Final Exam QUESTIONS BANK FOR AVIONICS(Spring) 2023

Q1. **Q1**. Fill in the blanks the correct answer ; **[20 marks]**

1. Goal of Avionic systems is……………………………..

   Air traffic control requirements, decreased safety, Increasing in fuel consumption.

   Answer : Air traffic control requirements

2. The avionic systems are essential to enable the flight crew to carry out the …………………….. and …………………...

   Answer : The avionic systems are essential to enable the flight crew to carry out the aircraft mission safely and efficiently.

3. Ailerons are mounted on the …………………….. of each wing..

   the trailing edge, the front edge, middle edge

   Answer : Ailerons are mounted on the trailing edge of each wing.

4. When the pilot moves the stick left, the left aileron goes…………… and the right aileron goes ………………...

   Up , Down , Middle

   Answer : When the pilot moves the stick left, the left aileron goes up and the right aileron goes down.

5. An autopilot is a mechanical, ……………., and ………….. system used to guide an aero plane ………………… assistance from the pilot.

   Answer : An autopilot is a mechanical, electrical, and hydraulic system used to guide an aero plane without assistance from the pilot.

Q2. Explain briefly the followings;

1. The importance and role of Avionics .
2. Goal of Avionic systems .
3. Main avionic subsystems can be grouped into five layers according to their role and function.

Answer :

1.

Importance and role of Avionics

- Systems which interface directly with pilot
- Aircraft state sensor systems
- Navigation systems
- External world sensor systems
- Task automation systems.
- Million dollar business , 30% of total cost of aircraft --- avionics equipments
- 40% - maritime/patrol/anti submarine aircraft
- 75% - Airborne early warning aircraft.

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- The avionic systems are essential to enable the flight crew to carry out the aircraft mission safely and efficiently.
- Mission: Carrying the passengers to their destination, intercepting a hostile aircraft, attacking a ground target, reconnaissance or maritime patrol. - In military operations, reconnaissance is the exploration outside an areaoccupiedby friendly forces to gain information about natural features and enemy presence.
- By automation of tasks, the crew s workload can be minimized.
- The reduction in weight is also significant and can be translated into more passengers or longer range on less fuel.
- The crew comprises of two members namely, the first pilot/ captain and the second pilot.

2. Goal of Avionic systems is

- increased safety

- Air traffic control requirements

- All weather operation
- Reduction in fuelconsumption
- Improved aircraft performance and control
- Handling and reduction of maintenance costs

3. Main avionic subsystems can be grouped into five layers according to their role and function.
   - Systems which interface directly with the pilot.
   - Aircraft state sensor systems
   - Navigation systems
   - External world sensor systems
   - Task automation systems

Q2. Draw and explain the Aircraft Structure and the main parts of a plane.

Answer :

There are lots of parts in a plane, but there are main parts, such as;

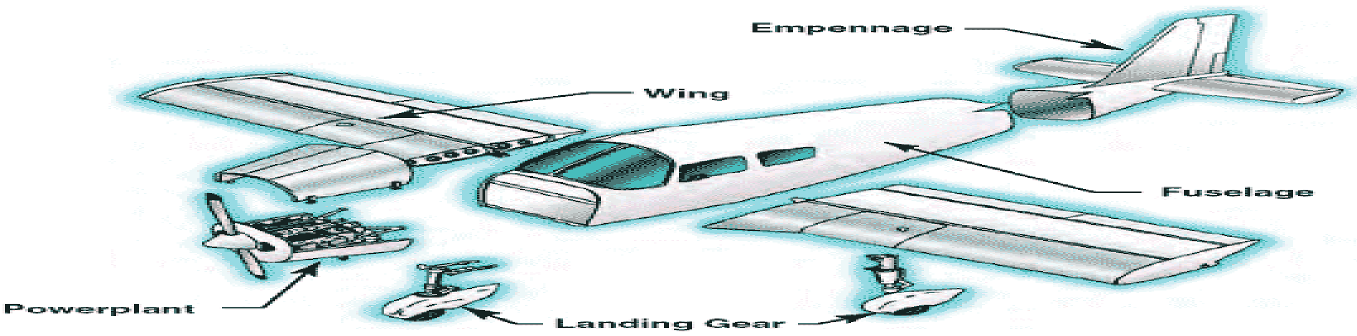
The Fuselage,

The Empennage

The Wings

Power plant (Engine) Landing Gear

Basic Aerodynamics



Q3.

1. What are the main flight control systems .

Answer: the main flight control systems are ;

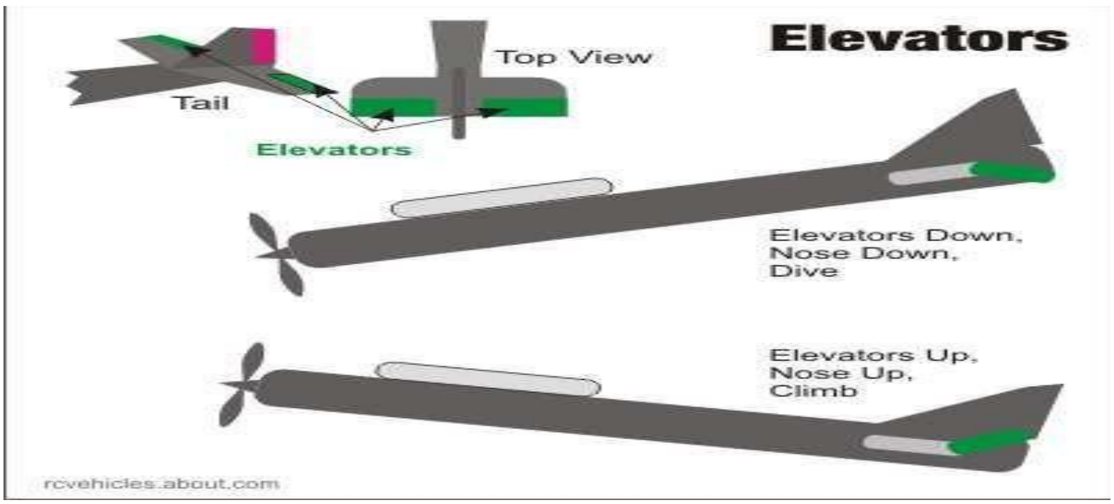
- Aircraft Flight Control Systems
- Primary Flight Controls
- Secondary Flight Controls
- Auxiliary Flight Controls
- Autopilot

2. Explain and draw the main parts of primary flight control system .

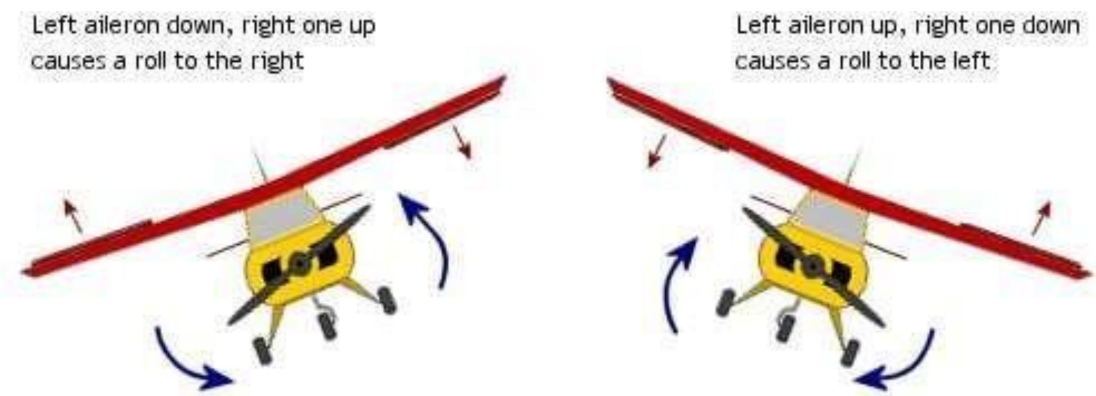
- Answer :
- Elevator Control System
- Aileron Control System
- Rudder Control System

Elevator Control System

- An elevator is mounted on the back edge of the horizontal stabilizer.

- They move up and down together.
- When the pilot pulls the stick backward, the elevators go up. And vice versa.
- This makes the wings fly at a higher angle of attack which generates more lift and more drag.
- Pitch movement
- 

- Aileron Control System
- Ailerons are mounted on the trailing edge of each wing.
- They move in opposite directions.
- When the pilot moves the stick left, the left aileron goes up and the right aileron goes down.
- A raised aileron reduces lift on the upward aileron and a lowered one increases lift
- Centering the stick returns the ailerons to neutral maintaining the bank angle.

- The plane will continue to turn until opposite aileron motion returns the bank angle to zero to fly straight.
- Longitudinal axis
- 

- Rudder Control System
- Mounted on the back edge of the fin in empennage.
- When the pilot pushes the left pedal, the rudder deflects left.
- Pushing the right pedal causes the rudder to deflect right.
- Deflecting the rudder right pushes the tail left and causes the nose to yaw right.
- Centering the rudder pedals returns the rudder to neutral and stops the yaw.

- 

Q4. Explain and draw the flow chart of the principles of operation of the pilot system

Answer :

- An autopilot is a mechanical, electrical, and hydraulic system used to guide an aero plane without assistance from the pilot.
- The pilot is relieved of most of the physical & mental fatigue of controlling an aircraft and is free to devote his attention to the management and direction of progress of the flight.
- On newer aircrafts today, the Autopilot has evolved into a complex feature encompassing microprocessors and decision making systems which take over the complete control of an aircraft from take-off to landing.

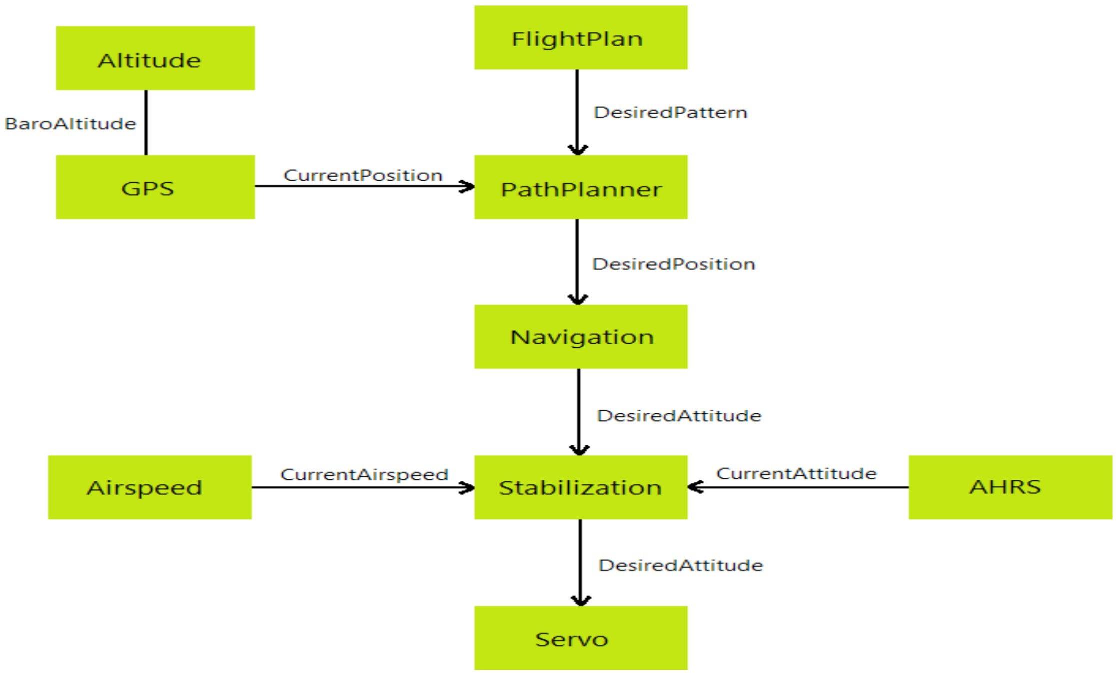
<u>Input to system</u>

1. Pilot commands
2. Sensors on exterior

3. Gyroscope
4. Accelerometer
5. Altimeter
6. GPS
7. ILS

Output from system

1. Servo motors
2. Actuators on exterior
3. Spoilers
4. Rudder
5. Elevator
6. Ailerons
7. Engines



Q5.

