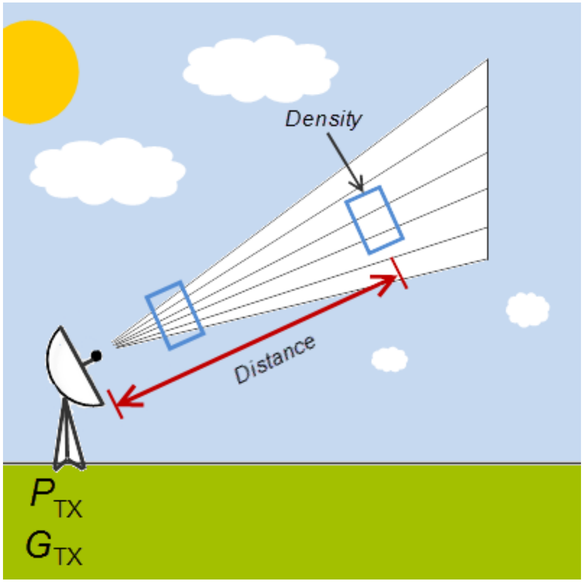
18ECE223T – Satellite Communication and Broadcasting

Unit 2 – Link Design

Formulas for Problem Solving

1. To find the power flux density at a distance R from the transmitting antenna



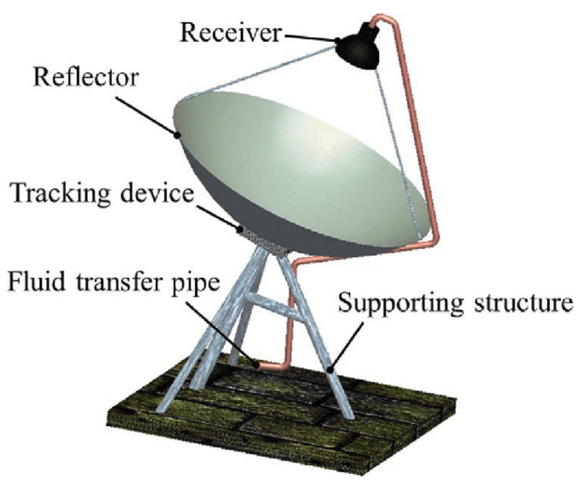
$$\Psi_M = \frac{GP_S}{4\pi r^2}$$

Ψ_m – Maximum Power Flux Density at a point
P_s – Source Power or Transmitted Power also denoted as P_t
r – distance between transmitting antenna and the point where flux density is measured
G – Gain of the transmitting antenna

2. To find Gain of a Parabolic Reflector Antenna

$$G = \eta(10.472fD)^2$$

f is the carrier frequency in GHz
D is the reflector diameter in m
η is the aperture efficiency
η range (0.55 to 0.73)



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3. **To find Equivalent Isotropic Radiated Power**

$$\mathrm{EIRP} = \mathrm{GP}_S$$

EIRP in dBW (decibel relative to 1 W) is expressed as

$$[\mathrm{EIRP}]_{\mathrm{dBW}} = 10\log_{10}(\mathrm{G}) + 10\log_{10}(\mathrm{P_s})$$

4. **To find received power P_R in a receiver at a distance r from the transmitting antenna <u>(considering only free space loss)</u>**

$$\begin{aligned} P_R &= \Psi_M A_{\mathrm{eff}} \\ &= \frac{\mathrm{EIRP}}{4\pi r^2}\frac{\lambda^2 G_R}{4\pi} \\ &= (\mathrm{EIRP})(G_R)\left(\frac{\lambda}{4\pi r}\right)^2 \end{aligned}$$

G_R – Gain of the receiving antenna

EIRP - $G_T P_T$ (Product of Gain of transmitting antenna and transmitted power)

$\lambda = c/f$ - Wavelength of the signal

c – Velocity of light in free space (3×10^8 m/s)

f – frequency of the signal

5. **To calculate received power in dBW <u>(only with free space loss)</u>**

$$[P_R] = [\mathrm{EIRP}] + [G_R] - 10\log\left(\frac{4\pi r}{\lambda}\right)^2$$

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$$[P_R] = [\mathrm{EIRP}] + [G_R] - [\mathrm{FSL}]$$

$$[\mathrm{FSL}] = 10\log\left(\frac{4\pi r}{\lambda}\right)^2$$

FSL is Free Space Loss

6. **To find received power considering all losses**

$$[P_R] = [\mathrm{EIRP}] + [G_R] - [\mathrm{LOSSES}]$$

$$[\mathrm{LOSSES}] = [\mathrm{FSL}] + [\mathrm{RFL}] + [\mathrm{AML}] + [\mathrm{AA}] + [\mathrm{PL}]$$

where [PR] = received power, dBW
[EIRP] = equivalent isotropic radiated power, dBW
[FSL] = free-space spreading loss, dB
[RFL] = receiver feeder loss, dB
[AML] = antenna misalignment loss, dB
[AA] = atmospheric absorption loss, dB
[PL] = polarization mismatch loss, dB