Signals, Circuits, and Computers
Part A

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Based on Dr. Ping Hsu's original lecture notes

Types of Signals

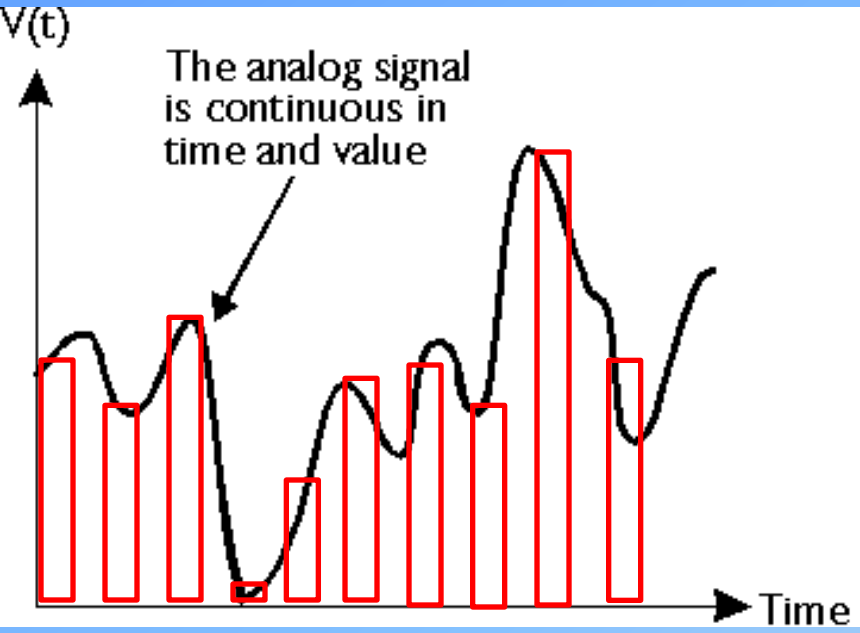
- **Analog**:
  An analog signal is a continuous signal and is often represented by a $V(t)$.

E.g., a dimmer light switch continuously increases/decreases the current.

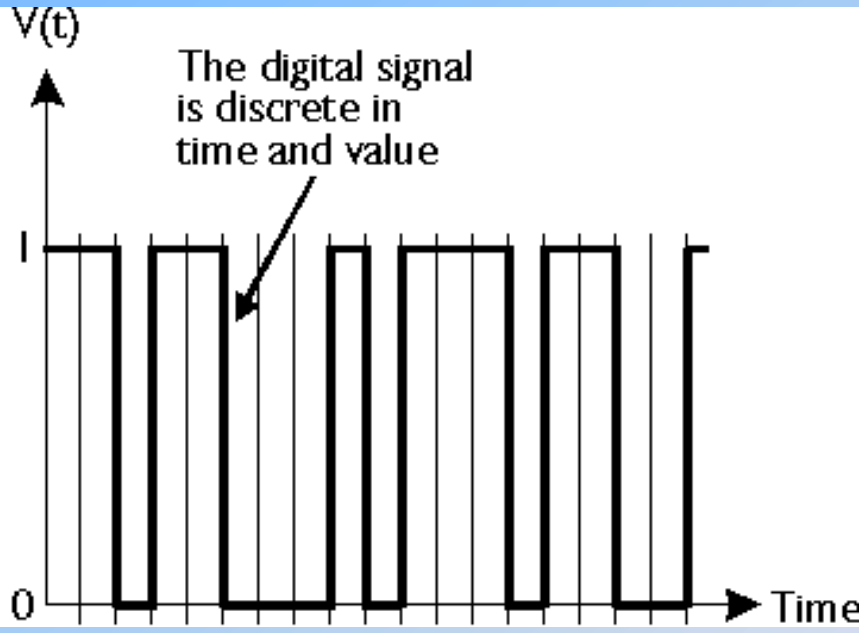
- **Digital** :
  A digital signal is a binary signal.

