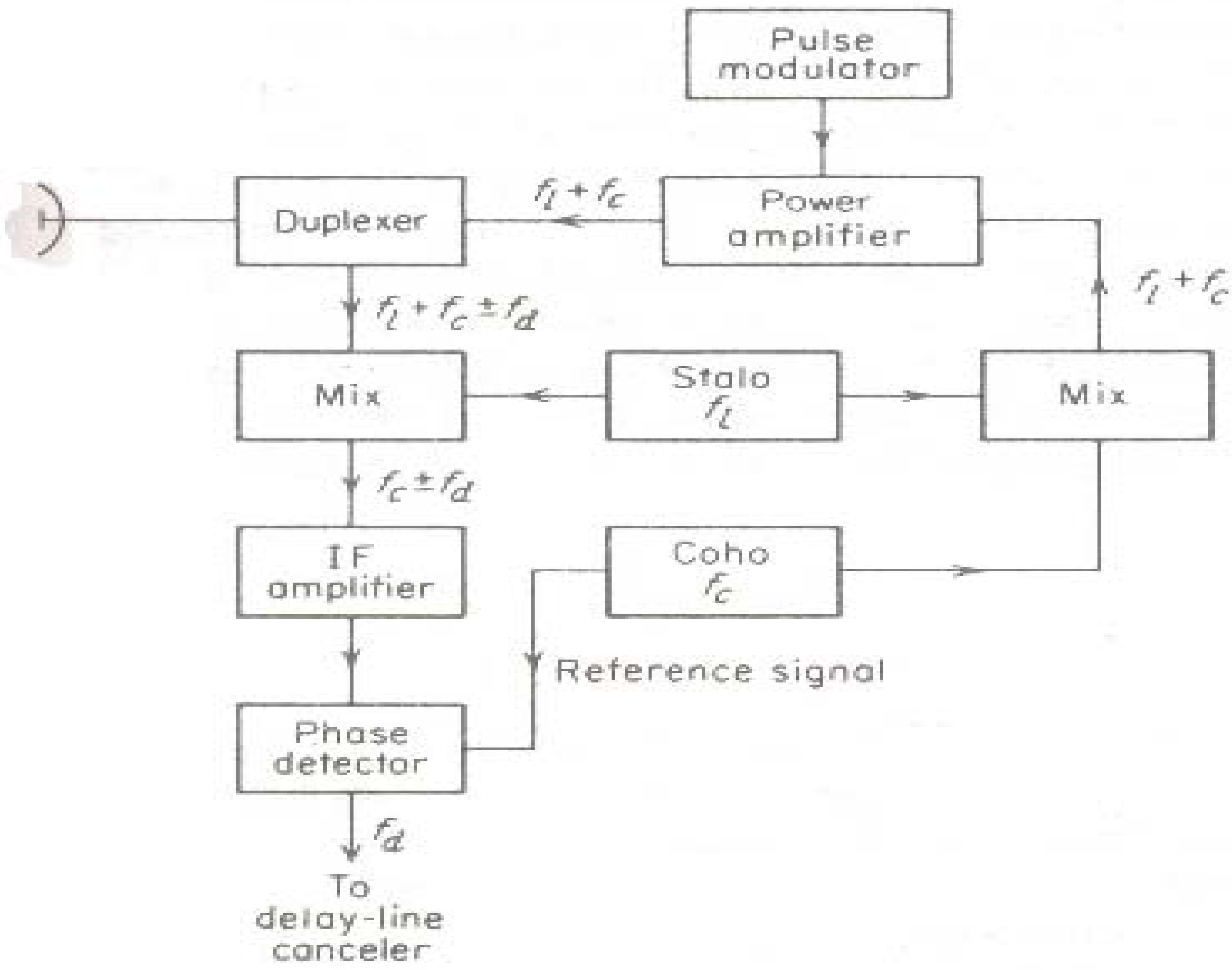
MTI- BLOCK DIAGRAM



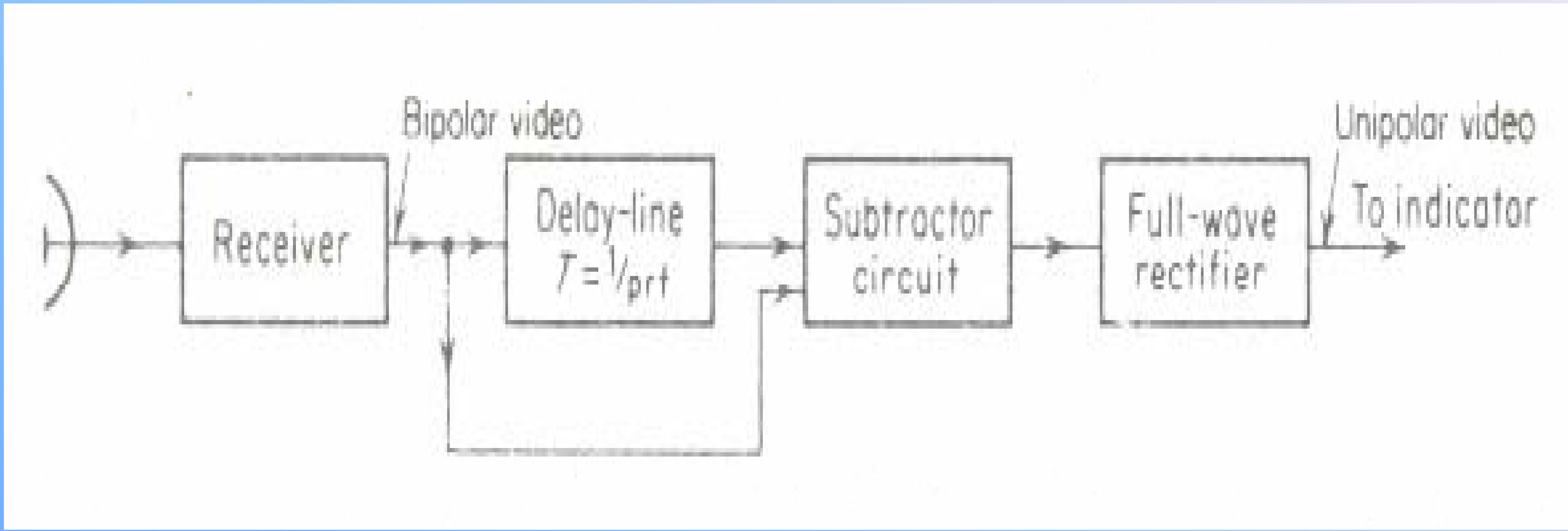
STALO-STABLE LOCAL OSCILLATOR

Tx FREQ- f l+fc

DLC ACTS AS A HIGH-PASS FILTER TO SEPARATE DOPPLER FREQUENCY (ECHO FROM MOVING TGTS) FROM UNWANTED ECHOES OF STATIONERY CLUTTER.

DELAY LINE CANCELERS (DLC)

- THE DELAY LINE CANCELLER IS A **FILTER IN THE TIME-DOMAIN** THAT REJECTS STATIONERY CLUTTER AT ZERO D0PPLER FREQUENCY.
- THE DLC IS USED FOR SWEEP TO SWEEP SUBTRACTION OF TWO SUCCESSIVE SWEEPS.



MTI- RECIEVER WITH DELAY LINE CANCELER

BLOCK DGM-SINGLE DLC

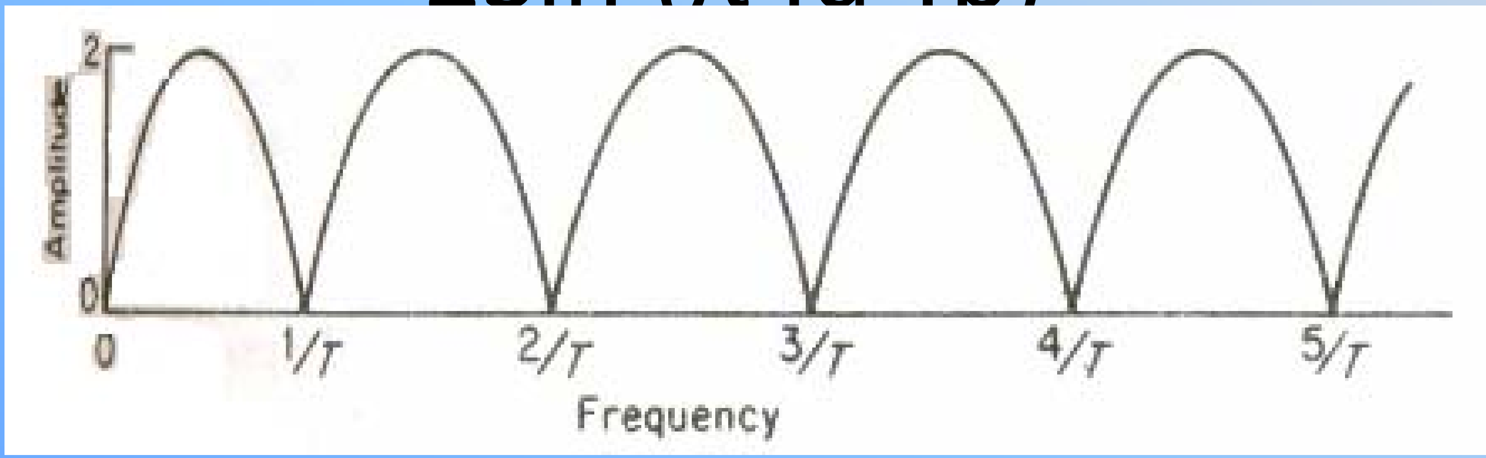
- SIGNAL FROM A TGT AT RANGE R AT O/P OF PHASE DETECTOR.
- V_1=k Sin (2πfdt- Φ_0)
- V_2 =k Sin [2πfd (t-Tp)- Φ_0]
- V=V_1-V_2=2k sin (π fd Tp) [Cos 2πfd (t-Tp/2)-Φ_0]
- k-AMPLITUDE (ASSUMED SAME FOR BOTH PULSES)
- **O/P IS A COSINE WAVE WITH FREQ fd BUT WITH AN AMPLITUDE 2ksin (π fd Tp)**

FREQ RESPONSE FUNCTION

H(f)=(O/P AMP)/(I/P AMP)

=[2k Sin π fd Tp]/k

2Sin (π fd Tp)



