



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.

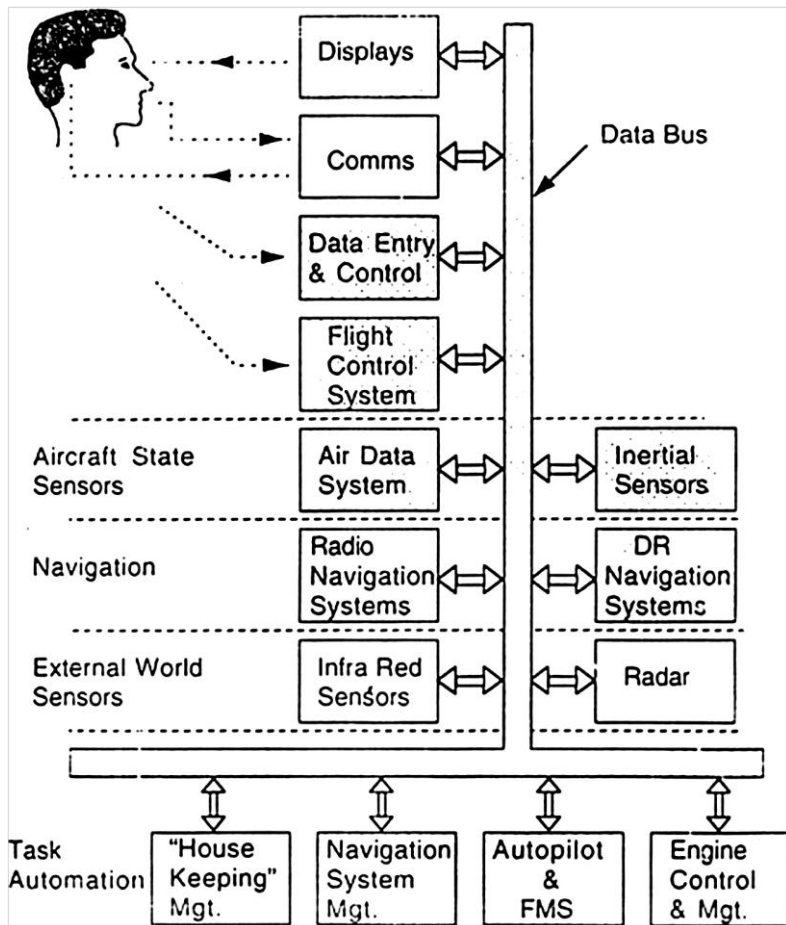


Figure 1.1 Core Avionics System

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.

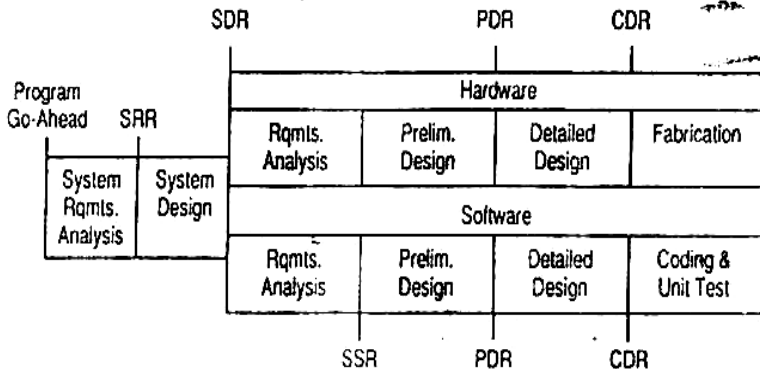
iii) Distributed

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.



Key: Rqmts: Requirements
 SRR: System Requirements Review
 SDR: System Design Review
 SSR: Software Specification Review
 PDR: Preliminary Design Review
 CDR: Critical Design Review

Figure 1.2 System Development Cycle

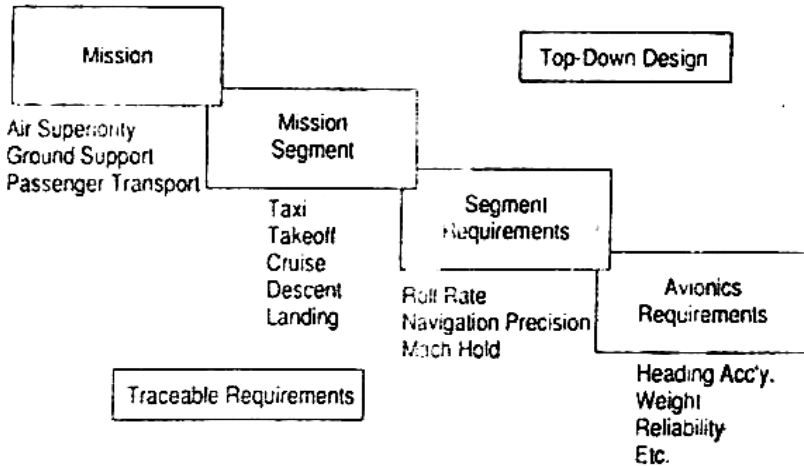


Figure 1.3 Aircraft Mission Requirements to Avionics System Requirements

“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

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

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 it 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 having 16 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: $(11101100)_2$

$$\begin{array}{ccc} \underline{111} & \underline{101} & \underline{100} \\ 7 & 5 & 4 \\ \text{Octal number} & = & (754)_8 \end{array}$$

2. Octal to Binary Conversion

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

Example: $(754)_8$

$$\begin{array}{ccc} 7 & 5 & 4 \\ \underline{111} & \underline{101} & \underline{100} \end{array}$$

$$\text{Binary number} = 111\ 101\ 100$$

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: $(110110001001011)_2$

$$\begin{array}{cccc} \underline{1101} & \underline{1000} & \underline{1001} & \underline{1011} \\ D & 8 & 9 & B \end{array}$$

$$\text{Hexadecimal number} = D89B_H$$

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

<u>0001</u>	<u>1000</u>	<u>1101</u>
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

<u>001</u>	<u>001</u>	<u>011</u>	<u>011</u>
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.

$$Y=A.B$$

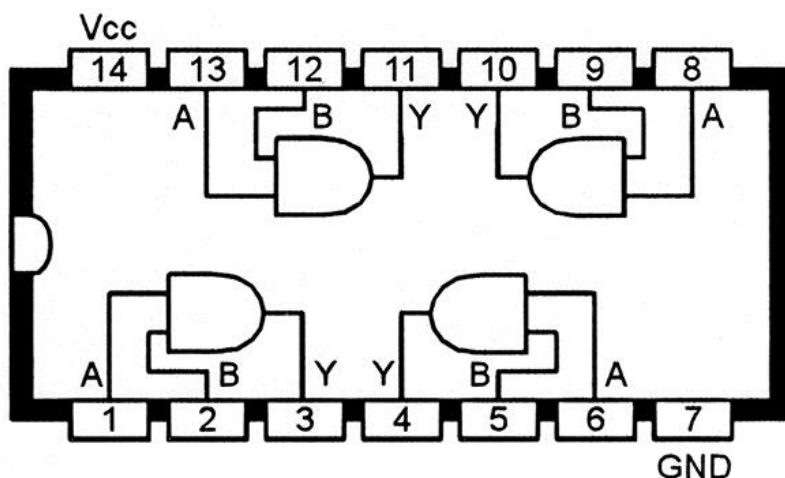


Figure 2.1 AND GATE IC 7408

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.

$$Y=A+B$$

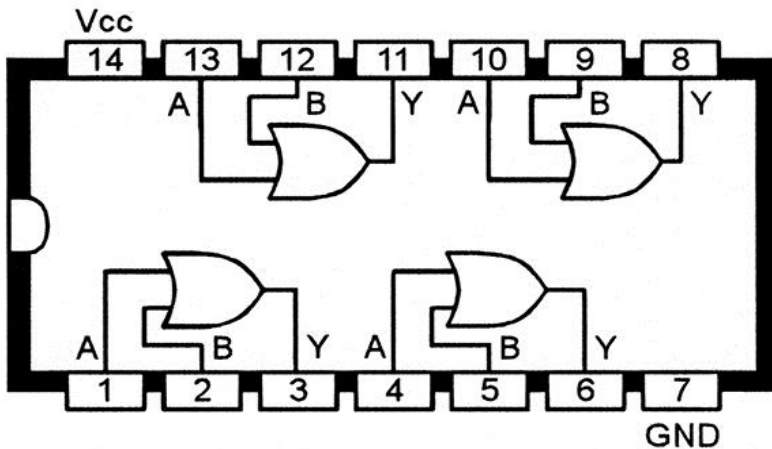


Figure 2.2 OR GATE IC 7432

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.

$$Y = \neg A.$$

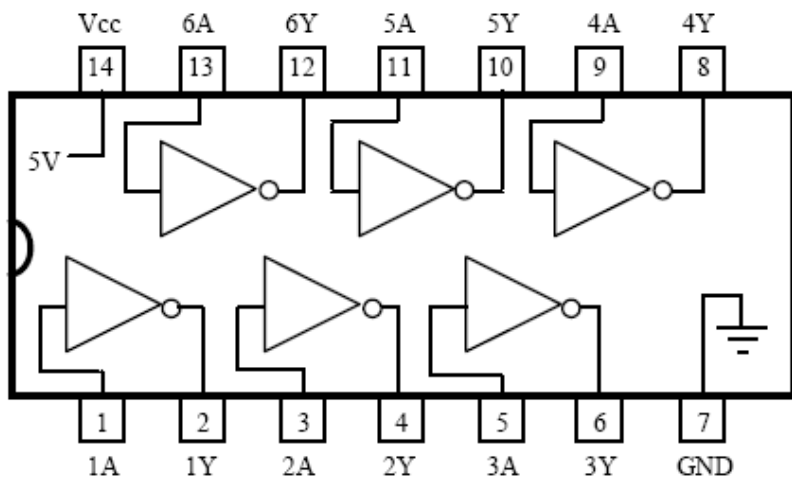


Figure 2.3 NOT GATE IC 7404

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.

$$Y = \neg (A \cdot B)$$

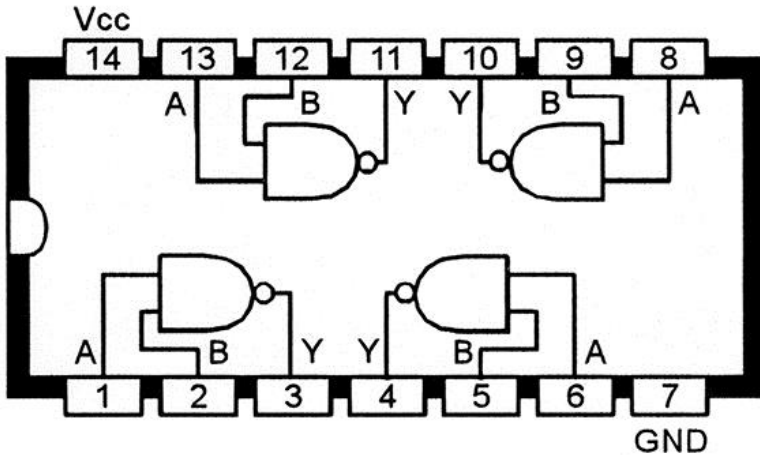


Figure 2.4 NAND GATE IC 7400

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.

$$Y = \overline{A+B}$$

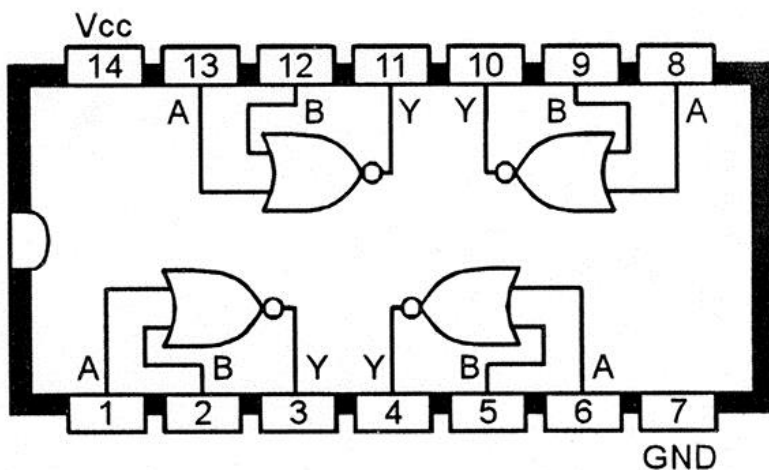


Figure 2.5 NOR GATE IC 7402**TRUTH TABLE**

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 or 11) means the output is always HIGH. For other inputs the output will be LOW.

