Random Sequences Analysis

This computer lab will investigate the random sequences and how it works in DSP (e.g. What can we do if signal mixed with noise). To better understand this, in the first step, we generate the signal and noise, respectively. We can then analysis their autocorrelation and power spectrum. Given the digital input signal $x(n)$ and $w(n)$:

$$x(n) = A_1 \sin(2\pi f_1 n T_s)$$

where:

- $A_1 = 1$ are the amplitudes, Number of samples $n = 0, \ldots, N-1$, $N = 50000$
- $f_1 = 10$ Hz,
- $T_s = 1/f_s$ is the sampling time in *s*, $f_s = 100$
- $w(n)$ is 0 mean with $\sigma = 1$ random noise (Gaussian distribution), $N = 50000$

Complete the following tasks:

1. (a) Generate $x(n)$ in MATLAB.

```
N = 50000;
fs = 100;Ts=1/fs;                    %sampling frequency
t = 0:Ts:(N-1)*Ts;                     %sampling point
f = 10;
x = sin(2*pi*f*t);
figure, subplot(311), plot(x(1:100)), title('Sinwave')
```

(b) Calculate the autocorrelation $\phi(m)$ $\quad m = -L+1, \ldots 0, \ldots, L-1 \quad L = 20$.

```
Rxx = xcorr(x,x,20);
subplot(312), plot(-20:20,Rxx/N), xlabel('m'), title('Autocorrelation')
```

(c) Analysis the power spectrum.

```
[Pxx,F] = psd(x);
subplot(313), plot(F*pi,Pxx), xlabel('\Omega'), axis([0 pi 0 max(Pxx)+1]),
title('Power Spectrum')
```

2. (a) Generate noise signal $w(n)$ in MATLAB.

```
clear all
N = 50000;
x = randn(1,N);
figure, subplot(311), plot(x(1:500)), title('White noise')
```

(b) Calculate the autocorrelation $\phi_w(m) \quad m = -L+1, \ldots 0, \ldots, L-1 \quad L = 20$.

```
Rxx = xcorr(x,x,20);
subplot(312), plot(-20:20,Rxx/N), xlabel('m'), title('Autocorrelation')
```

(c) Analysis the power spectrum.

```
[Pxx,F] = psd(x);
subplot(313), plot(F*pi,Pxx), xlabel('\Omega'), axis([0 pi 0 2]),
title('Power Spectrum')
```

The observed signal is now mixing of sine wave and noise.

$$y(n) = A_1 \sin(2\pi f_1 n T_s) + w(n)$$

Task 1, use your own code to generate $y(n)$ and plot the $y(n)$.

Task 2, calculate the autocorrelation $\phi_y(m) \quad m = -L+1, \ldots 0, \ldots, L-1 \quad L = 20$ of $y(n)$ and plot the $\phi_y(m)$

Task 3, plot the power spectrum of $\phi_y(m)$ and analysis the power spectrum (can you estimate the distinguish signal and noise?)

Task 4, try to increase the power of $w(n)$ (e.g. w=2*randn(1,N)); repeat the Task 3 to measure the changes.

Task 5, add another sine wave where $y(n) = A_1 \sin(2\pi f_1 n T_s) + A_2 \sin(2\pi f_2 n T_s) + w(n)$ and $A_2 = 1$, $f_2 = 20$,repeat Task 1, 2, 3 and 4.