Esempi/ esercitazioni:
Ricerca Short

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Radar di ricerca (Short range)

Si dimensioni un radar di ricerca con le seguenti caratteristiche:

Banda S: 3 GHz
Portata: 120 Km
Velocità massima ±300 m/s

Risoluzione in azimuth: 2°
Rotazione antenna: 5 giri/minuto

$P_{fa} = 10^{-6}$
$P_d = 0{,}9$ per bersaglio fisso con RCS= 1 m^2

Potenza di picco TX: $P_p = 5$ KW
Figura di rumore: F= 3dB

Risoluzione in distanza 200 m
Dinamica lineare istantanea 40 dB
L= perdite totali = 8 dB

Radar di ricerca (short range)

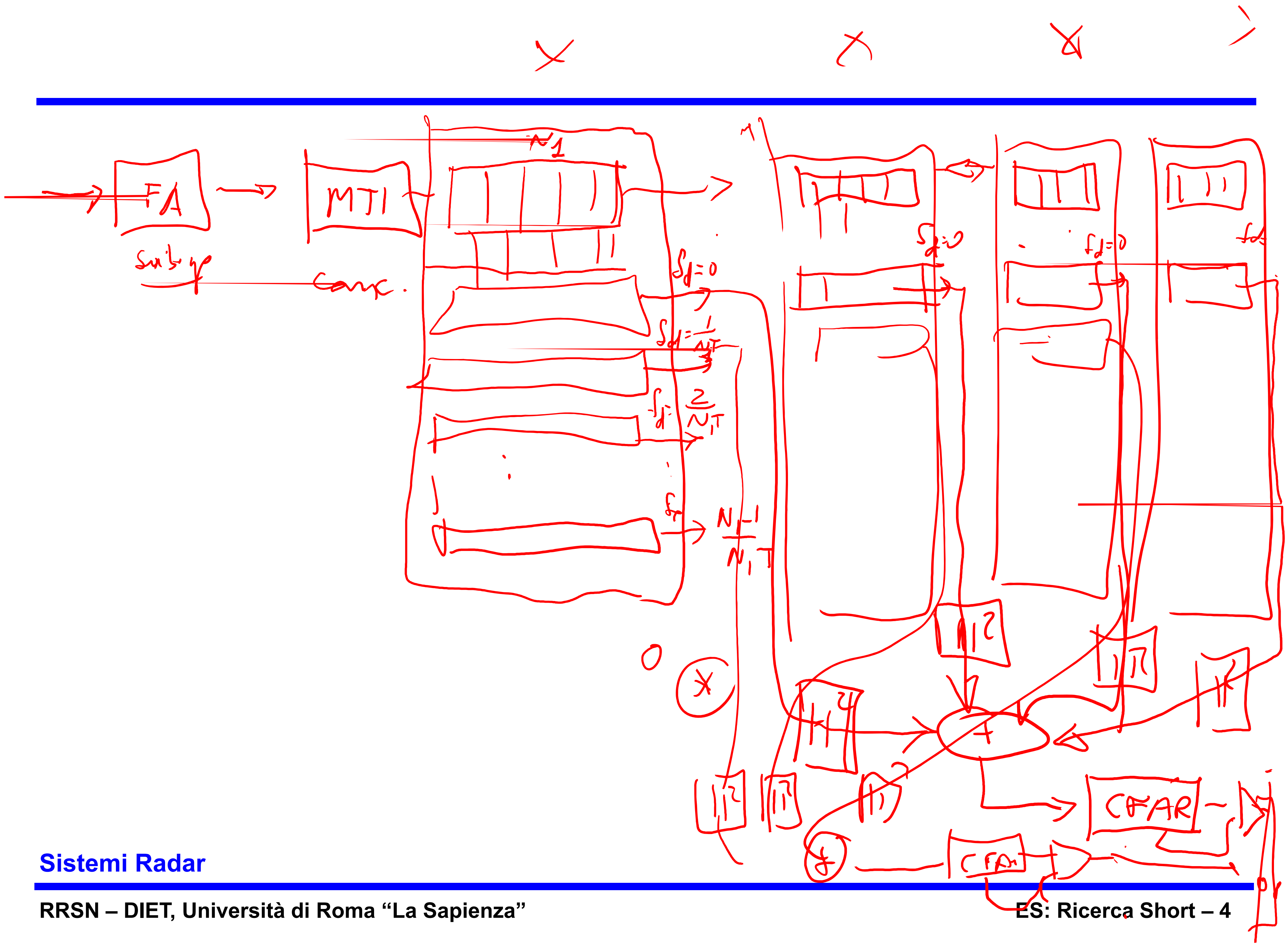
Banda L: 3 GHz
Portata: 120 Km
Velocità massima ±300 m/s

