Example. 1

The antenna of a satellite ground station is connected to a receiver via a length of transmission line having a loss factor L.

Define L in terms of noise temperature.

If the noise temperatures of the antenna, line feeder and receiver are T_A, T_F, T_R, respectively derive an expression for the system noise temperature and state the reference plane at which it is specified.

Calculate the overall noise temperature of the system described above if T_A = 50K, T_F = 300K, T_R = 290K and the feeder loss is 1.0 dB.

What is the new overall noise temperature of the system if an amplifier with a gain of 20 dB and a noise figure of 1 dB is inserted between the antenna and transmission line feeder?

Solution

(i) Loss factor L is defined as $$\mathrm{L} = \frac{\text{power.in}}{\text{power.out}} = \frac{\mathrm{kT_{e.in}B}}{\mathrm{kT_{e.out}B}} = \frac{\mathrm{T_{e.in}}}{\mathrm{T_{e.out}}}$$

and T_{in} and T_{out} the noise temperatures at the input and output of the lossy feeder.

(ii) At the receiver terminals the noise temperature of the antenna is reduced by a factor L. The feeder output noise is

$$\mathrm{T_{eout}} = (1 - 1/\mathrm{L})\mathrm{T_F}$$

Hence noise temperature at receiver is $$\mathrm{T'_S} = \frac{\mathrm{T_A}}{L} + (1 - \frac{1}{L})\mathrm{T_F} + \mathrm{T_R}$$

At the antenna $\mathrm{T_S} = \mathrm{LT'_S}$ $\quad \mathrm{T_S} = \mathrm{T_A} + (\mathrm{L}-1)\mathrm{T}_F + \mathrm{LT_R}$

OR use $$T_S = T_1 + \frac{T_2}{G_1} + \frac{T_3}{G_1 G_2} + \ldots\ldots + \frac{T_n}{G_1 G_2 \ldots G_{n-1}}$$

(i) Feeder has 1 dB loss, hence L = 1.26

T_S = 50 + 0.26.300 + 1.26.290

T_S = 493.4K at the antenna [remember $T'_S = T_S . \frac{G}{L}$]

(ii) Amplifier noise fig = 1 dB = 1.26

F = (1 + T_{amp}/290) hence T_{amp} = 75.1 K

Amplifier gain G = 20 dB = 100

Now $T_S = T_1 + \frac{T_2}{G_1} + \frac{T_3}{G_1 G_2} + \ldots\ldots + \frac{T_n}{G_1 G_2 \ldots G_{n-1}}$ at antenna

Therefore $T_S = \left(T_A + T_{amp}\right) + \frac{(L-1)T_F}{G} + \frac{T_R L}{G}$

T_S = 50 + 75.1 + 0.26.300/100 + 290.1.26/100 = **129.5K at antenna**