Noise Figure

The noise figure of a receiver is defined as the ratio of signal-to-noise ratio at the input of the receiver to signal-to-noise ratio at the output of the receiver. It is denoted by 'F_n' and written as,

$$F_n = \frac{(S/N)_{in}}{(S/N)_{out}} = \frac{N_{out}}{KT_0B_nG} \quad \text{... (3)}$$

Where,

S_{in} – Input signal power at receiver

N_{in} – Input noise power at receiver

S_{out} – Output signal power at receiver

N_{out} – Output noise power at receiver

K – Boltzmann's constant = 1.38×10^{-23} J/deg

T_o – Standard temperature of 290° K

G – Available gain.

Similarly, the noise figure of N networks in cascade can be written as,

$$\boxed{F_o = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \ldots\ldots + \frac{F_N - 1}{G_1 G_2 \ldots\ldots G_{N-1}}} \quad \ldots (4)$$

Noise Temperature

The noise temperature of a network is defined as, the temperature at the input of the network for the noise output 'ΔN'.

Where,

$$\Delta N = K T_e B_n G$$

T_e – Effective noise temperature.

Mathematically it is expressed as,

$$F_n = 1 + \frac{T_e}{T_o}$$

$$\Rightarrow \quad \boxed{T_e = T_o (F_n - 1)} \quad \ldots (5)$$

For the given N-network system, the effective noise temperature can be written as,

$$T_e = T_1 + \frac{T_2}{G_1} + \frac{T_3}{G_1 G_2} + ... + \frac{T_N}{G_1 G_2 ..... G_{N-1}} \quad ... (6)$$

Where,

$T_1, T_2, ..., T_N$ – Effective noise temperatures of respective networks

$G_1, G_2, ..., G_{N-1}$ – Gain of respective networks.

System Noise Temperature

System noise temperature is defined as the sum of effective noise temperature of the receiver system 'T_e' and antenna temperature 'T_a'. It is denoted by 'T_s' i.e.,

$$T_s = T_a + T_e = T_o(F_s - 1) \quad ... (7)$$

Where,

F_s - System noise figure.

The system noise temperature 'T_s' is sometimes called an operating noise temperature.

For the given N-network cascade system, the system noise temperature can be written as,

$$T_s = T_a + T_1 + \frac{T_2}{G_1} + \frac{T_3}{G_1 G_2} + ... + \frac{T_N}{G_1 G_2 ..... G_{N-1}} \quad ... (8)$$

Even though both effective noise temperature and noise figure describe the same characteristic of the network, for low-noise devices, effective noise temperature is preferred and for conventional receivers noise figure is preferred.

Even though both effective noise temperature and noise figure describe the same characteristic of the network, for low-noise devices, effective noise temperature is preferred and for conventional receivers noise figure is preferred.