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A

```
clc
clear

% a0 = 1 - deltat/R1C1
% b0 = Rs*Deltat/R1C1 - Rs + deltat/C1
% B1 = Rs
```

B

```
load 'polynomial.mat';
% Initialize variables
T0a = 25;
Delta_t = 1;
Tspan = 600;
Q = 5;
Current_Input = -2.5;
SOC_0 = 0.5;
mdl = "HW3_virtual_testbed"
set_param(mdl, 'SimulationCommand', 'update');
simIn = Simulink.SimulationInput(mdl);
simIn = setModelParameter(simIn, "StopTime", 'Tspan');
out = sim(simIn);
Current = -2.5 * ones(601, 1);

figure;

subplot(2,2,1);
plot(out.tout, Current);
title('Input Current');
xlabel('Time');
ylabel('Current');

subplot(2,2,2);
plot(out.tout, out.V_out);
title('Terminal Voltage');
xlabel('Time');
ylabel('Voltage');

subplot(2,2,3);
plot(out.tout, out.SOC_out);
title('Calculated SOC');
xlabel('Time');
ylabel('SOC');

subplot(2,2,4);
plot(out.tout, out.Temp);
title('Temp');
xlabel('Time');
ylabel('y');

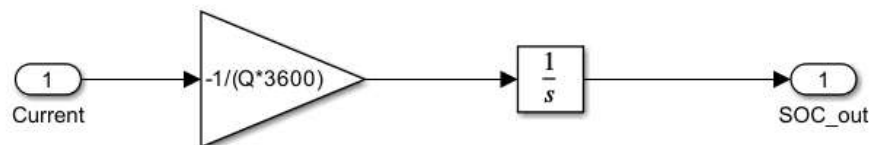
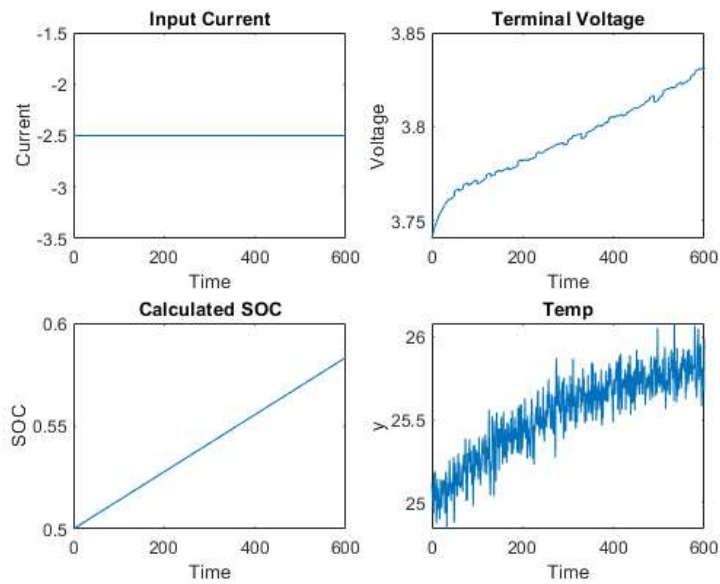
fprintf("The value of SOC at T=10mins is %d", out.SOC_out(end))

image_data = imread('HW3_2b_socestimator.PNG');
figure;
imshow(image_data);
```

mdl =

"HW3_virtual_testbed"

