Andre Winkel October 9, 2025

Lab 1

EE141, Digital Signal Processing, Fall 2025

Problem 1: Converting functions into zero-pole-gain form

In this problem, we are given a series of functions in transfer function form to convert into zero-pole-gain form. We can do so by using the `matlab` function `roots(coefficients)` to find the zeros and poles of the functions.

a) Given the transfer function

$$H(z) = \frac{2 + 16z^{-1} + 34z^{-2} + 20z^{-3}}{1 - 10z^{-1} + 35z^{-2} - 50z^{-3} + 24z^{-4}}$$

we can find the zeros and poles by finding the roots of the numerator and denominator, respectively. Finding them in MATLAB and plugging them into our standard zero-pole-gain form, we get

$$H(z) = 2\frac{z(z+1)(z+2)(z+5)}{(z-1)(z-2)(z-3)(z-4)}.$$

b) Given the transfer function

$$H(z) = \frac{10 - 21z^{-1} + 14z^{-2} - 3z^{-3}}{3 - 3z^{-1} - 6z^{-2}}$$

we do the same process as above to find the zeros and poles. Finding them in MATLAB gives us

$$H(z) = \frac{10}{3}\frac{(z-0.5)(z-0.6)(z-1)}{z(z+1)(z-2)}.$$

c) And again, given the transfer function

$$H(z) = \frac{1 - z^{-4}}{1 - z^{-8}}$$

we find our poles, zeros, and gain which reduce to

$$H(z) = \frac{z^4}{(z + \frac{\sqrt{2}}{2} - \frac{\sqrt{2}}{2}j)(z + \frac{\sqrt{2}}{2} + \frac{\sqrt{2}}{2}j)(z - \frac{\sqrt{2}}{2} - \frac{\sqrt{2}}{2}j)(z - \frac{\sqrt{2}}{2} + \frac{\sqrt{2}}{2}j)}.$$

Problem 2: Converting functions into transfer function form

In this problem, we are given a series of functions in pole-zero-gain form to convert into transfer function form. We can do so by using the `matlab` function `poly(roots)` to find the polynomial that correlates to the provided roots.

a) Given the pole-zero-gain function

$$H(z) = 8\frac{(z-5)(z+3)(z-1)}{(z-6)(z+11)(z+2)}$$

we can find the polynomials corresponding to the poles and zeros in MATLAB. We can plug the polynomials and gain into our standard transfer function form, wherein we observe our transfer function as

$$H(z) = 8\frac{z^3 - 3z^2 - 13z + 15}{z^3 - 7z^2 - 56z + 132}.$$

In standard form, this is equivalent to

$$H(z) = \frac{8 - 24z^{-1} - 104z^{-2} + 120z^{-3}}{1 + 7z^{-1} - 56z^{-2} - 132z^{-3}}.$$

b) Given the pole-zero-gain function

$$H(z) = 2\frac{(z-2)(z-2-j)(z-2+j)}{(z-3)(z+2)(z+j)(z-j)}$$

we follow the same steps as before to find the transfer function

$$H(z) = \frac{2 - 12z^{-1} + 26z^{-2} - 20z^{-3}}{1 - z^{-1} - 5z^{-2} - 1z^{-3} - 6z^{-4}}.$$

c) Given the pole-zero-gain function

$$H(z) = -3\frac{(z+1)(z-1)(z+j)(z-j)}{z(z-2)}$$

we follow the same steps as before to find the transfer function

$$H(z) = \frac{-3z^2 + 3z^{-2}}{1 - 2z^{-1}}.$$

Problem 3: Finding partial fraction expansions

In this problem, we are given a series of functions to convert into partial fraction form. We can do so by using the `matlab` function `[r,p,k]=residue(b,a)` to find the partial fraction expansion of the given functions.