MAGNITUDE OF FRQ. RESPONSE-SINGLE DLC

LIMITATION OF SINGLE DLC

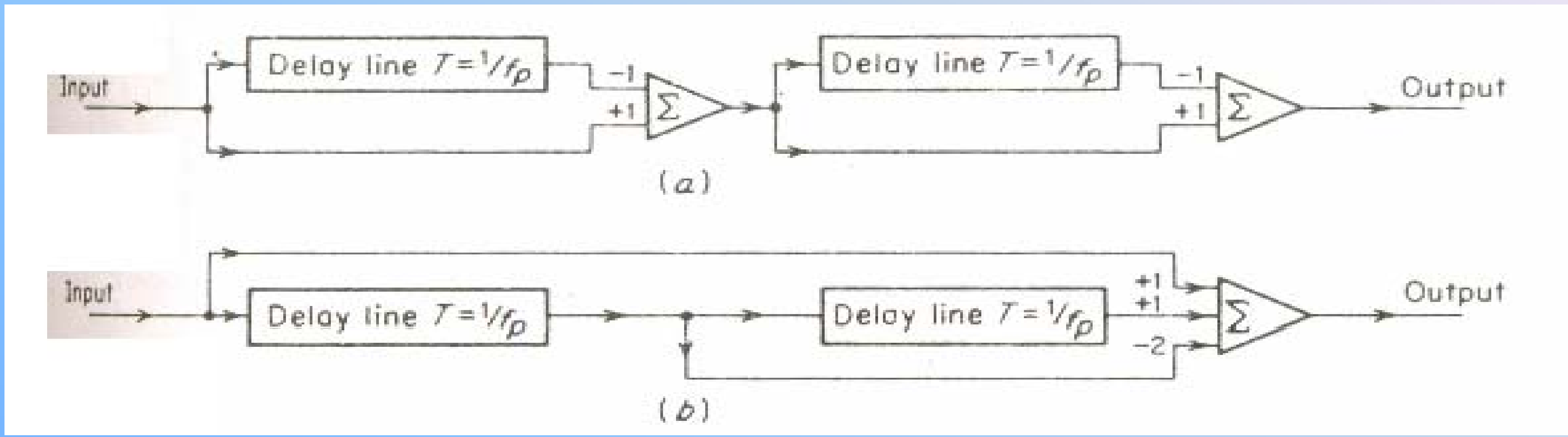
- **FREQUENCY RESPONSE FUNCTION HAS ZERO RESPONSE WHEN MOVING TGTS HAVE DOPPLER FREQUENCY AT PRF(fp) & ITS HARMONICS (BLIND SPEEDS)**

- CLUTTER HAS A FINITE WIDTH AND THUS APPEARS AT THE O/P OF DLC (UNCANCELLED CLUTTER RESIDUE)

MTI IMPROVEMENT FACTOR

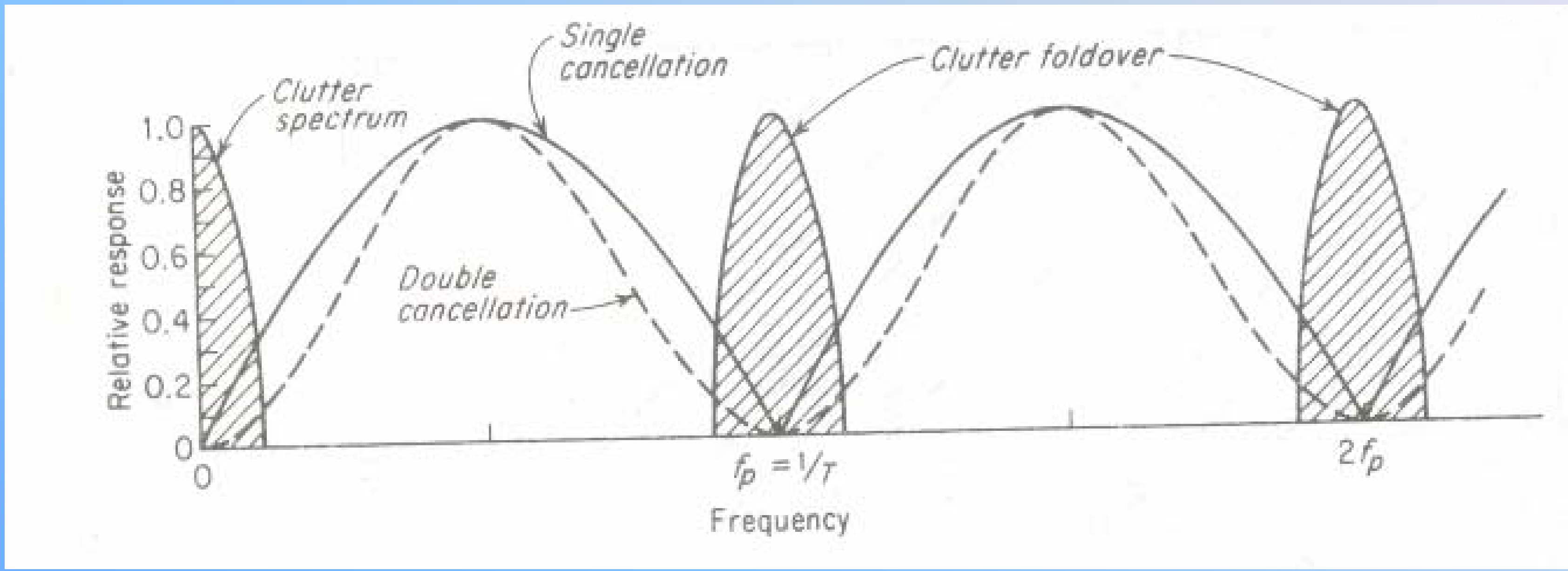
- **IT IS DEFINED AS SIGNAL TO CLUTTER RATIO AT THE O/P OF CLUTTER FILTER DIVIDED BY THE SIGNAL TO CLUTTER RATIO AT THE I/P OF CLUTTER FILTER**
- **IMP FACTOR=If**= $(S/C)_{out}/(S/C)_{in}$ |fd
- =Sout/S_{in}*Cin/Cout | fd
- =**CA*Av. GAIN** (FILTER)
- Av. GAIN FOR A SINGLE DLC IS 2 AND FOR A DOUBLE DLC IS 6.

DOUBLE DELAY LINE CANCELER



- INPUT=S(t)
- O/P AFTER SINGLE DELAY LC= S(t)- S(t+Tp)
- O/P AFTER DOUBLE DELAY LC= S(t) -S(t+Tp)-[S(t+Tp)-S(t+2Tp)]
- = S (t)-2 S (t+Tp) + S (t+2Tp)

CLUTTER ATTENUATION



DOUBLE DLC VS SINGLE DLC-RELATIVE RESPONSE

CLUTTER SPECTRUM HAS A FINITE WIDTH DUE TO

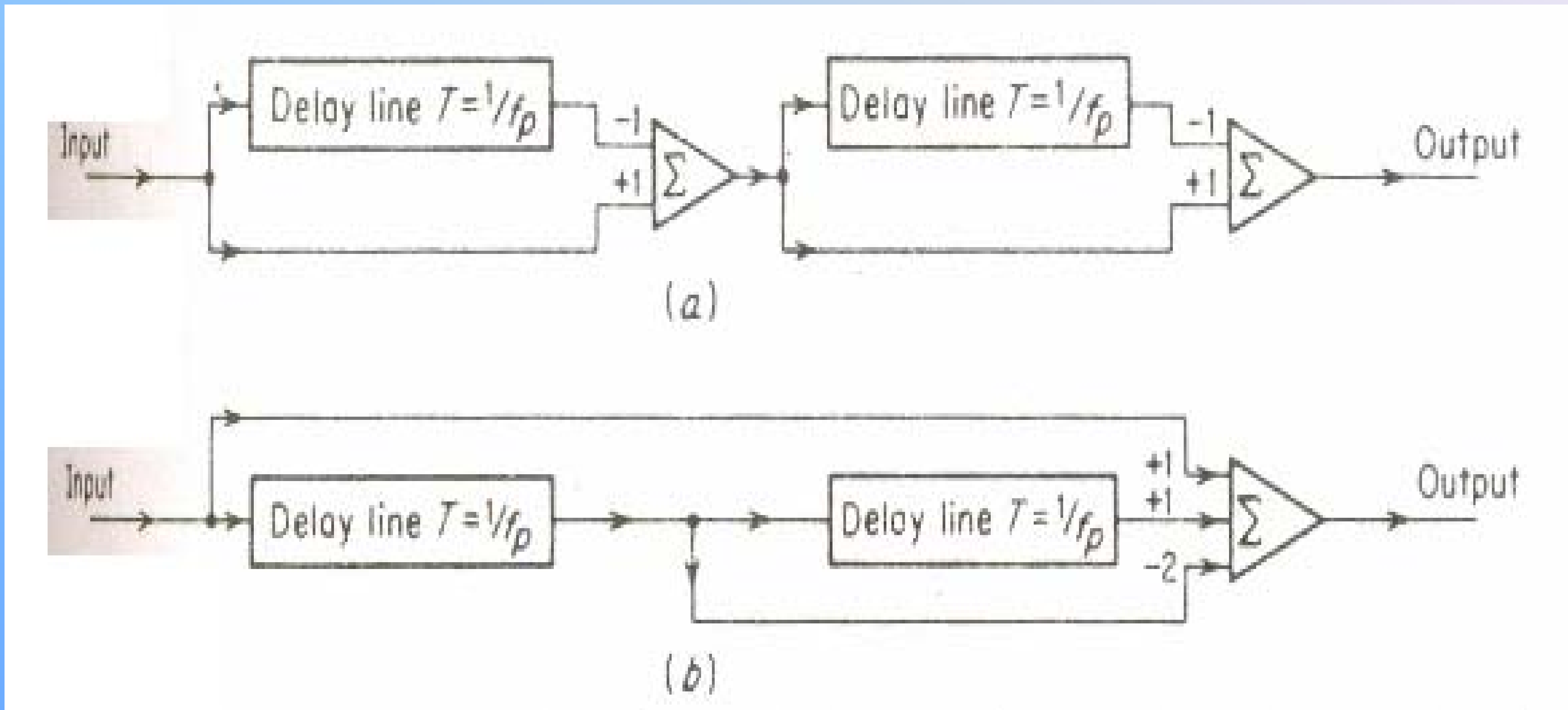
- INTERNAL MOTIONS OF CLUTTER.
- INSTABILITIES OF STALO & COHO OSC.
- OTHER IMPERFECTIONS OF RADAR & ITS SIGNAL PROCESSOR.
- FINITE SIGNAL DURATION.

