MOVING TARGET INDICATOR (MTI) RADAR

ECE 514E – RADAR & SATELLITE ENGINEERING
Tuesday, September 23, 2025

SYLLABUS

Course Content:

Basic Principles of Radar: Antenna parameters, Radar equation. Performance parameters, target cross-section,

MTI and Doppler radar: Doppler Effect, CW radar, FM CW, Delay line cancellers, Pulse Doppler Radar.

Scanning, Duplexers and Radar receivers: Sequential lobbing, Conical Scanning, Monopulse Tracking RADAR, Tracking with surveillance RADAR, Acquisition, Radar receiver, Radar Displays; Duplexers.

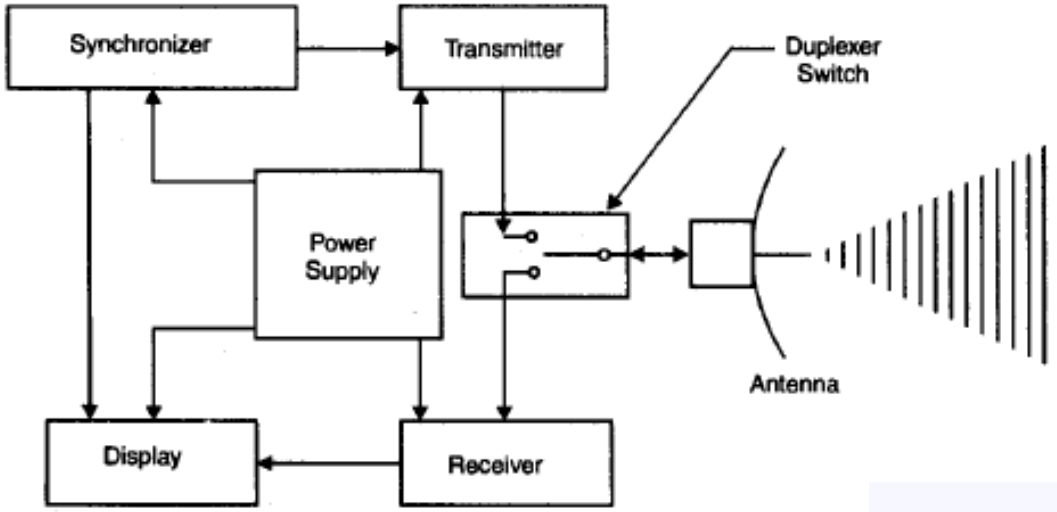
Introduction to satellite communication: international regulation & frequency coordination, satellite frequency allocation & band spectrum, active & passive satellites.

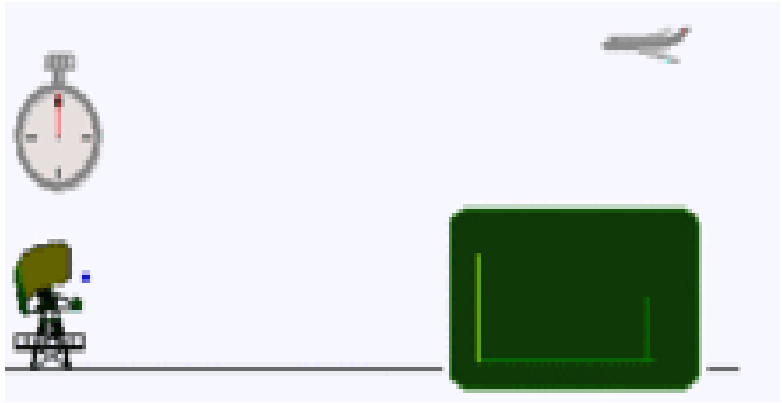
Orbits and Launching Methods: Kepler's laws, orbital elements, apogee and perigee heights, orbital perturbations, effects of non-spherical earth, atmospheric drag, the geostationary orbit, antenna look angles, polar mount antenna, limits of visibility, earth eclipse of satellite, sun transit outage, launches and launch vehicles, power supply, altitude control, station keeping, thermal control, transponders, antenna subsystem.

