TRACKING WITH RADAR

A radar not only recognizes the presence of target, but it determines the target's location in the range and in one or two angle co-ordinate. As it continues to observe a target over a time, the radar can provide the target's trajectory. There are four types of radar that can provide the tracks of targets.

1) Single target tracker:— This tracker is designed to continuously track a single target at a relatively rapid data rate. The data rate of course, depends on the amplification, but 10 observations per second might be "typical" of a military guided missile weapon control radar.

The antenna beam of a single target tracker follows the target by obtaining an angle error signal and employing a (~~Single target tracker~~) closed loop servo system to keep error signal small.

2) Automatic detection and track (ADT) This performs tracking as part of an air surveillance radar. It is found in almost all modern civil air-traffic control radars as well as military air surveillance radar. The rate at which observations are made depends on the time for the antenna to make a rotation. The ADT therefore, has a lower data rate than that of STT, but its advantage is that it can simultaneously track a large no. of targets

3) Phased array radar tracking:— A large no. of targets with a high data rate by an electronically steered phased array radar. Multiple targets are tracked can be held in track

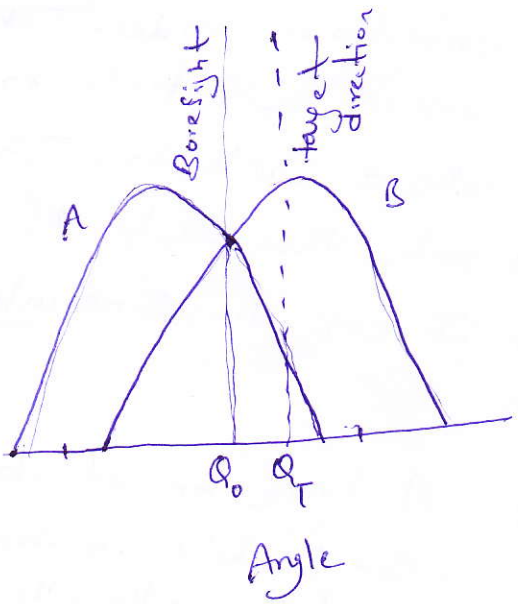
on a time shared basis under computer control since the beam of an electronically scanned array can be rapidly switched from one angular direction to another, sometimes in a few microseconds.

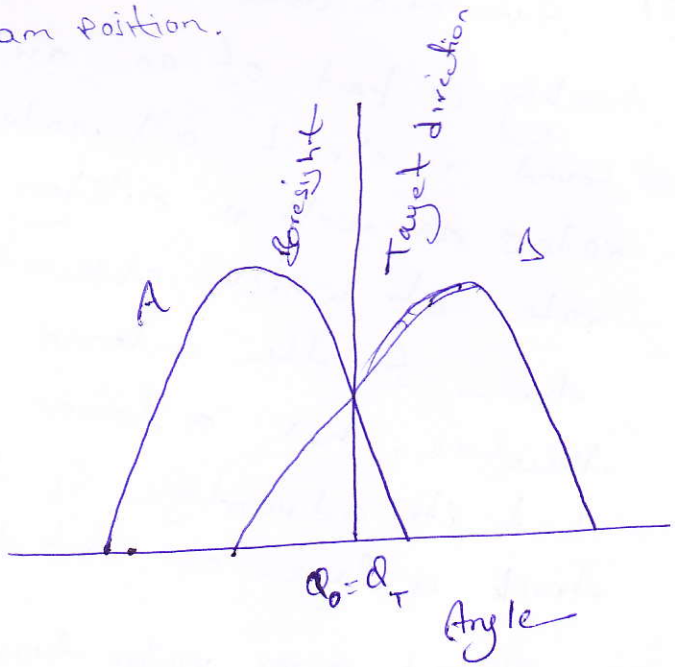
4) Track while Scan (TWS):-

This radar rapidly scans a limited angular sector to maintain tracks, while a moderate data rate, on more than one target within the coverage of the antenna. It has been used in past for air defense radars, aircraft landing radars, and in some air borne intercept radars to hold multiple targets in track.