$$Y = (-AB + A-B)$$

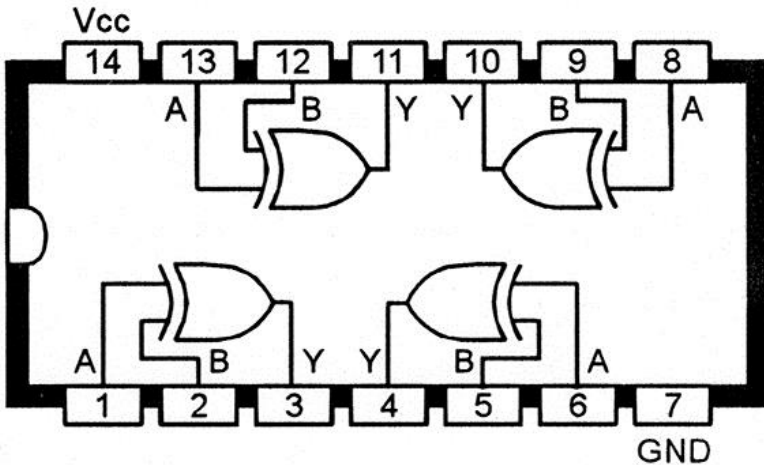


Figure 2.6 EX -OR GATE**TRUTH TABLE**

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

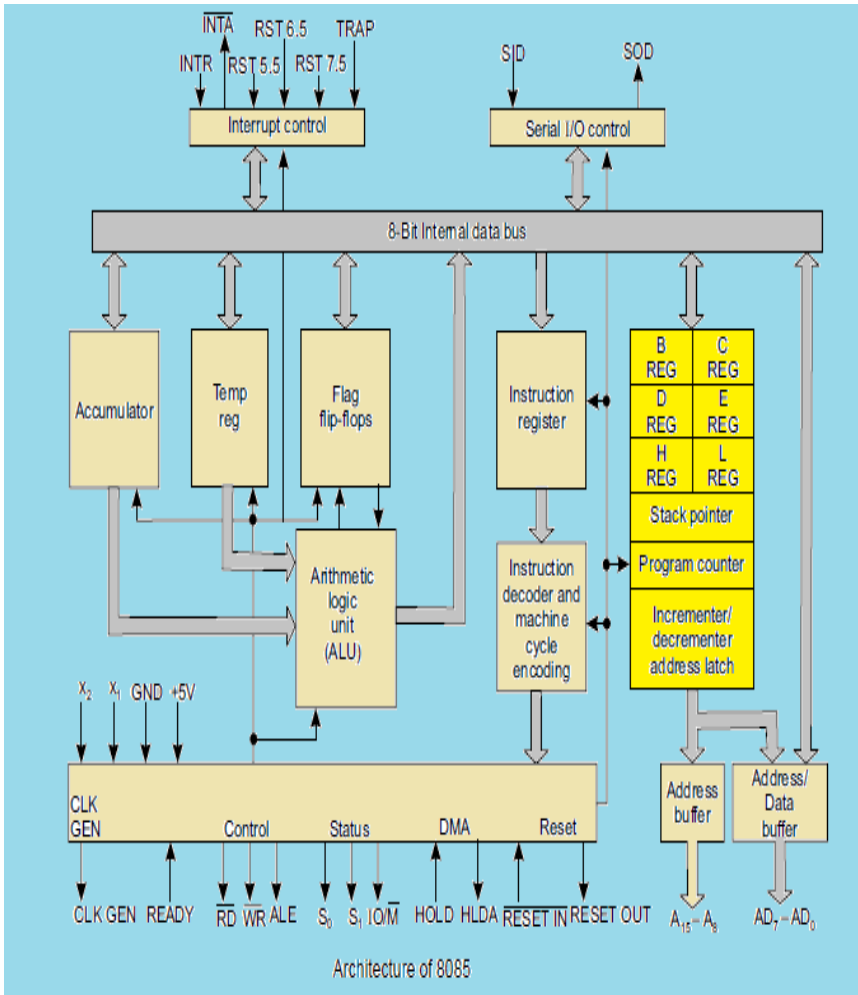


Figure 2.7 Microprocessor Architecture

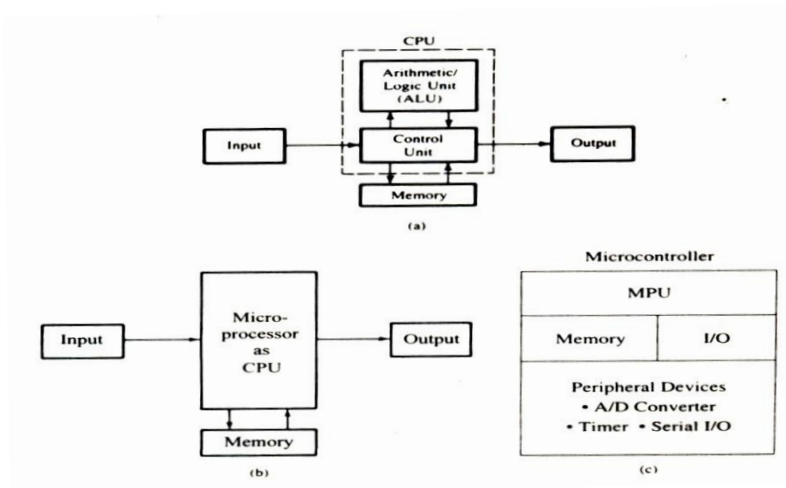


Figure 2.8 Components of Microprocessor

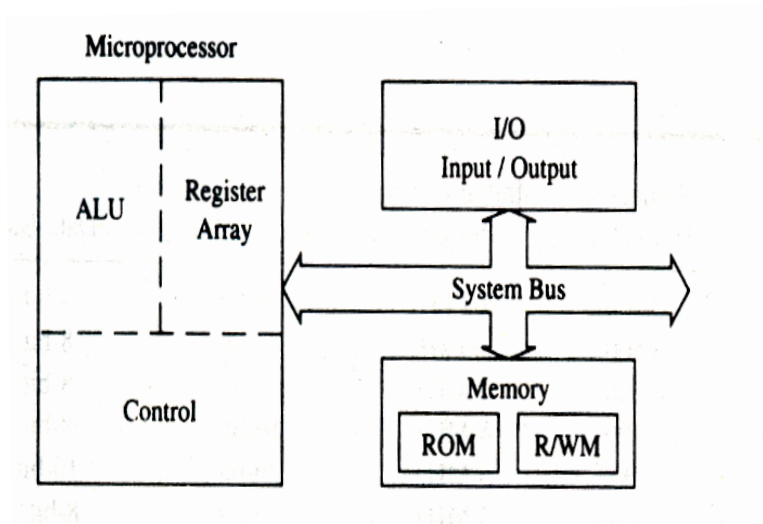
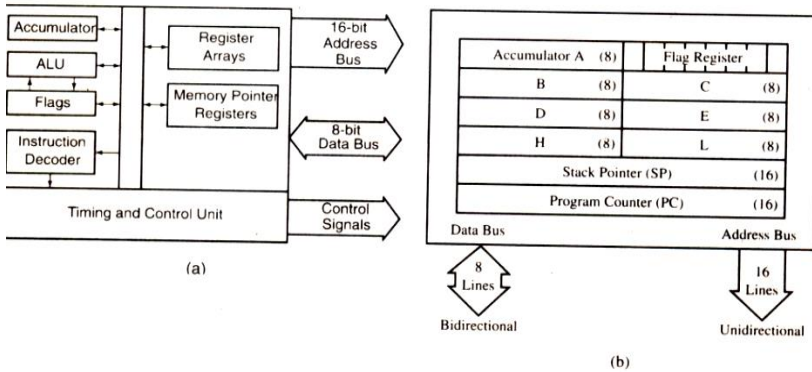


Figure 2.9 Internal Architecture of Microprocessor**Figure 2.10 Internal Registers and Flags of 8085A**

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

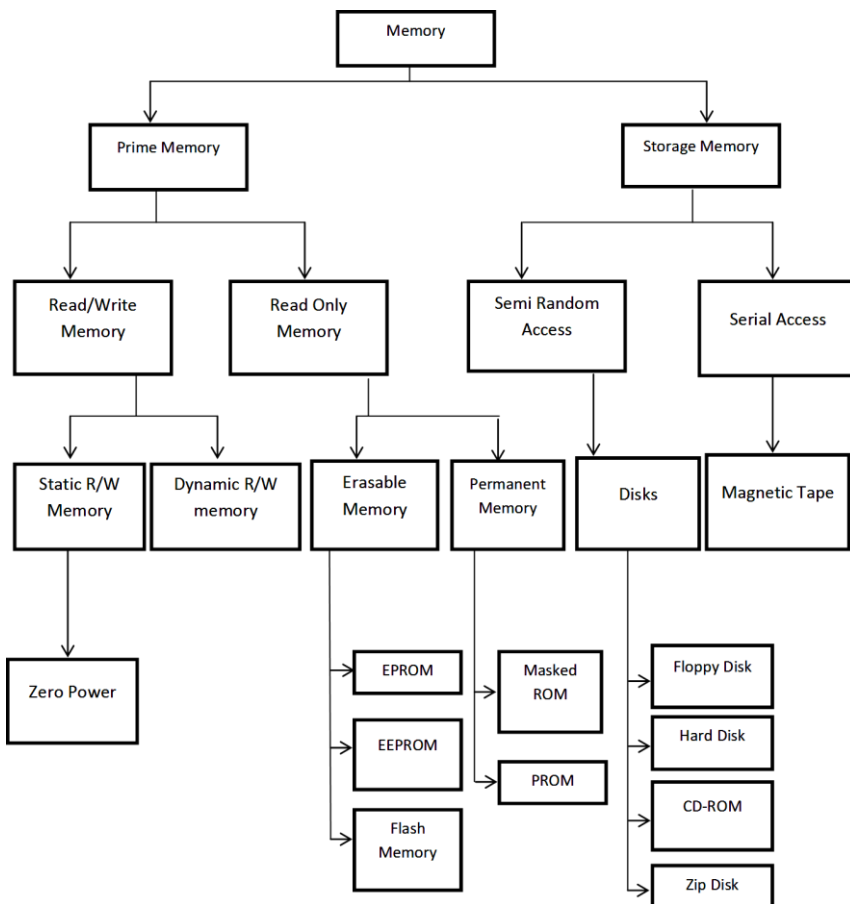
Memory stores binary instructions and data for the microprocessor. The read/write memory is made of registers, and each register has a group of flip-flops or FET that store bits of information. The Flip-Flops are called memory cells. The number of bits stored in a register is called memory word.

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.

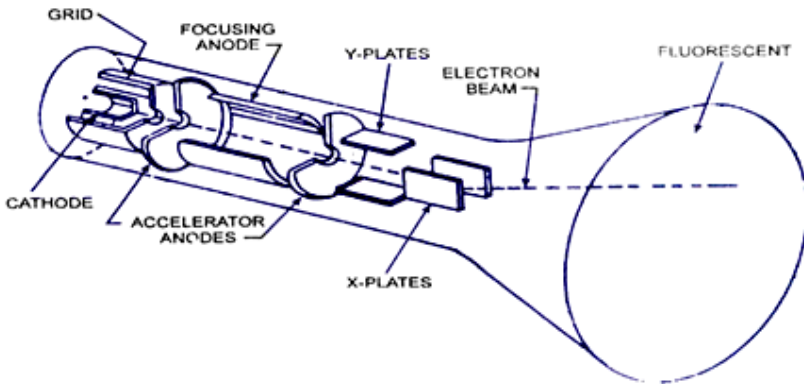


Figure 3.1 Cathode Ray Tube

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 in order 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 plane 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.

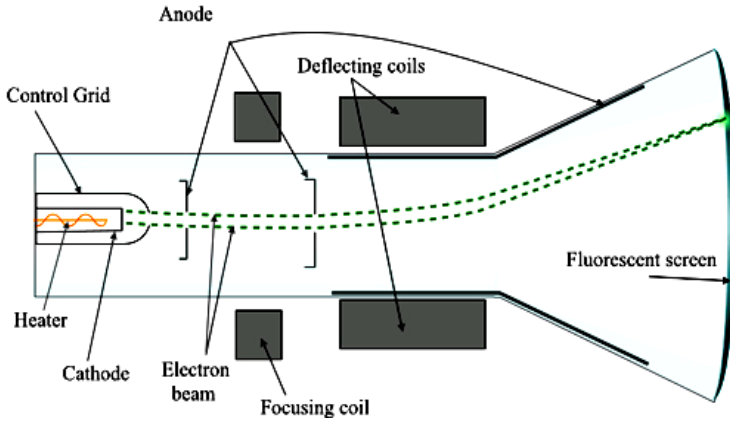


Figure 3.2 CRT with Deflection Coils

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.

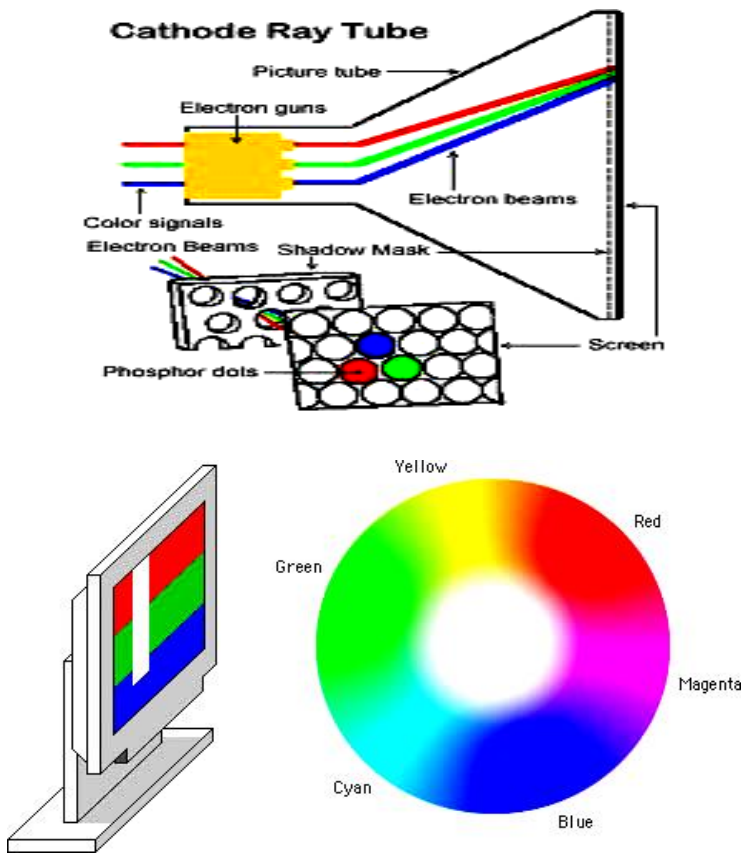


Figure 3.3 CRT with Colour Display System

CRT Control

A dedicated CRT controller integrated with a 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.

LCD

Liquid crystals have properties somewhere between solid and liquid. The orientation of molecules can be controlled by the application of an electric field. The LCD system and structure are shown in figure 3.4 and 3.5.

Types

- (i) Reflective – It uses Incident light
- (ii) Backlit – It uses own light source

Liquid crystal display needs a light source in order to operate. Larger displays can be easily made which displays several sets of information.

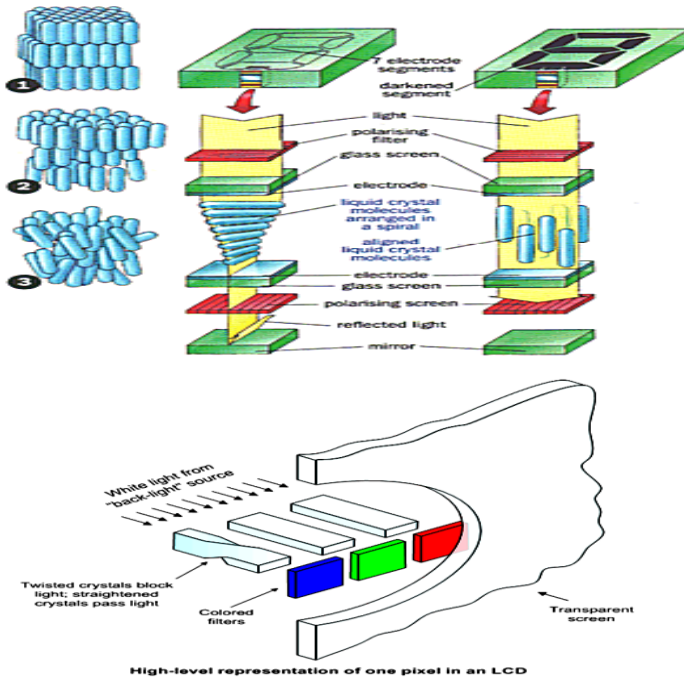


Figure 3.4 Liquid Crystal Display System

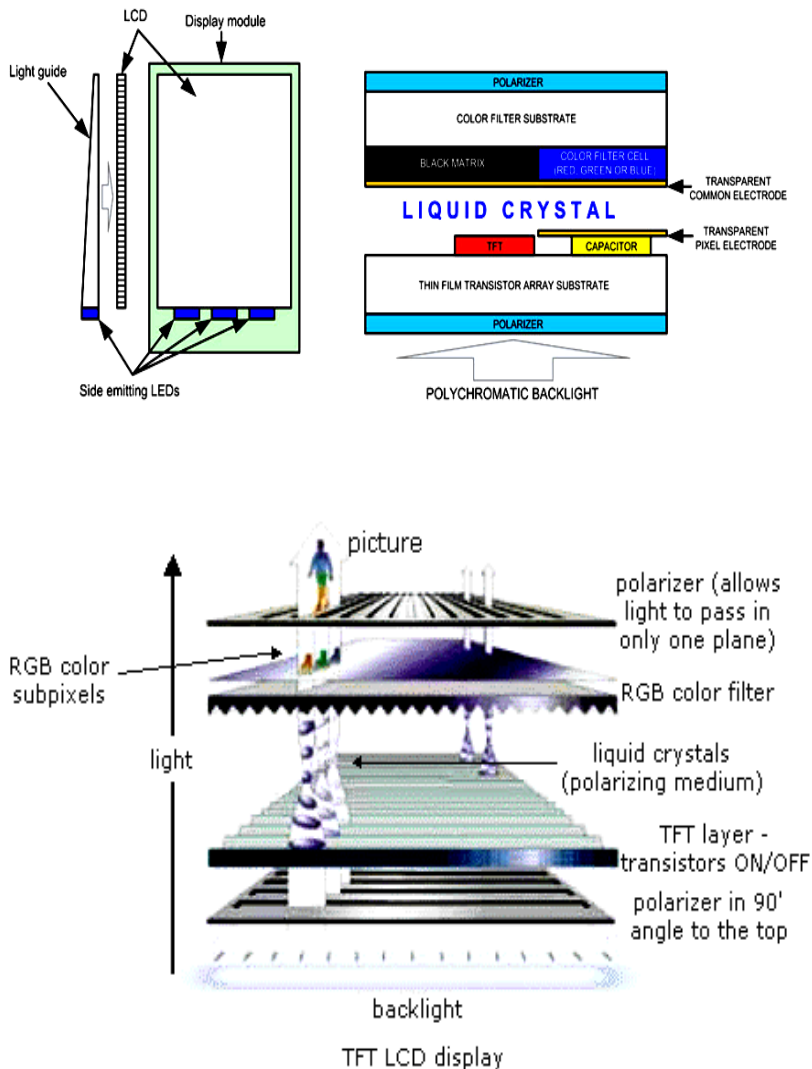


Figure 3.5 Structure of LCD display

Passive Matrix Displays

In order to display more detail information such as text and graphics LCD can be built using a matrix of rows and columns. The electrodes used in this type of display consist of rows and columns of horizontal and vertical conductors respectively and it is illustrated in figure 3.6.

Basic composition of a passive matrix display

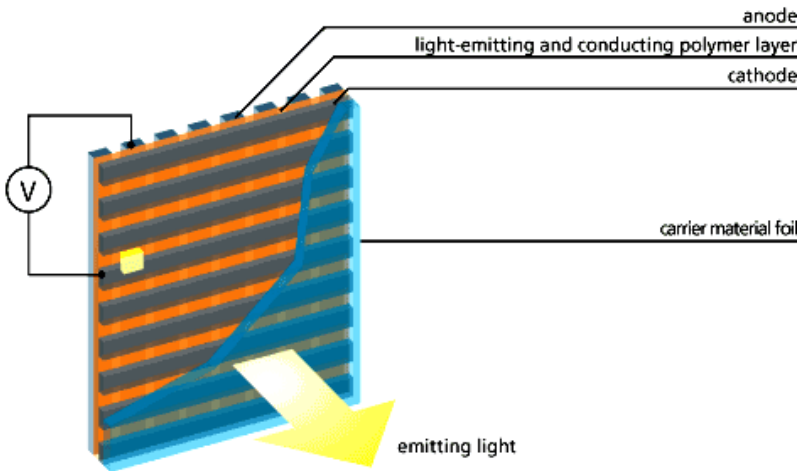


Figure 3.6 Passive Matrix Liquid Crystal Display system

Disadvantages

- Slow response
- Display is not as sharp as that which can be obtained from an active matrix display.

Active Matrix Displays

Active Matrix LCD shown in figure 3.7 uses thin film transistors which were fabricated on a glass substrate. Each transistor acts as a switch and it transfers charge to an

individual display element. The transistors are arranged on a row / column basis. By controlling the switching, it is possible to transfer precise amount of charge into the display element.

Colour AMLCD comprises a matrix of pixels corresponds to three colours red, green and blue. By precise application of charges to the appropriate pixels it is possible to produce displays having 256 shades of red, green and blue.

