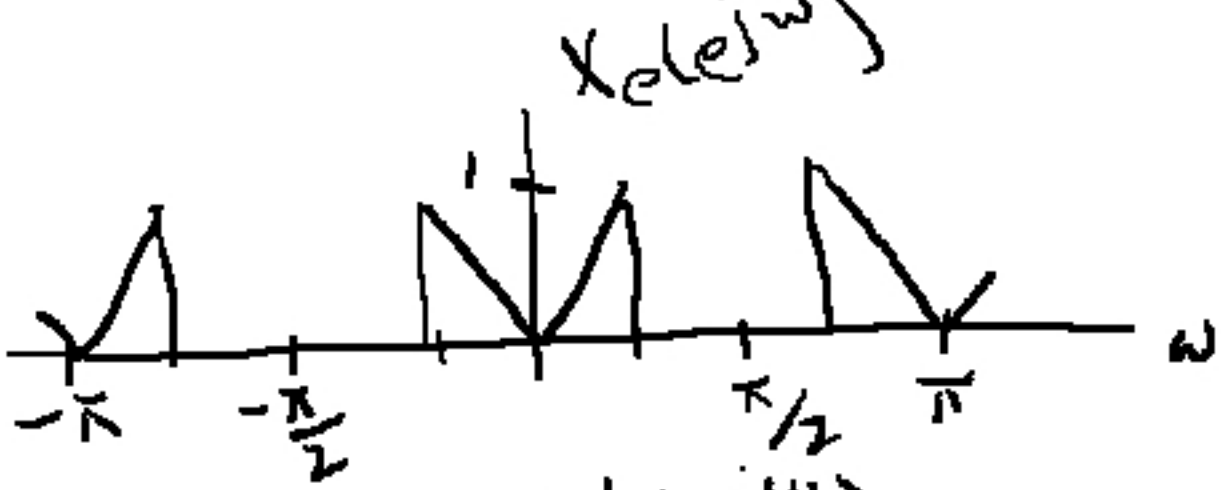
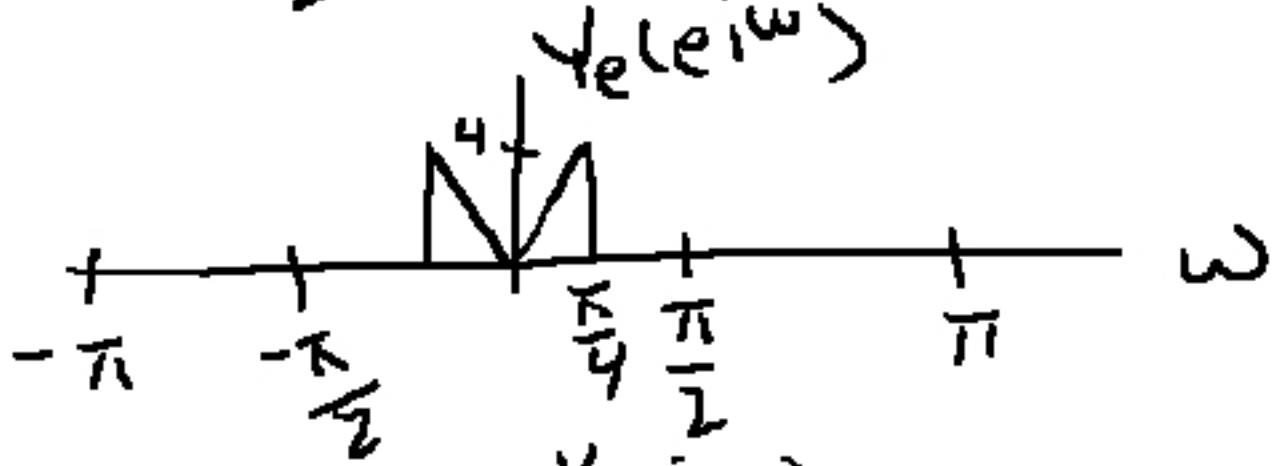
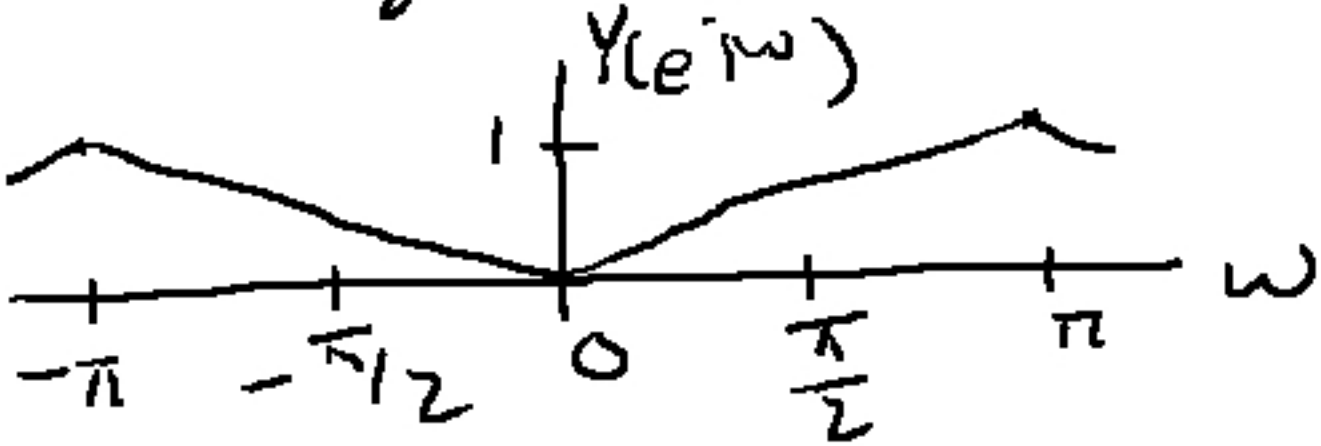
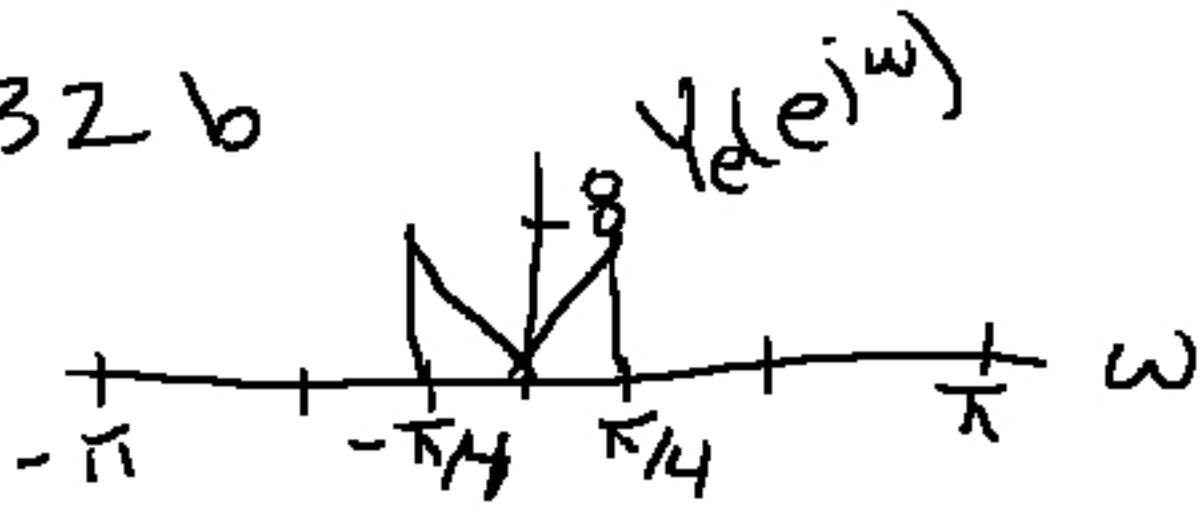
4.32a)


