Introduction to Radars
Lecture 4: MTI and Pulsed Doppler Radars

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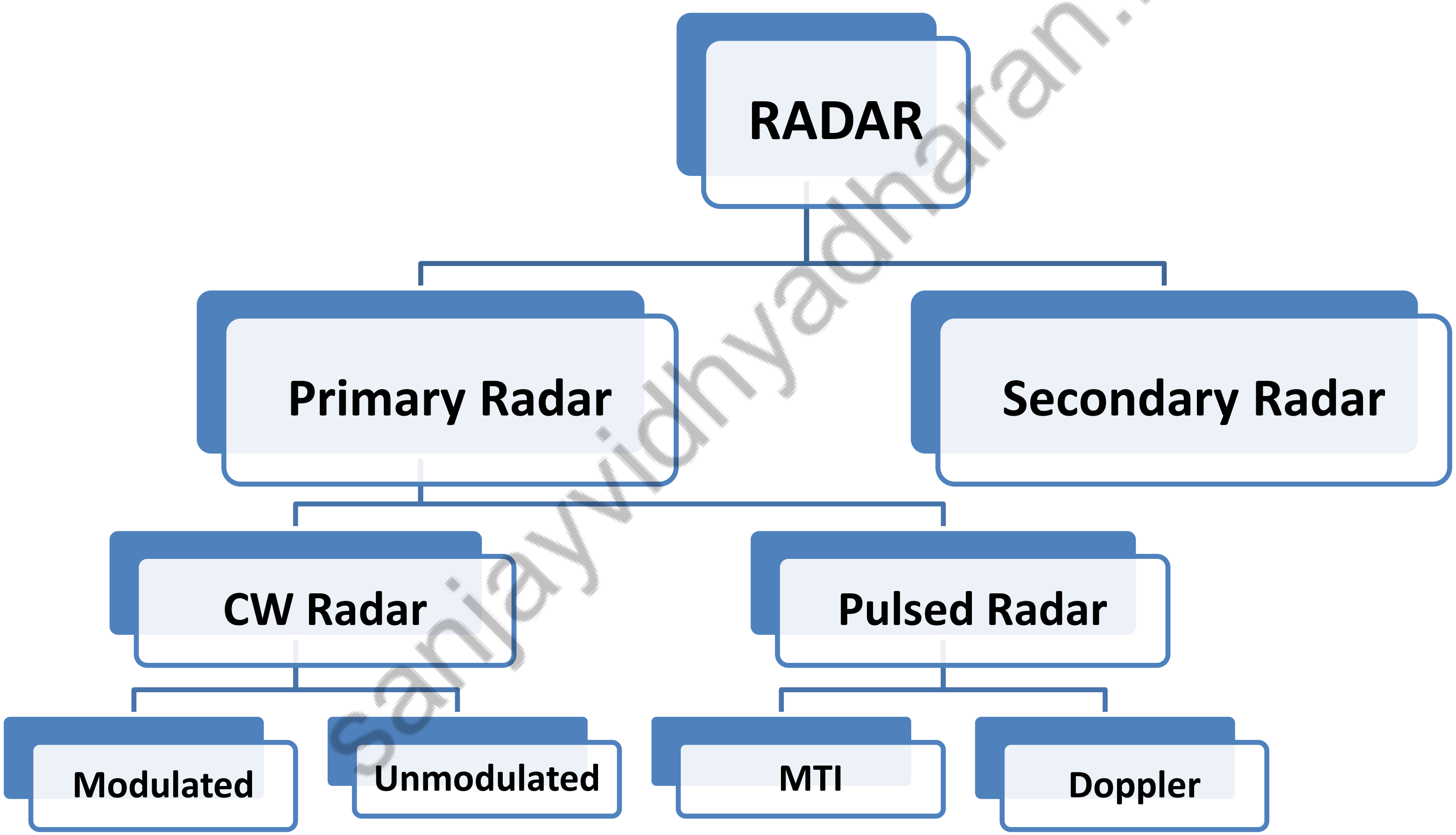
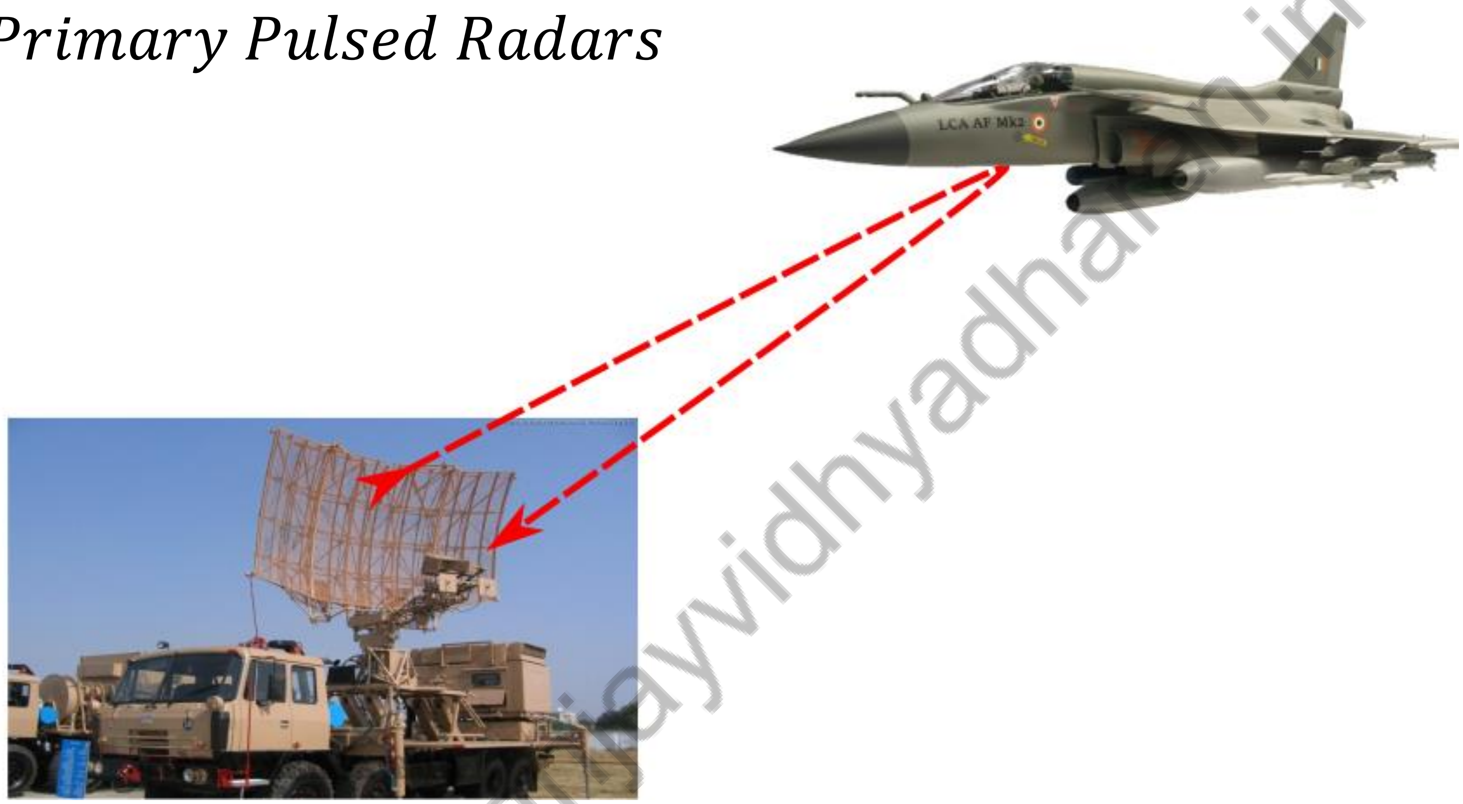
Classification of Radars



