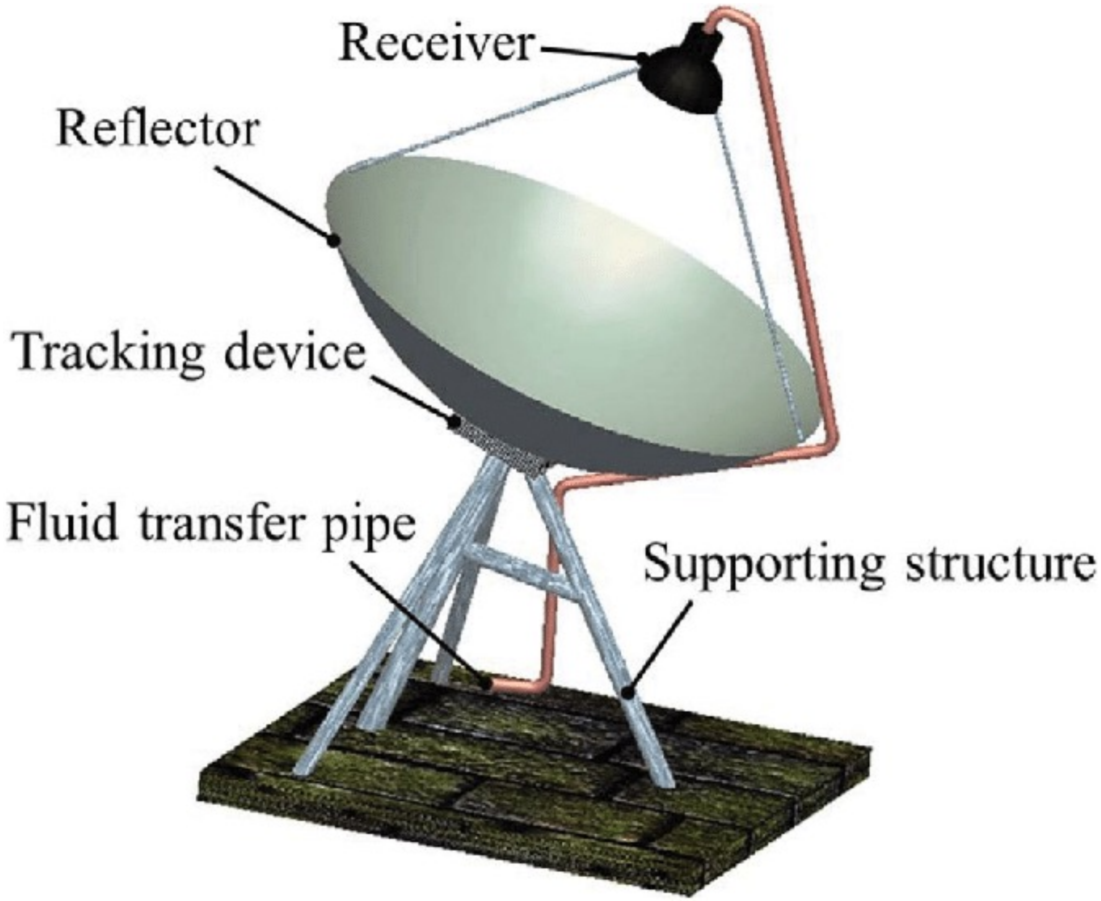
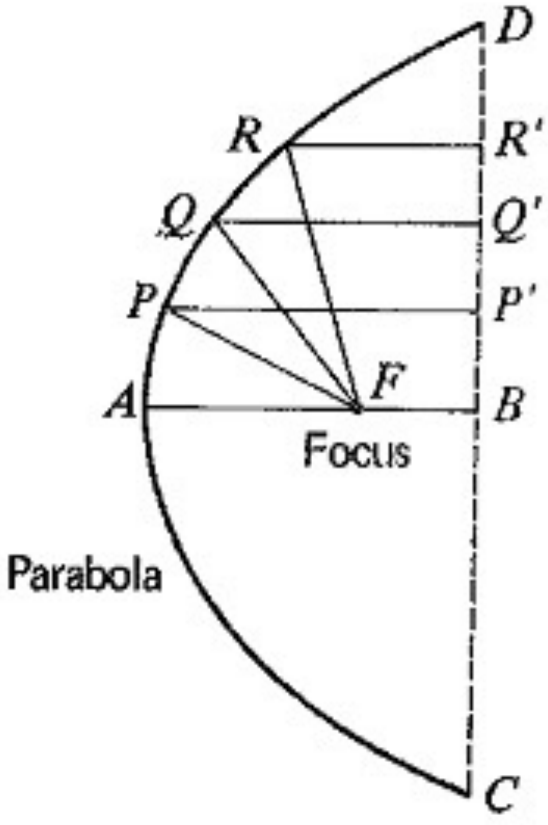
SRM
INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)
TIRUCHIRAPPALLI

