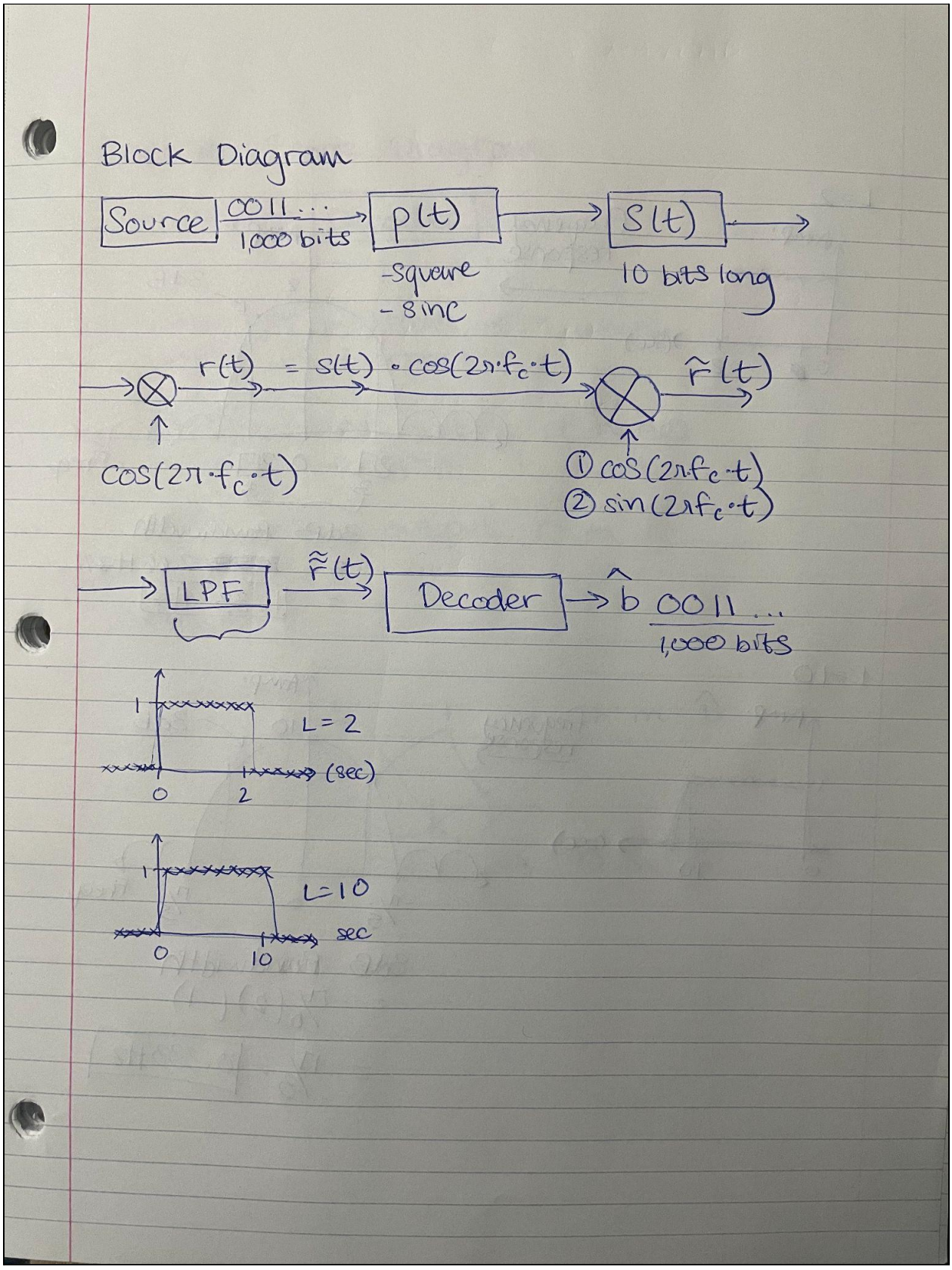
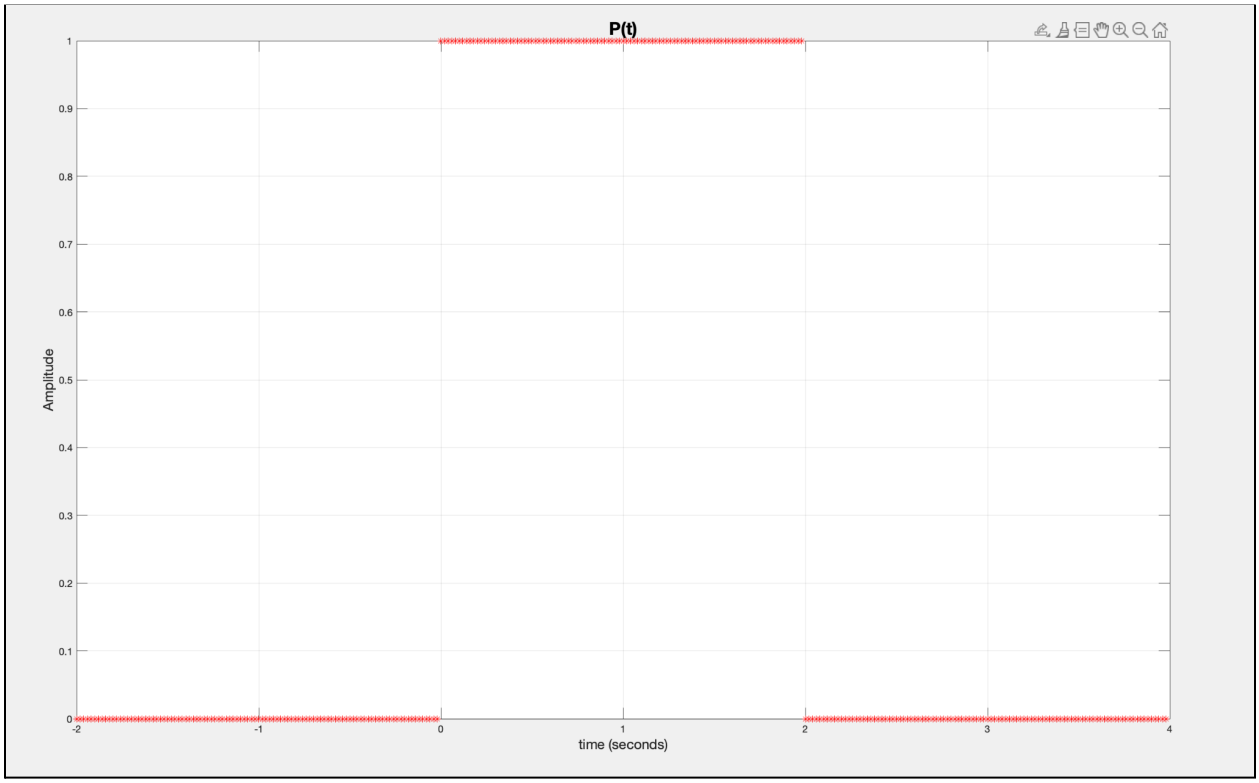
Name: Sibhithirumeni Ramadoss
RUID: 193004150
Date: 03/06/2022
Principles of Communication Systems: Homework 3

