100 0000 0000 0000 0000 000

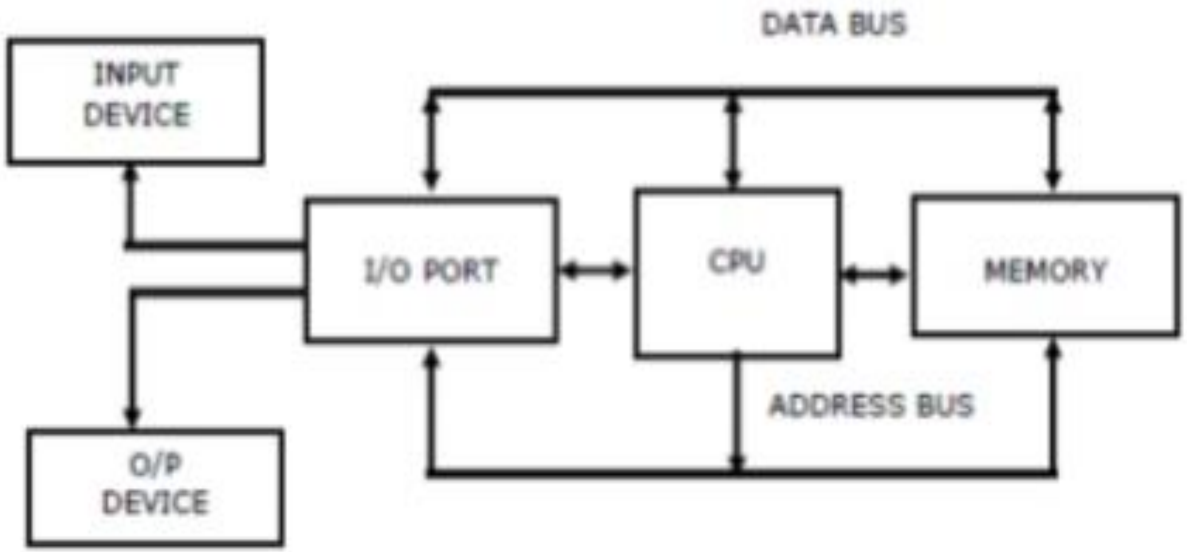
Exercise

- Convert $(-74.92)_{10}$ standard floating-point format.

Overview of microcomputer structure and operation

Major Parts:

1. CPU
2. Memory
3. Input / Output circuitry
4. Buses:
    a) Address bus
    b) Data bus
    c) Control bus



Overview of microcomputer structure and operation (Cont..)

- **Memory:**
  - It stores the binary codes for the sequences of instructions.
  - It stores binary coded data.
  - Example: ROM, RAM, magnetic / optical disks.
- **Input / Output:**
  - They are used to take in data from outside world or send data to the outside world.
  - I/O devices are connected with microprocessor through I/O ports.
  - Example: Keyboards, video display terminals, printers, modems

Overview of microcomputer structure and operation (Cont..)

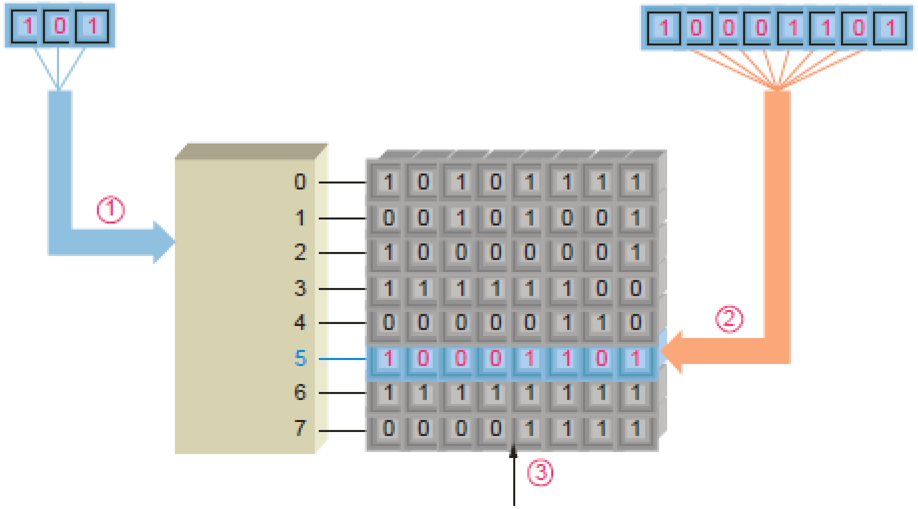
- **Central Processing Unit:**
  - It controls the operation of computer.
  - The CPU fetches binary-coded instructions from memory.
  - Decodes the instructions into a series of simple actions.
  - Carries out these actions in a sequence of steps.
  - Important components: IP, General purpose register and control bus signal generating circuits.
- **Address Bus:**
  - It consists of 16, 20, 24, 32 or 36 parallel unidirectional signal lines.
  - On these lines the CPU sends out the address of the memory location or I/O port that is to be written to or read from.
  - The number of locations that the CPU can address is determined by the number of address lines.

