IV/IV B.Tech (Supplementary) DEGREE EXAMINATION, November, 2022

SCHEME OF EVALUATION

Radar Engineering (14EC801)

SUBMITTED BY
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14EC801

Hall Ticket Number:

IV/IV B.Tech (Supplementary) DEGREE EXAMINATION

November, 2022 **Electronics andCommunication Engineering**

Eighth Semester **Radar Engineering**

Time: Three Hours **Maximum: 6**0 Marks

Answer Question No.1 compulsorily. (12X1 = 12 Marks)

Answer ONE question from each unit. (4X12=48 Marks)

1. **Answer the following.**
   a) Expand Radar?
   b) What are the Blind Speeds?
   c) Mention the applications of CW Radar?
   d) What is Doppler effect
   e) What is the use of delay-line cancellers in radar
   f) What type of displays are used for MTI radars
   g) What is the role of ADTin Surveillance Radar?
   h) State is the purpose of RHI?
   i) Give the factors effecting the range ambiguities?
   j) Write the Equation for figure of merit?
   k) Give the advantages ECM?
   l) Significance of height-finder radar

Unit - I

2. a) Explain of Prediction of Range Performance. 6M
   b) Explain various applications of radar. 6M

(OR)

3. a) Write about different radar cross section fluctuation models? 6M
   b) Write different propagation effects on performance of radar? 6M

Unit - II

4. a) Explain delay-line canceller in MTI radar 6M
   b) Explain about pulse radar using Doppler information 6M

(OR)

5. a) Explain the concept of Delay line Canceller. 6M
   b) Draw the block diagram of MTI Radar with Power Oscillator. 6M

Unit - III

6. a) With a neat diagram explain the sequentiallobing Tracking. 6M
   b) Draw the block diagram of a Phase comparison of Monopulse tracking Radar and explain its working. 6M

(OR)

7. a) Explain the operation of balanced duplexers using atr tubes 6M
   b) Write different displays used in radars 6M

Unit - IV

8. a) Explain about Synthetic Aperture radar. 6M
   b) Compare ECM and ECCM Techniques. 6M

(OR)

9. a) Explain electronic counter-counter measures in detail 6M
   b) Write a Short note on Radar Jamming. 6M

14EC801

Hall Ticket Number:

IV/IV B.Tech (Supplementary) DEGREE EXAMINATION

November, 2022 **ElectronicsandCommunicationEngineering**

EighthSemester **Radar Engineering**

Time: Three Hours **Maximum:60** Marks

Answer Question No.1 compulsorily. (12X1 = 12 Marks)

Answer ONE question from each unit. (4X12=48 Marks)

1. **Answer the following.**

a) Expand Radar?
Radio Detection And Ranging

b) What are the Blind Speeds?
The radar blind speed is **the speed at which the target will not be visible to the radar**

c) Mention the applications of CW Radar?

CW radar has been suggested for the control of traffic lights, regulation of toll booths, vehicle counting, as a replacement for the "fifth-wheel" speedometer in vehicle testing, as a sensor in antilock braking systems, and for collision avoidance.

For railways, CW radar can be used as a speedometer to replace the conventional axle-driven tachometer.

CW radar is also employed for monitoring the docking speed of large ships. It has also seen application for intruder alarms and for the measurement of the velocity of missiles, ammunition, and baseballs.

High-power CW radars for the detection of aircraft and other targets have been developed and have been used in such systems as the Hawk missile systems.

d) What is Doppler effect
Doppler Effect refers to **the change in wave frequency during the relative motion between a wave source and its observer**.

e) What is the use of delay-line cancellers in radar
Delay line canceller is a filter, which **eliminates the DC components of echo signals received from stationary targets**. This means, it allows the AC components of echo signals received from non-stationary targets, i.e., moving targets.

f) What type of displays are used for MTI radars
The output of a radar receiver may be displayed in any of a number of ways, the following three being the most common Display Methods in Radar System are: **Deflection Modulation of a cathode-ray-tube screen as in the A scope, Intensity Modulation of a CRT as in the Plan-Position Indicator (PPI)**

g) What is the role of ADTin Surveillance Radar?

h) State is the purpose of RHI?

i) Give the factors effecting the range ambiguities?
range ambiguity is caused by **the echoes of the previous and latter transmitted pulses scattered from undesired range zones**

j) Write the Equation for figure of merit?
The ratio of output SNR and input SNR is termed as Figure of Merit.

