1

INTRODUCTION TO AVIONICS

Need for Avionics in civil and military aircraft and space systems – Integrated Avionics system – Typical avionics sub systems – Design approaches and recent advances - Application Technologies.

INTRODUCTION

Avionics is a combination of aviation and electronics. Avionics system or Avionics sub-system depends on electronics. Avionics grew in 1950's and 1960 as electronic devices which replaces the mechanical or analog equipment in the aircraft.

Avionics equipment on a modern military or civil aircraft account for around;

- 30% of the total cost of the aircraft
- 40% in the case of a maritime patrol/anti-submarine aircraft or helicopter.
- Over 75% of the total cost in the case of an airborne early warning aircraft (AWACS).

NEED FOR AVIONICS

To enable the flight crew to carry out the aircraft mission safely and efficiently. For civil airliner the mission is carrying passengers to their destination. For military aircraft the mission is intercepting a hostile aircraft, attacking a ground target, reconnaissance or maritime patrol.

Advantages

- Increased safety
- Air traffic control requirements
- All weather operation
- Reduction in fuel consumption
- Improved aircraft performance and control and handling and reduction in maintenance costs

CORE AVIONICS SYSTEMS

A hierarchical structure comprising layers of specific task and avionics system function for enabling the crew to carry out the aircraft mission.

The core avionics system is depicted in figure 1.1. In the core avionics system, the systems which directly interface with pilot are given below:

Display System

It provides the visual interface between the pilot and the aircraft systems.

Types

- HUD - Head Up Displays
- HMD - Helmet Mounted Displays
- HDD – Head Down Displays

Communication System

It provides the two way communication between the ground bases and the aircraft or between aircrafts. A Radio Transmitter and Receiver was the first avionics system installed in an aircraft. The different types of frequencies used for several ranges are given below.

Long Range Communication – High Frequency (2 – 30 MHz)

Medium Range Communication – Very High Frequency (30 – 100 MHz)

Military Aircraft – Ultra High Frequency (250 – 400 MHz)

Now a days satellite communication systems are used to provide very reliable communication.

Data Entry and Control System

It is essential for the crew to interact with the avionic system. Ex: Keyboards, Touch Panels to use direct voice Input, Voice warning systems and so on.

Flight Control System

It uses the electronic system in two areas.

(i) Auto Stabilization
- Roll Auto Stabilizer System
- Pitch Auto Stabilizer System

(ii) FBW Flight Control Systems

It provides continuous automatic stabilization of the aircraft by computer control of the control surfaces from appropriate motion sensors.

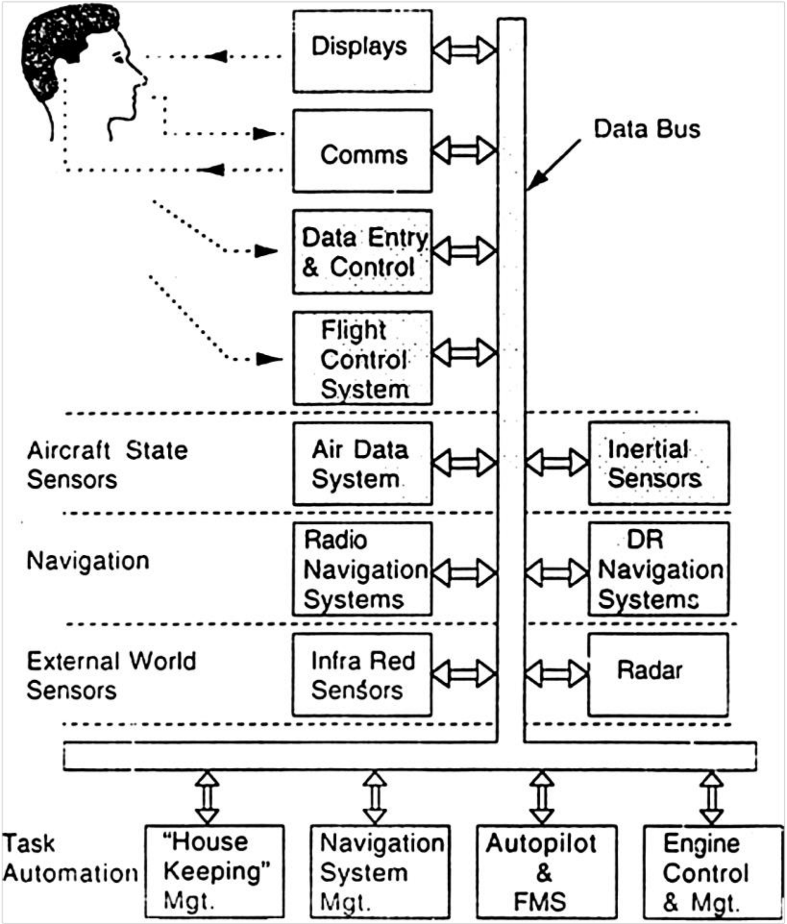


Figure 1.1 Core Avionics System

Aircraft State Sensor Systems

For control and navigation of the aircraft the air data quantities are essential.

Air Data Quantities are,

- Altitude
- Calibrated Airspeed

- Vertical speed
- True Airspeed
- Mach Number
- Airstream Incidence Angle.

The air data computing system computes these quantities from the outputs of sensors which measure the static and total pressure and the outside air temperature.

Inertial Reference System

The aircraft attitude and the direction in which it is heading are provided by the inertial sensor systems (Comprise a set of gyros and accelerometers which measures the aircraft's angular and linear motion).

Navigation System

The Navigation system provides Navigation Information (Aircraft's position, Ground speed, Track angle).

- Dead Reckoning Systems
- Position Fixing Systems

DR Navigation systems derive the vehicle's present position by estimating the distance travelled from a known position from knowledge of the speed and direction of the vehicle.

Types of DR Navigation systems are,

i) Inertial Navigation systems (Most Accurate)
ii) Doppler / Heading Reference Systems (Used in Helicopters)
iii) Air Data / Heading Reference Systems (Low Accuracy when compared to the above systems)

Radio Navigation Systems: (Position Fixing Systems)

Satellite or ground based transmitter is used to transmit the signal and it was received by the receiver in the aircraft. According to the received signals a supporting computer is used to derive the aircraft's position. The Prime Position Fixing System used in aircraft is GPS.

ILS

Instrument Landing Systems or Microwave Landing System is used for approach guidance to the airfield.

Outside World Sensor Systems

These systems comprise both radar and infrared sensor which enables all weather and night time operation.

Radar Systems

Weather Radar detects water droplets, cloud turbulence and warning about storms.

Fighter Aircrafts Radars

Multi Mode Radars for ground attack role and interception role. The Radar must be able to detect aircraft upto 100 miles away and track several aircraft simultaneously (12 aircraft's). The Radar must have a look down capability to track low flying aircraft below it.

Infrared Systems

It is used to provide a video picture of the thermal image scene of the outside world by using fixed Forward Looking Infra Red (FLIR) sensor or a gimbaled IR imaging sensor. The thermal image picture at night looks similar to the visual picture in day time, but highlights heat sources such as vehicle engines. FLIR can also be installed in civil aircraft to provide enhanced vision in addition with HUD.

Task Automation Systems

These systems reduce the crew workload and enable minimum crew operation.

Navigation Management System

It comprises the operation of all radio navigation aid systems and the combination of data from all navigation sources such as GPS and INS systems, to provide the best estimation of the aircraft position and ground speed.

Autopilots and Flight Management Systems

The autopilot relieves the pilot in long range mission.

FMS came into use in 1980's (Civil Aircraft). The FMS tasks are given below.

