ME456 LAB 03: FILTER DESIGN AND INTRODUCTION TO ARDUINO

Name: *put your name here*
A-num: *put your A-number.*
Collaborator: *(only Section 2 and 3 can have collaborator)*

Section 1. Filter Design

Exercise 1: Continuous Low-pass filter

Now let us play with a new signal with three frequency components, $y = 5\ sin\ (2\pi \times 100t)\ + sin\ (2\pi \times 2000t)\ + 0.5 sin\ (2\pi \times 8000t)$.

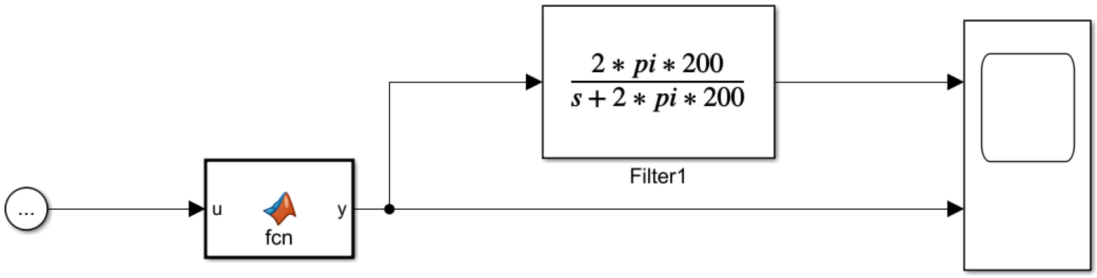
Modify the '*MATLAB Function*' block according to the new signal expression and design a continuous-time low-pass filter to **only** keep the lowest frequency portion (100 Hz) of signal.

What is the cutoff frequency that you will choose to design a low-pass filter?

Show the simulation results based on the filter design. Attach the Simulink model diagram, MATLAB Function code, and simulation results from the scope. (make sure the low-pass filter transfer function is visible).

If each of the requested answers is missing or wrong, then deduct 0.5 point.

A: Here is one example if the cutoff frequency is chosen as 200Hz.
The cut-off frequency should be chosen larger than 100 Hz and smaller than 2000 Hz, but cannot equal to 100, or 2000 Hz.



MATLAB Function1

```
function y = fcn(u)
y = 5*sin(2*pi*100*u)+sin(2*pi*2000*u)+0.5*sin(2*pi*8000*u);

end
```

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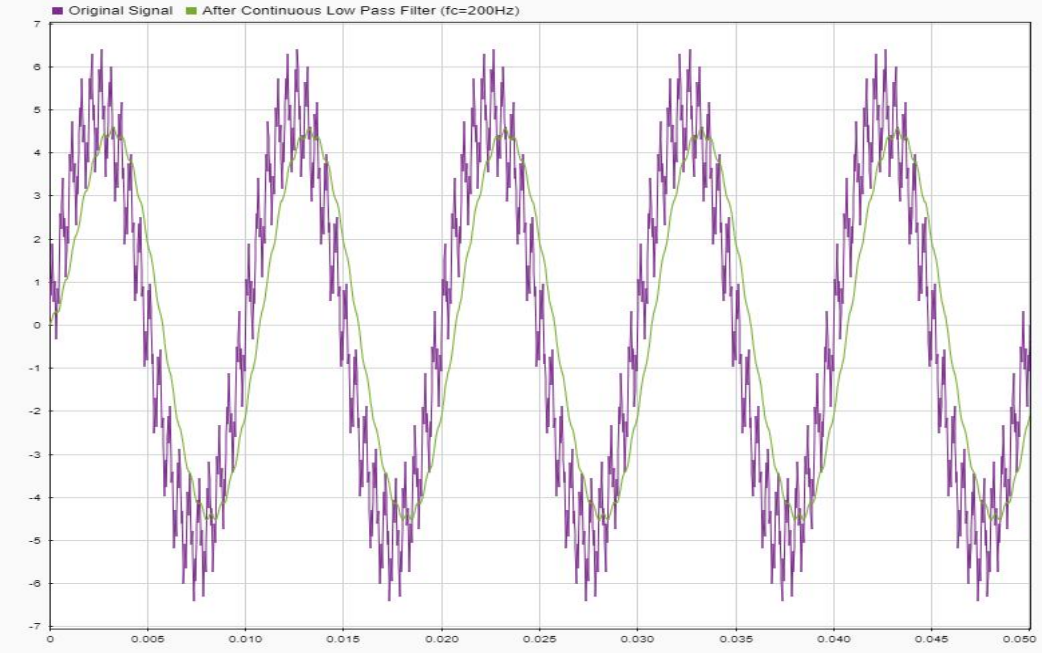

Exercise 2: Continuous High-pass filter

Now we still use three frequency components, $y = 5\ sin\ sin\ (2\pi \times 100t)\ + sin\ sin\ (2\pi \times 2000t)\ + 0.5 sin\ (2\pi \times 8000t)$.