Max Range: $2\ R/c = 2*120\ 10^3/3\ 10^8 = 0{,}8\ 10^{-3}$ s
Max Doppler: $2V/\lambda = 2V\ f/c = 2*300\ 3\ 10^9/3\ 10^8 = 9600 = 9{,}6$ KHz

Range-Doppler Area of interest $= 2*9600*\ 4/5\ 10^{-3} \cong 15$

Per non avere ambiguità in range PRF$<c/(2R) = 1/(4/5\ 10^{-3}\ s) = 1{,}25$ KHz

Uso PRF stagger con 4 valori di PRF



Radar di ricerca (short range)

Risoluzione in azimuth: 2°
Rotazione antenna: 5 giri/minuto

Apertura del fascio: 2°

Dimensione antenna azimuth: $L=\lambda/(2/180*\pi) = 0,1/\pi*90 = 9/\pi \cong 3$ m

time-on-target = 2°/ (5*360/60)= 2°/ (5*6)=2/30=1/15=0,0667 s= 66,7 ms

N° Impulsi nel time-on-target = 1/15*PRF=1/15 *1,25 10^3=1250/15=83,3

In ogni batch: 83/4 ≅ 21 impulsi

Da batch a batch cambio non solo PRF, ma anche frequenza

Radar di ricerca (short range)

$P_{fa}= 10^{-6}$
$P_d= 0{,}9$ per bersaglio fisso con RCS= 1 m^2

Bersaglio fisso → serve SNR=13 dB

Assumendo di guadagnare un fattore 20 sul rumore termico per integrazione coerente (13 dB)
-Basta su singolo impulso un SNR= 0 dB

(considerando un guadagno di integrazione non coerente fra batch di 3 dB)
Possiamo pensare che bastino -3 dB.

Radar di ricerca (short range)

Potenza di picco TX: $P_p = 5$ KW
Figura di rumore: F= 3dB

$$SNR = \frac{P_p G A_e \sigma_{av}}{(4\pi)^2 R^4 L \;\; kT_0 F B} B\tau_P$$

A_e=0,5 *3*2 m^2=3 m^2 → 5 dB

G=4π*A_e/λ^2=4π*3/(0,1)^2 → 11+5-2*(-10) dB
= 16+20=36

R=120 Km → 51 dB

$\tau_P|_{dB}$=-45-3=-48 scegliamo → 20 10^{-6} s= 20 μs

	dB+	dB-
P_p	37	
G	36	
A_e	5	
σ	0	
τ_P		
$(4\pi)^2$		22
R^4		204
F		3
kT_0		-204
L		8
	78+$\tau_P|_{dB}$	33
	45+$\tau_P|_{dB}$	
SNR	-3	

Radar di ricerca (short range)

Risoluzione in distanza 200 m
Dinamica lineare istantanea 40 dB

$$SNR = \frac{P_p G A_e \sigma_{av}}{(4\pi)^2 R^4 L \; kT_0 FB} B\tau_P$$

Risoluzione 200 m =k*c/(2B)=1,4*3 10^8 /(2 B)
k=1,4 per Hamming

B=2,1 10^8 /200= 10^6 = 1 MHz

$B\tau_P$ = 1 MHz*20 μs=20 Forma d'onda "difficile" in termini di dinamica

Barker insufficiente,
Chirp ha lobi di Fresnel a $S.L.F.|_{dB} = 20\log(BT) + 3$ = 26+3= 29 dB
Frank ha lobi : $PSR = \pi\sqrt{N} = \pi\ M$ $\Rightarrow 9.94 + 10 * \log_{10}(N)$ N=1024= $(32)^2$

Radar di ricerca (short range)

Riflettività del clutter: -27 dB

Cella di clutter

$$cella\,di\,clutter = \frac{\tau_C}{2\sin\theta}\theta_{AZ}\,R$$

Cella di clutter corretta

$$cella\,di\,clutter\,corretta = \frac{\tau_C}{2\sqrt{2}\sin\theta}\theta_{AZ}\,R$$

$$CNR = \frac{P_p G A_e \sigma_0}{(4\pi)^2 R^4 L \quad kT_0 F B} B\tau_P \frac{c\tau_C}{2\sqrt{2}}\theta_{AZ} R$$