(i) Flight Planning
(ii) Navigation Management
(iii) Engine control to maintain the planned speed
(iv) Control of Aircraft Flight Path
(v) Minimizing Fuel consumption
(vi) Ensuring the aircraft is at the planned 3D position at the planned time slot (for Air Traffic Control).

Engine Control and Management

Modern jet engines are having the Full Authority Digital Engine Control System (FADEC). This controls flow of fuel. This control system ensures the engine's temperature, speed and acceleration in control.

Engine health monitoring system record a wide range of parameters, so it will give early warning of engine performance deterioration, excessive wear, fatigue damage, high vibrations, excessive temperature etc.,

House Keeping Management

Automation of the background task which are essential for the aircraft's safe and efficient operation.

Background tasks include

i) Fuel management
ii) Electrical power supply management
iii) Hydraulic power supply management
iv) Cabin / Cockpit pressurization systems
v) Environmental control systems
vi) Warning systems
vii) Maintenance and monitoring systems.

INTEGRATED AVIONICS SYSTEM

The combination, interconnection and control of the individual sub-systems so that the overall system can carry out its tasks effectively are referred to as integrated system. The first major step towards integrating avionic system was taken in 1950s with the establishment of the weapon system concept. The integration of avionic sub-systems in civil aircraft was taken in 1950s with the adoption of ARINC specifications. ARINC defines systems and equipment specifications in terms of functional requirements and physical dimensions and electrical interfaces.

INTEGRATED AVIONICS and WEAPON SYSTEM

The Avionics and Weapon System (AWS) in any modern day fighter aircraft enables the pilot to perform various mission functions.

Functional requirements of AWS are,

(i) Receive Inputs from sensors, communication systems, Radio navigation systems, Identification system, Missiles, Electronic counter measures system, Pilot controls.
(ii) Computation of required parameters for Navigation and Fire control.
(iii) Transferring the computed results to displays, Audio system and weapons.
(iv) Controlling of weapon launch / Firing.
(v) Control / Co-ordinate / manage sensors optimally.

Sensors

A device which detects or measures a physical property and records, indicates, or otherwise responds to it. like, Radars, Inertial Navigation System, Air Data System, Forward Looking Infrared Sensor, etc,.

Communication Systems

It is a digital datalink **system** for transmission of short messages between **aircraft** and ground stations via airband radio or satellite. Data Link, Voice Link

Radio Navigation System

Tactical Air Navigation (TACAN) is a Ultra High Frequency Navigation system.

Identification System

Identification Friend or Foe (IFF) is designed for command and control. It identifies the friendly targets but not hostile ones.

Missiles: Locked on to target

Electronic Counter Measures Systems

Radar warning receiver, Self-protection jammer, Offensive jammer.

Self Protection Jammer – It is used to prevent detection by enemy radar by jamming the signal of hostile radar.

Pilot Controls

Hands on stick and throttle controls

Parameters for Navigation and Fire control

- Navigation Algorithms – Guidance to steer point
- Fire Control Algorithms – Weapon Aiming, Missile Launch

Control Weapon Launch / Firing

Weapon selection and preparation, launch sequence and jettison (throw or drop from the aircraft).

AVIONICS SYSTEM DESIGN

Starting point for designing a digital avionics system is a clear understanding of the mission requirements.
The three stages of avionics system design are:

- Conceptual design
- Preliminary design
- Detailed design

Conceptual design considerations are,

What will it do?
How will it do it?
What is the general arrangement of parts?

The end result of conceptual design is an artist's or engineer's conception of the vehicle/product.
Example: Clay model of an automobile.

Preliminary design considerations are,

How big will it be?
How much will it weight?
What engines will it use?
How much fuel or propellant will it use?
How much will it cost?
This is what you will do in this course.

Detailed design considerations are,

How many parts will it have?
What shape will they be?
What materials?
How will it be made?
How will the parts be joined?
How will technology advancements (e.g. lightweight material, advanced airfoils, improved engines, etc.) impact the design?

DESIGN and TECHNOLOGY

Specific things to be considered while designing an Avionics Systems are,

(i) Functional Requirements
(ii) Cost
(iii) Required Safety level
(iv) Selection of Design
  - Allocation of functions to sub-systems
  - Identification of failure modes and its effects
(v) Implementation, Testing and Evaluation
(vi) Validation

(vii) Reliability
(viii) Flexibility
(ix) Weight
(x) Power

Major Design aspects are,

a) Basic Architecture
b) Inter system communication
c) Incorporation of fault tolerant system
d) Evaluation of system design

System Architectures

i) Centralized

Signal conditioning and computations are done by computers in an avionics bay and the signals are transmitted over one way data bus.

Advantages

Simple design, Software can be written easily.

Disadvantages

Long data buses are required, Possibility for damage.

ii) Federated

Sharing of input, sensor data and computed results over data buses.

iii) Distributed

Multiple processors are used for computing the task under real time basis. This Architecture is used in modern avionics system.

APPLICATION OF AVIONICS SYSTEM DESIGN TECHNOLOGY

Example: Top-level Requirement for Military Purpose

The customer prepares the statement of need and top-level description of possible missions which describes the gross characteristic of a hypothetical aircraft that could fly the mission. Customer may also describe the mission environment and define strategic and tactical philosophies and principles and rules of engagement. The system development cycle and the Aircraft Mission Requirements to Avionics System Requirements are illustrated in figure 1.2 and 1.3.

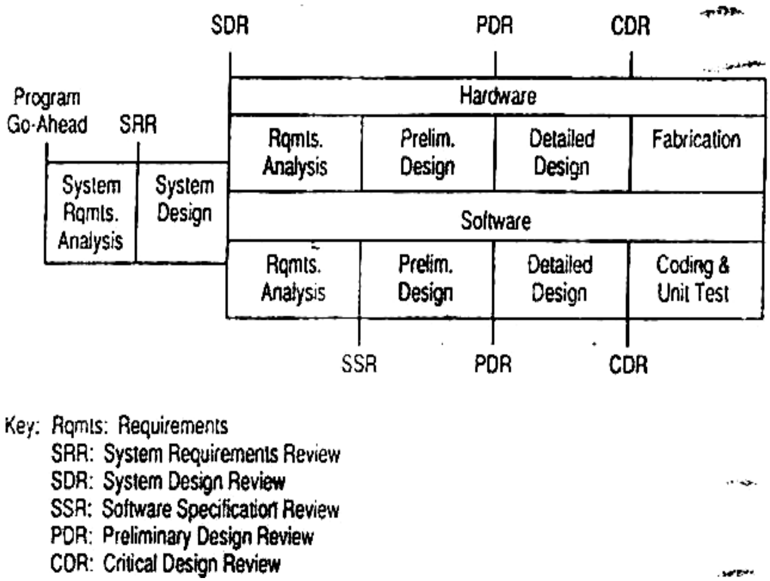


Figure1.2 System Development Cycle

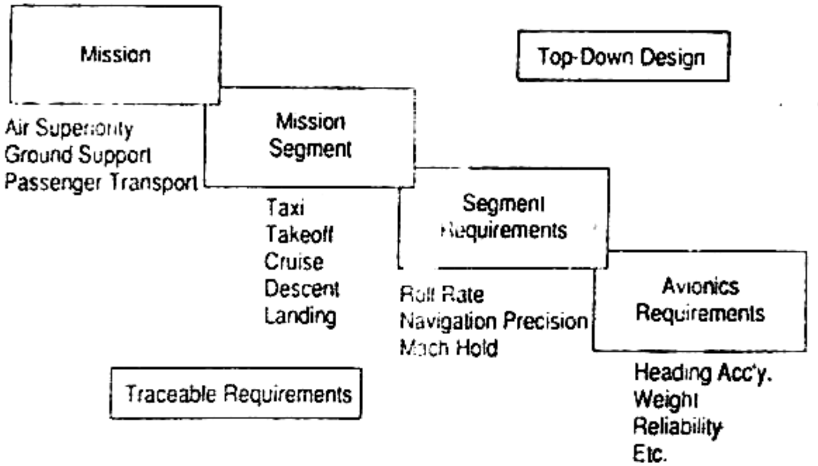


Figure 1.3 Aircraft Mission Requirements to Avionics System Requirements

"ILITIES" OF AVIONICS SYSTEM

- Capability
- Reliability
- Maintainability
- Certificability
- Survivability(military)
- Availability
- Susceptibility
- vulnerability
- Life cycle cost(military) or cost of ownership(civil)
- Technical risk
- Weight and power

Capability

- Whether the avionics system is capable?
- Can they do the job and even more?

