ABE 460

Lab Week 7: Process Identification and Empirical Modeling

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Monday

Problem 3.1

a) First order time function = $y(t) = y_{ss} + (y_0 - y_{ss})e^{-t/\tau}$

$Y_{ss} = 80$

$Y_0 = 256$

From MATLAB: τ = 17 seconds

Overall time function = $y(t) = 80 + (256 - 80)e^{-t/17s}$

First order transfer function = $\frac{1}{\tau s+1}$

Overall transfer function = $\frac{1}{17s+1}$

b) Output variable = temperature (degrees F)

c)

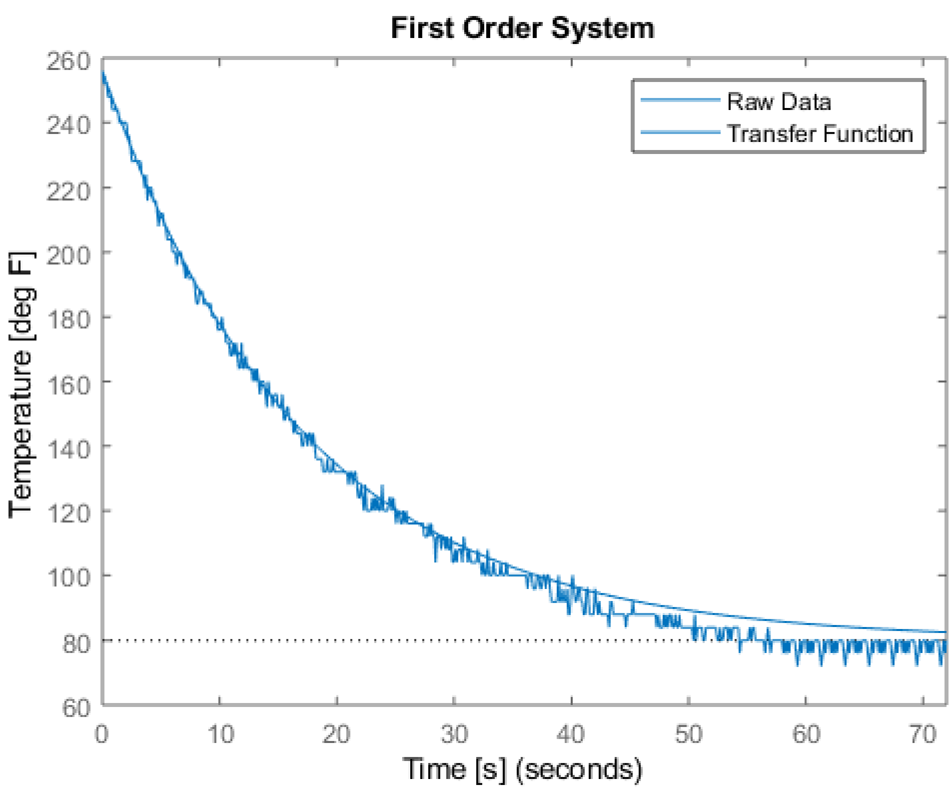
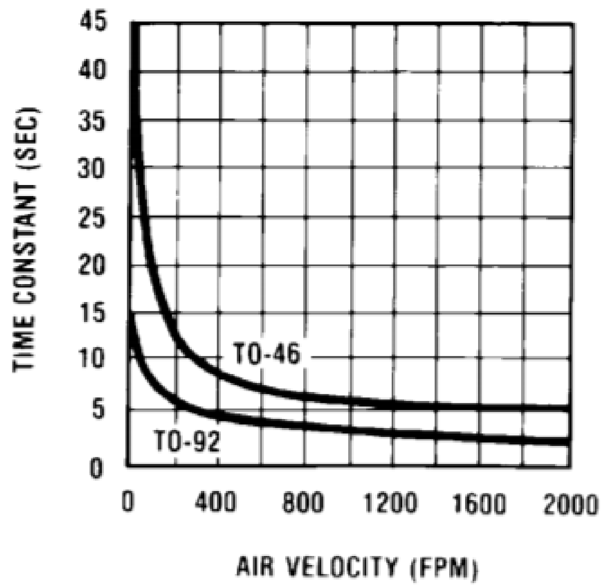


