KATHMANDU ENGINEERING COLLEGE
KALIMATI, KATHMANDU
TRIBHUVAN UNIVERSITY

LAB REPORT ON

Digital Signal Analysis and Processing

LAB NO: 1

SIGNAL GENERATION

Submitted by:
NIMESH POUDEL
KAT078BCT054
GROUP: B1
YEAR: IV/I

Submitted to:
DEPARTMENT
OF
COMPUTER
ENGINEERING

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SIGNAL GENERATION

Theory

Signal can be defined as a function of one or more independent variables which conveys information about the behavior or nature of some phenomenon. It's examples include electrical signal which is a voltage function of time. 1-D signals are of two types:

- **Continuous time signal (CT signal):** These signals are defined in every instance of time under consideration. It is represented as $x(t)$. Ex. Electrical Signal.
- **Discrete time signal (DT signal):** These signals are defined only at certain time instants. Amplitude between two time instances is not defined. It is represented as $x[n]$.

Some basic signals include:

1. **Unit Impulse Signal:** Also known as the Dirac delta function, it is defined as a signal that is zero at all times except at $t = 0$, where it is 1 (in DT) and ∞ (in CT).
   For DT:
   $$\delta[n] := \begin{cases} 1 & \text{if } n = 0 \\ 0 & \text{Otherwise} \end{cases}$$
   For CT:
   $$\delta(t) := \begin{cases} \infty & \text{if } t = 0 \\ 0 & \text{Otherwise} \end{cases}$$
2. **Unit Step Signal:** This signal is 0 for negative time and 1 for non negative time.
   $$\theta(t) := \begin{cases} 0 & \text{if } t < 0 \\ 1 & \text{if } t \geq 0 \end{cases}$$
3. **Unit Ramp Signal:** A ramp signal increases linearly with time.
   $$R(t) := \begin{cases} 0 & \text{if } t \leq 0 \\ t & \text{if } t > 0 \end{cases}$$
4. **Signum Signal:** This signal indicates the sign of a number, returning -1 for negative inputs, 0 at zero, and 1 for positive inputs.
   $$\operatorname{sgn}(t) := \begin{cases} -1 & \text{if } t < 0 \\ 0 & \text{if } t = 0 \\ 1 & \text{if } t > 0 \end{cases} \qquad \text{OR,} \qquad \operatorname{sgn}(t) := \begin{cases} 0 & \text{if } t = 0 \\ \dfrac{t}{|t|} & \text{if } t \neq 0 \end{cases}$$
5. **Sinusoidal Signal:** A periodic waveform described by sine or cosine functions.
   $$x(t) = A\sin(\omega t) \qquad\qquad y(t) = A\cos(\omega t)$$
6. **Rectangular Signal:** This signal has a constant amplitude for a fixed interval and is zero elsewhere.
   $$\operatorname{rect}\left(\frac{t}{a}\right) = \Pi\left(\frac{t}{a}\right) := \begin{cases} 0, & \text{if } |t| > \frac{a}{2} \\ 1, & \text{if } |t| \leq \frac{a}{2} \end{cases}$$

7. **Sinc funcion:** In mathematics, the historical unnormalized sinc function is defined as,

$$\operatorname{sinc}(t) := \begin{cases} 1 & \text{if } t = 0 \\ \dfrac{\sin(t)}{t} & \text{if } t \neq 0 \end{cases}$$

In digital signal processing and information theory, the normalized sinc function is commonly defined as,

$$\operatorname{sinc}(t) := \begin{cases} 1 & \text{if } t = 0 \\ \dfrac{\sin(\pi t)}{\pi t} & \text{if } t \neq 0 \end{cases}$$

PROGRAMS

Unit Impilse Signal

```
t = -10:0.1:10;
for k = 1:length(t)
    if t(k) == 0
        del_t(k) = 1;
    else
        del_t(k) = 0;
    endif
end
subplot(2,1,1);
plot(t, del_t);
axis([-10 10 -0.1 1.1]);
title('KAT078BCT054 Continuous-time delta function');
xlabel('t'); ylabel('\delta(t)');

n = -10:10;
for k = 1:length(n)
    if n(k) == 0
        del_n(k) = 1;
    else
        del_n(k) = 0;
    endif
end
subplot(2,1,2);
stem(n, del_n);
axis([-10 10 -0.1 1.1]);
title('KAT078BCT054 Discrete-time delta function');
xlabel('n'); ylabel('\delta[n]');
```

