Signal and Systems MATLAB HW3

April 20, 2024

Contents

1 Part I

(a)

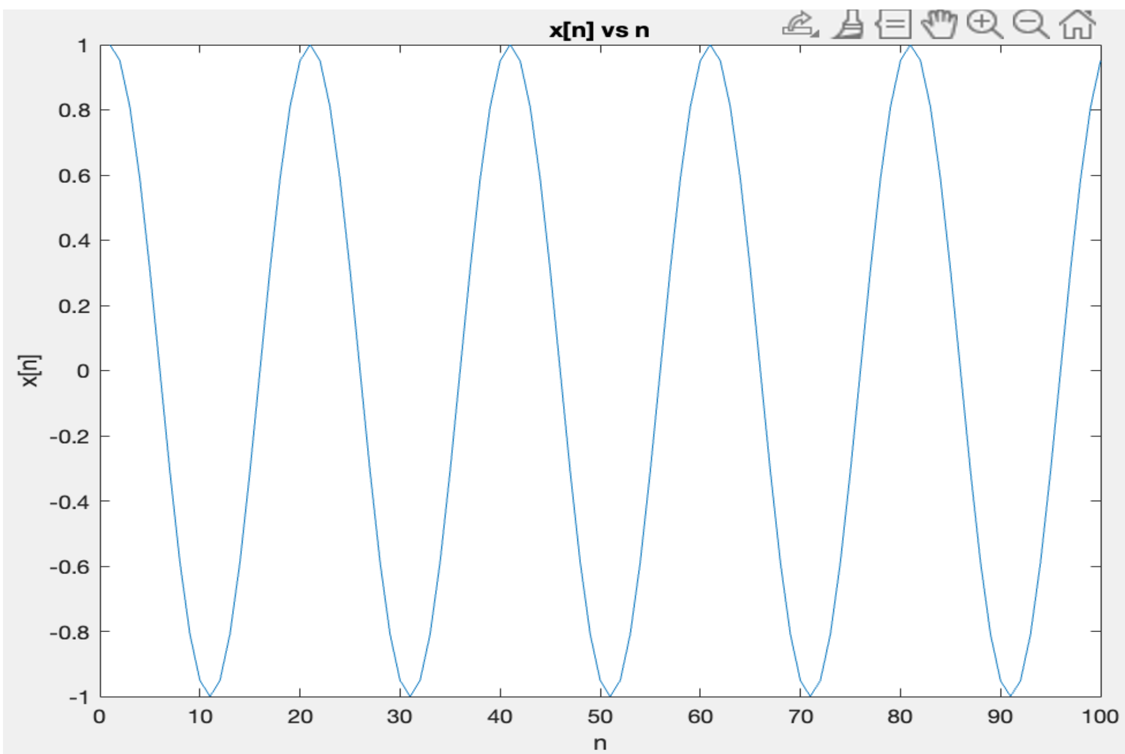
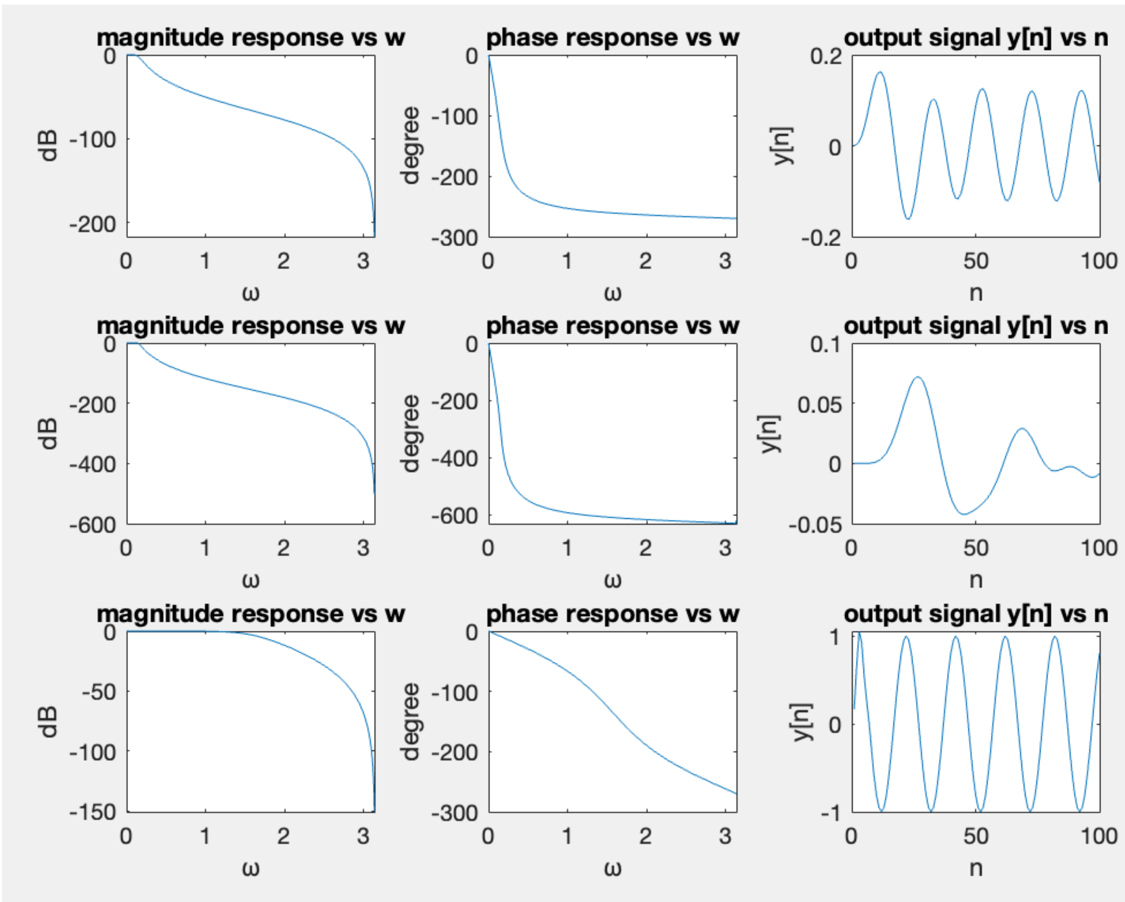