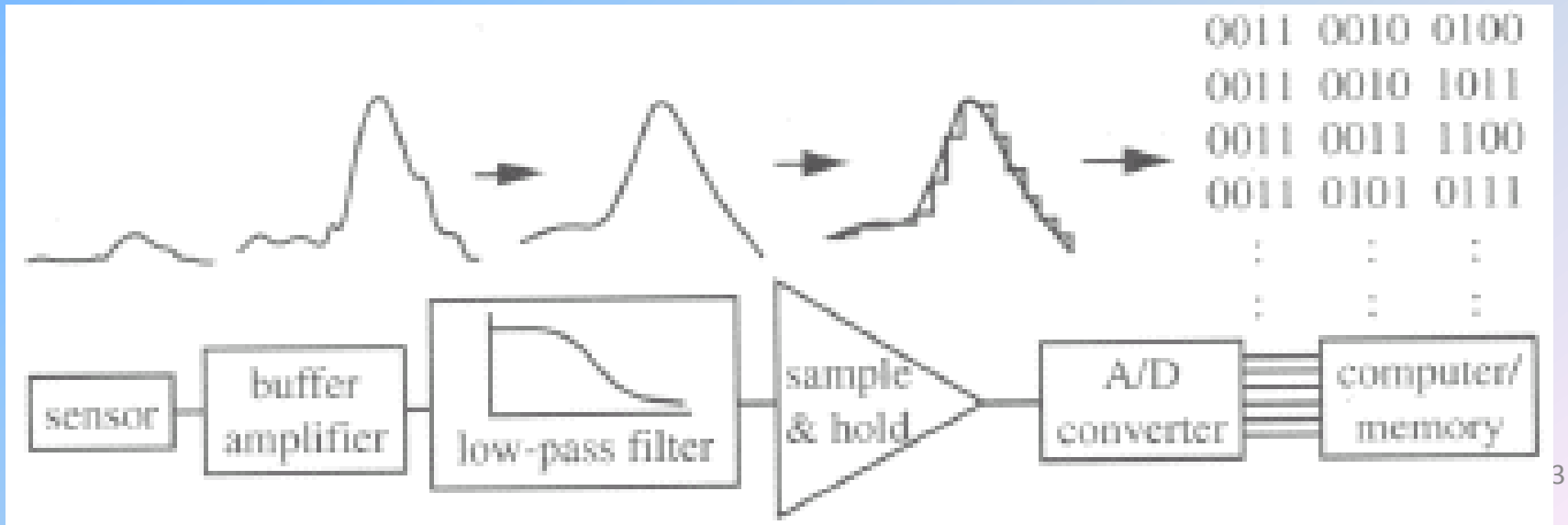
E.g., an On/Off light switch applies a fixed, predetermined voltage.