Radar di ricerca (short range)

Riflettività del clutter: -27 dB

$$SNR=\frac{P_p G A_e \sigma_{av}}{(4\pi)^2 R^4 L \;\; kT_0 F B} B\tau_P$$

$$CNR=\frac{P_p G A_e \sigma_0}{(4\pi)^2 R^4 L \;\; kT_0 F B} B\tau_P \frac{c\tau_C}{2\sqrt{2}} \theta_{AZ} R$$

$$SCR=\frac{\sigma_{av}}{\sigma_0 \frac{c\tau_C}{2\sqrt{2}} \theta_{AZ} R}=\frac{\sigma_{av}}{\sigma_0 \left(\frac{c\tau_C}{2}\right) \theta_{AZ} R}\sqrt{2}$$

$\theta_{AZ}=(2/180*\pi)=\pi/90 = 5-20=-15$

R=50 Km   47 dB

SCR	dB+	dB-
σ	0	
σ_0		-27
$c\tau_C/2$		23
θ_{AZ}		-15
R		47
$\sqrt{2}$	1,5	
	1,5	28
SCR	-26,5 dB	

Radar di ricerca (short range)

Spettro di clutter gaussiano
dev standard dello spettro di velocità σ_v=0.2 m/s

$$S(f) = P_c \frac{1}{\sqrt{2\pi}\sigma_f} e^{-\frac{f^2}{2\sigma_f^2}} \qquad R(t) = P_c \; e^{-2\pi^2\sigma_f^2 t^2}$$

$$R(K) = R(kPRT) = R(k/PRF) = P_c \; e^{-2\pi^2\left(\frac{\sigma_f}{PRF}\right)^2 k^2} = P_c \; \rho^{k^2}$$

$$\rho = e^{-2\pi^2\left(\frac{\sigma_f}{PRF}\right)^2}$$

σ_f=2 σ_v /λ =2 ∗0.2/0.1 = 4 Hz

$$\rho = \exp\left[-2\left(\pi\frac{\sigma_f}{PRF}\right)^2\right] = \exp\left[-2\left(\pi\frac{4}{1.25\;10^3}\right)^2\right] = \exp\left[-2\left(\frac{10}{10^3}\right)^2\right] = \exp\left[-2\;10^{-4}\right] = 0.9998$$

$$\rho^4 = \exp\left[-8\left(\pi\frac{\sigma_f}{PRF}\right)^2\right] = \exp\left[-8\;10^{-4}\right] = 0.9992 \qquad \rho^9 = \exp\left[-18\left(\pi\frac{\sigma_f}{PRF}\right)^2\right] = \exp\left[-18\;10^{-4}\right] = 0.9982$$

Radar di ricerca (short range)

Spettro di clutter gaussiano
dev standard dello spettro di velocità σ_v=0.2 m/s

Con singolo cancellatore:

$$IF(f_d) = \frac{\left|\sin(\pi f_d T)\right|^2 \int_{-\infty}^{\infty} S_i(f)\ df}{\int_{-\infty}^{\infty} \sin^2(\pi f T) S_i(f)\ df} = \frac{2\left|\sin(\pi f_d T)\right|^2 \int_{-\infty}^{\infty} S_i(f)\ df}{\int_{-\infty}^{\infty} \left[1-\cos(2\pi f T)\right] S_i(f)\ df} =$$

$$= \frac{2\sin^2(\pi f_d T)}{1-\mathrm{Re}\{\rho_i(T)\}} = \frac{2\sin^2(\pi f_d T)}{2\,10^{-4}} = 10^4 \sin^2(\pi f_d T)$$

$\rho = 0.9998$

Alla Doppler part a PRF/2 : $IF(f_d) = 10^4 \sin^2(\pi/2) \Leftrightarrow 40dB$

SCR_out= -26,5 dB+40 dB= 13,5 dB

Radar di ricerca (short range)

