CS & IT ENGINEERING

COMPUTER ORGANIZATION AND ARCHITECTURE

IO Organization

Lecture No.- 01

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Recap of Previous Lecture

Topic Floating Point Representation

Topic IEEE-754 Floating Point Representation

Topics to be Covered

- **Topic** Peripheral Device
- **Topic** IO vs Memory Buses
- **Topic** Memory Mapped IO vs IO Mapped IO
- **Topic** Asynchronous Data Transfer
- **Topic** Modes of Transfer

[MCQ]

#Q. The value of a float type variable is represented using the single- precision 32-bit floating point format IEEE-754 standard that uses 1bit for sign, 8 bits for biased exponent and 23 bits for mantissa. A float type variable X is assigned the decimal value of −14.25. The representation of X in hexadecimal notation is

A. C1640000H

B. 416C0000H

C. 41640000H

D. C16C0000H

[MSQ] GATE-2025

Q.49	Three floating point numbers X, Y, and Z are stored in three registers R_X, R_Y, and R_Z, respectively in IEEE 754 single precision format as given below in hexadecimal: -9 6 12 R_X = 0xC1100000, R_Y = 0x40C00000, and R_Z = 0x41400000 Which of the following option(s) is/are CORRECT?
(A)	$4(X + Y) + Z = 0$
(B)	$2Y - Z = 0$
(C)	$4X + 3Z = 0$
(D)	$X + Y + Z = 0$

[MCQ]

#Q. A certain well-known computer family represents the exponents of its floating-point numbers as "excess-64" integers; i.e., a typical exponent $e_6e_5e_4e_3e_2e_1e_0$ represents the number:

bias = 64

$(e_0 2^0 + e_1 2^1 + e_2 2^2 + \cdots + e_6 2^6) - 64$

A. $e = -64 + \sum_{i=0}^{6} 2^i e_i$

B. $e = -64 + \sum_{i=0}^{6} 2e_i$

C. $e = 64 - \sum_{i=0}^{6} 2^i e_i$

D. $e = 64 - \sum_{i=0}^{6} 2e_i$

[NAT]

#Q. Maximum value represented in IEEE-754 single precision?

$+\infty$

[NAT]

#Q. Minimum value represented in IEEE-754 single precision?

$-\infty$

[NAT]

#Q. Maximum normalized value represented in IEEE-754 single precision?

S	E	M
0	11111110	11.........1

$$\text{value} = +1.111\ldots1 * 2^{254-127}$$

$$= +1111\ldots1.0 * 2^{-23} * 2^{127}$$

$$= +(2^{24}-1) * 2^{104}$$

[NAT]

#Q. Minimum normalized value represented in IEEE-754 single precision?

S	E	M
1	11111110	111....1

$$\text{value} = -\left(2^{24}-1\right) * 2^{104}$$

[NAT]

#Q. Minimum positive normalized value represented in IEEE-754 single precision?

S	E	M
0	00000001	00 0

$$\text{value} = +\ 1.0 * 2^{1-127}$$

$$= +2^{-126}$$

[NAT]

#Q. Maximum negative normalized value represented in IEEE-754 single precision?

S	E	M
1	00000001	00----0

$$\text{value} = -2^{-126}$$

[NAT]

#Q. Maximum positive denormalized value represented in IEEE-754 single precision?

S	E	M
0	00000000	11111.....1

$$\text{Value} = +0.111....1 * 2^{-126}$$

$$= +111....1.0 * 2^{-23} * 2^{-126}$$

$$= +(2^{23}-1) * 2^{-149}$$

[NAT]

