UNIT 4

(1). 1KW, 3GHz Radar uses single Antenna with gain 30dB. The Rx has a B.W of 3KHz & noise factor of 5dB. σ is $10m^2$. Find the Range, If gain is increased to 60dB find the range, Find sensitivity of the reciever.

Sol:- Given, $P_t = 1KW$, $f = 3GHz \Rightarrow \lambda = \frac{c}{f} = 0.1m$, $\delta f = 3KHz$,

$F = \text{antilog}\frac{5}{10} = 3.16$; $\sigma = 10m^2$, $A_p = 30dB$

$\rightarrow A_p = \frac{4\pi A_0}{\lambda^2} \Rightarrow A_0 = \frac{A_p\lambda^2}{4\pi} = \frac{30 \times 0.1 \times 0.1}{4 \times 3.14} = 0.0238$

$\rightarrow A_0 = \frac{\eta \pi D^2}{4} \Rightarrow D^2 = \frac{A_0 \times 4}{\eta \times \pi} = \frac{0.0238 \times 4}{3.14 \times 0.65} = 0.04681$

$$\rightarrow r_{max} = 48\left[\frac{P_t \times D^4 \times \sigma}{\delta f \times \lambda^2 \times (F-1)}\right]^{1/4}$$

$$= 48\left[\frac{1000 \times 0.04681 \times 0.04681 \times 10}{3000 \times 0.1 \times 0.1 \times (3.16-1)}\right]^{1/4} \text{Km}$$

$$= 48\left[0.338\right]^{1/4} \text{km} = 36.59 \text{ Km}$$

$\rightarrow$ Sensitivity $= P_{min} = KT_0\delta f(F-1)$

$= 1.38 \times 10^{-23} \times 273 \times 3000 \times (3.16-1)$

$= 2441275.2 \times 10^{-23}$ W

$= 2.44 \times 10^{-17}$ W

$\rightarrow$ for $A_p = 60dB$ $\quad r_{max} = 52.12$ KM

$A_0 = 0.9477$

$D^2 = 0.0936$

(2). A 10GHz pulse radar operates with an antenna of 3m diametre, the Rx BW is 1KHz & noise factor is 6. If Tx power is 1KW, S is 2m². Find the range If F = 3 & D = 6m. Find range.

Sol:- Given, $f = 10GHz \Rightarrow \lambda = \frac{c}{f} = 0.03m$

$D = 3m$, $\delta f = 1KHz$, $F = 6$, $P_t = 1KW$, $S = 2m^2$

$$r_{max} = 48 \times \left[\frac{P_t D^4 S}{\delta f \lambda^2 (F-1)}\right]^{1/4} = 48\left[\frac{1000 \times 9 \times 9 \times 2}{1000 \times 0.03 \times 0.03 \times 5}\right]^{1/4}$$

$= 870.156 Km$

~~1Km = 1.852 NM~~

$\boxed{1NM = 1.852 Km}$

= ~~[illegible]~~

= 469.84 nautical miles

If F = 3 & D = 6m.

$$r_{max} = 48 \times \left[\frac{1000 \times 64 \times 64 \times 2}{1000 \times 0.03 \times 0.03 \times 2}\right]^{1/4}$$

$$= 48 \times \left[\frac{8192}{0.6}\right]^{1/4} = 518.86 Km$$

= 280.16 nautical miles

(3) A pulse radar operates at 5 GHz with a peak pulse power of 400 kW & min detectable power of −103 dB, area of 3 m² & can detect target of cross section area of 10 m². Find the R_{max} in N. miles. If BW of Rx is 5 KHz. Find N.F of Rx & power gain of Antenna.

$\rightarrow (P_{min})_{dB} = -103\,dBm = 5.0118 \times 10^{-14}\,W$

$$P_{min} = KT\delta f\,(F-1)$$

$$5.01 \times 10^{-14} = 1.38 \times 10^{-23} \times 273 \times 5000 \times (F-1)$$

$$F = 2661 //$$

$\rightarrow P_t = 400\,kW, \quad \lambda = \frac{c}{f} = 0.06$

$$A_0 = \frac{\eta \pi D^2}{4} = \frac{0.65 \times \pi \times 12}{4 \times \pi}$$

$$= 1.95\,dB$$

$$\boxed{\begin{aligned} &\cancel{100} \\ &A = \pi r^2 \\ &3 = \frac{\pi D^2}{4} \\ &D^2 = 12/\pi \end{aligned}}$$

$$\text{Antenna pow Gain } (A_p) = \frac{4\pi A_0}{\lambda^2} = \frac{4 \times \pi \times 1.95}{0.06 \times 0.06} = 6803.33\,dB //$$

$$\rightarrow r_{max} = \cancel{4\left(\frac{P_t A_0^2 S}{4\pi\lambda^2 P_{min}}\right)}\; 48 \times \left[\frac{P_t \times D^4 \times S}{\delta f \times \lambda^2 \times (F-1)}\right]^{1/4}$$

$$= 48 \times \left[\frac{400 \times 1000 \times 12/\pi \times 12/\pi \times 10}{5000 \times 0.06 \times 0.06 \times 2660}\right]^{1/4}$$

$$= 48 \times [1220.138]^{1/4} = 283.68\,Km //$$

(4). A radar has a N.F of 4.77dB, and diametre 1m. If BW of the Rx is 500 KHz at 8GHz. Radar can detect target of cross-sectional area $5m^2$ at a distance of 12km. Find P_t.