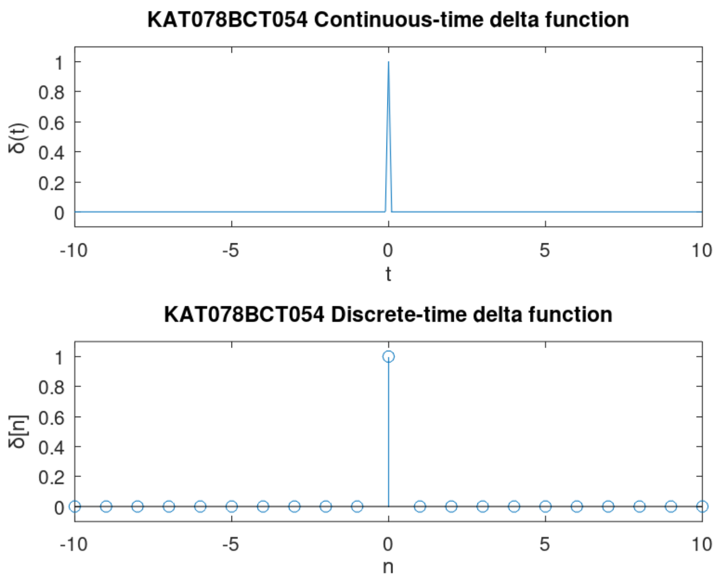

Figure 1: Unit Impulse Signal

Unit Step Signal

```
t = -10:0.1:10;
for k = 1:length(t)
    if t(k) < 0
        unit_step_t(k) = 0;
    else
        unit_step_t(k) = 1;
    endif
end
subplot(2,1,1);
plot(t, unit_step_t);
axis([-10 10 -0.3 1.1]);
title('KAT078BCT054 Continuous-time unit step function');
xlabel('t'); ylabel('\theta(t)');

n = -10:10;
for k = 1:length(n)
    if n(k) < 0
        unit_step_n(k) = 0;
    else
        unit_step_n(k) = 1;
    endif
end
subplot(2,1,2);
stem(n, unit_step_n);
axis([-10 10 -0.3 1.1]);
title('KAT078BCT054 Discrete-time unit step function');
xlabel('n'); ylabel('\theta[n]');
```

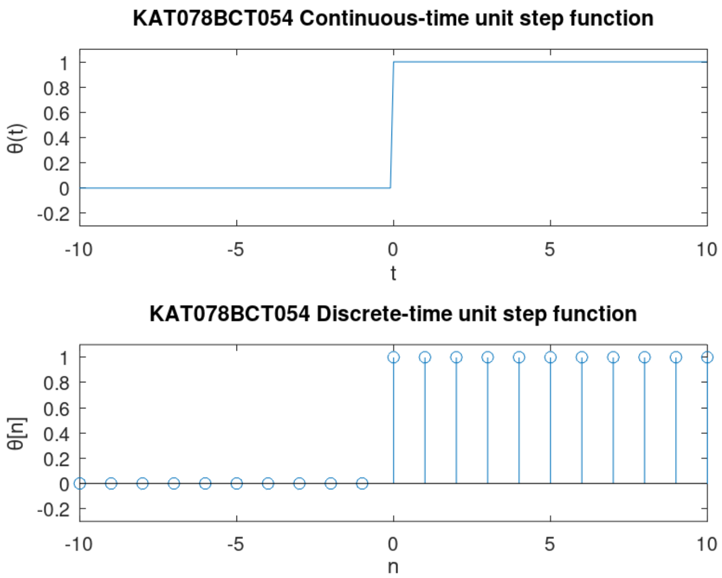

Figure 2: Unit Step Signal

Ramp Signal

```
t = -10:0.1:10;
for k = 1:length(t)
    if t(k) < 0
        ramp_t(k) = 0;
    else
        ramp_t(k) = t(k);
    endif
end
subplot(2,1,1);
plot(t, ramp_t);
axis([-10 10 -0.3 11]);
title('KAT078BCT054 Continuous-time ramp function');
xlabel('t'); ylabel('R(t)');

n = -10:10;
for k = 1:length(n)
    if n(k) < 0
        ramp_n(k) = 0;
    else
        ramp_n(k) = n(k);
    endif
end
subplot(2,1,2);
stem(n, ramp_n,'*');
axis([-10 10 -0.3 11]);
title('KAT078BCT054 Discrete-time ramp function');
xlabel('n'); ylabel('R[n]');
```