I_f(SINGLE DLC)=1/[$2\pi^2(\sigma c/fp)^2$;CA=$fp^2/4\pi^2\sigma_C^2$

I_f(DOUBLE DLC)=1/$8\pi^4(\sigma c/fp)^4$;CA=$fp^4/48\pi^4\sigma_C^4$

NOTE: **THE CLUTTER ATTENUATION PROVIDED BY A SINGLE DLC IS NOT SUFFICIENT FOR MOST MTI APPLICATIONS.**

N- PULSE DELAY LINE CANCELER



FINAL OUTPUT = $S(t) - 2S\,(t+T_P) + S\,(t+2T_P)$

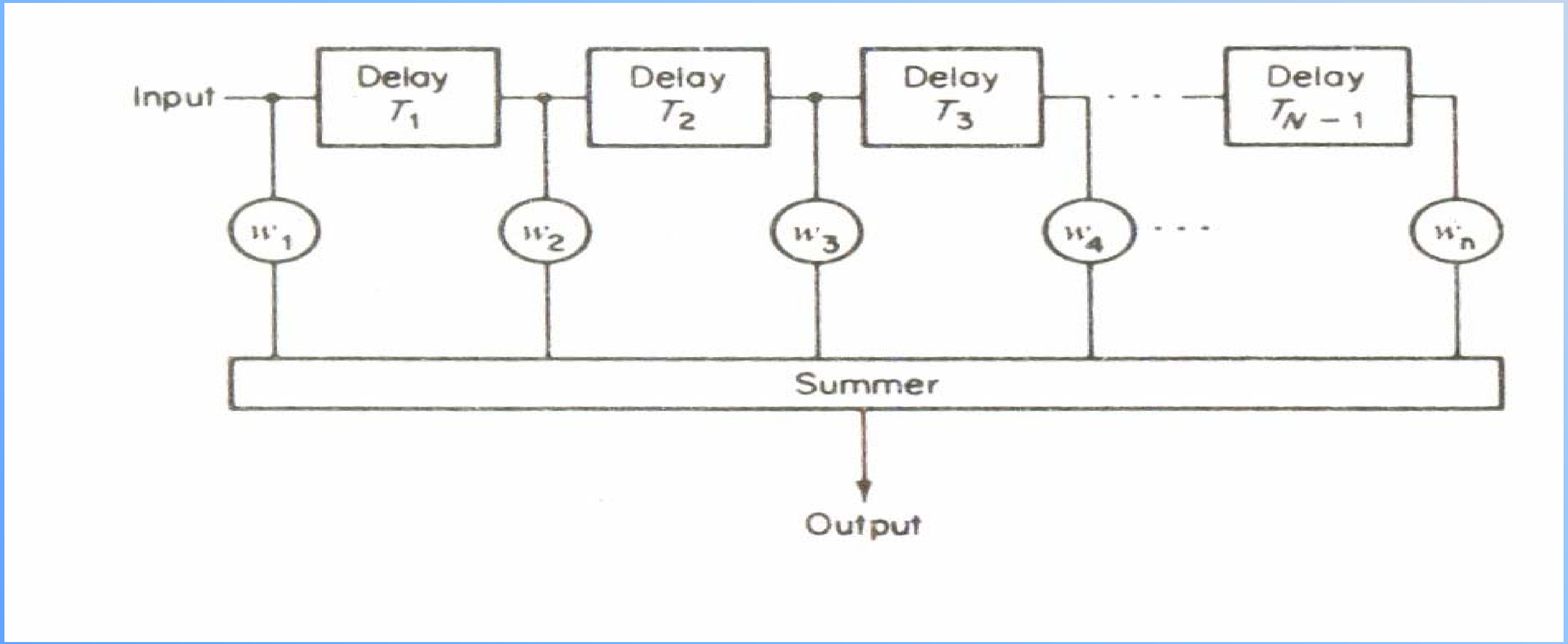
- SINCE O/P OF DOUBLE DELAY LINE CANCELER AND THREE PULSE CANCELER ARE THE SAME- THE TWO HAVE SAME FREQUENCY RESPONSE FUNCTION.
- THE WEIGHTS OF THE THREE PULSES ARE +1 -2,+1 [RESPONSE =$\sin^2(\pi f T_p)$]
- SIMILARLY A 4-PULSE CANCELER WILL HAVE WEIGHTS +1,-3,+3,-1 [RESPONSE=$\sin^3(\pi f T_p)$]

THUS IF n IS THE NUMBER OF DELAY LINES, N=n+1 PULSES WILL BE AVAILABLE TO PRODUCE A FREQ RESPONSE FUNCTION.

N DELAY LINE CANCELER

- FREQUENCY RESPONSE FUNCTION IS PROPORTIONAL TO $\text{Sin}^n (\pi f T_p)$. THE WEIGHTS ARE COEFFIENTS OF EXPANSION OF $(1-x)^n$ WITH ALTERNATING SIGNS.
- THE GREATER THE VALUE OF N, GREATER WILL BE THE CLUTTER ATTENUATION.

- THE WEIGHTS ARE THE COEFFICIENTS OF THE EXPANSION OF THE BIONOMIAL SERIES$(1-x)^n$ WITH ALTERNATING SIGNS.
- $Wi=(-1)^{i-1}\ n!/\{n-(i-1)\}!\{i-1\}!$
- i=1,2,3,……..n+1



N PULSE FILTER/CANCELER FOR MTI SIGNAL PROCESSING

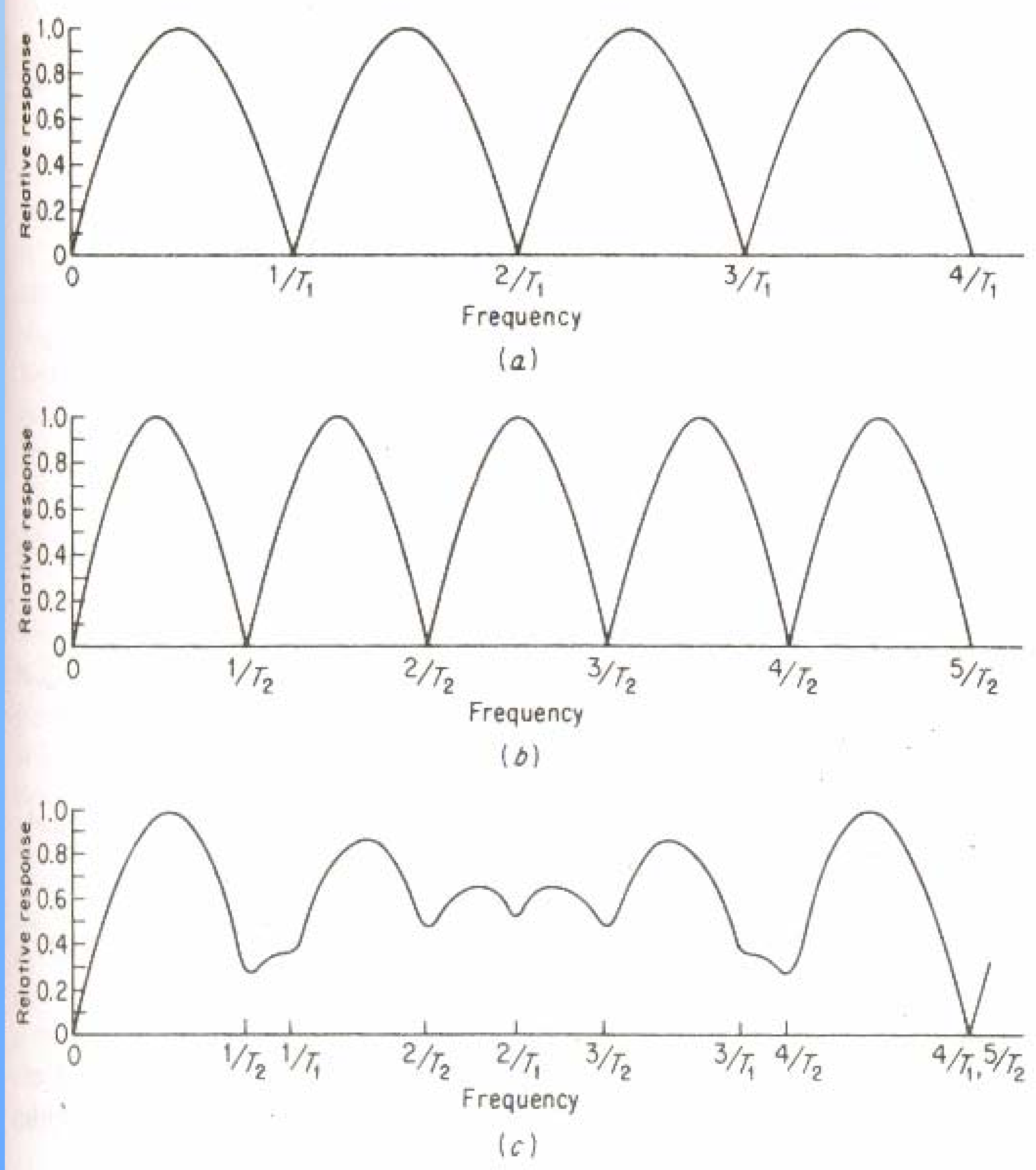
- THE N PULSE CANCELER HAS THE SAME FREQUENCY RESPONSE AS n SINGLE DLC's IN CASCADE WHERE n=N-1
- GREATER THE VALUE OF N,GREATER WILL BE CLUTTER ATTENUATION.

