Report on
UNDERSTANDING OF TRACKING RADAR SYSTEM

INTEGRATED TEST RANGE (ITR)

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UNDERSTANDING OF TRACKING RADAR SYSTEMS

Introduction

Radar systems have a long history of evolution since their early days when their functions were limited to target detection and target range detection. The word RADAR was an acronym that stood for radio detection and ranging. Modern radars are able to not only detect target and determine target range but also track, identify, image, classify targets. The goal of UNDERSTANDING OF TRACKING RADAR SYSTEM is to provide a comprehensive introduction to the functions of a modern radar system, and the principles of their operation and analysis.

Basic Radar:

Radar is an electrical system that transmits radiofrequency (RF) electromagnetic (RM) waves toward the target and receives and detects these EM waves when reflected from the object in the region of interest.

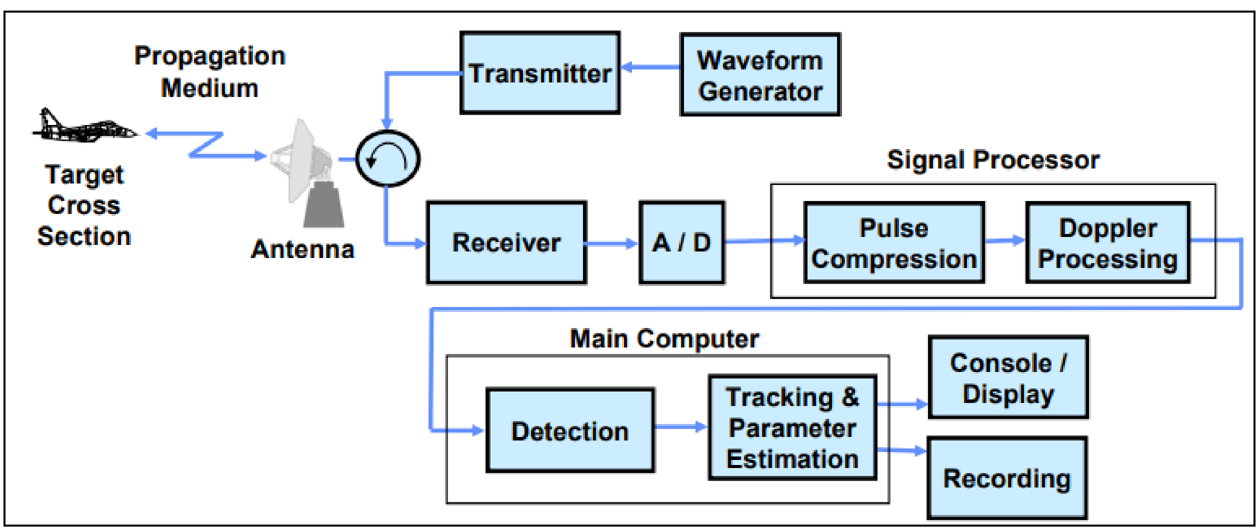


Fig1: *Major elements of the radar transmission/reception process.*

Table1: *Electromagnetic wave types*

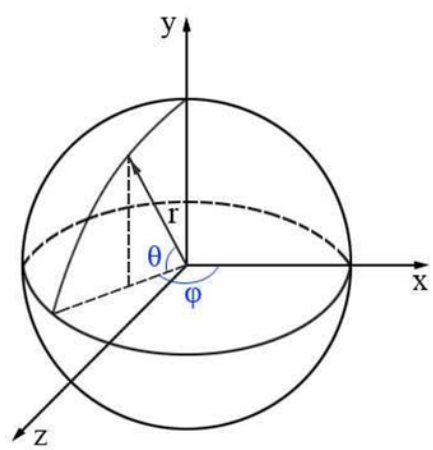
BAND	***FREQUENCY RANGE***
High frequency (HF)	**3-30MHz**
Very high frequency (VHF)	**30-300MHz**
Ultra-high frequency (UHF)	**300MHZ-1GHz**
L-band	**1-2GHz**
S-band	**2-4GHz**
C-band	**4-8GHz**

S-band Radars: Most ground and ship based medium range radar operate in the s-band. Ex: Airport surveillance Radar (ASR).

C-band Radars: Many of the mobile military battlefield surveillance, missile-control and ground surveillance radar systems operate in this band.

Target Parameters

- Range
- Azimuthal angle
- Elevation angle



Range

- The range R, is determined by Δt, the time it takes for the EM waves to propagate to the target and come back to the receiver at the speed of light (C =$3x10^8$ m/s).

$$R = c\Delta t/2$$

- Interference to Radar

  1) Internal and external electronic noise.

  2) Reflected EM waves from objects not of interest called clusters.

  3) Unintentionally external EM waves created by other human made sources, that is electromagnetic interference (EMI).

  4) Intentional jamming from electronic countermeasure (ECM) systems, in the form of noise or false target.

Azimuth Angle, Elevation Angle

The target's angular position, $\boldsymbol{\theta}$ and $\varnothing$, is determined by the pointing angle of the antenna main beam when the target detection occurs. This antenna pointing angle can either be the actual physical pointing angle of a mechanically scanned antenna or the electronic pointing angle of an electronically scanned antenna.

Doppler frequency shift

Due to the relative motion between the target and the radar, the frequency of the EM wave reflected from the target and received by the radar will be different from the frequency of the wave transmitted from the radar. This is the Doppler Effect. The Doppler shift is measured by performing a spectral analysis of the received signal in every range increment. Measurement of the Doppler characteristics is used to suppress returns from clutter, to determine the presence of multiple targets at the same range, and to classify and identify moving targets and targets with moving components.

Resolution

Resolution describes a radar's ability to distinguish between two or more targets that are closely spaced, whether in range, angle, or Doppler frequency.