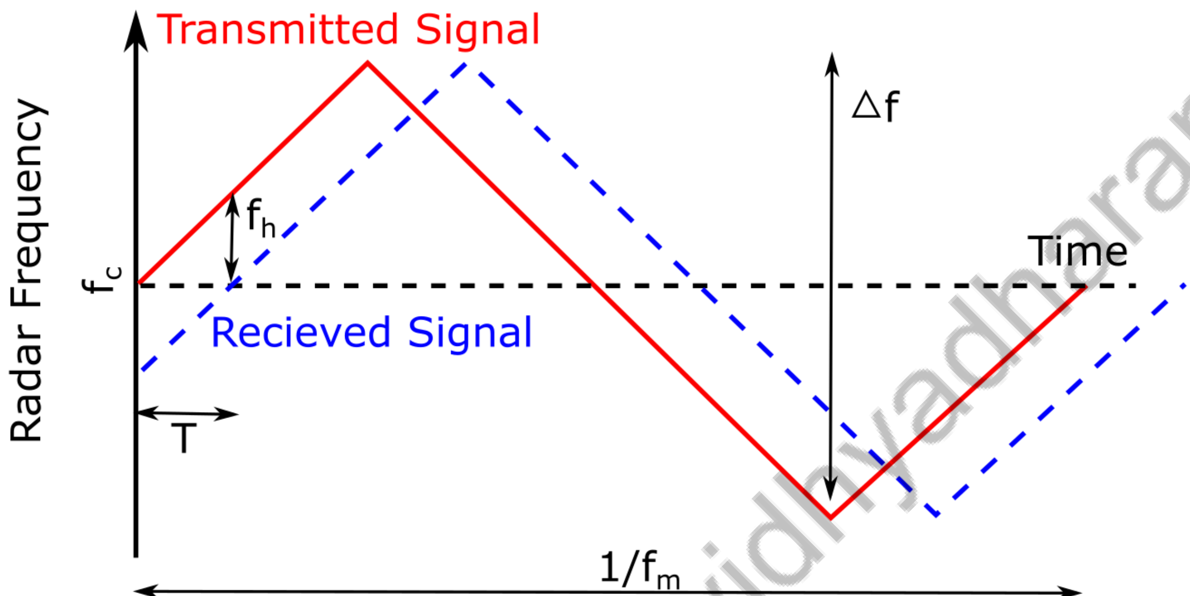
Primary Radars

Primary Pulsed Radars



$$Max\ Radar\ Range\ \ R_{max} = \left[\frac{P_t G \sigma A_e}{(4\pi)^2 F_n k T B_n \left({}^{S_o}/_{N_0}\right)_{min}}\right]^{1/4}$$

