

SCHEME OF EVALUATION

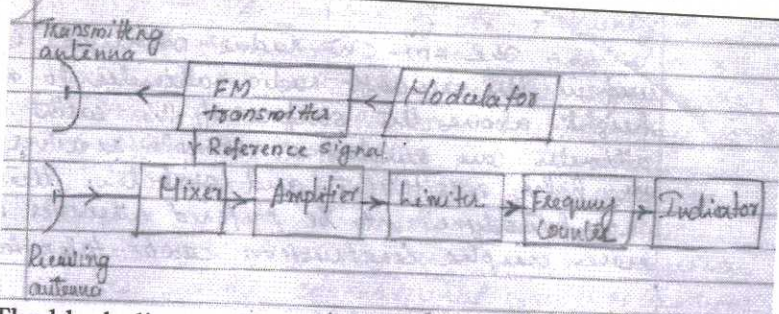
(Scoring Indicators)

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Course Title: Radar & Navigation

Course Code: 6045

Qst. No	Scoring Indicator	Split up Score	Sub Total	Total
I	<u>PART A</u>			
1	The receiver must be protected from damage caused by the high power of the transmitter. This will be done by a duplexer. It also serves to channel the returned echo signals to the receiver and not to the transmitter.	2	10	10
2	Conventionally radar generally have been operated at frequencies extending from about 220 MHz to 35 GHz.	2		
3	<ul style="list-style-type: none"> • It is being used as weather warning radar at the airbases to detect and measure thunderstorm, turbulence in the air. • It is very useful in detecting and estimating the target motion, locking of particular target out of a group. • To observe thunderstorm, rain & hail, a double polarization Doppler radar is being used. 	2 (any two)		
4	<p>Visual direction finders may be grouped into two main classes. They are:-</p> <ol style="list-style-type: none"> 1. Automatic direction finders (Radio Compass) Air borne equipments. 2. Right-Left type NDB(Non –Directional Beacons) ground equipment. 	2		
5	<ol style="list-style-type: none"> 1. One of the disadvantages of the ILS is that it provides a single approach path along the extended centre line of the runway. 2. It is sight sensitive and subject to distortion and bending of the approach path due to sight irregularities. Relatively small distortions can be overcome by the capture effect localizer, but this is not always possible and some sites can be bad that ILS cannot be installed. The main reason for this is that the ILS operates in the VHF/UHF band where the surrounding terrain plays an important part in shaping the beam. 3. It has also the drawback that the number of channels it can provide is limited to 40. 4. It is also prone to interference from broadcasting stations. 	2 (any two)		

II	PART B			
1	<p>Radar Cross Section for targets</p> <p>The Radar Cross Section of a target is the area intercepting that amount of power which, when scattered equally in all directions, produces an echo at the radar equal to that from the target or in other terms</p> $\sigma = \frac{\text{power reflected toward /unit solid angle}}{\text{incident power density /4}\pi} = \lim_{R \rightarrow \infty} 4\pi R^2 \left \frac{E_r}{E_i} \right ^2$ <p>where R = distance between radar and target</p> <p>E_r = reflected field strength at radar.</p> <p>E_i = strength of incident field at target.</p> <p>For most common type of radar targets such as aircraft, ships, terrain, the radar cross section does not necessarily bear a simple relationship to the physical area, except that the larger the target size, the larger the cross section is likely to be.</p> <p>Scattering and diffraction are variations of the same physical process. When an object scatters an electromagnetic wave, the scattered field is defined as the difference between the total field in the presence of the object and field that would exist if the object were absent. On the other hand, the diffracted field is the total field in the presence of the object. With radar backscatter, the two fields are the same, and one may talk about scattering and diffraction interchangeably. The region where the size of the sphere is small compared with the wavelength is called the Rayleigh region.</p>	6	6	
2	 <p>The block diagram shown above illustrating the principle of the FM- CW radar. A portion of the transmitted signal acts as the reference signal required to produce the beat frequency (difference frequency). It is introduced directly into the receiver via a cable or other direct connection. Ideally, the isolation between transmitting and receiving antennas is made sufficiently large so as to reduce to a negligible level the transmitter leakage signal which arrives at the receiver via the coupling between antennas. The beat frequency is amplified fluctuations. The frequency of the amplified limited beat not is measured with a cycle counting frequency meter calibrated in distance.</p>	Fig 3 Exp 3	6	

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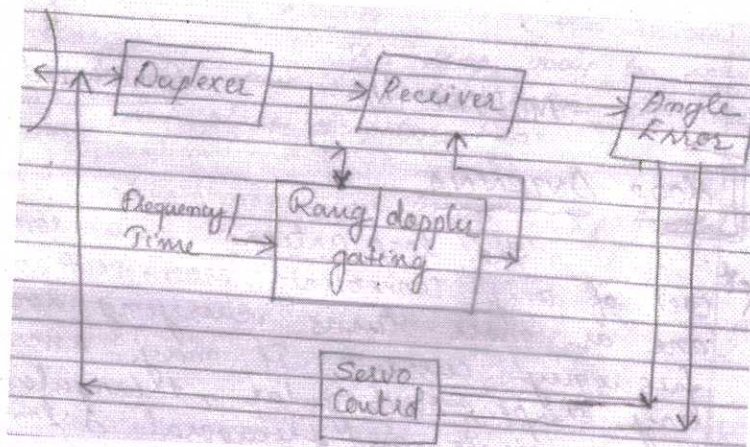


Figure shows the typical block diagram of tracking radar. Most tracking Radar use angular information as the basis of tracking operations. For better accuracy it important that radar concentrates on one target at the time. Range gating / Doppler filtering can be used for that purpose. Time and frequency control for range and Doppler gating, is done in range and Doppler trackers respectively. The angular error signal for the desired target to be tracked, are developed in the error demodulator block which also controlled by range / Doppler gate generation block and then fed back to the strength antenna in a closed loop for tracking.