Figure of Merit

The ratio of output SNR and input SNR can be termed as **Figure of Merit**. It is denoted by **F**. It describes the performance of a device.

$$F = \frac{(SNR)_O}{(SNR)_I}$$

Figure of merit of a receiver is

$$F = \frac{(SNR)_O}{(SNR)_C}$$

It is so because for a receiver, the channel is the input.

It is so because for a receiver, the channel is the input.

k) Give the advantages ECM?
ECM helps increase security by allowing users to: **Restrict access to folders, documents, fields and other information**

l) Significance of height-finder radar
A height-finder is an older one ground-based type of 2-dimensional radar that **measures the elevation angle and estimates the altitude of a target**

Unit - I

2. a) Explain various applications of radar. 6M

PREDICTION OF RANGE PERFORMANCE

1.6 PREDICTION OF RANGE PERFORMANCE

The simple form of the radar equation expressed in the maximum radar range $\mathbf{R_{max}}$ in terms of radar and target parameters:

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

Where, $\mathbf{P_t}$ = transmitted power, watts

G =antenna gain

$\mathbf{A_e}$=antenna effective aperture, m^2

σ =radar cross section, m^2

S_{min} =minimum detectable signal, watts

- ✓ All the parameters are to some extent under the control of the radar designer, except for the target cross section σ.
- ✓ The radar equation states that if long ranges are desired, the transmitted power must be large, the radiated energy must be concentrated into a narrow beam (high transmitting antenna gain), the received echo energy must be collected with a large antenna aperture (also synonymous with high gain), and the receiver must be sensitive to weak signals.
- ✓ The radar equation is the statistical or unpredictable nature of several of the parameters.
- ✓ The minimum detectable signal $\mathbf{S_{min}}$ and the target cross section σ are both statistical in nature and must be expressed in statistical terms.

b) Explain various applications of radar. 6M

Applications And Uses of RADAR

Military.

Law enforcement.

Space.

Remote sensing of environment.

Aircraft navigation.

Ship Navigation.

Air Traffic Controller.

(OR)

3. a) Write about different radar cross section fluctuation models? 6M

The radar cross section (RCS) of a target is **the equivalent area seen by a radar**. It is the fictitious 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.

For basic considerations of the strength of a signal returned by a given target, the radar equation models the target as a single point in space with a given radar cross-section (RCS). The RCS is difficult to estimate except for the most basic cases, like a perpendicular surface or a sphere.

1.11 RADAR CROSS SECTION OF TARGETS

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,

$$\sigma = \frac{\text{power reflected toward source/unit solid angle}}{\text{incident power density}/4\pi} = \lim_{R\to\infty} 4\pi R^2 \left|\frac{E_r}{E_i}\right|^2$$

Where R = distance between radar and target

E_r = reflected field strength at radar

E_i = strength of incident field at target

- ✓ The radar cross section of a simple sphere is shown in Fig. 2.9 as a function of its circumference measured in wavelengths (2πa/λ, where a is the radius of the sphere and λ is the wavelength).
- ✓ The region where the size of the sphere is small compared with the wavelength (2πa/λ << 1) is called the Rayleigh region.
- ✓ Since the cross section of objects within the Rayleigh region varies as λ^{-4}, rain and clouds are essentially invisible to radars which operate at relatively long wavelengths (low frequencies).
- ✓ The usual radar targets are much larger than raindrops or cloud particles, and lowering the radar frequency to the point where rain or cloud echoes are negligibly small will not seriously reduce the cross section of the larger desired targets.

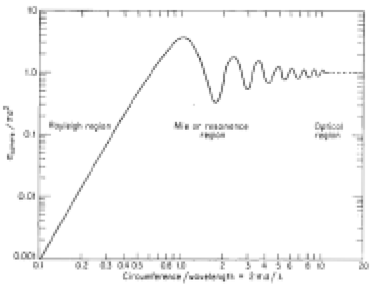

Figure 2.9 Radar cross section of the sphere. a = radius; λ = wavelength.

