ΗΜΜΥ ΕΜΠ

6^o Εξάμηνο

Ψηφιακές Επικοινωνίες Ι

Lab 1

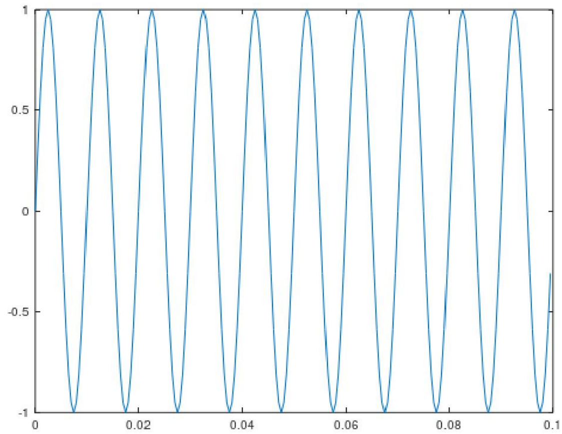
Μέρος 2

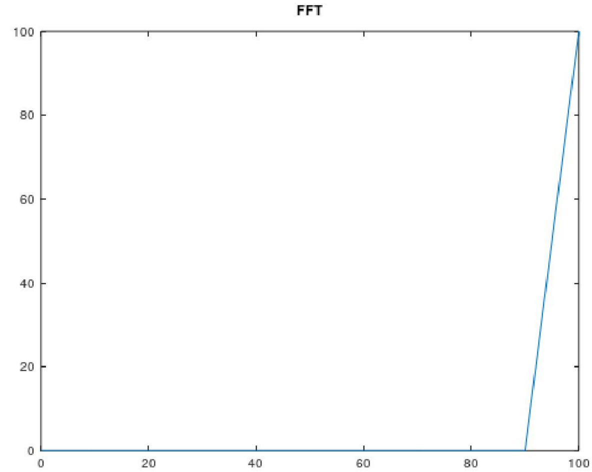
[redacted]

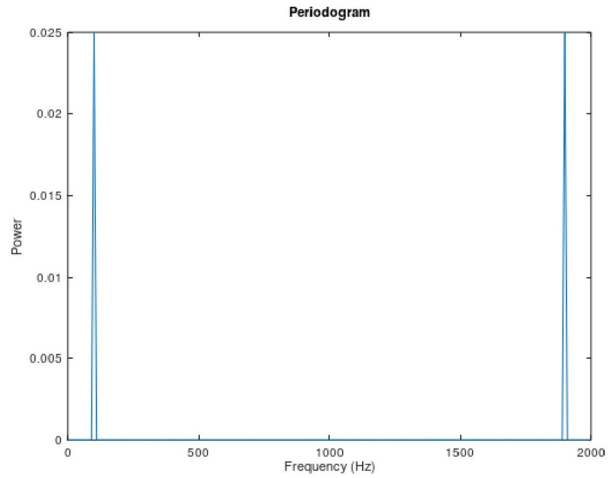
```
clear all
close all
clc

%sine wave (sampling frequency Fs)
Fs=2000;
Ts=1/Fs;
T=0.1;
t=0:Ts:T-Ts;
A=1;
x=A*sin(2*pi*100*t);
L=length(x);
plot(t,x)
pause

%DFT of sine wave
N=1*L;
Fo=Fs/N;
Fx=fft(x,N);
freq=(0:N-1)*Fo;
plot(freq,abs(Fx))
title('FFT')
pause
axis([0 100 0 L/2])
pause

%periodogram
power=Fx.*conj(Fx)/Fs/L;
plot(freq,power)
xlabel('Frequency (Hz)')
ylabel('Power')
title('Periodogram')
pause

%power of signal
power_theory=A^2/2
dB=10*log10(power_theory)
power_time_domain=sum(abs(x).^2)/L
power_frequency_domain=sum(power)*Fo
```

Command Window

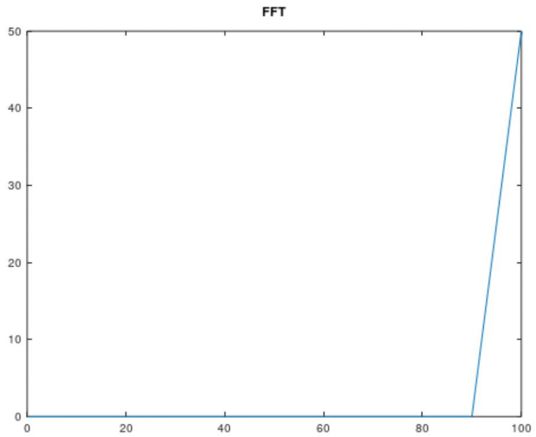
```
power_theory =  0.50000
dB = -3.0103
power_time_domain =  0.50000
power_frequency_domain =  0.50000
```

