CS : 215
Signal & Data Communication Laboratory

Experiment: I-B

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1 Scaling and Shifting Signals

1.1 Aim

To Plot Shifted and Scaled versions of:

$$f[n] = \begin{cases} -2 & n < -4 \\ n & -4 \leq n < 1 \\ \dfrac{1}{n} & 1 \leq n \end{cases}$$

1.2 Theoretical Background

Shifting and Scaling are two methods for Transformation of Signals. These can work on both Continuous and Discrete Signals. Further, these operations are not commutative.

1.3 Methodology

- Multiply or Shift the sampling range as per the requirement to obtain the desired Signal transformation.
- Generate the plot using the x-points and corresponding y-values.
- The discrete pairs (x, y) are plotted using stem function.

1.4 Code

```
clc;
clear all;
%Sample Signal
n = -50:1:50;
for i=1:length(n)
if n(i)<-4
f(i) = -2;
elseif n(i)<1
f(i) = n(i);
else
f(i) = 4/n(i);
endif
end

subplot(2,2,1);
stem(n,f,’filled’, ’r’, ’MarkerSize’, 3, ’linewidth’, 1);
xlabel(’n------>’);
```

```
ylabel('f[n]');
set(gca, ...
'Box', 'off', ...
'TickDir', 'out', ...
'YGrid', 'on', ...
'FontSize', 20, ...
'FontName', 'Calibri');
axis([-10 10 -4.2 4.2]);
%Signal Transformation
sample = [2-n; n/2; 2*n];
for i=2:4
subplot(2,2,i);
stem(sample(i-1, :),f,'filled', 'b', 'MarkerSize', 3,
'linewidth',1);
xlabel('n------->');
ylabel('g[n]');
set(gca, ...
'Box', 'off', ...
'TickDir', 'out', ...
'YGrid', 'on', ...
'FontSize', 20, ...
'FontName', 'Calibri');
axis([-10 10 -4.2 4.2]);
end
```

1.5 Input Data Description

4 functions are to be plotted: $f[n], f[2-n], f[2n], f\left[\frac{n}{2}\right]$.

The Range to be Taken: $[-10, 10]$

1.6 Result

The graphs for the analog signal and the corresponding discrete time signal for different sampling periods are as follows:

