

EE572 - Solution to Prelab1 (HW #3)

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/*Problem 1a)
#include <stdio.h>
main()
/*initialization of constants*/
float a0,b0,a1,wk,yk,ykminus1,wkminus1
int wint,yint

a0=__;
b0=__;
a1=__;
b1=__;

yk=0.0;
wk=0.0;
ykminus1=0.0;
wkminus1=0.0;

while(1){
    ykminus1=(-
a1*ykminus1+b1*wkminus1)/a0;
    wint=in();
    wk=(float)wint/204.8-10.0;
    yk=ykminus1+b0/a0*wk;
    out(yk);
    ykminus1=yk;
    wkminus1=wk;
    sleep(3);
}

% 1c Bilinear Integrator Design
Ts=0.01;
b_bilin=Ts/2*[1 1];
a_bilin=[1 -1];
%Impulse Invariant Design
b_impls=Ts*[1 0];
a_impls=[1 -1];
%Step Invariant Design
b_step=Ts^2*[0 1];
a_step=[1 -1];
%Inputs to the digital integrators
dk=[1 zeros(1,100)];
uk=ones(1,101);
t=[0:Ts:1];
yk=10*sin(16*pi*t);
%Find Integrator Outputs using Filter
y_bilin_dk=filter(b_bilin,a_bilin,dk);
y_bilin_uk=filter(b_bilin,a_bilin,uk);
y_bilin_yk=filter(b_bilin,a_bilin,yk);
y_impls_dk=filter(b_impls,a_impls,dk);
y_impls_uk=filter(b_impls,a_impls,uk);
y_impls_yk=filter(b_impls,a_impls,yk);
y_step_dk=filter(b_step,a_step,dk);
y_step_uk=filter(b_step,a_step,uk);
y_step_yk=filter(b_step,a_step,yk);

% 1d) Plot Responses
plot(t,y_bilin_dk,t,y_impls_dk,t,y_step_dk)
title('EE572 - Prelab1: Digital Integration of a
Discrete Impulse')
grid;xlabel('time (sec)');ylabel('y(kTs)')
plot(t,y_bilin_uk,t,y_impls_uk,t,y_step_uk)
title('EE572 - Prelab1: Digital Integration of a
Discrete Step')
grid;xlabel('time (sec)');ylabel('y(kTs)')
plot(t,y_bilin_yk,t,y_impls_yk,t,y_step_yk)
title('EE572 - Prelab1: Digital Integration of
10sin(16*pi*t)')
grid;xlabel('time (sec)');ylabel('y(kTs)')

%Corrected impulse definition
dk_correct=1/Ts*dk;
%Corrected Step Invariant Design
b_step_correct=Ts*[0 1];
a_step_correct=[1 -1];
y_step_correct_dk=filter(b_step_correct,a_step
p_correct,dk_correct);
y_step_correct_uk=filter(b_step_correct,a_step
p_correct,uk);
y_step_correct_yk=filter(b_step_correct,a_step
p_correct,yk);
y_impls_correct_dk=filter(b_impls,a_impls,dk
_correct);
y_bilin_correct_dk=filter(b_bilin,a_bilin,dk_co
rrect);
plot(t,y_bilin_correct_dk,t,y_impls_correct_d
k,t,y_step_correct_dk)
title('EE572 - Prelab1: Digital Integration of
1/Ts*dk')
grid;xlabel('time (sec)');ylabel('y(kTs)')
y_step_correct_dk=filter(b_step_correct,a_step

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p_correct,dk_correct);

%Plot corrected responses
plot(t,y_bilin_correct_dk,t,y_impls_correct_d
k,t,y_step_correct_dk)
title('EE572 - Prelab1: Corrected Digital
Integration of 1/Ts*dk')
grid;xlabel('time (sec)');ylabel('y(kTs)')
plot(t,y_bilin_uk,t,y_impls_uk,t,y_step_correc
t_uk)
title('EE572 - Prelab1: Corrected Digital
Integration of uk')
grid;xlabel('time (sec)');ylabel('y(kTs)')
plot(t,y_bilin_yk,t,y_impls_yk,t,y_step_correc
t_yk)
title('EE572 - Prelab1: Corrected Digital
Integration of yk')
grid;xlabel('time (sec)');ylabel('y(kTs)')
diary off

%Problem 2a
Fhigh=16*pi/(2*pi);
Fnyquist=2*Fhigh;