STAGGERED PRF'S

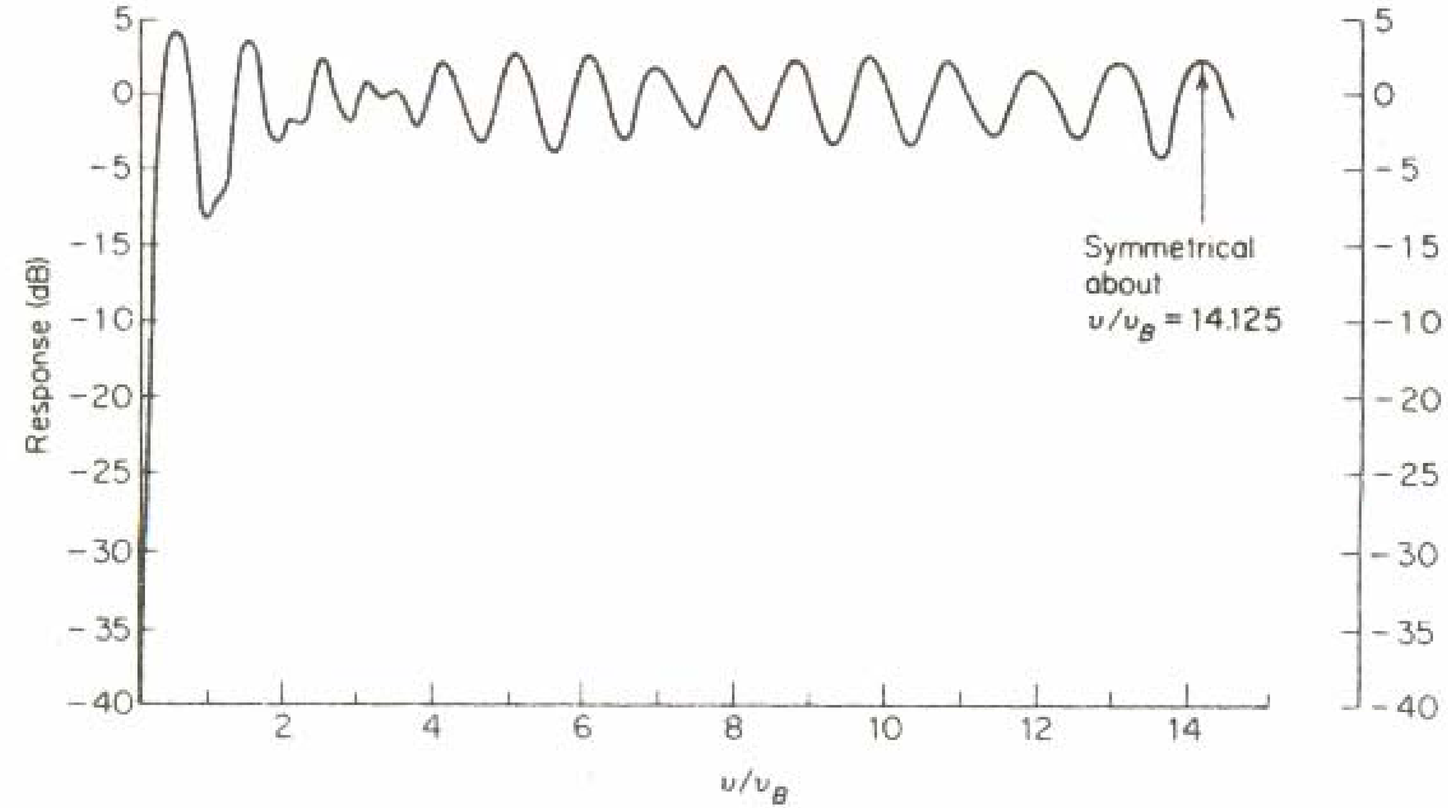
- USE OF DIFF. PRF'S ALLOWS THE DETECTION OF MOVING TGTS THAT WOULD HAVE BEEN ELIMINATED OTHERWISE IF A CONSTANT PRF WAS USED.

METHODS TO ADOPT MULTIPLE PRF'S

- **SCAN TO SCAN**
- **DWELL TO DWELL**
- **PULSE TO PULSE-> STAGGERED PRF**



Relative response
1.0
0.8
0.6
0.4
0.2
0
0
1/T1
2/T1
3/T1
4/T1
Frequency
(a)
Relative response
1.0
0.8
0.6
0.4
0.2
0
0
1/T2
2/T2
3/T2
4/T2
5/T2
Frequency
(b)
Relative response
1.0
0.8
0.6
0.4
0.2
0
0
1/T2
1/T1
2/T2
2/T1
3/T2
3/T1
4/T2
4/T1, 5/T2
Frequency
(c)



Response (dB)
5
0
−5
−15
−10
−20
−25
−30
−35
−40
2
4
6
8
10
12
14
υ/υ_B
Symmetrical about υ/υ_B = 14.125

DESIGN FACTORS FOR SELECTION OF VARIOUS PRP'S

- MIN PERIOD SHOULD NOT RESULT IN RANGE AMBIGUITIES.
- SEQUENCE OF PERIODS SHOULD NOT RESULT IN TOO WIDE VARIATION IN DUTY CYCLE.
- MAXIMUM PERIOD SHOULD NOT BE TOO LONG.
- REQUIRED MTI IMPROVEMENT FACTOR SHOULD BE AVAILABLE.
- THE VARIATION (RIPPLE) OF THE RESPONSE OVER THE PASS BAND SHOULD BE MINIMISED AND RELATIVELY UNIFORM.

FOUR PERIOD (FIVE PULSE) STAGGER

RATIO OF PRP=25:30:27:31

- $V_1/V_B=(25+30+27+31)/4=28.25\approx28$

- V_1- FIRST BLIND SPEED WITH STAGGERED PRF
- V_B-FIRST BLIND SPEED WITH CONSTANT PRF (SAME AVERAGE PERIOD)
- $\mathbf{V_1/V_B=(n_1+n_2+n_3+n_4)/n}$

COMPARISION OF MULTIPLE PRF METHODS

- 1) **STAGGERED PRF (PULSE TO PULSE VARIATION)**

- IT DOES NOT HAVE LARGE REGIONS OF DOPPLER SPACE WHERE MOVING TGTS ARE NOT DETECTED.
- IMPROVEMENT FACTOR IS SLIGHTLY DEGRADED , AS SOME CLUTTER ENERGY IS TRANSFERRED TO DOPPLER SPACE.

STAGGERED PRF (PULSE TO PULSE VARIATION) -contd

- DIFFICULT TO STABILISE Tx. (NON UNIFORM PRF)
- DOES NOT CANCEL OUT MULTIPLE TIME AROUND CLUTTER.

2) SSCAN TO SCAN

- EASIER TO IMPLEMENT.
- IT CAN CANCEL MULTIPLE TIME AROUND CLUTTER.
- REDUCTION IN BLIND SPEED IS NOT VERY EFFECTIVE AS IN STAGGERED p r f CASE.

STAGGERED PRF(CONTD)

3) DWELL TO DWELL

- ADVANTAGES ARE SIMILAR TO SCAN TO SCAN METHOD.
- UNMASKING OF BLIND SPEEDS IS QUICKER.

DOPPLER FREQUENCY SHIFT
-RADAR ECHO SIGNAL

- LET TRASMITTED SIGNAL= $A_t \text{Sin}(2\pi f_t\ t)$
- V_{REC} RECEIVED SIGNAL=$A_r \text{Sin}[2\pi f_t(t-T_R)$
- WHERE T_R=ROUND TRIP TIME =2R/C
- $R=R_0-v_r t$ (v_r=RADIAL VELOCITY)
- $V_{REC}=Ar\ \text{Sin}[2\pi f_t t-2\pi f_t T_R]$
- $=Ar[\text{Sin}(2\pi f_t t-2\pi f_t\cdot 2R/C)]$
- $=A_r[\text{Sin}\{2\pi f_t t-2\pi f_t\cdot 2(R_0-v_r t)/C\}]$
- $=A_r\ [\text{Sin}\{2\pi f_t-(4\pi f_t R_0)/C+(4\pi f_t v_r t)/C\}]$
- $=A_r\ [\text{Sin}\{2\pi f_t\,(1+2v_r/C)t-(4\pi f_t R_0)/C\}]$

- THE RECEIVED FREQUENCY CHANGES BY THE FACTOR

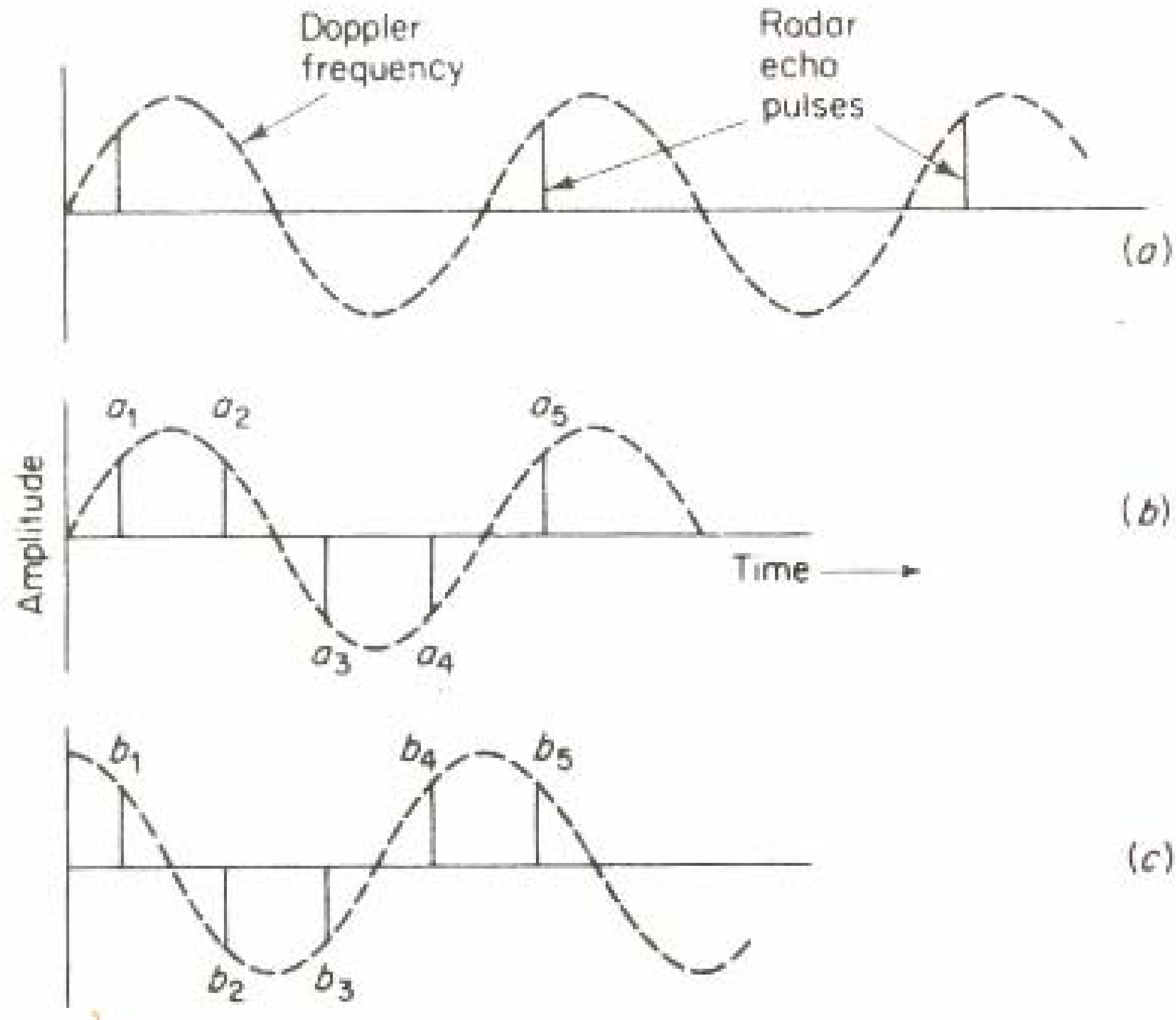
$$\mathbf{(2f_t v_r)/C = 2v_r/\lambda}$$

- NOTE: 1)THE ECHO SIGNAL FROM A MOVING TGT IS A TIME VARYING OUTPUT ,DUE TO DOPPLER SHIFT.
- 2)THE ECHO SIGNAL FROM A STATIONARY TGT ie.CLUTTER HAS ZERO DOPPLER FREQUENCY.