- ✓ At the other extreme from the Rayleigh region is the optical region, where the dimensions of the sphere are large compared with the wavelength ($2\pi a/\lambda >> 1$).
- ✓ For large $2\pi a/\lambda$, the radar cross section approaches the optical cross section πa^2. In between the optical and the Rayleigh region is the Mie, or resonance, region. The cross section is oscillatory with frequency within this region.
- ✓ An interesting radar scattering object is the cone-sphere, a cone whose base is capped with a sphere such that the first derivatives of the cone and sphere contours are equal at the join between the two.
- ✓ Figure 2.11 is a plot of the nose-on radar cross section. Figure 2.12 is a plot as a function of aspect.
- ✓ The cross section of the cone-sphere from the vicinity of the nose-on direction is quite low. Scattering from any object occurs from discontinuities.
- ✓ The discontinuities, and hence the backscattering, of the cone-sphere are from the tip and from the join between the cone and the sphere. There is also a backscattering contribution from a "creeping wave" which travels around the base of the sphere.
- ✓ The nose-on radar cross section is small and decreases as the square of wavelength. The cross section is small over a relatively large angular region.
- ✓ A large specular return is obtained when the cone-sphere is viewed at near perpendicular incidence to the cone surface, i.e., when $\theta = 90 - \alpha$ where α = cone half angle. From the rear half of the cone-sphere, tlie radar cross section is approximately that of the sphere.

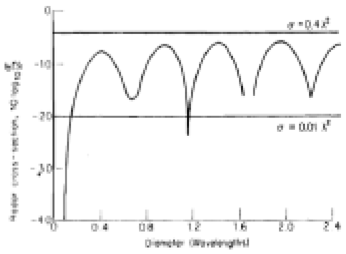

Figure 2.11 Radar cross section of a cone sphere with 15° half angle as a function of the diameter in wavelengths. (*After Blore*,[11] *IEEE Trans.*)

b) Write different propagation effects on performance of radar? 6M

2.13 PROPAGATION EFFECTS

In analyzing radar performance it is convenient to assume that the radar and target are both located in free space. However, there are very few radar applications which approximate free-space conditions. In most cases of practical interest, the earth's surface and the medium in which radar waves propagate can have a significant effect on radar performance. In some instances the propagation factors might be important enough to overshadow all other factors that contribute to abnormal radar performance. The effects of non-free-space propagation on the radar are of three categories: (1) *attenuation* of the radar wave as it propagates through the earth's atmosphere, (2) *refraction* of the radar wave by the earth's atmosphere, and (3) *lobe structure* caused by interference between the direct wave from radar to target and the wave which arrives at the target via reflection from the ground.

In general, for most applications of radar at microwave frequencies, the attenuation in propagating through either the normal atmosphere or through precipitation is usually not sufficient to affect radar performance. However, the *reflection* of the radar signal from rain (clutter) is often a limiting factor in the performance of radar in adverse weather.

Unit – II

4. a) Explain delay-line canceller in MTI radar 6M

3.6 DELAY-LINE CANCELERS:

- ✓ The simple MTI delay-line canceler shown in Fig. 4.4 is an example of a time-domain filter.

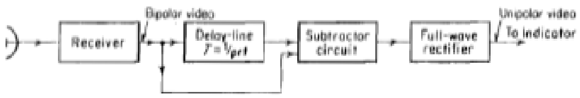

Figure 4.4 MTI receiver with delay-line canceler.

- ✓ The Delay line canceler acts as a filter to eliminate the DC component of fixed targets and to pass the AC components of moving targets.
- ✓ The capability of this device depends on the quality of the medium used as the delay line.
- ✓ The Pulse Modulator 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 times of this magnitude cannot be achieved with practical electromagnetic transmission lines.
- ✓ By converting the 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 electromagnetic waves.
- ✓ After the necessary delay is introduced by the acoustic line, the signal is converted back to an electromagnetic signal for further processing.
- ✓ These analog acoustic delay lines were, in turn supplanted in the early 1970s by storage devices based on digital computer technology.
- ✓ The use of digital delay lines requires that the output of the MTI receiver phase-detector be quantized into a sequence of digital words.
- ✓ The compactness and convenience of digital processing allows the implementation of more complex delay-line cancelers with filter characteristics not practical with analog methods.
- ✓ One of the advantages of a time-domain delay-line canceler as compared to the more conventional frequency-domain filter is that a single network operates at all ranges and does not require a separate filter for each range resolution cell.

