Lecture 6

PRINCIPLES OF SATELLITE COMMUNICATION

COMPLETE LINK DESIGN

- TWO EARTH STATION AND SATELLITE
- UP LINK AND DOWN LINK
- (UPLINK,SATELLITE TRANSPONDER, DOWN LINK
- UPLINK (C/No)u AT TRANSPONDER INPUT
- DOWNLINK (C/No)d

Uplink Design

$$\left(\frac{C}{N_0}\right)_{uplink\,\text{in db Hz}} = 10\log P_T G_T - 20Log\left(\frac{4\pi d}{\lambda}\right) + 10\log\frac{G}{T}$$

$$-10LogL_A - 10LogK - BO_i$$

Complete link design cont---

$$C = \frac{C_U G_s G_T G_R}{L}$$

C - Carrier Signal At Receiving Earth Station

CU - SIGNAL POWER AT THE SATELLITE TRANSPONDER INPUT

Gs – SATELLITE TRANSPONDER GAIN

GT- GAIN OF THE SATELLITE TRANSMITTING ANTENNA

GR – GAIN OF THE RECEIVING ANTENNA

L – LOSSES ON THE DOWN LINK

NOISE POWER SPECTRAL DENSITY AT THE INPUT OF THE RECEIVING ANTENNA

$$N_0 = N_{0D} + \frac{N_{0U} G_s G_T G_R}{L}$$

N_O IS NOISE POWER SPECTRAL DENSITY AT THE INPUT OF THE RECEIVING STATION

N_{OU} IS NOISE POWER SPECTRAL DENSITY AT THE TRANSPONDER INPUT

$$\frac{C}{N_0} = \frac{\dfrac{C_U G_s G_T G_R}{L}}{N_{0D} + \dfrac{N_{0U} G_s G_T G_R}{L}}$$

$$= \frac{C_U}{N_{0U} + \dfrac{N_{0D} L}{G_s G_T G_R}}$$

TRANSPONDER HAS A BAND WIDTH B AND RADIATES A CONSTANT POWER P_T AND ITS GAIN G_s

$$G_S = \frac{P_T}{C_U + N_{OU} * B}$$

FOR DOWN LINK SIGNAL POWER CD

$$C_D = \frac{P_T G_T G_R}{L}$$

THUS C/No

$$\frac{C}{N_0} = \frac{C_U}{N_{0U} + \frac{N_{0D}.L\left(C_U + N_{0U} * B\right)}{P_T.G_T G_R}}$$

$$= \frac{C_U}{N_{0U} + \frac{N_{0D}.\left(C_U + N_{0U} * B\right)}{C_D}}$$

$$\frac{C}{N_0}=\frac{\dfrac{C_U * C_D}{N_{0U} * N_{0D}}}{\dfrac{N_{0U} * C_D + N_{0D}.\left(C_U + N_{0U} * B\right)}{N_{0U} * N_{0D}}}$$

$$=\frac{\left(\dfrac{C}{N_0}\right)_u * \left(\dfrac{C}{N_0}\right)_D}{\left(\dfrac{C}{N_0}\right)_u + \left(\dfrac{C}{N_0}\right)_D + B}$$

$$\left(\frac{C}{N_0}\right)_T^{-1}=\left(\frac{C}{N_0}\right)_u^{-1}+\left(\frac{C}{N_0}\right)_D^{-1}\rightarrow B \leq \left(\frac{C}{N_0}\right)_u \,\&\left(\frac{C}{N_0}\right)_D$$

Complete link design

- Effect of interfering signals
- I is noise power involved with the interfering signals under the band width of the desired carrier than , the net C/N ratio (for uplink)

$$\left(\frac{C}{N}\right)_{netuplink} = \left[\left(\frac{C}{N}\right)_U^{-1} + \left(\frac{C}{I}\right)_U^{-1}\right]$$

$$\left(\frac{C}{N}\right)_{net\,downlink} = \left[\left(\frac{C}{N}\right)_D^{-1} + \left(\frac{C}{I}\right)_D^{-1}\right]^{-1}$$

$$\left(\frac{C}{N}\right)_{net} = \left[\left(\frac{C}{N}\right)_{Net\,uplink} + \left(\frac{C}{N}\right)_{net\,downlink}\right]^{-1}$$

$$= \left[\left(\frac{C}{N}\right)_u^{-1} + \left(\frac{C}{I}\right)_u^{-1} + \left(\frac{C}{N}\right)_D^{-1} + \left(\frac{C}{I}\right)_D^{-1}\right]^{-1}$$

$$\left[\left(\frac{C}{N}\right)^{-1} + \left(\frac{C}{I}\right)^{-1}\right]^{-1}$$

$$\left(\frac{C}{I}\right)^{-1} = \left(\frac{C}{I}\right)_u^{-1} + \left(\frac{C}{I}\right)_D^{-1}$$

Complete link design contt---

- C/N CARRIER TO NOISE OF OVERALL LINK
- C/I CARRIER TO INTERFACE RATIO OF OVERALL LINK
- C/I > C/N SATELLITE LINK IS NOISE DOMINANT
- C/I< C/N SATELLITE IS CALLED INTERFERANCE DOMINENT
- FOR A TYPICAL FM DEMODULATOR S/N AFTER DEMODULATOR
- $(S/N)_{OUTPUT} = (C/N)_{in} + FM_{IMPROVEMENT}$

Earth station parameter

$$\frac{C}{N_0} = \frac{P_T G_T G_R}{K T_S} \left(\frac{\lambda}{4\pi d} \right)^2 \frac{1}{L_A}$$

- d is the range between transmitting and receiving antenna

$$G = \eta \left(\frac{4\pi D}{\lambda} \right)^2$$

$$G = \frac{\eta 4\pi^2 70^2}{\theta_{3dB}^2}$$

Contt---

- η antenna efficiency
- (θ3db)sat satellite antenna beam width
- DES is earth station diameter

$$G = \eta\left(\frac{4\pi D}{\lambda}\right)^2$$

$$G = \frac{\eta 4\pi^2 70^2}{\theta_{3dB}^2}$$

Earth station parameter

$$\frac{C}{N_0} = \frac{P_T}{L_A N_0} \eta_T \eta_R - \frac{\pi^2 70^2 D_{ES}^2}{d^2 (\theta_{3db})_{sat}^2}$$

FOR FIXED EARTH STATION

$$\frac{C}{N_0} = \frac{P_T}{L_A N_0} \eta_T \eta_R \frac{\pi^2 C^2 70^2}{(4d)^2 (\theta_{3db})_{sat}^2 (\theta_{3db})_{ES}^2 \cdot f^2}$$

$$\frac{C}{N_0} = \frac{P_T}{L_A N_0} \eta_T \eta_R \left(\frac{\pi D_{sat} D_{ES}}{4dC} \right)^2 f^2$$