Radar & Navigational systems

2 Marks

1. What is a radar?

   Radar is an electromagnetic system for the detection and location of reflecting objects such as aircraft, ships, spacecraft, vehicles, people, and the natural environment. It operates by radiating energy into space and detecing the echo signal reflected from an object or target.

2. What do you mean by maximum unambiguous range?

   Echoes that arrive after the transmission of the next pulses are called the second time around echoes.The range beyond which the target appear as second-time-around echoes is called the maximum unambiguous range.$R_{un,}$ and is given by

   $$R_{un}=cT_p/2=c/2f_p$$

3. What is the fundamental range equation?

   $$R_{max}=(P_tGA_e\sigma/(4\Pi)^2S_{min})^(1/4)$$

   Pt=transmitted power , W
   G= Antenna gain
   Ae= Antenna effective aperture
   Smin=Minimum detectable signal

4. What is a PPI?

   A typical radar display for a surveillance radar is the PPI or Plan Position Indicator.The PPI is a presentation that maps in polar coordinates the location of the target in azimuth and range.

5. What are the applications of radar?
   - Military
   - Remotesensing
   - Air traffic control (ATC)
   - Law enforcement and highway safety
   - Aircraft safety and Navigation
   - Ship safety
   - Space

6. What are the main reasons for the failure of the simple form of the radar equation?

   The failure of the simple form of the radar equation is due to
   a. the statistical nature of the minimum detectable signal
   b. fluctuations and uncertainties in the targets radar cross section
   c. the losses experienced throughout the radar system

d. Propagation effects caused by the earth surface and atmosphere

7. Define minimum detectable signal?

The weakest signal that can just be detected by the receiver is the minimum detectable signal.

8. What is called a false alarm?

If the target were set too low, noise might exceed it and be mistaken for a target. This is called the false alarm.

9. What is called a missed detection?

If the threshold were set too high , noise might not be large enough to cause false alarms, but weak target echoes might not exceed the threshold and would not be detected .This is called as missed detection.

10. What is called threshold detection?

If the receiver output is not of sufficient amplitude to cross the threshold, only noise is said to be present. This is called threshold detection

11. What is called a thermal noise?

If the radar were to operate in a noise free environment so that no external sources of noise accompany the target signal, and if the receiver itself were so perfect that it did not generate any excess noise, there would still be noise generated by the thermal agitation of the conduction electrons in the ohmic portion of the receiver input stages. This is called as thermal or Jhonson noise.

12. What is said to be the rayleigh region?

Radar cross section depends on the characteristic dimensions of the object compared to the radar wavelength. When the wavelength is large compared to the objects dimensions, scattering is said to be rayleigh scattering.

13. Give some examples of simple targets?

Some examples of simple targets are sphere, cylinder, flatplate, rod, ogive and cone.

14. Define the term fluctuations?

A relative phase shift greater than 2Π radians can yield a significant change in the resultant phase and amplitude of the composite echo signal which results in target cross section fluctuations.

15. What is called frequency diversion?

It means that more than one transmitter, each at a different frequency is utilized in parallel with each transmitter channel operating as a separate radar.

16. What is called frequency agility?

Pulse to Pulse change in frequency is called frequency agility.

17. What is called as revisit time?

It is the time that an antenna takes to return to view the same region of space. It is also called as scan time.

18. What is a radome?

A typical ground based metal space frame radome might have a two-way transmission loss of 1.2 db at frequency ban from L to X band.

19. Define a scan to scan fluctuation?

The echo pulses received from a target on any one scan are of constant amplitude throughout the entire scan, but are independent from scan to scan. A target echo fluctuation of this type is called scan to scan or slow fluctuations.

20. What are complex targets?

The radar cross section of complex targets such as aircraft, missiles, ships, ground vehicles, fabricated structures, buildings and terrains can vary considerably depending on the viewing angle and frequency.

21. What is clutter?

When detecting targets radars have to deal with more than receiver noise since they can also receive echoes from the natural environment such as land ,sea and weather.These echoes are called clutter since they can "clutter" the radar display.