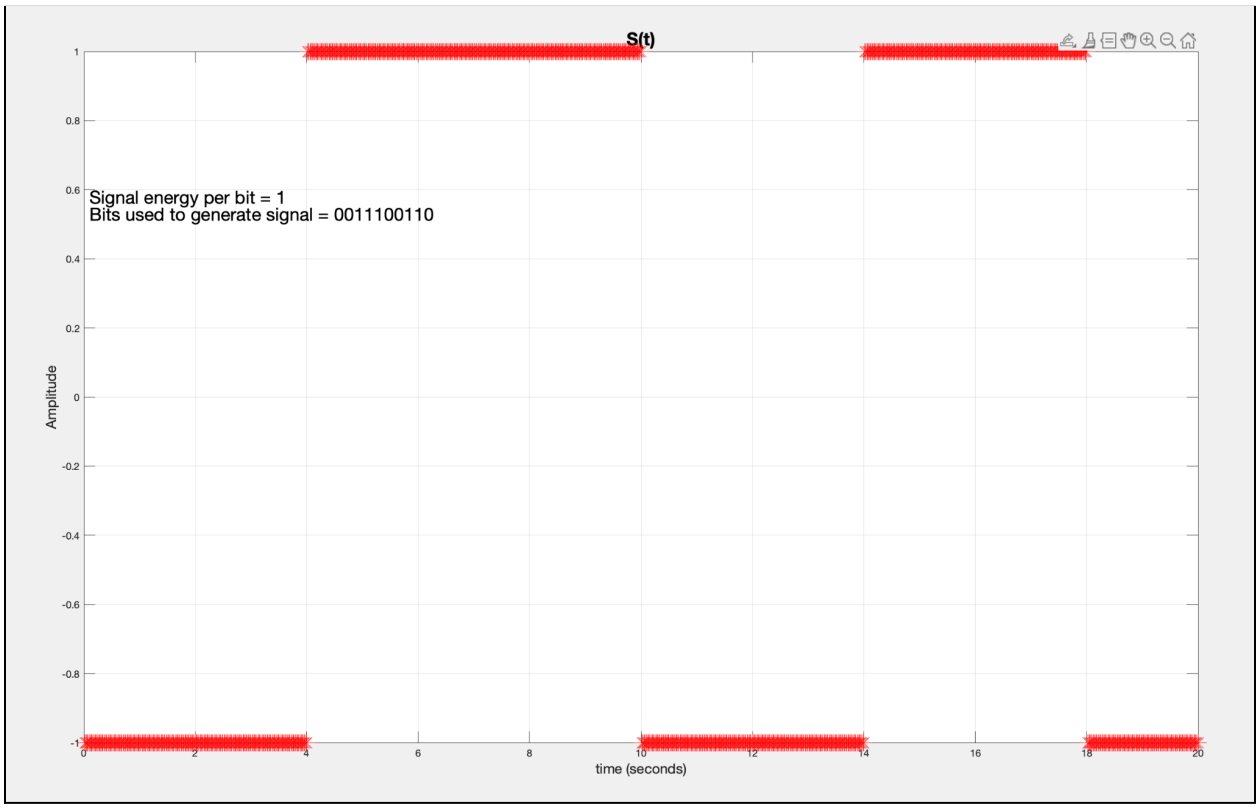
BLOCK DIAGRAM

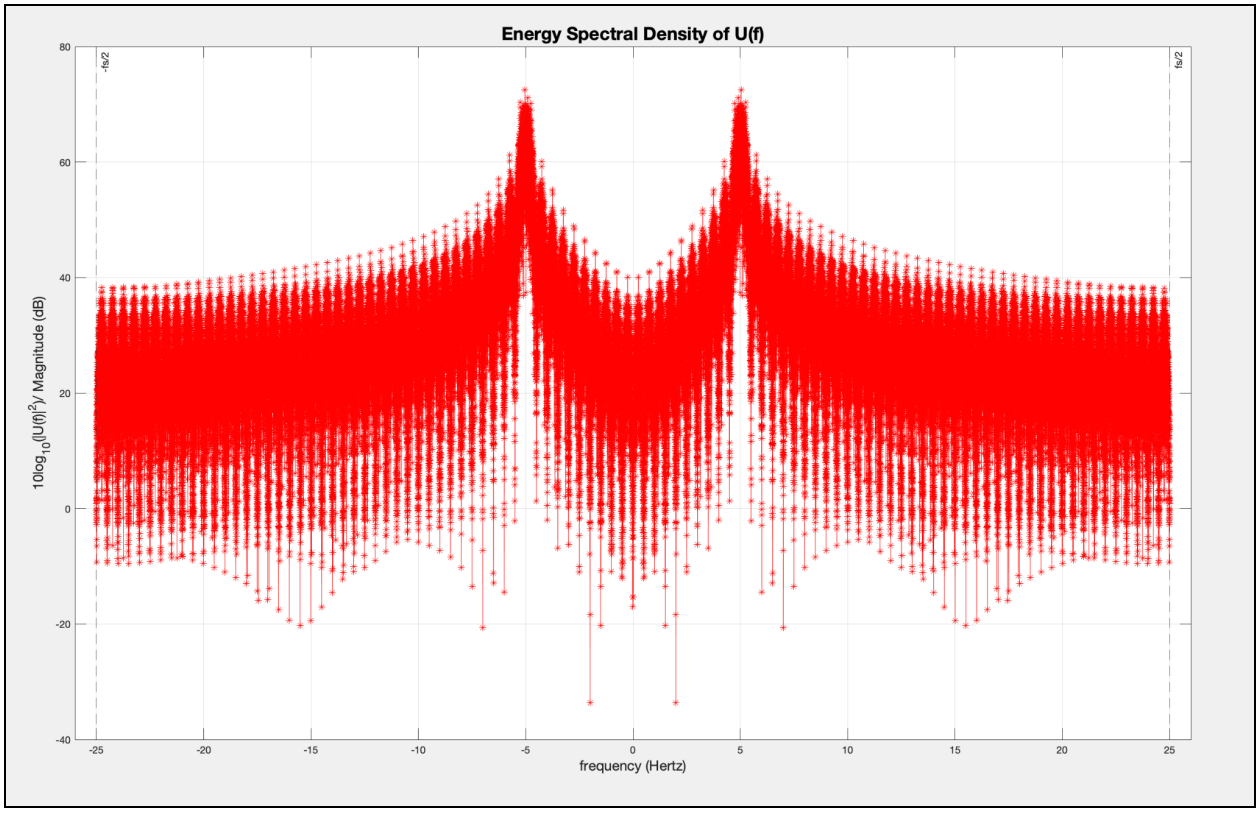


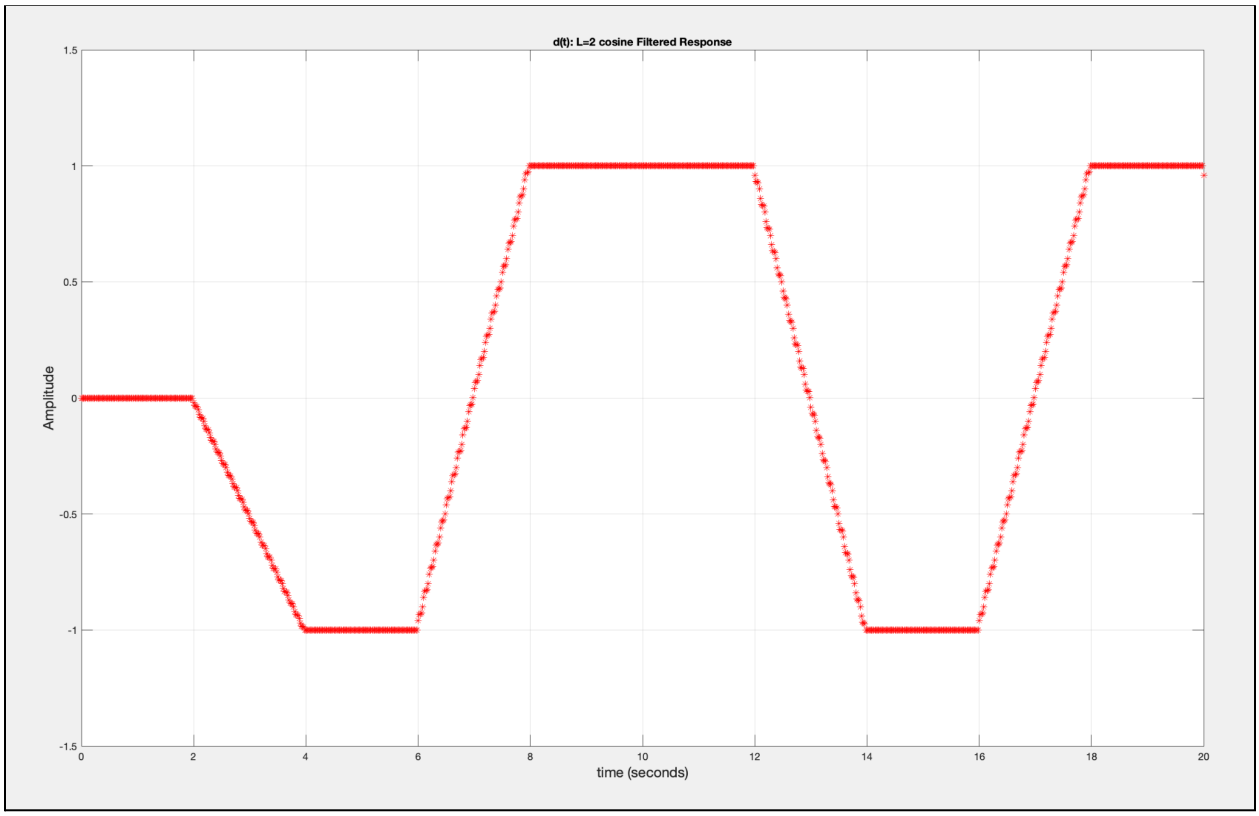
Results

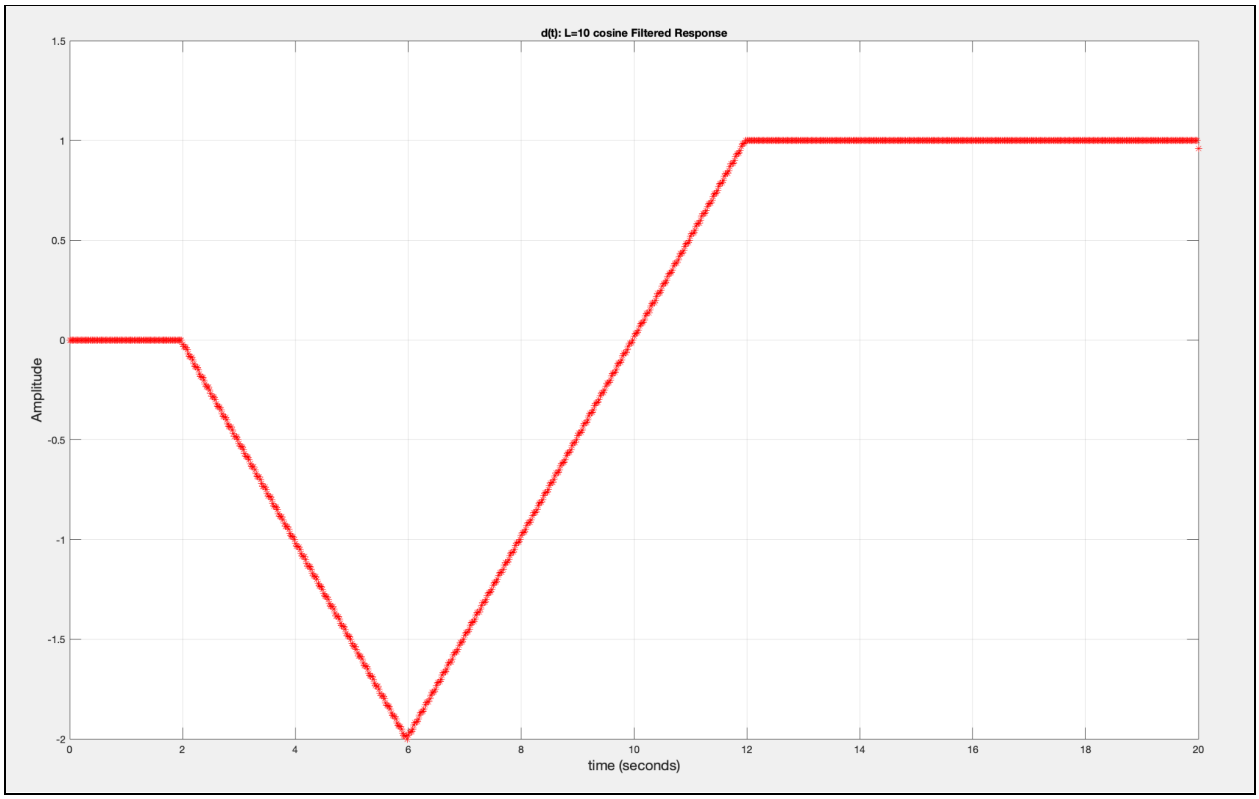
RUID: 193004150

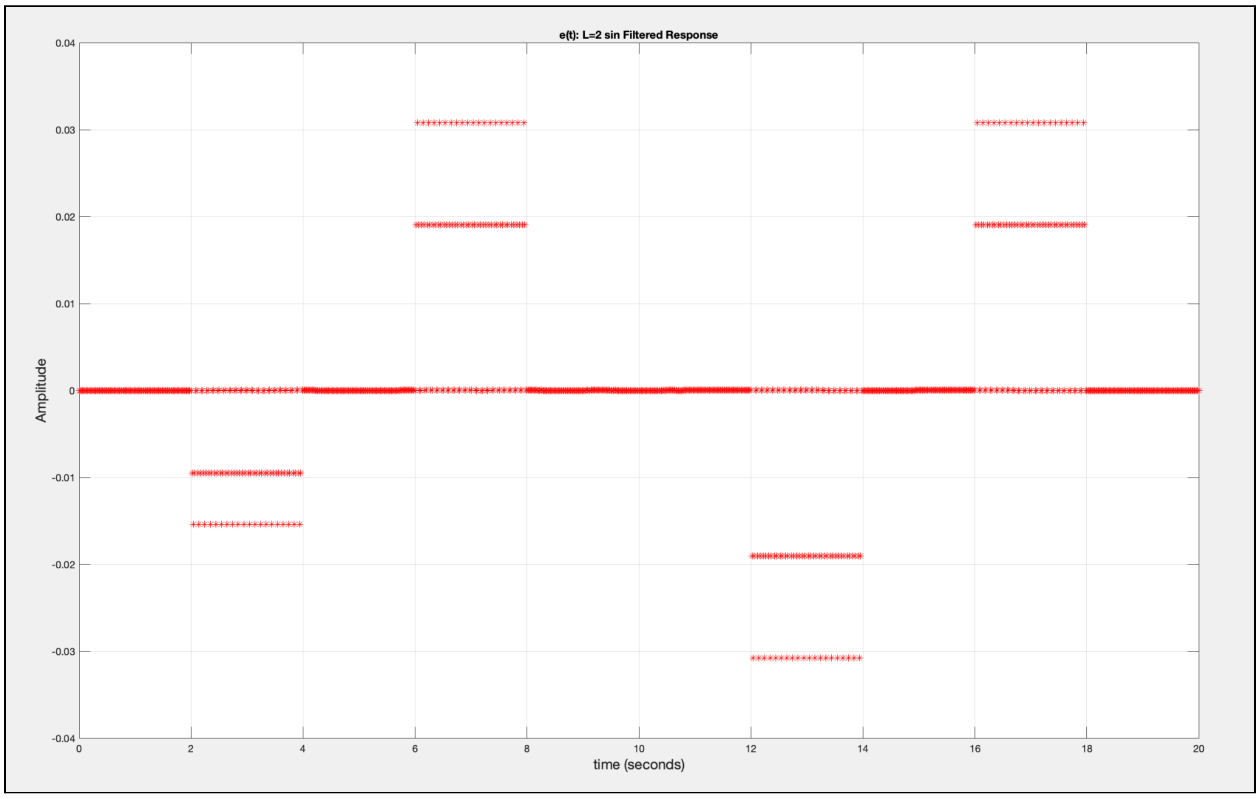


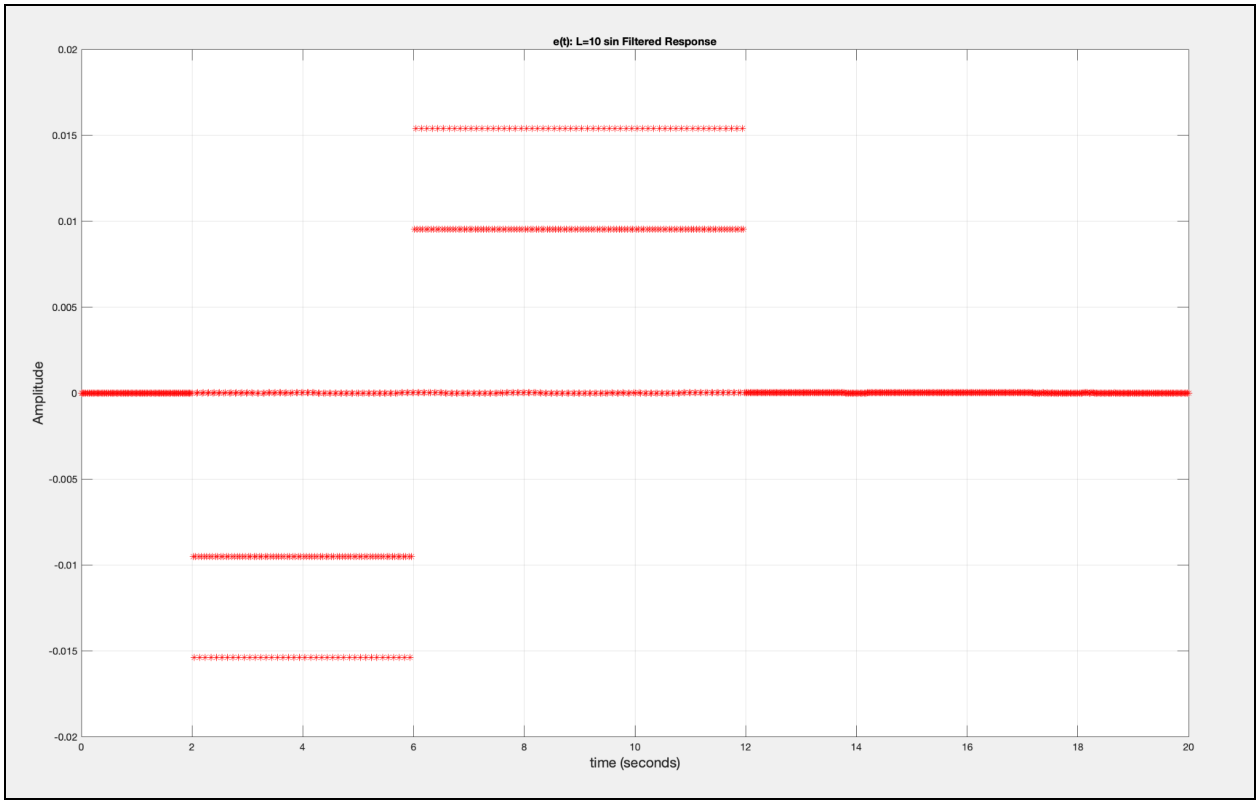