$X_e(e^{j\omega})$
1
ω
$-\pi$
$-\frac{\pi}{2}$
$\pi/2$
π


$Y_e(e^{j\omega})$
4
ω
$-\pi$
$-\frac{\pi}{2}$
$\frac{\pi}{4}$
$\frac{\pi}{2}$
π

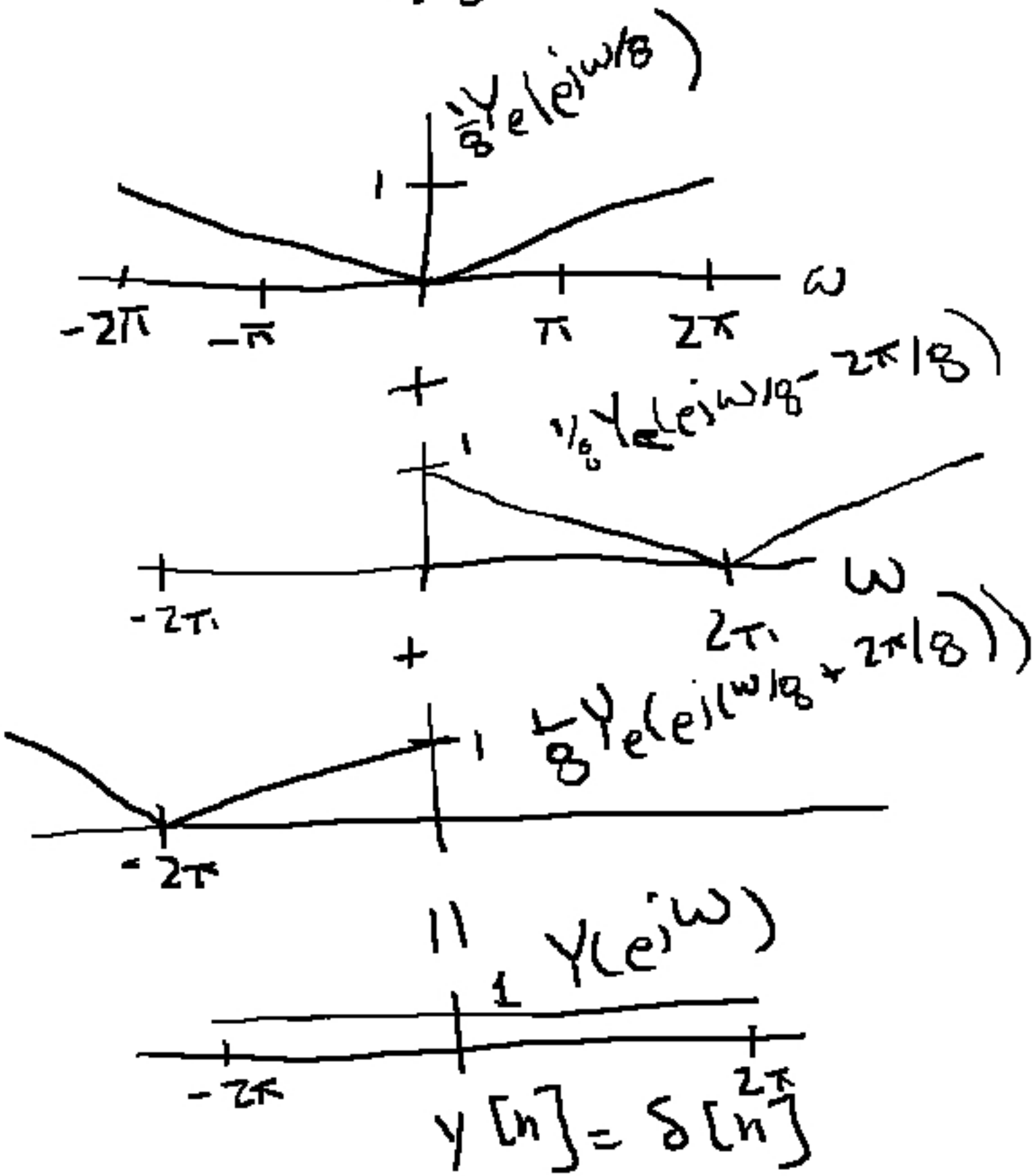

$Y(e^{j\omega})$
1
ω
$-\pi$
$-\pi/2$
0
$\frac{\pi}{2}$
π

4.32 b


$Y_d(e^{j\omega})$
8
ω
$-\pi$
$-\pi/4$
$\pi/4$
π

4.32

$$Y(e^{j\omega}) = \frac{1}{8}\sum_{i=0}^{7} Y_e(e^{j\omega/8} - 2\pi i/8)$$



Contents

