Course on Modelling and System Identification (MSI): Exercise 9: Simulation of a Heating System with Periodic Excitation

TASK 1

Write the system dynamics in the state-space form

```
clc;clear;close;
syms C1 C2 R12 R1a R2a
A = [-1/C1*(1/R12+1/R1a) 1/(R12*C1);...
    1/(R12*C2) -1/C2*(1/R12+1/R2a)];
B = [1/C1 0;...
      0 1/C2];
C = [0 1];
D = [0 0];
```

TASK 2

Construct the matrices A, B, C and D in Matlab using the following values for the constants

```
R1a = 5e-3;R2a = 10e-3;R12 = 10e-3;
C1 = 1e6;C2 = 7e5;

A = [-1/C1*(1/R12+1/R1a) 1/(R12*C1);...
    1/(R12*C2) -1/C2*(1/R12+1/R2a)];
B = [1/C1 0;...
      0 1/C2];
C = [0 1];
D = [0 0];
% Defining the system
sys = ss (A,B,C,D);
```

TASK 3

Generate an input signal to simulate an experiment. Set the sampling time **t_s = 60[s]** . The experiment should be last 6 days (therefore there should be 8640 samples). It consists of a periodic signal that is applied to the system three times (n_periods = 3). **qh(t)** should be periodic with a period N=2880 samples (which corresponds to 2 days). The