Analog Signal

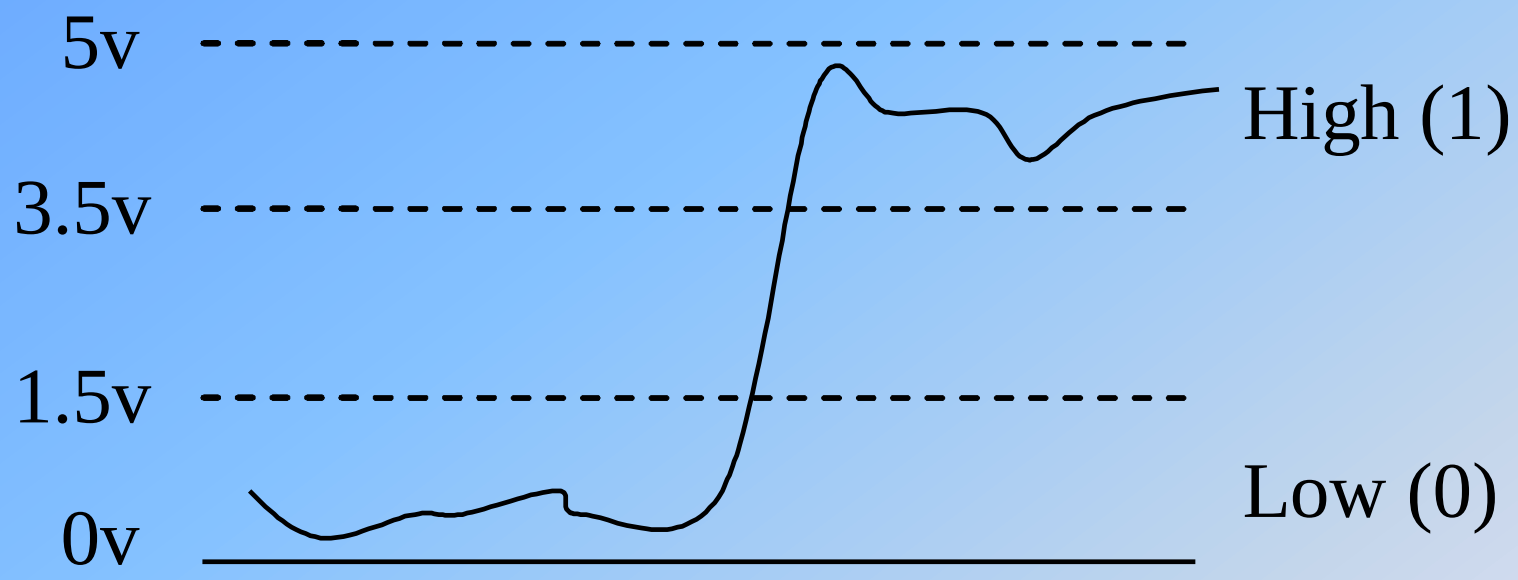


Digital Signal





Voltage Level vs. Logic State



Digital Signal has a high noise immunity level – the level of noise that can be added to the signal without affecting its state.

Analog Signal vs. Digital Signal

1. Analog signals

Pros: high resolution, efficient transmission (1 wire, 1 signal), no delay, 'real world' signals.

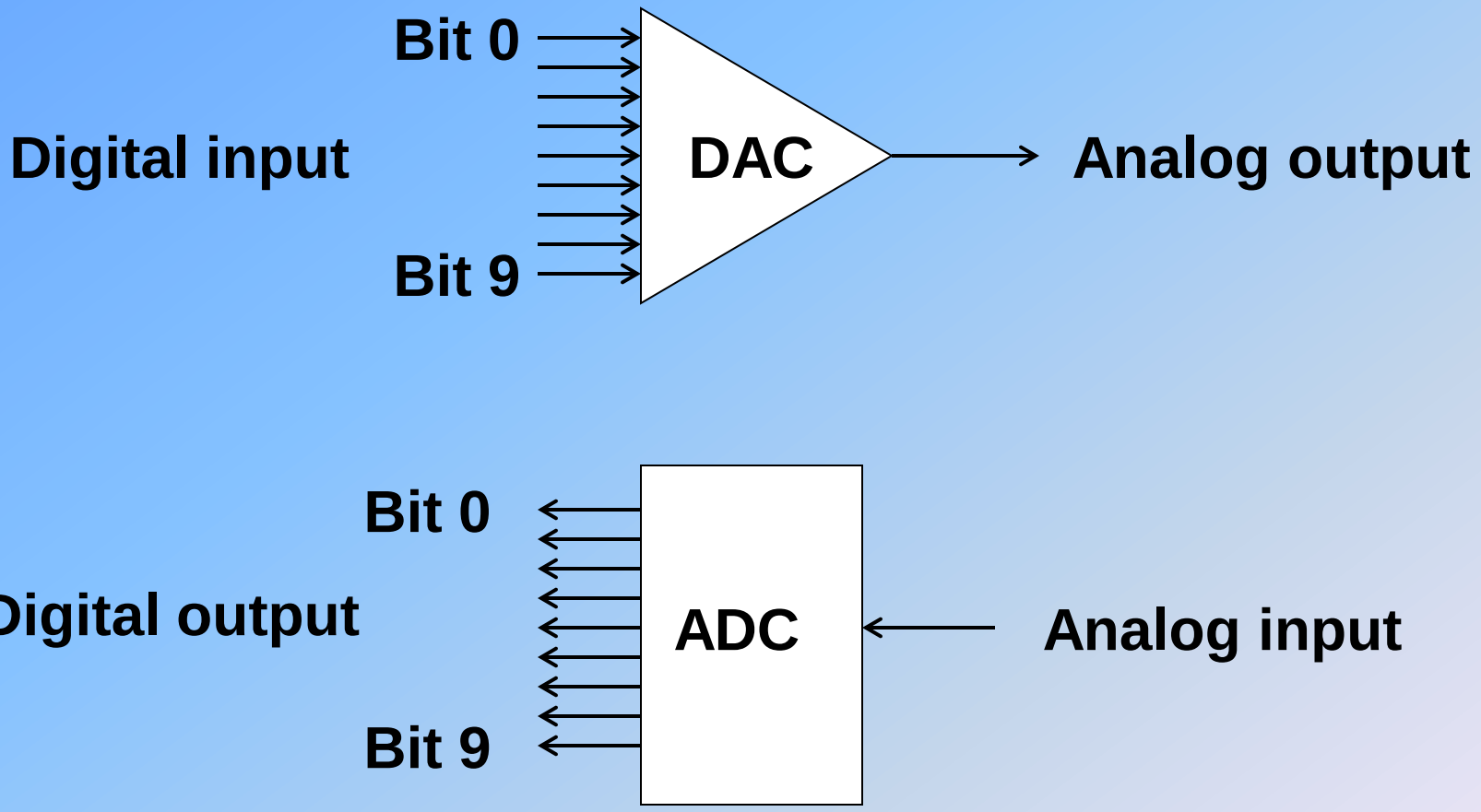
Cons: Difficult to process (perform operations, storage), **susceptible to noise.**