1. What are the six basic aircraft instruments and explain the pitot tube instruments briefly with drawings ?

   Answer : A quick scan of the six pack provides the pilot with current information on aircraft speed, altitude, climb/descent, attitude, heading, and turning/banking. Individually, the six pack instruments are:

   PITOT TUBE INSTRUMENTS

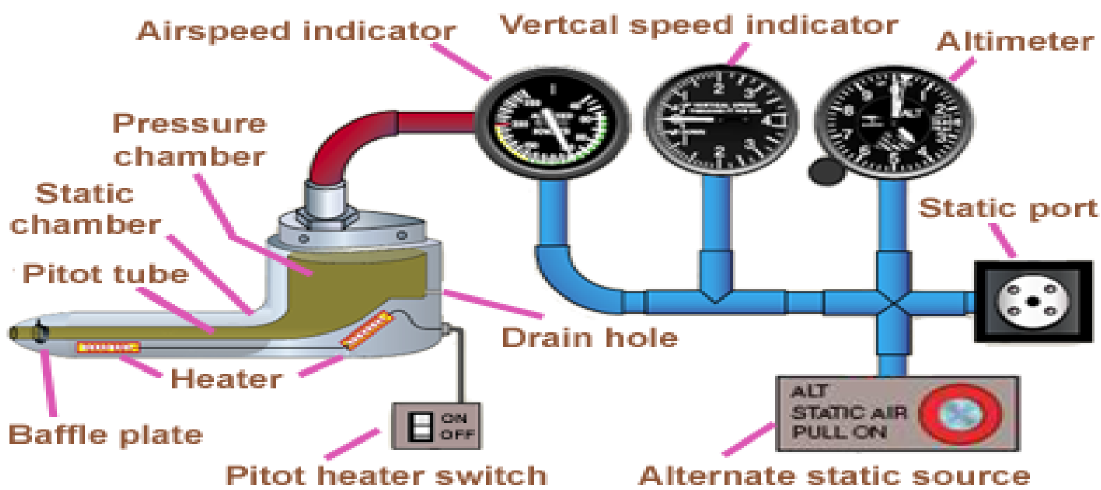
   - Airspeed Indicator (ASI)
   - Altimeter
   - Vertical Speed Indicator (VSI)
   - GYROSCOPE INSTRUMENTS

- Attitude Indicator (AI)
- Heading Indicator (HI)
- Turn Coordinator (TC)

- The following instruments are works by using pitot tube.
- Airspeed Indicator (ASI)
- Altimeter
- Vertical Speed Indicator (VSI)

Pitot Heater is used to prevent or melt the ice in high altitude

Static port is maintain atm.pressure with respect to altitude.



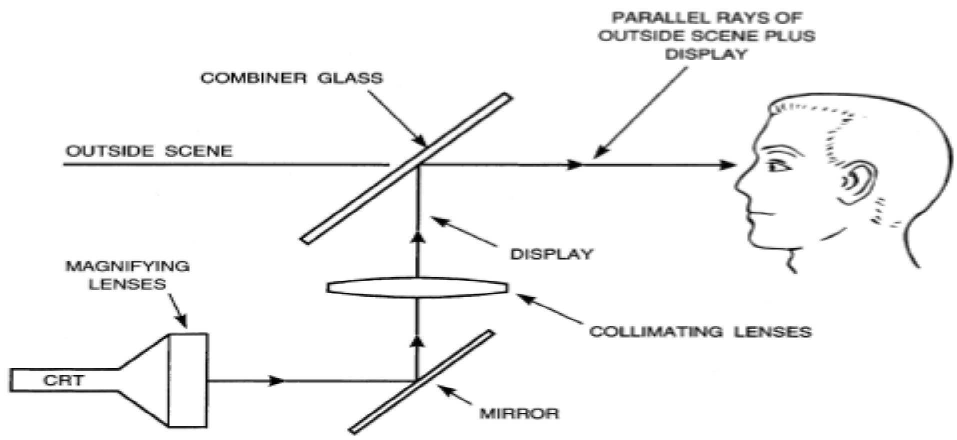
Source: www.faa.gov/handbooks_manuals/media

Q6. Draw and explain the basic principle configuration of a Head Unit Display HUD .

Answer :

The basic configuration of a HUD is shown schematically in Figure 1. The pilot views the outside world through the HUD combiner glass (and windscreen). The combiner glass is effectively a 'see through' mirror with a high optical transmission efficiency so that there is little loss of visibility looking through the combiner and windscreen. It is called a combiner as it optically combines the collimated display symbology with the outside world scene viewed through it. Referring to Figure 1 , the display symbology generated from the aircraft sensors and systems (such as the INS and air data system) is displayed on the surface of a cathode ray tube (CRT). The display images are then relayed through a relay lens system which magnifies the display and corrects for some of the optical errors which are otherwise present in the system. The relayed display images are then reflected through an angle of near 90◦ by the fold mirror and thence to the collimating lens which collimates the display images which are then reflected from the combiner glass into the pilot's forward field of view. The virtual images of the display symbology appear to the pilot to be at infinity and overlay the distant world scene, as they are collimated. The function of the fold mirror is to enable a compact optical configuration to be achieved so that the HUD occupies the minimum possible space in the cockpit.

The fundamental importance of collimation to any HUD system merits further explanation for the benefit of readers whose knowledge of optics needs refreshing.



Q7. What are the main advantages of a HUD in a civil aircraft ?

Answer The main advantages of a HUD in a civil aircraft are:

1. Increased safety by providing a better situational awareness for the pilot to control the aircraft by the head up presentation of the primary flight information symbology so that it is conformal with the outside world scene.

2. The HUD can also provide a flight path director display which allows for the effect of wind shear from a knowledge of the aircraft's velocity vector, airspeed, height and aerodynamic behavior.

2. Increased revenue earning ability by extending operations in lower weatherminima. The HUD is used to monitor the automatic landing system and to enable the pilot to take over on aircraft which are not equipped to full Category III automatic landing standards (automatic landing systems .

3. Use of the HUD as part of an enhanced vision system to enable operations in lower weather minima at airfields not equipped with automatic landing aids

(ILS/MLS). For example, the number of Type II and Type III ILS facilities in the US is very limited – typically less than 70.

4. The use of the HUD for displaying ground taxiway guidance is being actively investigated, and is considered a likely extension to the HUDs roles. Ground taxiway guidance could be provided by differential GPS.

Q9. Draw and explain the operation of the Head Tracking Systems and explain the types of these systems?

The need to measure the orientation of the pilot's head to determine the angular coordinates

of the pilot's line of sight with respect to the airframe axes . It should be noted that the problem of measuring the angular orientation of an object which can both translate and rotate can be a fundamental requirement in other applications such as robotics. In fact the solutions for head tracking systems

can have general applications. Space does not permit a detailed review of the various head tracking systems which have been developed. Most of the physical effects have been tried and exploited

such as optical, magnetic and acoustic methods.

Optical tracking systems work in a number of ways, for example,

(a) Pattern recognition using a CCD camera.

(b) Detection of LEDs mounted on the helmet.

(c) Sophisticated measurement of laser generated fringing patterns.

Magnetic tracking systems measure the field strength at the helmet from a magnetic field radiator located at a suitable position in the cockpit.

Q10. Explain and draw the binocular HMD (BHMD) Helmet Mounted Display and the Virtual Cockpit?

Answer :

The concept of a 'virtual cockpit' where information is presented visually to the pilot by means of computer generated 3D imagery is being very actively researched in a number of establishments both in the USA and the UK.

The ability to generate 3D displays opens up entirely new ways of presenting

information to the pilot (and crew), the objectives being to present the information

so that it can be visually assimilated more easily and in context with the mission.

Figure 1 illustrates the use of a BHMD to implement such a system. When head up, the pilot views the outside world directly, or indirectly by means of a TV display on the HMD from a head steered gimballed electro-optical sensor unit (e.g. infrared imaging sensor, low light

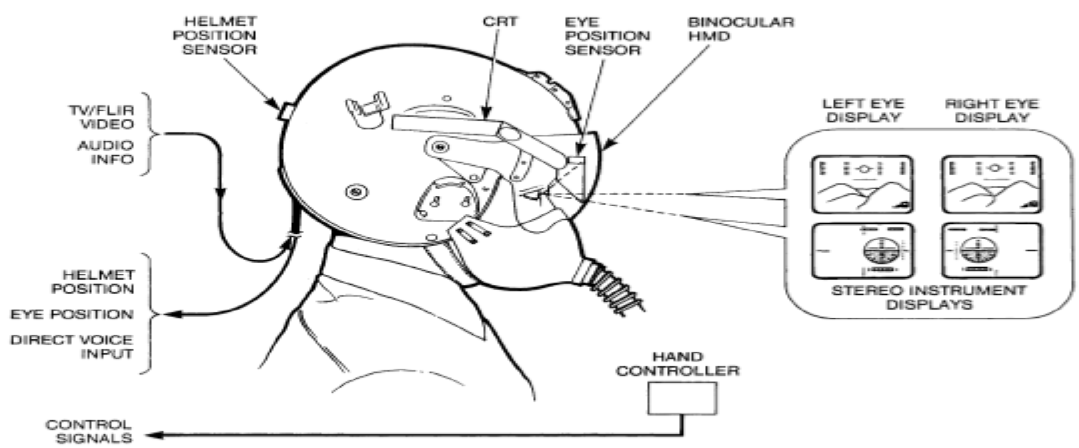
TV camera or CCD camera) When looking down at the instrument panel, the virtual cockpit computer system recognizes the pilot's head down sight line from the head tracker output and

supplies this information to the display generation system. The display generation

system then generates a stereo pair of images of the appropriate instrument display

on the panel which corresponds to the pilot's sight line. Thus, looking down into

the cockpit at the position normally occupied by a particular instrument display will result in the pilot seeing a 3D image of that instrument display appearing in the position it normally occupies .



Binocular HMD and virtual cockpit.

Q11. Explain and draw draw the Civil Cockpit Head Down Displays?

Answer:

The electronic Primary Flight Display (PFD) replaces six electro-mechanical instruments:

altimeter, vertical speed indicator, artificial horizon/attitude director indicator,

heading/compass indicator and Mach meter.

Figure 1, shows a representative primary flight display. Airspeed is shown on a scale on the left with pressure altitude and vertical speed on the right hand scales. Aircraft heading information is shown on a ‘tape’ scale type format below the attitude display. The artificial horizon/attitude display has a blue

background above the horizon line representing the sky and a brown background

below the horizon line representing the ground. This enables ‘which way is up’ and

the aircraft orientation to be rapidly assimilated by the pilot in recovering from an

unusual attitude, for example, as the result of a severe jet upset.

Primary flight display (by courtesy of Airbus).

Q13 . What are the main aircraft navigation systems and explain two of them with drawings ?

Answer :

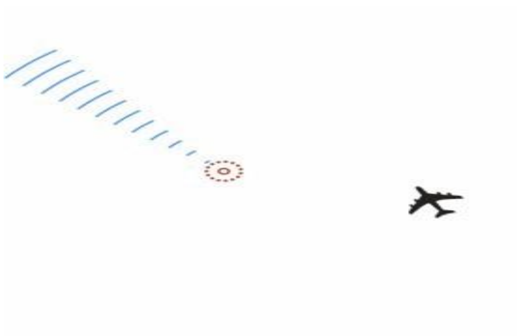
The main aircraft navigation systems

- ✓ VHF OMNIDIRECTIONAL RANGE (VOR)
- ✓ INSTRUMENT LANDING SYSTEM (ILS)
- ✓ DISTANCE MEASURING EQUIPMENT (DME)
- ✓ AUTOMATIC DIRECTION FINDERS (ADF)
- ✓ DOPPLER NAVIGATION SYSTEM
- ✓ INERTIAL NAVIGATION SYSTEM

VHF OMNIRANGE SYSTEM (VOR)

- ✓ VOR, short for VHF omnidirectional radio range, is a type of radio navigation system for aircraft, enabling them to find their position and stay on course by receiving radio signals emitted by a network of radio beacons. It uses frequencies in very high frequency (VHF) from 108 to 117.95 MHz.
- ✓ VHF Omnidirectional Radio Range (VOR), is an aircraft navigation system operating in the VHF band. VORs broadcast a VHF radio composite signal including the station's Morse Code identifier (and sometimes a voice identifier), and data that allows the airborne receiving equipment to derive the magnetic bearing from the station to the aircraft. This line of position is called the "radial". Alternatively, the VOR radial may be combined with magnetic heading from the aircraft compass to provide a bearing relative to the aircraft axis, which cn be used to home to the beacon. VOR beacons are frequently used as way-points on conventional Airway systems, or as the basis for a Non-Precision Approach.
- ✓ It produces 360 usable radials or courses ,any one of which is radial path connected to the station.

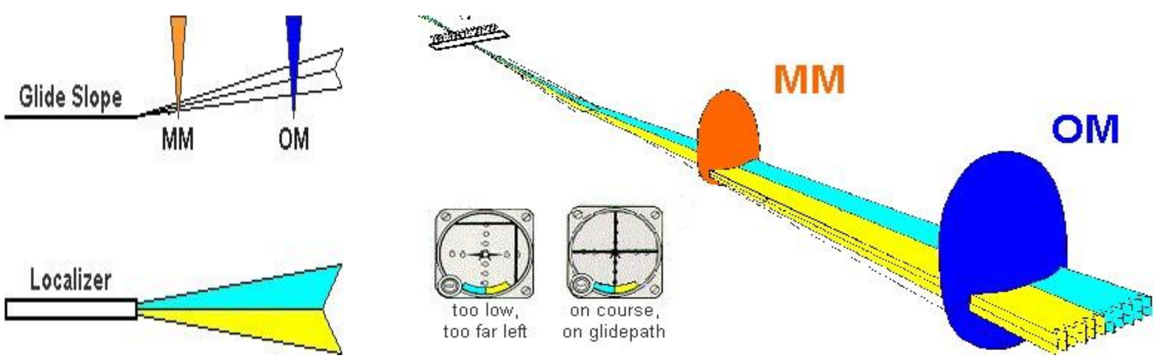
VORStation



Q. Figure 1, shows the INSTRUMENT LANDING SYSTEM (ILS) explain the functions of each part and How this system operates ?

- ✓ It Operates in the VHF portion of the electromagnetic spectrum
- ✓ System consists of a runaway localizer, a glide slope signal, and marker beacons for position location
- ✓ Localizer equipment produces a radio course aligned with the center of an airport runaway. The on course signals result from the equal reception of two signals; Blue sector(150 Hz) and yellow sector(90 Hz).
- ✓ In aviation, the instrument landing system (ILS) is a radio navigation system that provides short-range guidance to aircraft to allow them to approach a runway at night or in bad weather.