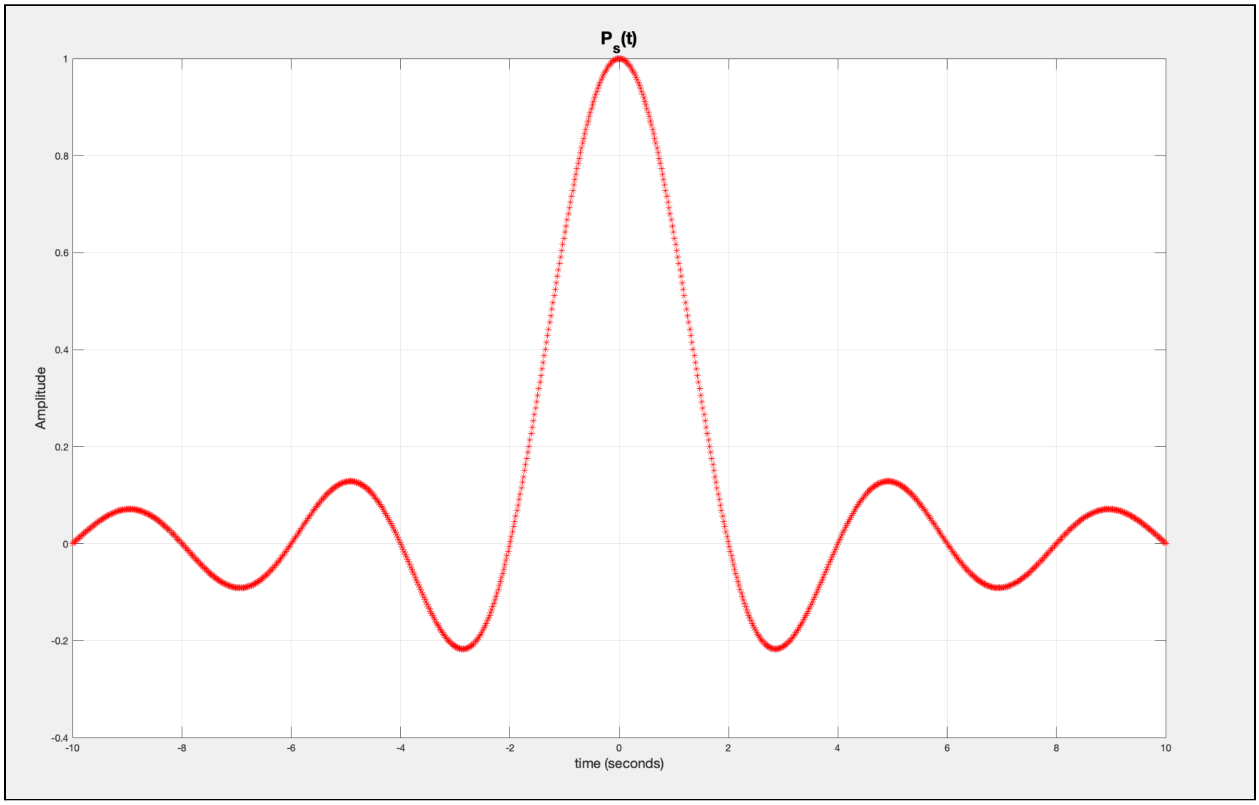

Energy Spectral Density of U(f)
-fs/2
fs/2
10log10(|U(f)|2)/ Magnitude (dB)
frequency (Hertz)
80
60
40
20
0
-20
-40
-25
-20
-15
-10
-5
0
5
10
15
20
25

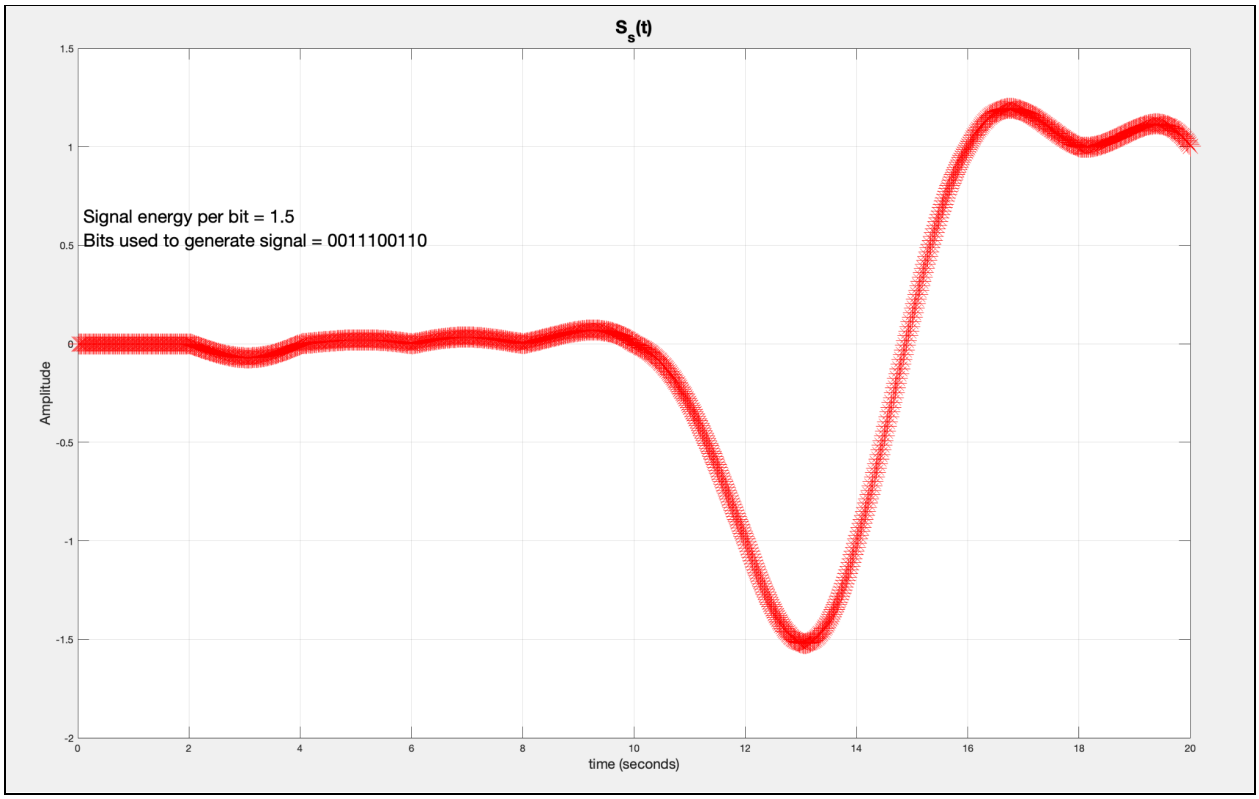

d(t): L=2 cosine Filtered Response