The value of SOC at T=10mins is 5.833333e-01



C

```
clc
clear

load 'polynomial.mat';
Step_Time = [0, 100, 400, 1000, 1300, 1500];
Step_Current = [0, 5, 0, -5, 0];
T = 0:1500;
%Preallocatie input current
Current = zeros(size(T));

for i = 1:5
    Current(T >= Step_Time(i) & T < Step_Time(i+1)) = Step_Current(i);
end
```

```
Current_Input = [0:1500;Current]';
plot(T, Current);

% Initialize variables
T0a = 25;
Delta_t = 1;
Tspan = 1500;
Q = 5;
SOC_0 = 0.5;
alpha = flipud(alpha);

mdl = "HW3_virtual_testbed_2";
set_param(mdl, 'SimulationCommand', 'update');
simIn = Simulink.SimulationInput(mdl);
simIn = setModelParameter(simIn,"StopTime","Tspan");
out = sim(simIn);

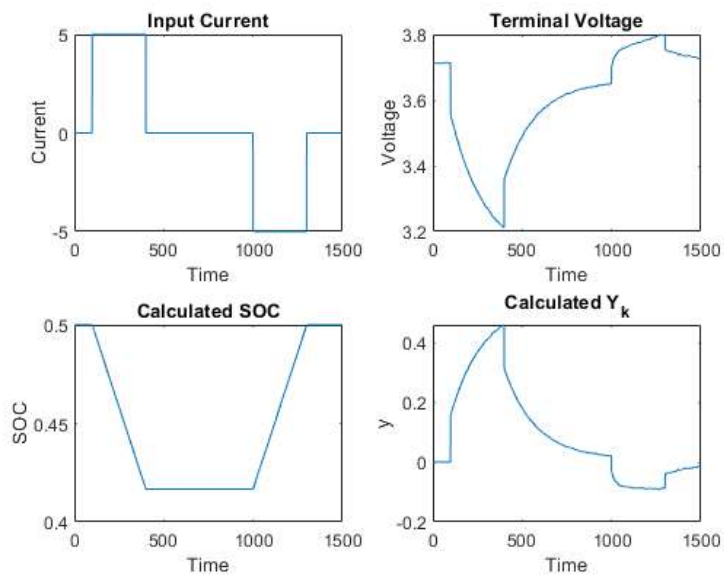
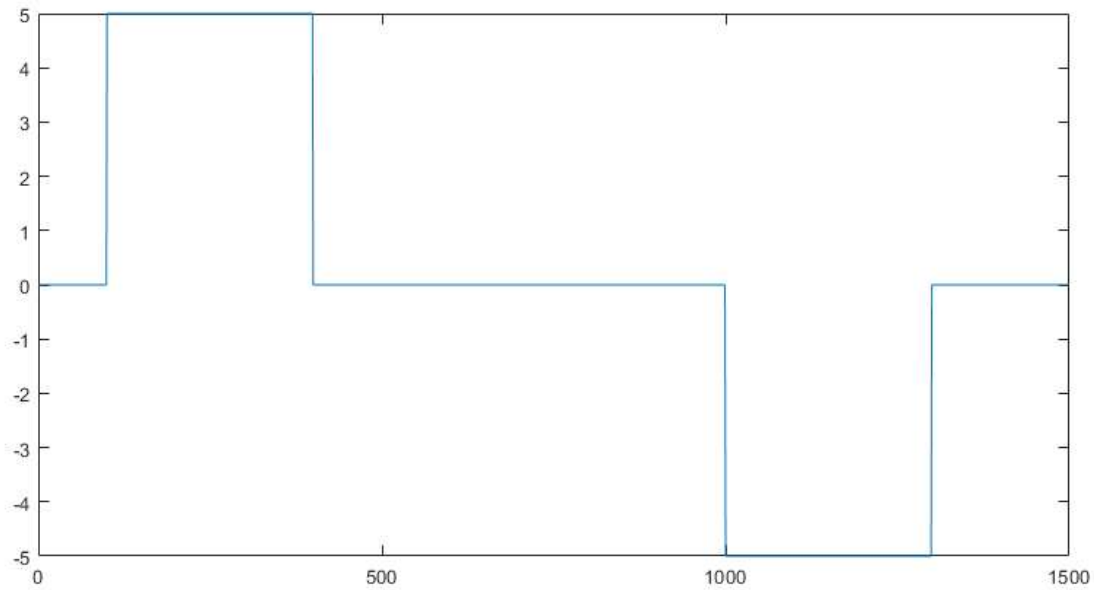
% Plot of all graphs
figure;

subplot(2,2,1);
plot(out.tout, out.I_out);
title('Input Current');
xlabel('Time');
ylabel('Current');

subplot(2,2,2);
plot(out.tout, out.V_out);
title('Terminal Voltage');
xlabel('Time');
ylabel('Voltage');

subplot(2,2,3);
plot(out.tout(1:1501), out.SOC_out);
title('Calculated SOC');
xlabel('Time');
ylabel('SOC');

subplot(2,2,4);
plot(out.tout, out.Y_k);
title('Calculated Y_k');
xlabel('Time');
ylabel('y');
```



