Karpagam Academy of Higher Education

(Deemed to be University Established Under Section 3 of UGC Act 1956)

Pollachi Main Road, Eachanari Post, Coimbatore, Tamil Nadu 641021

FACULTY OF ENGINEERING

Department of Mechanical Engineering

(Aerospace Engineering)

Subject Name	**: Avionics**	**(Credits - 3)**
Subject Code	**: 14BEAR705**	
Name of the Faculty	**: R. Suresh Baalaji**	
Designation	**: Asst. Professor**	
Year/Semester/Section	**: IV / VII / -**	
Branch	**: Aeronautical Engineering**	

14BEAR705 **AVIONICS** **3 0 0 3 100**

OBJECTIVES:

To introduce the basic concepts of various avionics systems of aircraft.

UNIT I INTRODUCTION TO AVIONICS

Need for avionics in civil and military aircraft and space systems – integrated avionics and weapon systems – typical avionics subsystems, design, technologies – Introduction to digital computer and memories.

UNIT II DIGITAL AVIONICS ARCHITECTURE

Avionics system architecture–8085 Architecture and 8086 Architecture -Bus Structure of 8085 Architecture and 8086 Architecture– data buses – MIL-STD-1553B – ARINC – 420 – ARINC – 629.

UNIT III FLIGHT DECKS AND COCKPITS

Control and display technologies: CRT, LED, LCD, EL and plasma panel – Touch screen – Direct voice input (DVI) – Civil and Military Cockpits: MFDS, HUD, MFK, HOTAS
.

UNIT IV INTRODUCTION TO NAVIGATION SYSTEMS

Radio navigation – ADF, DME, VOR, LORAN, DECCA, OMEGA, ILS, MLS – Inertial Navigation Systems (INS) – Inertial sensors, INS block diagram – Satellite navigation systems – GPS.

UNIT V AIR DATA SYSTEMS AND AUTO PILOT

Air data quantities – Altitude, Air speed, Vertical speed, Mach Number, Total air temperature, Mach warning, Altitude warning – Auto pilot – Basic principles, Longitudinal and lateral auto pilot.

TEXTBOOKS:

S.No.	Author(s)	Title of the Book	Publisher	Year of Publication
1.	Albert Helfrick.D	Principles of Avionics	Avionics Communications Inc 2004	2004
2.	R. P. G. Collinson	Introduction to Avionics Systems	Springer-Verlag, New York.	2011

REFERENCES BOOKS:

S.No.	Author(s)	Title of the Book	Publisher	Year of Publication
1.	Middleton, D.H., Ed.	Avionics Systems	Longman Group UK Ltd., England.	2009
2.	Spitzer, C.R.	Digital Avionic Systems	Prentice Hall, Englewood Cliffs, New Jersey, USA.	2007
3.	Brain Kendal	Manual of Avionics	The English Book House, New Delhi.	2003

WEB REFERENCES:

www.ntps.edu/courses/116-introduction-to-avionics-systems-course

www.ece.ucsb.edu/courses/ECE152/152A_Su11Shynk/Lec1.pdf

www.davi.ws/avionics/TheAvionicsHandbook_Cap_20.pdf

www.pbase.com/bruceleibowitz/cockpit

www.cranfield.ac.uk/soe/shortcourses/.../avionics-introduction.html

KARPAGAM UNIVERSITY
COIMBATORE – 21
FACULTY OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

COURSE PLAN

Subject Name : **Avionics**
Subject Code : **14BEAR705** **(Credits - 3)**
Name of the Faculty : R. Suresh Baalaji
Designation : Asst. Professor
Year/Semester/Section : IV / VII / -
Branch : **Aeronautical Engineering**

Sl. No.	No. of Periods	Topics to be Covered	Support Materials
UNIT – I : INTRODUCTION TO AVIONICS			
1.	1	Introduction to Avionics Systems.	
2.	1	Need for avionics in civil aircraft.	
3.	1	Need for avionics in military aircraft.	
4.	1	Need for avionics in space systems.	Principles of Avionics
5.	1	Integrated avionics and weapon systems.	
6.	1	Typical avionics subsystems.	
7.	1	Typical avionics design.	
8.	1	Typical avionics technologies.	
9.	1	Introduction to digital computer and memories.	
Total No. of Hours Planned for Unit - I			**9 Hours**

Sl. No.	No. of Periods	Topics to be Covered	Support Materials
UNIT – II : DIGITAL AVIONICS ARCHITECTURE			
10.	1	Introduction to Digital Avionics Architecture.	
11.	1	Avionics system architecture 8085.	
12.	1	Avionics system Architecture 8086.	
13.	1	Bus Structure of 8085Architecture.	Avionics Systems
14.	1	Bus Structure of 8086 Architecture.	
15.	1	Data buses – MIL-STD-1553B.	
16.	1	Data buses – MIL-STD-1553B.	
17.	1	ARINC – 420.	
18.	1	ARINC – 629.	
Total No. of Hours Planned for Unit - II			**9 Hours**

Sl. No.	No. of Periods	Topics to be Covered	Support Materials
UNIT – III : FLIGHT DECKS AND COCKPITS			
19.	1	Introduction to Aircraft Decks and Cockpits.	
20.	1	Basics of Control and display technologies.	
21.	1	CRT, LED, LCD, EL and plasma panel.	
22.	1	Touch screen technology.	Avionics Systems
23.	1	Direct voice input (DVI).	
24.	1	Introduction to Fighter aircraft avionics systems.	
25.	1	Introduction to Fighter aircraft avionics systems.	
26.	1	Civil and Military Cockpits: MFDS, HUD,	
27.	1	MFK, HOTAS.	
Total No. of Hours Planned for Unit - III			**9 Hours**

Sl. No.	No. of Periods	Topics to be Covered	Support Materials
UNIT – IV : INTRODUCTION TO NAVIGATION SYSTEMS			
28.	1	Introduction to Navigation Systems.	
29.	1	Radio navigation.	
30.	1	ADF, DME, VOR, LORAN.	
31.	1	DECCA, OMEGA, ILS, MLS.	
32.	1	Inertial Navigation Systems (INS).	Principles of Avionics
33.	1	Inertial sensors.	
34.	1	INS block diagram.	
35.	1	Satellite navigation systems.	
36.	1	Global Positioning System (GPS).	
Total No. of Hours Planned for Unit - IV			**9 Hours**

Sl. No.	No. of Periods	Topics to be Covered	Support Materials
UNIT – V : AIR DATA SYSTEMS AND AUTO PILOT			
37.	1	Introduction to auto pilot system	
38.	1	Concepts of Air data quantities	
39.	1	Altitude and Air speed.	
40.	1	Vertical speed and Mach Number,	Avionics Systems
41.	1	Total air temperature and Mach warning	
42.	1	Total air temperature and Mach warning	
43.	1	Altitude warning – Auto pilot system	
44.	1	Basic principles of Longitudinal and lateral autopilot.	
45.	1	Basic principles of Longitudinal and lateral autopilot.	
Total No. of Hours Planned for Unit - V			**9 Hours**
46.	1	End Semester Questions Discussion	
47	1	Part – A / Online Questions Discussion	

TOTAL PERIODS : 45 L + 2 = 47 Hours

TEXT BOOKS

S.No.	Author(s)	Title of the Book	Publisher	Year of Publication
1.	Albert Helfrick.D	Principles of Avionics, Avionics Communications	Connaught Circus, New Delhi	2004

REFERENCES

S.No.	Author(s)	Title of the Book	Publisher	Year of Publication
1.	Middleton, D.H., Ed.	Avionics Systems	Longman Group UK Ltd., England.	2009
2.	Spitzer, C.R.	Digital Avionic Systems Prentice Hall	Englewood Cliffs, New Jersey, USA	2007

WEBSITES

www.ntps.edu/courses/116-introduction-to-avionics-systems-course

www.ece.ucsb.edu/courses/ECE152/152A_Su11Shynk/Lec1.pdf

www.davi.ws/avionics/TheAvionicsHandbook_Cap_20.pdf

www.pbase.com/bruceleibowitz/cockpit

www.cranfield.ac.uk/soe/shortcourses/.../avionics-introduction.html

JOURNALS

J [1] – Journal of Digital Avionic Systems
J [2] – Journal of Avionics Communications

UNIT	Total No. of Periods Planned	Lecture Periods	Tutorial Periods
I	9	9	0
II	9	9	0
III	9	9	0
IV	9	9	0
V	9	9	0
TOTAL	45	45	0

I. CONTINUOUS INTERNAL ASSESSMENT : 40 Marks

(Internal Assessment Tests: 30, Attendance: 5, Assignment/Seminar: 5)

II. END SEMESTER EXAMINATION : 60 Marks

TOTAL : 100 Marks

FACULTY CO-ORDINATOR / AERO HOD / MECH DEAN / FOE

KARPAGAM UNIVERSITY

Karpagam Academy of Higher Education
Coimbatore-641021

FACULTY OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

Subject Name: Avionics **Year / Semester**: IV / VII

Subject Code: 14BEAR705 **Programme:** UG / B.E. Aeronautical Engineering

COURSE OBJECTIVE

This course is introduced to understand the principles of operation of microprocessors and various digital systems used in aircraft.

COURSE OUTCOMES

1. Ability to understand the application of avionics in civil, military and space aircraft.

2. Ability to understand the principle of Logic Gates, Digital Computers and number systems.

3. Ability to understand the different types of microprocessor architecture.

4. Ability to understand, discuss and apply concepts of LCD,LED and cockpit instruments.

5. Ability to understand, discuss and apply concepts of Communication Systems, Navigation systems and Flight control systems.

UNIT – I Introduction to Avionics

01. Need for avionics: civil and military aircraft and space systems

'Avionics' is a word derived from the combination of **Aviation and Electronics.** It comprises electronic systems for use on aircraft, artificial satellites and spacecraft, comprising communications, navigation and the display and management of multiple systems.

All electronic and electromechanical systems and subsystems (hardware and software) installed in an aircraft that are dependent on electronics for its operation. Avionics Systems are essential to enable the flight crew to carry out the aircraft mission safely and to meet the mission requirements with minimum flight crew.

1.1 Need for avionics in civil and military aircraft and space systems:

A major driver in the development and introduction of avionic system has been the need to meet the mission requirement with the minimum flight crew.

Needs are

Avionics systems are essential to enable the flight crew to carry out the aircraft mission safely and efficiently. In civil aircraft, the mission is to carrying of the passenger to their destination safely (eg: Civil Airliner).

In military aircraft,

(i) Incepting a hostile aircraft.

(ii) Attacking the ground target.

(iii) Maritime patrol.

In spacecraft, carrying the mission safely and

(i) Reduction in weight

(ii) Long life time mission. Other needs are

- Minimal power consumption
- Air Traffic Control (ATC) requirements
- All weather operations
- Reduction in fuel consumption
- Improved in aircraft performance and control
- Reduction in maintenance cost

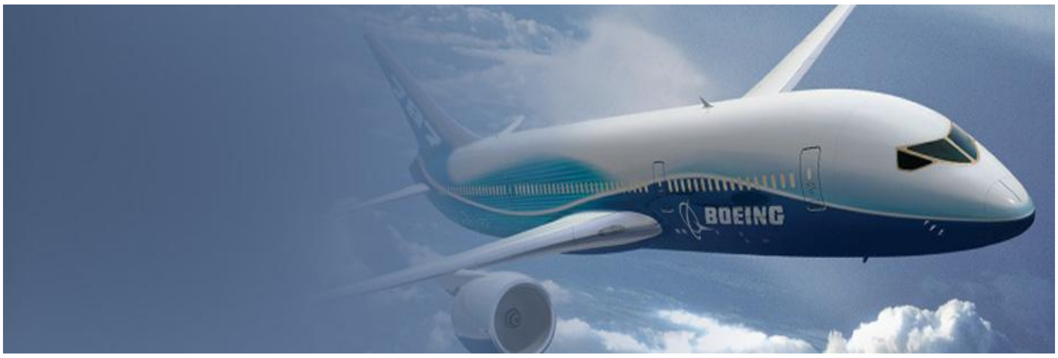
Avionics Equipment on

- A modern military or civil aircraft can account for around 30% of the total cost of the aircraft
- 40% in the case of a maritime patrol/anti-submarine aircraft (or helicopter)
- 75% of the total cost in the case of an airborne early warning aircraft (AWACS)
- Modern general aviation aircraft also have a significant avionics can account for 10% of their total cost

Advantage of using Avionics in CIVIL aircraft:

- Reducing the crew workload by automating tasks.
- The reduction in weight can be translated to increased passengers or long range.
- To enable the flight crew to carry out the aircraft mission safely and efficiently.

- All weather operation and
- Reduction in maintenance costs.



Advantage of using Avionics in MILITARY aircraft:

- A single seat fighter or strike aircraft is lighter and Costs less than an equivalent two seat version.
- Elimination of the second crew member (navigator/observer/crew member) results in reduction in training costs.
- Improved aircraft performance and control and handling and reduction in maintenance costs.
- Secure communication.

Advantage of Avionics in SPACE systems:

- Fly-by-wire control systems were used for vehicle attitude and translation control.
- Sensors used around the aircraft for data acquisition.
- Redundancy system and autopilot.
- On board computers used in satellites for processing.

General advantage of Avionics over the CONVENTIONAL aircraft:

- 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

02. INTEGRATED AVIONICS

1.2 INTEGRATED AVIONICS SYSTEM [IAS]

IAS is the combination of various system or subsystem which interconnects to the data bus and combining to form a single system.

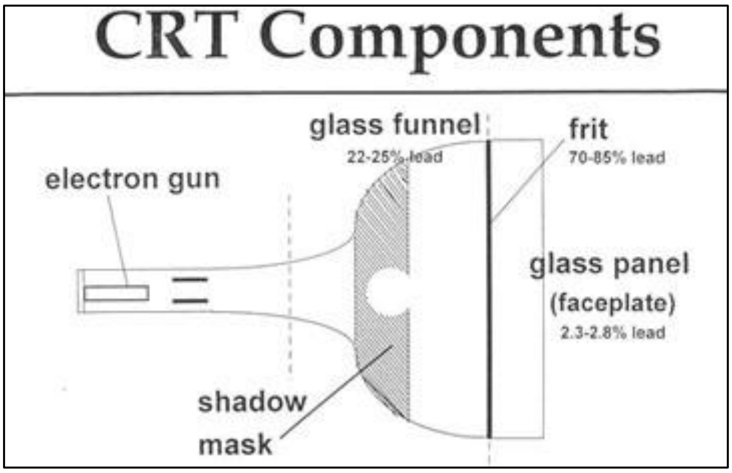
- The various types of IAS are,
    1. Cockpit Integration System
    2. Sensors Integration System
    3. Control Integration System

1.2.1 COCKPIT INTEGRATION SYSTEM

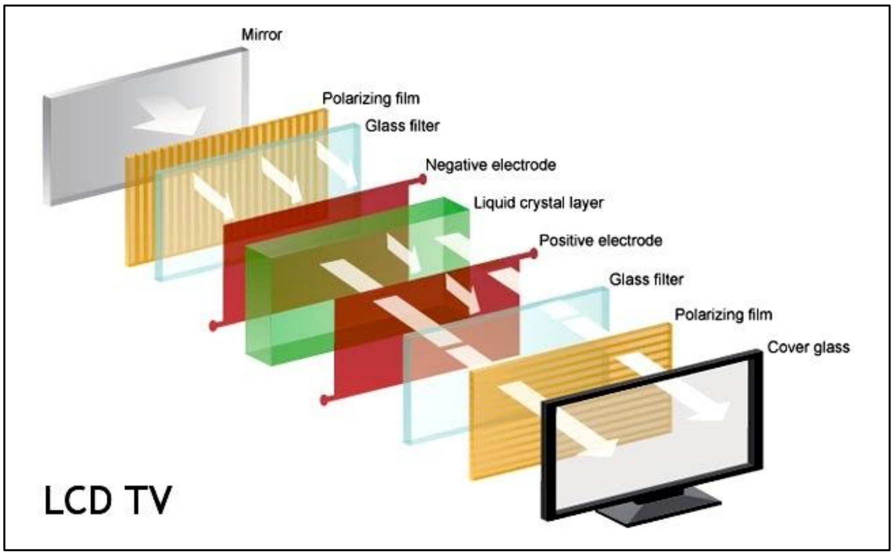
The major problem is the limited amount of instrument panel available in aircraft, one which is particularly acute in combat aircraft, where panel space is severely limited. The cockpit system integration involves the following displays system technology and control.

Cathode Ray Tube (CRT)

The cathode ray tube (CRT) is a vacuum tube that contains one or more electron guns and a phosphorescent screen, and is used to display images. It modulates, accelerates, and deflects electron beam(s) onto the screen to create the images.



Liquid Crystal Display (LCD)



❖

LCD (liquid crystal display) is the technology used for displays in notebook and other smaller computers. Like light-emitting diode (LED) and gas-plasma technologies, LCDs allow displays to be much thinner than cathode ray tube (CRT) technology.

❖ **Head Up Display (HUD)**

A head-up display or heads-up display, also known as a HUD, is any transparent display that presents data without requiring users to look away from their usual viewpoints.

❖ **Helmet Mounted Display (HMD)**

A helmet-mounted display (HMD) is a device used in some modern aircraft, especially combat aircraft. HMDs project information similar to that of head-up displays (HUD) on an aircrew's visor or reticle, thereby allowing them to obtain situation awareness and/or cue weapons systems to the direction his head is pointing.

1.2.3 SENSOR INTEGRATION SYSTEM

- Sensor integration not only reduces pilot workload it also expand coverage, increases confidence in target existence and identification, and is mutually supportive.
- Sensor fusion is an art of combining the various target data sources automatically and presenting the pilot with a unified and completes tactical picture within all ambiguities resolved.
- Sensor fusion produces a robust system that is difficult to jam, because all the elements are mutually supportive.

1.2.4 CONTROL INTEGRATION SYSTEM

- Integration of aircraft control function offers more significant benefits. The autopilot and flight management system grouped together to reduce the pilot workload and enables fuel saving flight profiles to be flows accurately and consistently.
- Engine control integrated with flight control. These control systems allows the engine measurement system to anticipate aircraft maneuvers and reduce the artificial margins currently imposed to ensure that engine operating limits are not over stepped in combat.

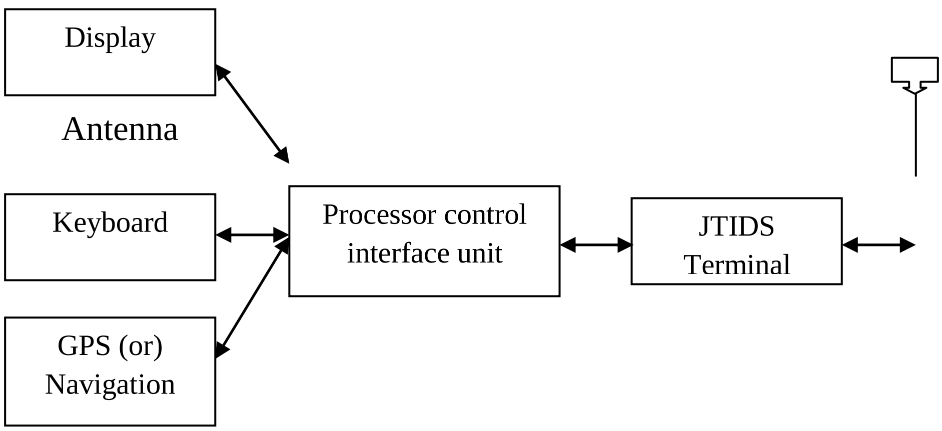


Figure 1: Various integrated avionics system design

Theavionics system specifications can be determined from aircraft crew comprising pilot and observer/navigator.

03. Weapon systems

1.3 INTEGRATED AVIONICS WEAPON SYSTEMS

1.3.1SONAR:

SONAR= **So**und **N**avigation **A**nd**R**anging

It is a technique that uses sound propagation (usually underwater, as in submarine navigation) to navigate, communicate with or detect objects on or under the surface of the water, such as other vessels.

Two types of technology share the name "sonar":

1.**Passive sonar** is essentially listening for the sound made by vessels.

2.Active sonar is emitting pulses of sounds and listening for echoes.

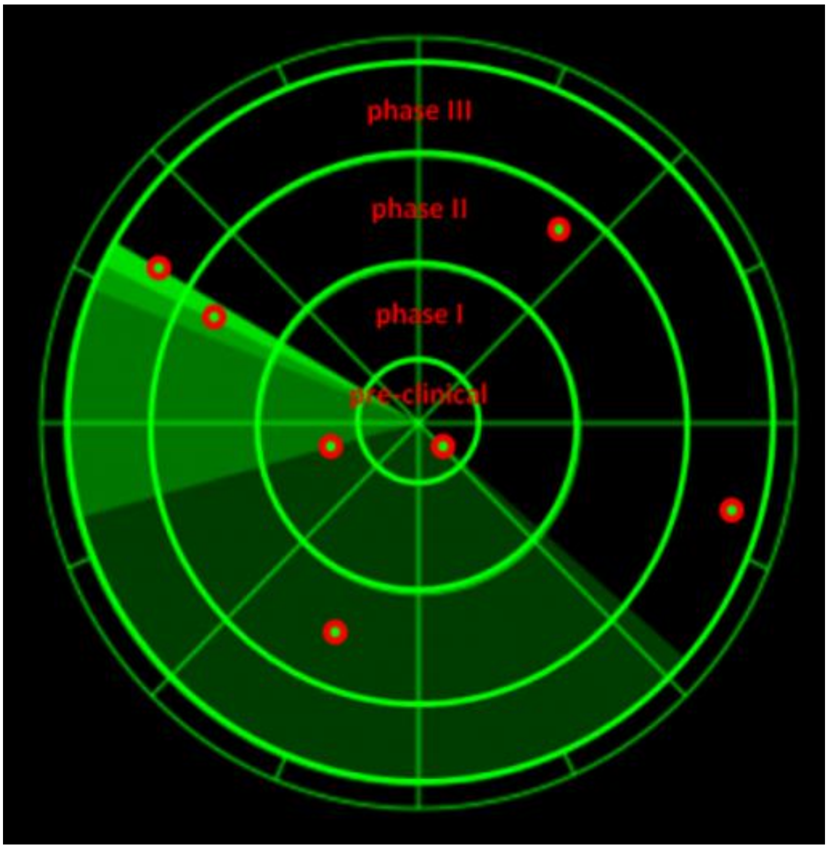
Sonar may be used as a means of acoustic location and of measurement of the echo characteristics of "targets" in the water. The acoustic frequencies used in sonar systems vary from very low (infrasonic) to extremely high (ultrasonic). The study of underwater sound is known as underwater acoustics or hydro acoustics.

1.3.2.RADAR:

RADAR= Radio Detection and Ranging

It is an object-detection system that uses radio waves to determine the range, altitude, direction, or speed of objects. It can be used to detect aircraft, ships, spacecraft, guided missiles, motor vehicles, weather formations, and terrain.

A radar system has a transmitter that emits radio waves called *radar signals* in predetermined directions. When these come into contact with an object they are usually reflected or scattered in many directions. Radar receivers are usually, but not always, in the same location as the transmitter. Although the reflected radar signals captured by the receiving antenna are usually very weak, they can be strengthened by electronic amplifiers.



Application:

In aviation, aircraft are equipped with radar devices that warn of aircraft or other obstacles in or approaching their path, display weather information, and give accurate altitude readings.

1.3.3. MILITARY COMMUNICATIONS

Military communications or **military signals** involve all aspects of communications, or conveyance of information, by armed forces. It includes text, audio, facsimile, tactical ground-based communications, terrestrial microwave, tropospheric scatter, naval, satellite communications systems and equipment, surveillance and signal analysis, encryption and security and direction-finding and jamming.

1.3.4. ELECTRO OPTICS

Electro-optics is a branch of Electrical engineering and Material physics involving components, devices (e.g Lasers, LEDs, waveguides etc.) and systems which operate by the propagation and interaction of light with various tailored materials.

E.g: Forward looking infrared (**FLIR**) cameras, typically used on military and civilian aircraft, use a thermo graphic camera that senses infrared radiation.

The sensors installed in forward-looking infrared cameras—as well as those of other thermal imaging cameras—use detection of infrared radiation, typically emitted from a heat source (thermal radiation), to create a "picture" assembled for video output. They can be used to help pilots and drivers steer their vehicles at night and in fog, or to detect warm objects against a cooler background. The wavelength of infrared that thermal imaging cameras detect differs significantly from that of night vision, which operates in the visible light and near-infrared ranges (0.4 to 1.0 μm).

1.3.5. ECM

An electronic countermeasure (ECM) is an electrical or electronic device designed to trick or deceive radar, sonar or other detection systems, like infrared (IR) or lasers. It may be used both offensively and defensively to deny targeting information to an enemy. The system may make many separate targets appear to the enemy, or make the real target appear to disappear or move about randomly. It is used effectively to protect aircraft from guided missiles. Most air forces use ECM to protect their aircraft from attack. It has also been deployed by military ships and recently on some advanced tanks to fool laser/IR guided missiles.

1.3.6. ESM

Electronic Support (ES) or **Electronic Support Measures** (ESM) describe the division of electronic warfare involving actions taken under direct control of an operational commander to detect, intercept, identify, locate, record, and/or analyze sources of radiated electromagnetic energy for the purposes of immediate threat recognition (such as warning that fire control RADAR has locked on a combat vehicle, ship, or aircraft) or longer-term operational planning.

This, Electronic Support provides a source of information required for decisions involving Electronic Protection (EP), Electronic Attack (EA), avoidance, targeting, and other tactical employment of forces. Electronic Support data can be used to produce signals intelligence (SIGINT), communications intelligence (COMINT) and electronics intelligence (ELINT).

UNIT: ***01.Introduction to Avionics***

TOPIC: ***04. Typical avionics sub systems: Man-Machine interface***

1.4 AVIONICS SUB_SYSTEMS

It can be seen that the main avionic sub-systems have been grouped into five layers according to their role and function. These are briefly summarised below

1.4.1 Systems which interface directly with the pilot: The *Display Systems*

It provides the visual interface between the pilot and the aircraft systems and comprise head up displays (HUDs), helmet mounted displays (HMDs) and head down displays (HDDs). The prime advantages of the HUD and HMD are that they project the display information into the pilot's field of view so that the pilot can be head up and can concentrate on the outside world.

The HUD now provides the primary display for presenting the essential flight information to the pilot and in military aircraft has transformed weapon aiming accuracy. The HUD can also display a forward looking infrared (FLIR) video picture one to one with the outside world from a fixed FLIR imaging sensor installed in the aircraft.

The multi-function colour displays provide the primary flight displays (PFDs) of height, airspeed, Mach number, vertical speed, artificial horizon, pitch angle, bank angle and heading, and velocity vector. They provide the navigation displays, or horizontal situation indicator (HSI) displays, which show the aircraft position and track relative to the destination or waypoints together with the navigational information and distance and time to go. Engine data are presented on multi-function colour displays so that the health of the engines can easily be monitored and divergences from the norm highlighted.

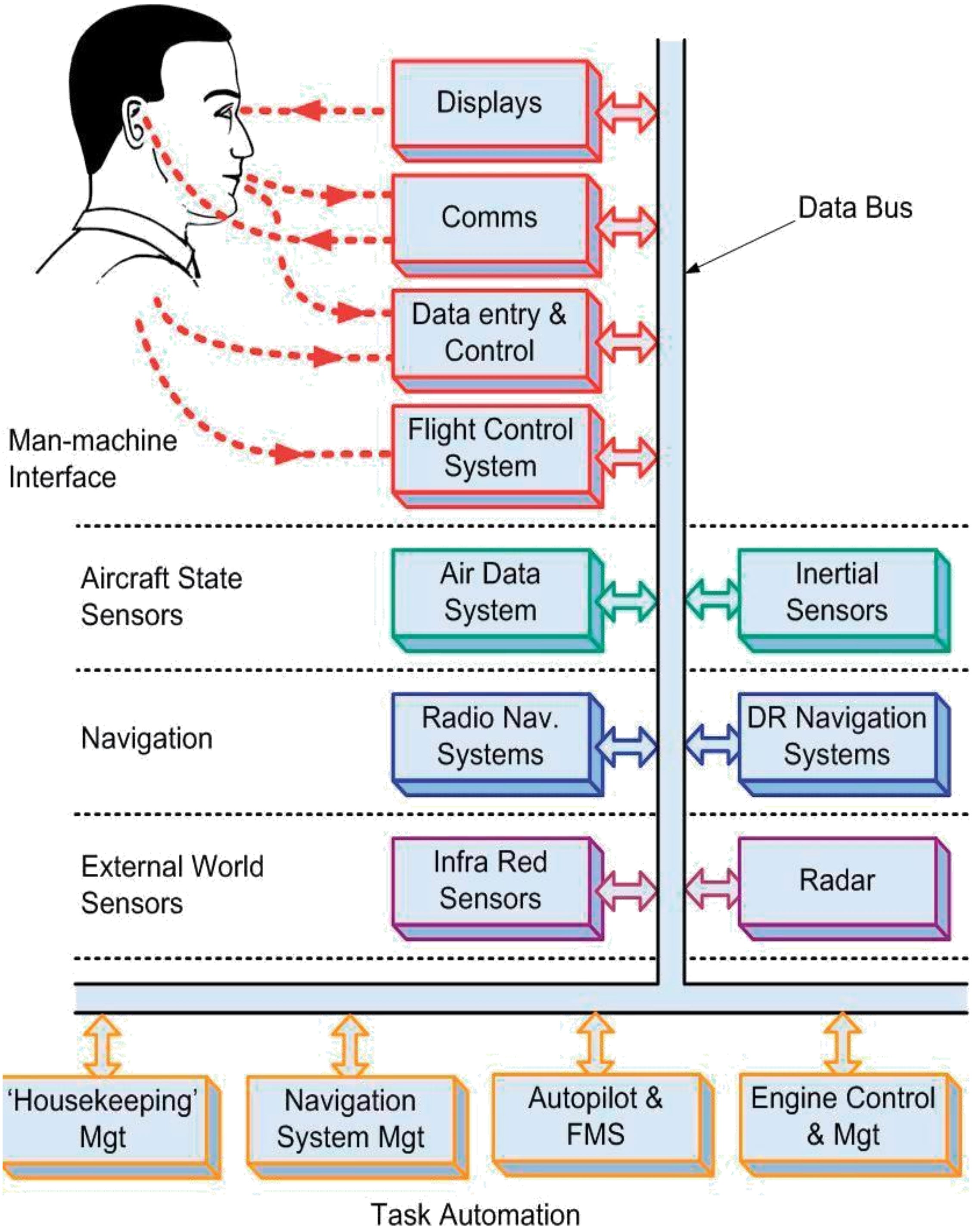


Figure 2: Different avionics system

1.4.2 The *Communications Systems*

It’s two way communications between the ground bases and the aircraft or between aircraft is self-evident and is essential for air traffic control.

Long range communication is provided by high frequency (HF) radios operating in the band 2–30 MHz. Near to medium range communication is provided in civil aircraft by very high frequency (VHF) radios operating in the band 30 –100 MHz, and in military aircraft by ultra-high frequency (UHF) radio operating in the band 250–400 MHz.

Satellite communications (SATCOM) systems are also installed in many modern aircraft and these are able to provide very reliable worldwide communication.

1.4.3 The *Data Entry and Control Systems*

This is essential for the crew to interact with the avionic systems. Such systems like

1. Keyboards
2. Touch panels
3. Use of direct voice input (DVI) control
4. Exploiting speech recognition technology,
5. Voice warning systems

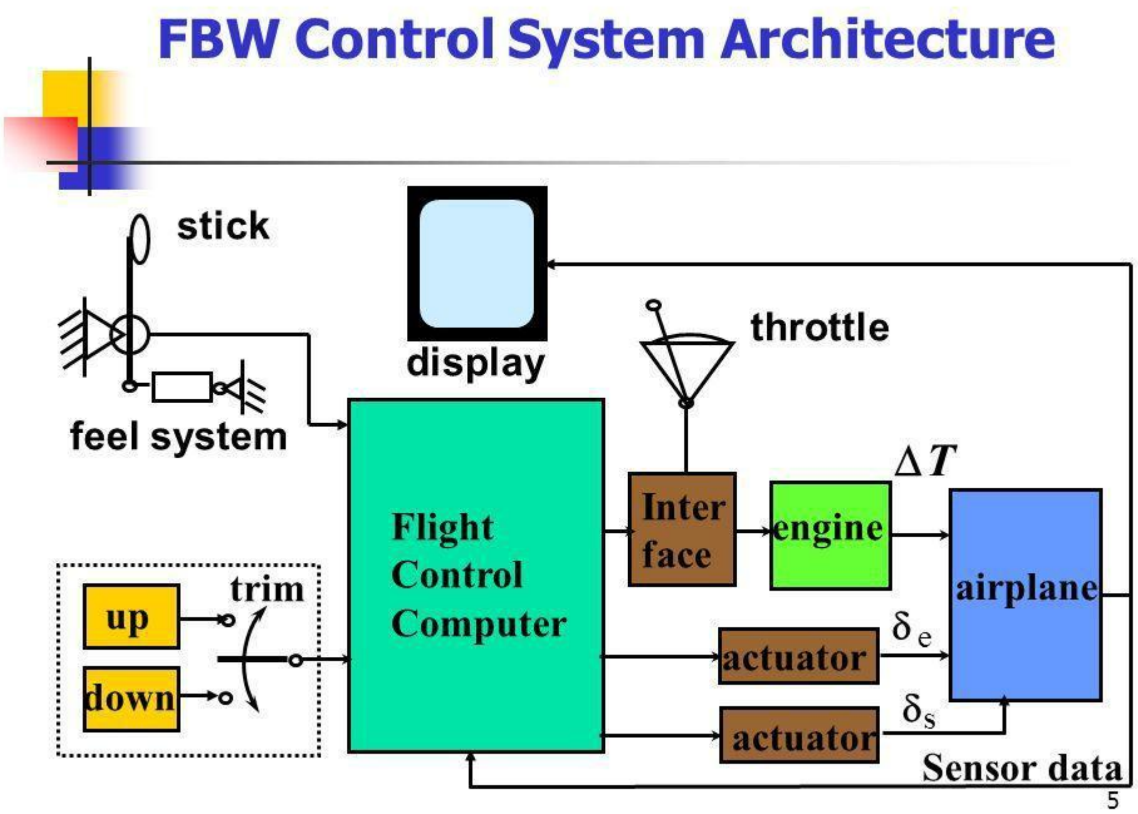
1.4.4 The *Flight Control Systems*

It exploits electronic system technology in two areas, namely

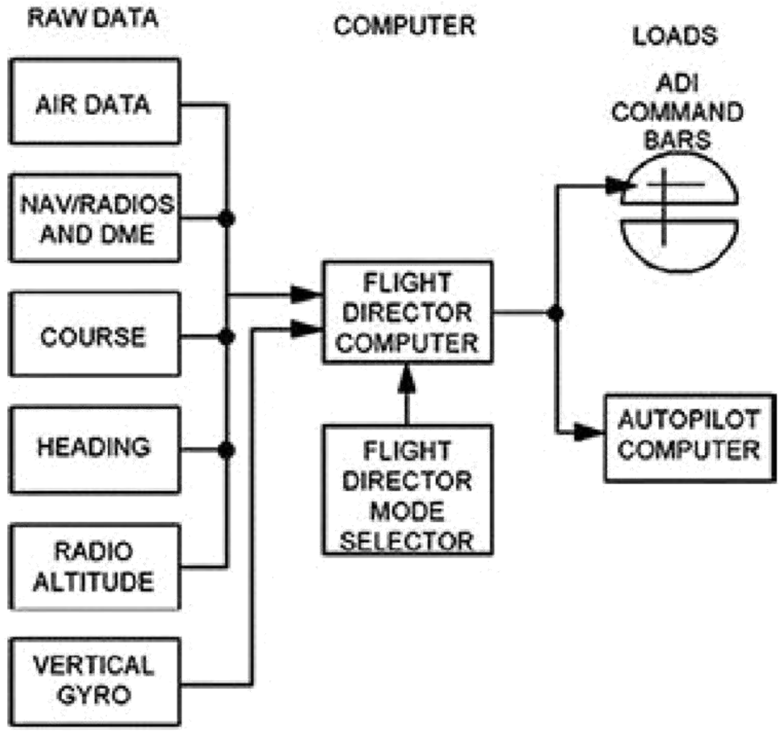
1. Auto-stabilisation (or stability augmentation) systems and
2. FBW flight control systems.

Most swept wing jet aircraft exhibit a lightly damped short period oscillatory motion about the yaw and roll axes at certain height and speed conditions, known as

Fly-by wire systems are quite complex, but their operation can be explained in simple terms. When a pilot moves the control column (or side stick), a signal is sent to a computer (analogous to moving a game controller) through multiple wires (channels) to ensure that the signal reaches the computer. In an analogy system, the computer receives the signals, performs a calculation (adds the signal voltages and divides by the number of signals received to find the mean average voltage) and adds another channel. These four 'Quadruplex' signals are then sent to the control surface actuator, and the surface begins to move. Potentiometers in the actuator send a signal back to the computer (usually a negative voltage) reporting the position of the actuator. When the actuator reaches the desired position, the two signals (incoming and outgoing) cancel each other out and the actuator stops moving (completing a feedback loop). In a Digital Fly by Wire Flight Control System complex software interprets digital signals from the pilots control input sensors and performs calculations based on the Flight Control Laws programmed into the Flight Control Computers and input from the Air Data Inertial Reference Units and other sensors. The computer then commands the flight control surfaces to adopt a configuration that will achieve the desired flight path.



Autopilot is a system used to control the trajectory of an aircraft without constant 'hands-on' control by a human operator being required. Autopilots do not replace a human operator, but assist them in controlling the aircraft, allowing them to focus on broader aspects of operation, such as monitoring the trajectory, weather and systems.


RAW DATA
COMPUTER
LOADS
AIR DATA
NAV/RADIOS AND DME
COURSE
HEADING
RADIO ALTITUDE
VERTICAL GYRO
FLIGHT DIRECTOR COMPUTER
FLIGHT DIRECTOR MODE SELECTOR
ADI COMMAND BARS
AUTOPILOT COMPUTER

5. Typical avionics sub systems: Aircraft state sensors, Navigation

1.5Aircraft State Sensor Systems

These comprise the air data systems and the inertial sensor systems.

1.5.1 The *Air Data Systems*

It provides accurate information on the air data quantities that is the altitude, calibrated airspeed, vertical speed, true airspeed, Mach number and airstream incidence angle. This information is essential for the control and navigation of the aircraft.

1.5.2 The *Inertial Sensor Systems*

It provides the information on aircraft attitude and the direction in which it is heading which is essential information for the pilot in executing a manoeuvre or flying in conditions of poor visibility, flying in clouds or at night. Accurate attitude and heading information are also required for the autopilot and the navigation system and weapon aiming in the case of a military aircraft.

The attitude and heading information is provided by the inertial sensor system(s). These comprise a set of gyros and accelerometers which measure the aircraft's angular and linear motion about the aircraft axes.

E.g: Attitude and Heading Reference Systems (AHRS)

Inertial Navigation System (INS) to be mechanised which provides very accurate attitude and heading information together with the aircraft's velocity and position data (ground speed, track angle and latitude/longitude co-ordinates).

1.5.3 Navigation Systems

Accurate navigation information, that is the aircraft's position, ground speed and track angle (direction of motion of the aircraft relative to true North) is clearly essential for the aircraft's mission, whether civil or military. Navigation systems can be divided into dead reckoning (DR) systems and position fixing systems;

1.5.4 The *Dead Reckoning Navigation Systems*-derives the vehicle's present position by estimating the distance travelled from a known position from knowledge of the speed and direction of motion of the vehicle.

The main types of DR navigation systems used in aircraft are:

(a) Inertial navigation systems. The most accurate and widely used systems.

(b) Doppler/heading reference systems. These are widely used in helicopters.

(c) Air data/heading reference systems. These systems are mainly used as a reversionary navigation system being of lower accuracy than (a) or (b).

1.5.6 The *Position Fixing Systems*-used are now mainly radio navigation systems based on satellite or ground based transmitters. A suitable receiver in the aircraft with a supporting computer is then used to derive the aircraft's position from the signals received from the transmitters.

E.g: VOR/DME and TACAN, ILS (Instrument Landing System), MLS (Microwave Landing System) and GPS.

6. Typical avionics sub systems: World sensor and Task automation

1.6.1 Outside World Sensor Systems

These systems, which comprise both radar and infrared sensor, systems enable all weather and night time operation and transform the operational capability of the aircraft (or helicopter).

A. The Radar Systems installed in civil airliners and many general aviation aircraft provides weather warning. The radar looks ahead of the aircraft and is optimised to detect water droplets and provide warning of storms, cloud turbulence and severe precipitation so that the aircraft can alter course and avoid such conditions, if possible.

In the airborne interception (AI) mode, the radar must be able to detect aircraft up to 100 miles away and track while scanning and keeping tabs on several aircraft simultaneously (typically at least 12 aircraft). The radar must also have a 'look down' capability and be able to track low flying aircraft below it.

B. The Infrared Sensor Systems have the major advantage of being entirely passive systems. Infrared (IR) sensor systems can be used to provide a video picture of the thermal image scene of the outside world either using a fixed FLIR sensor, or alternatively, a gimballed IR imaging sensor. The thermal image picture at night looks very like the visual picture in daytime, but highlights heat sources, such as vehicle engines, enabling real targets to be discriminated from camouflaged decoys.

1.6.2 Task Automation Systems

These comprise the systems which reduce the crew workload and enable minimum crew operation by automating and managing as many tasks as appropriate so that the crew role is a supervisory management one. The tasks and roles of these are very briefly summarised below.

Navigation Management comprises the operation of all the radio navigation aid systems and the combination of the data from all the navigation sources, such as GPS and the INS systems, to provide the best possible estimate of the aircraft position, ground speed and track.

<u>The</u> ***<u>Autopilots and Flight Management Systems</u>*** have been grouped together. Because of the very close degree of integration between these systems on modern civil aircraft. It should be noted, however, that the Autopilot is a ‘stand alone’ system and not all aircraft are equipped with an FMS.

The autopilot relieves the pilot of the need to fly the aircraft continually with the consequent tedium and fatigue and so enables the pilot to concentrate on other tasks associated with the mission.

In military applications, the autopilot system in conjunction with a suitable guidance system can provide automatic terrain following, or terrain avoidance. This enables the aircraft to fly automatically at high speed at very low altitudes (100 to 200 ft) so that the aircraft can take advantage of terrain screening and stay below the radar horizon of enemy radars.

<u>The tasks carried out by the FMS include:</u>

1. Flight planning.
2. Navigation management.
3. Engine control to maintain the planned speed or Mach number.
4. Control of the aircraft flight path to follow the optimised planned route.
5. Control of the vertical flight profile.
6. Ensuring the aircraft is at the planned 3D position at the planned time slot; often referred to as 4D navigation.
7. Flight envelope monitoring.
8. Minimising fuel consumption.

<u>The *Engine Control and Management Systems*</u>

It carries out the task of control and the efficient management and monitoring of the engines.

E.g: Full Authority Digital Engine Control System (FADEC). This automatically controls the flow of fuel to the engine combustion chambers by the fuel control unit so as to provide a closed-loop control of engine thrust in response to the throttle command.

The control system ensures the engine limits in terms of temperatures, engine speeds and accelerations are not exceeded and the engine responds in an optimum manner to the throttle command.

Other very important engine avionic systems include engine health monitoring systems which measure, process and record a very wide range of parameters associated with the performance and health of the engines. These give early warning of engine performance deterioration, excessive wear, fatigue damage, high vibration levels, excessive temperature levels, etc.

House Keeping Management

It *is* the term used to cover the automation of the background tasks which are essential for the aircraft's safe and efficient operation.