Fig 3
Exp 3

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4

Methods of Navigation

Navigation requires the determination of the position of the craft and the direction in which it has to go to reach the desired destination. The currently used methods of navigation may be divided into four classes.

- i. Navigation by pilotage (or visual contact)
- ii. Celestial or Astronomical Navigation
- iii. Navigation by dead- reckoning
- iv. Radio Navigation.

(i) Navigation by Pilotage : In this method, the navigator fires his position on a map by observing known visible land marks.

(ii) Celestial Navigation: It is also known as astronomical navigation. It is accomplished by measuring the angular position of celestial bodies. Almanacs it is an actual celestial bodies at various times are readily Available.

(iii) Navigation by dead- reckoning : In this method of Navigation The position of the craft any istout of time is calculated from the previously determined position, the speed of its motion with respect to earth along with the direction of its

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motion and the time elapsed.

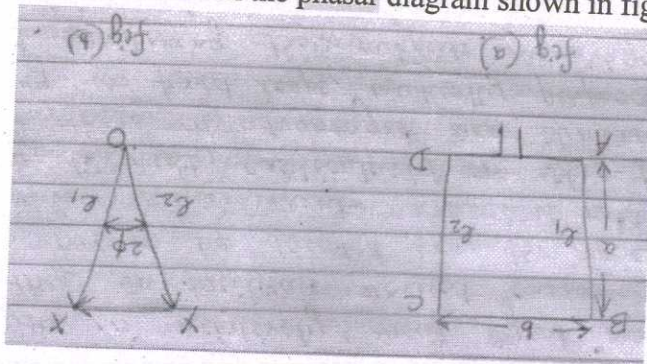
(iv) Radio Navigation:- this method is based on the use of electromagnetic waves to find the position of the craft. All these systems depend upon transmitters and /or receivers at known locations on the earth's surface and transmitters and/or receivers working in conjunction with them in the vehicle.

5

Loop Antenna: The loop antenna is a radiating coil of any convenient cross section of one or more turns carrying radio frequency current. It may assume any shape, rectangular, triangular, square, circle, and hexagonal. A loop of more than one turn is often called as frame.

consider a rectangular loop antenna of length 'a' and width 'b' which is shown in figure (a) with its plane vertical, mounted so that it can be rotated about the vertical axis. Let there be a vertically polarized electromagnetic wave incident on it coming from a direction making an angle θ with the plane of the loop the source will be assumed to be so far away that incident wave is a plane wave.

Voltages are induced in the vertical members of the loop, but not in its horizontal members as the wave is vertically polarized. The magnitude of the voltage induced in the two vertical members is $a \cdot \epsilon$, where ϵ is the magnitude of the electric field. The voltages in the two members will not be in phase, which can be seen in the phasor diagram shown in figure



Taking the electric field at the centre of the loop as the reference, the voltage induced in AB (represented by phasor OX in fig(b)) lags by an angle θ and that induced in CD leads by an equal angle.

If the loop has N turns instead of one, the output voltages of the turns add up and the resulting output is N times of a single turn loop. The loop voltage is proportional to the loop area, irrespective of the shape of the loop.

Fig 3
Exp 3

6

6	<p>1. MLS Advantages</p> <ol style="list-style-type: none"> i. Elimination of ILS/FM broadcast interference problems. ii. Capability to provide Precision guidance to small landing areas such as roof- top heliports iii. Continues availability of a wide range of glide paths.] iv. Accommodation of both segments and curved approach. v. Availability of 200 channels which is five times more than ILS. vi. Improved guidance quality with fewer flight path corrections required. vii. Provision of back- azimuth for missed approaches and departure guidance. viii. Elimination of service interpretation caused by snow accumulation. ix. Lower site preparation, repair and maintenance costs. 	6 (any six)		
7	<p>Global Navigation satellite System. (GNSS)</p> <p>A satellite navigation system with global coverage is termed as Global Navigation Satellite System (GNSS). GNSS is used to determine the position of a receiver on land, at sea or space.</p> <p>Architecture</p> <p>GNSS architecture mainly compared of three sections</p> <ol style="list-style-type: none"> (i) Space Segment (ii) Ground Segment and (iii) Closer Segment. <p>(i) Space Segment: The space segment is formed by satellites are placed above the earth is nearly orbital planes. Each satellite is required with devices that are used for navigation or other special tasks. The satellite receiver store and process transmitted information from a ground control centre. To identify each satellite, the satellite have various identification systems.</p> <p>The functions of a satellite are</p> <ul style="list-style-type: none"> • Receives and stores data from the ground control segment. • Maintain very precise time • Transmit data to users through the use of several frequencies. 	6	6	

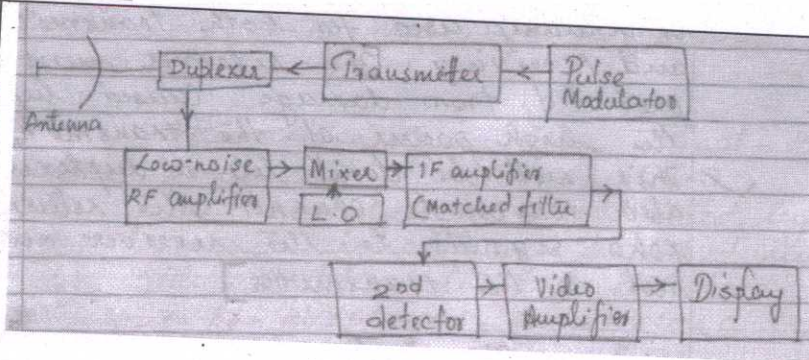
- Controls both its attitude & position.
- (ii) Ground Segment / Control Segment : The main function of ground segment are
- Deployment (the action of bringing resources into effective action) and maintenance of system.
 - Tracking of the satellite in their orbits.
 - Activate spare satellites.
 - Check the SV health
 - Monitoring of auxiliary data and upload of the data message to the satellite.

