→ * The System noise temperature & G/T Ratio :- Noise temperature is a useful concept

in communications recievers. It provide a way of determining how much thermal noise is generated by active and passive devices in receiving system.

Generally noise Power is given by,

$$P_n = 4\, k\, T\, R\, B$$

where R = Resistance

T = Temperature,

B = Bandwidth

At microwave frequencies, a black body with a physical temperature T_p degree kelvin, generates electrical noise over a wide bandwidth. The noise power is given by-

$$\boxed{P_n = k\, T_p\, B}$$

k = Boltzman constant
$= 1.39 \times 10^{-23}$ J/k $= -228.6$ dBW / k / Hz

T_p = physical temperature of source in kelvin degrees.

B = noise bandwidth in which i the noise-power is measured.

P_n is avialable noise power (in watts) and will be delivered only to a load that is impedance matched to the noise source. The term kT_p → reffered as a noise power spectral density in watt per hertz

→ Noise temperature T_n :- The noise temperature for any device defined as bellow -

Any device with a noise temperature of T_n K produces at it's output the same noise power as a black body at a temperature T_n - degree kelvin followed by a noisless amplifier the same gain with active device.

- **System Noise temp T_s:-** System noise temperature T_s defined as bellow- " The noise temp of a noise-temp source located at the input of a noisless reciever with gives the same noise power as the original reciever - measured at the output of the reciever and usually includes noise from antenna." The system noise temperature T_s, - used for modeling purpose.

If.

G_{Rx} = End to end over all gain of Reciever

B_x = Narrowest bandwidth in Hz

Then noise power at demodulator input is given by-

$$\boxed{P_n = k T_s B_n G_{Rx} \text{ Watts}}$$

The noise power at Reciever input-

$$\boxed{P_n = k T_s B_n \text{ Watts}}$$

- **Carrier to Noise Ratio $\left(\frac{C}{N}\right)$:-** The carrier to noise ratio at the demodulator input -

$$\left(\frac{C}{N}\right)_{\text{at Demod. Input}} = \frac{P_r G_{Rx}}{k T_s B_n G_{Rx}} = \frac{P_r}{k T_s B_n}$$

where, P_r = Signal power delivered by antenna to the reciever RF input.

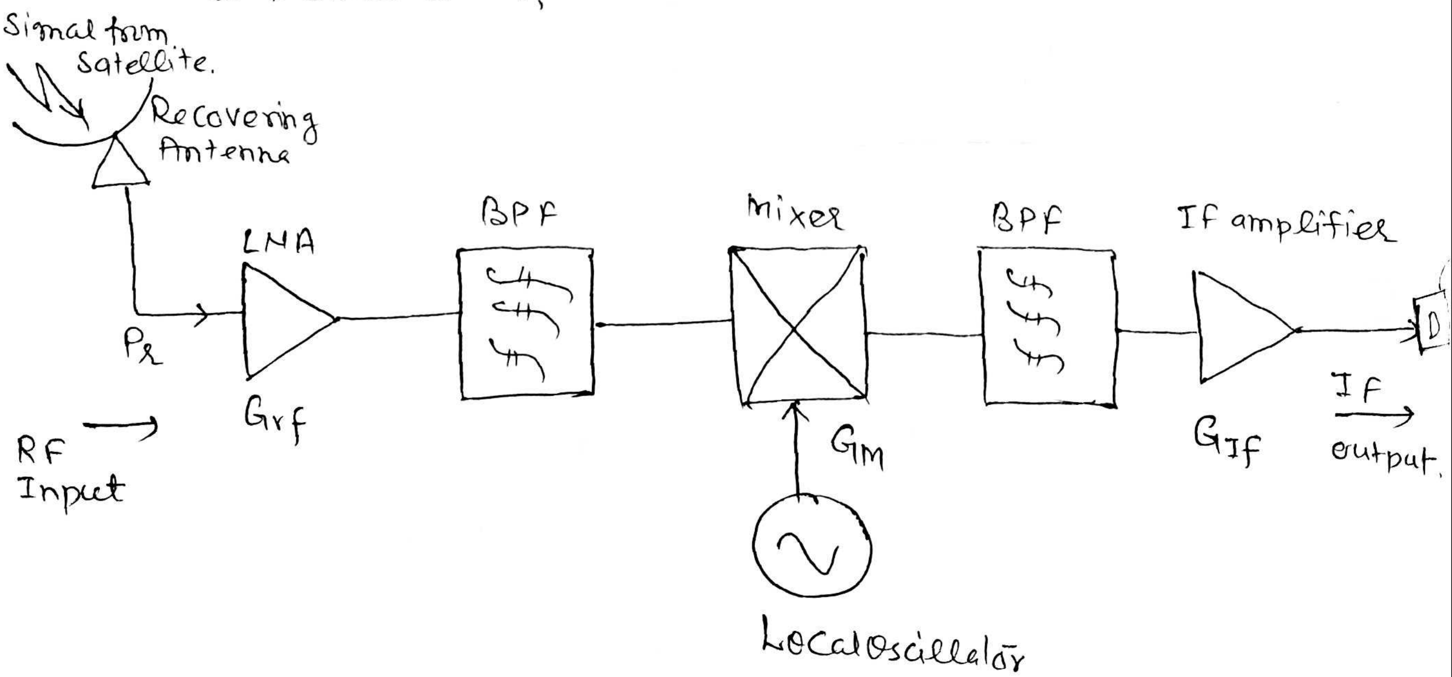
$P_r G_{Rx}$ Watt = Signal power at the demodulator input, represent the power contained in the carrier & sidebands after amplification and frequency conversion within the reciever.