GLIDESLOPEINFORMATION



Q14 . Figure 1, shows the marker beacons system , answer the following ;

1. What is the main function and purpose of this system.

2. Find the distances and frequencies for the three markers .

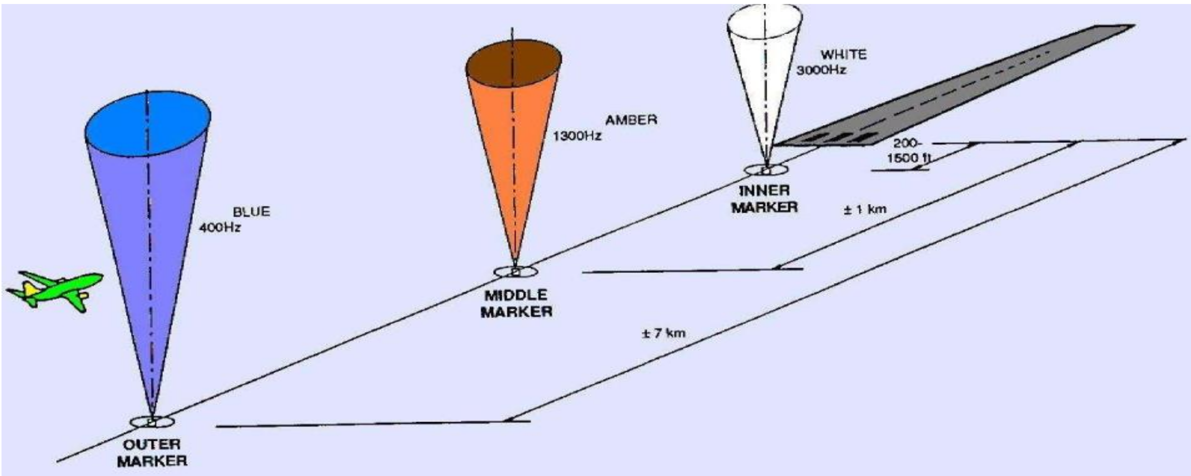


Figure 1

Answer :

- ✓ This system is used for the landing system instrument .
- ✓ In connection with the instrument landing system.
- ✓ signals which indicate the position of the aircraft along the approach to the runway
- ✓ Three markers are used in each installation:
- ➢ Outer marker - 7km the beginning of the approach path

is modulated by a 400 HZ signal, a tone keyed in long dashes

- ➢ Middle marker: 3500 ft from the end of the runway

is modulated at 1300 Hz, a higher-pitched tone keyed with alternate dots and dashes.

Inner marker distance : 200-1500 ft.

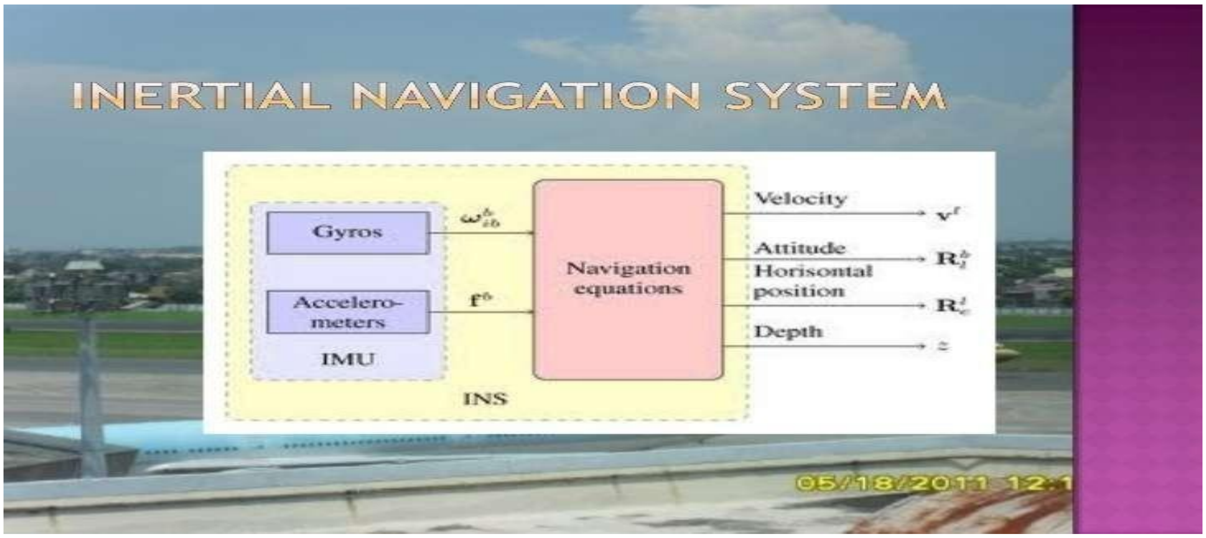
Q15 . Design the block diagram of the inertial navigation system and explain the function of each block .

Answer :

An inertial navigation system is a complex containing four basic components :-

- ✓ A stable platform which is oriented to maintain accelerometers horizontal to the earth's surface.
- ✓ Accelerometers arranged on the platform to supply specific components of acceleration

- ✓ Integrators which receive the output from the accelerometers and furnish velocity and distance.
- ✓ A computer which receives signals from the integrators and changes distance travelled to position in selected coordinates.



Q.16

1. Draw the operational drawing of the Radio altimeter and explain how it is working ?

2. If the aircraft altimeter is 5km and the speed of light is 3x100 Mm/sec , calculate the delay .

Answer :

The Radio altimeters are based on the principle of reflection of electromagnetic wave pulses by the surface of the earth or sea. These waves fall within the radio spectrum range. Electromagnetic waves travel at the speed of light and thus the calculation of the distance is effectively immediate. Although they are affected by surface irregularities generating deviations in the radio signal, radio altimeters provide a reliable and accurate method of measuring height.

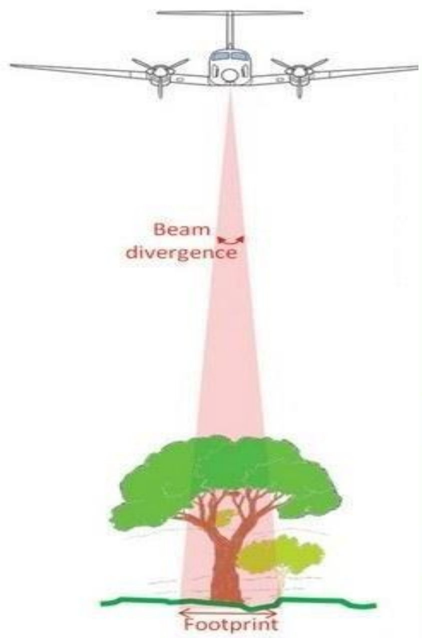
- ✓ Measures the distance from the aircraft to the ground.
- ✓ Accomplished by transmitting radio frequency energy to the

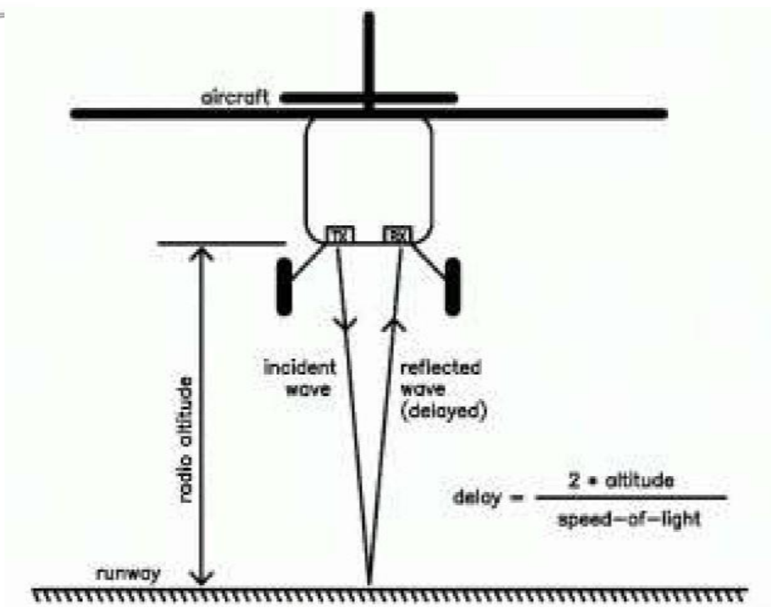
ground and receiving the reflected energy at the aircraft.

Pulse Type

- Altitude determined by measuring time required for transmitted pulse to hit ground and return.
- Indicating instrument gives true altitude of aircraft
- Used during landing to determine decision whether to continue

to land or execute climb-out





2. The delay is calculated by   the following equation ;

Delay = 2x altitude / speed of light = 5km/ 3x100 000000 m/sec= 0.000016 sec= 16 μsec

Q16 .

1. What are the differences between UAV Vs Drone ?

UAV Vs Drone

- **UAV**
- IT COMPRISES OF A NUMBER OF SUBSYSTEMS WHICH INCLUDE THE AIRCRAFT(UAV), ITS PAYLOADS, CONTROL STATION(S), LAUNCH AND RECOVERY SUBSTATIONS, COMMUNICATION SUBSYSTEMS ETC.
- SYSTEM IS DESIGNED FROM ITS CONCEPTION TO BE OPERATED WITHOUT AIRCREW.
- A UAV HAS SOME DEGREE OF "AUTOMATIC INTELLIGENCE".
- IT IS ABLE TO COMMUNICATE WITH ITS CONTROLLER AND RETURN PAYLOAD DATA ALONG WITH ITS PRIMARY STATE INFORMATION-AIRSPEED, POSITION, HEADING, ALTITUDE AND MOST IMPORTANTLY, HOUSEKEEPING INFORMATION.

- **DRONE**
- STANDS FOR DYNAMIC REMOTELY OPERATED NAVIGATION EQUIPMENT
- A DRONE IS REQUIRED TO FLY OUT OF SIGHT OF THE OPERATOR, BUT HAS ZERO INTELLIGENCE.
- IT IS MERELY LAUNCHED INTO A PRE-PROGRAMMED MISSION ON A PRE-PROGRAMMED COURSE WITH AN RTL COMMAND.
- IT DOES NOT COMMUNICATE AND THE RESULTS OF THE MISSION ARE USUALLY OBTAINED UNTIL ITS RECOVERED BACK.

2.Draw and explain the main parts of the UAV and explain the payloads of the UAV ?

PAYLOADS OF UAV

- **SENSORS:-**
- OPTICAL SENSORS
- EOIR SENSORS
- COLOR THERMAL IMAGER
- LIDAR
- SAR

- **ANTENNAS:-**
- DIRECTIONAL
- OMNIDIRECTIONAL
- FOLLOW ME OPTION USING GPS

- AUTOPILOT
- GIMBAL CONTROLLED CAMERA

Q17 . What are the communication systems used UAV and show the frequency band for each one ?

