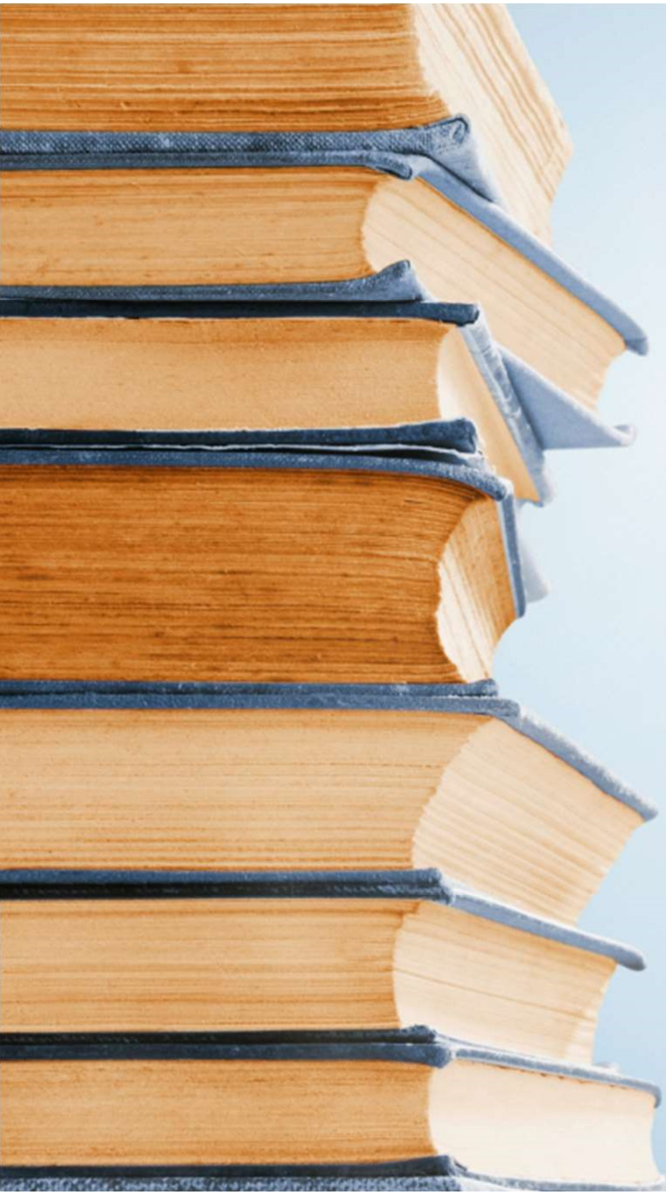

Microprocessors & Microcontrollers (ECE3004)

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Module-1 Syllabus

Introduction:

- CPU in computing systems (Laptop, Desktop, Server and Hidden Systems), CPU Choice – Performance Metrics, Evolution of Microprocessor, Internal microprocessor (8086 to Pentium), Introduction to Microprocessors and Microcontrollers
- Introduction to development tools , logic analyzer , in-circuit emulator

Module-2 Syllabus

8086 Microprocessor:

- Introduction to 8086 – Signals and pins - Microprocessor architecture – Addressing modes - Instruction set and assembler directives – Assembly language programming – Modular Programming - Linking and Relocation - Stacks - Procedures – Macros – Interrupts and interrupt service routines – Byte and String Manipulation.

Module-3 Syllabus

8051 Microcontroller:

- Intel MCS-51 family features – 8051 -organization and architecture, addressing modes, Instruction set, conditional instructions, I/O Programming, Arithmetic logic instructions, single bit instructions, interrupt handling, programming counters, timers and Stack.

Module-4 Syllabus

ARM microcontrollers:

- Need for RISC Processor-ARM processor fundamentals, ARM7TDMI Interface signals, Memory Interface, Bus Cycle types, Register set, Operational Modes. Instruction Format, ARM Core Data Flow Model, ARM 3 stage Pipeline, ARM family attribute comparison. ARM 5 stage Pipeline, Pipeline Hazards, Data forwarding - a hardware solution, ARM ISA and Processor Variants, Different Types of Instructions, ARM Instruction set

Module-5 Syllabus

Interfacing:

- **8086 –** Memory interfacing, timing diagram, 8255, 8254, 8279, 8259, 8259,8251
- **8051**- keyboard , LCD, LED, Real world interface - ADC, DAC, SENSORS Communication interface (asm & C)

Text Books

1. Doughlas V Hall, “Microprocessors and interfacing, Programming and Hardware”, TMH 2012.
2. Mohammad Ali Mazidi, Janice Gillispie Mazidi “The 8051 Microcontroller and Embedded Systems (Using assembly and C)” TMH 2012
3. ARM System-on-Chip Architecture, Second Edition, by Steve Furber, PEARSON, 2013
4. B. Ram on “Fundamentals of Microprocessors and Microcontrollers”, Dhanpat Rai publications.