D

```
% 0.25 SOC
T0a = 25;
Delta_t = 1;
Tspan = 1500;
Q = 5;
SOC_0 = 0.25;

mdl = "HW3_virtual_testbed_2";
set_param(mdl, 'SimulationCommand', 'update');
simIn = Simulink.SimulationInput(mdl);
simIn = setModelParameter(simIn, "StopTime", 'Tspan');
out_25 = sim(simIn);

%Preallocate big PHI_25
PHI_25 = zeros(1501, 3);
PHI_25(:, 1) = out_25.I_out;
PHI_25(2:end, 2) = out_25.I_out(1:end-1);
PHI_25(2:end, 3) = out_25.Y_k(1:end-1);

%solve least squares
Y_25 = out_25.Y_k;
Theta_25 = PHI_25 \ Y_25
```

```

b1_25 = Theta_25(1)
b0_25 = Theta_25(2)
a0_25 = Theta_25(3)

% 0.5 SOC
T0a = 25;
Delta_t = 1;
Tspan = 1500;
Q = 5;
SOC_0 = 0.5;

mdl = "HW3_virtual_testbed_2";
set_param(mdl, 'SimulationCommand', 'update');
simIn = Simulink.SimulationInput(mdl);
simIn = setModelParameter(simIn,"StopTime",'Tspan');
out_50 = sim(simIn);

%Preallocate big PHI_50
PHI_50 = zeros(1501, 3);
PHI_50(:, 1) = out_50.I_out;
PHI_50(2:end, 2) = out_50.I_out(1:end-1);
PHI_50(2:end, 3) = out_50.Y_k(1:end-1);

%solve least squares
Y_50 = out_50.Y_k;
Theta_50 = PHI_50\Y_50
b1_50 = Theta_50(1)
b0_50 = Theta_50(2)
a0_50 = Theta_50(3)

% 0.75 SOC
T0a = 25;
Delta_t = 1;
Tspan = 1500;
Q = 5;
SOC_0 = 0.75;

mdl = "HW3_virtual_testbed_2";
set_param(mdl, 'SimulationCommand', 'update');
simIn = Simulink.SimulationInput(mdl);
simIn = setModelParameter(simIn,"StopTime",'Tspan');
out_75 = sim(simIn);

%Preallocate big PHI_75
PHI_75 = zeros(1501, 3);
PHI_75(:, 1) = out_75.I_out;
PHI_75(2:end, 2) = out_75.I_out(1:end-1);
PHI_75(2:end, 3) = out_75.Y_k(1:end-1);

%solve least squares
Y_75 = out_75.Y_k;
Theta_75 = PHI_75\Y_75
b1_75 = Theta_75(1)
b0_75 = Theta_75(2)
a0_75 = Theta_75(3)