Earth station: transmit/receive earth stations. space links: Introduction, equivalent isotropic radiated power, transmission losses, link power budget equation, system noise, carrier-to noise ratio. Interference: interference between satellite circuits, combined (C/I) due to interference on uplink and downlink, antenna gain function, pass band interference.

Applications: direct broadcast satellite (DBS) services, MSAT, VSATs, GPS.

BLOCK DIAGRAM OF PULSE RADAR SYSTEM





There is an assumption that there are no unwanted objects in the neighbourhood

RADAR CROSS-SECTION

- Radar Cross Section (RCS), a measure of a size of a target at a given radar frequency.
- RCS depends on
  - complexity (surface, overall)
  - polarization
  - material parameters
  - Position of the target

FACTORS AFFECTING RADAR TARGET DETECTION

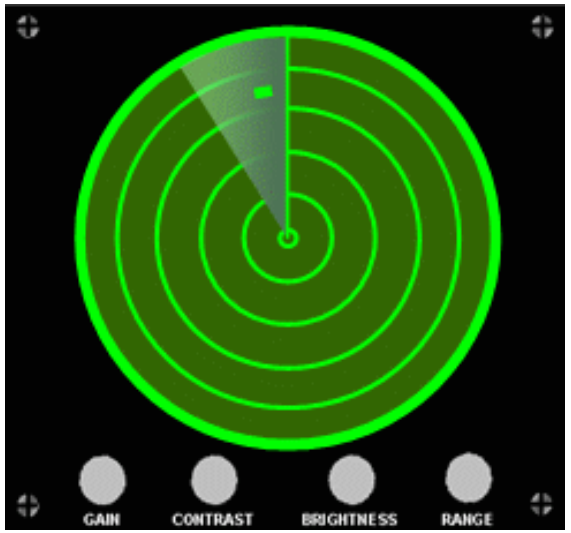
- Target detection is degraded by:
  - **(a)** Radar Cross Section
  - **(b)** Clutter
  - **(c)** Changes in propagation of radio waves
  - **(d)** Intentional/unintentional jamming

What is clutter?

1. ***Normal English:*** to cover or fill (something) with an untidy collection of things.
2. ***Radar Engineering:*** echoes returned from ground, sea, rain, animals/insects, chaff and atmospheric turbulences. Clutter can cause serious performance issues with radar systems.