22. Write the four methods for reducing the effects of blind speeds.

1.operate the radar at long wavelengths.
2. operate with a high pulse repetition frequency
3. operate with more than one pulse repetition frequency
4. operate with more than one RF frequency.

23. Why do blind speeds occur?

Blind speeds occur because of the sampled nature of the pulse radar waveform.Thus it is sampling that is the cause of ambiguities, or aliasing , in the measurement of the doppler frequency .

24.Define MTI improvement factor.

The signal-to-clutter ratio at the output of the clutter ratio divided by the signal-to-clutter ratio at the input of the clutter filter , average uniformly over all target radial velocities of interest.

25.What are bipolar and unipolar videos?

The output of the MTI radar is called bipolar video,since the signal has negative as well as positive values.Unipolar video is rectified bipolar video with only positive values.

26.Define doppler frequency in MTI radar?

In MTI radar ,the phase detector is a mixer-like device that combines the received signal and the reference signal from the coho so as to produce the difference between the received signal and the reference signal frequencies.This difference is the doppler frequency.

27.What are stalo and coho?

Stalo (Stable oscillator) is the local oscillator of an MTI receiver which is used to recognize the need for high stability.Coho stands for coherent oscillator to signify that it is the reference signal that has the phase of the transmitter signal.

28.State the properties of single DLC that limit the utility of simple doppler filter.

1.The frequency response function also has zero response when moving targets have doppler frequencies at the prf and its harmonis .

2.The clutter spectrum at zero frequency is not a delta function of zero width,but has a finite width so that clutter will appear in the pass band of the Delay Line Canceler.

29.Define blind speeds.

The limitations of single DLC results in target speeds called blind speeds,where the target will not be detected and there will be an uncancelled clutter residue that can interfere with the detection of moving targets.

30.Why VHF is not considered as a desirable frequency cchoice for a long range air-surveillance radar?

1.Resolution inrange and angle are poor due to narrow bandwidths and large beamwidths.

2.This portionof electromagnetic spectrum is crowded with other than radar services.

3.Low altitude coverage ally poor.

31.Define three-pulse canceler.

A canceler with two delay lines that has the same frequency response as the double delay-line canceler,but which is arranged differently is known as three-pulse canceler.

32.What are recursive filters?

Filter design using only zeros does not have the flexibility of filter design based on poles as well as zeros.Poles can be obtained with delay line cancelers by employing feedback.With both feedback and feed forward lines providing both poles and zeros ,arbitrary filter frequency response functions can be synthesized from cascaded delay lines within the limits of realizability.These are known as recursive filters or infinite impulse response(IIR)filters.

33.State the methods for employing multiple prfs to avoid losing target echoes due to blind speeds.

The prfs can be changed (1)scan to scan
(2)dwell to dwell or
(3)pulse to pulse(usually called stagered prf).

34.State two methods proposed for finding the effect of stagger periods.

The two methods are computer search and analytic formulation.The effect of the stagger periods on the depth of the null is based on computer search and the MTI improvement factor is based on analytic formulation.

35.What is clutter map?

It is used to detect crossing targets with zero radial velocity that would otherwise be cancelled by any other MTI.

36.What is a saturation detector?

It is used to detect whether any of the ten pulses within a processing interval saturates the A/D convertor and, if it does ,the entire ten pulses of that particular CPI are discarded.

37. Define Navigation?

Navigation is the art of directing the movements of craft from one point to another along a desired path.

38. What is the need of a Chronometer?

With the help of Chronometer, the navigator was able to determine his longitude by noting the transit time of heavenly bodies.

39. Define electronic navigational aids?

Navigational systems which employ electronics in some way

40. What are the four methods of navigation?

1. Navigation by pilotage
2. Celestial or astronomical navigation
3. Navigation by dead –reckoning
4.Radio navigation

41. Define astronomical navigation?

Celestial navigation is accomplished by measuring the angular position of celestial bodies.