Homework 4 problem 2

```
clear
close all
clc

load HW4.mat
%sound(song,fs)
```

Problem 2 part a)

```
b = 10;
c = 2^(b-1)-1;
quantsong10 = round(song*c)/c;
%sound(quantsong10,fs)

b = 8;
c = 2^(b-1)-1;
quantsong8 = round(song*c)/c;
%sound(quantsong8,fs))

b = 6;
c = 2^(b-1)-1;
quantsong6 = round(song*c)/c;
%sound(quantsong6,fs)
```

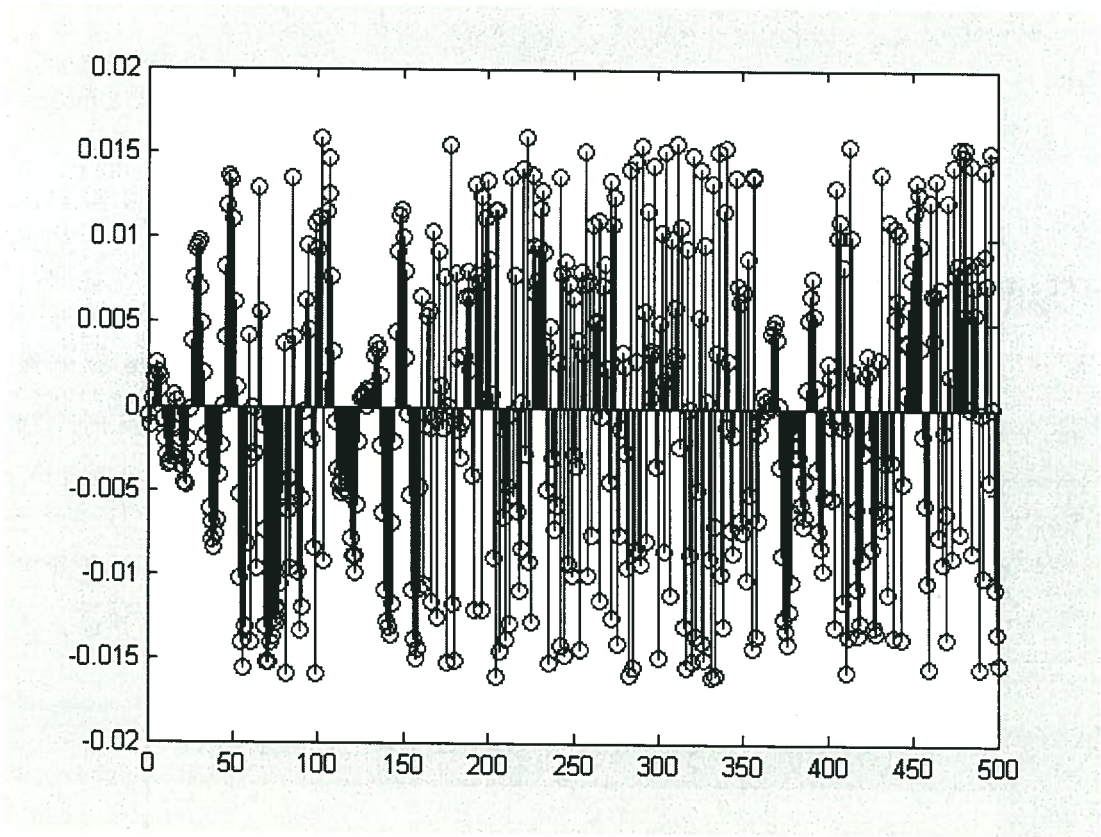
Problem 2 part b)