Amplitude
time (seconds)
1.5
1
0.5
0
-0.5
-1
-1.5
0
2
4
6
8
10
12
14
16
18
20

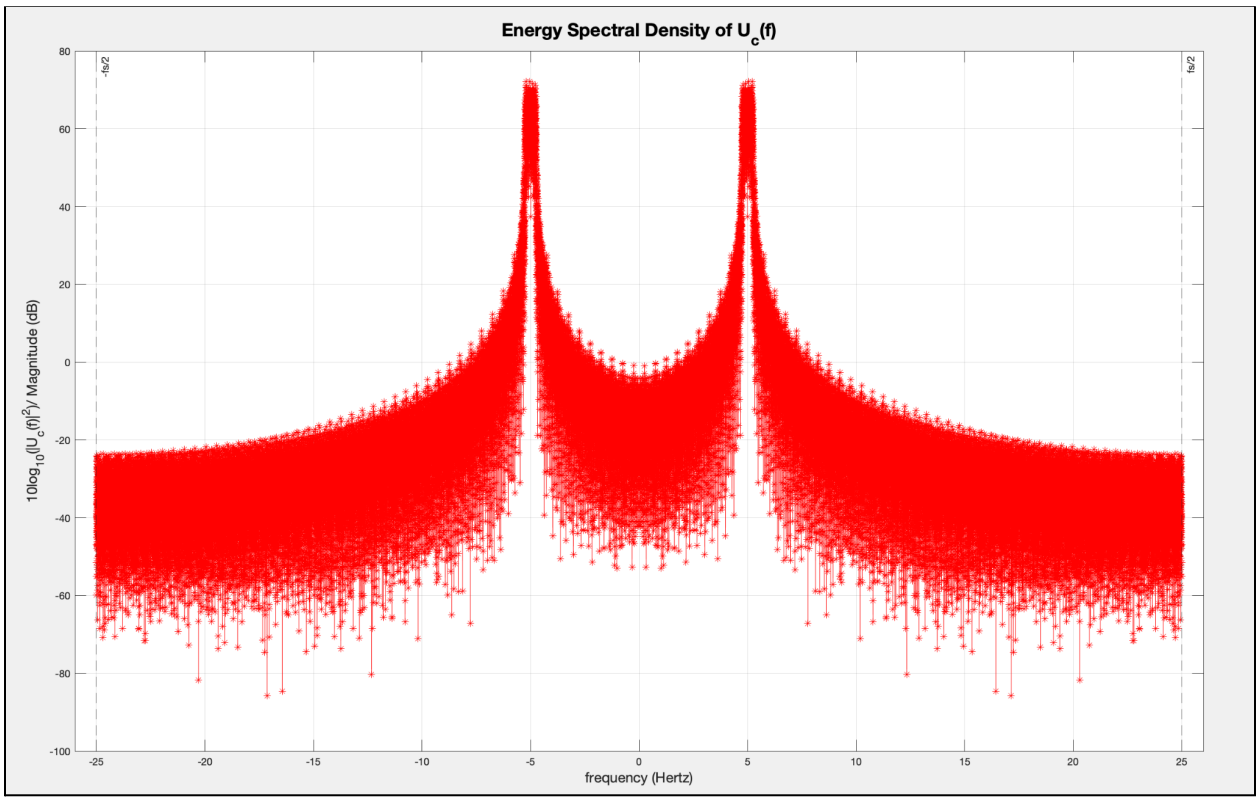

d(t): L=10 cosine Filtered Response
Amplitude
time (seconds)
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
2
4
6
8
10
12
14
16
18
20