Filter characteristics of the delay-line canceler:

- ✓ The delay-line canceler acts as a filter which rejects the d-c component of clutter. Because of its periodic nature, the filter also rejects energy in the vicinity of the pulse repetition frequency and its harmonics.
- ✓ The video signal received from a particular target at a range R, is

$$V_1 = k \sin (2\pi f_d t - \phi_0)$$

where Φ_0 = phase shift and k = amplitude of video signal. The signal from the previous transmission, which is delayed by a time T = pulse repetition interval, is

$$V_2 = k \sin [2\pi f_d (t - T) - \phi_0]$$

- ✓ Everything else is assumed to remain essentially constant over the interval T so that k is the same for both pulses. The output from the subtractor is

$$V = V_1 - V_2 = 2k \sin \pi f_d T \cos \left[2\pi f_d \left(t - \frac{T}{2}\right) - \phi_0\right]$$

- ✓ It is assumed that the gain through the delay-line canceler is unity.
- ✓ The output from the canceler consists of a cosine wave at the doppler frequency& with an amplitude 2k sin $\pi f_d T$.
- ✓ Thus the amplitude of the canceled video output is a function of the Doppler frequency shift and the pulse-repetition interval, or prf.
- ✓ The magnitude of the relative frequency-response of the delay-line canceler [ratio of the

amplitude of the output from the delay-line canceler, 2k sin (πf_d T), to the amplitude of the normal radar video k] is shown in Fig. 4.7.

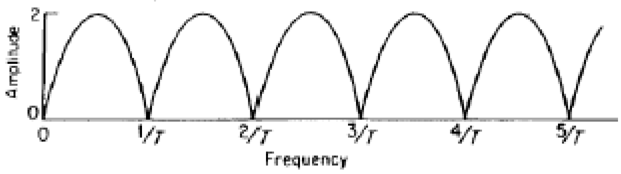

Figure 4.7 Frequency response of the single delay-line canceler; T = delay time = $1/f_p$.

b) Explain about pulse radar using Doppler information 6M

RADAR BLOCK DIAGRAM AND OPERATION

- ✓ The operation of a typical pulse radar block diagram shown Fig. 1.2. The transmitter may be an oscillator, such as a magnetron, that is "pulsed" (turned on and off) by the modulator to generate a repetitive train of pulses.
  - ✓ The magnetron has probably been the most widely used of the various microwave generators for radar.
  - ✓ The waveform generated by the transmitter travels 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 damage caused by the high power of the transmitter. This is the function of the duplexer.
  - ✓ The duplexer might consist of two gas-discharge devices, one known as a TR (transmit-receive) and the other an ATR (anti-transmit-receive). The TR protects the receiver during transmission and the ATR directs the echo signal to the receiver during reception.

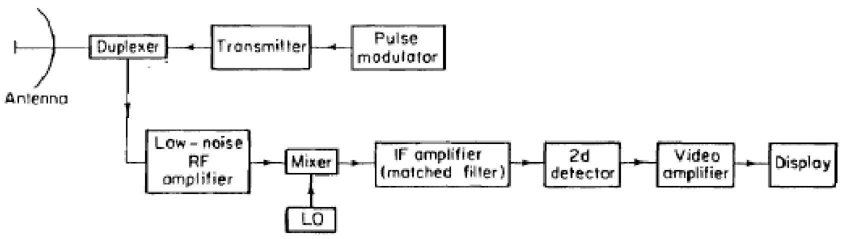

Figure 1.2 Block diagram of a pulse radar.

- ✓ The mixer and local oscillator (LO) convert the RF signal to an intermediate frequency (IF). The IF amplifier should be designed as a Matched filter, i.e. its frequency-response function *H(f)* should maximize the sigtial-to-mean-noise-power ratio at the output.
- ✓ This occurs when the magnitude of the frequency-response function $|H(f)|$ is equal to the magnitude of the echo signal spectrum $|S(f)|$, and the phase spectrum of the matched filter is the negative of the phase spectrum of the echo signal.
- ✓ In a radar whose signal waveform approximates a rectangular pulse, the conventional IF filter bandpass characteristic approximates a matched filter when the product of the IF bandwidth B and the pulse width τ is of the order of unity, that is, Bτ=1.
- ✓ After maximizing the signal-to-noise ratio in the IF amplifier, the pulse modulation is extracted by the second detector acd amplified by the video amplifier to a level where it can be properly displayed, usually on a cathode-ray tube (CRT).

(OR)

5. a) Explain the concept of Delay line Canceller. 6M

3.6 DELAY-LINE CANCELERS:

- ✓ The simple MTI delay-line canceler shown in Fig. 4.4 is an example of a time-domain filter.

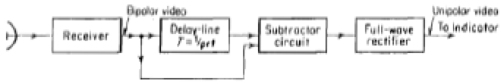

Figure 4.4 MTI receiver with delay-line canceler.