Potenza di picco TX: $P_p = 5$ KW
Figura di rumore: F= 3dB

$$SNR = \frac{P_p G A_e \sigma_{av}}{(4\pi)^2 R^4 L \ \ kT_0 FB} B\tau_P$$

A_e=5 dB

G=36 dB
R=50 Km → 47 dB
$\tau_P|_{dB}$= 20 μs → 13-60=-47 dB

$$SCNR = \frac{S}{C+N} = \frac{1}{1/SCR + 1/SNR} = \rightarrow 13{,}3\,dB$$

	dB+	dB-
P_p	37	
G	36	
A_e	5	
σ	0	
τ_P	-47	
$(4\pi)^2$		22
R^4		188
F		3
kT_0		-204
L		8
	31	17
SNR	14	
SNR	14+13=27	

Radar di ricerca (short range)

Spettro di clutter gaussiano
dev standard dello spettro di velocità σ_v=0.2 m/s

Con singolo cancellatore, a Doppler pari a PRF/20:

$$IF(f_d) = 10^4 \sin^2(\pi f_d T) = 10^4 \sin^2(\pi/20) = 10^4 (0{,}1564)^2 = 10^4\, 0{,}02447 = 40 - 16 = 24$$

SCR_out= -26,5 dB+24 dB= -2,5 dB

Radar di ricerca (short range)

Con cancellatore binomiale:

$$H(f)=\left(1-e^{j2\pi f/PRF}\right)^M=\sum_{n=0}^{M}\binom{M}{n}(-1)^n e^{j2\pi n\, f/PRF}$$

$$\left|H(f)\right|^2=\left|1-e^{j2\pi f/PRF}\right|^{2M}=\sum_{n=0}^{M}\sum_{k=0}^{M}\binom{M}{n}\binom{M}{n}(-1)^{n+k}e^{j2\pi(n-k)\, f/PRF}$$

$$\left|H(f)\right|^2=\left[2-2\cos(2\pi f/PRF)\right]^M=4^M\sin^{2M}(\pi f/PRF)=$$

$$=\frac{4^M}{(2j)^{2M}}\left[e^{j\pi f/PRF}-e^{-j\pi f/PRF}\right]^{2M}=(-1)^{-M}\sum_{n=0}^{2M}\binom{2M}{n}e^{j\pi n\, f/PRF}(-1)^{(2M-n)}e^{-j\pi(2M-n)\, f/PRF}=$$

$$=\sum_{n=0}^{2M}\binom{2M}{n}e^{-j2\pi(M-n)\, f/PRF}(-1)^{M-n}=\sum_{n=0}^{M-1}\binom{2M}{n}e^{-j2\pi(M-n)\, f/PRF}(-1)^{M-n}+\binom{2M}{M}+\sum_{n=M+1}^{2M}\binom{2M}{n}e^{-j2\pi(M-n)\, f/PRF}(-1)^{M-n}=$$

$$=\sum_{n=0}^{M-1}\binom{2M}{n}e^{-j2\pi(M-n)\, f/PRF}(-1)^{M-n}+\binom{2M}{M}+\binom{2M}{M}+\sum_{k=0}^{M-1}\binom{2M}{2M-k}e^{j2\pi(M-k)\, f/PRF}(-1)^{M-k}=$$

$$=\binom{2M}{M}+\sum_{n=0}^{M-1}\binom{2M}{n}(-1)^{M-n}\left[e^{-j2\pi(M-n)\, f/PRF}+e^{j2\pi(M-n)\, f/PRF}\right]=\binom{2M}{M}+2\sum_{n=0}^{M-1}\binom{2M}{n}(-1)^{M-n}\cos[2\pi(M-n)\ f/PRF]$$

$$k=2M-n\quad 2M-(M+1)=M-1\quad (M-n)=M-(2M-k)=-(M-k)$$

Radar di ricerca (short range)

Con cancellatore binomiale:

$$\int_{-\infty}^{\infty} |H(f)|^2 \, S_i(f)\, df =$$

$$\int_{-\infty}^{\infty} \binom{2M}{M} S_i(f)\, df + \int_{-\infty}^{\infty} \sum_{n=0}^{M-1} \binom{2M}{n} (-1)^{M-n} \left[e^{-j2\pi(M-n)\, f/PRF} + e^{j2\pi(M-n)\, f/PRF}\right] S_i(f)\, df =$$

$$= \binom{2M}{M} P_C + \sum_{n=0}^{M-1} \binom{2M}{n} (-1)^{M-n} \int_{-\infty}^{\infty} \left[e^{-j2\pi(M-n)\, f/PRF} + e^{j2\pi(M-n)\, f/PRF}\right] S_i(f)\, df =$$

$$= \binom{2M}{M} P_C + P_C \sum_{n=0}^{M-1} \binom{2M}{n} (-1)^{M-n} \left[\rho[-(M-n)/PRF] + \rho[(M-n)/PRF]\right] =$$

$$= \binom{2M}{M} P_C + 2P_C \sum_{n=0}^{M-1} \binom{2M}{n} (-1)^{M-n} \operatorname{Re}\{\rho[(M-n)/PRF]\} =$$

$$= \binom{2M}{M} P_C + 2P_C \sum_{m=1}^{M} \binom{2M}{M-m} (-1)^{m} \operatorname{Re}\{\rho[m/PRF]\}$$