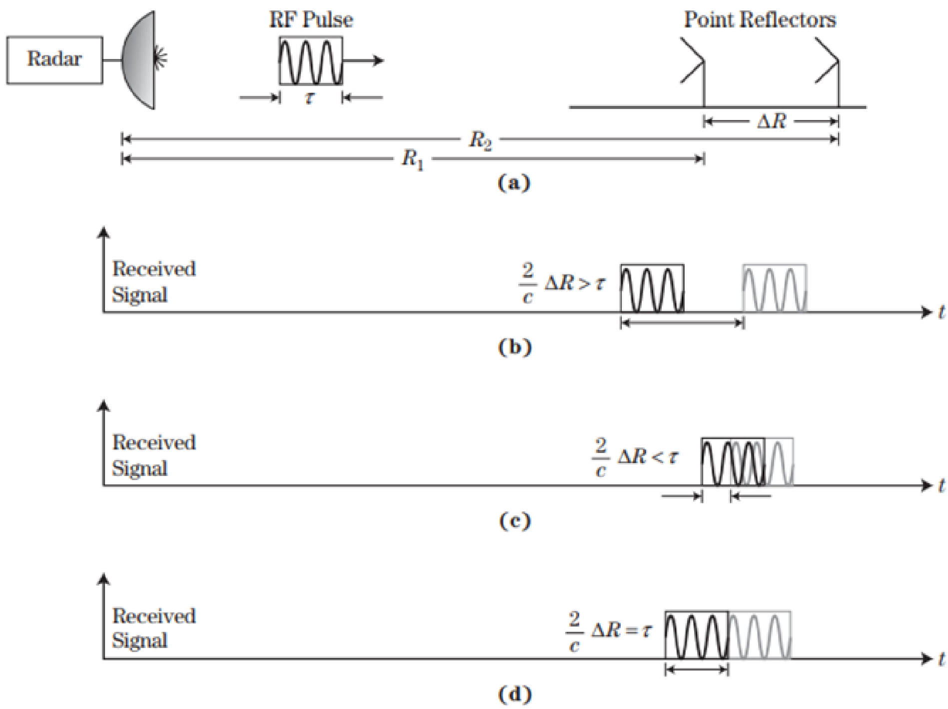


Fig2: *(a) Transmitted pulse and two targets. (b) Receiver output for resolved targets. (c) Receiver output for unresolved targets. (d) Receiver output for defining range resolution.*

The dividing line between these two cases is shown in Fig2, where the two pulses meet one another. This occurs when

$$\boxed{\Delta R = \frac{c\tau}{2}}$$

The quantity ΔR is called the range resolution of the radar. Two targets spaced by more than ΔR will be resolved in range; targets spaced by less than ΔR will not.

Radar Range Equation

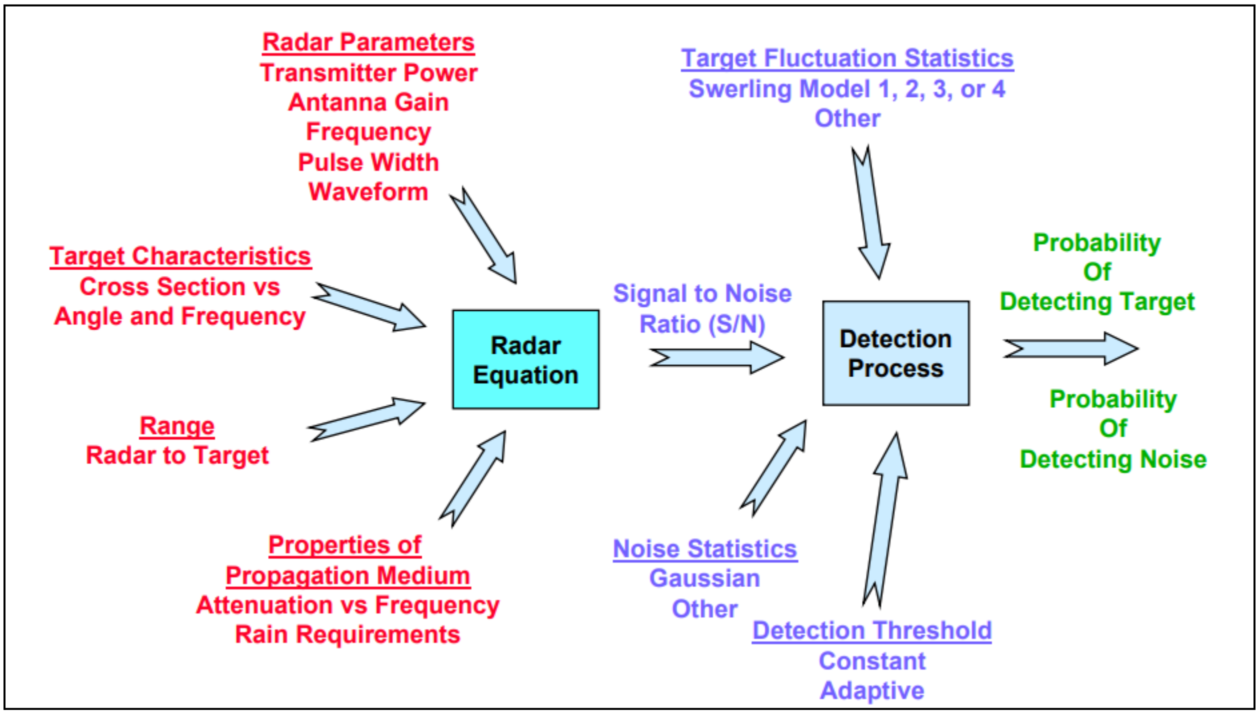
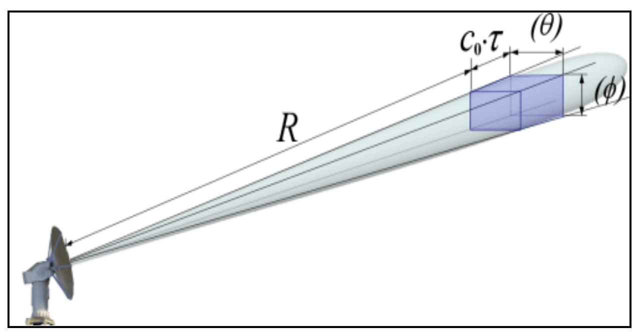


Fig 3: Radar Range field



Pt = peak transmitted power

R = distance from radar

Gt = Gr = transmitter /receiver gain

σ = radar cross-section units

k = Boltzmans constant = 1.38 x 10-23 joules / deg K

Ts = System Noise Temperature

Bn = Noise bandwidth of receiver

λ = Radar signal wavelength

$$S / N = \frac{P_t\, G^2 \lambda^2 \sigma}{(4\pi)^3 R^4 k\, T_s\, B_n\, L}$$

- The radar equation provides a simple connection between radar performance parameters and radar design parameters
- There are different radar equations for different radar functions
- Scaling of the radar equation lets you get a feeling for how the radar design might change to accommodate changing requirements
- Combination of the radar equation with cost or other constraints permits quick identification of critical radar design issues
- Be careful if the radar equation leads to unexpected results
  - ➢ Do a sanity check
  - ➢ Look for hidden variables or constraints
  - ➢ Try to compare parameters with those of a real radar

Precision and Accuracy

The quality of the measurement of a signal quantity such as position in range or angle is characterized by its precision and accuracy.

Accuracy measures the difference between the measured value and true value. Precision characterizes the repeatability of multiple measurements of the same quantity, even when the accuracy is poor.

In radar, measurement errors are due to a combination of many factors, including interference such as noise and cluster, target phenomenology such as glint and scintillation.