Such tasks include:

1. Fuel management. This embraces fuel flow and fuel quantity measurement and control of fuel transfer from the appropriate fuel tanks to minimise changes in the aircraft trim.
2. Electrical power supply system management.
3. Hydraulic power supply system management.
4. Cabin/cockpit pressurisation systems.
5. Environmental control system.
6. Warning systems.
7. Maintenance and monitoring systems. These comprise monitoring and recording systems which are integrated into an on-board maintenance computer system. The above brief summaries cover the roles and importance of the avionic systems.

7. Design technologies

1.7: Design Approaches and Recent Advances

Avionics is one of the most developing fields of aircraft design. Its importance and range has increased over recent years and as much as 40% of the cost of a new aircraft can be attributed to avionics. Modern avionics design with enhanced functionality makes it possible for airlines to operate safely and efficiently; designers to develop and manufacture electric and green aircraft; air traffic controllers to manage traffic efficiently; and for military pilots to perform their missions effectively.

Design objectives for Avionics systems:

- Fulfil the required performance
- Acceptable levels of availability and failure conditions
- Ease of use and maintenance
- Environmental requirements
- System safety

The process of designing consists of a sequence of steps, as is illustrated in below figure

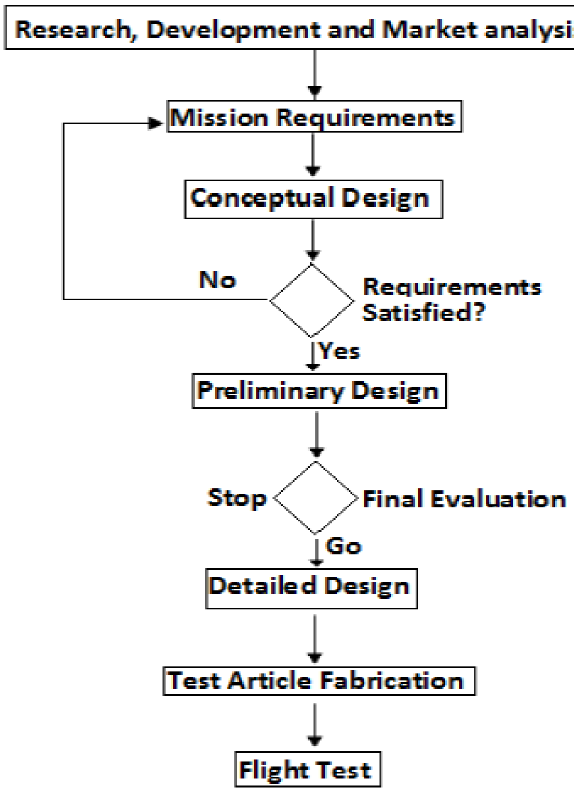


Figure: Design process flow chart

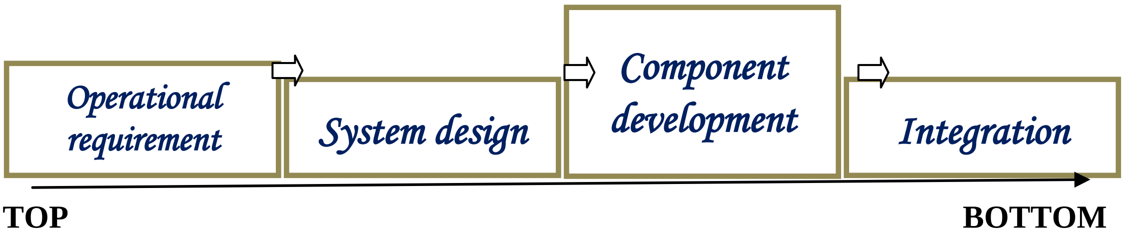
The avionics system design involves design and development and management of the total system which includes hardware and software as well as other system life cycle elements.

There are two types of Design approaches

(i) Top Down Design approach

(ii) Bottom Up Design Approach

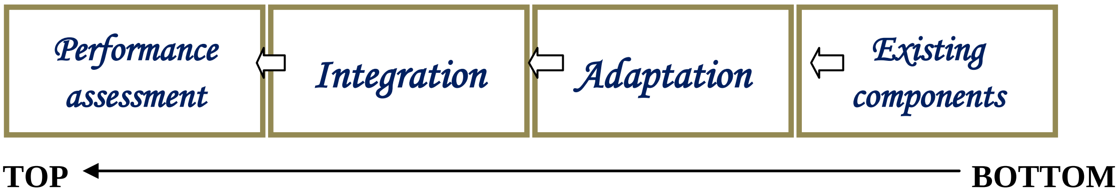
(I) Top Down Design Approach



- Developing a conceptual view of the system
- Establish system architecture
- Identifying data stream and data source
- Decomposing high level function into sub function
- Establishing relationship and interaction among components

- Developing concert data representation
- Specifying procedure details

(II) Bottom up Design Approach



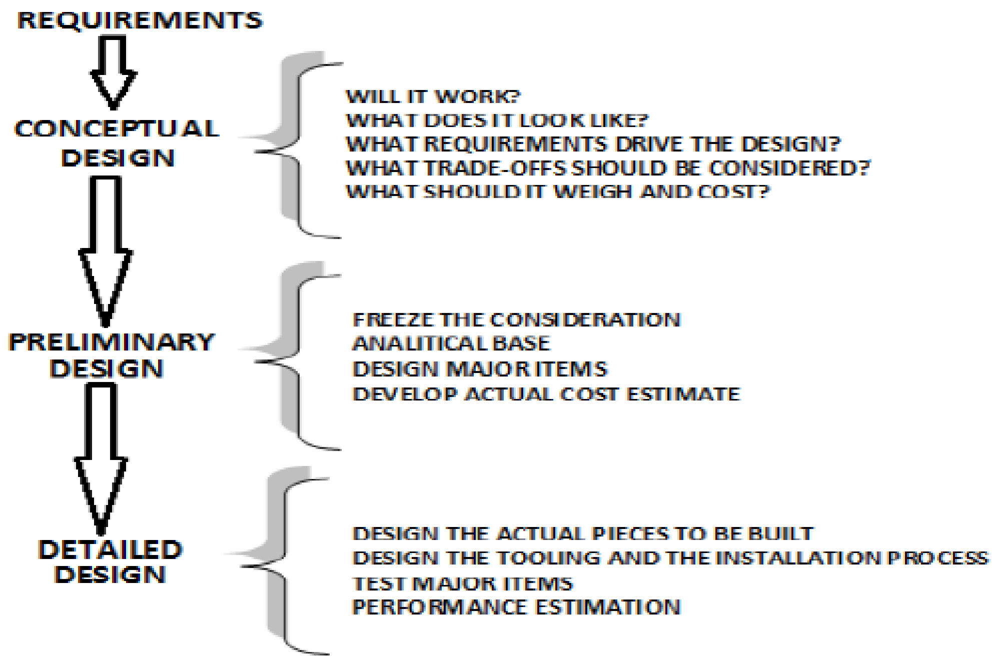
- Based on the reuse of the existing components, according to the self concept
- Cost oriented
- Reduced Development effort ,Technical risk program time schedule
- Can be easily adapted to different platform

The three stages involved in design of avionics system are

i. Conceptual design

ii. Preliminary design

iii. Detailed design



The environmental requirements of avionics equipment:

- Operating temperature is usually from -400C to 700C.
- Full performance at 20000 ft within two minutes of take-off
- Operate under maximum acceleration (20g)
- Electromagnetic compatibility (EMC)
- With stand against lightning strikes. Very high electromagnetic pulses (EMP), which can be encountered during such strikes.

RECENT ADVANCE:

1. TTNT= Tactical Targeting and Network Technology
2. AESA= Advanced Electronically Steered Array
3. Flight Path Management
4. Pilot/Vehicle Interface
5. Avionics and controls integration
6. Control functions applications
7. Aircraft power and actuation
8. Hardware Improvements

08. Introduction to digital computer

ILITIES OF AVIONICS SYSTEM

1. Capability
2. Reliability
3. Maintainability
4. Certificability
5. Survivability(military)
6. Availability
7. Susceptibility
8. vulnerability
9. Life cycle cost(military) or cost of ownership(civil)
10. Technical risk
11. Weight & power

1) Capability

- Must meet customer's requirements
- How capable are the avionics?
- Can they do the job and even more?
- The most important ility is Capability

2) Reliability

- Every designer strives to make systems as reliable as possible
- Higher reliability generally leads to lower maintenance costs

3) Maintenance

- Closely related to reliability
- Need preventive (or) Corrective maintenance. It has three levels

i) Level 1 - replace unit

ii) Level 2 - replace individual modules in unit

I ii) Level 3 - lowest level (e.g. repair circuit boards)

4) Availability

- The combination of reliability and maintainability is availability.
- It translates into
  1. Sorties- for military
  2. Revenue-for Civil

5) Certificability

- It is a major area of concern for avionics in civil aircraft.
- It conducted by the regulatory agencies, based on detailed, expert examination of all facts of the aircraft design and operation
- Avionics certification focus on

1. Preliminary Hazard

2. Fault Tree

3. Failure modes and effects

6) 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.

7) Life Cycle Cost (LCC) & Cost of Ownership (Cos):

- LCC for military and COS for civil.
- It deals with economic measures need for evaluating avionics architecture.
- It includes cost of varied items as spares acquisition, transportation and stroage, training, hardware development and test, depreciation and interest.

8) RISK

- Amount of failure and drawbacks in the design and implementation
- Overcome by using the latest technology

9) WEIGHT and POWER

- Design must be light weight and less power consuming
- Use of latest advanced electronic devices.

1.5 DIGITAL COMPUTER

Digital computer is defined as any of a class of devices capable of solving problems by processing information in discrete form. It operates on data, including magnitudes, letters, and symbols, that are expressed in binary form. (i.e.,) using only the two digits 0 and 1. By counting, comparing, and manipulating these digits or their combinations according to a set of instructions held in its memory.

First electronic digital computer:

ENIAC -- Electronic Numerical Integrator and Computer

1.5.1 Functional Elements

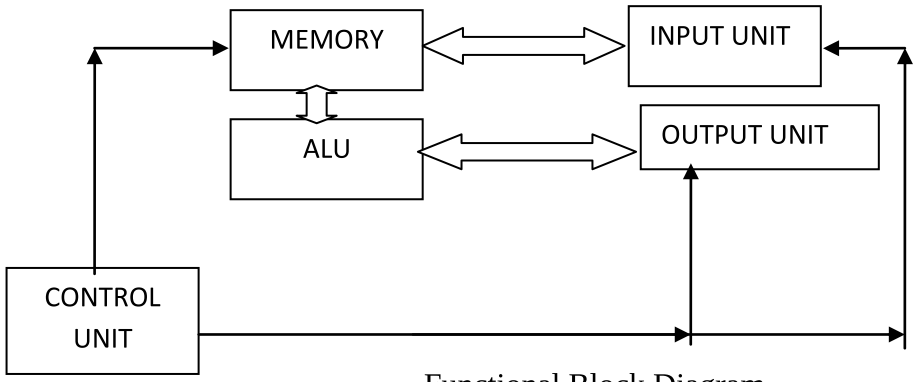
A typical digital computer system has four basic functional elements:

(1) Input-Output equipment,

(2) Main memory,

(3) Control unit, and

(4) Arithmetic-logic unit.



Functional Block Diagram

Any of a number of devices is used to enter data and program instructions into a computer and to gain access to the results of the processing operation. Common input devices include keyboards and optical scanners; output devices include printers and cathode-ray tube and liquid-crystal display monitors. The information received by a computer from its input unit is stored in the main memory or, if not for immediate use, in an auxiliary storage device.

The control unit selects and calls up instructions from the memory in appropriate sequence and relays the proper commands to the appropriate unit. It also synchronizes the varied operating speeds of the input and output devices to that of the arithmetic-logic unit (ALU) so as to ensure the proper movement of data through the entire computer system.

The ALU performs the arithmetic and logic algorithms selected to process the incoming data at extremely high speeds—in many cases in nanoseconds (billionths of a second). The main memory, control unit, and ALU together make up the central processing unit (CPU) of most digital computer systems, while the input-output devices and auxiliary storage units constitute peripheral equipment.

Digital computer any of a class of devices capable of solving problems by processing information in discrete form. It operates on data, including magnitudes, letters, and symbols, that are expressed in binary code—i.e., using only the two digits 0 and 1. By counting, comparing, and manipulating these digits or their combinations according to a set of instructions held in its memory, a digital computer can perform such tasks as to control industrial processes and regulate the operations of machines; analyze and organize vast amounts of business data; and simulate the behaviour of dynamic systems (e.g., global weather patterns and chemical reactions) in scientific research.
A brief treatment of digital computers follows. For full treatment, *see* computer science: Basic computer components.

Functional Elements

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(1) input-output equipment,
(2) main memory,
(3) control unit, and
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Any of a number of devices is used to enter data and program instructions into a computer and to gain access to the results of the processing operation. Common input devices include keyboards and optical scanners; output devices include printers and monitors. The information received by a computer from its input unit is stored in the main memory or, if not for immediate use, in an auxiliary storage device. The control unit selects and calls up instructions from the memory in appropriate sequence and relays the proper commands to the appropriate unit. It also synchronizes the varied operating speeds of the input and output devices to that of the arithmetic-logic unit (ALU) so as to ensure the proper movement of data through the entire computer system. The ALU performs the arithmetic and logic algorithms selected to process the incoming data at extremely high speeds—in many cases in nanoseconds (billionths of a second). The main memory, control unit, and ALU together make up the central processing unit (CPU) of most digital computer systems, while the input-output devices and auxiliary storage units constitute peripheral equipment.

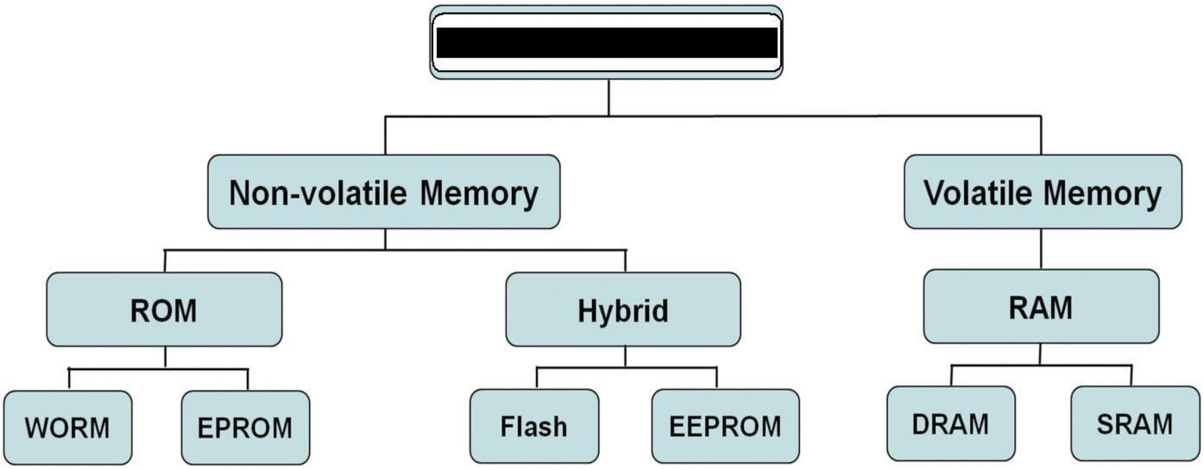
Development of the Digital Computer

Blaise Pascal of France and Gottfried Wilhelm Leibniz of Germany invented mechanical digital calculating machines during the 17th century. The English inventor Charles Babbage, however, is generally credited with having conceived the first automatic digital computer. During the 1830s Babbage devised his so-called Analytical Engine, a mechanical device designed to combine basic arithmetic operations with decisions based on its own computations. Babbage's plans embodied most of the fundamental elements of the modern digital computer. For example, they called for sequential control—i.e., program control that included branching, looping, and both arithmetic and storage units with automatic printout. Babbage's device, however, was never completed and was forgotten until his writings were rediscovered over a century later.

Of great importance in the evolution of the digital computer was the work of the English mathematician and logician George Boole. In various essays written during the mid-1800s, Boole discussed the analogy between the symbols of algebra and those of logic as used to represent logical forms and syllogisms. His formalism, operating on only 0 and 1, became the basis of what is now called Boolean algebra, on which computer switching theory and procedures are grounded.

9. Memories

1.9 MEMORY



RAM

A RAM constitutes the internal memory of the CPU for storing data, program and program result. It is read/write memory. It is called random access memory (RAM). Since access time in RAM is independent of the address to the word that is, each storage location inside the memory is as easy to reach as other location & takes the same amount of time. We can reach into the memory at random & extremely fast but can also be quite expensive.

RAM is volatile, i.e. data stored in it is lost when we switch off the computer or if there is a power failure. Hence, a backup uninterruptible power system (UPS) is often used with computers. RAM is small, both in terms of its physical size and in the amount of data it can hold.

RAM is of two types

I.Static RAM (SRAM)

II. Dynamic RAM (DRAM)

Static RAM (SRAM)

The word static indicates that the memory retains its contents as long as power remains applied. However, data is lost when the power gets down due to volatile nature. SRAM chips use a matrix of 6-transistors and no capacitors. Transistors do not require power to prevent leakage, so SRAM need not have to be refreshed on a regular basis. Because of the extra space in the matrix, SRAM uses more chips than DRAM for the same amount of storage space, thus making the manufacturing costs higher.

Static RAM is used as cache memory needs to be very fast and small.

Dynamic RAM (DRAM)

DRAM, unlike SRAM, must be continually refreshed in order for it to maintain the data. This is done by placing the memory on a refresh circuit that rewrites the data several hundred times per second. DRAM is used for most system memory because it is cheap and small. All DRAMs are made up of memory cells. These cells are composed of one capacitor and one transistor.

Volatile memory eventually loses the stored information unless it is provided with a constant power supply or refreshed periodically with a pulse.

Non-volatile memory no needs of periodic refreshing and it still retains its data in the case of power failure.

ROM

ROM stands for Read Only Memory. The memory from which we can only read but cannot write on it. This type of memory is non-volatile. The information is stored permanently in such memories during manufacture. A ROM, stores such instruction as are required to start computer when electricity is first turned on, this operation is referred to as bootstrap. ROM chip are not only used in the computer but also in other electronic items like washing machine and microwave oven.

Following are the various types of ROM:

MROM (Masked ROM)

The very first ROMs were hard-wired devices that contained a pre-programmed set of data or instructions. These kinds of ROMs are known as masked ROMs. It is inexpensive ROM.

PROM (Programmable Read Only Memory)

PROM is read-only memory that can be modified only once by a user. The user buys a blank PROM and enters the desired contents using a PROM programmer. Inside the PROM chip there are small fuses which are burnt open during programming. It can be programmed only once and is not erasable.

EPROM (Erasable and Programmable Read Only Memory)

The EPROM can be erased by exposing it to ultra-violet light for a duration of upto 40 minutes. Usually, an EPROM eraser achieves this function. During programming an electrical charge is trapped in an insulated gate region. The charge is retained for more than ten years because the charge has no leakage path. For erasing this charge, ultra-violet light is passed through a quartz crystal window (lid). This exposure to ultra-violet light dissipates the charge. During normal use the quartz lid is sealed with a sticker.

EEPROM (Electrically Erasable and Programmable Read Only Memory)

The EEPROM is programmed and erased electrically. It can be erased and reprogrammed about ten thousand times. Both erasing and programming take about 4 to 10 ms (millisecond). In EEPROM, any location can be selectively erased and programmed. EEPROMs can be erased one byte at a time, rather than erasing the entire chip. Hence, the process of re-programming is flexible but slow.

UNIT: ***<u>02. PRINCIPLES OF DIGITAL AVIONICS</u>***

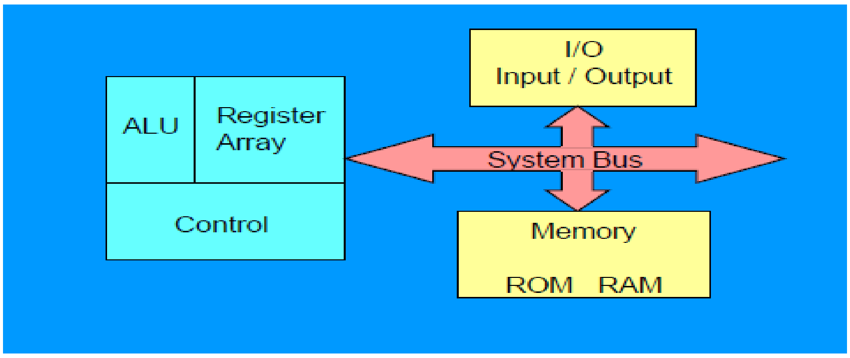
<u>TOPIC:1.Digital computers, Application of Digital computer</u>

MICROPROCESSOR:

The microprocessor is a programmable devicethat takes innumbers, performs on them arithmetic or logical operationsaccording to the programstored in memoryand then producesother numbers as a result.

<u>Programmable device:</u> The microprocessor can perform different sets of operations on the data it receives depending on the sequence of instructionssupplied in the given program.By changing the program, the microprocessor manipulates the data in different ways.

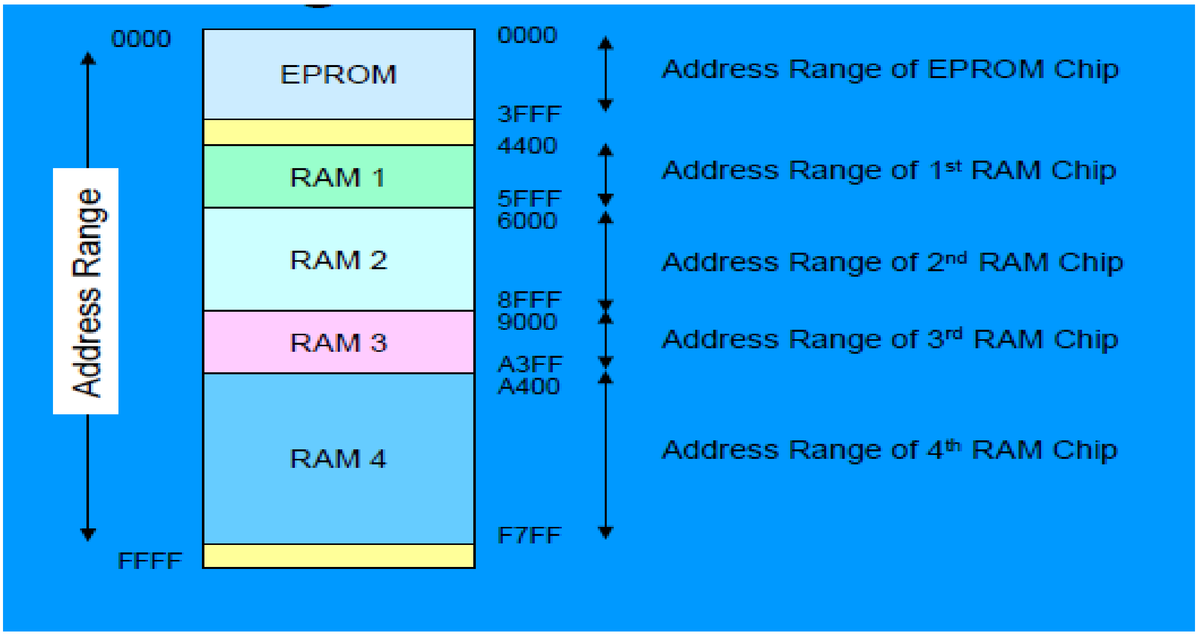
<u>Instructions:</u> Each microprocessor is designed to execute a specific group of operations. This group of operations is called an instruction set. This instruction set defines what the microprocessor can and cannot do.



<u>Memory</u> stores information such as instructions and data in binary format (0 and 1). It provides this information to the microprocessor whenever it is needed.

Memory Map and Addresses

The memory map is a picture representation of the address range and shows where the different memory chips are located within the address range.



Execution Model:

1. The microprocessor fetches each instruction,
2. decodes it,
3. Then executes it.

8085 features:

* 8085 is an 8-bit microprocessor.

* It is capable of addressing 64kbytes of memory.

* It requires a +5volts of power supply.

* 8085 operates on 3MHz clock. 8085 A-2 operates on maximum clock frequency 5MHz.

* It has 16 address lines, out of which 8 address lines are multiplexed with data lines.

* It is manufactured in NMOS technology

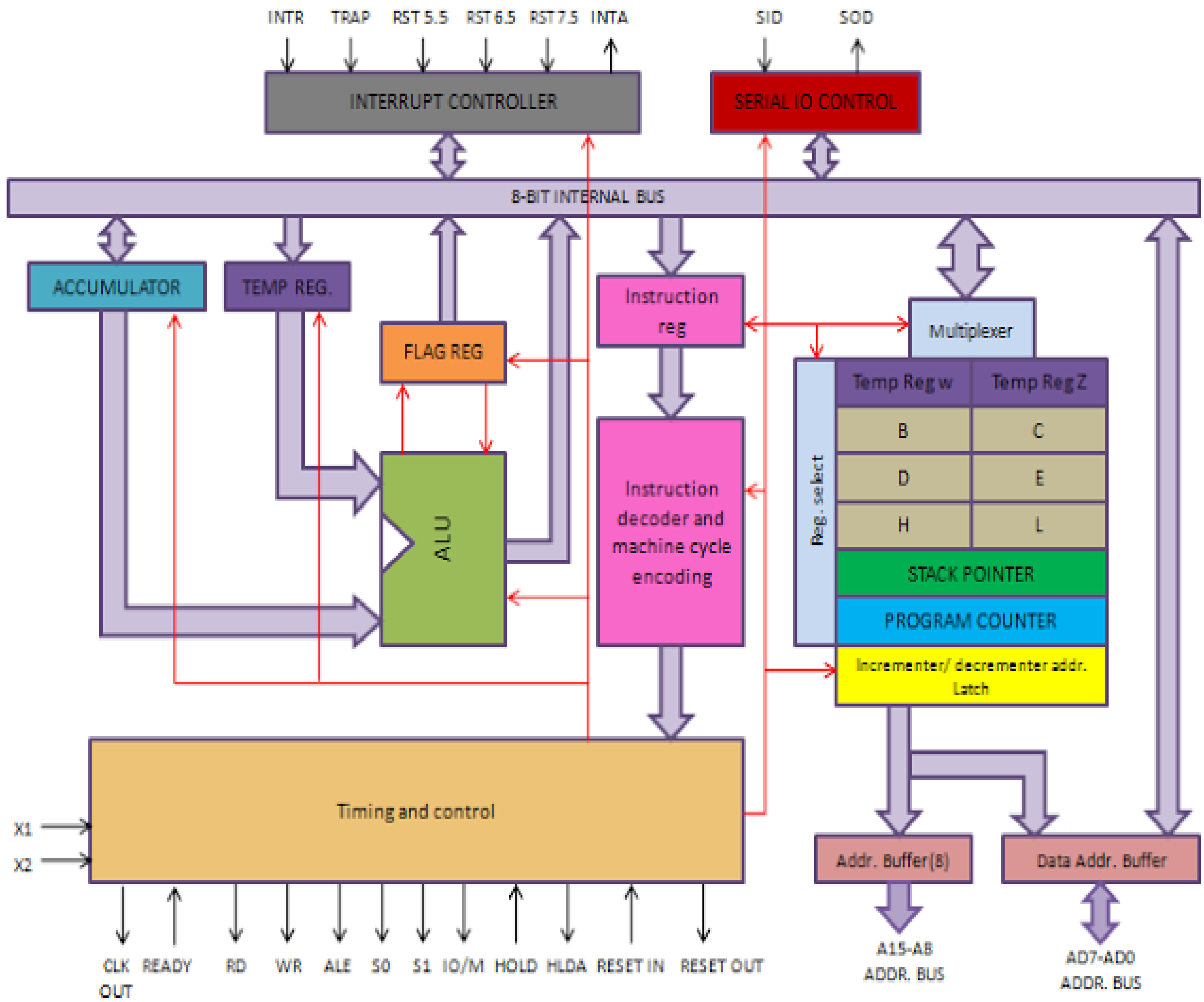
* It is available in 40 pin dual in line (DIP) package.

UNIT: ***02. PRINCIPLES OF DIGITAL AVIONICS***

TOPIC:2.Microprocessors: Architecture

8085 ARCHITECTURE

Below figure shows the architecture of 8085 microprocessor.



The following are the different blocks in the 8085 processor.

ALU:

It is 8-bit ALU.

It can perform arithmetic and logical operations on 8-bit data.

If an operation needs to be performed on 16-bit data, it needs to be broken into two 8-bit parts and each 8-bit operation should be performed on each 8-bit data.

Register Array:

Acc (8)	Flag Reg (8)
B	C
D	E
H	L
SP(16)	
PC(16)	

General Purpose Registers

1. B, C, D, E, H& L(8 bit registers)
2. Can be used singly
3. It can be used as 16 bit register pairsBC, DE, HL

4. H & L can be used as a data pointer (holds memory address)

Special Purpose Registers

1. Accumulator(8 bit register)Store 8 bit data
    - ❖ Store the result of an operation
    - ❖ Store 8 bit data during I/O transfer

Flag register:

The contents of flag register will be changed according to the result of ALU operation. Below figure shows the flag register format of 8085.

7	6	5	4	3	2	1	0
S	Z		AC		P		CY

Sign flag (S): when the result of ALU operation is negative sign flag is set. If the result is positive, then sign flag is reset.

Zero flag (Z): when the result of ALU operation is zero, Zero flag is set. If the result is non-zero then flag is reset.

Auxiliary carry (AC): If an ALU operation results in carry from lower nibble to upper nibble (or) bit D3 to bit D4, Auxiliary flag is set. Else it is reset. This flag is used in BCD arithmetic.

Parity flag (P): If the result contains even number of ones, the flag is set else it is reset. So the parity flag is odd parity bit.

Carry flag (CY): If the arithmetic operation results in carry, CY flag is set, else it is reset.

Timing and Control unit:

This is responsible for generation of control signals, such as RD’, WR’ to interface peripherals. It also synchronizes all microprocessor operations.

Instruction Register and Decoding:

Instruction register holds instruction that is fetched from memory. Instruction decoder decodes the opcode (which is part of fetched instruction present in instruction register). Instruction register is not accessible to the programmer.

Interrupt Controller:

8085 has 5 external interrupts. TRAP, INTR, RST 5.5, RST 6.5, and RST 7.5. Whenever processor gets interrupt it finishes current instruction execution and issues INTA (interrupt acknowledge) signal to the peripheral which raised the interrupt and goes to execute interrupt service routine. Interrupt controller controls the interrupts.

Serial I/O control:

Serial data can be sent out using SOD pin and serial data can be read from SID pin. It controls serial IO related operations.

8085 ADDRESSING MODES

Addressing modes define the way operands are specified in the instruction. In 8085 there are four addressing modes.

1. Immediate addressing mode
2. Register addressing mode
3. Direct addressing mode
4. Indirect addressing mode

Immediate addressing mode:

In this operand is specified in the instruction itself.

Example: MVI A, 55H

Register addressing mode:

In this addressing mode operand is stored in a register. And that register is specified in the instruction

Example: MOV C,A

Direct addressing mode:

Operand is stored in the memory. The address of operand is specified in the instruction.

Example: IN 10H

Indirect addressing mode:

Operand is stored in the memory. The address of operand is held in a register and the register is specified in the instruction.

Example: LXI H,1020H

MOV A,M ; indirect addressing mode

Here M points to(contains) address 1020H, At his address operand is stored. By executing this instruction, the content of 1020H is loaded into accumulator A

Address Bus

Unidirectional

Identifying peripheral or memory location

Data Bus

Bidirectional

Transferring data

Control Bus

Synchronization signals

Timing signals

Control signal

UNIT: ***02. PRINCIPLES OF DIGITAL AVIONICS***

TOPIC:4.Avionics system architecture: First and Second generation

AVIONICS SYSTEM ARCHITECTURE:

"Architecture is the structure of components, their relationships, and the principles and guidelines governing their design and evolution.

(or)

Architecture must conform to the overall aircraft mission and designwhile ensuring that the avionics system meets its performance requirements

Few avionics architecture

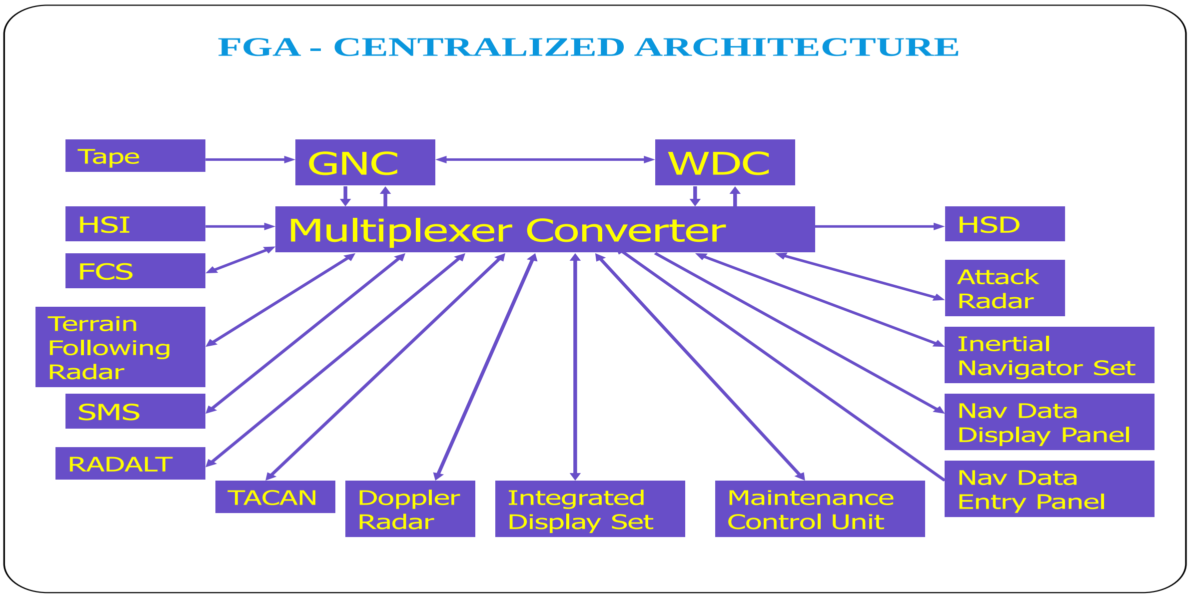
- First Generation Architecture (1940's –1950's)
  - i. Disjoint or Independent Architecture (MiG-21)
  - ii. Centralized Architecture (F-111)
- Second Generation Architecture (1960's –1970's)
  - i. Federated Architecture (F-16 A/B)
  - ii. Distributed Architecture (DAIS)
  - iii. Hierarchical Architecture (F-16 C/D, EAP)
- Third Generation Architecture (1980's –1990's)
  - i. Pave Pillar Architecture (F-22)
- Fourth Generation Architecture (Post 2005)
  - i. Pave Pace Architecture- JSF
  - ii. Open System Architecture

FIRST GENERATION ARCHITECTURE:-

DISJOINT ARCHITECTURE

The early avionics systems were standalone 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, orchestrate 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.

CENTRALIZED ARCHITECTURE:-

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 analogy, digital, synchrony and other interfaces.

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

SECOND GENERATION ARCHITECTURE:–

FEDERATED ARCHITECTURE

Federated: Join together - Each system acts independently but united

Data conversion occurs at the system level and the data's are sending 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. Resource sharing occurs at the last link in the information chain –via controls and displays. Programmability and versatility of the data processors

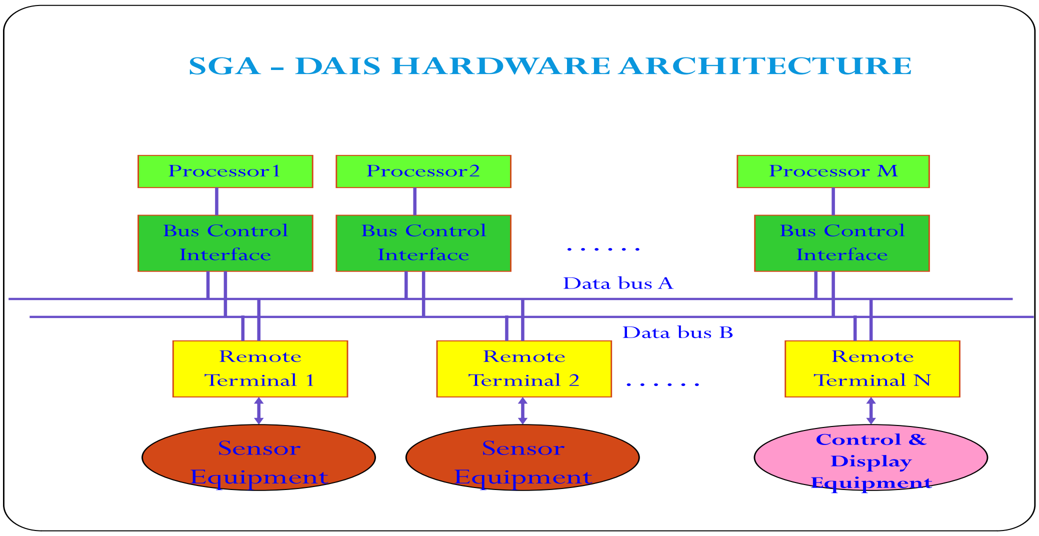
ADVANTAGES

i. Contrast to analog avionics – It provide precise solutions over long range of flight , weapon and sensor conditions
ii. Sharing of Resources
iii. Use of TDMA saves hundreds of pounds of wiring
iv. Standardization of protocol makes the interchange ability of equipments easier
v. Allows Independent system design and optimization of major systems
vi. Changes in system software and hardware are easy
vii. Fault containment – Failure is not propagated

DISADVANTAGES: Profligate of resources

Difference between federated architecture and centralized architecture

- In Federated Architecture Data conversion occurs at the system level and the data are sending as digital form – called Digital Avionics Information Systems (DAIS). It is fully digital.
- In centralized architecture Data conversion takes place at the central computer. Analogy wires are used.



DISTRIBUTED ARCHITECTURE

It has multiple processors throughout the aircraft that are designed for computing takes on a real-time basis as a function of mission phase and/or system status

Processing is performed in the sensors and actuators

Advantages:

- Fewer, Shorter buses

- Faster program execution
- Intrinsic Partitioning

Disadvantages:

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

HIERARCHICAL ARCHITECTURE

This architecture is derived from the federated architecture; it is based on the TREE Topology.

ADVANTAGES

i. Critical functions are placed in a separate bus and Non-Critical functions are placed in another bus
ii. Failure in non – critical parts of networks do not generate hazards to the critical parts of network
iii. The communication between the subsystems of a particular group are confined to their particular group
iv. The overload of data in the main bus is reduced

UNIT: ***02. PRINCIPLES OF DIGITAL AVIONICS***

TOPIC: 5.Avionics system architecture: Third and Fourth generation

THIRD GENERATION ARCHITECTURE:-

PAVE PILLAR

Pave Pillar is a USAF 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
- Voice Recognition /synthesis and Artificial Intelligence
- Provides capability for rapid flow of data in, through and 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***as opposed to subsystem operator/information integrator
- 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
- 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 (HW & SW))
- Ability to perform in-aircraft test and maintenance of avionics
- Use of VHSIC technology

FOURTH GENERATION ARCHITECTURE:-

PAVE PACE

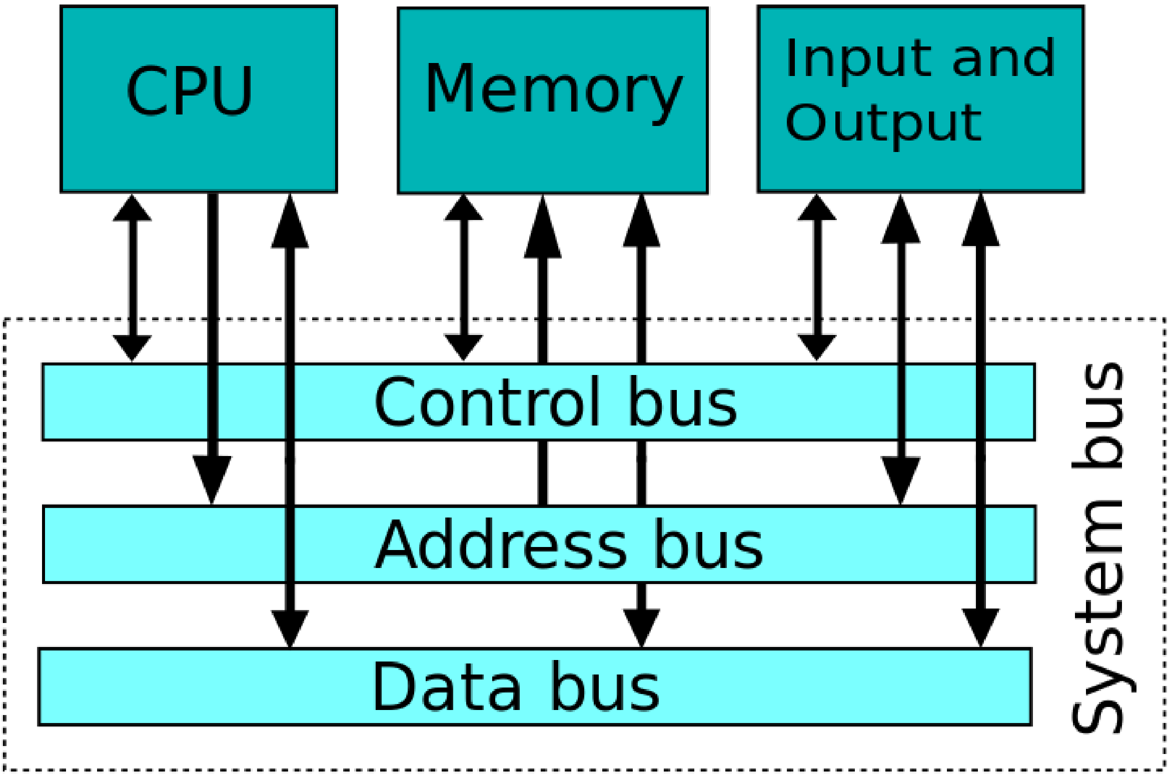
Modularity concepts **cuts down the cost of the avionics** related to VMS, Mission Processing, PVI and SMS.

- The sensor costs accounts for 70% of the avionics cost
- Come with the Concept of **Integrated Sensor System(IS)**
- 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

UNIT: ***02. PRINCIPLES OF DIGITAL AVIONICS***

TOPIC: 6.Data buses

The internal **bus**, also known as internal **data bus**, memory **bus**, system **bus** or Front-Side-**Bus**, connects all the internal components of a computer, such as CPU and memory, to the motherboard. Internal **data buses** are also referred to as a local**bus**, because they are intended to connect to local devices.



It is a group of wires or lines that are used to transfer the addresses of Memory or I/O devices. It is unidirectional. In Intel 8085 microprocessor, Address **bus** was of 16 bits.

The memory bus is the computer bus which connects the main memory to the memory controller in computer systems. Originally, general-purpose buses like VMEbus and the S-100 bus were used, but to reduce latency, modern memory buses are designed to connect directly to DRAM chips, and thus are designed by chip standards bodies such as JEDEC. Examples are the various generations of SDRAM, and serial point-to-point buses like SLDRAM and RDRAM. An exception is the Fully Buffered DIMM which, despite being carefully designed to minimize the effect, has been criticized for its higher latency.

TYPES OF DATABUS

MIL–STD 1553 B

ARINC 429

ARINC 629

UNIT: ***02. PRINCIPLES OF DIGITAL AVIONICS***

TOPIC:7.MIL–STD 1553 B

A data bus is used to provide a medium for the exchange of data and information between various systems.

MIL-STD-1553B

MIL-STD-1553 is a military standard that defines the electrical and protocol characteristics for a data bus.MIL-STD-1553B defines the term **Time Division Multiplexing** (TDM) as “the transmission of information from several signal sources through one communications system with different signal samples staggered in time to form a composite pulse train”.