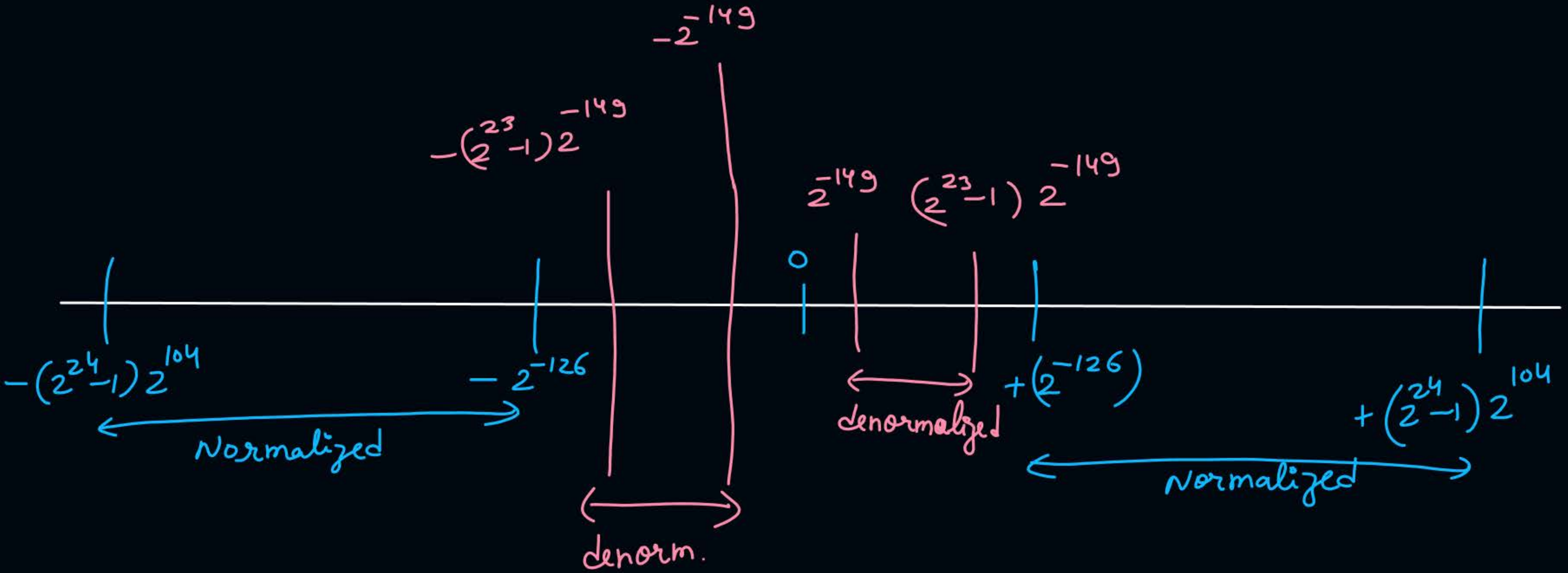
#Q. Minimum positive denormalized value represented in IEEE-754 single precision?

S	E	M
0	0.....0	0000.....01

$$\text{Value} = +0.000\ldots01 * 2^{-126}$$

$$= +1.0 * 2^{-23} * 2^{-126}$$

$$= 2^{-149}$$



-2^{-149}
$-(2^{23}-1)2^{-149}$
2^{-149}
$(2^{23}-1)2^{-149}$
0
$-(2^{24}-1)2^{104}$
-2^{-126}
$+(2^{-126})$
$+(2^{24}-1)2^{104}$
denormalized
Normalized
Normalized
denorm.

[NAT]

#Q. How to represent +1 in IEEE-754 single precision floating point number?

$$+(1.0)_{10} = +(1.0) \Rightarrow \text{Implicit normalize}$$

$$\Downarrow$$

$$1.0 * 2^{0}$$

$S = 0$

$M = 00\cdots0$

$e = 0$

$E = 0 + 127 = 127$

S	E	M
0	01111111	000...0

[NAT]

H.W.

#Q. How to represent $+(0.0000111)_2$ in IEEE-754 single precision floating point number?

[NAT]

GATE - 2021

#Q. The format of the single-precision floating-point representation of a real number as per the IEEE 754 standard is as follows:

Sign	Exponent	mantissa

Which one of the following choices is correct with respect to the smallest normalized positive number represented using the standard?