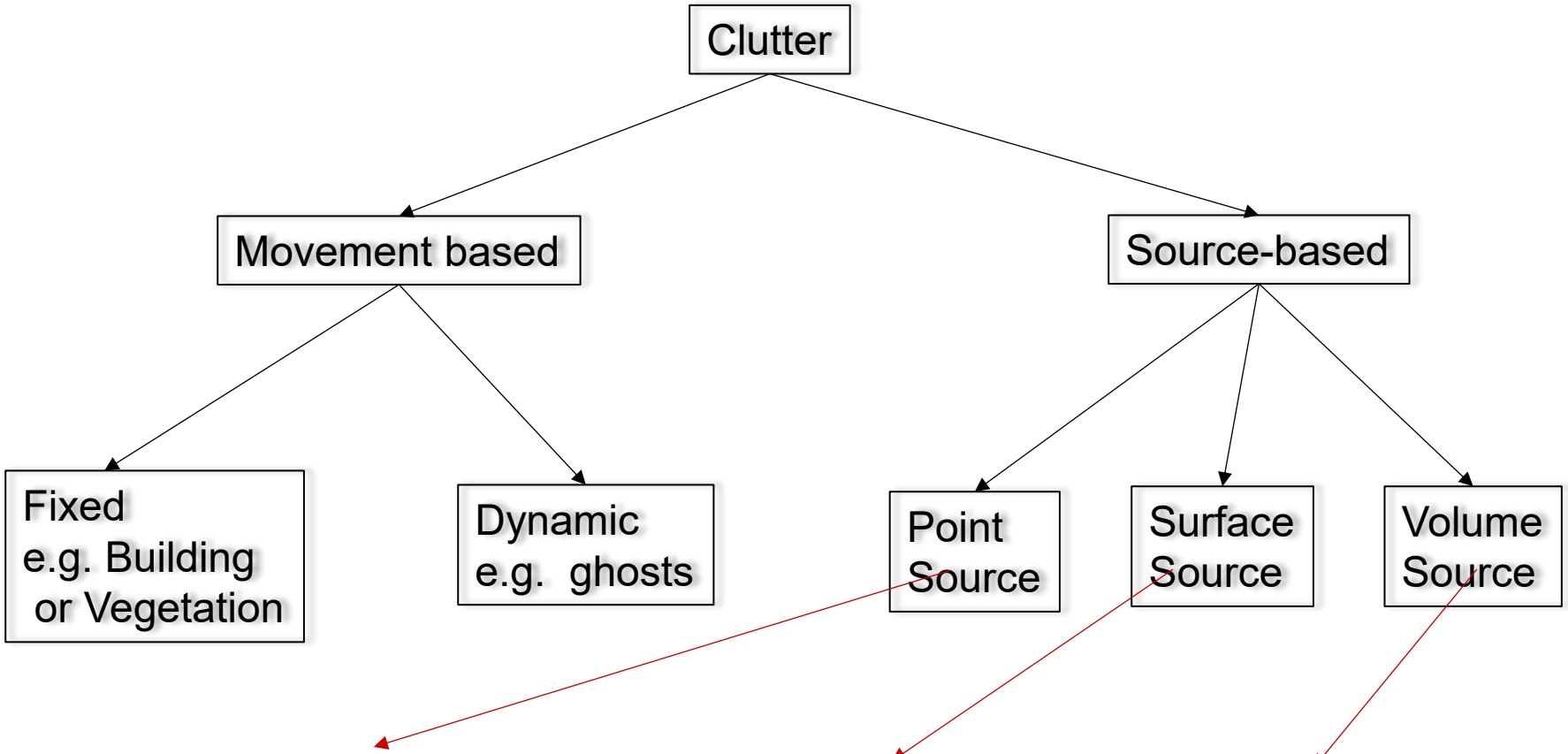
RADAR CLUTTER

1. Practical radars receive signals from many other sources other than the intended target.
2. They receive echoes from:
   - Buildings
   - Hills
   - Rain
   - Birds, etc.
3. **Clutte**r refers to return from any object that may generate unwanted radar echos that may interfere with normal radar operations.
4. The definition of clutter depends on the application.
5. For instance, rain induced echoes is not clutter in weather radars.




weather clutter
fixed clutter
targets

CATEGORIES OF CLUTTER



Point Clutter
Birds, windmills and individual tall buildings.

Surface Clutter
Returns from geographical land masses and the sea

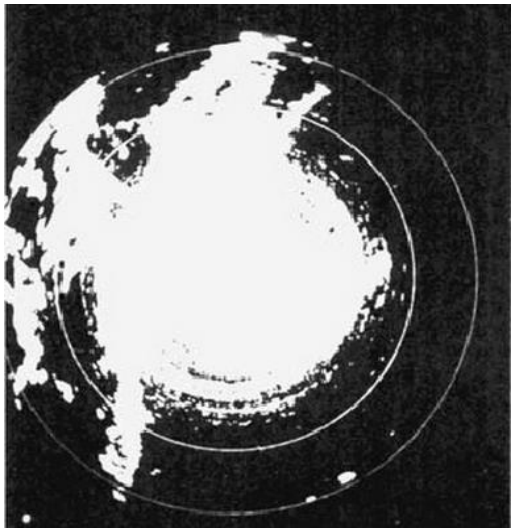
Volume Clutter
Weather or chaff produced from rain or snow

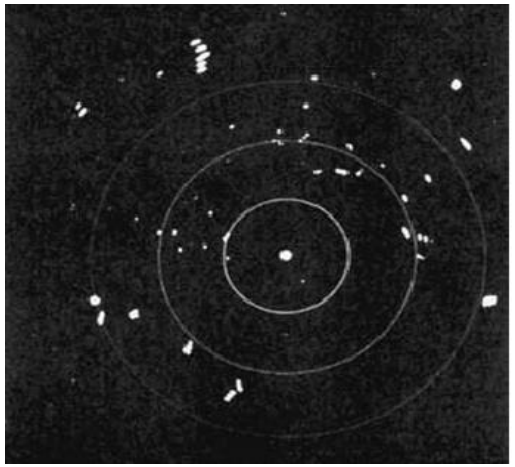
OPERASTION PRINCIPLE OF MTI RADAR

The Moving Target Indicator (MTI) radar:

