$$P_r = \sum P_r[k] = \sum \left(V_I^2[k] + V_Q^2[k]\right)$$

$$P_r = P_s + P_w$$

$$SNR = 10 \log_{10} \frac{P_s}{P_w}$$

$$P_w = \frac{P_r}{10^{\frac{SNR}{10}} + 1}$$

$$W[n] \sim CN(0, \sigma_n^2)$$

$$W[n] = W_I[n] + jW_Q[n]$$

$$W_I[n], W_Q[n] \sim N(0, \sigma_n^2)$$

$$P_W = E[|W[n]|^2] = E[W_I[n]^2] + E[W_Q[n]^2] = 2\sigma_n^2$$

$$\sigma_n = \sqrt{\frac{P_W}{2}}$$