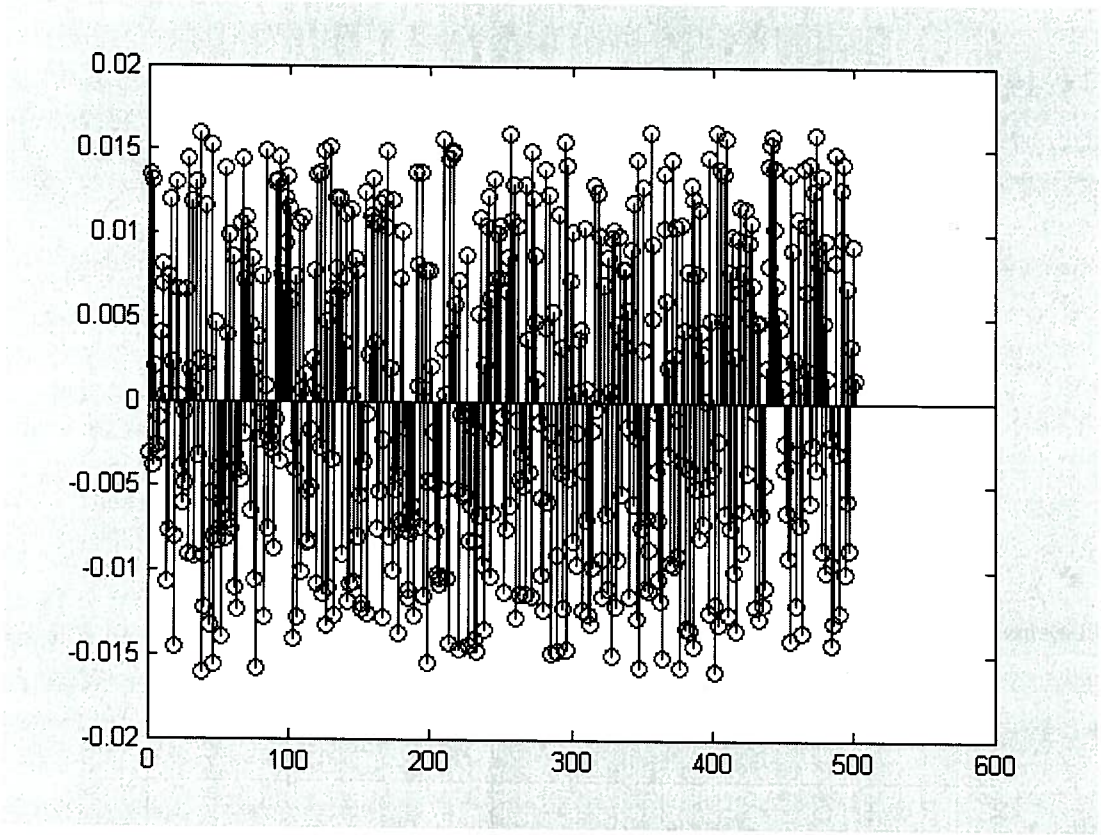
```
q_err10 = song - quantsong10;
q_err8 = song - quantsong8;
q_err6 = song - quantsong6;

10*log10(var(q_err10))
10*log10(var(q_err8))
10*log10(var(q_err6))

%Yes, this agrees with the 6dB per bit theory


ans =

  -64.9646


ans =

  -52.8668


ans =

  -40.6513
```

