Elec 303

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#HW4 Report

Question 1.

Or_B	8
Or_C1	5
Or_C2	5
Or_E	4

Figure 1.

Butterworth Filter

$$|H(j\Omega)|^2 = \frac{1}{1+\left(\frac{s}{j\Omega}\right)^{2N}}$$

Chebyshev Filters

Type 1:

$$|H(j\Omega)|^2 = \frac{1}{1+\mathcal{E}^2T^2(\frac{\Omega 0}{\Omega})}$$

Type 2:

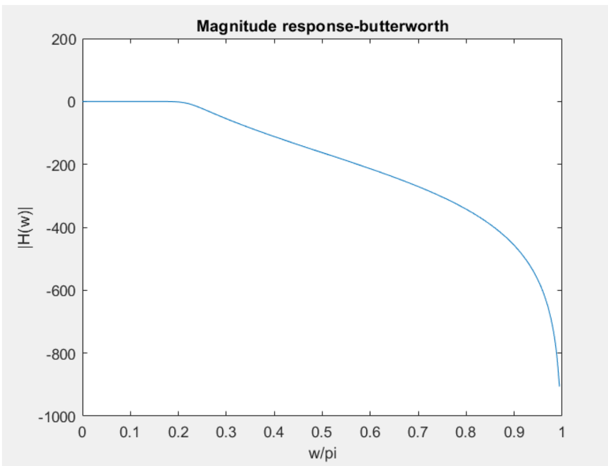
$$|H(j\Omega)|^2 = \frac{1}{1+\frac{1}{\mathcal{E}^2T^2(\frac{\Omega 0}{\Omega})}}$$

Elliptic:

$$|H(j\Omega)|^2 = \frac{1}{1+\mathcal{E}^2U^2(\frac{\Omega}{\Omega 0})}$$

Figure 1 shows the order of the butterworth(8), chebyshev-1(5), chebysev-2(5) and elliptic filters(4). As we can see, elliptic filter has the lowest order. The lowest order of the filter means the maximum number of delay elements used in the filter circuit. Therefore, if we calculate the transfer function of each filter, we will see that elliptic filter has lowest order of s namely 4(s^4) and butterworth has the highest order of s namely 8(s^8).

Question 2



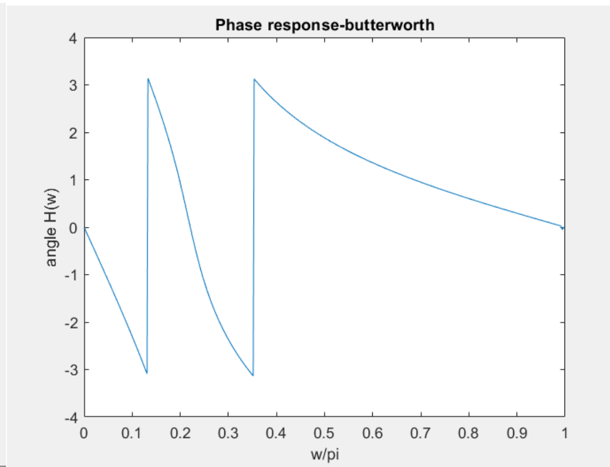


Figure 2.

Figure 3.

The magnitude and phase responses of butterworth shown in the figure 2 and 3. If we look at the figure 2 we can easily see that the passband and stopband conditions are met. To find H(s), we can use the coefficient of transform function found in matlab.