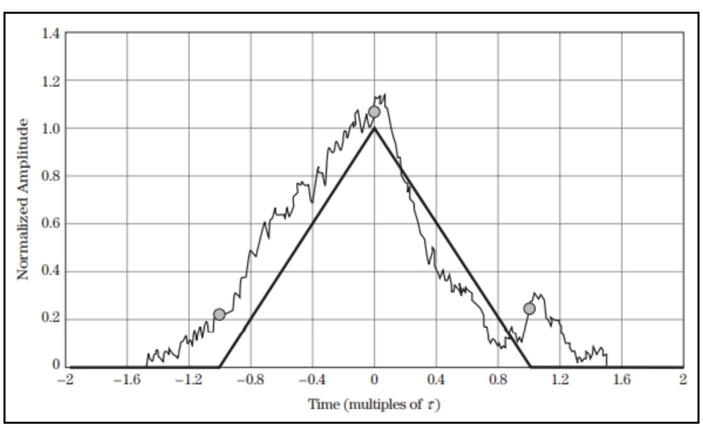


Fig 4:*Noise-free (bold line) and noisy (thin line) matched filter outputs for an ideal rectangular pulse of length τ seconds. The gray circles are samples taken at intervals of τ seconds.*

As an example of the effects of noise on the measurement accuracy and precision, consider the output of a matched filter detector for a single simple pulse.

Any uncertainty in the antenna boresight angle, due perhaps to mounting or pattern calibration errors or uncertainty, will affect the accuracy of a location measurement. Radiofrequency (RF) hardware or antenna gain calibration errors (gain uncertainty) will affect the accuracy of target signal power measurements.

Pulse Compression and Matched Filter:

Matched Filter:

Matched Filter is a filter generates an output to maximize the output peak power ratio to mean noise power within its frequency response then it is called a matched filter. In telecommunications, it is the optimal linear filter used to increase the SNR ratio in the existence of additive stochastic noise.These are used in radar, where a known signal is transmitted out and the reflected signal can be compared with the transmitted signal. The best example of the matched filter is pulse compression because the impulse response can be matched with input pulse signals.
The two-dimensional matched filter is used in SAR (Synthetic aperture radar) to enhance the SNR or signal to noise ratio however the gain of SNR of synthetic aperture radar is controversial. The traditional technique examines the signal-to-noise ratio of SAR based on coherent integration & pulse compression; however, it will have diverse calculation results.

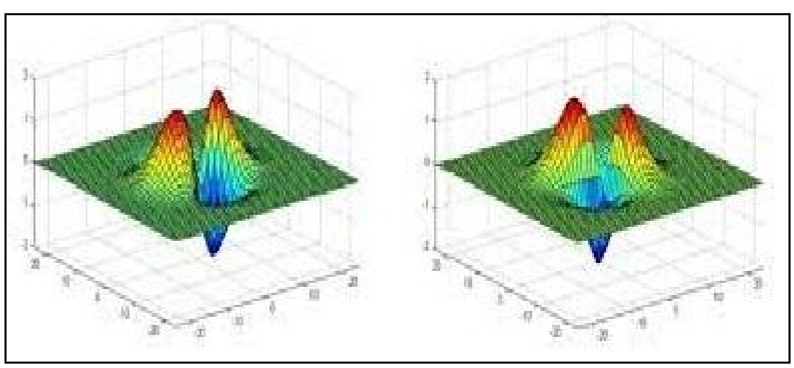


Fig 5

Pulse Compression:

Pulse compression is the technique commonly used by radar to increase the range resolution and SNR ,achieved by modulating the transmitting pulse and then correlating the received signal with the transmitted pulse.

To have large enough signal without poor resolution pulse compression technique is used.Its basic principles are:

- Signal is transmitted,with a long enough length so that the energy budget is correct.
- this signal is designed so that after matched filtering, the width of the intercorrelated signals is smaller than the width obtained by the standard sinusoidal pulse, as explained above ,hence the name of the technique: pulse compression.

Pulse Compression by linear frequency modulation:

In radar or sonar applications, linear chirps are the most typically used signals to achieve pulse compression.With this pulse compression method, the transmission pulse is frequency modulated linearly. This has the advantage that the circuit can still be kept relatively simple. However, the linear frequency modulation has the disadvantage that interference can be generated relatively easily by so-called “sweepers”.The transmission pulse is divided into several time intervals with an assumed constant frequency. Special filters for exactly the frequency in the respective time interval result in one output signal each, which is added to an output pulse in a cascade of delay lines and adding stages.
Application of linear frequency modulation is the radar AN/FPS-117.
If the entire uncompressed pulse is shifted by the Doppler effect, the filter frequencies no longer fit, and losses occur. In practice, several such circuits are therefore often used in parallel, each shifted by a small amount of the Doppler frequency. The signal with the highest signal-to-noise ratio is processed further.

Time side lobes: At the output of the compression filter, sidelobes appear in addition to the target pulse. These sidelobes are offset in time (i.e. in distance) from the main pulse and are called *time* or *range sidelobes*. The adjacent graph shows these sidelobes, which are shown once as a function of time (on the oscilloscope) and once as a function of distance (on a section of a brightness modulated display).

Since the time and amplitude distance both are constant, weighing the signal amplitudes can reduce these sidelobes to a acceptable value.if it is applies only receive path it may reduce the SNR.

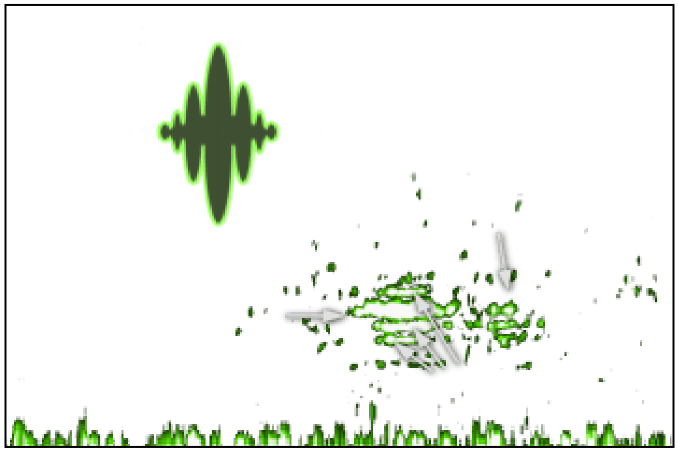


Fig 6: *View of sidelobes*

Simple impulsion:Transmitted signal in red (carrier 10 hertz, amplitude 1, duration 1 second) and two echoes (in blue).