Angle Tracking:- In an simple pencil-beam radar the detection of a target provides its location in angle at least somewhere within the antenna beamwidth; but more information is needed to determine the direction the antenna should be moved to maintain the target within its beam.

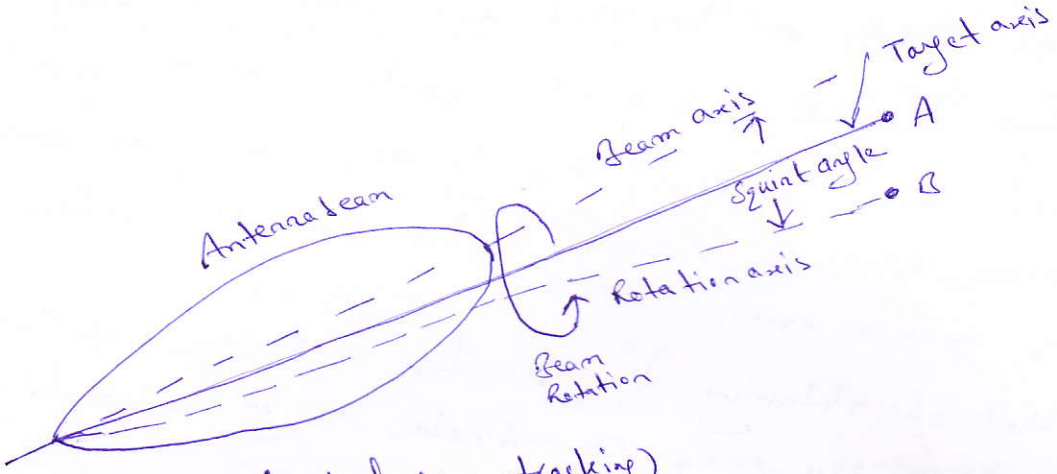
- In order to determine the direction in which the antenna beam needs to be moved, a measurement has to be made at two different beam position.