- Designer to maximize the capability of the system within the constraints that are imposed.

Reliability

- The ability of a system or component to perform its required functions under stated conditions for a specified time.
- Designer strives to make systems as reliable as possible.
- High reliability less maintenance costs.
- If less reliable customer will not buy it and in terms of civil airlines the certificating agencies will not certify it.

Maintainability

- Closely related to reliability.
- **Maintainability** is defined as the probability of performing a successful repair action within a given time.
- System must need preventive or corrective maintenance.
- System can be maintained through built in testing, automated troubleshooting and easy access to hardware.

Availability

- Combination of reliability and maintainability.
- Trade of between reliability and maintainability to optimize availability.
- Availability translates into sorties for military aircraft and into revenue flights for civil aircrafts.

Certificability

- Major area of concern for avionics in civil airlines.
- Certification conducted by the regulatory agencies based on detailed, expert examination of all facets of aircraft design and operation.
- The avionics architecture should be straight forward and easily understandable.
- There should be no sneak circuits and no obvious modes of operation.
- Avionics certification focus on three analyses: preliminary hazard, fault tree, and FMEA.

Survivability

- It is a function of susceptibility and vulnerability.
- Susceptibility: measure of probability that an aircraft will be hit by a given threat.
- Vulnerability: measure of the probability that damage will occur if there is a hit by the threat
- Life Cycle Cost(LCC)or Cost of ownership:
  - It deals with economic measures need for evaluating avionics architecture.
  - It includes costs of varied items as spares acquisition, transportation, storage and training (crew and Maintenance personnel's), hardware development and test, depreciation and interest.

Risk

- Amount of failures and drawbacks in the design and implementation.
- Overcome by using the latest technology and fail proof technique to overcome both developmental and long term technological risks.

Weight and power

- Minimize the weight and power requirements are two fundamental concepts of avionics design.
- So the design must be light weight and power consuming which is possible through the data bus and latest advancement of electronics devices.

QUESTIONS

Part A

1. What is meant by avionics and write short notes on need for avionics in space system?
2. List out the advantage of using avionics in civil aircraft.
3. Give the advantages of using avionics in military aircraft.
4. Give the general advantage of Avionics over the conventional aircraft system.
5. Discuss the usage of avionics in space systems.
6. Give few examples of integrated avionics system used in weapon system.
7. Give few examples of integrated avionics system used in civil airlines.
8. Provide the “illities” of Avionics system.
9. Give various systems where the avionics used in aircrafts.
10. Bestow the steps involved in design of avionics system.

Part B

1. Explain the need of avionics in Civil and military aircrafts.
2. Explain few Integrated Avionics system and weapon system.
3. What are the major design drivers for avionics system and also describe the various ‘illities’ in Avionics systems.
4. With a neat block diagram explain the integration of different avionics system.
5. Explain clearly the top down design procedure that is adopted in Avionics system design and also list the factor on which Avionics design is evaluated and explain each factor in brief.
6. Explain the various layers of Avionics systems used in a typical airplane with a neat sketch.
7. Explain the design and technologies involved in avionics system and the standards used for it.

2

PRINCIPLES OF DIGITAL SYSTEMS

Digital number system- number systems and codes - Fundamentals of logic and combinational logic circuits, Microprocessors, Memories, Digital Computers

NUMBER SYSTEM

Number system is a basis for counting various items. Modern computers communicate and operate with binary numbers which use only the digits 0 and 1.

Decimal number system

In decimal number system we can express any decimal number in units, tens, hundreds, and thousands and so on. When, we write a decimal number say, 5678.9. It can be represented as

$$5000+600+70+8+0.9 \quad = \quad 5678.9$$

The decimal number 5678.9 can also be written as 5678.9_{10}, where the 10 subscript indicates the radix or base. Decimal system with its ten digits is a base-ten system.

Example:

$5678.9_{10} = 5 \times 10^3 + 6 \times 10^2 + 7 \times 10^1 + 8 \times 10^0 + 9 \times 10^{-1}$

Binary number system

Binary system with its two digits is a base-two system. The two binary digits (bits) are 1 and 0.In binary system each binary digit commonly known as bit has its own value or weight. However in binary system weight is expressed as a power of 2.

Example:

$5678.9_2 = 5 \times 2^3 + 6 \times 2^2 + 7 \times 2^1 + 8 \times 2^0 + 9 \times 2^{-1}$

Octal number system

The octal number system uses first eight digits of decimal number system: 0, 1, 2, 3, 4, 5, 6 and 7. As its uses 8 digits, its base is 8.

Example:

$5678.9 = 5 \times 8^3 + 6 \times 8^2 + 7 \times 8^1 + 8 \times 8^0 + 9 \times 8^{-1}$

Hexadecimal number system

The hexadecimal number system has a base of 16 having16 digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E and F.

Example:

$3FD_{16} = 3 \times 16^2 + F \times 16^1 + D \times 16^0$

NUMBER SYSTEM CONVERSION

1. Binary to Octal Conversion

The base for octal number is the third power of the base for binary numbers. Therefore, by grouping 3 digits of binary number and then converting each group digit to its octal equivalent.

Example: $(11101100)_2$

<u>111</u> <u>101</u> <u>100</u>

7 5 4

Octal number = $(754)_8$

2. Octal to Binary Conversion

Conversion from octal to binary is a reversal of the process of octal to binary conversion.

Example: $(754)_8$ 7 5 4

<u>111</u> <u>101</u> <u>100</u>

Binary number =111 101 100

3. Binary to Hexadecimal Conversion

The base for hexadecimal number is the fourth power for binary numbers. Therefore by grouping 4 digits of binary numbers and then converting each group digit to its hexadecimal equivalent

Example: $(1\,1\,0\,1\,1\,0\,0\,0\,1\,0\,0\ \ 1\,0\,1\ \ 1\,)_2$

<u>1101</u> <u>1000</u> <u>1001</u> <u>1011</u>

D 8 9 B

Hexadecimal number = $D89B_H$

4. Hexadecimal to Binary Conversion

Conversion from hexadecimal to binary is a reversal process of binary to hexadecimal conversion. Each digit of the hexadecimal is individually converted to its binary equivalent to get hexadecimal to binary conversion of the number.

Example: $3FD_H$

3 F D

0011 1111 1101

Binary number = 0011 1111 1101

5. Octal to Hexadecimal conversion

1. Convert octal number to its binary equivalent
2. Convert binary number to its hexadecimal equivalent

Example: $(615)_8$

Step 1: Octal to Binary

6 1 5

110 001 101

Step 2: Binary to Hexadecimal

0001 1000 1101

1 8 D

Hexadecimal number = $18D_H$

6. Hexadecimal to Octal conversion

1. Convert hexadecimal number to its binary equivalent
2. Convert binary number to its octal equivalent

Example: $25B_H$

Step 1: Hexadecimal to Binary

2 5 B

0010 0101 1011

Binary number = 0010 01011011

Step 2: Binary to Octal

001 001 011 011

1 1 3 3

Octal number =1133_8

STUDY OF BASIC GATES

THEORY

The basic elements that make a digital system are logic gate. The most common gates are NAND, OR, NOR, AND, EXOR, EXNOR gates. The NAND and NOR gates can implemented using NOT, AND and OR gates. A simple logic element whose binary output in a Boolean function (AND, OR.......) of the input is known as gates.