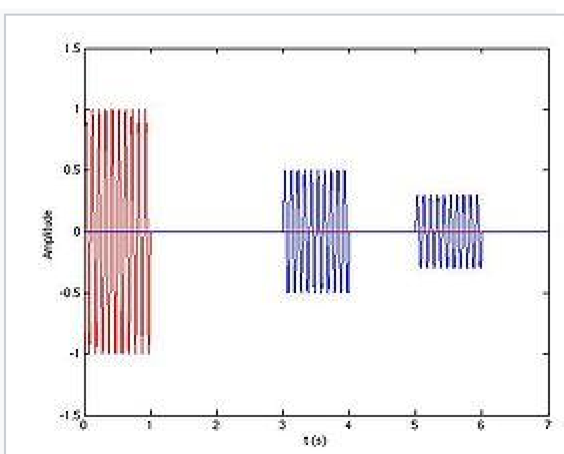


Fig 7: *a) Before matched filtering*

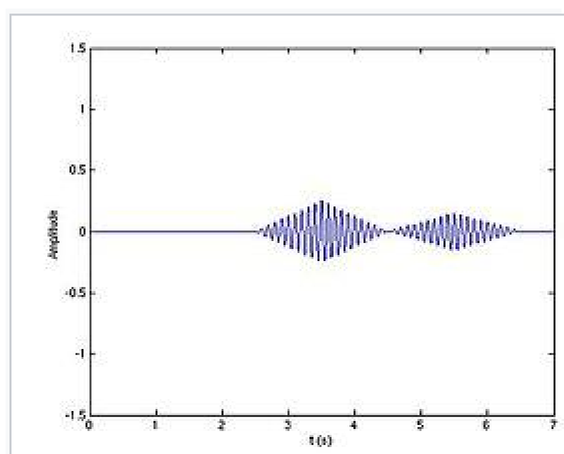


Fig 7: *b) After matched filtering*

If the targets are separated enough, echoes can be distinguished.
Linear chirped pulse: Transmitted signal in red (carrier 10 hertz, modulation on 16 hertz, amplitude 1, duration 1 second) and two echoes (in blue).

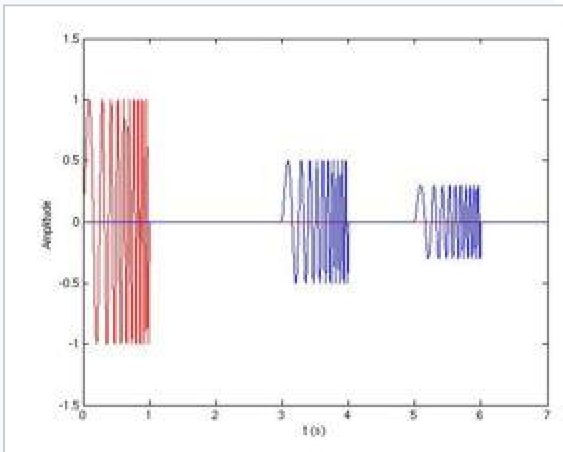


Fig 8: a) *Before matched filtering*

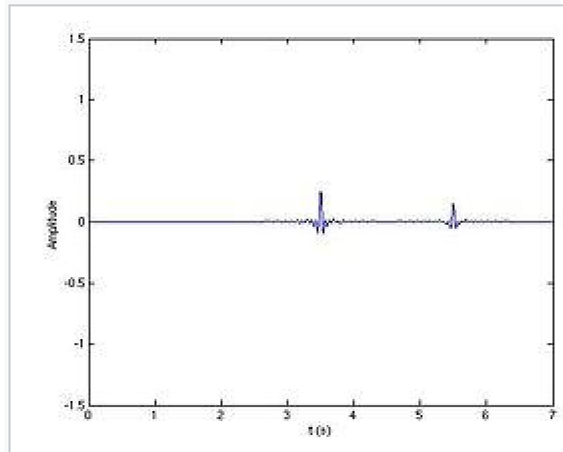


Fig 8: *b) After matched filtering: the echoes are shorter in*

<u>Pulse Compression by Non Linear Frequency Modulation:</u>

It don't need amplitude weighting which we used in Lfm to reduce the sidelobes.A filter adjustment with much steeper edges and nevertheless low time-sidelobes is now possible. In this way, the losses in the signal-to-noise ratio that otherwise occur due to amplitude weighting are avoided.
The symmetrical form of modulation has an increasing (or decreasing) frequency change during the first half of the transmission pulse duration and a decreasing (or now increasing) frequency change during the second half. An asymmetrical form of modulation is obtained when only one half of this symmetrical form is used.

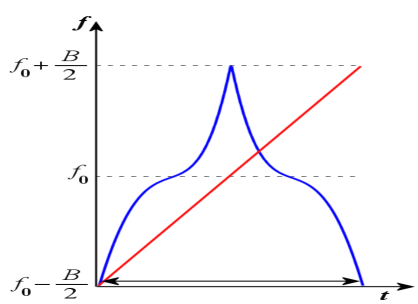


Fig 9

Red line :LFM and Blue:NLFM

This modulation requires a more complicated circuit design and also complicated modulation.

Pulse compression with phase modulation:

The phase-encoded pulse shape differs from the frequency-modulated pulse shape in that the long pulse is divided into smaller sub-pulses of equal length whose carrier frequency does not change. Within this pulse duration of the sub-pulses, the phase is constant. These sub-pulses always represent a *range-cell*, i.e. the smallest resolvable distance. So that these sub-pulses with the length τ_c can also be detected, the transmitter and receiver must have a bandwidth of $B = 1/\tau_c$. A phase jump can be programmed between the sub-pulses but does not have to take place at each pulse change.

This phase jump is usually linked with a binary code. The binary code consists of a sequence of logical states. Depending on this binary code, the phase position of the transmitted signal is switched between 0 and 180°. However, in contrast to the highly simplified picture shown, the transmission frequency is not necessarily a multiple of the frequency of the control pulses. The coded transmission frequency is therefore generally switched disharmoniously at the phase reversal points.

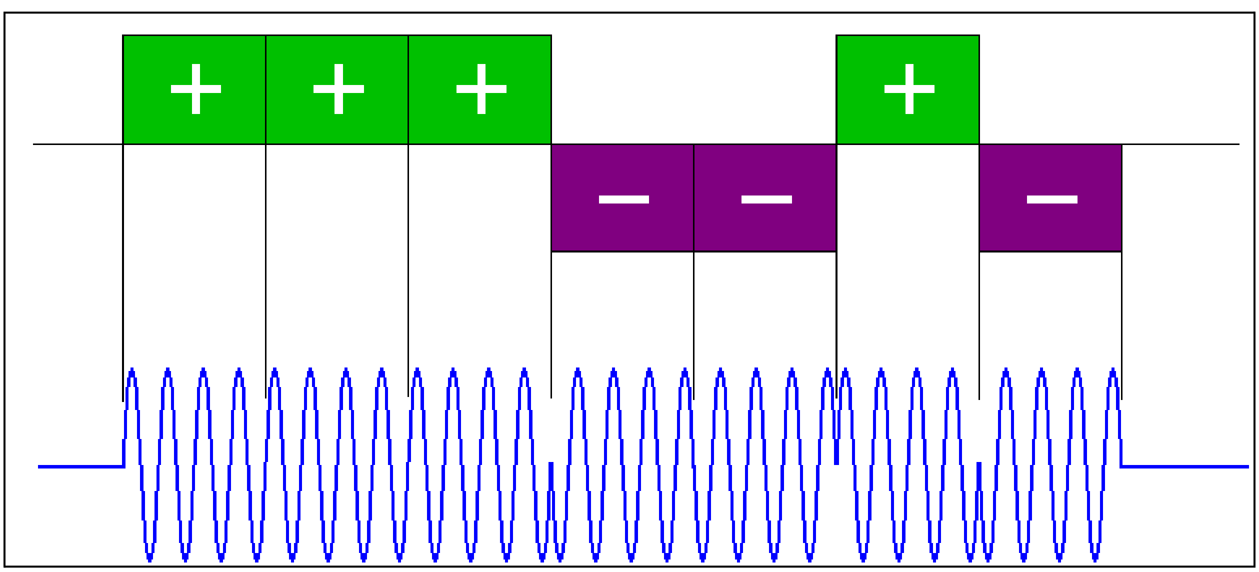


Fig 10: *Diagram of Phase coded modulation*

Barker Code use in phase modulation pulse compression:

The selection of a suitable code from these so-called $0/\pi$ phases is very critical, indeed. Several pulse patterns in the Barker code have proven to be the optimum. This optimum is measured at the level of the expected sidelobes. Only a small number of optimum codes exist, which are listed in the adjacent table. A computer-aided study has examined up to 6 000 different Barker codes and concluded that only the 13 have a maximum signal-to-sidelobes ratio.It can, therefore, be concluded that no greater number of pulses than this 13 is possible for Barker codes and that the number of 13 subpulses therefore also represents a maximum achievable pulse compression ratio of 13:1.

Table 2

Length of code n	*Code elements*	*peak sidelobe ratio, dB*
2	+-	*-6.0*
3	++-	*-9.5*
4	++-+ , +++-	*-12.0*
5	+++-+	*-14.0*
7	+++--+-	*-16.9*
11	+++---+--+-	*-20.8*

CLUTTER:

Clutter is a term used to describe any object that may generate unwanted radar returns that may interfere with normal radar operations.
The basic types of clutter can be summarized as follows:

- **Surface Clutter** – Ground or sea returns are typical surface clutter. Returns from geographical land masses are generally stationary, however, the effect of wind on trees etc means that the target can introduce a Doppler Shift to the radar return. This Doppler shift is an important method of removing unwanted signals in the signal processing part of the radar system. Clutter returned from the sea generally also has movement associated with the waves.

- **Volume Clutter** – Weather or chaff are typical volume clutter.
In the air, the most significant problem is weather clutter. This can be produced from rain or snow and can have a significant Doppler content.

- **Point Clutter** – Birds, windmills and individual tall buildings are typical point clutter and are not extended in nature. Moving point clutter is sometimes described as angels. Birds and insects produce clutter, which can be very difficult to remove because the characteristics are very much like aircraft.

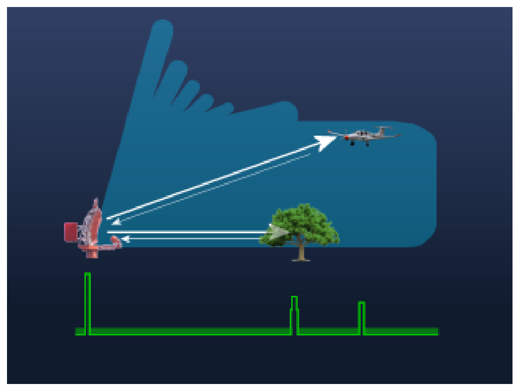


Fig 11: *Radar receives echo signals from all objects in the antenna pattern, including unwanted objects.*

MTI Radar:

Clutter spectrum is normally concentrated around DC and multiple integers of the radar PRF , as illustrated in Fig. 9.8a. In CW radars, clutter is avoided or suppressed by ignoring the receiver output around DC, since most the clutter power is concentrated about the zero frequency band. Pulsed radar systems may utilize special filters that can distinguish between slowly moving or stationary targets and fast moving ones. This class of filters is known as the **Moving Target Indicator (MTI)**. In simple words, the purpose of an MTI filter is to suppress target-like returns produced by clutter, and allow returns from moving targets to pass through with little or no degradation.

- MTI filters can be implemented using delay line cancelers. As we know the frequency response of this class of MTI filters is periodic,with nulls at integer multiples of the PRF. Thus, targets with Doppler frequencies equal

to nfr are severely attenuated. And since Doppler is proportional to target velocity (fd = 2v ⁄ λ), target speeds that produce Doppler
frequencies equal to integer multiples of fr are known as blind speeds. More precisely,

vblind=λ*fr/2

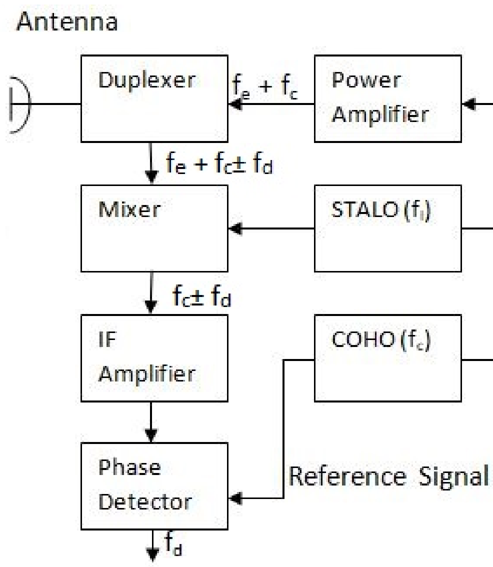
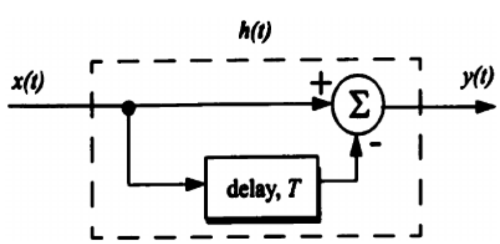


Fig 12: *shows a block diagram of a coherent MTI radar. Coherent transmission is controlled by the Stable Local Oscillator (STALO). The outputs of theSTALO, and the Coherent Oscillator (COHO),are mixed to produce the transmission frequency . The Intermediate Frequency (IF), is produced by mixing the received signal with local oscillator frequency(fe) . After the IF amplifier, the signal is passed through a phase detector and is converted into a base band.Finally, the video signal is inputted into an MTI filter.*

<u>Single Delay Line Canceler:</u> A single delay line canceler can be implemented as shown in fig. The canceler's impulse response is denoted as h(t) . The output y(t) is equal to the convolution between the impulse response h(t) and the input x(t) . The single delay canceler is often called a “two-pulse canceler” since it requires two distinct input pulses before an output can be read.



In most radar applications the response of a single canceler is not acceptable since it does not have a wide notch in the stop-band. A double delay line canceler has better response in both the stop- and pass-bands, and thus it is more frequently used than a single canceler.