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- ✓ The Pulse Modulator 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 times of this magnitude cannot be achieved with practical electromagnetic transmission lines.
- ✓ By converting the 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 electromagnetic waves.
- ✓ After the necessary delay is introduced by the acoustic line, the signal is converted back

b) Draw the block diagram of MTI Radar with Power Oscillator. 6M

3.4 MTI RADAR WITH POWER OSCILLATOR TRANSMITTER:

- ✓ The high-power transmitter available at microwave frequencies for radar application was the magnetron oscillator.
- ✓ In an oscillator the phase of the RF bears no relationship from pulse to pulse. For this reason the reference signal cannot be generated by a continuously running oscillator.
- ✓ However, a coherent reference signal may be readily obtained with the power oscillator by readjusting the phase of the coho at the beginning of each sweep according to the phase of the transmitted pulse.
- ✓ The phase of the coho is locked to the phase of the transmitted pulse each time a pulse is generated.
- ✓ A block diagram of an MTI radar (with a power oscillator) is shown in Fig. 4.6.

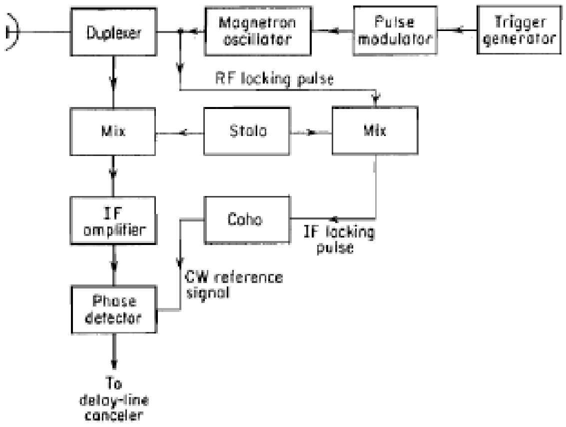

Figure 4.6 Block diagram of MTI radar with power-oscillator transmitter.

- ✓ A portion of the transmitted signal is mixed with the stalo output to produce an IF beat signal whose phase is directly related to the phase of the transmitter.
- ✓ This IF pulse is applied to the coho and causes the phase of the coho CW oscillation to "lock" in step with the phase of the IF reference pulse.
- ✓ The phase of the coho is then related to the phase of the transmitted pulse and may be used as the reference signal for echoes received from that particular transmitted pulse.
- ✓ Upon the next transmission another IF locking pulse is generated to relock the phase of the CW coho until the next locking pulse comes along.

Unit – III

6. a) With a neat diagram explain the sequentiallobing Tracking. 6M

4.2 SEQUENTIAL LODING:

- ✓ The antenna pattern commonly employed with tracking radars is the symmetrical pencil beam in which the elevation and azimuth beamwidths are approximately equal.
- ✓ However, a simple pencil-beam antenna is not suitable for tracking radars unless means are provided for determining the magnitude and direction of the target's angular position with respect to some reference direction, usually the axis of the antenna.
- ✓ The difference between the target position and the reference direction is the angular error. The tracking radar attempts to position the antenna to make the angular error zero.
- ✓ When the angular error is zero, the target is located along the reference direction.
- ✓ Obtaining the direction and the magnitude of the angular error in one coordinate is by alternately switching the antenna beam between two positions (Fig. 5.1).
- ✓ This is called lobe switching sequential switching, or sequential lobing. Figure 5.1a is a

b) Draw the block diagram of a Phase comparison of Monopulse tracking Radar and explain its working. 6M

Phase comparison monopulse:

- ✓ The angle of arrival (in one coordinate) may also be determined by comparing the phase difference between the signals from two separate antennas.
- ✓ Unlike the antennas of amplitude comparison trackers, those used in phase-comparison systems are not offset from the axis.

- ✓ The measurement of angle of arrival by comparison of the phase relationships in the signals from the separated antennas of a radio interferometer has been widely used by the radio astronomers for precise measurements of the positions of radio stars.
- ✓ The interferometer as used by the radio astronomer is a passive instrument, the source of energy being radiated by the target itself.
- ✓ A tracking radar which operates with phase information is similar to an active interferometer and might be called an interferometer radar. It has also been called simultaneous phase comparison radar, or phase comparison monopulse.
- ✓ In Fig. 5.12 two antennas are shown separated by a distance d. The distance to the target is H and is assumed large compared with the antenna separation d.
- ✓ The line of sight to the target makes an angle 0 to the perpendicular bisector of the line joining the two antennas. The distance from antenna 1 to the target is

$$R_1 = R + \frac{d}{2} \sin \theta$$

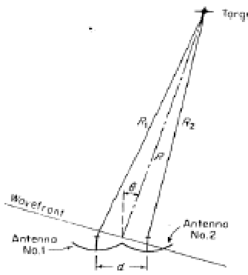

Figure 5.12 Wavefront phase relationships in phase-comparison monopulse radar.

and the distance from antenna 2 to the target is

$$R_2 = R - \frac{d}{2} \sin \theta$$

- ✓ The phase difference between the echo signals in the two antennas is approximately

$$\Delta\phi = \frac{2\pi}{\lambda} d \sin \theta$$

- ✓ For small angles where sin θ≈θ, the phase difference is a linear function of the angular error and may be used to position the antenna via a servo-control loop.

