Computer Systems
A Background Review

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2.1.1 Computer System Overview

- **Application** – The application consists of the physical entity whose function and operation is being monitored and controlled.
- **Computer** – The digital hardware and software that is monitoring and controlling the application in real time.
- **Effector** – A device that converts an electrical signal from the output of the computer to a physical quantity which controls the function of the application.

2.1.1 Computer System Overview

- **Sensor** – A device that converts an application's physical quantity into an electrical signal for input into the computer.
- **Operator** – The human or humans responsible for monitoring and operating the computer system in real time.
- **Data Communication Link** – A two-way pathway for transferring data between the computer and other external computers.

2.1.1 Computer System Overview

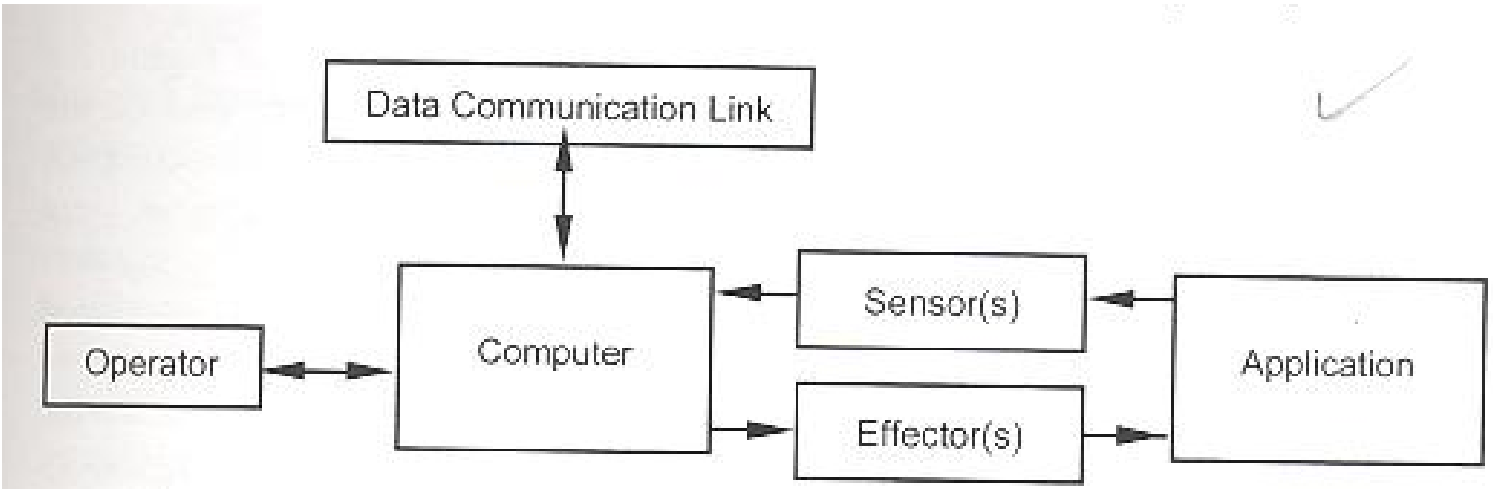

Figure 2.1 Basic Computer System Structure

2.1.2 Application

- Petroleum Refining
- Vehicular Traffic
- Home Appliances
- Manned Space Flight
- Electric Power Generation
- Entertainment Systems
- Explosives Manufacture
- High Speed Transportation
- Radiation Therapy
- Chemical Processing
- Mining
- Pharmaceutical Manufacture

2.1.2 Application

- Robotic Arm Control
  - Movement: Horizontal, Vertical, Extension
  - Position Sensor: Potentiometer
  - Rate Sensor: Tachometers and Velocimeter