A. exponent = 00000001 and mantissa = 00000000000000000000001

B. exponent = 00000001 and mantissa = 00000000000000000000000

C. exponent = 00000000 and mantissa = 00000000000000000000000

D. exponent = 00000000 and mantissa = 00000000000000000000001

Topic : Floating Point Multiplication

1. Check for zeros → If any of the numbers is zero then result is zero.
2. Add the exponents
3. Multiply the mantissas
4. Normalize the product

$$(1.M_1 * 2^{E_1 - bias}) * (1.M * 2^{E_2 - bias})$$

$3.5 * 5 = 17.5 \Rightarrow (10001.1)_2 = 1.00011 * 2^4$

ex:-

$$\left(1.11 * 2^{\underline{128-127}}\right) * \left(1.01 * 2^{129-127}\right)$$

$$10.0011 * 2^3$$
$$1.00011 * 2^1 * 2^3$$
$$\underline{1.00011 * 2^4}$$

$m = 0001100\ldots0$

$e = 4$

$E = 4 + 127 = 131$

$$\underline{1.11} * \underline{1.01}$$

$$\underline{111} * 2^{-2} * \underline{101} * 2^{-2}$$

$$(100011.0) * 2^{-4}$$

$$(10.0011)_2$$

[MCQ] GATE-2023

H.W.

Q.35	Consider the IEEE-754 single precision floating point numbers P=0xC1800000 and Q=0x3F5C2EF4. Which one of the following corresponds to the product of these numbers (i.e., $P \times Q$), represented in the IEEE-754 single precision format?
(A)	0x404C2EF4
(B)	0x405C2EF4
(C)	0xC15C2EF4
(D)	0xC14C2EF4

Topic : Booth Multiplication

→ It works only on 2's complement

→ very less number of operations

Normal multiplication

$$
\begin{array}{r}
10101 \\
* \quad 11001 \\
\hline
10101 \\
00000\times \\
00000\times\times \\
10101\times\times\times \\
10101\times\times\times\times \\
\hline
1000001101
\end{array}
\left.\vphantom{\begin{array}{c}1\\1\\1\\1\\1\end{array}}\right\}
$$

so many addition operations

Topic : Booth Multiplication

Example:

Multiplicand: 10111

Multiplier: 100110

1. Add a zero in Right side of multiplier.
2. for each subsequent 2 bits in multiplier
   - 10 ⇒ subtraction
   - 01 ⇒ Addition

100110

sub

Add.

Sub

2 sub

1 add.