signal should be the superposition of two sinusoidal curves with periods of 2880 samples and of 288 samples (the tenth harmonic). Scale the signal such that its value is contained in the interval [0; 6000]. Generate a plot of your input signal qh(t) for the full time horizon.

```
Ts = 60;
sysd = c2d(sys,Ts);
samples_period = 2880;
total_duration = 6*24*60*60;
period_duration = Ts*samples_period;
number_periods = total_duration/period_duration;
number_samples = total_duration/Ts;
t = linspace(0, total_duration-Ts,number_samples);
t_sinus = t*2*pi/period_duration;
input = sin(t_sinus);
input_h = sin(t_sinus*10);
qh = input + input_h;
amplitude_u = 6000;
qh = (amplitude_u/max(qh))*qh;
qd = wgn(number_samples,1,25);
figure(1);
subplot(2,1,1);plot(t,qh);grid on;      % Plot input qh
title('Input signal qh');xlabel('Time [s]');ylabel('Input qh [W]');
subplot(2,1,2);plot(t,qd,'b');grid on; % Plot input qd
title('Noise signal qd');xlabel('Time [s]');ylabel('Noise qd [W]');
```
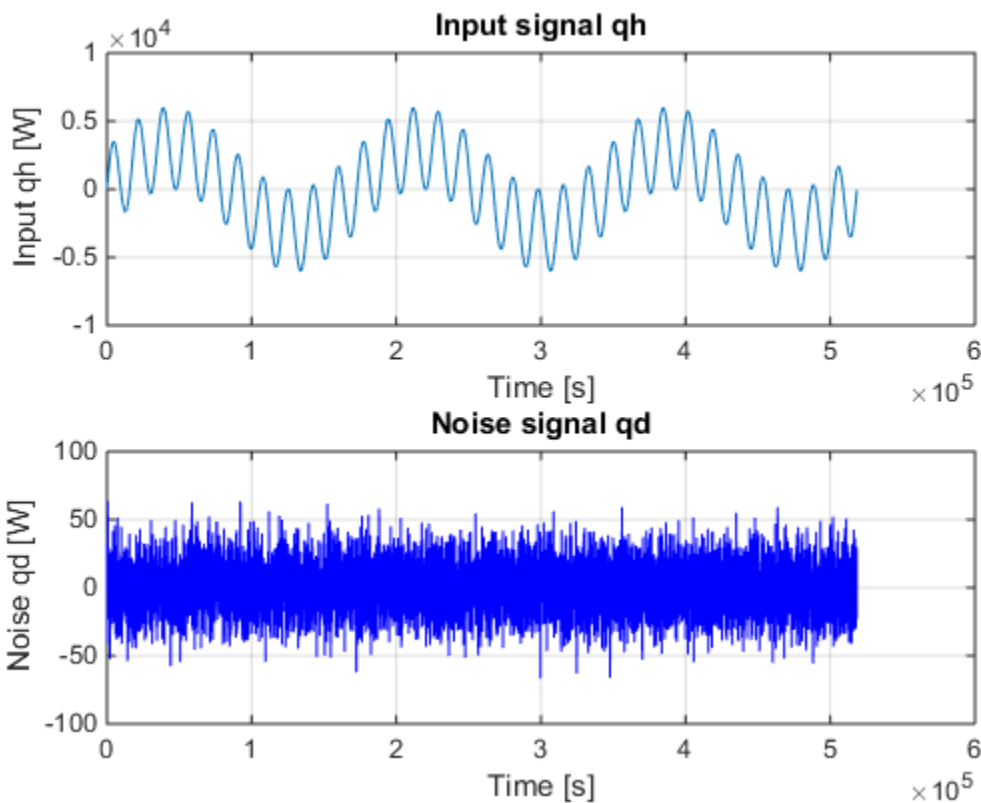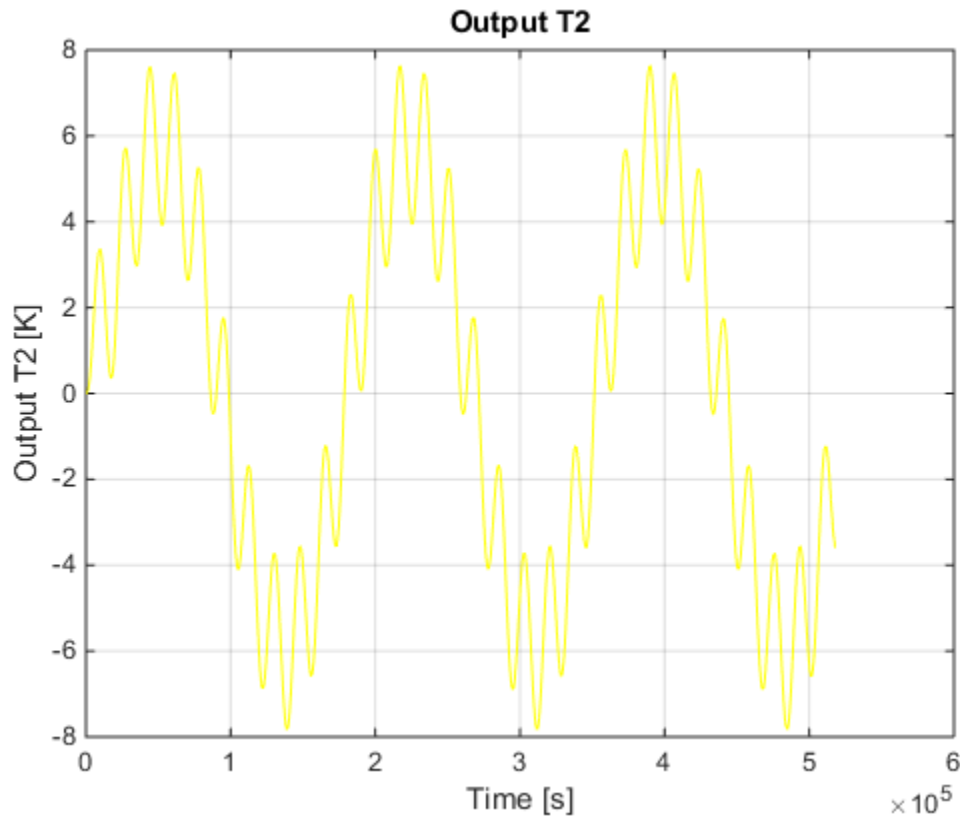