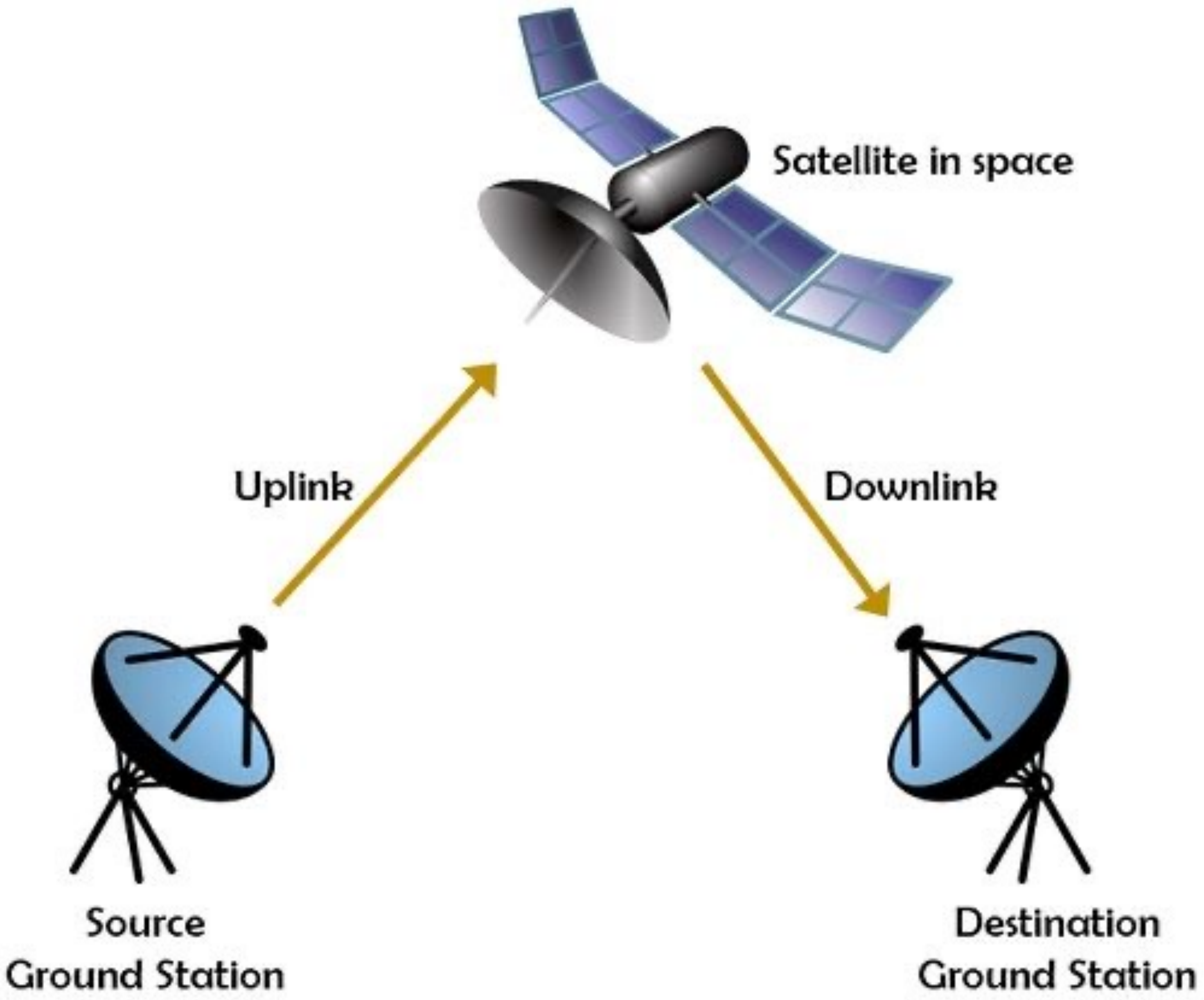
Unit 2 – Link Design

Mention the Antenna Type

Parabolic Reflector Antenna

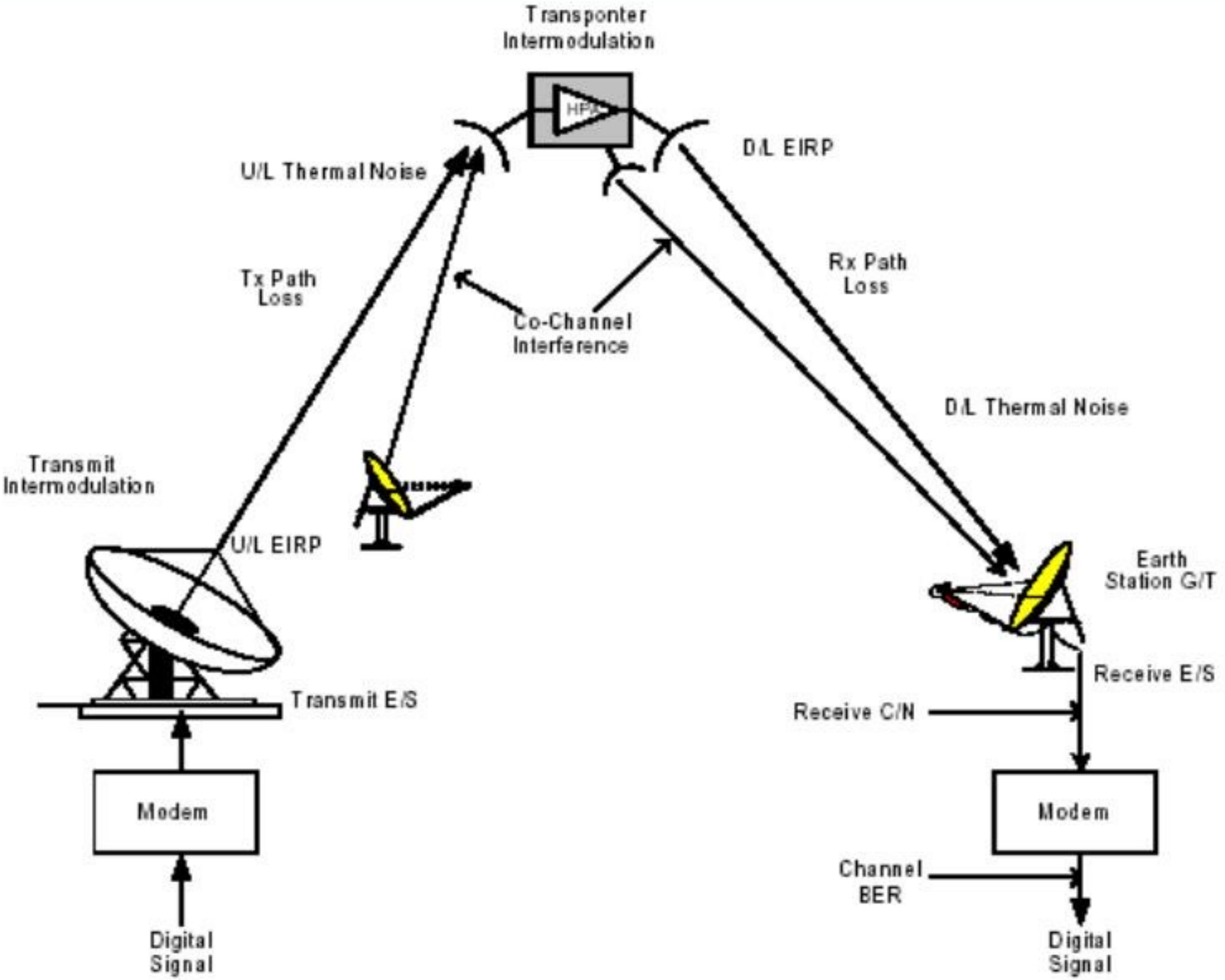




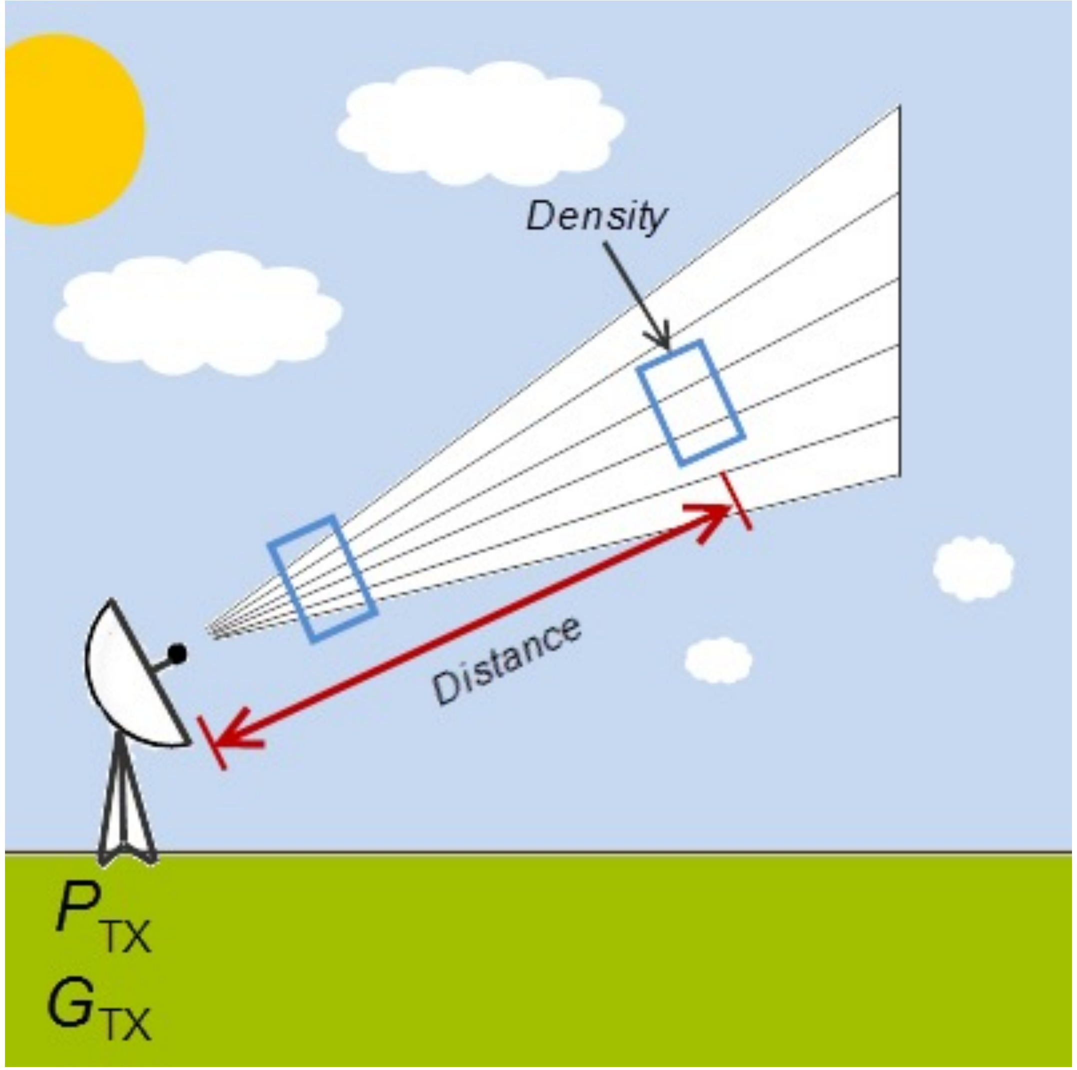

Satellite in space
Uplink
Downlink
Source
Ground Station
Destination
Ground Station

Discussion on Budget Calculation

Let’s Work on Satellite Link Budget Calculation



Power Flux Density or Power Density



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

Where,

S = Power Density

P = Power Input to Antenna

G = Power Gain of Antenna

R = Distance to the center of Radiation of Antenna

Equivalent Isotropic Radiated Power

A key parameter in link-budget calculations is the ***equivalent isotropic radiated power***, conventionally denoted as **EIRP**

An isotropic radiator with an input power equal to GP_S would produce the same flux density. Hence, this product is referred to as the EIRP

