# DIGITAL SIGNAL PROCESSING LAB

Debagnik Kar
Roll: 1804373, ETC -06, EC - 3096

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|---|---|
| **Experiment Number** | 02 |
| **Date of Experiment** | 06/01/2021 |
| **Date of Submission** | 13/01/2021 |
| **Name of the Student** | Debagnik Kar |
| **Roll Number** | 1804373 |
| **Section** | ETC - 06 |

**Aim of The Experiment :-**

To solve a given differential equation to find it's impulse and step responses. Plot the response and verify the solution

**Software Required :-**

- MATLAB R2018a

**Theory :-**

**Step response:** The step response of a system in a given initial state consists of the time evolution of its outputs when its control inputs are Heaviside step functions. In electronic engineering and control theory, step response is the time behaviour of the outputs of a general system when its inputs change from zero to one in a very short time. Knowing the step response of a dynamical system gives information on the stability of such a system

**Impulse response:** The impulse response, or impulse response function (IRF), of a dynamic system is its output when presented with a brief input signal, called an impulse. More generally, an impulse response is the reaction of any dynamic system in response to some external change. In both cases, the impulse response describes the reaction of the system as a function of time (or possibly as a function of some other independent variable that parameterizes the dynamic behaviour of the system). We cannot find the impulse response directly, hence we find the step response and then differentiate it to find the impulse response.

The equation given was:

$$y(n) = y(n-1) - \frac{1}{2}(n-2) + x(n) + x(n-1)$$

$$y(n) - y(n-1) - 0.5y(n-2) = x(n) + x(n-1)$$

$$y(z)(1 - z^{-1} + 0.5z^{-2}) = x(z)(1 + z^{-1})$$

$$\frac{y(z)}{x(z)} = \frac{(1 + z^{-1})z^2}{(1 - z^{-1} + 0.5z^{-2})z^2}$$

$$H(z) = \frac{(z+1)z}{z^2 - z + 0.5}$$

Hence, the Transfer Function is found by taking Z-transform and we got the coefficient a & b which we use in the code

**Code :-**

<<<File: main.m comment: Main programme>>>

```
% main.m for expt 2,
% Coded and written by Debagnik Kar 1804373
clc
clear all
close all

b = [1 1] %From the transfer function
a = [1 -1 0.5] %From the transfer function
n = 0:50

% Impulse response
h = impz(b,a,length(n))
subplot 311
stem(n,h,'g')
title('Impulse Response')

% step sequence
x = stepseq(0,0,50)
s = filter(b,a,x)
subplot 312
stem(n,s,'k')
title('Step Sequence Response')

% Plotting in z-plane
subplot 338
zplane(a,b)
xlabel('Real')
ylabel('Imaginary')


% Stability
p = roots(a)
m = abs(p)
if m<1
    legend('Stable Function')
else
    legend('Unstable Function')
end
```

<<<File: stepseq.m Comment: step sequence functional dependencies used for plotting>>>

```
function [x,n]= stepseq(n0,n1,n2)
  n=[n1:n2]
  x= [(n-n0)>=0]
end
```

## Graph/Output :-

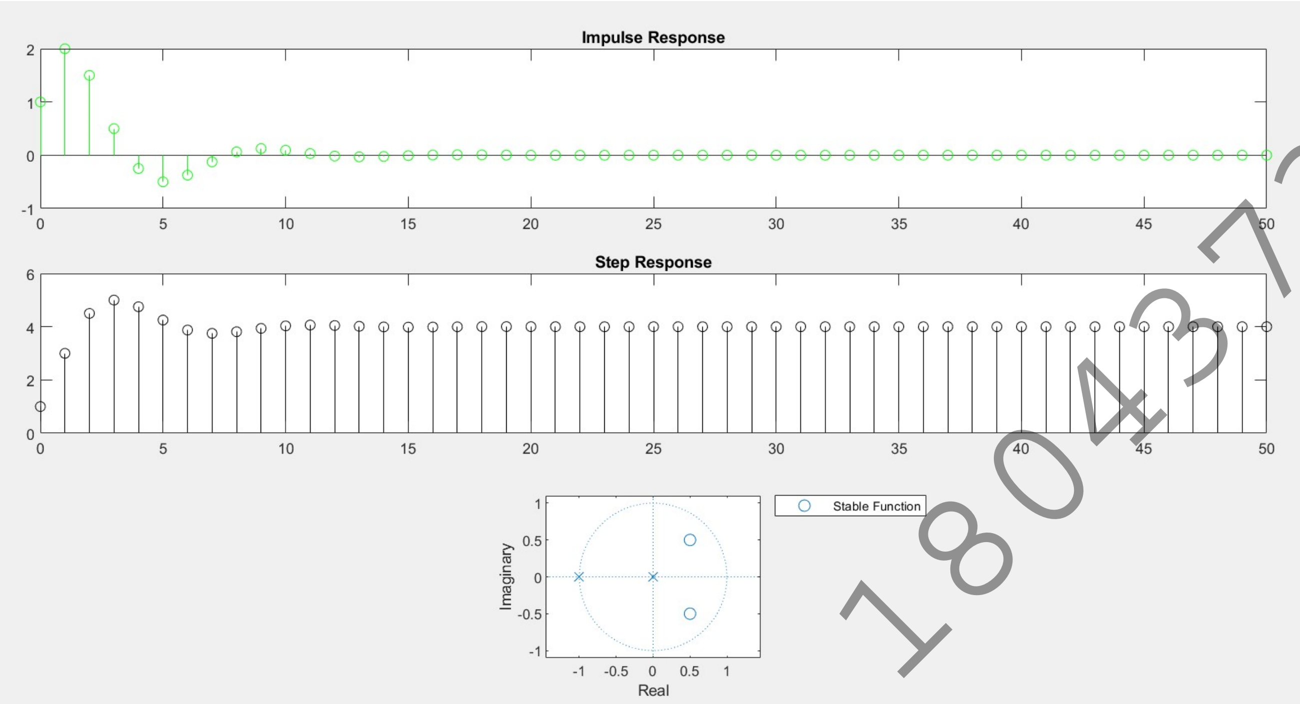


*Fig 2.1: Step and impulse response of the equation.*

## Discussion/Inference of the experiment :-

We got the transfer function by taking its Z-transform and from there we got the coefficients of a and b , where b=[1,1] and a=[1,-1,0.5]. The impulse response was plotted using impz() function the step response was plotted using stepseq() function which was also written. To check whether the system was stable or not magnitude of the roots was calculated and it was checked if it was less than one the system was stable otherwise the system was unstable and it was plotted using z-plane.

## Conclusion :-

Using MATLAB, we solved the differential equation given to us, and the impulse response and step responses were found. The differential equation was found to be stable. The responses have been plotted and the solution was verified. Hence, we have successfully performed this experiment.