PROJECT 2-GRADE SHEET

Submission Page Summary-Provide this page at the front of your project submission

Problem	**Max Score**	**Score**
Derivation	10	
2-A1	15	
2-A2	15	
2-B1	20	
2-B2	20	
2-B3	20	
Total	100	

Friday, July 20, 2018 7:31 PM

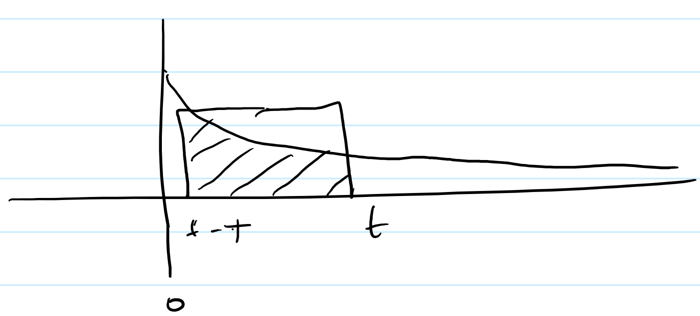
Capacitor:

$t \geq 0$,

$t - T < 0 \Rightarrow \underline{0 \leq t < T}$

$$\frac{A}{RC}\int_0^t e^{-\tau/RC}\, d\tau = -A\left[e^{-\tau/RC}\right]_0^t$$

$$= \boxed{A\left(1 - e^{t/RC}\right)}$$



$t - T \geq 0 \rightarrow \underline{t \geq T}$

$$\frac{A}{RC}\int_{t-T}^{t} e^{-\tau/RC}\,d\tau = -A\left[e^{\tau/RC}\right]_{t-T}^{t} = A\left[-e^{-t/RC} + e^{-t/RC}\right]$$

$$= \boxed{A\left(e^{T/RC} - 1\right)e^{-t/RC}}$$

Resistor:

$$0 \le t < T$$

$$\int_0^t \left[\delta(\tau) - \frac{1}{RC}e^{-\tau/RC}\right]d\tau$$

$$= A\left[u(\tau) + e^{-\tau/RC}\right]_0^t$$

$$= A\left[u(t) + e^{-t/RC} - u(0) - 1\right)$$

$$= A\left[1 + e^{-t/RC} - 0 - 1 \right]$$

$$= \boxed{A e^{-t/RC}}$$

$\underline{t \geq T}$

$$A \int_{t-T}^{t} \left(\delta(\tau) - \frac{1}{RC} e^{-\tau/RC} \right) d\tau$$

$$= A\left[u(\tau) + e^{-\tau/RC} \right]_{t-T}^{t}$$

$$= A\left[u(t) + e^{-t/RC} - u(t-T) + e^{(-t+T)/RC} \right]$$

$$= A\left[e^{-t/RC} - e^{(-t-T)/RC} \right]$$

$$= \boxed{A\left(1 - e^{T/RC}\right) e^{-t/RC}}$$

```
close all; clear; clc
```

PART A1

```
R = [600, 1000, 1200];
A = 5;
C = 1e-6;
T = 0.010;
T_end = 0.020;
t = 0:0.000001:0.020;

type('rc_voltages.m')

for m = 1:length(R)
    figure
    [V_c, V_r] = rc_voltages(R(m), C, A, T, T_end);
    plot(t, V_c(t), 'Linewidth', 2)
    hold on
    plot(t, V_r(t), 'Linewidth', 2)
    hold on
    plot(t, V_c(t) + V_r(t), '--c', 'Linewidth', 2)
    xlabel('time (s)')
    ylabel('voltage (V)')
    legend('V_c', 'V_r', 'impulse response')
    title([num2str(R(m)), ' ohms'])
    grid on
end
```