Overview of microcomputer structure and operation (Cont..)

- **Data Bus:**
  - Data bus consists of 8, 16, 32 parallel bidirectional signal lines.
  - Many devices in the system will have their output connected to data bus, but only one device at a time will have its output enabled.
- **Control Bus:**
  - The control bus consists of 4 to 10 parallel signal lines.
  - The CPU sends out signals on the control bus to enable the outputs of addressed memory devices or port devices.
  - Example of control signals: Memory read, Memory write.

How to read a byte of data?

- The CPU sends the address of the desired byte on the address bus
- Then sends out a memory read signal on the control bus
- Memory read signal enables the addressed memory device to output a data word on the data bus
- The data word from memory travels along the data bus to the CPU



Memory Organization

1. Processor memory
2. Primary or main memory
3. Secondary memory

1. Processor Memory:

- It refers to the microprocessor registers which are used to hold temporary results when computation is in progress.
- No speed disparity between these registers and microprocessor because they are fabricated using the same technology .
- Costly.

Memory Organization (Cont..)

2. Primary Memory:

- This is the storage area in which all programs are executed.
- The microprocessor can directly access only those items that are stored in primary memory.
- All programs and data must be within the primary memory prior to execution
- Example: ROM, RAM

3. Secondary Memory:

- It stores program and data in excess of main memory.
- Microprocessor can not directly execute programs which are stored in secondary memory.
- In order to execute these programs, the microprocessor must transfer them to its main memory by a system program called operating system.
- Example: Floppy disk, Hard disk, CD etc.

Main memory array design

- Large capacity memory is realized by interconnecting several small sized memory blocks.
- Three techniques are frequently used.

    1. Linear decoding
    2. Partial decoding
    3. Memory Decoding using PAL

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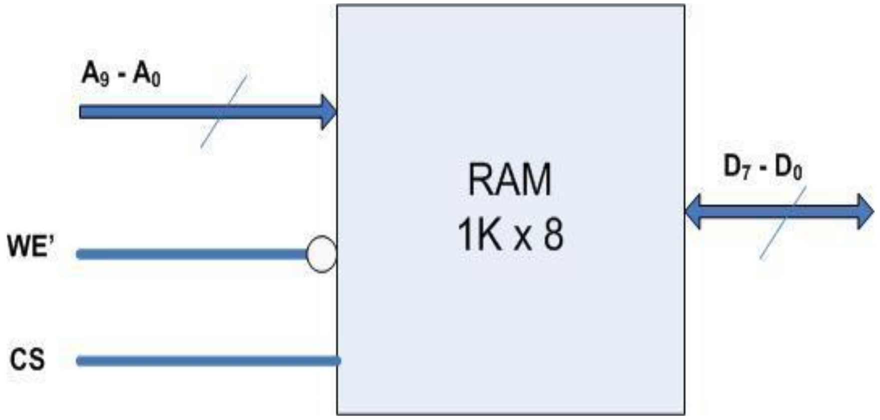
Single RAM chip