High resolution colour AMLCD aircraft displays having the capability to show graphics output.

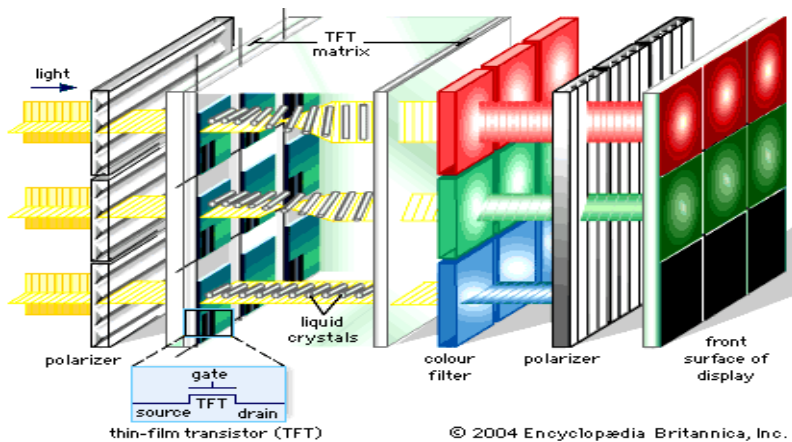


Figure 3.7 Active Matrix Liquid Crystal Display System

LED

Light Emitting Diodes can be used as general purpose indicators. It operates by a smaller voltages and currents. It is more reliable when compared to the filament lamps. LED's are shown in figure 3.8.

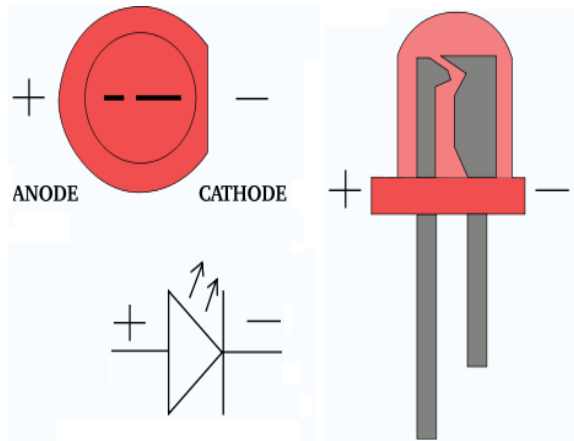
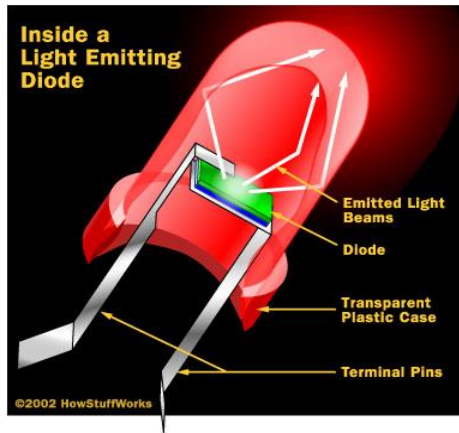


Figure 3.8 Light Emitting Diodes

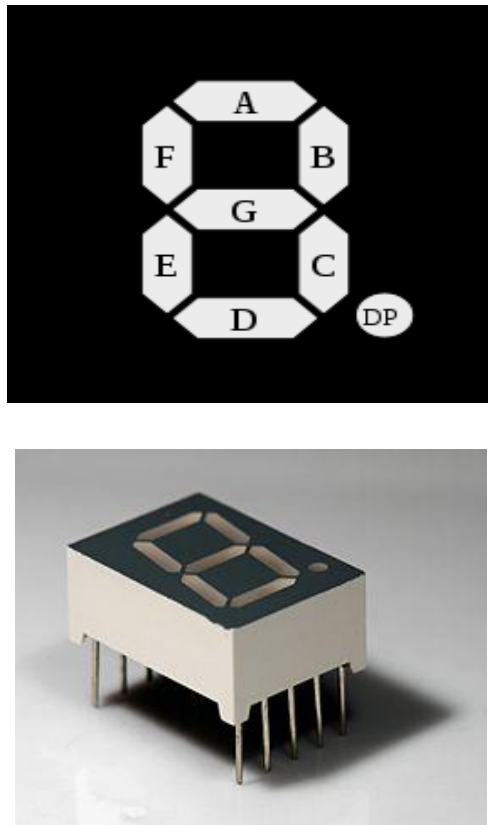


Figure 3.8 Light Emitting Diodes

Types

Round – 3mm and 5mm

Rectangular – 5mm X 2mm

Different colours of LED can be produced by using different semi-conductor materials and the required current level is 5mA to 20 mA.

LED displays are frequently used to display numerical data, which contains a seven segment indication. The seven

indicators are used in groups to form a complete display shown in figure 3.9.

The segments are illuminated according to the output.

Most Indoor screens use SMD technology. An SMD pixel consists of red, green and blue diodes mounted in a single package.

DISPLAY STRUCTURE

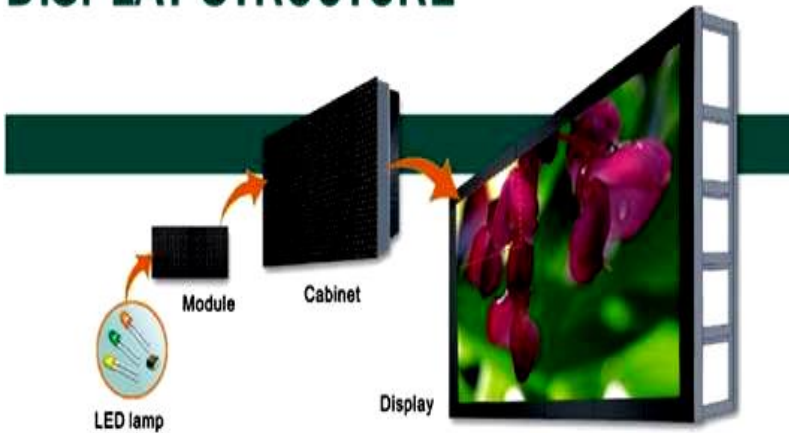


Figure 3.9 Led Display Structure

ELECTRO LUMINESCENT DISPLAY

It is a type of display created by sandwiching a layer electroluminescent material (GaAs) between two layers of conductors. When current flows, the layer of material emits radiation, in the form of visible light. ELD's are developed by two firms,

- i) Sharp – Japan
- ii) Planar systems – USA

Electroluminescence = Optical + Electrical phenomenon

It is a result of radiative recombination of electrons and holes in a material. The excited electrons release their energy

as photons. Prior to recombination the electrons and holes can be separated by doping.

This electroluminescent devices are fabricated using thin films of either organic (It emits light in response to an electric current) or of inorganic materials.

The thin film layers contain bulk semiconductor and a dopant which defines the visible colour emitted. The EL display system and its layers are given in figure 3.10 and 3.11.

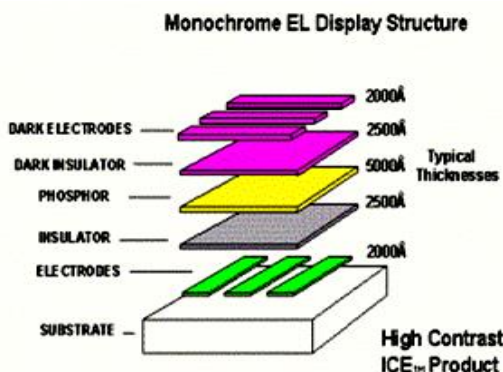


Figure 3.10 Electro Luminescent Display System

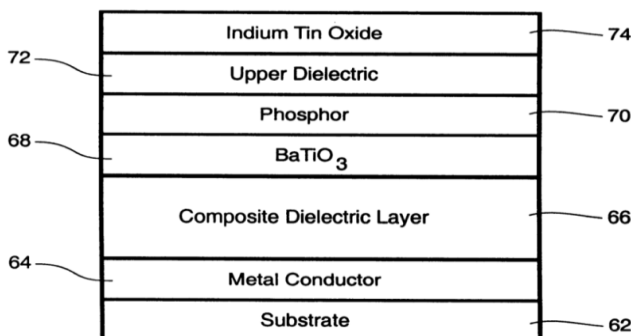


Figure 3.11 Layers of Electro Luminescent Display System

Inorganic thin film EL

Zinc sulphide powder doped with copper or silver.

Natural blue diamond with boron as dopant.

Now active matrix ELD are used for displaying large amount of text and graphics.

Advantages

- Speed
- Brightness
- High contrast
- Wide Angle vision

PLASMA DISPLAY

It is a type of flat panel display. This display utilizes small cells containing electrically charged ionized gases which is shown in figure 3.12 (Xenon or Neon gas). The xenon and neon gas in a plasma television is contained in hundreds of thousands of tiny cells positioned between two plates of glass. Long electrodes are also sandwiched between the glass plates, on both sides of the cells. The address electrodes sit behind the cells, along the rear glass plate. The transparent display electrodes, which are surrounded by an insulating dielectric material and covered by a magnesium oxide protective layer, are mounted above the cell, along the front glass plate. Both sets of electrodes extend across the entire screen. The display electrodes are arranged in horizontal rows along the screen and the address electrodes are arranged in vertical columns. The vertical and horizontal electrodes form a basic grid. To ionize the gas in a particular cell, the plasma display's computer charges the electrodes that intersect at that cell. It

does this thousands of times in a small fraction of a second, charging each cell in turn.

When the intersecting electrodes are charged (with a voltage difference between them), an electric current flows through the gas in the cell, which stimulates the gas atoms to release ultraviolet photons. The released ultraviolet photons interact with phosphor material coated on the inside wall of the cell. When an ultraviolet photon hits a phosphor atom in the cell, one of the phosphor's electrons jumps to a higher energy level and the atom heats up. When the electron falls back to its normal level, it releases energy in the form of a visible light photon.

Advantages

- Bright, Having wide colour gamut, Big sizes (150 inches)
- Plasma display screens are made from glass which reflects more light. The glass screen hold the gases.
- Superior contrast ration
- Wider viewing angles than LCD
- Less visible motion blur
- Faster response time
- Sine profile

Disadvantages

- i) Heavier than LCD
- ii) Uses more electricity
- iii) Doesn't works well at high altitudes due to pressure differential between the gases inside the screen and the air pressure at altitudes.
- iv) Power consumption varies greatly with picture content.

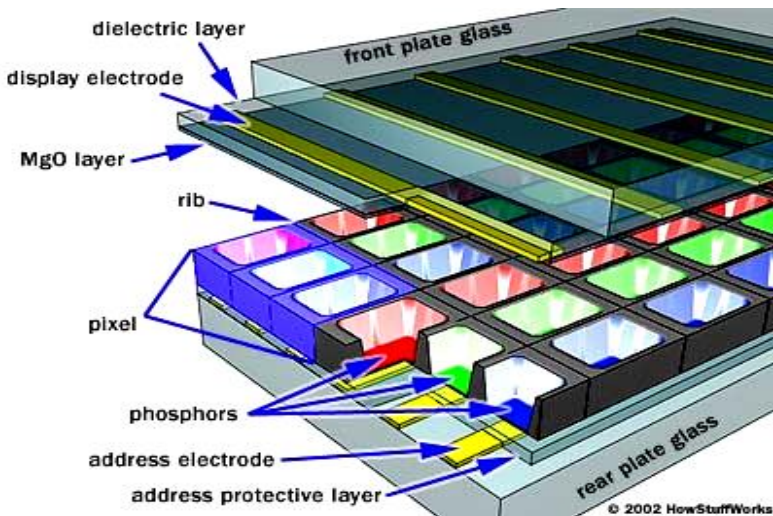
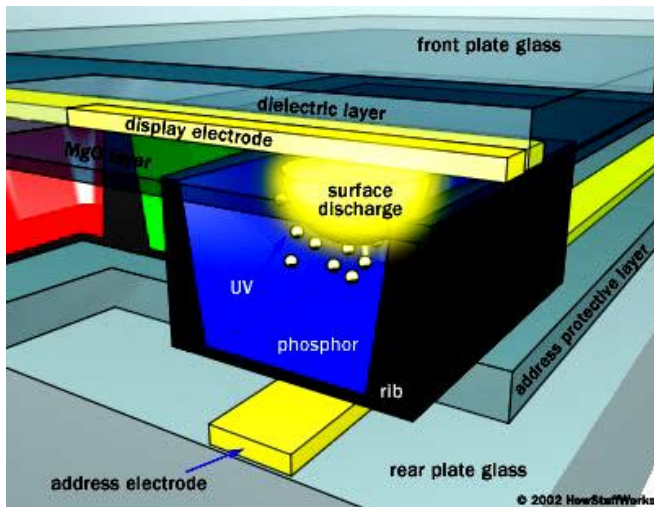


Figure 3.12 Plasma Display system

Direct Voice Input

It enables the pilot to enter data and control the operation of the aircraft's avionics system by means of speech.

The spoken commands and data are recognized by a speech recognition system which compares the spoken utterances with the stored speech templates. The recognized commands are then transmitted to the aircraft subsystems by the interconnecting data bus. (Example: MIL STD 1553 B data bus)

Example: To change a communication channel frequency, the pilot says 'Radio' followed by 'Select frequency three four five'. To enter navigation data, the pilot says 'Navigation' followed by 'Enter waypoint latitude fifty one degrees thirty one minutes eleven seconds north'.

If the HUD and HMD are installed the pilot's command is visually displayed on that and then the pilot confirms the correctly recognized command by saying 'enter' then the action is initiated. Thus the pilot can stay head up and doesn't have to divert attention for operating the touch panels, switches, push buttons, etc., thus the DVI reduces the pilot's work load in high work load situations.

Voice Interactive System

- It's a kind of Interface between the crew and aircraft in high work load situation in single crew member aircraft.
- F-16 routinely achieved 95% correct word recognition and reduced to less than 80% under high work load conditions.
- Voice control is not suitable for time critical system.

Speech recognition

Applied for non critical task such as requesting system

- Status,

- tuning radios,
- And requesting maps to be displayed on a CRT

Not been used for urgent inputs or critical task such as firing weapons.

Problem with Voice Recognition

- The words in the vocabulary are limited.
- Generating templates are time consuming.
- Microphones have the same electrical characteristics as the flight microphone.
- Difficult to stimulate the stress artificially.
- Speaker independent Speech Recognition requires large amount of memory and slow signal processing.

Main Characteristics and Requirements of DVI:

- i) Fully connected speech. The speech recognition system must be able to recognize the normal fully connected speech.
- ii) It must be able to operate in the cockpit noise environment.
- iii) The required vocabulary is around 200 to 300 words. (size)
- iv) The maximum duration of total vocabulary is around 160 seconds.
- v) The maximum number of syntax nodes required is 300.

TOUCH SCREENS

It uses a matrix array of infra-red beams across the surface of the display which displays the various function keys.

Touching the specific function key on the display surface interrupts the x and y infra-red beams. So the operation of that particular key function is executed.

Types of Touch screen

- i) Resistive Touch screen
- ii) Surface acoustic wave
- iii) Capacitive Touch screen panel
- iv) Optical Imaging
- v) Dispersive Signal Technology
- vi) Acoustic pulse Recognition.

i) RTS

In this two layers (Electrically conductive and Resistive layers) are separated by thin space. When some objects touches this panel, the layers are connected at certain point. This causes a change in the electrical current and sent to the controller for processing. The RTS system is shown in figure 3.13.

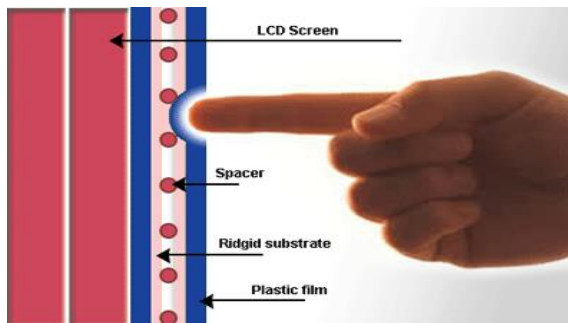


Figure 3.13 Resistive Touch Screen system

Advantages

- More affordable
- Most commonly used
- 75% clarity
- Layer can be damaged by sharp objects
- It won't be affected by dust or water.

ii) SAW

It uses ultrasonic waves that pass over the touch screen panel. When the panel is touched, a portion of wave is absorbed. This information is sent to the controller for processing which is provided in figure 3.14.

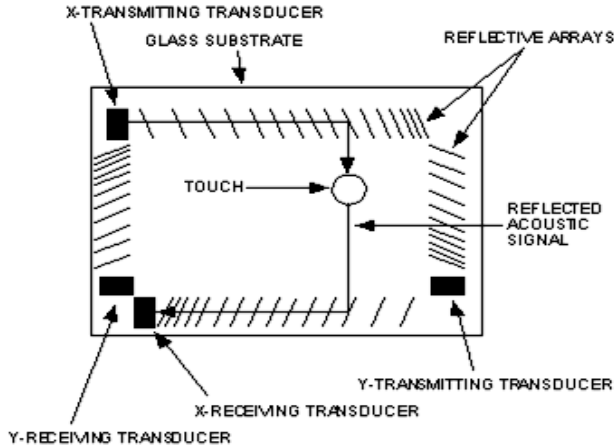


Figure 3.14 Surface Acoustic Wave Touch Screen system

It can be damaged by the outside elements, contaminants on the surface interface the function.

iii) CTP

It is coated with a material (Indium tin oxide) which conducts a continuous electrical current across the sensor. The CTP system is given in figure 3.15.