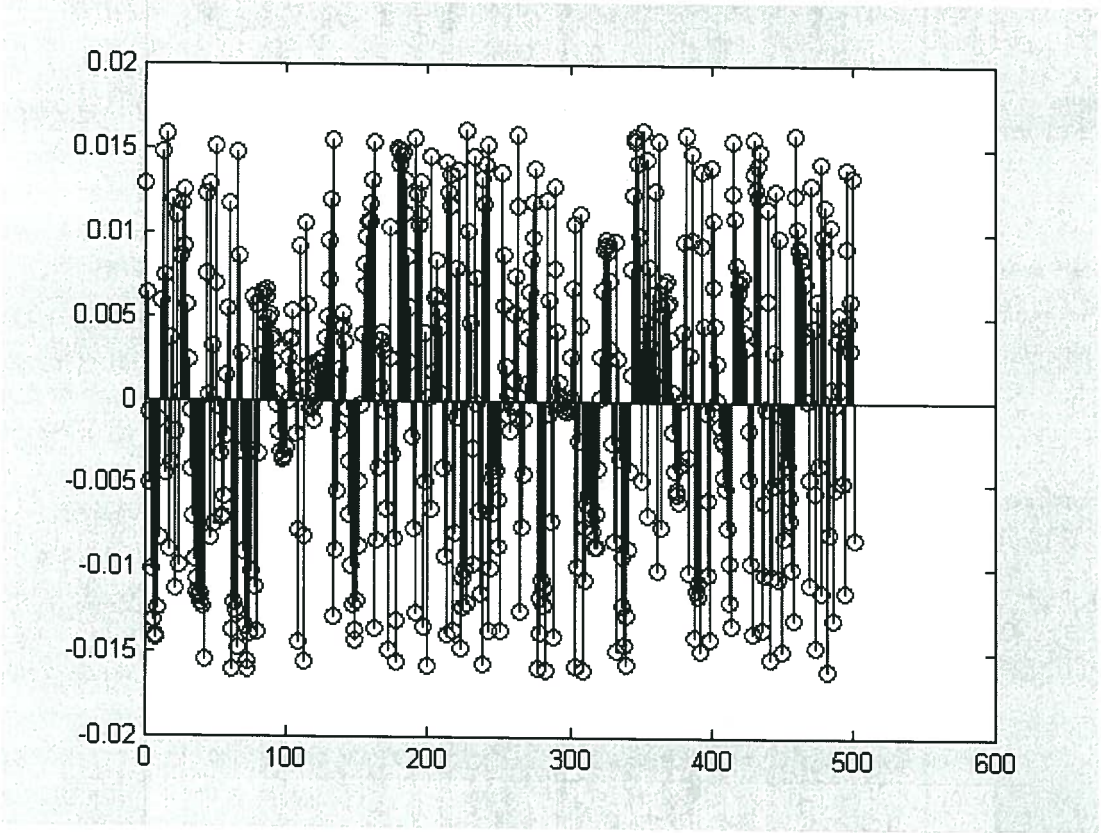
Problem 2 part c)

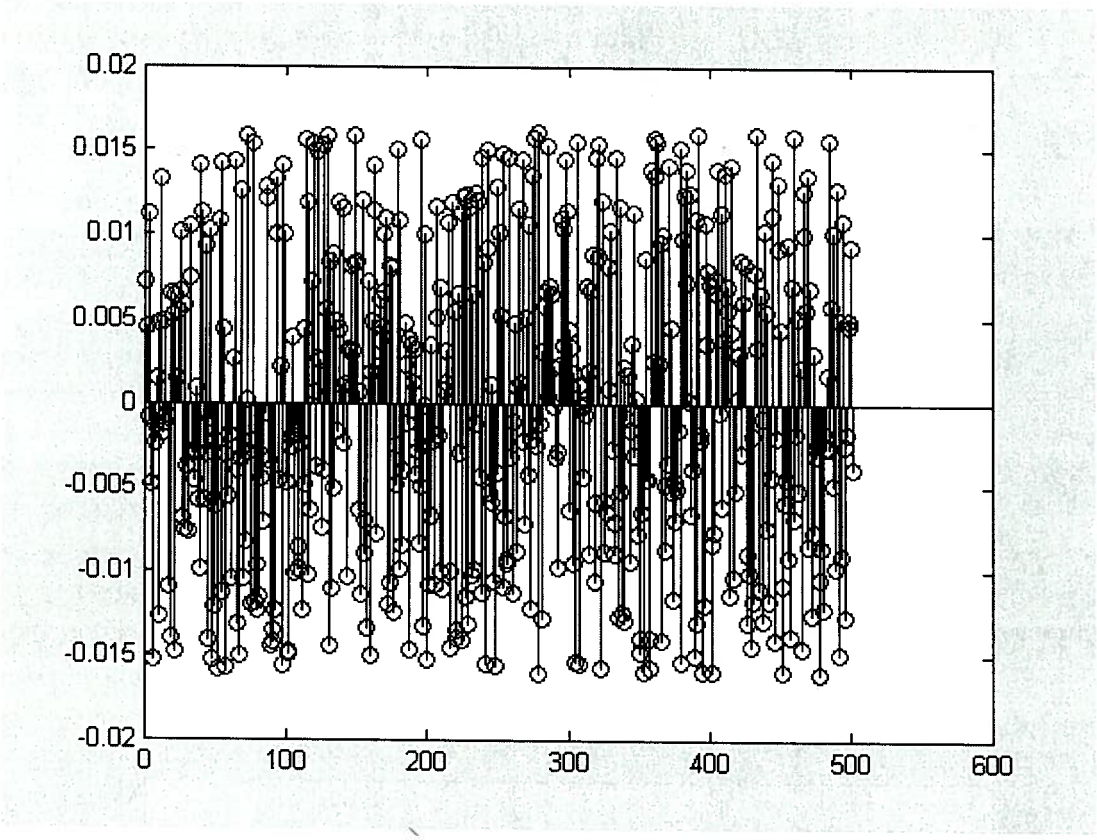
```
N = length(song)
stem(q_err6(1:500))
figure
stem(q_err6(round(N/5):round(N/5)+500))
figure
stem(q_err6(round(2*N/5):round(2*N/5)+500))
figure
stem(q_err6(round(3*N/5):round(3*N/5)+500))
figure
stem(q_err6(round(4*N/5):round(4*N/5)+500))

%There doesn't really appear to be any sort of pattern
```