- <u>BLIND SPEED :-</u>
- RESPONSE OF A SINGLE DLC IS ZERO WHENEVER

$H(f) = 2\sin(\pi f_d T_p) = 0$

- THIS WILL BE SO,WHEN
- **$\pi f_d T_p = 0, \pm\pi, \pm 2\pi, \pm 3\pi$**
- **$= n\pi$**
- **$f_d = 2v_r/\lambda = n f_p$**


Doppler frequency
Radar echo pulses
(a)
Amplitude
a_1
a_2
a_3
a_4
a_5
Time
(b)
b_1
b_2
b_3
b_4
b_5
(c)

THE RESPONSE IS ZERO WHENEVER fd=nfp

Vr IN SUCH CASE CORRESPONDS TO BLIND SPEED, SAY Vn (nth BLIND SPEED)

fd=2 Vn/λ = n fp

Vn= (n λ fp) / 2

n=1,2,3…….

fp↑ Vn↑

f↑ λ↓ Vn↓ S

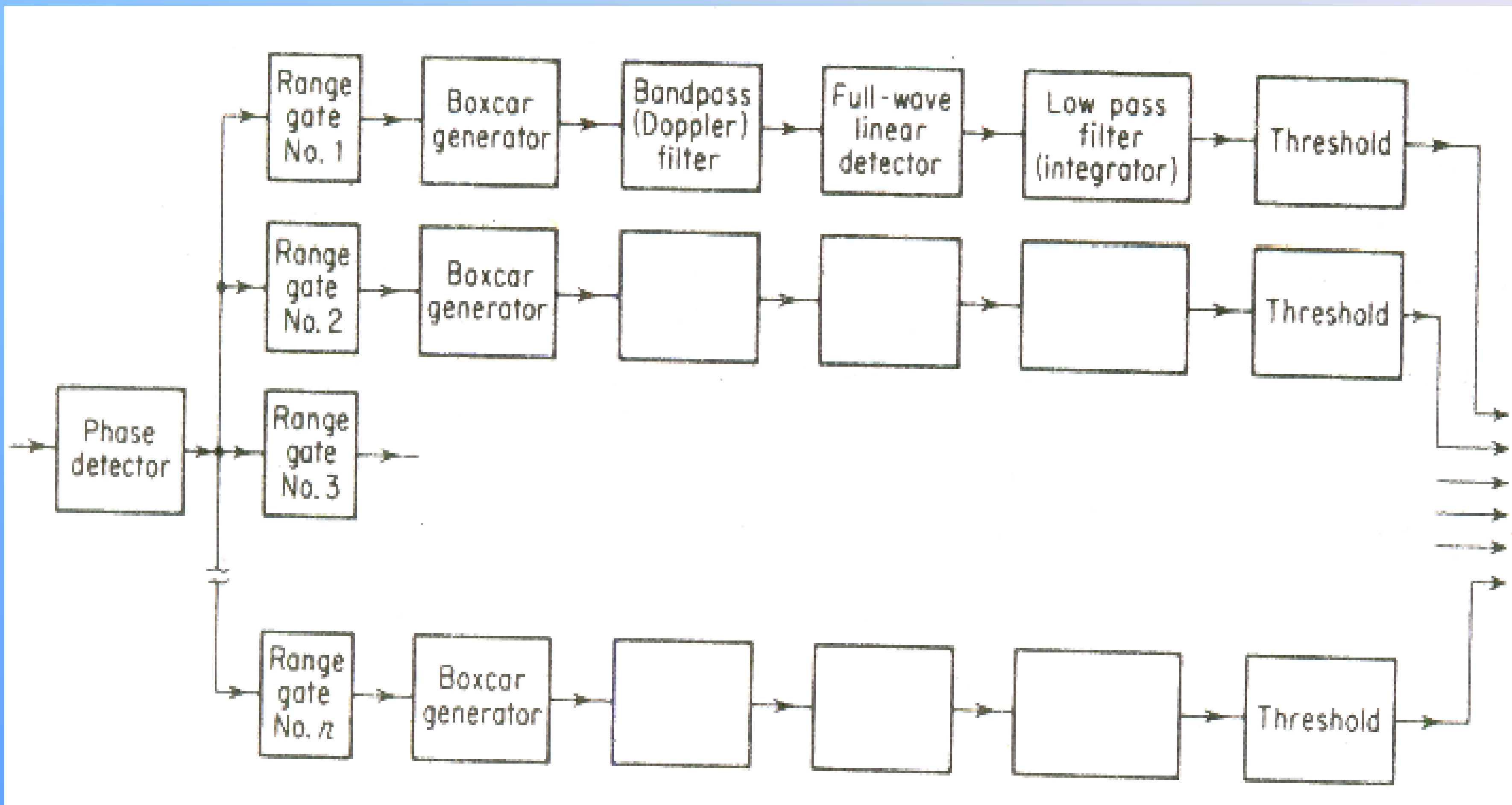
- **EFFECT OF INCREASING THE PRF(MTI)**
- **LOW PRF- NO RANGE AMBIGUITIES**

  - MANY DOPPLER AMBIGUITIES
- BLIND SPEED=n λ f_p /2
- **INCREASING THE PRF (fp), INCREASES THE FIRST BLIND SPEED.**
- **BUT RANGE AMBIGUITIES WILL ALSO INCREASE**.
- TRADING OF DOPPLER AMBIGUITIES (BLIND SPEEDS) FOR RANGE AMBIGUITIES IS SOMETHING THAT HAS TO BE TOLERATED IN MTI PERFORMANCE AT HIGH MW FREQUENCIES.

PULSE DOPPLER RADAR

- A RADAR THAT INCREASES ITS PRF HIGH ENOUGH TO AVOID PROBLEMS OF BLIND SPEEDS IS CALLED A PULSE DOPPLER RADAR.

MTI RADAR – USING RANGE GATES AND DOPPLER FILTER



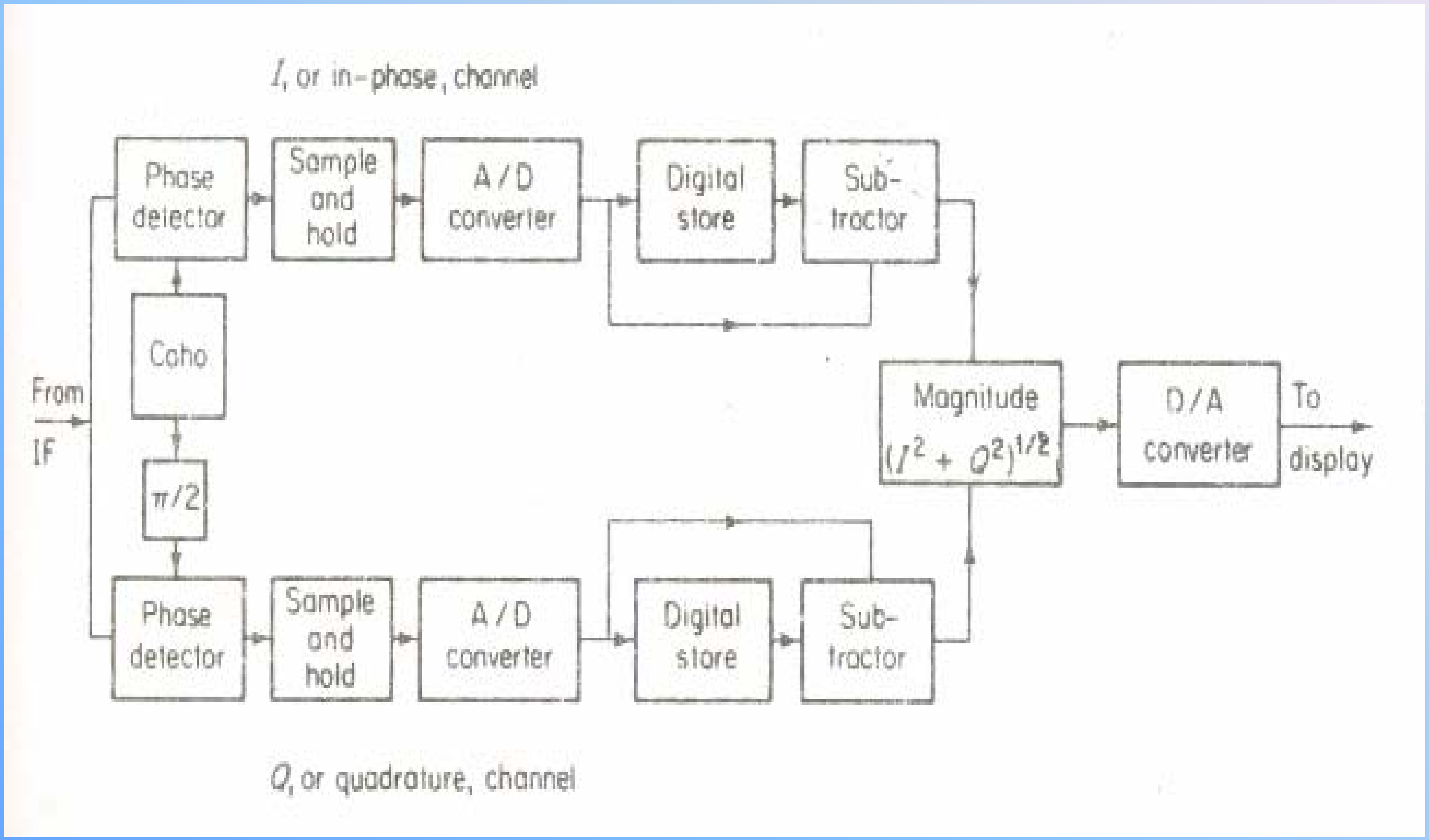
- **MTI RADAR – USING RANGE GATES AND DOPPLER FILTER**

- RANGE GATES SAMPLE THE O/P OF PHASE DET SEQUENTIALLY; ie EACH GATE OPENS AND CLOSES AT A PROPER TIME.
- BOX CAR GENERATOR (BCG) AIDS IN FILTERING AND ELIMINATES ANY UNWANTED HARMONICS OF PRF.
- FULL WAVE DET CONVERTS THE BIPOLAR VIDEO TO UNIPOLAR VIDEO.
- THE O/P'S FROM EACH RANGE CHANNEL ARE COMBINED FOR DISPLAY ON THE PPI OR ANY OTHER DISPLAY UNIT.
- MTI RADAR USING RANGE GATES AND FILTERS IS MORE COMPLEX THAN AN MTI USING SINGLE DLC.
- **BCG→SAMPLE & HOLD CIRCUIT**.