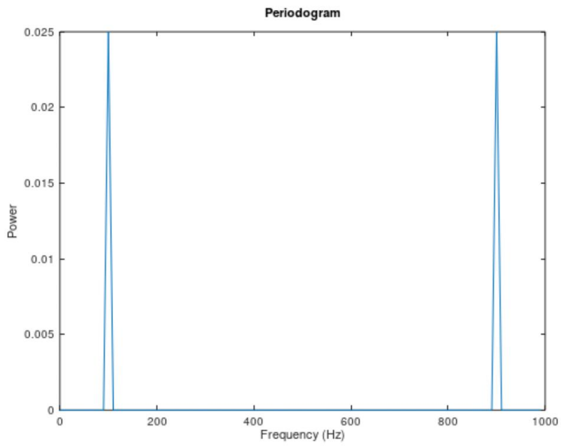




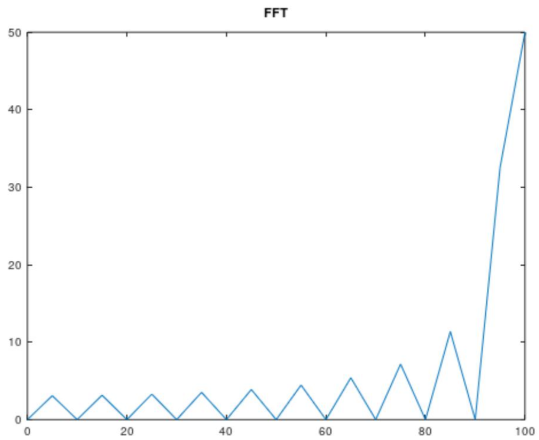


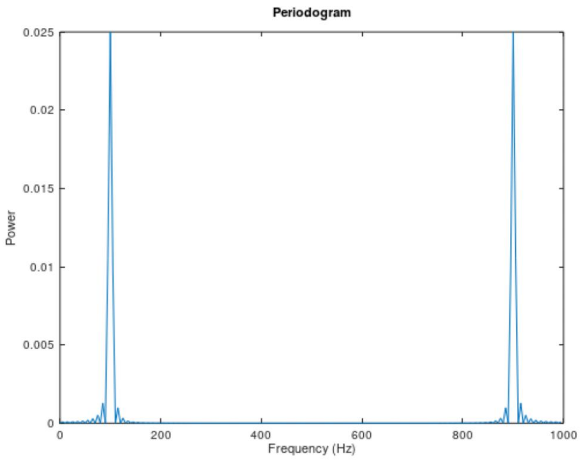
Αλλάζοντας τη συχνότητα δειγματοληψίας σε 1000 και 500 Hz παρατηρούμε αρχικά ότι χαλάει η ποιότητα του ημιτόνου στο χρόνο. Επίσης ο FFT έχει διαφορετικό πλάτος και το περιοδόγραμμα εμφανίζει ισχύ σε διαφορετικές συχνότητες:



