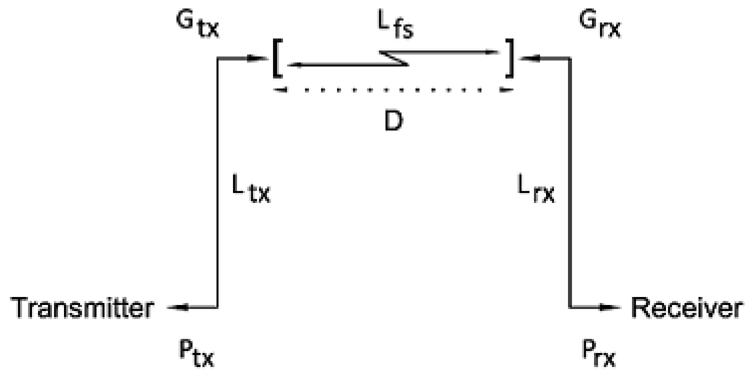
Up link Power Budget (VHF Band - 145 MHz)

We use the following figure to describe the up link power budget



Where:

Ptx – Output power of the earth station VHF transmitter (dBm)

Ltx – Transmitter cable losses (dB)

Gtx – Transmitter antenna gain (dBi)

Lfs – Free space losses (dB)

Grx – Receiver antenna gain (dBi)

Lrx – Receiver cable losses (dB)

Prx – Received power at the space station VHF receiver (dBm)

The received power at the VHF space station receiver can be calculated as:

Prx (VHF band) = Ptx + Gtx – Ltx – Lfs – Lrx + Grx

If the orbit height is 600 Km, then the distance to the space station at 0° will be 2830.8 Km, so the free space losses are: 20Log (4π 2830000/2.06)= 144.7dB, using this value in the up link power budget calculation we have:

P_{tx}=33dBm, Yagi Antenna gain is G_{tx}=11.5 dBi (VHF), L_{tx}=-3dB, L_{fs}=144.7dB, L_{rx}=-0.3dB, G_{rx}=2dBi

$P_{rx\,0°}$ (VHF band) = 33dBm + 11.5dBi – 3dB – 144.7dB – 0.3dB + 2dBi = -101.5dBm

Remark: In this calculation we consider an output power of 2 Watts (33 dBm) because this is the minimum output power of the ICOM radio in the earth station.

The sensitivity of the space station VHF receiver (Astrodev radio) is -104.7 dBm @ BER 10^{-3}, it is only 3 dB under the received power level. If necessary, the received power level at the space station can be improved by increasing the output power of the earth station transmitter (up to a maximum value of 48 dBm).

The equivalent noise temperature in the uplink receiver at the space station is calculated using the equation [1]:

$$T = T_A/L_{FRX} + T_F(1-1/L_{FRX}) + T_{eRX} \qquad \text{eq. (1)}$$

Where:
T_A= Antenna noise temperature= **160°K** worst case using figure 5.17 of [1]
L_{FRX}= feeder loss=0.3dB ($10^{0.03}$=**1.071**)
T_F= Thermodynamic temperature of the feeder= **343°K** (70°C) worst case

The sensitivity of the Astrodev receiver at VHF frequencies is -104.7dBm, if the bandwidth=15 KHz and considering a 22 dB SINAD, then the noise figure at the receiver can be calculated using the equation:

NF(dB)= Sensitivity (dBm)+ 174 dBm/Hz - 10Log(AB en Hz)-S/N=
=-104.7 + 174 – 41.76 - 24 = **3.54 dB** (VHF band)

Using the figure of page 179 [1] then:

T_{eRX}=Effective input noise temperature of the receiver= 365°K (VHF)

Therefore the equivalent noise temperature in the uplink receptor at the satellite is:

T = 160°K/1.071 + 343°K(1-1/1.071) + 365°K = **537°K**

Down link power budget

a) **UHF band (437 MHz)**

If the orbit height is 600 Km, then the distance at 0° will be 2830.8 km, so the free space loss is: 20Log (4π 2830000/0.686)= 154.2dB, using this in the **down link power budget** we have:

Prx (UHF band) = Ptx + Gtx – Ltx – Lfs – Lrx + Grx

$P_{rx\,0°}$ (UHF band) = 30dBm + 2dBi – 0.3dB – 154.2dB – 6.5dB + 14.8dBi = -114.2dBm

It is recommended that the output power of the space station transmitter must be at least 30 dBm (1W)

b) **S band (2,400 – 2,450 MHz)**

If the orbit height is 600 Km, then the distance at 45° will be 815.52 km, so the free space loss is: 20Log (4π 815520/0.125)= 158.2dB, using this in the **down link power budget calculation** we have:

Prx (S band) = Ptx + Gtx – Ltx – Lfs – Lrx + Grx

$P_{rx\,45°}$ (S band) = 30dBm + 5dBi – 0.3dB – 158.2dB – 0.5dB + 30dBi = - 94dBm

Reference:

[1] Gerard Maral, “SATELLITE COMMUNICATION SYSTEMS Systems, Techniques and Technology”, 2009, p 186.