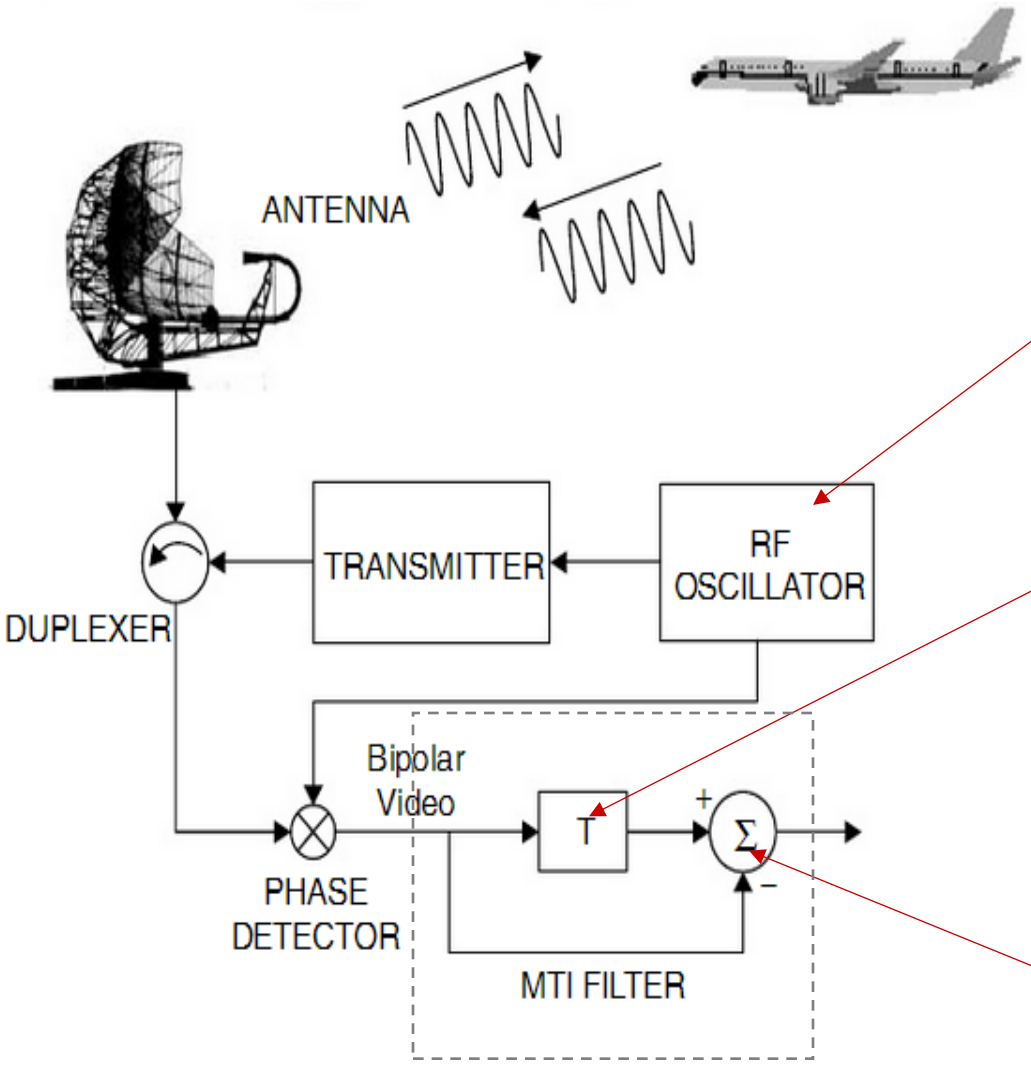
(a) rejects returns from fixed or slow-moving unwanted targets, such as buildings, hills, trees, sea, and rain.