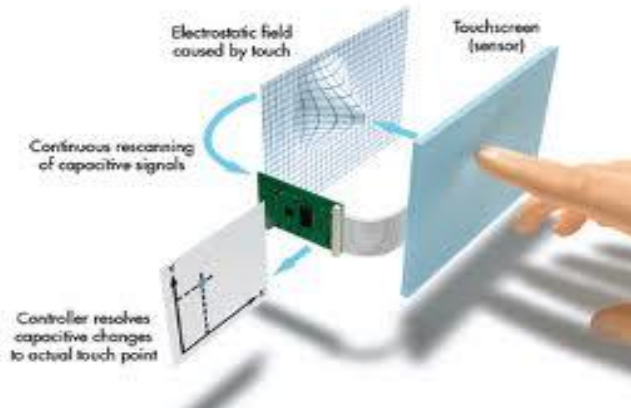


Figure 3.15 Capacitive Touch Screen system

iv) Optical Imaging

In this two or more image sensors are placed around the edges of the screen which is given in figure 3.16. Infrared backlights are placed in the camera's field of view on the other side of the screen. A touch shows a shadow and the sensors are used to locate the touch.

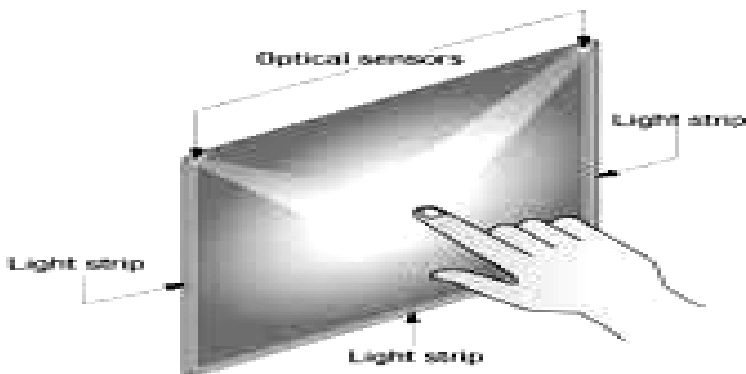


Figure 3.16 Optical Imaging Touch Screen system

The merits of this type are Scalability, Versatility and Affordability.

v) DST

It uses sensors to detect the mechanical energy in the glass due to a touch. Complex algorithms are used to find out the actual location of the touch. The main advantage of this type of touch screens has excellent optical clarity.

vi) APR

It uses more than two piezoelectric transducers located at some position of the screen. It converts the mechanical energy of a touch into an electric signal. This signal is then converted into an audio file and then compared to pre-existing audio profile for every position on the screen.

Advantages

- Accuracy is good.
- It is suitable for larger display.
- It doesn't need a conductive object to activate it.
- It works with scratches and dust on the screen.

MFD: (Multi Function Display)

MFD is a small screen (CRT or LCD) in an aircraft surrounded by multiple buttons that can be used to display information to the pilot in numerous ways which is shown in figure 3.17. The MFD's doesn't consume much space in the aircraft cockpit.

Many MFD's allow the pilot to display their navigation route, Moving map, Weather radar, NEXRAD (Next Generation Radar – weather surveillance radar), GPWS (Ground Proximity Warning Systems), TCAS (Traffic collision Avoidance Systems).

- GPWS - It alerts the pilot if the aircraft is in immediate danger of flying into an obstacle.
- TCAS - It reduces the incidence of wind – air collisions between the aircrafts.



Figure 3.17 Multi Function Display system

Currently display units are interfaced with either a Mode S transponder or the Ryan TCAD to provide a real-time display of traffic information in both the attitude indicator and the full-color moving map. Traffic symbols are colour-coded to allow you to quickly recognize any traffic at your altitude or on a possible collision course and take action. With the optional FLIR camera, the traffic can even be "visually" identified.

Ryan's latest and by far most sophisticated traffic alerting system, the TCAD 9900BX, has got certification from

the FAA. The 9900BX is an active system, which means it interrogates other aircraft's transponders, determines their position and then issues a warning if a potential conflict is predicted. Using bottom and top antennas, the 9900BX can simultaneously track up to 50 aircraft (it looks out 20 miles) and provides a maximum 30 second warning.

It has the feature of Audible Position Alerting. When the system detects a threat, it gives the pilot an audible warning, such as "Traffic! Twelve o'clock high! Two miles!".

HUD

The cockpit display system provides a visual presentation of the information and data from the aircraft sensors and systems to the pilot. This helps the pilot to fly the aircraft safely.

Civil cockpit display systems provides,

- Primary Flight Information
- Navigation Information
- Engine Data
- Airframe Data
- Warning Information

Apart from this data the military cockpit display system provides,

- Infrared Imaging Sensors
- Radar
- Tactical Mission data
- Weapon Aiming
- Threat Warnings

The HUD has enabled a major improvement in man-machine interaction and it helps the pilot to view and assimilate the essential flight data generated by the sensors and systems in the aircraft.

HUD basically projects a collimated display in the pilot's head up forward line of sight, so he can view both the display information and the outside world at the same time.

The pilot can able to observe both distant outside world objects and display data at the same time without changing the direction of gaze or re-focus the eyes.

During the landing phase the pilot can view the essential flight data such as artificial horizon, pitch angle, bank angle, flight path vector, height, airspeed and heading with the help of HUD.

HUD uses high brightness display and it projects some of the information normally on the primary flight displays and selected systems or weapons data into the Line of Sight of the pilot without substantially dimming or obscuring the outer view. HUD allows the pilot to simultaneously see critical aircraft information while viewing the outside scene.

Every HUD contains a Display generator and Combiner. The combiner combines the collimated display symbology with the outside world scene. The display symbology is generated from the aircraft sensors and systems. The relay lens magnifies the display and corrects for some of the optical errors. The relayed display images are reflected by the fold mirror to the collimating lens

In the current HUD,

Display Generator – CRT with P43 (Green) phosphor

Combiner – mirror with several unusual properties:

- Reflective coating – Highly wavelength selective in angle of incidence so that only that light which impinging within a very narrow range of angles will be reflected

- Combiner is sometimes incorrectly referred to as *Hologram*, but it contains no image information as found in true hologram

High performance aircraft HUD's use one of two basic designs for the combiner

Single element combiner HUD (figure 3.18)

Three element combiner HUD (figure 3.19)

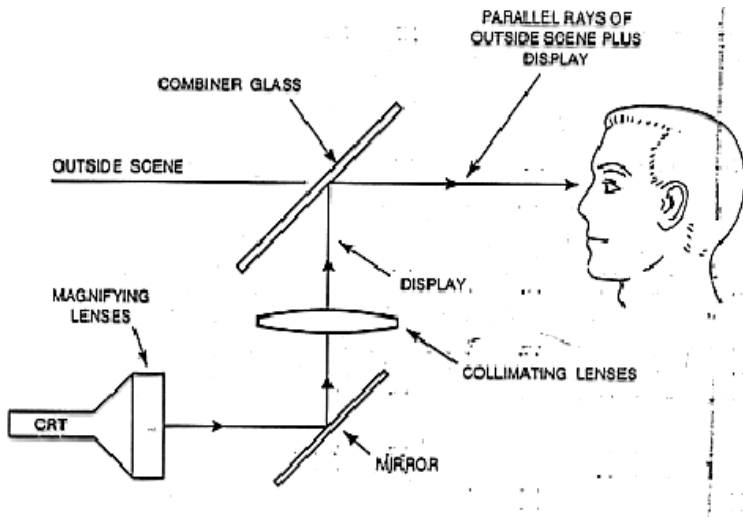


Figure 3.18 Single element combiner HUD

Merits

Simplest design of the two methods
Transmission of outside scene is higher
Transport aircraft uses this method

Demerits

Less advantageous than three-element combiner HUD.

Three element combiner HUD

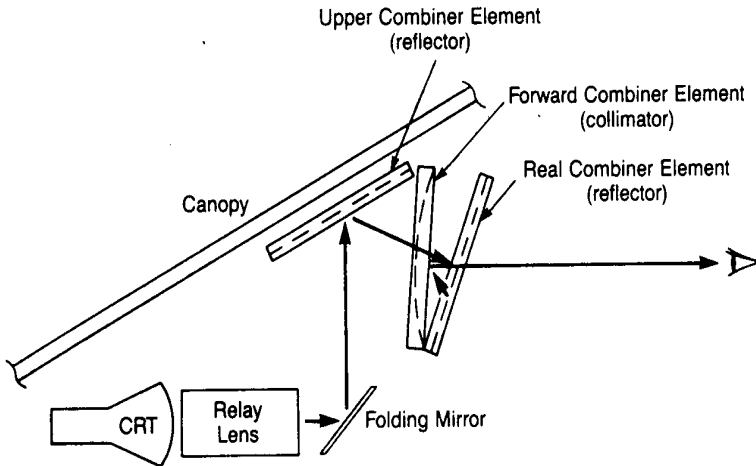


Figure 3.19 Three element combiner HUD

Merits

- ❖ Used on high-performance aircraft to achieve better producibility
- ❖ This design has achieved 30° horizontal and 20° vertical field of view
- ❖ All three elements contains gelatinous combiners as the middle layer, but only the forward element is curved to collimate the image from the CRT.

Colour HUD's are controversial for two reasons:

- ❖ There may be some loss of brightness, although brightness is becoming less of an issue as color CRTS improve
- ❖ Colours may be confused with or lost in the natural exterior scene

Practical problem

HUD occupies large volume and the necessity to be mounted in the cockpit with the combiner in LOS to the pilot

On high performance aircraft, HUD is mounted at the top of and behind the instrument panel. So that the combiner is between the top of the panel and the canopy in the pilot's LOS when looking straight ahead.

For civil transport, HUD is mounted above the seat of each cockpit crew member, and the combiner is hinged to swing down into the LOS when HUD is in use, generally only during approach and landing.

Single element combiner can be used as an alternative for civil transport.



Figure 3.20 Head Up Display System

In military Aircrafts

The pilot freely concentrates on the outside world during maneuvers. In combat situations the pilot can scan for possible threats from any direction. The military Aircrafts HUD is shown in figure 3.20. The combined FLIR with HUD enables the pilot to fly at low level by night in fair weather. This provides a realistic night attack capability.

In Civil Aircrafts

The HUD provides situational awareness and increased safety in circumstances such as wind shear or terrain/ traffic avoidance maneuvers. If the flight path vector is below the horizon the aircraft is descending. Flight path vector provides a two dimensional display of drift angle and flight path angle. It helps the pilot to land the aircraft safely in conditions of very low visibility due to fog.

Multi-Function Keyboard

It is an avionics sub system through which the pilot interacts to configure mission related parameters like flight plan, airfield database, communication equipment during initialization and operation flight phase of mission. The MFK consist of a processor with ROM, RAM and EEPROM memory which is shown in figure 3.21. It is connected to one of the 1553B buses used for data communication. The MFK has a built-in display unit and a keyboard.

It is also connected to the Multi Function Rotary switch (MFR) through a RS422 interface. The MFK has a built-in display unit. The display unit is a pair of LCD based Colour Graphical Display. The Real-time operating specifications are very stringent in such applications because the performance and safety of the aircraft depend on it. Efficient design of the architecture and code is required for successful operation.

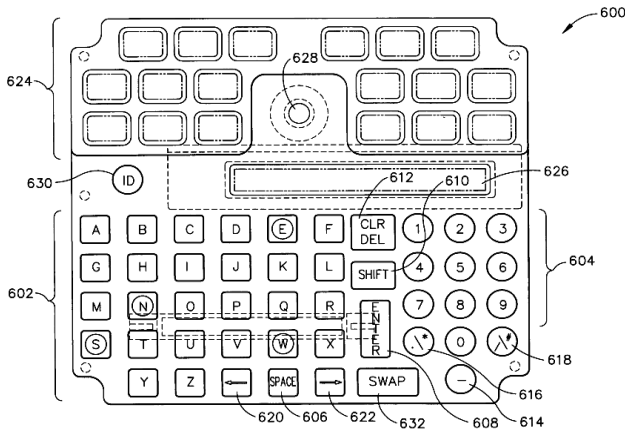


Figure 3.21 Multi-Function Keyboard

HOTAS: (Hands on Throttle and Stick)

In this buttons and switches are placed on the throttle stick and flight control stick (figure 3.22) allowing the pilot to access vital cockpit functions and fly the aircraft without removing his hands from the throttle and flight controls.

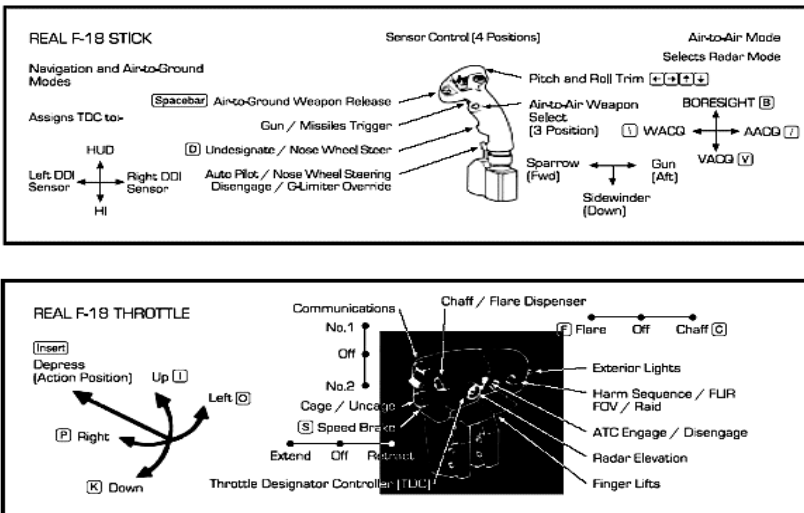


Figure 3.22 HOTAS System

It allows the pilot to remain focused on important duties than looking for controls in the cockpit.

The HOTAS system can be enhanced by DVI or HMD. This will allow the pilot to control various systems using his line of sight, and to guide missiles to the target by simply looking at it.

Helmet Mounted Display

It includes a transparent visor, a display device including an opaque multi-element LCD display mounted on the visor (figure 3.23) so as to be directly viewable by a wearer at a location outside field of view and a display control cockpit placed remotely from the display element and coupled by signal transmission apparatus.



Figure 3.23 Helmet Mounted Display system

QUESTIONS

Part-A

1. Define plasma panel.
2. Differentiate LED and LCD.
3. Explain CRT and its usage in aircraft displays.
4. What is meant by DVI?
5. What are MFD and its significance in Aircraft?
6. Explain the advantage of HMD over MUD.
7. Explain MFK and its usage.
8. What is HOTAS?
9. Explain about HUD.
10. Explain advantage of EL over Plasma display.

Part-B

1. Compare and contrast the display technologies CRT,LED,LCD,EL and plasma panel.
2. What are the various types of CRTs used in civil and military aircraft and explain them in detail.
3. Explain the basic principle of HUD and what are its limitations? How are they overcome in HMD?
4. Explain about the special features of DVI and also describe voice recognition and speech synthesis technology.
5. Explain MFKs, HMD, HUD and HDD in detail.

4

DIGITAL AVIONICS ARCHITECTURE

Avionics system architecture– salient features and applications of Data buses MIL–STD 1553 B–ARINC 429–ARINC 629.

AVIONICS SYSTEM ARCHITECTURE INTRODUCTION

Establishing the basic architecture is the first and the most fundamental challenge faced by the designer.

The architecture must conform to the overall aircraft mission and design while ensuring that the avionics system meets its performance requirement. These architectures rely on the data buses for intra and intersystem communications. The optimum architecture can only be selected after a series of exhaustive design tradeoffs that address the evaluation factors. The evolution of Avionics architecture is shown in figure 4.1.

AVIONICS ARCHITECTURE EVOLUTION

First Generation Architecture (1940's –1950's)

Disjoint or Independent Architecture (MiG-21)

Centralized Architecture (F-111)

Second Generation Architecture (1960's –1970's)
Federated Architecture (F-16 A/B)
Distributed Architecture (DAIS)
Hierarchical Architecture (F-16 C/D, EAP)
Third Generation Architecture (1980's –1990's)
Pave Pillar Architecture (F-22)
Fourth Generation Architecture (Past 2005)
Pave Pace Architecture- JSF
Open System Architecture.