PART A2

```
R = 1000;
A = 5;
C = 1e-6;
T = 0.010;
T_end = 0.020;
t = 0:0.000001:0.060;
delay = [0.007 0.012 0.017];
for i = 1:length(delay)
    figure,
    [V_c, V_r] = rc_voltages(R, C, A, T, T_end);
    plot(t, V_c(t) + V_c(t-delay(i)) + V_c(t-2*delay(i)), 'Linewidth',
 2);
    hold on
    plot(t, V_r(t) + V_r(t-delay(i)) + V_r(t-2*delay(i)), 'Linewidth',
 2)
    hold on
    plot(t, V_c(t) + V_r(t) + V_c(t-delay(i)) + V_r(t-delay(i)) +
 V_c(t-2*delay(i)) + V_r(t-2*delay(i)), '--c', 'Linewidth', 2)
    xlabel('time (s)')
    ylabel('voltage (V)')
    legend('V_c', 'V_r', 'impulse response')
```

```
    title([num2str(delay(i)*1000), ' ms'])
    grid on
end
```

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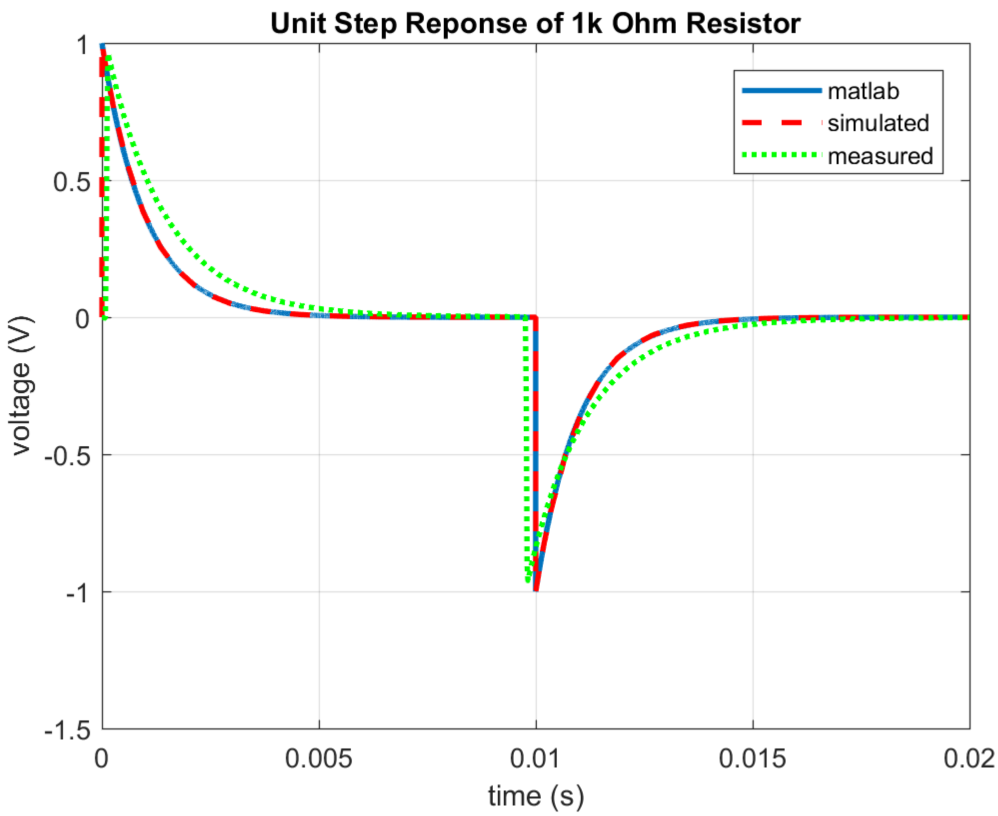
Table of Contents


```
close all, clear all, clc
```