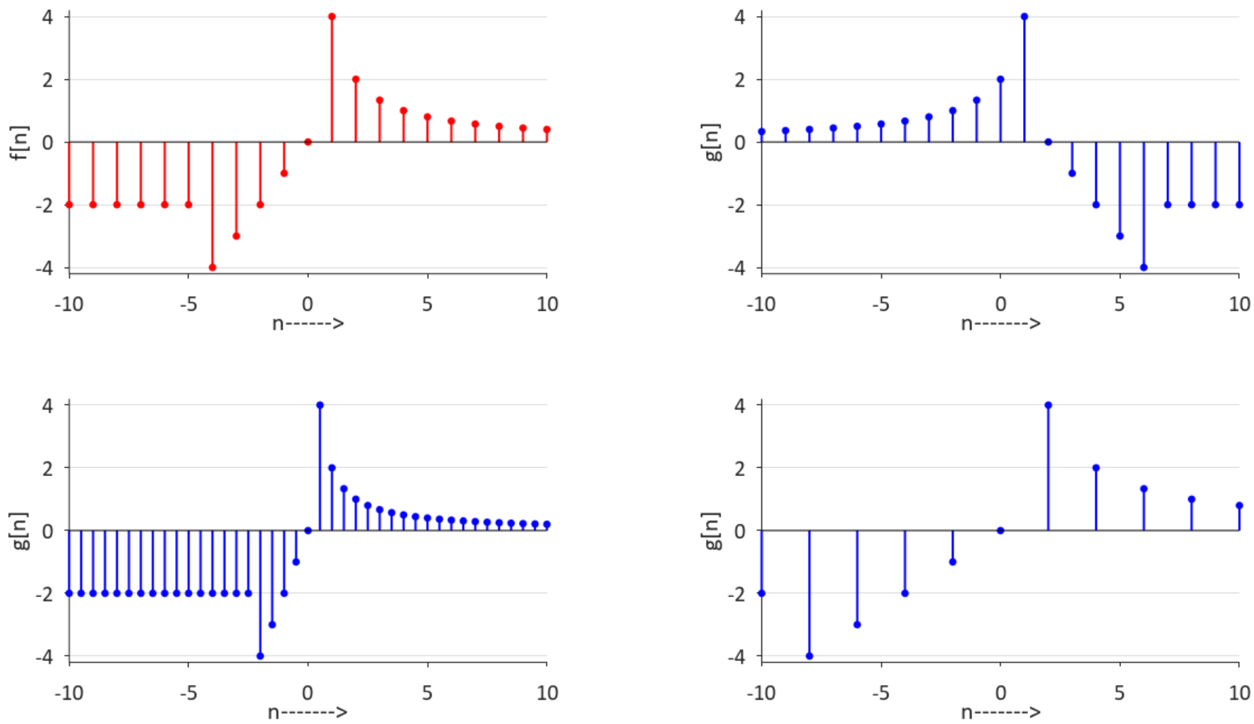

Figure 1: Scaling and Shifting Signals

1.7 Discussion

The function value ranges between $[-4, 4]$.

2 Symbolic & Numeric Integration

2.1 Aim

To Integrate $\sin x$ symbolically & numerically (both cumulative and trapezoidal), thereby comparing them.

2.2 Theoretical Background

Under numerical method, Cumulative and Trapezoidal method are used. Cumulative index merely add the current index with all the previous indices, while Trapezoidal Sum approximates the functions as Trapezoid of fixed width.

2.3 Methodology

- Using symbolic function syms and int we calculate the symbolic integration for $\sin x$.
- Using Trapezoidal function cumtrapz and cumulative function cumsum we calculate the numerical integration for $\sin x$.
- all the discrete and continuous sums are plotted. Discrete sums can be plotted using STAIRS.

2.4 Code

```
clc;
clear all;

xRange = [-10:10];
xPoints = [-20:20];
scale = 0.1;

% Symbolic Integrationrn
syms t;
F(t) = sin(t)
f(t) = int(F);

f_ =  (t) sin(t);
points = f_(xPoints);

hold on;
fplot(matlabFunction(F),[0,2*pi],'r-', 'linewidth', 1);
xlabel('t------>');
```

```
ylabel('f(t)');
fplot(matlabFunction(f),[0,2*pi],'k--', 'linewidth', 1);

% Numerical Integration
% 1)Cummulative Integration
stairs(xPoints, cumsum(points), '-.b', 'linewidth', 2);
% 2) Trapezoidal Integration
stairs(xPoints,cumtrapz(points),':m', 'linewidth', 2);
lgd = legend('f(t) = sin(t)','int(f) = -cos(t)', ...  'Cummulative Sum', 'Trapezoidal Sum');
set(lgd, 'FontName', 'Times', 'FontSize', 15);

set(gca, ...
'Box', 'off', ...
'TickDir', 'out', ...
'FontSize', 15);
axis([0 2*pi*(1+scale) -1.5 1.5 ]);
pbaspect([2, 1, 1]);

print(gcf, ['symbolicInt', '.eps'], '-depsc');
```

2.5 Input Data Description

3 Integration Technique to be used on $\sin x$: Symbolic, Cumulative, Trapezoidal.
The Range is taken as $[0, 2\pi]$.

2.6 Result

The superimposed graph for the analog signal along with corresponding discrete time signal for different sampling periods is :

