

20 Computations on Recorded RP Data

Load the data file `homework4.dat` from the course website. The first column is time t and the second column is a measured signal $h(t)$, in Volts.

1. What is the variance of h , from the simple time formula? What is the significant (average 1/3-highest) height based on this variance?

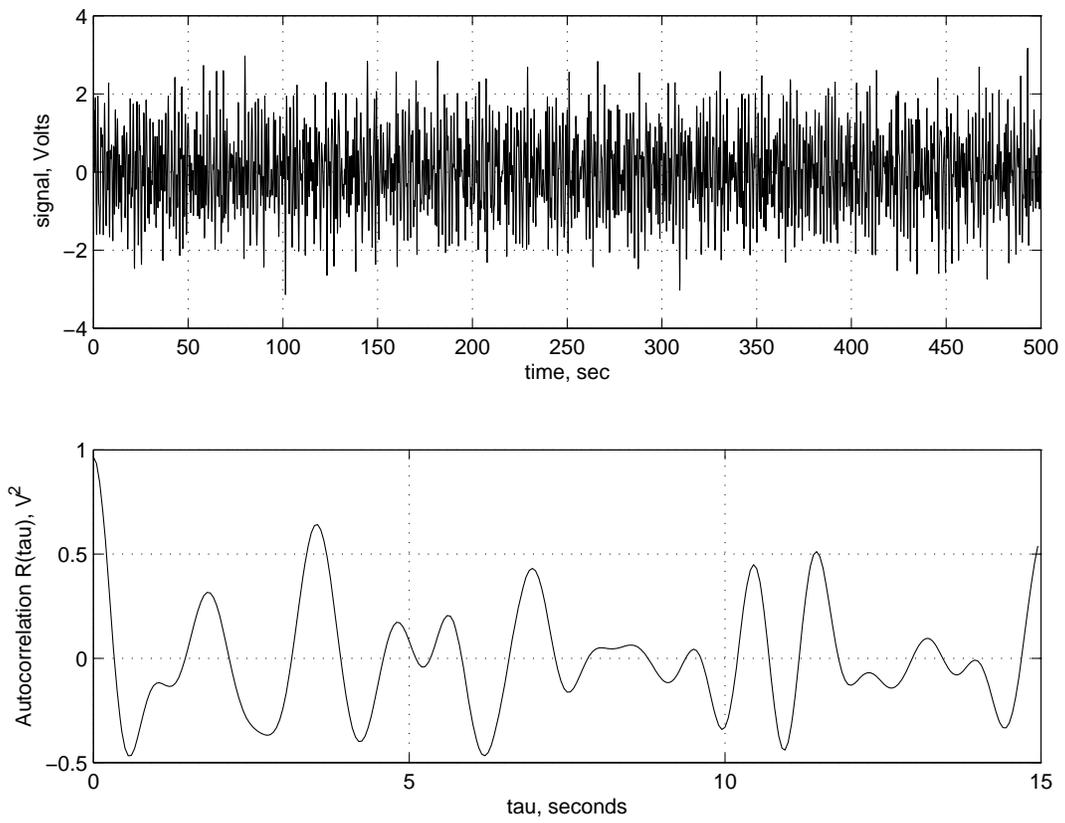
The variance is the time average of $h(t)^2$, because the signal has zero mean; it comes out to $0.97V^2$, so that the significant height is $3.93V$.