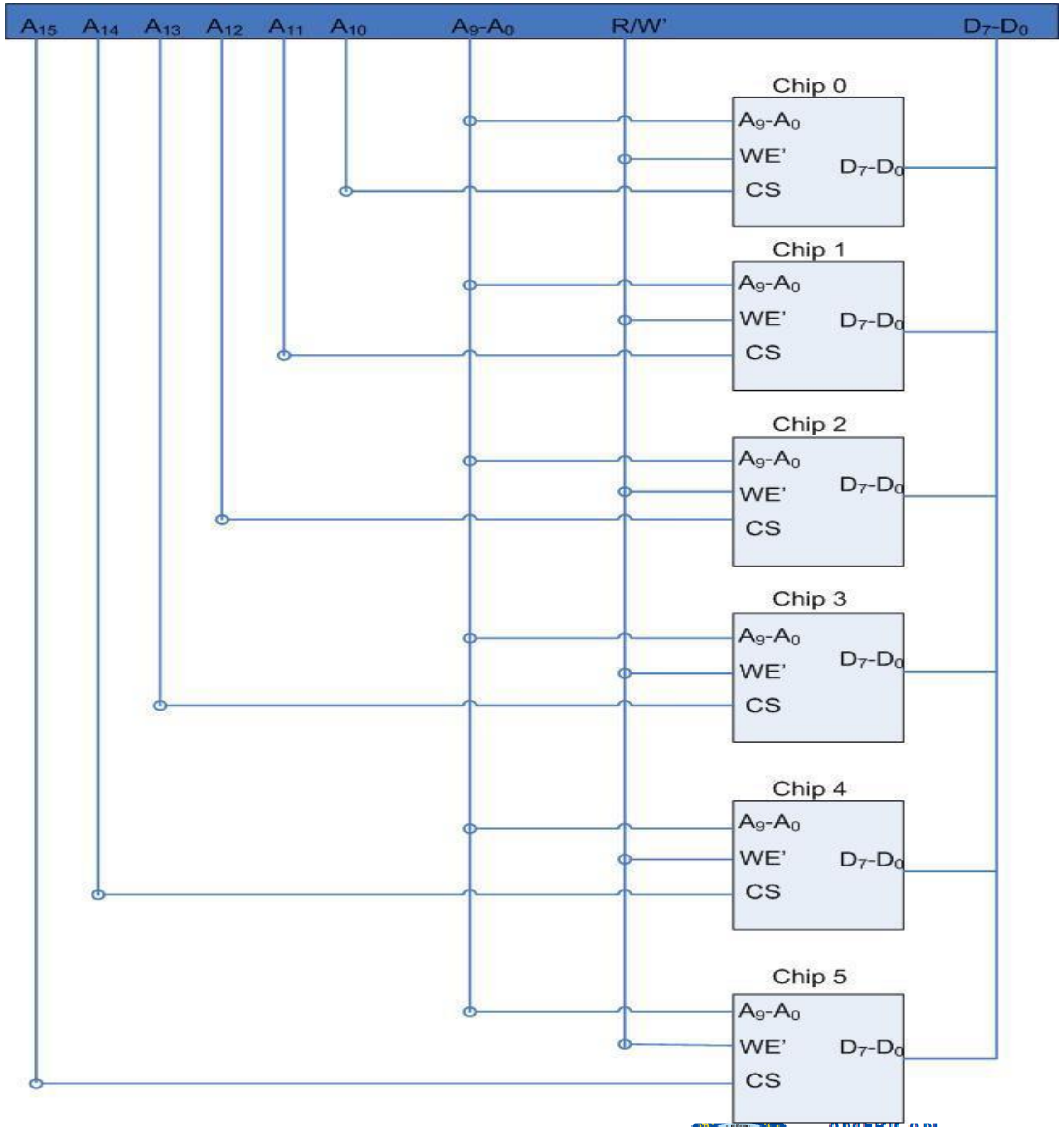
- Memory is organized as 1024 words with 8 bits /word. Each word has specific address and this is specified on 10 bit address lines A9–A0.
- The inputs and outputs are routed through 8 bit bidirectional data lines.
- The operation of this chip is governed by two control inputs WE' (write enable) and CS (chip select).



CS	WE'	Mode	$D_7 - D_0$	Power
L	X	Not select	High Impedance	Standby
H	L	Write	Input Bus	Active
H	H	Read	Output Bus	Active

Linear Decoding

- This technique uses the unused address lines of the microprocessor as chip selects for the memory chip. This method is used for small systems.
- A simple way to connect an **8-bit** microprocessor to a **6Kbyte** RAM system utilizing 1kbyte RAM chips using linear decoding is shown in the following diagram. The principle advantage of this method is that it does not require any decoding hardware.



