SCHOOL OF ENGINEERING
Faculty of Science and Engineering

MACQUARIE University

ELEC4844/8844 Practical Class – Week 12, 2024

Simulation of QPSK Transmission

TASK

Write a MATLAB program to simulate QPSK transmission:

a) Generate a sequence of random binary digits $m[n]$ with equal probability taking '0' or '1'. The total number of the digits in the sequence is $N_{\text{bit}} = 200$.

Convert $m[n]$ to the QPSK baseband signals $b_{ip}(t)$ and $b_{qp}(t)$, with sampling frequency $f_s = 10$ kHz, symbol rate $R_{\text{sym}} = 1$ kHz, and symbol energy $E_s = 1$.

To generate the baseband pulses, use a squared-root raised cosine pulse-shaping filter $g(t)$, which can be created using MATLAB function rcosdesign. Set the roll-off factor $\beta = 1$ and span of the filter to 6 symbols. Note that the output of the rcosdesign function is normalised, so that proper scaling is required to satisfy the symbol energy requirement.

Plot the baseband signals as a function of time and their power spectral density.

b) Quadrature modulate the baseband signals to the passband,

$$s(t) = \sqrt{\frac{2}{T_{\text{sym}}}}\left[b_{ip}(t)\cos 2\pi f_c t - b_{qp}(t)\sin 2\pi f_c t\right]$$

with carrier frequency $f_c = 1.6$ kHz. Plot $s(t)$ as a function of a time and its PSD. Also, calculate its average energy per symbol to verify $E_s = 1$.

c) Assume the transmitted signal goes through an AWGN channel with SNR = $E_s/2N_0 = 10$ dB, so that the received signal $r(t) = s(t) + w(t)$. Use a precise local carrier with frequency $f_{lo} = f_c$ and phase delay $\theta = 0°$ to quadrature demodulate the received signal, followed by matched filtering and sampling. Plot the constellation diagram to compare the transmitted and received symbols.

Make symbol decision and obtain the estimated binary digits $\hat{m}[n]$. Plot it in comparison to $m[n]$, and obtain the number of bit errors N_{err}.

d) Use the procedure above to simulate the bit error rate $\text{BER} = \lim_{N_{\text{bit}}\to\infty} N_{\text{err}}/N_{\text{bit}}$ for QPSK transmission as a function of SNR (= E_b/N_0) from 0 to 10 dB, with 0.1 dB steps. Set $N_{\text{bit}} = 10^5$ to simulate for each SNR value.

Present the simulation result in the logarithmic scale, and compare with the theoretical relationship $\text{BER} = Q\left(\sqrt{\frac{2E_b}{N_0}}\right)$.