- **<u>RANGE GATING</u>**

- THE PROCESS OF QUANTIZING THE TIME INTO SMALL INTERVALS TO ELIMINATE THE LOSS OF ANY RANGE INFORMATION IS CALLED RANGE GATING.
- WIDTH OF THE RANGE GATE DEPENDS UPON THE RANGE ACCURACY DESIRED.

DIGITAL MTI PROCESSOR



DIGITAL MTI PROCESSOR

- I CH DOPPLER SIG. = A_d Cos (2π fd t + Φ_0)
- Q CH DOPPLER SIG. = A_d SIN (2π fd t+ Φ_0)
- **DOPPLER SIGNAL AMP. = $\sqrt{(I^2+Q^2)}$ $\approx |I|+|Q|$**
- **OUTPUT OF PHASE DETECTOR → DOPPLER SIGNAL.**

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ADVANTAGES OF DIGITAL MTI PROCESSING-

- COMPENSATION FOR BLIND PHASES.
- GREATER DYNAMIC RANGE.
- ACCURATE DELAY LINE TIMING.
- DIGITAL PRPCESSOR CAN BE MADE PROGRAMMABLE.
- DIGITAL MTI IS MORE STABLE & RELIABLE, THAN ANALOG MTI.
- REQUIRES LESS ADJUSTMENT IN THE FIELD

- SAMPLING IS AT +VE &-VE PEAKS OF fd AND HENCE COMPLETE RECOVERY OF SIGNAL
- I CHANNEL SIGNAL = $\sin 2\pi f_{if}\, t$ (IN-PHASE CHANNEL)
- Q CHANNEL SIGNAL= $\cos 2\pi f_{if}\, t$ (QUADERATURE CHANNEL)
- **BLIND PHASE-** THERE IS A LOSS WHEN DOPPLER SHIFTED SIGNAL IS NOT SAMPLED AT PEAK +/- VALUES OF SINE WAVE.
- **WHEN THE PHASE BETWEEN DOPPLER SIGNAL AND THE SAMPLING AT PRF RESULTS IN A LOSS, IT IS CALLED A "BLIND PHASE".**

LIMITATIONS TO MTI PERFORMANCE

- THE DEGRADATION IN PEREFORMANCE OF MTI RADARS IS CAUSED BY-
- 1) ANTENNA SCANNING MODULATION
- 2) INTERNAL MODULATION OF CLUTTER
- 3) EQUIPMENT INSTABILITIES
- 4) LIMITING
- 5) OTHER THAN 90^0 PHASE DIFFERENCE BETWEEN I & Q REFERENCE SIGNALS
- 6) GAIN & PHASE IMBALANCE IN 2 CHANNELS.
- 7) TIMING JITTER IN SAMPLE & HOLD CKT.

- 8) QUANTIZATION OF ANALOG SIGNAL (IN A/D CONVERTER) RESULTS IN QUANTIZATION NOISE, WHICH LIMITS THE MTI IMPROVEMENT FACTOR.
- 9) LOSS DUE TO THE SAMPLING NOT BEING AT THE PEAK OF O/P OF MATCHED FILTER.
- 10) LOSS DUE TO BLIND PHASES IN USING A SINGLE CHANNEL.

  (LOSS IS ABOUT 2db WHEN 20 PULSES ARE INTEGRATED)

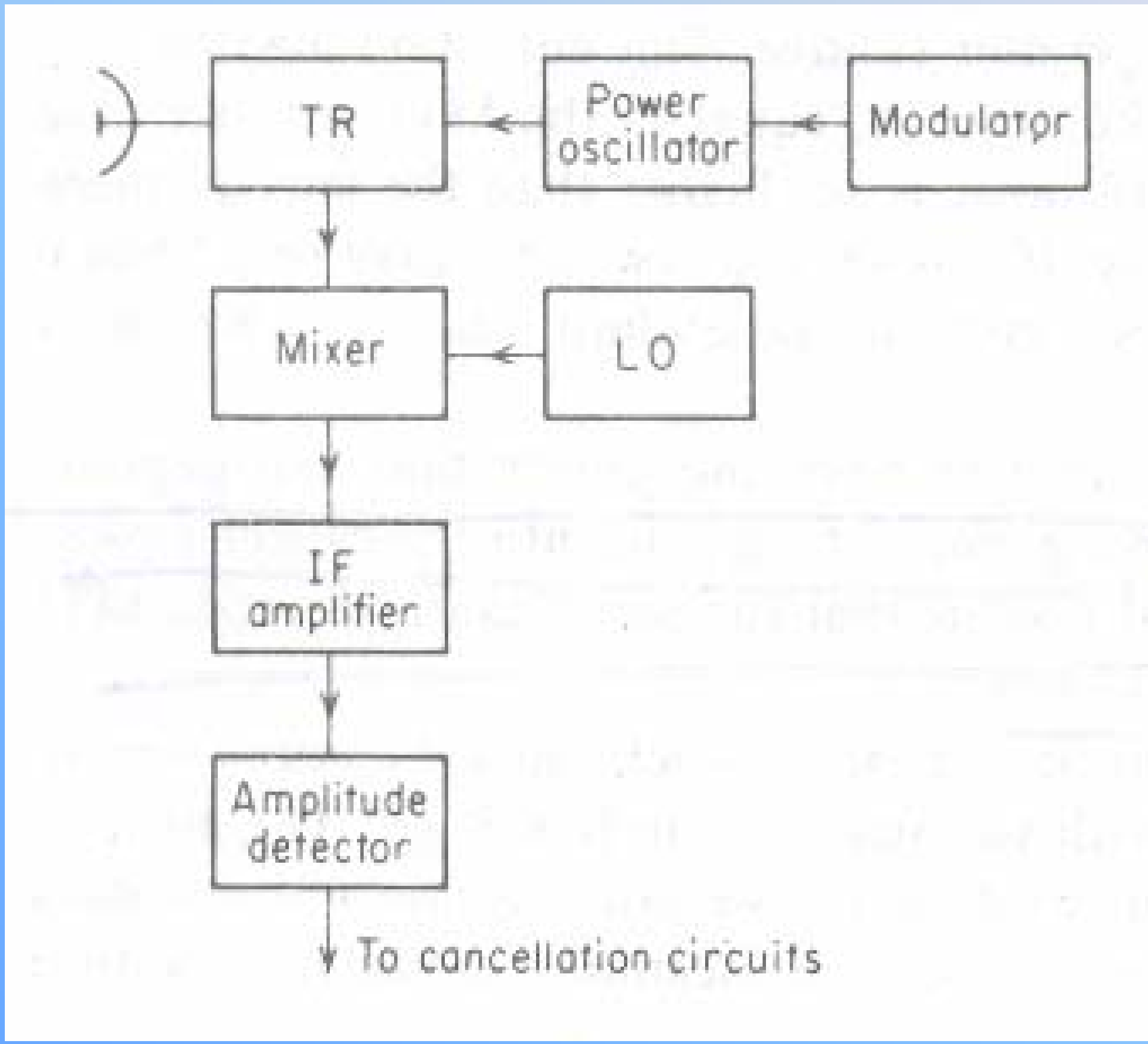
ANTENNA SCANNING MODULATION

- DURATION OF ECHO SIGNAL (FROM A TGT/CLUTTER SCATTERER) $t_0 = \theta_B/\theta_s$
- **$\eta_B = (\theta_B/\theta s)*fp$**
- FREQUENCY SPECTRUM BW IS INVERSLY PROPORTIONAL TO TIME DURATION t_0.
- THUS EVEN IF CLUTTER SCATTERERS WERE PERFECTLY STATIONERY AND NO INSTABILITIES IN RADAR EQPT, THERE WILL STILL BE A FINITE SPECTRAL SPREAD DUE TO FINITE DURATION OF THE ECHO SIGNAL.

ANTENNA SCANNING MODULATION (contd)

- THIS LIMITATION IS CALLED ANT SCANNING MODULATION BUT IT IS BASICALLY DUE TO **FINITE TIME ON TARGET**.
- PULSE TO PULSE DIFFERENCE IN ECHO AMPLITUDE DUE TO ANTENNA PATTERN SHAPE ALSO CONTRIBUTES TO CLUTTER RESIDUE THAT IS PART OF ANT SCANNING MODULATION.
- LONG DURATION SIGNALS ARE NEEDED FOR GOOD CLUTTER REJECTION.

NON COHERENT MTI RADAR



NON COHERENT MTI RADAR (CONTD)

- NON COHERENT MTI RADAR USES CLUTTER ECHO AS THE REFERENCE SIGNAL, TO EXTRACT DOPPLER SHIFTED (ECHO) FREQUENCY.

- PHASE DETECTOR (IN MTI) HAS BEEN REPLACED BY CONVENTIONAL AMPLITUDE DETECTOR.

- NOTE:- **ECHO SIGNAL FROM CLUTTER ALSO HAS THE CHARACTERISTICS OF THE TRANSMITTED SIGNAL AND THUS CAN BE USED AS REFERENCE TO EXTRACT THE DOPPLER FREQ SHIFT OF THE TGT ECHO SIGNAL**

APPLICATIONS- NON COHERENT MTI

- TO DETECT MOVING GROUND VEHICLES/TGTS
- SIDE-LOOKING AIR BORNE RADAR(SLAR) WITH NON-COHERENT MTI IS USED FOR THIS PURPOSE.
- THIS TECHNIQUE OBTAINS A MAP LIKE IMAGE OF THE SCENE AS WELL AS DETECT MOVING TGTS.
- <u>PRACTICAL EXAMPLE-</u> **MOTOROLA SLAMMER**
- **X BAND RADAR** (AIR BORNE)
- 16' SIDE LOOKING ANTEENA,0.2 μs PW
- Tx POWER= 60 W (AVERAGE)

- NON COHERENT MTI (Contd)

- THIS RADAR WITH NON-COHERENT MTI CAN EXTRACT SMALL MOVING TARGETS WITH SPEEDS DOWN TO 5 mph, AT A RANGE OF 50 nmi – 80nmi.

ADVANTAGE/LIMITATIONS OF NON-COHERENT MTI

- ADVANTAGE- RELATIVE SIMPLICITY
- LIMITATIONS-
- REQUIRES CLUTTER ECHO TO BE PRESENT ALONG WITH THE TGT ECHO.
- OTHERWISE TGT WILL BE CANCELLED OUT BY DLC IF NO CLUTTER WAS PRESENT.
- THE DLC MUST BE SWITCHED OFF IF NO CLUTTER WAS PRESENT. THE DLC MIGHT HAVE TO BE SWITCHED OFF ON A NUMBER OF TIMES AS THE PULSE TRAVELS OUT IN RANGE.