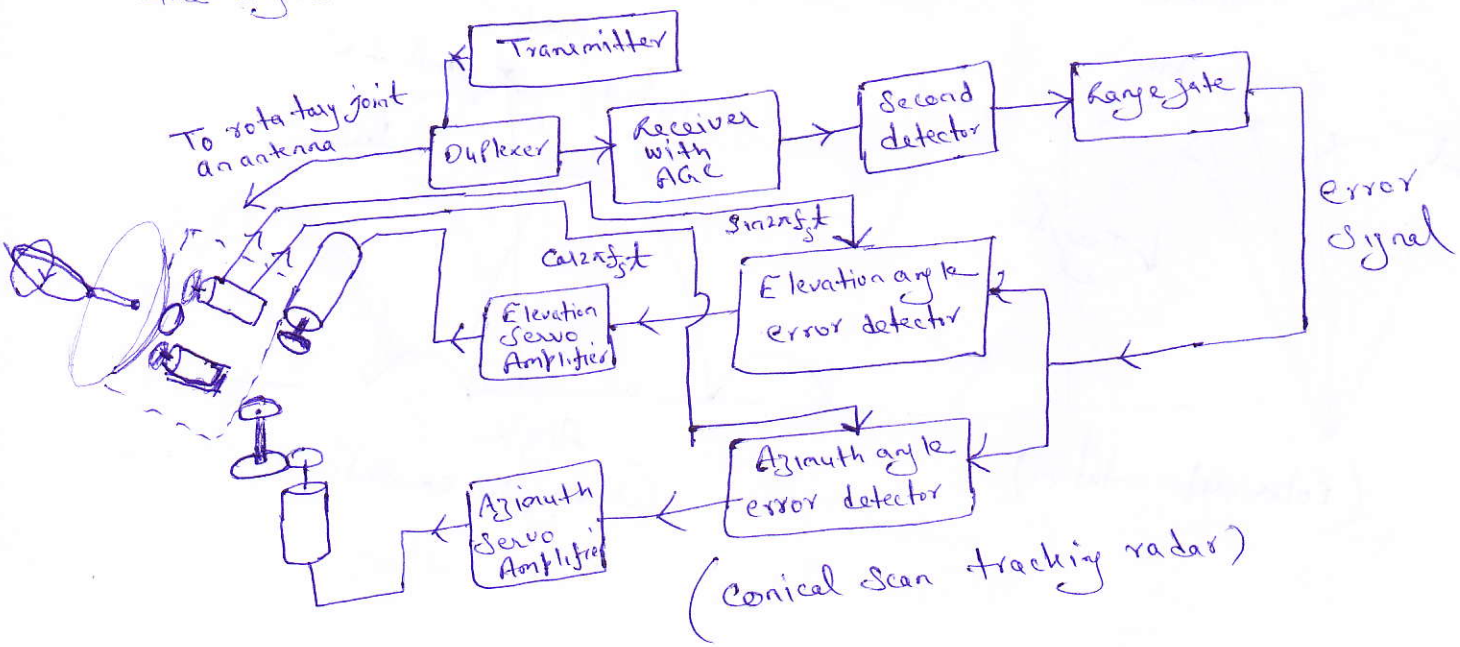
CONICAL SCAN

The logical extension of the Simultaneous lobing techniques is to rotate continuously an offset antenna beam rather than discontinuously step the beam b/w the four discrete positions. This is known as Conical Scanning.



(Conical scan tracking)

The angle b/w the axis of rotation which is usually but not always the angle of the antenna reflector and the axis of the antenna beam is called squint angle. Consider a target at position A. The echo signal will be modulated at a frequency equal to rotation frequency of the beam. The amplitude of the echo signal modulation will depend upon the shape of antenna pattern, the squint angle, and the angle b/w the target line of sight and rotation axis.