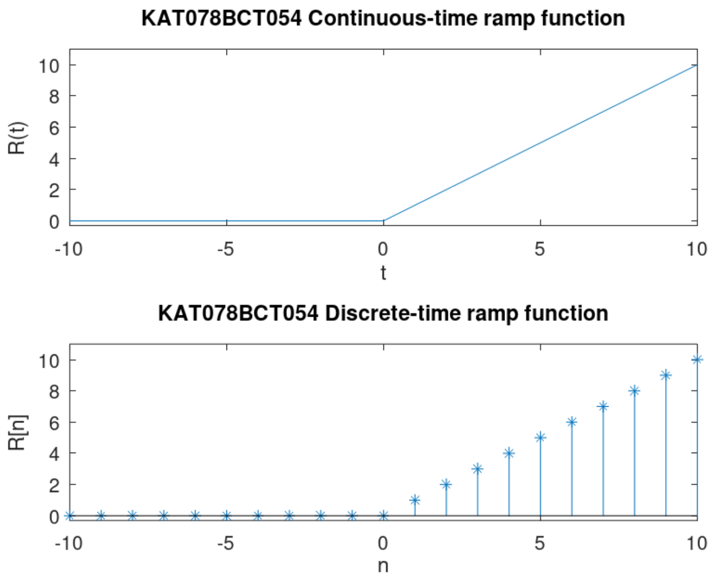

Figure 3: Ramp Signal

Signum Signal

```
t = -10: 0.01: 10;
for k = 1:length(t)
  if t(k) != 0
    sgn_t(k) = t(k)/abs(t(k));
  endif
end
subplot(2,1,1)
plot(t, sgn_t);
axis([-10 10 -1.3 1.3])
xlabel('t'), ylabel('sin(t)')
title('KAT078BCT054 Continous signum function')

n = -10:10;
for k = 1:length(n)
  if n(k) != 0
    sgn_n(k) = n(k)/abs(n(k));
  endif
end
subplot(2,1,2)
stem(n, sgn_n);
axis([-10 10 -1.3 1.3])
xlabel('n'), ylabel('sin[n]')
title('KAT078BCT054 Discreet signum function')
```

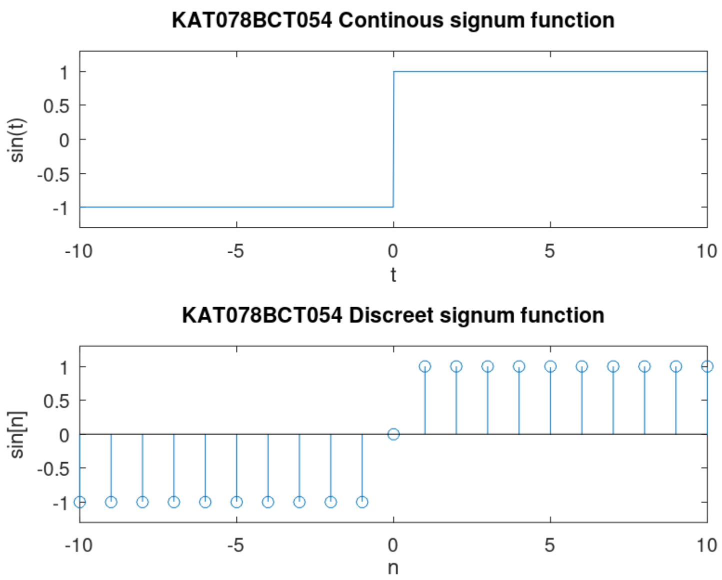

Figure 4: Signum Signal

Rectangular Signal

```
a = 6;
t = -10:0.01:10;
rect_t = zeros(size(t));
for k = 1:length(t)
    if abs(t(k)) <= a/2
        rect_t(k) = 1;
    else
        rect_t(k) = 0;
    endif
end
subplot(2,1,1);
plot(t, rect_t);
axis([-10 10 -0.3 1.1]);
title('KAT078BCT054 Continuous-time rect(t/a)');
xlabel('t'); ylabel('rect(t/a)');

n = -10:10;
rect_n = zeros(size(n));
for k = 1:length(n)
    if abs(n(k)) <= a/2
        rect_n(k) = 1;
    else
        rect_n(k) = 0;
    endif
end
subplot(2,1,2);
stem(n, rect_n);
axis([-10 10 -0.3 1.1]);
title('KAT078BCT054 Discrete-time rect[n/a]');
xlabel('n'); ylabel('rect[n/a]');
```

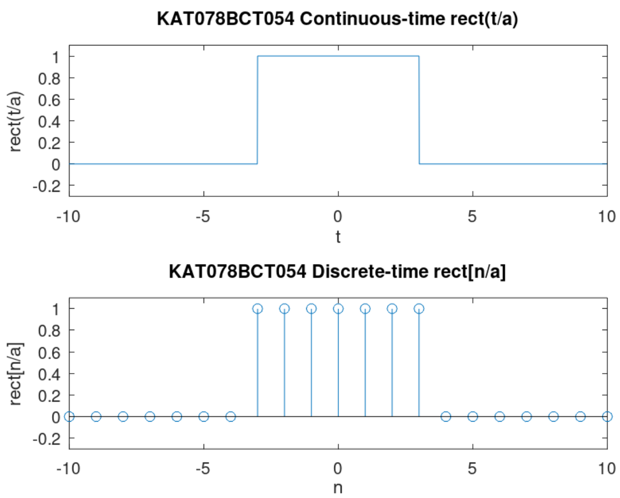

Figure 5: Rectangular Signal

Sin Signal

```
t = -2*pi:0.01:2*pi;
subplot(2,1,1)
plot(t, sin(t));
axis([-2*pi 2*pi -1.3 1.3])
xlabel('t'), ylabel('sin(t)')
title('KAT078BCT054 Continous sin function')

n = floor(-2*pi):ceil(2*pi);
subplot(2,1,2)
stem(n, sin(n));
axis([floor(-2*pi) ceil(2*pi) -1.3 1.3])
xlabel('n'), ylabel('sin[n]')
title('KAT078BCT054 Discreet sin function')
```