Modulated CW Radar



$$R = \frac{cT}{2}$$

Radio Altimeters

$$f_c = 4.2 - 4.4 \text{ GHz}$$

$$\Delta f = 100 - 200 \text{ MHz}$$

$$f_m = 50 - 300\ Hz$$

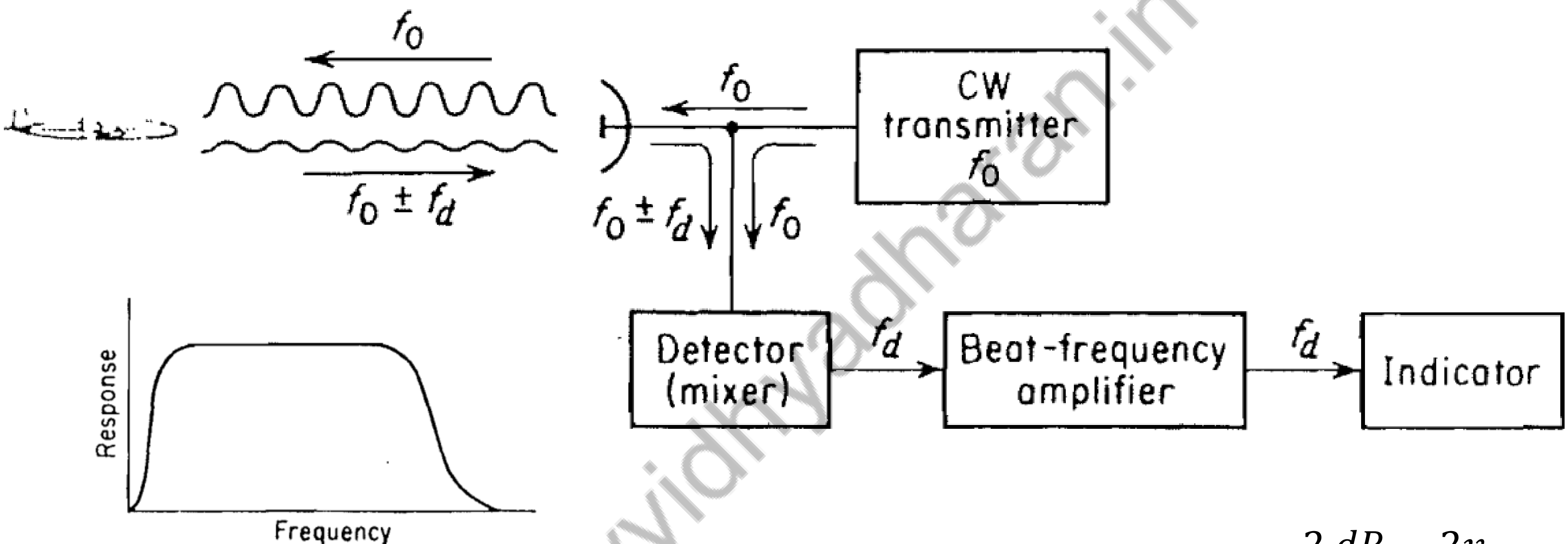
$$Range = 1 - 2\ Kms$$

$$Rate\ of\ Change\ \ of\ f_c = \frac{\Delta f}{1/2f_m} = 2.\Delta f.f_m$$

$$Change\ \ in\ f_c\ in\ Time\ T = f_h = 2.\Delta f.f_m\ .T = \frac{2.\Delta f.f_m\, 2R}{c}$$

$$Target\ Range\ R\ = \frac{cf_h}{4.\Delta f.f_m}$$

Unmodulated CW Radar



$$f_d = \frac{2\,dR}{\lambda dt} = \frac{2v_r}{\lambda}$$

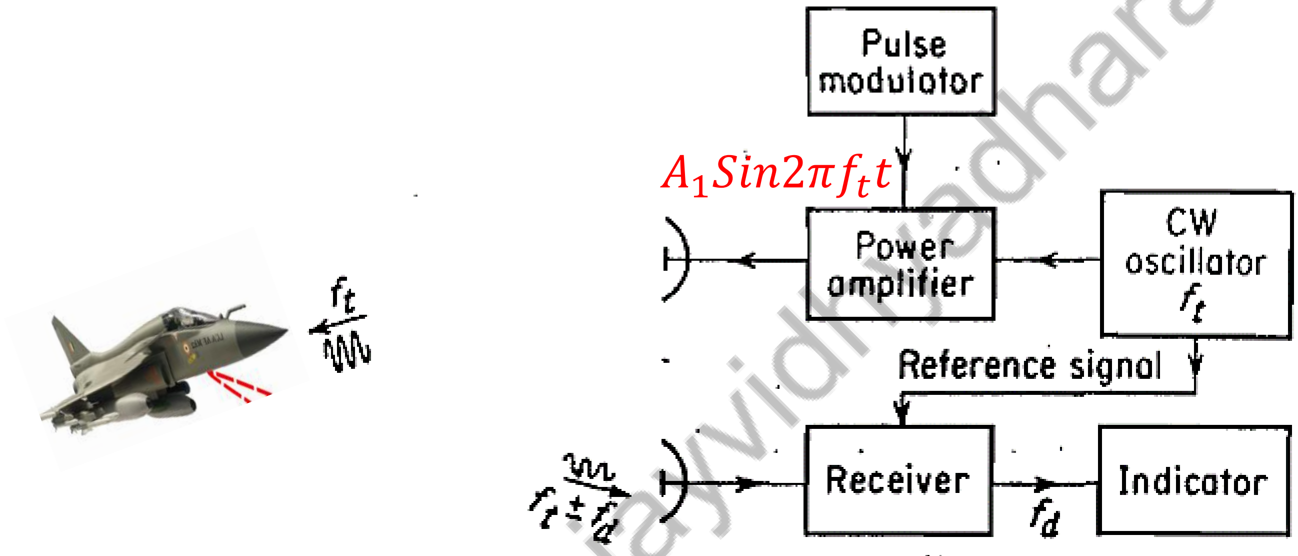
The sign of f_d is lost in this process

The purpose of the doppler amplifier is to eliminate echoes from stationary targets and to amplify the doppler echo signal to a level where it can indicate a moving object.

