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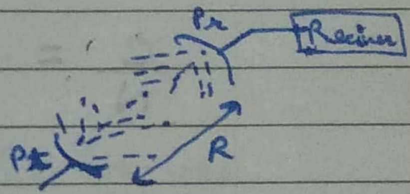
# * Satellite Link Design:

Crucial design parameters are –
Dimension, Weight, Freq. Band

Dimension ↓ mainly dia. of Antenna

Weight ↓ Dir. Prop. to Cost
mainly due to fuel, batteries

## ⇒ Carrier - Noise Ratio (C/N)




$$P_r = \frac{P_t}{4\pi R^2}$$

(Receiving Ant. Power Flux Density)

Basic Ant. Power $P(\theta) = \frac{P_o}{4\pi}$

If Trans. antenna gain $= G_T$,

EIRP → $P_r = \frac{P_t \cdot G_t}{\cancel{4\pi R^2}}$

(Eff. Isotropically Receiving Power)

Eff. Receiving Ant. Power Flux → $P_r = \frac{P_t \cdot G_t \cdot G_r}{4\pi R^2}$

$A_r$ = aperture area ; $A_e$ = eff. area

$A_e = \eta A_r$ ; $G_r = \frac{4\pi A_e}{\lambda^2}$

Rec. Power O/P ⇒ $P_{o/p} = \frac{P_t \cdot G_t \cdot A_e}{4\pi R^2}$

$$= \frac{P_t \cdot G_t \cdot G_r \cdot \lambda^2}{(4\pi R)^2}$$

$(C_n)$, $P_{o/p} = \frac{EIRP \times G_r}{\text{Path loss}}$

Path loss (optical) $= \left(\frac{4\pi R}{\lambda}\right)^2$

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## Link-Budget

$\Rightarrow P_{o/p}\,(dB) = \left[EIRP + G_r - \text{Path loss} - P_{rain} - P_{rec} - P_{atmos}\right]$ dBW

$\swarrow$ $C_u$

### * System Noise Power for Black body –

$$P_N = \underbrace{kT_p}_{\substack{\text{Noise}\\ \text{Spectral Power}}} B_n \rightarrow \text{Noise B.W. / System B.W.}$$

$T_p \rightarrow$ Phy. Temp.

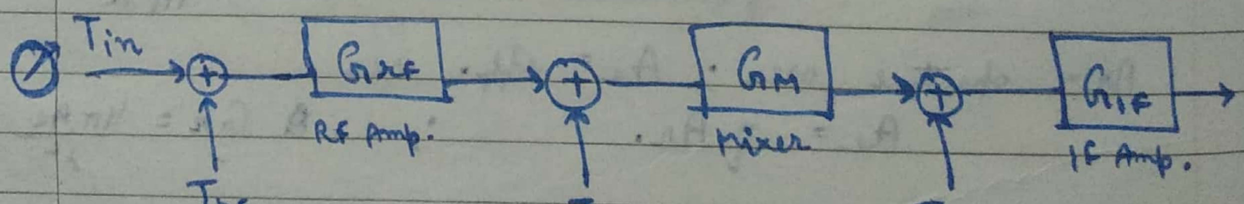
Also, $P_N = k\,T_S\,B_n$ $\qquad$ $T_S \rightarrow$ System Temp.

$$\frac{C}{N} = \frac{P_t \cdot G_t \cdot G_r}{kT_S\,B_n}\left(\frac{\lambda}{4\pi R}\right)^2$$

$$\frac{C}{N} = \frac{P_t \cdot G_t}{kB_n}\left(\frac{\lambda}{4\pi R}\right)^2\left(\frac{G_r}{T_S}\right)$$

$$\therefore \quad \frac{C}{N} \propto \frac{G_r}{T_S}$$

### $\Rightarrow$ System Noise Calc :-




$$P_N = kB_n\left[(T_{in}+T_{RF})\,G_{RF}\,G_M\,G_{IF} + T_M\,G_M\,G_{IF} + T_{IF}\,G_{IF}\right]$$

$$P_N = G_{RF}G_M \cdot G_{IF}\left[(T_{in}+T_{RF}) + \frac{T_M}{G_{RF}} + \frac{T_{IF}}{G_M \cdot G_{RF}}\right]$$