```

Theta_25 =

```

    0.0203
   -0.0201
    0.9979

```

b1_25 =

```

    0.0203

```

b0_25 =

```

   -0.0201

```

a0_25 =

```

    0.9979

```

Theta_50 =

0.0203
-0.0201
0.9979

b1_50 =

0.0203

b0_50 =

-0.0201

a0_50 =

0.9979

Theta_75 =

0.0203
-0.0201
0.9975

b1_75 =

0.0203

b0_75 =

-0.0201

a0_75 =

0.9975

E

```
%Expressions:
```

```
% Rs = b1
```

```
% C1 = deltat/(b0+b1a0)
```

```
% R1 = -deltat/c1(a0-1)
```

```
% 25% SOC
```

```
Rs_25 = b1_25
```

```
C1_25 = Delta_t/(b0_25+b1_25*a0_25)
```

```
R1_25 = -Delta_t/(C1_25*(a0_25-1))
```

```
% 50% SOC
```

```
Rs_50 = b1_50
```

```
C1_50 = Delta_t / (b0_50 + b1_50 * a0_50)
```

```
R1_50 = -Delta_t / (C1_50 * (a0_50 - 1))
```

```
% 75% SOC
```

```
Rs_75 = b1_75
```

```
C1_75 = Delta_t / (b0_75 + b1_75 * a0_75)
```

```
R1_75 = -Delta_t / (C1_75 * (a0_75 - 1))
```

Rs_25 =

0.0203

C1_25 =

5.2431e+03

R1_25 =

0.0928

Rs_50 =

0.0203

C1_50 =

5.8581e+03

R1_50 =

0.0800

Rs_75 =

0.0203

C1_75 =

5.5780e+03

R1_75 =

0.0728

P3

A

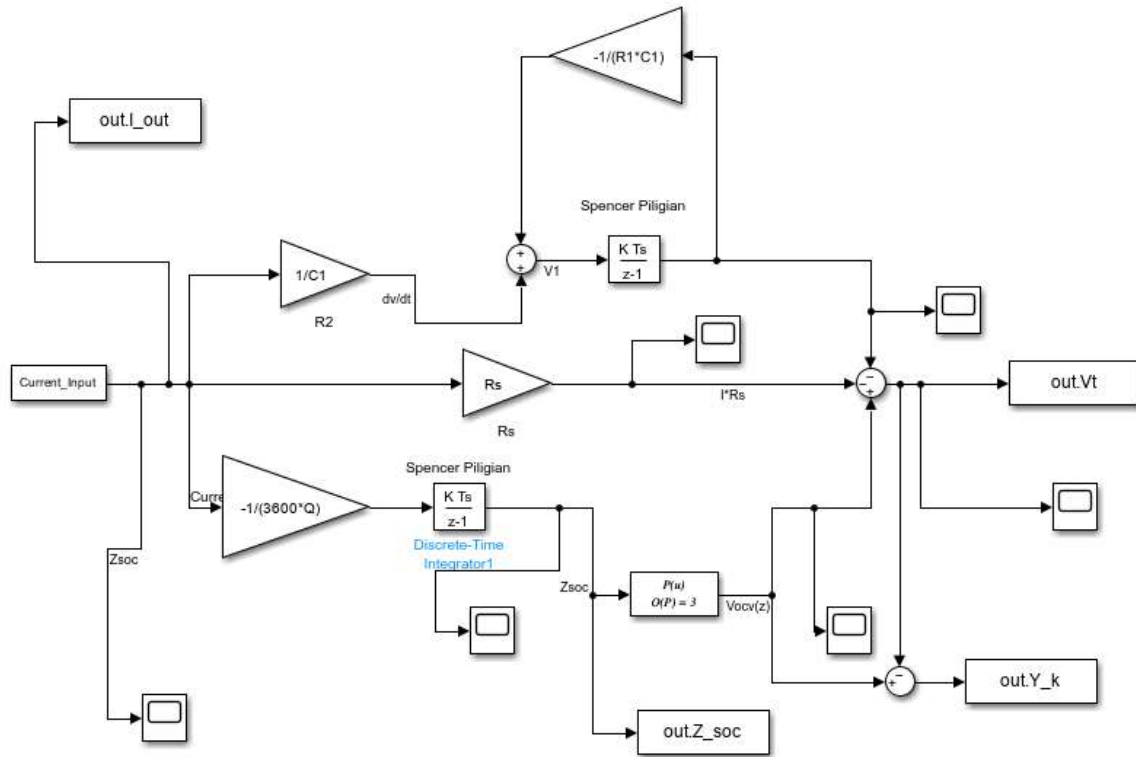
```
OCV_Poly = [3.2152,-5.2313,3.0532,3.1264];
Delta_t = 1;
Tspan = 1500;
Rs = 0.04;
R1 = 0.1;
C1 = 300;
Q = 5;
Soc_Init = 0.5;

mdl = "HW3_virtual_testbed_3";
set_param(mdl, 'SimulationCommand', 'update');
simIn = Simulink.SimulationInput(mdl);
simIn = setModelParameter(simIn,"StopTime", 'Tspan');
out = sim(simIn);

image_data = imread('HW3_3a.PNG');

figure;
imshow(image_data);
title('3A Simulink');
```