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

EIRP is often expressed in decibels relative to 1 W

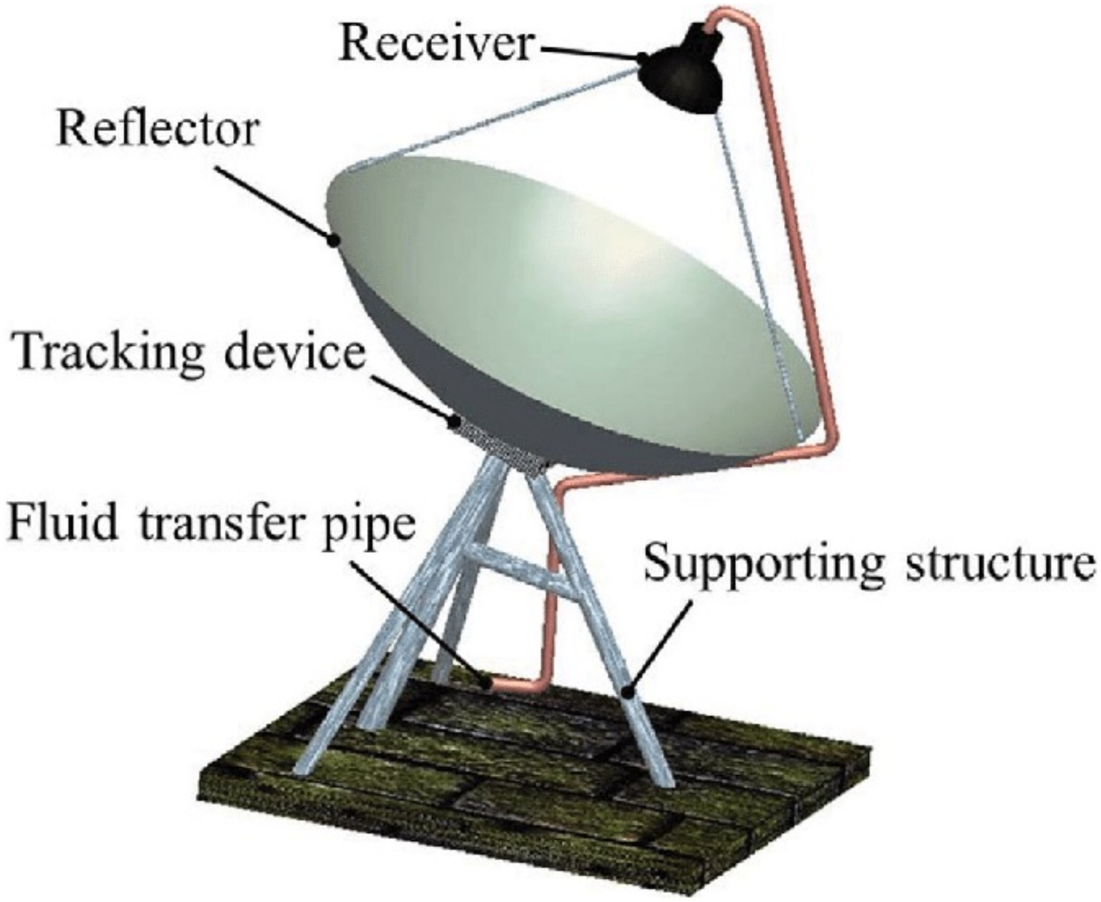
$$[\mathrm{EIRP}] = [P_S] + [G]\ \mathrm{dBW}$$

Equivalent Isotropic Radiated Power

Problem: A satellite downlink at 12 GHz operates with a transmit power of 6 W and an antenna gain of 48.2 dB. Calculate the EIRP in dBW.

Ans: 56 dBW

Gain of 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)

Gain of Parabolic Reflector Antenna

Problem: Calculate the gain in decibels of a 3-m paraboloidal antenna operating at a frequency of 12 GHz. Assume an aperture efficiency of 0.55.

Ans: 48.9 dB

Free-space transmission Loss

The power delivered to a matched receiver is this power-flux density multiplied by the effective aperture of the receiving antenna.

The received power is therefore

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

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Free-space transmission Loss