Required Software:

1. CMU8086
2. Keil
3. Proteus

List of Experiments:

8086 Microprocessor

1. Arithmetic operations using various
2. Sorting
3. Serial communication between two microprocessor kits using 8251

8051 Microcontroller

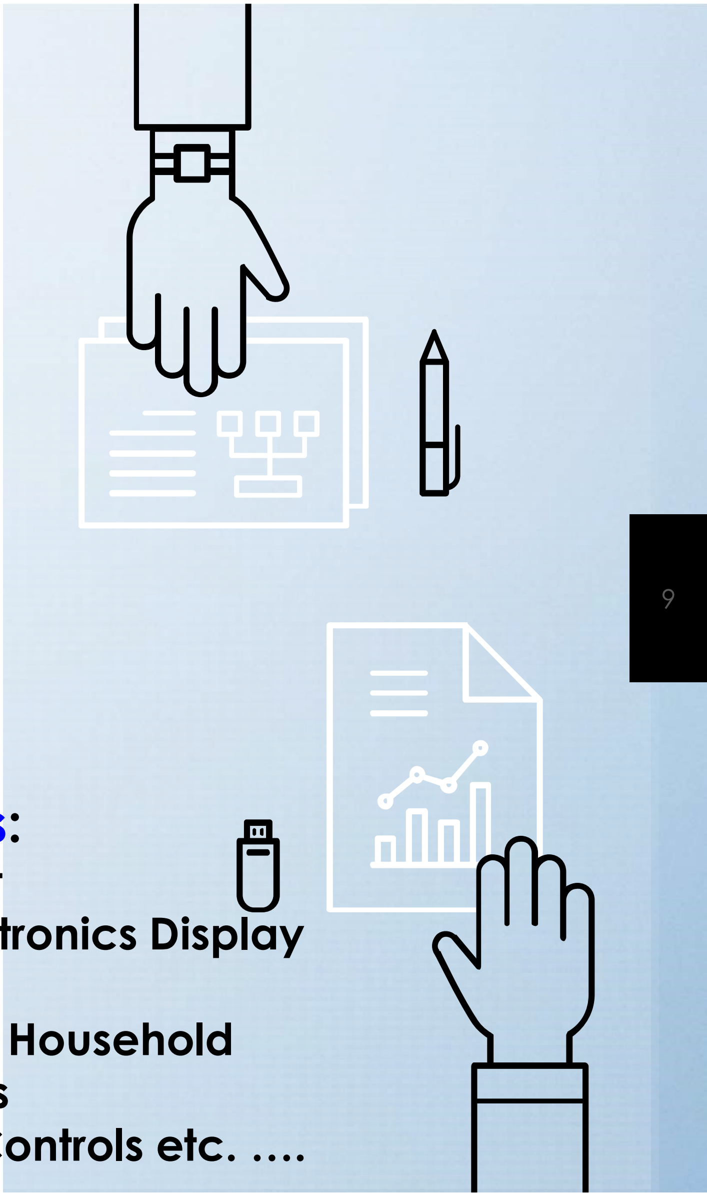
1. Program using constructs(Sorting an array) [Assembly]
2. Programming using Ports [Assembly and C]
3. Delay generation using Timer[Assembly and C]
4. Interfacing LCD Display. [Assembly / C]
5. Interfacing with Keypad[Assembly / C]
6. Programming ADC/DAC [Assembly / C]
7. Interfacing with stepper motor. [Assembly / C & Proteus Simulation]

Module-1 (Introduction)

Processors

[Why do you need to learn?]

Throughout the world use smartphones, personal digital assistant devices (also known as PDAs) and microcomputers.
All of these devices utilize a key component: known as ***Microprocessor***.



Applications:

1. **Traffic Light**
2. **Public Electronics Display Boards**
3. **Electronics Household Appliances**
4. **Industrial Controls etc. ....**

Microprocessor(μP)

Microprocessor is a controlling unit of a microcomputer, fabricated on a small silicon chip capable of performing Arithmetic Logical Operations and communicating with other devices connected to it.