(ii) User Segment

User segment consists of passive receivers able to decode received signals from satellites.

PART C

III (a)



4

Figure shows the block diagram of Pulse radar

The transmitter may be an oscillator such magnetron that is pulsed by the modulator to generate a respective train of pulses.

A typical radar for the detection of air craft at ranges of 100 or 200nmi might employ a peak power of the order of a mega watt an average power of several kilo watts, a pulse width of several micro seconds and a pulse repetition frequency of several 100 pulses per second.

The wave form generated by the transmitter travel via a transmission line to the antenna, where it is radiated into space. A single antenna is generally used for both transmitting and receiving. The receiver must be protected from damaged caused by the high power of the transmitter. This will be done by a duplexer. It also serves to channel the returned echo signals to the receiver and not to the transmitter,

The Duplexer might consist of two gas discharge devices. One known as TR (transmit receive) and the other as ATR (Ant-transmit receiver). The TR protects the receiver during transmission and ATR directs the echo signals to the

4

8

	<p>receiver during reception.</p> <p>The receiver is usually of the super heterodyne type. The first stage might be a low noise RF amplifier. In some cases the C/P can simply be the mixer stage especially in military radars. Although a low noise front end will be more sensitive. The mixer and local oscillator convert the RF signal to the IF amplifier should be designed as matched fitter that is its frequency response function should maximize the peak signal to mean noise power ration at the O/P. After maximizing the signal to noise ratio is the IF amplifier the pulse modulation is extracted by the second detector and amplified by the video amplifier to a level where it can be displayed usually on a CRT. The most common form of CRT display in the plan position indicator or PPI.</p>			
III (b)	<p><u>Radar range equation</u></p> <p>The radar equitation relates the range of a radar to the characteristics of the transmitter receiver, antenna, target, and environment. If the power of the radar transmitter is denoted by P_t, and if an Isotropic antenna is used (one which radiates uniformly in all directions), the power density (watts per unit area) at a distance R from the radar is equal to the transmitter power divided by the surface area $4\pi R^2$ of an imaginary sphere of radius R or</p> $\text{Power density from Isotropic antenna} = \frac{P_t}{4\pi R^2} \rightarrow 1$ <p>The gain G of an antenna is a measure of the increased power radiated in the direction of the target as compared with the power that would have been radiated from an Isotropic antenna. The power density at the target from an antenna with a transmitting gain G is</p> $\text{Power density from directive antenna} = \frac{P_t G}{4\pi R^2} \Rightarrow 2$ <p>The target intercepts a portion of the incident power and reradiates in its various directions. The measure of the amount of incident power intercepted by the target and reradiates back in the direction of the radar is denoted as the radar cross section σ, and is defined by the relation.</p> $\text{Power density of echo signal at radar} = \frac{P_t G}{4\pi R^2} \cdot \frac{\sigma}{4\pi R^2} \rightarrow 3$ <p>The radar cross section σ as units of area. It is a characteristic of the particular target and is a measure of its size as seen by the radar. The radar antenna captures a portion of the echo</p>	7	7	

power. If the effective area of the receiving antenna is denoted as A_e , the power P_r received by the radar is,

$$P_r = \frac{P_t G}{4\pi R^2} \cdot \frac{\sigma}{4\pi R^2} \quad A_e = \frac{P_t G A_e \sigma}{(4\pi R)^2 R^4} \quad \text{--->4}$$

The maximum radar range R_{max} is the distance beyond which the target cannot be detected. It occurs when the receiver echo signal power P_r just equals the minimum detectable signal S_{min} there fore;

$$R_{max} = \left[\frac{P_t G A_e \sigma}{(4\pi)^2 S_{min}} \right]^{1/4} \quad \text{--->5}$$

This is the fundamental form of radar equation. The important antenna parameters are the G & A_e .

Antenna theory gives the relationship between the transmitting gain and the receiving effective area of an antenna as

$$G = \frac{4\pi A_e}{\lambda^2} \quad \text{---> 6}$$

Since radar generally use the same antenna for both transmission and reception the EQ6 can be substituted into EQ5, first for A_e and then for G , to give two other forms of radar equations.

$$R_{max} = \left[\frac{P_t G^2 \lambda^2 \sigma}{(4\pi)^3 S_{min}} \right]^{1/4} \quad \text{--->7}$$

$$R_{max} = \left[\frac{P_t A_e^2 \sigma}{4\pi \lambda^2 S_{min}} \right]^{1/4} \quad \text{--->8}$$

IV (a)

Applications of Radar

Radar has been employed on the ground, in the air, on the sea and in space around- based radar has been applied chiefly to the detection, location and tracking of the air craft or space targets. Ship board radar is used as a navigation aid and safety device to locate Vuoy shore lines, and the other ships as well as for observing aircraft. The major areas of the radar applications are briefly described below,

1. **Air traffic control (ATC):** Radars are employed throughout the world for the purpose of safely controlling air traffic in route and in the vicinity of air force. Air craft and ground vehicular traffic at large airports are monitored by means of high resolution radar. Radar has been used with GCA (Ground Control Approach) system to guide air craft to a safe landing in bad weather.