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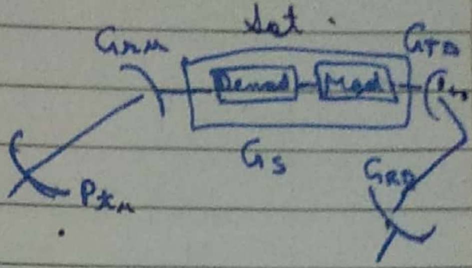
# * Overall Link Design-

$$C_o = \frac{C_u G_s G_{TD} G_{RD}}{L_D}$$




$C_u \rightarrow$ Uplink Carrier Power
$G_{TD} \rightarrow$ Sat. Trans. Antenna gain
$G_s \rightarrow$ Transponder Gain
$G_{RD} \rightarrow$ E.S. Transponder Ant. Gain
$L_D \rightarrow$ Downlink Path Loss

D.L. Noise $\Rightarrow$ $N_o = N_{oR} + N_{oU} \cdot \frac{G_s \cdot G_{TD} \cdot G_{RD}}{L_D}$

$N_{oR} \rightarrow$ Rec. Noise at ES of D.L.
$N_{ou} \rightarrow$ uplink Noise.

$$G_s = \frac{P_{TD}}{C_u + N_{ou} \cdot B}$$

$N_{ou} \rightarrow$ Noise Spectral Den.
$B \rightarrow$ B.W.

So,

$$\left(\frac{C}{N}\right) = \frac{C_u \cdot G_s \cdot G_{TD} \cdot G_{RD} / L_D}{N_{OR} + \frac{N_{ou} \cdot G_s \cdot G_{TD} \cdot G_{RD}}{L_D}}$$

$$= \frac{C_u}{N_{ou} + \frac{N_{OR} \cdot L_D}{G_s \cdot G_{TD} \cdot G_{RD}}}$$

$$= \frac{C_u}{N_{ou} + N_{OR} \cdot \frac{L_D (C_u + N_{ou} \cdot B)}{P_{TD} \cdot G_{TD} \cdot G_{RD}}}$$

$$= \frac{C_u}{N_{ou} + \frac{N_{OR} \cdot (C_u + N_{ou} \cdot B)}{G_p}}$$

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$$\Rightarrow \left(\frac{C}{N}\right)_T = \frac{C_u \cdot C_D}{N_{ou} C_D +}$$

$$= \frac{\dfrac{C_u C_D}{N_{ou} \cdot N_{OR}}}{\dfrac{C_D}{N_{OR}} + \dfrac{C_u}{N_{ou}} + B}$$

$$\left(\frac{C}{N}\right)_T = \frac{\left(\frac{C}{N}\right)_u \cdot \left(\frac{C}{N}\right)_D}{\left(\frac{C}{N}\right)_D + \left(\frac{C}{N}\right)_u + B}$$

$$\left(\frac{C}{N}\right)_T^{-1} = \left(\frac{C}{N}\right)_D^{-1} + \left(\frac{C}{N}\right)_u^{-1} \quad ; \text{ as } B << \left(\frac{C}{N}\right)_u$$

ex. $\left(\frac{C}{N}\right)_u = 25\,dB$ ; $\left(\frac{C}{N}\right)_D = 20\,dB$ ; $\left(\frac{C}{N}\right)_T = ?$