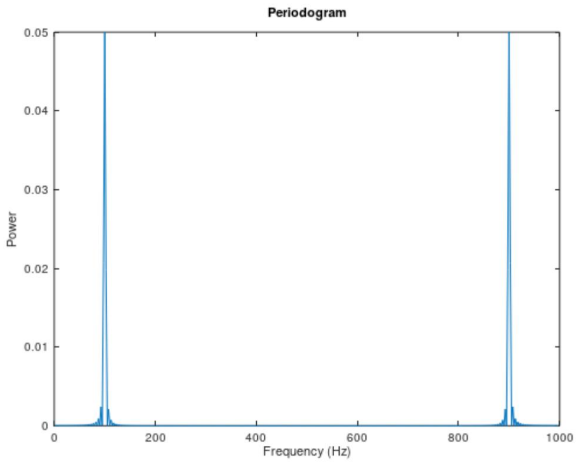


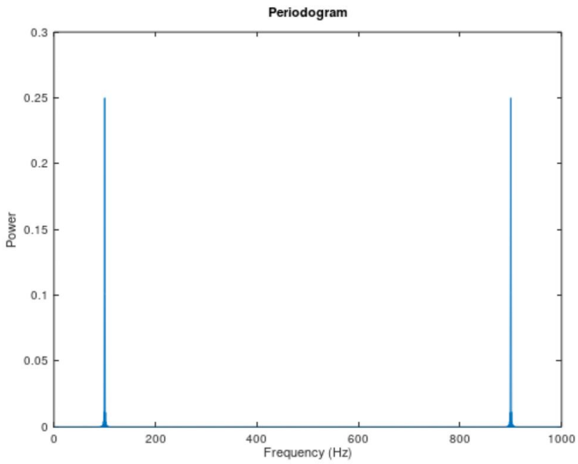
Αλλάζοντας το μήκος του μετασχηματισμού Fourier σε N=2L, 4L παρατηρούμε το φαινόμενο της φασματικής διαρροής καθώς εμφανίζονται κι άλλες μη μηδενικές συχνότητες που εξασθενούν:





Αυξάνοντας τη διάρκεια του φάσματος σε T=0.2, 0.5, 1 sec παρατηρούμε ότι το φάσμα συγκλίνει προς τη συνάρτηση δέλτα:

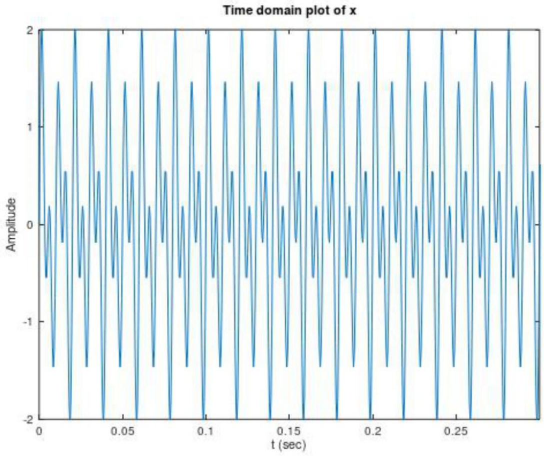




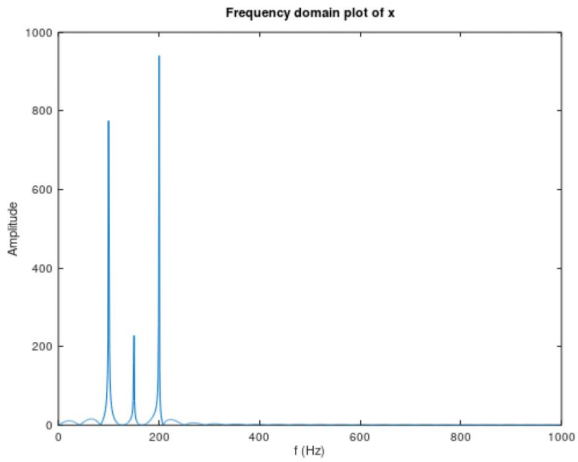
Μέρος 3

[redacted]

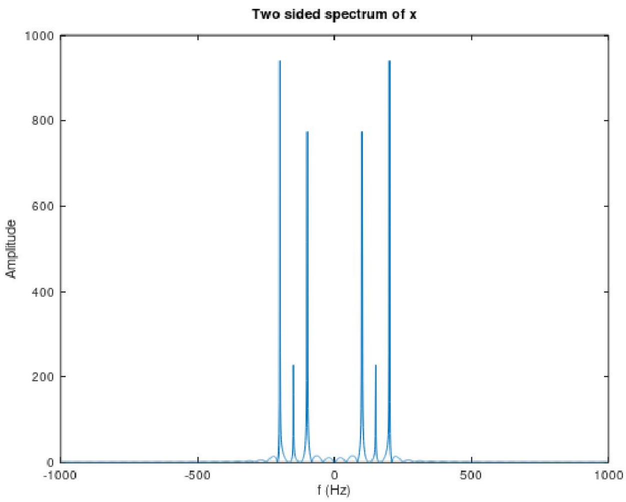
```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Part 1 : Create the signal
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

close all
clear all
clc
Fs=2000;
Ts=1/Fs;
L=2000;
T=L*Ts;
t=0:Ts:(L-1)*Ts;

x=sin(2*pi*100*t)+0.3*sin(2*pi*150*(t-2))+sin(2*pi*200*t);

% Plot signal in time domain

figure(1)
plot(t,x)
title("Time domain plot of x")
xlabel('t (sec)')
ylabel('Amplitude')
axis([0 0.3 -2 2])
```