Hardware Elements

MIL-STD-1553B has four hardware elements. These are:

1. The transmission media.
2. Remote terminals.
3. Bus controllers.
4. Bus monitors.

Transmission Media

The transmission media, or data bus, is defined as a twisted shielded pair transmission line consisting of the main bus and a number of stubs. There is one stub for each terminal connected to the bus.

Remote Terminals

Remote terminals are defined within the standard as “All terminals not operating as the bus controller or as a bus monitor”. Therefore if it is not a controller, monitor, or the main bus or stub, it must be a remote terminal. *The remote terminal comprises the electronics necessary to transfer data between the data bus and the subsystem.*

A remote terminal typically consists of *a transceiver, an encoder/decoder, a protocol controller, a buffer or memory, and a subsystem interface.*

A remote terminal must follow the protocol defined by the standard. It can only respond to commands received from the bus controller (i.e., it speaks only when spoken to). When it receives a valid command, it must respond within a very small, closely defined amount of time. If a message doesn’t meet the validity requirements defined, then the remote terminal must invalidate the message and discard the data (not allow it to be used by the subsystem).

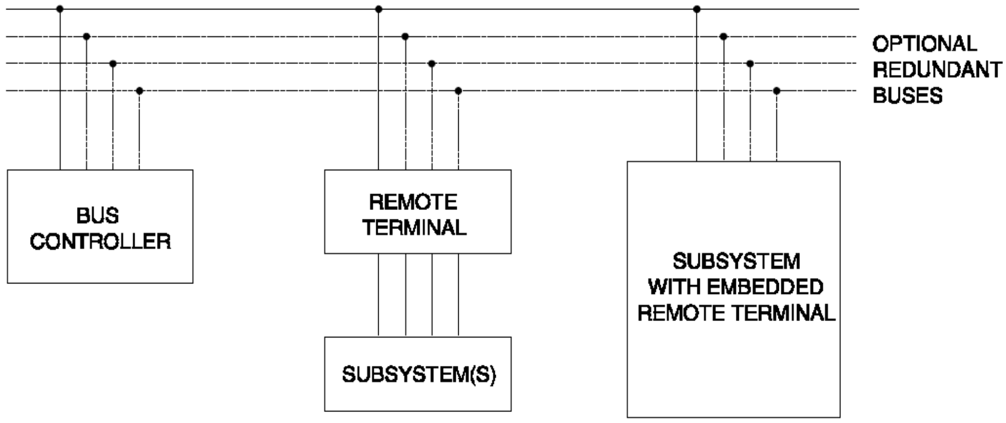


Fig: MIL-STD-1553B Hardware components

Bus Controller

The bus controller is responsible for directing the flow of data on the data bus. While several terminals may be capable of performing as the bus controller, only one bus controller may be active at a time. The bus controller is the only one allowed to issue commands onto the data bus.

The commands may be for the transfer of data or the control and management of the bus (referred to as mode commands).

There are three types of bus controller architectures:

1. A word controller.
2. A message controller.
3. A frame controller.

Word Controller

A word controller, the terminal electronics transfers one word at a time to the subsystem. Message buffering and validation must be performed by the subsystem.

Message Controller

These controllers output a single message at a time, interfacing with the computer only at the end of the message or perhaps when an error occurs. Some message controllers are capable of performing minor error processing.

Frame Controller

A frame controller is capable of processing multiple messages in a sequence defined by the host computer. The frame controller is typically capable of performing some error processing as defined by the message control word.

Bus Monitor

A bus monitor is a terminal that listens (monitors) to the exchange of information on the data bus.

A monitor may collect all the data from the bus or may collect selected data. Bus monitors fall into two categories:

1. A recorder for testing.

2. A terminal functioning as a back-up bus controller.

In collecting data, a monitor must perform the same message validation functions as the remote terminal and if an error is detected, inform the subsystem of the error.

As recorders for testing, the subsystem is typically a recording device such as a magnetictape or disk, or a telemetry transmitter.

Word Types

Three distinct word types are defined by the standard. These are:

1. Command words.

2. Data words.
3. Status words.

Each word type has a unique format, yet all three maintain a common structure. Each word is twenty bits in length.

The first three bits are used as a synchronization field, thereby allowing the decode clock to re-sync at the beginning of each new word.

The next sixteen bits are the information field and are different between the three word types.

The last bit is the parity bit. Parity is based on odd parity for the single word.

Sync Fields

The first three bit times of all word types is called the sync field.

Two distinct sync patterns are used:

1. The command/status sync, and
2. The data sync.

The command/status sync has a positive voltage level for the first one and a half bit times and then transitions to a negative voltage level for the second one and a half bit times.

The data sync is the opposite, a negative voltage level for the first one and a half bit times, and then a positive voltage level for the second one and a half bit times.

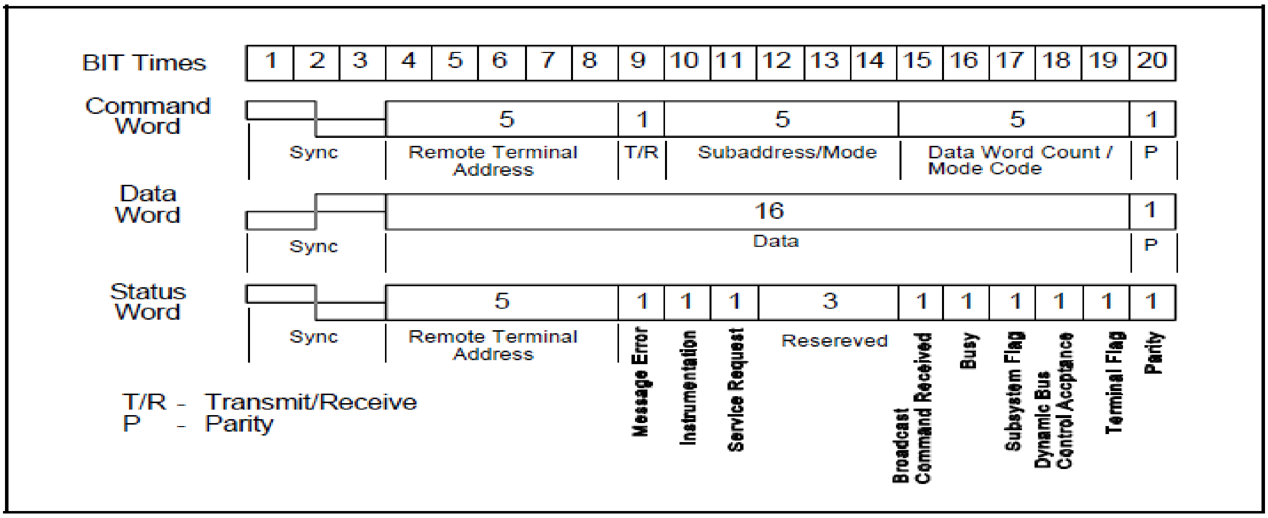


Fig: Mil-Std-1553B Word Format

Command Words

The Command Word (CW) specifies the function that a remote terminal is to perform. Only the active bus controller transmits this word.

The word begins with command sync in the first three bit times.

The next five bit positions are defined as Terminal Address (TA) field (bit times 4-8) states to which unique remote terminal the command is intended. (no two terminals may have the same address).

The next bit (bit time 9) makes up the Transmit/Receive (T/R) bit. This defines the direction of information flow and is always from the point of view of the remote terminal. A transmit command (logic 1) indicates that the remote terminal is to transmit data, while a receive command (logic 0) indicates that the remote terminal is going to receive data. The only exceptions to this rule are associated with mode commands.

The next five bits (bit times 10-14) make up the Sub address (SA)/Mode Command bits.

The next five bit positions (bit times 15-19) define the Word Count (WC) or Mode Code to be performed.

The last bit (bit time 20) is the word parity bit. Only odd parity is used.

Data Word

The Data Word (DW) contains the actual information that is being transferred within a message.

The first three-bit time contains data sync. This sync pattern is the opposite of that used for command and status words and therefore is unique to the word type.Data words can be transmitted by either a remote terminal (transit command) or a bus controller (receive command). Transmit and Receive, by convention, references the remote terminal.

The next sixteen bits of information are left to the designer to define. The only standard requirement is that the most significant bit (MSB) of the data be transmitted first.

The last bit (bit time 20) is the word parity bit. Only odd parity is used.

Status Word

A remote terminal in response to a valid message transmits only the status word (SW). The status word is used to convey to the bus controller whether a message was properly received or to convey the state of the remote terminal (i.e., service request, busy, etc.).

The (bit times 4-8) bits are the information of Terminal Address (TA). These five bits should match the corresponding field within the command word that the terminal received.

The next bit (bit time 9) is the Message Error (ME) bit. This bit is set by the remote terminal upon detection of an error in the message or upon detection of an invalid message (i.e. Illegal Command) to the terminal.

The Instrumentation bit (bit time 10) is provided to differentiate between a command word and a status word (remember they both have the same sync pattern).

The Service Request bit (bit time 11) is provided so that the remote terminal can inform the bus controller that it needs to be serviced. This bit is set to a logic “1” by the subsystem to indicate that servicing is needed.

Bit times 12-14 are reserved for future growth of the standard and must be set to logic “0”. The bus controller should declare a message in error if the remote terminal responds with any of these bits set in its status word.

The Broadcast Command Received bit (bit time 15) indicates that the remote terminal received a valid broadcast command. On receiving a valid broadcast command, the remote terminal sets this bit to logic “1” and suppresses the transmission of its status words.

The Busy bit (bit time 16) is provided as a feedback to the bus controller as to when the remote terminal is unable to move data between the remote terminal electronics and the subsystem in compliance to a command from the bus controller.

The Subsystem Flag bit (bit time 17) is used to provide “health” data regarding the subsystems to which the remote terminal is connected.

The Dynamic Bus Control Acceptance bit (bit time 18) informs the bus controller that the remote terminal has received the Dynamic Bus Control Mode Code and has accepted control of the bus.

The Terminal Flag bit (bit time 19) informs the bus controller of a fault or failure within the remote terminal circuitry (only the remote terminal). Logic “1” shall indicate a fault condition.

The last bit (bit time 20) is the word parity bit. Only odd parity is used.

INFORMATION TRANSFERS

Three basic types of information transfers are defined by 1553:

1. Bus Controller to Remote Terminal transfers
2. Remote Terminal to Bus Controller transfers
3. Remote Terminal to Remote Terminal transfers

These transfers are related to the data flow and are referred to as messages. The basic formats of these messages are shown in Figure

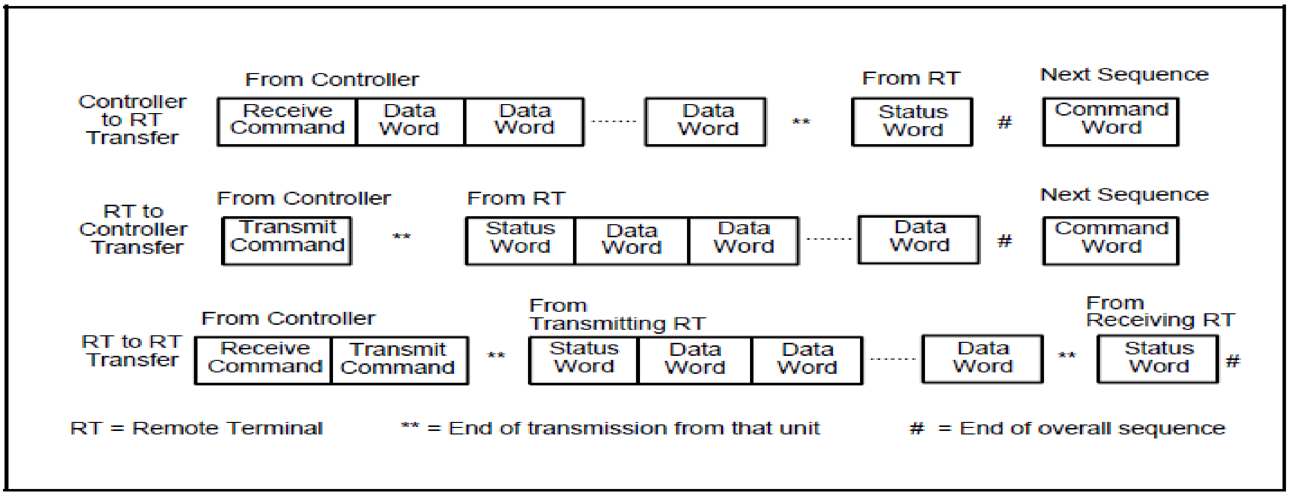


Table 1. Summary of MIL-STD-1553 Characteristics

Data Rate	1 MHz
Word Length	20 bits
Data Bits / Word	16 bits
Message Length	Maximum of 32 data words
Transmission Technique	Half-duplex
Operation	Asynchronous
Encoding	Manchester II bi-phase
Protocol	Command/response
Bus Control	Single or Multiple
Fault Tolerance	Typically Dual Redundant, second bus in "Hot Backup" status
Message Formats	Controller to terminal Terminal to controller Terminal to terminal Broadcast System control
Number of Remote Terminals	Maximum of 31
Terminal Types	Remote terminal Bus controller Bus monitor
Transmission Media	Twisted shielded pair
Coupling	Transformer and direct

UNIT: ***02. PRINCIPLES OF DIGITAL AVIONICS***

TOPIC:8.ARINC 429

ARINC 429

ARINC 429 is a self-clocking, synchronizing data bus; hence messages can start at any moment of the time line.It employs unidirectional transmission of 32 bit words over two wire twisted pairs using bipolar RZ format.

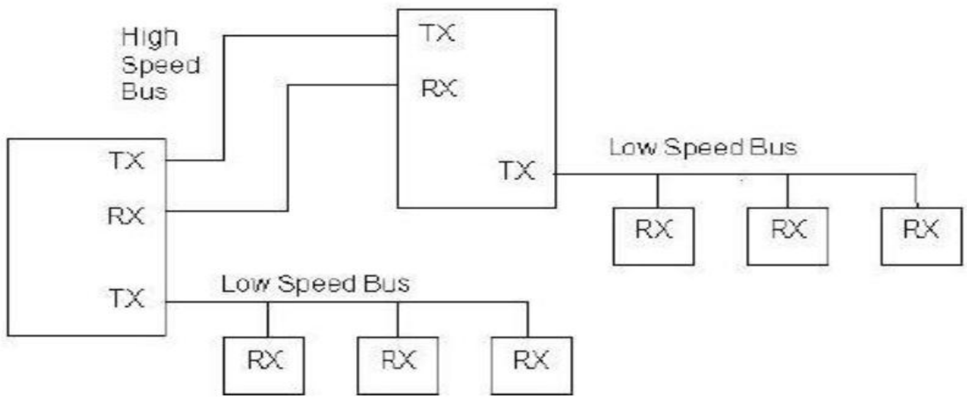


Fig: ARINC 429 architecture

It has two variants; a high speed variant operating at 100 kbps and low speed variant at 13 kbps.

PROTOCOL

ARINC 429 is a very simple, point-to-point protocol. There can be only one transmitter on a wire pair. The transmitter is always transmitting either 32-bit data words. There is at least one receiver on a wire pair; there may be up to 20.

ARINC 429 WORD FORMAT

ARINC data words are always 32 bits and typically use the format shown in below Figure which includes five primary fields, namely *Parity, SSM, Data, SDI, and Label*. ARINC convention numbers the bits from 1 (LSB) to 32 (MSB).

PARITY

The 32 bit is always the parity bit for ARINC 429.

Parity is normally set to odd except for certain tests. Odd parity means that there must be an odd number of “1” bits in the 32-bit word.

SSM

Bits 31 and 30 contain the Sign/Status Matrix or SSM. This field contains hardware equipment condition, operational mode, or validity of data content.

Bit		Meaning
31	30	
0	0	Plus, North, East, Right, To, Above
0	1	No Computed Data
1	0	Functional Test
1	1	Minus, South, West, Left, From, Below

DATA

Bits 29 through 11 contain the data, which may be in a number of different formats. There are also many non-standard formats that have been implemented by various manufacturers.

SDI

Bits 10 and 9 provide a Source/Destination Identifier or SDI. This is used for multiple receivers to identify the receiver for which the data is destined. It can also be used in the case of multiple systems to identify the source of the transmission.

LABEL

Bits 8 through 1 contain a label identifying the data type and the parameters associated with it. The label is an important part in ARINC. It is used to determine the data type of the word. Labels are typically represented as octal numbers.

ARINC 429 DATA TYPES

All ARINC data is transmitted in 32 bit words. The data type may be

1. Binary Coded Decimal (BCD),
2. Two's complement binary notation (BNR),
3. Discrete Data,
4. Maintenance Data and Acknowledgment, and
5. ISO Alphabet #5 character data.

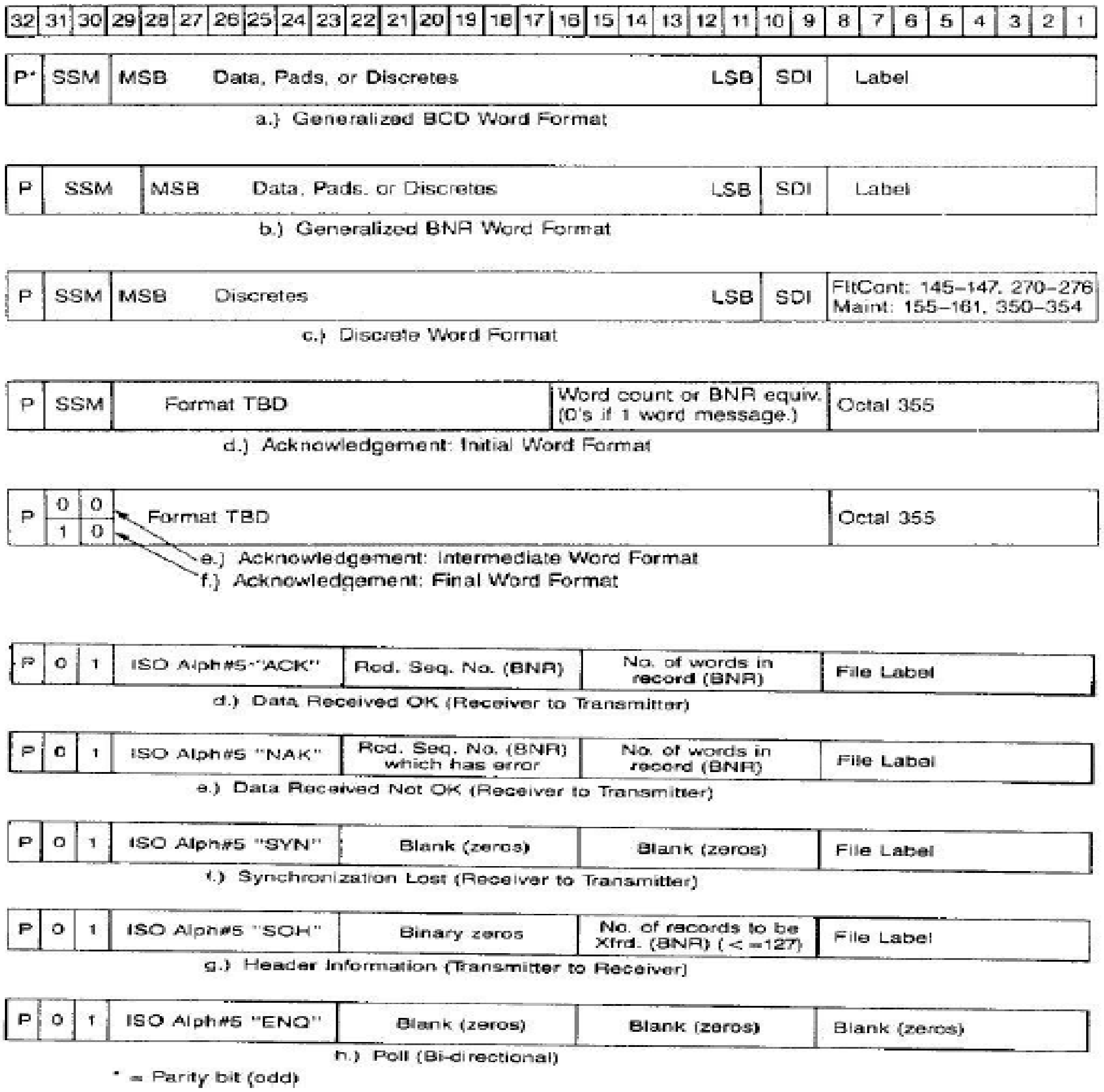


Fig: 429 word types

1. BCD Data Encoding

BCD, or binary-coded-decimal, is a common data format in ARINC 429.In this format, four bits are allocated to each decimal digit. A generalized BCD message is shown in below figure. Its data fields contain up to five sub-fields. The most significant sub-field contains only the bits, so that its maximum decimal value can be 7.

<table>
<tr><td>32</td><td>31</td><td>30</td><td>29</td><td>28</td><td>27</td><td>26</td><td>25</td><td>24</td><td>23</td><td>22</td><td>21</td><td>20</td><td>19</td><td>18</td><td>17</td><td>16</td><td>15</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>1</td></tr>
<tr><td>P</td><td colspan="2">SSM</td><td colspan="3">CHAR 1</td><td colspan="4">CHAR 2</td><td colspan="4">CHAR 3</td><td colspan="4">CHAR 4</td><td colspan="4">CHAR 5</td><td colspan="2">SDI</td><td colspan="2">LABEL</td></tr>
</table>

2. BNR Data Encoding

BNR or "binary" encoding is also a very common ARINC data format. This type of encoding simply stores the data as a binary number. Below figure shows the general BNR format. Bit 29 is the sign bit and bit 28 is the most significant bit of the data field.

32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8 1
P	SSM		Data																	Pad		SDI		LABEL

3. Discrete Formats

The 32-bit message words can also include discrete information, either mixed with BCD or BNR data, or as separate messages.

ARINC Transmission Order

The least significant bit (LSB) of each byte apart from the label (which is transmitted MSB at the beginning) is transmitted first; the label is transmitted in front of the data in each case.

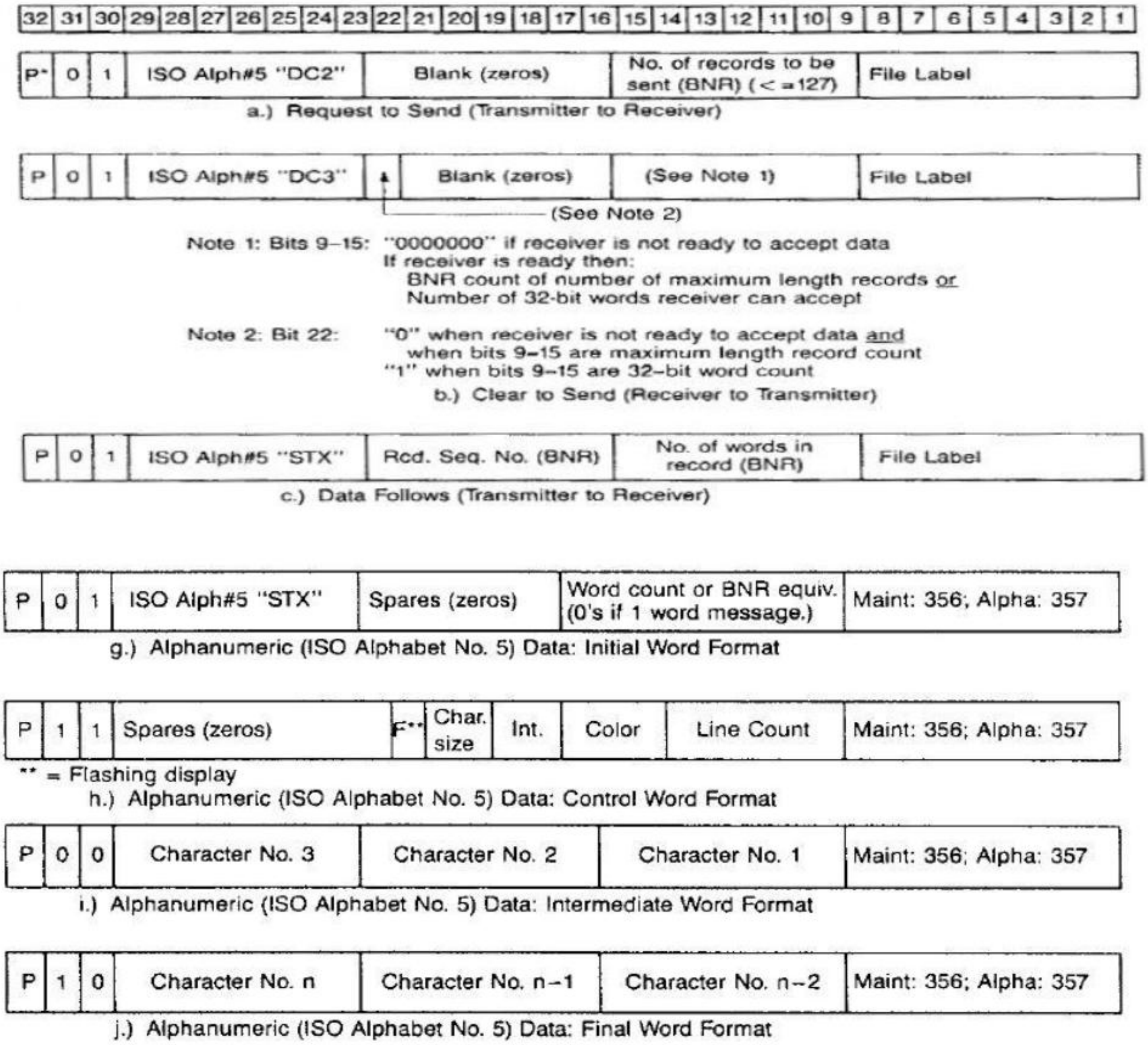


Fig: 429 transfer word formats

Bit Rate

1 High-Speed Operation

The bit rate for high-speed operation of the system is 100 kilobits per second (kbps) ±1%.

2 Low-Speed Operations

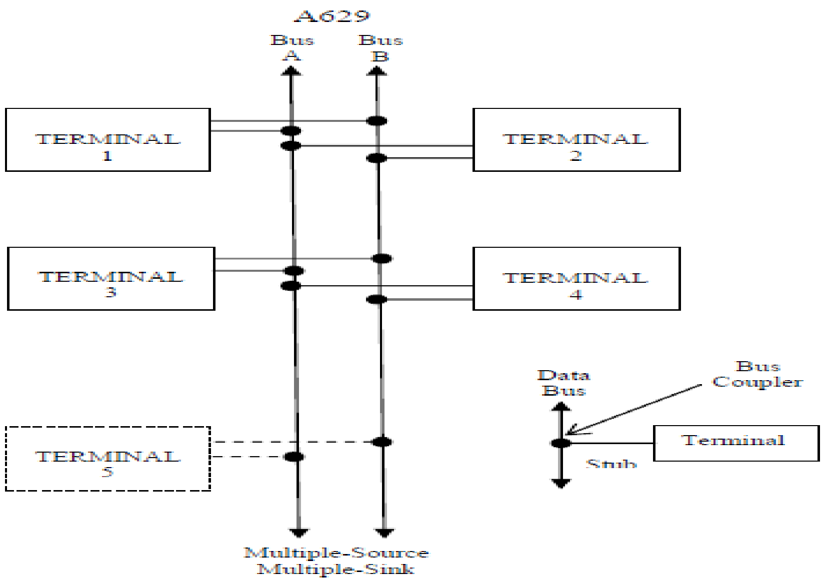
The bit rate for low-speed operation of the system is within the range 12.0 to 14.5 kbps. The selected rate is maintained within 1%.

UNIT: ***02. PRINCIPLES OF DIGITAL AVIONICS***

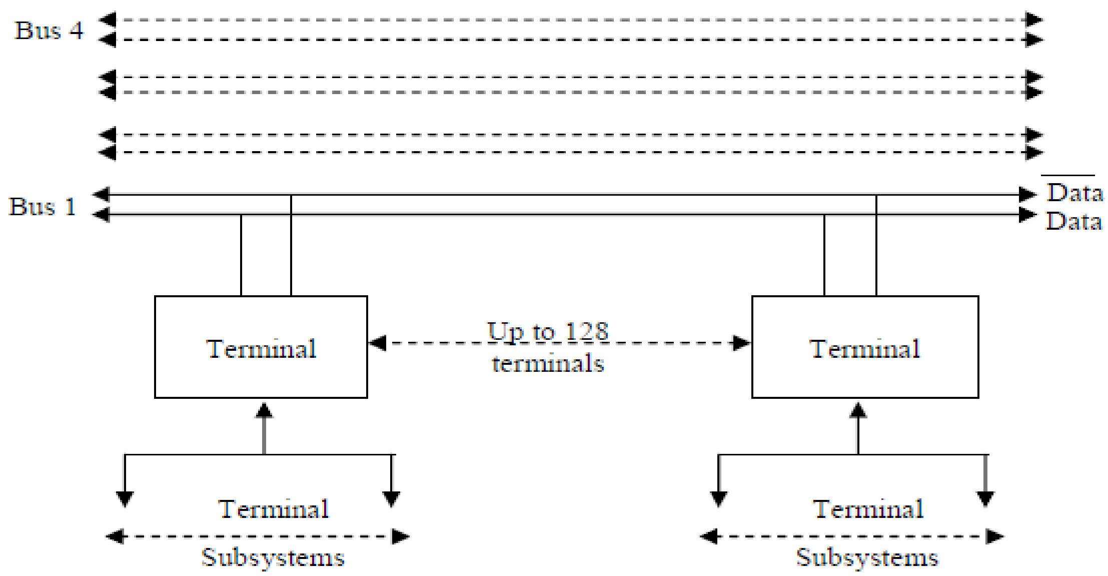
TOPIC:9.ARINC 629

ARINC 629

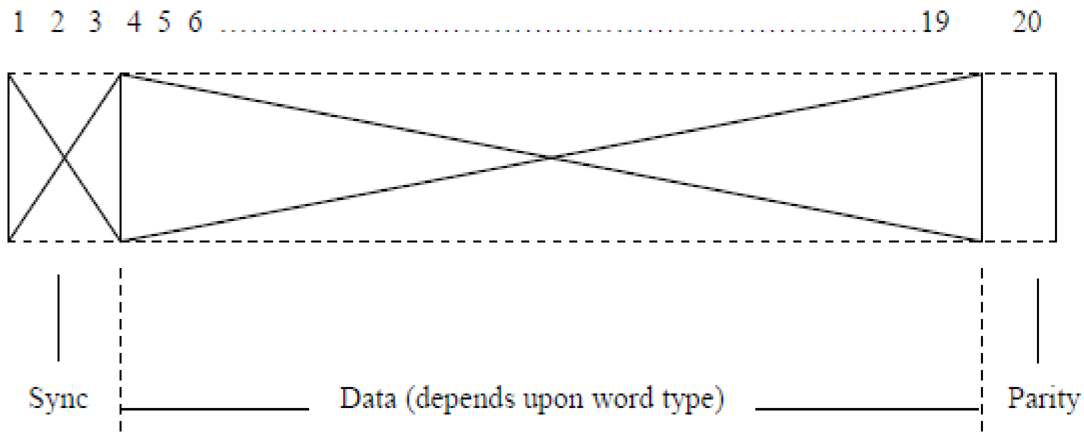
ARINC 629 was introduced in May 1995 and is currently used on the Boeing 777, Airbus A330 and A340 aircraft. The ARINC 629 bus is a true data bus in that the bus operates as a multiple-source, multiple sink system as shown in Figure. That is, each terminal can transmit data to, and receive data from, every other terminal on the data bus. This allows much more freedom in the exchange of data between units in the avionics system.



ARINC 629 is the ability to accommodate up to a total of 128 terminals on a data bus shown in Figure.



The protocol utilized by ARINC 629 is a time based, collision-avoidance concept in which each terminal is allocated a particular time slot to access the bus and transmit data on to the bus. Each terminal will autonomously decide when the appropriate time slot is available through the use of several control timers embedded in the bus interfaces and transmit the necessary data. The typical ARINC 629 20 bit data word format which is very similar to MILSTD- 1553B.



The first three bits are related to word time synchronization. The next 16 bits are the data contents, and the final bit is a parity bit. The data words may have a variety of formats depending on the word function; there is provision for general formats, systems status, function status, parameter validity, and binary and discrete data words.

– It has Various timing conditions

(1) XPP [Transmit Personality Programmable Read Only Memory] in the host terminal.

(2) RPP [Receive Personality Programmable Read Only Memory] to identify the labels of messages

ARINC 629 word Formats:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

LB	15 14 13 12	11 10 9 8 7 6 5 4 3 2 1 0	
HL Sync	CID	Label	P

(a) Generalized label word format.

DB	15 14 13 12 11	10 9 8	7 6 5 4 3 2 1 0	
LH SYNC	See text	Spare	word count (or) pad	P

(b) system status word

DB	15	14 13 12	11 10 9 8 7 6 5 4 3 2 1 0	
LH SYNC	H	Function	Function Subgroups	P

(c) function status word

DB	15 14 13 12	11 10 9 8 7 6 5 4 3 2 1 0	
LH SYNC	Refresh ctr	Parameter validity Bits	P

(d) Parameter validity word

DB	15	14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	
LH SYNC	S	Data	P

(e) Binary data

DB	15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	
LH SYNC	Discretes	P

(f) discrete word

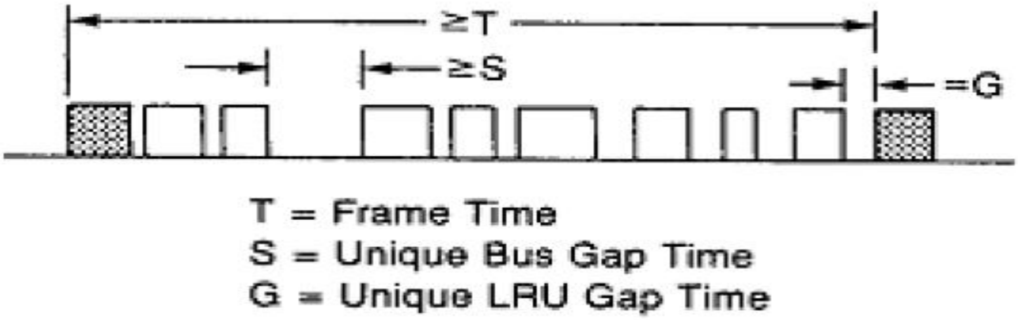


Fig: ARINC 629 Timing Parameters

The ARINC 629 data bus cable consists of an unshielded twisted pair of wires. The wires are #20

AWG and are bonded together continuously along their length. The cables can be up to 100 meters long and have no provisions for field splicing. ARINC 629 is defined for both voltage and current modes of operation.

The unique feature of ARINC 629 is that access to the bus to transmit by a given terminal is based on meeting three timing conditions. They are Transmit Interval (TI), Terminal Gap (TG) and Synchronization Gap (SG).

Transmit Interval (TI) is a global Bus Parameter. For a particular terminal, TI begins the moment the terminal starts transmitting. Once it has transmitted, it must wait the length of time specified by the TI before it can transmit again (0.5 to 64 ms).

Terminal Gap (TG) is an unique timer assigned to each terminal on the Bus. TG begins only after the SG has elapsed and only if no carrier is present. TG and SG cannot overlap in time, they must run consecutively (4 to 128 μs).

Synchronization Gap (SG) is a global access parameter. SG is the second longest timer and is set to the same value in all terminals. SG starts the moment the bus is quiet, it is reset if a carrier appears on the bus before it has elapsed.

****

COMPARISON OF DATABUSES

	Mil-Std-1553	ARINC 429	ARINC 629
Bus architecture	time division Multiplex	simplex point-to-point	time division multiplex
Encoding	bipolar Manchester II	bipolar, return to zero	bipolar, doublets Manchester
Transmission mode & coupling	voltage, direct or transformer	voltage direct connection	current coupling
Media	shielded twisted wire pair	shielded twisted wire pair	shielded twisted wire pair
Data bit rate	1 Mbps	12-14,5 kbps HS 100 kbps	2 Mbps
Effective data rate	800 kbps	HS 53 kbps	1,6 Mbps
# of terminals	1BC+31RT+xM	1TX+20RC	120

*UNIT: **<u>03.FLIGHT DECKS AND COCKPITS</u>***

<u>TOPIC:1.Control And Display Technologies: CRT</u>

FLIGHT DECK AND COCKPIT

A cockpit or flight deck is the area, usually near the front of an aircraft, from which a pilot controls the aircraft. Most modern cockpits are enclosed, except on some small aircraft, and cockpits on large airliners are also physically separated from the cabin. From the cockpit an aircraft is controlled on the ground and in the air. The cockpit of an aircraft contains flight instruments on an instrument panel, and the controls which enable the pilot to fly the aircraft. In most airliners, a door separates the cockpit from the passenger compartment.

COCKPIT DISPLAY SYSTEMS

The Cockpit display systems (or CDS) provides the visible (and audible) portion of the Human Machine Interface (HMI) by which aircrew manage the modern Glass cockpit and thus interface with the aircraft avionics.

<u>CATHODE RAY TUBE (CRT)</u>

The cathode ray tube (CRT) is a vacuum tube containing one or more electron guns (a source of electrons or electron emitter) and a fluorescent screen used to view images. It has a means to accelerate and deflect the electron beam(s) onto the screen to create the images. The images may represent electrical waveforms (oscilloscope), pictures (television, computer monitor), radar targets and others.

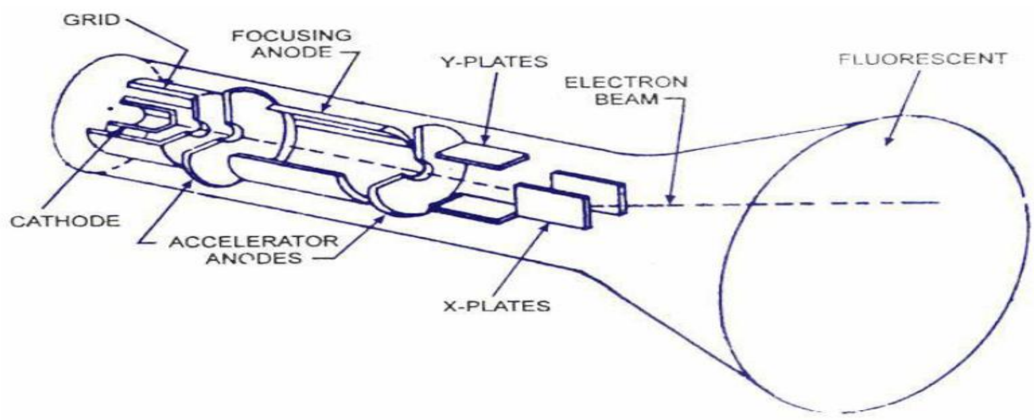


Fig: Cathode Ray Tube

Basic principle:

It works on the following principles:

(i) Thermionic emission

(ii) Deflection of the electron beam by the electric and magnetic field

(iii) Fluorescence produced by the electron beam on a fluorescent screen.

The screen itself is one end of a sealed glass tube, coated on the inside with substances (phosphors) which glow when electrons strike them. The other end of the tube has a substance such as barium oxide, with electrical connections from the control circuits. When a current flows from the control circuits, the oxide is heated. The heated oxide releases electrons from this negatively charged 'cathode' or 'electron gun'; they flow to the screen at the other end which has a positive electrical charge. When the electrons strike the fluorescent screen, the phosphors emit light (glow), and continue to glow for a finite time depending on the particular phosphor.

The image may represent electrical waveforms (oscilloscope), radar targets and others. CRTs have also been used as memory devices, in which case the visible light emitted from the fluorescents material (if any) is not intended to have significant meaning to a visual observer (though the visible pattern on the tube face may cryptically represent the stored data).

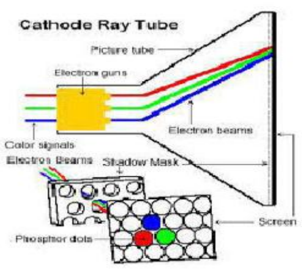
COLOR CRTS

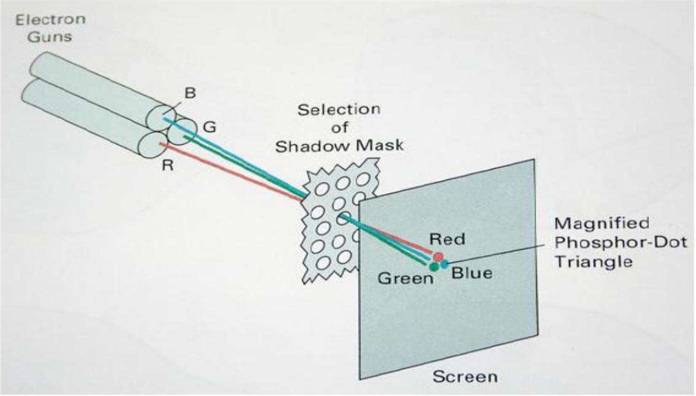
Color tubes use three different phosphors which emit **red, green, and blue** light respectively. They are packed together in **stripes** (as in aperture grille designs) or clusters **called "triads"** (as in shadow mask CRTs).

Color CRTs have three electron guns, one for each primary color, arranged either in a straight line or in an equilateral triangular configuration (the guns are usually constructed as a single unit).

The triangular configuration is often called "**delta-gun",** based on its relation to the shape of the Greek letter delta.) A grille or mask absorbs the electrons that would otherwise hit the wrong phosphor. A shadow mask tube uses a metal plate with tiny holes, placed so that the electron beam only illuminates the correct phosphors on the face of the tube. Another type of color CRT uses an aperture grille to achieve the same result. There are two popular techniques for producing colour displays with a CRT are:

1. Beam-penetration method 2. Shadow-mask method





1. Beam Penetration method

This CRT is similar to the simple CRT, but it makes use of multi coloured phosphorus of number of layers. Each phosphorus layer is responsible for one colour. All other arrangements are similar to simple CRT. It can produce a maximum of 4 to 5 colours.

The organization is something like this - The red, green and blue phosphorus are coated in layers - one behind the other. If a low speed beam strikes the CRT, only the red colored phosphorus is activated, a slightly accelerated beam would activate both red and green (because it can penetrate deeper) and a much more activated one would add the blue component also.

But the basic problem is a reliable technology to accelerate the electronic beam to precise levels to get the exact colors - it is easier said than done. However, a limited range of colors can be conveniently produced using the concept.

2. **The Shadow - Mask method**.

This works, again, on the principle of combining the basic colors - Red, green and Blue - in suitable proportions to get a combination of colors, but it's principle is much more sophisticated and stable. The shadow mask CRT, instead of using one electron gun, uses 3 different guns placed one by the side of the other to form a triangle or a "Delta" as shown. Each pixel point on the screen is also made up of 3 types of phosphors to produce red, blue and green colors. Just before the phosphor screen is a metal screen, called a "shadow mask".

This plate has holes placed strategically, so that when the beams from the three electron guns are focused on a particular pixel, they get focused on particular color producing pixel only i.e. If for convenience sake we can call the electronic beams as red, blue and green beams (though in practice the colors are produced by the phosphors, and until the beams hit the phosphor dots, they produce no colors), the metal holes focus the red beam onto the red color producing phosphor, blue beam on the blue producing one etc. When focused on to a different pixel, the red beam again focuses on to the red phosphor and so on.

Now, unlike the beam penetration CRTs where the acceleration of the electron beam was being monitored, we now manipulate the intensity of the 3 beams simultaneously. If the red beam is made more intense, we get more of red color in the final combination etc. Since fine-tuning of the beam intensities is comparatively simple, we can get much more combination of colors than the beam penetration case. In fact, one can have a matrix of combinations to produce a wide variety of colours.