2.5 x
4= 10
(any
4)

	<p>2. Aircraft Navigation: The weather avoidance radar used on aircraft to outline regions of precipitation to the pilot is a classical form of radar. Radar is also used for terrain avoidance. Sometimes ground-mapping radars of moderately high resolution are used for aircraft navigation purposes.</p> <p>3. Ship Safety: Radar is used for enhancing the safety of ship travel by warning of potential collision with other ships, and for detecting navigation buoys, especially in poor visibility. Automatic detection and tracing equipments are commercially available for use with such radars for the purpose of collision avoidance</p> <p>4. Space: Space vehicle have used radar for rendezvous (meeting place) and docking (join with a space station or another space craft in space) and for landing on the moon. Some of the largest ground based radars are for the largest ground based radars are for the detection and tracking of satellites.</p> <p>5. Remote Sensing: All radars are remote sensor. Sometimes radars has been used as a remote sensor of the weather. Remote sensing with radar is also concerned with Earth resources, which includes the measurement and mapping of sea conditions, water resources, the cover, agriculture, forestry condition etc.</p> <p>6. Law Enforcement: In addition to the wide use of radar to measure the speed of automobile traffic by highway police, radar has also been employeed as a means for the detection of intruders.</p> <p>7. Military: Many of the civilian applications of radar are also employed by the military. The role of radar for military applications has been for surveillance, navigation and for control and guidance of weapons.</p>			
IV (b)	<p><u>Radar Frequencies</u></p> <p>Conventional radars generally have been operated at frequencies extending from about 220 MHz to 35 GHz</p>			

Band Designation	Nominal frequency range
HF	3-30 MHz
VHF	30-300 MHz
UHF	300-1000 MHz
L	1000-2000 MHz
S	2000-4000 MHz
C	4000-8000 MHz
X	8000-12000 MHz
Ku	12-18 MHz
K	18-27 MHz
Ka	27-40 MHz
mm	40-300 MHz

The above table lists the radar-frequency letter-band nomenclature (naming system) adopted by IEEE.

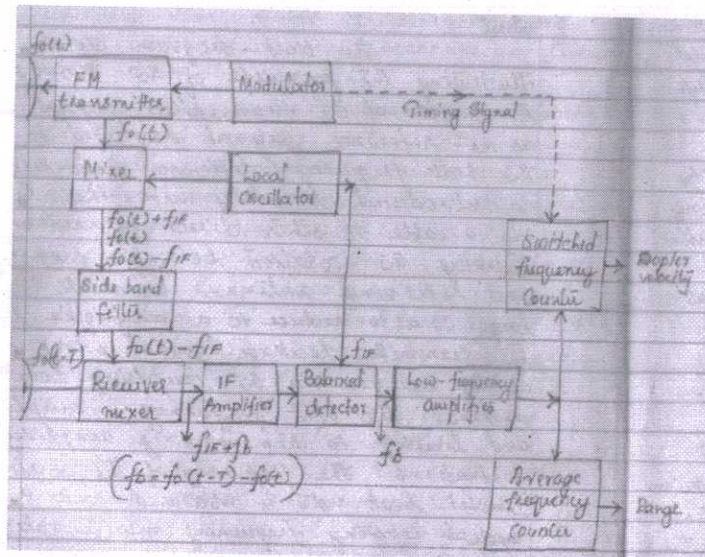
V (a)

Block diagram of FM-CW Altimeter

The FM-CW radar principle is used in the aircraft radio altimeter to measure height above the surface of the earth. The altimeter can employ a simple receiver, but for better sensitivity and stability the super heterodyne is to be preferred whenever its more complex construction can be tolerated.

Fig 4

Expl 4



Block diagram of the FM-CW radar with a sideband super heterodyne receiver is shown.

A portion of the frequency-modulated transmitted signal is applied to a mixer along with the oscillator signal. The selection of the local-oscillator frequency is a bit different from that in the usual super heterodyne receiver. The local oscillator frequency f_{IF} should be the same as the intermediate frequency used in the receiver, whereas in the conventional super heterodyne the LO frequency is of the same order of magnitude as the RF signal. The output of the varying transmitter frequency $f_o(t)$ plus two sideband frequencies, one on either side of $f_o(t)$ and separated from $f_o(t)$ by the local oscillator frequency f_{IF} . The filter selects the lower sideband $f_o(t) - f_{IF}$ and rejects the carrier and the upper sideband. The sideband that is passed by the filter is modulated in the same fashion as the transmitted signal. The side band filter must have sufficient band width to pass the modulation, but not the carrier or other side band. The filtered side band serves the function of the local oscillator.

When an echo signal is present, the output of the receiver mixer is an IF signal of frequency $f_{IF} + f_b$, where f_b is composed of the range frequency f_r and the doppler velocity frequency f_d .

The IF signal is amplified and applied to the balanced detector along with the local oscillator signal f_{IF} . The output of the detector contains the beat frequency which is

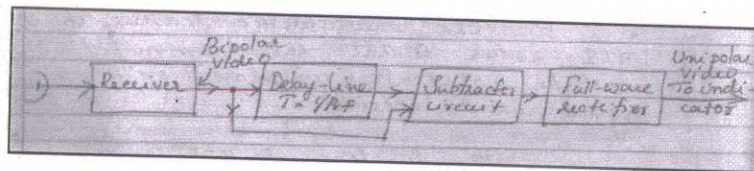
amplified to a level where it can actuate the frequency-measuring circuits.

In the block diagram, the output of the low-frequency amplifier is divided into two channels. One feeds an average frequency counter to determine range, the other feeds a switched frequency counter to determine the doppler velocity (assuming $f_i > f_d$). Only the averaging frequency counter need be used in an altimeter application, since the rate of change of altitude is usually small.

V (b)

Delay-Line Cancellers

The delay line canceller acts as a filter to eliminate the dc component of fixed targets and to pass the ac components of moving targets. The video portion of the receiver is divided into two channels. In the other the video channel. In other the video signal experiences a time delay equal to one pulse-repetition period. The O/Ps from the two channels are subtracted from one another.