Design a continuous-time high-pass filter to **only** keep the highest frequency portion (8000 Hz) of signal.

What is the cutoff frequency that you will choose to design a high-pass filter?

Show the simulation results based on the filter design. Attach the Simulink model diagram, and simulation results from the scope. (make sure the high-pass filter transfer function is visible).

If each of the requested answers is missing or wrong, then deduct 0.5 point.

A: Here is one example if the cutoff frequency is 7000Hz.
The cut-off frequency should be chosen larger than 2000 Hz and smaller than 8000 Hz, but cannot equal to 2000, or 8000 Hz.

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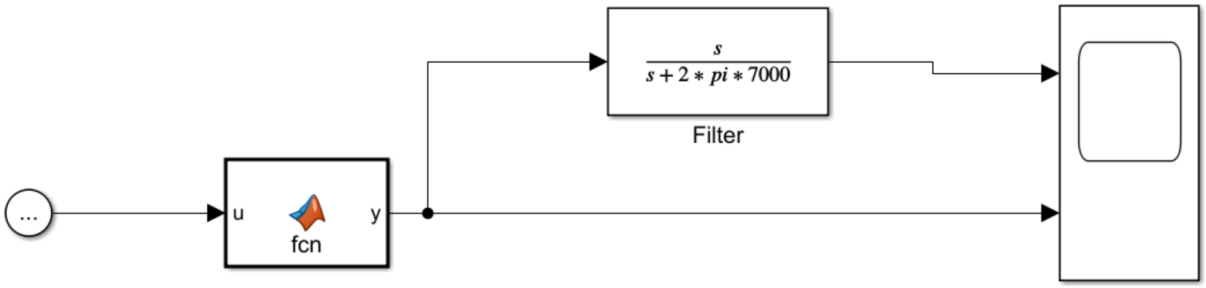

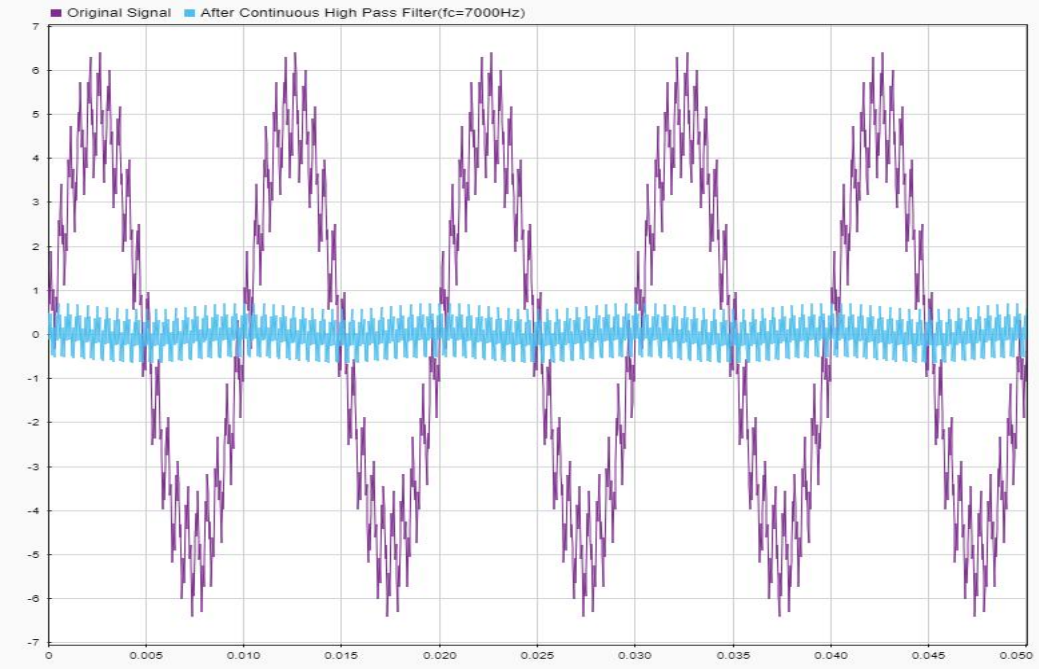

Exercise 3: Continuous Band-pass filter

We keep on using three frequency components, $y = 5\ sin\ sin\ (2\pi \times 100t)\ + sin\ sin\ (2\pi \times 2000t)\ + 0.5sin\ (2\pi \times 8000t)$.