→ **System Noise temperature** :- The figure shows simplified communication reciever with an RF amplifier. It is used for single frequency conversion from RF input to IF output. For example superhetrodyne [also called superhet] reciever. The superhetrodyne reciever has three main subsystems-

→ 1. Front-end. { RF amplifier, Mixer & Local Oscillator. } mixter and Local Oscillator form a frequency conversion stage that down convert the RF signal into IF,

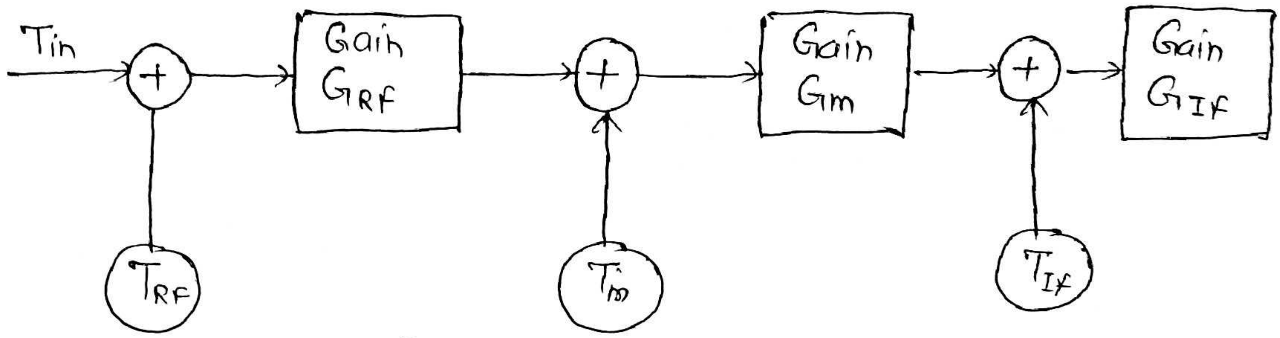
→ 2. IF amplifier. (IF amplifier & filters)

→ 3. Demodulator,



LNA = Low noise amplifier

The noise equivalent model of reciever is given bellow. This equivalent ckt can be used to represent a reciever for the purpose of noise analysis. The noisy devices in the reciever are replaced by a equivalent noisless blocks.



Equivalent Noise-Source.

T_{in} = Noise temperature of antenna measured at it's output port.