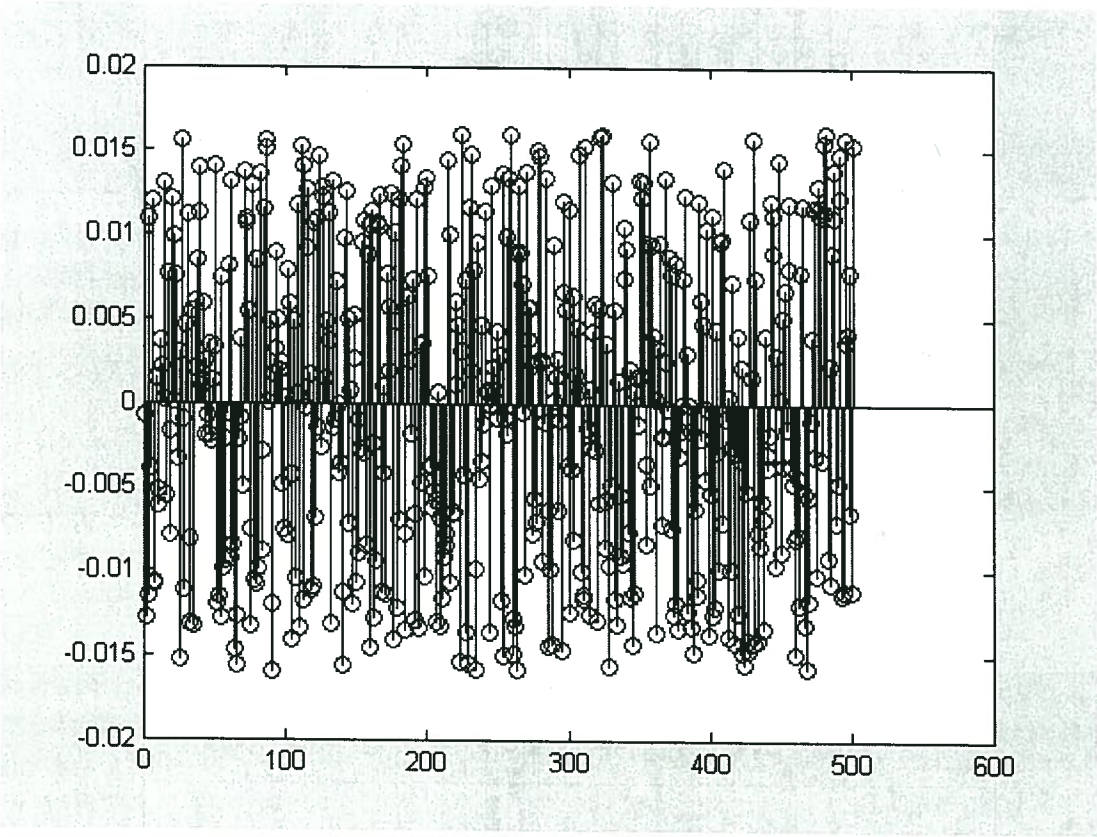
```
N =

      862820
```




0.02
0.015
0.01
0.005
0
-0.005
-0.01
-0.015
-0.02
0
100
200
300
400
500
600


0.02
0.015
0.01
0.005
0
-0.005
-0.01
-0.015
-0.02
0
100
200
300
400
500
600





Problem 2 part d)