Design a continuous-time band-pass filter based on lecture slide (combine low- and high-pass filter) to get the middle frequency portion (2000 Hz) of the signal.

What are the cutoff frequencies that you will choose for low-pass filter and high-pass filters? Attach the Simulink diagram and simulation results from the scope.

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If each of the requested answers is missing or wrong, then deduct 0.5 point.

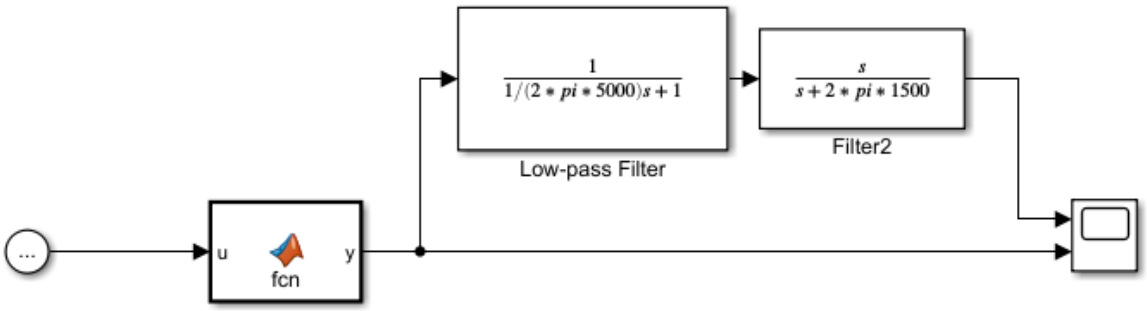
A: Here is one example if the bandwidth for low-pass is 5000 and cut-off frequency for high-pass filter is 1500 Hz.