COMMUNICATION SYSTEM USED IN UAV

- **THERE ARE VARIOUS TYPES OF COMMUNICATION SYSTEMS BEING USED FOR OPERATION OF UAV'S SUCH AS**

❑ TELE COMMAND

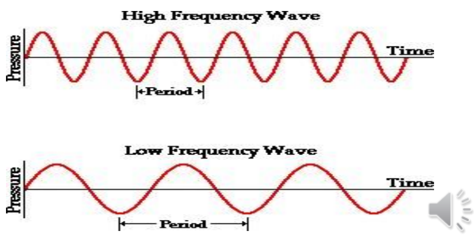
❑ TELEMETRY(2.3GHZ)

❑ TELEVISION(5.8GHZ)

❑ SATCOM

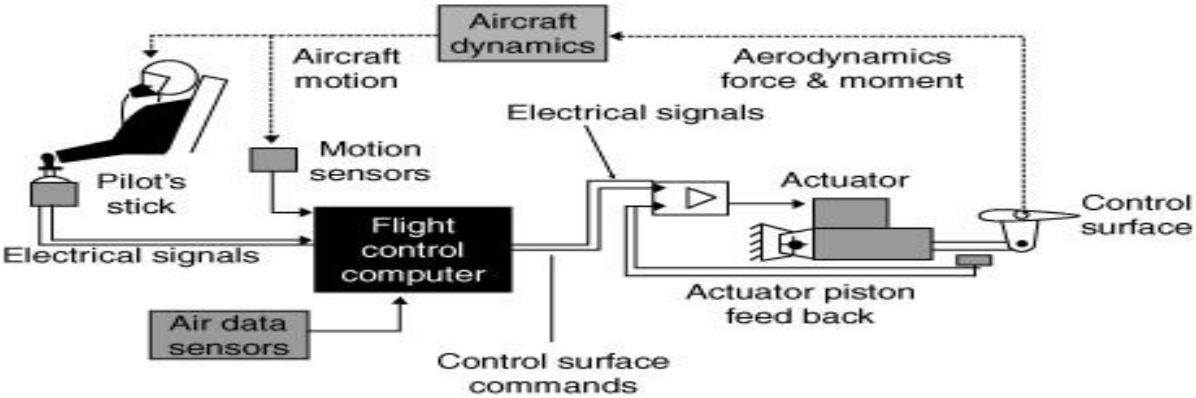
FOR A/V SIGNALS, THE FREQUENCY RANGE IS-

- 433MHZ-900MHZ(LOW FREQUENCY,AUDIO SIGNALS)
- 1.2-5.8GHZ (HIGH FREQUENCY,LIVE FEED VIDEOS)



Q18 . Design the block diagram of the flowchart of a typical FBW and explain the operation ?

FLOWCHART OF A TYPICAL FBW DESIGN



INTRODUCTION

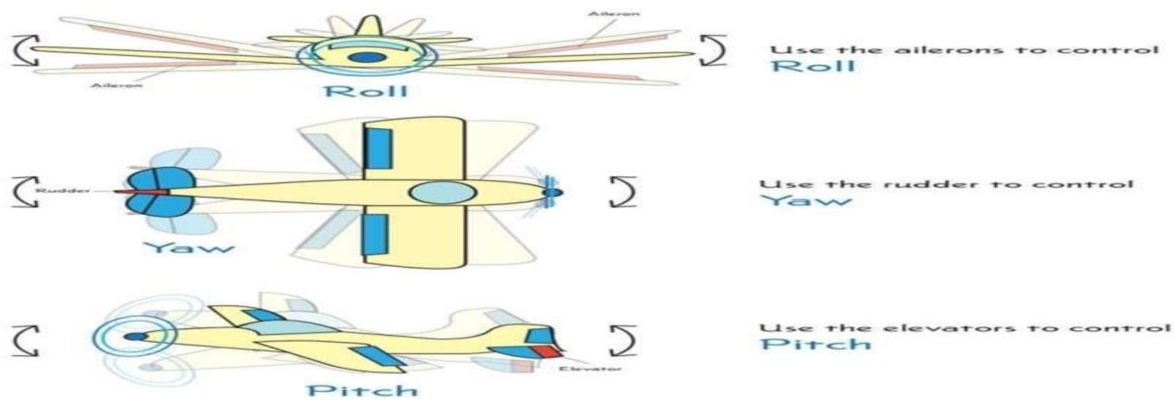
- “Fly-by-wire" implies a purely electrically-signaled control system.
- Used in the general sense of computer-configured controls.
- Computer system interposed between the operator and the final control actuators.
- Manual inputs of the pilot modified in accordance with control parameters.

ELECTRONICS IN FBW

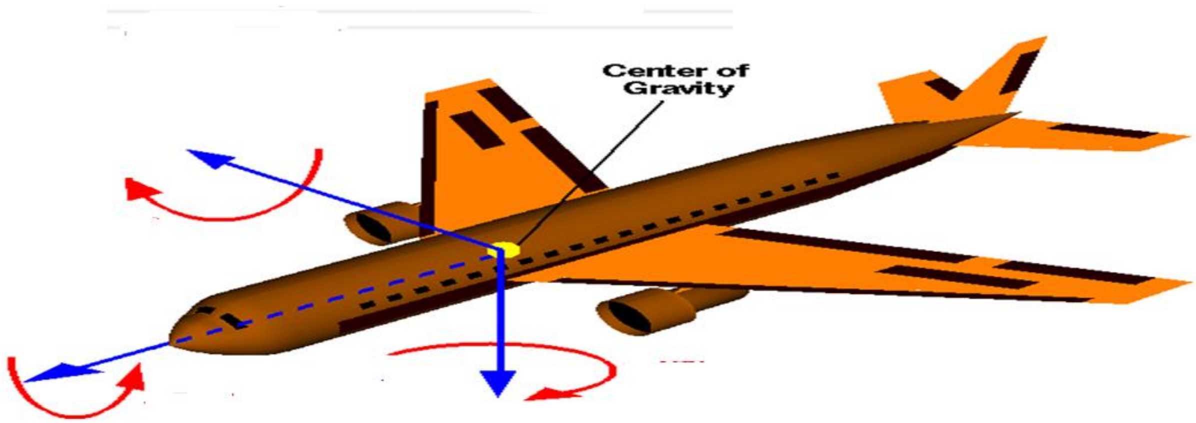
- Microcontroller becoming very popular.
- Basically Arduino based ATmega microcontroller are used in aircrafts.
- Advantage – Fast response, inbuilt ADC, reprogramming etc.
- Example Arduino Atmel ATmega328P microprocessor.

Q19 .

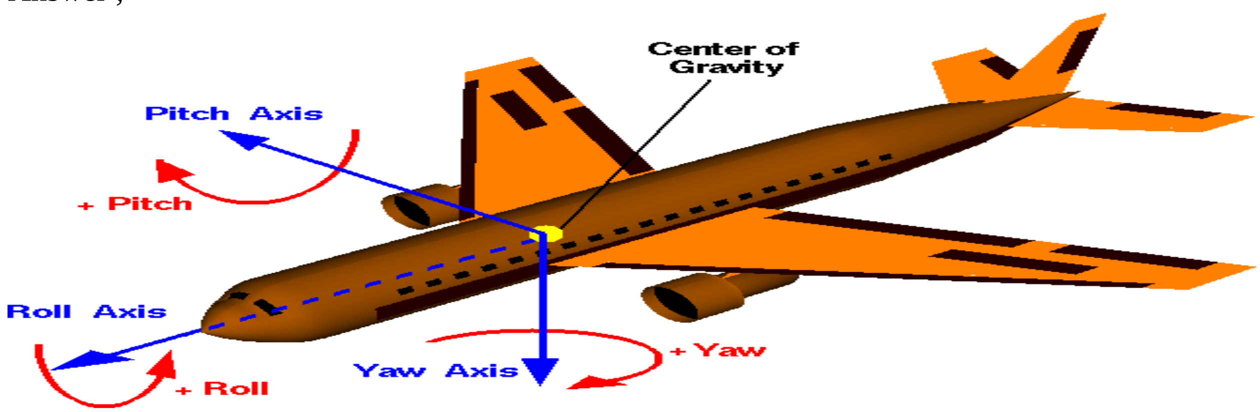
1. Define the followings with drawings the roll, pitch, yaw of the aircraft motion .



2. Figure 1, shows the Aircraft motion involves controlling roll, pitch, yaw.
Assign the roll, pitch, yaw motion axis and direction of motion .

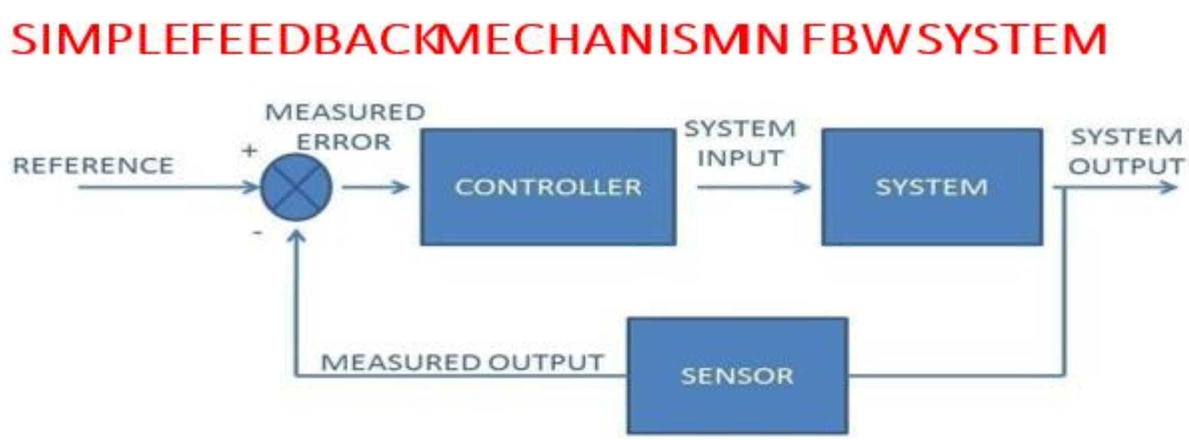


Answer ;



Q20 .

1. Design and explain the block diagram of the simple feedback mechanism in FBW system.



2. What are the types of the FBW systems and explain them briefly and show the differences between them ?

- Analog systems
- Replace hydromechanical or electromechanical control systems with electronic circuits.
- Control system in cockpit operate signal transducers, to generate the appropriate electronic commands.
- Signalsare then processed by an electronic controller with an analog signal.

- Digital systems
- A digital FBW control system similar to its analogcounterpart.
- Pilot literally can "fly-via-computer“.
- Increases the flexibility of the flight control system.
- Multiple redundancy techniques.
- Increase electronic stability, as system is less dependent on the value

COMPARISONAnalogVs Digital

ANALOG SYSTEMS	DIGITAL SYSTEMS
Accuracy low.	Accuracy high.
Circuit complication	Circuit is simplified.
Calibration is tough.	Calibration is easy.

Q21. Draw and explain the block diagram of the Gyro and accelerometer operation ?

Figures 5.2 and 5.3 show the 'Gyro Chip' vibrating quartz tuning fork rate gyro developed by the BEI Systron Donner Inertial Division; the author is indebted to the company for permission to publish this information.

The basic configuration is shown schematically in Figure 5.2 and comprises a vibrating quartz tuning fork to sense angular rate which is coupled to a similar fork as a pick-up to produce the rate output signal.

The piezo-electric drive tines are driven by an oscillator to vibrate at a precise amplitude. An applied rotation rate about an axis parallel to the vibrating tines causes a sine wave of torque to be produced resulting from the Coriolis acceleration as explained earlier. This oscillatory torque in turn causes the tines of the Pick-up Fork to move up and down in and out of the plane of the fork assembly. This causes an electrical output signal to be produced by the Pick-up Amplifier which is amplified and phase sensitive rectified to provide a DC signal which is directly proportional to the input rate. (The sign of the DC output signal changes sign when the input rate reverses due to the action of the phase sensitive rectifier.)

The pair of tuning forks and their support flexures and frames are batch fabricated from thin wafers of single crystal piezo-electric quartz and are micro-machined us-

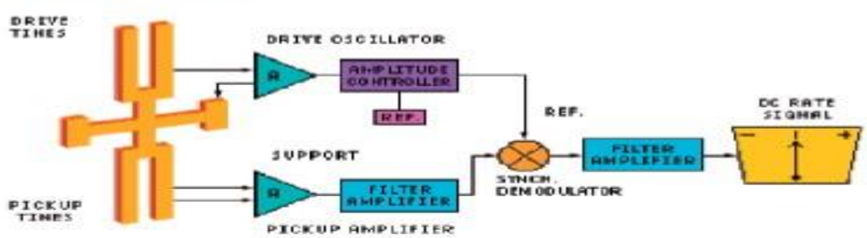


Fig. 5.2 Quartz rate sensor (courtesy of Systron Donner Inertial Division).

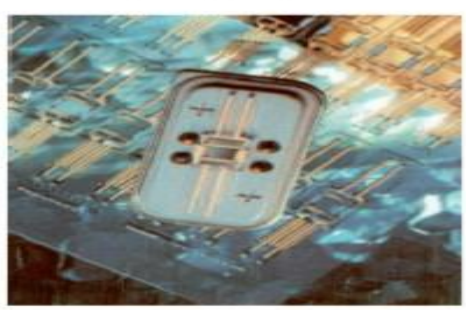


Fig. 5.3 Quartz rate sensor fabrication wafer with device overlaid (courtesy of Systron Donner Inertial Division).

Q22. Design and explain the Auto pilot of UAV (ardupilot) and its features with drawings ?