H(s)= *4.689e-05 s^8 + 0.0003751 s^7 + 0.001313 s^6 + 0.002626 s^5 + 0.003282 s^4 + 0.002626 s^3 + 0.001313 s^2 + 0.0003751 s + 4.689e-05*

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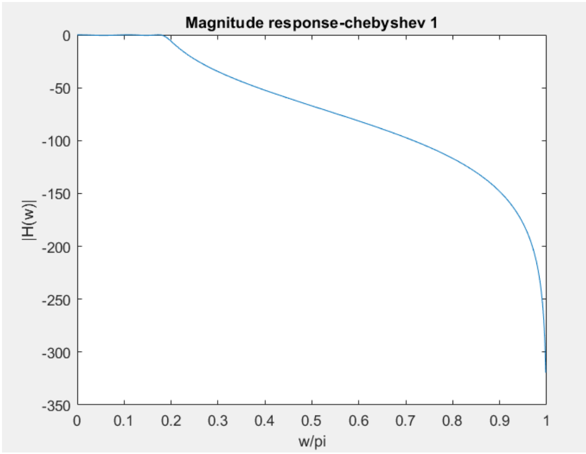
s^8 - 4.452 s^7 + 9.168 s^6 - 11.24 s^5 + 8.894 s^4 - 4.631 s^3 + 1.543 s^2 - 0.2998 s + 0.02596

We found H(s) as above, after that we can transform H(s) to H(z) with one of the transform function.



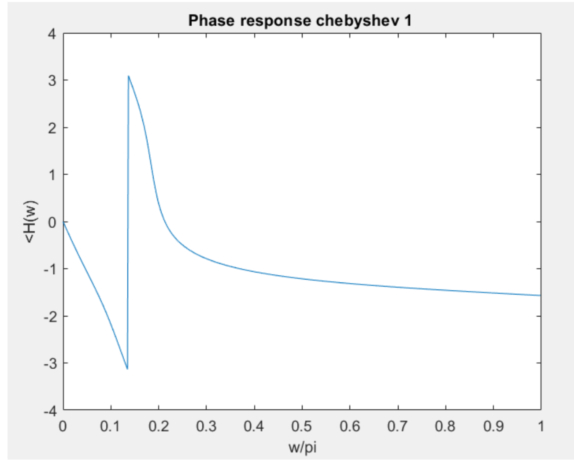


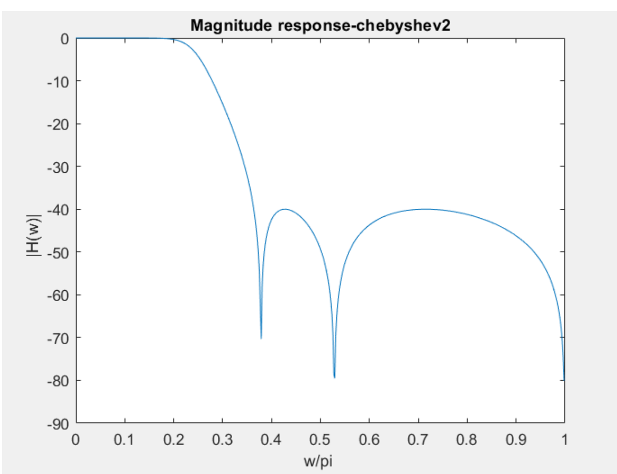
Figure 4.

Figure 5.

For chebyshev filter, we used cheby1 and cheby1ord functions and we found magnitude and transfer function as figure 4 and 5. We can see that they satisfies the given requirements. We can write the analytical formula as follows,

$$H(z)= \frac{0.0002519 z^5 + 0.001259 z^4 + 0.002519 z^3 + 0.002519 z^2 + 0.001259 z+ 0.0002519}{z^5 - 3.965 z^4 + 6.645 z^3 - 5.838 s^2 + 2.678 z - 0.5126}$$

As, we can see from H(z), the order of the filter is satisfied the result of the question 1.