$m = M - n \quad n = M - m \qquad n = 0 \; m = M \quad n = M - 1 \; m = 1$

Radar di ricerca (short range)

Con cancellatore binomiale:

$$\int_{-\infty}^{\infty} |H(f)|^2 \; S_i(f)\; df = \binom{2M}{M} P_C + 2P_C \sum_{m=1}^{M} \binom{2M}{M-m} (-1)^m \; \mathrm{Re}\{\rho[m/PRF]\}$$

$M = 1$

$$\rightarrow 2P_C + 2P_C \sum_{m=1}^{1} \binom{2}{1-m} (-1)^m \; \mathrm{Re}\{\rho[m/PRF]\} = 2P_C\left[1 - \mathrm{Re}\{\rho[PRT]\}\right]$$

$M = 2$

$$\rightarrow \binom{4}{2} P_C + 2P_C \sum_{m=1}^{2} \binom{4}{2-m} (-1)^m \; \mathrm{Re}\{\rho[m/PRF]\} = 6 - 8\; \mathrm{Re}\{\rho[PRT]\} + 2\,\mathrm{Re}\{\rho[2\,PRT]\}$$

$M = 3$

$$\rightarrow \binom{6}{3} P_C + 2P_C \sum_{m=1}^{3} \binom{6}{3-m} (-1)^m \; \mathrm{Re}\{\rho[m/PRF]\} =$$

$$= P_C\left[\binom{6}{3} - 2\binom{6}{2}\mathrm{Re}\{\rho[PRT]\} + 2\binom{6}{1}\mathrm{Re}\{\rho[2PRT]\} - 2\binom{6}{0}\mathrm{Re}\{\rho[3PRT]\}\right] =$$

$$= P_C\left[20 - 30\; \mathrm{Re}\{\rho[PRT]\} + 12\,\mathrm{Re}\{\rho[2\,PRT]\} - 2\,\mathrm{Re}\{\rho[3PRT]\}\right]$$

Radar di ricerca (short range)

Con cancellatore binomiale:

$$IF(f_d)=\frac{|H(f)|^2\int_{-\infty}^{\infty} S_i(f)\ df}{\int_{-\infty}^{\infty}|H(f)|^2 S_i(f)\ df}=\frac{4^M\ \sin^{2M}(\pi\, f_d\, T)P_C}{\binom{2M}{M}P_C+2P_C\sum_{m=1}^{M}\binom{2M}{M-m}(-1)^m\ \mathrm{Re}\{\rho[m/PRF]\}}=\frac{4^M\ \sin^{2M}(\pi\, f_d\, T)}{\binom{2M}{M}+2\sum_{m=1}^{M}\binom{2M}{M-m}(-1)^m\ \mathrm{Re}\{\rho[m/PRF]\}}$$

$M=1$

$$IF(f_d)=\frac{4\sin^2(\pi\, f_d\, T)}{2\left[1-\mathrm{Re}\{\rho[PRT]\}\right]}$$

$M=2$

$$IF(f_d)=\frac{16\sin^4(\pi\, f_d\, T)}{6-8\,\mathrm{Re}\{\rho[PRT]\}+2\,\mathrm{Re}\{\rho[2PRT]\}}$$

$M=3$

$$IF(f_d)=\frac{64\sin^6(\pi\, f_d\, T)}{20-30\,\mathrm{Re}\{\rho[PRT]\}+12\,\mathrm{Re}\{\rho[2PRT]\}-2\,\mathrm{Re}\{\rho[3PRT]\}}$$

Radar di ricerca (short range)

