Satellite Communications

Part IV-Lecture 5-Satellite Link Design

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Learning Objectives

- Solving calculations of Link Budget for various satellite systems

- Calculate uplink transmitter power required to achieve $(C/N)_{up}$ =30 dB

Uplink Noise Power Budget	
k	-228.6dB
Ts=500K	27.0dBK
B=43.2 MHz	76.4 dBHz
Transponder Noise Power=N	-125.2dBW

Satellite Parameters	
Total RF output power	2.4kW
Antenna Gain,(txt & rx)	31dB
Rxr sys noise temp	500K
Transponder saturated output power	80 W
Transponder bandwidth	54 MHz
symbol rate of 43.2 Msps	
Minimum permitted overall $(C/N)_o$ in receiver	9.5 dB

Transmitting Earth Station	
Antenna Diameter	5.0 m
Antenna efficiency	68%
Uplink frequency	14.15 GHz
Required C/N in Ku-band Transponder	30 dB
Transponder HPA output backoff	1 dB
Miscellaneous uplink losses	0.3 dB
Location:-2dB contour of satellite receive antenna	

Receiving Earth Station	
Downlink Frequency	11.45 GHz
Receiver IF noise Bandwidth	43.2 MHz
Antenna noise temperature	30 K
LNA noise temperature	110 K
Required overall $(C/N)_o$ in clear air	17 dB
Miscellaneous downlink losses	0.2 dB
Location:-3dB contour of satellite transmitting antenna	

- Received Power level at transponder input must be 30 dB greater than noise power
- P_r=power at transponder input=-95.2dBW
- Now establish uplink power budget

Uplink Power Budget	
P_t =Earth station transmitter power	P_t dBW
G_t =Earth Station Antenna gain	55.7 dB
G_r =Satellite Antenna gain	31.dB
$L_{p=}$ Free space loss	-207.2dB
$L_{ant=}$ E/S on 2dB contour loss	-2.0dB
$L_{miscellaneous}$	-1.0dB
P_r =Received power at the transponder	P_t -123.5 dB

clear air attenuation	
Uplink 14.15 GHz	0.7 dB
Downlink 11.45 GHz	0.5 dB
Rain attenuation	
Uplink 0.01% of year	6.0dB
Downlink 0.01% of year	5.0 dB

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- The required power at the transponder input to meet the $(C/N)_{up}$ =30dB objective is -95.2dBW
- **P_t -123.5 dB=-95.2dBW**
- **P_t =28.3 dBW or 675 W**

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- First step is to calculate the downlink $(C/N)_{dn}$ that will provide $(C/N)_{o}$ =17 dB when $(C/N)_{up}$ =30
- $1/(C/N)_{o} = 1/(C/N)_{up} + 1/(C/N)_{dn}$
- $1/(C/N)_{dn} = 1/(C/N)_{o} + 1/(C/N)_{up}$
- $1/(C/N)_{dn} = 1/50 + 1/1000 = 0.019$
- $(C/N)_{dn} = 52.6 = 17.2$dB

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- Find required receiver input power to give $(C/N)_{dn}$ =17.2dB then find receiving antenna gain

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Downlink Noise Power Budget	
k	-228.6dB
Ts= 30+110 K=140 k	21.5dBK
B=43.2 MHz	76.4 dBHz
Earth station receiver Noise Power=N	-130.7 dBW

- Power level at earth station receiver input must be 17.2 dB greater then the noise power in clear
- P_r = -130.7dBW+17.2 dB=-113.5 dBW

clear air attenuation	
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Downlink 11.45 GHz	0.5 dB
Rain attenuation	
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- To calculate the downlink power budget
  - Calculate path loss
  - Calculate Power transmitted from the transponder P_t

- Transponder is operated at 1dB backoff,so output power is 1 dB below 80 W
- P_t =19dBW-1dB=18dBW

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Downlink Power Budget	
P_t =Satellite Transponder output power	18.0W
G_t =Satellite antenna gain	31.0 dB
G_r =Earth station antenna gain	G_r
$L_{p=}$ Free space loss	-205.4 dB
$L_{ant=}$ E/S on -3dB contour loss	-3.0dB
$L_{miscellaneous}$	-0.7dB
P_r =Received power at the earth station receiver	G_r -160.2dB

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- Power required into E/S receiver to meet $(C/N)_{dn}$ = 17.2 dB is P_r = -113.5 dBW
- Hence **G_r is given as G_r -160.2dB=-113.5dBW**
- **G_r =46.7dB**

- **Rain Effects at Ku Band(Assuming linear transponder)**

- **Uplink**

- **The uplink C/N was 30 dB in clear air**
- **Uplink path attenuation due to rain is 6 dB**

- **Effect on uplink C/N**
  - **The C/N in the transponder falls to 30-6=24dB**
- **Effect on downlink C/N**
  - **The downlink C/N falls by 6 dB from 17.2 dB to 11.2dB**
- **Effect on Overall C/N**
  - **Falls by 6 dB i-e from 17dB to 11dB**
- **Minimum over C/N is set to 9.5 dB**
- **Additional fade margin =11-9.5 db=1.5 dB**

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Downlink

- Given in the paper
- Please see page 136 for solution
- **Be careful about the two different approaches we have done in class**

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- **ERRATA**: Correction on page 135,Other losses are -0.7 dB and the inline Pr=-113.5 dBW instead of -120.1dBW. Also Pr=Received power at earth station receiver. In Rain effects at Ku band paragraph,correct transponder output power falls to 18-6=12dBW.On page 134,in downlink noise power budget N=Noise power at earth station receiver in clear air

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