Answer :

Auto pilot of UAV(ardupilot)

- **ArduPilot**(also **ArduPilotMega**- APM) is an open source unmanned aerial vehicle (UAV) platform, able to control autonomous multicopters, fixed-wing aircraft, traditional helicopters and ground rovers.
- The system was improved to replace thermopiles with an Inertial Measurement Unit (IMU) using a combination of accelerometers, gyroscopes and magnetometers.

https://www.sparkfun.com/products/retired/9710

❖ Features of Ardupilot:-

- Programmable 3D way points
- Return to launch
- inflight reset
- fully programmable actions at waypoints
- Stabilization options to negate the need for a third party co-pilot
- Fly By Wire mode
- Optimization of 3 or 4 channel airplanes.
- Flight Simulations

Q23. Define the following with help of drawings ;

Aircraft flight control systems , Spoilers

, Rudder , Flight control, Dead Reckoning system, Arinc429, Ailerons, Instrumental Flight Rules (IFR) , VHF OMNIRANGE SYSTEM (VOR), INSTRUMENT LANDING SYSTEM (ILS), Head up display, **Gyroscopes.**

Answer :

Aircraft flight control systems consist of flight control surfaces, the respective cockpit controls, connecting linkages, and the necessary operating mechanisms to control an aircraft's direction in flight. Aircraft engine controls are also considered as flight controls as they change speed. They can be divided into three main groups:

- Primary flight control

- Secondary flight control
- Auxilliary flight control

Spoilers

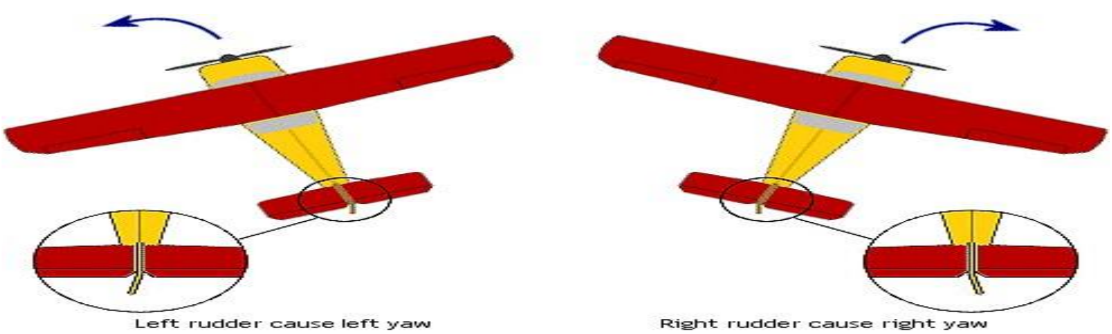
- On low drag aircraft like sailplanes, spoilers are used to disrupt airflow over the wing and greatly increase

the amount of drag.

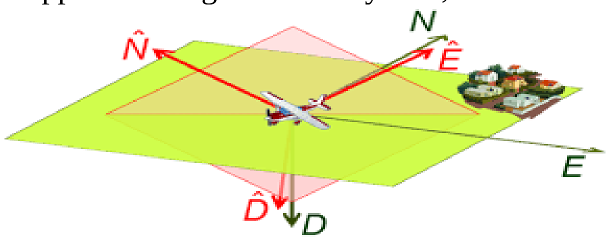
- This allows a glider pilot to lose altitude without gaining excessive airspeed.
- Spoilers are sometimes called "lift dumpers". Spoilers that can be used asymmetrically are called spoilerons and are able to affect an aircraft's roll.

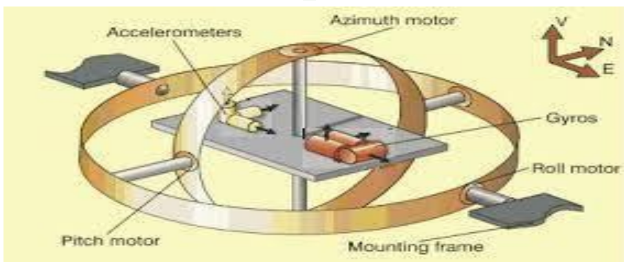
Rudder - Located at the end of the Empennage (tail)

It rotates to help the plane turn. The way it works is when the Rudder turns to the left, the plane goes left, and if the Rudder turns to the right, the plane goes right.



Flight control: Auto stabilization/ Stability Augmentation. FBW flight control systems Auto stabilization systems are required for achieving acceptable control and handling motion characteristics across flight envelope. FBW flight control systems provide continuous automatic stabilization of the aircraft by computer control of the control surfaces from appropriate motion sensors

- Dead Reckoning system: DR navigation derives the vehicles present position by estimating the distance traveled from a known position's speed and direction of motion of vehicle. They are of 3 types
  - ✓ Inertial navigation systems
  - ✓ Doppler/heading reference system,
  - ✓ 

  - ✓ 

Arinc429: ARINC 429 is a single-source, multiple-sink, half-duplex bus that operates at two transmission rates; most commonly the higher rate of 100 Kbit/s is used. Although the data

bus has its origins in the civil marketplace, it is also used extensively on civil platforms that have been adopted for military use, such as the Boeing 737, Boeing 767 and A330. High-

performance business jets such as the Bombardier Global Express and Gulfstream GV that

are frequently modified as electronic intelligence (ELINT) or reconnaissance platforms also employ A429

b. History: The ARINC 429 Specification developed out of the original commercial aviation

digital communication spec, the ARINC 419 Specification. The ARINC 419, first released in

1966 and last revised in 1983, describes four different wiring topologies, including a serial, twisted shielded pair interface used by the Digital Air Data System (DADS), known as the ARINC 575 or DADS 575 Spec.

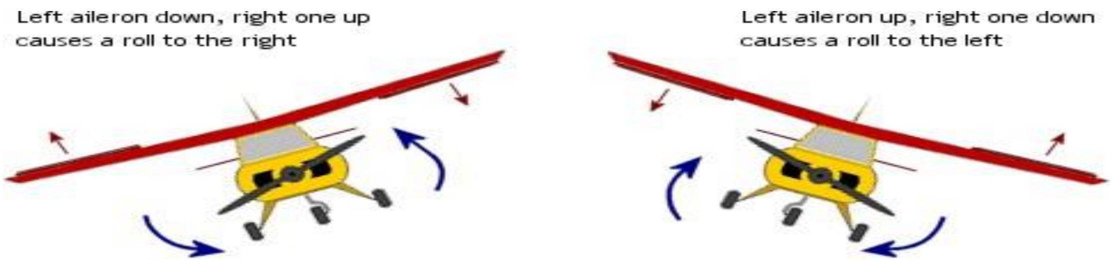
Aileron assist the plane in turning. It's located on the far end of the wings.

The purpose of the Ailerons is to roll the plane, which helps it turn.

- They are much smaller than the wind flaps. When the Aileron on wing side goes up, the other wing's Aileron goes down.

- The wing with the Aileron up tilts down, and the other Aileron which is

down, makes the wing go up.



Instrumental Flight Rules (IFR)

IFR may be described as bad weather or blind weather, when visibility is poor or the height of the clouds falls below the visual meteorological conditions. In IFR conditions, ATC personnel guide the safe separation between aircrafts.

To avoid possibility of mid air collision at high speeds and density of traffic, IFR are described regardless of the weather conditions. This is called “positive control airspace” which is used where high speed jet operate at Airport Radar Service Area (ARSA) as well as the airspace at above 6000 m above MSL, in which jet fly from one airport to another airport.

- ✓ VOR, short for VHF omnidirectional radio range, is a type of radio navigation system for aircraft, enabling them to find their position and stay on course by receiving radio signals emitted by a network of radio beacons. It uses frequencies in very high frequency (VHF) from 108 to 117.95 MHz.

INSTRUMENT LANDING SYSTEM (ILS)

- ✓ It Operates in the VHF portion of the electromagnetic spectrum
- ✓ System consists of a runaway localizer, a glide slope signal, and marker beacons for position location
- ✓ Localizer equipment produces a radio course aligned with the centre of an airport runaway. The on course signals result from the equal reception of two signals; Blue sector(150 Hz) and yellow sector(90 Hz)
- ✓ In aviation, the instrument landing system (ILS) is a radio navigation system that provides short-range guidance to aircraft to allow them to approach a runway at night or in bad weather.

Head up display

- A head-up display,[1] also known as a HUD (/hʌd/), 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. A HUD also has the advantage that the pilot's eyes do not need to refocus to view the outside after looking at the optically nearer instruments.
- **Gyroscopes (hereafter abbreviated to gyros) and accelerometers are known as inertial sensors. This is because they exploit the property of inertia, namely the resistance to a change in momentum, to sense angular motion in the case of the gyro and changes in linear motion in the case of the accelerometer. They are fundamental to the control and guidance of an aircraft.**

Q24 .

1. What are the main cockpit display systems

Answer :

The main cockpit display systems

- Primary display
- Head Up Display
- Helmet mounted display
- Head down display
- Multi function display

2. Design and explain the Primary Flight Display showing the marker of the following parameters ;

Altitude indicator, slip/skid indicator, air speed indicator, turn indicator, vertical speed indicator, altimeter, horizontal stabilization indicator, .

- A PFD presents information about primary flight instruments, navigation instruments, and the status of the flight in one integrated display. Some systems include powerplant information and other systems information in the same display. A typical primary flight display is shown in Figure

Q25. Figure 1 , shows the BLEU automatic landing system , explain the operation of this system and find the following parameters ;

1. The ILS Gliding slope angle,
2. The Hight of the Outer marker,
3. The Hight of the Middle marker,
4. The Hight of the Inner marker,

Answer :

The BLEU automatic landing system is shown in Figure and is divided into four phases from the time the outer marker radio beacon is reached, about 8000 m from the threshold. These phases are briefly described below.

1. Final approach. This phase covers the approach from the outer marker beacon to the inner marker beacon. At the inner marker beacon the aircraft flight path.

2. Constant attitude. The guidance signals from the ILS are disconnected from the autopilot when the aircraft reaches a height of 100 ft above the ground.

3. Flare. The aircraft pitch attitude is controlled by the feedback of the radio altimeter derived height to produce an exponential flare trajectory. The flare is initiated at a height of around 50 ft where the aircraft is over or very near the runway threshold. The aircraft is progressively rotated

in pitch during the flare so that the flight path angle changes from the −2.5 ◦ to −3 ◦ value at the start of the flare to the positive value specified for touchdown.

4. Kick off drift. Just prior to touchdown a 'kick off drift' manoeuvre is initiated through the rudder control so that the aircraft is rotated about the yaw axis to align it with the runway. This ensures the undercarriage wheels are parallel to the runway centre line so that no sideways velocity is experienced by the wheels when they make contact with the runway.

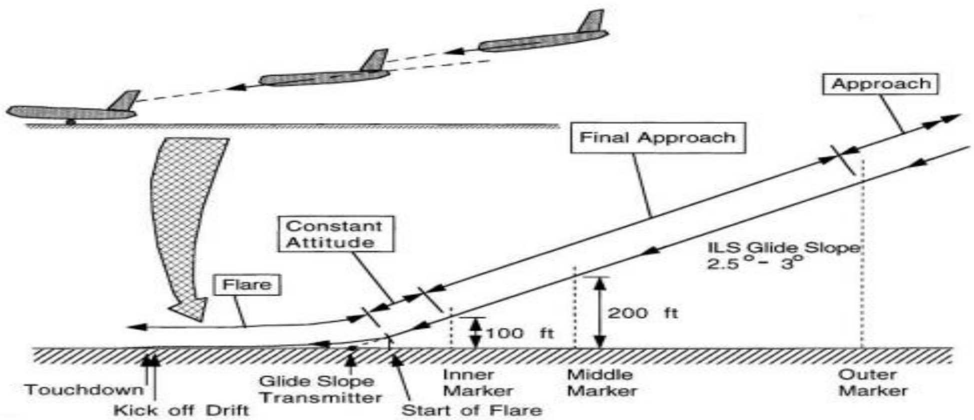


Figure 1

Q25. Figure 1, shows 3D dimension Movement of an Aircraft explain the basic operation and assign and showing the following parameters directions ;

Roll, Pitch, Yaw, Right aileron, Wing, Vertical stabilizer, horizontal stabilizer, Rudder, Elevator, Left aileron.

Answer ; figure 1, shows the directions of movement of the Roll, Pitch, Yaw, Right aileron, Wing, Vertical stabilizer, horizontal stabilizer, Rudder, Elevator, Left aileron.