Double Delay Line Canceler: Two basic configurations of a double delay line canceler are shown in Fig.. Double cancelers are often called "three-pulse cancelers" since they require three distinct input pulses before an output can be read. The double line canceler impulse response is given by

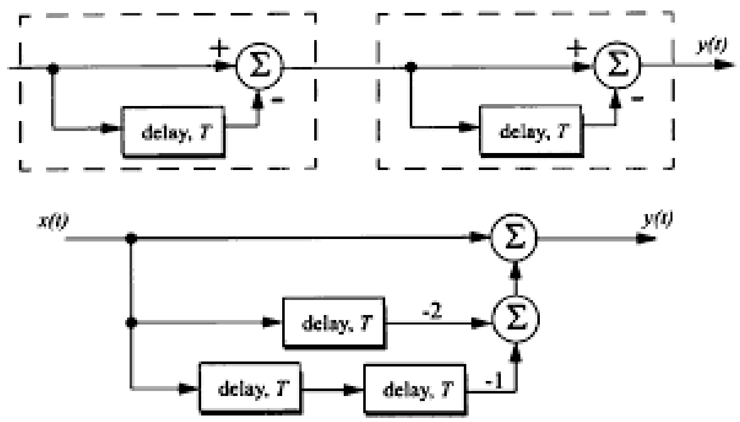
$$h(t) = \delta(t) - 2\delta(t - T) + \delta(t - 2T).$$

Again, the names "double delay line" canceler and "double canceler" will be used interchangeably. The power gain for the double delay line canceler is

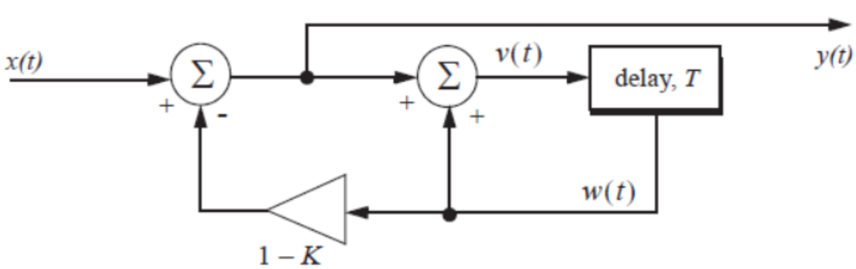
$$H(\omega)\ \hat{}2= H1(\omega)\hat{}\ 2*\ H1(\omega)\hat{}\ 2$$

where $H1(\omega)^2$ is the single line canceler power gain. It follows that

$$H(\omega)\ \hat{}2=16(\sin(\omega T/2))\hat{}4.$$



Delay Lines with Feedback (Recursive Filters): Delay line cancelers with feedback loops are known as recursive filters. The advantage of a recursive filter is that through a feedback loop we will be able to shape the frequency response of the filter. As an example, consider the single
canceler shown in . From the figure we can write



$$y(t) = x(t) - (1 - K)w(t)$$

$$v(t) = y(t) + w(t)$$
$$w(t) = v(t – T)$$
$$Y(z) = X(z) – (1 – K)W(z)$$
$$V(z) = Y(z) + W(z)$$
$$W(z) = z^{(–1)} * V(z)$$
$$H(z) = Y(z) / X(z)$$
$$H(z) = 1- z^{(–1)} / 1-Kz^{(-1)}$$

Using the transformation yields

$z= ej\omega T$

$H (ej\omega T)= 2(1 – \cos\omega T)/1+K^2 – 2K\cos (\omega T)$

PRF Staggering: Blind speeds can pose serious limitations on the performance of MTI radars and their ability to perform adequate target detection.If the radar is operating at multiple PRF's then the effect of blind speed can be eliminated.The use of more than one prf offers additional flexibility in the design of MTI doppler filters.Consider a radar system with two different interpulse periods T1 and T2.When n1 and n2 integers the first true blnd speed occurs when n1/T1=n2/T2. Staggering Ratio (Ks)=n1/n2.If Ks tends to 1.0 it pushes the first blind speed farther out. If there are n PRF's then n1/T1=n2/T2=n3/T3=..........=n(N)/T(N).

MTI Improvement Factor: The MTI CA is defined as the ratio between the MTI filter input Ci clutter power to the output Co clutter power , CA = Ci / Co.

The MTI improvement factor is defined as the ratio of the Signal to Clutter (SCR) at the output to the SCR at the input, I=(So/Co)/(Si/Ci) which can be rewritten as I=(So/Si)*CA

The ratio So/Si is the average power gain of the MTI filter, and it is equal to H(w)^2.

A Gaussian-shaped clutter power spectrum is given by

$W(f)=[Pc/(2\pi)^{1/2} * \sigma c]*\exp(f2 / (2\sigma c)^2)$

where is Pc the clutter power (constant), and is σc the clutter rms frequency and is given by $\sigma c= 2\sigma v / \lambda$.

Where λ is the wavelength, and v is the rms wind velocity, since wind is the main reason for clutter frequency spreading. Substituting Eq. yields

$$W(f)=[\lambda Pc /2*(2\pi)^{1/2} * \sigma v]*\exp(-f^2\lambda^2/8\sigma v^2)$$

Subclutter Visibility: Radar performance in clutter is summarized by two parameters; improvement factor I_f and subclutter visibility.

The phrase **Subclutter Visibility** (SCV) describes the radar's ability to detect non-stationary targets embedded in a strong clutter background with a given signal-to-clutter ratio (SCR), for some probabilities of detection and false alarm. It is often used as a measure of the effectiveness of moving-target indicator radar, equal to the ratio of the signal from a fixed target that can be canceled to the signal from a just visible moving target.

The Improvement factor I_f is defined as the signal-to-clutter ratio at the output of the clutter filter divided by the signal-to-clutter ratio at the input of the clutter filter, averaged uniformly over all target velocities of interest. This definition includes the signal gain as well as the clutter attenuation. With respect to Doppler frequency, the Improvement factor can be expressed as:

$$I(f)=(S/C)out.(C/S)in=(Cin/Cout*Gav)$$

C_{in} = strength of clutter at clutter filter input

C_{out} = strength of clutter at clutter filter output

G_{av} = average filter gain for moving targets

The subclutter visibility is expressed as the ratio of the improvement factor to the minimum MTI output given signal-to-clutter ratio (SCR) required for proper detection for a given probability of detection. SCV=If/(SCR)out.

SCV = Subclutter Visibility

SCR = Signal-to-Clutter Ratio

Moving Target Detection - how does it work?

Moving Target Detection is a newer approach to turn the moving targets visible. It is a composite algorithm.

It benefits from advancing technology of fully coherent radars and digital receivers as well as monopulse processing . It consists of a set of filters:

- Doppler filter
- CFAR
- Zero velocity filter
- Clutter map subtraction
- Post processing

Doppler Filter: The Doppler filter compares the reflected signals of at least two pulses allowing to measure the targets radial velocity.

CFAR: C-FAR stands for **C**onstant **F**alse **A**larm **R**ate.It is an adaptive thresholding technique to detect even weak targets against clutter

Zero Velocity Filter: A zero velocity filter is a low-pass filter with the task to keep only clutter. It is a Recursive Filter.These filters, also called Infinite Impulse Response (IIR) filters, are an efficient way of achieving a long impulse response, without having to perform a long convolution. They execute very rapidly, but have less performance and flexibility than other digital filters.But they fill well into the parallel branch for the clutter preparation.