%Find yk and FFT for 4*Nyquist
Fs4=4*Fnyquist;
Ts4=1/Fs4;
t4=[0:N-1]*Ts4;
y4=10*sin(16*pi*t4);
Y4=fft(y4);
f4=[0:N-1]*Fs4/N;

%Find yk and FFT for 2*Nyquist
Fs2=2*Fnyquist;
Ts2=1/Fs2;
t2=[0:N-1]*Ts2;
y2=10*sin(16*pi*t2);
Y2=fft(y2);
f2=[0:N-1]*Fs2/N;

%Find yk and FFT for 1*Nyquist
Fs1=Fnyquist;
Ts1=1/Fs1;
t1=[0:N-1]*Ts1;
y1=10*sin(16*pi*t1);
Y1=fft(y1);
f1=[0:N-1]*Fs1/N;

%Find yk and FFT for 3/4*Nyquist
Fs34=3/4*Fnyquist;
Ts34=1/Fs34;
t34=[0:N-1]*Ts34;
y34=10*sin(16*pi*t34);
Y34=fft(y34);
f34=[0:N-1]*Fs34/N;

%Problem 2b)
%Plot the results
plot(t4,y4,'*')
title('EE572 - Prelab 1: Plot of 10sin(16*pi*t)
when sampled at Fs=4*Fnyq.')
grid;ylabel('y(kTs)');xlabel('kTs (sec)')
plot(t2,y2,'*')
title('EE572 - Prelab 1: Plot of 10sin(16*pi*t)
when sampled at Fs=2*Fnyq.')
grid;ylabel('y(kTs)');xlabel('kTs (sec)')
plot(t1,y1,'*')
title('EE572 - Prelab 1: Plot of 10sin(16*pi*t)
when sampled at Fs=Fnyq.')
grid;ylabel('y(kTs)');xlabel('kTs (sec)')
plot(f4,imag(Y4))
title('EE572 - Prelab 1: FFT of 10sin(16*pi*t)
with Fs=4*Fnyq.')
grid;ylabel('Imag(Y)');xlabel('f (Hz)')
plot(f2,imag(Y2))
title('EE572 - Prelab 1: FFT of 10sin(16*pi*t)
with Fs=2*Fnyq.')
grid;ylabel('Imag(Y)');xlabel('f (Hz)')
plot(f1,imag(Y1))
title('EE572 - Prelab 1: FFT of 10sin(16*pi*t)
with Fs=Fnyq.')
grid;ylabel('Imag(Y)');xlabel('f (Hz)')
f34=[0:N-1]*Fs34/N;
title('EE572 - Prelab 1: FFT of 10sin(16*pi*t)

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with Fs=3/4*Fnyq.')
plot(f34,imag(Y34))
title('EE572 - Prelab 1: FFT of 10sin(16*pi*t)
with Fs=3/4*Fnyq.')
grid;ylabel('Imag(Y)');xlabel('f (Hz)')

%Problem 2c)
D=10*(-10)
D =
    20

N=12
N =
    12

MSE_12bit=D^2/(12*2^(2*N))
MSE_12bit =
    1.9868e-006

N=6
N =
    6

MSE_6bit=D^2/(12*2^(2*N))
MSE_6bit =
    0.0081

N=2
N =
    2

MSE_2bit=D^2/(12*2^(2*N))
MSE_2bit =
    2.0833

EE572 - Prelab1: Digital Integration of a Discrete Impulse
time (sec)
y(kTs)

EE572 - Prelab1: Digital Integration of a Discrete Step
time (sec)
y(kTs)

EE572 - Prelab1: Digital Integration of 10sin(16*pi*t)
time (sec)
y(kTs)

EE572 - Prelab1: Corrected Digital Integration of 1/Ts*dk
time (sec)
y(kTs)

EE572 - Prelab1: Plot of 10sin(16*pi*t) when sampled at Fs=4*Fnyq.
time (sec)
y(kTs)

EE572 - Prelab1: Plot of 10sin(16*pi*t) when sampled at Fs=2*Fnyq.
time (sec)
y(kTs)

EE572 - Prelab1: Plot of 10sin(16*pi*t) when sampled at Fs=Fnyq.
time (sec)
y(kTs)

EE572 - Prelab1: Corrected Digital Integration of uk
time (sec)
y(kTs)