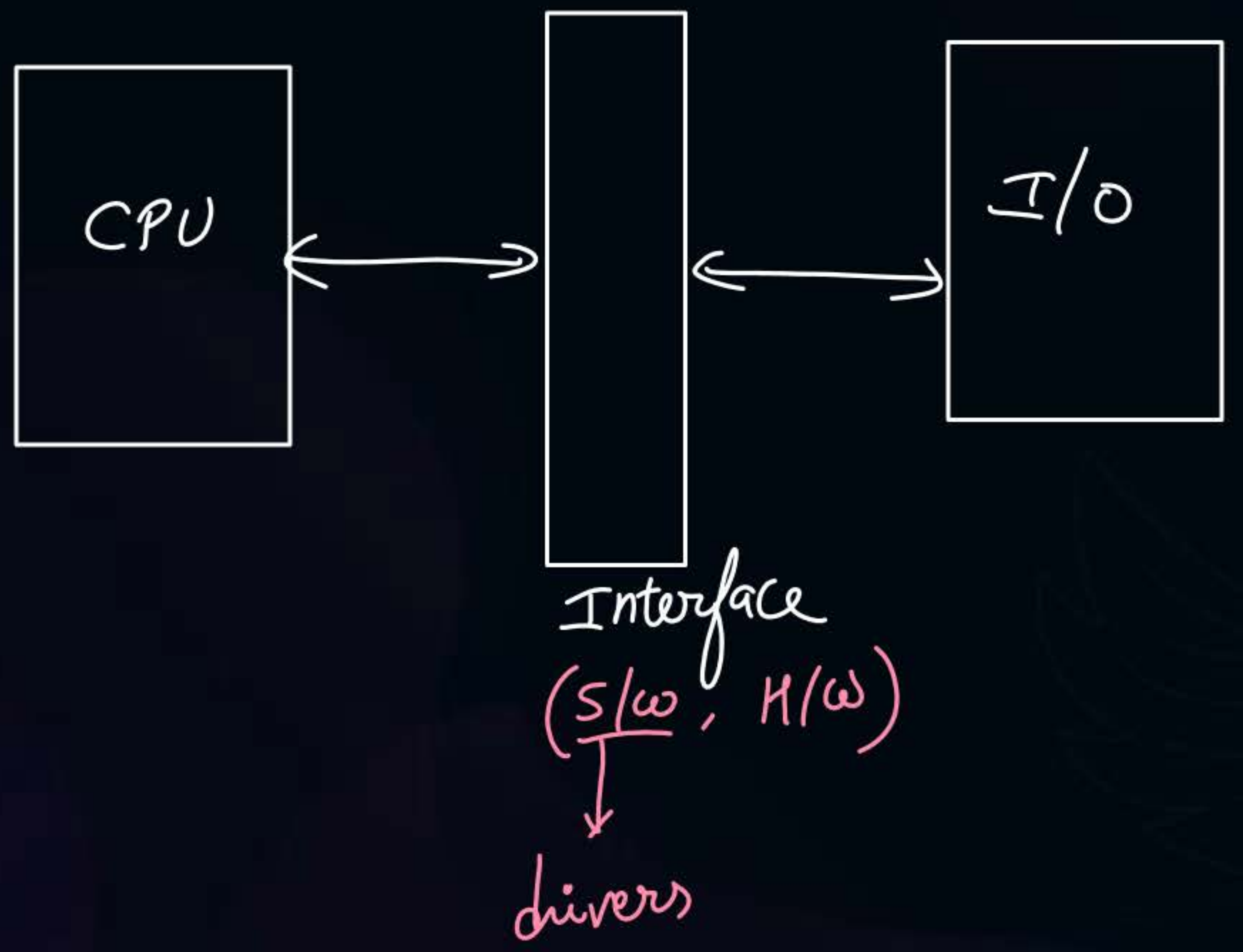
[NAT] GATE-2025

Q.32	The following two signed 2's complement numbers (multiplicand M and multiplier Q) are being multiplied using Booth's algorithm: M: 1100 1101 1110 1101 and Q: 1010 0100 1010 1010 0 The total number of addition and subtraction operations to be performed is ___13___. (Answer in integer)

Topic : Peripheral Device (I/O)

externally connected devices with CPU, except main memory.

Topic : CPU Connected to IO Directly?