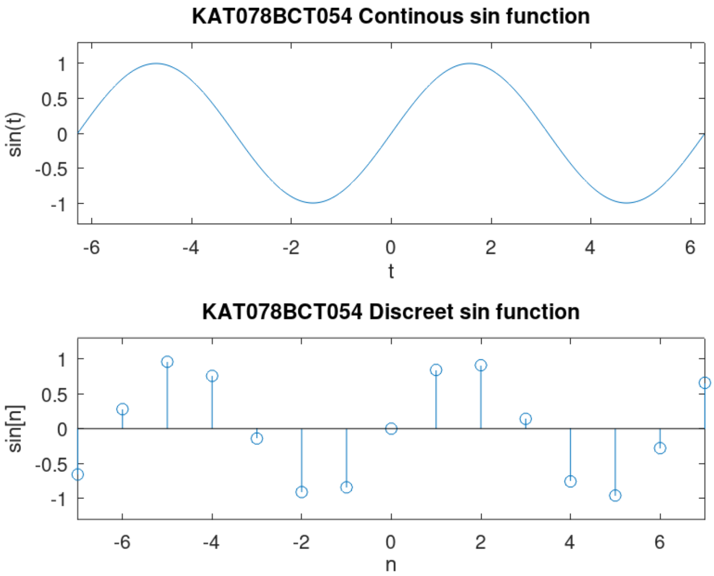

Figure 6: Sin Signal

Sinc Signal

```
t = -10:0.1:10;
for k = 1:length(t)
    if t(k) == 0
        sinc_t(k) = 1;
    else
        sinc_t(k) = sin(t(k)*pi)/(t(k)*pi);
    endif
end
subplot(2,1,1);
plot(t, sinc_t);
axis([-10 10 -0.3 1.1]);
title('KAT078BCT054 Continuous-time normalized sinc function');
xlabel('t'); ylabel('sinc(t)');

n = -10:10;
for k = 1:length(n)
    if n(k) == 0
        sinc_n(k) = 1;
    else
        sinc_n(k) = sin(n(k))/(n(k));
    endif
end

subplot(2,1,2);
stem(n, sinc_n);
axis([-10 10 -0.3 1.1]);
title('KAT078BCT054 Discrete-time sinc function');
xlabel('n'); ylabel('sinc[n]');
```

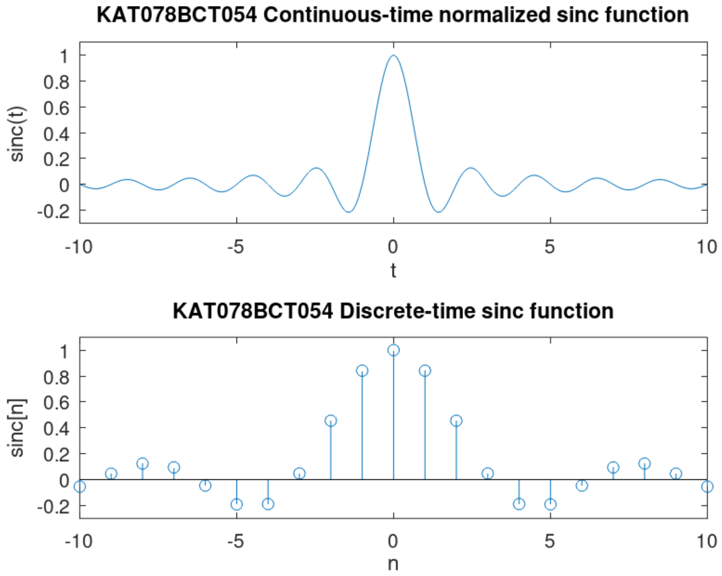

Figure 7: Sinc Signal

Discussion

During this lab, we implemented MATLAB scripts to generate various fundamental signals. We observed that the continuous signals were plotted using smooth curves, while discrete signals were plotted using discrete data points, providing a clear representation of sampled data.

Conclusion

Hence, we successfully generated various basic signals using MATLAB. Through this, we visualized the behavior of fundamental signals that are essential in the analysis and design of communication systems, control systems, and signal processing applications.