B1

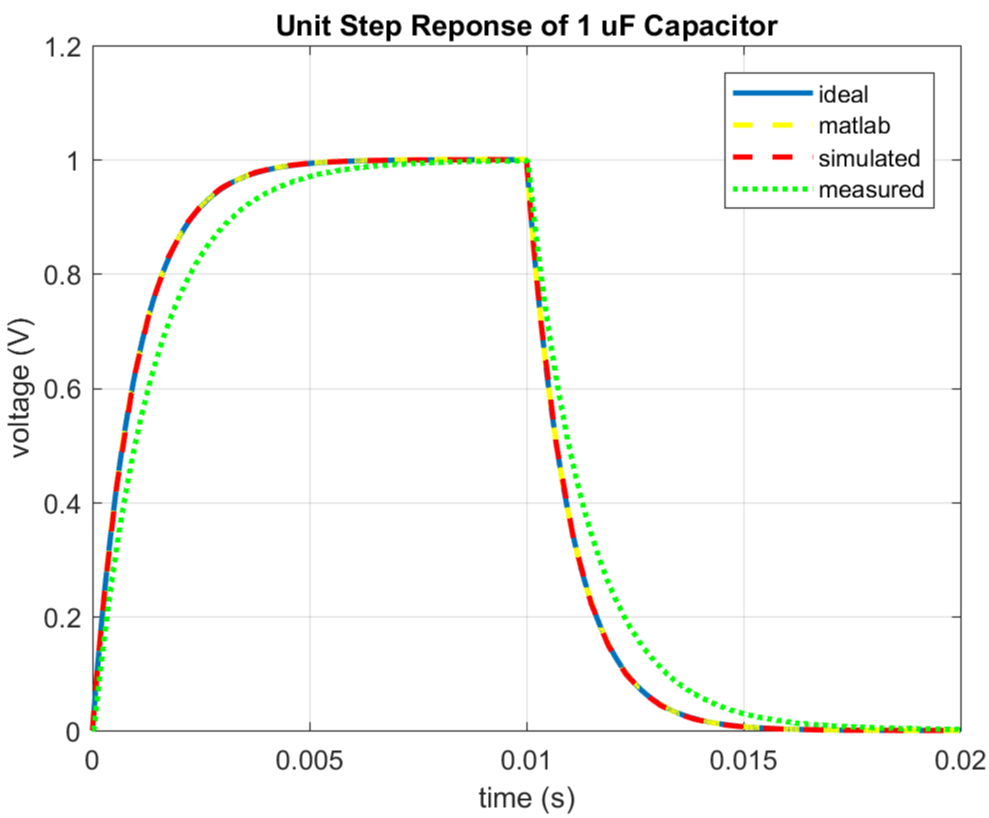
```
R = 1000;
C = 0.000001;

% matlab
t = 0:0.000001:0.020;
x1 = (1/(R*C))*exp(-t/(R*C)).*(t>=0);
x2 = heaviside(t) + -1 * heaviside(t-0.01);
y = (conv(x1,x2)) * 0.000001;
y = 1 - y(1:20001);
y(10000:20001) = y(10000:20001) - 1;
plot(t, y, 'Linewidth', 2)
hold on

% simulated
data = xlsread('multisim_data_r.xlsx');
t = data(:,1);
y = data(:,2);
plot(t, y, '--r', 'Linewidth' , 2)

% measured
t = 0:0.00002:0.020;
data = xlsread('mydaq_data_r.xlsx');
plot(t, data, ':g', 'Linewidth', 2)


title('Unit Step Reponse of 1k Ohm Resistor')
xlabel('time (s)')
ylabel('voltage (V)')
legend('matlab', 'simulated', 'measured')
grid on
```



B2

```
R = 1000;
C = 0.000001;
A = 1;

figure
% ideal capacitor voltage
T = 0.010;
T_end = 0.020;
[V_c, ~] = rc_voltages(R, C, A, T, T_end);
plot(t, V_c(t), 'Linewidth', 2)
hold on

% discrete convolution
t = 0:0.000001:0.020;
x1 = (1/(R*C))*exp(-t/(R*C)).*(t>=0);
x2 = heaviside(t) + -1 * heaviside(t-0.01);
y = (conv(x1,x2)) * 0.000001;
plot(t, y(1:20001), '--y', 'Linewidth', 2);
hold on

% simulated
data = xlsread('multisim_data_c.xlsx');
t = data(:,1);
```

```
y = data(:,2);
plot(t, y, '--r', 'Linewidth' , 2)

% measured
t = 0:0.00002:0.020;
data = xlsread('mydaq_data_c.xlsx');
plot(t, data, ':g', 'Linewidth', 2)


title('Unit Step Reponse of 1 uF Capacitor')
xlabel('time (s)')
ylabel('voltage (V)')
legend('ideal', 'matlab' ,'simulated', 'measured')
grid on
```