AND GATE

In AND gate the output Y is product of two inputs A and B. Hence even if one input is zero, the output becomes zero. If both input signals are equal to one then the output is also one.

$$Y = A.B$$

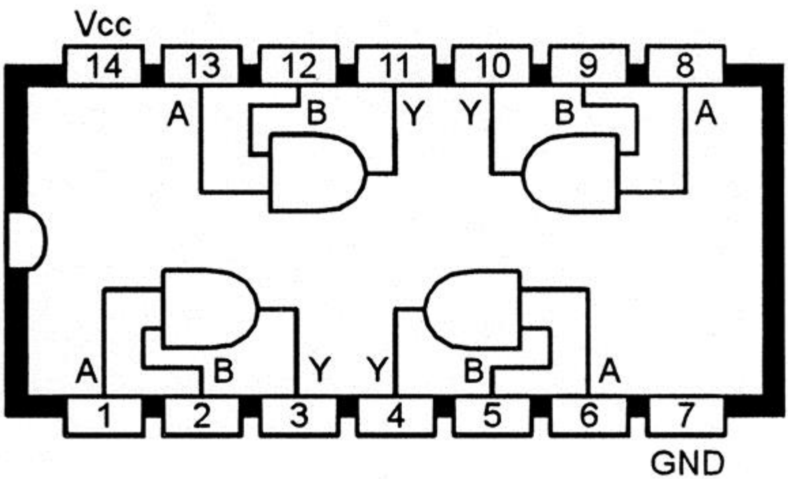


Figure 2.1 AND GATE IC 7408

TRUTH TABLE

input		output
A	**B**	**Y**
0	0	0
0	1	0
1	0	0
1	1	1

OR GATE

In the OR gate the output Y is sum of two inputs A and B. Hence even if anyone of input is one or both input are one then output becomes one. The output becomes zero only when both inputs are zero.

$$Y=A+B$$

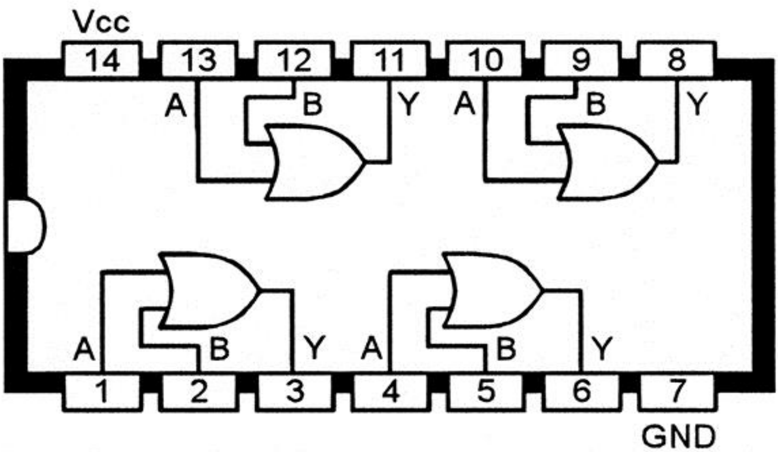


Figure 2.2 OR GATE IC 7432

TRUTH TABLE

INPUT		OUTPUT
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

NOT GATE

The NOT gate performs the basic function called inversion or complementation. The purpose of this gate is to convert one logic level into opposite logic level. It has one input and one output. When a high level is applied to an inverter, a low level appears at its output and vice versa.

Y= -A.

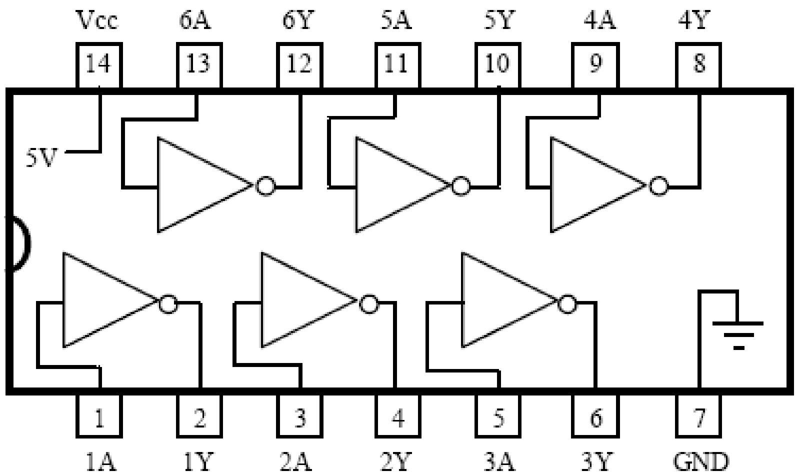


Figure 2.3 NOT GATE IC 7404

TRUTH TABLE

Input	Output
A	**B**
0	1
1	0

NAND GATE

NAND gate is construction of NOT & AND gate. It has two or more input and only one output. When inputs are HIGH, the output is LOW. If any one or both input is LOW, then the output is HIGH. The smallest circle or bubble represents the operation of inversion.

Y= - (A.B)

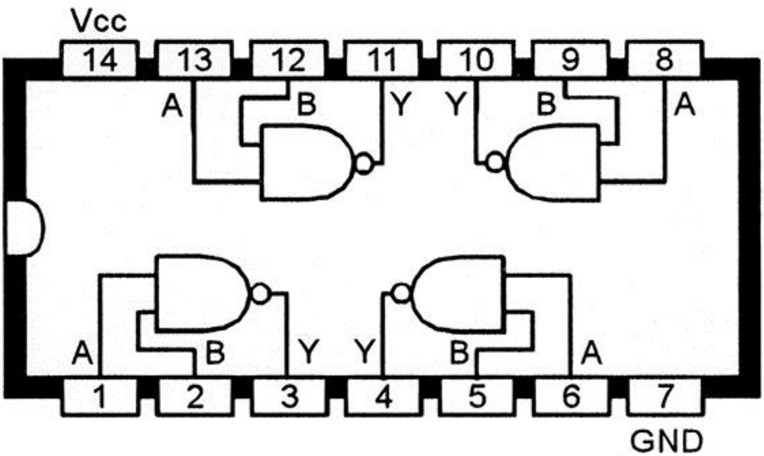


Figure 2.4 NAND GATE IC 7400

TRUTH TABLE

input		output
A	**B**	**Y**
0	0	1
0	1	1
1	0	1
1	1	0

NOR GATE

NOR is construction of NOT-OR gates. It has two or more inputs and one output. The output is HIGH only when all the input is LOW. If both inputs are HIGH then output is low. The small circle or bubble represents the operation of inversion.

Y= - (A+B)

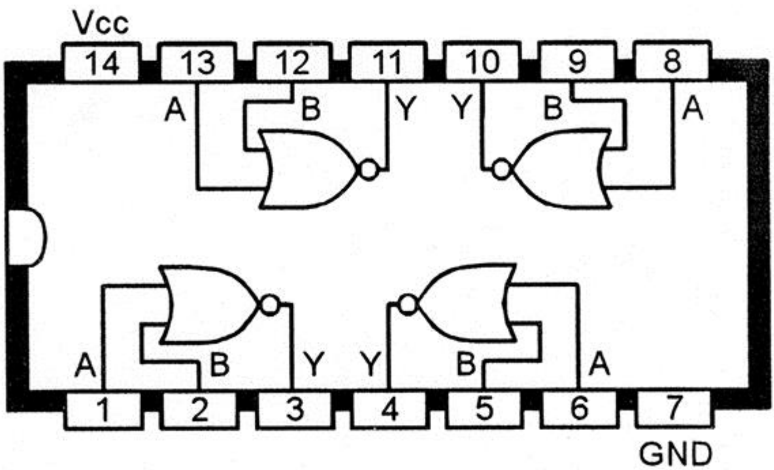


Figure 2.5 NOR GATE IC 7402

TRUTH TABLE

Input		Output
A	**B**	**Y**
0	0	1
0	1	1
1	0	1
1	1	0

EX-OR GATE

An exclusive OR gate is a gate with one or more inputs and one output. In two input EX-OR gate, if both inputs A and B same (00 or11) means the output is always HIGH. For other inputs the output will be LOW.