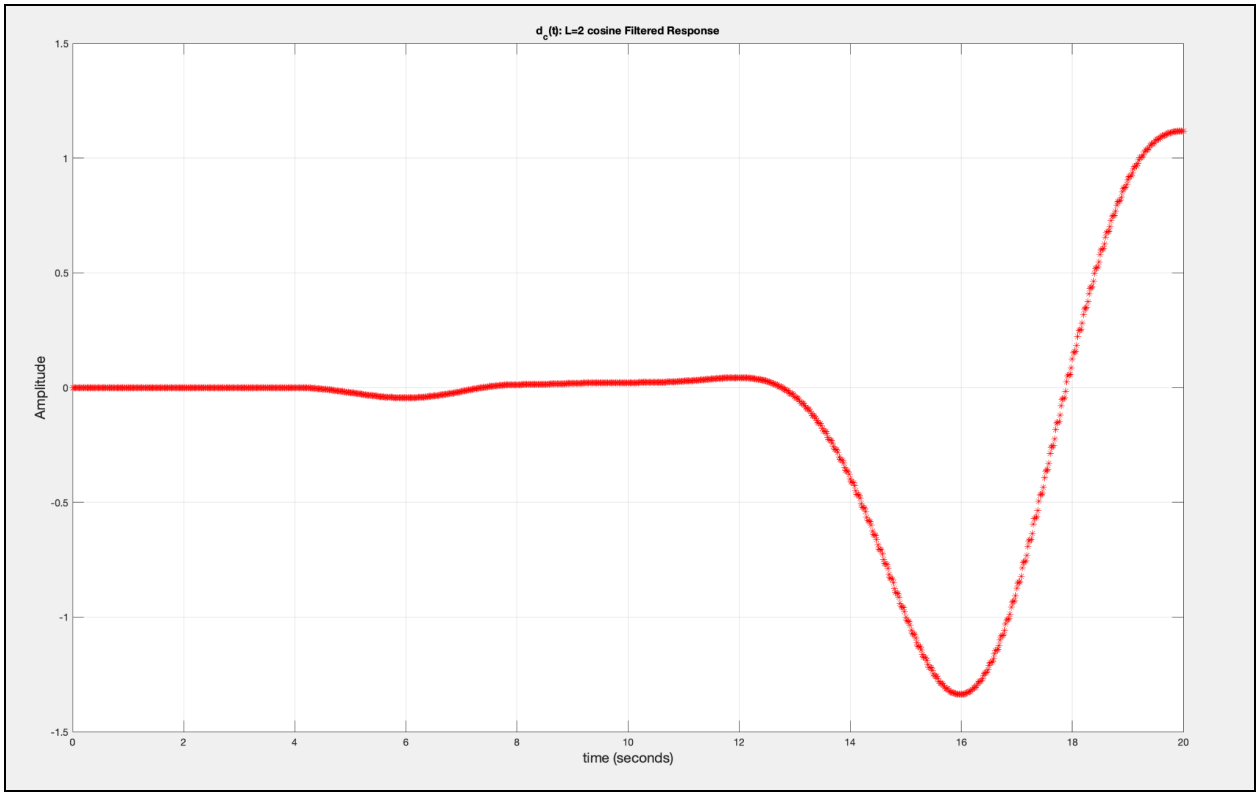

e(t): L=2 sin Filtered Response
Amplitude
time (seconds)
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
0
2
4
6
8
10
12
14
16
18
20

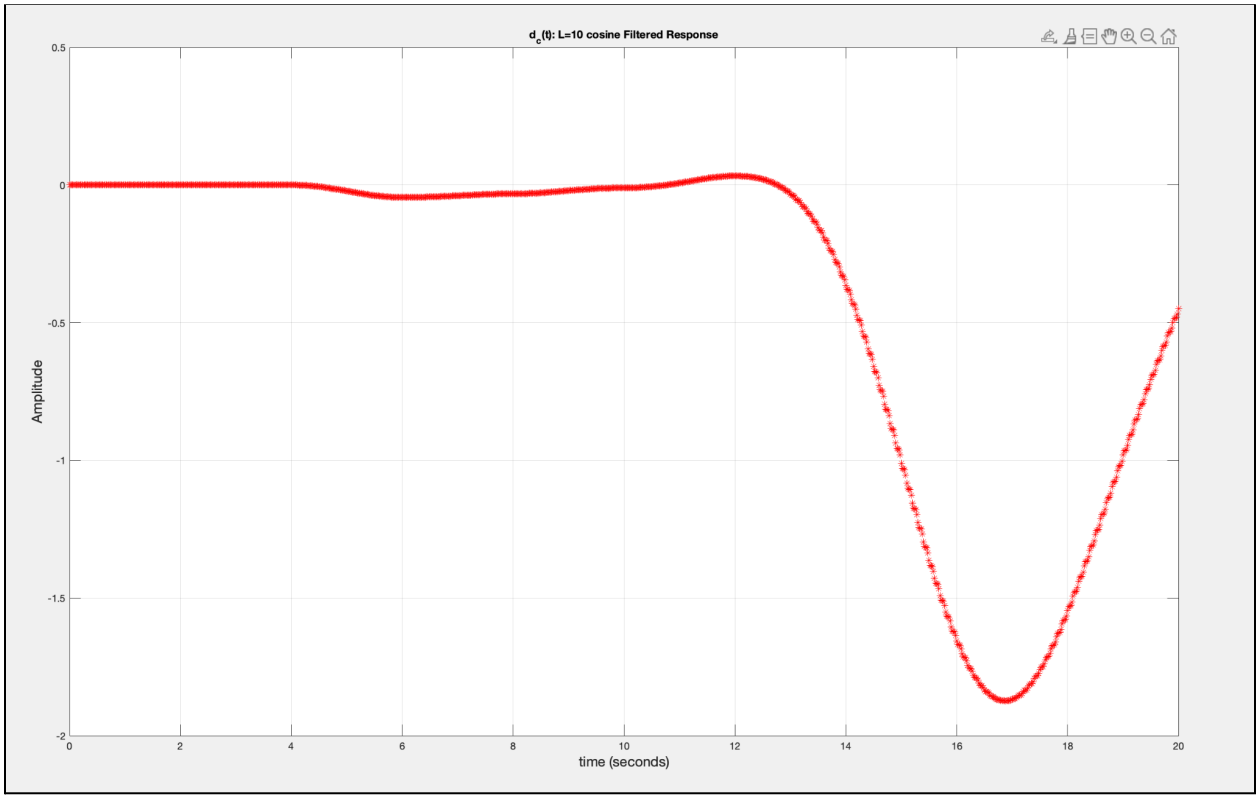

e(t): L=10 sin Filtered Response
Amplitude
time (seconds)
0.02
0.015
0.01
0.005
0
-0.005
-0.01
-0.015
-0.02
0
2
4
6
8
10
12
14
16
18
20

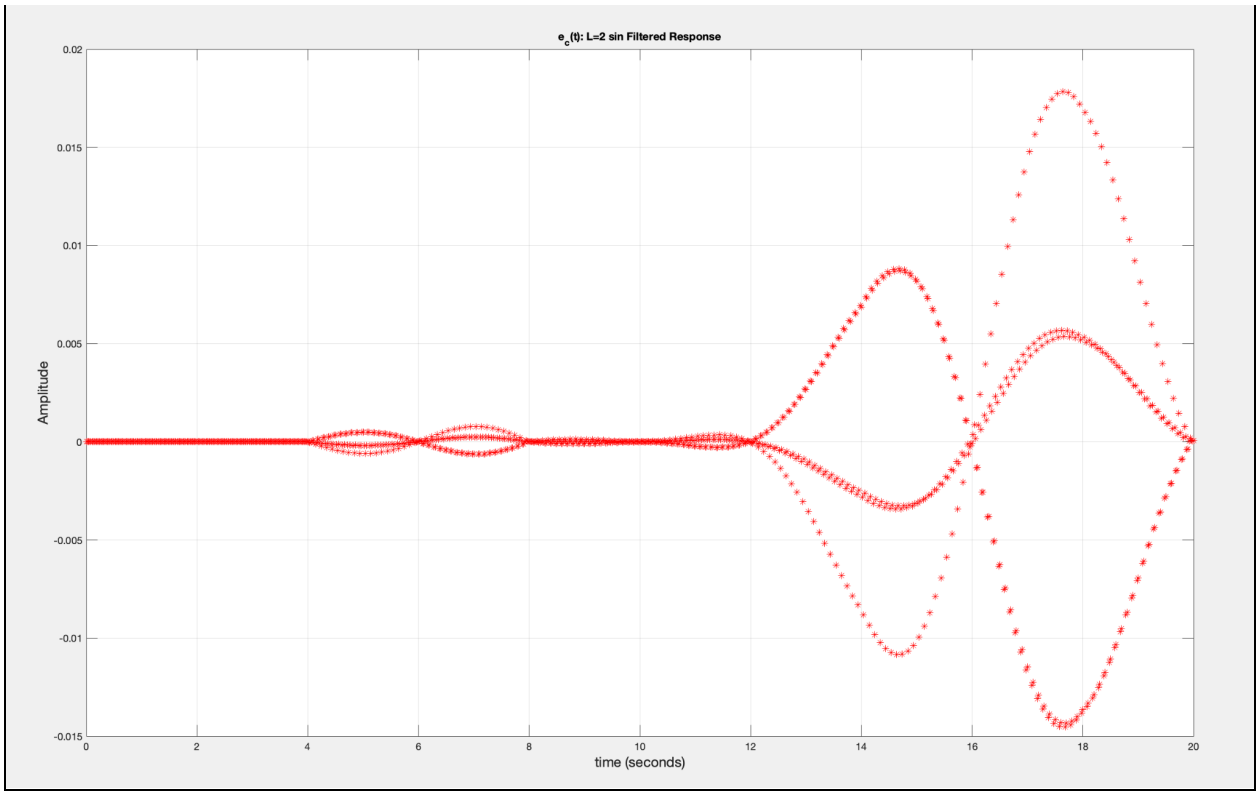

P s (t)
Amplitude
time (seconds)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-10
-8
-6
-4
-2
0
2
4
6
8
10

