RF Tasarım

RF Link, Antenna Gain, Path Loss, Link Margin

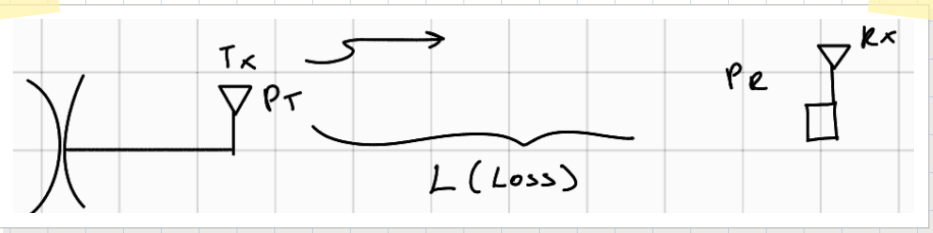
Orijinal not: Ders9.pdf

UYARI Bu belge, el yazısı ders notlarından Claude (Anthropic) yardımıyla dijitale aktarılmıştır. Yardımcı kaynak olarak hazırlanmıştır; hata veya eksik içerebilir. Lütfen orijinal notları ve ders kaynaklarını esas alın.

NOTICE *This document was transcribed from handwritten lecture notes with the help of Claude (Anthropic). It is meant as a supplementary resource and may contain errors or omissions. Always check against the original notes and official course material.*

orj. s. 1

RF link

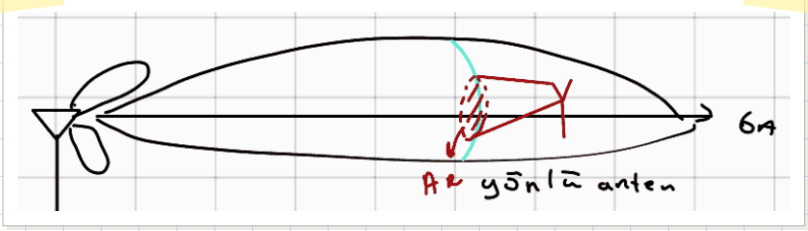


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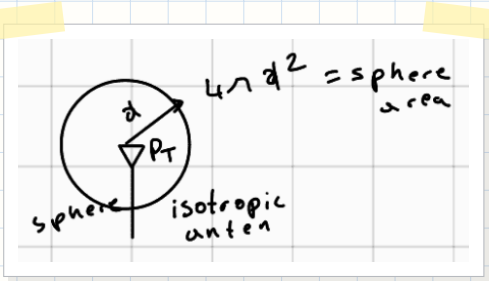
1) Antenna Gain

Antenna efficiency $\eta = \frac{P_T}{P_{in}} < 1$

$$G_A = \frac{\text{Maximum power density of the actual antenna}}{\text{power density of isotropic antenna}}$$



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orijinal çizim, s. 1

eğer P_T gücünü yayıyorsa

$$\underbrace{P_D}_{\text{power density}} = \frac{P_T}{4\pi d^2}$$

Antenler her yöne eşit dağılım yapmaz. Bu nedenle her yöne eşit dağılım yaptığını varsaydığımız isotropic antenle mukayese ederiz

$$G_A \rightarrow P_D = \frac{P_T \cdot \overbrace{G_A}^{\text{if antenna has gain}}}{4\pi d^2}$$

if antenna has Gain and efficiency

$$\rightarrow P_D = \frac{P_T G_A \eta}{4\pi d^2} \; [W/m^2]$$

→ Güç yoğunluğu mesafenin karesiyle ters orantılı olarak değişiyor.

Alıcıdaki:

for

$$R_x \rightarrow A_R = \frac{G_R \cdot \overbrace{\lambda}^{\text{wave length}}{}^2}{4\pi} \; [m^2] \rightarrow \underset{\text{(Etkin açıklık)}}{\text{Effective Arpeture Size}}$$

$$P_R = P_D A_r$$

$$P_R = \frac{P_T G_A \cdot \eta_A}{4\pi d^2} \cdot \frac{G_R \cdot \lambda^2 (\eta_r)}{4\pi}$$

$$P_R = P_T \cdot G_A \cdot G_R \cdot \eta_A \cdot \eta_R \left(\frac{\lambda}{4\pi d}\right)^2$$

Tx antenna: G_A, η_A Rx antenna: G_R, η_R

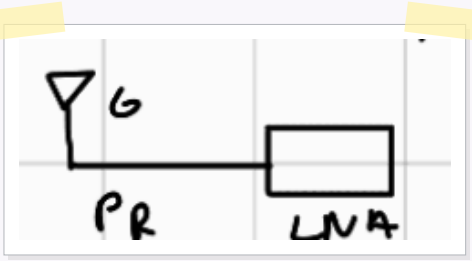
orj. s. 2

$$P_R|_{dBm} = P_T|_{dBm} + \underbrace{G_A|_{dB} + G_R|_{dB} + \eta_A|_{dB} + \eta_R|_{dB} + \overbrace{20\log\left(\frac{\lambda}{4\pi d}\right)}^{L_{path,loss(LOS)}}}_{L_{link\,dB}(LOS)\text{ Line of side}}$$

→ Alıcıyla vericinin birbirini gördüğü durum için

Örnek

point-point (LOS)
G_R = 60 dB
f = 60 GHz
$P_{density}$ = 1 pW/cm^2
what is the power at output of antenna connected to RF electronics