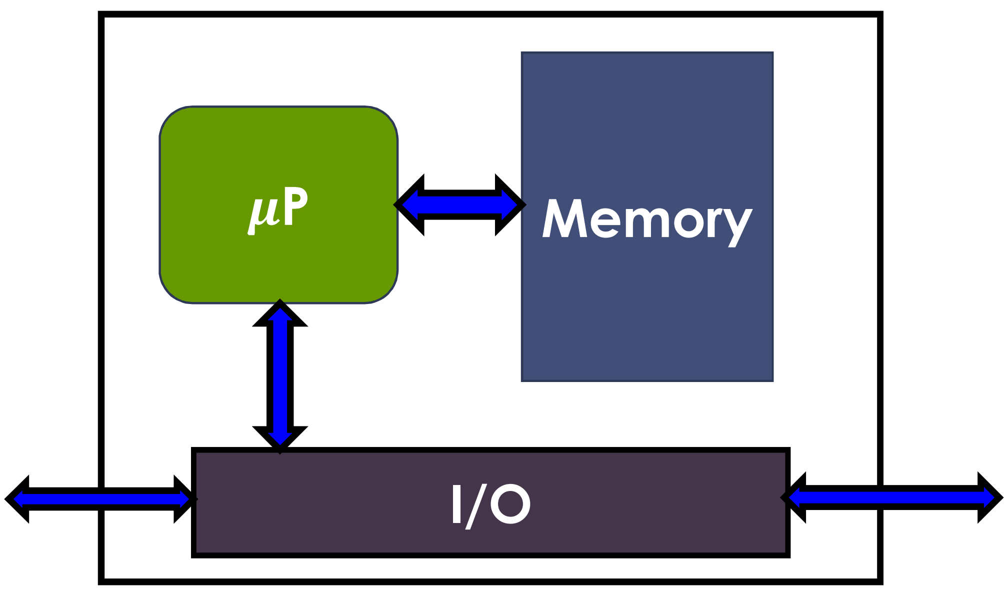
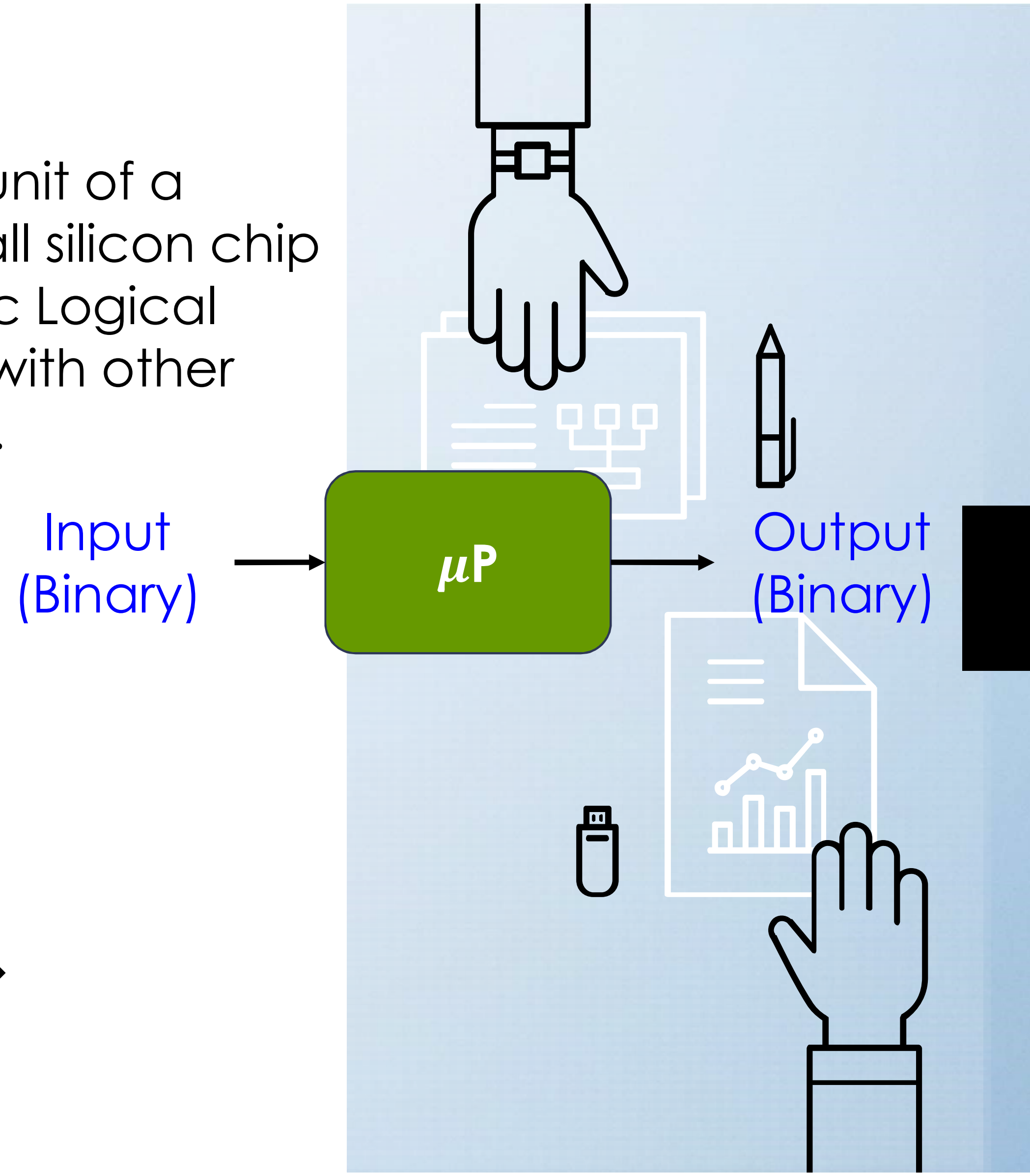
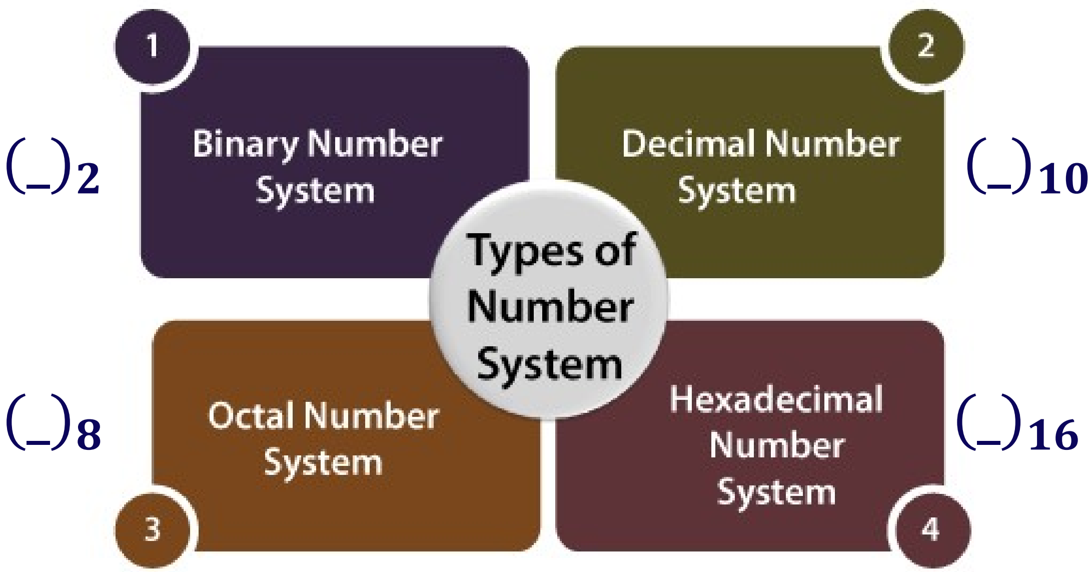