In decibel notation, the equation becomes

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

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

The free-space loss component in decibels is given by

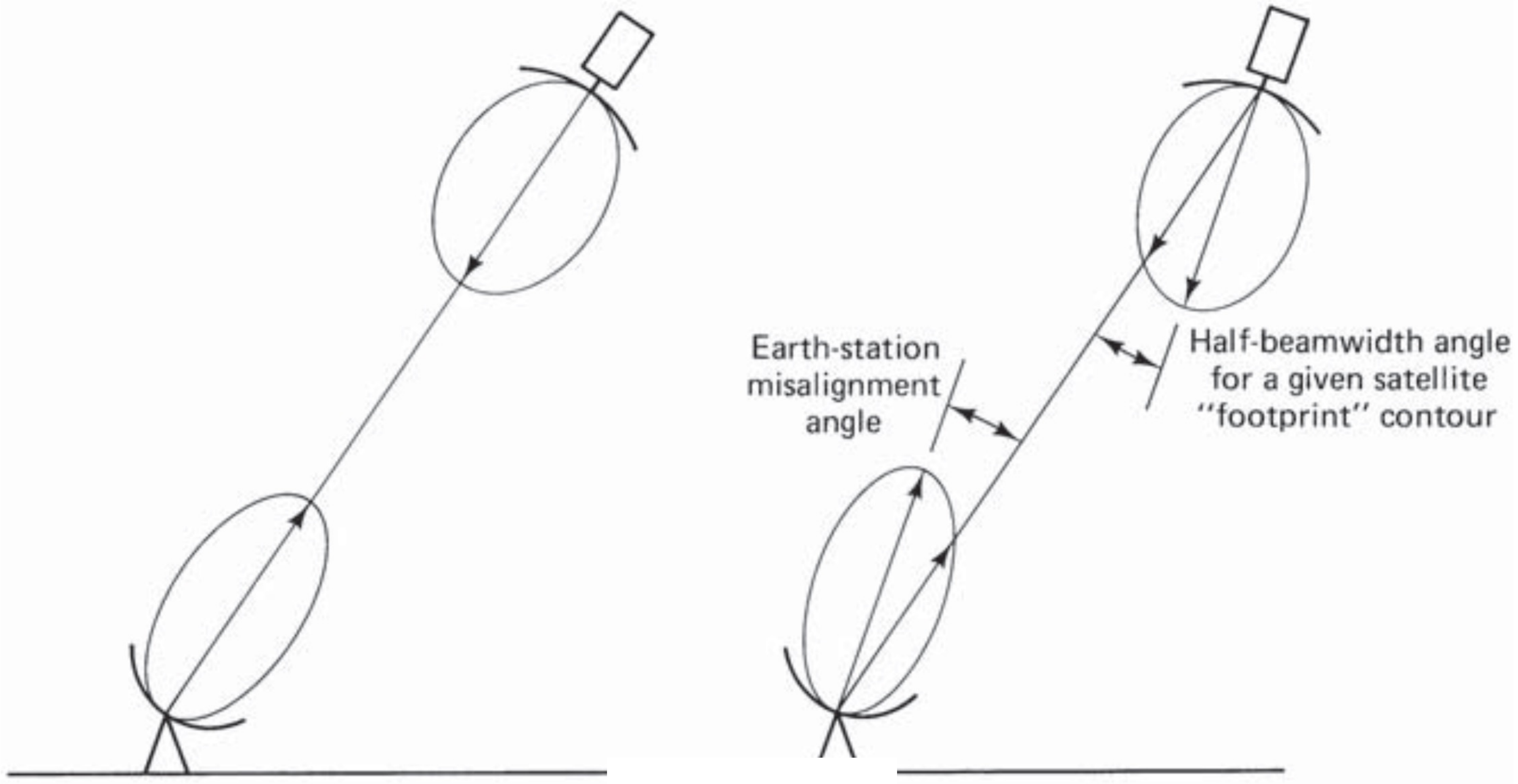