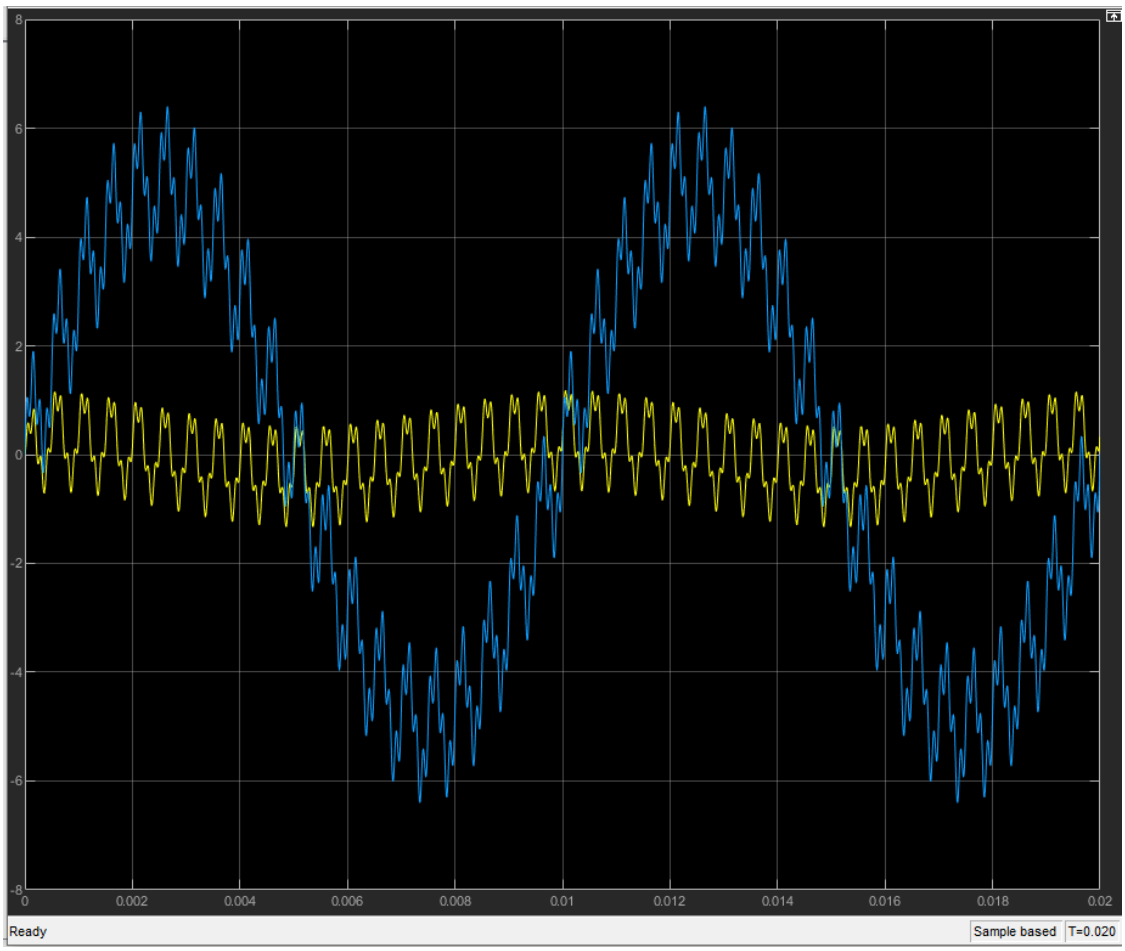
high

The cut-off frequency of ~~low~~-pass should be chosen between the domain (100, 2000) and

low **~~high~~-pass is (2000, 8000), but cannot equal to 100, 2000 or 8000 Hz.**

(Low-pass and high-pass filter can commute their locations, i.e. it doesn't matter whichever comes first)





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Exercise 4: Digital Low-pass filter

The signal is $y = 5\ sin\ sin\ (2\pi \times 100t)\ + sin\ sin\ (2\pi \times 2000t)\ + 0.5 sin\ (2\pi \times 8000t)$.

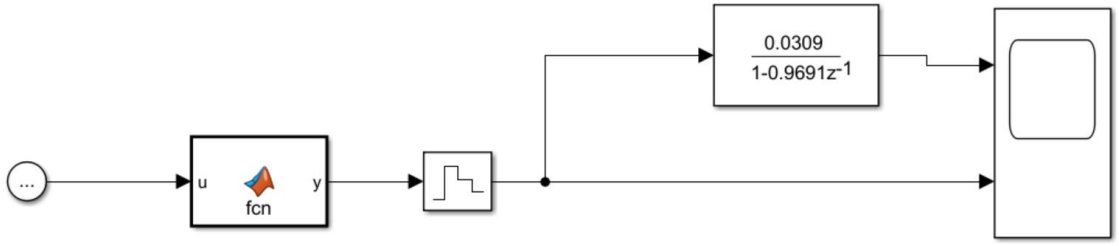
Design a discrete-time low-pass filter to get the lowest frequency portion of the signal.

Let us choose the cut-off frequency as 500 Hz, change sampling time of zero-order holder block to $T = 1.0 \times 10^{-5}$ second, what is the value of filter parameter α? Show your calculation equations and results.

Set stop time to 0.02 and show the simulation results based on the filter design. Attach the Simulink model diagram, MATLAB Function code, and simulation results from the scope. (make sure the low-pass filter transfer function is visible).

If each of the requested answers is missing or wrong, then deduct 0.5 point.

A: $\alpha = e^{-\omega_c T} = exp(-2 * pi * 500 * 1 * 10\text{^} - 5) = \mathbf{0.9691}$