Y= (-AB+A-B)

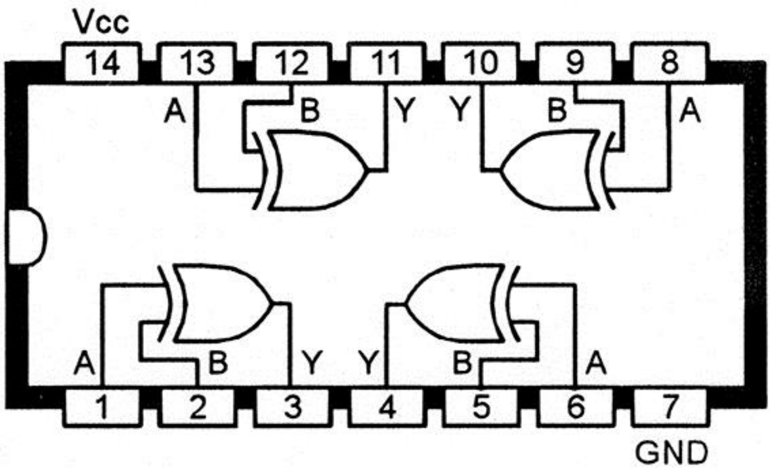


Figure 2.6 EX -OR GATE

TRUTH TABLE

Input		Output
A	**B**	**Y**
0	0	0
0	0	1
1	1	1
1	1	0

MICROPROCESSOR

Architecture of 8085 Microprocessor

A simplest microprocessor and its minimum blocks are:

- Arithmetic Logic Unit
- Register array
- Timing and Control unit

The Architecture, components, interconnection of all the blocks and internal registers and flags of a microprocessor are shown in figure 2.7. The components, internal architecture and internal registers & internal flags are shown in figure 2.8, 2.9 and 2.10.

BUS

The various blocks are interconnected by a set of wires called "**BUS". **The bus is used to transfer the information in binary form. The bus is also used for connection to the external devices. There are two types of Buses. The address bus and data bus.

- The address bus transfers the address which is required for the selection of the external devices.

- The data bus is used for transfer data.

ARITHMETIC LOGIC UNIT

The arithmetic logic unit is the main part of the microprocessor which performs the arithmetic and logical operations.

- One of the data to ALU is supplied through the BUS-A, and the other data is given through BUS-B.
- The result of the ALU is returned back to the internal bus through BUS-C.
- The flag register is a block that contains part of the result like CARRY after addition.

REGISTER ARRAY

The register consists of group of registers. A register consists of set of flip flops. Each flip flop can store one bit of data. If 8 flip flops are grouped to form a register, the register can hold 8 bits of data and it is called 8-bit register.

- All the registers are connected to the internal bus so that the data in the register can be used by ALU and data in the registers can be changed by ALU.

TIMING AND CONTROL

The operation of the various blocks of the microprocessor need to be synchronized for co-ordinated operations to achieve the required results. For this purpose, the microprocessor will have a block called “timing and control unit”.

This block generates various “timing control signals” which are connected to each block of the microprocessor. These signals will decide the operation of the blocks and the time at which the operation of the block need to be initiated.

INSTRUCTION REGISTER and INSTRUCTION DECODE

The microprocessor executes a program. The program is written in the form of series of instructions. One of the instructions to be executed is stored in the “instruction”. Thus the “instruction register” is used to hold the instruction to be executed.

Each instruction is in the form of code. The block “instruction decode” perform the operation of decoding the instruction.

ADDRESS BUS, CONTROL BUS and DATA BUS

These are set of wires used for connecting the external devices to microprocessor.

The address bus is required for the microprocessor to send the address to the external devices. The address is required for selecting one of the many peripheral devices connected to the microprocessor.

The control bus is used for sending the control signals to the selected external hardware to specify whether the device should give the data to the microprocessor or take the data from the microprocessor. If the data is given to the microprocessor by the external device, it is called READ operation. The WRITE operation specifies the transfer of data from microprocessor to the external device.

The data bus is used for transfer of data between the microprocessor and the external device in either of the direction