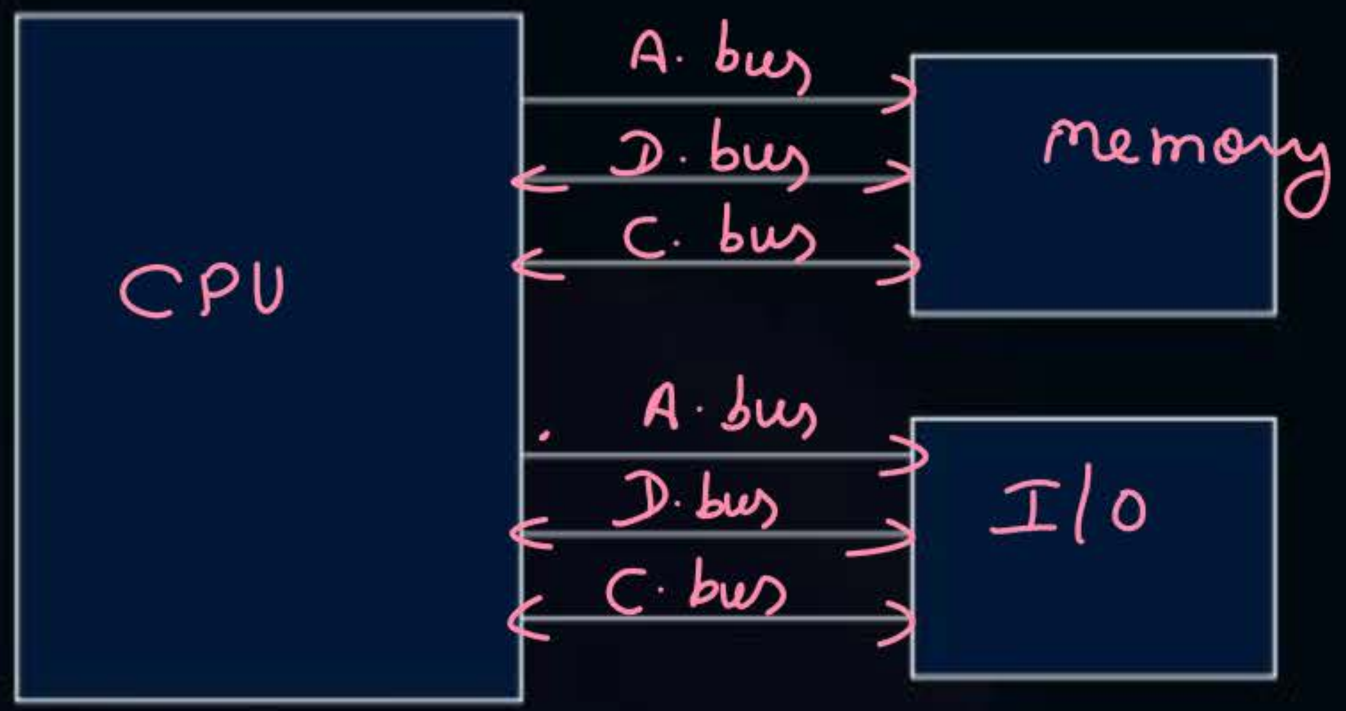


Topic : Need For Interface

1. Peripherals are electromechanical or electromagnetic devices; and their manner of operation is different from the operation of the CPU and memory. Which are electronic devices. So conversion of signal required.
2. The data transfer rate of peripherals is usually slow. So synchronization is required.
3. Data codes and format in peripherals differ from the word format in the CPU and memory. So conversion of formats is required.
4. The operating modes of peripherals are different from each other and each must be controlled so a peripheral does not disturb the operation of other peripherals.

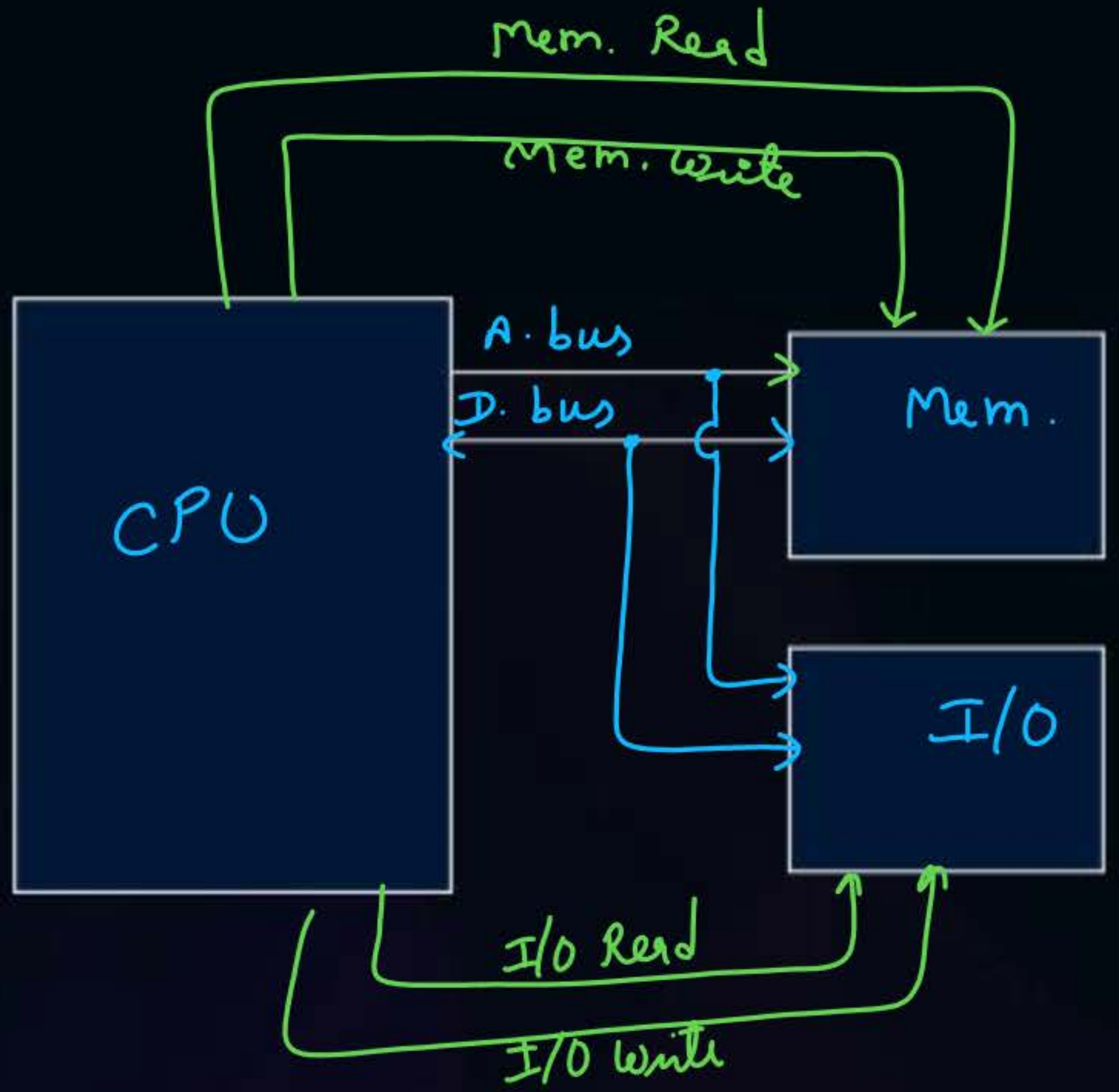
I/O interface	Interfacing
DMA Controller	— " — + DMA
I/O Processor	— " — + — " — + I/O instn execution

