J-DSP Lab 3: Frequency Responses and Pole-Zero Plots

Lab 3 concentrates on generating frequency responses and pole-zero plots from transfer functions of systems. J-DSP contains a ***PZ Placement*** block under the **Filter Block** menu, which can be used to place the poles and zeros of a system. Connect the output of the ***PZ Placement*** block to a ***Freq-Resp*** block to view the frequency response of the system whose poles and zeros are at the locations specified in the ***PZ Placement*** block.

Problem 3-1: Pole-Zero Plots

Find the poles and zeros of the following transfer functions and use the J-DSP editor to plot the magnitude and phase of the frequency response. Observe the structure of poles and zeros in each system relative to the frequency response.

a)

$$H(z) = \frac{1-1.2z^{-1}}{1-0.5z^{-1}}$$

Is the system stable?

b)

$$H(z) = 1 - z^{-3}$$

Determine the zeros and plot the frequency response.

c)

$$H(z) = \frac{1}{1-0.85z^{-5}}$$

Note the pole locations. What kind of filter is this?

Problem 3-2: Poles and Zeros to Frequency Responses

Consider a system that has the complex conjugate poles

$$p_{1,2} = re^{\pm j\pi/4}$$

and a zero located at

$$z_1 = 0.7071r$$

Here

i) r = 0.96
ii) r = 0.71
iii) r = 0.14

For each condition, i)-iii), please do the following:

(a) Derive analytically the impulse response of the system and show its dependence on r. Plot the impulse response for r=0.96 (use J-DSP).

(b) Plot the frequency and phase response for each case using J-DSP.
(c) Note the differences in the frequency responses relative to the position of the poles.

Problem 3-3: Low-pass/High-pass Filter

For this problem, plot the magnitude in dB.

(a) Use the ***Filter*** and the ***PZ Placement*** blocks of J-DSP to design a low-pass filter. Use three sets of zeros and two sets of poles. Design the filter with an approximate cutoff frequency of

$$\Omega_c = \pi / 3$$

(b) Use the ***Filter*** and the ***PZ Placement*** blocks of J-DSP to design a high-pass filter. You are supposed to use two sets of zeros and five sets of poles. Design the filter with an approximate cutoff frequency of

$$\Omega_c = \pi / 2$$

Hint: Poles raise the frequency response up (create peaks) and zeros create valleys. Poles and zeros are entered in conjugate pairs to get real-valued filter coefficients.

Remember that when entering zeros and poles graphically, J-DSP will compute the transfer function automatically.

Problem 3-4: An Interesting Frequency Response

Consider the following all-pass system:

$$H(z) = \frac{z^{-3} - 1.8z^{-2} + 1.62z^{-1} - 0.729}{1 - 1.8z^{-1} + 1.62z^{-2} - 0.729z^{-3}}$$

a) Use J-DSP and find the poles and zeros of the transfer function.
b) Plot magnitude and phase responses of the system.
c) Note the symmetry of the numerator relative to the denominator

All-pass filters are often used to obtain design delay and phase characteristics in a signal without altering its magnitude spectrum.