3A Simulink



B

```
%Preallocate big phi
PHI = zeros(1501, 3);
PHI(:, 1) = out.I_out;
PHI(2:end, 2) = out.I_out(1:end-1);
PHI(2:end, 3) = out.Y_k(1:end-1);

%solve least squares
Y = out.Y_k;
Theta = PHI\Y
b1 = Theta(1)
b0 = Theta(2)
a0 = Theta(3)

Rs = b1;
C1 = Delta_t / (b0 + b1 * a0);
R1 = -Delta_t / (C1 * (a0 - 1));

figure;

subplot(2,2,1);
plot(out.tout, out.I_out);
title('Input Current');
xlabel('Time');
ylabel('Current');

subplot(2,2,2);
plot(out.tout, out.Vt);
title('Terminal Voltage');
xlabel('Time');
ylabel('Voltage');

subplot(2,2,3);
plot(out.tout, out.Z_soc);
title('Calculated SOC');
```



```
xlabel('Time');
ylabel('SOC');

subplot(2,2,4);
plot(out.tout, out.Y_k);
title('Calculated Y_k');
xlabel('Time');
ylabel('y');
```

```
Theta =

    0.0400
   -0.0353
    0.9667
```

```
b1 =

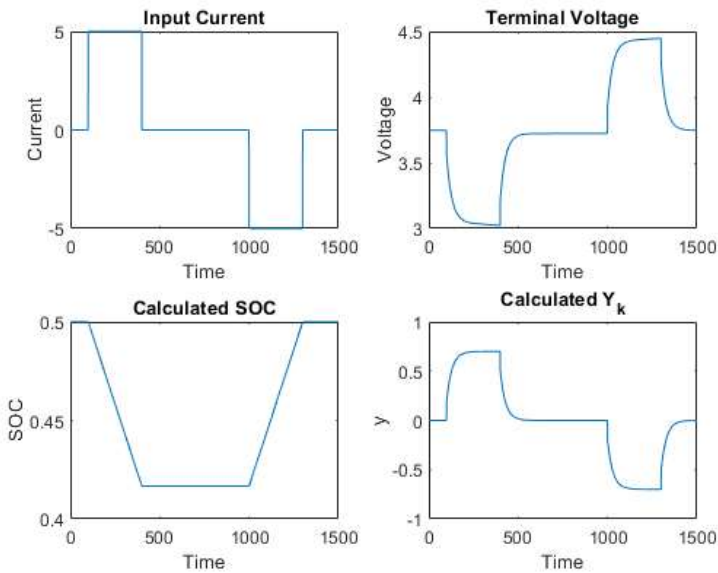
    0.0400
```

```
b0 =

   -0.0353
```

```
a0 =

    0.9667
```



C

make table

```
col = {'Actual', 'Estimated'};
titles = {'0.04', '0.01', '300'};
Nums = double([Rs,R1,C1]);
vals = Nums';
configTable = cell2table([titles, num2cell(vals)], 'VariableNames', col);
configTable(1) = categorical(configTable(1));
disp(configTable)
```

%Parameters calculated and estimated are the same.

Actual	Estimated
0.04	0.04

0.01	0.1
300	300