The low-frequency cutoff must be high enough to reject d-c component caused by stationary targets, but it should be low enough to pass the smallest doppler frequency expected

Moving Target Indicators and Pulsed Doppler Radar

A pulse radar that utilizes the doppler frequency shift as a means for discriminating moving from fixed targets is called an **MTI** (moving target indication) or a **Pulse Doppler** radar

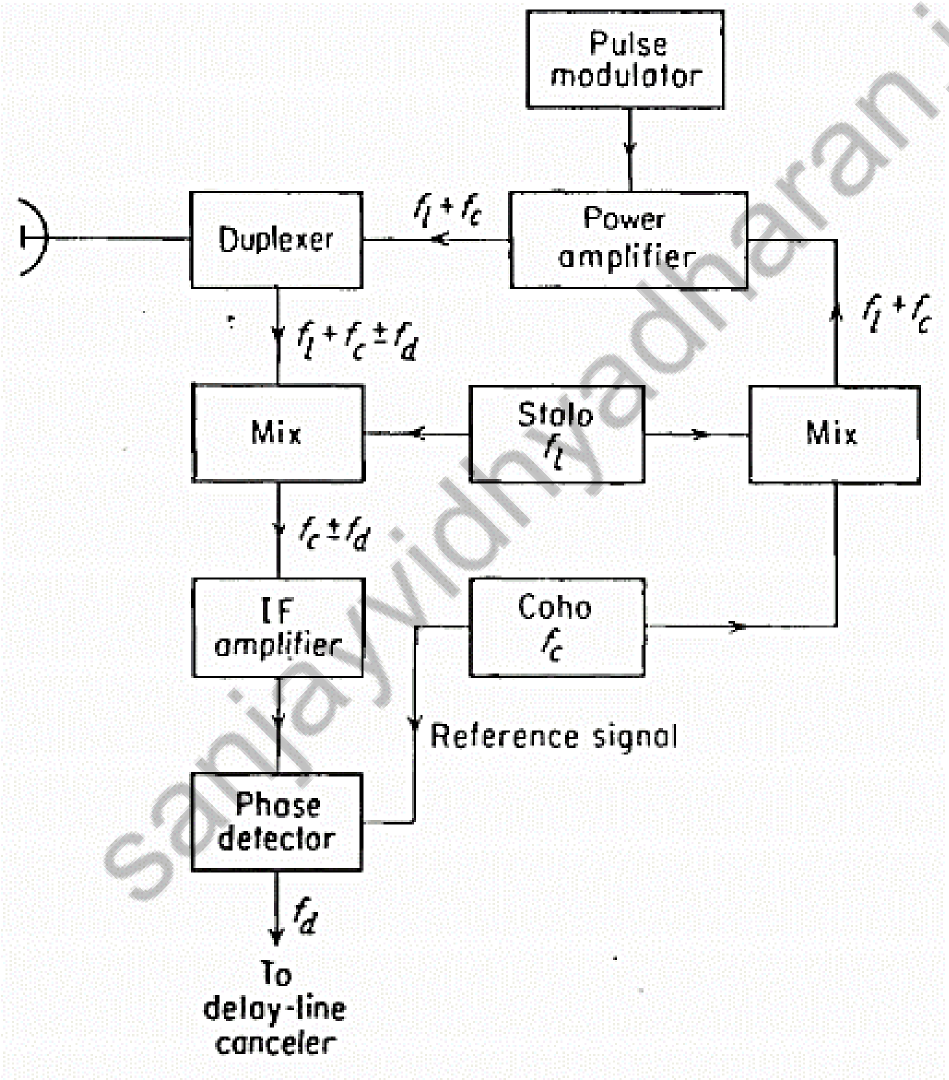


$$V_{Ref} = A_2 Sin2\pi f_t t$$

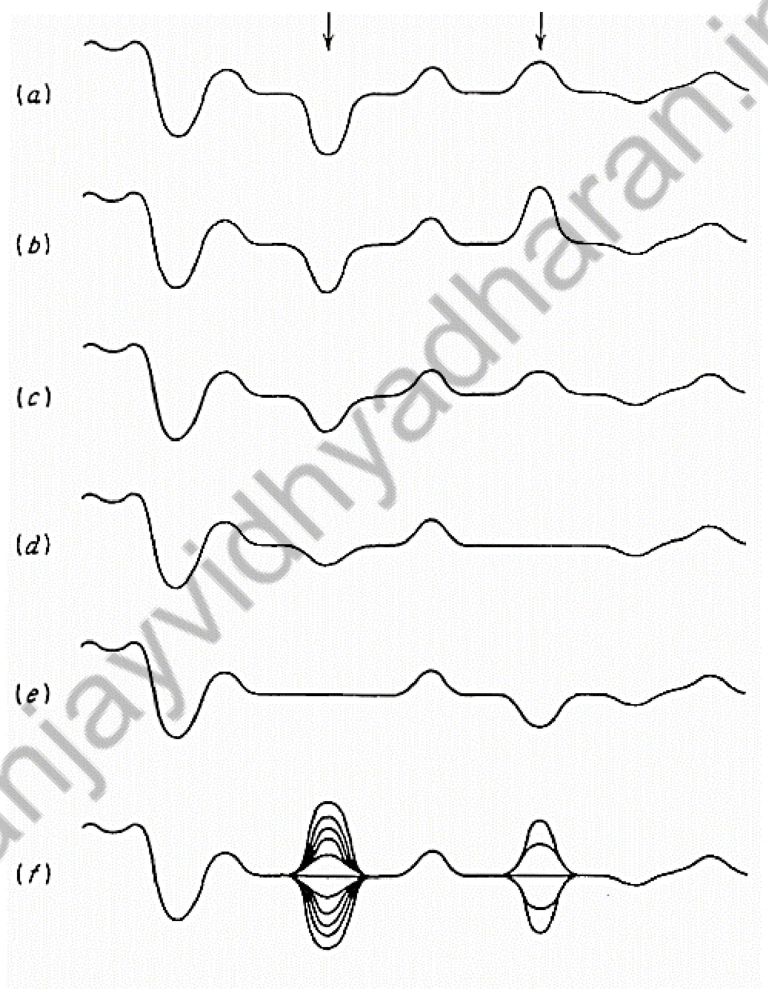
$$V_{Echo} = A_3 Sin[2\pi(f_t \pm f_d)t - \frac{4\pi f_t R}{c}]$$