Topic : 1. Separate Buses for Both



waste of money

Topic : 2. Common Data, Address Bus



Isolated I/O

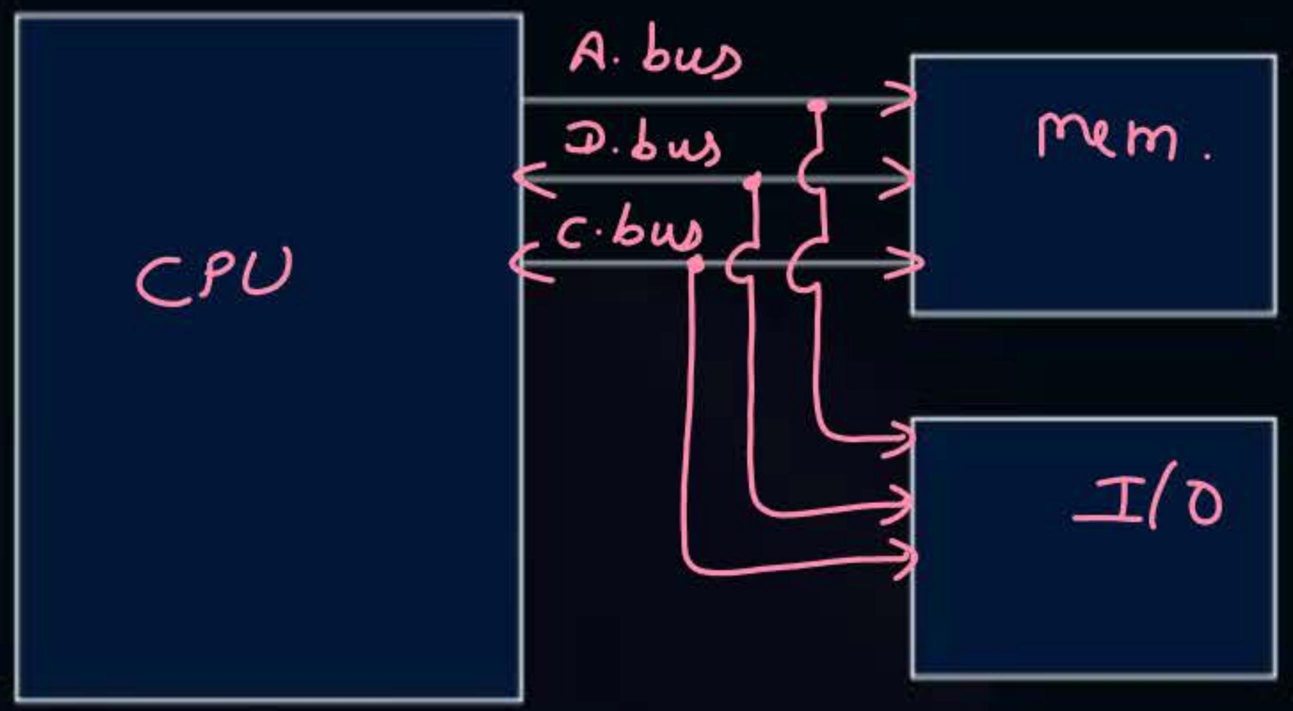
or

I/O mapped I/O

or

port mapped I/O

Topic : 3. Common Address, Data & Control Bus



memory mapped I/O

Topic : 3. Common Address, Data & Control Bus

Some of the mem. addresses are assigned to I/O devices.

whenever assigned add. is generated then I/O device is accessed.