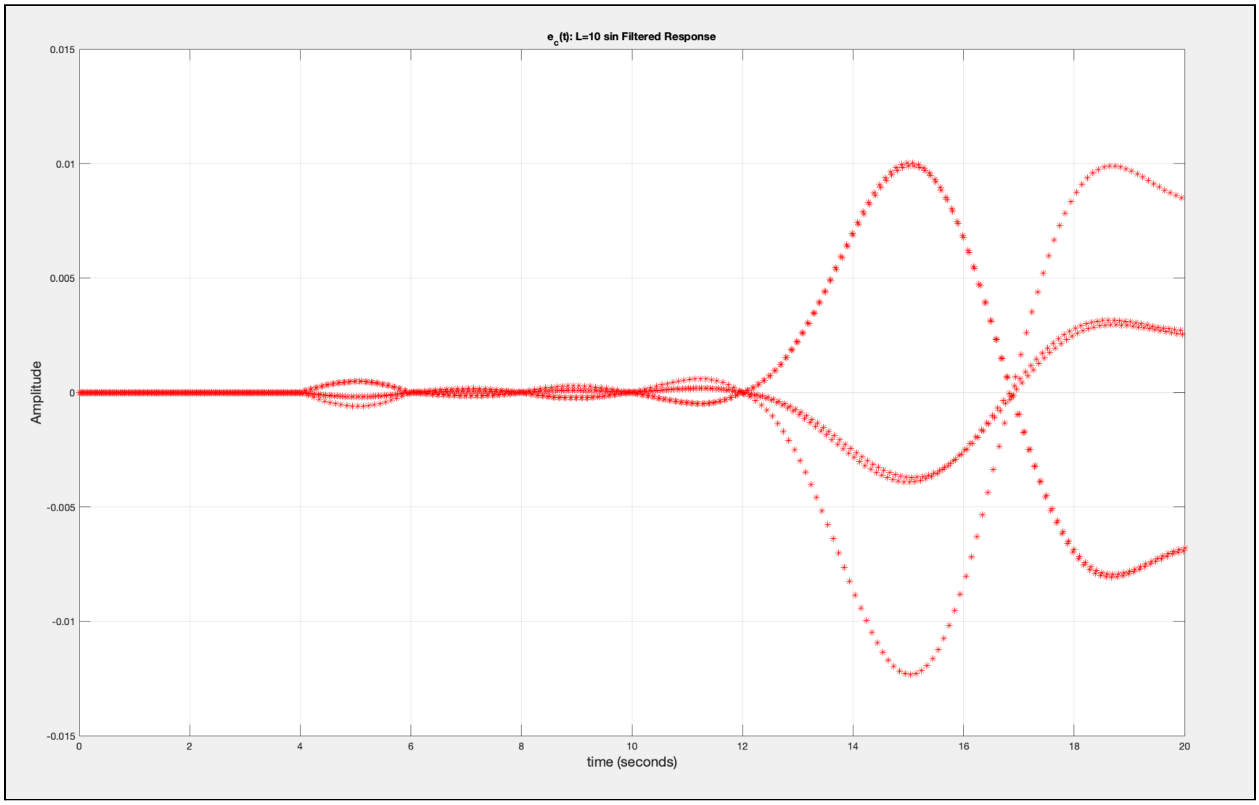

$S_s(t)$
Signal energy per bit = 1.5
Bits used to generate signal = 0011100110
Amplitude
time (seconds)

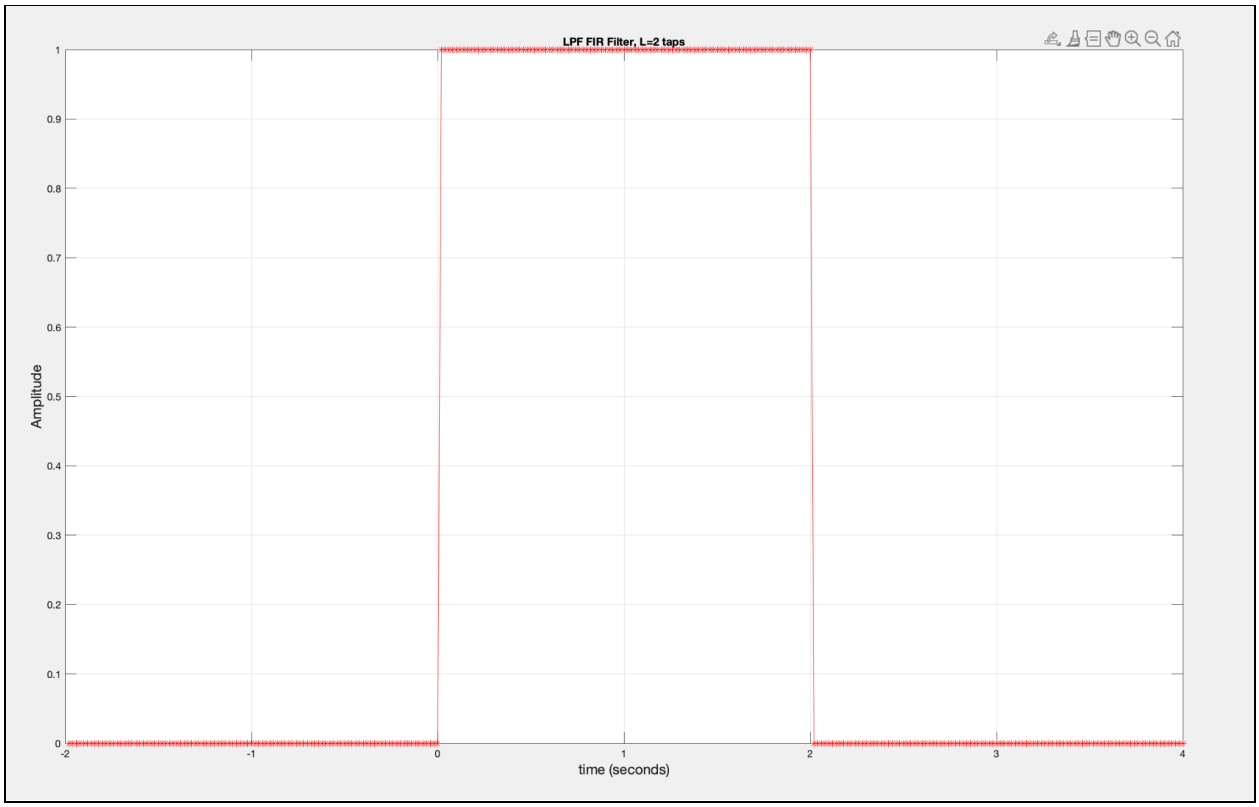

Energy Spectral Density of $U_c(f)$
-fs/2
fs/2
$10\log_{10}(|U_c(f)|^2)$ Magnitude (dB)
frequency (Hertz)

