The Link Budget Calculation

If a transmiter sends a signal to the receiver with power P_t, the power at the receiver is

$$P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi r)^2},$$

where G_t is a linear gain of the transmit antenna, G_r is a linear gain of the receiver antenna, r is the distance between the transmiter and the receiver, and λ is the signal wavelength.

The total noise power at the receiver is

$$N = kT_{sys}B,$$

where k is the Boltzmann constant, T_{sys} is the system temperature, and B is the signal bandwidth. In addition to that, if M_i signals are sharing the same bandwidth, we have interference

$$I = M_i P_r.$$

The carrier-to-noise (C/N) ratio before despreading is hence

$$\left(\frac{C}{N}\right)_{\text{spread}} = \frac{P_r}{N + I}$$

and after despreading it becomes

$$\left(\frac{C}{N}\right)_{\text{despread}} = M \cdot \left(\frac{C}{N}\right)_{\text{spread}},$$

where M is the spreading factor (or processing gain).