Architecture of 8085 Microprocessor

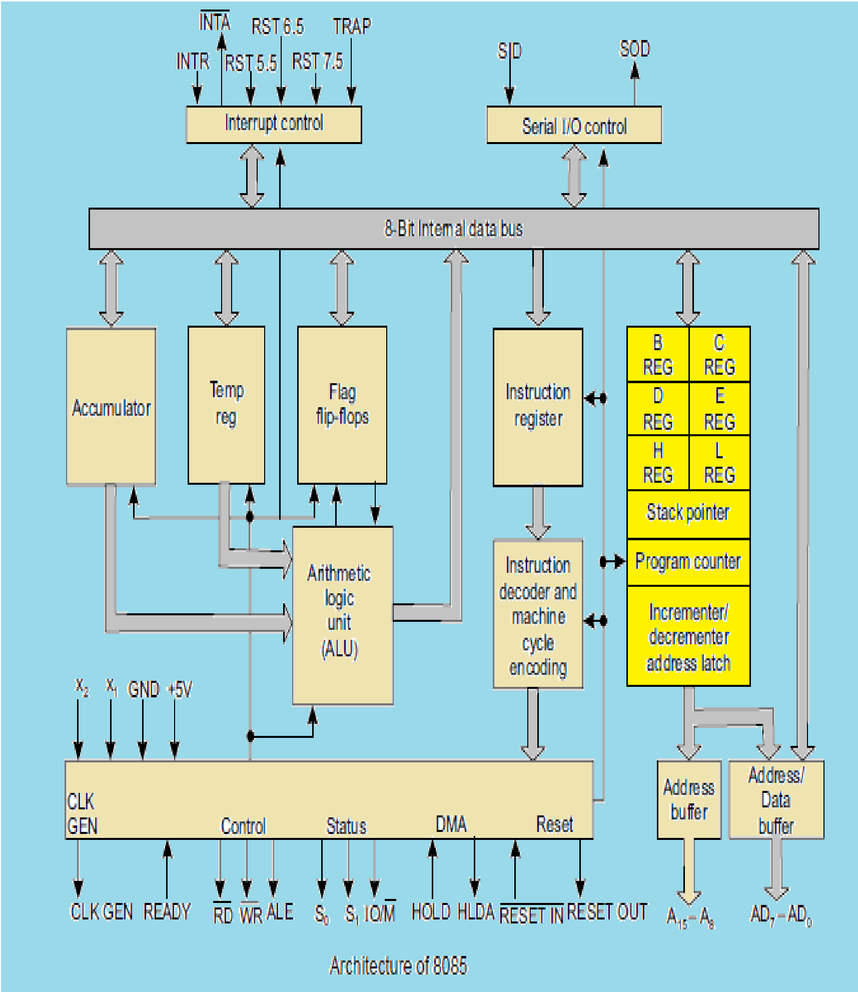


Figure 2.7 Microprocessor Architecture

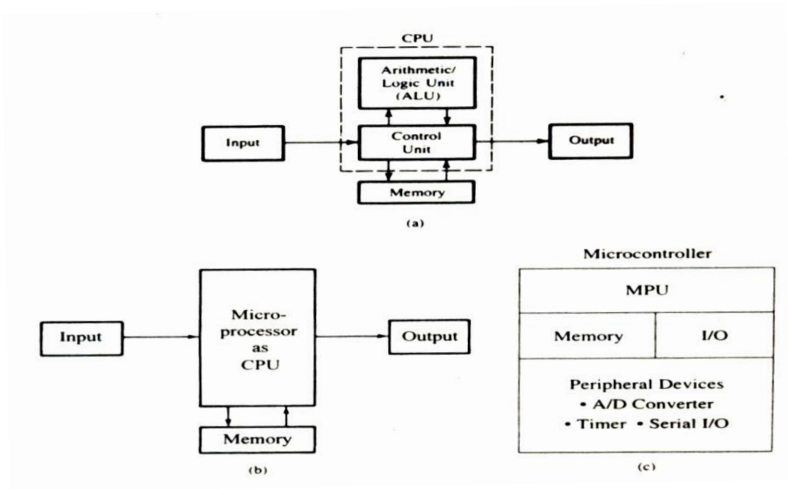


Figure 2.8 Components of Microprocessor

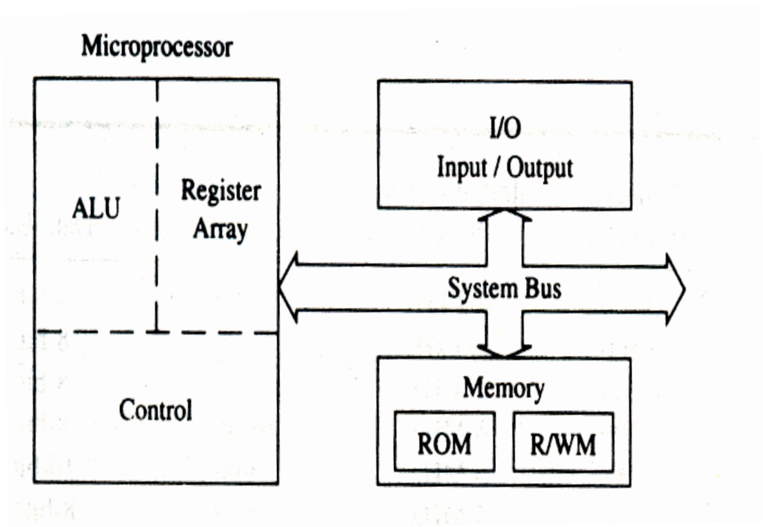


Figure 2.9 Internal Architecture of Microprocessor

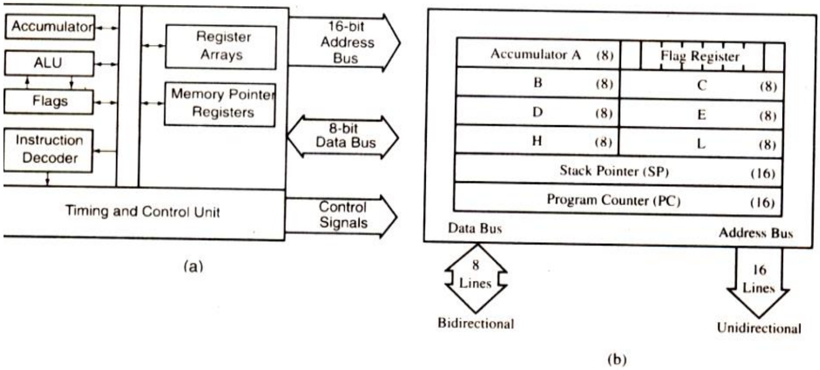


Figure 2.10 Internal Registers and Flags of 8085A

WORKING PRINCIPLE OF MICROPROCESSOR

The basic operation of the microprocessor is execution of program. A program is a series of instructions stored in the memory. Each instruction is a code that specifies the operation to be performed by the microprocessor. The program is stored in an external memory.

The memory is connected to microprocessor through data bus, address bus, and control bus as shown in the figure 2.9. Similarly the input and output devices are also connected to the microprocessor as shown in the figure 2.9.

Each input or output device is connected through a port. A port is an electronic hardware used for the purpose of connecting input/output device to the microprocessor.

The operation of the microprocessor which is execution of the program can be explained as follows:

The first operation done by the microprocessor is **instruction fetch**. The following steps are performed to fetch an instruction.

1. The microprocessor generates the address of the memory and sends the same on the address bus to enable the memory device.
2. Using the control bus, the microprocessor sends a control signal to memory.
3. In response to this signal the memory sends one information to the microprocessor on the data bus.

The second operation is **instruction decodes and execute**. This requires the following steps.

1. Inside the microprocessor, the instruction sent by the memory will be stored in the instruction register.
2. The instruction decode block of the instruction to understand which operation to be performed.
3. Timing and control unit generates the timing control signals to synchronize the operation of the various blocks of the microprocessor. One of these control signals is connected to ALU to indicate which operation is to be performed.

The ALU takes data from the internal registers of the microprocessor and the result of the operation is stored in one of the register. Sometimes the data can be taken from memory also and the result can be stored in the memory.

To access the data in the input /output device:

1. The corresponding port is enabled by sending the address of the port on the address bus.
2. Suitable control signal is sent on the control bus.
3. The data is transferred on the data bus.

MEMORY

It is a circuit that can store bits – high or low, generally voltage levels or capacitive charges representing 1 or 0.

A flip – flop or a latch is a basic element of memory. To write or store a bit in the latch, we need an input data and an enable signal. The stored bit is always available on the output line D_{out}. This latch which can store one binary bit is called a memory cell.

Four such cells or latches grouped together is called as register, which has four input lines and four output lines and can store four bits.

ROM doesn't need the WR signal

CS –Chip Select

RD-Read Signal

WR –Write signal

The primary function of memory is to store instructions and data and to provide that information to the MPU whenever it requires it. The MPU request information by sending the address of a specific memory register on the address bus and enables the data flow by sending the control signal.