$$V_{Diff} = A_4 Sin(2\pi f_d t - \frac{4\pi f_t R}{c})$$

MTI Block Diagram



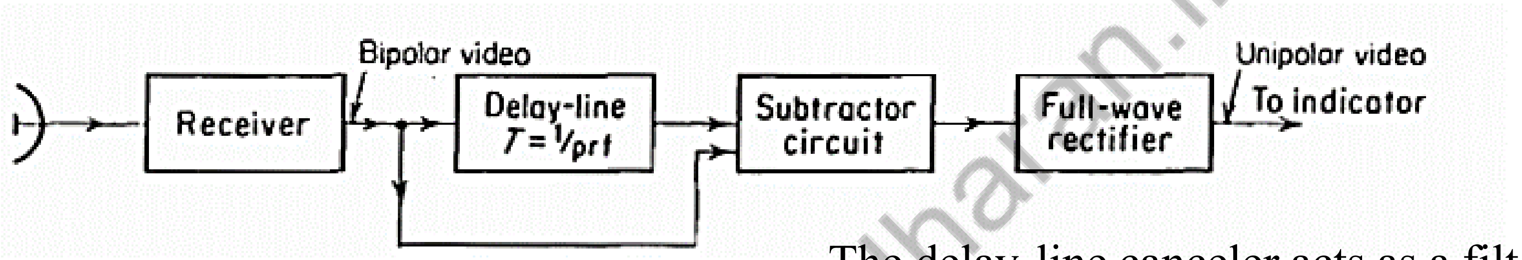
MTI A-Scope



Amplitude

Range

Two Pulse MTI Canceller



The delay-line canceler acts as a filter which rejects the d-c component of clutter

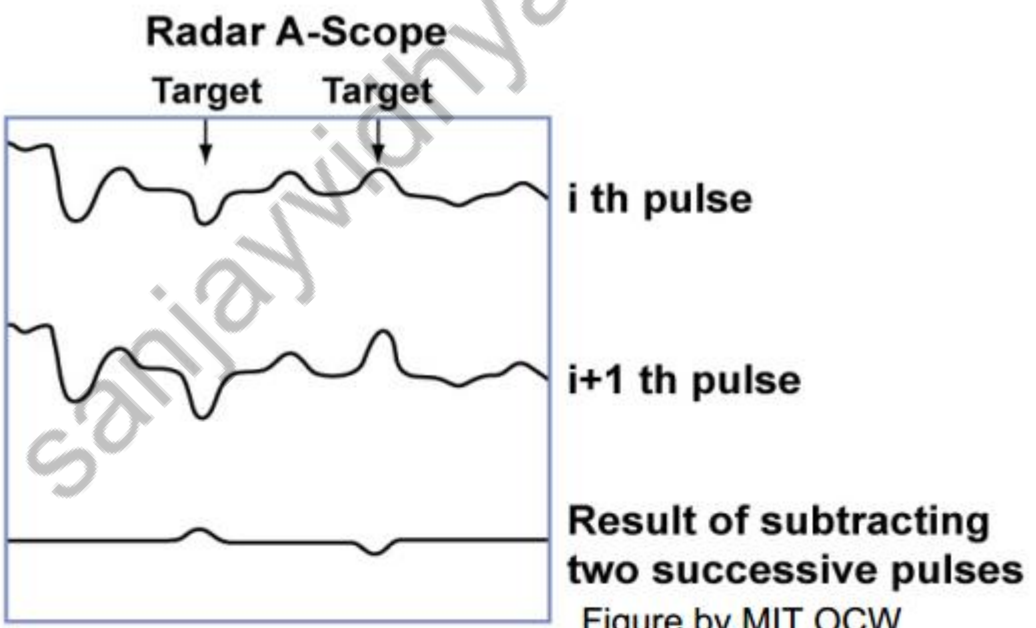


Figure by MIT OCW.

Filter Characteristics of the Delay-line Canceler

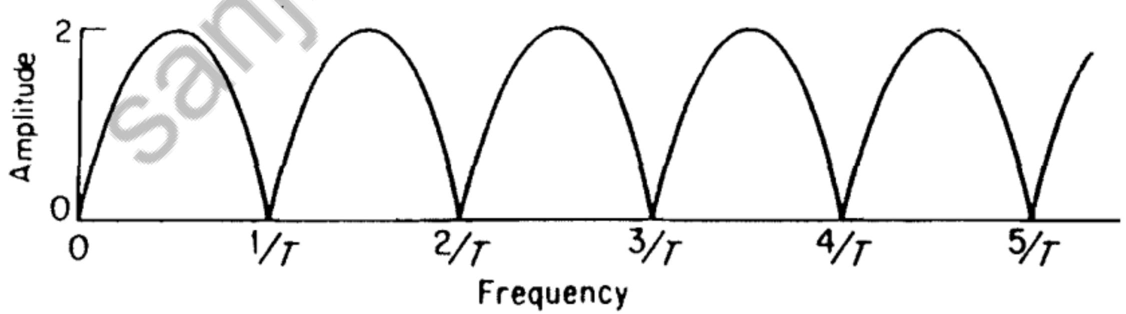
The video signal received from a particular target at a range ***R*** ,

$$V_1 = k\sin(2\pi f_d t - \emptyset_0)$$

The signal from the previous transmission, which is delayed by a time T = pulse repetition interval, is