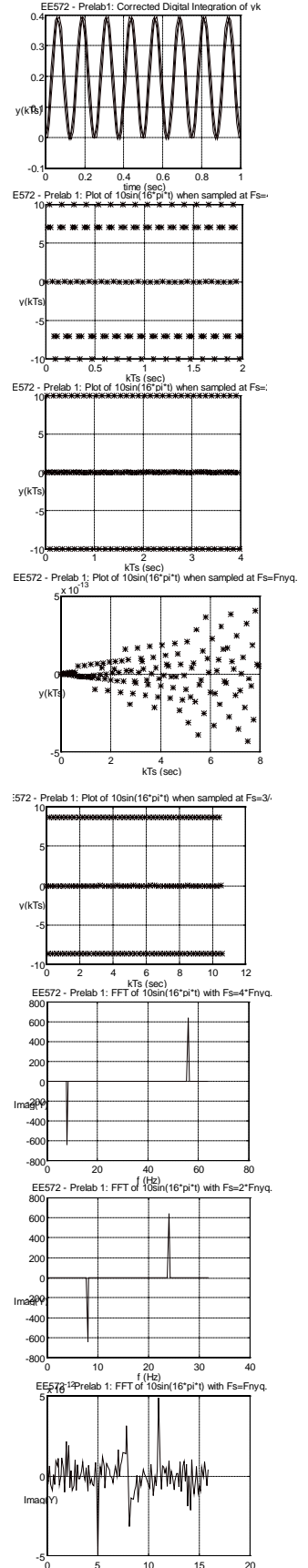
EE572 - Prelab1: Corrected Digital Integration of yk
time (sec)
y(kTs)

EE572 - Prelab 1: FFT of 10sin(16*pi*t) with Fs=4*Fnyq.
f (Hz)
Imag(Y)

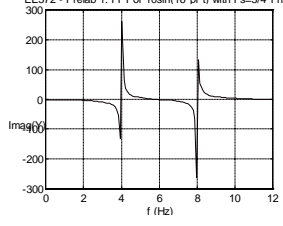
EE572 - Prelab 1: FFT of 10sin(16*pi*t) with Fs=2*Fnyq.
f (Hz)
Imag(Y)

EE572 - Prelab 1: FFT of 10sin(16*pi*t) with Fs=Fnyq.
f (Hz)
Imag(Y)