2.1.2 Application

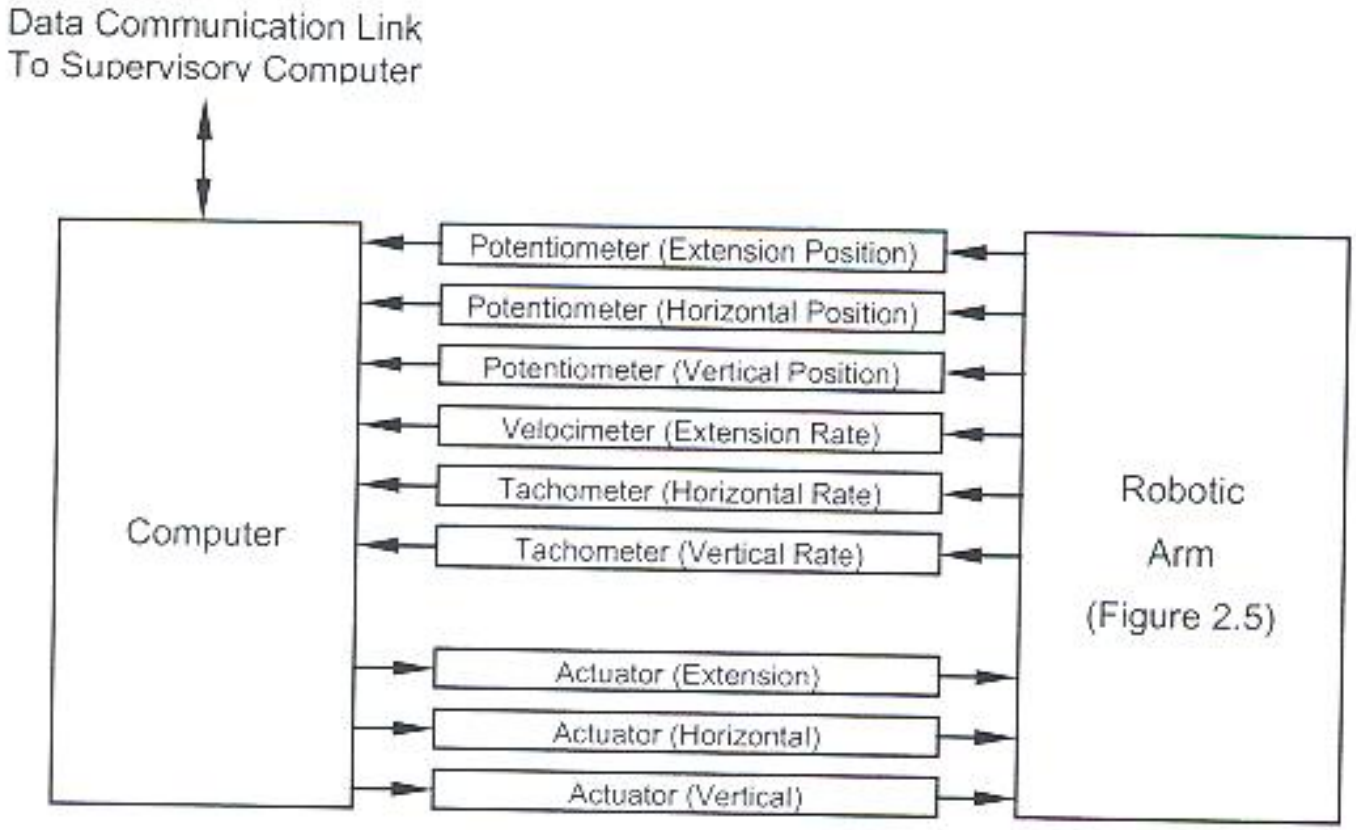

Figure 2.6 Robotic Arm Control – Computer System

2.1.3 Sensors

- A sensor is a hardware device which converts a physical stimulus can consist of motion, heat, light, or pressure.
  - **Discrete**: Signals that correspond to sensor outputs that take on only one of two possible states.
  - **Analog**: Signals that are continuous and vary as the input stimulus is varied.
  - **Digital**: Signals that represent continuous data by digits which are a measure of the value of the data.

2.1.4 Effectors

- Effectors convert electrical signals into a physical quantity such as motion, heat, light or pressure.
- Effectors consume a lot more power to function.
- Example: Karaoke

2.1.5 Data Communication Link

- Basic Communication Function
  - The communicated information primarily consists of data or commands.
  - Data represents information to be used to in computing results.
  - Commands represent tasks that the receiving computer is supposed to perform.

2.1.5 Data Communication Link

- Bus Structure
  - Star, Ring, and Bus Networks
  - Bus Networks are commonly used in industrial and aerospace systems.
  - The physical medium used in these structures are Optical Fibers and CAT cables.

2.1.5 Data Communication Link

- The bus controller and associated software in the communicating computers are designed such that the computers are able to conduct communications following a set or predefined, orderly sequences called a communications protocol.

2.1.6 Operator

- Define tasks that the operator is to perform.
- Determine ways in which the operator is to perform.
- Redesign the system so that these failures do not lead to mishap.

2.1.6 Operator

- Operator performs two task:
  - Monitoring and Controlling

- Monitoring
  - Perceive that a change has occurred.
  - Know what the change mean.
  - Be able to correctly decide what action to take.