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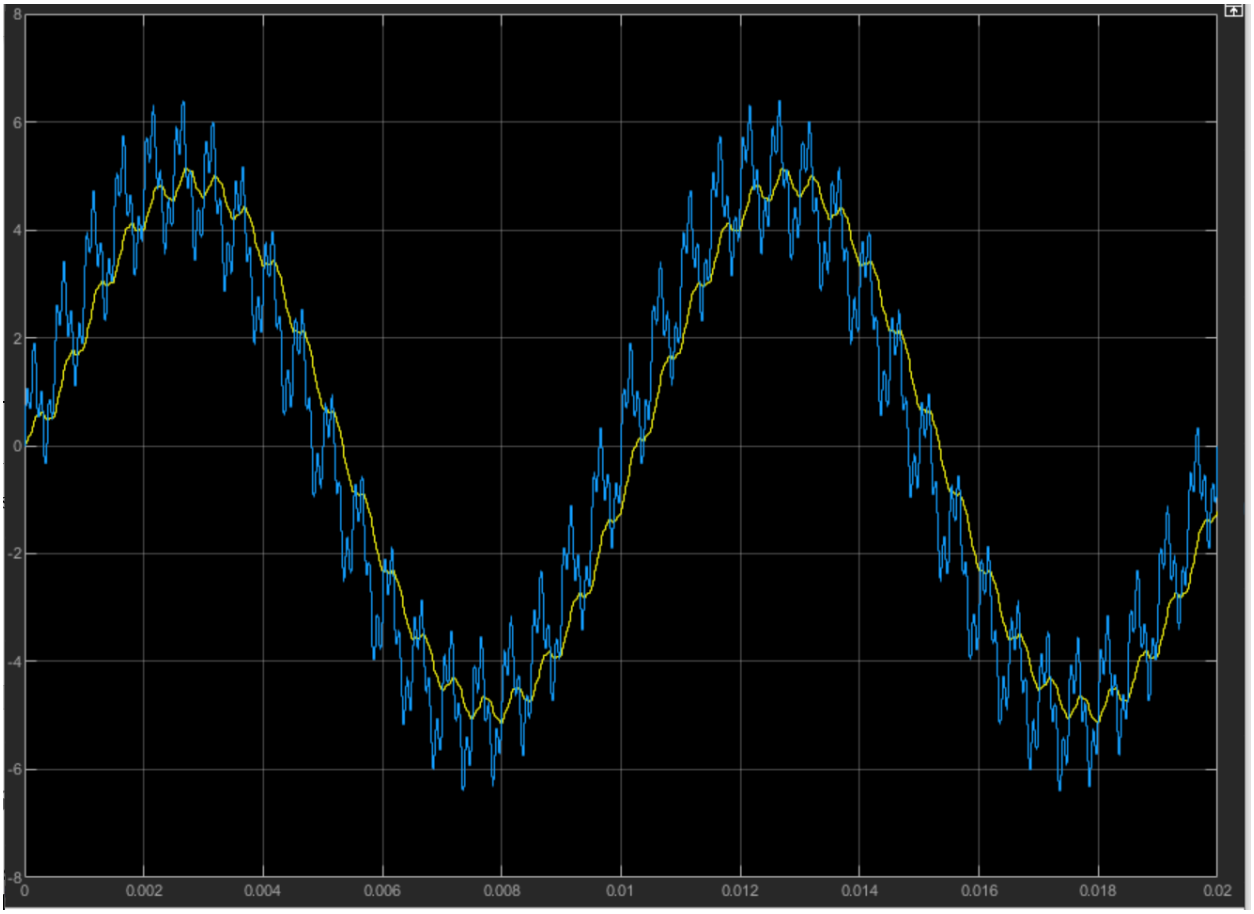

Exercise 5: Digital High-pass filter

The signal is $y = 5\ sin\ sin\ (2\pi \times 100t)\ + sin\ sin\ (2\pi \times 2000t)\ + 0.5 sin\ (2\pi \times 8000t)$.

Design a discrete-time high-pass filter to get the highest frequency portion of the signal.

Let us choose the cut-off frequency as 5000 Hz, keep sampling time of zero-order holder block to $T = 1.0 \times 10^{-5}$ second, what is the value of filter parameter α? Show your calculation equations and results.

Set stop time to 0.02 and show the simulation results based on the filter design. Attach the Simulink model diagram, MATLAB Function code, and simulation results from the scope. (make sure the high-pass filter transfer function is visible).