figure of (b)(c)(d)



$H(e^{j\omega})$ of (b):

$$H(e^{j\omega}) = 10^{-4}\frac{4.17 + 12.5e^{-j\omega} + 12.5e^{-2j\omega} + 4.17e^{-3j\omega}}{1 - 2.69e^{-j\omega} + 2.42e^{-2j\omega} - 0.73e^{-3j\omega}}$$

$H(e^{j\omega})$ of (c):

$$H(e^{j\omega}) = 10^{-8}\frac{1.3 + 9.2e^{-j\omega} + 27.6e^{-2j\omega} + 46e^{-3j\omega} + 46e^{-4j\omega} + 27.6e^{-5j\omega} + 9.2e^{-6j\omega} + 1.3e^{-7j\omega}}{1 - 6.3e^{-j\omega} + 17e^{-2j\omega} - 25.6e^{-3j\omega} + 23.1e^{-4j\omega} - 12.6e^{-5j\omega} + 3.8e^{-6j\omega} - 0.5e^{-7j\omega}}$$

$H(e^{j\omega})$ of (d):

$$H(e^{j\omega}) = 10^{-1}\frac{1.67 + 5e^{-j\omega} + 5e^{-2j\omega} + 1.67e^{-3j\omega}}{1 - 5*10^{-16}e^{-j\omega} + 0.33e^{-2j\omega} - 1.85*10^{-17}e^{-3j\omega}}$$

(e)

(1) What is the effect of increasing L?