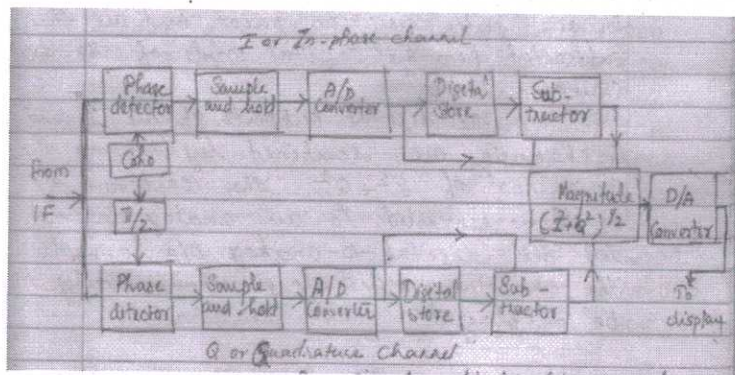


The simple MTI delay line canceller is shown in fig; and is an example of a time-domain filter. Capability of this device depends on the quality of the medium used as the delay-line. The delay line must introduce a time delay equal to the pulse repetition interval. For typical ground-based air-surveillance radars this might be several milliseconds. Delay time of this magnitude cannot be achieved with practical electromagnetic signal to an acoustic signal, it is possible to utilize delay lines of a reasonable physical length since the velocity of propagation of acoustic waves is about 10^{-5} that of electro-magnetic waves. After the necessary delay is introduced by the acoustic line, the signal is converted back to an electromagnetic signal for further processing.

Fig 3
Exp 4

7

VI (a)



MTI Radar with Power Amplifier Transmitter

The coherent reference is supplied by an oscillator called the coho, which stands for coherent oscillator. This coho is a stable oscillator whose frequency is same as the intermediate frequency used in the receiver. In addition to providing the reference signal, the o/p of the coho f_c is also mixed with the local oscillator frequency f_l . The local oscillator must also be a stable oscillator and is called stalo, for stable local oscillator. The RF coho signal is heterodyne with the stalo signal to produce the IF signal just as in the conventional super heterodyne receiver. The Stalo, coho and the mixer in which they are combined plus any low level amplifications are called the receiver-exciter because of the dual role they serve in both the receiver and the transmitter.

The characteristics feature of coherent MTI radar is that the transmitted signal must be coherent (in phase) with the reference signal in the receiver.

The function of the stalo is to provide the necessary frequency translation from the IF to the transmitted (RF) frequency.

The reference signals from the coho and the IF coho signal are both fed into a mixer called the phase detector. The phase detector differs from the normal amplitude detector. Since its o/p is proportional to the phase difference between the two input signal.

Fig 4
Exp 4

8

VI (b)

Pulse Doppler Radar: Pulse radar is a combination of pulse radar and CW radar. It works on the principal of Doppler Shift as MTI radar follows. As per the Nyquist criterion the sampling rate (ie, PRF) should be greater and equal to the twice of the Doppler shift frequency but in MTI due to use of low frequency its become under sampled.

Pulse Doppler radar being high PRF radar, it can remove the Doppler ambiguities. To extract the Doppler shift information of the carrier the pulse radar should be modified by introducing a coherent oscillator (COHO) for frequency stability in the transmitter and receiver chain. It employs the coherent radar system.

Pulse Doppler radar is classified as high PRF and as medium PRF. In high PRF pulse radar there is ambiguity in the range but un-ambiguities in the velocity. IN the medium PRF pulse radar there is ambiguities in range and velocity both.

Block diagram of pulse Doppler radar is shown;

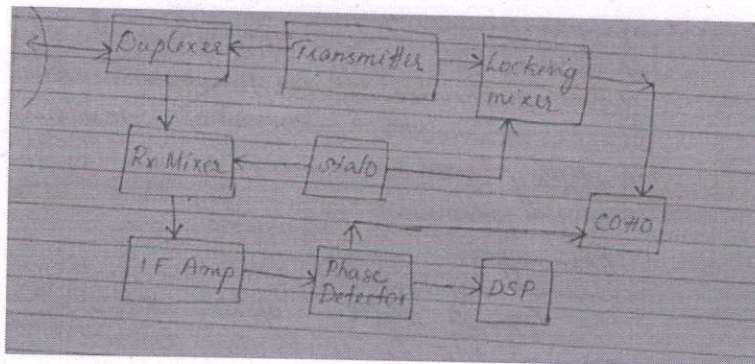
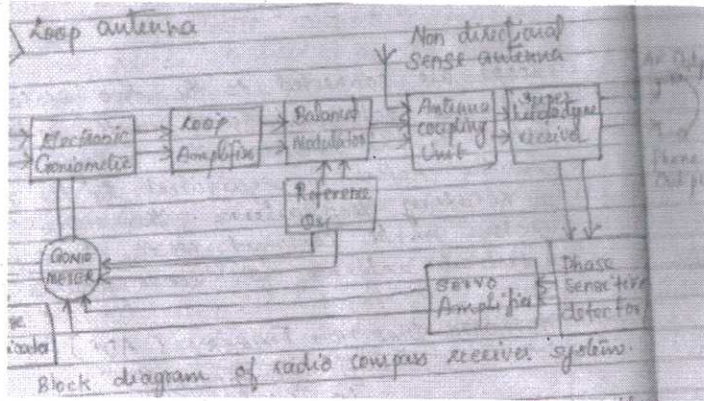


Fig 3
Exp 4

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A STALO (Stable local oscillator) is used to allow the phase of transmitter signal to be maintained by a locking mixer. The output of locking mixer given to lock the COHO phase and in turn it serves as reference phase for the detector at intermediate frequency. Now the phase detector measures the difference in phase between two RF signals. Due to target motion the phase path of the echo changes pulse to pulse and by the same amount phase difference will vary.