2.1.6 Operator

- Controlling Task
  - Invoking built-in sequences of effector commands.
  - Invoking operator-programmed sequences of commands.
  - Invoking manual commands

2.1.6 Operator

- Built in Sequences – These are developed as a part of the computer system design and are a permanent part of the system.
- Operator Programmed Sequences – The operator can develop his/her own set of sequences offline to be subsequently executed in real time.
- Manual Commands – The operator uses an input device to directly move effectors.

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2.2.1 Digital Information – Bits, Codes, and Binary Numbers

- All computer information is based on groups of binary digits each of which takes on a value of "1" or "0".

- 8 bits = byte,
- 16 bits = word
- 32 bits = double word

- Bytes are members of a code called an extanded ASCII code in which each alphabetical, numeric, and punctuation character is represented by a unique byte.

2.2.1 Digital Information – Bits, Codes, and Binary Numbers

- Keyboards generate scan codes which software then converts to extended ASCII code.

- Binary (base 2)
- Octal (base 8)
- Hexadecimal (base 16)

- Floating point numbers can also be supported with binary system.

2.2.2 Computer Overview

- **Central Processing Unit** (CPU) – The core element of the computer which transfer data to and from the other components and which performs arithmetic and logic operations.

- **Memory** – The electronic element which stores digital data and contains the instructions which direct the CPU.

- **Software** – The computer program embodied in the instructions contained in memory.

2.2.2 Computer Overview

- **Sensor Input Modules** – Electronic modules which respectively convert sensor discrete, analog, or digital signals to digital inputs to the CPU.

- **Effector Output Modules** – Electronic modules which respectively convert CPU digital outputs to discrete, analog, or digital signals for driving effectors.

- **Operator Input Devices** – Electronic devices which allow the operator to enter data into the CPU.

2.2.2 Computer Overview

- **Operator Output Devices** – Electronic devices which allow the operator to receive data from the CPU.
- **Communication Module** – An electronic module enabling two way communication between the CPU and other computers.
- **Peripheral Units** – External devices connected to the CPU.
- **Electrical Power Supply** – The electrical power supply converts the wall voltage into the voltage levels needed to run the computer electronic systems.