$$[\text{FSL}] = 10 \log\left(\frac{4\pi r}{\lambda}\right)^2$$

Free Space Loss Problem

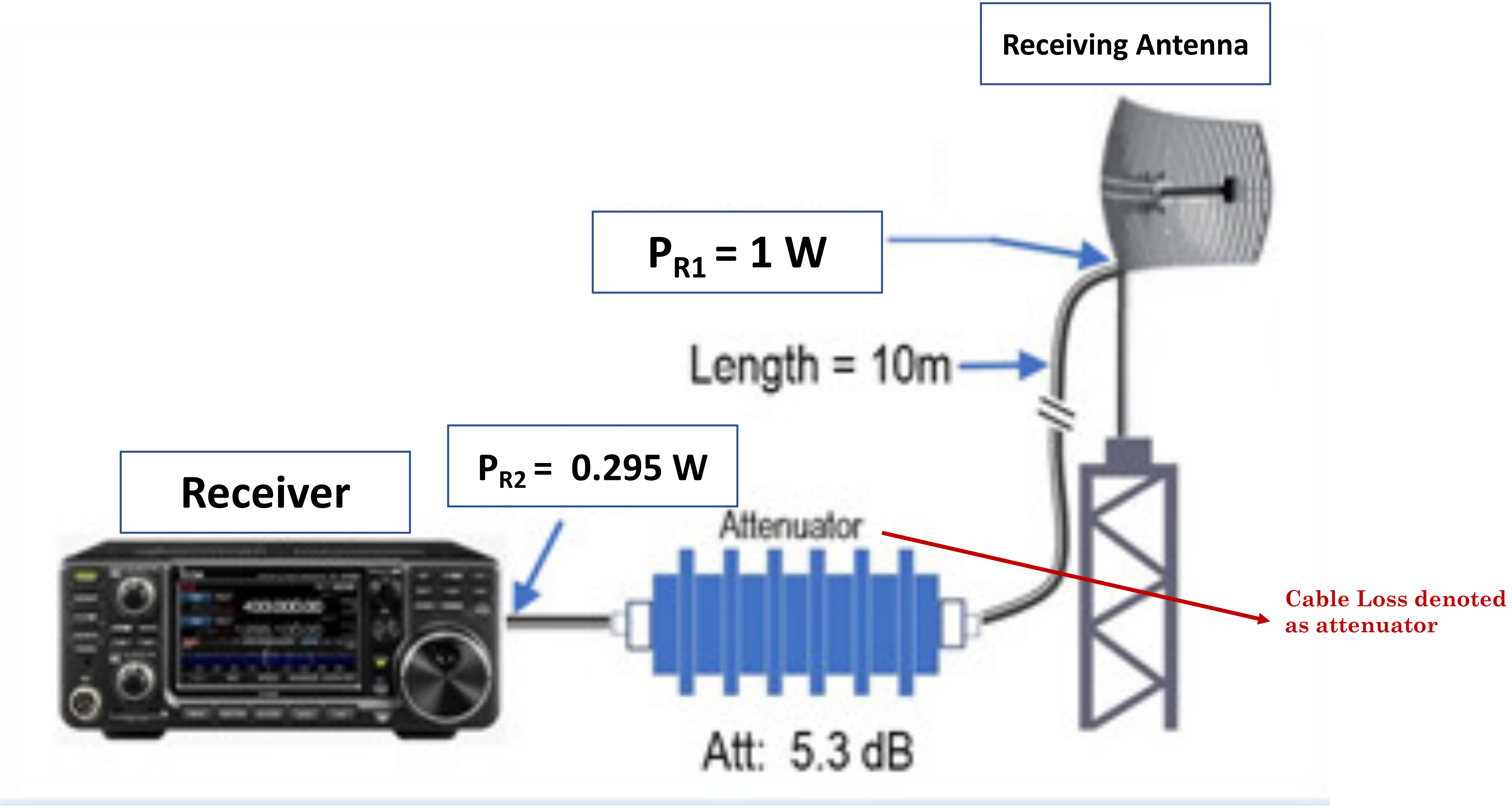
Problem: The range between a ground station and a satellite is 42,000 km. Calculate the free-space loss at a frequency of 6 GHz.