$$V_2 = k\sin[2\pi f_d(t - T) - \emptyset_0]$$

$$V_1 - V_2 = 2k\sin\pi f_d T\, cos(2\pi f_d(t - \frac{T}{2}) - \emptyset_0)$$



Filter Characteristics of the Delay-line Canceler

Blind Speeds

$$f_d = \frac{n}{T} = n * f_p$$

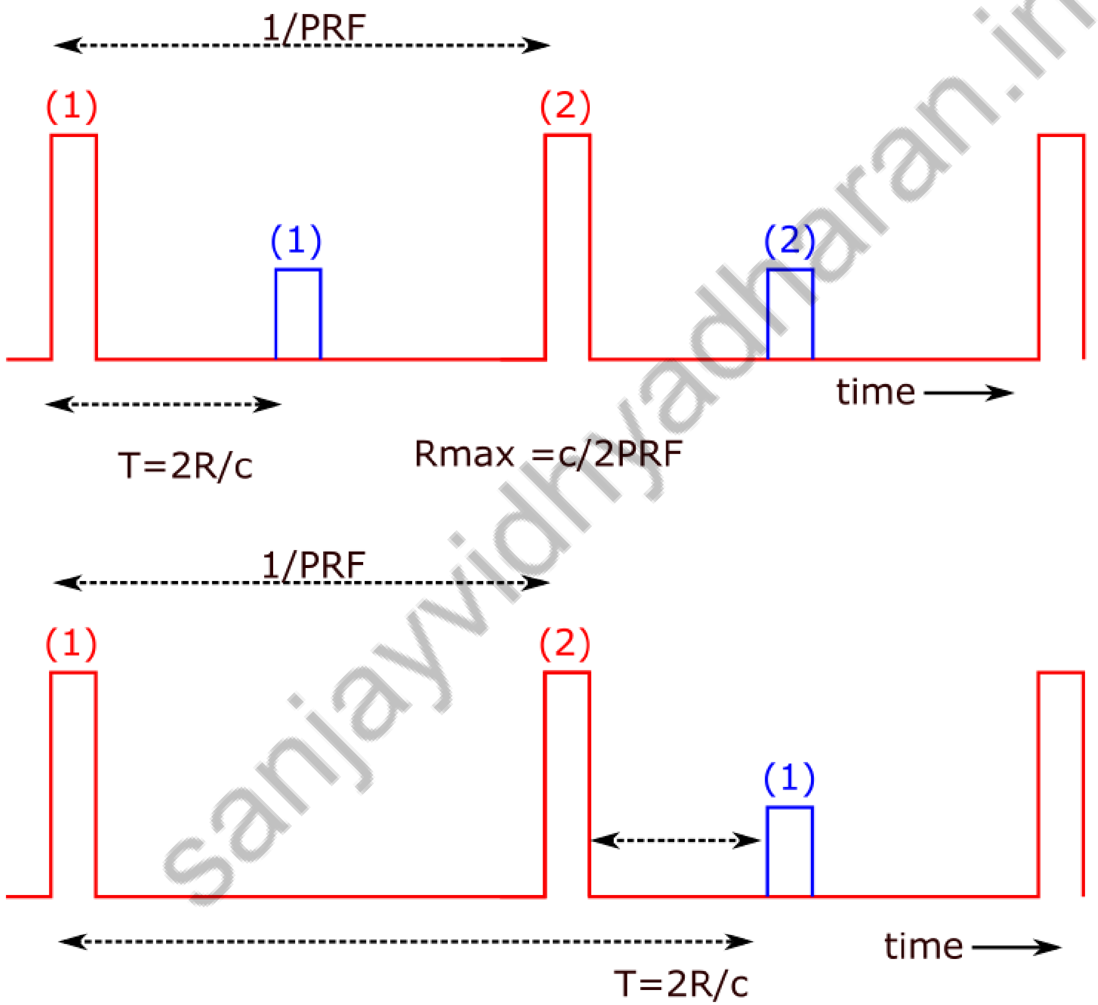
$$Blind\ Speeds\ v_n = \frac{\lambda f_d}{2} = \frac{n\lambda}{2T} = \frac{n\lambda f_p}{2}$$

$$f_d = \frac{2\,dR}{\lambda dt} = \frac{2v_r}{\lambda}$$

$$n = 1,2,3, \dots \dots$$

The blind speeds are one of the limitations of pulse MTI radar which do not occur with CW radar

MTI Blind Speed and Unambiguous range



Moving Target Indicators and Pulsed Doppler Radar

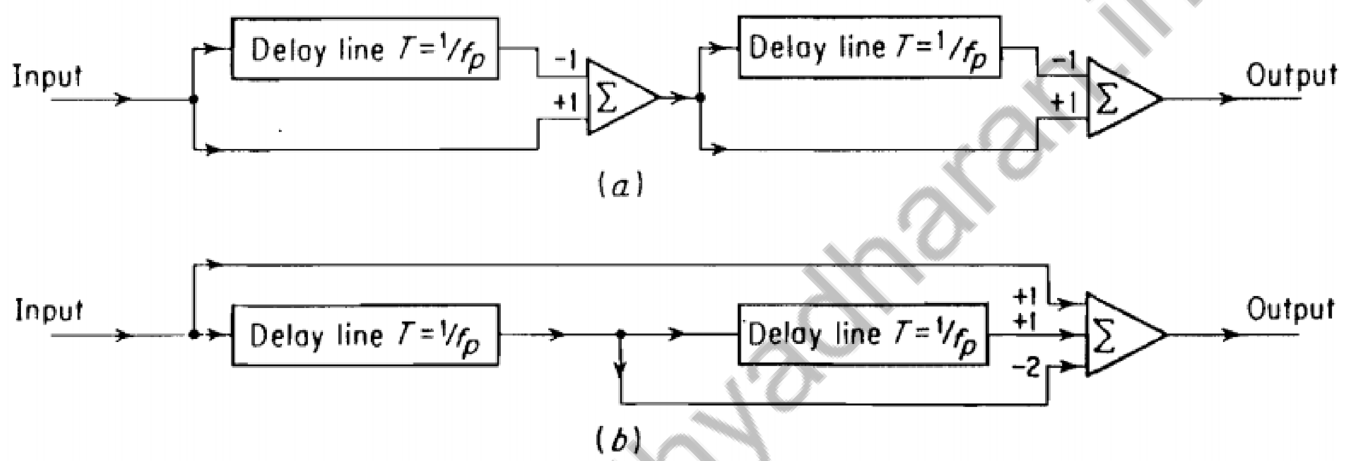
Moving Target Indicators

1. Just separate moving targets from clutter
2. Usually operates with ambiguous doppler measurement (so-called blind speeds) but with unambiguous range measurement (no second-time-around echoes).
3. Low PRF
4. Clutter Removal