$10 \log_{10}(x) = 25$

$\log_{10} x = 2.5$

$x = 10^{2.5}$

$= 316.22$

$x = 10^2$

$= 200$

$$\left(\frac{C}{N}\right)_T^{-1} = \left(\frac{1}{316.22}\right) + \left(\frac{1}{200}\right)$$

$$= (0.00316) + (0.005)$$

$$\left(\frac{C}{N}\right)_T^{-1} = 0.00816$$

$$\therefore \left(\frac{C}{N}\right)_T = \frac{1}{0.00816} = 122.55$$

Evergreen

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ex. Calc. Noise P. of 6GHz rec. with $T_{in} = 75k$; $T_{RF} = 75k$; $T_M = 400k$; $T_{IF} = 1000k$; $G_{RF} = 23dB$; $G_M = 0dB$; $G_{IF} = 35dB$.

~~$P_N$~~ =

ex. Sat at dist of 36000km, rad. P = 4W; E.S. Ant. Gain = 15dB (G_T). Find flux Des. & Prec. by ant. with area of 12 m².

If $G_{Tx} = 50dB$; Calc. Prec.

~~(flux des.) $P_r = \frac{P_t}{4\pi R^2}$~~ $= \frac{4W}{4\pi(36000)^2}$

$= \frac{1}{\pi\cdot(36000)^2}$

Now,

For $G_T = 15dB$,

flux. $= \frac{P_t \cdot G_t \cdot G_r \cdot \frac{\lambda}{4}}{4\pi R^2}$

$= \frac{4 \times 10^{1.5} \times 10^5}{4\pi(36000)^2}$

Prec. = Flux × Ae

∴ = flux × 12 m²

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# * Ground Segment :

Major design parameters
Reliability & Availability
Link-Budget → G/T ratio
Customer specific req.
Special req.

Moving → Aero, Maritime, Railway } Tx & Rx

Fixed → DTH — Rx
VSAT — Tx & Rx
TV station — Tx

→ **Components of E.S. :-**
Antenna, Tx-Rx, Power system, Satellite Controlling.

→ **Components of**

**Trans. (Tx)**

Base-band Signal → [Mod.] → [Up-Conv.] → SWITCHES → [Power Comb.] → [HPA]

Signal → [Mod.] → [Up-Conv.] → SWITCHES

**Rec. (Rx)**

Rec. Signal → [LNA] → [Down Conv.] → [Demod.] —

LNA: R.F. Amplifier

→ If a single ant. is used for both Tx & Rx, then, Parabolic reflector is used.

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⇒ If diff. Ant: are used, then
for $T_x \rightarrow$ Horn Antenna
for $R_x \rightarrow$ Parabolic Ant.

ex. Transponder of Ku band sat. has linear gain $(G_r)$ of 127 dB, & nominal o/p power at sat. is 5W. 14 GHz Rec. ant. has gain of 26 dB. Calc. power o/p of uplink Tx that gives 1W (0dB) output from sat. Trans. at 14.45 GHz.
$G_T$ = 50 dB ; Waveguide loss = 1.5 dB ; Atm. loss = 0.5 dB
E.S. contour loss = 2 dB, Rain atten. = 7 dB.

Sol. ~~Total loss → 1.5+0.5−2+7 = 7dB~~
$P_r$ = EIRP + $G_r$ − Losses
We need 0 dB (1W), but we have 127 dB gain,
so $P_r = -127$ dB.

$$-127 = (P_t + G_t) + G_r - \text{losses}$$

$$-127 = (P_t + 52) + 26 - 0.5 - 1.5 - 7$$

ex. i) Ant. with dia = 30m, eff. = 68%, f = 4950 MHz, sys. Noise Temp = 79 k, elevation = 25°, What is G/T ratio.
ii) If Temp inc to 84 k, What is G/T.