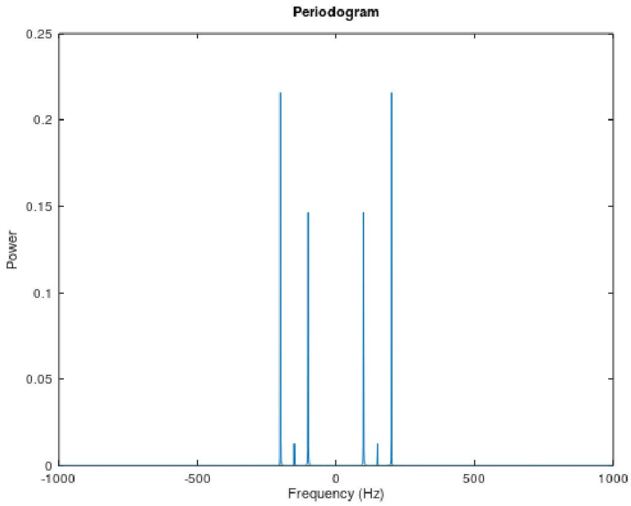



```
% Compute DFT

N = 2^nextpow2(L);
Fo=Fs/N;
f=(0:N-1)*Fo;
X=fft(x,N);

% Plot the signal in frequency domain

figure(2)
plot(f(1:(N-1)/2),abs(X(1:(N-1)/2)))
title("Frequency domain plot of x")
xlabel('f (Hz)')
ylabel('Amplitude')
```

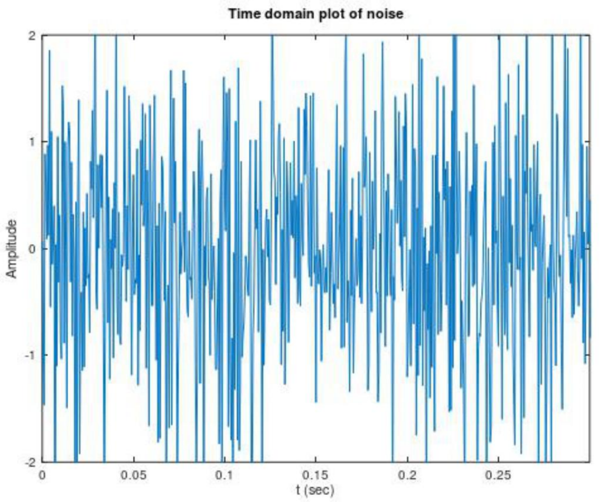


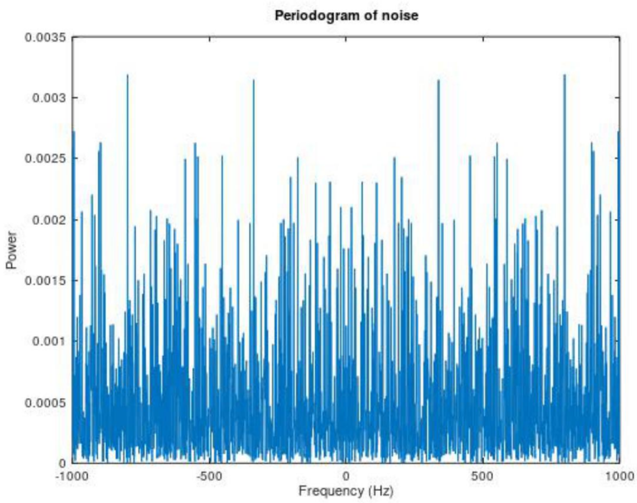

```
% Shift to center of spectrum with fftshift

figure(3)
f=f-Fs/2;
X=fftshift(X);
plot(f,abs(X));title("Two sided spectrum of x"); xlabel('f (Hz)');
ylabel('Amplitude')

% Compute power
power=X.*conj(X)/N/L;
figure(4)
plot(f,power)
xlabel('Frequency (Hz)')
ylabel('Power')
title("Periodogram")
```