Ans: 200.4 dB

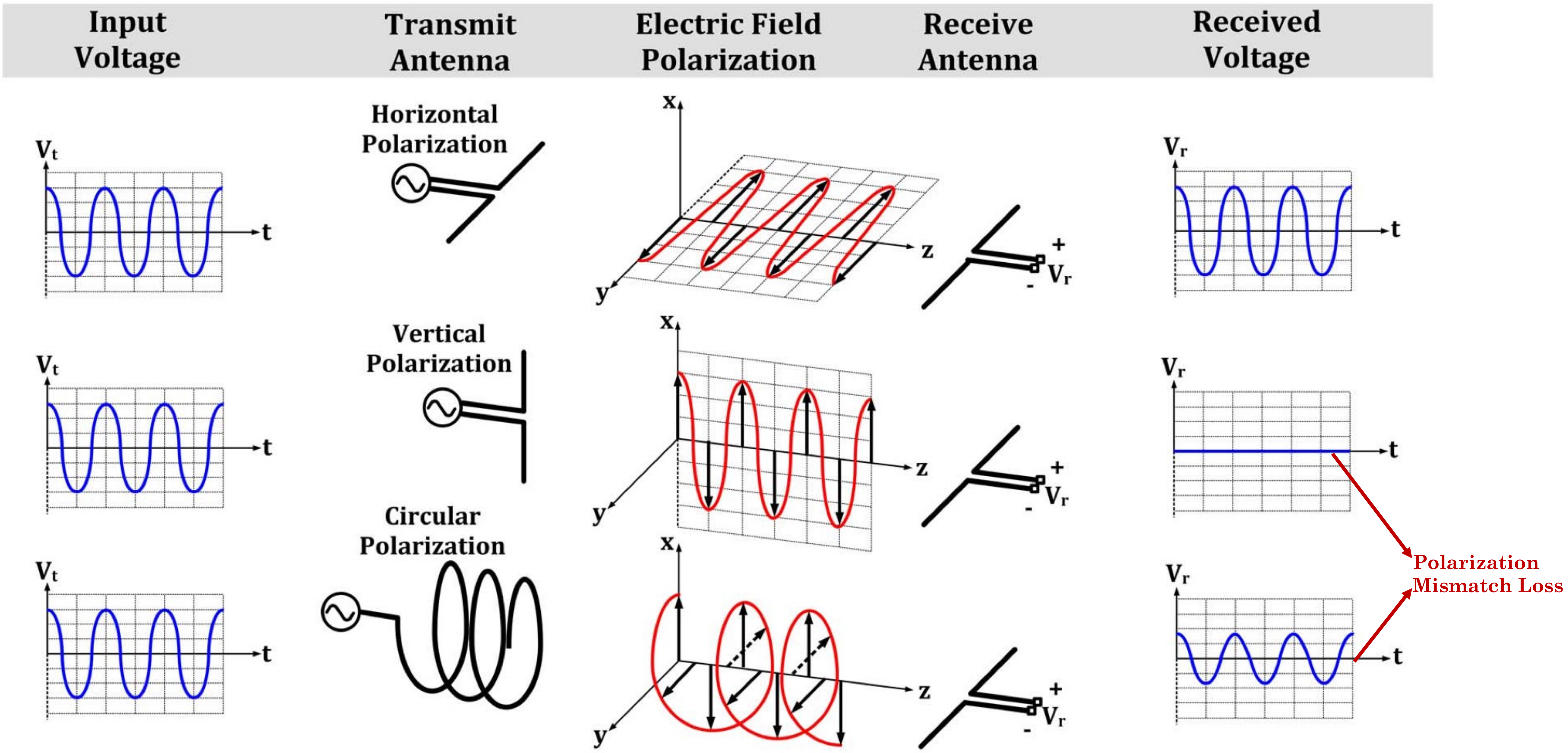
Antenna Misalignment Loss



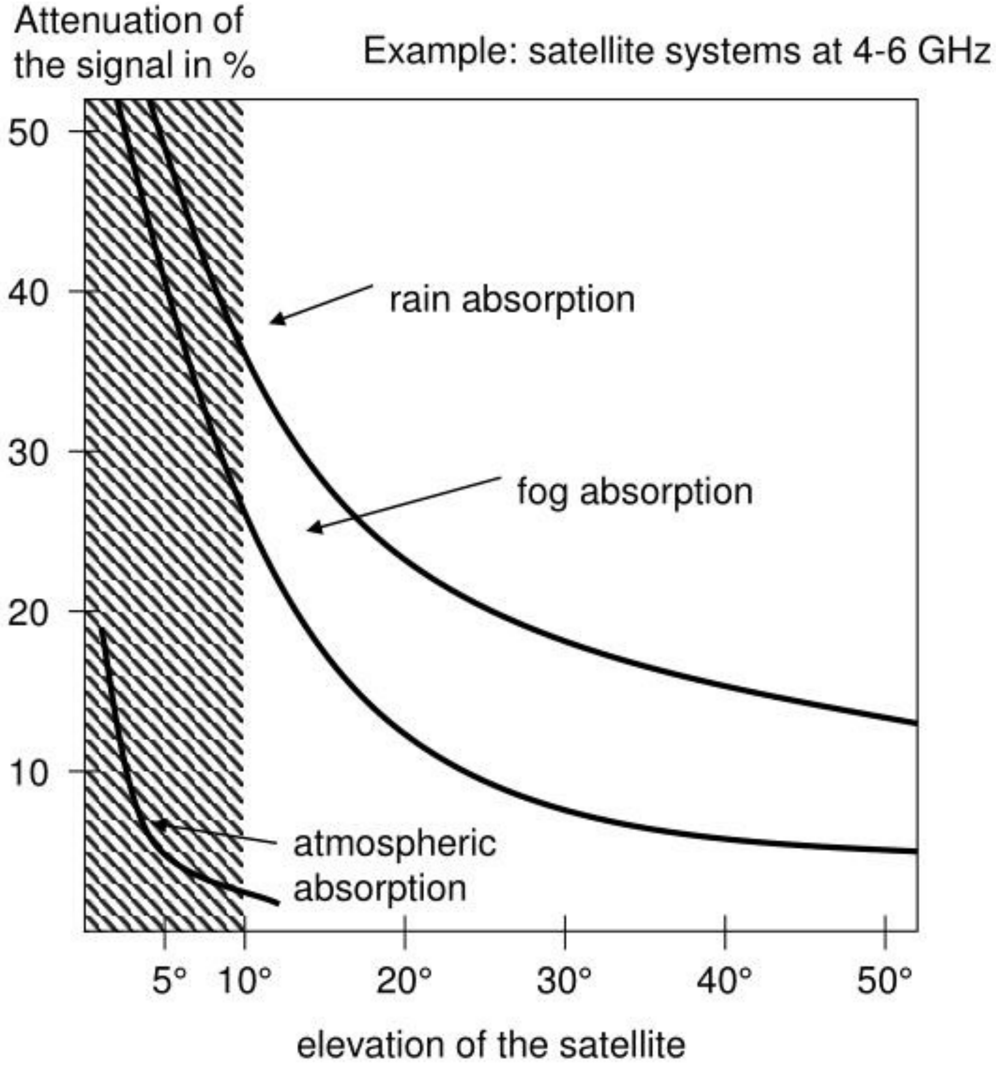
Receiver Feeder Loss



Polarization Mismatch Loss



Atmospheric Absorption Loss



The Link-Power Budget Equation

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

The decibel equation for the received power is then

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

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

Link Power Budget Calculation

Problem: A satellite link operating at 14 GHz has receiver feeder losses of 1.5 dB and a free-space loss of 207 dB. The atmospheric absorption loss is 0.5 dB, and the antenna pointing loss is 0.5 dB. Depolarization losses may be neglected. Calculate the total link loss for clear-sky conditions.

Ans: 209.5 dB