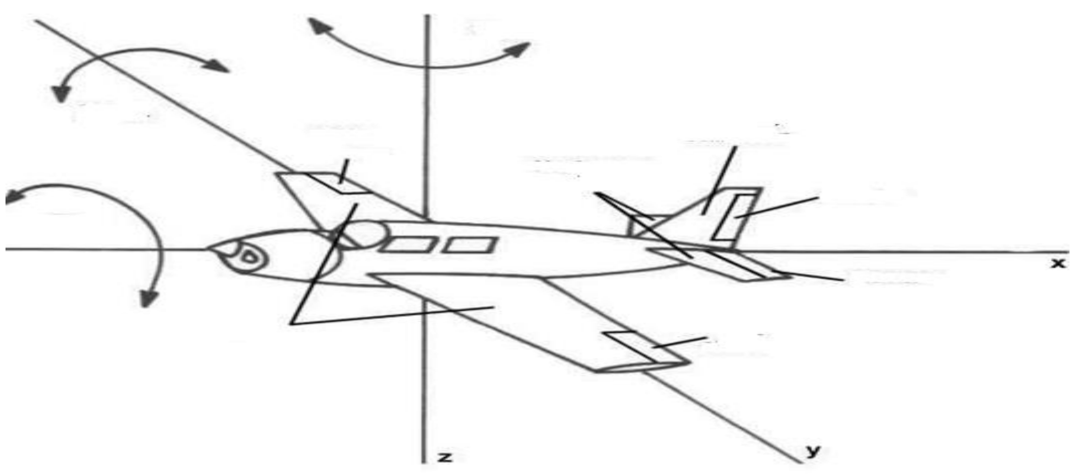
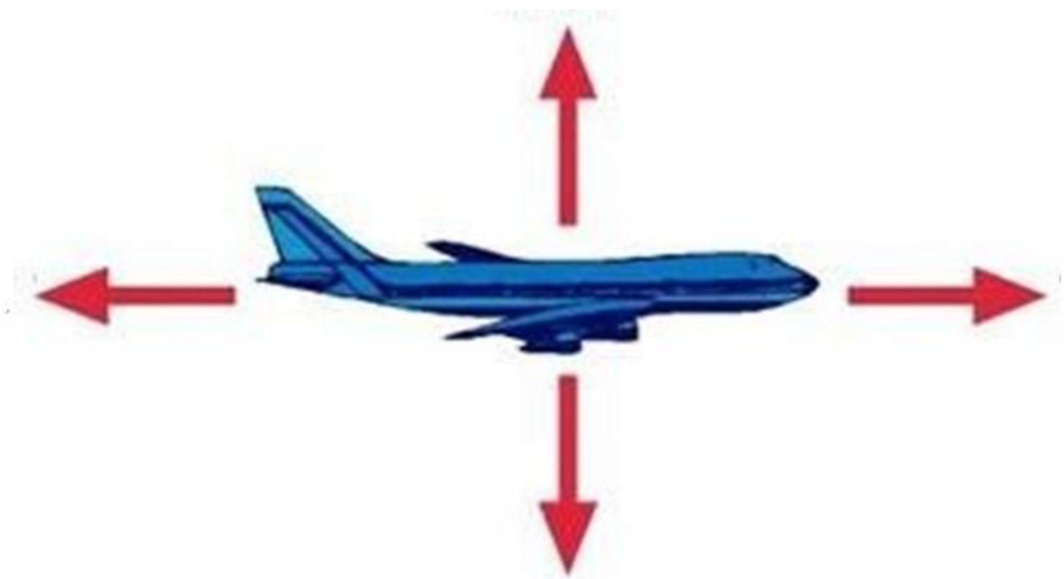


Figure 1

Q26 . Figure 1, shows an aircraft structure , assign the following forces on suitable red arrow and explain the function of each one ;

Lift, Thrust, Weight, and Drag.

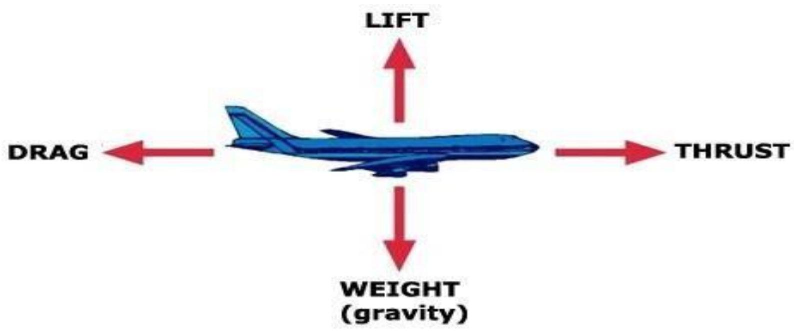


Answer :

Each force has an opposite force that works against it. Lift works opposite of weight. Thrust works opposite of drag. When the forces are balanced, a plane flies in a level direction. The plane goes up if the forces of lift and thrust are more than gravity and drag.

- Drag: the force that acts in the opposite direction of the plane and slows the plane down
- Lift: the upward force that allows an airplane to stay in the air
- Thrust: the forward force that propels the plane forward

- Weight: the downward force of gravity that pulls the plane toward the ground

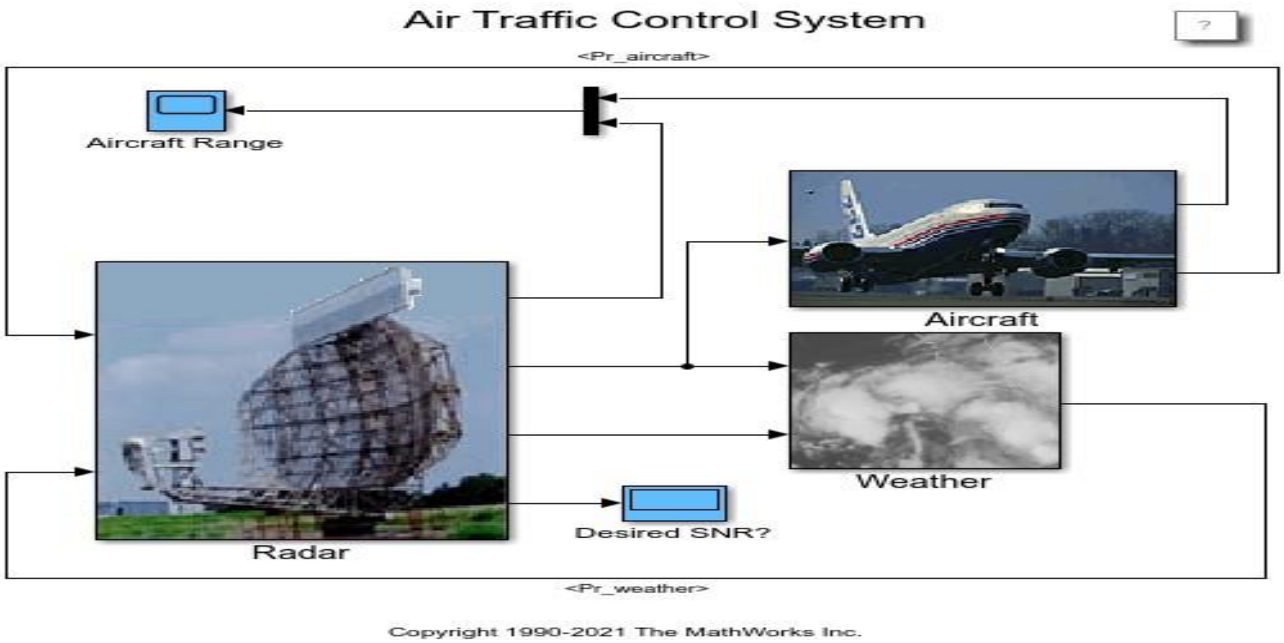


Q27 . Design and explain the Air Traffic Control Radar system and explain its operation .

Air traffic control (ATC) is a service provided by ground-based air traffic controllers (also called control tower operators (CTO)) who direct aircraft on the ground and through a given section of controlled airspace, and can provide advisory services to aircraft in non-controlled airspace. The primary purpose of ATC worldwide is to prevent collisions, organize and expedite the flow of air traffic, and provide information and other support for pilots.

Model Description

To make parameters for *Radar System Design* easier to change and easier to determine their values, the model has a GUI. Radar and weather parameters may be changed from this GUI. While simulating, the effects of these parameters can be seen on the scope display which shows the actual aircraft range in yellow and the estimated aircraft range from the radar in magenta. Another output that can be viewed is the calculated signal to noise ratio (SNR) is compared to the ideal SNR. Ideal SNR is also specified from the GUI. The result is shown in the display block and will be either 1 (SNR >= ideal SNR) or 0 (SNR < ideal SNR).



Q27. Design and dray the **'Gyro Chip' vibrating quartz tuning fork rate gyro block diagram and explain its operation.**

Answer :

Figures 1, shows the 'Gyro Chip' vibrating quartz tuning fork rate gyro developed by the BEI Systron Donner Inertial Division; the author is indebted to the company for permission to publish this information. The basic configuration is shown schematically in the figure and comprises a vibrating quartz tuning fork to sense angular rate which is coupled to a similar fork as a pick-up to produce the rate output signal. The piezo-electric drive tines are driven by an oscillator to vibrate at a precise amplitude. An applied rotation rate about an axis parallel to the vibrating tines causes a sine wave of torque to be produced resulting from the Coriolis acceleration as explained earlier. This oscillatory torque in turn causes the tines of the Pickup Fork to move up and down in and out of the plane of the fork assembly. This causes an electrical output signal to be produced by the Pick-up Amplifier which is amplified and phase sensitive rectified to provide a DC signal which is directly proportional to the input rate. (The sign of the DC output signal changes sign when the input rate reverses due to the action of the phase sensitive rectifier.) The pair of tuning forks and their support flexures and frames are batch fabricated from thin wafers of single crystal piezo-electric quartz and are micro-machined us- 260 5 Inertial Sensors and Attitude Derivation ing photo-lithographic processes similar to those used to produce millions of digital quartz wristwatches each year.

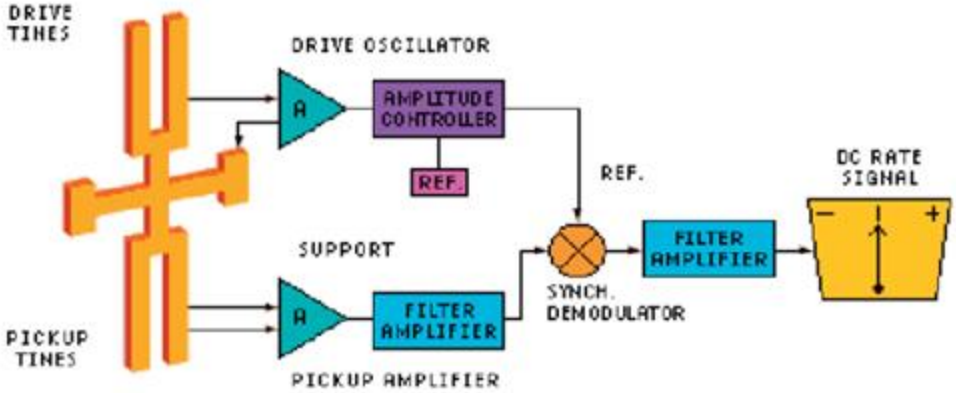


Figure 1

Q 28. Design and explain the block diagram of the navigation inertial for the aircraft Gyro and accelerometer systems.

Figure 1, illustrates the basic concepts of deriving the velocity and distance travelled of the vehicle from its acceleration components. Put like this it seems simple. Any errors, however, in deriving the aircraft acceleration components from the accelerometer outputs will be integrated with time, producing velocity errors which in turn are integrated with time generating position errors. For example, a constant accelerometer bias error, B (which can be equated to an initial tilt error), will result in a distance error which is equal to B dt dt, that is Bt2 /2. The resulting distance error is thus proportional to the square of the elapsed time. An accelerometer bias error of 10−3 g will produce a distance error of 0.45 km after 5 minutes and 1.8 km after 10 minutes, for example.

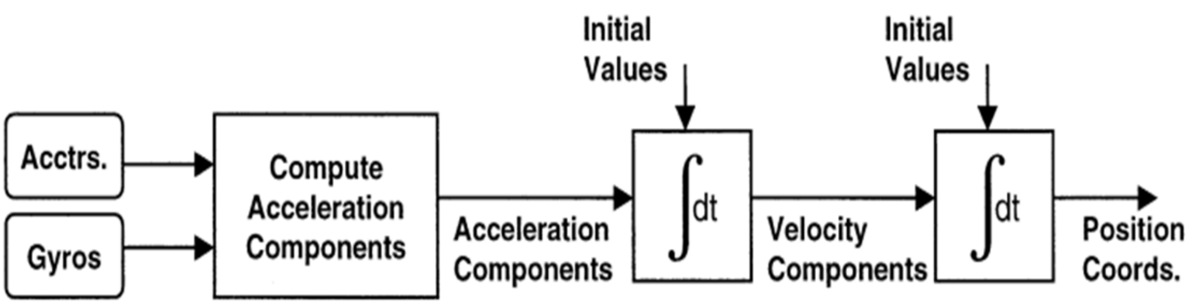


Figure 1

Q.29. Figure 1, shows the GPS spherical ranging , explain the following ;

1. The basic operation principle of the GPS ,
2. There are three segments for the GPS system , state and explain one of them.
3. How many satellites the space segment comprises ?