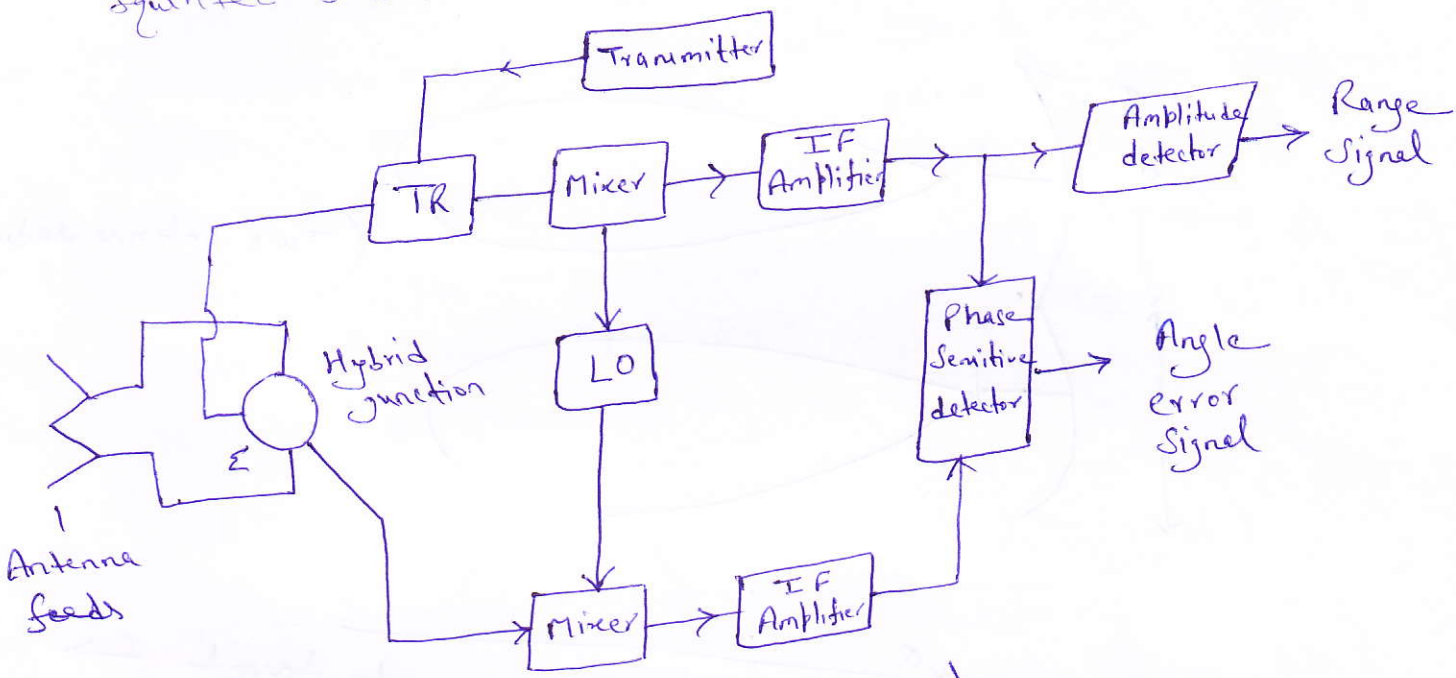


(Conical Scan tracking radar)

MONOPULSE TRACKING

A monopole tracker is defined as one in which information concerning the angular location of a target is obtained by comparison of signals received in two or more simultaneous beams. A measurement of angle may be made on the basis of a single pulse, hence the name monopulse.

There are several methods by which a monopulse angle measurement can be made. The most popular by far has been the amplitude-comparison monopulse which compares the amplitudes of the signals simultaneously received in multiple squinted beams to determine the angle.



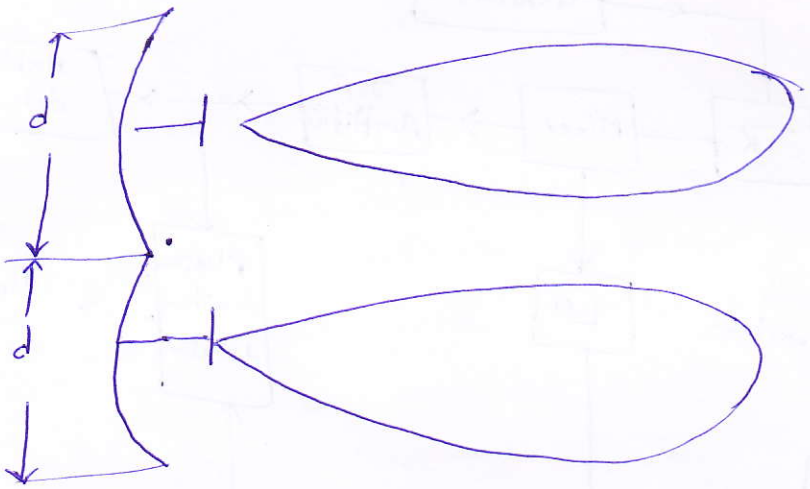
(Amplitude Comparison monopole)

Two antenna feeds which are adjacent are connected to the two input arm of a hybrid junction, which is a four port micro-wave device with two I/P and two O/P. The Sum pattern is used for transmission while both Sum and difference patterns are used for reception. The Signal received with differe pattern provide the magnitude and angle error.

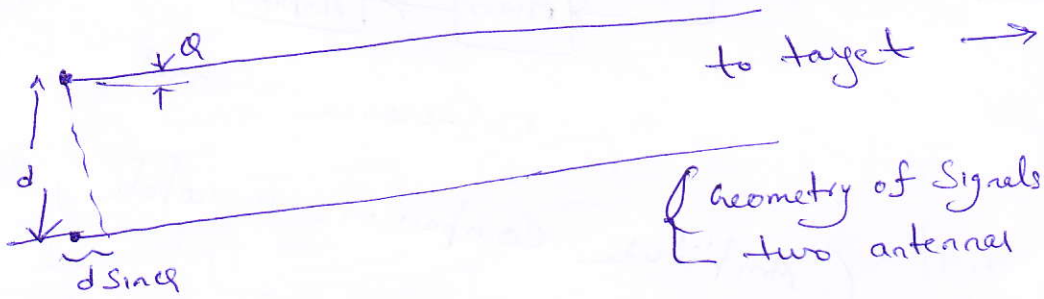
The sign of the difference signal is determined by comparing the phase of the difference signal with the phase of the Sum signal.