(OR)

7. a) Explain the operation of balanced duplexers using atr tubes 6M

Balanced duplexers:

- ✓ The balanced duplexer, Fig. 9.6, is based on the short-slot hybrid junction which consists of two sections of waveguides joined along one of their narrow walls with a slot cut in the common narrow wall to provide coupling between the two.
- ✓ The short-slot hybrid may he considered as a broadband directional coupler with a coupling ratio of 3 dB. In the transmit condition (Fig. 9.6a) power is divided equally into each waveguide by the first short-slot hybrid junction.
- ✓ Both TR tubes break down and reflect the incident power out the antenna arm as shown. The short-slot hybrid has the property that each time the energy passes through the slot in either direction, its phase is advanced 90^0.

- ✓ Therefore, the energy must travel as indicated by the solid lines. Any energy which leaks through the TR tubes (shown by the dashed lines) is directed to the arm with the matched dummy load and not to the receiver.
- ✓ In addition to the attenuation provided by the TR tubes, the hybrid junctions provide an additional 20 to 30 dB of isolation.
- ✓ On reception the TR tubes are unfired and the echo signals pass through the duplexer and into the receiver as shown in Fig. 9.6b.
- ✓ The power splits equally at the first junction and because of the 90^0 phase advance on passing through the slot, the energy recombines in the receiving arm and not in the dummy-load arm.
- ✓ The power-handling capability of the balanced duplexer is inherently greater than that of the branch-type duplexer and it has wide bandwidth, over ten percent with proper design.
- ✓ A receiver protector, to be described later, is usually inserted between the duplexer and the receiver for added protection.

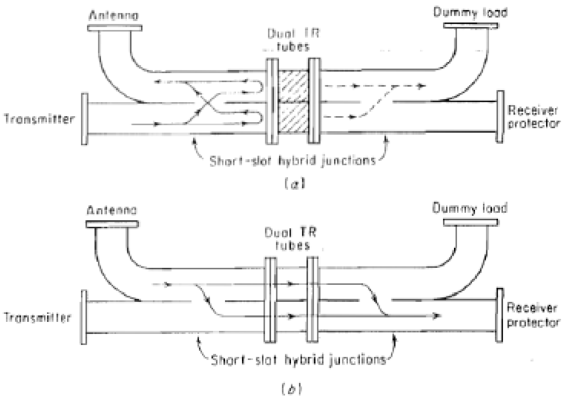

Figure 9.6 Balanced duplexer using dual TR tubes and two short-slot hybrid junctions. (a) Transmit condition; (b) receive condition.

b) Write different displays used in radars 6M

6.5 DISPLAYS

- ✓ The purpose of the display is to visually present in a form suitable for operator interpretation and action the information contained in the radar echo signal.
- ✓ When the display is connected directly to the video output of the receiver, the information displayed is called raw video.
- ✓ This is the traditional type of radar presentation. When the receiver video output is first processed by an automatic detector or automatic detection and tracking processor (ADT), the output displayed is sometimes called synthetic video.
- ✓ The cathode-ray tube (CRT) has been almost universally used as the radar display. There are two basic cathode-ray tube displays.
- ✓ One is the dejection-modulated CRT, such as the A-scope, in which a target is indicated by the deflection of the electron beam.
- ✓ The other is the intensity-modulated CRT, such as the PPI, in which a target is indicated by intensifying the electron beam and presenting a luminous spot on the face of the CRT.
- ✓ In general, deflection-modulated displays have the advantage of simpler circuits than those of intensity-modulated displays, and targets may be more readily discerned in the presence of noise or interference.
- ✓ On the other hand, intensity-modulated displays have the advantage of presenting data in a convenient and easily interpreted form.
- ✓ The deflection of the beam or the appearance of an intensity-modulated spot on a radar display caused by the presence of a target is commonly referred to as a blip.