a) Given the function

$$H(z) = 2\frac{(z+1)(z-1)}{z(z-4)}$$

we can call the MATLAB function to find that our corresponding values allow us to directly plug in values to observe the standard partial fraction expansion form as

$$H(z) = \frac{7.5}{z-4} + \frac{0.5}{z} + 2.$$

b) Doing the same for the function

$$H(z) = \frac{z^3 + 1}{z^2 + 1}$$

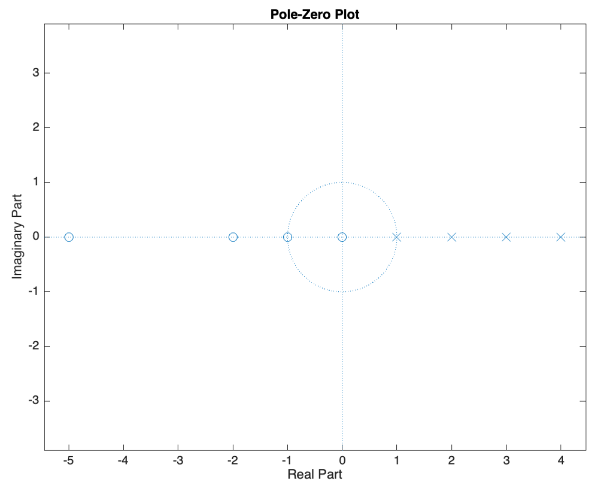
we observe

$$H(z) = \frac{-0.5 - 0.5j}{z - j} + \frac{-0.5 + 0.5j}{z + j} + z.$$

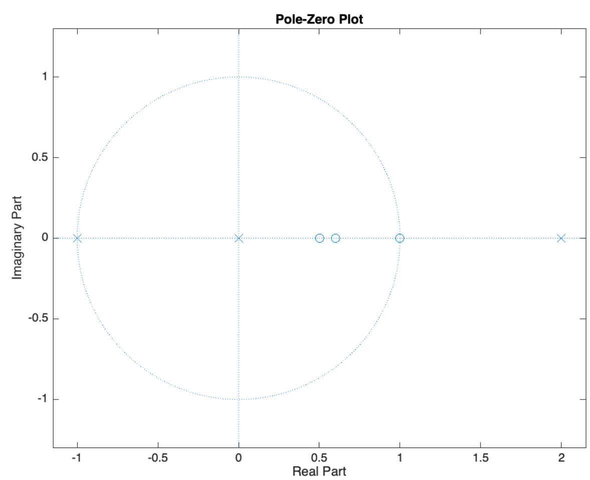
Problem 4: Plotting the pole-zero diagrams

In this problem, we will plot the pole-zero diagrams using our values obtained in problem 1. We will use the `zplane(zeros, poles)` function to plot the pole-zero diagrams.

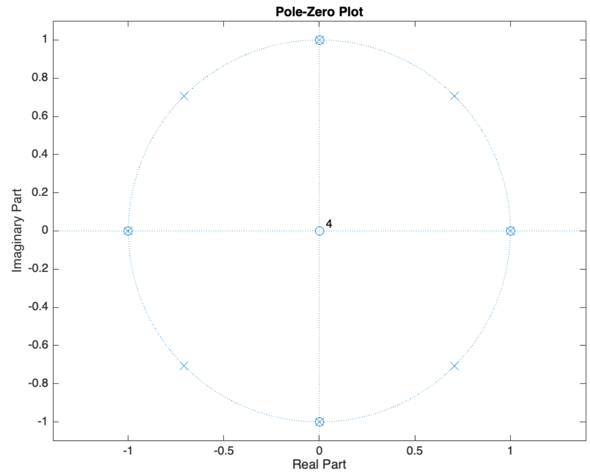
a) For the first transfer function, we observe the following plot:



b) Again, for the second transfer function, we observe the following:



c) And finally:


Pole-Zero Plot
Imaginary Part
Real Part
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1
-0.5
0
0.5
1
4