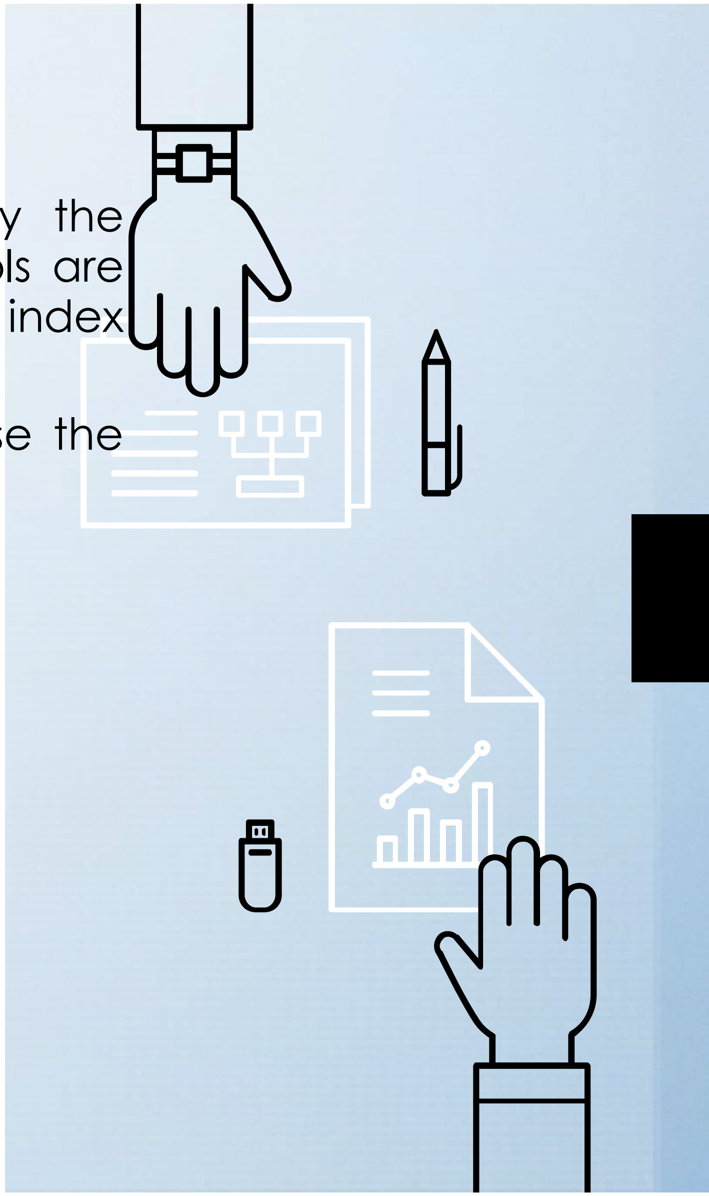
Fig.: Computing System



Number System

- In a digital system, the system can understand only the optional number system. In these systems, digits symbols are used to represent different values, depending on the index from which it settled in the number system.
- In simple terms, for representing the information, we use the number system in the digital system.





Binary Number System

- It holds only two values, i.e., either 0 or 1.
- It is also known as the base 2 number system.
- The LSB of the number represents the 0 power of the base(2). Example: 2^0
- The MSB of the number represents the $x - 1$ power of the base(2). Example: 2^{x-1}, where x represents the last MSB.

- **Examples:**

$(10100)_2$, $(11011)_2$, $(11001)_2$, $(000101)_2$, $(011010)_2$.

Octal Number System

- An octal number system carries eight digits starting from 0, 1, 2, 3, 4, 5, 6, and 7.It is also known as the base 2 number system.
- It is also known as the base 8 number system.
- The LSB of the number represents the 0 power of the base(8). Example: 8^0
- The MSB of the number represents the $x-1$ power of the base(8). Example: 8^{x-1}, where x represents the last MSB.