The minimum and max are

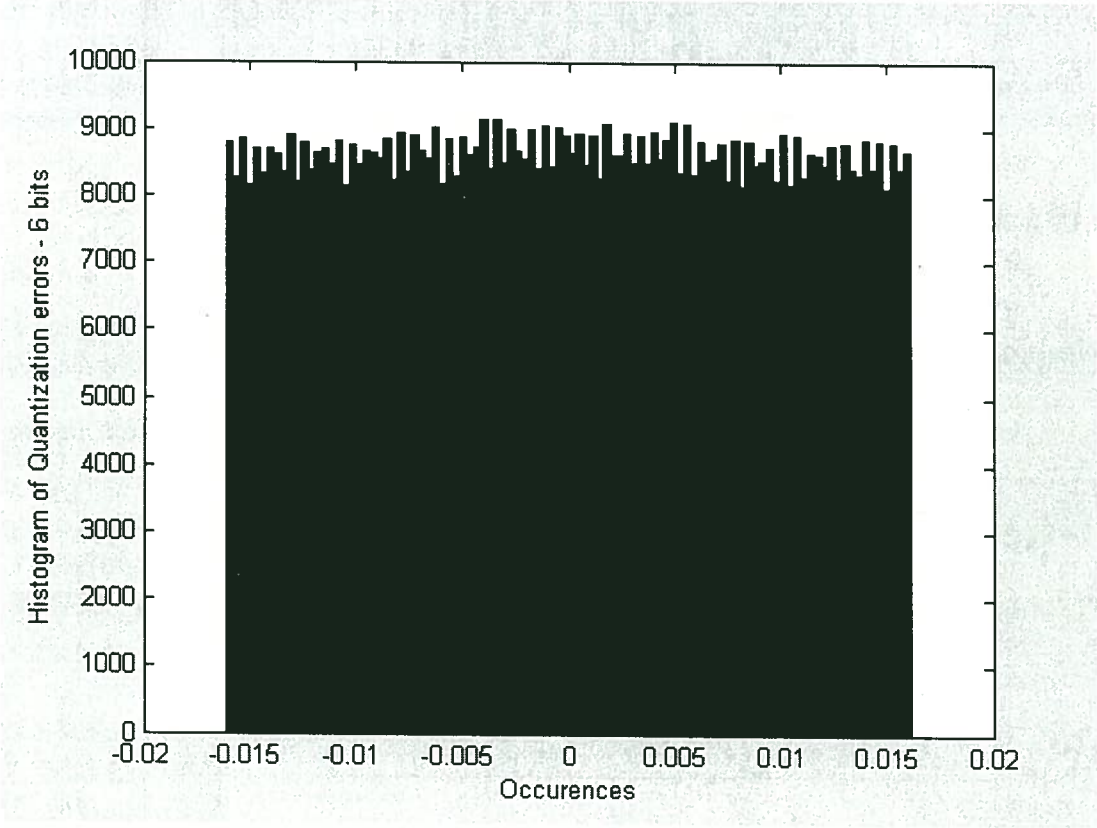
$$\frac{\Delta}{2} = \frac{1}{2^6}$$

```
minq = min(q_err6)
maxq = max(q_err6)
mean = mean(q_err6)
```

```
minq =

   -0.0161

maxq =

    0.0161

mean =

 -7.3438e-006
```

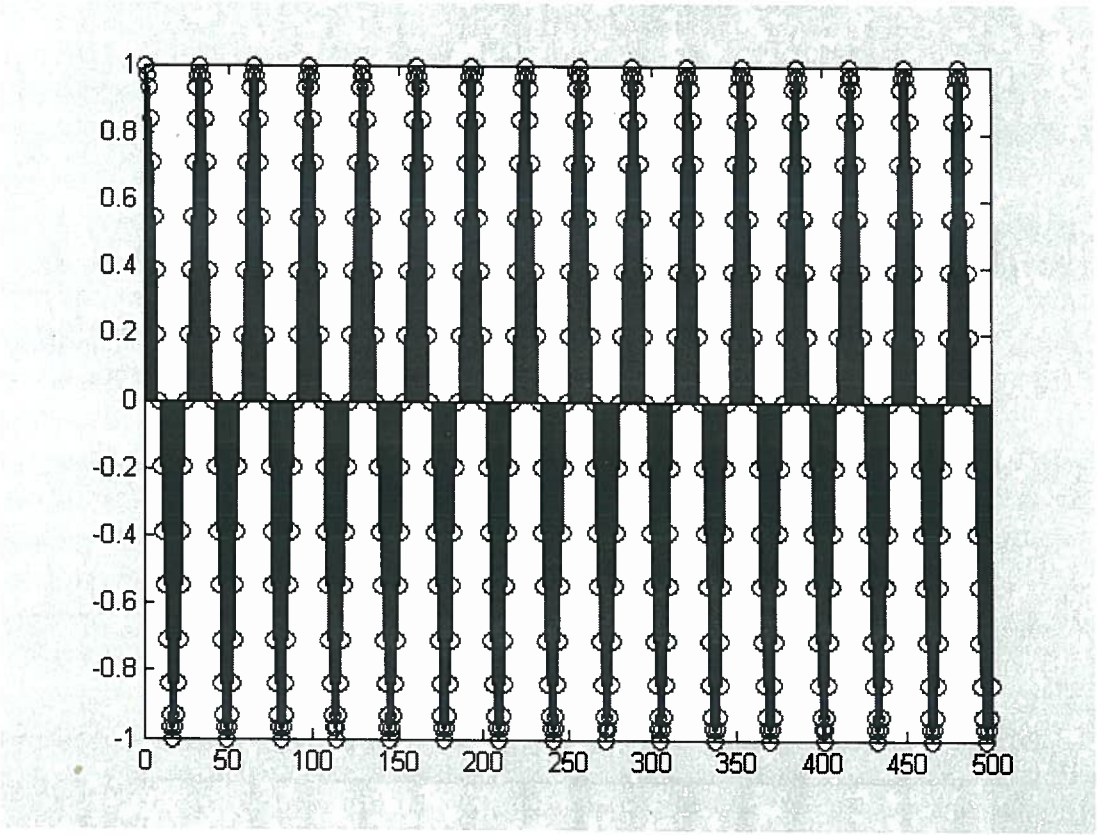
Problem 2 part e)