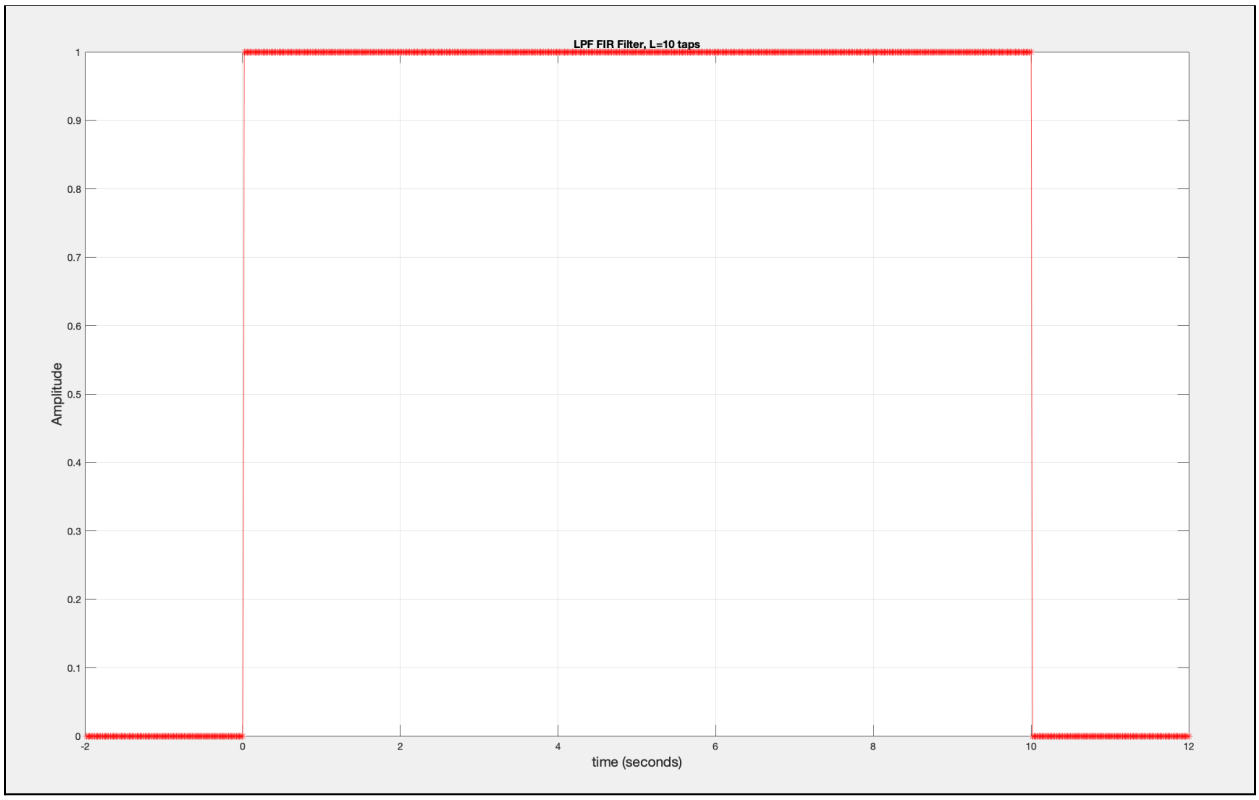

$d_c(t)$: L=2 cosine Filtered Response
Amplitude
time (seconds)
1.5
1
0.5
0
-0.5
-1
-1.5
0
2
4
6
8
10
12
14
16
18
20

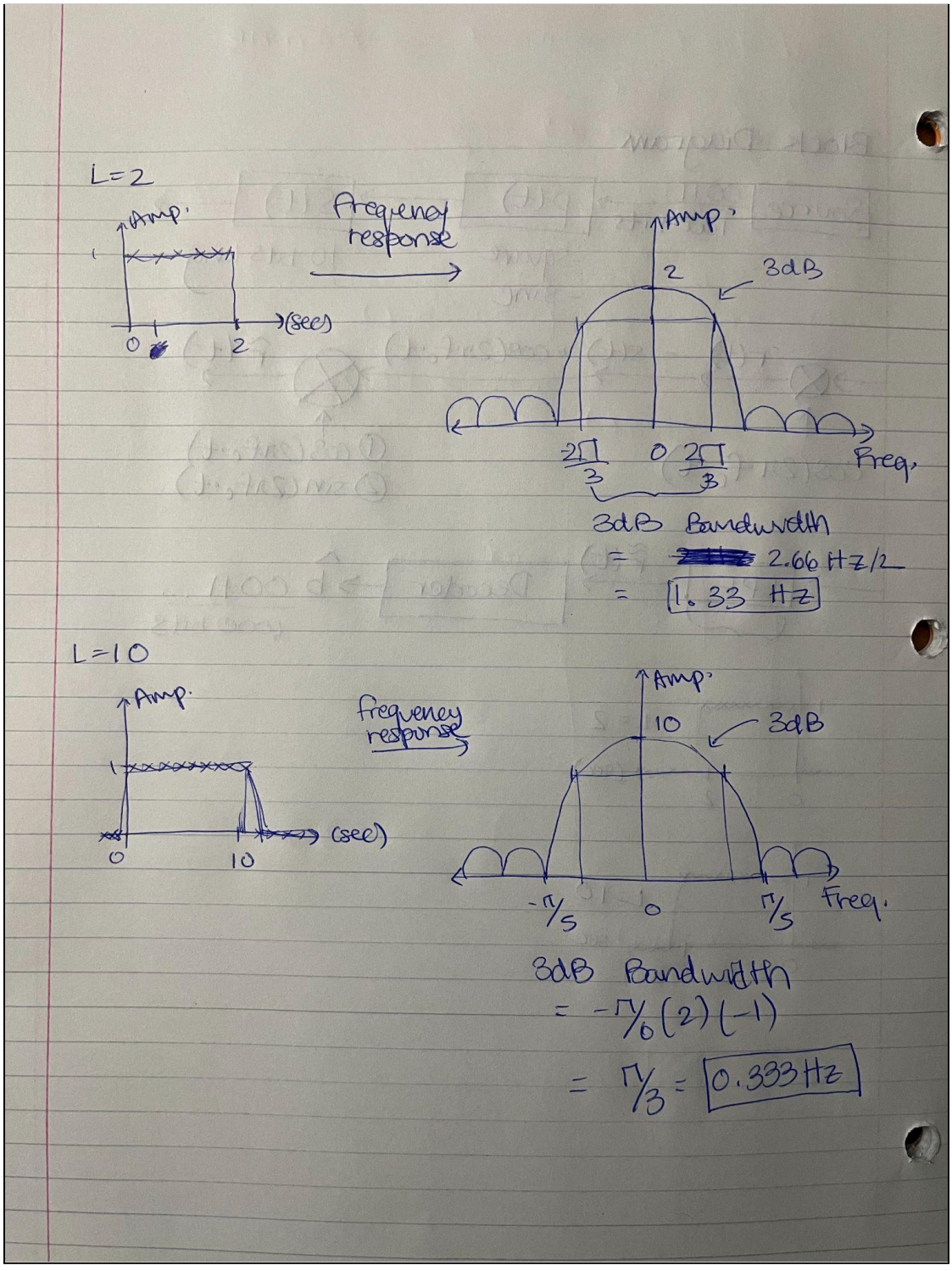

$d_c(t)$: L=10 cosine Filtered Response
Amplitude
time (seconds)
0.5
0
-0.5
-1
-1.5
-2
0
2
4
6
8
10
12
14
16
18
20


$e_c(t)$: L=2 sin Filtered Response
Amplitude
time (seconds)
0.02
0.015
0.01
0.005
0
-0.005
-0.01
-0.015
0
2
4
6
8
10
12
14
16
18
20


$e_c(t)$: L=10 sin Filtered Response
Amplitude
time (seconds)
0.015
0.01
0.005
0
-0.005
-0.01
-0.015
0
2
4
6
8
10
12
14
16
18
20


LPF FIR Filter, L=2 taps
Amplitude
time (seconds)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
-2
-1
0
1
2
3
4


LPF FIR Filter, L=10 taps
Amplitude
time (seconds)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
-2
0
2
4
6
8
10
12



FREQUENCY RESPONSE OF L=2, L=10 Filters

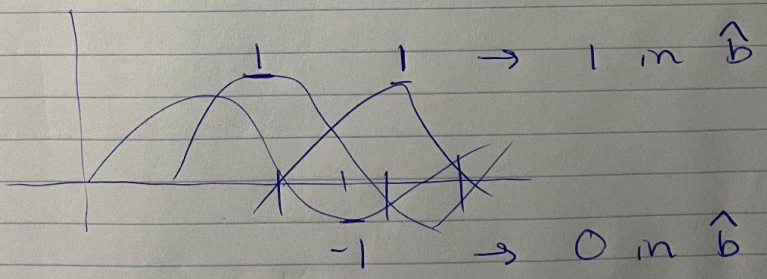
Decoder Block Diagram

$\rightarrow \tilde{\tilde{r}}(t) \rightarrow$ [Decoder]

|

- Look for multiples of T where nodes intersect
- If combined value of nodes == 1 → output 1 in $\hat{b}$
- otherwise, output 0 in $\hat{b}$

Sketch:



DECODER BLOCK DIAGRAM

BIT ERROR TABLE			
Pulse Shape	L=2/L=10	sin/cosine	Percentage
Square	L = 2	sin	51.5%
Square	L = 2	cosine	60.3%
Square	L = 10	sin	49%
Square	L = 10	cosine	75%
Sinc	L = 2	sin	47.5%
Sinc	L = 2	cosine	61.7%
Sinc	L = 10	sin	48.8%
Sinc	L = 10	cosine	71.4%

MATLAB CODE

USE THIS LINK TO OPEN DOCUMENT IN GOOGLE DOCS:

https://docs.google.com/document/d/1gWC3E31sIxT3pumOq9daVVHS7Diya-JYf28_aN_fYUA/edit?usp=sharing