VII (a) Automatic Direction Finders (ADF)



Block diagram of radar compass receiver system.

Figure shows the typical circuit elements of automatic direction finder.

The AC supply serves to modulate the RF enter in the loop channel, by means of balanced modulator. In this the input consist of the large amplitude local a.c signal and a much smaller RF signal. The difference is amplitude and the fact that two different frequencies are find in are points of importance.

The incoming RF signal are amplified by loop amplifier and fed the balanced modulator which produces the product of gonio meter o/p with an oscillator output at frequency supplying a reference.

The output of the balanced modulator in further added with signal pickup of non-directional sense antenna which is independent of the azimuth direction of arrival of the radio wave.

Input voltage of RF amplifier represents an amplitude modulated signal which is modulated at frequency of reference oscillator.

The demodulated and reference signal are fed to a pair of coils which are right angle with a 90^0 phase shift between them to produce a rotating magnetic field for a synchronous motor.

Fig 4
Exp 4

In case of heavy lightning it fails to indicate correct direction due to interference by the lightning. In case of heavy wind storm which makes aircraft to drift perpendicular to the direction of motion causes misleading of homing direction because of the radio compass will always pointed towards the runway field.

VII (b)

The loop direction finder has the disadvantage that the loop has to be small enough to be rotated easily. This results in relatively small signal pickups loop has to be located near the receiver. This is a requirement which is not always easy to meet, particularly on ship-board. Both these disadvantages are eliminated by using two fixed loops, mutually perpendicular, and combining their outputs in a goniometer. The loops, being fixed, can be as large as practicable and the goniometer can be placed along with the receiver in any convenient location. The antenna and goniometer arrangement is shown in figure.

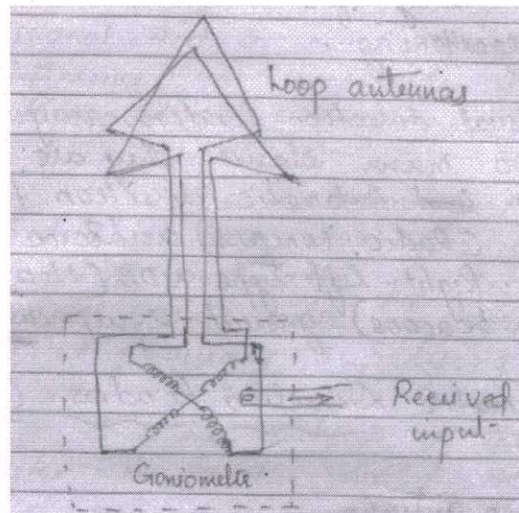


Fig 3
Exp 4

The goniometer consists of two winding mutually perpendicular (called the stator), and a winding at the centre of these, (called the rotor), which can be rotated about the axis of symmetry. The two fixed loops are connected to the two stator windings and the voltage induced in the rotor is taken to the receiver. The voltage induced in the rotor is equivalent to the voltage in a rotating loop antenna. The signal from the rotor can be combined with the signal from a vertical antenna for sense finding.

VIII (a)

VHF phase-Comparison Automatic Direction Finder

The principle of operation of this DF can be understood if one examines the nature of the output obtained from an Adcock aerial to which the output of a vertical aerial situated in the centre is added. As an Adcock pair is equivalent to a loop aerial, the output is amplitude modulated signal. It is demodulated in an envelope detector.

Suppose a reference sinusoid of the same frequency is obtained by coupling alternator to the rotating antenna. The phase difference between the demodified receiver output and the alternator voltage gives the direction of arrival of the signal. The bearing may, therefore, be read off directly on a phase measuring device.

This is the basic principle of some VHF DFs employing a phase-comparison technique.

The block diagram of VHF automatic direction finder is shown in figure.

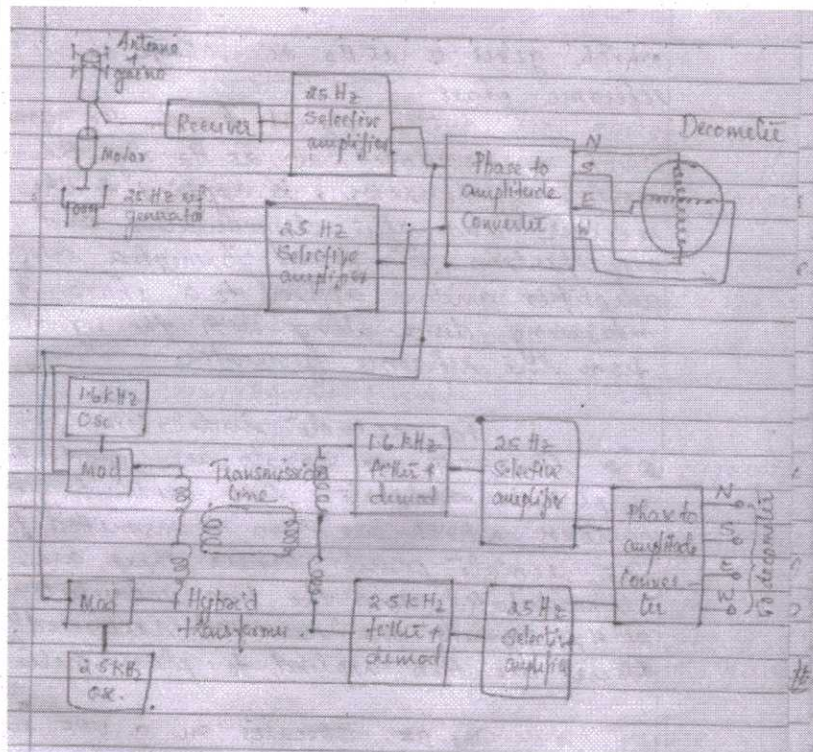


Fig 5
Exp 4

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The direction finder (DF) employs a pair of fixed Adcock antennas with a capacitance goniometer to obtain the rotating figure-of-eight pattern. Instead of casing a vertical antenna for obtaining a fixed phase signal, an unbalanced output is taken from the capacitance goniometer.