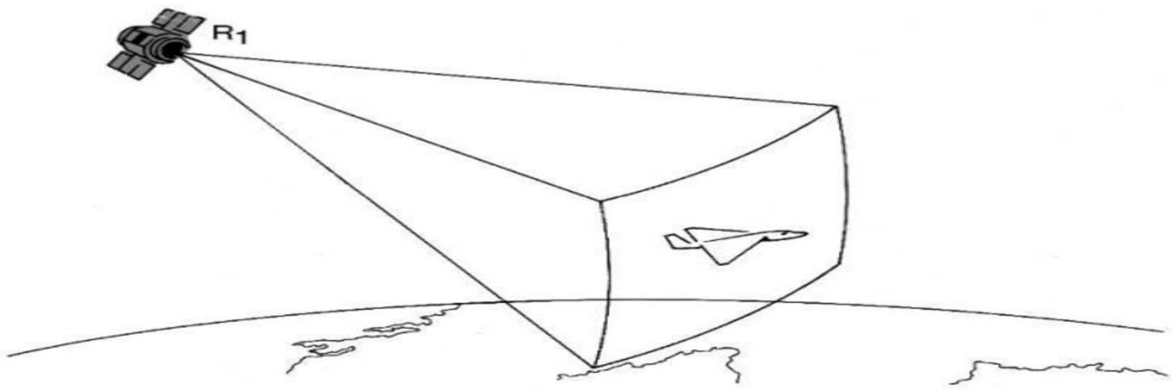


Figure 1,

Answer :

1. **Basic Principles of GPS**
   The basic principle of position determination using the GPS system is to measure the spherical ranges of the user from a minimum of four GPS satellites. The orbital positions of these satellites relative to the Earth are known to extremely high accuracy and each satellite transmits its orbital position data. Each satellite transmits a signal which is modulated with the C/A pseudo-random code in a manner which allows the time of transmission to be recovered. 6.5 GPS – Global Positioning System 359 Fig. 1 GPS spherical ranging. The spherical range of the user from the individual transmitting satellite can be determined by measuring the time delay for the satellite transmission to reach the user. Multiplying the time delay by the velocity of light then gives the spherical range, R, of the user from the transmitting satellite. The user's position hence lies on the surface of a sphere of radius, R, as shown in Figure 1. The system depends on precise time measurements and requires atomic clock reference standards. The need for extremely high accuracy in the time measurement can be seen from the fact that a 10 ns (10−8 seconds) time error results in a distance error of 3 metres, as the velocity of light is 3 × 108 m/s.

2.

The overall GPS system comprises three segments, namely the space segment, the control segment and the user segment and is shown schematically in Figure 6.30. The three segments are briefly summarised below.

Space Segment. This comprises 24 GPS satellites placed in six orbital planes at 55◦ to the equator in geo-synchronous orbits at 20,000 km above the Earth. The orbit tracks over the Earth, forming an 'egg beater' type pattern. Twenty-one satellites are required for full worldwide coverage and three satellites act as orbiting spares. The GPS satellites use two frequency transmissions, L1 at 1575.42 MHz and L2, at 1227.6 MHz for transmitting the digitally encoded navigation message data at 50 Hz modulation on both the L1 and L2 channels. The navigation message data will be explained in more detail in the next section but

basically comprises the satellite orbital position parameters, clock correction parameters and health information for itself and the other satellites, and the almanac data for all the satellites. Spread spectrum techniques are used on both the L1 and L2 frequency channels.

Control Segment. This comprises a Master Control Station at Colorado Springs in the USA and five monitor stations located worldwide. The control segment is operated by the United States Department of Defense (DoD). The control segment tracks the satellites and predicts their future orbital position data and the required satellite clock correction parameters, and updates each satellite on the uplink as it goes overhead. The GPS full system accuracy is only available when the operational control system is functioning properly and navigation messages are uploaded on a daily basis. The GPS satellites are, however, designed to function with the control system inoperable for a period of 180 days with gradually degraded accuracy. This gives the GPS system a high degree of robustness.

User Segment. The user segment equipment as mentioned earlier is entirely passive and comprises a GPS receiver. A very wide variety of compact, light weight and inexpensive GPS receivers are now available, all using the same basic concepts. The user system operation is very briefly as follows. The operator first enters the estimated present position and the time. The GPS receiver then starts to search for and track satellites. The data coming in identifies the satellite number, locates the satellite in space and establishes the system time. As will be explained in the next section the GPS receiver needs to track the signals from at least four satellites to determine the user's position. As mentioned in the introduction to this chapter, the user's 3D position is determined to an accuracy of 16 m RMS, 3D velocity to 0.1 m/s RMS by measuring the Doppler shifts, and time to within 100 ns (1 sigma).

3. **Space Segment. This comprises 24 GPS satellites placed in six orbital planes at 55◦ to the equator in geo-synchronous orbits at 20,000 km above the Earth.**

Q.31. Figure 1, shows the differential GPS (DGPS) system ,

1. Define the DGPS system.
2. Explain the basic operations of DGPS system.
3. The GPS satellite clock, the errors of the pseudo range measurements .

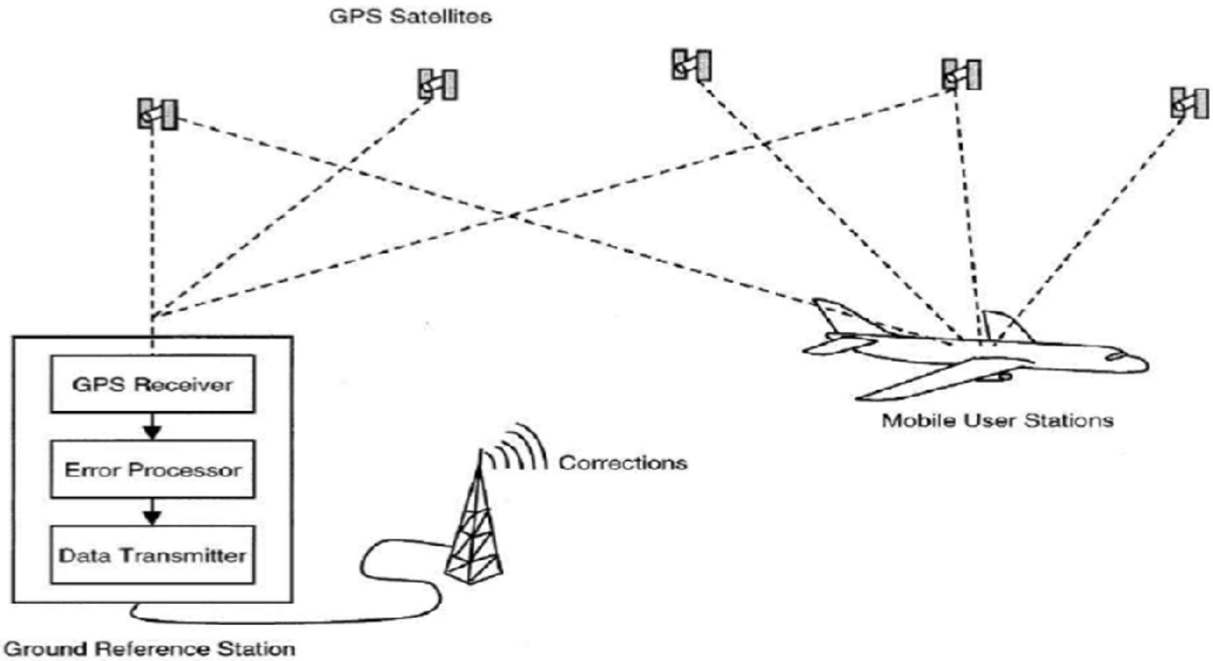


Figure 1,

Answer ;

1.

DGPS can be defined as:

The positioning of a mobile station in real-time by corrected (and possibly Doppler or phase smoothed) GPS pseudo ranges. The corrections are determined at a static 'reference station' and transmitted to the mobile station. A monitor station may be part of the system, as a quality check on the reference station transmissions.

2.

Basic Principles

The basic principle underlying DGPS is the fact that the errors experienced by two receivers simultaneously tracking a satellite at two locations fairly close to each other will largely be common to both receivers.

The basic differential GPS concept is illustrated in Figure 1 The position of the stationary GPS Reference Station is known to very high accuracy so that the satellite ranges can be very accurately determined, knowing the satellite ephemeris

3.

data. The errors in the pseudo-range measurements can then be derived and the required corrections computed and transmitted to the user's receiver over a radio link. The errors present in a GPS system are illustrated schematically in Figure 6.36 and are briefly discussed below.

GPS satellite clocks. GPS satellites are equipped with very accurate atomic clocks and corrections are made via the Ground Stations, as explained in the preceding section. Even so, very small timing errors are present and so contribute to the overall position uncertainty.

Selective Availability deliberately introduced noise equivalent to around 30 m in the individual satellite clock signals.

Satellite ephemeris errors. The satellite position is the starting point for all the positioning computations, so that errors in the Ephemeris data directly affect the system accuracy. GPS satellites are injected into very high orbits and so are relatively free from the perturbing effects of the Earth's upper atmosphere. Even so, they still drift slightly from their predicted orbits and so contribute to the system error.

Atmospheric errors. Radio waves slow down slightly from the speed of light in vacuo as they travel through the ionosphere and the Earth's atmosphere. This is due respectively to the charged particles in the ionosphere and the water vapour and neutral gases present in the troposphere. These delays translate directly into a position error.

Answer the followings ;

1. Draw and explain the Radar block diagram.
2. Figure 3, shows the detection range between the air traffic control radar and the aircraft, find the following ; The equation of calculating the distance d between the air traffic control radar and the aircraft and if the time delay of **1µsec**, find the distance **d** .

3. Explain the main functions of Air Traffic Control Radar system ..

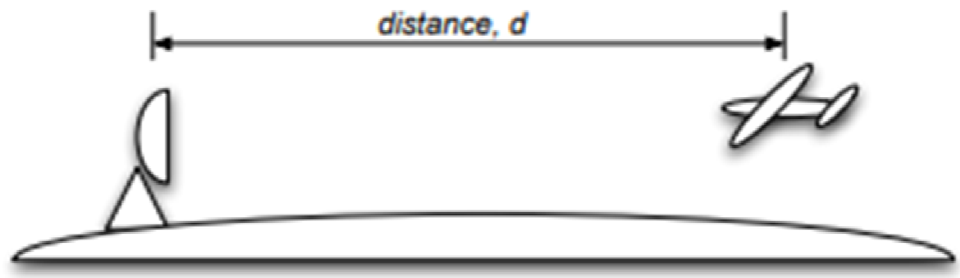
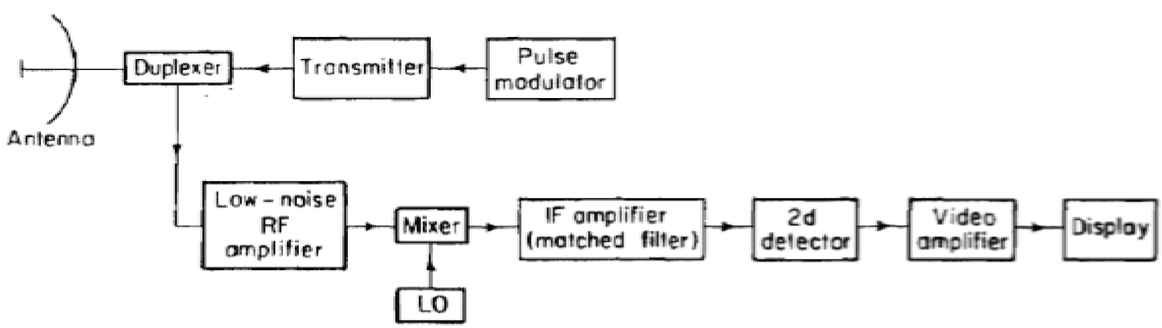


Figure 3

Answer :

Radar block diagram



Transmitter section

- Transmitter : the transmitter may be a power amplifier such as klystron, travelling wave tube or transistor amplifier. This will generates the Electrical energy at R.F.(Radio Frequency).
- Pulse modulator : The power amplifier (Such as Klystron, TWT) produces a high power signal, may be in terms of megawatts. Pulse modulator shown in the block is used as a switch, which will turn on and off the power amplifier.
- Wave form generator: A low power signal is produced by the waveform generator which is given as an input to the power amplifier.
- Duplexer: The duplexer allows a single antenna to be used on a time shared basis for both transmitting and receiving. The duplexer is generally a gaseous device that produces a short circuit at the input to the receiver when the transmitter is operating, so that high power flows to the antenna and not to the receiver. On the reception, the duplexer directs echo signal to the receiver and not to the transmitter. Solid state ferrite circulators and receiver protector devices can also be part of the duplexer

Act

Receiver section:

- Low noise RF amplifier: The receiver is almost always a super heterodyne. LNA is used immediately after the antenna. This reduces the Noise Figures and produces the RF pulse proportional to the transmitted signal.
- Mixer and local oscillator: It converts the RF signal to an intermediated frequency where it is amplified by the IF amplifier. The IF frequency might be 30 or 60 MHz.
- IF amplifier:

  i) It amplifies the IF pulse.

  ii) IF amplifier is designed as a matched filter which maximizes the output peak signal to mean noise ratio.

  iii) The matched filter maximizes the detectability of weak echo signals and attenuates unwanted signals.

  iv) The signal bandwidth of super heterodyne receiver is determined by the bandwidth of its IF stage.

  v) For example when pulse width is of the order of 1μs the IF bandwidth would be about 1MHz.

