**Satellite link Design :-

We want to maintane the bit error rate & S/N ratio for this purpose we calculate all the Losses. Let us consider an isotropic source.

EIRP = Effective Isotropic Radiated power

EIRP $= P_t G_t$

$\longleftarrow$ R m distance $\longrightarrow$

Same Recieved Power

G_t = Gain of Tx antenna

$$P_R = \frac{P_t G_t}{4\pi R^2} A_r$$

Link design limited by many factors but mainly weight of satellite, frequency band, maximum diemention of Ground antenna.

$$\text{Cost of satellite} \propto \frac{1}{\text{Weight}}$$

for omnidirection fluxdensity -

$$F = \frac{P_t}{4\pi R^2} \quad W/m^2$$

$$G(\theta) = \frac{P(\theta)}{P_0/4\pi}$$

where $P(\theta)$ = Power radiated per unit solid angle

P_0 = Omnidirectional Power

$G(\theta)$ = Gain of antenna at angle θ,

Normaly $G(\theta)$ defined at $\theta = 0$, This size is often called bore size of antenna

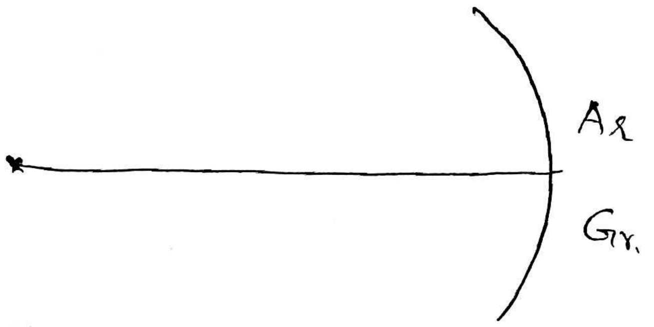
$G(\theta)$ is a major measure of the increase in flux density radiated from the antenna over that from an ideal isotropic antenna radiating the same total power.

Recieved flux density -

$$F = \frac{P_t G_t}{4\pi R^2} \quad W/m2$$

$$P_t G_t = EIRP$$

= Isotropic Radiative Power



A_r = area of antenna, & Having Gain G_{Ar}

Recieved power,

$$\boxed{P_r = \frac{P_t G_t}{4\pi R^2} A_e}$$

where A_e = effective area

$= \eta_A A_r$, A_r = Area of recieving antenna.

η_A = Aperture effeciency.

All the losses includes following parameters -

→ 1. Illumination effeciency

→ 2. Spill over effeciency

→ 3. Blockage

→ 4. Phase errors

→ 5. Deflection effect

→ 6. Polarisation mismatch Losses.

$$G_r = \frac{4\pi A_e}{\lambda^2}$$

so recieved power can be written as -

$$P_r = \frac{P_t G_t G_r}{(4\pi R/\lambda)^2}$$

This can be also written as-

$$\boxed{P_r = P_t G_t G_r \left(\frac{\lambda}{4\pi R}\right)^2}$$

above equation called basic link equation where $\left(\frac{\lambda}{4\pi R}\right)$ $\left(\frac{4\pi R}{\lambda}\right)^2$ called path Loss. The path loss is a loss in the sense of energy being spreads out not power being absorbed.

Basic link equation can be also written as-

$$P_r = \frac{\text{EIRP} \times \text{Gain of Recieving antenna}}{\text{Path Loss}}$$

$$\left.\begin{aligned} P_r \text{ in dB} &= (\text{EIRP} + G_r - L_p) \text{ dB W} \\ \text{EIRP} &= 10 \log (P_t G_t) \quad \text{dB} \\ G_r &= 10 \log \left[\frac{4\pi A_e}{\lambda^2}\right] \quad \text{dB} \\ L_p &= 10 \log \left[\frac{4\pi R}{\lambda}\right]^2 \text{ dB} \end{aligned}\right\} \begin{array}{l}\text{Basic} \\ \text{link equation} \\ \text{in dB in} \\ \text{Ideal} \\ \text{conditions.}\end{array}$$

above link equations in dB are in practical cases Ideal cases bus in practical cases -

$$\boxed{P_r \text{ in dB} = \text{EIRP} + G_r - L_p - L_a - L_{ta} - L_{ra}}$$

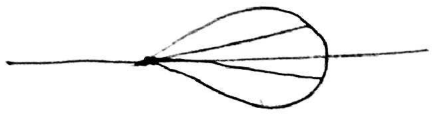
where L_p = Path Loss.

L_a = Attenuations in Atmosphere

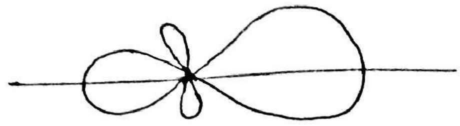
L_{ta} = Losses associated with transmitting antenna.

L_{ra} = Losses associated with Recieving antenna.

Ideal dipole



Practicaldipole



Letus assume range of earth station to satellite-

$R = 40,000\ Km, = 4\times10^7 m$

$P_t = 2W, \quad 10W$

$G_t = 17 dB$

$A_e = 10 m2$

calculate Flux density F in dB and Recieved power in dB.

according to formula.

$$F \text{ in dB} = 10 \log P_t + 10 \log G_t - 10 \log 4\pi - 10 \log R2$$

$$= 10 \log P_t + 10 \log G_t - 10 \log 4\pi - 20 \log R$$

$$= 10 \log 2 + 17 dB - 11 dB - 20 \log 40000$$

$$= 10 \times .300 + 17 dB - 11 dB - 20 \log 2^2 \times 10^7 \times 10^3$$

$$= 3 + 17 - 11 - 40\times7 \log 2$$

$$= 20 - 11 - 280 \times .3$$

$$= 20 - 11 - 152$$

$40\times4\times.3$

160

$$F \text{ in dB} = -143 \ dB\ W/m2$$

& Recieved Power

$$P_R = -143 dB + 10$$

$$= -133 \ dB W.$$

F in dB = -143 dB W/m2
P_r in dB = -133 dB W } Answer

'$-$' Sign indicate how much less in comparision to one watt power,

⇒ **Problem:-** If Recieving antenna gain 52.3 dB & operating frequency 11 GHz EIRP ($P_t G_t$) 27 dBW. What willbe recieved power in this case.

Solution:- Given, $EIRP = P_t G_t = 27\,dB\,W$.

$G_r = 52.3\,dB$

$\lambda = \frac{c}{f} = \frac{3\times10^8}{11\times10^9} = \frac{3}{11}\times10^{-1} = \frac{30}{11}\times10^{-2} = 2.72\times$

path Loss $L_p = \left(\frac{4\pi R}{\lambda}\right)^2$

$= \left[\frac{4\pi\times4\times10^7}{2.72\times10^{-2}}\right]^2$

∴ path Loss L_p in dB

$= 20\log_{10}\left[\frac{4\pi\times4\times10^7}{2.72\times10^{-2}}\right]^2$

$= -205.3\,dBW$

Hence Recieved power. P_r –

$P_r = EIRP + G_r - \text{Path Loss}\ dBW$

$= 27\,dBW + 52.3\,dB - 205.3$

$= -126.0\,dBW$

∴ $P_r = -126.0\,dBW$