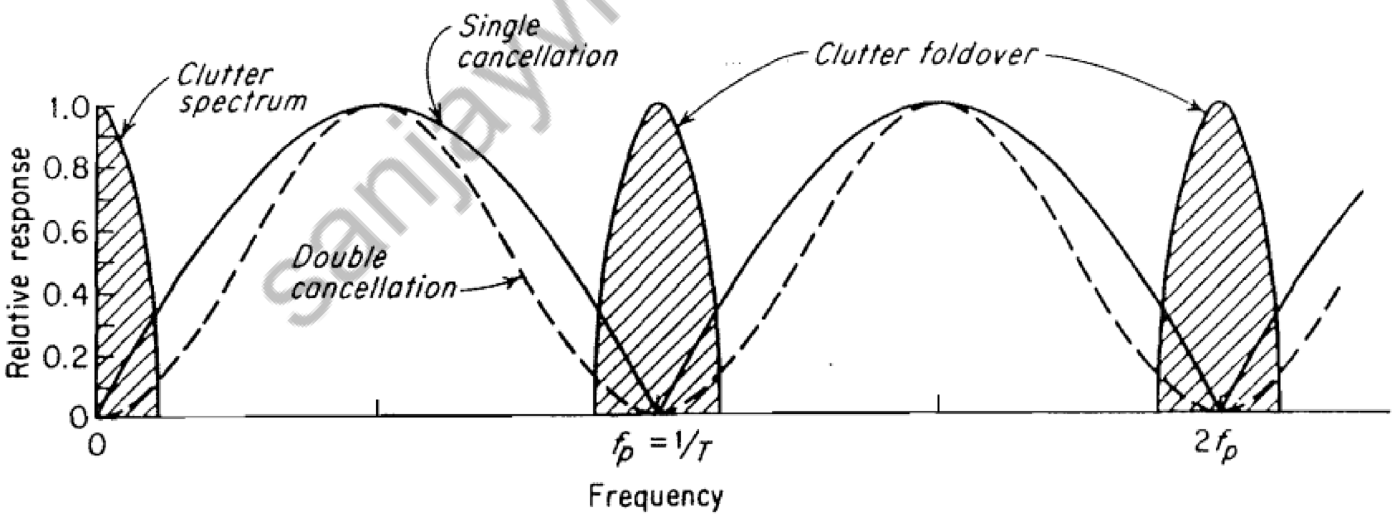
Pulsed Doppler Radar

1. Usually operates with unambiguous doppler measurement (no blind speeds) but with ambiguous range measurement (second-time-around echoes).
2. High PRF
3. Separate targets into different velocity regimes