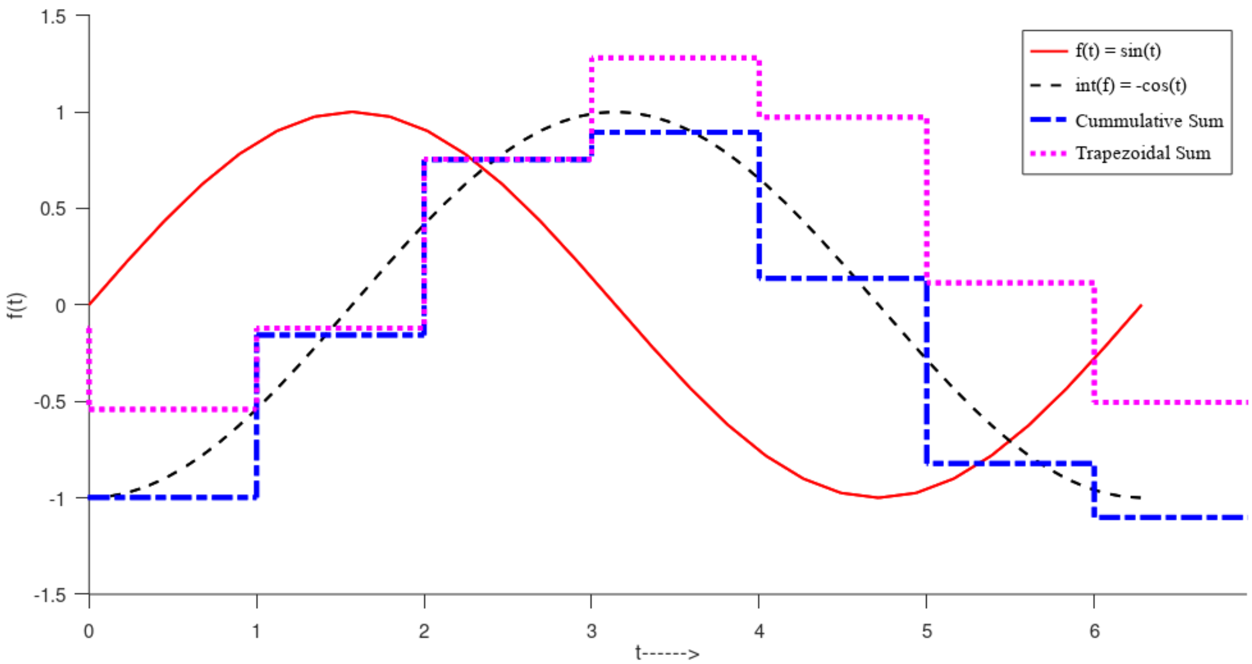

Figure 2: Comparison of Sampling Periods

2.7 Conclusion

Trapezoidal Signal can make better approximation even closely matching original one with better scaling.

Cumulative Sum seems to be far from approximating the original signal.

3 Odd & Even Functions

3.1 Aim

To plot even and odd parts of:

a. $f(t) = t(t^2 + 3)$
b. $g(t) = t(2 - t^2)(1 + 4t^2)$

3.2 Theoretical Background

A function $f(x)$ such that

$$f(-x) = f(x)$$

is called an Even Function.

A function $f(x)$ such that

$$f(-x) = -f(x)$$

is called an Odd Function.

A function can essentially be decomposed into an even function and an odd function:

$$f(x) = f_e(x) + f_o(x)$$

$$f_e(x) = \frac{f(x) + f(-x)}{2}$$

$$f_o(x) = \frac{f(x) - f(-x)}{2}$$

3.3 Methodology

- Odd and even parts of the function are obtained through the given equations.
- Mixed Plots are generated to show the Odd, even and Original function in one and observe the difference.

3.4 Code

```
clc;
clear all;

t = -20:0.05:20;
t1 = -t;

% Function f(t)
subplot(2,1,1);
f = t.*(t.^2+3);
fmin = t1.*(t1.^2+3);
plot(t,f,'g', 'linewidth', 1);
```

```
xlabel('time(s)');
ylabel('x(t)');
set(gca, ...
'Box', 'off', ...
'TickDir', 'out', ...
'YGrid', 'on', ...
'FontSize', 15, ...
'FontName','Typewriter');
axis([-5 5 -150 150]);
hold on;
% Even Function
ef = (f+fmin)/2;
% Odd Function
of = (f-fmin)/2;
plot(t,ef,'b', 'linewidth', 1.5);
hold on;
plot(t,of,'k–','linewidth', 2);
hold on;
legend('boxoff', 'location', "Northwest");
legend('f(t)','Even Function: (f(t)+f(-t))/2','Odd Function: (f(t)-f(-t))/2')
% Function g(t)
subplot(2,1,2);
g = t.*(2-t.^2).*(1+4.*t.^2);gmin =t1.*(2-t1.^2).*(1+4.*t1.^2);
plot(t,g,'g','linewidth', 1);
xlabel('time(s)');
ylabel('x(t)');
set(gca, ...
'Box', 'off', ...
'TickDir', 'out', ...
'YGrid', 'on', ...
```

```
'FontSize', 15, ...
'FontName','Typewriter');
axis([-5 5 -12000 12000]);
hold on;
% Even Function
eg = (g+gmin)/2;
plot(t,eg,'b', 'linewidth', 1.5);
hold on;
% Odd Function
og = (g-gmin)/2;
plot(t,og,'k–','linewidth', 2);
hold on;
legend('boxoff', 'location', "best");
legend('g(t)','Even Function: (g(t)+g(-t))/2','Odd Function: (g(t)-g(-t))/2');
```