2. Digital Signals

Pros: high immunity to noise, easy to process

Cons: needs a lot of 'bits' and circuits, data processing delay

Analog – Digital Conversion



Q3. Which of the following is NOT an advantage of a digital signal:

A: Easy to perform math operation

B: Easy to store

C: High noise immunity

D: Need less circuitry.

E: All the above

Bits, Bytes and Words

Bits: (2^0)

One 'bit' can only represent a binary state:

0 or 1,
on or off,
stop or go.

Bytes. (2^3)

One byte consists of 8 bits.

Words: (2^4 or 2^5)

One word consists of 16 bits (or 32 bits, depending on the computer).

Number of bits	Number of different values that can be represented
4-bit (1 nibble)	2^4 =16
8-bit (1 byte)	2^8 = 256
10-bit	2^{10} = 1024
16-bit (1 word)	2^{16}=65536
32-bit	2^{32}=4294967296

A 4-bit binary number

2^3 (b_3)	2^2 (b_2)	2^1 (b_1)	2^0 (b_0)
8	4	2	1

MSB

LSB

Most Significant Bit

Least Significant Bit

Binary number: 0110 = (0x8)+(1x4)+(1x2)+(0x1)=6

Binary number: 1101 = 8+4+1=13

Q1: What is the decimal value of the 4-bit binary number 0101?

(A) 3

(B) 4

(C) 5

(D) 6

(E) 7

Q2. What do we call the bit that is in the leftmost position in a binary number?

A: SNB

B: LMB

C: MSB

D: LSB

E: USB

Binary Code

In a computer, a binary number is used to represent:

(1) Numerical values

(2) Characters and symbols (A, a, ¥,+, , @, ….)

(3) Picture, sound, video, etc.

(4) Machine language (for math operations, etc.)