TASK 4

Simulate the system using the command **lsim** and plot the resulting output

```
y = lsim(sysd,[qh' qd],t);
figure(2);plot(t,y,'y');grid on;title('Output T2');
xlabel('Time [s]');ylabel('Output T2 [K]');
```
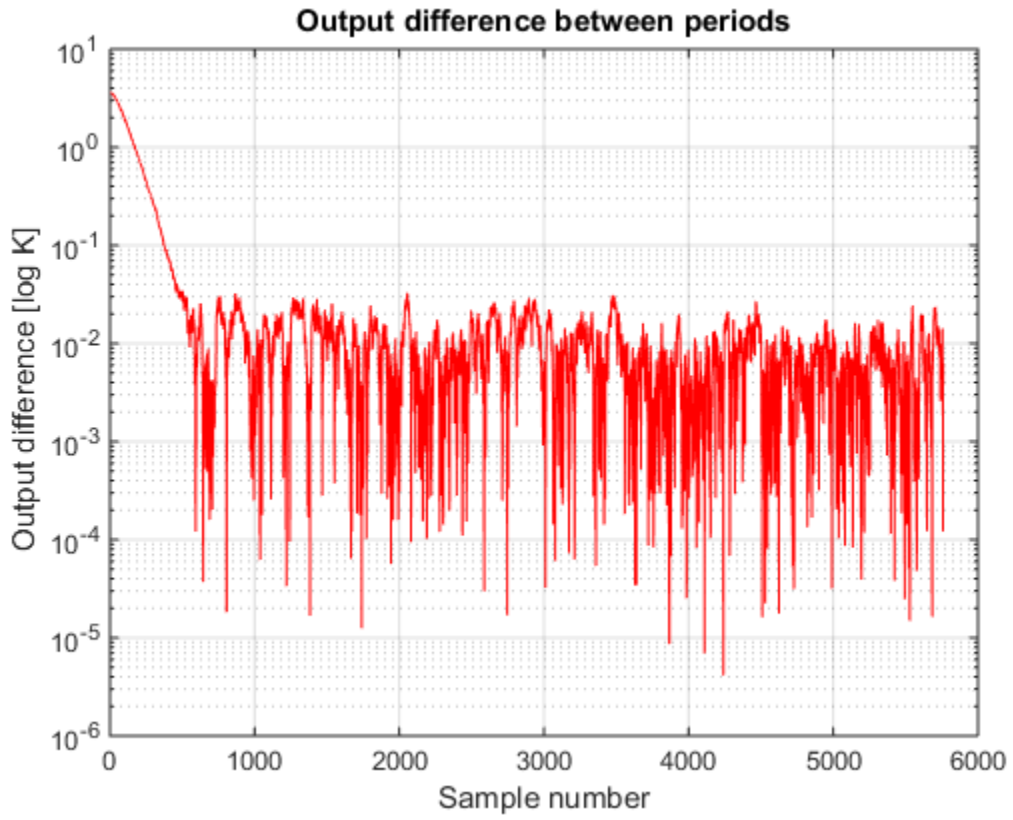

TASK 5

Verify that in the last two days of the experiment the effects of the transient response are negligible. To do this you can consider the following signal **y_diff = abs(y(1:(n_periods-1)*N)-y(N+1:end))** where y is the output signal resulting from the simulation and *n_periods=3* is the number of repetitions of the input signal. If there was no disturbance, after the transient effects have disappeared, the output signal should be periodic of period *N*. Plot **y_diff** in logarithmic scale and verify that after **N** samples the transients have died out

```
y_diff = abs(y(1:(number_periods-1)*samples_period)-...
    y(samples_period+1:end));
figure(4);
sample_number = linspace(0,(number_periods-1)*samples_period,...
    (number_periods-1)*samples_period);
semilogy(sample_number,y_diff,'r');
title('Output difference between periods');
xlabel('Sample number');ylabel('Output difference [log K]');grid on;
```

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