Sol.
$$G_r = \frac{4\pi A_e}{\lambda^2} = \frac{4\pi \times 0.68 \times (4\pi \times 15^2)}{(c/f)^2} = \underline{4623436}$$

$$= \underline{66.64 \text{ dB}}$$

$$T_{dB} = 18.97$$

$$G/T = (66.64 - 18.97) = \underline{47.67} \text{ dB/k}$$

If T = 84k ; $G/T = 66.64 - 19.24 = \underline{47.4}$ dB/k

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# * DTH: (Direct To Home Broadcast)

→ Defined as the reception of satellite programmes with a personal dish in an individual house.

→ Works on DBS concept (Direct Broadcast Satellite)

→ Takes place in Ku Band (12 GHz)

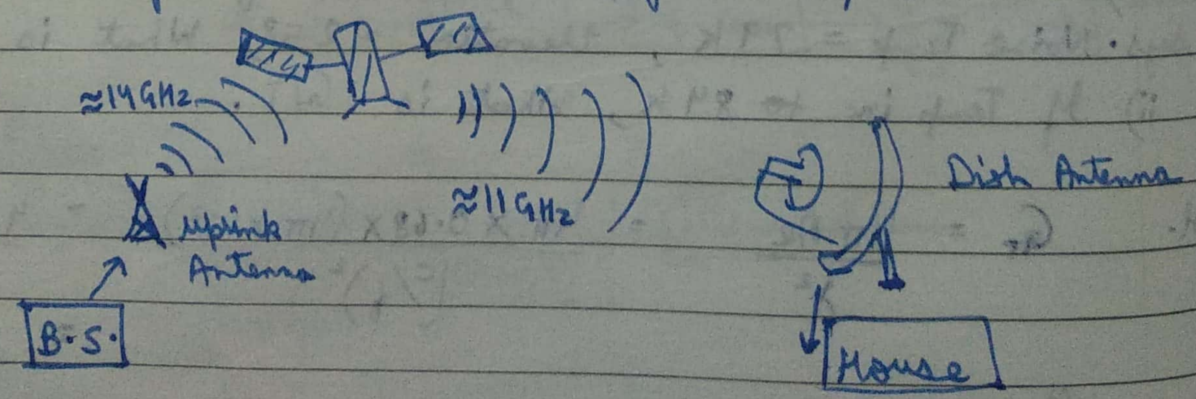
→ Modulation used - 16QAM or VSB or QPSK

→ The broadcaster (service provider) modulates the received signal and transmit it to the satellite in Ku Band.

From satellite, one can receive signal by Dish & STB.

→ DTH consists of:

1. Minidish antenna (Parabolic)
2. LNBF - Low Noise Blockdown-converter Feedhorn
   Used to receive the signal & converts it to be carried by the co-axial cable.
3. Co-axial Cable
4. Connector
5. Set-Top Box - consists of Audio/Video ~~decoders~~ modulators.



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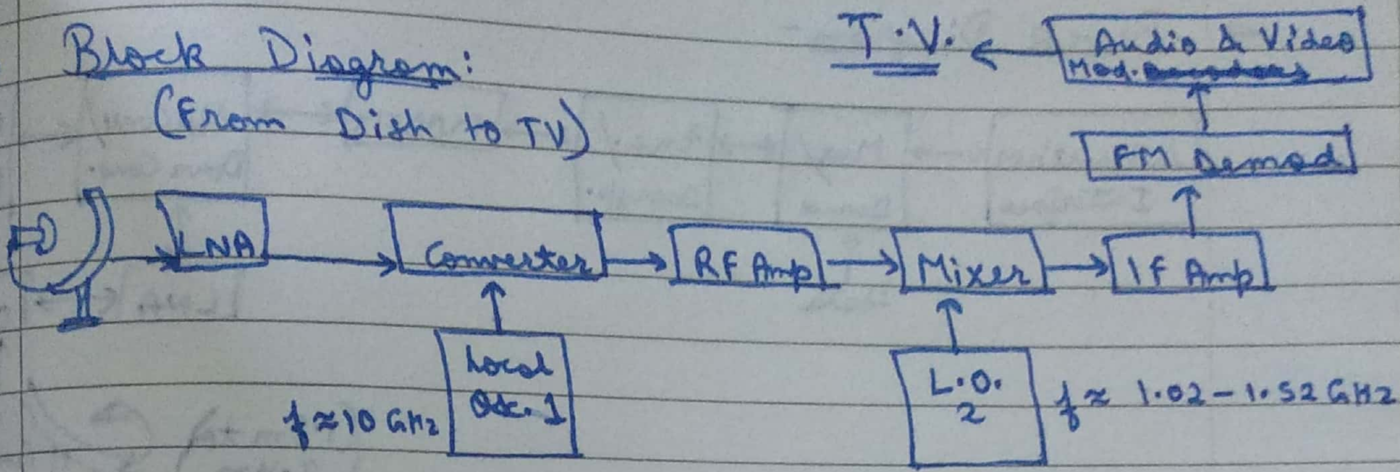
→ Block Diagram:
(From Dish to TV)