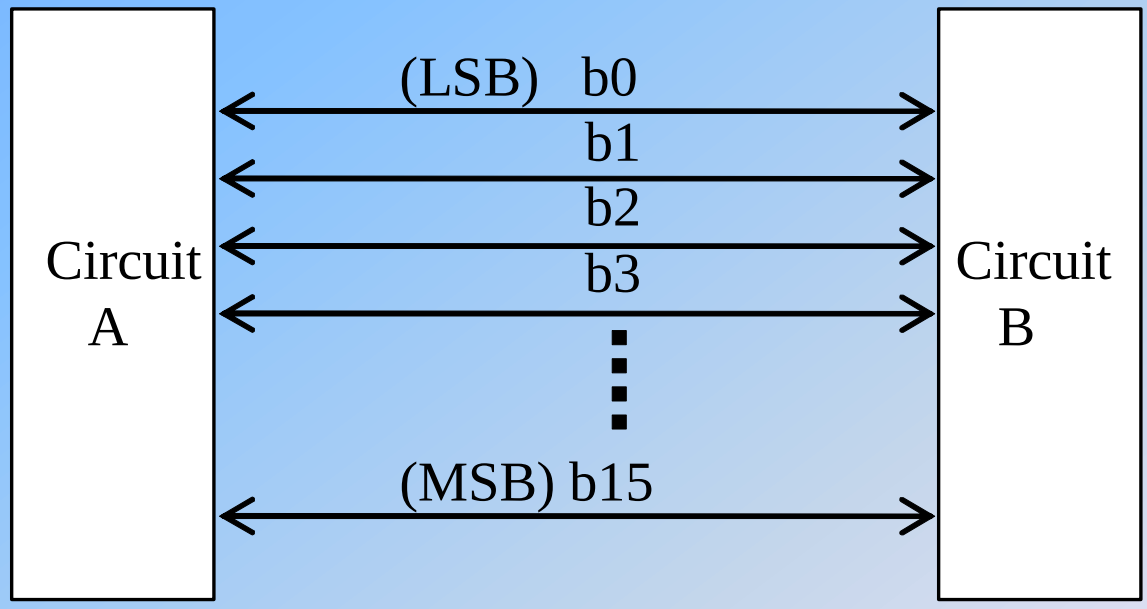
(5) others …

An example of a binary coding

4-bit Binary Code	Short hand Notation-HEX	Numerical value represented	Machine language represented
0000	0	0	NOOP
0001	1	1	ADD
0010	2	2	SUB
0011	3	3	MUL
:	:	:	:
1001	9	9	DIV
1010	A	10	COPY
1011	B	11	MOV
1100	C	12	AND
1101	D	13	OR
1110	E	14	SHIFT
1111	F	15	XOR

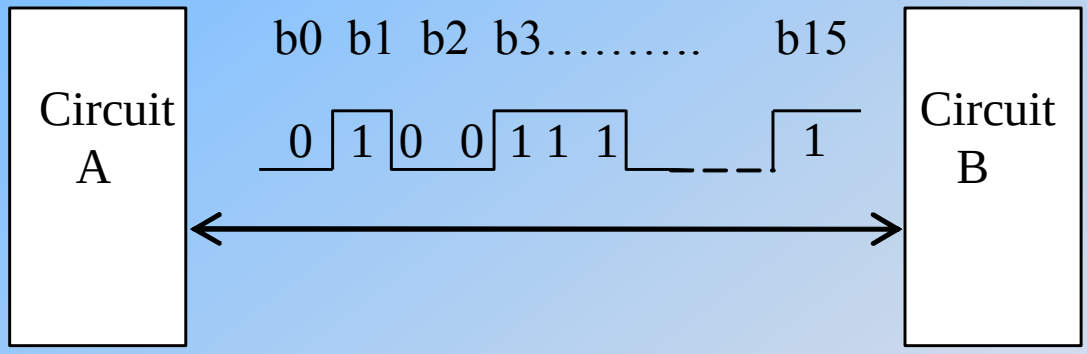
Digital Communication

Parallel connection: a dedicated wire for each bit (needs a lot of wires).