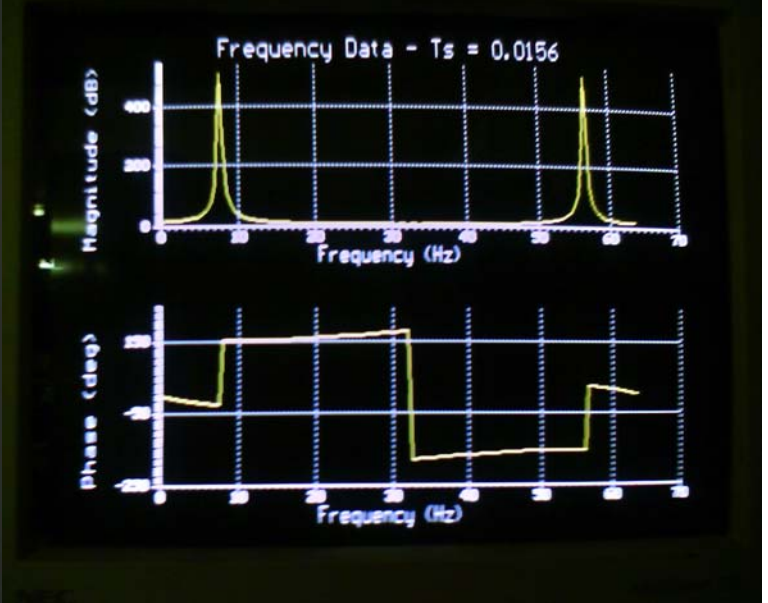
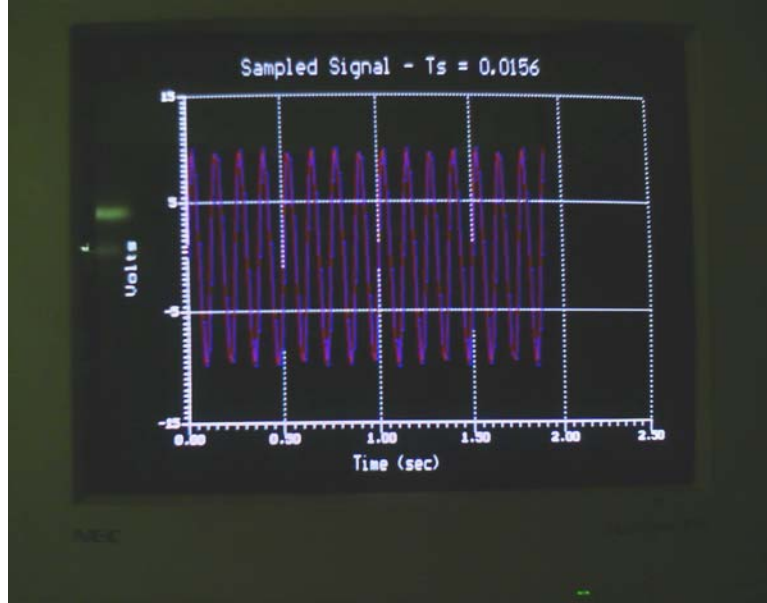
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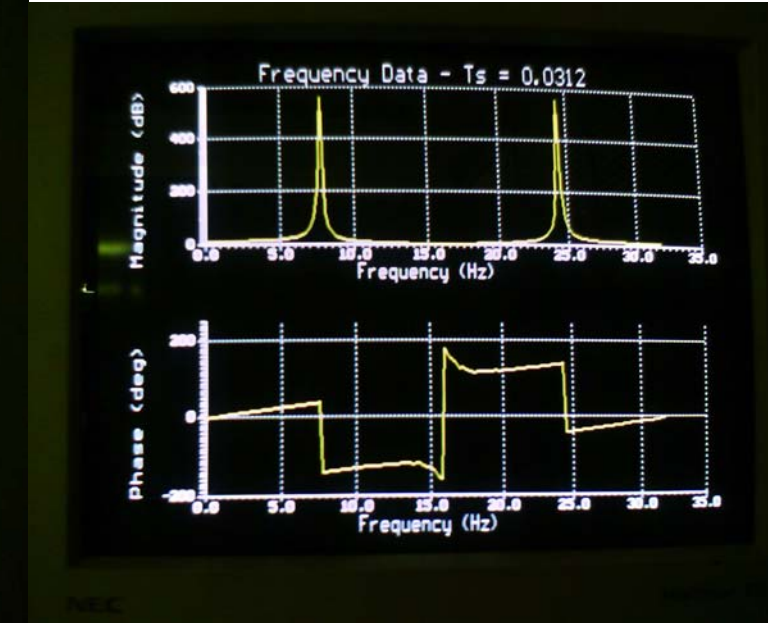
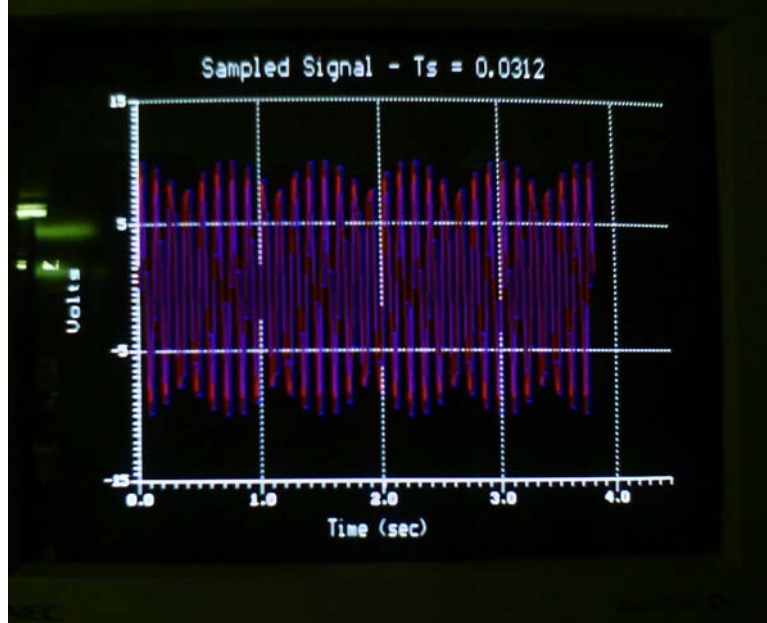
EE572 - Prelab 1: FFT of $10\sin(16\pi t)$ with $F_s=3/4 F_{Nyq}$.