42. Define navigation by dead reckoning?

The position of the craft at any instant of time is calculated from the previously determined position, the speed of its motion with respect to earth along with the direction of its motion and the time elapsed.

43. What is the important source of antenna effect?

The important source is the asymmetry of the loop antenna with respect to the ground.

44. How the antenna effect is minimized?

To minimize the antenna effect, the centre of the loop is earthed and its output is thereby balanced.

45. Give the disadvantage of loop direction finder?

1. The loop is small enough to be rotated easily. This results in a small signal pick ups.
2. To facilitate manual operation, the loop is located near the receiver.

46. What are the errors arising in direction finders?

1. Errors due to abnormal polarization of the incoming wave
2. Errors due to abnormal propagation
3. Site errors
4. Instrumental errors

47. Define mountain effect?

In air borne direction finders, mountainous terrain may cause errors when there is simultaneous reception of signal from the transmitter by a direct path and by reflection from the mountain side. This is called mountain effect.

48. What is the need of Adcock direction finders?

The Adcock direction finders are designed to eliminate polarization errors by dispensing with the horizontal members.

49. What are the types of automatic direction finders?

1. The radio compass
2. A VHF phase comparison automatic direction finders

50. What are the two types of radio ranges in use?

1. Low frequency four course radio range
2. VHF Omni directional radio range

51. What are the sources of errors in VOR system?

1. Ground station and aircraft equipment
2. Site irregularities
3. Terrain features
4. Polarization

52. Define hyperbolic system of navigation?

Hyperbolic systems are based on the measurement of the difference in the time of arrival of electromagnetic waves from two transmitters to the receiver in the craft.

53. What are the different hyperbolic navigational systems?

Different hyperbolic navigational systems are LORAN, DECCA and OMEGA.

54. Define LORAN?

LORAN is Long Range Navigational Aid and is a pulse system. The ground station transmit a train of pulses with fixed time relation between them

and at the receiver, these pulses are identified and the delay between them is measured on a cathode ray oscilloscope

55. What is the operating frequency of LORAN-C?

LORAN-C operates in the band 90-110 KHZ.

56. Define DECCA navigation system?

The measurement of the time difference in the reception of signals from two stations is by measuring the phase difference between the signals of the two stations, the radiations which are phase locked, instead of time interval between pulses in the LORAN

57. What are the advantages of OMEGA system?

1. At low frequency in the 10KHZ range, the coverage is increased
2. Loss of power at this frequency is low.

58. Give the Secondary Radar systems?

1. DME (Distance Measuring Equipment)
2. TACAN (Tactical Air Navigation)

59. Define TACAN?

TACAN provides both range and bearing information with the same radiation.

60. What are the types of landing aids?

1. Instrument landing system
2. Microwave Landing system
3. Ground controlled approach.

61. What is meant by Localizer?

The 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 90 Hz and other with 150 Hz.

62. What are the types of Radar present in the Ground controlled approach systems?

1. Surveillance radar element
2. Precision approach radar

63. What are the disadvantages of ILS?

1. Provides a single approach path along the extended centre line of the runway.
2. It is site sensitive and subject to distortion and bending of the approach path due to site irregularities.

64. What are the basic elements of a MLS system?

1. Azimuth beam equipment
2. Elevation beam equipment

3. Distance measuring equipment

65. What is meant by Doppler navigation?

It employs the Doppler Effect to determine the velocity of the craft in a frame of coordinates fixed with respect to the aircraft.

66. Define Frequency trackers?

The frequency tracker locates the centre of the noise like Doppler spectrum and gives the output the pure signal of this frequency.

67. Define inertial navigation?

Inertial navigation is a system of dead reckoning navigation in which the instruments in the craft determines its accelerations and by successive integration, obtain its velocity and displacement.

68. What are the features of Navigation over earth?

1. The system of coordinated should be fixed with reference to earth.
2. The coordinate system most convenient for use is latitude and longitude.
3. Avery large gravitational fields is present at the surface of the earth.