Linear Decoding

Disadvantage:

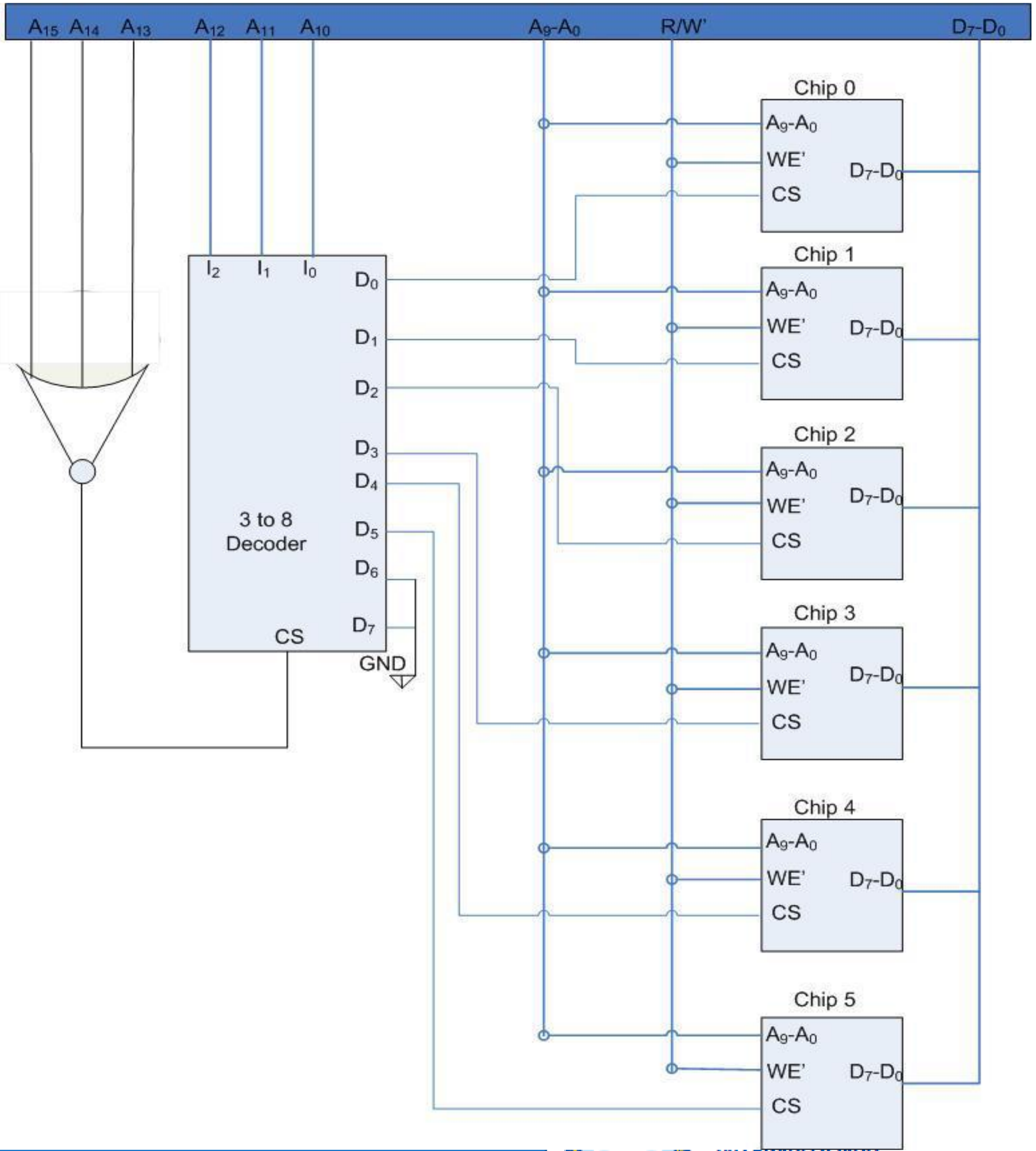
1. Wastage of address space
2. Address map is not contiguous (next or together in sequence)
3. Bus conflict may occur. (If more than one chips are selected at a time)
4. Foldback(If all unused address lines are not connected as chip select)

Partial Decoding

- Difficulties such as bus conflict and sparse address distribution are eliminated by the use of the full/partial decoded address technique.

A12	A11	A10	Chip
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5

- The memory system is enabled only when the lines A15 through A13 are zero.
- Full decoding requires all address bits to be used by necessary size decoders.



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Exercise

- A 8 bit processor has **20 bit address bus.** This processor uses a single **4k x 8**RAM chip. To increase the memory capacity to **32 kbytes** how many RAM chips required?
- Show the memory organization using both Linear and Partial Decoding.
- Which decoding method is better and why?