2.2.2 Computer Overview

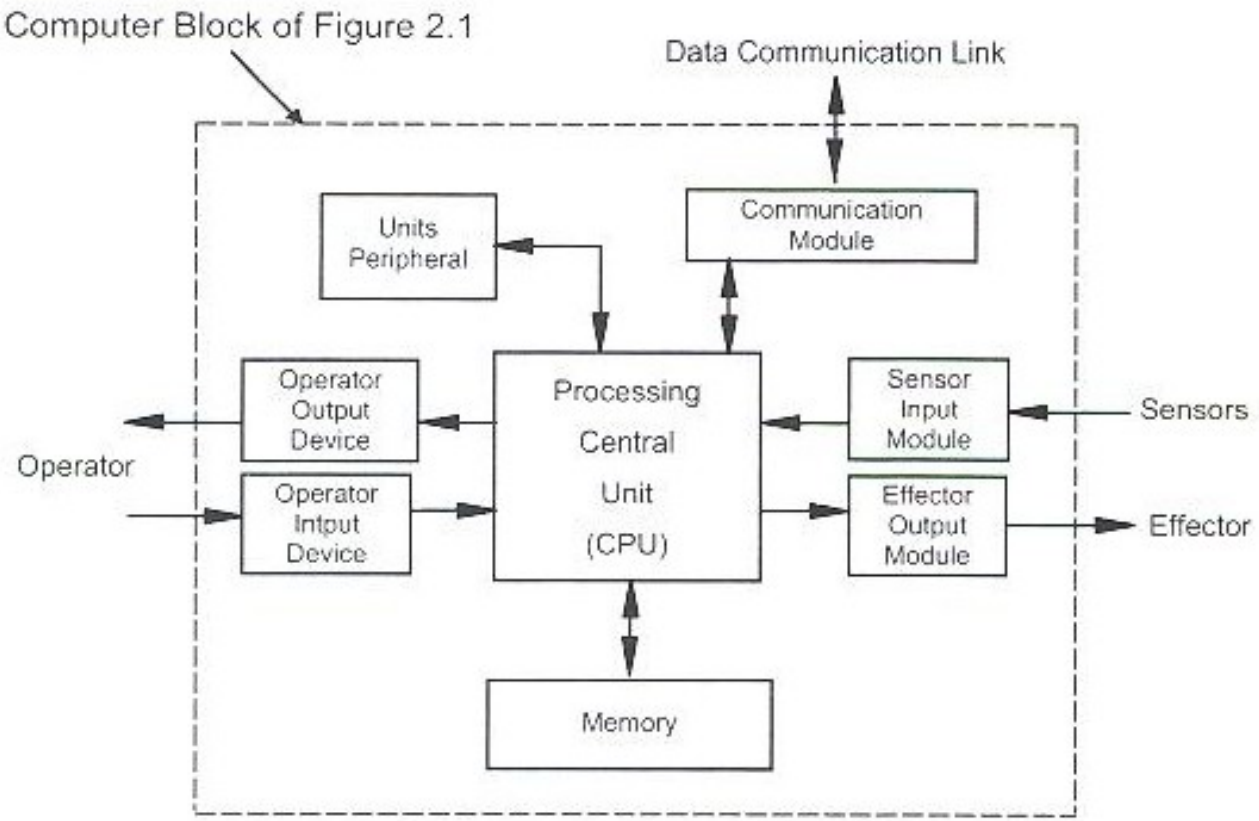

Figure 2.8 Computer Block Diagram

CPU Basic Operations

- Input/Output (I/O) Operations
  - Inputting data from the operator.
  - Outputting data to the operator.
  - Inputting sensor data.
  - Outputting effector data.
  - Sending and Receiving data from different modules.

- Memory Data Transfer Operations – the CPU can write data to memory and read data from memory.

- Arithmetic and Logic Operations – these are performed on data to generate new data, which in turn are written to memory.

2.2.3 Sensor Input Modules

- **The Discrete/Digital Converter** – Handles 8, 12, or 16 discrete inputs, and outputs 8, 12, or 16 bits respectively. Each bit takes on a "1" or "0" depending upon whether the corresponding discrete input is "on" or "off".

- **The Digital/Digital Converter** – Is used for sensors that produce digital outputs but whose but pattern and/or electrical characteristics do not allow direct connection to the CPU hardware.

2.2.3 Sensor Input Modules

- The Analog/Digital (A/D) Converter – Can accept 8 analog input signals and convert any one of these to an 8, 12, or 16 bit binary number. The specific analog input that is to be converted is selected by the CPU, which outputs 3 select bits.