- **Examples:**

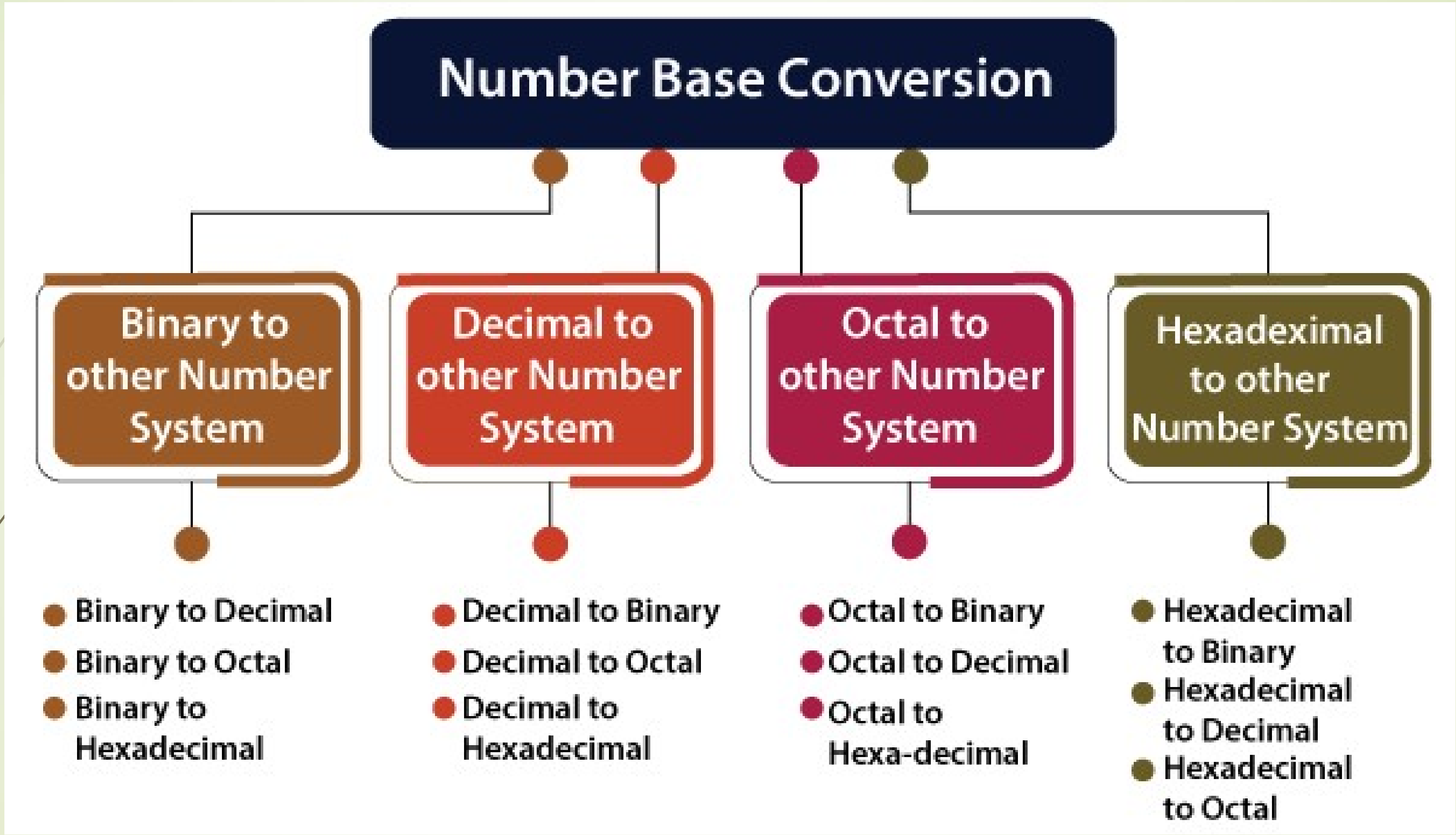
$(273)_8$, $(5644)_8$, $(0.5365)_8$, $(1123)_8$, $(1223)_8$.

Hexadecimal Number System

- It has ten digits from 0 to 9 and 6 letters from A to F.
- The letters from A to F defines numbers from 10 to 15.
- It is also known as the base 16 number system.
- The LSB of the number represents the 0 power of the base(16). Example: 16^0
- The MSB of the number represents the $x-1$ power of the base(16). Example: 16^{x-1}, where x represents the last MSB.

- **Examples:**

$(FAC2)_{16}$, $(564)_{16}$, $(0ABD5)_{16}$, $(1123)_{16}$, $(11F3)_{16}$.