AVIONICS SYSTEM EVOLUTION

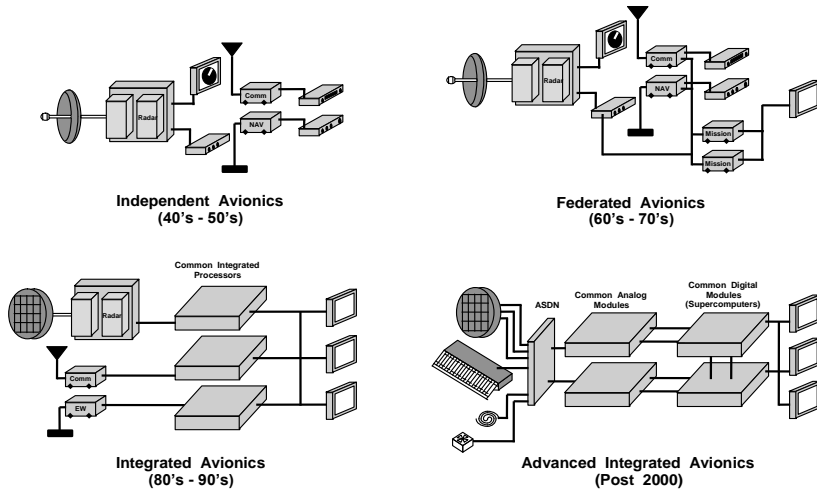


Figure 4.1 Avionics System Evolution

First Generation - DISJOINT ARCHITECTURE

The early avionics systems were stand alone black boxes where each functional area had separate, dedicated sensors, processors and displays and the interconnect media is point to point wiring.

The system was integrated by the air-crew who had to look at various dials and displays connected to disjoint sensors

correlate the data provided by them, apply error corrections, arrange the functions of the sensors and perform mode and failure management in addition to flying the aircraft

This was feasible due to the simple nature of tasks to be performed and due to the availability of time. The FGA – DA is shown in figure 4.2.

FGA - DISJOINT ARCHITECTURE

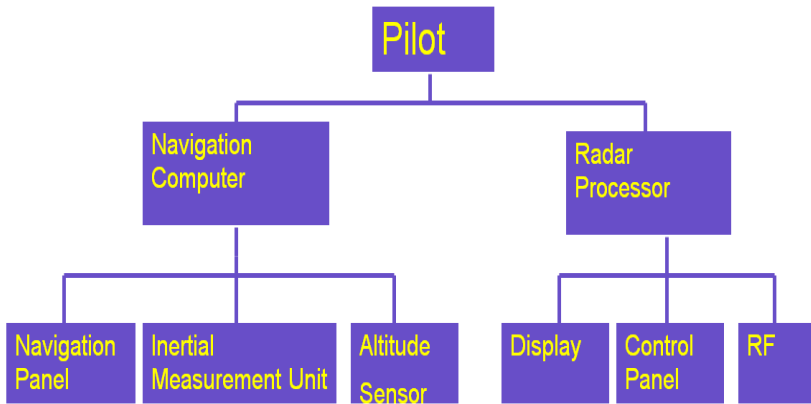


Figure 4.2 FGA - DISJOINT ARCHITECTURE

First Generation - CENTRALIZED ARCHITECTURE

As the digital technology evolved, a central computer was added to integrate the information from the sensors and subsystems. The central computing complex is connected to other subsystems and sensors through analog, digital and other interfaces.

When interfacing with computer a variety of different transmission methods are required and some of which needs signal conversion (A/D).

Signal conditioning and computation take place in one or more computers in a LRU located in an avionics bay, with signals transmitted over one way data bus.

Data are transmitted from the systems to the central computer and the data conversion takes place at the central computer which is illustrated in figure 4.3.

Advantages

Simple Design

Software can be written easily

Computers are located in readily accessible bay.

Disadvantages

Requirement of long data buses

Low flexibility in software

Increased vulnerability to change

Different conversion techniques needed at Central Computer.

FGA - CENTRALIZED ARCHITECTURE

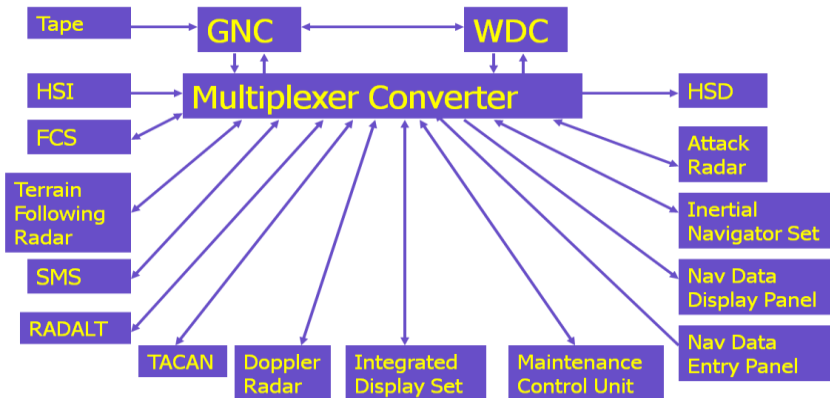


Figure 4.3 FGA – Centralized Architecture

Second Generation – FEDERATED ARCHITECTURE

Federated: (Join together, Become partners)

In this SG-Federated Architecture, each system acts independently but united (Loosely Coupled).

Data conversion occurs at the system level and the data are sent as digital form – called Digital Avionics Information Systems (DAIS)

Several standard data processors are often used to perform a variety of Low – Bandwidth functions such as navigation, weapon delivery, stores management and flight control Systems are connected in a Time – Shared Multiplex Highway.

Resource sharing occurs at the last link in the information chain – via controls and displays. Programmability and versatility of the data processors.

Advantages

It provides precise solutions over long range of flight, weapon and sensor conditions

Sharing of Resources

- ❖ Use of TDMA saves hundreds of pounds of wiring
- ❖ Standardization of protocol makes the interchangeability of equipments easier
- ❖ Allows Independent system design and optimization of major systems
- ❖ Changes in system software and hardware are easy to make
- ❖ Fault containment – Failure is not propagated

Disadvantages

Profligate of resources

Second Generation – DISTRIBUTED ARCHITECTURE

It has multiple processors throughout the aircraft that are designed for computing tasks on a real-time basis as a function of mission phase and/or system status. This Architecture which is given in figure 4.4 is used in modern avionics system. Processing is performed in accordance with the sensors and actuators.

Advantages

Fewer, Shorter buses
Faster program execution
Intrinsic Partitioning

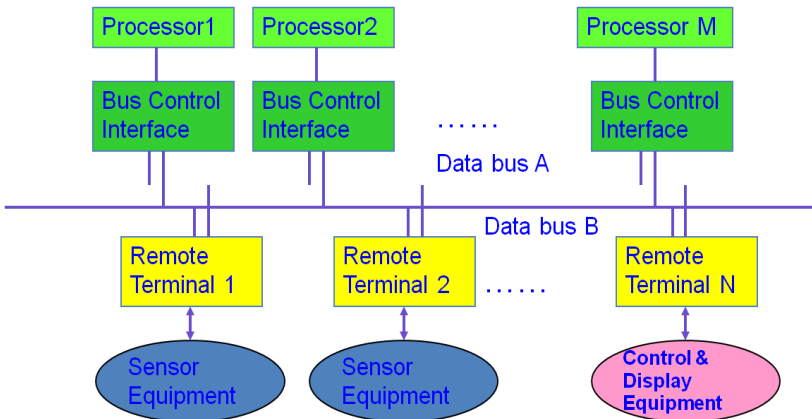


Figure 4.4 SGA – Distributed Architecture

Disadvantages

Potentially greater diversity in processor types which aggravates software generation and validation.

Second Generation -HIERARCHICAL ARCHITECTURE

This architecture which is given in figure 4.5 is derived from the federated architecture. It is based on the TREE Topology

Advantages

- ❖ Critical functions are placed in a separate bus and Non-Critical functions are placed in another bus.
- ❖ Failure in non – critical parts of networks does not generate hazards to the critical parts of network.
- ❖ The communications between the subsystems of a particular group are confined to their particular group.
- ❖ The overload of data in the main bus is reduced.
- ❖ Most of the military avionics flying today based on hierarchical architecture.

SGA - HIERARCHICAL SYSTEM

- This architecture derived from the federated architecture.
- It is based on the TREE Topology.

Advantages

- Critical functions are placed in a separate bus functions are placed in another bus.
- Failure in non-critical parts of networks do not generate hazards to the critical parts of network.
- The communication between the subsystems of a particular group are confined to their particular group.
- The overload of data in the main bus is reduced.
- Most of the military avionics flying today based on hierarchical architecture.

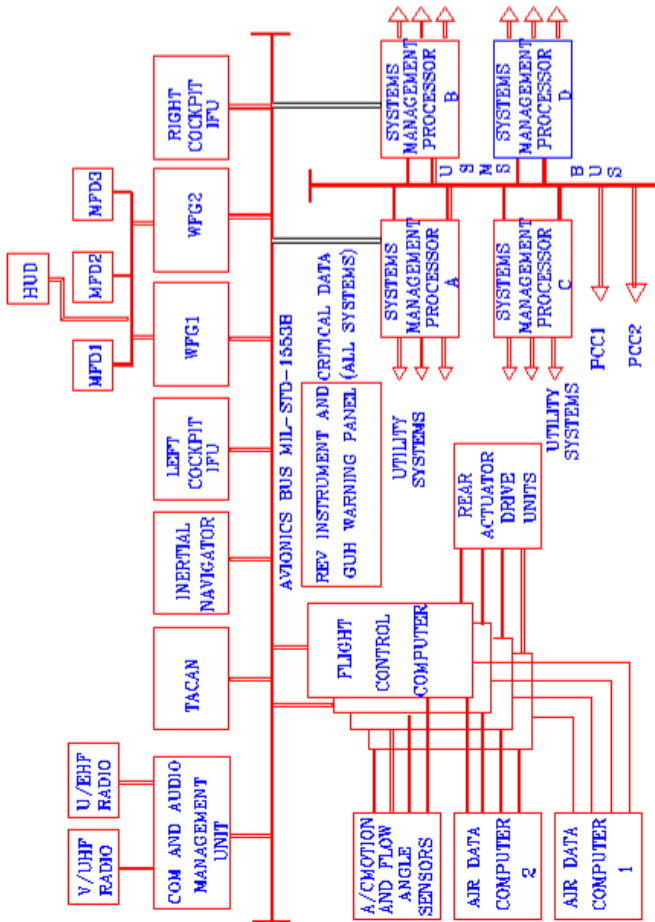


Figure 4.5 SGA – Hierarchical System Architecture

Third Generation Architecture - PAVE PILLAR

Pave Pillar is a US Air Force program to define the requirements and avionics architecture for fighter aircraft of the 1990s.

The Program Emphasizes,

- ❖ Increased Information Fusion

- ❖ Higher levels and complexity of software
- ❖ Standardization for maintenance simplification
- ❖ Lower costs
- ❖ Backward and growth capability while making use of emerging technology – Voice Recognition /synthesis and Artificial Intelligence.
- ❖ Provides capability for rapid flow of data from the system as well as between and within the system
- ❖ Higher levels of avionics integration and resource sharing of sensor and computational capabilities
- ❖ Pilot plays the role of a weapon system manager.
- ❖ Able to sustain operations with minimal support, fly successful mission day and night in any type of weather
- ❖ Face a numerically and technologically advanced enemy aircraft and defensive systems.

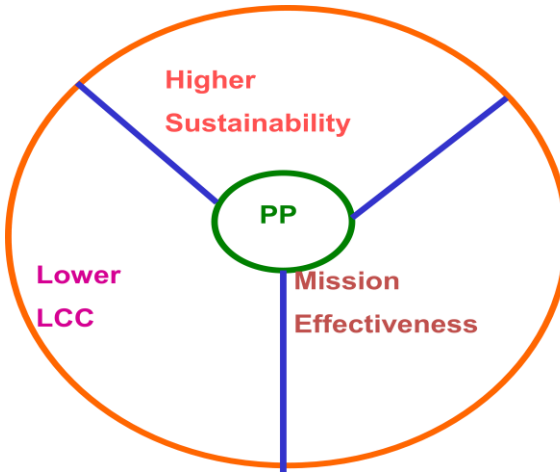


Figure 4.6 TGA - Pave Pillar Capability

Advantages

- ❖ Component reliability gains

- ❖ Use of redundancy and resource sharing
- ❖ Application of fault tolerance
- ❖ Reduction of maintenance test and repair time
- ❖ Increasing crew station automation
- ❖ Enhancing stealth operation
- ❖ Wide use of common modules
- ❖ Ability to perform in-aircraft test and maintenance of avionics
- ❖ Use of VHSIC technology and
- ❖ Capability to operate over extended periods of time at severe, deployed locations and be maintainable without the Avionics Intermediate Shop.

Fourth Generation Architecture - PAVE PACE

US Air Force initiated a study project to cut down the cost of sensors used in the fighter aircraft. In 1990, Wright Laboratory – McDonnell Aircraft, Boeing Aircraft Company and Lockheed launched the Pave Pace Program and Come with the Concept of Integrated Sensor System (IS²). Pave Pace takes Pave Pillar as a base line standard. The integration concept extends to the skin of the aircraft – Integration of the sensors and this architecture was originally designed for Joint Strike Fighter (JSF) which is shown in figure 4.7.

FTGA – PAVE PACE

- Modularity concepts cuts down the cost of the avionics related to VMS, Mission Processing, PVI and SMS
- The sensor costs accounts for 70% of the avionics cost.
- Pave Pace takes Pave Pillar as a base line standard.
- The integration concept extends to the skin of the aircraft integration of the RF & EO sensors.
- Originally designed for Joint Strike Fighter (JSF).

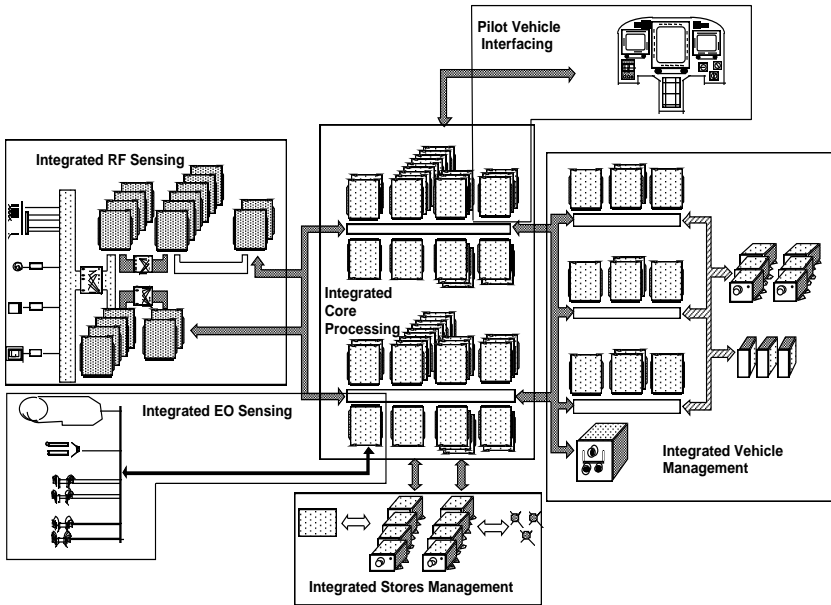


Figure 4.7 FTGA – Pave Pace Architecture

Data Bus

It provides a medium for the exchange of data and information between various Avionics subsystems.

It provides the Integration of Avionics subsystems in military or civil aircraft and spacecraft.

Protocol

- ❖ Set of formal rules and conventions governing the flow of information among the systems.
- ❖ Low level protocols define the electrical and physical standards.
- ❖ High level protocols deal with the data formatting, including the syntax of messages and its format.

Types

Command/Response	:	Centralized Control Method
Token Passing	:	Decentralized Control Method
CSMA/CA	:	Random Access Method

Topology

It describes how the systems are interconnected in a particular fashion.

LINEAR NETWORK

Linear Cable

All the systems are connected in across the Cable

RING NETWORK

Point to Point interconnection

Datas flow through the next system from previous system

SWITCHED NETWORK

Similar to telephone network

Provides communications paths between terminals.

MIL STD 1553B:

The MIL STD 1553B is a US military standard which defines TDM multiple source-multiple sink data bus system. It is widely used in military aircraft in many countries. It is also used in naval surface ships, submarines and battle tanks. The system is a half duplex system.

- The system was initially developed at Wright Patterson Air Force base in 1970s.
- Published First Version 1553A in 1975
- Introduced in service on F-15 Programme.

- Published Second version 1553B in 1978.

Elements of MIL-STD-1553B

- ❖ Bus Controller (BC)
- ❖ Remote Terminal (RT)
- ❖ Monitoring Terminal (MT)
- ❖ Transmission Media

The basic bus configuration is shown in figure 4.8. The system is a command response system with all data transmission being carried out under the control of the bus controller. Each sub-system is connected to the bus through a unit called a remote terminal (RT). Data can only be transmitted from one RT and received by another RT following a command from the bus controller to each RT.

Broadcast Mode:

The operation of the data bus system such that information transmitted by the bus controller or a remote terminal is addressed to more than one of the terminals connected to the data bus is known as the broadcast mode.