→ Receiver is a parabolic reflector horn antenna.
→ LNA used is a Wide Band Amplifier.

## * VSAT : (Very Small Aperture Terminal)

→ A VSAT is a small Earth Station that is used to receive & transmit real time data through a satellite.
→ Used for broadcast as well as narrowband data or Broadband data (satellite Internet, VoIP)
→ Uses FTDMA, FDMA or TDMA techniques in
Ex – C Band (~7 GHz uplink & ~4.5 GHz downlink)

⇒ Applications –
1. Distance Education
2. Retail Networks (POS, Banking)
3. Corporate N/W (Internet/Intranet)
4. High Speed Internet Access.

→ Topologies used for VSAT N/W → Star, Mesh.
(Mostly used)

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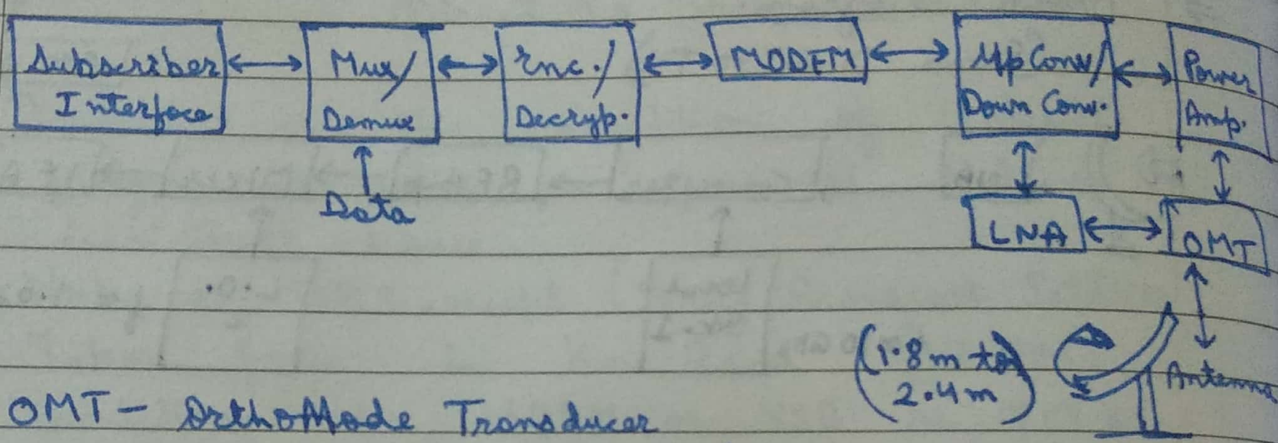
⇒ Block Diagram -




→ OMT - OrthoMode Transducer
(A waveguide Component)

→ Up Converter converts 70MHz to 6 GHz
Down Conv. converts 4 GHz to 70 MHz.

→ Modulation Tech. - QPSK
FEC in modem to enhance BER
↓
Forward error Correction.

→ Bit Rate - 128 kbps.

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