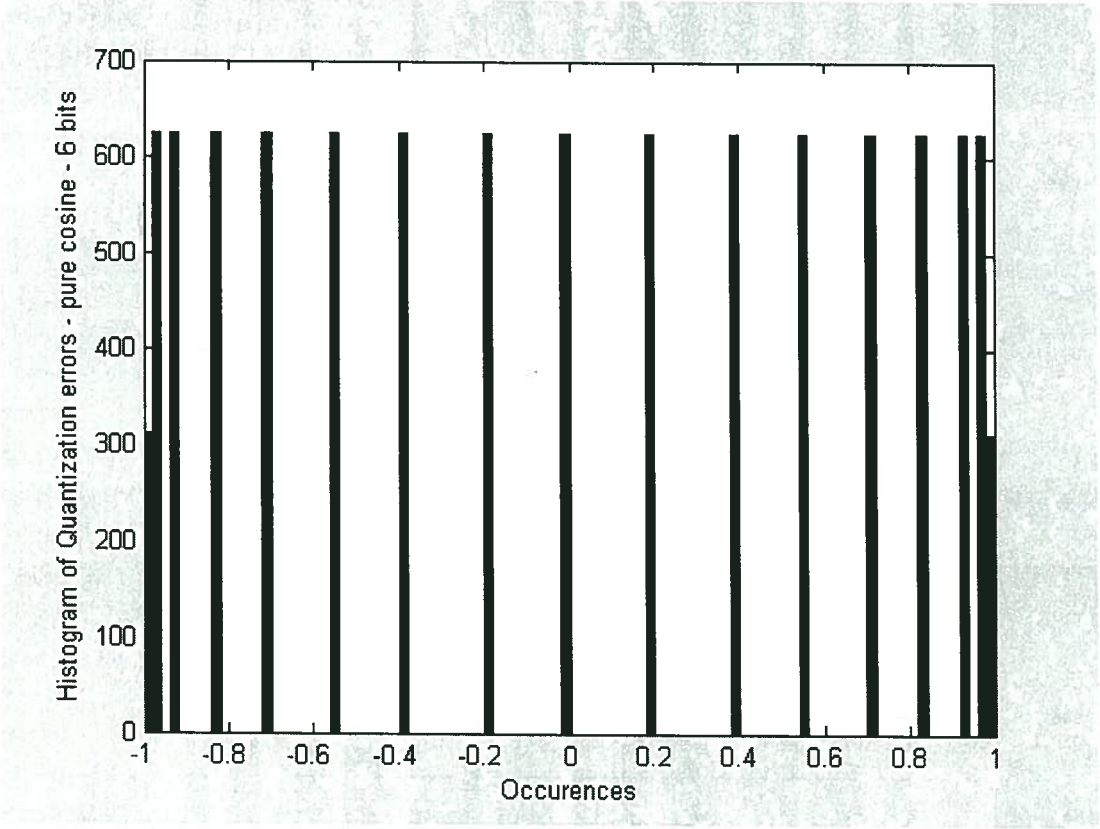
```
figure
hist(q_err6,100)
ylabel('Histogram of Quantization errors - 6 bits')
xlabel('Occurences')

%Yes, this histogram agrees with a normal distribution
```



Problem 2 part f)

```
n = [0:1:9999];
x = cos(2*pi*n/32);

b = 6;
c = 2^(b-1)-1;
qx = round(x*c)/c;

N = length(x)
figure
stem(qx(1:500))
%all look same
%figure
%stem(qx(round(N/5):round(N/5)+500))
%figure
%stem(qx(round(2*N/5):round(2*N/5)+500))
%figure
%stem(qx(round(3*N/5):round(3*N/5)+500))
%figure
%stem(qx(round(4*N/5):round(4*N/5)+500))

%Yes, there is clearly a pattern
figure
hist(qx,100)
ylabel('Histogram of Quantization errors - pure cosine - 6 bits')
xlabel('Occurences')

%A uniform distribution is not a good approximation - since we are sampling
%a periodic function, at an integer rate of the period, we repeat values of
%x, and hence repeat values of quantization error.


N =

       10000
```





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