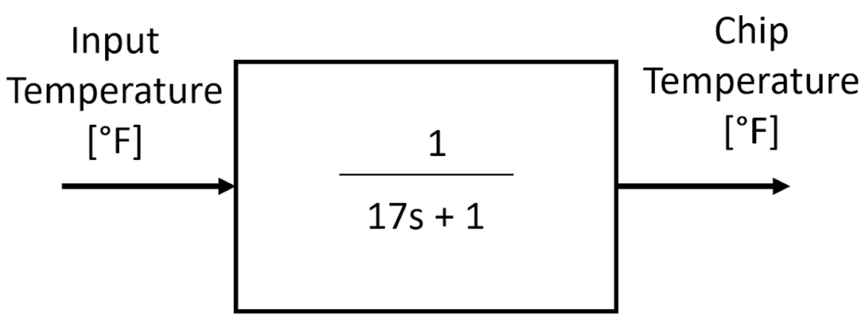
Figure 1: First Order System Raw Data and Transfer Function Plot



d)

Figure 3: Time constant comparison for T0-92 Model

According to Figure 3, the published time constant is about 15 seconds when the air velocity is 0 fpm. This is an 11% error.



e)

Figure 4: First Order Transfer Function Block Diagram

```
chip_temp = IC_chip;
chip_time = 0:0.12:72;
time_constant = 16.8;
output_exp = chip_temp ./ 10;

y_ss = 80;
yo = 256;

num = [1];
den = [time_constant 1];
sys = tf(num, den);
stepOpts = stepDataOptions('InputOffset', yo,'StepAmplitude',y_ss-yo);
step(sys, 72, stepOpts);

figure(1)
hold on
plot(chip_time, output_exp, '--')
axis([0 80 0 300])
xlabel('Time (sec)')
ylabel('Temp (F)')
legend('Experiment')
```

Figure 5: MATLAB Code for Problem 3.1

Problem 3.2

a) $V_{in} - V_R - V_L - V_C = 0$

$V_{in} - Ri - L\frac{di}{dt} - \frac{1}{C}\int i\,dt = 0$

$i = \frac{dq}{dt}$

$L\frac{d^2q}{dt^2} + R\frac{dq}{dt} + \frac{1}{C}q = V_{in}$

$V_C = \frac{1}{C}\int i\,dt = \frac{q}{C}$

$LC\frac{d^2V_C}{dt^2} + RC\frac{dV_C}{dt} + V_C = V_{in}$

b) Zeta = 0.55680

Peak time = 31.84

Natural frequency = 0.1188

$$c(t) \;=\; 1 - \frac{e^{-0.55680\cdot 0.1188t}}{\sqrt{1-0.55680^2}} \cdot sin(0.1188\sqrt{1-0.55680^2}\,t \;+\; tan^{-1}\frac{\sqrt{1-0.55680^2}}{0.55680})$$

