Signals and Systems MATLAB HW4
Deadline: 2019/06/24 before 23:59

The objective of this homework is to learn the relating MATLAB commands of z-transform. You will learn how to use the following MATLAB commands:

- **residuez**
- **zplane**
- **roots**
- **zp2sos**

You may use the commands **freqz** and **filter** learned from last homework to finish the problem set below.

1. Background

The z-transform of a signal $x[n]$ can be expressed by

$$X(z) = \frac{b_1 + b_2 z^{-1} + ... + a_N z^{-N+1}}{a_1 + a_2 z^{-1} + ... + a_M z^{-M+1}} \quad (1)$$

Where $\{a_k\}_{k=1}^{M}$ and $\{b_k\}_{k=1}^{N}$ are the coefficients of denominator and nominator, respectively.

- To obtain the inverse z-transform of (1), we may apply the command **residuez**. This command computes partial-fraction expansions for z-transform expressed as a ratio of two polynomials in z^{-1}. Let the vector **r** denotes the partial-fraction expansion coefficients corresponding to the poles in **p** and the vector **k** contains the direct terms, the syntax is

[r, p, k] = residuez(b, a)

where

$$\mathbf{a} = [a_1, a_2 ..., a_M]$$

and

$$\mathbf{b} = [b_1, b_2 ..., b_N]$$

With these computed vectors (i.e., **r**, **p** and **k**), we may obtain $x[n]$ by observing the coefficients of the partial-fraction expansion.

- To find the poles and zeros of $x[n]$, we may use the command **roots**. For a polynomial with finite orders which is written as

$$C(z) = c_1 + c_2 z^{-1} + ... + c_K z^{-K+1}$$

We give the command **roots**([$c_1, c_2, .., c_k$]) to find its roots. Furthermore, the poles and zeros in (1) can be displayed by giving the command **zplane(b, a)**.

- An useful method for implementing a discrete-time LTI system is to divide the system into two LTI systems. This method aims at reducing the probability of overflow of registers memorizing the coefficients. Now we redefine (1) as

$$X(z)=\frac{(1-d_1z^{-1})(1-d_2z^{-1})\ldots(1-d_Lz^{-1})}{(1-m_1z^{-1})(1-m_2z^{-1})\ldots(1-m_Pz^{-1})}$$

and define

$$\mathbf{z} = [d_1, d_2, \ldots, d_L]$$
$$\mathrm{p} = [m_1, m_2, \ldots, m_P]$$
$$\mathrm{k} = 1$$

By giving the command **sos = zp2sos(z, p, k)**, we may obtain two divided system respectively with transfer function $X_1(z)$ and $X_2(z)$ such that $X(z)=X_1(z)X_2(z)$.

2. Lab Procedure and Questions

A causal discrete-time LTI systems has the transfer function

$$H(z)=\frac{0.0976(z-1)^2(z+1)^2}{(z-0.3575-0.5889i)(z-0.3575+0.5889i)(z-0.7686-0.3338i)(z-0.7686+0.3338i)}. \tag{2}$$

Please program a MATLAB script (save as **myztran.m** file) to answer the following problems.

(a) (15%) Use the MATLAB function **stem** to plot $h[n]$ v.s. n, where $h[n]$ is the inverse z-transform of $H(z)$. And, please state the ROC in your report.

(b) (20%) Use the MATLAB function **zplane** to plot the locations of poles and zeros of $H(z)$.

(c) (15%) Use the MATLAB function **plot** to plot the magnitude and phase response of $H(z)$, v.s. ω for $z=e^{j\omega}$.

(d) (15%) Write down a representation of $H(z)$ as a cascade of two second-order sections with real coefficients in your report, just like $H(z)=H_1(z)H_2(z)$.

(e) (20%) Use the MATLAB function **plot** to plot the magnitude response of each section in (d), $H_1(z)$ & $H_2(z)$, v.s. ω for $z=e^{j\omega}$. Furthermore, directly plot the multiplication result of the magnitude response $|H_1(z)|$ and $|H_2(z)|$. Compare your result with (c) in your report.

(f) (15%) Use the MATLAB function **stem** to plot the impulse response $y[n]$ v.s. n of the system $H(z)$ for an input $x[n]=\delta[n]$, and compare it with the result of (a).

Note: It is better that total 8 figures in (a)(b)(c)(e)(f) can become 8 sub-figures, which are integrated into a big figure while executing your **myztran.m** file.

3. CEIBA Submission

- Please upload a compressed file (.zip, .rar or .tar), which includes your **m-file** (save as **myztran.m** file) and a **word file** (save as report.doc file). Please show the relevant plots mentioned above in the word file (report.doc) and answer the questions.
- The compressed file name should be ID_MATLAB4.
  (ex: B07901xxx_MATLAB4)