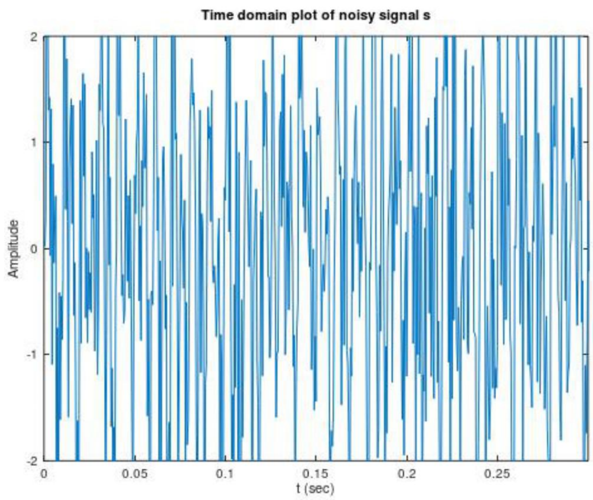

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Part 2 : Add noise to the signal
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
disp('Part2')

%Plot noise in time domain
n=randn(size(x));
figure(5)
plot(t,n)
title("Time domain plot of noise")
xlabel('t (sec)')
ylabel('Amplitude')
axis([0 0.3 -2 2])

%Power spectral density of noise
noise_power=fftshift(fft(n,N)).*conj(fftshift(fft(n,N)))/N/L;
figure(6)
plot(f,noise_power)
xlabel('Frequency (Hz)')
ylabel('Power')
title("Periodogram of noise")
```

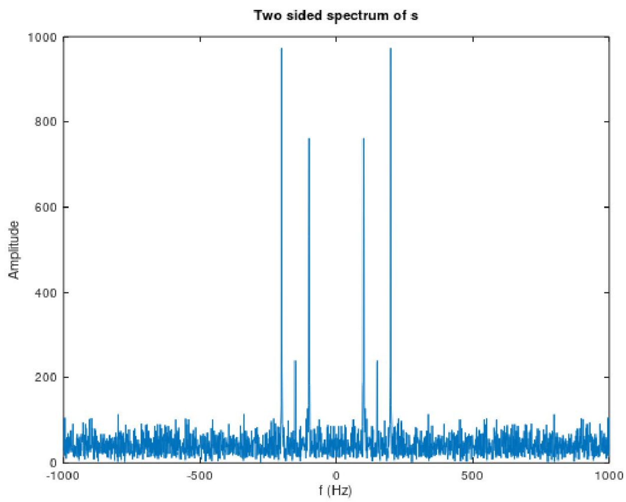




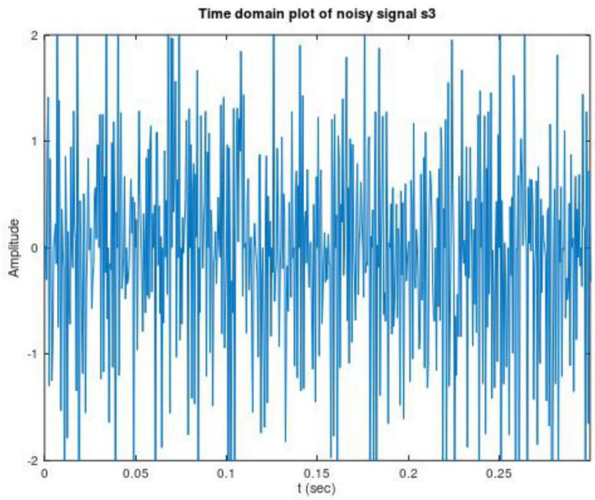
```
%Plot noisy signal in time domain
s=x+n;
figure(7)
plot(t,s)
title("Time domain plot of noisy signal s")
xlabel('t (sec)')
ylabel('Amplitude')
axis([0 0.3 -2 2])
```

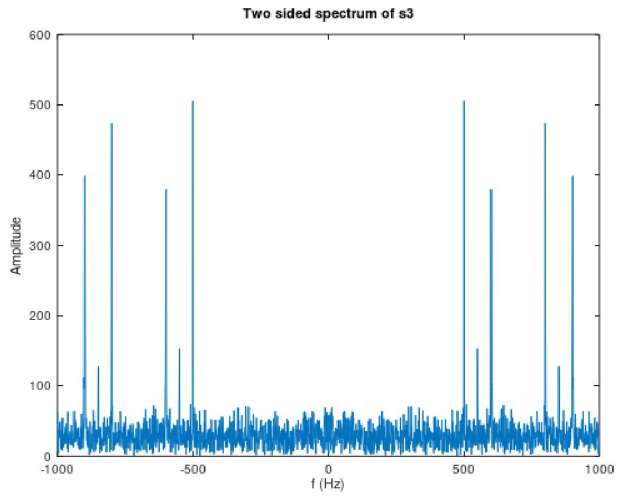
```
%Plot s in frequency domain
S=fftshift(fft(s,N));
figure(8)
plot(f,abs(S));title("Two sided spectrum of s"); xlabel('f (Hz)');
ylabel('Amplitude')
```