Con cancellatore binomiale: $\rho = 0.9998 \quad \rho^4 = 0.9992 \quad \rho^9 = 0.9982$

$$f_d T = 1/20 \rightarrow 10\log_{10}\sin(\pi f_d T) = -8$$

$M = 1$

$$IF(f_d) = \frac{4\sin^2(\pi f_d T)}{2[1-\mathrm{Re}\{\rho[PRT]\}]} = \frac{2\sin^2(\pi f_d T)}{1-0.9998} = \frac{\sin^2(\pi f_d T)}{10^{-4}} \rightarrow 40+2*10\log_{10}(\pi f_d T)\ dB$$

$f_d T = 1/2 \quad IF = 40dB \qquad f_d T = 1/20 \quad IF = 24dB$

$M = 2$

$$IF(f_d) = \frac{16\sin^4(\pi f_d T)}{6-8\,\mathrm{Re}\{\rho[PRT]\}+2\mathrm{Re}\{\rho[2PRT]\}} = \frac{8\sin^4(\pi f_d T)}{3-4\cdot 0.9998+0.9992} = \frac{\sin^4(\pi f_d T)}{3\cdot 10^{-8}} \rightarrow 75+4*10\log_{10}(\pi f_d T)\ dB$$

$f_d T = 1/2 \quad IF = 75dB \qquad f_d T = 1/20 \quad IF = 43dB$

$M = 3$

$$IF(f_d) = \frac{64\sin^6(\pi f_d T)}{20-30\mathrm{Re}\{\rho[PRT]\}+12\mathrm{Re}\{\rho[2PRT]\}-2\mathrm{Re}\{\rho[3PRT]\}} = \frac{\sin^6(\pi f_d T)}{1.5\cdot 10^{-11}} \rightarrow 108{,}5+6*10\log_{10}(\pi f_d T)$$

$f_d T = 1/2 \quad IF = 108{,}5dB \qquad f_d T = 1/20 \quad IF = 60{,}5dB$

Radar di ricerca (short range)

Con cancellatore binomiale:

$$\left|H(f)\right|^2 = \binom{2M}{M} + 2\sum_{n=0}^{M-1}\binom{2M}{n}(-1)^{M-n}\cos[2\pi(M-n)\ f/PRF]$$

$$\frac{1}{PRF}\int_{-PRF/2}^{PRF/2}\left|H(f)\right|^2 df = \frac{1}{PRF}\int_{-PRF/2}^{PRF/2}\binom{2M}{M}df + \frac{1}{PRF}\int_{-PRF/2}^{PRF/2}2\sum_{n=0}^{M-1}\binom{2M}{n}(-1)^{M-n}\cos[2\pi(M-n)\ f/PRF]df = \binom{2M}{M} = \frac{(2M)!}{(M!)^2}$$

$$M=1 \qquad \rightarrow \frac{(2M)!}{(M!)^2} = 2$$

$$M=2 \qquad \rightarrow \frac{(2M)!}{(M!)^2} = 4*3/2 = 6$$

$$M=3 \qquad \rightarrow \frac{(2M)!}{(M!)^2} = 6*5*4/(3*2) = 20$$

Radar di ricerca (short range)

Con cancellatore binomiale:

$$IF\_medio = \frac{\frac{1}{PRF}\int_{-PRF/2}^{PRF/2} |H(f)|^2 df \int_{-\infty}^{\infty} S_i(f)\ df}{\int_{-\infty}^{\infty} |H(f)|^2 S_i(f)\ df} = \frac{\binom{2M}{M}}{\binom{2M}{M} + 2\sum_{m=1}^{M}\binom{2M}{M-m}(-1)^m \ \mathrm{Re}\{\rho[m/PRF]\}} = \frac{1}{1+2\sum_{m=1}^{M}\frac{(-1)^m\ (M!)^2}{(M-m)!(M+m)!}\mathrm{Re}\{\rho[m/PRF]\}}$$

$$\binom{2M}{M-m}\Big/\binom{2M}{M} = \frac{(2M)!}{(M-m)!(M+m)!}\frac{(M!)^2}{(2M)!} = \frac{(M!)^2}{(M-m)!(M+m)!}$$

$M = 1$

$$IF\_medio = \frac{2}{2\left[1-\mathrm{Re}\{\rho[PRT]\}\right]} = \frac{1}{1-\mathrm{Re}\{\rho[PRT]\}} = \frac{1}{2\ 10^{-4}} \to 37\ \ dB$$