Phase Comparison monopulse :→

In this two antenna beams are used to obtain an angle measurement in one co-ordinat just as in amplitude comparision monopulse. The two bean however, look in the same direction and cover the same region of space rather than be squinted to look in two slightly different directions. In order for the two beams to look in same direction, two antenna have to be used in the phase comparison monopulse.



(Two antenna radiati



{ Geometry of Signals at two antennas }

Phase difference in Signals received in the two anten is

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

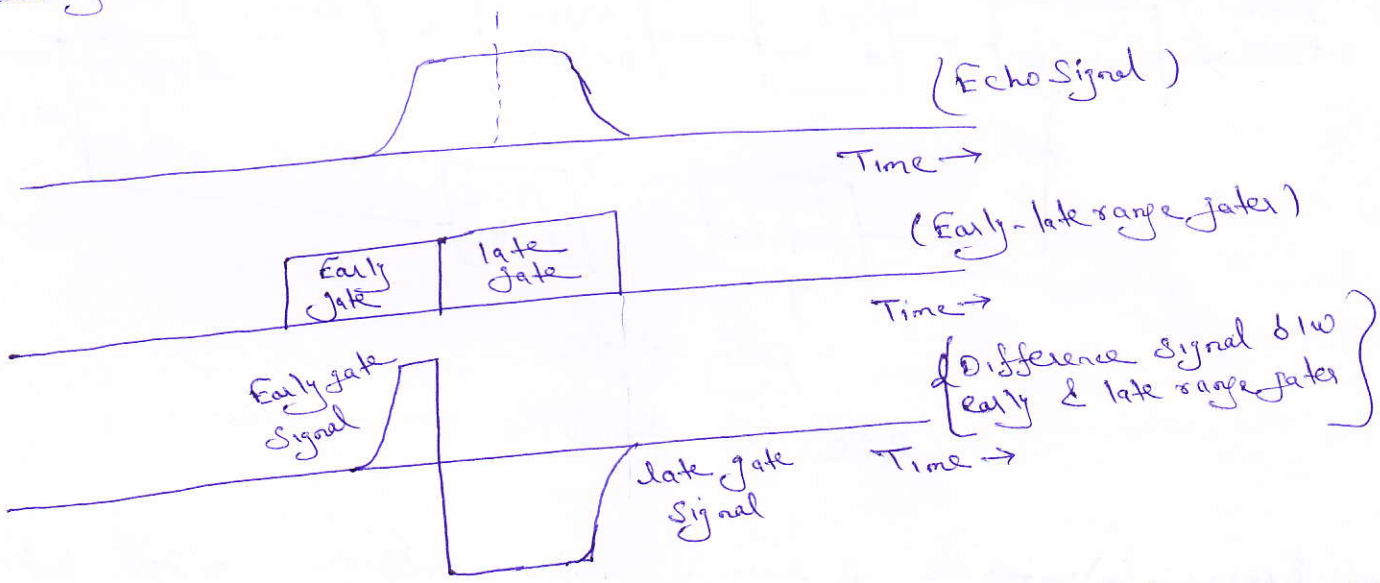
The phase-comparison monopulse is sometimes known as an interferometer radar.

TRACKING IN RANGE

In most tracking-radar applications the target is continuously tracked in range as well as in angle. Range tracking might be accomplished by an operator who watches an A-scope or I-scope representation and manually positions a handwheel in order to maintain a marker over the desired target pip. The setting of handwheel is a measure of the target range and may be converted to a voltage that is supplied to a data processor.

As the target speeds increases it is increasingly difficult for an operator to perform at the necessary level of efficiency over a sustained period of time, and automatic tracking become a necessity.