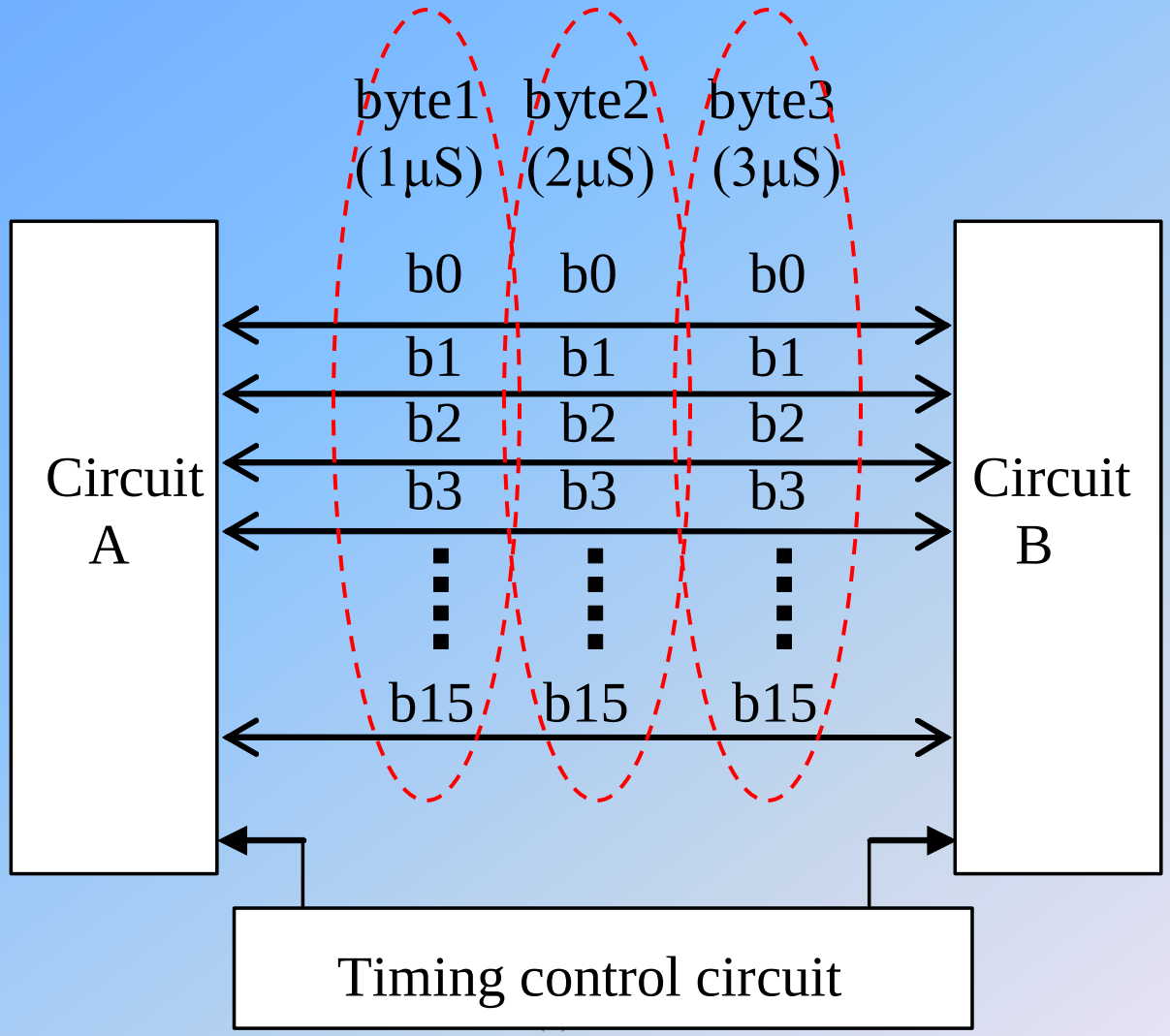


Digital Communication

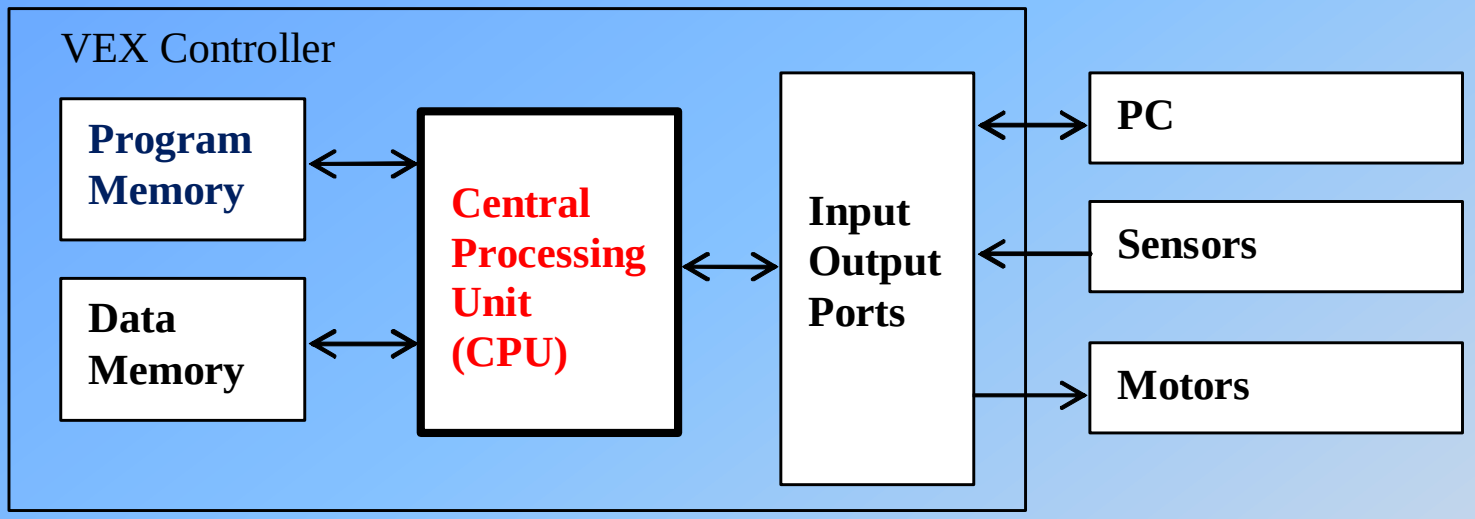
Serial connection: bits are sent sequentially (takes long time).



Sending a byte or a word in parallel, sequentially (commonly used between circuits within a computer)



VEX Microcontroller



CPU: Executing instructions, performing arithmetic and logic operations. It is the 'brain' of the computer.