$M = 2$

$$IF\_medio = \frac{6}{6-8\ \mathrm{Re}\{\rho[PRT]\}+2\mathrm{Re}\{\rho[2PRT]\}} = \frac{1}{1-4/3\ \mathrm{Re}\{\rho[PRT]\}+1/3\mathrm{Re}\{\rho[2PRT]\}} = \frac{1}{8\cdot 10^{-8}} \to 71\ dB$$

$M = 3$

$$IF\_medio = \frac{20}{20-30\ \mathrm{Re}\{\rho[PRT]\}+12\mathrm{Re}\{\rho[2PRT]\}-2\mathrm{Re}\{\rho[3PRT]\}} =$$

$$= \frac{1}{1-3/2\ \mathrm{Re}\{\rho[PRT]\}+3/5\mathrm{Re}\{\rho[2PRT]\}-1/10\mathrm{Re}\{\rho[3PRT]\}} = \frac{1}{4{,}8\cdot 10^{-11}} \to 103\ dB$$

Radar di ricerca (short range)

Effetto rotazione antenna:

$\sigma_v = 0,2\ m/s$

$$\sigma_f = \frac{2}{\lambda}\sigma'_v$$

$$\sigma'_v = \sqrt{\sigma_v^2 + \sigma_A^2}$$

$$\sigma_A = 0.13\ \frac{\lambda PRF}{N} = 0.13\ \frac{\lambda}{ToT} = 0.13\ \lambda\ \frac{\omega_a}{\theta_0}$$

$\frac{PRF}{N} \rightarrow \frac{1}{NT} = \frac{1}{T_{ot}}$

$0{,}26 \cdot \frac{\lambda}{2} \cdot \frac{PRF}{N}$

$$\sigma_A = 0.13\ \frac{\lambda}{ToT} = 0.13\ \frac{0.1}{66.7\ 10^{-3}} = \frac{13}{66.7} = 0.195$$

$$\sigma'_v = \sqrt{\sigma_v^2 + \sigma_A^2} = 0.27925$$

$$\sigma_f = \frac{2}{\lambda}\sigma'_v = 5.585\,Hz$$

$$\rho = \exp\left[-2\left(\pi\frac{\sigma_f}{PRF}\right)^2\right] = \exp\left[-2\left(\pi\frac{5.584}{1.25\ 10^3}\right)^2\right] = 0.9996$$

Radar di ricerca (short range)

Con cancellatore binomiale: $\rho = 0.999$ $\rho^4 = 0.996$ $\rho^9 = 0.991$

$$f_d T = 1/20 \rightarrow 10\log_{10}\sin(\pi f_d T) = -8$$

$M = 1$

$$IF(f_d) = \frac{4\sin^2(\pi f_d T)}{2\left[1-\mathrm{Re}\{\rho[PRT]\}\right]} = \frac{2\sin^2(\pi f_d T)}{1-0.999} = \frac{2\sin^2(\pi f_d T)}{10^{-3}} \rightarrow 33+2*10\log_{10}(\pi f_d T) \;\; dB$$

$$f_d T = 1/2 \;\; IF = 33dB \qquad f_d T = 1/20 \;\; IF = 17dB$$

$M = 2$

$$IF(f_d) = \frac{16\sin^4(\pi f_d T)}{6-8\,\mathrm{Re}\{\rho[PRT]\}+2\mathrm{Re}\{\rho[2PRT]\}} = \frac{8\sin^4(\pi f_d T)}{3-4\cdot 0.999+0.996} = \frac{8\sin^4(\pi f_d T)}{10^{-7}} \rightarrow 61+4*10\log_{10}(\pi f_d T)\, dB$$

$$f_d T = 1/2 \;\; IF = 61dB \qquad f_d T = 1/20 \;\; IF = 29dB$$

$M = 3$

$$IF(f_d) = \frac{64\sin^6(\pi f_d T)}{20-30\mathrm{Re}\{\rho[PRT]\}+12\mathrm{Re}\{\rho[2PRT]\}-2\mathrm{Re}\{\rho[3PRT]\}} \rightarrow 87{,}5+6*10\log_{10}(\pi f_d T)$$

$$f_d T = 1/2 \;\; IF = 87{,}5dB \qquad f_d T = 1/20 \;\; IF = 39{,}5dB$$

Radar di ricerca (short range)

Spettro di clutter gaussiano largo

Con triplo cancellatore:

A Doppler pari a PRF/2:

SCR_out= -26,5 dB+87,5 dB= 61 dB

A Doppler pari a PRF/20:

SCR_out= -26,5 dB+39,5 dB= 13 dB