- Second Detector: the IF amplifier followed by a crystal diode which is called the second detector or demodulator. Its purpose is to assist in extracting the echo signal modulation from the carrier. It is called as 2ndDetector since it is the second diode used in the chain. The first diode is used in the mixer. Output of the 2ndDetector is the Video Pulse.
- Video amplifier: It is designed to provide the sufficient amplification to rise the level of the input signal to a magnitude where it can be diplay (CRT or Digital computer).
- Threshold decision: The output of video amplifier is given to the threshold detector where it is decided whether the received signal is from a target or just because of the presence of noise.
- Display: The Display is generally a CRT (Cathode Ray Tube)

  (a) 'A' scope (b) PPI

  i) 'A' scope provided Range and Echo power.

  ii) PPI measures Range and bearing (azimuth angles)

  iii) In addition there are other displays like 'B' scope, ' D ' scope etc.

2.

The pulse travels a total distance of $2d$ at the speed of light c, which is 3×10^8 m/s, or 300 m/μs.

The echo returns after a delay of

$$t_d = \frac{2d}{c}$$

A delay of 1 μs corresponds to a distance of

$$d = ct_d/2 = (300 \text{ m}/\mu\text{s})(1\mu\text{s})/2 = 150 \text{ m}$$

3 . Explain the main functions of the Air Traffic Control Radar system .

Answer :

Air traffic control (ATC) is a service provided by ground-based air traffic controllers (also called control tower operators (CTO)) who direct aircraft on the ground and through a given section of controlled airspace, and can provide advisory services to aircraft in non-controlled airspace. The primary purpose of ATC worldwide is to prevent collisions, organize and expedite the flow of air traffic, and provide information and other support for pilots.

Model Description

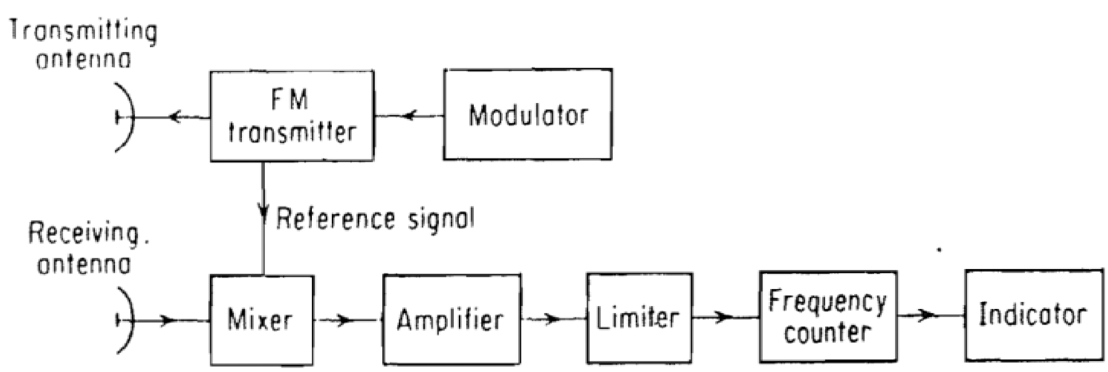
To make parameters for *Radar System Design* easier to change and easier to determine their values, the model has a GUI. Radar and weather parameters may be changed from this GUI. While simulating, the effects of these parameters can be seen on the scope display which shows the actual aircraft range in yellow and the estimated aircraft range from the radar in magenta. Another output that can be viewed is the calculated signal to noise ratio (SNR) is compared to the ideal SNR. Ideal SNR is also specified from the GUI. The result is shown in the display block and will be either 1 (SNR >= ideal SNR) or 0 (SNR < ideal SNR).

Q.32 . Draw the block diagram of the FM-CW Radar and explain the basic operation of this radar.

One of the most applications of the FM-CW radar is the aircraft FM Altimeter , explain How its operation ?

Answer :

Block diagram illustrating the principle of the FM-CW radar



- A portion of the transmitter signal acts as the reference signal required to produce the beat frequency. It is introduced directly into the receiver via a cable or other direct connection.

- **FM CW radar is capable of measuring the relative velocity and the range of the target with the expense of bandwidth.**

- **The inability of the simple CW radar to measure range is related to the relatively narrow spectrum (bandwidth) of its transmitted waveform.**

- **By providing timing marks into the Tx signal the time of transmission and the time of return can be calculated. This will increase the bandwidth**

- **More distinct the timing, more accurate the result will be and more broader will the**

FM Altimeter

- The FM-CW radar principle is used in the aircraft radio altimeter to measure height above the surface of the earth.
- Relatively short ranges of altimeters permit Low Tx power and low antenna gain.
- Since the relative motion between the aircraft and ground is small, the effect of the Doppler frequency shift may usually be neglected.
- Frequency range: 4.2 to 4.4 GHz (reserved for altimeters)
- Solid state Tx is used here.
- High sensitive super-heterodyne Rx is preferred for better sensitivity and stability

Q.33. Explain and draw the block diagram of the Autopilot system and explain the function of each block

Answer :

The basic function of the autopilot is to control the flight of the aircraft a maintain it on a pre-determined path in space without any action being requir by the pilot. (Once the pilot has selected the appropriate control mode(s) of t autopilot.) The autopilot can thus relieve the pilot from the fatigue and tedium having to maintain continuous control of the aircraft's flight path on a long durati flight so the pilot can concentrate on other tasks and the management of the missi

8.2 Autopilots

8.2.1 Basic Principles

The basic loop through which the autopilot controls the aircraft's flight path is shown in the block diagram in Figure 8.1. The autopilot exercises a guidance function in the outer loop and generates commands to the inner flight control loop. These commands are generally attitude commands which operate the aircraft's control surfaces through a closed-loop control system so that the aircraft rotates about the pitch and roll axes until the measured pitch and bank angles are equal to the commanded angles. The changes in the aircraft's pitch and bank angles then cause the aircraft flight path to change through the flight path kinematics.

8.2 Autopilots 417

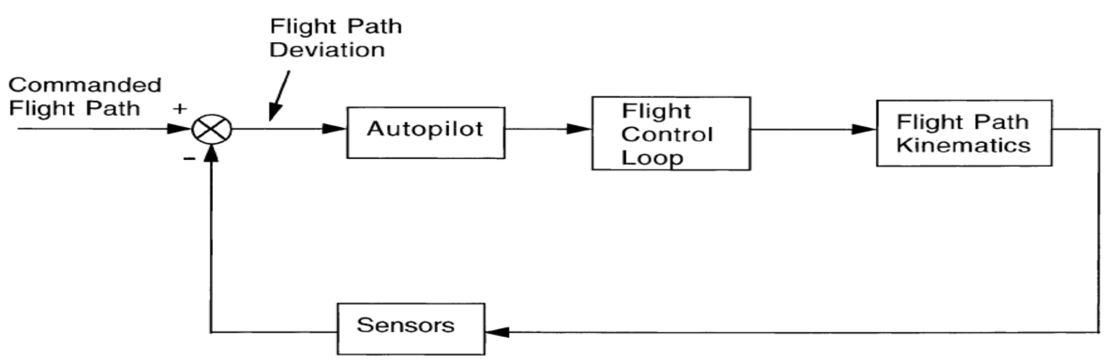


Fig. 8.1 Autopilot loop.

Q.34. Answer only one of the followings ;

1. Figure 1, shows the GBAS automatic landing system.
   Define the word GBAS system, and explain the basic operation of this system
   .

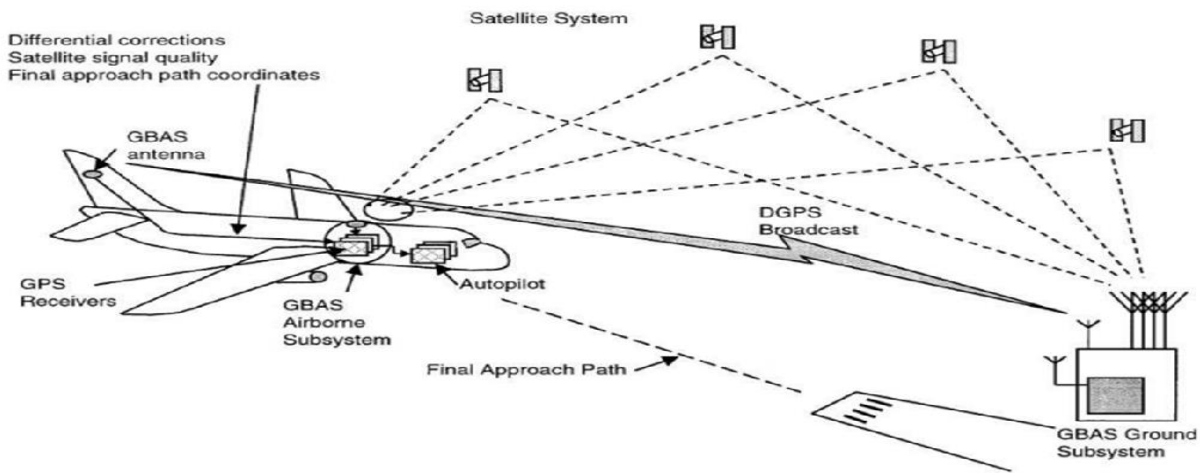


Figure 1

Answer :

Satellite Landing Guidance Systems

The navigation position accuracy of 1 m which can be achieved with the differential GPS technique is being exploited in the US for landing guidance with a system called the Ground Based Augmentation System, GBAS. The Ground Based Augmentation System, when installed at an airport, will be able to provide the high integrity and accurate guidance necessary for landing in Cat. III visibility conditions. The equipment is simpler and less expensive to install and maintain than an Instrument Landing System (ILS) or Microwave Landing System (MLS), so the GBAS life-cycle operation costs are a fraction of the other systems. It is therefore an attractive proposition for the many smaller airports which are not equipped with ILS or MLS.

It is also a more flexible system. For example, the final approach path need not be limited to straight line approaches, but can be curved or stepped, horizontally or vertically.

The Ground Based Augmentation System is shown schematically Figure 8.13. It consists basically of several GPS receivers connected to a base station in an equipment room. The base station processes the measurements from the GPS receivers, determines the differential corrections (as explained in Chapter 6, Section 6.5.6), estimates their quality and broadcasts this information to nearby aircraft. In addition, the co-ordinates of the final approach paths are transmitted to the aircraft.

The control laws exercised by the autopilot during the automatic landing are basically similar whether the guidance is provided by an ILS or MLS, or the GBAS.

2. What are the main tasks of the FMS and Draw and explain the block diagram of the flight management system .

Answer :

The FMS carries out the following tasks:

1. Flight guidance and lateral and vertical control of the aircraft flight path.
2. Monitoring the aircraft flight envelope and computing the optimum speed for each phase of the flight and ensuring safe margins are maintained with respect to the minimum and maximum speeds over the flight envelope.
3. Automatic control of the engine thrust to control the aircraft speed.

Figure 8.15 is a block diagram of a typical flight management system. The benefits they confer are briefly set out below:

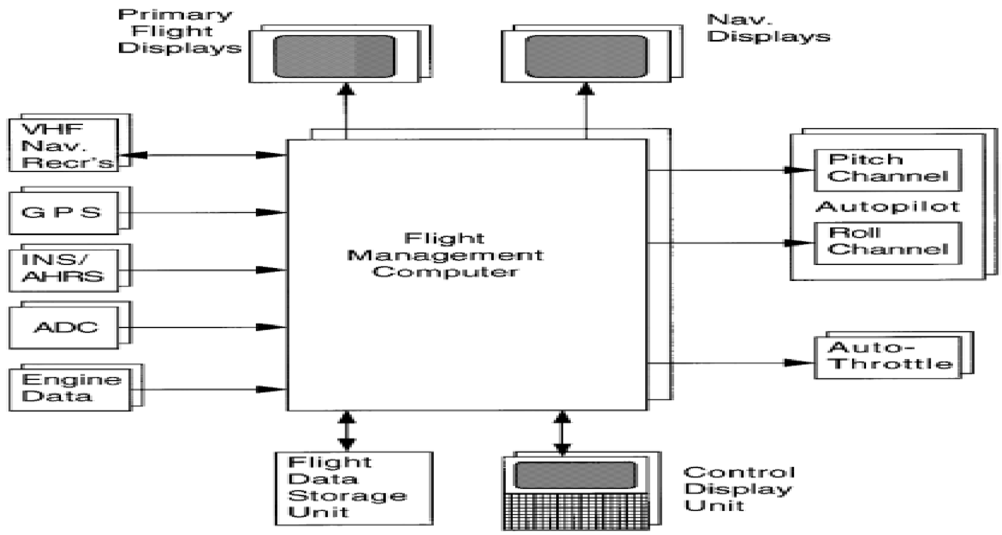


Fig. 8.15 Flight management system block diagram.

- *Quantifiable economic benefits* – provision of automatic navigation and flight path guidance to optimise the aircraft's performance and hence minimise flight costs.
- *Air traffic* – growth of air traffic density and consequently more stringent ATC requirements, particularly the importance of 4D navigation.
- *Accurate navigation sources* – availability of accurate navigation sources. For example, INS /IRS, GPS, VOR, DME and ILS / MLS.
- *Computing power* – availability of very powerful, reliable, affordable computers.
- *Data bus systems* – ability to interconnect the various sub-systems.