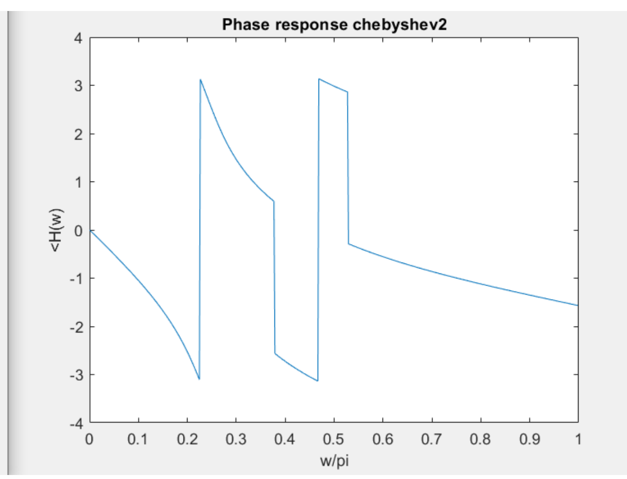


Figure 6.

Figure 7.

In figure 6 and 7, we see the magnitude and phase response of the chebshey type 2 filter. They are more laggy compared to other types of filter, however, they also satisfied conditions that we set into first question. If we write the analytical formula,

H(z)=

0.02652 z^5 + 0.01145 z^4 + 0.03445 z^3 + 0.03445 z^2 + 0.01145 z + 0.02652

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z^5 - 2.39 z^4 + 2.692 z^3 - 1.6 z^2 + 0.5089 z - 0.06587

This is fifth order filter as we indicated first question.

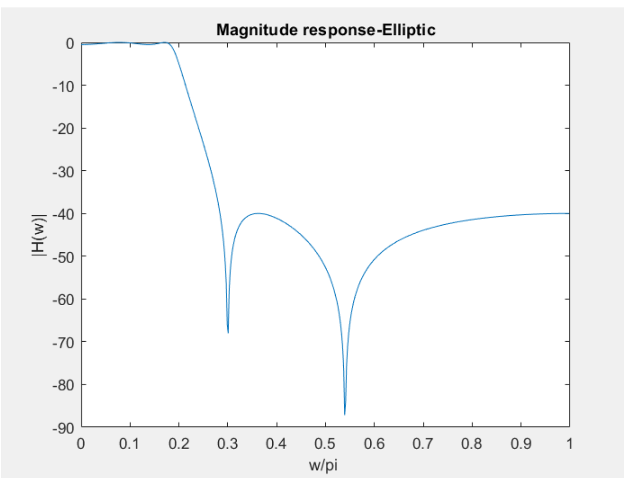

Figure 8.

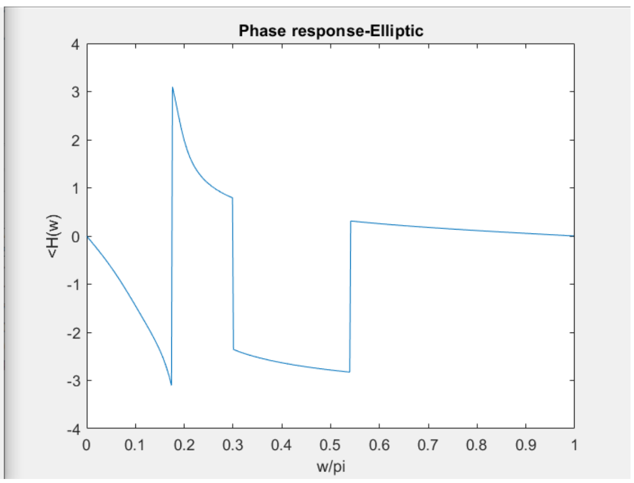

Figure 9.

Lastly, figure 8 and figure 9 show the magnitude and phase response of the elliptic filter. If e look at passband and stopband corners, they also satisfy the requirements that we set in the first question and the transfer function of the elliptic filter as follows,

H(z)=

0.01883 z^4 - 0.01744 z^3 + 0.03213 z^2 - 0.01744 z+ 0.01883

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z^4 - 3.025 z^3 + 3.741 z^2 - 2.191 z + 0.5111

It is the lowest order filter among all as we suggest in the first question.