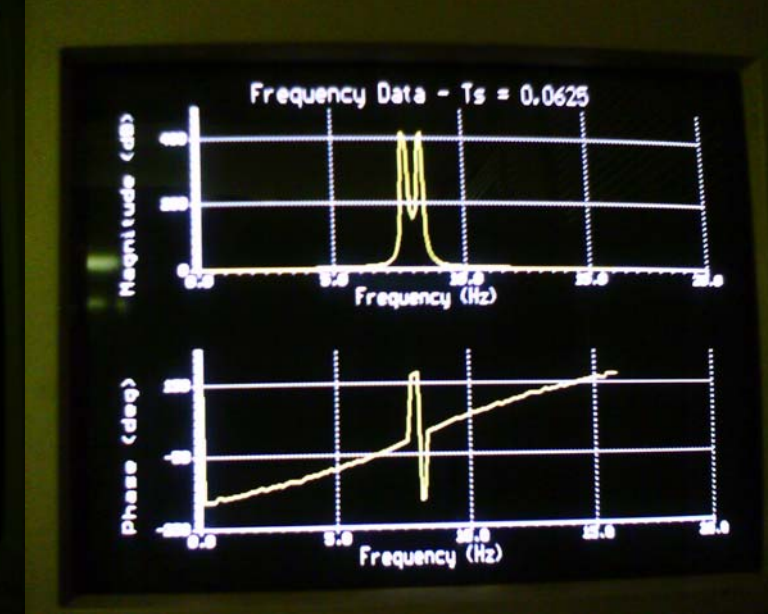
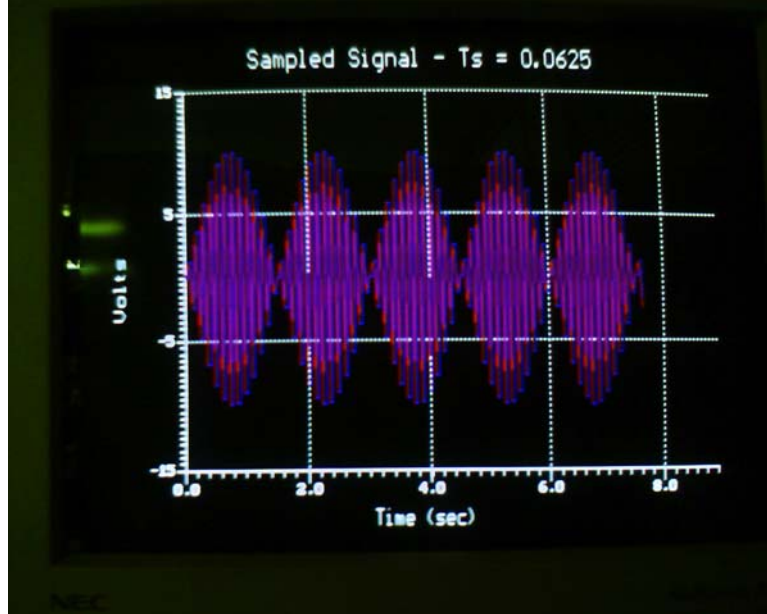
Lab 1 DataPart 1 $T_s = 4 \times \text{Nyquist} = 1/64 = 0.0156$