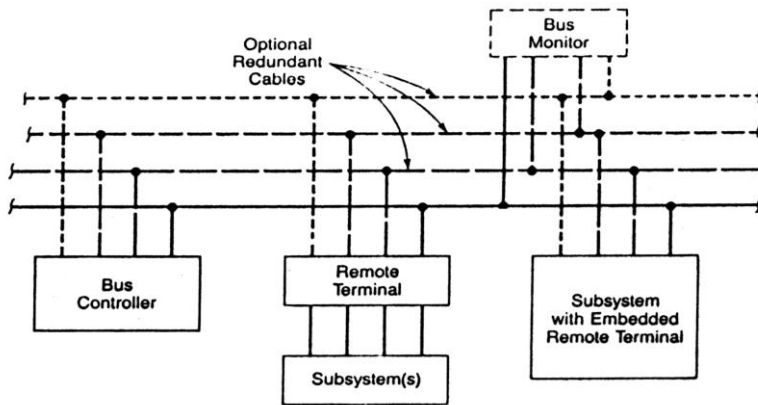


Figure 4.8 Data Bus system Architecture

In this bus system three types of words are transferred. The word format is provided in figure 4.9

- ❖ Command words,
- ❖ Status words,
- ❖ Data words.

A command word comprises six separate fields, they are;

SYNC, Terminal address, T/R, Subaddress / Mode, Data word Count/Mode Code and Parity bit.

A status word is the first word of a response by an RT to a BC command. It provides the summary of the status/health of the RT and also the word count of the data words to be transmitted in response to a command.

A status word comprises four fields, they are; SYNC, Terminal Address, Status field and Parity bit.

The data words contain the actual data transmitted between stations. The data field is 16 bits. The SYNC signal is the inverse of the command and status word SYNCs. The most significant bit of the data is transmitted after the SYNC bits.

There are ten possible transfer formats, but the three most commonly used formats are,

- BC to RT
- RT to BC
- RT to RT

Specifications of MIL-STD 1553B

Data Rate	1 Mbps
Word Length	20 Bits
Maximum data transmission rate	50,000 words/s
Maximum terminals connection to the bus	31

Message Length	32 word strings
Data Bits per Word	16 bits
Transmission Technique	Half Duplex
Encoding	Manchester II Bi-Phase
Protocol	Command Response
Transmission Mode	Voltage Mode.

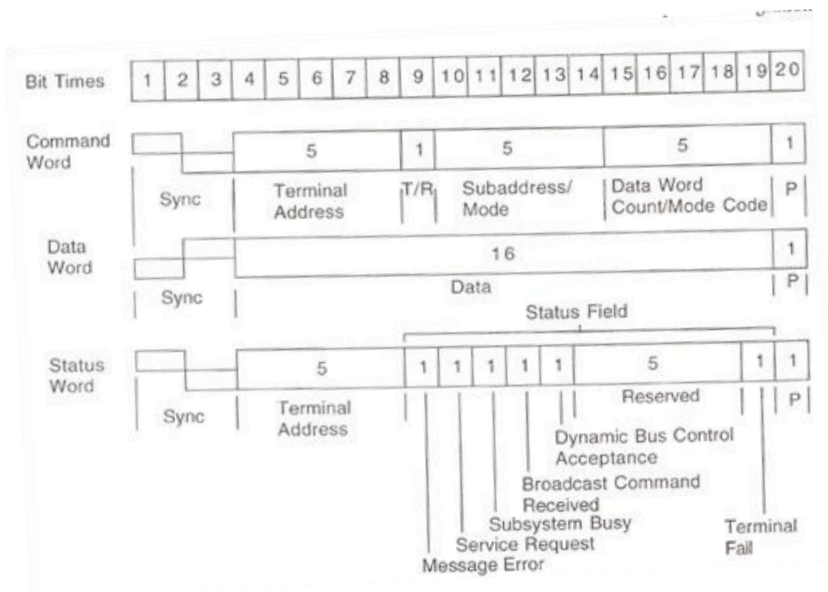


Figure 4.9 Word Formats

MIL-STD-1553, Command/Response Aircraft Internal Time Division Multiplex Data Bus, is a Military standard (presently in revision B), which has become one of the basic tools being used today for integration of Avionics subsystems. This standard describes the method of communication and the electrical interface requirements for the subsystems connected in the data bus.

Coupling Methods

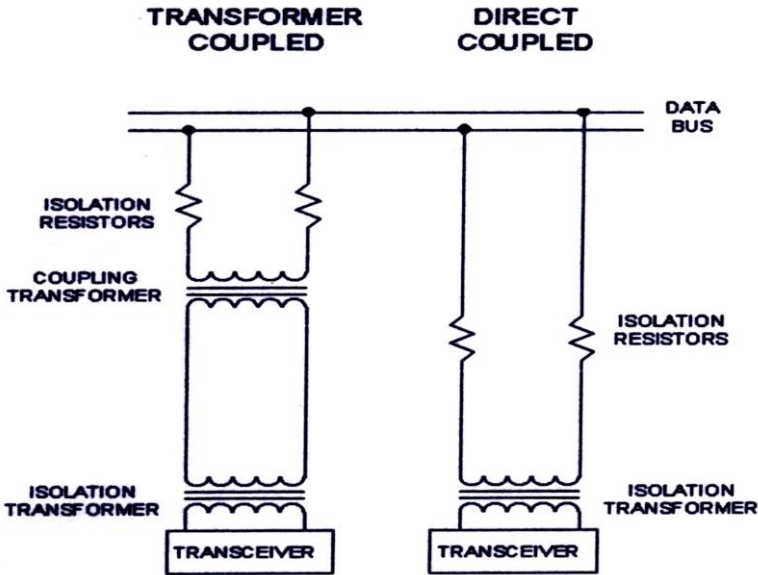


Figure 4.10 Coupling Methods

ARINC

ARINC (Aeronautical Radio Incorporated) is a nonprofit organization in the USA which is run by the civil airliners with industry and establishment representation, which defines systems and equipment specifications in terms of functional requirements, performance and accuracy, input and output interfaces, environmental requirements, physical dimensions and electrical interfaces.

ARINC 429

- ❖ Single point failure in 1553B leads to Certificability problem in civil aircraft. Addition of remote terminal requires changes in bus controller software which

requires frequent certification. So ARINC 429 Standard was adopted in the year 1977 and made its appearance in the C-17 transport aircraft. The ARINC 429 architecture is shown in figure 4.11.

- ❖ It is a Point to Point Protocol System.
- ❖ It is a specification that defines a local area network for transfer of digital data between avionics system elements in civil aircraft.
- ❖ It is simplex data bus using one transmitter but no more than twenty receivers for each bus implementation. There is no physical addressing. But the datas are sent with proper identifier or label.
- ❖ ARINC 429 is viewed as a permanent as a broadcast or multicast operation
- ❖ In this system two alternative data rates of 100kbps and 12-14 Kbps are possible.
- ❖ There is no bus control in the data buses as found in MIL-STD 1553B. It has direct coupling of transmitter and receiving terminals.

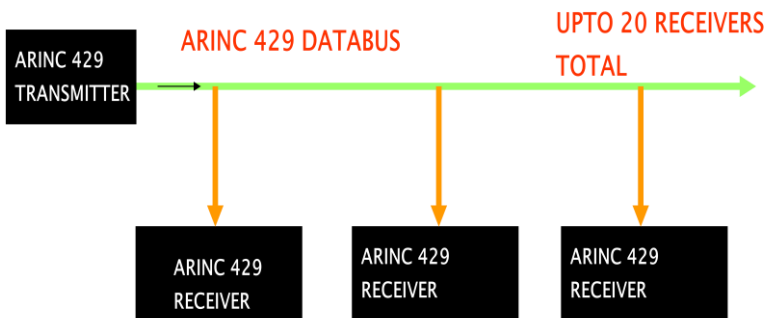


Figure 4.11 ARINC 429 ARCHITECTURE

ARINC 629 ARCHITECTURE

History:

- 1977 - Boeing began to work on “DATAC” project
- 1977 - 85 - DATAC Emerged as ARINC 629
- 1989 - ARINC 629 was adopted by AEEC
- 1990 - ARINC 629 was first implemented in BOEING-777

ARINC 629 Specifications

Data Rate	2 Mbps
Word Length	20 Bits
Maximum terminals connection to the bus	31
Message Length	31 word strings
Data Bits per Word	16 bits
Transmission Technique	Half Duplex
Encoding	Manchester II Bi-Phase
Protocol	Carrier Sense Multiple Access Collision avoidance
Transmission Mode	Voltage Mode, Current Mode, Fiber Optic Mode

ARINC 629 Architecture

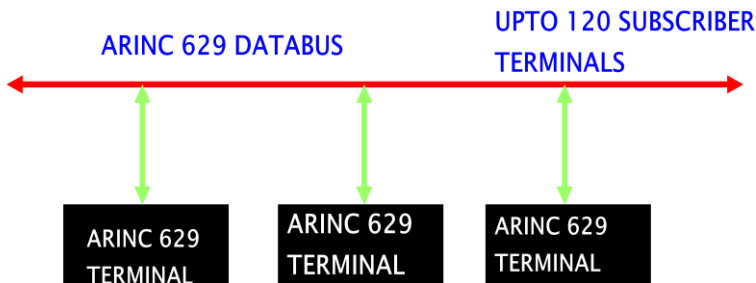


Figure 4.12 ARINC 629 ARCHITECTURE

QUESTIONS

Part – A

1. Give few avionics architecture.
2. Write about Federated architecture.
3. Discuss on centralized architecture.
4. How is federated architecture different from centralized architecture?
5. Write down the MIL-STD 1553B components.
6. Give details about the status word of MIL-STD 1553B.
7. Write short notes on ARINC 429 standard.
8. Brief about ARINC 629 standard.
9. Differentiate between Civil and military communication standards.
10. Differentiate between ARINC 429 and ARINC 629.
11. Differentiate between MIL and ARINC standard in terms of RT.
12. Differentiate between MIL and ARINC standard in terms of BUS speed.

Part-B

1. Discuss the various avionics architecture in detail.
2. Explain the ARINC 429 data bus in detail.
3. Explain the ARINC 629 data bus in detail.
4. Explain MIL STD 1553 B data bus in detail bring out clearly the bus architecture, protocol, word and message formats and coupling methods.
5. List the evolution of avionics architecture starting from first generation to fourth generation.
6. Describe in detail about one of the third generation Avionics Architecture with block schematics.



DESIGN ASPECTS: AVIONICS, CONTROLS AND WEAPON SYSTEMS

Communication system, Navigation system, Radar, Flight control system, Weapon systems, and weapon system interface. Utility systems Reliability and maintainability - Certification

Communication Systems

It connects the flight deck to the ground and the flight deck to the passengers. Radio transmitter and receiver equipment was the first avionic system installed in an aircraft in 1909 manufactured by Marconi Company. The VHF aviation communication system works on the air band of 108.00 MHz to 136.975 MHz.

This system is used for voice transmission and reception between aircraft and aircraft or ground station. The concept of radio communication involves in transmission and

reception of electromagnetic energy waves through space. Alternating current passing through a conductor creates an EMF around the conductor. If the frequency of alternating current increases, the energy stored in the field is radiated into the space in the form of electromagnetic waves. A conductor which radiates the energy is called as transmitting antenna. These transmitted radio waves travel at a speed of 186000 miles per second.

If a radiated EMF passes through a conductor, some of the energy in the field will cause the electrons in motion, in the conductor. So this electron flow constitutes a current in the receiving antenna which is similar to the varying current in the transmitting antenna.

Frequencies between 108 to 117.975 are splitted into 200 narrow band channels and they are used for VOR, Automatic Terminal information Service, ILS and Local Area Augmentation System.

Frequencies between 118 – 137 MHz is splitted into 760 Channels and they are used for AM voice transmission

Some channels between 123.100 to 135.950 are available for government agencies, search and rescue and National Aviation authority use.

Aircraft communication can also take place using HF i.e. for transoceanic flights or satellite communication.

Frequency – It is the number of occurrences of a repeating event per unit time.

$$\text{Period } T = 1/f$$

Frequency Types:

Very Low Frequency	- 3 to 30 KHz
Low Frequency	- Less than 500 KHz
Medium Frequency	- 300 – 3000 KHz

High Frequency	- 3 to 30 MHz
Very High Frequency	- 30 MHz – 300 MHz
Ultra High Frequency	- 300 MHz – 3 GHz
Super High Frequency	- 1GHz – 300 GHz
Extremely High Frequency	- 30 GHz – 300 GHz
Microwaves	- 300 MHz – 300 GHz

Basic components of a Communication System:

a) Microphone

It converts the sound energy into corresponding electrical energy.

b) Transmitter

- (i) Oscillator – to generate RF signal
- (ii) Amplifier – increase the output
- (iii) Modulator – To add the voice signal

c) Transmitting Antenna

It is the special type of electrical circuit.

d) Receiving Antenna

e) Receiver

f) Power supply.

The receiver must be able to select the desired frequency signal from lot of signals present in the air and also it should amplify the small ac signal voltage.

The receiver contains Demodulator (to remove the added signal). The demodulator contains detector (is used to AM) and discriminator (is used for FM).

ACARS

Aircraft communications addressing and reporting system is a digital datalink system for transmission of short, relatively simple messages between aircraft and ground

stations via radio or satellite. The protocol was designed by ARINC (Aeronautical Radio, Incorporated) in 1978.

Long Range Communication – HF (2 – 30 MHz)

Near to Medium Range Communication – VHF (30 – 100 MHz)

Military Aircraft (UHF) – (250 – 400 MHz)

Equipment is usually at duplex level of redundancy. The VHF radios are generally at triplex level on modern aircrafts. Satellite communications are installed in modern aircraft and provide reliable worldwide communication.

Analog Modulation (AM)

Amplitude modulation is the simplest and earliest form of communication. AM is used to transmit the information via a radio carrier.

AM application includes broadcasting in medium and high frequency applications, aircraft communications and CB Radio (Citizen's Band Radio)

Modulation

The process by which some characteristics of a carrier signal is varied in accordance with message signal.

Modulation is required to expand the bandwidth of the transmitted signal for better transmission quality. (To reduce noise and Interference) Information (Low frequency such as audio or voice)

Radio Communication

It uses the ability of an electromagnetic wave to transfer information from one point to another.

AM is the first method used to transfer voice information from one place to another.

Voice frequencies ranges from 50 Hz to 3000 Hz.

Basic Principle of Analog Modulation

Mix the voice frequencies with a radio frequency signal, so that they are converted to radio frequencies, which can propagate through free space.

Carrier – Sinusoidal High Frequency Radio Signal.

Voice Frequency + Carrier Frequency = Radio Frequency

→ Radiate through Antenna → Propagate at light speed

→ Recover those voice Frequency

Types

Double – sideband Full carrier

Single – sideband Reduced carrier

Single – sideband Full carrier

Single – sideband Suppressed carrier

Independent – sideband Emission

Vestigial – Sideband

Aircraft Navigation

Navigation is the science of conducting journeys over land or sea.

Position

To define a two dimensional position on the earth's surface, a co-ordinate system using imaginary lines of latitude and longitude are drawn over the globe.

Longitude – These lines are placed or passing from North – South. On the globe, lines of constant longitude or meridians extend from pole to pole (i.e. N to S).

The longest latitude is the equator.

Types of Radio Navigation

- ❖ Automatic Direction Finder
- ❖ VOR
- ❖ Distance measuring Equipment
- ❖ Inertial Navigation System
- ❖ Doppler Navigation System
- ❖ Satellite Navigation System

Distance and Speed:

- ❖ For Aircraft navigation purposes, the quantity of distance used is Nautical Miles.
- ❖ Aircraft Speed – Rate of change of distance with respect to time in knots.
- ❖ 1 Nautical mile per hour – 1.852 Km per hour

Position Fixing

The position of an aircraft can be fixed with the help of two VOR (VHF omnidirectional Radio Range). It is a type of Radio navigation system which uses VHF Radio composite signal, which includes stations Identifier, Voice and Navigation signal. This was broadcast by VOR ground station.

The station's Identifier is a Morse code. Morse code is a method of transmitting textual information as a series of on-off tones, lights or click and that can be understood by a skilled listener.

Example:

- Dash is equal to three dots

- Space between parts of same letter is equal to one dot
- Space between two letters is equal to three dots
- Space between two words is equal to seven dots

The origin of this code was developed by Samuel. F.B. Morse. The advantage of Morse code for transmitting over radio waves is that it is able to be received over poor signal conditions. (i.e. when voice communications are not possible).

The navigational signal sent by ground station allows the airborne receiving equipment to determine the magnetic bearing (Bearing is the direction of one object from another object and the magnetic bearing is the direction toward the magnetic north pole).

The intersection of two radials from different VOR stations is used to find the position of the aircraft.

Inertial Navigation System

It is an autonomous dead reckoning method of navigation. (i.e. it won't require any external inputs or references from ground station). This system was developed by US Military in 1950's and it was introduced in commercial aircrafts in 1970's. This system can compute navigation data such as present position, distance, heading, ground speed, wind speed and wind direction.

Principles

The primary sensors used in the system are accelerometers and gyroscopes to determine the motion of the aircraft. These sensors provide reference outputs to develop navigation data.

Accelerometer

This is formed with a mass and two springs within a housing which is shown in figure 5.1. Moving the

accelerometer to the right causes a relative movement of mass to the left. When the accelerometer is moved to the left, the relative movement of mass is to the right.