Types of display presentations:

The various types of CRT displays which might be used for surveillance and tracking radars are defined as follows:

A-scope: A deflection-modulated display in which the vertical deflection is proportional to target echo strength and the horizontal coordinate is proportional to range.

B-scope: An intensity-modulated rectangular display with azimuth angle indicated by the horizontal coordinate and range by the vertical coordinate.

C-scope: An intensity-modulated rectangular display with azimuth angle indicated by the horizontal coordinate and elevation angle by the vertical coordinate.

D-scope: A C-scope in which the blips extend vertically to give a rough estimate of distance.

E-scope: An intensity-modulated rectangular display with distance indicated by the horizontal coordinate and elevation angle by the vertical coordinate: Similar to the RHI in which target height or altitude is the vertical coordinate.

F-Scope: A rectangular display in which a target appears as a centralized blip when the radar antenna is aimed at it. Horizontal and vertical aiming errors are respectively indicated by the horizontal and vertical displacement of the blip.

G-Scope: A rectangular display in which a target appears as a laterally centralized blip when the radar antenna is aimed at it in azimuth and wings appear to grow on the pip as the distance to the target is diminished; horizontal and vertical aiming errors are respectively indicated by horizontal and vertical displacement of blip.

H-scope: B-scope modified to include indication of angle of elevation. The target appears as two closely spaced blips which approximate a short bright line, the slope of which is in proportion to the sine of the angle of target elevation.

I-scope: A display in which a target appears as a complete circle when the radar antenna is pointed at and in which the radius of the circle is proportional to target distance; incorrect aiming of the antenna changes the circle to a segment whose arc length is inversely proportional to the magnitude of the pointing error, and the position of the segment indicates the reciprocal of the pointing direction of the antenna.

J-scope: A modified A-scope in which the time base is a circle and targets appear as radial deflections from the time base.

K-scope: A modified A-scope in which a target appears as a pair of vertical deflections. When the radar antenna is correctly pointed at the target, the two deflections are of equal height, and when not so pointed, the difference in deflection amplitude is an indication of the direction and magnitude of the pointing error.

L-scope: A display in which a target appears as two horizontal blips, one extending to the right from a central vertical time base and the other to the left; both blips are of equal amplitude when the radar is pointed directly at the target, any inequality representing relative pointing error, and distance upward along the baseline representing target distance.

M-scope: A type of A-scope in which the target distance is determined by moving an adjustable pedestal signal along the baseline until it coincides with the horizontal position of the target signal deflections; the control which moves the pedestal is calibrated in distance.

N-scope: A K-scope having an adjustable pedestal signal, as in the M-scope, for the measurement of distance.

O-scope: An A-scope modified by the inclusion of an adjustable notch for measuring distance.

PPI or Plan Position Indicator (also called P-scope). An intensity-modulated circular display on which echo signals produced from reflecting objects are shown in plan position with range and azimuth angle displayed in polar (rho-theta) coordinates, forming a map-like display. An offset, or off center, PPI has the zero position of the time base at a position other than at the center of the display to provide the equivalent of a larger display for a selected portion of the service area. A delayed PPI is one in which the initiation of the time base is delayed.

R-scope: An A-scope with a segment of the time base expanded near the blip for greater accuracy in distance measurement.

RHI or Range-Height Indicator: An intensity modulated display with height (altitude) as the vertical axis and range as the horizontal axis.

8. a) Explain about Synthetic Aperture radar. 6M

➢ Synthetic aperture radar (SAR)

- A synthetic aperture radar (SAR) achieves high resolution in cross range dimension by taking advantages of the motion of the vehicle Carrying the radar synthesized the effect of the large antenna aperture.
- Synthetic aperture radar is a form of radar in which sophisticated post-processing of radar data is used to produce a very narrow effective beam. It can only be used by moving instruments over relatively immobile target, but it has seen wide application in remote sensing and mapping.
- The imaging of the earth surface by SAR to provide a map like display can be applied to military reconnaissance, measurement of sea state and ocean wave condition, geological and mineral explorations.

- **Basic operation**

- In a typical SAR application, a single radar antenna will be attached to the side of an aircraft. A single pulse form the antenna will be rather broad because diffraction require a large antenna to produce a narrow beam.
- The pulse will also be broad in the vertical direction; often it will illuminate the terrain from directly beneath the aircraft out if the horizon.
- However if the terrain is approximately flat the time at which echoes return allows point at different distance from the flight track to be distinguished.
- Distinguishing point along track of the aircraft is difficult with a small antenna.

