Noise Figure Calculation

Given: bit rate, R = 20kbps, transmit power, W = 10dBm, receive power, P = -110dBm, maximum BER = 10^{-3}, and the minimum energy per bit/noise density ($\frac{E_b}{N_0}$) = 10dB (value derived from the BER vs $\frac{E_b}{N_0}$ graph shown in Figure 2.1)

The energy per bit of the received signal E_b can be calculated using P and R thus:

$$E_b = \frac{P}{R} = P(dB) - R(dB)$$

$$= -110 - 10\log\left(20 \times 10^3\right)$$

$$= -110 - 43.01$$

$$= -153.01 dBm/Hz$$

The maximum noise, N_{omax} is given by:

$$N_{omax} = \frac{E_b}{N_0}^{-1} E_b$$

$$= E_b(dB) - \frac{E_b}{N_0}(dB)$$

$$= 153.01 dBm/Hz - 10dB$$

$$= -163.01 dBm/Hz$$

$$= -163.01 dBm/Hz - 30dB$$

$$= -193.01 dBW/Hz$$

The effective temperature T_e of the receiver can be calculated using the equation:

$$N_e = kT_eB$$

where N_e is the effective noise, k is the boltzman constant and B is the noise bandwidth. However, t is known that:

$$N_{omax} = kT_{emax}$$

which is solved for T_{emax} to give:

$$T_{emax} = \frac{N_{omax}}{k}$$

$$= N_{omax}(dB) - k(dB)$$

$$= -193.01 - 10\log\left(1.38 \times 10^{-23}\right)$$

$$= -193.01 + 228.6$$

$$= 35.59dBK$$

$$= 3622.43K$$

Therefore, the maximum allowable noise figure NF_{max} for the receiver is calculated thus:

$$NF_{max} = 10\log\left(1 + \frac{T_{emax}}{290}\right)$$

$$= 10\log\left(1 + \frac{3622.43}{290}\right)$$

$$= 11.3dB$$