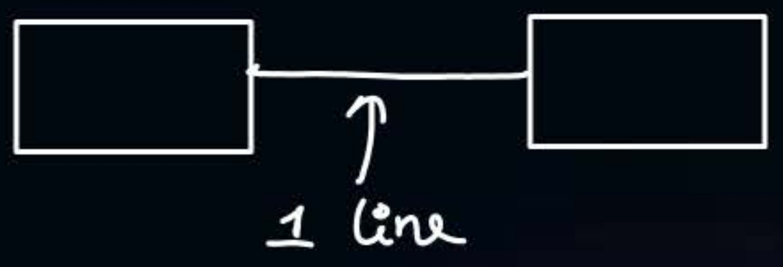
otherwise mem. is accessed.

Topic : Memory Mapped IO vs IO Mapped IO

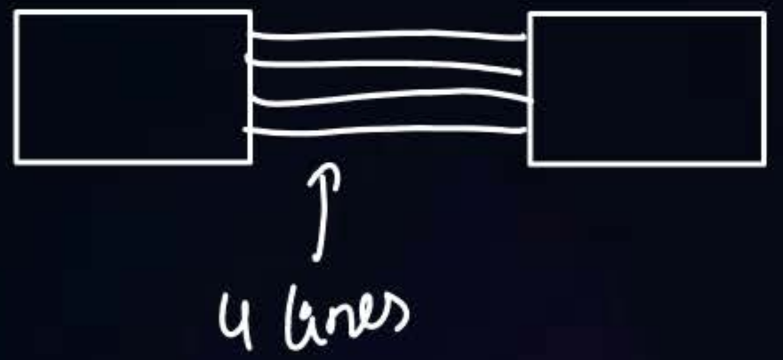
Memory Mapped IO	IO Mapped IO
1. Memory wastage	1. No Memory wastage
2. All Memory access instructions used for IO access also	2. IO access instructions and memory access instructions are different
3. No separate address space for IO	3. IO have their own separate address space
4. More Instructions for IO access	4. Less Instructions for IO access
5. More addressing modes for IO access	5. less addressing modes for IO access
6. More devices can be connected to system	6. Less devices can be connected to system
7. ALU operands can be taken from I/O directly	7. ALU operands can not be taken from I/O directly.