Clutter Map Filter: In the 2nd step a clutter map filter averages the number of measurements over a number of scans (alternative techniques exist) The advantage: even an object that stops moving for a certain time period will be detected (e.g., helicopter of drone, or a human being in search and rescue application).The result will be added (in a weighted way) to the CFAR filter.

Post Processing: This processing allows to eliminate moving objects like birds or rain, e.g., based on reasoning such as: objects smaller than value x are eliminated.

An Introduction to tracking radar

The radar which is used to track the path of one or more targets is known as tracking radar. In general, it performs the following functions before it starts tracking activity.

- Target detection
- Range of the target
- Finding elevation and azimuth angle
- Finding doppler frequency shift

Therefore, the tracking radar tracks the target by tracking one of the 3 parameters i.e., range, angle & doppler frequency shift.

Different types of radar tracking techniques are available, most of the tracking radars used the principle of tracking in angle.

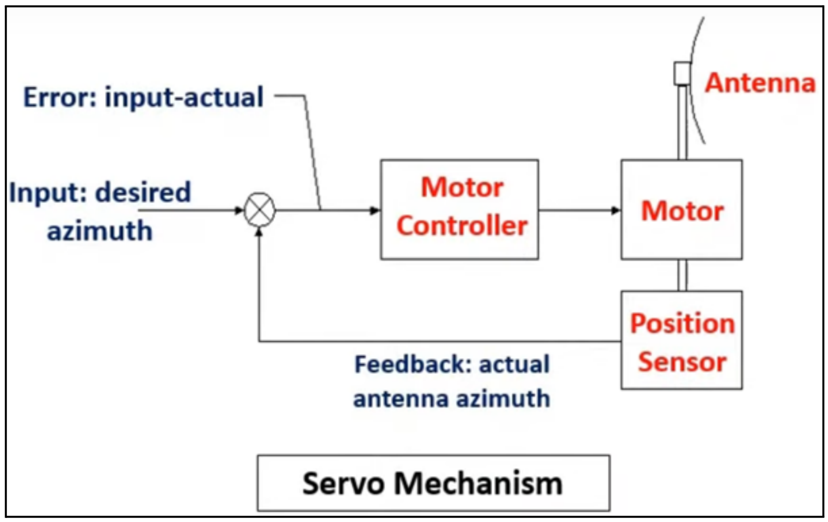


Fig 12: *Block Diagram of Servo Tracking Mechanism*

Mechanism

- The pencil beams of Radar Antenna perform tracking in angle.
- The axis of Radar Antenna is considered as the reference direction.
- If the direction of the target and reference direction is not the same, then there will be an angular error.
- If the angular error signal is applied to a servo control system, then it will move the axis of the Radar Antenna towards the direction of the target.
- Both the axis of Radar Antenna and the direction of target will coincide when the angular error is zero.
- There exists a feedback mechanism in the Tracking Radar, which works until the angular error becomes zero.

Some radars work as **Search Radar** to find the target before switching to a tracking mode. Due to some operational limitations, single radars for both search and tracking are not favorable.

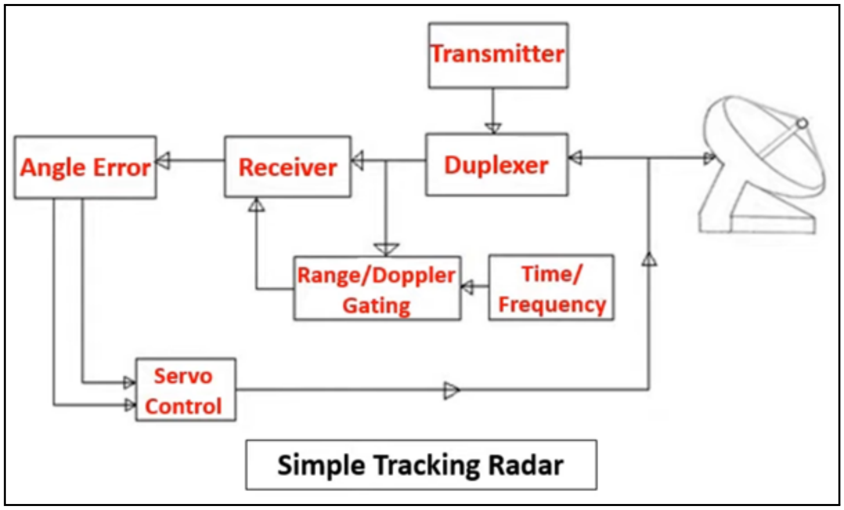


Fig 13: *Basic Tracking Block Diagram*

Mechanism

- The tracking operation in the radar depends upon angular information.
- Very narrow antenna beam is used here which will track one target object at one time.
- This can be performed using range gating and Doppler filtering module.
- Range tracking is carried out using a timing control unit.
- Doppler tracking is carried out using the Doppler gating unit.
- The angle error signal is provided as input for servo motor-based control systems.
- This servo system will steer the antenna as per error input and hence will track the target.

Types of tracking radar

1. **Single target tracking (STT)**
    - It is used where continuous tracking of a single target with higher data rate is required.
    - It used closed loop servomechanism to keep the angle coordinate error minimum.
    - Generally, it is used in controlling the missile movements as it is carried out by a Missile Guided Radar (GMR).
2. **Track while scan (TWS)**

- This radar scans beams over a large area.
- It rapidly tracks in the angular sector to keep track of the targets, maybe moving one target at a time.

3. Automatic detection and track (AD&T)

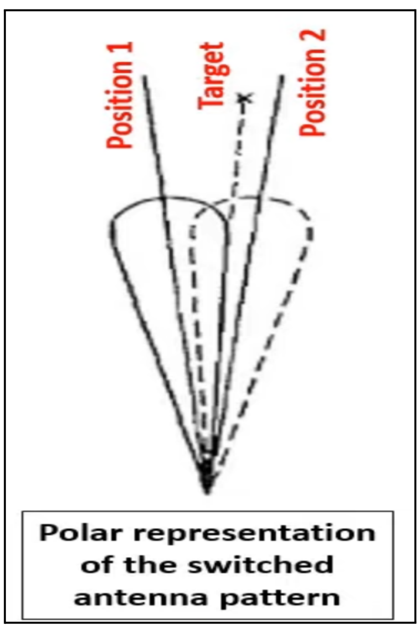
- It tracks multiple targets at a time
- Open loop servo mechanism is used
- Mostly used in air traffic control radar

4. Phase array radar tracking

- It can track multiple targets on a time sharing basis.
- Electronically steered phased array method is used so large number of targets can be scanned rapidly

Sequential Lobing Method of Tracking

Generally, there is a difference between the actual target location and the reference direction of tracking radar, this difference is known as the angular error in sequential lobing, the position of the antenna beam is switched between two positions, this gives us the direction and magnitude of the angular error. The method of switching a single beam between two squinted angular positions to obtain an angle of measurement is called sequential lobing. Sequential lobing is also known as lobe switching or sequential switching.