The shadow mask CRT, though better than the beam penetration CRT in performance, is not without its disadvantages. Since three beams are to be focused, the role of the "Shadow mask" becomes critical. If the focusing is not achieved properly, the results tend to be poor. Also, since instead of one pixel point in a monochrome CRT now each pixel is made up of 3 points (for 3 colors), the resolution of the CRT (no. of pixels) for a given screen size reduces.

Another problem is that since the shadow mask blocks a portion of the beams (while focusing them through the holes) their intensities get reduced, thus reducing the overall brightness of the picture. To overcome this effect, the beams will have to be produced at very high intensities to begin with. Also, since the 3 color points, though close to each other, are still not at the same point, the pictures tend to look like 3 colored pictures placed close by, rather than a single picture. Of course, this effect can be reduced by placing the dots as close to one another as possible.

UNIT: **03.FLIGHT DECKS AND COCKPITS**

TOPIC:2.Control And Display Technologies: LED, LCD

LIGHT EMITTING DIODE (LED)

An LED is a solid- state display device comprising a forward –biased p-n junction transistor formed from a slice or chip of gallium arsenide phosphate (GaAsP) mounted into a transparent covering. When the current flows through the chip it emits light which is in direct proportion to the current flow.

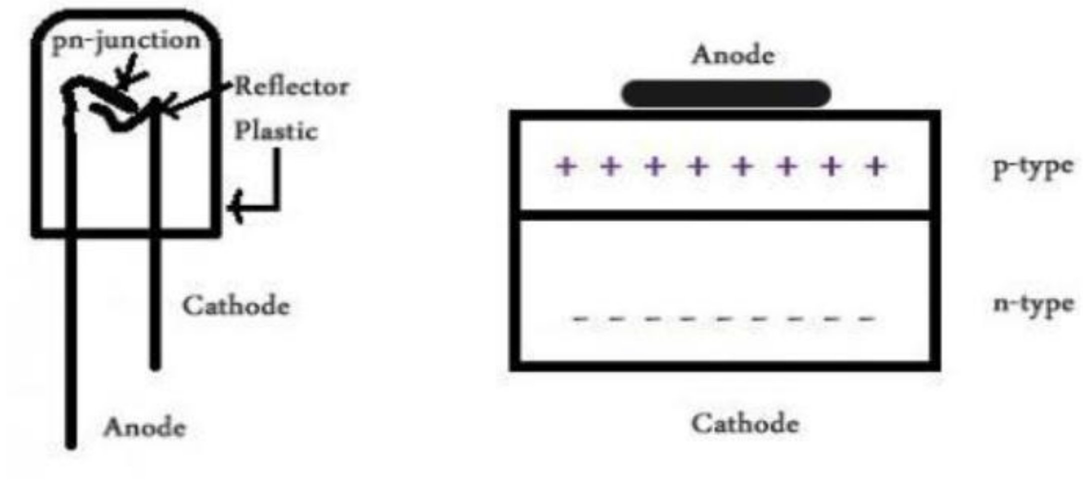


Fig: LED

Fig: Sectional view

Light emission in different colors of spectrum can be obtained by varying the proportions of the elements comprising the chip, and can also be obtained by using the technique called doping with other elements, e.g. Nitrogen.

Working principle

When a light-emitting diode is forward-biased (switched on), electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence and the color of the light (corresponding to the energy of the photon) is determined by the energy gap of the semiconductor. LEDs are often small in area (less than 1 mm2), and integrated optical components may be used to shape its radiation pattern.

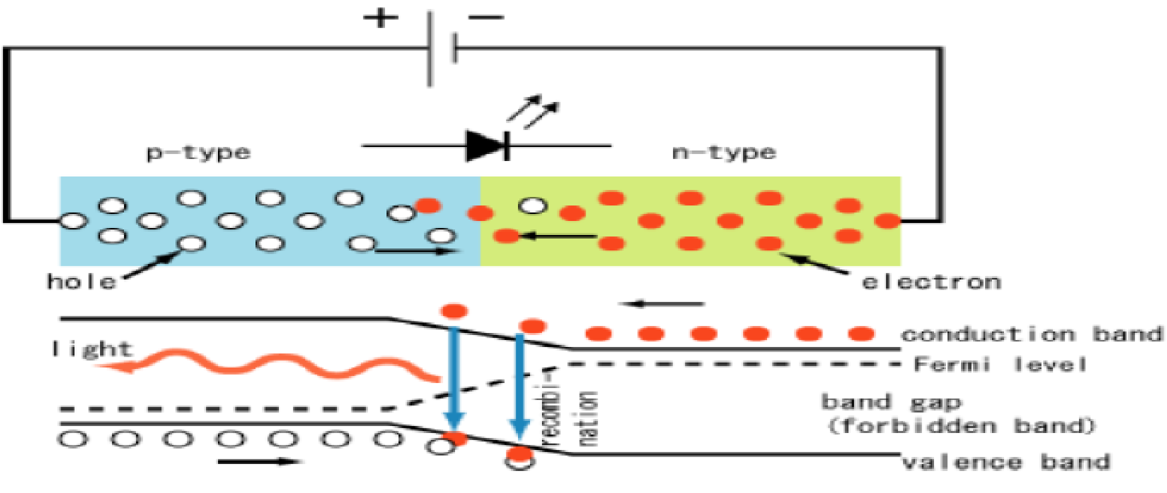


Fig: The inner workings of an LED

The heart of the display is a slice or chip of gallium arsenide phosphide (GaAsP) mounted into a transparent plastic covering which not only serves to protect the chip, but also as a diffuser lens. The diode leads are soldered to a printed circuit board to form the numerical display required.

When current flows through the chip it produces light, which is directly transmitted in proportion to the current flow. To provide different colors, the proportion of GaP and GaAs is varied during manufacture of the chip, and also the technique of 'doping' with other elements eg, Oxigen or Nitrogen is applied.

Advantages:

LEDs present many advantages over incandescent light sources including lower energy consumption, longer lifetime, improved robustness, smaller size, and faster switching. LEDs powerful enough for room lighting are relatively expensive and require more precise current and heat management than compact fluorescent lamp sources of comparable output.

Applications :

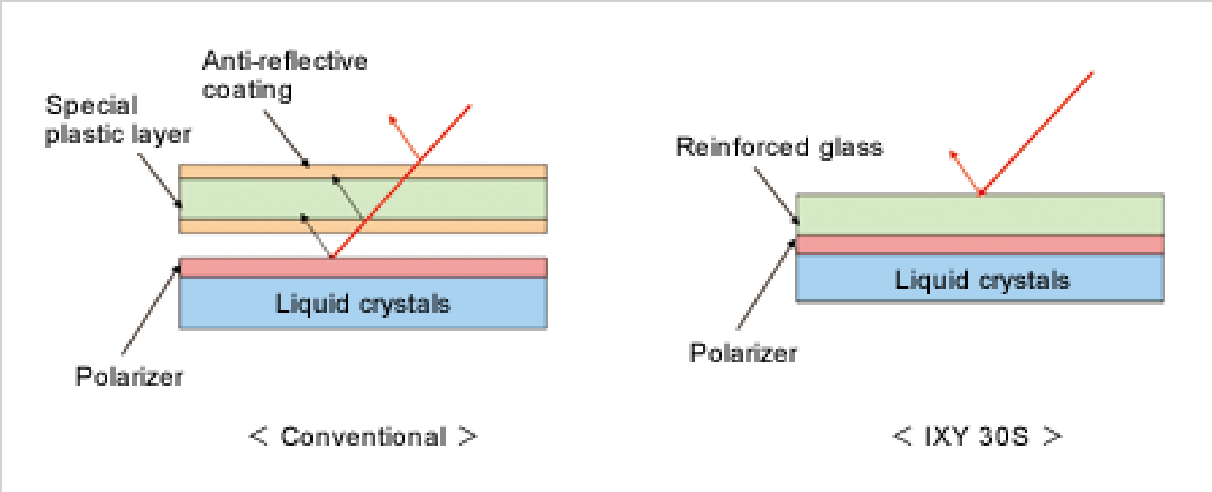
Light-emitting diodes are used in applications as diverse as aviation lighting, automotive lighting, advertising, general lighting, and traffic signals. LEDs have allowed new text, video displays, and sensors to be developed, while their high switching rates are also useful in advanced communications technology. Infrared LEDs are also used in the remote control units of many commercial products including televisions, DVD players, and other domestic appliances.

LIQUID CRISTAL DISPLAY (LCD)

A liquid crystal display (LCD) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals (LCs). LCs do not emit light directly.

Basic structure of an LCD

A liquid crystal cell consists of a thin layer (about 10 u m) of a liquid crystal sandwiched between two glass sheets with transparent electrodes deposited on their inside faces. With both glass sheets transparent, the cell is known as *transmittive type cell.* When one glass is transparent and the other has a reflective coating, the cell is called *reflective type.* The LCD does not produce any illumination of its own. It, in fact, depends entirely on illumination falling on it from an external source for its visual effect.



Working principle

LCDs are made from liquid crystals, an intermediary substance between a liquid and a solid. When liquid crystals are inserted between alignment layers, they line up with the grooves of the layers. Light then follows the direction in which the liquid crystal molecules are arranged. When an electrical charge is applies, the molecules re-arrange themselves in a vertical pattern and light passes through without being twisted.

A combination of polarizing filters along with alignment layers and liquid crystal molecules form a liquid crystal display. Two types of drive panels are used to control an LCD, active and passive. An active matrix display contains a transistor while a passive one does not. A transistor allows for superior picture quality and faster response times. All Vision Touch LCDs contain a transistor.

TYPES OF LCD/LIQUID CRYSTAL DISPLAYS

Two types of display available are **dynamic scattering display** and **field effect display**.

1. When dynamic scattering display is energized, the molecules of energized area of the display become turbulent and scatter light in all directions. Consequently, the activated areas take on a frosted glass appearance resulting in a silver display. Of course, the unenergized areas remain translucent.
2. Field effect LCD contains front and back polarizers at right angles to each other. Without electrical excitation, the light coming through the front polarizer is rotated 90° in the fluid.

COLOUR LIQUID CRYSTAL DISPLAY

Colour LCDs are those that can display pictures in colours. For this to be possible there must be three ***sub-pixels with red, green and blue colour filters to create*** each colour pixel. For combining these sub-pixels these LCDs should be connected to a large number of transistors. If any problem occurs to these transistors, it will cause a bad pixel. One of the main disadvantages of these types of LCDs is the size. Most manufacturers try to reduce the height than gain it. This is because more transistors and greater pixels will be needed to increase the length. This will increase the probability of bad pixels. It is very difficult or also impossible to repair a LCD with bad pixels. This will highly affect the sale of LCDs.

Applications

LCDs are used in a wide range of applications, including computer monitors, television, instrument panels, aircraft cockpit displays, signage, etc. They are common in consumer devices such as video players, gaming devices, clocks, watches, calculators, and telephones. LCDs have replaced cathode ray tube (CRT) displays in most applications. They are available in a wider range of screen sizes than CRT and plasma displays, and since they do not use phosphors, they cannot suffer image burn-in. LCDs are, however, susceptible to image persistence.

Advantages

The LCD is more energy efficient and offers safer disposal than a CRT. Its low electrical power consumption enables it to be used in battery-powered electronic equipment. It is an electronically modulated optical device made up of any number of segments filled with liquid crystals and arrayed in front of a light source (backlight) or reflector to produce images in color or monochrome. The most flexible ones use an array of small pixels.

Disadvantages

The main drawbacks of LCDs are additional requirement of light source, a limited temperature range of operation (between 0 and 60° C), low reliability, short operating life, poor visibility in low ambient lighting, slow speed and the need for an ac drive.

MAJOR DIFFERENCE BETWEEN LED & LCD

LEDs are based on the semiconductor diode. When the diode is forward biased (switched on), electrons are able to recombine with holes and energy is released in the form of light. This effect is called electroluminescence and the color of the light is determined by the energy gap of the semiconductor. LEDs present many advantages over traditional light sources including lower energy consumption, longer lifetime, improved robustness, smaller size and faster switching. However, they are relatively expensive and require more precise current and heat management than traditional light sources.

A liquid crystal display (LCD) is a thin, flat panel used for electronically displaying information such as text, images, and moving pictures Among its major features are its lightweight construction, its portability, and its ability to be produced in much larger screen sizes than are practical for the construction of cathode ray tube (CRT) display technology. Its low electrical power consumption enables it to be used in battery-powered electronic equipment. It is an electronically-modulated optical device made up of any number of pixels filled with liquid crystals and arrayed in front of a light source (backlight) or reflector to produce images in color or monochrome.

UNIT: ***03.FLIGHT DECKS AND COCKPITS***

TOPIC:3.EL and Plasma Panel

ELECTROLUMINISCENT DISPLAY (EL)

Electroluminescent Displays (ELDs) are a type of Flat panel display created by sandwiching a layer of electroluminescent material such as GaAs between two layers of conductors. When current flows, the layer of material emits radiation in the form of visible light. Electroluminescence (EL) is an optical and electrical phenomenon where a material emits light in response to an electric current passed through it, or to a strong electric field. EL works by exciting atoms by passing an electric current through them, causing them to emit photons. By varying the material being excited, the colour of the light emitted can be changed.

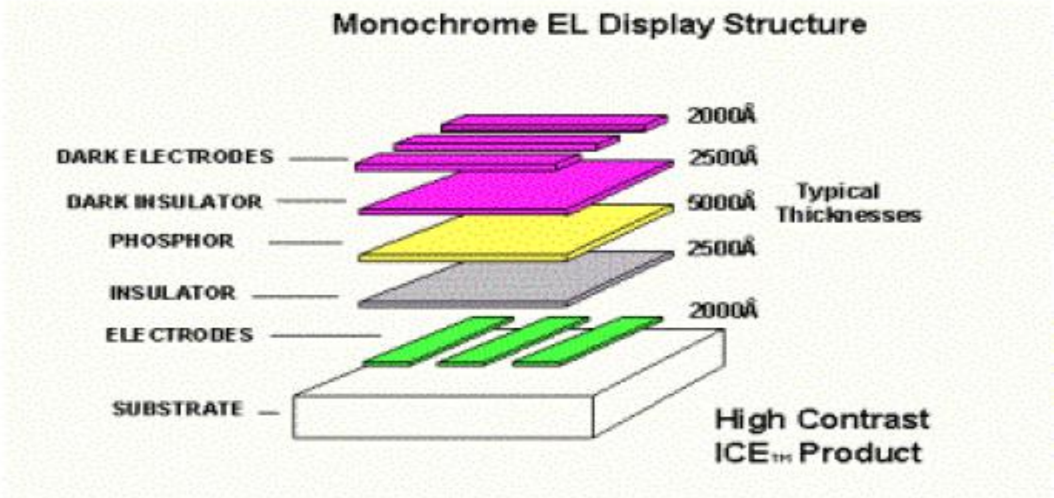


Figure 4

The actual ELD is constructed using flat, opaque electrode strips running parallel to each other, covered by a layer of electroluminescent material, followed by another layer of electrodes, running perpendicular to the bottom layer. This top layer must be transparent in order to let light escape. At each intersection, the material lights, creating a pixel.

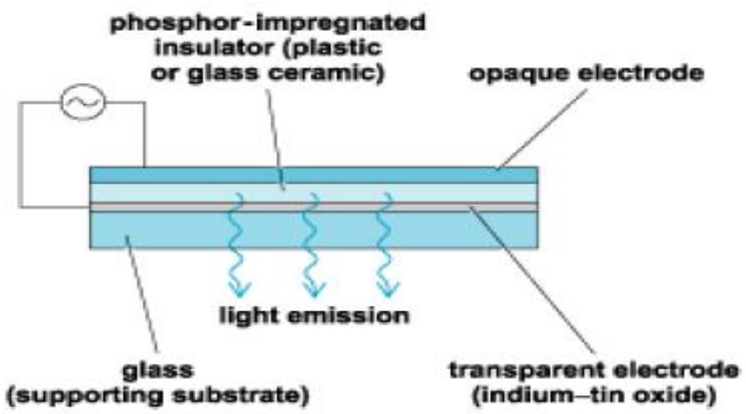


Fig: A structure of Electroluminescence

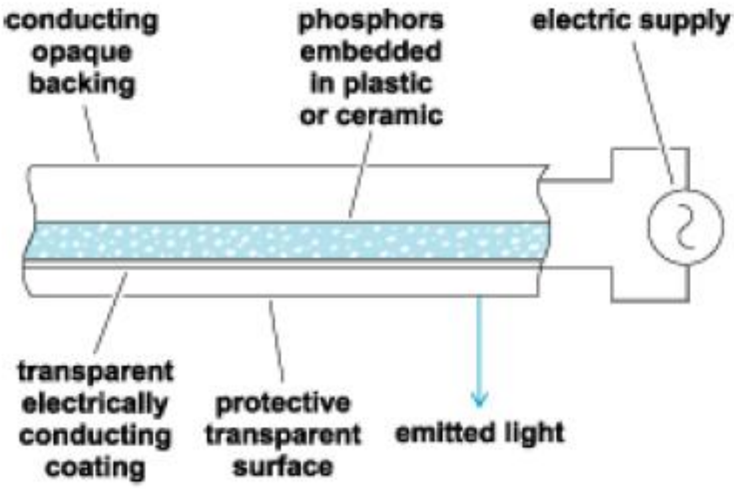


Fig: simplified diagram of EL cell

There are four steps necessary to produce electroluminescence in ELDs:

1. Electrons tunnel from electronic states at the insulator/phosphor interface;
2. Electrons are accelerated to ballistic energies by high fields in the phosphor;
3. The energetic electrons impact-ionize the luminescent center or create electron-hole pairs that lead to the activation of the luminescent center; and
4. The luminescent center relaxes toward the ground state and emits a photon.

All ELDs have the same basic structure. There are at least six layers to the device. The first layer is a baseplate (usually a rigid insulator like glass), the second is a conductor, the third is an insulator, the fourth is a layer of phosphors, and the fifth is an insulator, and the sixth is another conductor.

Advantages

An electroluminescent (EL) device is similar to a laser in that photons are produced by the return of an excited substance to its ground state, but unlike lasers EL devices require much less energy to operate and do not produce coherent light. EL devices include *light emitting diodes*, which are discrete devices that produce light when a current is applied to a doped p-n junction of a semiconductor, as well as EL displays (ELDs) which are matrix-addressed devices that can be used to display text, graphics, and other computer images.

Applications

ELDs are particularly useful in applications where full color is not required but where ruggedness, speed, brightness, high contrast, and a wide angle of vision is needed. EL is also used in lamps and backlights.

PLASMA PANNEL

A plasma display is an element displaying letter or graphic using light from plasma, generated during gas discharge. A plasma display panel (PDP) is a type of flat panel display. Many tiny cells between two panels of glass hold a mixture of noble gases (Neon and Xenon). The gas in the cells is electrically turned into a plasma which then excites phosphors to emit light.

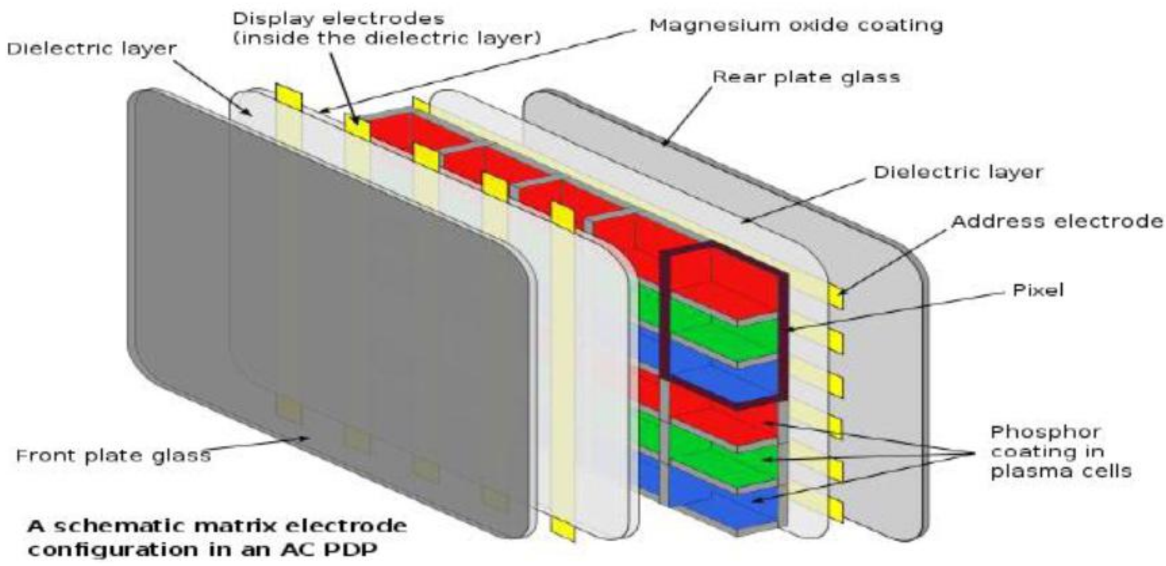


Fig: Composition of plasma display panel

Fig: Composition of plasma display panel

Working principle

A plasma display panel (PDP) is essentially a matrix of tiny fluorescent tubes which are controlled in a sophisticated fashion. There are two main types, DC and AC of which the latter has become mainstream because of simpler structure and linger lifetime. This section treats the AC type.

A plasma discharge is first induced by the positive period of an AC field and a layer of carriers is shortly thereafter formed on top of the dielectric medium. This causes the discharge to stop but is induced again when the voltage changes polarity. In this way, a sustained discharge is achieved.

The AC voltage is tuned just below the discharge threshold so the process can be switched on/off by adding a relatively low voltage at the address electrode.

The discharge creates plasma of ions and electrons which gain kinetic energy by the electric field. These particles collide at high speed with neon and xenon atoms, which thereby are brought to higher-energy states. After a while, the excited atoms return to their original state and energy is dissipated in the form of ultraviolet radiation. This radiation, in turn, excites the phosphors which **glow in red, green and blue (RGB) colors,** respectively. Since each discharge cell can be individually addressed, it is possible to switch on and off picture elements (pixels).

TYPES

Plasma Display is divided into Direct Current type and Alternating Current type. Electrode used to supply voltage from the outside and make plasma is exposed to the plasma directly and conduction current flows directly through electrode, which is Direct Current type. On the other hand, the electrode is covered by a dielectric and it is not directly exposed. So, displacement current flows, which is Alternating Current type. And also it is divided into Partners Facing Discharge type, Surface Discharge type, Barrier Rib Discharge type, etc in accordance with the electrode structure of discharge cell. In case of using visible rays directly from discharge gas, it is mostly used for single color displaying PDP element.

For a typical example, there is a PDP using orange color from Ne gas. If full color display is required, ultraviolet rays from discharge gas such as Kr or Xe excite red, green, and blue phosphors and generate visible light, which is available.

Advantages

- Slim profile
- Can be wall mounted
- Less bulky than rear-projection televisions
- Produces deep blacks allowing for superior contrast ratio
- Wider viewing angles than those of LCD; images do not suffer from degradation at high angles unlike LCDs

Disadvantages

Susceptible to screen burn-in and image retention, although most recent models have pixelorbiter, that moves the entire picture faster than it's noticeable to the human eye, which reduces the effect of burn-in but doesn't prevent burn-in. However turning off individual pixels does counteract screen burn-in on modern plasma displays. Phosphors lose luminosity over time, resulting in gradual decline of absolute image brightness(newer models are less susceptible to this, having lifespan exceeding 100,000 hours, far longer than older CRT technology)

- Susceptible to "large area flicker"
- Generally do not come in smaller sizes than 37 inches
- Susceptible to reflection glare in bright rooms
- Heavier than LCD due to the requirement of a glass screen to hold the gases
- Use more electricity.

ADVANTAGE OF EL OVER PLASMA DISPLAY

- Less flickering
- Sustainable luminosity even during aging
- Light weight than plasma displays
- Simple light weight component
- Available in smaller size (unlike plasma displays, which are available only at 32”)

UNIT: ***<u>03.FLIGHT DECKS AND COCKPITS</u>***

<u>TOPIC:4. Touch screen</u>

<u>TOUCH SCREEN</u>

A touch screen is an electronic visual display that can detect the presence and location of a touch within the display area. The term generally refers to touching the display of the device with a finger or hand. Touch screens can also sense other passive objects, such as a stylus. Touch screens are common in devices such as game consoles, all-in-one computers, tablet computers, and smart phones.

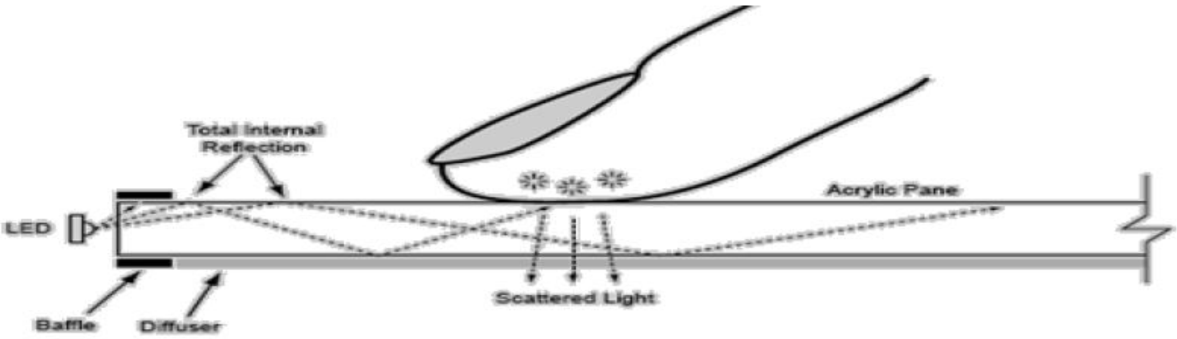


Fig: Touch screen technology with LED

Fig: Touch screen technology with LED

The touch screen has two main attributes.

1. It enables one to interact directly with what is displayed, rather than indirectly with a pointer controlled by a mouse or touchpad.
2. It lets one do so without requiring any intermediate device that would need to be held in the hand (other than a stylus, which is optional for most modern touch screens).

Such displays can be attached to computers, or to networks as terminals. They also play a prominent role in the design of digital appliances such as the personal digital assistant (PDA), satellite navigation devices, mobile phones, and video games.

Construction

There are several principal ways to build a touchscreen. The key goals are to recognize one or more fingers touching a display, to interpret the command that this represents, and to communicate the command to the appropriate application.

In the most popular techniques, the capacitive or resistive approach, there are typically four layers:

1. Top polyester coated with a transparent metallic conductive coating on the bottom
2. Adhesive spacer
3. Glass layer coated with a transparent metallic conductive coating on the top
4. Adhesive layer on the backside of the glass for mounting.

When a user touches the surface, the system records the change in the electrical current that flows through the display. Dispersive-signal technology which 3M created in 2002, measures the piezoelectric effect—the voltage generated when mechanical force is applied to a material—that occurs chemically when a strengthened glass substrate is touched.

There are two infrared-based approaches. In one, an array of sensors detects a finger touching or almost touching the display, thereby interrupting light beams projected over the screen. In the other, bottom-mounted infrared cameras record screen touches. In each case, the system determines the intended command based on the controls showing on the screen at the time and the location of the touch.

*UNIT: **<u>03.FLIGHT DECKS AND COCKPITS</u>***

<u>TOPIC:5.Direct voice input (DVI)</u>

DIRECT VOICE INPUT (DVI)

Direct Voice Input (DVI) (also sometimes called Voice Input Control (VIC)) is a style of Human-Machine Interaction "HMI" in which the user makes voice commands to issue instructions to the machine. It has found some usage in the design of the cockpit of several modern military aircrafts.

Basic concept

DVI is a very simple concept: the pilot uses his/her voice to provide an input to an aircraft system in order to obtain an action or information from that system. DVI systems may be "user-dependent" or "user-independent". User-dependent systems require a personal voice template to be created by the pilot which must then be loaded onto the aircraft before flight. User-independent systems do not require any personal voice template and will work with the voice of any user.

The technical process basically consists of a real time comparison between the incoming audio signal (pilot voice) and stored data (general/individual speech models).

<u>The key issues are:</u>

- **Injected audio signal** (acoustic nature: speaker speech style, reverberations and echoes when talking into the oxygen mask, background cockpit noise; electrical nature: frequency response from microphone, transmission channel)
- Speech models (speaker dependant/independent system)
- Recognition algorithms Computing capability of the processor/system (including syntax structure and total number of words)

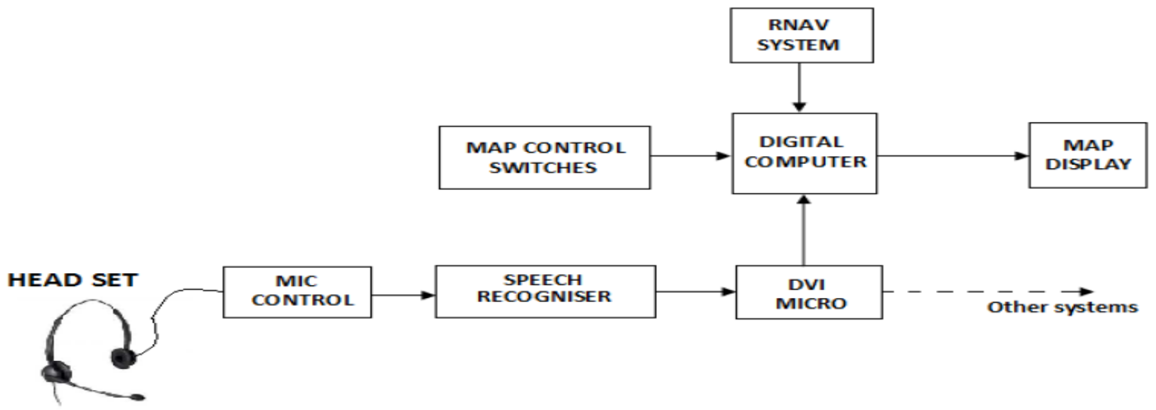


Fig: DVI concept

DVI allows the pilot to activate non-safety critical moding and data entry functions as an alternative to using manual methods.

<u>Options include:</u>

Manual data entry

Multi-Function Head Down Display (MHDD) selection and manipulation

Radio selection and navigation route manipulation

Target selection

Target allocation to formation members

DVI commands are confirmed by visual and/or aural feedback. This unique VTAS capability drastically reduces the pilot's workload to focus on the mission and systems operation. In an air battle scenario, this system even allows the lead pilot to assign targets to himself with two simple voice commands or to any of his wingmen with only five commands.

DVI has been targeted for use in the commands that can reduce pilot workload without compromising flight safety (a press button or soft key backup is incorporated):

CIVIL AND MILITARY COCKPIT

As aircraft displays have modernized, the sensors that feed them have modernized as well. Traditional gyroscopic flight instruments have been replaced by electronic Attitude and Heading Reference Systems (AHRS) and Air Data Computers (ADCs), improving reliability and reducing cost and maintenance. GPS receivers are usually integrated into glass cockpits.

Glass cockpit

A glass cockpit is an aircraft cockpit that features electronic (digital) instrument displays, typically large LCD screens, rather than the traditional style of analog dials and gauges. While a traditional cockpit relies on numerous mechanical gauges to display information, a glass cockpit uses several displays driven by flight management systems, which can be adjusted to display flight information as needed. This simplifies aircraft operation and navigation and allows pilots to focus only on the most pertinent information. They are also popular with airline companies as they usually eliminate the need for a flight engineer. In recent years the technology has become widely available in small aircraft.

Head Level displays (HLD)

An HLD avoids the physiological limitation on eye refocusing time by placing directly below the HUD or top edge of the instrument panel a display in which an image and supplemental alphanumeric information are focused at a long distance. Thus, the need for the pilot to refocus his or her eyes to scan at least some information inside the cockpit is eliminated. Typically the HLD will contain a radar or infrared image of the outside scene. An HLD uses a high-intensity lamp coupled with dichroic filters to sort the white light into red, green and blue and with optics to collimate and fold the light. The red and green bands are each modulated by liquid crystal shutters in which each pixel is either opaque or transparent as required to generate a color image.

Multi-Function Displays (MFDS)

A Multi-function display (MFD) (part of Multi-Function structures) 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 configurable ways. Often an MFD will be used in concert with a Primary Flight Display.

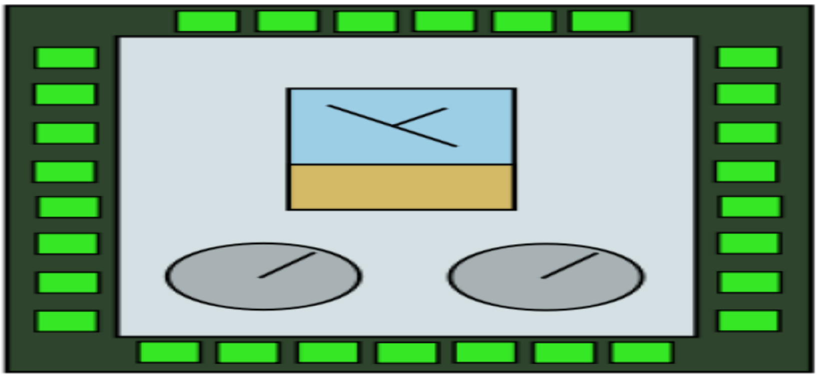


Fig: A schematic example of a multi-function display

Significance in Aircraft

MFDs are part of the digital era of modern planes or helicopter. The first MFD were introduced by air forces. The advantage of an MFD over analog display is that an MFD does not consume much space in the cockpit. All information is displayed on the MFD pages. The possible MFD pages could differ for every plane, complementing their abilities (in combat).

Many MFDs allow the pilot to display their navigation route, moving map, weather radar, NEXRAD, GPWS, TCAS and airport information all on the same screen. MFDs are added to the Space Shuttle (as the glass cockpit) starting in 1998 replacing the analog instruments and CRTs. The information being displayed is similar, and the glass cockpit was first flown on the STS-101 mission. In modern automotive technology, MFDs are used in cars to display navigation, entertainment and vehicle status information.

Installation and Location

In multifunction displays, CRT displays serve as MFKs. The most common way is for the CRT face to contain function labels correlated with adjacent switches mounted in the bezel surrounding the CRT. It is easy through software to change the switch function and the associated label on the CRT. The second method of implementing MFKs on CRTs is to overlay the CRT face with a touch-sensitive screen. The CRT face contains various switch function legends and the corresponding function is selected by touching that portion of the screen over the switch label.

Multi-function display is normally located in the centre console of the flight deck. An EFIS (electronic flight instrument system) with MFD is often referred to a tube EFIS. The MFD unit is normally installed in the location reserved for the radar display and is therefore accessible to both members of the flight crew.

The MFDs different from the other two displays in that it contains its own power unit, check list data file and display controls. During a normal flight, the MFD will display navigation and will weather radar information. In the event of a system mal function, the MFD can be used as a backup for the primary displays and also it is used for displaying diagnostic information retrieved from (MPU) multi-function processor unit.

UNIT: ***<u>03.FLIGHT DECKS AND COCKPITS</u>***

<u>TOPIC:6.Civil Cockpit And Military Cockpit: MFDS</u>

Multi-function display:

The primary flight instruments can all be displayed simultaneously on one reasonably easy-to-read video monitor much like the flat panel displays in laptop computers. These displays are called primary flight displays **(PFDs)**. You must still cross-check around the panel and on the display, but more information is available in a smaller space in easier to read colors. These convenient displays receive data from sensors such as magnetometers or magnetic flux valves to determine heading referenced to magnetic north. The attitude (pitch and roll) of the aircraft is sensed by the attitude heading reference system **(AHRS)** and displayed as the attitude gyro would be in conventional instrumentation. The altitude, airspeed, and outside temperature values are sensed in the air data computer **(ADC)** and presented in the PFD on vertical scales or portions of circles.

The multi-function display **(MFD)** can often display the same information as the **PFD**and can be used as a backup **PFD**. Usually the **MFD** is used for traffic, route selection, and weather and terrain avoidance. However, some **PFDs** also accommodate these same displays, but in a smaller view due to the primary flight instrument areas already used in the display. You must learn and practice using that specific system.

It is important to be very careful in the selection (programming) of the various functions and features. In the event of failures, which have a large impact on flight safety and situational awareness, you must always be ready and able to complete the flight safely using only the standby instruments.

A **multi-function display** (MFD) (part of multi function structures) 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 configurable ways. Often an MFD will be used in concert with a primary flight display. MFDs are part of the digital era of modern planes or helicopter. The first MFD were introduced by air forces. The advantage of an MFD over analog display is that an MFD does not consume much space in the cockpit. For example the cockpit of RAH-66 “Comanche” does not have analog dials or gauges at all. All information is displayed on the MFD pages. The possible MFD pages could differ for every plane, complementing their abilities (in combat).

Many MFDs allow the pilot to display their navigation route, moving map, weather radar, NEXRAD, GPWS, TCAS and airport information all on the same screen.

MFDs were added to the Space Shuttle (as the glass cockpit) starting in 1998 replacing the analog instruments and CRTs. The information being displayed is similar, and the glass cockpit was first flown on the STS-101 mission.

In modern automotive technology, MFDs are used in cars to display navigation,

Head-up display:

A **head-up display** or **heads-up display**—also known as a **HUD**—is any transparent display that presents data without requiring users to look away from their usual viewpoints. The origin of the name stems from a pilot being able to view information with the head positioned "up" and looking forward, instead of angled down looking at lower instruments.

Although they were initially developed for military aviation, HUDs are now used in commercial aircraft, automobiles, computer gaming, and other applications.

Types:

Other than fixed mounted HUDs, there are also head-mounted displays (HMDs). Including helmet mounted displays (both abbreviated HMD), forms of HUD that features a display element that moves with the orientation of the user's head.

Many modern fighters (such as the F/A-18, F-16 and Eurofighter) use both a HUD and HMD concurrently. The F-35 Lightning II was designed without a HUD, relying solely on the HMD, making it the first modern military fighter not to have a fixed HUD.

Generations:

HUDs are split into four generations reflecting the technology used to generate the images.

- First Generation—Use a CRT to generate an image on a phosphor screen, having the disadvantage of the phosphor screen coating degrading over time. The majority of HUDs in operation today are of this type.
- Second Generation—Use a solid state light source, for example LED, which is modulated by an LCD screen to display an image. These systems do not fade or require the high voltages of first generation systems. These systems are on commercial aircraft.
- Third Generation—Use optical waveguides to produce images directly in the combiner rather than use a projection system.
- Fourth Generation—Use a scanning laser to display images and even video imagery on a clear transparent medium.

Newer micro-display imaging technologies are being introduced, including liquid crystal display (LCD), liquid crystal on silicon (LCoS), digital micro-mirrors (DMD), and organic light-emitting diode (OLED).

UNIT: ***<u>03.FLIGHT DECKS AND COCKPITS</u>***

<u>TOPIC:7.Civil Cockpit And Military Cockpit: HUD</u>

HEAD UP DISPLAY (HUD)

A head-up display or heads-up display—also known as a HUD—is any transparent display that presents data without requiring users to look away from their usual viewpoints. It allows the pilot to see representations of the flight instruments while looking out of the wind screen. The origin of the name stems from a pilot being able to view information with the head positioned "up" and looking forward, instead of angled down looking at lower instruments.

Principle and Working of HUD

The principle adopted in a HUD system is to display the required data on the face of a CRT and to project them through a collimating lens as a symbolic image on to a transparent reflector plate, such that the image is superimposed on a pilot's normal view, through the window screen, of the terrain ahead. The display is a combined alphanumeric and symbolic one, and since it is focused at infinity it permits simultaneous scanning of the 'outside world' and display without refocusing the eyes.

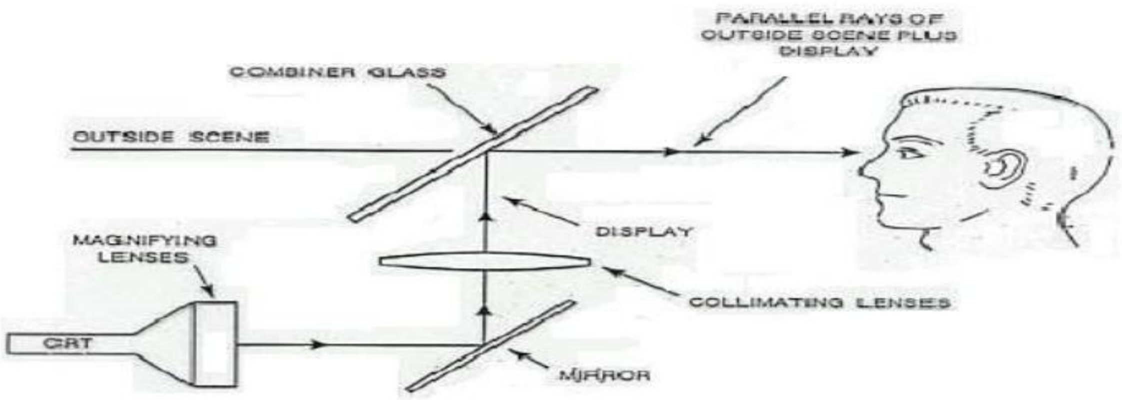


Fig: HUD Schematic

Fig: HUD Schematic

HUDs are initially developed for military aviation, HUDs are now used in commercial aircraft, automobiles, and other applications.

DESIGN FACTORS

Field of View – also "FOV", indicates the angle(s), vertically as well as horizontally, subtended at the pilot's eye, that the combiner displays symbology in relation to the outside view.

Collimation – The projected image is collimated which makes the light rays parallel. Because the light rays are parallel the lens of the human eye focusses on infinity to get a clear image.

Eye box – The optical collimator produces a cylinder of parallel light so the display can only be viewed while the viewer's eyes are somewhere within that cylinder, a three-dimensional area called the *head motion box* or *eyebox*. Modern HUD eye boxes are usually about 5 lateral by 3 vertical by 6 longitudinal inches.

Luminance/contrast – Displays have adjustments in luminance and contrast to account for ambient lighting, which can vary widely.

Bore sight – Aircraft HUD components are very accurately aligned with the aircraft's three axes – a process called *bore sighting* – so that displayed data conforms to reality typically with an accuracy of ±7.0 mill radians.

Scaling – The displayed image (flight path, pitch and yaw scaling, etc.), are scaled to present to the pilot a picture that overlays the outside world in an exact 1:1 relationship.

Compatibility – HUD components are designed to be compatible with other avionics, displays, etc.

DISPLAYED DATA

Typical aircraft HUDs display

Airspeed- to display the craft's airspeed, typically in knots, to the pilot

Altitude-altitude is a distance measurement, usually in the vertical or "up" direction, between a reference datum and a point or object.

A horizon line-to inform the pilot of the orientation of the aircraft relative to Earth's horizon

Heading- to inform the pilot of the aircraft's heading

Turn/bank and slip/skid indicators

Bore sight or waterline symbol—is fixed on the display and shows where the nose of the aircraft is actually pointing.

Flight path vector (FPV) or velocity vector symbol—shows where the aircraft is actually going, acceleration indicator or energy cue—typically to the left of the FPV symbol, it is above it if the aircraft is accelerating, and below the FPV symbol if decelerating.

Angle of attack indicator—shows the wing's angle relative to the airflow, often displayed as "α".

Navigation data and symbols—for approaches and landings, the flight guidance systems can provide visual cues based on navigation aids such as an Instrument Landing System or augmented Global Positioning System such as the Wide Area Augmentation System.

TYPES

Other than fixed mounted HUDs there are also head-mounted displays, including helmet mounted displays (both abbreviated HMD), forms of HUD that features a display element that moves with the orientation of the users' heads.