The goniomotor is coupled to a motor and rotate at 25 rps. (rotations per second). To the same shaft is attached

an ac generator which gives a 25 Hz ac voltage of fixed reference phase.

The signal from the goniometer which is modulated at 25 HZ by the rotation of the rotor, is applied to the receiver and after demodulation and amplification is passed through a selective amplifier and is applied to a phase measuring device along with the signal from the reference generator.

For remote indications, the two 25 Hz signals are made to amplitude modulate two audio frequency carriers which are then transmitted to the remote point where they are demodulated and the two modulating 25Hz signals are recovered. These are then applied to phase-meter.

The DF operates on a VHF radio telephony channel. The speech frequencies are modulated at 25 Hz by the goniometer intelligibility is impaired. To overcome this drawback, the receiver output going to the speech channel is demodulated by applying a 25 Hz voltage to variable gain amplifier.

VIII (b)

DME System: DME is the secondary radar with the location of the transponder and interrogator reversed figure shows the elements of the DME system.

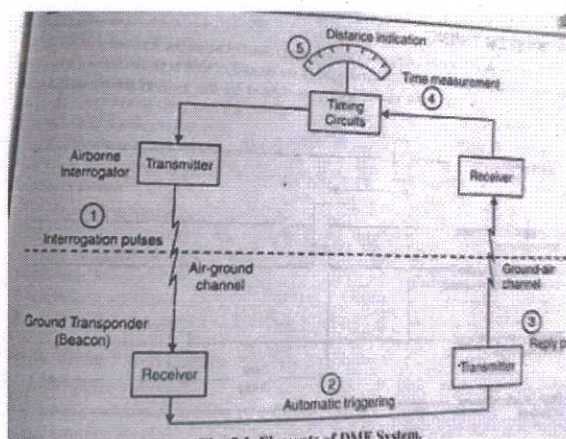


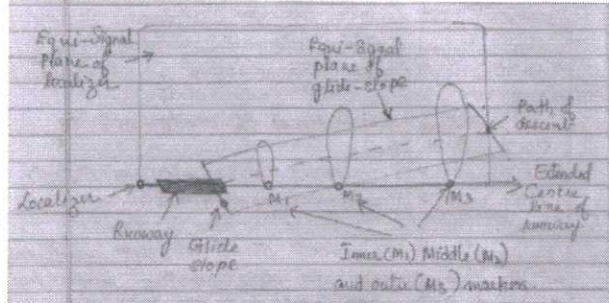
Fig 3
Exp 3

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IX (a)

Instrument Landing System

The Instrument landing system (ILS) comprises the units localizers, glide-path (or glid-slope) and marker beacons as shown in fig.



The localizer defines a vertical equi-signal plane which passes over the centre line of the runway and the glide-slope, and equi-signal plane inclined to the horizontal at the desired angle of descent, generally between 2° and 4° . The intersection of these two planes gives the approach path. Three marker beacons are also installed at certain specified distances from the end of the runway. They give an indication in the aircraft as it flies over them and thereby help the pilot to each his position in the approach path.

Localizer

Localizer operates in the VHF band (108-110 MHz) and consists of a transmitter with an antenna system, the radiation of which has two lobes, one with a predominant modulation of 90Hz and the other with a predominant modulation of 150 Hz.

Localizer provides guidance in the horizontal plane. Aircraft guidance is provided by localizer receiver in the aircraft. The localizer transmitting antenna array are vertical antennas located as far end of run way. The antenna array consist of several pairs of directional antennas, which transmit two amplitude modulated carrier signals out of which one signal is modulated at 90 Hz audio signal. These two beams are transmitted from separate but collocated localizer.

The on-board Loc receiver measures the difference in Depth of Modulation(DDM) of the 90 Hz and 150 Hz signal.

$$\text{Depth is given by } D = \frac{M}{A}$$

D → Depth of modulation or modulation Index.

M → Peak amplitude of modulating audio frequency.

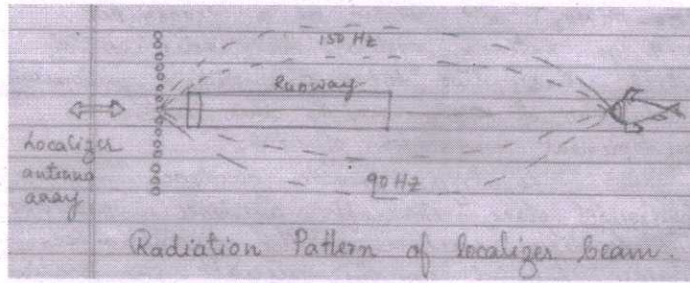
3

2

15

2

A → Another chosen constant of the carrier frequency.



2

The depth of modulation for the localizer beam is set at 20% for each of two modulating frequencies (90 Hz & 150 Hz). The difference between the two signals DDM changes depending on the position of the approaching aircraft with respect to the centerline of runway.