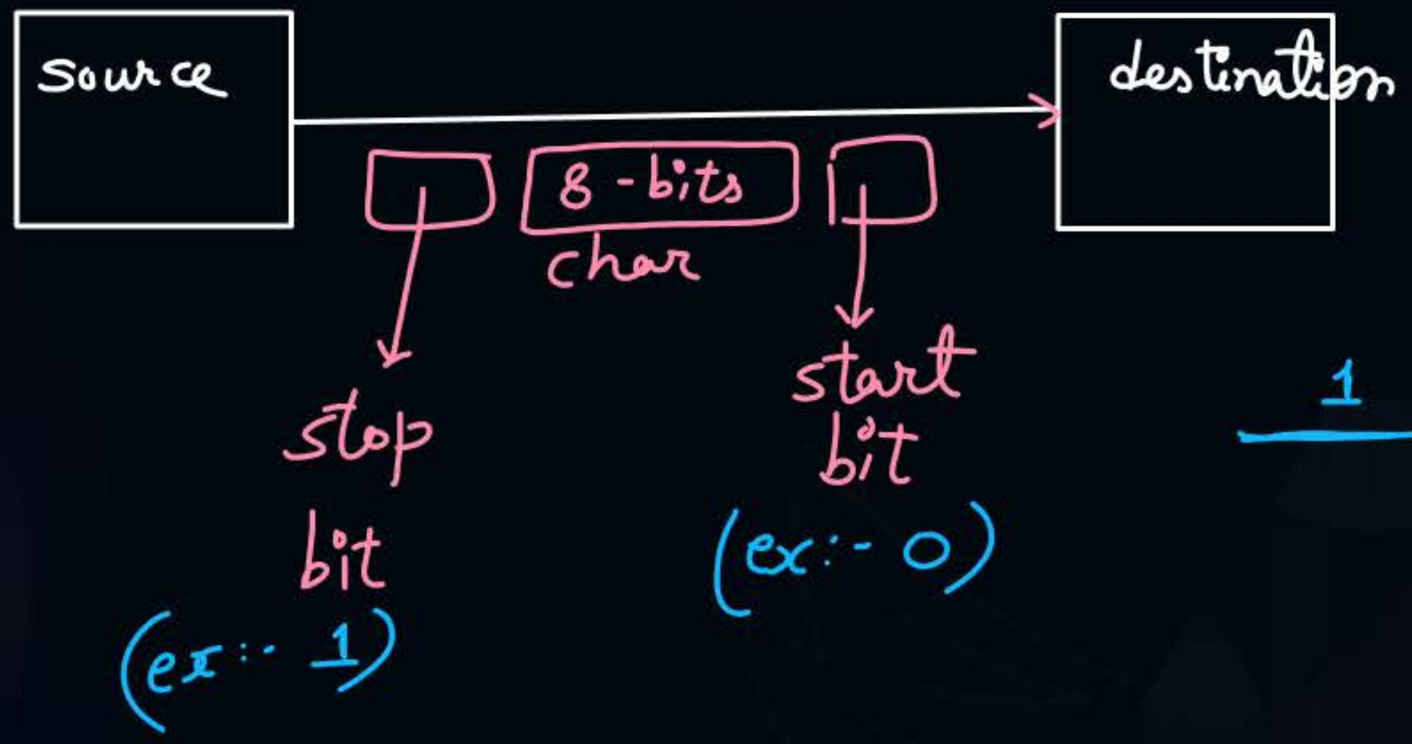
Topic : Asynchronous Data Transfer (serial)

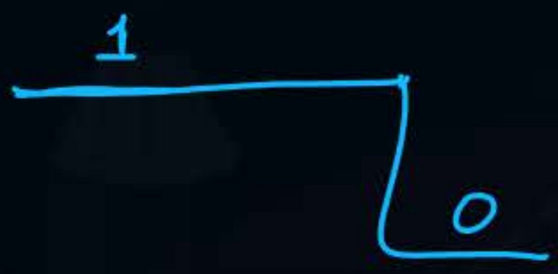
serial



Parallel







to send 8 bits char $\Rightarrow$ $8 + 1 + 1 = 10$ bits are transmitted

efficiency of communication line $= \frac{8}{10} = 0.8 = 80\%$

Effective transmission rate of line = efficiency * Actual rate

[NAT]

#Q. How many 8-bit characters can be transmitted per second over 960 bits per second serial communication link using a parity synchronous mode of transmission with 1 start bit, 8 data bits, 2 stop bits and 1 parity bit?

bits per char $= 8+1+2+1 = 12$ bits

no. of char per sec $= \dfrac{960}{12} = 80$ char/sec.

[NAT]

#Q. An asynchronous serial communication is employing 8-character bits, 1 parity bit, 2 start bits and 1 stop bit. To maintain a rate of 256 char/sec the minimum transfer rate should be required is 3072 bits/sec?

bits per char = 8+1+2+1 = 12 bits

$\Rightarrow 256 * 12$

$= 3072$ bits/sec

[NAT]

#Q. 8-bit characters can be transmitted using a parity synchronous mode of transmission with 1 start bit, 8 data bits, 2 stop bits and 1 parity bit.

1. What is the efficiency of the transmission line? $\frac{8}{1+8+2+1} = \frac{8}{12} = \frac{2}{3} = 0.67$

2. If the transfer rate of the line is 6000 bits per second, then effective transfer rate is? $= \frac{2}{3} * 6000$ bits/sec

$= 4000$ bits/sec

2 mins Summary

Topic Peripheral Device

Topic IO vs Memory Buses

Topic Memory Mapped IO vs IO Mapped IO

Topic Asynchronous Data Transfer

Topic Modes of Transfer

Happy Learning

THANK - YOU