Satellite Communications

Communication satellite link budget

Chapter two

Lecture 7

By lecturer Marwa Mohammed

Introduction

The first step in designing a satellite network is performance of a satellite link budget analysis.

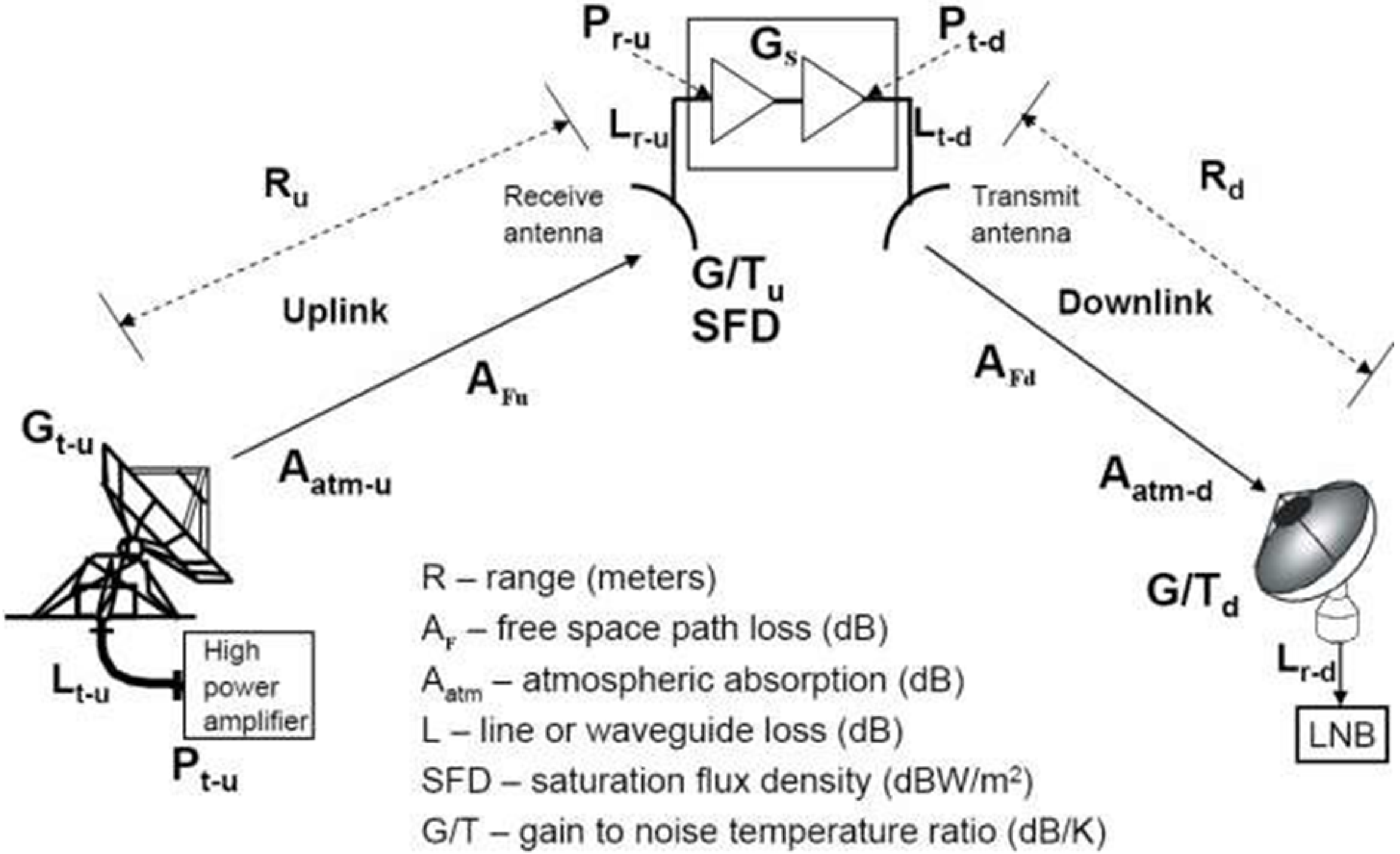
The link budget will determine what the antennae size to use, power amplifier requirements, link availability and bit error rate (BER).

What is a link budget?

A link budget is the sum the total of all gains and losses in the radio connection between two parties from end to end, including antenna's, feed lines and the path between the antenna's ..etc.

A link consists of three parts:

1. Transmitter
2. Receiver
3. Media



For a line-of-sight radio link, the link budget might look like this:

$$P_{Rx} = P_{Tx} + G_{Tx} - L_{Tx} - L_{Fx} - L_M + G_{Rx} - L_{Rx}$$

where:

- P_{RX} = received power (dBm)
- P_{TX} = transmitter output power (dBm)
- G_{TX} = transmitter antenna gain (dBi)
- L_{TX} = transmitter losses (coax, connectors...) (dB)
- L_{FS} = free space loss or path loss (dB)
- L_M = miscellaneous losses (fading margin, body loss, polarization mismatch, other losses...) (dB)
- G_{RX} = receiver antenna gain (dBi)
- L_{RX} = receiver losses (coax, connectors...) (dB)

<u>Note:</u>

- All power must be specified in dBm or dBW.

How to convert mW to dBm:

$$P_{(\text{dBm})} = 10 \cdot \log_{10}(P_{(\text{mW})} / 1\text{mW})$$

Ex: Convert 20mW to dBm.

$$P_{(\text{dBm})} = 10 \cdot \log_{10}(20\text{mW} / 1\text{mW}) = 13.0103\text{dBm}$$

2.1 Main Link Parameters

- Antenna
- gain EIRP
- Free space loss
- Atmospheric
  absorption loss
- Receiver noise power density
- Antenna noise
- Noise temperature
- Noise figure
- Equivalent input noise temperature
- G/T

Antenna gain

The gain of parabolic antennas that are often used in satellite communications is

$$G = \eta\left(\frac{\pi D}{\lambda}\right)^2$$

η is aperture efficiency <u>(50-70%)</u>, D is antenna diameter,

λ is wavelength.

<u>Note</u> : Physical antennas are not ideal – some energy is reflected away by the structure, some energy is absorbed by lossy components.

HW

Prove that the gain $G = \eta\left(\frac{\pi D}{\lambda}\right)^2$ will be in dB equal to

G = 10 log $(109.66\, f^{\,2}\, \mathrm{D}^{\,2}\, \eta)$ dB

Note that the antenna diameter D given in meters, and the frequency f in GHz

Effective Isotropic Radiated Power (EIRP)

- An important parameter in the evaluation of the RF link.
- EIRP is a product of transmit antenna gain (Gt) and transmitter output power (Pt),

$$EIRP = P_t G_t$$

- EIRP is typically due to antenna thermal distortion, satellite attitude instabilities, atmospheric disturbance (i.e. rain) and unit thermal and aging effects.

Example :

(a). An earth station transmits with 10 watts. Its antenna has a gain of 50 dB What is it EIRP?

Solution:

EIRP= 10 log 10 +50 =60 dBw

(b). Another Earth station transmits with 8 Watts but has an antenna gain of 52 dB. Which of these would you prefer?

EIRP = 10 log 8 + 52 = 61 dBw

Other things being equal the second Earth Station is preferable. It has a better "rating" or the EIRP.