The total noise power at the output of the IF amplifier of the Reciever –

$$P_n = G_{IF} k T_{IF} B_n + G_{IF} \times G_m k T_m B_n + G_{IF} G_m G_{RF} k B_n (T_{RF} + T_{in})$$

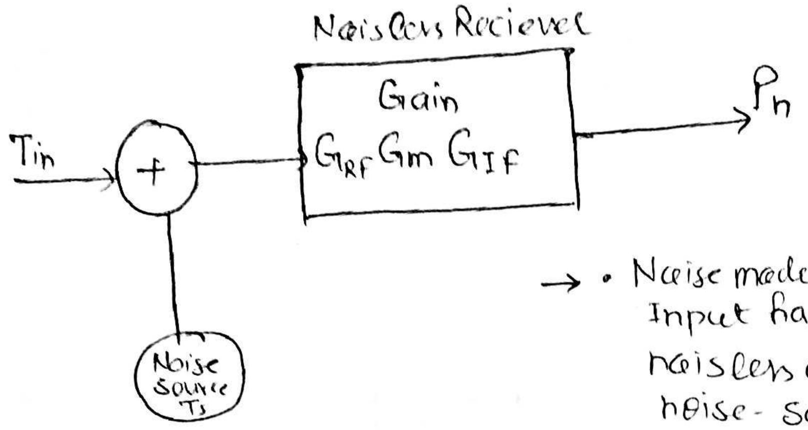
$$= G_{IF} G_m G_{RF} \left[\frac{k T_{IF} B_n}{G_m G_{RF}} + \frac{k T_m B_n}{G_m G_{RF}} + k B_n (T_{RF} + T_{in}) \right]$$

$$= G_{IF} G_m G_{RF} k B_n \left[\frac{T_{IF}}{G_m G_{RF}} + \frac{T_m}{G_{RF}} + (T_{RF} + T_{in}) \right]$$

$$\boxed{P_n = G_{IF} G_m G_{RF} k B_n T_s}$$

Where T_s called system Noise temperature and given as bellow –

$$\boxed{T_s = T_{RF} + T_{in} + \frac{T_{IF}}{G_m G_{RF}} + \frac{T_m}{G_{RF}}}$$



→ • Noise model of reciever. All noisy Input have been replaced by one noisless amplifier, with a single noise-source. T_s. ←

Noise Figure and Noise temperature :- The noise figure is used to specify the noise generated within the device. The operational noise figure (NF) is given

$$NF = \frac{\text{Signal to Noise Ratio at Input}}{\text{Signal to Noise ratio at output}}$$

$$= \frac{S/N \text{ at Input}}{S/N \text{ at Output}}$$

where NF is a linear ratio not in dB. If Noise figure given in dB then must convert it in ratio. A relation between noise figure NF and noise temperature is given-

$$\boxed{T = T_0\,(NF - 1)}$$

where T_0 = Reference temperature and usually used 290k for calculating standard noise figure.

An amplifer has a quoted noise figure of 2.5 dB. what is a equivalent noise temperature.

Given. NF = 2.5 dB

= 1.78

Hence according to formula.

$$T = T_o (NF - 1)$$

$$= 290 (1.78 - 1)$$

$$= 226 K$$

→ **G/T ratio for Earth stations:-** The quality of earth station reciever measured in the terms of G/T ratio.

The link equation can be also written in the terms of $\left(\frac{C}{N}\right)$ at the earth station-

$$\left(\frac{C}{N}\right) = \left[\frac{P_t G_t G_r}{k T_s B_n}\right]\left[\frac{\lambda}{4\pi R}\right]^2$$

$$= \underbrace{\left[\frac{P_t G_t}{k B_n}\right]}_{\text{Constant Given for a Satellite System.}} \underbrace{\left[\frac{\lambda}{4\pi R}\right]^2}_{\text{Constant for a Given Satellite System.}} \left[\frac{G_r}{T_s}\right]$$

$$\therefore \frac{C}{N} \propto \frac{G_r}{T_s}$$

$\frac{G_r}{T_s}$ normally expressed as '$\frac{G}{T}$', called $\frac{G}{T}$ ratio and given in dB

Note:- A INTELSAT G/T = 40.7 dB for G 4 GHz & 5° elevation angle declared as 'A' standard earth station.

Usually value of T_s = 70k
= 18.4 dB

maximum Gain of Recieving antenna = 65 dB

$$G_{max} \leq 65 \text{ dB}$$