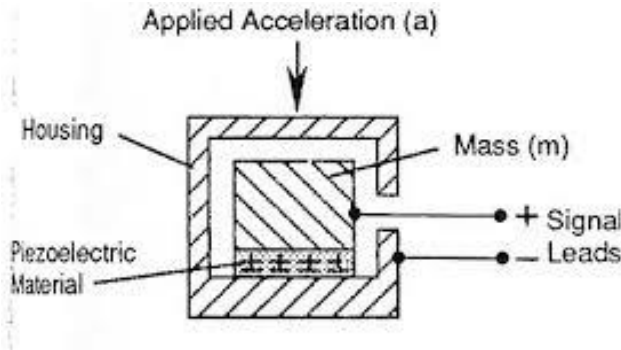


Figure 5.1 Basic Accelerometer

Inertia

A mass continues in its existing state of rest or movement unless the applied forces changes and this is the property of inertia.

A transducer is used to measure the amount of relative movement of the mass. This relative movement is in direct proportion to the acceleration being applied to the device.

$$\text{Time} \times \text{Acceleration} = \text{Velocity}$$

$$\text{Time} \times \text{Velocity} = \text{Distance}$$

So the accelerometer is providing the velocity and distance, but measured in one direction. If we take two accelerometers and mount them on a platform at right angles to each other we can measure the quantities in any lateral direction. In the aircraft three accelerometers are used for sensing longitudinal, lateral and vertical motion.

Gyros

It is defined as a system containing a heavy metal wheel or rotor, and it has 3 degrees of freedom.

- i) Spinning freedom
- ii) Tilting freedom
- iii) Veering freedom

These degrees of freedom are obtained by mounting the rotor in two concentrically pivoted rings called inner rings called inner ring and outer gimbal ring.

When the rotor is made to spin at high speed, then the device possesses two properties,

- i) Gyroscopic Inertia
- ii) Precession

These properties depend on the principle of conservation of angular momentum. The angular momentum of a body about a given point remains constant unless some force is applied to change it.

Directional Gyros (Depends on Gyroscopic Inertia) and Gyro horizons – Attitude Gyros.

Rate Gyros (Turn and slip Indicator) – depends on precession

Electromechanical gyros are used in inertial navigation system, and this is replaced by more reliable and accurate ring laser gyro. Ring Laser Gyros (figure 5.2a) uses interference of laser beam within an optic path or ring to detect the rotational displacement.

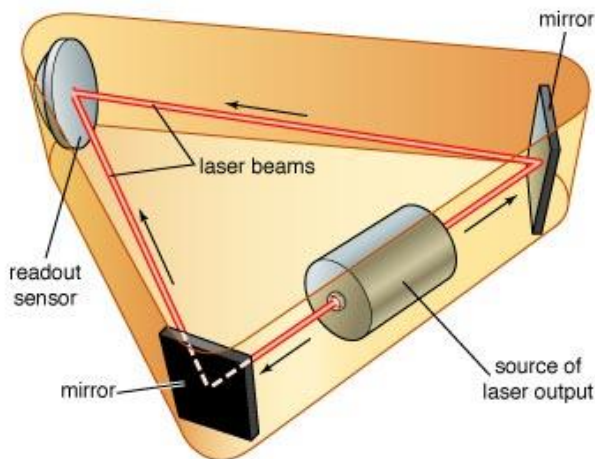
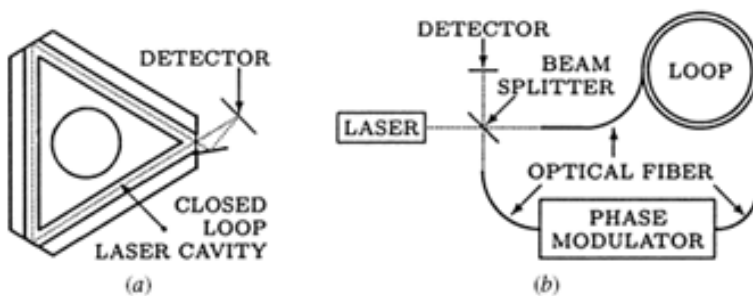


Figure 5.2a Laser Gyroscope



Laser gyroscopes: (a) ring laser gyro (RLG); (b) fiberoptic gyro.

Figure 5.2 Laser Gyroscope

Inertial Reference Unit – Accelerometer + Gyros

Inertial Navigation Unit – Accelerometer + Gyros + Navigation
Processing Unit

Advantages

There is no moving parts in RLG, so no friction, Compact, Light weight, Long and Reliable life time (30000 hrs), fit and forget and Low cost.

Sagnac Effect

A beam of light is split and the two beams are made to follow a trajectory in opposite directions. On return to the point of entry the light is allowed to exit the apparatus, in such a way that an interference pattern is obtained. A ring laser is a laser in which the laser cavity has the shape of a ring.

An optical cavity or optical resonator is an arrangement of mirrors that forms a standing wave cavity resonator for light waves.

The detector measure differences in frequency using Doppler principle. The beam that is travelling in the direction of rotation of the path form has a longer distance to travel having a low frequency. The beam travelling against the direction of motion has a shorter path and a higher frequency. The difference in frequency is directly proportional to the rotation rate.

Resonance

It is the tendency of a system to oscillate at greater amplitude at some frequencies than at others. This resonance was exhibited by a resonator.

Standing wave is formed by the superposition of two waves of the same frequency propagating in opposite directions.

If a ring laser is rotating, the two counter propagating waves are slightly shifted in frequency and a beat interference

pattern is observed, which can be used to determine the rotational speed.

Ring laser gyros use interference of a laser beam within an optical path or ring to detect rotational displacement. An IRU contains three such devices for measuring changes in pitch, roll and azimuth. Two laser beams are transmitted in opposite direction within a triangular block. The two laser beams travel the same distance, but in opposite directions, and they arrive at the detector at the same time.

In the aircraft RLG application, when the aircraft attitude changes, the RLG rotates. So the laser beam in one path now travels a greater distance than the beam in the other path. This changes its phase at the detector with respect to the other beam.

The angular position is measured by the phase difference of two beams. This phase difference appears as a fringe pattern. The fringe pattern is in the form of light pulses that can be directly translated into a digital signal.

Disadvantages

Lock-in, when the frequency difference between the two beams is low (i.e. 1000 Hz), the two beams merge their frequencies. This can be avoided by mechanically oscillate or either or vibrate the RLG to minimize the amount of time in this lock-in region.

Fiber Optic Gyros:

The fiber optic gyroscope (figure 5.2b) also uses the interference of light through several kilometers of coiled fiber optic cable to detect angular rotation. Two light beams travel along the fiber in opposite directions and produce a phase shift due to Sagnac effect.

Doppler Navigation:

It is a self-contained dead reckoning system. (i.e. It won't require any external inputs or references from ground stations). Ground speed and drift can be determined using Doppler shift. Doppler Navigation systems are developed in 1940's and introduced in 1950's, as a primary navigation system. This system can be used for long distance navigation over oceans and undeveloped areas of the globe.

Doppler Effect:

The frequency of a wave apparently changes as its source moves closer to, or further away from an observer.

DNS in aircraft have a focused beam of electromagnetic energy transmitted ahead of the aircraft at a fixed angle θ . This beam is scattered in all directions when it arrives at the surface of the earth. But some of the energy is received back at the aircraft. By measuring the difference in frequency between the transmitted and received signals, the aircraft's ground speed can be calculated.

The signal to noise ratio of the received signal is a function of number of factors.

- i) Aircraft range to terrain
- ii) Backscattering features of the terrain
- iii) Atmospheric condition
- iv) Radar equipment

If the aircraft were pitched up or down, then the angle of beam with respect to aircraft and the surface will change. This can be overcome by any one of two ways.

- i) The transmitter and receiver can be mounted on a stabilized platform.
- ii) Two beams can be transmitted from the Doppler shift of both beams a true value of ground speed can be calculated.

$$F_D = 2 \cos \theta \times V f / c$$

F_D – Frequency difference, θ – The angle between the beam and aircraft, V – Aircraft velocity, f – Frequency of transmission, c – speed of electromagnetic propagation (3×10^8 m/s).

Drift

- ❖ The drift can be calculated by directing a beam at right angles to the direction of travel, and applying the same principle.
- ❖ Due to wind forces, the direction of movement of aircraft or track is not the same as heading.
- ❖ The angle between heading and track is known as drift angle.
- ❖ Ground speed is the speed of an aircraft relative to the ground.
- ❖ Ground speed = Vector sum of aircraft's True Air Speed, current wind speed and direction.

Satellite Navigation

Technology:

GPS, Wide Area Augmentation system, Ground based Augmentation system, Receiver Autonomous Integrity Monitoring.

GPS is operated and maintained by the US DOD. GPS is a revolutionary navigation system. In this system active 24 satellites orbiting the earth and 3 satellites are spare, so 27 a constellation of 27 satellites are used which is given in figure 5.3.

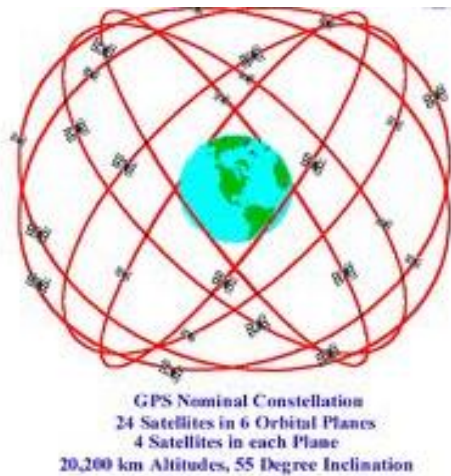


Figure 5.3 GPS

It provides the location within meters or less anywhere on the globe.

- Civilians use the L1 frequency of 1575. 42 MHz.
- Orbit is 12,600 miles above the earth.
- The first satellite launched in 1978 and 24th operational in 1994.

The GPS receiver's job is to locate four or more satellites and figure out the distance to each satellite and use this information to deduce its own location. This is called as triangulation or trilateration.

Four essential ingredients of GPS satellite are,

- i) Start time (Transmission time)
- ii) Ephemeris (Satellite location)
- iii) Arrival time (Reception time)
- iv) Distance travelled (Travel time and range)

Travel time = Arrival time – Start time

Range = Speed of light x Travel time

Operation of three GPS satellites estimate latitude, longitude and altitude.

A low Earth orbit (LEO) is an orbit around Earth with an altitude between 160 kilometers. All manned space stations to date, as well as the majority of satellites, have been in LEO. Comparison of GPS, GLONASS, Galileo and Compass (medium earth orbit)satellite navigation system orbits with the International Space Station, Hubble Space Telescope and Iridium constellation orbits, Geostationary Earth Orbit, and the nominal size of the Earth which is shown in figure in 5.4.

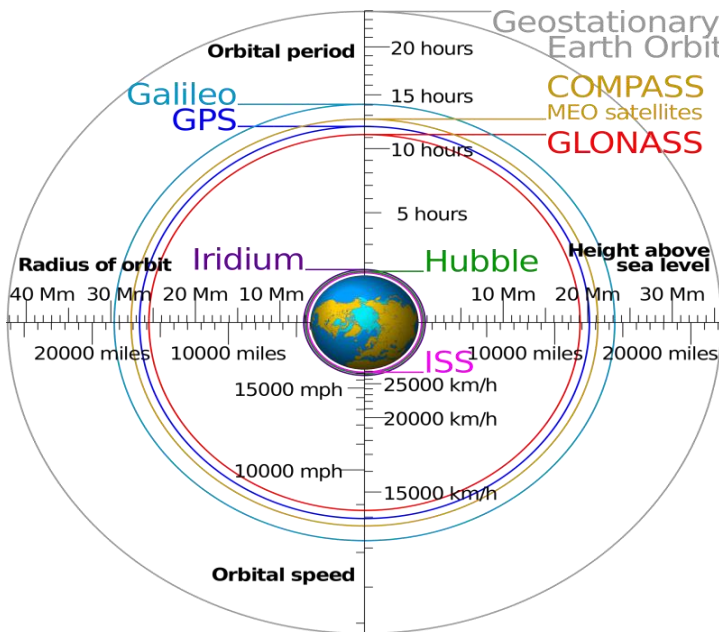


Figure 5.4 Navigation system orbits

Radar Systems

Radar is an electromagnetic system for the detection and location of reflecting objects such as aircraft, ships, spacecraft, vehicle, people and the natural environment. It operates by radiating energy into space and detecting the echo signal reflected from an object or target. By comparing the received echo signal with the signal that was transmitted, its location can be determined. Radars can operate in darkness, haze, fog, rain and snow. It measures the distance with high accuracy in all weather conditions. Weather Radar detects water droplets, cloud turbulence and warning about storms.

The range to a target is determined by the time T_R it takes the radar signal to travel to the target and back. Electromagnetic energy in free space travels with the speed of the light ($C=3 \times 10^8$ m/s). Thus the time for the signal to travel to a target at a range R and return back to the radar is $2R/c$. The range to the target is given as,

$$R = CT_R/2$$

In Fighter Aircrafts Multi Mode Radars are used 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.

Radar Electronic Warfare:

Electronic warfare is a military action which exploits the Electro Magnetic spectrums.

Electronic Warfare Equipment:

Passive EWE:

It includes reconnaissance or surveillance equipment which detects and analyses electromagnetic radiation from

radar and communication transmitters. These EWE is used to identify and map the location of emitters without altering the nature of the signals they receive.

Active EWE

It generates energy either in the form of noise to confuse enemy's electromagnetic sensors or by generating false or time delayed signals to confuse the radar equipment and their operators.

Passive EWE:

i) Warning Receiver Systems:

The warning receiver is programmed to alert a pilot when the aircraft is being illuminated by a specific radar signal.

Chaff

These are metallic strips cut to length, resonant at the defense radar frequency, so they return spurious radar echoes to enemy radar. Chaff can confuse an enemy by generating false targets or noise.

Chaff can screen or mask aircraft or higher speed ships, so that the enemy is unable to determine their presence.

Materials

By using special radar absorbing materials such as ceramics or ferrites (which reduce reflection coefficients) we can reduce the amount of radar energy returned to the illuminating radar. Special shaping of bodies will reduce the vehicle's radar cross section.

Active Systems

- ❖ Noise (Oldest, simple and require higher average power levels, more expensive) Deception Jamming

Deception Jamming:

In this technique the deception set may receive an enemy radar pulse, circulate its through a delay line, amplify it and reradiate it back towards the enemy. Due to this the radar decision circuitry will conclude that the target is at greater distance than its original.

The Deception set also returns many pulses instead of one, in an effort to deceive the enemy into believing there are many targets spaced at different positions.

Electronic Attack: (EA)

EA or Electronic counter measures (ECM) involves the use of electromagnetic energy or counter electromagnetic radiation weapons to attack the enemy's equipment.

Electronic Protection: (EP)

EP or Electronic protective measures or Electronic Counter Measures uses actions to protect equipment from any affects caused by enemy.

Electronic Warfare Support:

It is the sub division of EW involving actions tasked by an operational commander to search for, intercept, identify and locate the intentional and unintentional radiated. Electromagnetic energy for the purpose of immediate threat recognition, targeting, planning and conduct of future operations.

FLIGHT CONTROL SYSTEM

Conventional Systems:

The attitude of the flight during flight can be controlled with the help of control surfaces.

The primary flight control system provides pitch, yaw and roll control of the aircraft. This system includes,

- a) Elevator
- b) Rudder
- c) Aileron

The primary flight control surfaces are incorporated in the wing and the empennage.

Horizontal Tail - Elevators (Pitch)

Vertical Tail - Rudder (Yaw)

Wings - Aileron (Roll)

In addition to the basic primary control surfaces, other surfaces are also used to attain the pitch, yaw and roll action.

Pitch control – Elevators – (Variable Incidence horizontal Stabilizer) It is used where the elevator surface is of In adequate size.

Canards

Inorder to attain the longitudinal stability the pitch control surfaces can be placed on the front fuselage. This is called as canards.

Longitudinal Stability – Pitch (Up and down)

Lateral Stability – Roll (Up and down)

Directional Stability – Yaw (Turn Right and left)

The yawing can be achieved through rolling.

Elelevons:

It is a wing trailing edge. It is used on tailless delta wing aircraft inorder to provide both the pitch and roll control.

Flaperons:

It is a wing trailing edge surface. This is used on the aircraft for lifting from short runways.

Ruddervators:

Combination of rudder and the elevator on the tail.

Stabilator

A Stabilator performs the function of a horizontal stabilizer and an Elevator. These are used on the light aircraft and the high performance military aircraft.

Secondary Control Surfaces:**i) Trim control surfaces**

Trim tabs were used for trimming an aircraft for straight and level flight. These small auxiliary control surfaces are hinged to the trailing edge of the elevator.

ii) High Lift Devices

- a) Trailing edge flaps
- b) Leading edge flaps or slats

These devices are used to provide higher lift at low speeds for take-off. And also used to increase the drag to slow down the aircraft during landing.

iii) Speed Brakes

These are called as air brakes, dive brakes or drag brakes. This is used to decelerate the aircraft in flight. It is designed to pop out of the wing at a near 90° angle to the airflow, which will increase the drag by spoiling the stream line.

iv) Spoilers

This is used to reduce the lift.