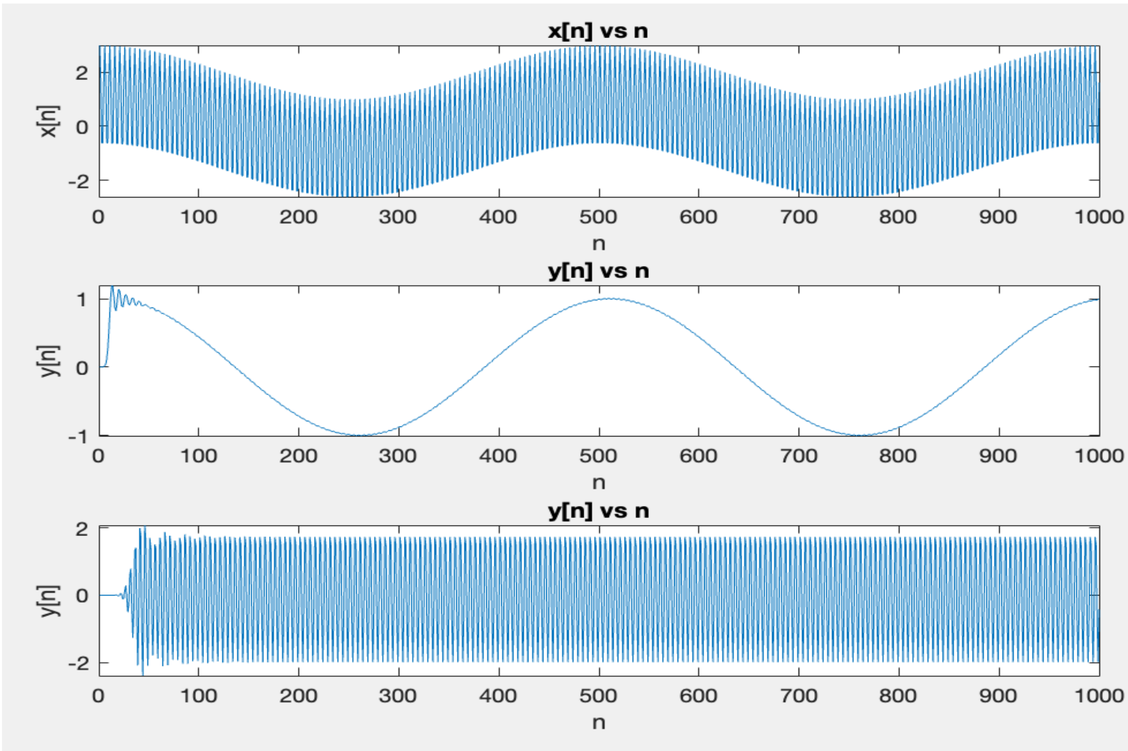
Compare (b) and (c), the magnitude response of (c) drops more rapidly, and the phase response of (c) also changes more rapidly. In the third plot, it can be observed that the high-frequency components of the signal in (c) are attenuated.

(2) What about increasing f_c ?

Compare (b) and (d), from the first plot of (d), it can be observed that this filter preserves more frequency components because it increases the cutoff frequency. Therefore, in the third plot of (d), it can be observed that it closely resembles the input signal. The phase response also changes more smoothly compared to (b).

2 Part II

figure of (a)(b)(c)



(b)

(1) cutoff frequency = 0.3

Because we want to filter out ω above $2*\pi*f_1*Ts = 2*\pi*100*0.002 = 0.4\pi$, I choose 0.3 as the cutoff frequency of lowpass filter.