APPLICATIONS:

Military applications include

- Navigation and situation awareness
- Targeting
- Night vision systems
- Visual enhancement
- Security monitoring
- Simulation and training
- Maintenance and inspection

- Remotely-piloted vehicle interface
- Commercial applications include:
- Computer-aided design/ Computer-aided engineering (CAD/CAE)
- Surgical aid - microsurgery, endoscopic surgery
- Emergency medical telepresence
- Security monitoring
- Maintenance, Repair and Overhaul (MRO)

*UNIT: **03.FLIGHT DECKS AND COCKPITS***

TOPIC:7.Civil Cockpit And Military Cockpit: MFK

MULTI FUNCTION KEYS

As the cockpits of modern aircraft have more controls jammed into them, the point reached where there is no more space. Multifunction keyboards (MFKs) offer a very attractive solution to this space problem wherein a single panel of switches performs a variety of functions depending on the phase of the mission or the keyboard menu selected. The Multi-Function Keyboard (MFK) 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.

Multifunction keyboards can be implemented in several ways. The first two ways use LEDs or LCDs in panels in a central location. Designs using LEDs have arrays (typically ranging from five rows of three switches to seven rows of five switches) of standard sized push button switches with legends built into the surface of the switches. The MFK consists of a MOTOROLA 68000 series processor with ROM, RAM and EEPROM memory. It is connected to one of the 1553B buses used for data communication. It is also connected to the Multi-Function Rotary switch (MFR) through a RS422 interface. The MFK has a built-in display unit and a keyboard. The display unit is a pair of LCD based Colour Graphical Display, as well as a Monochrome Heads-Up Display.

Multi-function display:

The primary flight instruments can all be displayed simultaneously on one reasonably easy-to-read video monitor much like the flat panel displays in laptop computers. These displays are called primary flight displays (PFDs). You must still cross-check around the panel and on the display, but more information is available in a smaller space in easier to read colors. These convenient displays receive data from sensors such as magnetometers or magnetic flux valves to determine heading referenced to magnetic north. The attitude (pitch and roll) of the aircraft is sensed by the attitude heading reference system (AHRS) and displayed as the attitude gyro would be in conventional instrumentation. The altitude, airspeed, and outside temperature values are sensed in the air data computer (ADC) and presented in the PFD on vertical scales or portions of circles.

The multi-function display (MFD) can often display the same information as the PFDand can be used as a backup PFD. Usually the MFD is used for traffic, route selection, and weather and terrain avoidance. However, some PFDs also accommodate these same displays, but in a smaller view due to the primary flight instrument areas already used in the display. You must learn and practice using that specific system.

It is important to be very careful in the selection (programming) of the various functions and features. In the event of failures, which have a large impact on flight safety and situational awareness, you must always be ready and able to complete the flight safely using only the standby instruments.

A multi-function display (MFD) (part of multi function structures) 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 configurable ways. Often an MFD will be used in concert with a primary flight display. MFDs are part of the digital era of modern planes or helicopter. The first MFD were introduced by air forces. The advantage of an MFD over analog display is that an MFD does not consume much space in the cockpit. For example the cockpit of RAH-66 "Comanche" does not have analog dials or gauges at all. All information is displayed on the MFD pages. The possible MFD pages could differ for every plane, complementing their abilities (in combat).

Many MFDs allow the pilot to display their navigation route, moving map, weather radar, NEXRAD, GPWS, TCAS and airport information all on the same screen.

MFDs were added to the Space Shuttle (as the glass cockpit) starting in 1998 replacing the analog instruments and CRTs. The information being displayed is similar, and the glass cockpit was first flown on the STS-101 mission.

In modern automotive technology, MFDs are used in cars to display navigation,

Using multi-function keys, the system is very powerful and provides the pilot with everything needed for both vertical (VNav) and lateral (LNav) navigation.

UNIT: ***03.FLIGHT DECKS AND COCKPITS***

TOPIC:7.HOTAS

HOTAS:

HOTAS an abbreviation for **Hands On Throttle-And-Stick**, is the name given to the concept of placing buttons and switches on the throttle stick and flight control stick in an aircraft's cockpit, allowing the pilot to access vital cockpit functions and fly the aircraft without having to remove his hands from the throttle and flight controls. Application of the concept was pioneered with the Ferranti AIRPASS radar and gunsight control system used by the English Electric Lightning[1] and is widely used on all modern fighter aircraft such as the F-16 Fighting Falcon.

HOTAS is a shorthand term which refers to the pattern of controls in the modern fighter aircraft cockpit. Having all switches on the stick and throttle allows the pilot to keep his "hands on throttle-and-stick", thus allowing him to remain focused on more important duties than looking for controls in the cockpit. The goal is to improve the pilot's situational awareness, his ability to manipulate switch and button controls in turbulence, under stress, or during high G-force maneuvers, to improve his reaction time, to minimize instances when he must remove his hands from one or the other of the aircraft's controls to use another aircraft system, and total time spent doing so.

The concept has also been applied to the steering wheels of modern open-wheelracecars, like those used in Formula One and the Indy Racing League. HOTAS has been adapted for game controllers used for flight simulators (most such controllers are based on the F-16 Fighting Falcon's) and in cars equipped with radio controls on the steering wheel. In the modern military aircraft cockpit the HOTAS concept is sometimes enhanced by the use of Direct Voice Input to produce the so-called "V-TAS" concept, and augmented with helmet mounted display systems such as the "Schlem" used in the MiG-29 and Su-27, which allow the pilot to control various systems using his line of sight, and to guide missiles by simply looking at the target.

HANDS ON THROTTLE AND STICK (HOTAS)

A design of a fighter cockpit so that every control switch, button, or trigger the pilot needs to operate radar, weapons, and aircraft controls in combat is located either on the throttle or the control column. Also called HOTAS—hand on throttle and stick.

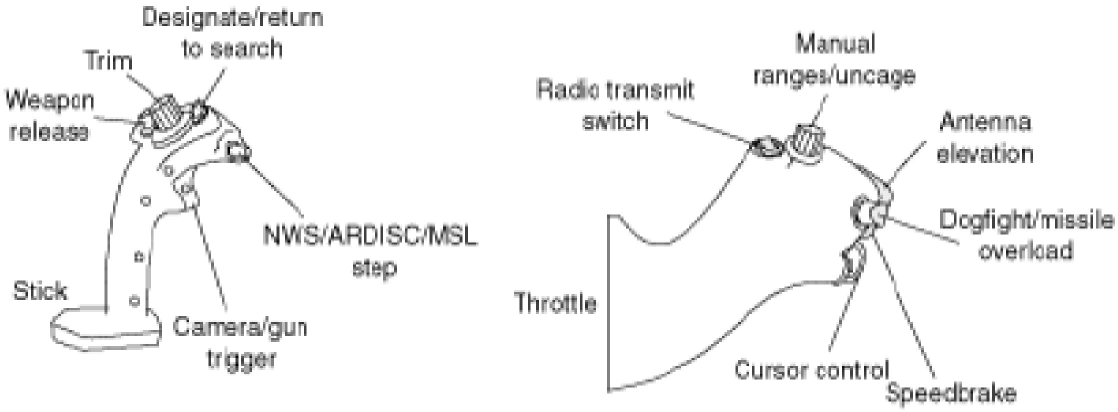


Fig: A typical HOTAS arrangement.

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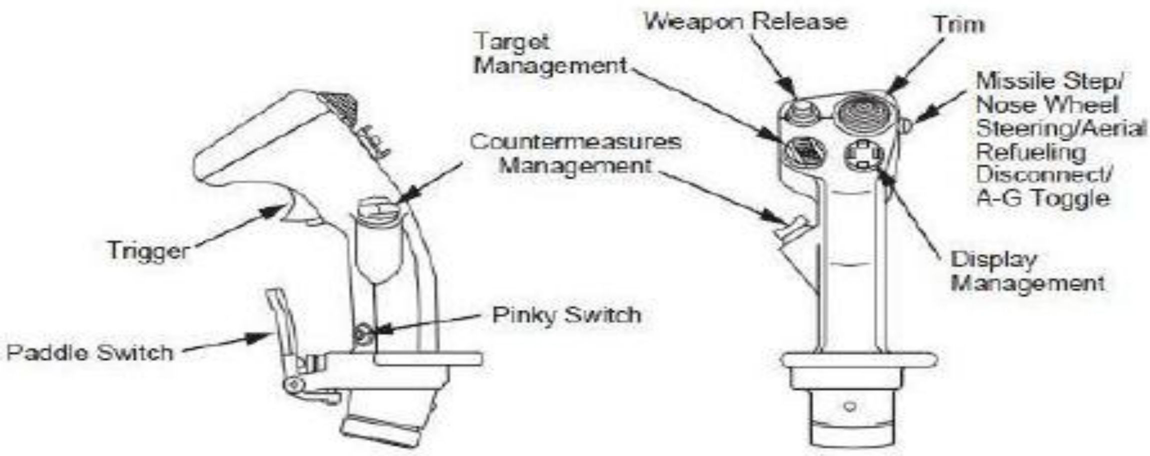
The Hands-On Throttle And Stick (HOTAS) are the primary flight controls for the F-16. They are referred to as "hands-on" since many of the common tasks the pilot needs to perform can be done using buttons and switches on the throttle and stick, which precludes the pilot from having to take his hands off the controls in combat or in other high-workload situations.

SIDE-STICK CONTROLLER (SSC)

SWITCH	FUNCTION
Trigger	The trigger on the SSC is a two-stage trigger (similar to many computer flight sticks including the Saitek X52). The first detent performs several functions, including starting ACMI recording. The second stage fires the aircraft's cannon.

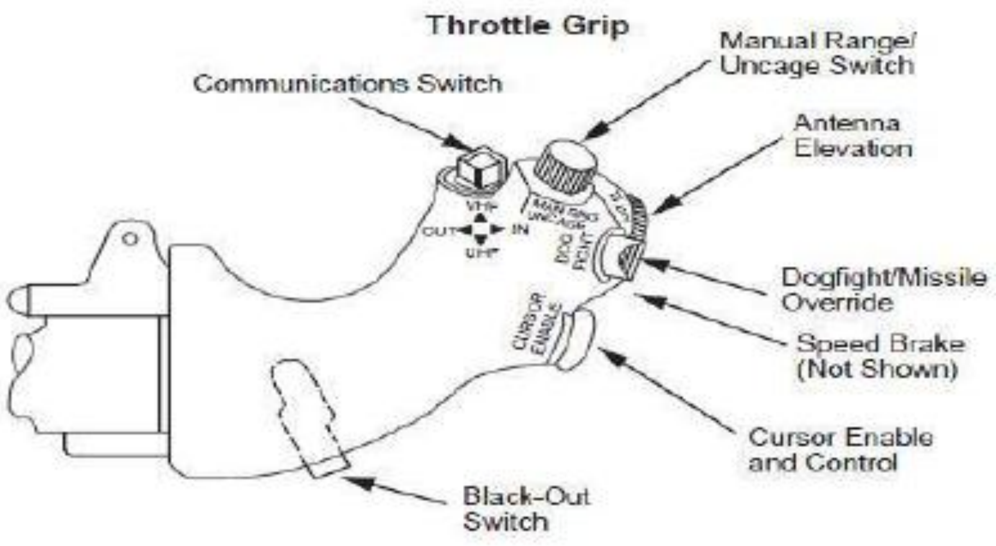


Weapon Release	The weapon release switch (also called the "pickle" button) is used to fire missiles, drop bombs, and jettison stores. The exact switch usage to release the weapon depends on which weapon is being used.
Trim Hat	This hat switch is used to control the aircraft's trim. Pressing up/down on the switch changes the pitch trim position, and pressing left/right changes the roll trim position. Most players do not use this switch, since trim is rarely required to keep the aircraft stable. Instead, it is usually used to control the view direction.
Target Management Switch	-
Display Management Switch	-
Countermeasures Management Switch	The countermeasures management switch is used to control the various countermeasures of the aircraft, including the jammer and chaff/flares. It is not generally simulated in Falcon 4 games, since its exact operation was unknown at the time the simulator was first created.

Missile Step/NWS	This switch has a number of different functions depending on what mode the aircraft is in and where it is located. When the aircraft is on ground, it toggles the nose wheel steering system. If the aircraft is connected to a tanker during in-air refueling, it disconnects from the boom. If the aircraft is in A-A master mode, it is used to toggle the missile hardpoint to be used for the next launch. If the aircraft is in A-G mode, it toggles between CCRP, CCIP, and other bombing modes.
Pinky Switch	This switch is used to cycle the field of view for the currently selected sensor of interest. This works for many MFD pages, including the FCR, infrared/laser targeting, and the HSD.
Paddle Switch	This act as a momentary disconnect for the aircraft's autopilot while it is engaged. As long as the switch is held down, the pilot will have control of the aircraft (instead of the autopilot). If the autopilot is not engaged, the switch has no effect.

THROTTLE

The HOTAS throttle is summarized below.



SWITCH	**FUNCTION**
Communications Switch	This switch is used to talk on various radio frequencies. This is not generally simulated in Falcon 4, although it is often used to toggle Teamspeak/Ventrilo communications.
Uncage Switch	This switch is used to "uncage" the seeker head for infrared missiles such as the AIM-9. When the seeker head is uncaged, it freely seeks targets and is not slaved to the aircraft's radar

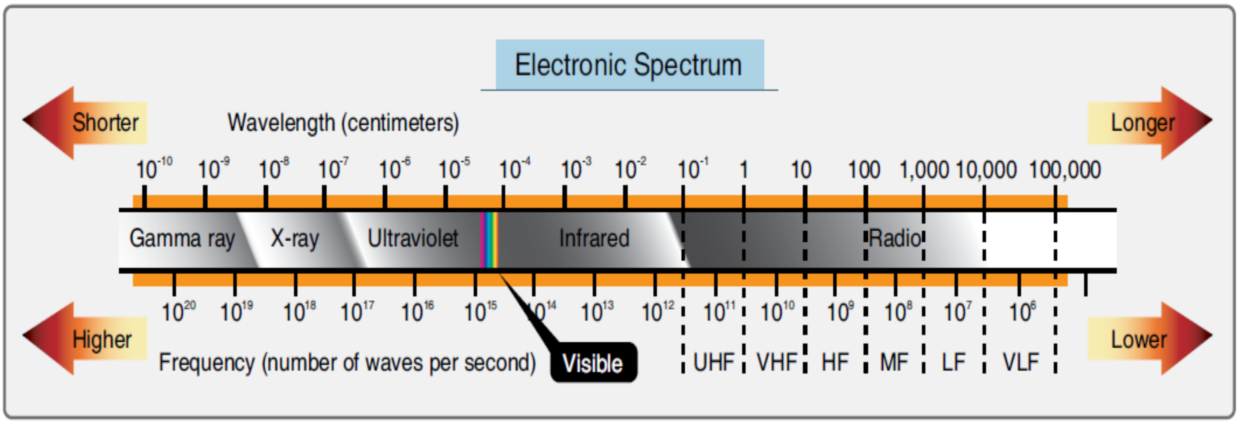
Radio Navigation – ADF, DME, VOR, LORAN, DECCA, OMEGA, ILS, MLS

Introduction about Radio Waves

A radio wave is invisible to the human eye. It is electromagnetic in nature and part of the electronic spectrum of wave activity that includes Gamma rays, X-rays, Ultraviolet rays, Infrared waves, and visible light rays, as well all radio waves. The atmosphere is filled with these waves.

Each wave occurs at a specific frequency and has a corresponding wavelength. The relationship between frequency and wavelength is inversely proportional. A high frequency wave has a short wave length and a low frequency wave has a long wave length.

Radio waves are directional and propagate out into space at **1, 86,000** miles per second. The distance they travel depends on the frequency and the amplification of the signal AC sent to the antenna.



Types of Radio Waves

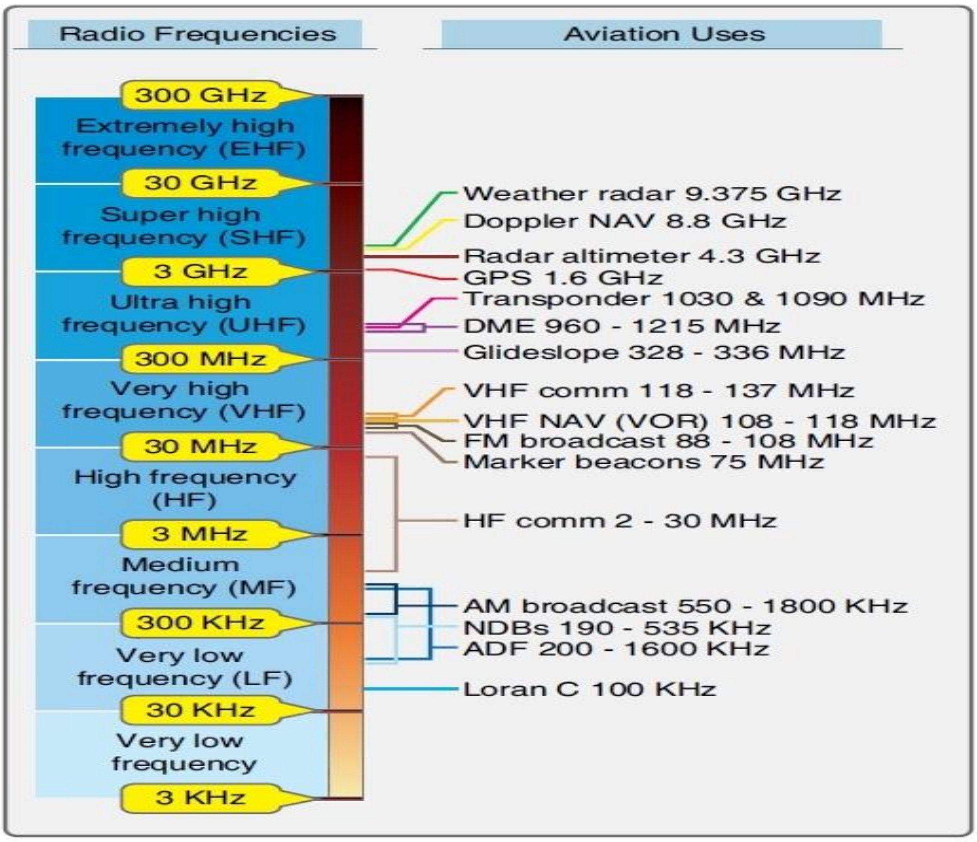
Radio waves of different frequencies have unique characteristics as they propagate through the atmosphere. **Very low frequency (VLF), LF,** and **medium frequency (MF) waves** have relatively long wavelengths and utilize correspondingly long antennas. Radio waves produced at these frequencies ranging from 3KHz to 3MHz are known as ground waves or surface waves.

This is because they follow the curvature of the earth as they travel from the broadcast antenna to the receiving antenna. Ground waves are particularly useful for long distance transmissions.

High frequency (HF) radio waves travel in a straight line and do not curve to follow the earth's surface. This would limit transmissions from the broadcast antenna to receiving antennas only in the line-of-sight of the broadcast antenna except for a unique characteristic. HF radio waves bounce off of the ionosphere layer of the atmosphere. This refraction extends the range of HF signals beyond line-of-sight.

As a result, transoceanic aircraft often use HF radios for voice communication. The frequency range is between 2 to 25 MHz. These kinds of radio waves are known as sky waves. Above HF transmissions, radio waves are known as space waves.

They are only capable of line-of-sight transmission and do not refract off of the ionosphere. Most aviation communication and navigational aids operate with space waves. This includes **VHF (30-300MHz), UHF (300MHz-3GHz),** and **Super High Frequency (SHF) (3 Ghz- 30 GHz) radio waves.**



VHF communication radios are the primary communication radios used in aviation. They operate in the frequency range from 118.0 MHz to 136.975MHz. VHF radios are used for communications between aircraft and air traffic control (ATC), as well as air-to-air communication between aircraft. When using VHF, each party transmits and receives on the same channel. Only one party can transmit at any one time.

Radio Transmitters and Receivers

Radio transmitters and receivers are electronic devices that manipulate electricity resulting in the transmission of useful information through the atmosphere or space.

Transmitters

A transmitter consists of a precise oscillating circuit or oscillator that creates an AC carrier wave frequency. This is combined with amplification circuits or amplifiers. The distance a carrier wave travels is directly related to the amplification of the signal sent to the antenna.

Receivers

An antenna captures the desired carrier wave as well as many other radio waves that are present in the atmosphere. A receiver is needed to isolate the desired carrier wave with its information. The receiver also has circuitry to separate the information signal from the carrier wave. It prepares it for output to a device, such as speakers or a display screen.

Radio Navigation

In the early years of aviation, a compass, a map, and dead reckoning were the only navigational tools. These were marginally reassuring if weather prevented the pilot from seeing the terrain below. Voice radio transmission from someone on the ground to the pilot indicating that the aircraft could be heard overhead was a preview of what electronic navigational aids could provide. For aviation to reach fruition as a safe, reliable, consistent means of transportation. Navigation aids were needed to indicate where an aircraft was over the earth as it progressed towards its destination.

ADF (Automatic Direction Finder)

ADF (Automatic Direction Finder) is the radio signals in the low to medium frequency **band of 190 Khz to 1750 Khz.** It was widely used today. It has the major advantage over VOR navigation in the reception is not limited to line of sight distance. The ADF signals follow the curvature of the earth. The maximum of distance is depending on the power of the beacon.

The ADF can receive on both AM radio station and NDB (Non-Directional Beacon). Commercial AM radio stations broadcast on 540 to 1620 Khz. Non-Directional Beacon operate in the frequency band of 190 to 535 Khz.

ADF COMPONENTS

1. **ADF Receiver**: Pilot can tune the station desired and to select the mode of operation. The signal is received, amplified, and converted to audible voice or morse code transmission and powers the bearing indicator.

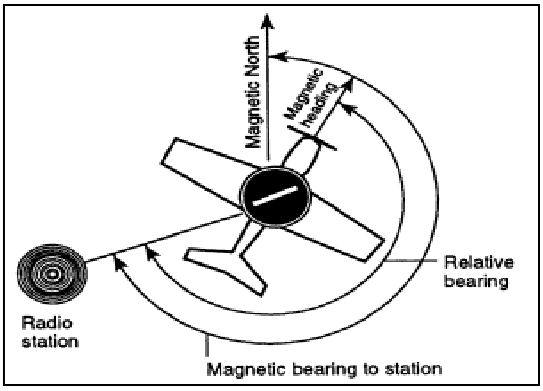
2. **Control Box (Digital Readout Type):** Most modern aircraft has this type of control in the cockpit. In this equipment the frequency tuned is displayed as digital readout. ADF automatically determines bearing to selected station and it on the RMI.

1. **Antenna:** The aircraft consist of two antennas.
   The two antennas are called
   - LOOP antenna and
   - SENSE antenna.

The ADF receives signals on both loop and sense antennas. The loop antenna in common use today is a small flat antenna without moving parts. Within the antenna are several coils spaced at various angles.The loop antenna senses the direction of the station by the strength of the signal on each coil but cannot determine whether the bearing is TO or FROM the station. The sense antenna provides this latter information.

Bearing Indicator: displays the bearing to station relative to the nose of the aircraft. Relative Bearing is the angle formed by the line drawn through the center line of the aircraft and a line drawn from the aircraft to the radio station. Magnetic Bearing is the angle formed by a line drawn from aircraft to the radio station and a line drawn from the aircraft to magnetic north (Bearing to station).

Magnetic Bearing = Magnetic Heading + Relative Bearing.



TYPES OF ADF INDICATOR

Four types of ADF indicators are in use today.

1. **Fixed Compass Card:** It is fixed to the face of instrument and cannot rotate. 0 degree is always straight up as the nose of aircraft.

2. **Rotatable Compass Card:** The dial face of the instrument can be rotated by a knob. By rotating the card such that the Magnetic Heading (MH) of the aircraft is adjusted to be under the pointer at the top of the card.

3. **Single-Needle Radio Magnetic Indicator**: Radio Magnetic Indicator [RMI] is an instrument that combines radio and magnetic information to provide continuous heading, bearing and radial information.

4. **Dual-Needle Radio Magnetic Indicator**: The dual needle RMI is similar to single needle RMI except that it has a second needle. The first needle indicated just like single needle. In the picture, the yellow needle is a single which indicate the Magnetic Bearing to the NDB station. The second needle is the green needle in the picture.

The second needle (green) is point to VOR station .The dual needle indicator is useful in locating the location of an aircraft.

OPERATION

ADF operate in the low and medium frequency bands. By tuning to NDB [non directional beacon] station or commercial AM radio stations. NDB frequency and identification information may be obtained from aeronautical charts and Airport Facility Directory. The ADF has automatic direction seeking qualities which result in the bearing indicator always pointing to the station to which it is tuned. The easiest and perhaps the most common method of using ADF is to **"home"** to the station. Since the ADF pointer always points to the station, the pilot can simply head the airplane so that the pointer is on the 0 (zero) degree or nose position when using a fixed card ADF.

The station will be directly ahead of the airplane. Since there is almost always some wind at altitude and you will be allowing for drif, meaning that your heading will be different from your track. Off track, if the aircraft is left of track, the head of the needle will point right of the nose. If the aircraft is right of track, the head of the needle will point left of the nose.

* **For fixed compass card,** if you are not fly Homing and you want to fly heading at some degrees. You must use the formula MB = MH + RB to find out what degree the ADF pointer should be on. Today, the fixed card indicator is very unsatisfactory for everyday use which can still be found on aircraft panels but not many planes that pilot actually uses it due to it has easier type of indicator.

*** For rotatable compass card,** it was a big step over the fixed card indicator. The pilot can rotate the compass card with the heading knob to display the aircraft MH "straight up". Then the ADF needle will directly indicate the magnetic bearing to the NDB station.

* **For Single needle Radio Magnetic Indicator,** the compass card is a directional gyro and it rotates automatically as the aircraft turns and provide continuous heading. It is accurately indicates the magnetic heading and the magnetic bearing to the beacon. This instrument is a “hands off “instrument.

* **For dual needle Radio Magnetic Indicator**, it is give the pilot information the same as the single needle such as aircraft heading and magnetic bearing to the NDB. The second indicator will point to VOR station. This help pilot to check the location of the aircraft at that time.

NDB can transmit other information for local aircraft like:

ATIS: Automatic Terminal Information Service

AWIS: Automatic Weather Information Service

AWOS: Automated Weather Observation System

ASOS: Automated Surface Observation System

VOLMET: Meteorological Information Broadcast

TWEB: Transcribed Weather Broadcast

The Method of Navigation

There are three main methods of air navigation. There are:

1. Pilotage
2. Dead Reckoning
3. Radio.

Pilot age or Piloting is the most common method of air navigation. This method, the pilot keeps on course by following a series of landmarks on the ground. Usually before take-off, pilot will making pre-flight planning, the pilot will draw a line on the aeronautical map to indicate the desired course. Pilot wills not’s various landmarks, such as highways, railroad tracks, rivers, bridges. As the pilot flies over each of landmark, pilot will checks it off on the chart or map. If the plane does not pass directly over the landmark, the pilot will know that he has to correct the course.

Dead Reckoning is the primary navigation method used in the early days of flying. It is the method on which Lindberg relied on his first trans-Atlantic flight. A pilot used this method when flying over large bodies of water, forest, deserts. It demands more skill and experience than pilotage does. It is based on time, distance, and direction only. The pilot must know the distance from one point to the next, the magnetic heading to be flown. Pilot works on the pre-flight plan chart, pilot plan a route in advance. Pilot calculates the time to know exactly to reach the destination while flying at constant speed. In the air, the pilot uses compass to keep the plane heading in the right direction. Dead reckoning is not always a successful method of navigation because of changing wind direction. It is the fundamental of VFR flight.

Radio Navigation is used by almost all pilots. Pilots can find out from an aeronautical chart what radio station they should tune to in a particular area. They can then tune their radio navigation equipment to a signal from this station. A needle on the navigation equipment tells the pilot where they are flying to or from station, on course or not.

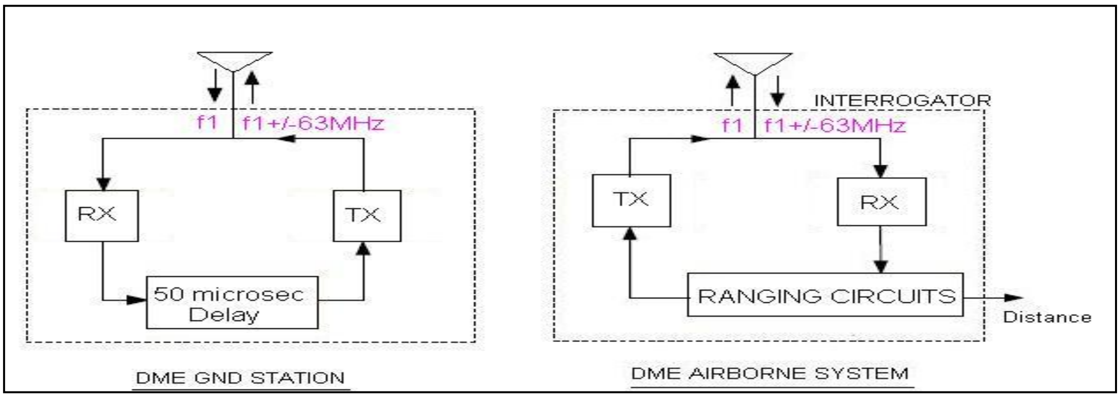
Distance Measuring Equipment (DME)

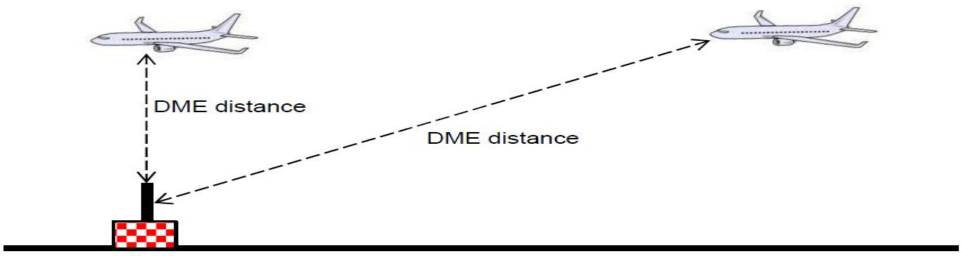
Distance Measuring Equipment (DME) is defined as a combination of ground and airborne equipment which gives a continuous slant range distance-from-station readout by measuring the time-lapse of a signal transmitted by the aircraft to the station and responded back.

DME ground equipment:

DME ground and on-board equipment use the UHF radio frequency band between 962MHz and 1213MHz.

An aircraft can compute its distance to the beacon from the delay of the signal perceived by the aircraft's DME equipment using the speed of light.

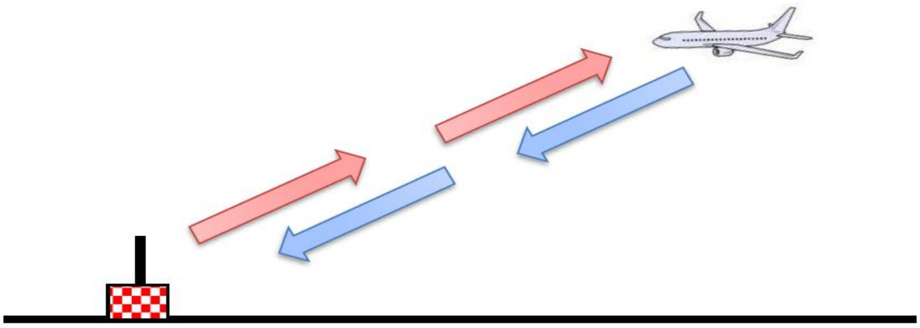




DME works like a receiver and re-emitter like a transponder:

- The aircraft transmits a paired pulse spaced about **12µs or 36µs** on the UHF frequency.
- The DME on the ground receives it and transmits with a constant delay of 50µs on an UHF frequency (with ± 63 MHz offset) a paired pulse spaced 12µs or 36µs
- When 50% of the signals emitted have been received by the aircraft's receiver, aircraft instrument can compute the signal in order to find the propagation time and then, calculate the distance.

The aircraft has also two modes for DME tracking: One for searching the station and another for tracking the station using fewer signals.



DME ON-BOARD EQUIPMENT

1.Frequency selector

The NAV frequency selector is the control unit where pilots select DME frequencies.

The DME frequency is usually "paired" with VOR or ILS or localizer (LOC) frequencies. Selection of the appropriate VOR or ILS frequency automatically tunes the DME attached (if existing).

2.Indicator instruments

There are several types of instruments for receiving a DME:

2.1. Standalone instrument

A standalone instrument is an instrument that displays only DME related information.

The information displayed are:

* Distance in NM between aircraft and DME station
* Speed of the aircraft in Knots
* Time to reach the station if you navigate direct to the DME station

2.2 DME displayed on electronic navigation instrument

In many modern jets and propeller aircraft, electronic navigation instruments are usually used. These modern electronic navigation instruments are all-in-one instruments to display:

- VOR and paired DME distance
- ILS and paired DME distance
- NDB
- Navigation fixes
- FMC route
- Traffic (TCAS)
- Weather

Channels are numbered from 1 to 126 and each channel number is further divided into two channels designated ‘X’ and ‘Y’.

Each numbered pair of channels is separated from the adjoining pair by 1 MHz. The ‘X’ channels are separated from the ‘Y’ channels by varying the pulse separation time. The pulse separation spacing is the same for all ‘X’ channels, being 12 micro-seconds for both the interrogator and the transponder. In the case of ‘Y’ channels the pulse spacing is 36 micro-seconds for the interrogator and 30 micro-seconds for the transponder.

Advantages

* DME system is rarely affected by precipitation static and thunderstorms.

Disadvantages

• We use DME equipment for the purpose of getting the distance D. However the system will provide slant distance(S).

Error between actual distance D and S is less when slant distance(S) is taken larger than the Aircraft altitude.

DME system is limited to LOS due to UHF band of operation.

VHF OMNI-DIRECTIONAL RADIO RANGES [VORS]

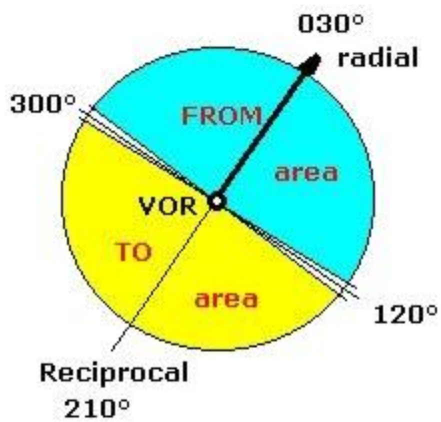
VHF Omni-directional Radio Ranges [VORs] operate in the Very High Frequency aviation navigation [NAV] **band between 112.1 and 117.9 MHz.**

As VHF transmissions are line-of-sight the ground to air range depends on the elevation of the beacon site, the height of the aircraft and the power output. The VOR beacons are usually located at airfields but as they serve to define designated air routes [airways] some are located away from airfields, often on high ground. A simplified concept of the ground beacon is that it simultaneously transmits two signals, a constant omni-directional signal called the reference phase and a directional signal which rotates through **360°, during a 0.03 second system cycle**, and consistently varies in phase through each rotation. The two signals are only exactly in phase once during each rotation – when the directional signal is aligned to magnetic north. Imagine a wheel with 360 spokes, at one degree azimuth spacing, with the VOR beacon being the hub.

The spokes are numbered clockwise from one to 360 and each spoke or radial represents a magnetic bearing from the VOR beacon. The airborne navigation circuitry measures the phase angle difference between the directional signal phase received and the reference signal phase and interprets that as the angular, or 'radial', indication currently being received. Radials are identified by magnetic bearing – e.g. the 30° radial – and thus form the basis for VOR, and designated air route, navigation. Essentially the system indicates a line of position, from the selected VOR, on which the aircraft is located at any time. The beacon also transmits a Morse code aural identification signal at about 10 second intervals. The airborne system utilising the VOR beacon transmissions usually consists of an antenna (probably a V -type dipole mounted horizontally on the fin or fuselage but could be the more expensive 'blade' or 'towel rail' types), a conventional VHF receiver (if combined with the VHF communications transceiver it is then called a NAV / COMM unit), navigation circuitry and the separate panel mounted navigation indicator or 'Omni Bearing Indicator' [OBI].

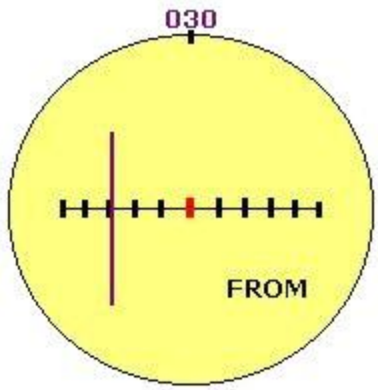
- Some hand held aviation COMMS transceivers can also receive the NAV band VOR transmissions and appear to have some navigation circuitry but, from all reports, their VOR navigation capability, if it exists at all, is limited.

- Basic Omni Bearing Indicator, like this Bendix-King model, has a manually operated radial or 'omni bearing' selector [OBS] which rotates an azimuth ring marked from 0° to 355°. The OBS selected radial is indicated by the arrow at top dead centre and the reciprocal bearing is indicated by the bottom arrow. The other features of a basic OBI are the TO–FROM indicators, a deviation bar, a deviation indicator needle and a NAV/OFF alarm flag.



- The **TO–FROM** indications on the OBI are dependent on the aircraft's position relative to a notional ground baseline, formed perpendicular to the selected radial and passing through the beacon site. Unlike the NDB the indication is completely independent of the aircraft's heading. The navigation circuitry compares the difference between the radial being received and the radial selected. If the aircraft is located anywhere within range on the radial side of the baseline the 'FROM' indication will be displayed on the OBI and, if located within range on the reciprocal side, the 'TO' indication will be displayed. For example if the 030° radial is selected on the OBI, the ground baseline is established between 300° and 120°.

- If the radial received indicates the aircraft is anywhere in the blue shaded area of the diagram and no matter whether it is headed towards or away from the VOR, or in any direction whatsoever, the OBI will display 'FROM'. Similarly if it is in the yellow area the OBI will display 'TO' no matter which direction the aircraft is headed. There are two areas of ambiguity – near bearings at right angles to the radial (e.g. shown at 120° and 300°) – where the OBI will give fluctuating indications, or display the 'OFF' flag.



- The deviation bar and the deviation indicator needle together form the Course Deviation Indicator or CDI. If the needle is over the centre point the aircraft is then located at some position along the selected radial – or its reciprocal. The five division marks or dots either side of the centre point are spaced at two degree intervals, thus if the needle is over the third mark, left or right of centre, the aircraft is positioned at a radial six degrees in azimuth from the selected radial, or its reciprocal. (Actually the aircraft is at the centre mark and the needle indicates the position of the selected radial). Full travel of the needle from the centre to either side represents 10° – or more – of azimuth. The ambiguity of whether the OBS selection is the radial or the reciprocal is determined by the TO / FROM indication; in the diagram at left 030 must be the radial as the aircraft is in the FROM area. When the aircraft passes overhead the beacon the needle will swing from side to side, the alarm flag may temporarily indicate that navigation is 'OFF' and the TO/FROM indication will reverse.

VOR applications:

1. Like the NDB / ADF there are several applications for the VOR in light aircraft cross country navigation.
2. Homing & tracking to a VOR. Even with a crosswind component tracking toward a VOR is quite simple.
3. Tracking from a VOR. Rotate the OBS to the required track [radial], ensure FROM is indicated, and turn onto that magnetic heading.

LONG RANGE NAVIGATION

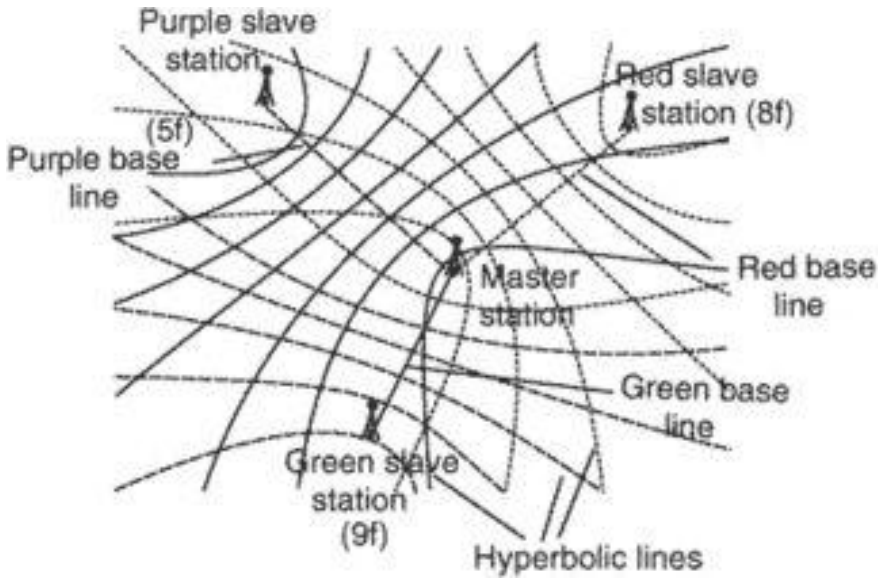
LORAN, short for **long range navigation**, is a hyperbolic radio navigation system.

LORAN (Long Range Navigation) The latest system known as LORAN-C .This system will be discontinued due to cost not effective.

OPERATION LORAN is a net work of land based radio transmitters and was developed to provide an accurate system for long range navigation. LORAN Stations Operations are organized into sub-groups of four to six stations called “CHAIN ".One station in the Chain is designated the “MASTER " and others are called " SECONDARY " or " SLAVE " Stations.

The theory is to calculate the time between reception of the signals from the MASTER and SLAVE stations, which are emitted at different frequencies , at low or very low bands 90kHz - 110 kHz. in pulse group and has power of 400 - 1600 kilowatts.

The master station emits its own signal first, when that signals reach the slave station; it emits its own signal after a predetermined delay. When the master station's signal reaches the aircraft, its Navigation system counts the time until the slave station's signal arrives. Your position is found as the intersection of the line of two LORAN stations.



LORAN UNIT

* SIGNAL PROCESSOR
* NAVIGATION COMPUTER
* CONTROL and DISPLAY

Signal Processor receives the signals and measures the difference between the time of arrival of each secondary station pulse group and the master station pulse group. The time difference is depend on the location of the receiver on the aircraft in relation to the three or more transmitters. Each time difference value is measured to a precision of about 0.1 microseconds.

Navigation Computer converts time difference values to location corresponding latitude and longitude.

Control and Display

The functions of the LORAN UNIT are:

* Preset Position in Latitude-Longitude and/or relative to a destination, waypoint or check point.
* Bearing and distance to your destination
* Ground speed and estimated time enroute.
* Course Deviation Indicator.
* Storage in memory of airports. add-on programmable and updatable database.
* Continuous computation of bearing and distances to the nearest airports. Computation of wind direction and velocity.
* Add-on such as fuel flow analyzers to estimate fuel need to reach destination.etc.

LIMITATIONS

1. LORAN suffers from electronic effects of weather and the ionospheric effects of sunrise and sunset. The most accurate signal is the ground wave that follows the Earth's surface, ideally over seawater. At night the indirect sky wave, bent back to the surface by the ionosphere, is a problem as multiple signals may arrive via different paths (multipath interference). The ionosphere's reaction to sunrise and sunset accounts for the particular disturbance during those periods. Magnetic storms have serious effects as with any radio based system.
2. LORAN uses ground based transmitters that only cover certain regions. Coverage is quite good in North America, Europe, and the Pacific Rim.
3. The absolute accuracy of LORAN-C varies from 0.10 to 0.25 nmi (185 to 463 m). Repeatable accuracy is much greater, typically from 60 to 300 ft (18 to 91 m)

DECCA

The Decca Navigator System, herein abbreviated as DNS for convenience, is a hyperbolic radio navigation system which was established in the United Kingdom after World War 2 and later used in many areas around the world. It operated by measuring the phase differences between continuous signals from a master and slave stations. These differences were then related to a hyperbolic lines printed on a chart. By plotting the readings from two pairs of hyperbolas at any particular instant, users could plot their position instantly.