Given, $F = 4.77dB = \text{antilog}\,\frac{4.77}{10} = 2.991$

$D = 1m$, $\delta f = 500\,KHz$, $f = 8GHz$

$\lambda = \frac{c}{f} = 0.0375$, $\sigma = 5m^2$, $r_{max} = 12\,km$

$$r = 48 \times \left[\frac{P_t D^4 \sigma}{\delta f \lambda^2 (F-1)}\right]^{1/4}$$

$$\left(\frac{12}{48}\right)^4 = \left[\frac{P_t \times 1 \times 5}{500 \times 1000 \times 0.0375 \times 0.0375 \times 1.991}\right]$$

$$3.906 \times 10^{-03} = \frac{P_t\, 5}{1399.92}$$

$$P_t = \frac{5468.09 \times 10^{-3}}{5}$$

$$P_t = 1.093\,KW$$ //

Since, we took r in km, here we get KW.

(5). Find the R_{max} of a 2GHz Radar with $P_t = 25MW$ antenna $D = 70m$, target c/s area $2m^2$. N.F = 1.1, B.W of Rx 5KHz. Find sensitivity of the Rx.

Sol:- Given, $f = 2GHz \Rightarrow \lambda = \frac{c}{f} = 0.15m$

$P_t = 25MW$, $D = 70m$, $\sigma = 2m^2$, $F = 1.1$, $\delta f = 5KHz$,

Sensitivity, $P_{min} = KT\delta f(F-1)$.

$= 188370 \times 10^{-23} W$

$$R_{max} = 48 \times \left[\frac{P_t D^4 \sigma}{\delta f \lambda^2 (F-1)} \right]^{1/4}$$

$$= 48 \times \left[\frac{25 \times 10^6 \times 2401000 \times 2m}{5000 \times 0.15 \times 0.15 \times 0.1} \right]$$

$= 4878.58 Km$

(6). A 1MW, pulse radar with $\lambda = 5.6 cm$, antenna gain 44dB, Rx BW 1.6MHz, F = 10dB, $\sigma = 1m^2$. Find r_{max} in Km & N.miles. Find sensitivity.

Given, $P_t = 1MW$, $\lambda = 0.056m$, $A_p = 44dB$

$\delta f = 1.6MHz$, $F = 10dB = \text{antilog} \frac{10}{10} = 10$

$\sigma = 1m^2$.

$\rightarrow A_0 = \frac{A_p \lambda^2}{4\pi} = \frac{44 \times 0.056 \times 0.056}{4 \times 3.14} = 0.0109$

$\rightarrow D^2 = \frac{A_0 4}{\eta \pi} = \frac{0.0109 \times 4}{0.65 \times 3.14} = 0.0215$

$$r_{max} = 48 \times \left[\frac{10^6 \times 0.0215 \times 0.0215 \times 1}{1.6 \times 10^6 \times 0.056 \times 0.056 \times 9} \right]^{1/4}$$

$$= 48 \times (0.01025)^{1/4}$$

$$= 15.27 \text{ Km}$$

$$= 8.246 \text{ N. miles}$$

Sensitivity. $P_{min} = KT\delta F(F-1)$

$$= 1.38 \times 10^{-23} \times 273 \times 1.6 \times 10^6 \times 9$$

$$= 5425.056 \times 10^{-17} \text{ W}$$

(7). Find the range of radar beacon with

Radar

$P_{tT} = 0.5\,MW$; $F_T = 1.1$

$\delta f = 5\,KHz$ λ

$D_1 = 4m$, $f = 2.5\,GHz$

$\sigma = 1m^2$

Beacon

$P_{tB} = 25\,mW$

$D_2 = 1m$

$F_b = 13\,dB = \text{antilog } 1.3$

$= 10^{1.3} \approx 20$

Sol:- $A_{oB} \rightarrow$ power Gain of Txn Beacon Antenna

$$A_{oB} = \frac{\eta \pi D^2}{4} = \frac{0.65 \times \pi \times 1}{4} = 0.510\,dB$$

$A_{pT} \rightarrow$ Txn power from base station

$$A_{pT} = \frac{4\pi A_{oT}}{\lambda^2} \qquad \lambda = \frac{3 \times 10^8}{2.5 \times 10^9} = 0.12m$$

$A_{oT} \rightarrow$ power gain of Basestation Txn Antenna

$$A_{oT} = \frac{\eta \pi D^2}{4} = \frac{0.65 \times \pi \times 16}{4} = 8.164\,dB$$

When the Basestation is Transmitting

$$r_{max} = \sqrt{\frac{A_{oB}\ P_{tT}\ A_{oB}}{K T_o \delta f \lambda^2 (F_B - 1)}}$$

$$= \sqrt{\frac{0.51 \times 0.5 \times 10^9 \times 8.164}{1.38 \times 10^{-23} \times 273 \times 5000 \times 0.12 \times 0.12 \times (20-1)}}$$

$$= \sqrt{\cancel{4.524 \times 10^{14}}} \quad 6.35 \times 10^8\,km$$

$= \cancel{2.14 \times 10^7\,km}$

We can also find the range when the beacon is transmitting.

$$r_{max} = \sqrt{\frac{A_{eB} \, P_{tB} \, A_{eT}}{K T_0 \delta f \lambda^2 (F_T - 1)}}$$

$$= \sqrt{\frac{0.51 \times 25 \times 10^{-3} \times 8.164}{1.38 \times 10^{-23} \times 273 \times 5000 \times 0.12 \times 0.12 \times (1.1 - 1)}}$$

$$= \sqrt{0.038374 \times 10^{20}}$$

$$= 0.195893 \times 10^{10}$$

$$= 19589.3 \times 10^{5} \text{ Km} \rightarrow (2)$$

Beacon Range is usually the min of (1) & (2)

Hence, Beacon Range is ~~[illegible]~~ Km

$$\min(6.35 \times 10^{8}, 19.589 \times 10^{8} \text{ Km})$$

$$\Rightarrow 6.35 \times 10^{8} \text{ Km}$$