69. What are the components of inertial navigation systems?

1. Accelerometers
2. Gyros and stabilized platforms

70. Define DECTRA?

DECTRA is a Decca tracking and ranging. This is a long range hyperbolic navigational system working at a frequency of about 70 KHz. The system is designed to provide navigation information over a long route, particularly along the sea.

71. Define CONSOL?

IT is a rotating beacon operating in the LF/MF band which employs a system of three antennas producing a multi lobed pattern which is switched to produce a number of equi signals as in the radio range.

72. Define CONSOLAN?

It is same as CONSOL except that a two antenna system is used instead of three antennas .

73. What are Marker Beacons?

These are Radio beacons which are intended to mark some salient points.

74. Define SHORAN?

Short Navigation System is a secondary radar system in which fix is obtained by the craft, which carriers the interrogator, by simultaneously interrogating two ground beacons.

75. What is meant by Radio Sextant?

This is a Sextant operating on the radio frequency emission of heavenly bodies, like a radio telescope.

76.What are the various system losses?

- Microwave plumbing losses
- Antenna losses
- Signal processing losses
- Collapsing losses
- Operator losses
- Equipment degradation
- Propagation losses
- Radar system losses

77. What are the disadvantages of low frequency four course radio range?

1. Limited number of courses (four)
2. Poor signal/noise ratio
3. Fatigue caused by listening to the tones
4. Difficulty of identifying the course

78. What are angel echoes?

Echoes produced by birds, insects

79. What is called velocity modulation?

The electrons getting accelerated and decelerated by the signal producing bunching of electrons.

80. What are called Linear beam tubes and Cross field tubes?

The electric field and magnetic field are parallel to each other in linear beam tubes and they are perpendicular to each other in cross field tubes.

81.Define Signal Processing?

Methods for the detection of desired signals and the rejection of undesired noise, clutter and interference in radar are called signal processing

82.Define Matched filter?

Filter that maximizes the output signal to noise ratio of a radar receiver which maximizes the delectability of a target.

83.What is meant by automatic detection?

Automatic delectation performs the operation required for the detection decision without the operator intervention.

84.What is the need of integrator?

Integrator integrates or adds the energy from the received pulses available from the target

85.Define moving window detector?

Continuous integration of the last n pulses at the output from the receiver from each range resolution cell is accomplished with a moving window integrator called as moving window detector.

86.Define binary integrator?

The use of a detection criterion that require m out of n pulses to be present in the form of integration is called binary integrator

87.What is meant by Electromagnetic compatibility?

The elimination of interference from other radars and other electromagnetic radiations that can enter the radar receiver.

88.What is the need of pulse compression?

Pulse compression is used to achieve high range resolution without the need of high peak power.

89.what are the basic radar measurements that can be achieved from a point target?

1.Range
2.Angle
3.Radial velocity
4.Tangential velocity.

90. What are the basic radar measurements that can be achieved from a Distributed target?

1.Size and shape
2.Symmetry
3.Radial Profile
4.Tangential Profile.

91.What are the factors affecting the transmitted waveform by a radar?

1.Target detection
2.Accuaracy
3.Resolution
4.Ambiguities

92.Define ECCM?

A short pulse radar can negate the effects of certain electronic countermeasures such as range gate stealers, repeater Jammer and decoys.

93.What is meant by interdigital transducers?

The input/output devices arranged on the surface are known as interdigital transducers.

94.Define apodization?

Amplitude shaping of the frequency response of a SAW filter can be obtained by the amount of overlap of the electrodes of IDT is called as apodization.

95.What is meant by Doppler tolerant waveform?

A Doppler tolerant waveform is one whose signal to noise ration out of its matched filter is independent of the Doppler frequency shift. Such waveforms are called as Doppler invariant

96.What is meant by Welti codes?

These are related to Golay complementary codes in that they are used in pairs that are subtracted from one another to obtain autocorrelation functions with zero side lobes,

97.Define synthetic Aperture radar?

