# ELEC4844/8844 Practical Class – Week 11, 2024

# BPSK Transmission over AWGN Channels

## TASK

Write a MATLAB program to realise BPSK transmission:

a) Generate a sequence of binary digits $x[n]$ corresponding to the message string "Hello World!", with each character corresponding to 8 bits (= 1 byte) based on ACSII coding.

It is suggested using the <u>int2bit</u> function if your MATLAB version is 2021b or newer, or the <u>dec2bin</u> and <u>bin2dec</u> functions if you have an older version of MATLAB.

b) Convert $x[n]$ to the BPSK baseband signal $b(t)$, with sampling frequency $f_s$ = 50 kHz and bitrate $R_b$ = 1 kbit/s. How many samples per bit (denoted as $N_{\text{spb}}$) do you have in this case?

The conversion can be achieved through the following steps:

1. let $b[n] = \begin{cases} \sqrt{E_b}, & \text{if } x[n] = 1 \\ -\sqrt{E_b}, & \text{if } x[n] = 0 \end{cases}$
2. upsampling $b[n]$ by the number of samples per bit $N_{\text{spb}}$ to obtain $b(t)$
3. filter $b(t)$ through a pulse-shaping filter $g(t)$; use the rectangular pulse shape here

Plot the baseband signal $b(t)$ as a function of time, and its centred two-sided power spectral density.

c) Modulate $b(t)$ by a carrier wave $\phi(t) = \sqrt{2/T_b}\cos 2\pi f_c t$, in which $T_b = 1/R_b$ is the bit period and carrier frequency $f_c$ = 4 kHz. Obtain the passband transmitted signal $s(t) = b(t)\phi(t)$.

Plot $b(t)$, $\phi(t)$, and $s(t)$ in the time range between 0 and 10 ms to illustrate how BPSK modulation works. Also, plot the centred two-sided PSD of $s(t)$, and calculate its energy per bit.

d) Perform BPSK detection in the absence of noise, in which case the received signal $r(t) = s(t)$. This can be achieved through the following steps:

1. demodulate $r(t)$ by $\phi(t)$ to obtain $z(t) = r(t)\phi(t)$
2. filter $z(t)$ through a matched filter $q(t) = g(t)$, to obtain $y(t) = z(t) * q(t)$
3. sample $y(t)$ at $t = n \cdot N_{\text{spb}}$ to obtain $Y[n]$
4. make symbol decision as $m[n] = \begin{cases} 1, & \text{if } Y[n] > 0 \\ 0, & \text{if } Y[n] < 0 \end{cases}$

Plot $z(t)$ and $y(t)$ as a function of time, and $m[n]$ in comparison to $x[n]$. Obtain the number of errors between the transmitted binary digits $x[n]$ and the recovered digits $m[n]$.

e) Perform BPSK detection in the presence of additive white Gaussian noise $w(t)$. Generate $w(t)$ so that the signal-to-noise ratio SNR = $E_b/N_0$ = 10 dB. Let $r(t) = s(t) + w(t)$, and plot its centred two-sided PSD.

Repeat the steps in (d) above, and plot $z(t)$ and $y(t)$ as a function of time as well as $m[n]$ in comparison to $x[n]$.