The system used groups of at least three shore based transmitter stations called chains operating in the 70-130 kHz radio band. Each chain comprised of one Master and two or three Slave stations, usually located 80 to 110 km from the Master station. The accuracy of DNS ranged from 50 meters during daytime to 200 meters at night. It could decrease up to 800 meters as the distance from the baseline increased. Accuracy was also affected by seasonal effects which generally reduced the accuracy by a factor of 6 to 8. The maxium daytime range for DNS was 300 to 400 miles with a reproducibility of 200 meters. At night, accuracy was guranteed out to 240 nm by the British Admiralty.

THE CHAIN

A Decca chain normally consisted of a master station controlling the phase of three slaves, which were situated about 120 degrees apart, at a radius of 60 to 100 miles from the master. That provided all-round coverage, and, because ground waves of this frequency band are not seriously attenuated by passing over land, the stations could advantageously be situated well inland.

Each Station in the chain would normally transmit a particular unmodulated phase stable carrier wave. These carriers were all harmonically related to an internal station reference which was about 14.2kHz, referred to as “f”.

* The **Master** Station normally transmitting a “**6f**” unmodulated carrier wave signal in the **85** kHz band,
* **Red** Slave Station transmitting a “**8f**” signal in the **112** kHz Band,
* **Green** Slave transmitting a “**9f**” signal in the **127** kHz band,
* **Purple** Slave transmitting a “**5f**” signal in the **71** kHz band.

The Slave stations received and phase locked their station reference oscillators to the Master “6f” Transmission.

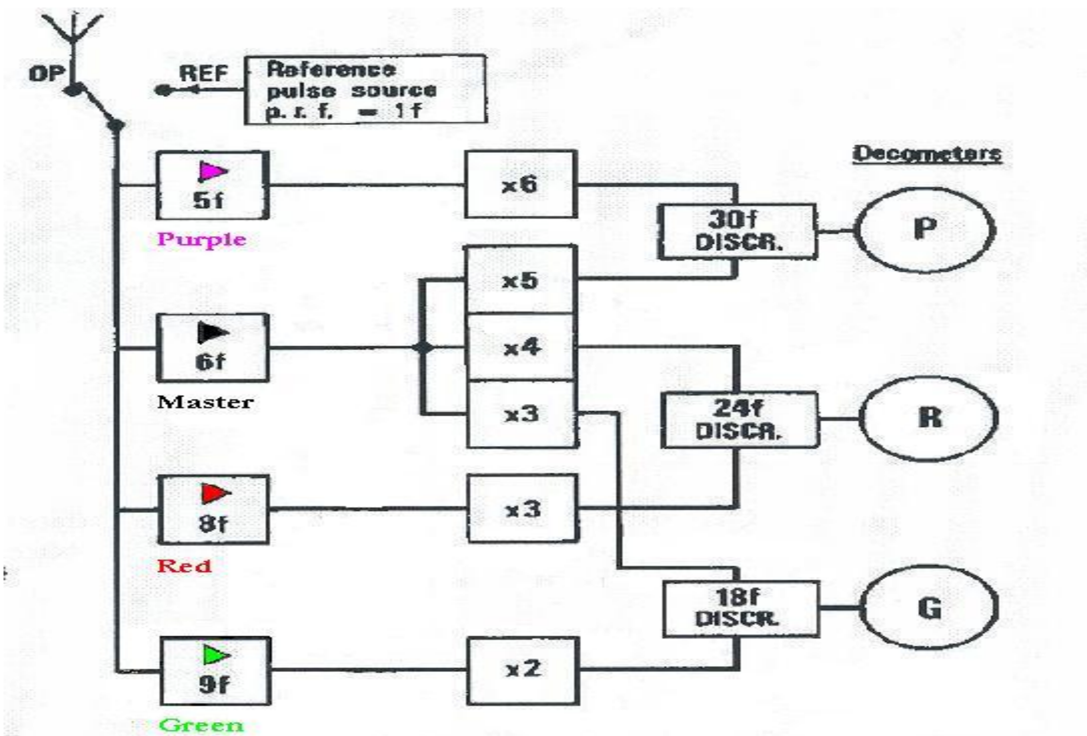
The frequency ranges for the master and slave stations were:

Master: 84 - 86 kHz
Red slave: 112 - 115 kHz
Greenslave: 126 - 129 kHz
Purple slave: 70 - 72 kHz

Since the signals were continuous wave (CW), 150 Hz spacing was sufficient to ensure there would be no interference.

These transmissions were received by a special receiver and frequency multiplying circuits therein produced phase comparisons of:

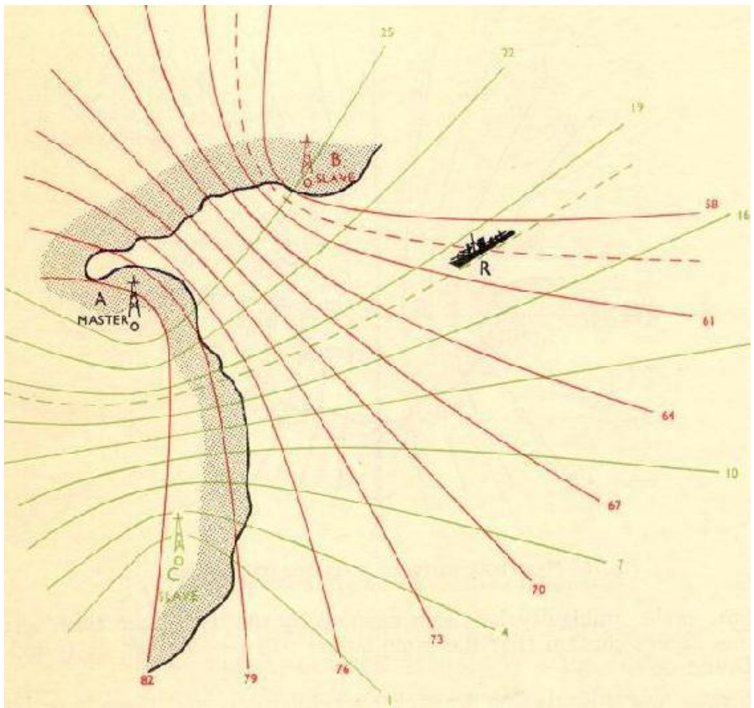
24f for the Master and Red
18f for Master and Green
30f for the Master and Purple



Although for most of the time the stations only transmitted their single carrier, during part of the transmission cycle, each station would transmit what was termed a Multi-pulse also called "Mark 10" transmission. In the Mark 10 context, it meant that Multipluse could only be received on Mk X receiver equipment and higher.

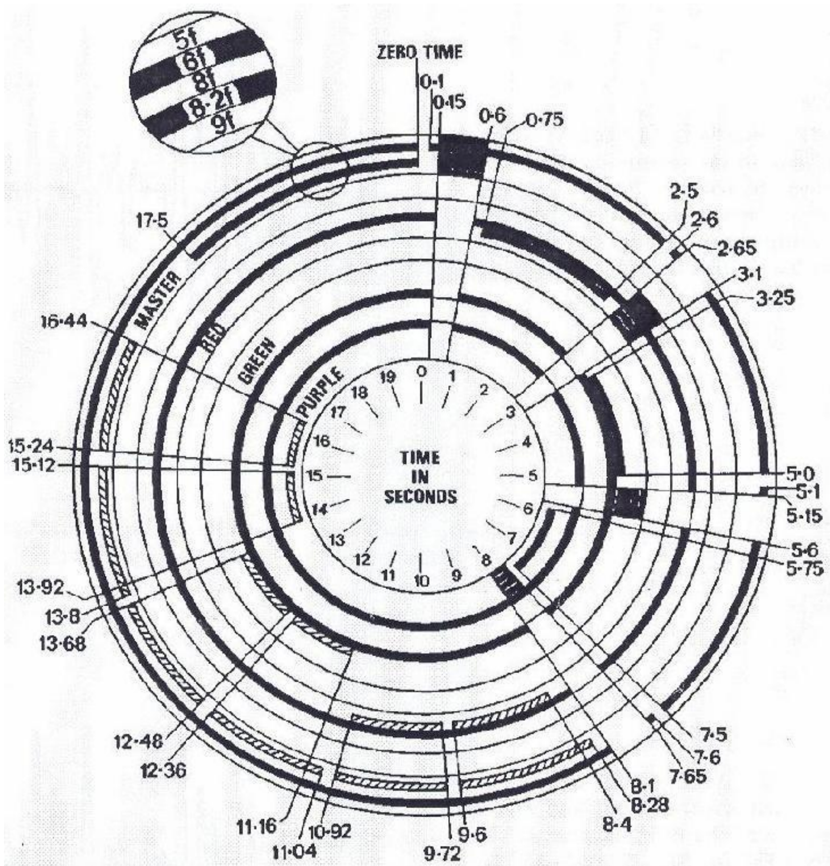
The Multi-pulse was transmitted by each of the stations in turn during the 20 second transmission cycle to provide a coarse reading, or a Zone reading, and was generated by all 5 transmitters at the given station briefly transmitting simultaneously. During transmission of the Multi-pulse by, say the Red Slave, all transmissions from the other stations in the Chain would be suppressed.

The original 'V type transmissions, prior to the introduction of Multipulse also had V-1 and V-2 variants. Both of these were being phased out by the mid-'70's when many of the chains were being updated. More on this as soon as additional information becomes available.



Decca Lattice: An example of a Decca lattice chart showing the lines of hyperbola from the read and green slaves.

The transmissions from the chain are received by a special shipborne receiver, which measures the difference in phase of signals arriving from master and slaves. All stations in a Decca chain must 'phase locked', and this has to be done over an appreciable distance separating the stations, sometimes up to 100 nautical miles, the phase difference being determined by this distance. Each slave station is fitted with equipment which receives the master signal, converts it to the slave frequency, and uses it to control the drive oscillator of the slave transmitter. Thus a constant phase relationship is maintained. To ensure that this relationship is maintained accurately, a monitoring station checks the transmissions.



ZERO TIME
0·1
0·15
0·6
0·75
2·5
2·6
2·65
3·1
3·25
5·0
5·1
5·15
5·6
5·75
7·5
7·6
7·65
8·1
8·28
8·4
9·6
9·72
10·92
11·04
11·16
12·36
12·48
13·68
13·8
13·92
15·12
15·24
16·44
17·5
MASTER
RED
GREEN
PURPLE
TIME IN SECONDS
5f
6f
8f
8·2f
9f

OMEGA

Omegais a system which works on the same principle as Decca. But its operating frequency is very low (VLF). Essentially ground based transmitters are employed to transmit in four fixed frequencies - 10.20 KHz, 11.05 KHz, 11.33 KHz and 13.60 KHz. Using VLF enables full worldwide coverage with only eight transmitters placed at stations in Norway, Liberia, Hawaii, NorthDakota, La Reunion Islands, Argentina, Australia and Japan.

To give station identification the stations transmit the various frequencies at set times in a common 10 sec sequence. The low operating frequency of Omega causes quite large inaccuracies in position identification, but it has the advantage that submarine vehicles can receive its signals at appreciable depths underwater.

Though Omega was developed for maritime use, it has been widely adopted as a navigational aid on the transoceanic air routes. It was also used by the British quite extensively in the Falklands war, even though one of the transmitters was located in Argentina.

SYSTEM CONFIGURATION

The extensive and accurate measurements of the phase stability of the V L F Omega signals made throughout the past decade show that such signals can provide global position-fixing of good accuracy and high reliability. The viability of this V L F system is further enhanced by the low attenuation experienced in this portion of the spectrum. Long-range propagation of low power transmissions will permit worldwide navigation coverage with a relatively small number of stations. This is a decided fiscal benefit both in initial investment and, over the years, in operation and maintenance costs.

Optimum system geometry would call for six stations. Unfortunatelythe earth's surface characteristics and properties will not support such a systematic scheme. Therefore an alternate scheme was developed which took into consideration economic factors, properties o f V L F propagation and availability of land areas. This plan called for eight stations to be distributed throughout the world with an average separation of 5 000 - 6 000 nautical miles. The existing Omega stations in Norway, Trinidad, and Hawaii and a new station in North Dakota were included in this pian. Four remaining locations in the vicinity of Australia, Southern South America, Indian Ocean, and Western Pacific were needed. The tentative configuration led to theopening of negotiation with nations situated or having possessions in these regions of the world.

STATION ELECTRONIC EQUIPMENTS

Omega ground stations correspond very closely to the concepts of theirhigher frequency counterparts, Loran A and Loran C. The station fundamentally consists of an atomic frequency source, timing and signal formatgenerating equipment, signal transmitter, antenna and associated tuningequipment.

The Timing and Control Set, receiving its input from cesium beam- frequency standards, generates the Omega frequencies and signal formatfor transmission.The Transmitting Set amplifies the CW signals provided by theTiming and Control Set and applies the higher powered signals to theantenna system. Transmitting in the 10 - 14 kHz band from an antennawith a bandwidth of 10 Hz not only requires immense components in thetuning network, but also requires special attention to insure that the antenna remains tuned to the frequency being transmitted. This isaccomplished through the use of separate tuning networks for eachfrequency and servo controlled tuning adjustments.

Equipment redundancy has been designed into nearly all functions ofthe Omega signal transmission process, from signal generation to theantenna, which will contribute to maximum station reliability. To insureequipment standardization and minimize the scope of logistics supportrequired, the United States Navy has procured eight complete sets of station electronics equipments for use throughout the system.

OPERATING CHARACTERISTICS

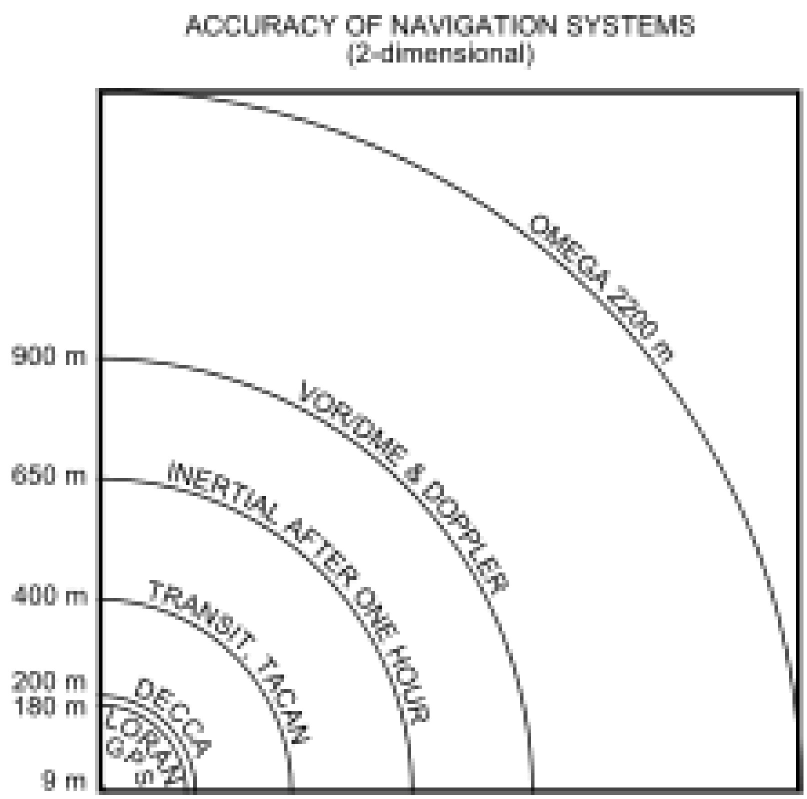
Certain advantages postulated for the Omega system can immediatelybe seen by examination of the operating characteristics shown in table 1.With an arrangement of stations as illustrated in figure 1, a completeelectro-magnetic environment can be established around the globe. Inaddition, in view of the extreme long range of the signals in this frequencyrange, there will be a high order of redundancy of lines-of-position. It is predicted that at any point on the surface o f the earth at least five linesof position will be available, allowing the navigator to take advantage ofLO P redundancy and of optimum geometry and crossing angles by properlychoosing station pairs.

The accuracy of the V L F navigation concept is a point of controversy.The practicality of the system is based on the fact, verified over many years of measurement, that RF signals in the V L F band demonstrate remarkablephase stability over extremely long distances. The degree of accuracy claimed includes the limitations of the inherent stability and predictabilityof variations of phase along the transmission path.

The figures quoted include any geometrical effects such as hyperbolic divergence and lines of position (LOP) crossing angles and, while admittedly conservative, compare quite nicely with the established accuracies o fLoran A. What is remarkable about the Omega system is not its potential accuracy but that this accuracy is obtainable anywhere on the globe with only eight ground stations.

Since the Omega signal varies diurnally as a function of the ionosphere activity along the signal transmission paths, propagation corrections at a given location are required. Use of published propagation correction tables will enable the user to achieve accuracies of 1 - 2 nautical miles.

Differential Omega employs real-time propagation information provided to the navigator to reduce errors caused by vagaries in the velocity of the transmitted signal. Simply stated a monitor at a fixed, known location transmits real-time propagation corrections to moving vehicles operating in the local area.



INSTRUMENT LANDING SYSTEM (ILS)

1. Introduction

The instrument landing system (ILS) is the ICAO standard, non-visual aid to final approach and landing. The ILS is defined as a precision runway approach aid which provides pilots with both vertical and horizontal guidance during an approach to land. Ground equipment consists of 2 directional transmitting systems and sometimes paired with 2 or 3 marker beacons along the approach. The directional transmitters are known as the localizer and the glide slope.

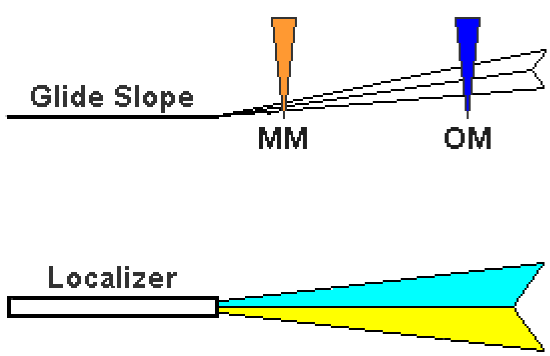
The instrument landing system (ILS) provides the pilot with:

* Guidance information regarding the approach path derived from the localizer and the glide slope

* Range information at significant points along the approach path by marker beacons or continuous range information from distance measuring equipment (DME)

* Visual information in the last phase of flight from approach lights, touchdown and centre line lights, runway lights

The ILS Components



A localizer for lateral guidance (VHF); and a glide slope for vertical guidance (UHF).

The FAA categorizes the components this way:

Guidance information: the localizer and glide slope.

Range information: the outer marker (OM) and the middle marker (MM) beacons.

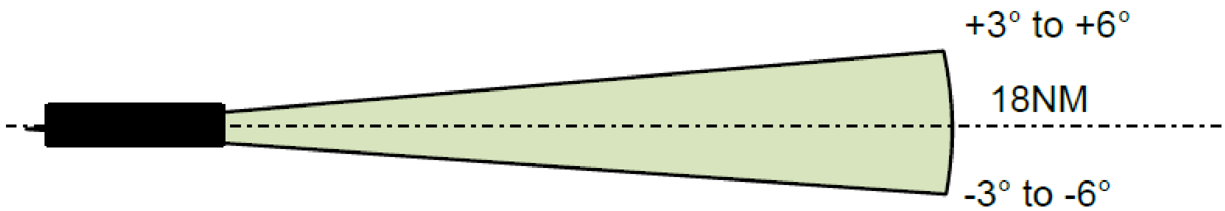
Visual information: approach lights, touchdown and centerline lights, runway lights.

Ground equipment

1. Localizer

The localizer transmitter operates on one of 40 ILS channels within the very-high frequency (VHF) band from 108 MHz to 112 MHz . Each localizer's frequency first decimal shall be odd like the following examples: 108.1, 108.15, 108.3, and 108.35. The localizer system consists of a network system from 13 to 41 VHF antennas.

The localizer signal emitted from the transmitter site at the far end of the runway is confined within an angular width between 3° and 6°. The localizer provides course guidance throughout the descent path to the runway threshold from a distance of 18 NM from the antenna between a height of 1000ft above the highest terrain along the approach path and 4500ft above the elevation of the antenna site.

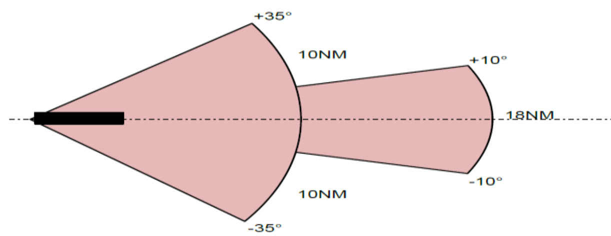


The course line along the extended centre line of a runway, in the opposite direction to the approach direction served by the ILS is called back course. Distinct off-course indications are provided throughout the areas of the operational volume.

These areas extend:

* 10° either side of the course within a radius of 18NM from the antenna

* 35° either side of the course within a radius of 10NM from the antenna



2. Glide Path

The glide slope transmitter operates on one of 40 ILS channels within the ultra-high frequency (UHF) band from 329.15 MHz to 335MHz. The glide path radiates its signal only in the direction of the localizer front course.

The glide slope frequency is usually paired with the localizer frequency as the pilot enters only the localizer frequency in the aircraft instruments. The glide scope transmitter is located between 230m/750ft and 380m/1250ft from the approach end of the runway and offset between 75m/250ft and 198m/650ft from the runway centre line. It transmits a glide path with a beam width of 1.4°. The glide path projection angle is normally adjusted to 3° above the horizontal plane so that it passes through the middle marker at about 60m/200ft and the outer marker at about 426m/1400ft.

The glide slope is normally usable to a distance of 10NM (it can be extended when requested). The glide path provided by the glide slope transmitter is arranged so that it flares from 5 to 8m (18 to 27ft) above the runway.

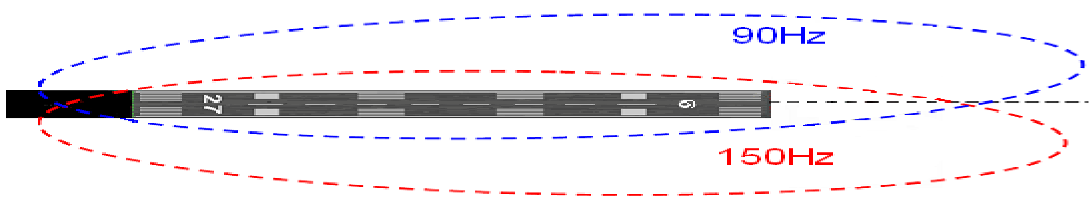
It should not be expected that the glide path will provide guidance to the touchdown point on the runway.

Principles of ILS signals

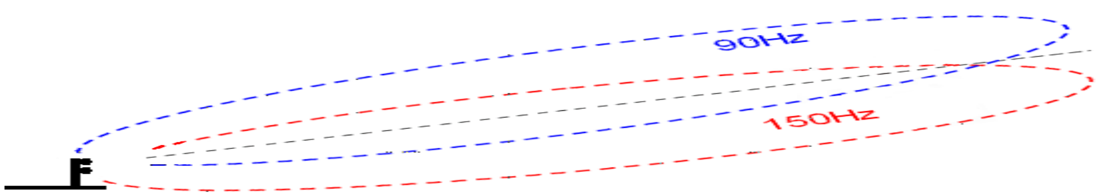
The principle of ILS signal generation is to create, via a complex electromagnetic field generated by the antennas, radiofrequency waves which can be simply represented by 2 fictive transmitters:

* One transmitter sends a 90Hz sine signal amplitude modulated on the VHF frequency of ILS.

* One transmitter sends a 150Hz sine signal amplitude modulated on the VHF frequency of ILS.



Simple representation of the 2 fictive transmitters for the localizer



Simple representation of the 2 fictive transmitters for the glide slope

On-board equipment: ILS

The on-board equipment controls demodulating the VHF ILS signal in order to get the amplitude of the 90Hz and 150z modulation.

1. Frequency selector

The navigation receiver is the control unit where pilots select the ILS frequency. The ILS frequency should be usually entered on the **NAV 1** selector.

These images above show a Beechcraft (at the left), a Cessna (at the centre) and a Boeing (at the right) Selector.

NAV1 equipment has its own controls:

* Frequency selector: frequency is tuned by rotating 2 knobs until the wanted frequency is obtained. One knob for the main digits and another for decimal digits. You can tune on the smallest aircraft the wanted frequency directly, or tune a standby frequency (non-active)

* Band selector on heavier aircraft (Airbus, Boeing)

* Mode selector (NAV, DME ...) on light aircraft

* Frequency switch between Active frequency and standby frequency (only when standby frequency exists)

2. Indicator instruments

The ILS signal is analyzed by a receiver and displayed by:

* A Course Deviation Indicator (CDI).

* A Horizontal Situation Indicator (HSI)

* An Electronic Horizontal Situation Indicator (EHSI) named Navigation Display (ND)

CDI (Cessna)

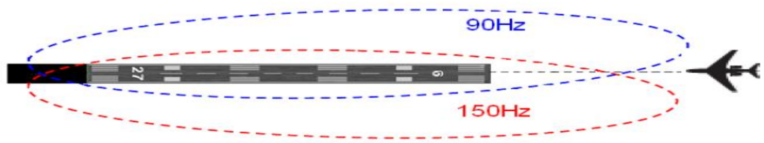
HSI (Beechcraft)

EHSI(Beechcraft)

EHSI/ND(Boeing)

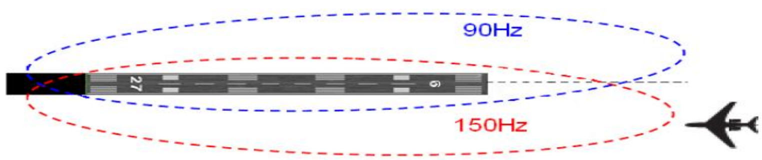
Position of aircraft and display in the cockpit

1. Aircraft on localizer optimal path



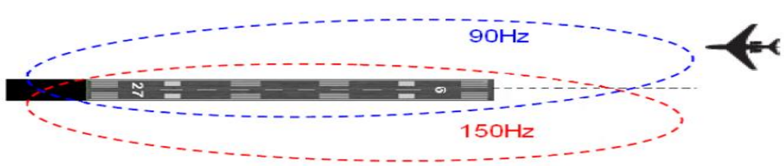
The aircraft is exactly on the optimal path direct to the runway. No lateral shift is noticed.
The localizer vertical indicator on the navigation instrument is at the centre position.

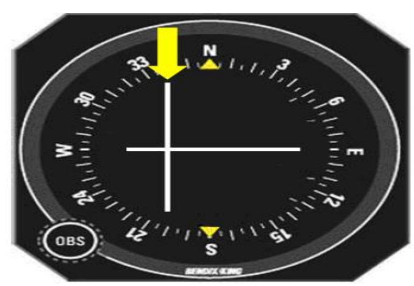
2. Aircraft at the left of localizer optimal path



The aircraft is at the left of the optimal path direct to the runway. Lateral shift is noticed. The localizer vertical indicator on the navigation instrument is on the right. The centre of the instrument shall be taken as the aircraft direction and the localizer indicator represents the optimal path. In order to join the optimal path, the pilot shall turn to the right towards the indicator.

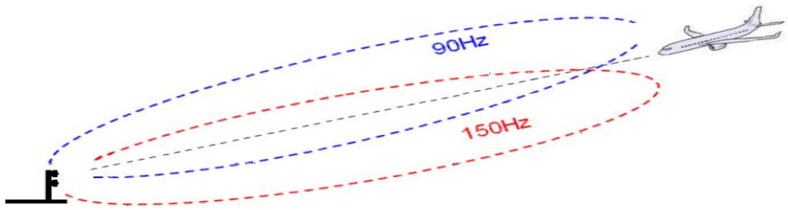
Aircraft at the right of localizer optimal path

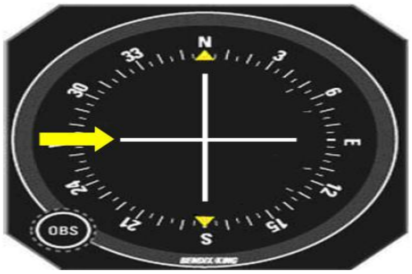




The aircraft is at the right of the optimal path direct to the runway. Lateral shift is noticed. The localizer vertical indicator on the navigation instrument is on the left. The centre of the instrument shall be taken as the aircraft direction and the localizer indicator represents the optimal path. In order to join the optimal path, the pilot shall turn to the left towards the indicator.

Aircraft on glide slope optimal path

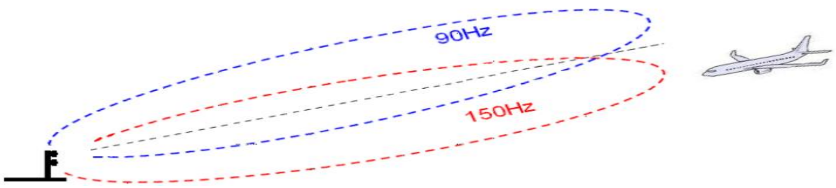


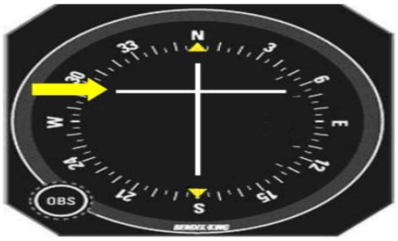


The aircraft is exactly on the optimal path direct to the runway. No vertical shift is noticed.

The glide slope horizontal indicator on the navigation instrument is at the centre position.

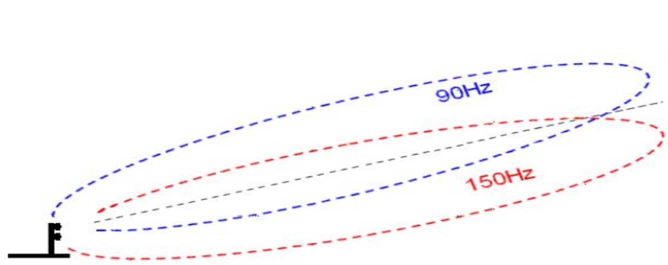
Aircraft below glide slope optimal path





The aircraft is below the optimal path direct to the runway. Vertical shift is noticed. The glide slope horizontal indicator on the navigation instrument is above the centre of the instrument. The centre of the instrument shall be taken as the aircraft direction and the glide slope indicator represents the optimal path. In order to join the optimal path, the pilot shall stop his descent until he reaches the optimal descent path.

Aircraft above glide slope optimal path



The aircraft is above the optimal path direct to the runway. Vertical shift is noticed.

The glide slope horizontal indicator on the navigation instrument is below the centre of the instrument. The centre of the instrument shall be taken as the aircraft direction and the glide slope indicator represents the optimal path. In order to join the optimal path, the pilot shall increase the descent rate or lower thrust power until he reaches the optimal descent path.

Optimal ILS descent path

In order to maintain the optimal descent path, the pilot shall keep the ILS instrument centred like the image until the ILS procedure minima or the visual reference is acknowledged.

ILS LIMITATIONS

The Instrument Landing System (ILS) has served as the standard precision approach and landing aid for the last 40 years. During this time it has served well and has undergone a number of improvements to increase its performance and reliability. However, in relation to future aviation requirements, the ILS has a number of basic limitations:

1. site sensitivity and high installation costs;
2. single approach path;
3. multi path interference; and
4. Channel limitations - 40 channels only.

MICROWAVE LANDING SYSTEM (MLS)

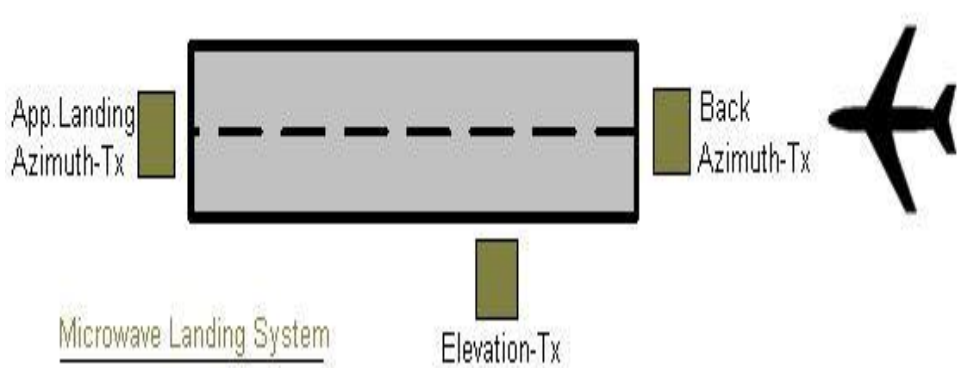
SYSTEM DESCRIPTION

The time-referenced scanning beam **Microwave Landing System (MLS)** has been adopted by ICAO as the standard precision approach system to replace ILS.

MLS provides precision navigation guidance for alignment and descent of aircraft on approach to a landing by providing azimuth, elevation and distance. The system may be divided into five functions:

1. Approach azimuth;
2. Back azimuth;
3. Approach elevation;
4. Range; and
5. Data communications.

With the exception of DME, all MLS signals are transmitted on a single frequency through time sharing. Two hundred channels are available between 5031 and 5090.6 Megahertz (MHz). By transmitting a narrow beam which sweeps across the coverage area at a fixed scan rate, both azimuth and elevation may be calculated by an airborne receiver which measures the time interval between sweeps.



Azimuth Tx:

- Function: Provides bearing information.
- NAV: Horizontal Guidance.
- Quantity per runway: 2
- Location: One is placed at the end of the runway, and the other one at the begging.
- Frequency of operation is: SHF 5.031 to 5.0907 GHz with he number of Channels equal to 200
- Horizontal Range of Operation: 37 km
- Deviation from Centerline is approx. +/- 40 Degree.

Elevation Tx:

- Function: Provides ALT information.

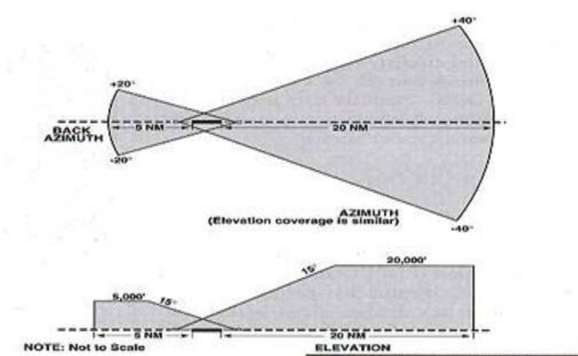
- NAV: Vertical Guidance.
- Quantity per runway: 1
- Location: On the side of the runway.
- Frequency of operation is SHF from 5.031 to 5.0907 GHz
- Number of Channels: 200
- Vertical Range of Operation is approx. 6 km
- Typical MLS Inclination is about 8 Degree
- Deviation from MLS is approx. +/- 7 degree

1. APPROACH AZIMUTH GUIDANCE

The approach azimuth antenna normally provides a lateral coverage of 40º either side of the center of scan (see **MLS Azimuth and Elevation Coverage** figure, below). Coverage is reliable to a minimum of 20 NM from the runway threshold and to a height of 20,000 feet (ft). The antenna is normally located about 1000 feet beyond the end of the runway.

2. BACK AZIMUTH GUIDANCE

The back azimuth antenna provides lateral guidance for missed approach and departure navigation. The back azimuth transmitter is essentially the same as the approach azimuth transmitter. However, the equipment transmits at a somewhat lower data rate because the guidance accuracy requirements are not as stringent as for the landing approach. The equipment operates on the same frequency as the approach azimuth bur at a different time in the transmission sequence. On runways that have MLS approaches on both ends, the azimuth equipment can be switched in their operation from the approach azimuth to the back azimuth and vice versa. The MLS Azimuth and Elevation Coverage figure, below, shows MLS azimuth coverage volumes.



MLS AZIMUTH AND ELEVATION COVERAGE

3. ELEVATION GUIDANCE

The elevation station transmits signals on the same frequency as the azimuth station. The elevation transmitter is normally located about 400 ft from the side of the runway between the threshold and the touchdown zone. The **MLS Azimuth and ElevationCoverage** figure, above, shows coverage volumes for the MLS elevation signal. It allows for a wide range of glide path angles selectable by the pilot.

4. RANGE GUIDANCE

Range guidance, consistent with the accuracy provided by the azimuth and elevation stations, is provided by the MLS precision DME (DME/P). DME/P has an accuracy of $\pm$100 ft as compared, with $\pm$ 1200 ft accuracy of the standard. DME system. In the future it may be necessary to deploy DME/P with modes which could be incompatible with standard airborne DME receivers.

5. DATA COMMUNICATIONS

The azimuth ground station includes data transmission in its signal format which includes both basic and auxiliary data. Basic data may include approach azimuth track and minimum glide path angle. Auxiliary data may include additional approach information such as runway condition, wind-shear or weather.

ADVANTAGES

[1]. Improved guidance accuracy with greater coverage area.
[2]. Provide flexible landing path NAV.
[3]. Offers guidance for missed approaches and departure NAV.
[4]. MLS has low sensitivity from weather conditions and airport GNS traffic as oppose to ILS.
[5]. MLS offers 200 frequency channels, 10-times more than ILS.
[6]. Maintenance and installation of MLS is cheaper.

DISADVANTAGES

The use of Microwave Landing System is not much in use in civilian aircrafts.

INERTIAL NAVIGATION

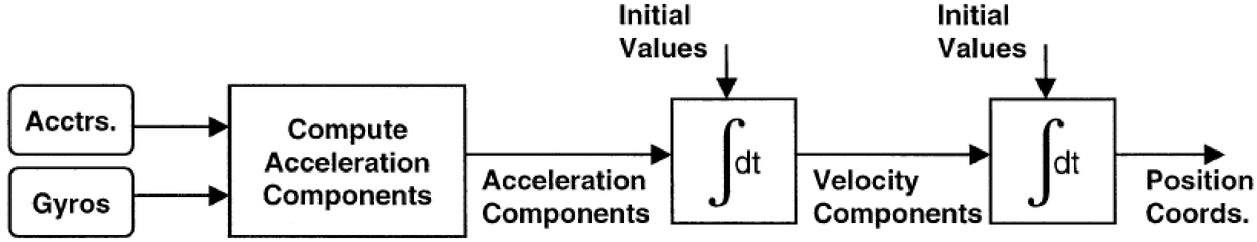
Introduction

It is instructive to briefly review the reasons for the development of inertial navigation and its importance as an aircraft state sensor. The attributes of an ideal navigation and guidance system for military applications can be summarized as follows:

• High accuracy
• Self-contained
• Autonomous – does not depend on other systems
• Passive – does not radiate
• Unjammable
• Does not require reference to the ground or outside world the INS can provide:
• Accurate position in whatever coordinates are required – e.g. latitude/longitude, etc.
• Ground speed and track angle.
• Euler angles: heading, pitch and roll to very high accuracy.
• Aircraft velocity vector (in conjunction with the air data system).

A FEW DEFINITIONS

• ***Inertia*** is the property of bodies to maintain constant translational and rotational velocity, unless disturbed by forces or torques, respectively (Newton's first law of motion).
• An ***inertial reference frame*** is a coordinate frame in which Newton's laws of motion are valid. Inertial reference frames are neither *rotating* nor *accelerating*.
• *Inertial sensors* **measure *rotation rate* and *acceleration***, both of which are vector valued variables.
• ***Gyroscopes***are sensors for measuring *rotation*: *rate gyroscopes* measure *rotation rate*, and *integrating gyroscopes* (also called *whole-angle gyroscopes*) measure *rotation angle.*
• ***Accelerometers*** are sensors for measuring *acceleration*. However, accelerometers *cannot* measure *gravitational acceleration*. That is, an accelerometer in free fall (or in orbit) has no detectable input.
• *An* ***inertial measurement unit (IMU)***or *inertial reference unit (IRU)* contains a cluster of sensors: *accelerometers* (three or more, but usually three) and *gyroscopes* (three or more, but usually three). These sensors are rigidly mounted to a common base to maintain the same relative orientation.



Inertial navigation is a self-contained navigation technique in which measurements provided by accelerometers and gyroscopes are used to track the position and orientation of an object relative to a known starting point, orientation and velocity. Inertial measurement units (IMUs) typically contain three orthogonal rate-gyroscopes and three orthogonal accelerometers, measuring angular velocity and linear acceleration respectively.

An INS consists of the following:

– An IMU

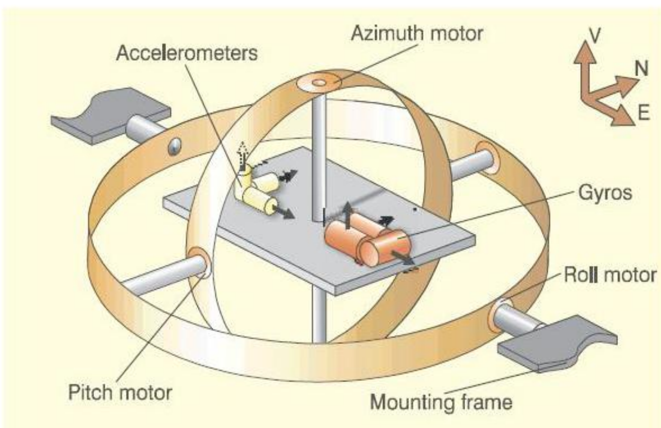
– Instrument support electronics

– Navigation computers (one or more) calculate the gravitational acceleration (not measured by accelerometers) and doubly integrate the net acceleration to maintain an estimate of the position of the host vehicle.

INS TYPES

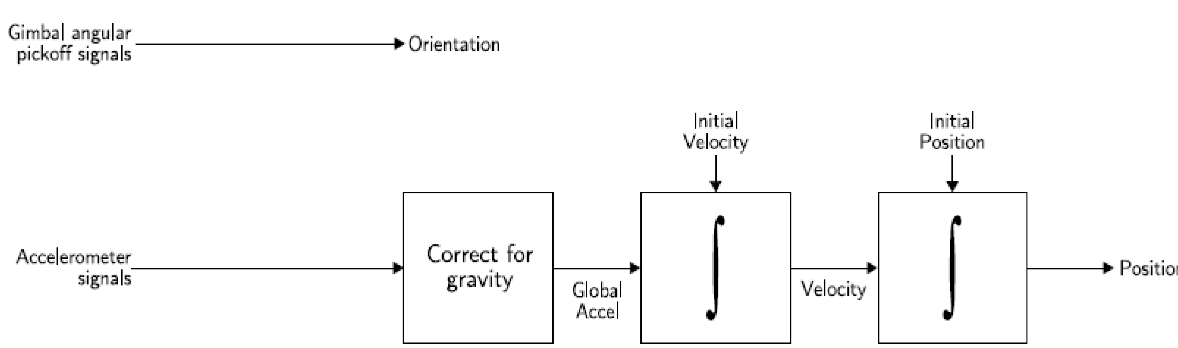
1. Stable Platform Systems (or) Gimbaled Platform:

In stable platform type systems the inertial sensors are mounted on a platform which is isolated from any external rotational motion. In other words the platform is held in alignment with the global frame. This is achieved by mounting the platform using gimbals (frames) which allow the platform freedom in all three axes, as shown in Figure.



The platform mounted gyroscopes detect any platform rotations. These signals are fed back to torque motors which rotate the gimbals in order to cancel out such rotations, hence keeping the platform aligned with the global frame.