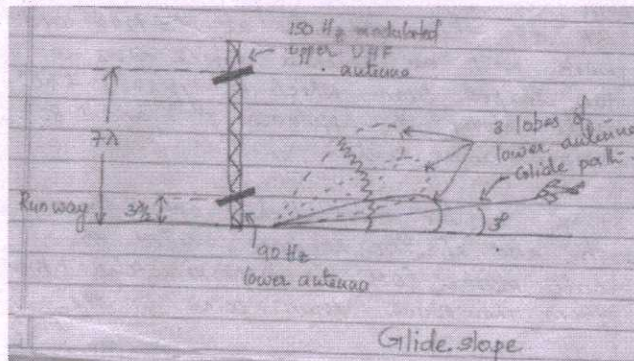
If 90 Hz signal predominates over the 150 Hz modulation, then the aircraft is flying to the left of the centerline and the opposite is true when 150 Hz modulation predominates over the 90 Hz signal – i.e., the aircraft is flying to the right of the center line.

If DDM equals zero, the aircraft is flying right on the center line of runway. This is the operating principle of Localizer.

Glide Slope

Glide Slope gives vertical guidance to the aircraft. A radio frequency beam at an angle of 3° to the horizontal plane of runway, is fanned out. The standard glide slope path is 3° downhill to the approach end of runway. The glide path projection is normally adjusted to 3° above horizontal so that it intersects the middle marker is about 200 ft altitude.

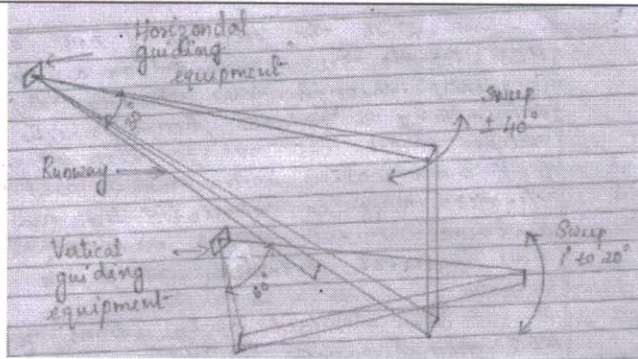
2



2

Glide slope system consists of two horizontal antennas, one is placed at a height of $3\lambda/2$ and the upper

	<p>antenna placed at 7λ. The number of lobes of upper and lower antennas are 14 and 3 respectively which can be calculated by,</p> $\text{No. of lobes} = \frac{\text{height}}{\lambda/2}$ <p>From the combined radiation pattern of upper and lower antenna the intersection of lowest lobes at both antenna creates an angle with respect to horizontal plane. Through that angle of an aircraft has to be landed to the runway.</p> <p><u>Marker Beacons</u></p> <p>The ILS employs three marker beacons which gives an indication in the aircraft when it passes over them. All of them operates at 75MHz and work with an antenna with an antenna which gives a fan shaped beam which in typically $\pm 40^\circ$ wide along the approach path and $\pm 80^\circ$ perpendicular to it.</p> <p>The most distant one (from the end of the runway) called the outer marker (OM) is approximately 7 Km from the touchdown point on the runway. The radiation is modulated at 400 Hz.</p> <p>The second one, called the middle marker (mm) is placed where the glide path is 200 ft (approx. 60 m) which generally is about 1 Km from the touch-down point. The modulation is at 1300 Hz.</p> <p>The inner marker (which is not used at all airports) is place were the glide-path is 100 ft (approx. 30 m) above the ground. It is modulated at 3000 Hz.</p> <p>In the aircraft, a single receiver turned to 75 MHz is employed. The output is available as an audio signal and also actuates three lamps, one for each marker beacon.</p>	2		
X (a)	<p><u>Microwave Landing System</u></p> <p>A later development is landing aids is the microwave landing system which operates in the range of 5031 to 5090 MHz. It was developed to overcome some of the disadvantages of ILS.</p> <p>The MLS can accommodate 200 channels. Because of the small wavelength, the antennas are small and they can be designed to be relatively free from the effect of the surrounding area. The techniques of scanning employed covers a larger area.</p> <p>The basic elements of the MLS are shown in figure.</p>	Fig 4 Exp 5	9	



MLS provides precision navigation guidance for alignment and descent 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
5. Data communication

With the exception of DME, all MLS signals are transmitted on a single frequency through time sharing. 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.

The standard configuration of MLS ground system includes,

a) An azimuth station to perform the functions of approach azimuth and data communications. In addition to providing azimuth navigation guidance, the station transmits basic data which consist of information associated directly with the operation of landing system, as well as advisory data on the performance and state of the ground equipment. The standard versions of MLS is capable to provide a maximum coverage region of ± 40 degree.

b) An elevation station which performs the function of the Approach Elevation. The elevation signal can provide coverage up to $+30$ degree above the ground level.

c) DME to perform the range guidance, both standard DME and precision DME information.

	<p>The standard configuration can be upgrade too gibe enhanced capabilities by adding the following functions or characteristics.</p> <ol style="list-style-type: none"> 1. Back Azimuth → Provides lateral guidance for missed approach and departure navigation. 2. Auxiliary Data Communication → Provides additional data, including refined airborne positioning, meterological data, runway status and other supplementary information. 3. Expanded Service Volume (ESV) → The azimuth coverage region is extended from ± 40 degrees to ± 62 degrees. 			
X b	<p><u>Advantages</u></p> <ol style="list-style-type: none"> 1. Inter visibility between points is not requires. 2. Can be used at anytime of the day or night and is and is any weather. 3. Produces results with very high geodetic accuracy. 4. More work can be accomplished is less time with fewer people. <p><u>Disadvantages</u></p> <ol style="list-style-type: none"> 1. In order to operate with GPS it is important that the GPS antenna has a clear view to at least 4 satellites. 2. Sometimes the satellite signals can be blocked by tall buildings, trees. 3. GPS cannot be used indoors. 	3	3	