- THE IMPROVEMENT FACTOR OF A NON-COHERENT MTI IS USUALLY MUCH POORER THAN THAT OF A COHERENT MTI.
- SEPARATE Q CHANNEL CAN NOT BE USED, SINCE CLUTTER REFERENCE SIGNAL IS NOT SEPARATELY AVAILABLE. THUS SIGNIFICANT LOSS CAN OCCUR DUE TO BLIND PHASES.
- CLUTTER ECHO AS THE REFERENCE SIGNAL IS LIKELY TO BE NOISIER THAN THAT OF COHO OF A MTI RADAR.
- THUS NON-COHERENT MTI IS NOT AN ATTRACTIVE OPTION FOR MOST MTI APPLICATIONS.

PULSE DOPPLER RADAR

- MTI RADAR CANNOT PERFORM SATISFACTORILY AT HIGHER MICROWAVE REQUENCIES.
- f ↑ λ ↓
- THIS RESULTS IN MORE BLIND SPEEDS IN THE AVAILABLE DOPPLER SPACE.
- [v_n= n λ fp) /2]
- **PRF IS NORMALLY CHOSEN TO BE LOW TO AVOID RANGE AMBIGUITIES.BUT THERE ARE MANY DOPPLER AMBIGUITIES**.
- A REDUCTION IN DOPPLER SPACE CAN RESULT IN MISSED TARGETS (MOVING)
- FURTHER AMTI SUFFERS WIDENING OF THE CLUTTER SPECTRAL WIDTH, DUE TO PLATFORM MOTION.

PULSE DOPPLER RADAR (contd)

- THE AIRBORNE RADAR NEEDS TO OPERATE AT HIGH (MW) FREQUENCIES TO HAVE A NARROW BEAMWIDTH WITH A SMALL SIZE ANTENNA.
- THUS THE MTI TECHNIQUE NEEDS TO BE REPLACED AT HIGHER (MW) FREQUENCIES.

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TYPES OF PULSE DOPPLER RADARS-

1) MTI- NO RANGE AMBIUITIES

MANY DOPPLER AMBIGUITIES

2) HIGH PRF PD RADAR- MANY RANGE AMBIGUITIES & NO DOPPLER AMBIGUITIES.

3) MEDIUM PRF PULSE DOPPLER RADAR- WITH SOME RANGE & SOME DOPPLER AMBIGUITIES

BASIC DIFFERENCE BETWEEN AN MTI & PULSE DOPPLER RADAR

- PRF & DUTY CYCLE EMPLOYED
- **MTI- LOW PRF, LOW DUTY CYCLE(≈.005)**
- **PD RADAR- HIGH PRF, HIGH DUTY CYCLE(0.3 TO 0.5)**
- PD RADAR GENERALLY RECEIVES MUCH MORE CLUTTER THAN A MTI RADAR.
- THEREFORE THE PD RADAR REQUIRES A MUCH GREATER IMPROVEMENT FACTOR THAN DOES AN MTI RADAR OF COMPARABLE PERFORMANCE.

MTI FROM MOVING PLATFORM (AMTI)

- DOPPLER FREQ SHIFT FROM CLUTTER IS NO LONGER AT ZERO FREQUENCY.
- DOPPLER FREQ OF CLUTTER DEPENDS ON RELATIVE VELOCITY WRT MOVING RADAR PLATFORM AS WELL AS β & ε OF CLUTTER WRT RADAR.
- THIS DOPPLER SHIFT BECAUSE OF CLUTTER MUST BE TAKEN INTO ACCOUNT, OTHERWISE THE MTI IMPROVEMENT FACTOR WILL BE DEGRADED.

- THIS IS DONE BY CHANGING THE FREQ OF COHO. **O/P OF COHO IS MIXED WITH A SIGNAL FROM A TUNABLE OSCILLATOR WHOSE FREQ IS MADE EQUAL TO THAT OF CLUTTER DOPPLER**.
- FURTHER , NOT ONLY DOES THE CENTRE FREQ OF CLUTTER SPECTRUM VARY, SO DOES THE CLUTTER SPECTRAL WIDTH.
- **THE WIDENING OF THE CLUTTER SPECTRUM IS DUE TO THE FINITE BEAMWIDTH OF ANTENNA**, WHICH MAKES THE DOPPLER FREQ SHIFT FROM CLUTTER SCATTERERS DIFFER, DEPENDING ON THEIR LOCATION WITHIN THE ANTENNA BEAM.

AMTI

- AN MTI RADAR ON A MOVING PLATFORM THAT USES TWO METHODS(TACCAR & DPCA) FOR COMPENSATING FOR PLATFORM MOTION IS KNOWN AS AN AMTI RADAR.

TACCAR & DPCA

- PERFORMANCE OF A MOVING MTI RADAR CAN BE DEGRADED BY-
- 1) **NON ZERO DOPPLER SHIFT FROM CLUTTER**
- **2) VARIATION IN CLUTTER SPECTRAL WIDTH**

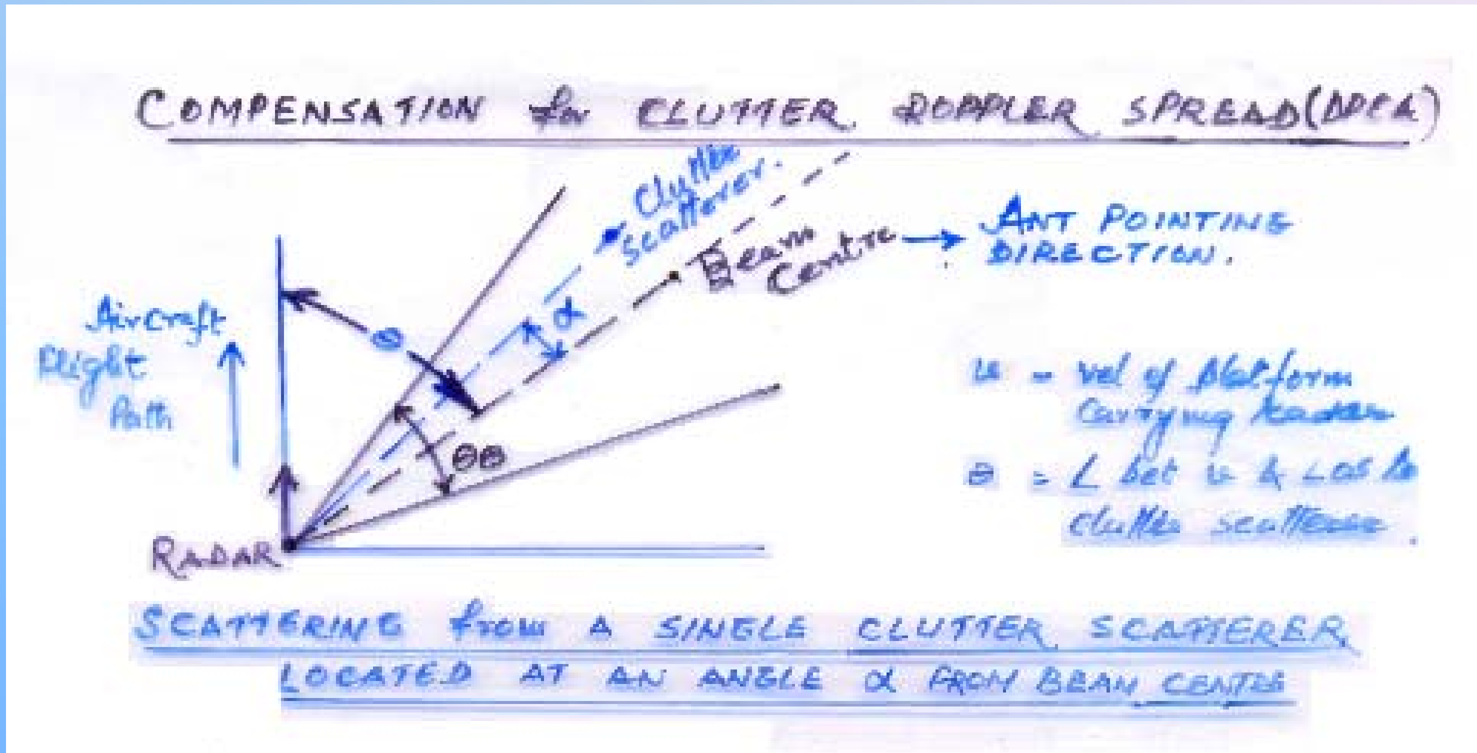
  THE ABOVE TWO ARE COMPENSATED BY
- **- TACCAR (CLUTTER- LOCK MTI) TIME AVERAGED CLUTTER COHERENT AIRBORNE RADAR**
- **- DPCA (DISPLACED PHASE CENTRE ANTENNA) COMPENSATION FOR CLUTTER DOPPLER SPREAD.**

TACCAR

- CLUTTER ECHO ITSELF IS UTILISED TO SET THE FREQ OF COHO (REF OSC) SO THAT CLUTTER ECHO IS ATTENUATED.
- EFFECT OF MOVING CLUTTER (OCEAN CURRENTS ETC) CAN BE REDUCED BY USING TACCAR.
- HOWEVER**, BOTH MOVING AND STATIONARY CLUTTER CAN'T BE REMOVED SIMULTANEOUSLY.**

TACCAR (contd)