(b) It retains for detection and display signals from required moving targets such as aircraft.





MTI SYSTEM OPERATION PRINCIPLE

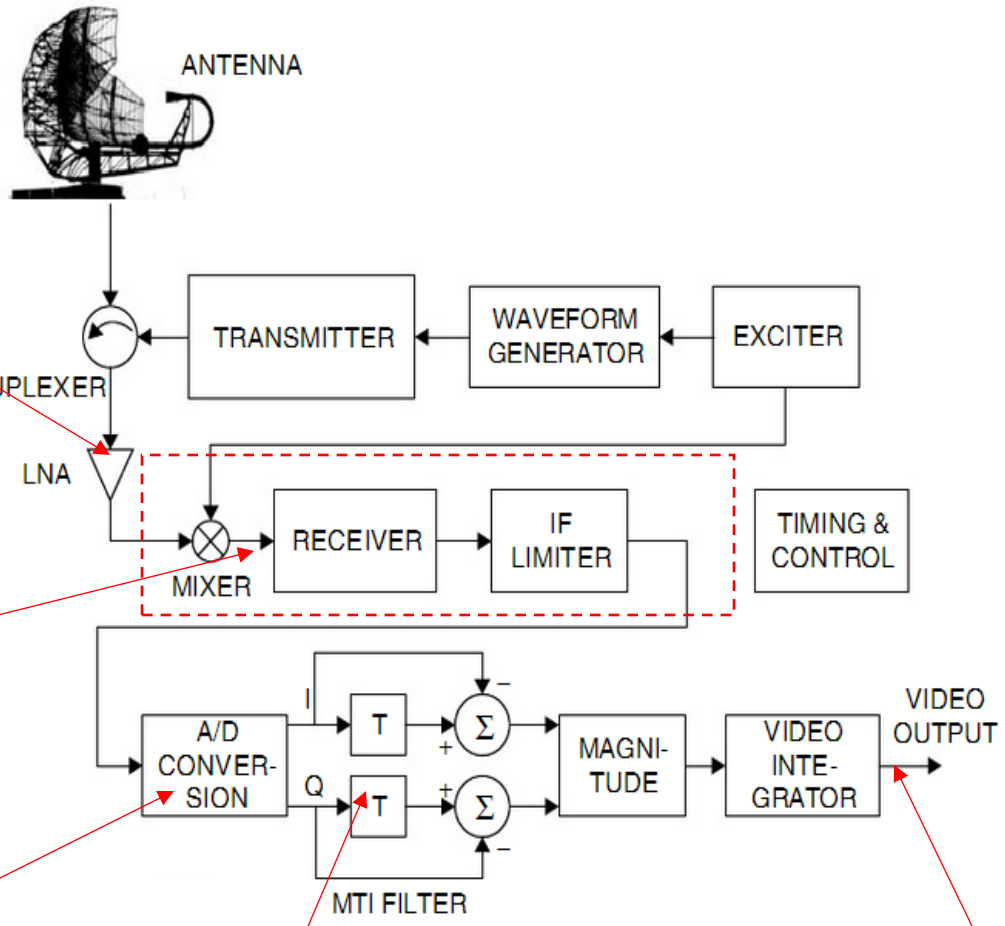


RF Oscillator
Used to generate RF signal and as a phase reference for determining the phase of reflected signals.

Memory
The phase information is stored in a pulse repetition interval (PRI)) memory for the period, *T,* between transmitted pulses,

Moving Target Detector
Memory signal is subtracted from the phase information of the current received pulse.

BLOCK DIAGRAM OF MTI RADAR



Low-Noise Amplifier (LNA)
Amplifies the signal from antenna

IF Down-converter
Mixes the received signal with that from a Stable Local Oscillator.

A/D Converter
Converts analog signal to digital and creates in-phase and quadrature components

PRI Memory
Stores in-phase and quadrature components

Video Output
Composed of current pulse signal less that from the previous pulse

MTI RADAR BLOCK DIAGRAM