SAR produces a high-resolution image of a scene of the earth's surface in both range and cross range. It can produce images of scenes at long range and in adverse weather that are not possible with infrared or optical sensors.

98.What are the different radar cross section modulations?

1.Propeller modulation
2.Helicopter Blade modulation
3.Jet engine modulation

99.What are the target recognition applications?

1.Military combat identification
2.Ballistic missile target discrimination
3.Meterological observation
4.Battlefield surveillance

100.Define Point clutter?

Buildings and other constructed objects can result in large echoes known as discretes or point clutter.

16 marks

1. Explain the radar block diagram?
   - Block diagram
   - Explanation

2. Derive the simple form of the radar equation?

3. Explain about the Receiver noise and derive the signal to noise ratio?
   - Noise figure
   - Minimum detectable signal
   - Maximum range

4. Explain about the radar cross section of targets?
   - Simple targets
   - Complex targets

5. Explain the various system losses?

   - Microwave plumbing losses
   - Antenna losses
   - Signal processing losses
   - Collapsing losses

Operator losses
Equipment degradation
Propagation losses
Radar system losses

6.Explain the four methods of navigation in detail?

1. Navigation by pilotage
2. Celestial or astronomical navigation
3. Navigation by dead –reckoning
4.Radio navigation

7. Explain the errors arising in direction finders?

1. Polarization Errors
2. Errors due to abnormal propagation
3. Site errors
4. Instrumental errors

8. Explain briefly the Automatic Direction finders?

1.The radio compass
2. A VHF phase comparison automatic direction finders

-------Block diagram and explanation

9. Briefly discuss the VHF Omni Directional Range (VOR)?

Block diagram
Modulation Eliminator
VOR receiver
Range and Accuracy

10. Explain hyperbolic system of Navigation?

1. LORAN –A
   Equipment
   Range and precision
2. LORAN-C
3. DECCA navigation system
   Block diagram
   Range and Accuracy
4. OMEGA system

11. Briefly explain the secondary radar systems?

1. DME
2. TACAN

12. Explain the Instrument LANDING systems?

1. Localizer
2. Glide slope system
3. Receiving equipment
4. Course sharpness and width
5. Marker beacon

13. Discuss the Doppler navigation with a neat block diagram?

Doppler Effect
Doppler frequency equations

Block diagram and explanation

14. Explain the concept of inertial navigation systems?
    1. Accelerometers
    2. Gyros and stabilized platforms

    Explanation

15. Discuss the Satellite Navigational systems in detail?
    GPS
    Explanation

16.Explain the operation of cavity magnetron and discuss the importance of performance chart and Ricke Diagram
    Magnetron construction
    Explanation
    Pi –mode
    Ricke diagram

17.Explain the principle of Parabolic antennas
    Reflector antennas –basic concept
    Various feeds
    Radiation patterns

18.Explain the principle of Cassegrain antennas
    Cassegrain antennas-basic concept
    Various feeds
    Feed support

19.Draw the block diagram of two co-ordinate mono-pulse tracking radar and its operation.
    Block diagram
    Two coordinate explanation
    Hybrid rings

20.Draw the block diagram of one co-ordinate mono-pulse tracking radar and its operation.
    Block diagram
    One coordinate explanation
    Hybrid rings

21.Draw the block diagram of conical scan radar and sequential lobing tracking radar and its operation.
    Block diagram
    conical scan radar explanation
    sequential lobing explanation

22.Explain Superheterodyne receivers. Add notes on Receiver noise figure.
    Block diagram
    Operation
    Explanation of each block

Noise figure

23.Draw the block diagram of conical scan radar , one-coordinate monopulse tracking and explain its operation.

Block diagram
conical scan radar explanation

24.Explain blind speed and the methods for reducing the effects of blind speeds.

Explanation

1.operate the radar at long wavelengths.
2. operate with a high pulse repetition frequency
3. operate with more than one pulse repetition frequency
4.operate with more than one RF frequency.

25. Draw the block diagram of MTI radar and explain in detail?

MTI radar
Block diagram
Explanation