2.2.3 Sensor Input Modules

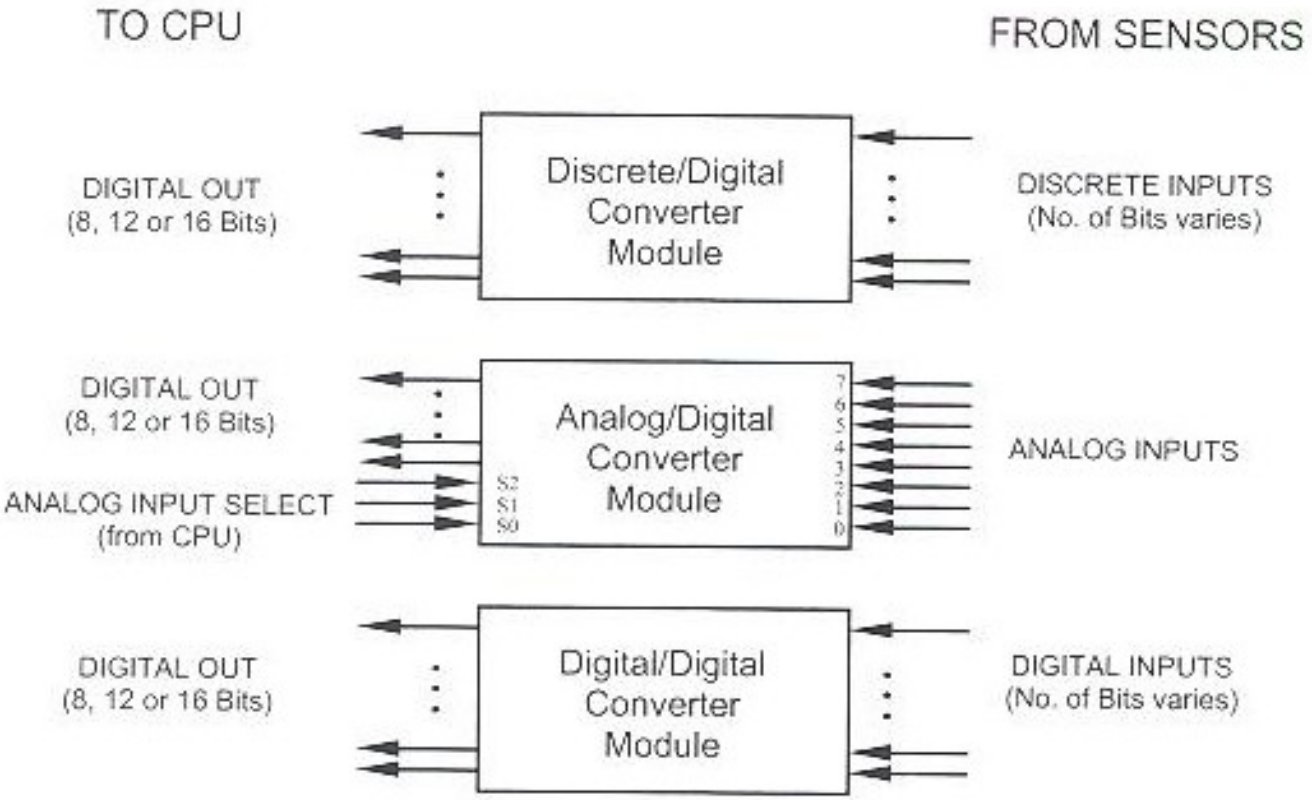

Figure 2.11 Sensor Input Modules

2.2.4 Effector Output Modules

- The Digital/Discrete converter module- generates either a "on" or "off" voltage or current depending on the binary signal from the CPU.

- The Digital to Analog (D/A) converter module – Has four outputs that are selected by the CPU outputs S0 and S1.

2.2.4 Effector Output Modules

- The Digital to Digital Converter – same function as the sensor module but at a higher output power.

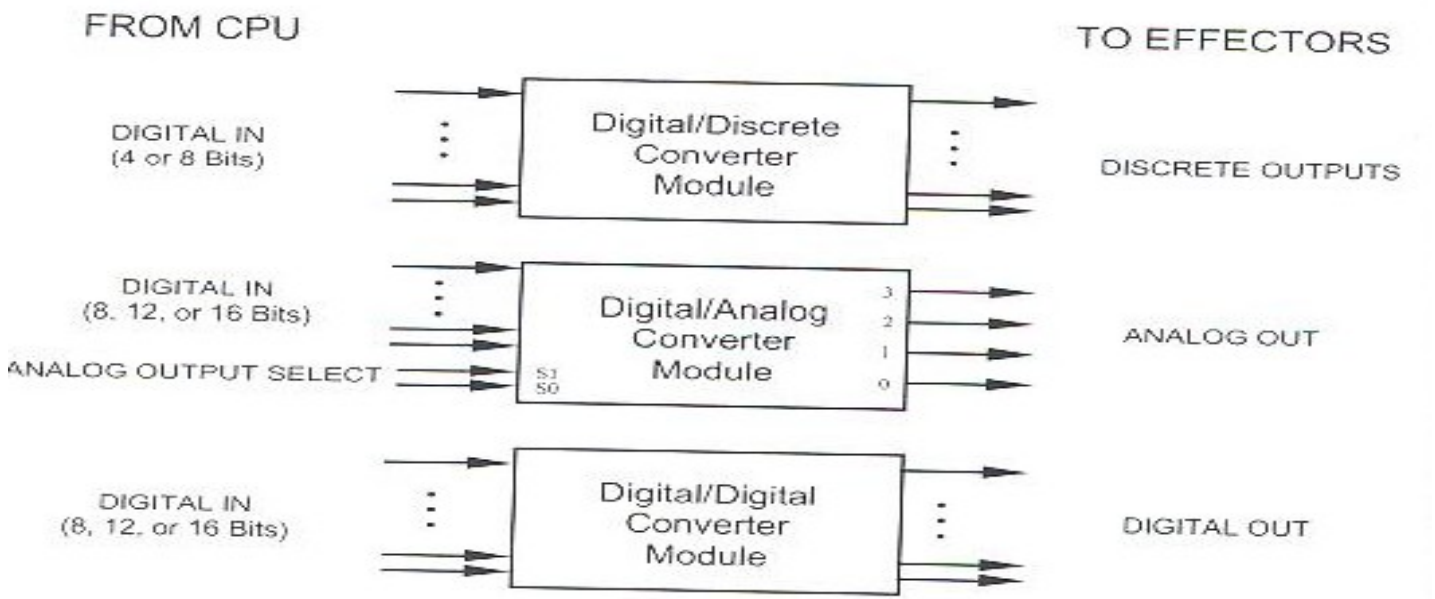

Figure 2.12 Effector Output Modules

2.2.5 Operator I/O Devices

- Allows the operator to enter information into the CPU or to receive data from it.
- Output Examples: CRT, LED, Speakers
- Input Examples: Mouse, Keyboard, Touch Screen.