The technique for automatically tracking in range is based on the split range gate. Two range gates are generated as shown in Figure

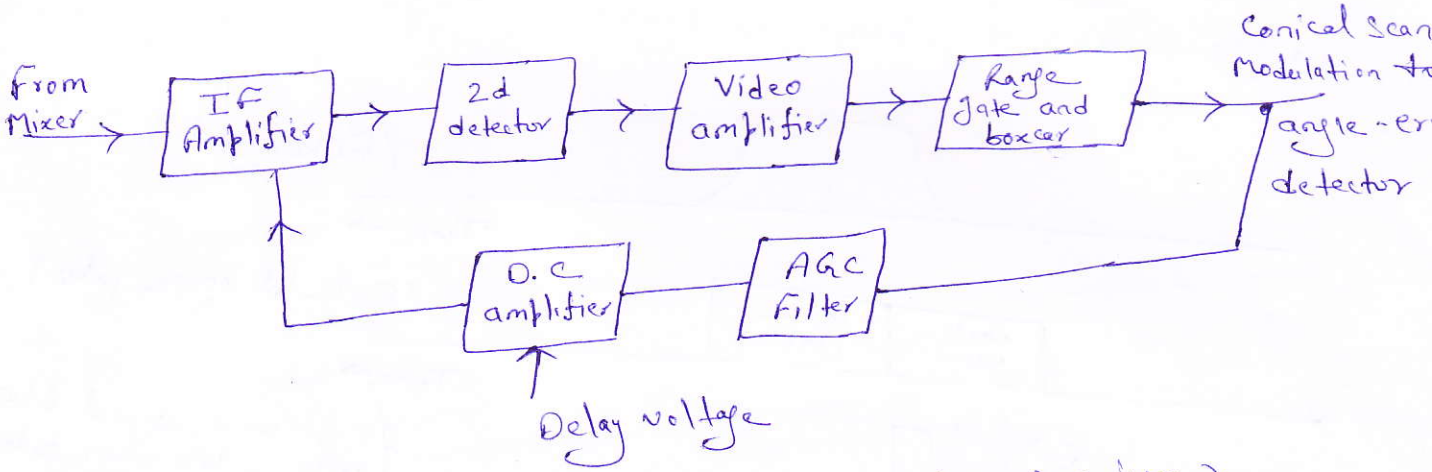


The range gating necessary to perform automatic tracking offers several advantages as by products. it isolates one target, excluding targets at other ranges. This permits the boxcar generator to be employed.

One of the simplest conical scan antenna is a parabola w an offset rear feed rotated about the axis of reflector. if the feed maintains the plane of polarization fixed as it rotates

Boxcar generator:— when extracting the modulation imposed on a repetitive train of narrow pulses, it is usually convenient to stretch the pulses before low pass filtering. This is called boxcaring, or sample and hold.

Automatic gain control:→ The echo signal amplitude at the tracking radar receiver will not be constant but will vary with time. The function of AGC is to maintain the d-c level of the o/p of receiver constant and to smooth or eliminate as much of the noiselike amplitude fluctuat as possible without disturbing the extraction of desired err signal at the conical scan frequency.



(AGC for tracking radar receiver)

Range Glint:→ A target with multiple scatters distributed in range can cause tracking errors because of glint

$$\Delta T_K = \frac{\Delta T}{2} \cdot \frac{1-a^2}{1+a^2+2a\cos(2\pi f_0 \Delta T)}$$

ACQUISITION

A tracking radar must first find and aquire (look on it) its target before it can operate as a tracker. Most tracking radars employ a narrow pencil beam for accurate tracking in angle but it can be difficult to search a large volume for targets when using a narrow antenna beamwidth. Some other radar, therefore must first find the target to be tracked and then designate the target's co-ordinates to the tracker. These radars has been called acquisition radars or designation radar.

The tracker is slewed to the direction of target based on the target co-ordinates supplies by the aqusition radar. These co-ordinate are always accurate enough to bring the tracker directly onto the target. Some searching in both azimuth and elevation angle might have to be done by the tracker in order to find a target. There have been seval different types of patterns employed to search a limited angular region

If a 2D air-surveillance radar (range and azimuth) is used for deriging a target to a surface based mechanical tracking radar, the tracker might acquire its target with nodding beam scan in elevation, which is raster scan in vertical rather than horizontal.

The target must be find in range as well as in angle. During the aquisition Procss, the tracking radar receiver range gate is scanned in rage as well as the pulse propagate outwards in space.