Memory: Memory is for keeping program and data.

IO Port: Gateway to and from the external devices.

Q4: What is the abbreviated name of the circuit in a computer that performs arithmetic operation?

A: USB

B: AOU

C: CPU

D: AIO

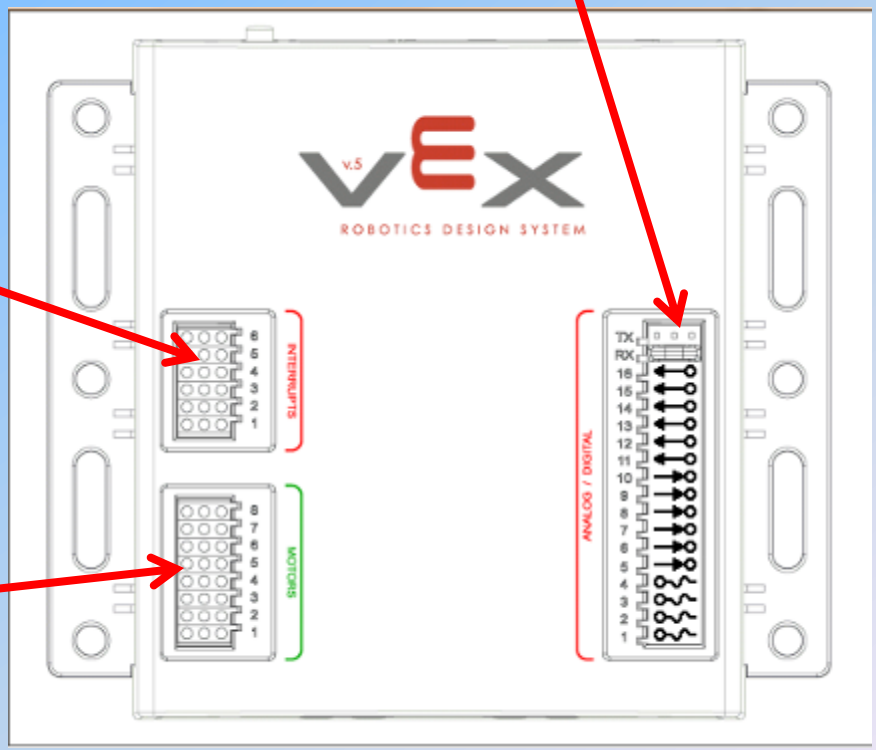
E: MOU

VEX controller IO Ports

Analog/Digital Port (16 ports)

Interrupt Ports

Motor Ports (8 ports)



Infrared Receiver Board