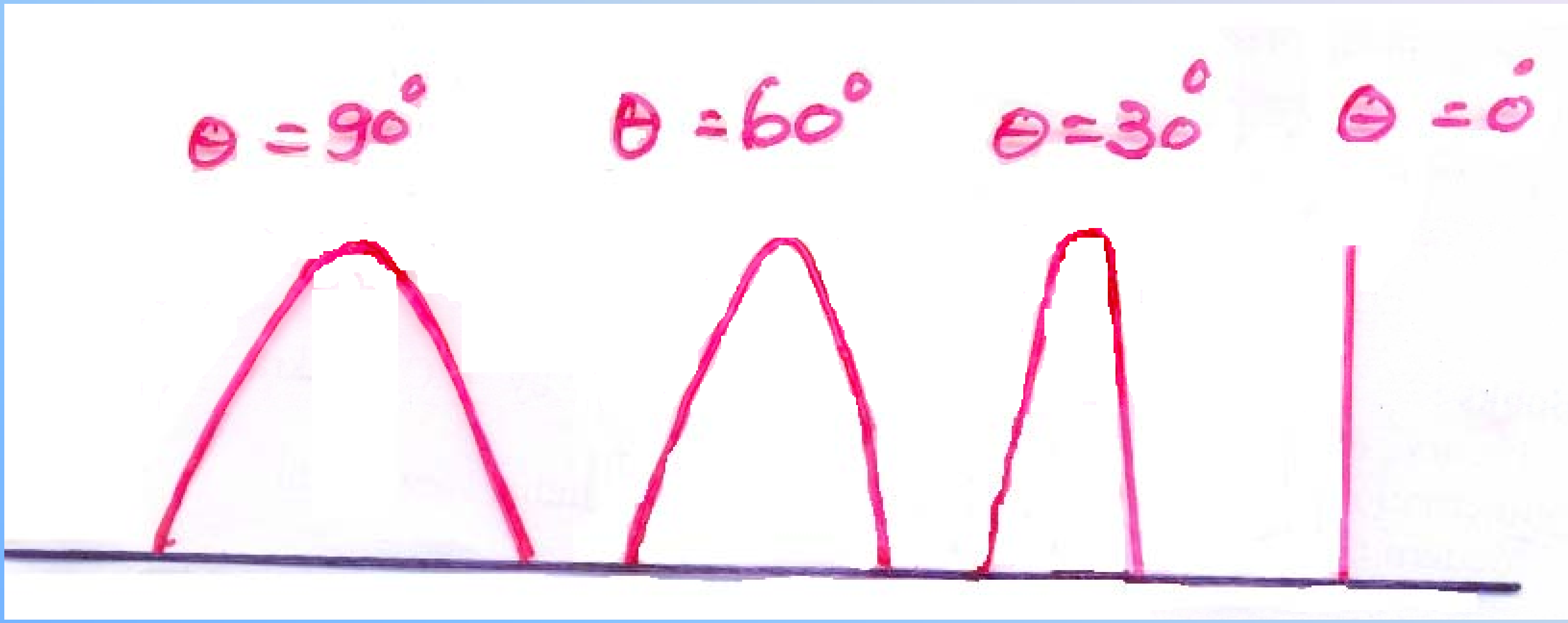
- IN SUCH A CASE 'DOPPLER FILTER BANK' CAN DETECT MOVING TGTS IN THE PRESENCE OF BOTH MOVING CLUTTER AS WELL AS STATIONARY CLUTTER, IF THEIR DOPPLER FREQ.SHIFTS ARE DIFFERENT.
- NOTE:- THE DOPLLER FREQ.OF CLUTTER DEPENDS UPON RADIAL VELOCITY WRT MOVING RADAR PLATFORM AS WELL AS β & ε OF CLUTTER CELL WRT RADAR.



- DOPPLER FREQ. FROM SCATTERERS AT THE CENTRE OF THE BEAM WILL BE COMPENSATED BY TACCAR SO THAT IT APPEARS AT ZERO FREQ.

- ECHOES THAT DONOT LIE ALONG THE CENTRE OF THE MAIN BEAM WILL NOT BE COMPENSATED BY **TACCAR**.
- THUS THERE IS A SPREAD IN THE CLUTTER DOPPLER FREQ.SPECTRUM DUE TO FINITE ANTENNA BEAM WIDTH.
- DOPPLER FREQ.SHIFT (FROM A STATIONARY CLUTTER SCATTER WHEN VIEWED FROM A MOVING RADAR)
- $fc = 2(v/\lambda) \cos\theta$
- CLUTTER SPECTRAL SPREAD-
- $\Delta fc = (2v/\lambda)\sin\theta . d\theta = (2v/\lambda)\sin\theta .\ \theta_B$
- THUS **SPECTRAL SPREAD α θ**

- **$\theta=0^0$-** MEANS ANTENNA POINTS IN THE DIRECTION OF PLATFORM VELOCITY VECTOR.
- **$fc= (2v/\lambda) \cos\theta$ = MAX**
- **$\Delta fc=(2v/\lambda)\sin\theta.d\theta$ = ZERO**
- ie DOPPLER SHIFT OF CLUTTER ECHO IS MAX BUT Δfc THE WIDTH OF SPECTRAL SPREAD IS ZERO.
- **$\theta=90^0$-** ANTENNA POINTS PERPENDICULAR TO PLATFORM VEL. VECTOR.
- **$fc= (2v/\lambda)\cos 90$ = ZERO**
- **Δfc =MAX**
- OBVIOUSLY, **WIDENING OF THE CLUTTER SPECTRUM NEEDS TO BE REDUCED IN ORDER FOR AMTI RADAR TO BE EFFECTIVE**.



CULLTER SPECTRUM SPREAD AS A FUNCTION OF AZIMUTH ANGLE DUE TO PLATFORM MOTION

TACCAR (contd)

- **THERE WOULD BE NO SPREADING OF CLUTTER SPECTRUM($\Delta fc=0$), IF ANTENNA COULD BE ASSUMED TO BE STATIONARY IN BEHAVIOUR**.
- TO ACHIEVE THIS, TWO SEPARATE ANTENNAS ARE USED- FORWARD ANT & TRAILING ANT.
- BEAMS POINTING BROADSIDE AT $\theta=90^0$.
- SPACING BETWEEN PHASE CENTERS OF TWO ANTENNAS IS MADE EQUAL TO vTp (v – VEL OF A/C AND Tp IS PRP)

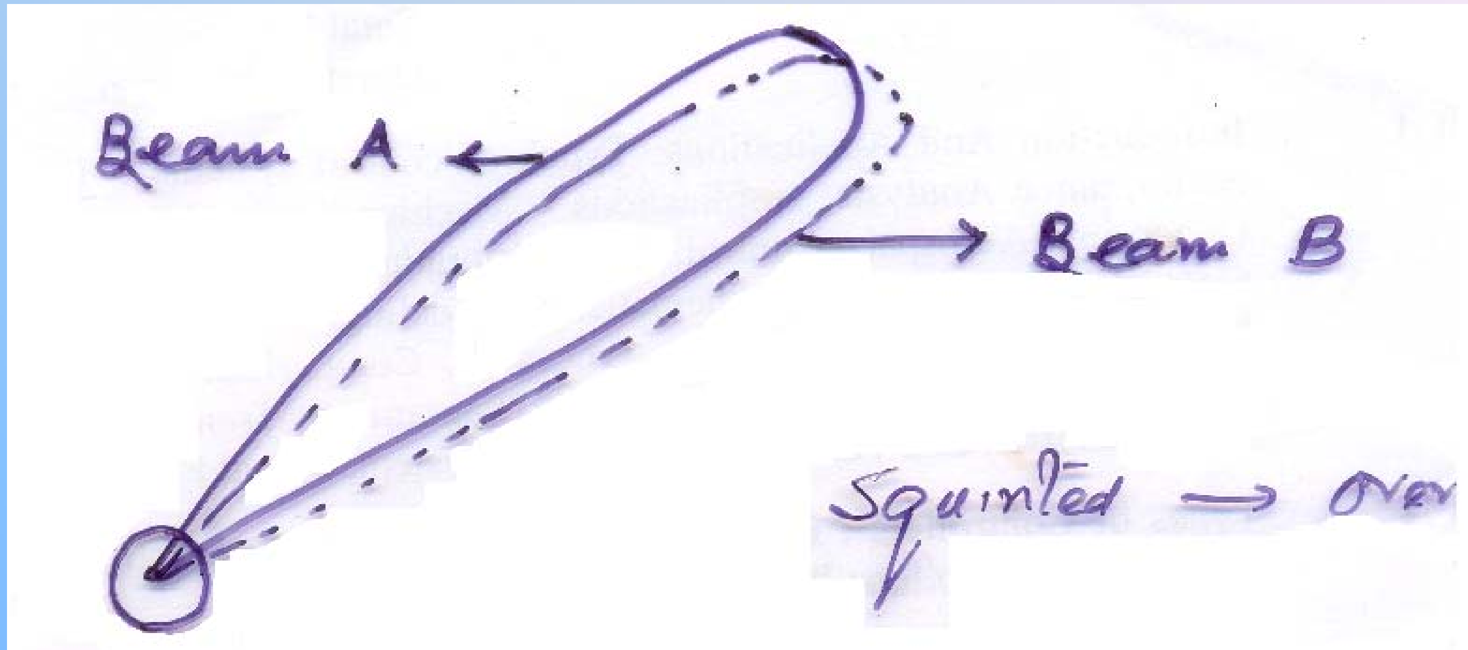
- FIRST PULSE IS TRANSMITTED & RECEIVED BY FORWARD ANTENNA.
- **THE TRAILING ANTENNA ALSO TRANSMITS WHEN IT REACHES THE POSITION OF FORWARD ANTENNA (AT TIME OF TRANSMISSION OF PULSE BY FORWARD ANTENNA.)**
- THUS THE TWO PULSES FROM THE TWO ANTENNAS ARE TRANSMITTED AND RECEIVED AT THE SAME POINT IN SPACE.

- **TO THE RADAR, IT IS AS IF THERE WAS A SINGLE STATIONARY ANTENNA**.
- THE TWO PULSES ARE THESN PROCESSED IN A DLC AND THERE IS NO EFFECT OF PLATFORM MOTION.
- HOWEVER, THERE ARE PROBLEMS WITH THIS SOLUTION.
- **PRF NEEDS TO BE SYNCHRONISED WITH A/C SPEED**.
- THE OTHER ALTERNATIVE IS TO USE A SINGLE ANTENNA WITH TWO SQUINTED BEAMS.

DPCA

- A MECHANICALLY ROTATING ANTENNA THAT GENERATES 2 OVERLAPPING (SQUINTED) BEAMS ACTS AS DPCA

- THE SUM AND DIFF OF TWO BEAMS ARE TAKEN



MECHANICALLY ROTATING AIR BORNE ANTENNA (WITH 2 SQUINTED BEAMS)

∑ OF BEAMS IS USED FOR TRANSMISSION.

ECHO SIGNAL IS RECEIVED ON BOTH THE SUM & DIFF. OF TWO BEAMS.

DPCA (contd)

- RECEIVED SIGNAL FROM FIRST PULSE IS PROCESSED TO FORM $\sum r + j K \Delta r$
- WHERE + j REPRESENT 90^0 PHASE ADVANCE APPLIED TO DIFF. SIGNAL.
- K- CONSTANT THAT DETERMINES AMOUNT OF PHASE CENTER SHIFT.
- K DEPENDS ON A/C VELOCITY, PRF & θ.
- RECEIVED SIGNAL FROM 2^{nd} PULSE IS PROCESSED TO FORM $\sum r - j K \Delta r$ WHERE - j IS 90^0 PHASE LAG.
- THE TWO SIGNALS ARE THEN SUBTRACTED FROM ONE ANOTHER, RESULTING IN CANCELLATION OF DOPPLER SPREAD IN THE CLUTTER.