$$c(t) \;=\; 1 - \frac{e^{-006615t}}{0.8306} \cdot sin(0.09868t \;+\; 0.9037)$$

$$TF \;=\; \frac{0.01411}{s^2+0.1323s+0.01411}$$

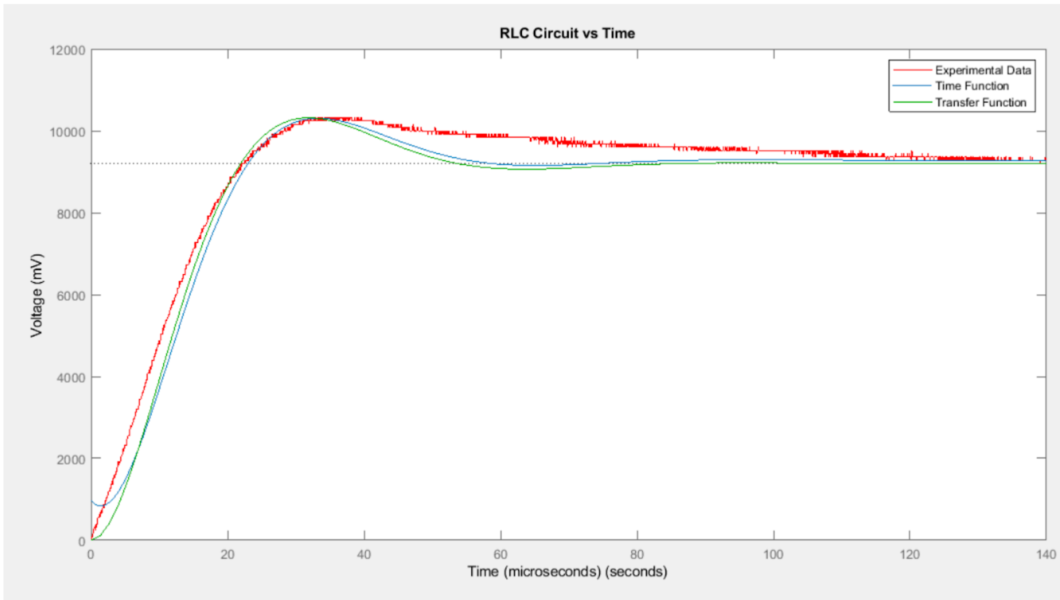
c) 

Figure 6: Second Order System Raw Data, Time Function, and Transfer Function Plots

d) C = 1μF

$1 = \frac{1}{LC}$

$1 = \frac{1}{L*1}$

L = 1μF^{-1}

$0.1323 = \frac{RC}{LC} = \frac{R}{L}$

R = 0.1323 μF

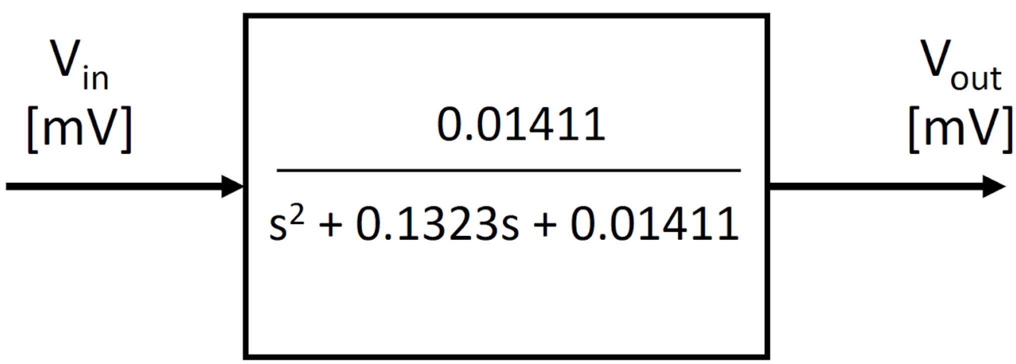
e) 

Figure 7: Second Order Transfer Function Block Diagram

```
circuit_time = 0:0.04:140; %Time matrix
output_volt = VC_output'; %Experimental data matrix of voltage values
peak_val = max(output_volt); %Peak value of Vc
zeta = 0.55680; %Damping ratio
peak_time = 31.84; %Time it takes to cross steady state value (9280) in us
natural_freq = 3.14159265 / peak_time / sqrt(1-zeta^2);
sq_nat_freq = natural_freq^2;
mid = 2*zeta*natural_freq;

top = [sq_nat_freq];
bottom = [1 mid sq_nat_freq];
system = tf(top, bottom);


figure(2)
plot(circuit_time,output_volt, 'r')
hold on
ezplot('9280*(1 - ((exp(-0.557*0.118804*x)/sqrt(1-0.557^2)) * sin(0.118804*sqrt(1-0.557^2)*x + atan(sqrt((1-0.557^2)/0.557)))))'
stepOpts = stepDataOptions('InputOffset',0,'StepAmplitude',9200);
step(system, 140, stepOpts, 'g');
ylabel('Voltage (mV)')
xlabel('Time (microseconds)')
title('RLC Circuit vs Time')
legend('Experimental Data', 'Time Function', 'Transfer Function')
```

Figure 8: MATLAB Code for Problem 3.2