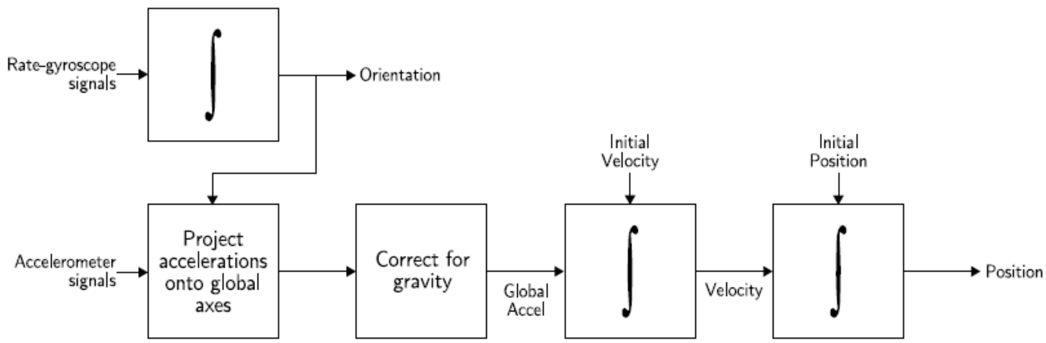
To track the orientation of the device the angles between adjacent gimbals can be read using angle pick-offs. To calculate the position of the device the signals from the platform mounted accelerometers are double integrated. General Stable Platform Systems (or) Gimbaled Platform based algorithm is shown below.



1. Strap down Systems

In strap down systems the inertial sensors are mounted rigidly onto the device, and therefore output quantities measured in the body frame rather than the global frame. To track position the three accelerometer signals are resolved into global coordinates using the known orientation, as determined by the integration of the gyro signals. The global acceleration signals are then integrated as in the stable platform algorithm.

Strapdown systems have reduced mechanical complexity and tend to be physically smaller than stable platform systems. These benefits are achieved at the cost of increased computational complexity. As the cost of computation has decreased strap down systems have become the dominant type of INS. General **Strapdown System's** algorithm is shown below.



Advantages of INS

• It is autonomous and does not rely on any external aids or visibility conditions. It can operate in tunnels or underwater as well as anywhere else.

• It is inherently well suited for integrated navigation, guidance, and control of the host vehicle. Its IMU measures the derivatives of the variables to be controlled (e.g., position, velocity, and attitude).

• It is immune to jamming and inherently stealthy. It neither receivers nor emits detectable radiation and requires no external antenna that might be detectable by radar.

Disadvantages of INS

• Mean-squared navigation errors increase with time.

• Cost, including:

– Acquisition cost, which can be an order of magnitude (or more) higher than GPS receivers.

– Operations cost, including the crew actions and time required for initializing position and attitude. Time required for initializing INS attitude by gyrocompass alignment is measured in minutes. TTFF for GPS receivers is measured in seconds.

– Maintenance cost. Electromechanical avionics systems (e.g., INS) tend to have higher failure rates and repair cost than purely electronic avionics systems (e.g., GPS).

• Size and weight, which have been shrinking

• Power requirements, which have been shrinking along with size and weight but are still higher than those for GPS receivers.

• Heat dissipation, which is proportional to and shrinking with power requirements.

Gyroscopic Principles

Any spinning object exhibits gyroscopic properties. A wheel or rotor designed and mounted to utilize these properties is called a gyroscope. Two important design characteristics of an instrument gyro are great weight for its size, or high density, and rotation at high speed with low friction bearings.

There are two general types of mountings; the type used depends upon which property of the gyro is utilized. A freely or universally mounted gyroscope is free to rotate in any direction about its center of gravity. Such a wheel is said to have three planes of freedom. The wheel or rotor is free to rotate in any plane in relation to the base and is balanced so that, with the gyro wheel at rest, it remains in the position in which it is placed. Restricted or semi-rigidly mounted gyroscopes are those mounted so that one of the planes of freedom is held fixed in relation to the base.

There are two fundamental properties of gyroscopic action: rigidity in space and precession.

Rigidity in Space

Rigidity in space refers to the principle that a gyroscope remains in a fixed position in the plane in which it is spinning. An example of rigidity in space is that of a bicycle wheel. As the bicycle wheels increase speed, they become more and more stable in their plane of rotation. This is why a bicycle is very unstable and very maneuverable at low speeds and very stable and less maneuverable at higher speeds.

By mounting this wheel, or gyroscope, on a set of gimbal rings, the gyro is able to rotate freely in any direction. Thus, if the gimbal rings are tilted, twisted, or otherwise moved, the gyro remains in the plane in which it was originally spinning.

Precession

Precession is the tilting or turning of a gyro in response to a deflective force. The reaction to this force does not occur at the point at which it was applied; rather, it occurs at a point that is 90° later in the direction of rotation. This principle allows the gyro to determine a rate of turn by sensing the amount of pressure created by a change in direction. The rate at which the gyro precesses is inversely proportional to the speed of the rotor and proportional to the deflective force.

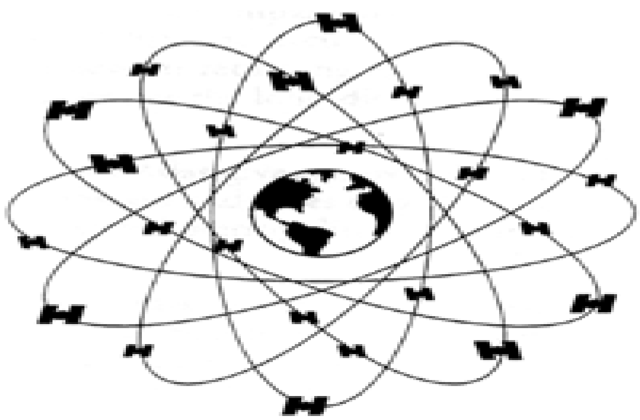
GLOBAL POSITIONING SYSTEM

GPS (Global Positioning System) is the only system today able to show you where you're exactly position on the earth at anytime and any weather condition. 24 satellites are all orbit around the earth at 11,000 nautical miles or approximately 20,200 kms above the earth. The satellites are placed into six different orbital planes and 55 degree inclination. They are continuously monitored by ground stations located worldwide.

GPS ELEMENTS can divide GPS system into three segments.

*SPACESEGMENT
*USERSEGMENT
* CONTROL SEGMENT

SPACE SEGMENT The space segment comprises a network of satellites. The complete GPS space system includes 24 satellites, 11,000 nautical miles above the earth; take 12 hours each to go around the earth once or one orbit. They are orbit in six different planes and 55 degrees inclination. These positions of satellites, we can receive signals from six of them nearly of the time at any point on earth. Satellites are equipped with very precise clocks that keep accurate time to within three nanoseconds (0.000000003 of a second or 3e-9).



This precision timing is important because the receiver must determine exactly how long it takes for signals to travel from each GPS satellite to receiver. Each satellite contains a supply of fuel and small servo engines so that it can be moved in orbit to correct for positioning errors.

Each satellite contains four atomic clocks. These clocks are accurate to a nanosecond. Each satellite emits two separate signals, one for military purposes and one for civilian use.

USER SEGMENT as the pilot fly, the GPS receiver continuously calculates the current position and display the correct position / heading. The GPS unit listens to the satellite's signal and measure the time between the satellites transmission and receipt of the signal. By the process of triangulation among the several satellites being received, the unit computes the location of the GPS receiver. GPS receiver has to see at least four satellites to compute a three dimensional position (it can compute position with only three satellites if know altitude). Not only latitude and Longitude but altitude as well. There are numerous forms of display among the various manufacturers. No frequency tuning is required, as the frequency of the satellite transmissions are already known by the receiver.

CONTROL SEGMENT

The control Segment of GPS consist of:

* **Master Control Station** (one station): The master control station is responsible for overall management of the remote monitoring and transmission sites. As the center for support operations, It calculates any position or clock errors for each individual satellite from monitor stations and then orders the appropriate corrective information back to that satellite.

* **Monitor Stations** (four stations): Each of monitor stations checks the exact altitude , position , speed , and overall of the orbiting of satellites. A station can track up to 11 satellites at a time. This check-up is performed twice a day by each station as the satellites go around the earth.

OPERATION

The principle of GPS is the measurement of distance between the receiver and the satellites. The satellites also tell us exactly where they are in their orbit above the earth . The receiver knows our exact distance from satellite, knows the distance between satellites. GPS receivers have mathematical method by computer to compute exactly where the GPS receiver could be located.

AIR DATA SYSTEMS AND AUTOPILOT

Air data quantities: Altitude

Pressure Measuring Equipment

Pressure is the force per unit area acting on a body. Pressure can have several units of measurement, the common ones used in aviation are: inches of mercury, pounds per square inch (Psi), Pascals (Pa) or bars. Pressure is measured on aircraft from two probes:

1) Static probe which measures the atmospheric pressure.

2) Pitot pressure which measures the ram pressure.

Absolute Pressure:

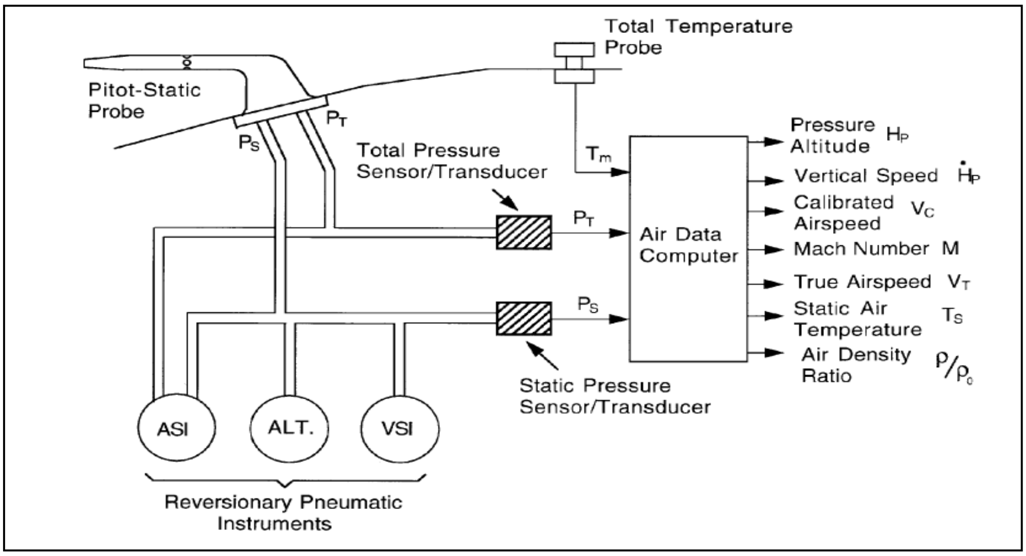
Pressure above a vacuum, absolute pressure is used on aircraft as a comparison to other pressures. A device called an Aneroid Barometer is used, it is a device that consists of an enclosed chamber made from thin sheet metal, and this chamber is evacuated to provide reference to measure absolute pressure.

Gauge Pressure:

Pressure above or below ambient. Gauge pressure is determined by comparing the difference between atmospheric pressure and the pressure being measured. This type of pressure measurement is the most common in today's light aircraft instruments. Lower pressures are compared using "bellows", while higher pressures are compared using a bourdon tube, a bourdon tube tends to straighten when high pressure is applied.

Differential Pressure:

The difference between two pressures, this is the system used in an airspeed indicator.

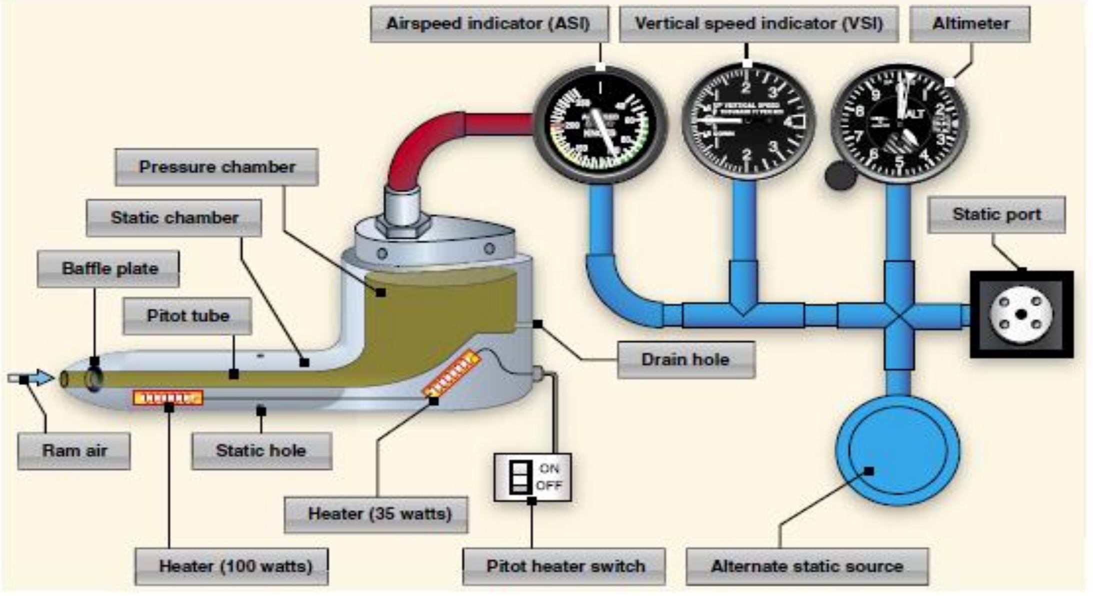


When you are sitting in the airplane, you will probably notice six flight instruments in front of you. The typical arrangement of these instruments is shown below:

1. Airspeed indicator 2. Attitude indicator 3. Altimeter

4. Turn coordinator 5. Heading indicator 6. Vertical speed indicator

The pitot-static system is a combined system that utilizes the static air pressure, and the dynamic pressure due to the motion of the aircraft through the air. These combined pressures are utilized for the operation of the airspeed indicator (ASI), altimeter, and vertical speed indicator (VSI).



Air Data, Air Data System, and Its Advancement

Various types of air data which are generated from the Air Data System provide the more precise information about different issues that inevitably alter the Aircraft System. Air Data System computes pressure altitude, vertical speed, calibrated airspeed, true airspeed, Mach number, static air temperature and air density ratio. This information is very much essential for the pilot to fly the aircraft safely and also there required by a number of key avionic sub-systems which enable the pilot to carry out aircraft mission. Let's you imagine that you flying the aircraft without air data and air data system then what happened your mission??? You can easily handle the aircraft initially but there is no guarantee on your flight mission further. Obviously, you can't forecast about your flight mission. So this system is much sensitive avionic systems and part of the essential core of avionic sub-systems required in all other types of modern aircraft, civil or military.

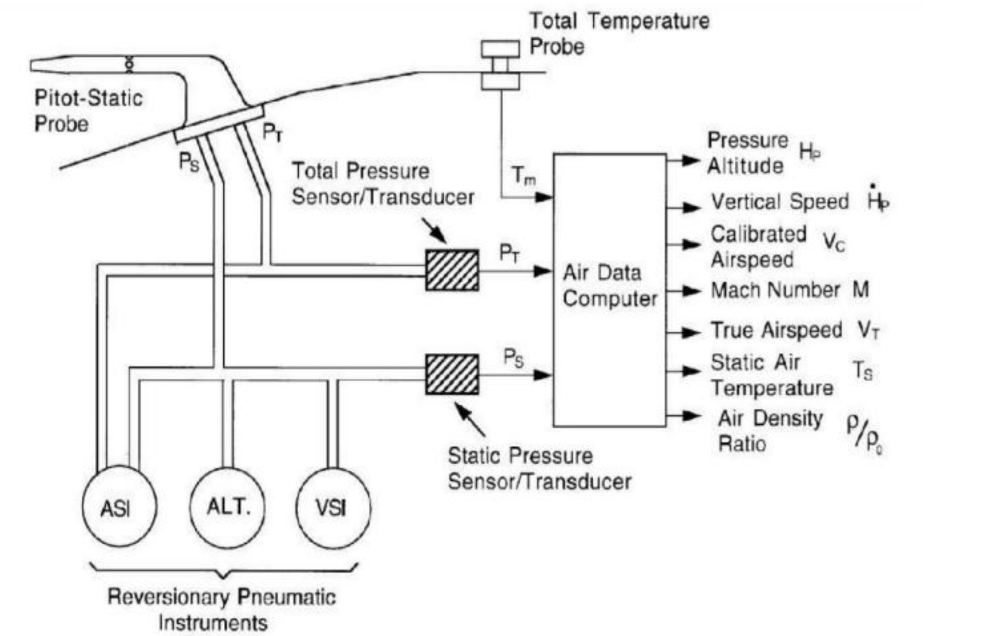


Fig: Air Data System *Source: Avionic-*

The air data quantities like pressure altitude (HP), vertical speed (ḢP), calibrated airspeed (VC), true airspeed (V), etc. are derived from the three basic measurable parameters by sensors connected to probes which measure total or pitot pressure and static pressure. After measurement of these quantities then other parameters like Mach number (M), and total or indicated air temperature (Tt) can be calculated. Overally the air data is applicable for aircraft's behavior, controllability and safety. In any system that can be mechanical or electrical/electronic the sensor is necessary to provide data for system effectively and efficiently. So the main air data sensors comprise two pressure

sensors and a temperature sensor. Temperature sensor generally comprises a simple resistance bridge with one arm of the bridge consisting of a resistive element exposed to the airstream and is a relatively simple and straightforward device which fairly meets the system accuracy requirements. Pressure sensors are high accuracy requirements and thus influence on the overall system accuracy, long-term stability, reliability and overall cost.

An air data computer (ADC) is one of the most essential avionics component usually found in modern glass cockpits. It is the store and manipulate function in air data unit. This computer rather than individual instruments can determine the calibrated airspeed, Mach number, altitude, and altitude trend data from an aircraft's pitot-static system. In the case of very high-speed aircraft such as the Space Shuttle, the equivalent airspeed is calculated instead of calibrated airspeed. The first air data computer patented is in the US and it was developed by John H. Andresen. Total air temperature usually input on Air data computers. This enables computation of static air temperature and true airspeed. In Airbus aircraft the air data computer is combined with altitude, heading and navigation sources in a single unit known as the Air Data Inertial Reference Unit (ADIRU). This has now been replaced by Global Navigation Air Data Inertial Reference System (GNADIRS).

In Air Data System another advanced and integrated system i.e. Optical Air Data Systems (OADS) which is a high technology, a rapid developer of lightweight, rugged Light Detection and Ranging (LIDAR) remote sensing solutions for real world precision measurement applications. Currently the OADS has customized all fiber optic motion-compensated LIDAR solutions that meet the reliability, maintainability, and survivability requirements essential for platform based sensors. It also design, construct, and further research on world's first laser-based air data system for rotary and fixed wing aircraft, LIDAR for wind turbine control, handheld laser wind sensors as well as laser range finders.

Generally in military aircraft 'Advanced air data systems' (ADS) is implemented which deliver the flight critical information to the aircraft and pilot throughout the flight region. Key features include an angle of attack and stall protection systems, pitot and pitot-static probes, outside and total air temperature sensors.

Conclusion:

Without complete information of air data, it is not possible to secure our flight mission and there must be no compromise of such system in any aircraft and chronologically advancement of such system makes our flight journey safer.

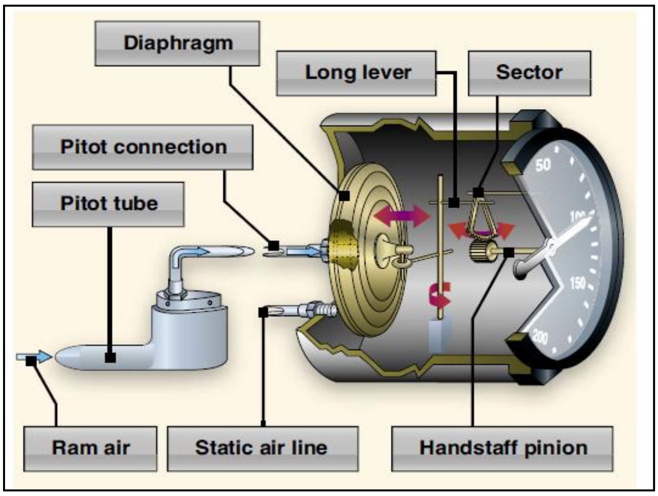
AIR DATA SYSTEMS AND AUTOPILOT

02. Air speed

Airspeed Indicator (ASI)

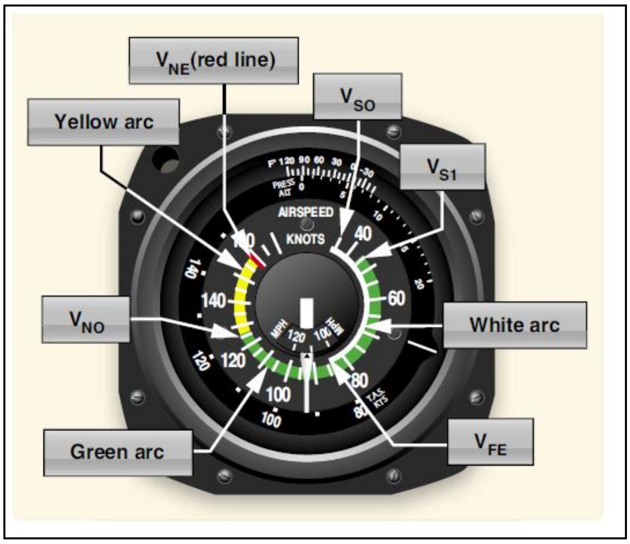
The ASI is a sensitive, **differential pressure gauge which measures and promptly indicates the difference between pitot (impact/dynamic pressure) and static pressure.** These two pressures are equal when the aircraft is parked on the ground in calm air. When the aircraft moves through the air, the pressure on the pitot line becomes greater than the pressure in the static lines. This difference in pressure is registered by the airspeed pointer on the face of the instrument, which is calibrated in miles per hour, knots (nautical miles per hour), or both.

Airspeed Indicator



The ASI is the one instrument that utilizes both the pitot, as well as the static system. The ASI introduces the static pressure into the airspeed case while the pitot pressure (dynamic) is introduced into the diaphragm. The dynamic pressure expands or contracts one side of the diaphragm, which is attached to an indicating system. The system drives the mechanical linkage and the airspeed needle.

The altimeter can display also other speed information:



 White arc: This arc is commonly referred to as the flap operating range since its lower limit represents the full flap stall speed and its upper limit provides the maximum flap speed (Approaches and landings are usually flown at speeds within the white arc.

 Lower limit of white arc (VS0): The stalling speed or the minimum steady flight speed in the landing configuration. In small airplanes, this is the power-off stall speed at the maximum landing weight in the landing configuration (gear and flaps down).

 Upper limit of the white arc (VFE): The maximum speed with the flaps extended.

 Green arc: This is the normal operating range of the airplane. Most flying occurs within this range.

 Lower limit of green arc (VS1): The stalling speed or the minimum steady flight speed obtained in a specified configuration. For most airplanes, this is the power-off stall speed at the maximum takeoff weight in the clean configuration (gear up, if retractable, and flaps up).

 Upper limit of green arc (VNO): The maximum structural cruising speed. Do not exceed this speed except in smooth air.

 Yellow arc: Caution range. Fly within this range only in smooth air, and then, only with caution.

 Red line (VNE): Never exceed speed. Operating above this speed is prohibited since it may result in damage or structural failure.

Types of Airspeed

Just as there are several types of altitude, there are multiple types of airspeed: Indicated Airspeed (IAS), Calibrated Airspeed (CAS), Equivalent Airspeed (EAS), and True Airspeed (TAS).

1. Indicated Airspeed (IAS)

IAS is shown on the dial of the instrument, uncorrected for instrument or system errors.

2.Calibrated Airspeed (CAS)

CAS is the speed at which the aircraft is moving through the air, which is found by correcting IAS for instrument and position errors. The POH/AFM has a chart or graph to correct IAS for these errors and provide the correct CAS for the various flap and landing gear configurations.

3. Equivalent Airspeed (EAS)

EAS is CAS corrected for compression of the air inside the Pitot tube. EAS is the same as CAS in standard atmosphere at sea level. As the airspeed and pressure altitude increase, the CAS becomes higher than it should be, and a correction for compression must be subtracted from the CAS.

4. True Airspeed (TAS)

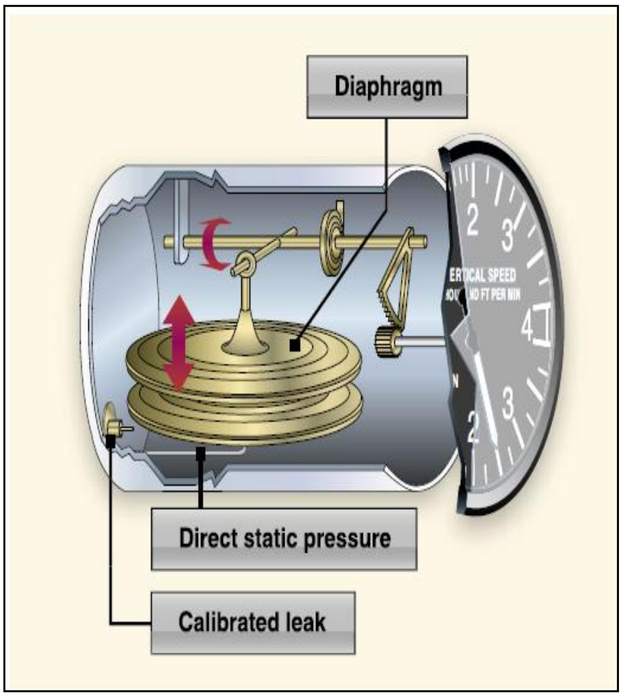
TAS is CAS corrected for nonstandard pressure and temperature. TAS and CAS are the same in standard atmosphere at sea level. Under nonstandard conditions, TAS is found by applying a correction for pressure altitude and temperature to the CAS. Some aircraft is equipped with true ASIs that have a temperature-compensated aneroid bellows inside the instrument case. This bellows modifies the movement of the rocking shaft inside the instrument case so the pointer shows the actual TAS. The TAS indicator provides both true and IAS. These instruments have the conventional airspeed mechanism, with an added subdial visible through cut-outs in the regular dial. A knob on the instrument allows the pilot to rotate the subdial and align an indication of the outside air temperature with the pressure altitude being flown. This alignment causes the instrument pointer to indicate the TAS on the subdial.

AIR DATA SYSTEMS AND AUTOPILOT

Vertical speed

Vertical Speed Indicator (VSI)

The VSI, which is sometimes called a vertical velocity indicator (VVI), indicates whether the aircraft is climbing, descending, or in level flight. The rate of climb or descent is indicated in feet per minute (fpm). If properly calibrated, the VSI indicates zero in level flight.



Vertical Speed Indicator

Principle of Operation

Although the VSI operates **solely from static pressure, it is a differential pressure instrument.** It contains a diaphragm with connecting linkage and gearing to the indicator pointer inside an airtight case. The inside of the diaphragm is connected directly to the static line of the pitot-static system. The area outside the diaphragm, which is inside the instrument case, is also connected to the static line, but through a restricted orifice (calibrated leak).

Both the diaphragm and the case receive air from the static line at existing atmospheric pressure.

The diaphragm receives unrestricted air while the case receives the static pressure via the metered leak. When the aircraft is on the ground or in level flight, the pressures inside the diaphragm and the instrument case are equal and the pointer is at the zero indication. When the aircraft climbs or descends, the pressure inside the diaphragm changes immediately, but due to the metering action of the restricted passage, the case pressure remains higher or lower for a short time, causing the diaphragm to contract or expand. This causes a pressure differential that is indicated on the instrument needle as a climb or descent.

When the pressure differential stabilizes at a definite ratio, the needle indicates the rate of altitude change.

The VSI displays two different types of information:

1. Trend information shows an immediate indication of an increase or decrease in the aircraft's rate of climb or descent.
2. Rate information shows a stabilized rate of change in altitude.

The trend information is the direction of movement of the VSI needle. For example, if an aircraft is maintaining level flight and the pilot pulls back on the control yoke causing the nose of the aircraft to pitch up, the VSI needle moves upward to indicate a climb. If the pitch attitude is held constant, the needle stabilizes after a short period (6–9 seconds) and indicates **the rate of climb in hundreds of fpm.**

The time period from the initial change in the rate of climb, until the VSI displays an accurate indication of the new rate, is called the lag. Rough control technique and turbulence can extend the lag period and cause erratic and unstable rate indications.

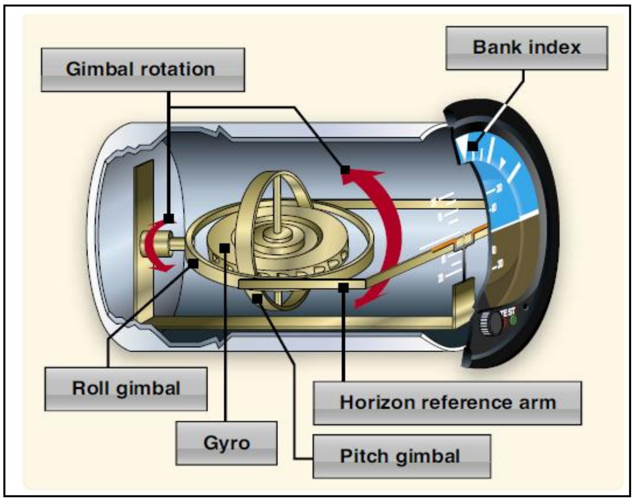
Attitude Indicator

The attitude indicator, with its miniature aircraft and horizon bar, displays a picture of the **attitude of the aircraft**. The relationship of the miniature aircraft to the horizon bar is the same as the relationship of the real aircraft to the actual horizon. The instrument gives an instantaneous indication of even the smallest changes in attitude.

The gyro in the attitude indicator is mounted in a horizontal plane and depends upon rigidity in space for its operation. The horizon bar represents the true horizon. This bar is fixed to the gyro and remains in a horizontal plane as the aircraft is pitched or banked about its lateral or longitudinal axis, indicating the attitude of the aircraft relative to the true horizon.

The gyro spins in the horizontal plane and resists deflection of the rotational path. Since the gyro relies on rigidity in space, the aircraft actually rotates around the spinning gyro.

An adjustment knob is provided with which the pilot may move the miniature aircraft up or down to align the miniature aircraft with the horizon bar to suit the pilot's line of vision. Normally, the miniature aircraft is adjusted so that the wings overlap the horizon bar when the aircraft is in straight-and-level cruising flight. The pitch and bank limits depend upon the make and model of the instrument. Limits in the banking plane are usually from 100° to 110°, and the pitch limits are usually from 60° to 70°.



If either limit is exceeded, the instrument will tumble or spill and will give incorrect indications until realigned. A number of modern attitude indicators do not tumble.

Most banking scale indicators on the top of the instrument move in the same direction from that in which the aircraft is actually banked. Some other models move in the opposite direction from that in which the aircraft is actually banked. This may confuse the pilot if the indicator is used to determine the direction of bank. This scale should be used only to control the degree of desired bank. The relationship of the miniature aircraft to the horizon bar should be used for an indication of the direction of bank. The attitude indicator is reliable and the most realistic flight instrument on the instrument panel. Its indications are very close approximations of the actual attitude of the aircraft.

Air Data Systems And Autopilot

Mach Number

MACH NUMBER

As an aircraft approaches the speed of sound, the air flowing over certain areas of its surface speeds up until it reaches the

speed of sound, and shock waves form. The IAS at which these conditions occur changes with temperature. Therefore, in this case, airspeed is not entirely adequate to warn the pilot of the impending problems. Mach number is more useful.

Mach number is the ratio of the TAS of the aircraft to the speed of sound in the same atmospheric conditions. An aircraft flying at the speed of sound is flying at Mach

1.0. Some older mechanical Mach meters not driven from an air data computer use an altitude aneroid inside the instrument that converts pitot-static pressure into Mach number.

These systems assume that the temperature at any altitude is standard; therefore, the indicated Mach number is inaccurate whenever the temperature deviates from standard. These systems are called indicated Mach meters.

Modern electronic Mach meters use information from an air data computer system to correct for temperature errors. These systems display true Mach number.

Mach Indicator

Most high-speed aircraft are limited to a maximum Mach number at which they can fly. This is shown on a Mach meter as a decimal fraction. if the Mach meter indicates .83 and the aircraft is flying at 30,000 feet where the speed of sound under standard conditions is 589.5 knots, the airspeed is 489.3 knots. The speed of sound varies with the air temperature.

If the aircraft were flying at Mach .83 at 10,000 feet where the air is much warmer, its airspeed would be 530 knots.

Maximum Allowable Airspeed

Some aircraft that fly at high subsonic speeds are equipped with maximum allowable ASIs like the one in Figure.

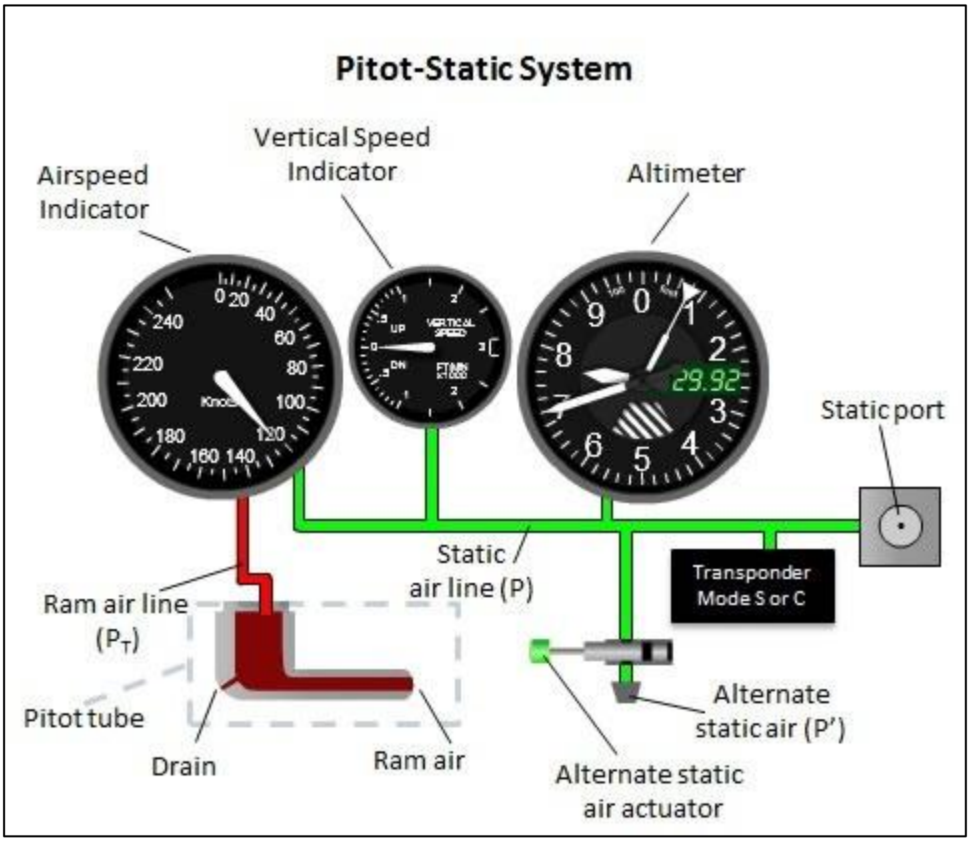
This instrument looks much like a standard air-speed indicator, calibrated in knots, but has an additional pointer colored red, checkered, or striped. The maximum airspeed pointer is actuated by an aneroid, or altimeter mechanism, that moves it to a lower value as air density decreases. By keeping the airspeed pointer at a lower value than the maximum pointer, the pilot avoids the onset of transonic shock waves.

Airspeed Indicator

5. Total air temperature

Total Air Temperature (TAT)

If temperature is measured by means of a sensor positioned in the airflow, kinetic heating will result, raising the temperature measured above the OAT. The temperature measured in this way is known as the Total Air Temperature (TAT) and is used in ADCs to calculate True Airspeed (TAS). Careful design and sitting of the TAT probe is necessary to ensure accurate measurement of TAT.



Total Air Temperature Indicator

In aviation, stagnation temperature is known as total air temperature and is measured by a temperature probe mounted on the surface of the aircraft. The probe is designed to bring the air to rest relative to the aircraft. As the air is brought to rest, kinetic energy is converted to internal energy. The air is compressed and experiences an adiabatic increase in temperature. Therefore total air temperature is higher than the static (or ambient) air temperature.

Total air temperature is an essential input to an air data computer in order to enable computation of static air temperature and hence true airspeed.

What is Air Temperature?

- Temperature is a measure of the kinetic (motion) energy of air molecules
  - K.E. = $\frac{1}{2}mv^2$ m = mass, v = velocity
  - So…temperature is a measure of air molecule speed
- The sensation of warmth is created by air molecules striking and bouncing off your skin surface
  - The warmer it is, the faster molecules move in a random fashion and the more collisions with your skin per unit time

FORMULAS

TOTAL AIR TEMPERATURE

- $TT = \dfrac{\text{Indicated Total Air Temp + Total Air Temp Error Corr. Due to Wire Resistance}}{\text{1- 0.2 * Computer Mach Number Squared}}$

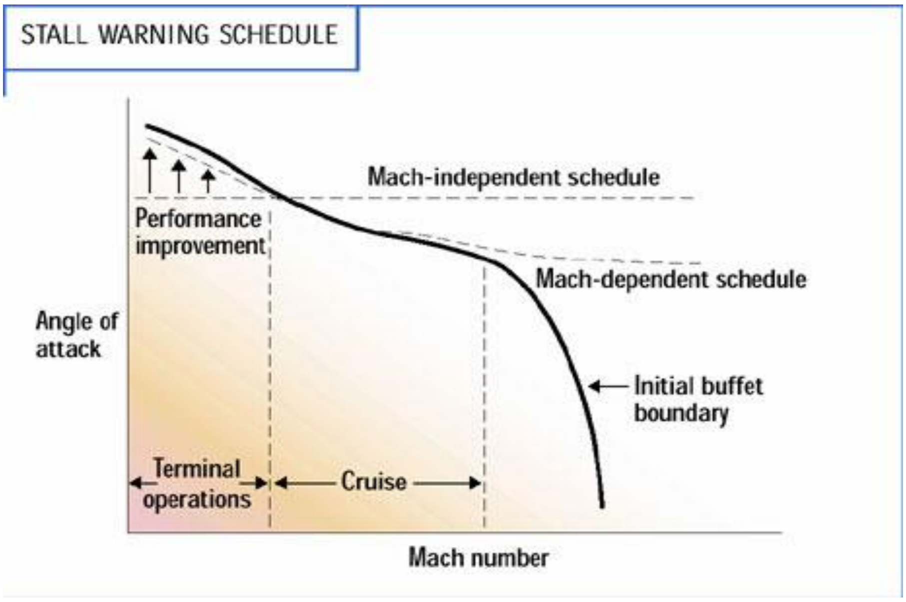
STATIC AIR TEMPERATURE

- $TS = \dfrac{\text{Total Air Temp}}{\text{1+ 0.2 * Computer Mach Number Squared}}$

TOTAL AIR TEMPERATURE

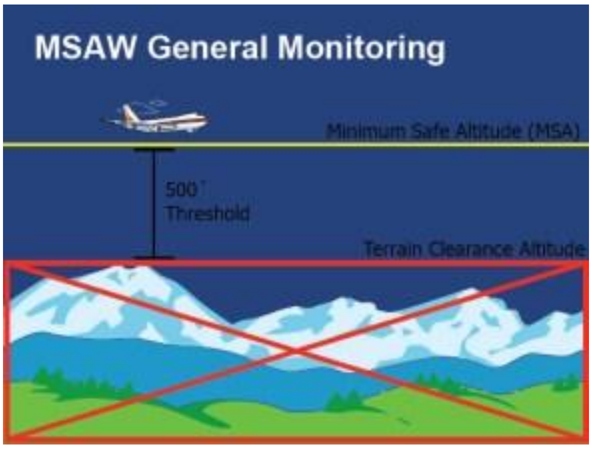
- Δtw Total air temperature error correction due to resistance of the nominal length of wiring between the probe and the air data computer (degrees).
- TTi Indicated total air temperature - the total air temperature as measured at the input terminals of the air data computer (degrees absolute).

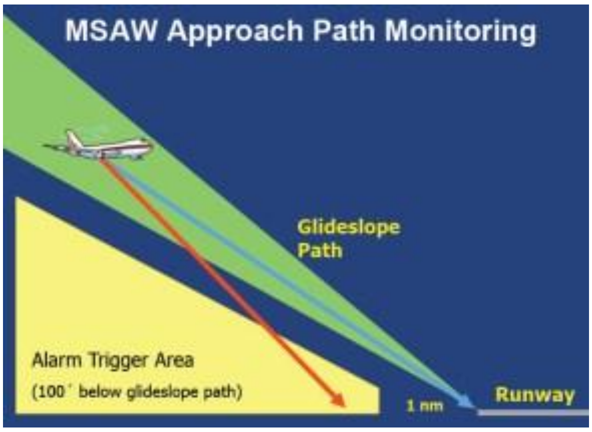
6. Mach warning, Altitude warning



Minimum Safe Altitude Warning (MSAW)

Minimum Safe Altitude Warning (MSAW) is a system designed to aid air traffic controllers to advise pilots when their aircraft appears to be at risk of colliding into terrain or obstacles. It is a computer system that projects the recent track history of a flight and compares that projection to a terrain model built into the computer database. When the projection indicates a hazard, the system generates alarms (visual and/or audible) to the controller, who then uses standard phraseology to alert the flight crew. For example, a landing aircraft who appears to have descended too early might hear: **"Low altitude alert. Check your altitude immediately. The (airport name) Decision Height is 1,200 feet."**





MSAW has two flight monitoring functions. General Monitoring protects flights from descending too low while flying en route, while Approach Path Monitoring protects aircraft flying charted approach procedures. To be functional, accurate digital terrain maps must be built into the computer database. The system is designed to trigger alerts with a buffer of 500′ above terrain (or obstacles such as antennas), and 100′ below the designed glide path for arrivals.

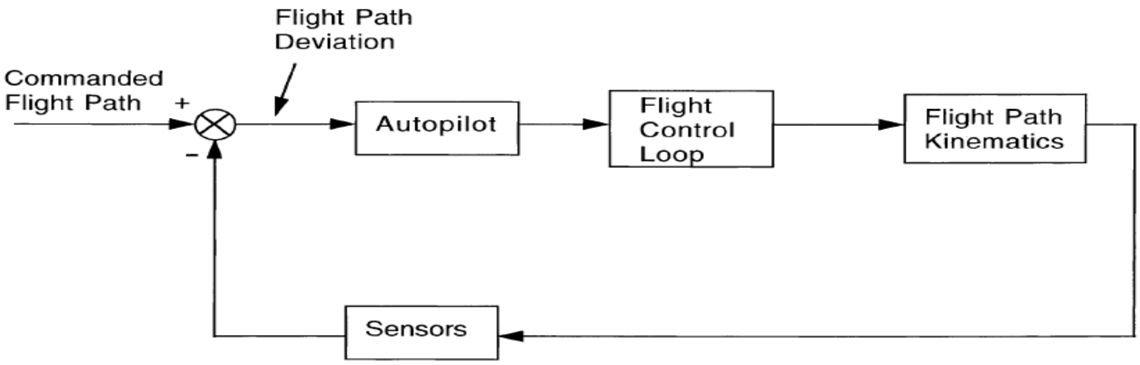
7. Auto pilot-Basic principles

Integrated Flight Control System

The integrated flight control system integrates and merges various systems into a system operated and controlled by one principal component.

Autopilot Concepts

An autopilot can be capable of many very times intensive tasks, helping the pilot focus on the overall status of the aircraft and flight. Good use of an autopilot helps automate the process of guiding and controlling the aircraft. Autopilots can automate tasks, such as maintaining an altitude, climbing or descending to an assigned altitude, turning to and maintaining an assigned heading, intercepting a course, guiding the aircraft between waypoints that make up a route programmed into an FMS, and flying a precision or non-precision approach.



Many advanced avionics installations really include two different, but integrated systems. One is the autopilot system, which is the set of servo actuators that actually do the control movement and the control circuits to make the servo actuators move the correct amount for the selected task. The second is the flight director (FD) component. The FD is the brain of the autopilot system. Most autopilots can fly straight and level. When there are additional tasks of finding a selected course (intercepting), changing altitudes, and tracking navigation sources with cross winds, higher level calculations are required.