2.2.6 Communication Modules

- Parallel and Series Communications
  - In **parallel** communication, eight parallel electrical lines are used to transfer a sequence of bytes, with each line dedicated a bit.
  - In **series** a single wire is used such that a byte is transmitted one bit at a time at the sending end and received and reconstructed to the original byte at the receiving end.

2.2.6 Communication Modules

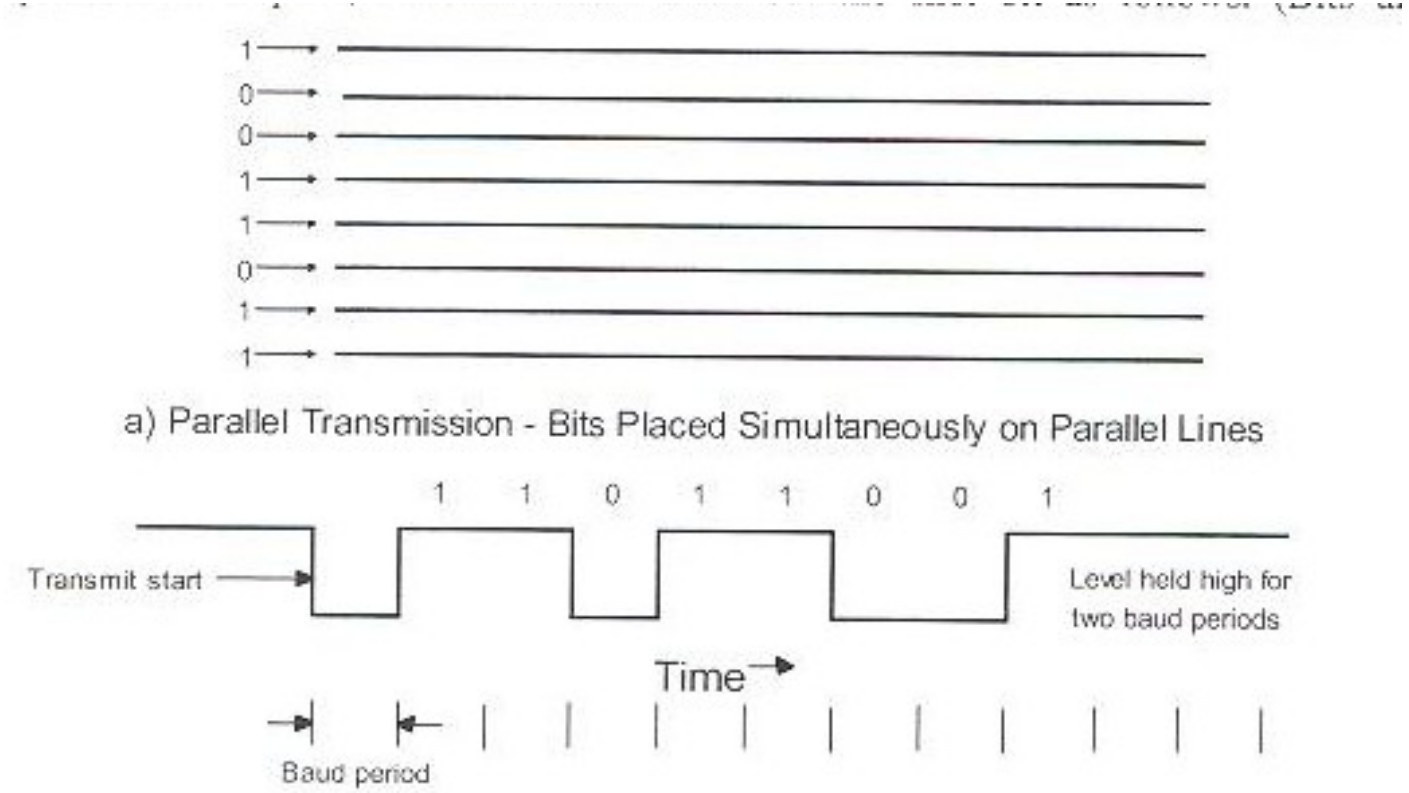

Figure 2.14 Parallel and Serial Communications

2.2.6 Communication Modules

- Universal Asynchronous Receiver Transmitter (UART)
  - It can be used across a larger number of different computer types.
  - The device contains both a receive and transmitter.
  - The device is asynchronous which means that the different baud rates on different computers would not affect the communication.