Number Base Conversion
Binary to other Number System
Decimal to other Number System
Octal to other Number System
Hexadeximal to other Number System
Binary to Decimal
Binary to Octal
Binary to Hexadecimal
Decimal to Binary
Decimal to Octal
Decimal to Hexadecimal
Octal to Binary
Octal to Decimal
Octal to Hexa-decimal
Hexadecimal to Binary
Hexadecimal to Decimal
Hexadecimal to Octal

Binary to Decimal Conversion

- $(10110.001)_2=(1\times2^4)+(0\times2^3)+(1\times2^2)+(1\times2^1)+(0\times2^0)+(0\times2^{-1})+(0\times2^{-2})+(1\times2^{-3})$
  $(10110.001)_2=(1\times16)+(0\times8)+(1\times4)+(1\times2)+(0\times1)+(0\times1/2)+(0\times1/4)+(1\times1/8)$
  $(10110.001)_2=16+0+4+2+0+0+0+0.125$
  $(10110.001)_2=(22.125\ )_{10}$

Binary to Octal Conversion

- **$(111110101011.0011)_2$**
- 1. Firstly, we make pairs of three bits on both sides of the binary point.
- 111 110 101 011.001 1
- On the right side of the binary point, the last pair has only one bit. To make it a complete pair of three bits, we added two zeros on the extreme side.
- 111 110 101 011.001 100
- 2. Then, we wrote the octal digits, which correspond to each pair.
- **$(111110101011.0011)_2=(7653.14)_8$**

Binary to Octal Conversion

- **$(111110101011.0011)_2$**

1. Firstly, we make pairs of three bits on both sides of the binary point.

111 110 101 011.001 1

On the right side of the binary point, the last pair has only one bit. To make it a complete pair of three bits, we added two zeros on the extreme side.

111 110 101 011.001 100

2. Then, we wrote the octal digits, which correspond to each pair.

$(111110101011.0011)_2=(7653.14)_8$

Binary to Hex Conversion

- **$(10110101011.0011)_2$**

1. Firstly, we make pairs of four bits on both sides of the binary point.

111 1010 1011.0011

On the left side of the binary point, the first pair has three bits. To make it a complete pair of four bits, add one zero on the extreme side.

0111 1010 1011.0011

2. Then, we write the hexadecimal digits, which correspond to each pair.

$(011110101011.0011)_2=(7AB.3)_{16}$

Decimal to Binary Conversion

Example: $(152.25)_{10}$

Step 1:

- Divide the number 152 and its successive quotients with base 2.

Operation	Quotient	Remainder
152/2	76	0 (LSB)
76/2	38	0
38/2	19	0
19/2	9	1
9/2	4	1
4/2	2	0
2/2	1	0
1/2	0	1(MSB)

$$(152)_{10}=(10011000)_2$$

Step 2:

- Now, perform the multiplication of 0.25 and successive fraction with base 2.

Operation	Result	carry
0.25×2	0.50	0
0.50×2	0	1

$$(0.25)_{10}=(.01)_2$$

$$(152.25)_{10}=(10011000.01)_2$$

Decimal to Octal Conversion

Example: $(152.25)_{10}$

Step 1:

- Divide the number 152 and its successive quotients with base 8.

Operation	Quotient	Remainder
152/8	19	0
19/8	2	3
2/8	0	2

$$(152)_{10}=(230)_8$$

Step 2:

- Now, perform the multiplication of 0.25 and successive fraction with base 8.

Operation	Result	carry
0.25×8	__.00	2

$$(0.25)_{10}=(.2)_8$$

$$(152.25)_{10}=(230.2)_8$$

Decimal to Hex Conversion

Example: $(152.25)_{10}$

Step 1:

- Divide the number 152 and its successive quotients with base 16.

Operation	Quotient	Remainder
152/16	9	8
9/16	0	9

$$(152)_{10}=(98)_{16}$$

Step 2:

- Now, perform the multiplication of 0.25 and successive fraction with base 16.

Operation	Result	Carry
0.25×16	___.00	4

$$(0.25)_{10}=(.4)_{16}$$

$$(152.25)_{10}=(98.4)_{16}$$

Octal to Decimal Conversion

- **$(152.25)_8$**

Step 1:

We multiply each digit of **152.25** with its respective positional weight, and last we add the products of all the bits with its weight.

$(152.25)_8=(1\times8^2)+(5\times8^1)+(2\times8^0)+(2\times8^{-1})+(5\times8^{-2})$
$(152.25)_8=64+40+2+(2\times1/8)+(5\times1/64)$
$(152.25)_8=64+40+2+0.25+0.078125$
$(152.25)_8=106.328125$

So, the decimal number of the octal number 152.25 is **106.328125**

Octal to Binary Conversion

- **$(152.25)_8$**

We write the three-bit binary digit for 1, 5, 2, and 5.

$(152.25)_8$ $=(001101010.010101)_2$

So, the binary number of the octal number 152.25 is **$(001101010.010101)_2$**

Octal to Hex Conversion

- **Example 1: $(152.25)_8$**

Step 1:

We write the three-bit binary digit for 1, 5, 2, and 5.

$(152.25)_8$ $=(001101010.010101)_2$

So, the binary number of the octal number 152.25 is **$(001101010.010101)_2$**

Step 2:

1. Now, we make pairs of four bits on both sides of the binary point.

0 0110 1010.0101 01

On the left side of the binary point, the first pair has only one digit, and on the right side, the last pair has only two-digit. To make them complete pairs of four bits, add zeros on extreme sides.

