NOISE CHARACTERIZATION OF A RECEIVER

Analyze the noise characteristics of a complete antenna–transmission line– receiver front end, as shown in Figure. In this system the total noise power at the output of the receiver, No, will be due to contributions from the antenna pattern, the loss in the antenna, the loss in the transmission line, and the receiver components. This noise power will determine the minimum detectable signal level for the receiver and, for a given transmitter power, the maximum range of the communication link.

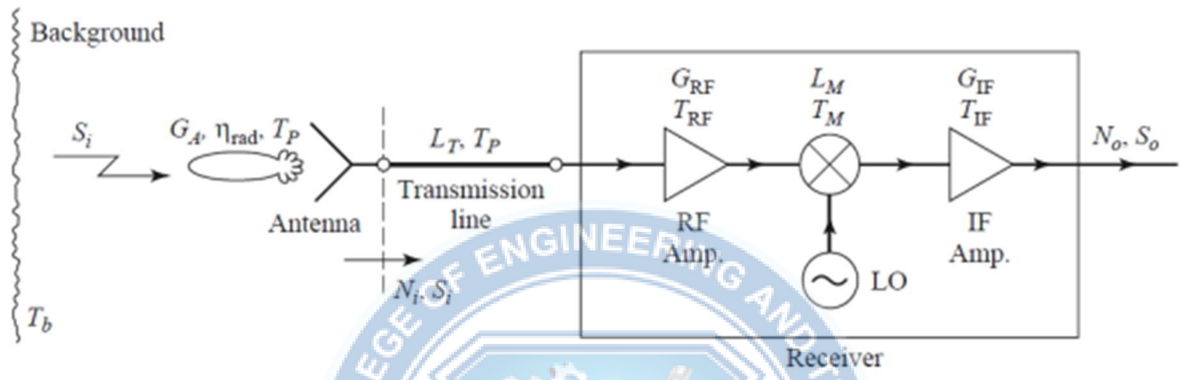

Figure 1.18 Noise analysis of a microwave receiver front end, including antenna and transmission line contributions.

The receiver components in Figure consist of an RF amplifier with gain GRF and noise temperature TRF, a mixer with an RF-to-IF conversion loss factor LM and noise temperature TM, and an IF amplifier with gain GIF and noise temperature TIF. The noise effects of later stages can usually be ignored since the overall noise figure is dominated by the characteristics of the first few stages. The component noise temperatures can be related to noise figures as $T = (F - 1)To$. The equivalent noise temperature of the receiver can be found as

$$T_{REC} = T_{RF} + (T_M / G_{RF}) + (T_{IF} L_M / G_{RF})$$

The transmission line connecting the antenna to the receiver has a loss LT, and is at a physical temperature Tp. So from its equivalent noise temperature is

$$T_{TL} = (L_T - 1)\, T_p$$

We find that the noise temperature of the transmission line (TL) and receiver (REC) cascade is

$$T_{L+REC} = T_{TL} + L_T T_{REC} = (L_T - 1)\, T_p + L_T T_{REC}$$

This noise temperature is defined at the antenna terminals (the input to the transmission line). The entire antenna pattern can collect noise power. If the antenna has a reasonably high gain with relatively low sidelobes, we can assume that all noise power comes via the main beam, so that the noise temperature of the antenna is given by

$$T_A = \eta_{rad} T_b + (1 - \eta_{rad})\, T_p$$

$$\eta_{rad} - Efficiency\ of\ the\ Antenna$$

$$T_p - Physical\ Temperature$$

T_b − equivalent brightness temperature

The noise power at the antenna terminals, which is also the noise power delivered to the transmission line, is

$$N_i = kBT_A = kB\,[\eta_{rad}T_b + (1 - \eta_{rad})\,T_p]$$

If Si is the received power at the antenna terminals, then the input SNR at the antenna terminals is Si/Ni . The output signal power is

$$So = S_iG_{RF}G_{IF}/L_TL_M = S_iG_{SYS}$$

$$G_{SYS} - System\ power\ gain.$$

The output noise power

$$N_o = (N_i + kBT_{TL+REC})G_{SYS}$$

$$= kB(T_A + T_{TL+REC})G_{SYS}$$

$$= kB\,[\eta_{rad}T_b + (1 - \eta_{rad})\,T_p + (L_T - 1)\,T_p + L_TT_{REC}]\,G_{SYS}$$

$$= kBT_{SYS}G_{SYS}$$

The output SNR is

$$So\ /\ No = S_i\ /\ kBT_{SYS} = Si/\ (\ \ kB\,[\eta_{rad}T_b + (1 - \eta_{rad})T_p + (L_T - 1)T_p + L_TT_{REC}]\ \ )$$

It may be possible to improve this SNR by various signal processing techniques. Note that it may appear to be convenient to use an overall system noise figure to calculate the degradation in SNR from input to output for the above system, but one must be very careful with such an approach because noise figure is defined only for $Ni = kToB$, which is not the case here