2.2.6 Communication Modules

- Bus Communications
  - These systems use serial communication but employ devices that transmit larger groups information at a time and at a much higher rate than the UART.
- Modem
  - It converts a serial data stream to a complex phase modulated signal that can be transmitted over land or wireless base telephone circuits.

2.2.7 Peripheral Units

- Large scale systems will frequently include familiar computer peripherals such as disk drives, tape drives, and printers which are all set up for the purpose of recording sensor data taken form the application.

2.2.8 Computers Within the Computer

- Computers within the computer are the microchips that are located in devices connected to the PC or within the PC.
  - Keyboard
  - Video Cards
  - Printers

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The Central Processing Unit

- **Arithmetic Logic Unit**
- **Arithmetic** – The ALU is able to perform the usual arithmetic operations of addition, subtraction, multiplication and division. The ALU operates by performing arithmetic operations on pairs of numbers yielding a single result.

- **Logic** – Each member of the pair must have the same number of bits. There are three basic logic operations within the ALU: AND, OR, XOR

Memory – How it Works

- Memory consists of a very large group of identically constructed electronic cells, each of which is either a "1" or "0" state.

- The CPU/Memory Interface has two sets of interconnections, a set of 8 parallel data lines and a set of 16 parallel address lines.

Memory – How it Works

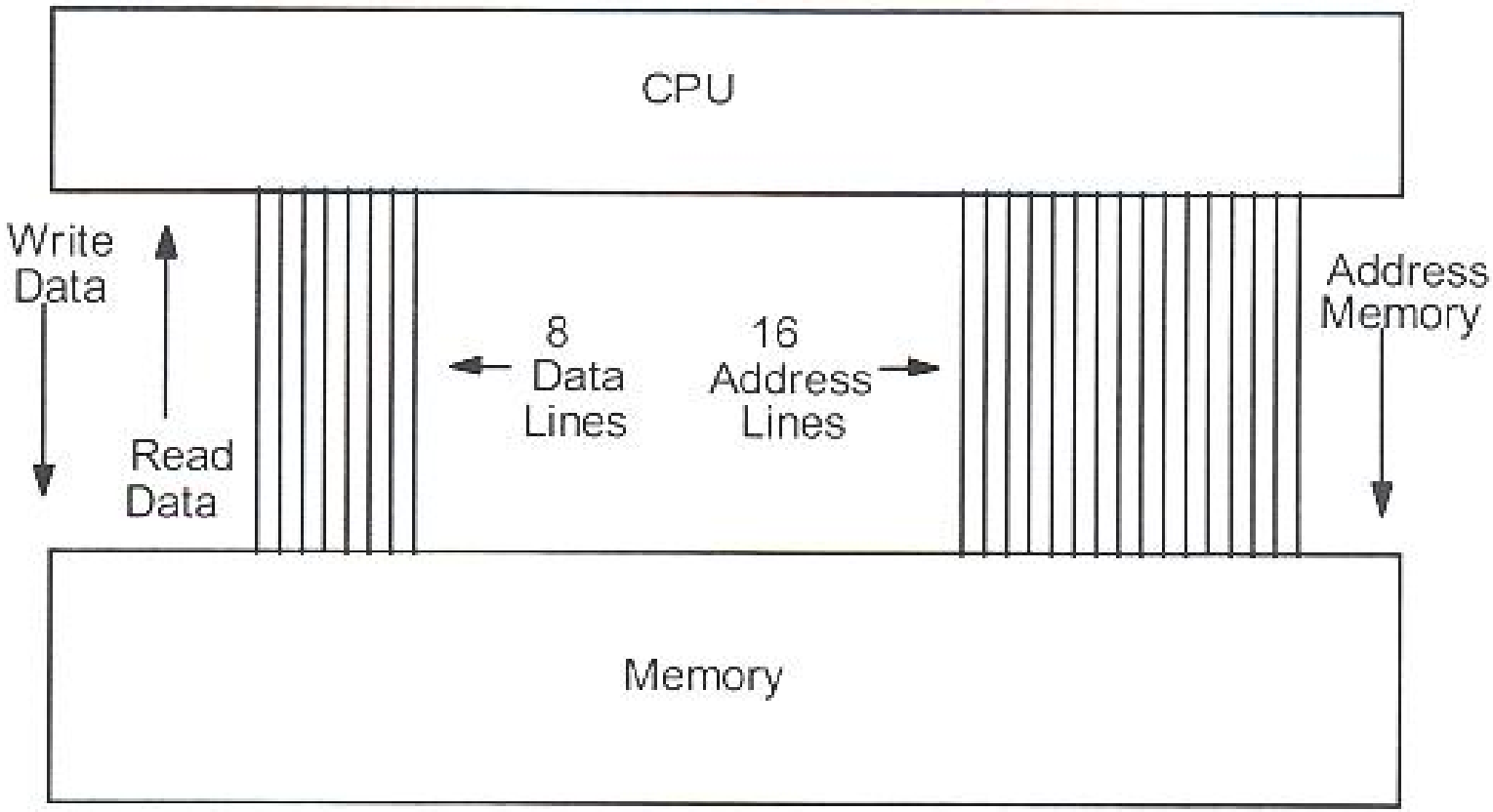

Figure 2.16 Portion of Computer Memory (16K X 1 Byte)

Memory – How it Works

- ROM – Read only Memory
- RAM – Random Access Memory

- Methods of Addressing Memory
  - Direct Addressing
  - Indexed Addressing
  - Indirect Addressing

- Devices are given a specific location in memory.

CPU Instructions – Basic Concept

- Each instruction configures CPU circuitry to perform a predetermined, distinct operation of moving data or performing arithmetic or logic.
- Each memory access CPU circuitry is set to receive either an instruction or data.
- The CPU always fetches the next available address in memory unless told to go to another location.
- Conditional branching is when is there is a choice of which address to go to. It is one of the most important inventions in modern times.

Processor Clock and Processing Speed

- The CPU is supplied with an electronic clock which is used to regulate the speed of these basic electronic operations.
- The time interval between each pulse pair is called a clock cycle.
- The rate at which a computer process information and transfer it is call throughput which is measured in bytes per second.

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How Software Works

- Software Requirements – This is the clear, and correct definition of what the software is suppose to do.

- Hardware Programming Model – This a diagram of all the components in system and how they communicate between themselves.

How Software Works

- CPU Architecture – Internal components of the CPU and their interconnect.
- CPU Function – How these components work together.