The FD is designed with the computational power to accomplish these tasks and usually displays the indications to the pilot for guidance as well. Most flight directors accept data input from the air data computer (ADC), Attitude Heading Reference System (AHRS), navigation sources, the pilot's control panel, and the autopilot servo feedback, to name some examples. The downside is that you must program the FD to display what you are to do. If you do not pre-program the FD in time, or correctly, FD guidance may be inaccurate.

The programming of the FD increases the workload for the pilot. If that increased workload is offset by allowing the autopilot to control the aircraft, then the overall workload is decreased. However, if you elect to use the FD display, but manually fly the aircraft, then your workload is greatly increased. In every instance, you must be absolutely sure what modes the FD/autopilot is in and include that indicator or annunciator in the crosscheck. You must know what that particular mode in that specific FD/autopilot system is programmed to accomplish, and what actions will cancel those modes. Due to numerous available options, two otherwise identical aircraft can have very different avionics and autopilot functional capabilities.

How to Use an Autopilot Function

The following steps are required to use an autopilot function:

1. Specify desired track as defined by heading, course, series of waypoints, altitude, airspeed, and/or vertical speed.

2. Engage the desired autopilot function(s) and verify that, in fact, the selected modes are engaged by monitoring the annunciator panel.

3. Verify that desired track is being followed by the aircraft.

4. Verify that the correct navigation source is selected to guide the autopilot’s track.

5. Be ready to fly the aircraft manually to ensure proper course/clearance tracking in case of autopilot failure or mis-programming.

6. Allow the FD/autopilot to accomplish the modes selected and programmed without interference, or disengage the unit. Do not attempt to “help” the autopilot perform a task. In some instances this has caused the autopilot to falsely sense adverse conditions and trim to the limit to accomplish its tasking. In more than a few events, this has resulted in a total loss of control and a crash.

8. Longitudinal Autopilot

Autopilot Concepts

An autopilot can be capable of many very times intensive tasks, helping the pilot focus on the overall status of the aircraft and flight. Good use of an autopilot helps automate the process of guiding and controlling the aircraft. Autopilots can automate tasks, such as maintaining an altitude, climbing or descending to an assigned altitude, turning to and maintaining an assigned heading, intercepting a course, guiding the aircraft between waypoints that make up a route programmed into an FMS, and flying a precision or non-precision approach.

1. **Basic longitudinal autopilot systems**

We will now examine how we can hold the pitch attitude, the altitude, the airspeed and the climb/descent rate constant.

Holding the pitch attitude

The pitch attitude hold mode prevents pilots from constantly having to control the pitch attitude. Especially in turbulent air, this can get tiring for the pilot. This system uses the data from the vertical gyroscope as input (feedback). It then controls the aircraft through the elevators. To be more precise, it sends a signal to the SAS, which then again uses this as a reference signal to control the servo. An overview of the system can be seen in figure 1.

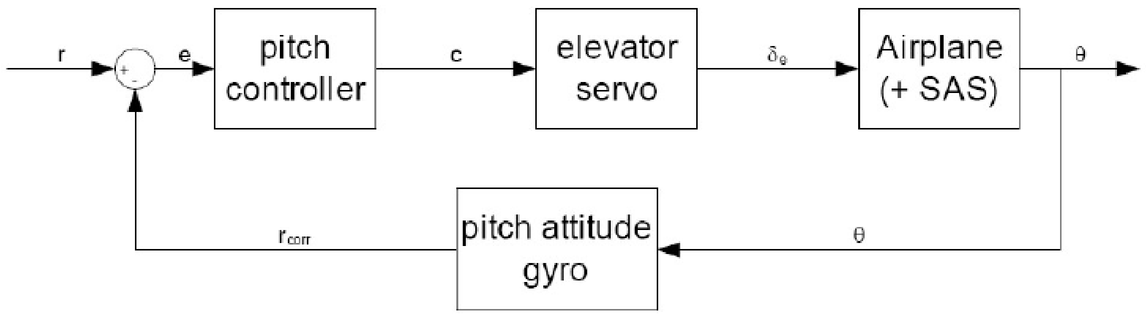


Figure 1: An overview of the pitch attitude holding system.

The relations used for this are

$$H_{gyro}(s) \approx 1 \qquad \text{and} \qquad H_{servo}(s) \approx \frac{1}{\tau_{servo}s + 1}.$$

Holding the altitude

The altitude hold mode prevents pilots from constantly having to maintain their altitude. The input (feedback) comes from the altimeter. The system then uses the elevator to control the altitude. The way in which the altimeter is modeled depends on the type of altimeter. For a radar or GPS altimeter, we use $H_{altimeter}$ _ 1. However, for a barometric altimeter, we include a lag. Thus,

$$H_{altimeter}(s) \approx \frac{1}{\tau_{altimeter}s + 1}.$$

The reference value of the height h is set in the mode control panel. To control h, we must have some expression for h in our aircraft model. But h isn't one of the parameters in the basic state space model of the aircraft. So, we need to derive an expression for it. This is done,using

$$\dot{h} = V \sin\gamma \approx V\gamma \qquad \Rightarrow \qquad h(s) = \frac{V}{s}\gamma(s) = \frac{V}{s}\left(\theta(s) - \alpha(s)\right).$$

When a constant gain is used for the altitude controller, the phugoid may become unstable.

Holding the airspeed

The airspeed hold mode holds certain airspeed. It uses the airspeed sensor as input and it controls

the throttle. Of course, we need to model the airspeed sensor. For GPS airspeed calculations, we can use HV □sensor(s) _ 1. However, if we use a pitot-static tube, then we use

$$H_{V-sensor}(s) \approx \frac{1}{\tau_{V-sensor}s + 1}.$$

Next to the sensor, there is also the engine servo and the engine itself. Both have a bit of lag. We thus model them as

$$H_{servo}(s) = \frac{1}{\tau_{servo}s + 1} \qquad \text{and} \qquad H_{engine}(s) = \frac{\Delta T(s)}{\delta_T(s)} = K_T \frac{1}{\tau_{engine}s + 1}.$$

Holding the climb or descent rate

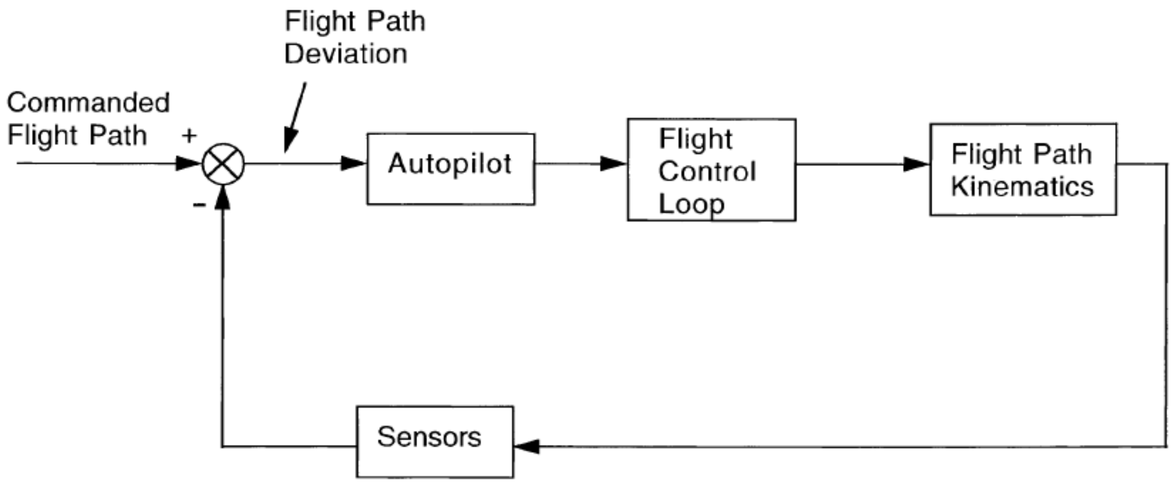
The flight path angle hold mode is similar to the pitch attitude hold mode. However, this time the flight path angle/climb rate is kept constant. As input (feedback), the flight path angle is Y used.

However, Y can't be measured directly. So, we use Y= Φ - α can be measured using a gyro, while α follows from an angle of attack sensor. The flight path angle hold mode eventually uses the elevators to control the flight path angle.

9. Lateral autopilot

Autopilot Concepts

An autopilot can be capable of many very times intensive tasks, helping the pilot focus on the overall status of the aircraft and flight. Good use of an autopilot helps automate the process of guiding and controlling the aircraft. Autopilots can automate tasks, such as maintaining an altitude, climbing or descending to an assigned altitude, turning to and maintaining an assigned heading, intercepting a course, guiding the aircraft between waypoints that make up a route programmed into an FMS, and flying a precision or non-precision approach.



Many advanced avionics installations really include two different, but integrated systems. One is the autopilot system, which is the set of servo actuators that actually do the control movement and the control circuits to make the servo actuators move the correct amount for the selected task. The second is the flight director (FD) component. The FD is the brain of the autopilot system. Most autopilots can fly straight and level. When there are additional tasks of finding a selected course (intercepting), changing altitudes, and tracking navigation sources with cross winds, higher level calculations are required.

BASIC LATERAL AUTOPILOT SYSTEMS

It is time to turn our attention to lateral motion. How do we hold the roll angle, the coordinated roll angle and the heading angle constant?

The roll angle hold mode

The roll angle hold mode prevents the pilot from constantly having to adjust/control the roll angle during a turn. It uses the roll angle gyro as sensor and it effects the ailerons. The roll angle gyro and the aileron servo are again modeled as

$$H_{gyro}(s) \approx 1 \qquad \text{and} \qquad H_{servo}(s) \approx \frac{1}{\tau_{servo}s + 1}.$$

The roll angle that is used as reference angle is denned on the mode control panel.

When modelling the aircraft, it is often assumed that rolling is the only degree of freedom. This reduced model significantly simplifies matters.

The coordinated roll angle hold mode

The coordinated roll angle hold mode is an extension of the roll angle hold mode. It also tries to make sure that the sideslip angle β is equal to zero. This should result in a coordinated turn, thus giving the aircraft less drag and the passengers more comfort. The coordinated roll angle hold mode uses the sideslip sensor as input (feedback). (That is, in addition to the roll angle gyro that was already used in the roll angle hold mode.) It then sends a signal to the rudder. (In addition to the signal to the aileron that was already present.)

The sideslip sensor is modeled as H_{β}sensor(s) = 1. We don't have to model the rudder servo anymore, as this was already incorporated in the inner-loop SAS. (To be more precise, in the yaw damper.) The sideslip angle β that is used as reference input is always simply zero: we do not want any sideslip in a coordinated turn.

The heading angle control mode

The heading angle control mode controls the heading. It does this by giving the aircraft a roll angle. In fact, it sends a signal to the (coordinated) roll angle hold mode, telling it which roll angle the aircraft should have. This roll angle is maintained until the desired heading is achieved. As sensor, this system uses the directional gyro, modeled as $H_{gyro}(s) = 1$. Its output effects the ailerons. (The latter is evident, since the system controls the roll angle hold mode.)

The reference angle ψ is denoted by the pilot, through the mode control panel. There is, however, a problem. In our aircraft model, we don't have as one of the state parameters. To find it, we can use the equation

$$\dot{\psi} = q\frac{\sin\phi}{\cos\theta} + r\frac{\cos\phi}{\cos\theta}.$$

Degree	UG / B.E.
Course	Aeronautical Engineering
Year /Sem	IV / VII
Subject Name	Avionics
Subject Code	14BEAR705

Questions	a	b	c	d	answers
Avionics is the combination of ____________	Airline and Electronics	Aviation and Electronics	Aircraft and Electrical	Aviation and Electrical	Aviation and Electronics
Navigation system is used to ____________	Traffic control	Communication	Weather detection	Find position and direction	Find position and direction
During the First World War __________ technology is used for communication.	wireless	Dopple	Radio	RADAR	wireless
DME stands for _________	Distance measuring equipment	Distance monitoring equipment	Direct measuring equipment	Doppler monitoring equipment	Distance measuring equipment
Following one is the type of navigation system	Medium frequency	pilotage	High frequency	Low frequency	pilotage
Electronic Warfare is mainly used to search the ___________	Communication signals	Ultrasonic waves	Sound waves	Radio frequency band	Radio frequency band
In communication system __________ is used as a transmitter links.	fiber	iron	mica	Silver	fiber
__________ memory is require a power to maintain the stored information.	Non volatile	virtual	protected	volatile	volatile
In communication system _______ is used to convert the natural signal into an electrical signal.	antenna	compressor	Transducer	generator	Transducer
Fly-By-Wire system sends the information in the form of ____________	Electrical signals	Analog signals	Radio signals	Sky waves	Electrical signals
Loran stands for____________	Lost range navigation	Low range navigation	Least range navigation	Long range navigation	Long range navigation
Satellites are used in ____________	Global positioning system	Global point system	Global plane system	Galaxy l positioning system	Global positioning system
Localizer is used in ___________	ILS	IOP	IAP	ISI	ILS
Doppler is used for ___________ communication.	Long range	Short range	Medium range	Pilotage	Long range
The signal using dots and dashes is called ____________.	Analog signal	Morse signal	Digital signal	Radio signal	Morse signal
ATC stands for ___________.	Air Traffic Control	Aviation Transport Control	Air Transport Control	Air Traffic Control	Air Traffic Control
Sky wave propagation is suitable for ____________	Very high frequency	Medium frequency	low frequency	High frequency	High frequency
VOR stands for____________	Very High Frequency Omni range	Very High distance Omni range	Very High signal Omni range	Very low FrequencyOmni range	Very High Frequency Omni range
ADF is used in ____________	Communication system	Navigation system	ILS	GPS	Navigation system
Doppler RADAR uses the _____________	Microwave signal	Digital signal	Direct signal	Pulse signal	Microwave signal
Critical frequency is the ____________ frequency of the radio wave.	minimum	maximum	Maximum usable	medium	maximum
RADAR stands for ____________	Radio organization	Radio detection and ranging	Radio development organization	Radio communication	Radio detection and ranging
Another name for primary surveillance RADAR is _______________	Mirror image radar	Low frequency radar	Skin paint radar	INR	Skin paint radar
ADF is used in _______________	Communication system	Navigation system	ILS	GPS	Navigation system
In communication system receiver contains ______________	IN	Doppler	Sensitive amplifier	Loud speaker	Sensitive amplifier
INS system contains ______________	Gyros and sensitive accelerometer	Doopler radar	Primary surveillance radar	holes	Gyros and sensitive accelerometer
FBW system first introduced in ________Aircraft	YF-16	cessna	Sukai	vikas	YF-16
Primary memory stored in secondary memory is called _____________	ROM	PROM	Virtual memory	Flash memory	Virtual memory
Instrument Landing System consist of_____________	localizer	slope	Doppler	Gyros	localizer
AIRCOM stands for	Air computers	Airbone communication	Air communication services	Air computation	Air communication services
SITA stands for	Society international telecommunication	Satellite international telecommunication	society international topographic aeronautics	None of the given option	aeronautics
VHF stands for	Very high flow	Varying high frequency	Very high frequency	Vertical high frequency	Very high frequency
___________is form of a semi-conductor device.	intrinsic	doping	junction	pole	intrinsic
Doping is a process of adding	ions	Electric field	Foreign atoms	cells	Foreign atoms
__________is a separate bits of semiconductor in use.	p-type	c-type	b-type	c-type	p-type
__________ diode is designed to operate in reverse direction.	rectifier	zener	ideal	real	zener
The principle element of a radar transmitter is	duplexer	receiver	Magnetron tube	mixer	Magnetron tube
_____________ is a electronic switching device.	duplexer	receiver	indicator	mixer	duplexer
___________ type memory, that can only read.	ROM	PROM	RAM	EPROM	ROM
CCV stands for	coupled circuit voltage	Closed circuit voltage	Closed current voltage	coupled current voltage	Closed circuit voltage
RLG is a form of _________ technology.	Radar	airborne	strap down	laser	strap down
_________stores energy in analog radar systems.	duplexer	synchronizer	indicator	mixer	mixer
CDS stands for ____________	Co-Pilot display unit	Co-Pilot decision unit	Co-Pilot direction unit	Co-Polar display unit	Co-Pilot display unit
SAS is used for ____________	Stability and control of aircraft	Only stability	augmentation	storage	Stability and control of aircraft
SATCOM stands for _______________	Scale communication	Satellite vision communication	Satellite communication	Scalar communication	Satellite communication
___________ provides timing for radar signals.	duplexer	synchronizer	indicator	mixer	synchronizer
Air and fuel have dielectrics of approximately	unity and zero respectively	unity and unity respectively	unity and two respectively	two and unity respectively	unity and zero respectively
When fuel level decreases, the capacitance of the fuel quantity sensor	decreases and the reactance increases	becomes zero	increases and the reactance increases	increases and the reactance decreases.	increases and the reactance increases
Under-wing fuel quantity measurements are used during	level flight	Cruise	all flight conditions	ground servicing only.	ground servicing only.
A high-intensity white fl ash is produced from a	strobe light	cabin light	fluorescent tube	landing light.	landing light.

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Questions	a	b	c	d	answers
A clear (white) light with a divergence of ± 70 degrees either side of aircraft centreline is the	landing light	Forward position light	rear position light	logo light.	rear position light
Anti-collision lights can be provided by	rotating beacon	strobe lights	fluorescent tubes	retractable assembly.	retractable assembly.
Green or blue lights in the instrument panel indicate	a safe condition exists	a pleasant condition ex	an unsafe condition e:	an abnormal condition exists.	a safe condition exists
Flood lighting in the fl ight compartment is normally from	strobe lights	Sodium Vapour lamps	incandescent lamps	position lights.	incandescent lamps
Sealed quartz or glass tubes fi lled with xenon gas are called:	luorescent tubes	CFL	LEDs	strobe lights	strobe lights
The starboard wing tip navigation light has the following colour and divergence:	red and 110 degrees	blue and 110 degrees	green and 110 degrees	white and ± 70 degrees.	red and 110 degrees
Anti-collision lights are used in conjunction with the:	master warning lights	Engine inspection light	wing inspection lights	navigation lights.	wing inspection lights
Red warning lights in the instrument panel indicate the existence of:	unsafe conditions	Normal Conditions	abnormal conditions	safe conditions.	safe conditions.
Master caution and warning lights are located on the	lower instrument panel	Side panel	upper instrument panel	overhead panel.	lower instrument panel
Multiplexing is a technique used for	increasing the amount of	decreased immunity to	reducing the amount c	Increased immunity to electromagnet	reducing the amount of IFE wiring
Fibre optic cable bends need to have a suffi ciently large radius to:	minimize losses and damage	miminize immunity to	maximize immunity t	accurately align the connector	accurately align the connector
ACM outlet temperature is measured using	a Bourdon tube	sensor	an RTD	a thermocouple.	a Bourdon tube
The Iridium network allows voice and data messages to be routed	anywhere in the world	between the fl ight crew	between the fl ight crew a	via a fi bre optic network	between the fl ight crew and cabin crew
The passenger address (PA) system is primarily a safety system that provides passengers with	in-fl ight entertainment	increased amount of IF	reduced amount of IF	voice announcements and chime signals.	voice announcements and chime signals.
To assist ram air recovery, some aircraft use:	modulating vanes on the r	modulating vanes on tl	modulating vanes on the	modulating vanes on the ACM outlet.	modulating vanes on the ram air exhaust
Satellite communication systems use a low earth orbit to:	provide greater coverage	maximize voice delays.	maintain a geostationary	minimize voice delays.	maintain a geostationary position
Audio-video on demand (AVOD) entertainment enables passengers to:	stop a programme	send voice message via	make phone calls via	ignore PA system voice announcements	ignore PA system voice announcements
Supplemental oxygen is generally required fl ight operations above	3000 ft	30000 ft	10,000 ft	sea level.	3000 ft
The optical fi bre receiver unit consists of a photodiode or phototransistor that passes a:	negligible current when not	no current when not ill	high current when not ill	low current when not illuminated.	high current when not illuminated
The gasper fan is used in cabin ventilation systems to:	increase air pressure in the ai	increase oxygen	re-circulate filtered cabi	assist with ram air recovery.	assist with ram air recovery.
Cabin altitude is typically	cruising altitude	between 2000–7000 fe	sea level	between 6000–7000 feet	cruising altitude
The cargo compartment is normally pressorized to be	equal to cabin pressure	zero pressure	above cabin pressure	below cabin pressure.	above cabin pressure
The iridium system satellite orbits are	random	bi-polar.	equatorial	polar.	polar.
Indications of landing gear fully down and locked are	red lights on, green lights of	red lights on, blue ligh	red lights on, green light	red lights off, green lights on.	red lights on, green lights off
Two state conditions include	flap position on doors	slot position on doors	landing gear (up or do	control surface position	landing gear (up or down) on doors
An electrical fl ap drive system uses a:	reversible DC motor	bidirectional DC motor	variable speed DC moto	unidirectional DC motor	unidirectional DC motor
Level 3 ECAM failures are indicated by:	requiring immediate crew ac	requiring pilot attention	requiring crew attention	no immediate impact on the aircraft.	requiring immediate crew action
Variable position features include:	doors (open or closed) and fl	heat sensor position	proximity sensor positio	control surface and proximity sensor position	proximity sensor position
When an electrically operated landing gear is fully retracted, the up-lock switch contacts:	open, thereby removing pow	close, thereby removing	close, thereby removing p	open, thereby applying power to the motor	open, thereby applying power to the motor
Engine fire or loss of cabin pressure would be displayed on ECAM as:	level 3 failures	level 4 failures	level 2 failures	level 1 failures.	level 3 failures
Two state position devices include:	micro switches and variable	proximity sensors	synchros and proximity s	micro switches and proximity sensors.	synchros and proximity sensors
Electrically driven fl aps continue to travel until they are:	fully retracted	the down-limit switch	fully extended	the up-limit switch is operated.	the up-limit switch is operated.
Variable position devices include	synchros and variable resi:	synchros and constai	micro switches and va	synchros and proximity sensors.	synchros and variable resistors
Stall warning systems provide the crew with a clear and distinctive warning:	before the stall is reached	at high angles of attack	after the stall is reached	at all angles of attack.	after the stall is reached
When an ultrasonic ice detector probe accumulates ice, it vibrates at a:	higher frequency	zero frequency	lower frequency	constant frequency	constant frequency
The stall identifi cation system contains an actuator that:	maintains the angle of attack	maintains the angle of	pulls the control column	pushes the control column forward	maintains the angle of attack
When not in use, pneumatic de-icing boots are	inflated and kept flush wit	cycled when required	deflated and kept flush w	cycled on a periodic basis.	
When the AoA reaches a certain angle, the airfl ow over the wing:	the lift is dramatically decre	cycled when at high sp	the lift is dramatically de	the lift is dramatically increased.	the lift is dramatically increased.
When a wheel is approaching a skid condition, this is detected when the speed is:	decreasing at a given rate	increasing at a given r	increasing at a given rate	constant.	decreasing at a given rate
At normal angles of attack, the vane sensor is held	back by spring pressure agai	back by spring pressure	forward by the airfl ow a	back by the airfl ow against spring pressure.	forward by the airfl ow against spring pressure
An angle of attack (AoA) sensor vane aligns itself with the	boundary layer	air inlet	prevailing airstream	stagnation point.	stagnation point.
When airfl ow passes over the wing without breaking up, it is said to have a:	boundary layer	turbulent flow	streamline airflow	stalled airflow.	boundary layer
The action of twisting a fire handle closes micro- switches that	activate the engine fire exting	shuts off the engine	cancels the alarm	shuts off the fuel.	cancels the alarm
When eutectic salt melts, the resistance between the centre wire and outer sheath:	drops very rapidly	becomes zero	increases very rapidly	the control unit signals a warning.	the control unit signals a warning.

Open area smoke detectors rely on the transfer of particulate matter from the source	convection	electricity	radiation	conduction.	convection
Dual-loop fi re detector systems can be confi gured to only go into alarm if:	both loops sense fire	decreasing the probabil	either loop senses fire	increasing the probability of a false warning.	either loop senses fire
Multiple bimetallic overheat detectors are connected in parallel to provide:	variable alarm temperatures	increased oxygen leve	increased detection pro	linear fire detection.	linear fire detection.
A discharge plug on the aircraft fuselage provides confi rmation that the fi re extinguisher:	is fully pressurized	is partiallypressurized	squib is still intact	has been fired.	is fully pressurized
When a pneumatic fi re detector is rapidly heated; hydrogen is liberated causing:	sufficient gas pressure	the integrity switch to	the integrity switch to op	the alarm switch to reset.	the integrity switch to open
Photoelectric smoke detectors measure	light attenuation	absorption of beta part	radiated heat within a c	absorption of alpha particles within a chamber.	absorption of alpha particles within a chamber.

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When a thermistor sensor is heated, the resistance of the insulating material:	decrease because of its negative tempe	increases because of its positive temperature	decreases because of its positive temperature	increases because of its negative temperature	decrease because of its negative temperature
To operate an engine fi re extinguisher, the fi re handle is:	twisted	pulled	twisted and then pulled	pulled and then twisted.	twisted and then pulled
A terrain awareness display is only required for:	Class A TAWS	GlWS.	Class-B TAWS	GPWS.	GPWS.
Mode 1 terrain awareness cautions are given for:	altitude loss after take-off	altitude callout at 500 m	excessive descent rate	altitude callout at 500 feet.	altitude loss after take-off
When approaching a microburst, it creates:	a decrease in headwind	an increase in low wind	an increase in headwind	a temporary increase of airspeed and lift	an increase in headwind
Warning alerts are given for a terrain threat that requires:	immediate crew awareness	immediate pilot action.	confirmation with air traffic control	immediate crew action.	immediate crew action.
Red areas are used on TAWS displays to indicate terrain that is:	above the aircraft's current altitude	1000m above the aircraft's current altitude	level with the aircraft's current altitude	safe in terms of required terrain clearance.	above the aircraft's current altitude
Mode 7 (wind shear) is normally inhibited:	above 50 feet radio altitude	during landing	below 50 feet radio altitude	during take-off and landing	below 50 feet radio altitude
The TAWS computer function creates a four- dimensional situation comprising	latitude, longitude, heading and time	latitude, longitude and time.	latitude, speed, altitude and time	latitude, longitude, altitude and time.	latitude, longitude, altitude and time.
GPWS Mode 3 is defi ned as	Excessive terrain closure rate	Excessive terrain rate	altitude loss after take off or go around	excessive descent below the glide slope	Excessive terrain closure rate
_________flag is set if a negative signal is received in microprocessor.	zero	sign	null	parity	sign
An 8- bit Microprocessor signifies that it has	8- bit address bus	8- bit control bus	8- bit data bus	None of these	8- bit address bus
Microprocessors are	Programmable	General purpose	Single chip CPU	All the above	General purpose
Microprocessor contains	Control and arithmetic unit	RAM, ROM	peripherals	all the above	peripherals
The register which keeps track of the execution of program is	program counter	Stack pointer	Instruction Register	Accumulator	program counter
OCV stands for …………..	Open circuit voltage	Overall circuit voltage	Open current voltage	Overall current voltage	Open current voltage
LRU stands for	Link replaceable unit	Line replaceable unit	Linear replaceable unit	Line resisting unit	Line replaceable unit
IR stands for	Internal resistance	Inner resistance	Internal ratio	Internal reluctance	Internal resistance
Erasable memory is	RAM	ROM	PROM	EPROM	EPROM
If arithmetic operation is zero ____________ flag is set in microprocessor	zero	Sign	null	parity	zero
One of the following memories can do read operation only.	EPROM	RAM	PROM	ROM	ROM
8085 microprocessor contains _____________	Arithmetic logic unit	ROM	peripherals	PROM	Arithmetic logic unit
The parity flag is set to 1 when the result of operation contains _______	Negative numbers	Even numbers	zero	ones	Even numbers
HUD stands for_______________	Head Up Display	Heat Up Display	Head Use Display	Head Use Doppler	Head Up Display
An 8- bit Microprocessor signifies that it has _______________	8- bit address bus	8- bit control bus	8- bit data bus	all of these	8- bit data bus
In arithmetic operation CY is ______________	Carry hold	Carry over	Carry flag	Carrier	Carry flag
In microprocessor the results are stored in ____________	demodulator	accumulator	ALU	rectifier	accumulator
NAND is the combination of ________________	NOT and AND	NOT and EXOR	NOT and OR	OR and EXOR	NOT and AND
Microprocessors are _____________	Programmable	General purpose	Single chip CPU	All the above	All the above
Hexa decimal number system has a base of _____________	16	8	2	4	16
Data memory is _____________	Bi directional	Uni directional	Multi directional	three directional	Uni directional
8085 architecture has a ________________	8 bit register	16 bit register	Combination of both	32 bit register	Combination of both
In communication system _____________ is used for accuracy.	modulator	Frequency generator	Frequency synthesizer	Doppler	Frequency synthesizer
Decimal number has a base of _____________	10	2	8	10	10
Several data output and one single input is called _____________	memory	multiplexer	Modifier	gates	multiplexer
_____________ is the main brain of a computer.	monitor	CPU	mouse	key board	CPU
_________ gate has only one input and one output.	NAND	NOR	NOT	OR	NOT
ALU stands for___________	Arithmetic logic unit	Arithmetic loss unit	Auxiliary logic unit	Auxiliary loss unit	Arithmetic logic unit
_______ data bus comprises a screened, twisted wire pair	ARINC 429	ARINC 629	MIL STD 1553	MIL STD 1553 B	ARINC 429
ALU includes _____________ flip flops.	5	3	2	1	5
Flight into terrain whilst not in the landing confi guration is GPWS Mode:	one	five	three	four	one
Inputs form the audio system are recorded on the:	FDR	mike	CVR	ULB.	ULB.
The mandatory parameters required for an aircraft DFDR depend on the:	speed and weight of the aircraft	speed of the aircraft	maximum weight of the aircraft	size the aircraft and the prevailing regulatory	speed and weight of the aircraft
The DFDR on large aircraft has to be able to retain the recorded data for a minimum of the last	30 minutes of its operation	24 hours of its operation	25 hours of its operation	25 flights.	25 hours of its operation
Lateral acceleration and radio altitude are typical parameters recorded on the:	FDR	FDR	CVR	ULB.	ULB.
The ability of operate alongside other items of equipment without causing EMI is called	EMC	CVR	ESSD	HIRF.	EMC
Radio and radar transmitters in the external environment are sources of:	EMC	CVR	ESSD	HIRF.	ESSD
MIL-STD stands for _____________	Military standard	Military statical	Mild satellite	Moving satellite	Military standard
Bus controller in the MIL-STD is used for _________.	Initiates the information	Save the information	Store the information	Initiates the information	Initiates the information
Data bus consists of ______________	Hardware and software components	Hardware only	Software only	No components	Hardware and software components

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Questions	**a**	**b**	**c**	**d**	**answers**
ARINC 429 uses _________	Single source	Multiple sink	Single source and Multiple sink	Multiple source and Multiple sink	Single source and Multiple sink
ARINC 629 uses _______________	Single source	Multiple sink	Single source and Multiple sink	Multiple source and Multiple sink	Multiple source and Multiple sink
ARINC 429 employs a _____________	Uni directional data bus	Bi directional data bus	semi directional data bus	3 directional data bus	Uni directional data bus
__________is not a form of a transistor	npn	pnp	Anp	snp	Anp
Which data bus comprises a screened, twisted wire pair _____________	ARINC 429	ARINC 629	MIL STD 1553	MIL STD 1553 B	ARINC 429
The entire group of instruction is called as ____________	Instruction decoder	Instruction set	Instruction data	Instruction encoder	Instruction set
The linear variable differential transformer (LVDT) is used for measuring:	small rotary displacements	variable resistance	small linear displacements	variable current	small linear displacements
RADAR in the aircraft is used for __________	Communication	navigation	Warning of storms	All of these	All of these
ASPP is responsible for control of ___________	weapons	radar	Rudder	rotar	weapons
A command word in MIL STD 1553 B is transmitted only by ______________	Bus monitor	Remote terminal	Bus controller	Remote display	Bus controller
____________ is the largest fraction of units in a 1553 system.	Digital display	Bus moniter	Remote terminal	Control bus	Remote terminal
ARINC stands for	Air speed Radio Incorporated	Aeronautical Radio Incorporated	Aeronautical Radar Incorporated	Aeronautical Radio Installation	Aeronautical Radio Incorporated
INTR is	Interrupt request	Inter request	Interrupt ratio	Inter resistance	Interrupt request
In arithmetic operation CY is	Carry hold	Carry over	Carry flag	Carrier	Carry flag
________ is not a form of a transistor.	npn	pnp	anp	Option a & option b	anp
In __________ the results are stored.	demodulator	accumulator	rectifier	ALU	accumulator
The presence of unwanted voltages or currents in systems is caused by	EMC	FDR	ESSD	HIRF.	HIRF.
ACARS is a digital data link system transmitted in the:	VHF range	VVHF range	LF range	UHF range	VHF range
Bonding is categorized as primary or secondary determined by the:	use of composite or metal structur	locations of dynamic wicks	locations of static wicks	magnitude of current being conducted	magnitude of current being conducted
The use of composite materials for aircraft structures results in:	less natural paths for bonding	lesser probability of a lightning strike.	more natural paths for bonding	higher probability of a lightning strike.	less natural paths for bonding
Bonding is made between components and structure using:	coaxial cable	general-purpose cable	purpose-made straps	general-purpose wiring.	purpose-made straps
Static electricity is discharged from the aircraft to atmosphere through:	composite structure	metal structure	earth stations	static wicks	static wicks
HEIUs can remain charged for several:	seconds	minutes	hours	days	minutes
Data loader in a FMS is a	cell	memory	disk	Disk or tape	Disk or tape
FCC in FMS stands for	Federal communication computer	Federal communication counter	Flight control computer	Federal communication commission	Flight control computer
RLG is subjected to	Linear displacement	Horizontal axis	Vertical axis	Angular diaplacement	Angular diaplacement
Range control is used to establish the ……….of the indicator.	Pitch	endurance	range	Cathode rays	range
__________ lights is used to alert the flight crew.	Anti-collision	landing	warning	position	warning
___________is generated during radio transmission.	Electro magnetic waves	Magnetic flux	Electric field	magnitude	Electric field
FCC stands for	Federal communication computer	Federal communication counter	Federal computer concepts	Federal communication commission	Federal communication commission
In ___________ point in which data is available.	Mid	Terminal	intersecting	orgin	Terminal
ADI in instruction set says	Add with carry	Add immediate	Add with register	Add without carry	Add immediate
________is used to check whether an interrupted is masked or not.	EI	SIM	HLT	RIM	RIM
Which of these is not a amplifier classes	Class A	Class B	Class A&B	Class E	Class E
CRT is used to display	Analog signals	Digital signals	Alphanumeric data	All the given option	Alphanumeric data
High frequency covers the communication band between ____________	3 – 30 MHz	5 – 60 MHz	2 – 40 MHz	6 – 80 MHz	3 – 30 MHz
Energy gap for diode in LED is __________	1.1 ev	2.2ev	1.3ev	4.1ev	1.1 ev
In LED energy is releases in the form of ____________	photon	neutron	electron	boran	photon
AFCS stands for ____________	Automatic flight control systems	Audio flight control systems	Automatic flight communication systems	Audio flight communication systems	Automatic flight control systems
____________ have twisted molecules	LCD	LED	EL	INS	LCD
CRT consist of ______________	mirror	Touch screen	Electron gun	Conduction band	Electron gun
Electronically generated display with the input controls is called ____________	analog display	Touch screen	Manual display	Mechanical display	Touch screen
Electroluminescent media is constructed in___________ layers	5	3	2	4	5
Dead reckoning method is used in _____________	Desert areas	Fighter aircrafts	Rush areas	All of these	Desert areas
Radio method is used to find the position with the help of ______________	Radar	Radio frequencies	sounds	Lights	Radio frequencies
______________ is used to match antenna and transmitter.	transmitter	accumulator	Loop antenna	receivers	receivers
Mirrors are used to reflect beams in	duplexer	synchronizer	RLG	mixer	RLG
The gain control is used to adjust IF receiver __________	Pitch	Gain	range	Cathode rays	Gain
_________ lights are used to make the presence of aircraft visible to flight crew.	Anti-collision	Landing	warning	position	Anti-collision
Which of the option is not a available flag in microprocessor.	zero	Sign	null	parity	null

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Which of the option is not a form of interrupts in 8085?	software	Hard ware	disable	mask able	mask able
…………is not a form of carrier wave.	sky	space	ground	radio	radio
INR reg stands for	Intermediate	immediate	increment	All of the given option	increment
………….indicates no operation.	NOp	EI	SIM	HLT	NOp
………..number of servo controls available.	2	3	4	5	3
The length of a radio wave depends on ………	Electric field	modulation	frequency	Wave length	frequency
………….is used to convert sound d energy into electric energy.	transmitter	accumulator	Loop antenna	microphone	microphone
…………….cells are called as small button batteries.	Mercury	primary	dry	alkaline	Mercury
Earlier radar systems were ……….	Light weight	heavy	medium	Easy assessable	heavy
PDS stands for	Pilot display unit	Pilot decision unit	Pilot direction unit	Polar display unit	Pilot display unit
The tilt control is used to change ……….of the antenna.	Rotation	angle	Sensing capacity	Receiving signals	angle
LED has ___________Junction	p-n	n-p	r-p	s-p	p-n
EICAS warning messages are:	red, accompanied by an audio alert (prompt action is required	yellow, accompanied by an audio alert (timely action is required by the crew)	yellow, no audio alert (time available attentior	red, accompanied by an video alert	red, accompanied by an audio alert (prompt action is required by the crew)
Engine pressure ratio (EPR) is used to measure a gas turbine engine's:	torque	thrust	temperature	pressure	thrust
Low-, intermediate- and high-pressure shafts are also referred to as:	N1, N2 and N3	N2, N3 and N1	N3, N1 and N2	N2, N1 and N0	N1, N2 and N3
Typical units of fuel mass flow are given in:	pounds or kilograms per hour	gallons per hour	litres per hour	kg	pounds or kilograms per hour
A gas turbine engine's self-sustaining speed is when sufficient energy is being developed by the engine to provide continuous operation:	with the starting device still engaged	with the ignition system in operation	without the starting device and ignition	without the ignition system in operation	without the starting device and ignition
In turboprop engines, power is measured from:	engine pressure ratio	torque	torque × speed.	EGT	torque × speed.
Ground idle speed occurs when the engine has:	stabilized (slightly above self-sustaining speed)	stabilized (slightly below self-sustaining speed)	just been started	minimum speed	stabilized (slightly above self-sustaining speed)
Power from an engine is derived from measuring:	torque and speed	temperature and speed	engine pressure ratio (EPR)	FADEC	torque and speed
When lube oil operates at high temperatures, its viscosity:	reduces and its lubrication performance decreases	reduces and its lubrication performance increases	increases and its lubrication performance incr	reamins constant	reduces and its lubrication performance decreases
The starting sequence for a gas turbine engine is to:	turn on the ignition, develop sufficient airfl ow to compress the air, and then open the fuel valves	develop sufficient airfl ow to compress the air, open the fuel valves and then turn on the ignition	air, turn on the ignition and then open the	develop sufficientlift to compress the air, open the fuel valves and then turn on the ignition	develop suffi cient airfl ow to compress the air, turn on the ignition and then open the fuel valves
The thermocouple principle is based on the Seebeck effect; when heat is applied:	a change of resistance is measured	this causes the element to bend	an electromotive force (e.m.f.) is generated	this causes the element to straighten	an electromotive force (e.m.f.) is generated
A rheostat performs the same function as a:	resistance temperature detector	potentiometer	Wheatstone bridge	voltmeter	potentiometer
The solenoid is a type of transducer that converts:	electrical energy into linear motion	linear motion into electrical energy	electrical energy into thermal energy	thermal energy	electrical energy into linear motion
Proximity switches perform the same function as:		relays	toggle switches	short switched	
ECAM system employs ………….number of CRT displays	3	1	4	2	2
TMC stands for	Torque management computer	Thrust management control	Thrust management computer	None of the given option	Thrust management computer
Central Air-data computers employs …….number of computers.	3	4	2	1	2
Turn bank indicator is used to determine	Rate of turn	Ratio of turn	Turn angle	All the given option	Rate of turn
DPU stands for	Digital processor unit	Display processor unit	Display plan unit	Digital path unit	Display processor unit
RLG stands for	Ring laser gyro	Radar laser gyro	Ring layout gyro	Ring layer gyro	Ring laser gyro
If arithmetic operation is zero………..flag is set in microprocessor.	zero	Sign	null	parity	zero
___________is used to convert sound energy into electric energy.	transmitter	accumulator	microphone	Doppler	microphone
Satellite communication provide reliable method of communication using __________	INMARSAT	INTR	VHF	VOR	INMARSAT
__________is generated during radio transmission.	Electromagnetic waves	Magnetic flux	Electric field	magnitude	Electromagnetic waves
___________ flag is not available in microprocessor.	Zero	sign	null	parity	null
Satellite navigation is using a ____________ for its operation.	GPS	pilotage	frequency	Doppler	GPS
Materials like GaAs, GaAsP are used in _________	LED	LCD	CRT	EL	LED
LCD stands for __________	Light Crystal Display	Liquid Crystal Display	Light Copper Display	Liquid Crystal Display	Liquid Crystal Display
Single LED is used as _________	Indicator lights	Induction lights	Indicator switch	Induction switch	Indicator lights
The light of an LED comes when the diode is __________	Forward biased	Backward biased	unbiased	over biased	Forward biased
Pilotage is used to find the direction with the help of ____________	Land marks	Radio signals	radar	maps	Land marks
RLG stands for __________	Real Laser Gyro	Ring Laser Gas	Ring Laser Gyro	Ring large Gyro	Ring Laser Gyro
EL stands for_____________	Electro Luminescence	Electro Light	Electro Laser	Electronic Laser	Electro Luminescence
Following one is the principle of touch screen________	Scanning infrared	radar	Radio	Digital display	Scanning infrared
LED has_________ Junction	p-n	n-p	r-p	s-p	p-n
CRT is coated inside with ___________	phosphorous	neutron	electron	polymer	phosphorous
SELCAL is the ____________	Separate calling	Selective calling	Selective calculation	Sensor calling	Selective calling
MLS stands for_______________	Microwave Landing System	Microcontrol Landing System	Micronics Landing System	Microwave Lane System	Microwave Landing System
No. of cycles per seconds is known as _____________	Wave length	frequency	Sound	Light	frequency
_________is generated during radio transmission	Electromagnetic waves	Magnetic flux	Electric field	Magnitude	Electromagnetic waves
The split bus system is sometimes called a:	non-parallel system	parallel system	standby and essential power system	essential power system	non-parallel system
Inductive or capacitive loads consume:	real power	DC power	reactive power	AC power	reactive power
Essential DC power could be supplied from a	transformer rectifier unit (TRU) powered from the essential D	transformer rectifier unit (TRU) powered from the essential AC bus	inverter powered from the essential AC bus	inverter powered from the essential DC bus	transformer rectifi er unit (TRU) powered from the essential AC bus
The third pin on external DC power connectors is used to:	charge the battery	energize the reverse current relay	energize the ground power relay	energize the current relay	energize the ground power relay
How many types of antennas used for radio communication ____________	1	6	5	3	5
Automatic Direction Finder is used in ____________	Communication system	Navigation system	ILS	GPS	Navigation system
RLG stands for_________	Real Laser Gyro	Ring Laser Gas	Ring Laser Gyro	Ring large Gyro	Ring Laser Gyro
Instruction which specifies the task to be performed by the computer is called _________	opcode	encode	operand	operation	opcode
SELCAL is the __________	Separate calling	Selective calling	Selective calculation	Sensor calling	Selective calling
VHF uses the range between_______________	30 – 300 MHz	30 – 600 MHz	90 – 300 MHz	90 – 900 MHz	30 – 300 MHz