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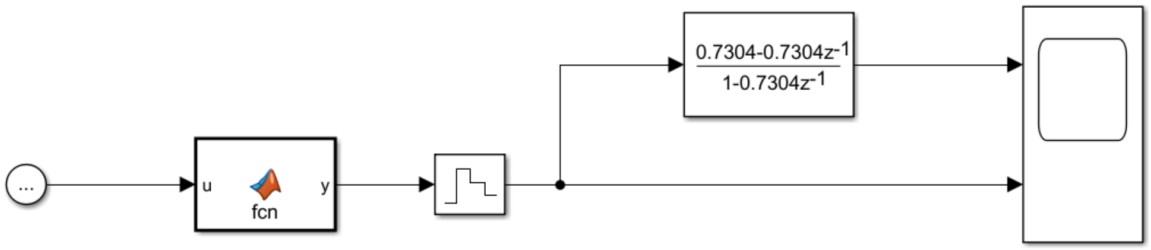
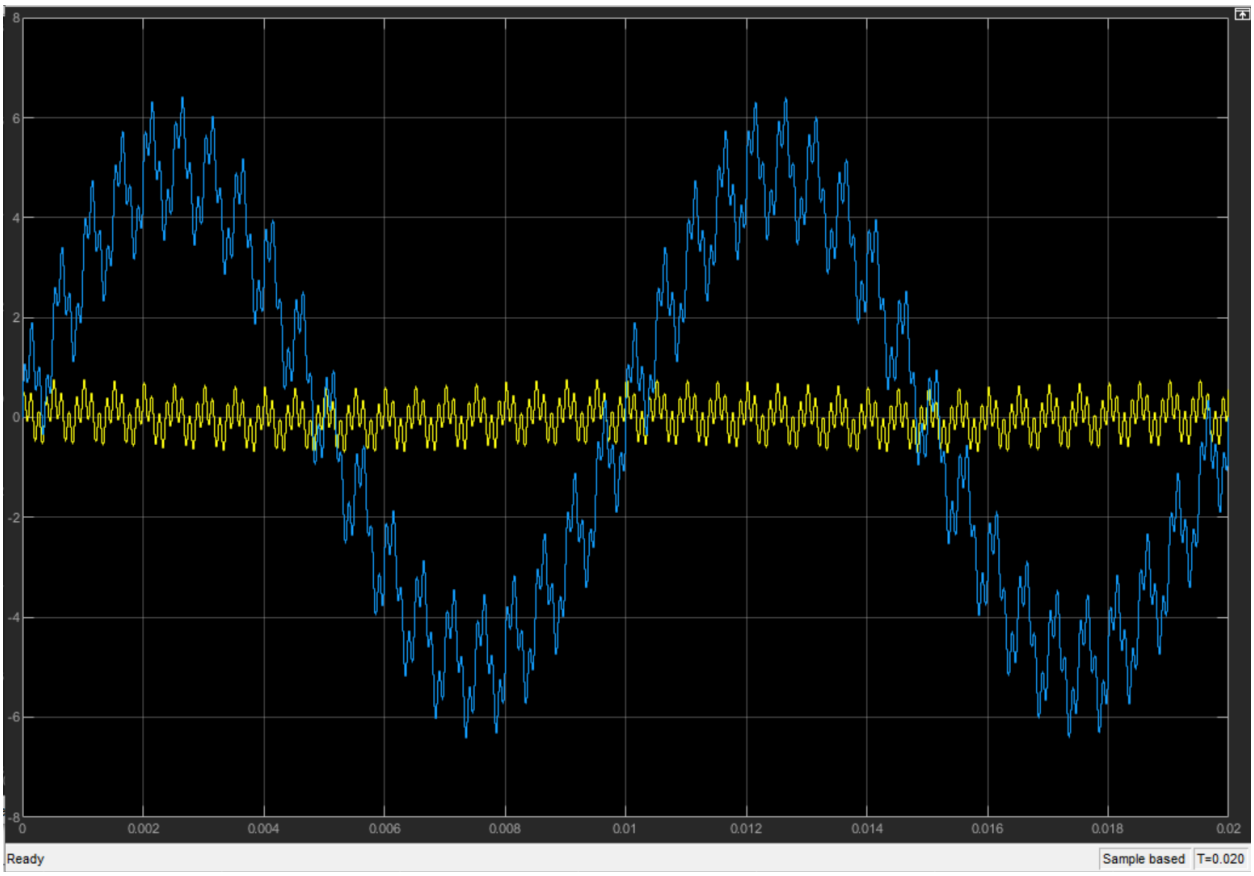
If each of the requested answers is missing or wrong, then deduct 0.5 point.

A: $\alpha = e^{-\omega_c T} = exp(-2 * pi * 5000 * 1 * 10\text{^} - 5) = \mathbf{0.7304}$





Exercise 6:

After the hardware setup process is done, we need to check the status of Arduino.

Keep Arduino plugged in, and type 'arduino' in MATLAB command window. Then you will get something like this. **Attach the display on your own computer.**

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```
>> arduino

ans =

  arduino with properties:

                Port: 'COM7'
               Board: 'Uno'
       AvailablePins: {'D2-D13', 'A0-A5'}
  AvailableDigitalPins: {'D2-D13', 'A0-A5'}
      AvailablePWMPins: {'D3', 'D5-D6', 'D9-D11'}
   AvailableAnalogPins: {'A0-A5'}
    AvailableI2CBusIDs: [0]
             Libraries: {'I2C', 'RotaryEncoder', 'SPI', 'Servo'}
```

Exercise 7: Arduino illuminating LED on Uno

Attach a photo of your own Arduino board with LED illuminated.

Assume everyone should have got this photo.