(2) $H(e^{j\omega})$

$$H(e^{j\omega}) = \frac{\sum_{k=0}^{16} b_k e^{-kj\omega}}{\sum_{k=0}^{16} a_k e^{-kj\omega}}$$

$b_0 = 0.000000131050451, b_1 = 0.000002096807220, b_2 = 0.000015726054148, b_3 = 0.000073388252690, b_4 = 0.000238511821243, b_5 = 0.000572428370984, b_6 = 0.001049452013471, b_7 = 0.001499217162101, b_8 = 0.001686619307363, b_9 = 0.001499217162101, b_{10} = 0.001049452013471, b_{11} = 0.000572428370984, b_{12} = 0.000238511821243, b_{13} = 0.000073388252690, b_{14} = 0.000015726054148, b_{15} = 0.000002096807220, b_{16} = 0.000000131050451$
$a_0 = 1.000000000000000, a_1 = -6.392244679605255, a_2 = 20.666858508317389, a_3 = -43.960283476181679, a_4 = 68.135642921693176, a_5 = -81.018344456010652, a_6 = 76.062835393227289, a_7 = -57.289739393309084, a_8 = 34.877514890668365, a_9 = -17.176352387942671, a_{10} = 6.805824376883978, a_{11} = -2.143070995492463, a_{12} = 0.524938973313177, a_{13} = -0.096565666192365, a_{14} = 0.012566808123298, a_{15} = -0.001032619608023, a_{16} = 0.000040324487492$

(c)

(1) cutoff frequency = [0.3, 0.5]

Because we want to preserve ω equal to $2*\pi*f_1*Ts = 2*\pi*100*0.002 = 0.4\pi$,
I choose [0.3, 0.5] as the cutoff frequency of bandpass filter.

(2) $H(e^{j\omega})$

$$H(e^{j\omega}) = \frac{\displaystyle\sum_{k=0}^{32} b_k e^{-kj\omega}}{\displaystyle\sum_{k=0}^{32} a_k e^{-kj\omega}}$$

$b_0 - b_3 = 10^{-5}(0.000058242025971, 0, -0.000931872415536, 0)$
$b_4 - b_7 = 10^{-5}(0.006989043116523, 0, -0.032615534543772, 0)$
$b_8 - b_{11} = 10^{-5}(0.106000487267259, 0, -0.254401169441422, 0)$
$b_{12} - b_{15} = 10^{-5}(0.466402143975941, 0, -0.666288777108488, 0)$
$b_{16} - b_{19} = 10^{-5}(0.749574874247048, 0, -0.666288777108488, 0)$
$b_{20} - b_{23} = 10^{-5}(0.466402143975941, 0, -0.254401169441422, 0)$
$b_{24} - b_{27} = 10^{-5}(0.106000487267259, 0, -0.032615534543772, 0)$
$b_{28} - b_{32} = 10^{-5}(0.006989043116523, 0, -0.000931872415536, 0, 0.000058242025971)$

$a_0 - a_3 = 10^{-4}(0.000100000000000, -0.000831541914969, 0.004209587155332, -0.015461109745311)$
$a_4 - a_7 = 10^{-4}(0.045584912114387, -0.112628394882144, 0.240660520296479, -0.453014828162661)$
$a_8 - a_{11} = 10^{-4}(0.762233110209198, -1.157565947602996, 1.599237534363229, -2.021107033475771)$
$a_{12} - a_{15} = 10^{-4}(2.347131764816701, -2.512524870898874, 2.485302903083284, -2.275023792512123)$
$a_{16} - a_{19} = 10^{-4}(1.929121663165509, -1.515548737892352, 1.102795687092367, -0.742425107760182)$
$a_{20} - a_{23} = 10^{-4}(0.461690866614429, -0.264525154294745, 0.139188201844919, -0.066948988652430)$
$a_{24} - a_{27} = 10^{-4}(0.029272511236739, -0.011541874655208, 0.004064223161911, -0.001259516412901)$

$a_{28}-a_{31} = 10^{-4}(0.000337307706961, -0.000075632183443, 0.000013615910965, -0.000001777603351)$
$a_{32} = 10^{-4} * 0.000000142442542$