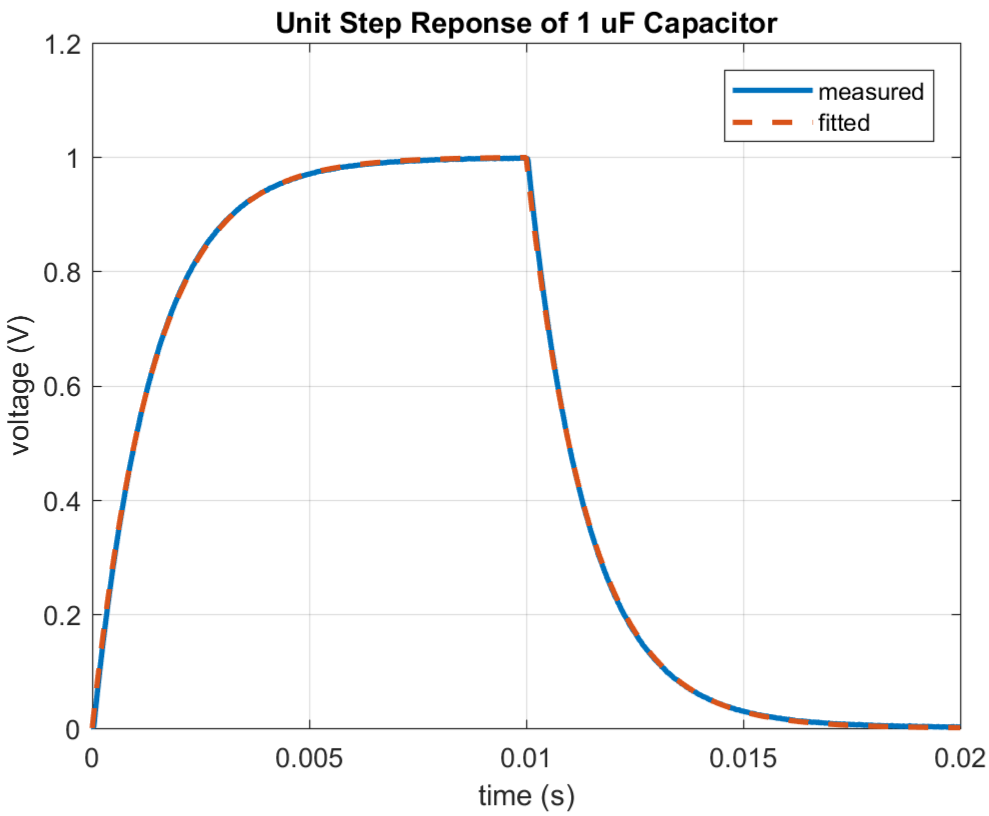
B3

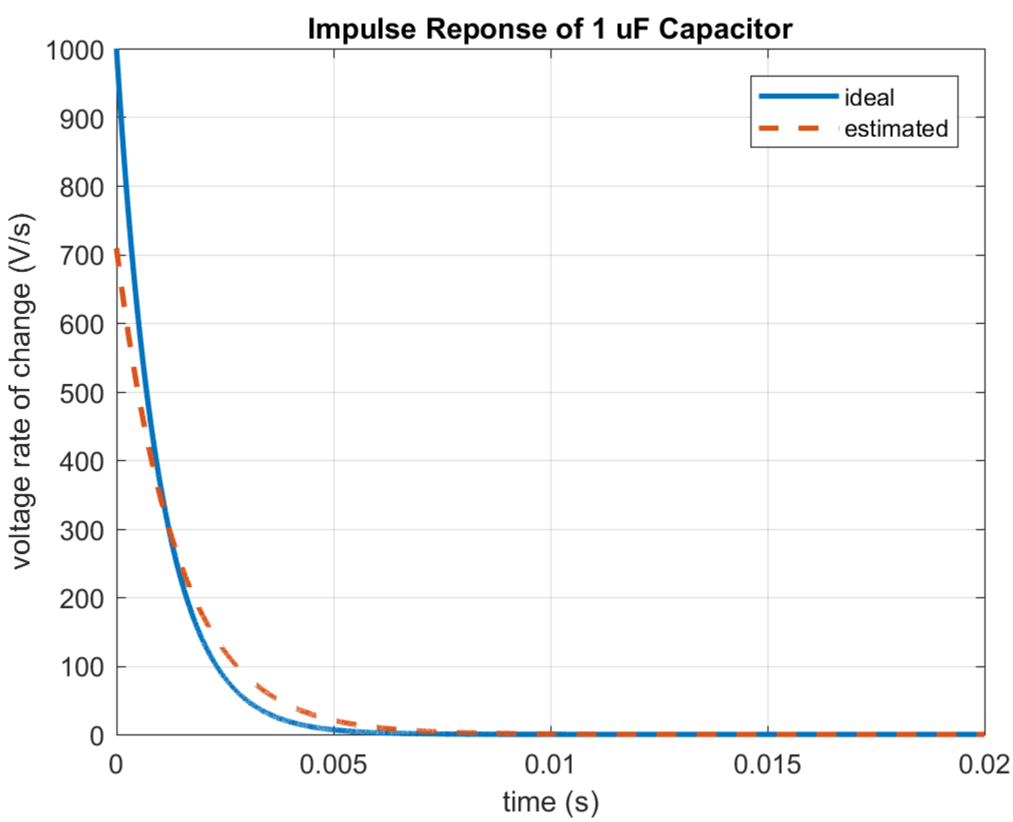
```
figure
% measured
t = 0:0.00002:0.020;
data = xlsread('mydaq_data_c.xlsx');
plot(t,data, 'Linewidth' , 2)
hold on

% fitted
t_o = 0.01;
```

```
V_o = 1;
V_c = @(tau, t) (t < t_o & t >= 0) .* (V_o .* (1 - exp(-t/(tau)))) ...
    + (t >= t_o) .* (V_o .* (1 - exp(-t_o/(tau))) .* exp(-(t - t_o)/
(tau)));
yi=data(end);
idx=max(find(abs(y - yi) >= 0.37 * yi));
tau_est = data(idx);
tau_est = lsqcurvefit(V_c, tau_est, t', data);
plot(t, V_c(tau_est, t), '--', 'Linewidth', 2)
hold on

title('Unit Step Reponse of 1 uF Capacitor')
xlabel('time (s)')
ylabel('voltage (V)')
ylim([0 1.2])
legend('measured', 'fitted')
grid on

figure
% ideal impulse response
syms T t
f = @(T, t) (V_o .* (1 - exp(-t/(T))));
H_c = matlabFunction(diff(f(T, t)));

tau = R*C;
t = 0:0.000001:0.020;
plot(t, H_c(tau, t), 'Linewidth', 2)
hold on

% estimated impulse response
syms T t
f = @(T, t) (V_o .* (1 - exp(-t/(T))));
H_c = matlabFunction(diff(f(T, t)));

t = 0:0.000001:0.020;
plot(t, H_c(tau_est, t), '--' ,'Linewidth', 2)

title('Impulse Reponse of 1 uF Capacitor')
xlabel('time (s)')
ylabel('voltage rate of change (V/s)')
legend('ideal', 'estimated')
grid on
```

Local minimum possible.

lsqcurvefit stopped because the final change in the sum of squares relative to its initial value is less than the default value of the function tolerance.


Unit Step Reponse of 1 uF Capacitor
measured
fitted
voltage (V)
time (s)
1.2
1
0.8
0.6
0.4
0.2
0
0
0.005
0.01
0.015
0.02


Impulse Reponse of 1 uF Capacitor
ideal
estimated
voltage rate of change (V/s)
time (s)
1000
900
800
700
600
500
400
300
200
100
0
0
0.005
0.01
0.015
0.02

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