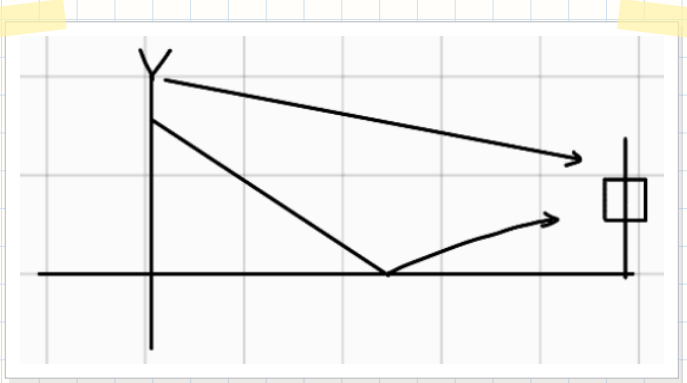
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$$\lambda = \frac{c}{f}$$

$$A_R = \frac{G_R \cdot \lambda^2}{4\pi} = \frac{10^6\left(\frac{3\cdot 10^8}{60\cdot 10^9}\right)^2}{4\pi} = 1{,}99\ m^2 \approx 2\ m^2$$

$$P_R = P_D \cdot A_R = \frac{10^{-12}}{cm^2} \cdot 2\cdot 10^4\ cm^2 = 20\ nW$$

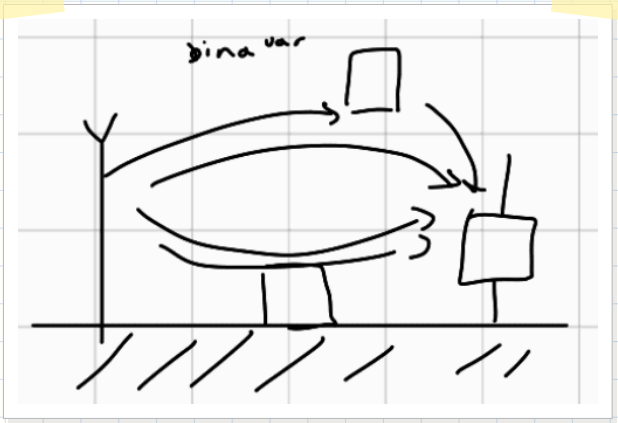
LOS olmazsa



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direct signal is dominant

Ricean fading $\left[\frac{1}{d}\right]$



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$$\rightarrow \frac{\text{reflected waves}}{\text{Rayleigh fading}} \left[\frac{1}{d^4}\right]$$

$$L_{path,loss}(LOS) = \left(\frac{4\pi d}{\lambda}\right)^2$$

$$L_{path,loss}\underbrace{(NLOS)}_{\substack{\text{non line}\\ \text{of side}}} = \left(\frac{4\pi d}{\lambda}\right)^2 (d)^{n-2}$$

n: number of paths

$$L_{path,NLOS}|_{dB} = 20\log\left(\frac{4\pi d}{\lambda}\right) + 10(n-2)\log(d)$$

$$= 10n\log(d) + 20\log\left(\frac{4\pi}{\lambda}\right)$$

orj. s. 3

Örnek

$f = 5{,}6$ GHz
$G_A = 35$ dB
$G_R = 6$ dB
$d = 200$ m
$\frac{1}{d^3} \rightarrow n = 3$

$$L_{Link} = -G_A - G_R + 10n\log(d) + 20\log\left(\frac{4\pi}{\lambda}\right)$$

$$= -35 - 6 + 10 \cdot 3\log(100)^{1} + 20\log\left(\frac{4\pi}{\frac{3 \cdot 10^8}{5{,}6 \cdot 10^9}}\right)$$

$$= 75{,}4 \text{ dBm}$$

Link Margin

$$P_R = P_T - L_{Link}$$

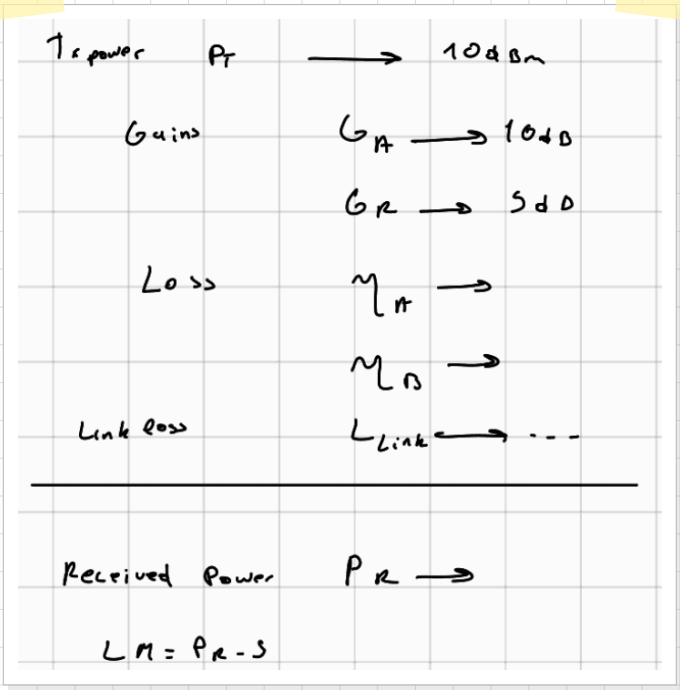
$$\underbrace{LM}_{\text{Link Margin}} = P_R - \overbrace{S}^{\text{alıcı hassasiyeti}}$$

$$S = -100 \text{ dBm}$$
$$P = -97 \text{ dBm}$$
$$LM = -97 - (-100)$$
$$LM = 3 \text{ dB}$$

Bu linkte oluşabilecek bozulmalara 3 dBm bir pay bulunmaktadır. Eğer 5 dBm'lik bir bozulma olursa alıcı artık çalışmıyordur (3 – 5 = –2 dBm)

[1] Claude notu: d = 200 m olduğundan muhtemelen log(200) olmalı (75,4 sonucu buna uyuyor).

Link Budget Table



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