The code does not paste properly out of a PDF File so link above might be useful^

```
rng(193004150);
bb = randi([0 1], 1, 1000);
t = linspace(-10,10,1000);
y = sinc(t/2);
sst=zeros(1,100000);
tt = (1:100000)*0.02;
fr = -y;
j=1;

for i = 1:990
   if bb(i) == 0
      d = length(zeros(1,i*100))+length(y);
      sst = sst + [zeros(1,i*100), fr, zeros(1, 100000-d)];
   else
      d = length(zeros(1,i*100))+length(y);
      sst = sst + [zeros(1,i*100), y, zeros(1, 100000-d)];
   end
end

figure(1);
plot(tt, sst, 'r*', 'markersize', 20)
title('S_s(t)', 'fontsize', 18);
ylabel('Amplitude', 'fontsize', 14);
xlabel('time (seconds)', 'fontsize', 14);
text(0.1,0.65,'Signal energy per bit = 1.5', 'fontsize', 18)
text(0.1,0.53,'Bits used to generate signal = 0011100110', 'fontsize', 18)
grid on;
xlim([0 20]);


fc = 5;
v = cos(2*pi*fc*t);
tc = linspace(0,2000,100000);
ust = sst.* cos(2*pi*fc*tc);

Ts = 0.02;
Fs = 1/Ts;

figure(2);
ftsct = fft(ust);
SFC = 10*log10(abs(fftshift(ftsct)).^2);
freq = (-Fs/2):Fs/length(ust):(Fs/2)-(Fs/length(ust));
plot(freq, SFC, 'r*-');
title('Energy Spectral Density of U_c(f)', 'fontsize', 18);
ylabel('10log_1_0(|U_c(f)|^{2})/ Magnitude (dB)', 'fontsize', 14);
xlabel('frequency (Hertz)', 'fontsize', 14);
xline(-25, '--', '-fs/2');
xline(25, '--', 'fs/2');
xlim([-26 26]);
grid on;
```

```
dcx = ust .* cos(2*pi*fc*tc);

a=zeros(1,100);
b=1*ones(1,100);
c=zeros(1,100);

figure(3);
tcx=[-99:200]*Ts;
plot(tcx, [a,b,c], 'r*-');
title('LPF FIR Filter, L=2 taps');
ylabel('Amplitude', 'fontsize', 14);
xlabel('time (seconds)', 'fontsize', 14);
grid on;

figure(4);
w = Ts*conv([a,b,c], dcx);
tpt=[0:100298]*Ts;
plot(tpt, w, 'r*');
title('d_c(t): L=2 cosine Filtered Response');
ylabel('Amplitude', 'fontsize', 14);
xlabel('time (seconds)', 'fontsize', 14);
xlim([0 20]);
grid on;

a=zeros(1,100);
b=1*ones(1,500);
c=zeros(1,100);

figure(5);
tcx=[-99:600]*Ts;
plot(tcx, [a,b,c], 'r*-');
title('LPF FIR Filter, L=10 taps');
ylabel('Amplitude', 'fontsize', 14);
xlabel('time (seconds)', 'fontsize', 14);
grid on;

figure(6);
g=Ts*conv([a,b,c], dcx);
tpx=[0:100698]*Ts;
plot(tpx, g, 'r*');
title('d_c(t): L=10 cosine Filtered Response');
ylabel('Amplitude', 'fontsize', 14);
xlabel('time (seconds)', 'fontsize', 14);
xlim([0 20]);
grid on;


ecx = ust .* sin(2*pi*fc*tc);

a=zeros(1,100);
b=1*ones(1,100);
c=zeros(1,100);

figure(7);
h = Ts*conv([a,b,c], ecx);
tpt=[0:100298]*Ts;
plot(tpt, h, 'r*');
title('e_c(t): L=2 sin Filtered Response');
ylabel('Amplitude', 'fontsize', 14);
xlabel('time (seconds)', 'fontsize', 14);
xlim([0 20]);
grid on;

a=zeros(1,100);
b=1*ones(1,500);
```

```
c=zeros(1,100);

figure(8);
k = Ts*conv([a,b,c], ecx);
tpx=[0:100698]*Ts;
plot(tpx, k, 'r*');
title('e_c(t): L=10 sin Filtered Response');
ylabel('Amplitude', 'fontsize', 14);
xlabel('time (seconds)', 'fontsize', 14);
xlim([0 20]);
grid on;


nwsew = zeros(1,1000);

for i = 1:1000
  if w(i*100) >= 0
     nwsew(i) = 1;
  else
     nwsew(i) = 0;
  end
end

nwser = zeros(1,1000);

for i = 1:1000
  if g(i*100) >= 0
     nwser(i) = 1;
  else
     nwser(i) = 0;
  end
end

nwseh = zeros(1,1000);

for i = 1:1000
  if h(i*100) >= 0
     nwseh(i) = 1;
  else
     nwseh(i) = 0;
  end
end

nwsek = zeros(1,1000);

for i = 1:1000
  if k(i*100) >= 0
     nwsek(i) = 1;
  else
     nwsek(i) = 0;
  end
end


sum = 0;

for i = 1:1000
   bre = abs(bb(i) - nwsek(i));
   sum = sum + bre;
end

%accuracy checks

rng(193004150);
bb = randi([0 1], 1, 1000);
```

```
st = zeros(1,100000);
j=1;
Ts = 0.02;
tt = (1:100001)*Ts;

for i=1:length(bb)
   for j = j:j+100
      if  bb(i) == 0
         st(j) = -1;
      else
         st(j) = 1;
      end
   end
end

figure(9);
plot(tt, st, 'r*', 'markersize', 15)
title('S(t)', 'fontsize', 18);
ylabel('Amplitude', 'fontsize', 14);
xlabel('time (seconds)', 'fontsize', 14);
text(0.1,0.58,'Signal energy per bit = 1', 'fontsize', 18)
text(0.1,0.53,'Bits used to generate signal = 0011100110', 'fontsize', 18)
grid on;
xlim([0 20]);

fc = 5;
v = cos(2*pi*fc*t);
tc = linspace(0,2000,100001);
ut = st .* cos(2*pi*fc*tc);

Ts = 0.02;
Fs = 1/Ts;

figure(10);
ftsct = fft(ut);
SFC = 10*log10(abs(fftshift(ftsct)).^2);
freq = (-Fs/2):Fs/length(ut):(Fs/2)-(Fs/length(ut));
plot(freq, SFC, 'r*-');
title('Energy Spectral Density of U(f)', 'fontsize', 18);
ylabel('10log_1_0(|U(f)|^{2})/ Magnitude (dB)', 'fontsize', 14);
xlabel('frequency (Hertz)', 'fontsize', 14);
xline(-25, '--', '-fs/2');
xline(25, '--', 'fs/2');
xlim([-26 26]);
grid on;

dt = ut .* cos(2*pi*fc*tc);

a=zeros(1,100);
b=1*ones(1,100);
c=zeros(1,100);

figure(11);
tcx = [-99:200]*Ts;

w = Ts*conv([a,b,c], dt);
tpt=[0:100299]*Ts;
plot(tpt, w, 'r*');
title('d(t): L=2 cosine Filtered Response');
ylabel('Amplitude', 'fontsize', 14);
xlabel('time (seconds)', 'fontsize', 14);
xlim([0 20]);
grid on;

a=zeros(1,100);
```

```
b=1*ones(1,500);
c=zeros(1,100);

figure(12);
tcx=[-99:600]*Ts;

g=Ts*conv([a,b,c], dt);
tpx=[0:100699]*Ts;
plot(tpx, g, 'r*');
title('d(t): L=10 cosine Filtered Response');
ylabel('Amplitude', 'fontsize', 14);
xlabel('time (seconds)', 'fontsize', 14);
xlim([0 20]);
grid on;

ec = ut .* sin(2*pi*fc*tc);

a=zeros(1,100);
b=1*ones(1,100);
c=zeros(1,100);

figure(13);
h = Ts*conv([a,b,c], ec);
tpt=[0:100299]*Ts;
plot(tpt, h, 'r*');
title('e(t): L=2 sin Filtered Response');
ylabel('Amplitude', 'fontsize', 14);
xlabel('time (seconds)', 'fontsize', 14);
xlim([0 20]);
grid on;

a=zeros(1,100);
b=1*ones(1,500);
c=zeros(1,100);

figure(14);
k = Ts*conv([a,b,c], ec);
tpx=[0:100699]*Ts;
plot(tpx, k, 'r*');
title('e(t): L=10 sin Filtered Response');
ylabel('Amplitude', 'fontsize', 14);
xlabel('time (seconds)', 'fontsize', 14);
xlim([0 20]);
grid on;

nwsiw = zeros(1,1000);

for i = 1:1000
  if w(i*100) >= 0
     nwsiw(i) = 1;
  else
     nwsiw(i) = 0;
  end
end

nwsig = zeros(1,1000);

for i = 1:1000
  if g(i*100) >= 0
     nwsig(i) = 1;
  else
     nwsig(i) = 0;
  end
end
```

```
nwsih = zeros(1,1000);

for i = 1:1000
  if h(i*100) >= 0
     nwsih(i) = 1;
  else
     nwsih(i) = 0;
  end
end

nwsik = zeros(1,1000);

for i = 1:1000
  if k(i*100) >= 0
     nwsik(i) = 1;
  else
     nwsik(i) = 0;
  end
end


sum = 0;

for i = 1:1000
   bre = abs(bb(i) - nwsig(i));
   sum = sum + bre;
end

t = linspace(-10,10,1000);
y = sinc(t/2);
figure(15);
plot(t,y,'r*');
grid on;
title('P_s(t)', 'fontsize', 18);
ylabel('Amplitude', 'fontsize', 14);
xlabel('time (seconds)', 'fontsize', 14);

a = zeros(1,100);
b = ones(1,100);
c = zeros(1,100);
t = [-100:199]*Ts;
figure(16);
plot(t, [a, b, c], 'r*');
grid on;
title('P(t)', 'fontsize', 18);
ylabel('Amplitude', 'fontsize', 14);
xlabel('time (seconds)', 'fontsize', 14);
```