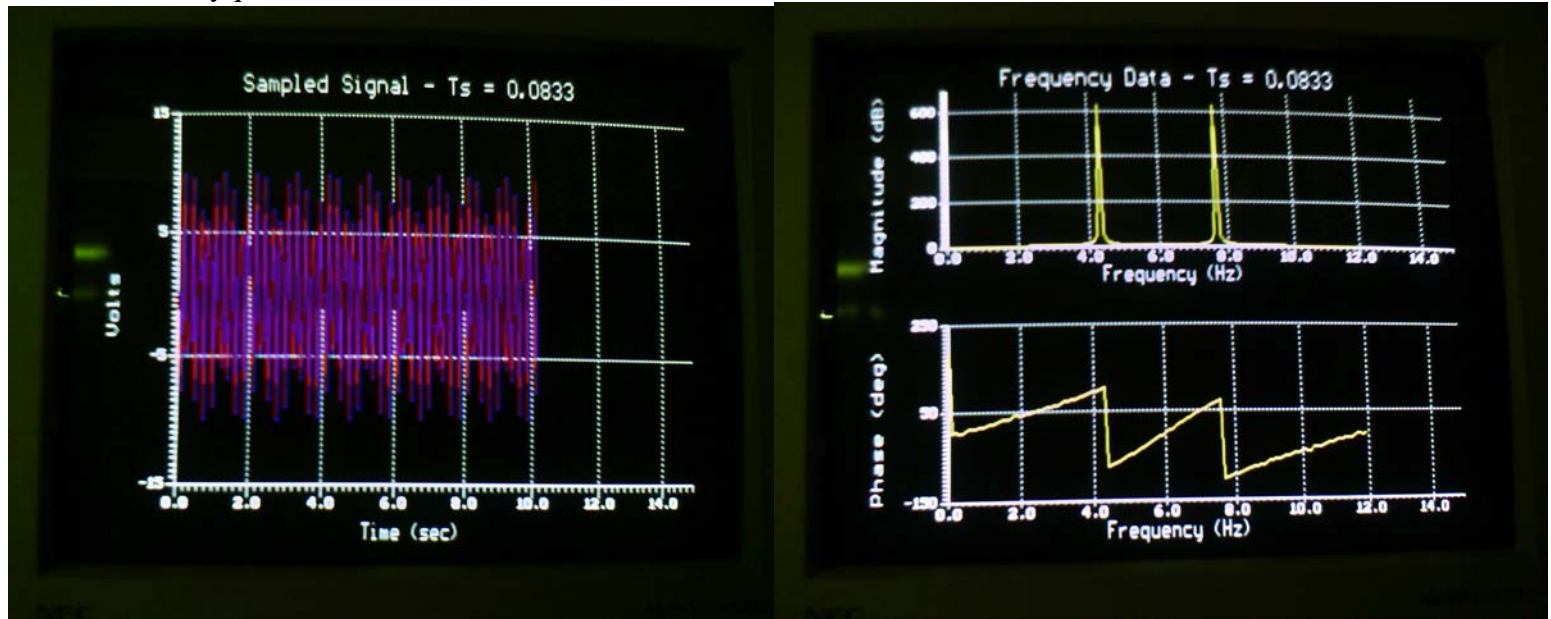
Part 1 $T_s = 2 \times \text{Nyquist} = 1/32 = 0.0312$



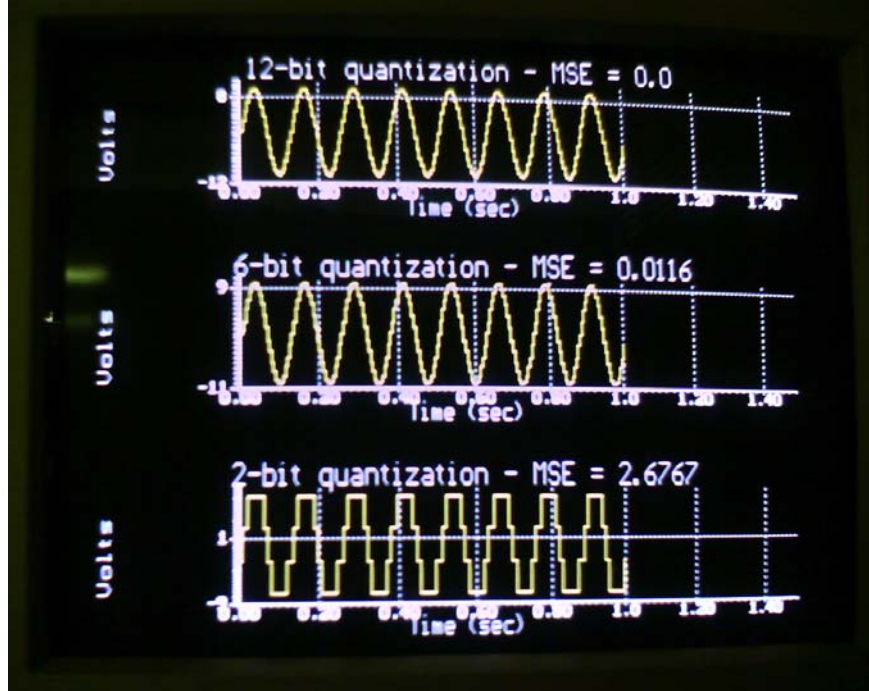
Part 1 $T_s = \text{Nyquist} = 1/16 = 0.0625$



Part 1 $T_s = 3/4N_{\text{yquist}} = 1/12 = 0.0833$



Part 2 – Quantization Error



Part 3 – Digital Filter Implementation