0000 0110 1010.0101 0100

2. Now, we write the hexadecimal digits, which correspond to each pair.

$(0000\ 0110\ 1010.0101\ 0100)_2=(6A.54)_{16}$

Hex to Binary Conversion

- **Example 1: $(152A.25)_{16}$**

  We write the four-bit binary digit for 1, 5, A, 2, and 5.

  $(152A.25)_{16}$=$(0001\ 0101\ 0010\ 1010.0010\ 0101)_2$

  So, the binary number of the hexadecimal number 152.25 is **$(1010100101010.00100101)_2$**

Binary equivalent	Hexadecimal
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	A
1011	B
1100	C
1101	D
1110	E
1111	F

Hex to Octal Conversion

- **Example 1: $(152A.25)_{16}$**

Step 1:

We write the four-bit binary digit for 1, 5, 2, A, and 5.

$(152A.25)_{16}=(0001\ 0101\ 0010\ 1010.0010\ 0101)_2$

So, the binary number of hexadecimal number 152A.25 is **$(0011010101010.010101)_2$**

Step 2:

3. Then, we make pairs of three bits on both sides of the binary point.

001 010 100 101 010.001 001 010

4. Then, we write the octal digit, which corresponds to each pair.

$(001010100101010.001001010)_2=(12452.112)_8$

Mathematical Operations (Hex)

- **Addition**
- **Subtraction**
- **Multiplication**
- **Division**

```
  A 8 D 2
- 3 E A C
-------------
```

```
  A 8 D 2
+ 3 E A C
-------------
```

```
    24
 × 3A
-------------
```

```
A 8 D 2
  ÷ 3
-------------
```

Power of 2

2^0	1	
2^1	2	
2^2	4	*1 Nibble*
2^3	8	*1 Byte*
2^4	16	*1 Word*
2^5	32	
2^6	64	
2^7	128	
2^8	256	
2^9	512	
2^{10}	1024	*1Kilo Byte*

2^{11}	2048 (2×2^{10})	*2KB*
2^{12}	4098 $(2^2 \times 2^{10})$	*4KB*
2^{13}	8192 $(2^3 \times 2^{10})$	*8KB*
2^{14}	$2^4 \times 2^{10}$	*16KB*
2^{20}	$2^{10} \times 2^{10}$	*1Mega Byte*
2^{21}	$2^1 \times 2^{20}$	*2MB*
2^{22}	$2^2 \times 2^{20}$	*4MB*
2^{23}	$2^3 \times 2^{20}$	*8MB*
2^{30}	$2^{10} \times 2^{20}$	*1Giga Byte*
2^{31}	$2^1 \times 2^{30}$	*2GB*
2^{32}	$2^2 \times 2^{30}$	*4GB*
2^{40}	$2^{10} \times 2^{30}$	*1 Tera Byte*