3.5 Input Data Description

The two functions are:

$$f(t) = t(t^2 + 3)$$
$$g(t) = t(2 - t^2)(1 + 4t^2)$$

The Range is :
$[-150 : 150]$ for $f(t)$
$[-10000 : 10000]$ for $g(t)$

3.6 Result

Following graphs demonstrate our observations :

3.7 Discussion

Since both f and g are Odd Functions, hence there even part is zero. Also see the relation between f and g. Seems like reverted about x- axis with different ranges.

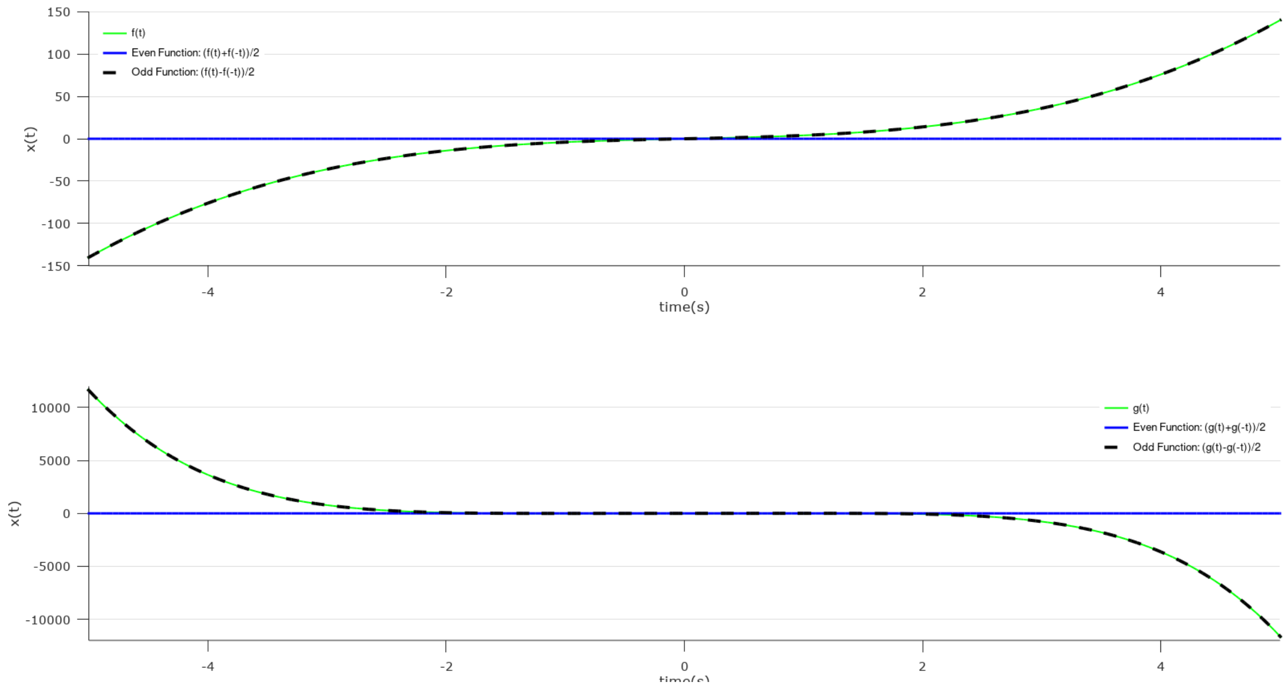

Figure 3: Odd and Even Signals