- However if the amplitude and phase of the signal returning from a given piece of ground are recorded and if the aircraft emits a series of observation can be combined just as if they had all been made simultaneously from a very large antenna: this process creates synthetic aperture much larger than the length of the antenna.
- Combining the series observation is done using FFT. The result is map of radar reflectivity on the ground. The phase information is in the simplest application, discarded. The amplitude information contains information about ground cover.

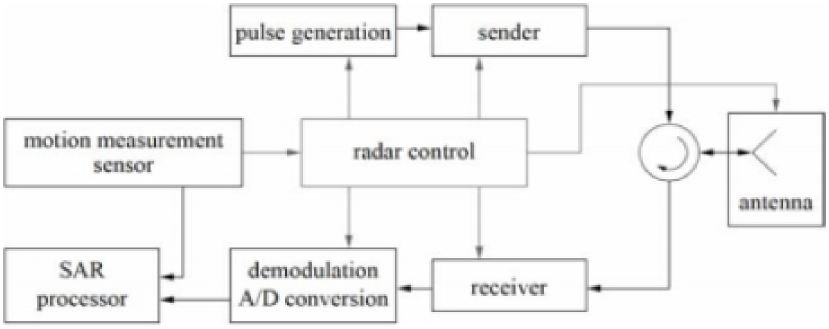

Figure 29.2. General structure of SAR

- Main parts of a SAR system are depicted in Figure 29.2. A pulse generation unit creates pulses with a bandwidth according to the aspired range resolution. They will be amplified by the sender and are transferred to the antenna via a circulator.
- The receiver gets the antenna output signal (echoes of the scene) amplifies them to an appropriate level and applies a band pass filter. After the demodulation and A/D conversion of the signals the SAR processor starts to calculate the SAR image.
- Additional motion information will be provided by a motion measurement system. A radar control unit arranges the operation sequence, particularly the time schedule.

b) Compare ECM and ECCM Techniques. 6M

Electronic Countermeasures have 2 primary focuses:

ECM can be directed at aircraft, ships, sensors or weapon systems like radar-guided missiles. ...

ECCM on the other hand is about defending against ECM techniques and rendering them ineffective.

(OR)

9. a) Explain electronic counter-counter measures in detail 6M

11.2.3 **Electronic Counter-Countermeasures (ECCM)**

Electronic counter-countermeasures is the art of reducing the effectiveness of an EW threat with the objective of making the cost of effective EW prohibitive for the enemy. As in ECM, ECCM includes both radar design and operator training. The radar ECCM designer must understand the various forms of ECM that his radar is likely to encounter, hence he is very interested in intelligence about the ECM threat. Likewise, the radar operator would like to know what ECM he will be facing. But in both cases detailed intelligence will probably be lacking. Therefore, the designer must provide a variety of options to be used against the expected threats. And the operator must be trained both to recognize the various countermeasures that might be used against him and to select the appropriate combination of options against each of them. The most effective measure to combat ECM is an up-to-date piece of equipment operated by a well-trained operator. Radar design for ECCM can be broken down into three areas: radar parameter management, signal processing techniques, and design philosophy.

b) Write a Short note on Radar Jamming. 6M

RADAR jamming

Radar jamming is a form of electronic countermeasures (ECM), designed to degrade the effectiveness of enemy radar systems. Usually, this is done by emitting radio signals at specific frequencies which impair the ability of radar systems to accurately detect and depict objects in the operational environment. This can generate “noise” in the radio spectrum which will confuse or mislead the enemy and affect their decision-making accordingly.

Popular Types of Radar Jamming

There are multiple types of noise jamming. The simplest is Spot Jamming, which involves concentrating jamming power on a single frequency. In previous eras, spot jamming could be very effective when the military understood which types of radars enemy forces were likely to be using and on what frequencies. While spot jamming can be effective against a specific frequency, all the enemy had to do is switch to another frequency, as frequency-agile radar systems are designed to do, and the jamming was rendered ineffective. As this became feasible, more sophisticated techniques were needed.

Barrage and Sweep Radar Jamming techniques were developed in response to this challenge. Sweep jamming focuses the full power of the jammer one frequency at a time while allowing for quick changes between frequencies. Barrage jamming involves jamming more than one frequency at a time, which certainly “covers more ground” in a manner of speaking, but the power of the jamming is lessened since it is dispersed across multiple frequencies at once. Related techniques like Pulse Radar Jamming have been developed which add an additional layer of protection for friendly forces by obscuring the location from which the jamming signal is emanating.