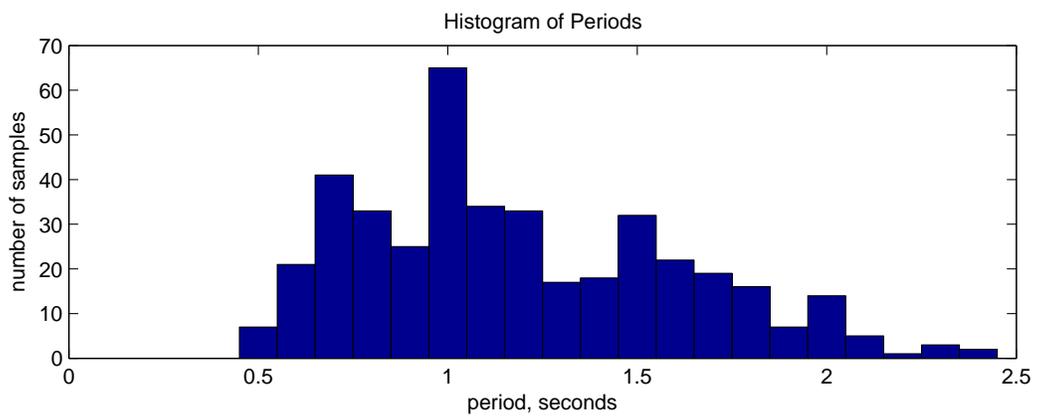
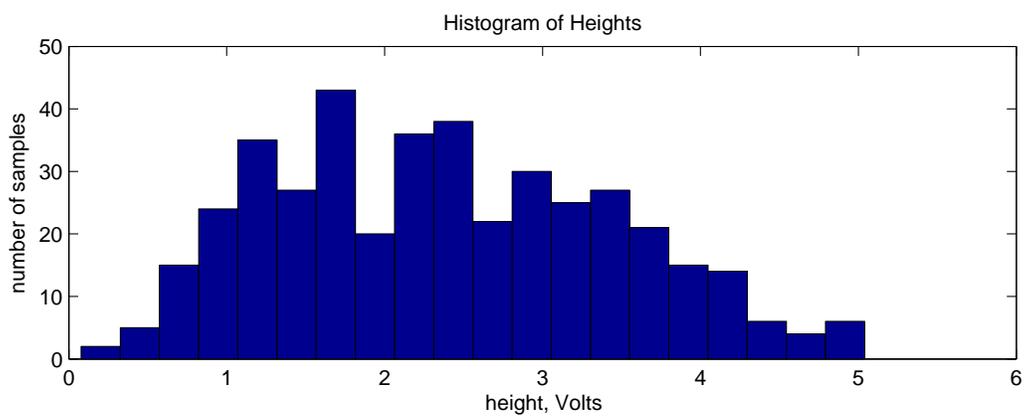
2. Write a program to count the waves using zero upcrossings as the endpoints for cycles. How many full waves do you get? What is the significant height from these observations? What is the average period? Make histograms (20 bins please) of the heights and of the periods observed.

There are 415 complete waves, the one-third average highest height is $3.63V$, and the average period is 1.20sec . The height histogram confirms a Rayleigh-like distribution (although 415 data are not really enough to be conclusive). Note the significant height calculated here is a little low because this is not a very narrow-band process. You can see this by looking at the signal close-up: lots of false peaks.

3. Calculate and plot the autocorrelation function $R(\tau)$ for $\tau = [0, 15]\text{sec}$.

See the plot. Notice the value at $\tau = 0\text{s}$ is $0.97V^2$, which is of course the variance calculated another way, $\frac{1}{2} \sum a_i^2$, where the amplitudes a_i are given in the program.





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%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Analyze time-domain data
% MIT 2.017 FSH October 2009

clear all ;

dt = .05 ; % time step
t = 0:dt:10000*dt; % time vector

%w = [1 2 3 4 5 6 7 8 9 10] ;
%w = w + randn(size(w))*0.3 ;
w = [1.1871    1.6613    3.4060    3.7160    5.4306    6.6176    ...
      7.1664    7.7864    8.9320    9.7945] ; % slightly perturbed freqs

a = [.1 .4 .6 .7 .6 .5 .4 .3 .2 .1] ; % amplitudes

%phi = 2*pi*rand(1,length(w));
phi = [6.0486    6.2545    5.8839    4.8933    1.1329    5.9219    ...
       6.0299    1.3844    4.9657    4.5073] ; % random phases

VPure = sum(a.^2)/2 ; % area under the curve = variance
HsigPure = 4*sqrt(VPure);

% build up the time-domain signal
n = length(t) ;
h = zeros(1,n) ;
for i = 1:length(w),
    h = h + a(i)*sin(w(i)*t + phi(i)) ;
end;

figure(1);clf;hold off;
subplot(211);
plot(t,h) ;
xlabel('time, sec');
ylabel('signal, Volts');
grid;

Vt = 1/n*sum(h.*h) ; % the time average
Hsigt = 4*sqrt(Vt) ;

% calculate the heights from zero up-crossings
[ind] = find( (h(1:end-1) < 0) & (h(2:end) > 0)) ;
for i = 1:length(ind)-1,
    height(i) = max(h(ind(i):ind(i+1))) - min(h(ind(i):ind(i+1)));

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