Mechanical Flight Control System:

It is generally used on small aircraft. The primary flight control surfaces are moved manually by using push-pull rods.

Push Pull Rod Type

In this a sequence of rods are used to link the control surfaces to the cabin input which is shown in figure 5.5.

Bell crank lever is used to alter the direction of the force and to obtain the coupling between stick movement and the control surface deflection.

This is used to transfer either tension or compression loads.

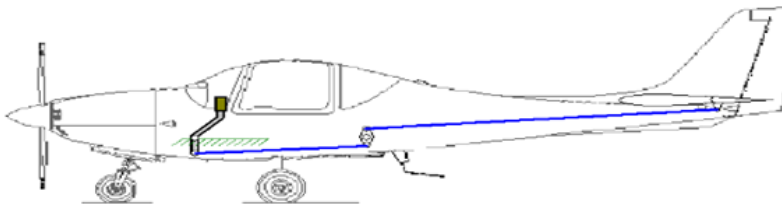


Figure 5.5 Push Pull Rod system for Elevator Control

Cable Pulley Type

The cable pulley system requires large no of pulleys, brackets and guards. So this system becomes more complex and heavier. In this system we are using the cables instead of rods which is illustrated in figure 5.6.

Pulleys – Used to alter the direction of lines

Quadrant is employed at the base of the control column to impact force and motion to the cable system. A torque tube is attached to the control surface, which changes linear motion of the cable into rotary motion.

For large aircrafts this type is preferable, because more flexible.

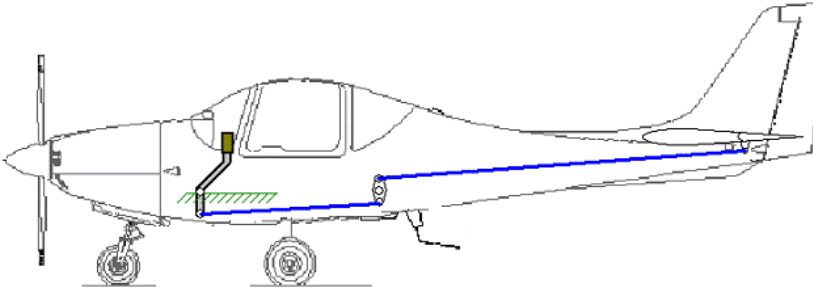


Figure 5.6 Cable and Pulley System for Elevator Control

ELECTRONIC FLIGHT CONTROL SYSTEM:

Due to the advent of advanced micro-electronics (light weight and reliable) systems are used to operate the conventional systems. In this the electronic signals are used to operate hydraulic jacks which can move the control surfaces.

This modern control system is divided into three types.

- Fly-by-wire system,
- Fly-by-light system,
- Autopilots.

Fly By Wire:

In this control system the control inputs from the pilot are transmitted to the control surfaces by electronic signals which is given in figure 5.7. In this system, the control columns are having electronic transducers which sense the position of the control column and sends that information to independent computers. This information is used to adjust the position of control surfaces. The control signals are transmitted by wires

to hydraulic unit. The hydraulic power is used to move the control surfaces.

In this flight control system the actuators are operated by electro – hydraulic servo valves. The electro – hydraulic servo valve is used to convert electric voltages into hydraulic power.

Linear Variable Differential Transformation:

LVDT are used to translate linear motion into electrical signal.

RVDT are used to translate angular displacements into electrical signal.

The pilot's demand is compared with the feedback from LVDT/RVDT. When the feedback signal is equal to the command signal from the cockpit the movement of control surface stops.

In this system primary and secondary flight control computers are used for calculations concern with aircraft control and sending signals to the actuators. So this system is having less amount of common errors.

In this system the following data are processed,

- a) Pitch, Roll, Yaw rate and Linear Accelerations
- b) Angle of Attack
- c) Airspeed, Altimeter, Mach meter, Pressure gauge Indications.
- d) Stick and pedal demands.

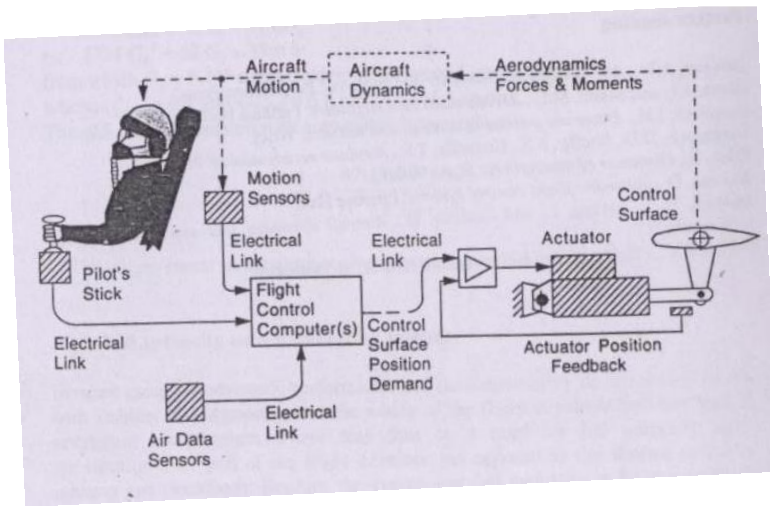


Figure 5.7 Fly by Wire System

Fly By Wire Basic Concepts and Features

- i) Total elimination of all the complex mechanical control runs and linkages. All commands and signals are transmitted electrically along wires.
- ii) The interposition of a computer between the pilot's commands and the control surface actuators.
- iii) The aircraft motion sensors which feedback the components of the aircraft's angular and linear motion to the computer.
- iv) The air data sensors which supply height and airspeed information to the computer.

The pilot thus controls the aircraft through the flight control computer and the computer determines the control surface movement for the aircraft to respond to the pilot's command.

Modern FBW systems use a serial digital data transmission system with TDM, through a digital data bus. Military FBW system uses the MIL STD 1553 B data bus system. It has a data rate of 1 Mbit/s and a word length of 20 bits, so can receive or transmit upto 50000 data words/second. The Boeing 777 uses the ARINC 629 data bus system which operates at 2 Mbit/s.

The FBW system without motion sensor is called as direct electric link system. The motion sensors comprise rate gyros for angular rates and linear accelerometers for linear rates.

Fly By Light:

It uses the optic cables for transmitting the control signals. It uses the electro – optic converters for converting light signals into electrical signals for actuating the hydraulic control valves.

Advantages

- i) Fibre Optic cables are light weight
- ii) Fibre optic cables are having high band width
- iii) Fibre optic cables are having immunity to EMI
- iv) Special shielding is not required.

Autopilot System:

An autopilot is a system used to guide a vehicle without assistance from a person. Autopilots are used in aircraft, boats, space craft, missiles and others.

A single axis autopilot controls an aircraft in the roll axis only.

A two axis autopilot controls the pitch and roll axis.

A three axis autopilots controls the yaw, pitch and roll axis.

Modern autopilots use computer software to control the vehicle. The software reads the vehicle's current position and then controls a flight control system to guide the vehicle. Besides classic flight controls many autopilots incorporate thrust control capabilities that can control throttles to optimize the speed.

The modern autopilot reads the vehicle's position and attitude from an inertial guidance system, which uses a six dimensional kalman filter. The six dimensions are Roll, Pitch, Yaw, Altitude, Latitude and Longitude.

Types

- a. Longitudinal Autopilot Systems (Displacement Autopilot)
- b. Lateral Autopilot Systems (Roll attitude Autopilot)
- c. Self-adaptive Autopilot

Autopilots are used to reduce the work, strain of controlling the aircraft during long flights. It provides control for one, two or three axis. The three axis system contains ailerons, elevators and rudders.

Autopilot system contains,

- i) Gyros (to sense the aircraft's position)
- ii) Servos (to move the control surfaces)
- iii) Amplifier (to increase the strength of gyro signals)

The Gyro sensing units are connected to flight instruments which indicate direction, rate of turn, bank or pitch. If the flight attitude is changed electrical signals are developed in the gyros, and this is transmitted to the servo unit. And this servo unit is used to convert the electrical signals into mechanical force, which is used to move the control surfaces.

Basic Autopilot Components:

- i) The sensing elements
- ii) Command elements
- iii) Output elements
- iv) Computing elements

The command unit is manually operated to produce signals which cause the aircraft to climb, dive or turns.

Sensing Elements

- a) Directional Gyro
- b) Turn and Bank Gyro
- c) Attitude Gyro
- d) Altitude control and Navigation signals
- e) Heading Selector

Computing Elements

This is used to process the signal and passes that one to the control surfaces.

Output Elements

- Servos – 1) Electric Motors
2) Electro / Pneumatic servos

Servos are used to actuate the control surfaces.

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,

- (vi) Receive Inputs from, Sensors, communication systems, Radio Navigation Systems, Identification system, Missiles, Electronic counter measures system, Pilot controls.

- (vii) Computation of required parameters for Navigation and Fire control.
- (viii) Transferring the computed results to displays, Audio system and weapons.
- (ix) Controlling of weapon launch / Firing.
- (x) Control / Co-ordinate / manage sensors optimally.

Sensors

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

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).

FAULT TOLERANT SYSTEMS:

This is used to continue satisfactory operation in the presence of one or more hardware or software faults.

Fault Detection in Hardware:

- i) Duplication and comparison
- ii) Self checking

Fault Detection in Software:

Fault Tolerant Software,

i) Multi-version Programming:

In this two or more versions of a program are developed with performs a specific function.

A common input is given and results are compared to detect any fault.

ii) Recovery Blocks:

It consist of primary and other alternate versions and each version is subjected to a test. If the versions

produces an acceptable result means that block is ok otherwise it is under fault.

iii) Run – time Assertion:

- a) Watch dog timer (detects crash, overload, Infinite Loop)
- b) Analytical Redundancy Technique

Hardware Assessment and Validation:

- i) Fault Tree Analysis
- ii) Failure mode and Effect Analysis
 - Catastrophic Failure
 - Critical Effect
 - Slight Effect
 - No Effect

Software Assessment and Validation

- i) Top down Design
- ii) Interfacing and Partitioning
- iii) Coding
- iv) Testing
- v) Integration
- vi) Integration with Hardware

Computer Based Reliability Modeling and Prediction

ARIES – Automated Reliability Interactive Estimation System

CARSRA – Computer – Aided Redundant System Reliability Analysis

CARE III – Computer Aided Reliability Estimation

**Utility Systems Reliability And Maintainability:
Maintenance**

An item to be retained in or restored to specific condition when maintenance is performed by a person having

specified skill levels, using prescribed procedures and resources.

Skilled persons are required for maintenance. The maintenance tasks may be performed in flight line or in maintenance department.

For easy maintenance one have to prepare the maintenance manuals, procedures and equipments. Use standard units for design.

Electro static Discharge sensitive devices should have protection facilities built into the LRU's.

Line Replaceable Unit is a modular component of an airplane, that is designed to be replaced quickly at an operating location. It is usually a sealed unit such as radio or other auxiliary equipment.

Many LRU's for commercial aircraft core designed according to ARINC specifications.

In the military, Electronic LRU's are typically designed to interface according to data bus standards such as MIL STD 1553.

BITE: (Built In Test Equipment)

It is a powerful maintenance tool that takes advantage of the intrinsic capabilities of digital avionics, which is given in figure 5.8.

This BITE should be capable of providing extensive data for engineering analysis. This should be able to recognize and correctly identify at least 95% of possible faults. Failure of BITE should also be clearly indicated.

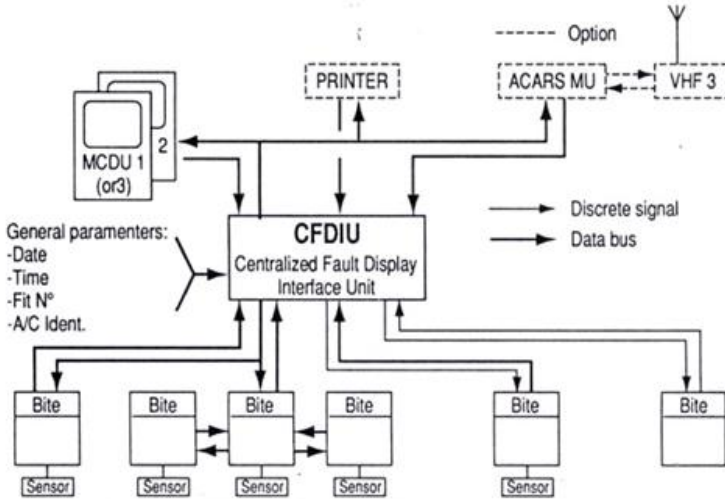


Figure 5.8 Fault Display system

Reliability

- ❖ The probability that an item can perform its intended functions for a specified interval under stated conditions.
- ❖ The duration or probability of failure-free performance under stated conditions
- ❖ The probability that an item can perform its intended functions for a specified interval under stated conditions

Reliability Analysis

It is a well known method which is used for predicting equipment failure rates.

$$\lambda_{Equip} = \sum_{i=1}^n N_i \lambda G_i^{II} Q_i$$

Where

λ_{Equip}	=	total equipment failure rate
λ_{Gi}	=	generic failure rate for the generic part type
Π_{Qi}	=	quality factor for i^{th} generic part type
N_i	=	quantity of i^{th} generic part type
n	=	number of different generic part types

CERTIFICATION

Certification refers to the confirmation of certain characteristics of an object, person, or organization. This confirmation is often, but not always, provided by some form of external review, education or assessment.

Steps in certification

- ❖ Assessment
- ❖ Validation
- ❖ Verification

Other major steps like

- ❖ Functional Hazard Assessment (FHA)
- ❖ Fault Tree Analysis (FTA)
- ❖ Failure Mode Effect Analysis (FMEA)

Document Support for Certification

In Military aircrafts, the documents support for certification

MIL-STD-1629A (Hardware)

DOD-STD-2167 (Software)

In Civil aircrafts, the document support for certification

FAR 25: 1309A (systems)

RTCA-DO-178A (Software)

Within the overall task of hardware assessment and validation, certification is perhaps the most difficult part for

civil/military avionics designers. Certification is the challenging process of negotiation and compromise between the designers and the regulatory authorities support by technical analysis and expertise on both sides.

QUESTIONS

Part – A

1. Write about the need of communication system in airline.
2. List out the types of navigation.
3. Write notes on Dead reckoning type of navigation.
4. What is INS?
5. What is GPS?
6. Explain about P and C/A codes.
7. Compare INS and GPS.
8. What is Flight control system?
9. Give the advantage of FBW over conventional FCS.
10. What is meant by strap down Navigation?
11. What is FMS?
12. Write about jammers in electronic warfare.
13. Give short notes on RADAR.
14. Discuss about Electronic warfare.
15. Bestow the advantages of GPS over conventional navigation.

Part – B

1. Describe a FBW flight control system and its characteristics and redundancy concept in detail.
2. Explain the operation of inertial navigation system and explain its two types of construction.
3. What is the need for a communication system in aircraft? Explain one of the most modern reliable communication systems used in aircraft with a block diagram.

4. What is GPS and explain the working of it with codes of communication used for locating the object.
5. Explain in detail about Radar Electronic warfare and its salient features and its usage.
6. Explain Certification and explain the various steps involved in certification of avionics system.
7. What is Dead reckoning navigation system and explain any one type in detail.
8. Explain Conventional Flight control system and advantage of FBW to overcome the disadvantage of Conventional FCS.

References

1. R.P.G. Collinson, Introduction to Avionics Systems, Third Edition, Springer.
2. E.H.J. Pallet, Aircraft Instruments, Second Edition, Pearson.
3. E.H.J. Pallet, Aircraft Electrical Systems, Third Edition, Pearson.
4. E.H.J. Pallet, Aircraft Flight Control, Second Edition, Pearson.
5. Lalit Gupta, O.P. Sharma, Fundamentals of Flight - Aircraft Systems, Himalayan Books.
6. D.H. Middleton, Avionics Systems, Longman Scientific and Technical Group UK Ltd.
7. C.R. Spitzer, Digital Avionic Systems, Prentice Hall.
8. R.B. Underdown and Tony Palmer, Navigation, Black Well Publishing.
9. Ian Moir and Allan Seabridge, Aircraft Systems: Mechanical, Electrical and Avionics-Subsystem Integration`, AIAA Educational Series.
10. E.H.J. Pallet, Aircraft Instruments and Integrated Systems, Longman Scientific and Technical Group.
11. N.S. Nagaraja, Elements of Electronic Navigation, Second Edition, Mc Graw Hill Education.
12. Amitava Bose, K.N. Bhat, Thomas Kurian, Fundamentals of Navigation and Inertial Sensors, PHI Learning.
13. Skolnik, Introduction to Radar Systems, Third Edition, Mc Graw Hill Education.

14. E.D. Kaplan, Understanding GPS: Principles and Applications, Artech House Telecommunication Library, USA.
15. Parvin, H. Richard, Inertial Navigation, D.Van Nostrand Company, New York.