```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Part 3 : signal multiplication
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
disp('Part3')
s3=sin(2*pi*700*t).*s;
figure(9)
plot(t,s3)
title("Time domain plot of noisy signal s3")
xlabel('t (sec)')
ylabel('Amplitude')
axis([0 0.3 -2 2])

S3=fftshift(fft(s3,N));
figure(10)
plot(f,abs(S3));title("Two sided spectrum of s3"); xlabel('f (Hz)');
ylabel('Amplitude')
```





Μέρος 4

Την έκανα σε octave οπότε δε δουλεύει σε matlab γιατί είναι λίγο διαφορετική η σύνταξη:

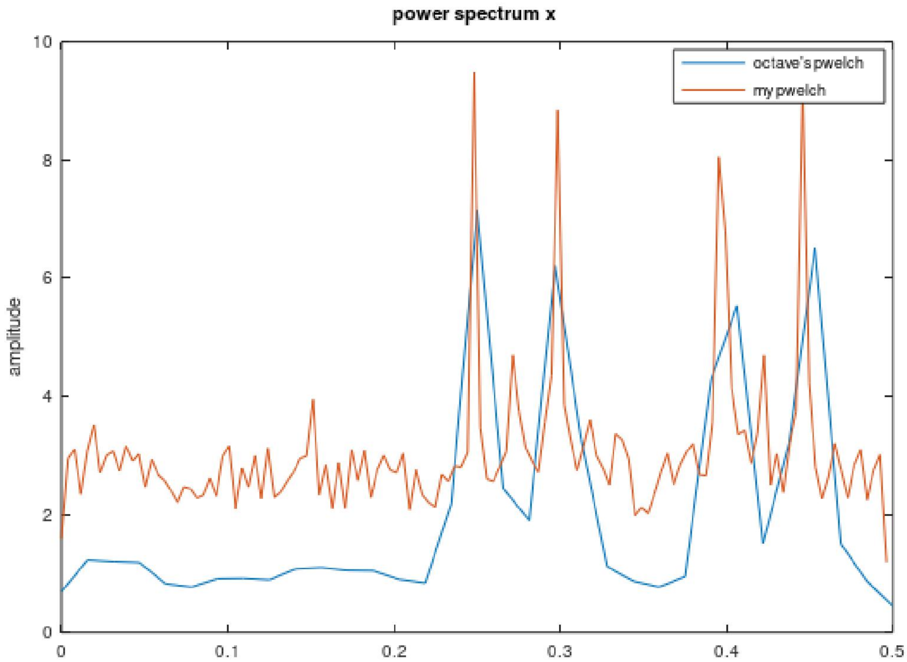
mypwelch.m

```
function mypwelch(s,Fs)
  L=length(s);
  w=max(2^nextpow2(L/8),256);
  overlap=0.5;
  num=floor(L/(w*overlap));

  Pxx_sum=zeros(1,w);
  for i=1:num-1
    if i==1
      block=[zeros(1,w*(1-overlap)) s(1:w*overlap)];
    else
      block=s((1:w)+(i-2)*w*overlap);
    endif
    blockf=fft(block);
    power=abs(blockf).^2;
    power=10*log10(power);
    Pxx=(power.*conj(power))/w;
    Pxx_sum=Pxx_sum+Pxx;
  endfor
  psd_avg=Pxx_sum/num;
  psd_avg_2=psd_avg(1:w/2+1)+[0,psd_avg(w:-1:w/2+2),0];

  plot(0:0.5/length(psd_avg_2):0.5-0.5/length(psd_avg_2),psd_avg_2)
endfunction
```

Τρέχω την pwelch στο σήμα s3 του μέρους 3 (σήμα πολλαπλασιασμένο με θόρυβο)

Γράφω στο command line:

```
pwelch(s3); hold on; mypwelch(s3,Fs);
legend("octave's pwelch","my pwelch");
```



Παρατηρώ ότι τα peaks μου συμφωνούν με την pwelch της octave αλλά έχω περισσότερο θόρυβο και φαίνεται ότι πέφτω έξω προς τα πάνω στο πλάτος (δεν καταλαβαίνω αν είναι DC συνιστώσα η συντελεστής).