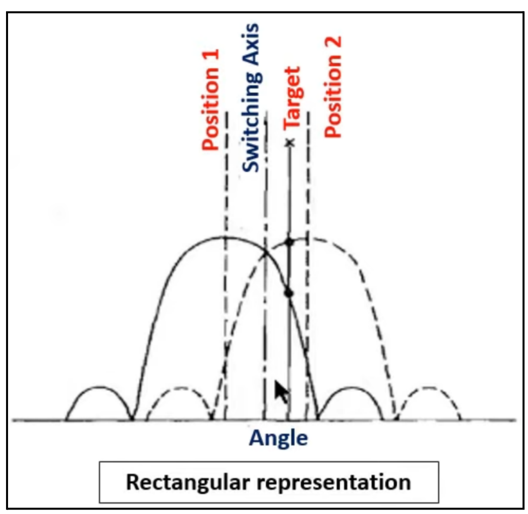


Fig 14 **Fig 15**

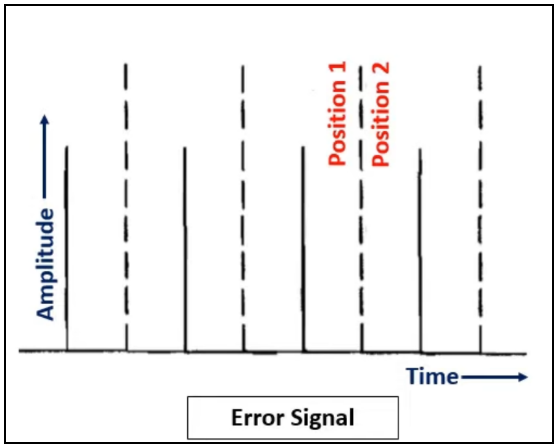


Fig 16

Two additional switching position i.e., total four switching positions are required to obtain the angle measurement in the orthogonal coordinate, therefore a 2-D sequential lobing radar consist of a cluster of four feed horn illuminating a single reflector antenna arrangement can be made such that right-left, up-down sectors are covered by successive antenna position. A cluster of five feed horn might also be used with a central feed used for transmission and four outer feeds used for reception on a sequential basis.

Conical Scan Tracking Radar

If an antenna beam continuously rotates for tracking a target, then it is called conical scanning, conical scan modulation is used to find the position of the target

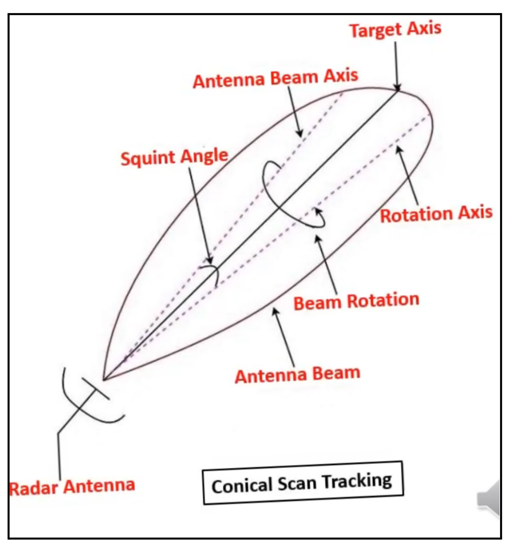


Fig 17

- Two servos are required, one for azimuth and other for elevation.
- When the antenna is “on target”, the conical scan modulation is of zero amplitude.
- Squint angle is the angle between beam axis and rotation axis.
- The echo signal obtained from the target gets modulated at a frequency equal to the frequency at which the antenna beam rotates.
- The angle between the direction of the target and rotation axis determines the amplitude of the modulated signal
- So, the conical scan modulation has to be extracted from the echo signal and then it is to be applied to the servo control system, which moves the antenna beam axis towards the direction of the target.

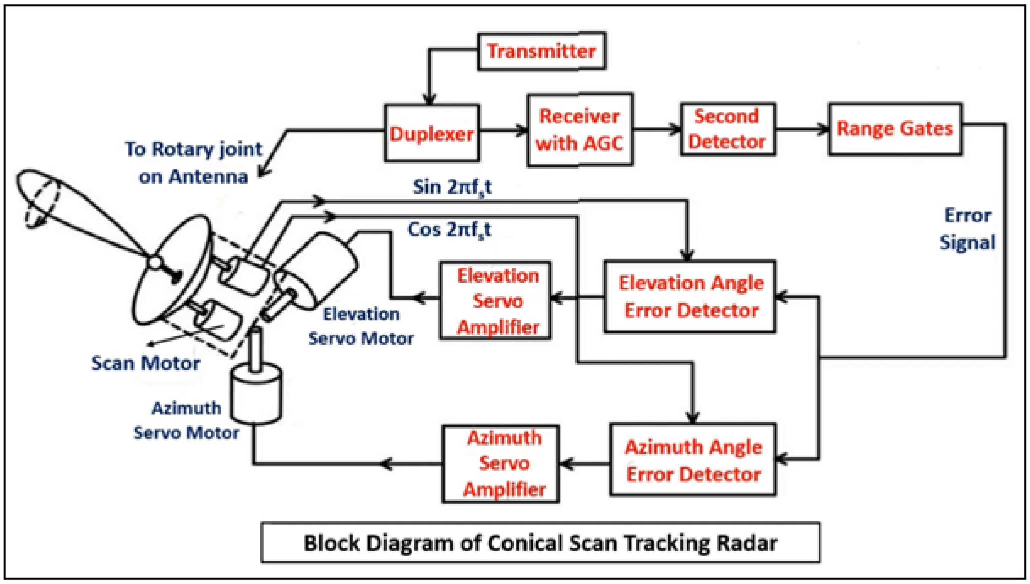


Fig 18

Mechanism

- The rotating beam of a conical scan traces out the shape of a cone, named as a conical scan.
- This beam can be achieved by using a rotating feed that is driven by a motor. This motor is kept in a housing or enclosure at the end of the dish.
- A change in the amplitude of the reflected signal is observed, this data from the echo signal is sent to an angle-error detector circuit.
- The data from this circuit drives the servo motors that control the antenna.

- A nutating feed design is given preference over a rear feed design in the conical scan, this is because we need to maintain the plane of polarization, a rear feed design rotates it.
- This can cause amplitude shifts and hence, is undesirable. Nutating means to spin without affecting the polarization.
- However, the nutating feed is more complex than the rear feed.
- The reference generator has two outputs that extract elevation and azimuth errors.
- The echo signal that is received is fed to the receiver from the antenna via two rotary joints
- One rotary joint control the azimuth movement and the other controls the elevation movement
- The receiver is a superheterodyne receiver.
- The error signal is extracted after the second detector. Range gate is used to search and lock the target and continuously track the target

Advantages of conical scan

Conical scan system requires a minimum number of hardware and therefore commonly used on inexpensive mobile systems like AAA or mobile SAM sites.

Disadvantages of conical scan

There is a disadvantage of not being able to see a target outside their narrow scan patterns.

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