# EE-432 Solutions – DSSS Exercises

Spring Semester 2025

## 8.1 DSSS with Constant Energy/Symbol and Variable Bandwidth in AWGN

(a) $B_c = \frac{G}{T_s} = \frac{1}{T_c}$

(b) Signal energy per chip: $\frac{E_s}{G}$; noise energy per chip: $N_0$

(c) Spectrum: flat over $B_c$, narrows after despreading

(d) After despreading: signal energy $E_s$, noise energy $N_0$

(e) SNR before: $\frac{E_s}{GN_0}$; after: $\frac{E_s}{N_0}$

(f) Only noise in the useful bandwidth affects the SNR after despreading

## 8.2 DSSS with Narrow Band Interferer

(b) Interferer energy per chip: $\frac{E_I}{G}$

(c) Spectrum: interferer spreads across $B_c$ after mixing

(d) After despreading: PSD $\frac{N_I}{G}$, bandwidth $\frac{1}{T_s}$, total energy $\frac{E_I}{G}$

(e) SIR before: $\frac{E_s}{E_I}$; after: $\frac{GE_s}{E_I}$

## 8.3 Numerical Example

(a) $R_c = R_s \cdot G = 10\,\text{kchips/s}$, $B_c = 10\,\text{kHz}$

(b) $\text{SNR} = \frac{E_s}{N_0} = 10^3 = 30\,\text{dB}$

(c) $\text{SIR} = \frac{E_s}{E_I/G} = 10 = 10\,\text{dB}$

## 8.4 DSSS with Constant Power and Fixed Bandwidth

(a) $E_{s,\text{chip}} = P_s \cdot T_c$

(b) $E_{n,\text{chip}} = N_0$

(c) SNR before: $\frac{P_s}{N_0}$

(d) Spectrum before: flat over $B_c$; after despreading: narrows to $\frac{B_c}{G}$

(e) Bandwidth after despreading: $\frac{B_c}{G}$

(f) $E_{s,\text{symbol}} = P_s \cdot G \cdot T_c$

(g) $E_{n,\text{symbol}} = N_0$

(h) SNR after: $\frac{P_s G T_c}{N_0}$

(i) Only noise in the reduced post-despreading bandwidth affects detection

(j) SNR improves linearly with $G$

## 8.5 Despreading with Two Users

(a) $\hat{b}^{(1)} = \sum c_i^{(1)} y_i$

(b) $\hat{b}^{(1)} = b^{(1)} \sum c_i^{(1)} c_i^{(1)} + b^{(2)} \sum c_i^{(1)} c_i^{(2)}$

(c) If $c^{(1)}$ and $c^{(2)}$ are orthogonal, interference from user 2 is eliminated

(d) Example of a third orthogonal sequence:

$$c^{(3)} = \left[+\frac{1}{\sqrt{4}}, -\frac{1}{\sqrt{4}}, -\frac{1}{\sqrt{4}}, +\frac{1}{\sqrt{4}}\right]$$

(e) Maximum number of orthogonal sequences of length $G = 4$ is 4