- CPU Instructions – the set of individual that direct the specific workings of the components

How Software Works

- CPU Architecture
  - **Control/Decoder Unit-** Decodes instructions and activates the functions of the internal blocks.
  - **Instructions Pointer** – Contains the address of the next instruction.
  - **Arithmetic Logic Unit** – Computes pairs of binary numbers.
  - **Accumulator** – An 8 bit cell group for holding data to be transferred by the ALU.
  - **Register** – An 8 bit cell group for temporarily holding data.

How Software Works

- CPU Function
  - Information Flow – Data bus or Address bus
  - Instruction Access – This is how the CPU obtain data from the bus lines.
  - Opcodes and Operands – the first byte is the opcode which is function to perform on the operands which is the data.
- The source is the location where data is transferred from.
- The destination is the location where data is transferred to.

Code Oriented Software Languages

- **Machine Language** – Is where instructions are written in the form of instruction bytes.
- **Assembly Language** – Basically replaces the bytes with words similar to its function.
- **High Level Languages** – Allow lines of code to be written which fit more naturally into the way people solve problems.

Code Oriented Software Languages

- **The Functional Diagram** – A widely used graphical device for stating software requirements. It can be used to represent input/output relationships for continuous systems.

- **Subroutines, Functions, and Software Libraries** – These are call code that is written and can be call to perform a certain function without the programmer developing a method.

Additional Computer System Software Requirements

- Task – Is a function that is responsible for performing a distinct portion of the overall software function.
- Initialization Task – These are the instructions that CPU follow on boot up.
- Modes
  - Startup – Initialization Task are performed
  - Standby – Operator can perform other task with other systems before putting the main system back to work.
  - Operating – Where task are perform normally

Additional Computer System Software Requirements

- Executive Software – To select modes and execute tasks, an overall, supervisory program.
- State Transition Diagrams – The design and understanding of executive software and its role in changing mode and performing task.
- Interrupts – allows the CPU to change where it gets its next instruction from.

Additional Computer System Software Requirements

- Time Structuring and Time-Critical Task Scheduling
  - This method is used in order to allows the CPU to execute commands in a very controlled order. This in turn makes the system very stable allowing it to perform at its optimum.

General Purpose Computer Software

- Off the Shelf Systems Hardware and Software
  - This is system software which the Basic Input Output System and Operating System.
- Graphic – This is the graphic user interface.

User Oriented Software Languages

- These are the software languages like Pspice, VHDH, AutoCAD and many more.
- What these program do is that they translate the images and text to code and then perform the function.
- This method has allow so many people to perform calculations that are humanly impossible.