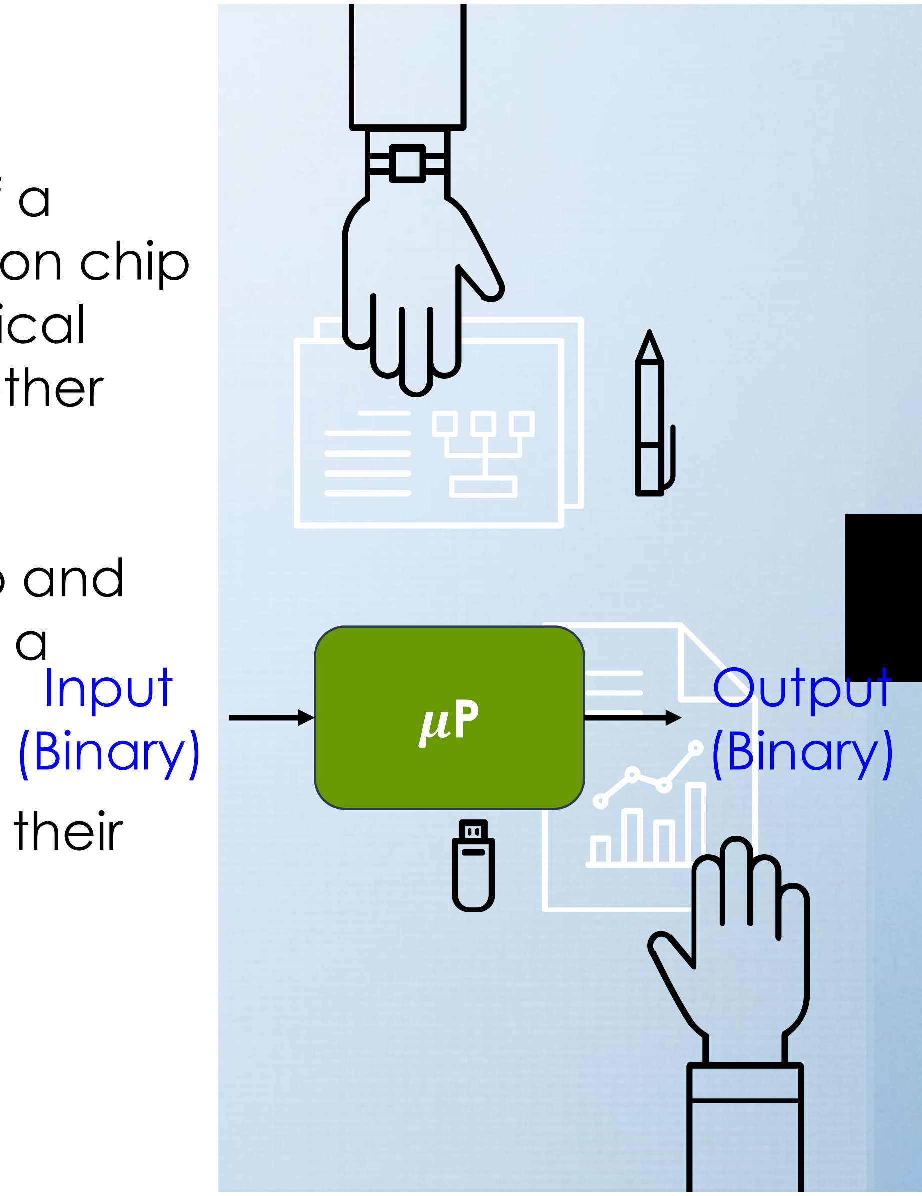
Microprocessor (μP) Architecture

Microprocessor($\boldsymbol{\mu}$P)

Microprocessor is a controlling unit of a microcomputer, fabricated on a small silicon chip capable of performing Arithmetic Logical Operations and communicating with other devices connected to it.

- It is also a logical circuit that responds to and process the basic instructions that drives a computer
- One processor differs from other only by their **architecture**.

The general way in which the computers are done.



Microprocessor(μP) Architecture

The major difference between the Microprocessor and Microcontroller architectures are:

- The Length of microprocessors data word.
- The size of the memory which μP can directly address.
- The speed which the μP can execute.

Some additional architectural differences:

- ✓ The No. of registers available to program.
- ✓ The types of registers available to program.
- ✓ The different types of instructions available to program.
- ✓ Different types of memory addressing modes.
- ✓ Compatibility with hardware development system.

Microprocessor(μP) Word Length

- Word length of a processor is the maximum number of bits it can accept as input, process (execute) or deliver as output.
- It depends upon the width of internal data bus, registers, ALU, etc.
- The more the word length, the more the speed of execution of any instruction.
- 4 Bit, 8 Bit, 16 Bit, 32 Bit and 64 Bit Microprocessors.
- It is a measurement to compute the power of a microprocessor.

Question:

1. Why are you learning 8086?
2. Why still the low-level processors (4-Bit and 8-Bit) are popular?
3. What is the meaning of Dual/Quad core processors ?

Microprocessor(μP) Addressable Memory

- The amount of memory which a particular μP can address is also a part of the architecture.

- It depends upon the width of internal address bus.

- **Ex**: Intel 4004 (4-Bit) μP has 14-bit address bus:
  - Addressable Memory : $2^{14} = 16{,}384$ memory locations.

  Intel 8085 (8-Bit) μP has 16-bit address bus:
  - Addressable Memory: $2^{16} = 65,536$ memory locations.

- 2 Types of single chip microcomputer address bus:
  i. Only access the number of memory locations which are actually on the chip.
  ii. On chip Memory + Can address enough memory locations outside the chip.

Memory Utilization and Task

1. General purpose application:

   Where the task performed by the microprocessor is fixed, thus the system program is fixed and a great deal of ROM memory is occupied.

2. Control Applications:

   If the application program changes frequently and is controlled by the user and can change the program that is to be executed, then a great deal of RAM memory is required.

Ex: Process control computers, which may be used to monitor and control a number of different processes.

Microprocessor($\boldsymbol{\mu}$P) Speed

2-types of speed:

1. Clock Speed: This is the frequency at which microprocessor's clock oscillator operates.

   More clock speed → can fetch more instructions in less time

Measured in: Million Instructions Per Second (MIPS)

2. Word Length: Number of bits that a processor can execute (Process) at a time.

NB:

The clock speed or the frequency at which a microprocessor operates are mostly depends on the semiconductor manufacturing technology.

(2-types of semiconductor technology: NMOS and CMOS)

NMOS	CMOS
Operating frequency: $\approx 1 MHz$ to $20\ MHz$	Operating frequency: $\approx 20\ MHz$ to $100\ MHz$
Less expensive	More expensive
Draws more power	Draws less power
Becomes more hot	
In this type of semiconductor technology very large integration (VLSI) is not possible, as it draws more power and can burn the device.	VLSI Technology

Other μP Architectural Characteristics

The following architectural characteristics are used to increase the speed of the processor:

- Parallel processing.
- Co-Processing.
- Cache memory technique.
- Pipelining technique.
- Wider buses.

Advantages of Microprocessor

- High processing speed
- Compact size
- Easy maintenance
- Can perform complex mathematatics
- Flexible
- Can be improved according to requirement

Disadvantages of Microprocessor

- Overheating occurs due to overuse
- Performance depends on size of data
- Large board size than microcontrollers
- Most microprocessors do not support floating point operations