

HW #4

Due: February 17th, 2017

CBE470: Process Dynamics and Control - Spring 2017

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<http://zavalab.engr.wisc.edu/teaching/cbe470spring2017>

Problem 1: Thanks, Jean-Baptiste

Consider the time signal $y(t)$ and the Fourier diagram provided in Figure 1. Using this information derive the analytical form of the time-domain signals that combine to create $y(t)$. Provide a plot of each one of these signals.

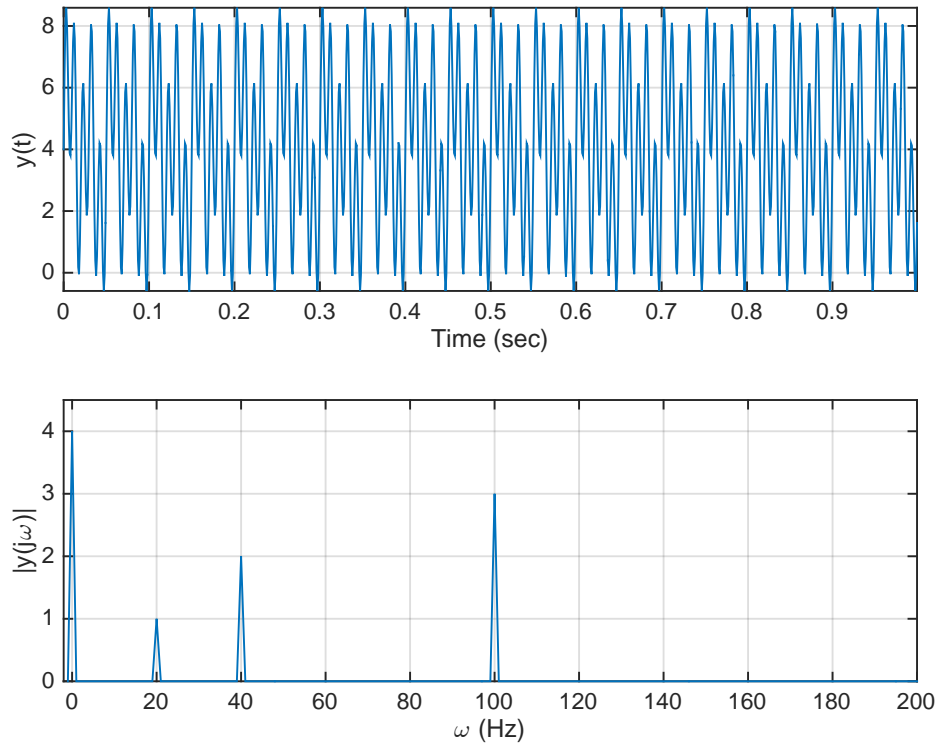


Figure 1: Time signal (top) and Fourier diagram (bottom).

Problem 2: Am I sleepy? Part II

In HW#2 you found that the dynamics of CO_2 in a classroom are described by:

$$\frac{dC(t)}{dt} = \frac{Q}{V}(C_{in} - C(t)) + \frac{G}{V}n_{oc}(t) \quad (1)$$

and

$$y(s) = \frac{K}{\tau s + 1}u(s) \quad (2)$$

where $y(s)$ is the CO_2 concentration in [ppm] (using a reference steady-state value of 400 ppm) and $u(s)$ is the number of occupants (using a reference steady-state value of 0). Due to concerns of high CO_2 concentrations expressed by the students, the control engineer in charge of the building has been asked to verify the actual airflow rate that the duct is delivering to the classroom. To do so, she has installed a CO_2 sensor in the classroom and has monitored attendance to different lectures during a day. The data collected are provided in file `data_eh2255.dat` where the first column is time (in minutes), the second is occupancy $n_{oc}(t)$, and the third is CO_2 level $C(t)$. The data is plotted in Figure 2.

Address the following:

1. Use the data recorded to estimate K, τ using the system identification toolbox of Matlab (example provided in class). Report values.
2. If the engineer knows that the volume of the classroom is $V = 10,000$ cf, what is Q in cfm?
3. Can we use the data to also estimate the generation rate per occupant G in ppm-cf/min? If so, explain how and provide an estimate.
4. Make a plot of ω (rad/min) vs. $|u(j\omega)|$ and ω (rad/min) vs. $|y(j\omega)|$. In what frequency range do you see the most activity?
5. Construct an experimental Bode plot using the data (ω (rad/min) v.s. AR) and compare this with the Bode plot of the system model (2) that uses the estimated values of K, τ .

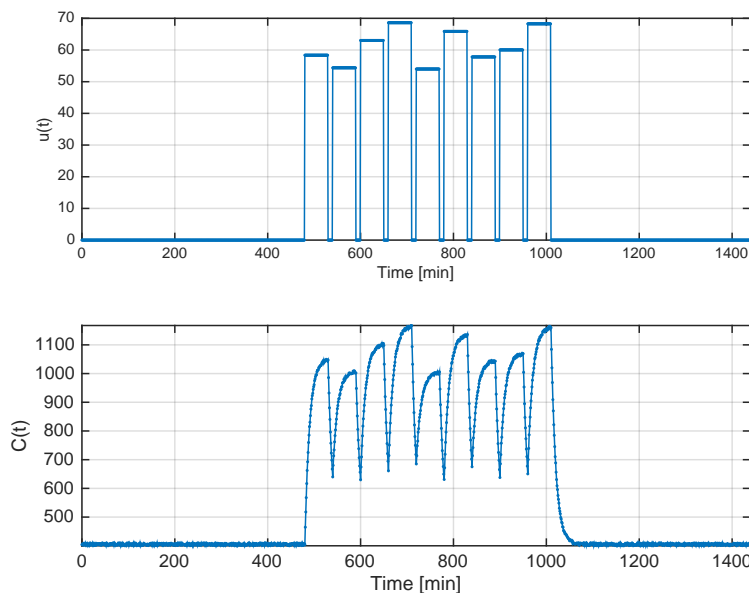


Figure 2: Recorded data for occupancy (top) and CO_2 concentration (bottom).