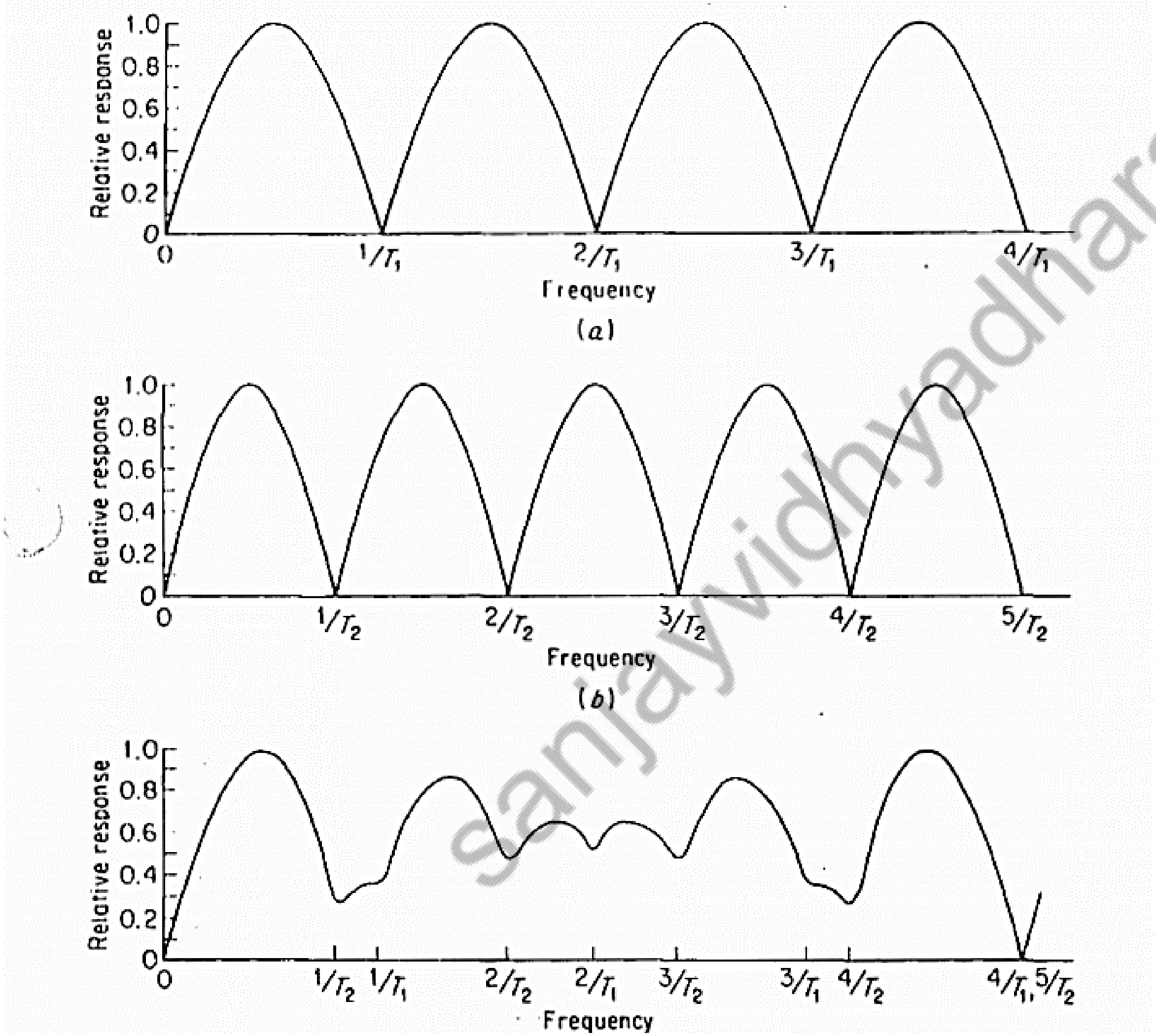
Delay Line Cancellers



(a) Double-delay-line canceler; (b) three-pulse canceler



MULTIPLE OR STAGGERED PRF

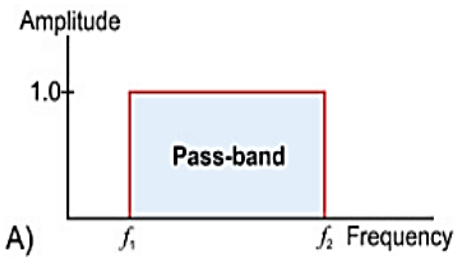


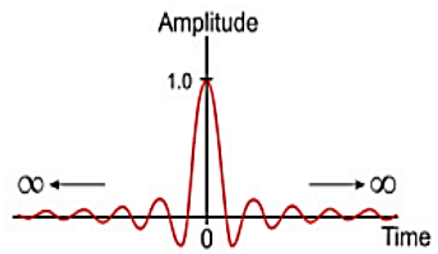
$$\frac{4}{T_1} = \frac{5}{T_2}$$

The closer the ratio $T_1 : T_2$ approaches unity, the greater will be the value of the first blind speed. However, the first null in the vicinity of fd = l/Tl becomes deeper.

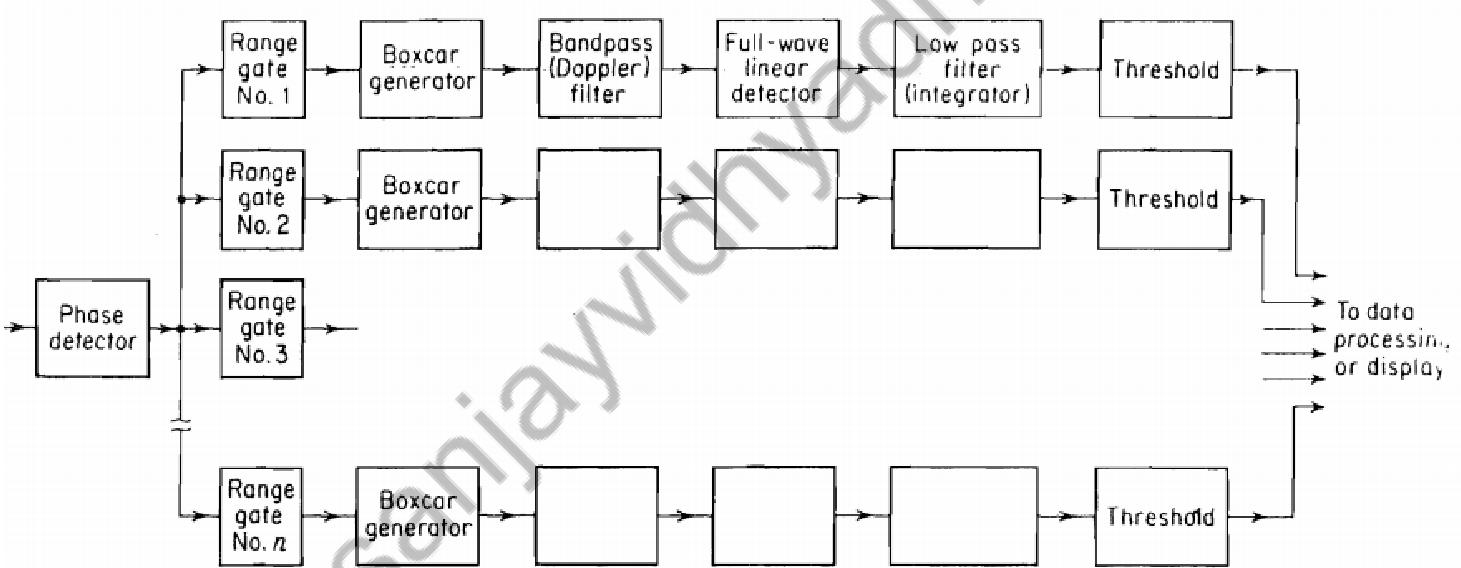
T1 : T2 is a compromise between the value of the first blind speed and the depth of the nulls within the filter pass band

RANGE-GATED DOPPLER FILTERS





The narrowband filter "smears" the input pulse which destroys the range resolution If more than one target is present, they cannot be resolved.



The width of the range gates depends upon the range accuracy desired and the complexity which can be tolerated, but they are usually of the order of the pulse width. the output from each gate may be applied to a narrowband filter since the pulse shape need no longer be preserved for range resolution.

Thankyou