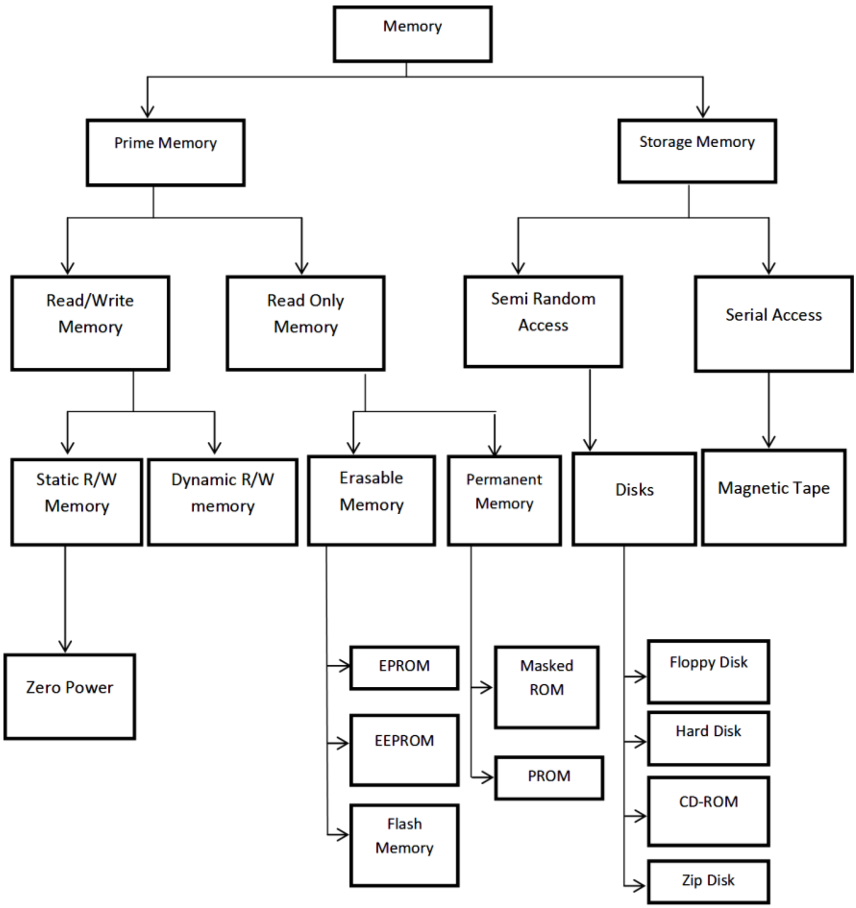
CLASSIFICATION OF MEMORIES

Memory stores binary instructions and data for the microprocessor. The read/write memory is made of registers, and each register has a group of flip-flops or FET that store bits of information. The Flip-Flops are called memory cells. The number of bits stored in a register is called memory word.

ROM stores information permanently in the form of diodes. Group of diodes can be viewed as registers. In a memory chip all the registers are arranged in a sequence and identified by binary numbers called memory address. The size of the memory chip is specified in terms of bits.

To communicate with memory, the MPU should be able to

i) Select the chip
ii) Identify the Register
iii) Read from or write into the register



Read/Write and ROM – Microprocessor uses this memory for executing and sharing programs.

Read/Write Memory

The memory is volatile, i.e. all the contents are destroyed when the power is turned off.

RAM

This memory is made up of flip flops, and it stores the bit as a voltage. It is more expensive and consumes more power than dynamic memory. It has low density but its speed is very high.

DRAM

This is made up of MOS transistor gates, and it stores the bit as charge. It has high density and it consumes low power, and cheaper. But the charge leak is a disadvantage for it.

ROM

It is a non-volatile memory.

Masked ROM

A bit pattern is permanently recorded by the masking and metallization process.

PROM

It has nichrome or polysilicon wires arranged in a matrix. This memory can be programmed by a special PROM programmer. The process is known as burning the PROM and the information stored is permanent.

EPROM

This memory stores a bit by charging the floating gate of an FET. High voltages are required to charge the gate. All the information can be erased by exposing the chip to ultraviolet light through its quartz window.

Disadvantages

The erasing process takes 15 to 20 minutes.
The entire chip has to be erased.

EE-PROM

This is similar to EPROM, except that information can be altered by using electrical signals at the register levels rather than erasing all the information.

Flash Memory

The Flash memory can be erased either entirely or at the sector level. These chips can be erased and programmed atleast a million times. This is suitable for low power systems. Zero power RAM is a CMOS R/W memory with battery backup built internally. It includes lithium cells and voltage sensing circuitry. When the external power supply falls below 3V, the power switching circuitry connects the lithium battery.

DIGITAL COMPUTER

Any accessory with a micro processing chip can be considered as a type of digital computer. However, today digital computers are commonly referred to as personal computers, and laptops.

A digital computer is designed to process data in numerical form. Its circuits directly perform the mathematical operations of addition, subtraction, multiplication and division. The numbers operated by a digital computer are expressed in binary digits.

Binary digits are easily expressed in the computer circuitry by the presence (1) or absence (0) of a current or voltage.

Digital computers can store the results of calculations for later use, and also it compares the results with other data. DC's are used for reservation systems, scientific investigation, data processing and many others.

Processing Data

The operations of DC are carried out by logic circuits, whose single output is determined by the conditions of the inputs, usually two or more. The various circuits processing data in the computer must operate in highly synchronized manner and this can be achieved by using the clock. Clock rates ranges from several million cycles per second to several hundred million.

Clock rate – The speed at which a microprocessor executes instructions. Every computer contains an internal clock that regulates the rate at which instructions are executed and synchronizes all the various computer components.

Clock rates of about billion cycles per second. Operating at these rates, DC's are capable of performing thousands to trillions of arithmetic or logic operations per second.

Storage and Retrieval of Data

An information storage and retrieval system (ISRS) is a network with a built-in user interface that facilitates the creation, searching, and modification of stored data. The data or results are stored for periods of time ranging from small fraction of second to days or weeks.

Computer Programs and Languages

The computer is programmed to translate this high level language into machine language and then it solves the original program or problem.

Analog Computers

It represents data as physical quantities and operates on the data by manipulating the quantities. The key component of Analog Computers is the Operational Amplifier, and the Analog Computers capacity is determined by the number of amplifiers it contains. Analog Computers are found in such forms as speedometers and watt-hour meters.

QUESTIONS

Part – A

1. What are digital computers?
2. What is a volatile memory and give examples?
3. Differentiate between volatile and non volatile memories.
4. Write short notes about 8085 microprocessor.
5. Give the usage of microprocessors in Avionics system.
6. Write notes about the registers in microprocessor.
7. What is Accumulator?
8. List the types of memories.
9. Bestow the major components of microprocessor.
10. What is meant by fetching?

Part – B

1. With a neat sketch explain 8085 microprocessor architecture in detail.
2. Draw the functional representation of ROM memory cell and explain the concept underlying the ROM.
3. Describe with a block schematic how a digital computer can be used to measure analog signal.
4. Explain the interference of seven segment LED with the microprocessor to display a binary data.
5. Compare the memory mapped I/O and peripheral mapped I/O in Microprocessor.

3

FLIGHT DECK AND COCKPITS

Control and display technologies CRT, LED, LCD, EL and plasma panel - Touch screen - Direct voice input (DVI) - Civil cockpit and military cockpit: MFDS, HUD, MFK, HOTAS, HMD.

Introduction

Modern aircrafts employs a variety of display technologies on the flight deck which includes,

a) Cathode Ray Tubes (CRT)
b) Light Emitting Diodes (LED)
c) Liquid Crystal Display (LCD)
d) Electro Luminescent Display (ELD)
e) Plasma Display (PD)

Flat panel displays such as Active Matrix Liquid Crystal Displays (AMLCD) offer savings in volume compared to CRT displays. Developments in the miniaturization of electronic components (Ex: Modern Surface Mounted Devices and VLSI) leads to production of complex multi-function instrument with display in a single enclosure. This single box concept reduces the amount of cabling required and also simplifies the maintenance.

Advantages of AMLCD

i) Less weight
ii) Consumes less power
iii) Consumes less volume
iv) Reliability
v) High Resolution
vi) Supports Adjustable brightness levels
vii) Immunity to colour desaturation
viii) Maintains display performance over a range of viewing Angles.

CRT Displays

The CRT is the oldest display technology in current aircraft use. Some very Old Displays like Mechanical Indicators, Filament lamps and moving coil meters are not in use today.

Advantages

a) They operate at any resolution, geometry and aspect ratio without the need for rescaling the image.

b) CRTs run at the highest pixel resolutions generally available.

c) Produce a very dark black and the highest contrast levels normally available. Suitable for use even in dimly lit or dark environments.

d) CRTs produce the very best color and gray-scale and are the reference standard for all professional calibrations. They have a perfectly smooth gray-scale with an infinite number of intensity levels. Other display technologies are expected to reproduce the natural power-law Gamma curve of a CRT, but can only do so approximately.

e) CRTs have fast response times and no motion artifacts. Best for rapidly moving or changing images.

f) CRTs are less expensive than comparable displays using other display technologies.

Disadvantages

a) The CRT's Gaussian beam profile produces images with softer edges that are not as sharp as an LCD at its native resolution. Imperfect focus and color registration also reduce sharpness. Generally sharper than LCDs at other than native resolutions.

b) All color CRTs produce annoying Moiré patterns. Many monitors include Moiré reduction, which normally doesn't eliminate the Moiré interference patterns entirely.

c) Subject to geometric distortion and screen regulation problems. Also affected by magnetic fields from other equipment including other CRTs.

d) Relatively bright but not as bright as LCDs. Not suitable for very brightly lit environments.

e) Some CRTs have a rounded spherical or cylindrical shape screen. Newer CRTs are flat.

f) CRTs give off electric, magnetic and electromagnetic fields. There is considerable controversy as to whether any of these pose a health hazard, particularly magnetic fields. The most authoritative scientific studies conclude that they are not harmful but some people remain unconvinced.

g) They are large, heavy, and bulky. They consume a lot of electricity and produce a lot of heat.

Arrangement

The cathode, heater, grid and anode assembly are shown in figure 3.1. The assembly forms an electron gun which produces a beam of electrons. These electrons are focused on the rear phosphor coating of the screen.

The heater raises the temperature of the cathode which is coated with thoriated Tungsten. This material emits electron when it is heated. These electrons form a cloud above the cathode and become attracted by various anodes. The grid is used to control the flow of electrons.

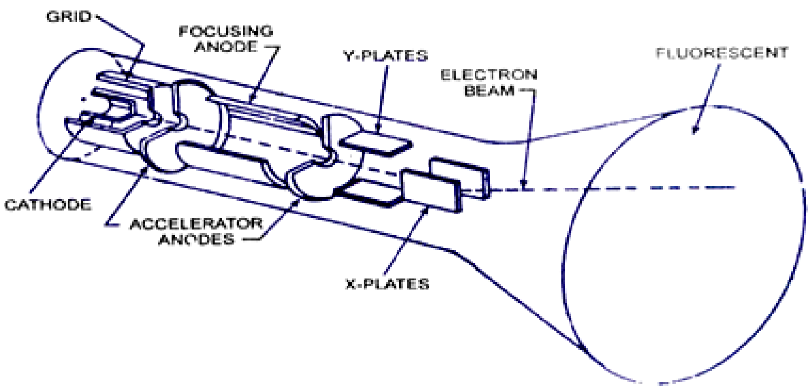


Figure 3.1 Cathode Ray Tube

Grid

It consists of fine wire mesh through which the electrons must pass. The grid is made negative with respect to cathode and this negative potential is used to repel the electrons. By controlling the grid potential it is possible to vary the amount of electrons passing through the grid, which controls the intensity (brightness) of display on screen.

The focus anode consists of two or three tubular structures through which the electron beam passes. By varying the relative potential on these anodes it is possible to bend and focus the beam.

The final anode consists of graphite coating and this anode is given a very high positive potential for accelerating the beam of electrons. So an electron beam of high energy impacts on the phosphor coating. The energy liberated by the collision of the electrons with phosphors is converted into light.

Deflection

It is necessary to bend the beam inorder to move the beam to different parts of the screen. Electrostatic deflection is commonly used for small CRT. In this method two sets of plates are introduced between the focus anodes and the final anode.

One pair of plates is aligned with the vertical plane (i.e. X plates) which provides the deflection of beam in the Horizontal direction. The other pair of plates is aligned in the horizontal lane which provides the deflection of beam in the vertical direction which is shown in figure 3.2.

By placing the voltage on the plates it is possible to bend the beam towards or away from a particular plate. Electromagnetic Deflection is an alternative to electrostatic deflection, and it uses externally applied magnetic field to deflect the electron beam. In this method two sets of coils are placed (externally) around the neck of the CRT.

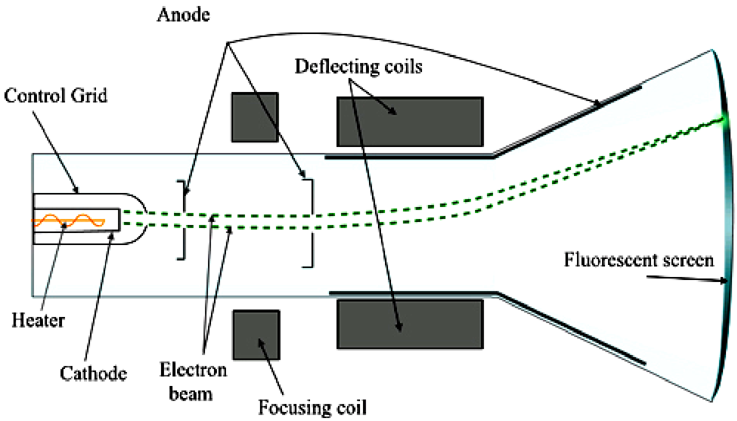


Figure 3.2 CRT with Deflection Coils

Scanning

It is used to cover the full screen area of a CRT display. It can be done by scanning the beam up and down and also left to right.

Colour Displays

By using a pattern of phosphors of different colours and also by using a CRT with three different cathodes, it is possible to display colour information.

A range of colours can be generated by combining three different colours in various amounts.

In the diagram 3.3 three separate video signals are fed to the three cathodes of the CRT. These signals are derived with the help of video processing circuit.

Ex: The beam generated by the red cathode coincides with the red phosphors.

A synchronizing system generates the ramp wave form which ensures the time relationship between the signals are correct.

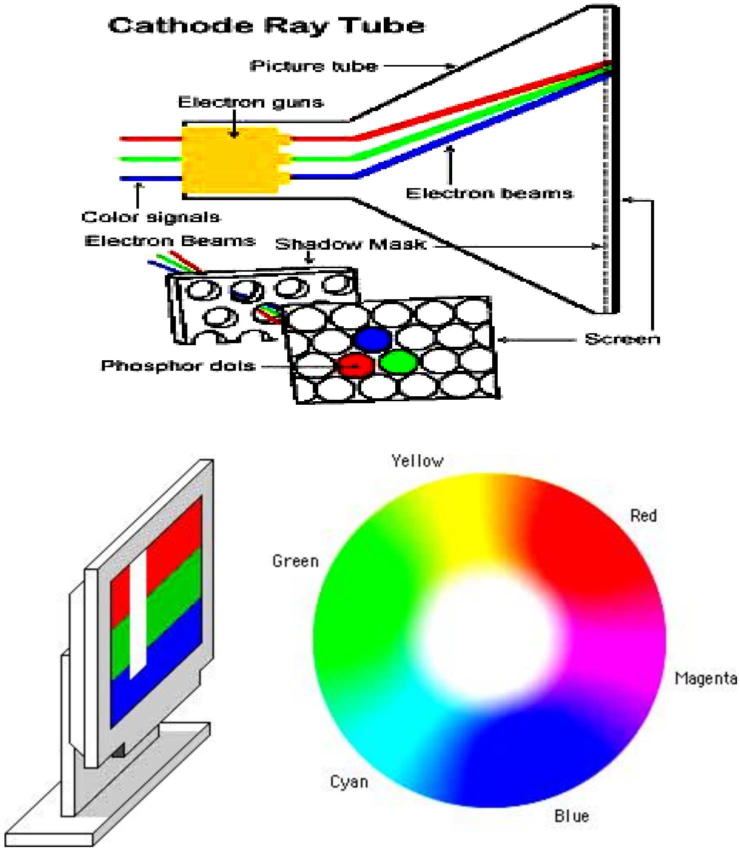


Figure 3.3 CRT with Colour Display System

CRT Control

A dedicated CRT controller integrated CRT acting in conjunction with video / synchronizing interface provides the necessary control signals for the CRT.

The CRT controller is controlled by a dedicated CPU, which accepts data from the bus and buffers the data for display.

The Direct Memory Access (DMA) is used to minimize the burden on the CPU.