

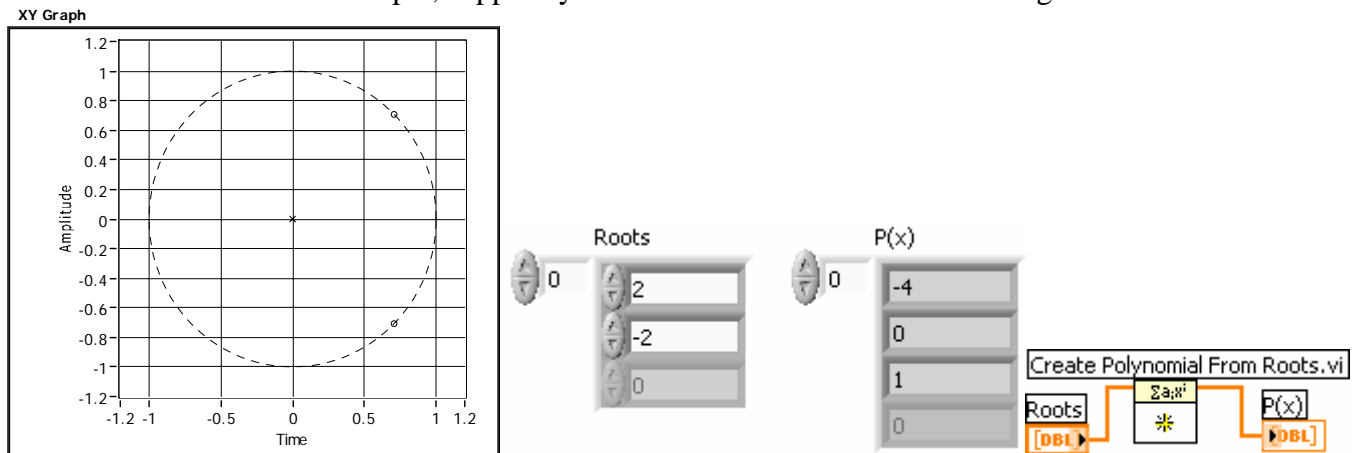
# Mini-Project 04: PeZ

## Do This First

Do Lab 11: PeZ - The  $z$ ,  $n$ , and  $\hat{\omega}$  Domains from the DSP First web site.

## Redo Tone Removal Step 1: Using Zeros

Redo your tone removal project, this time thinking of placing zeros to remove the tone. You will get the same answer, however your approach is more general which will allow you to do more complicated filters in the future. For example, suppose you want zeros as shown in the left figure.



The zeros appear to be located at  $e^{j\pi/4}$  and  $e^{-j\pi/4}$ , therefore  $H(z) = (z - e^{j\pi/4})(z - e^{-j\pi/4})$ . In LabVIEW you can use the Create Polynomial From Roots command (search for poly and look about halfway down for more information) to convert from the roots of a polynomial to the coefficients of that polynomial. For example, the LabVIEW above says the polynomial  $1x^2 + 0x - 4$  has the roots 2 and -2. Note: the order of the coefficients is reversed from what Matlab does.

Therefore the left half of the diagram below would create an array representing a polynomial that has the roots we are looking for.



The zplane VI plots those zeros on the complex z-plane as shown above.

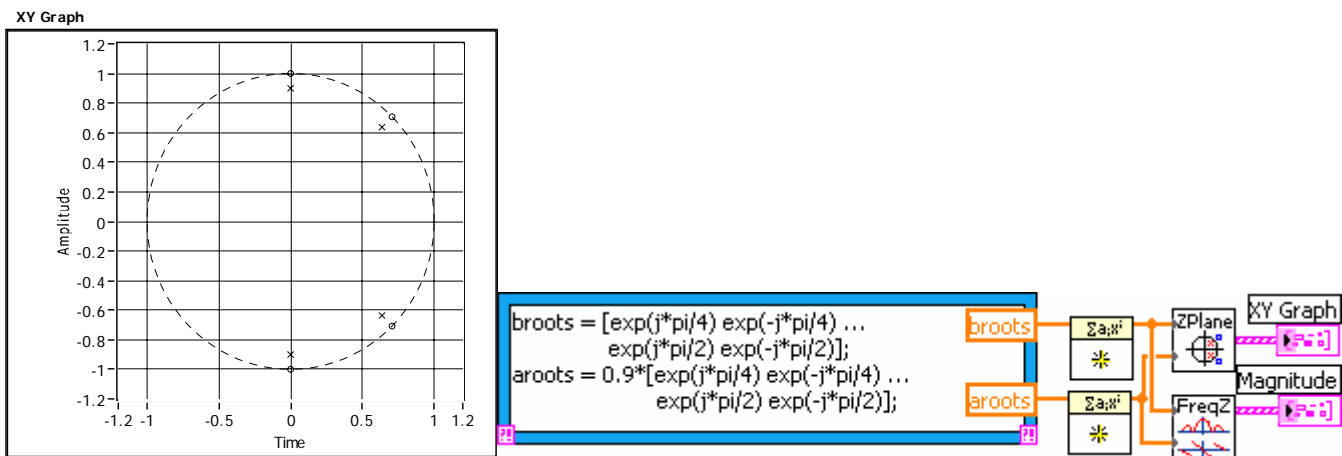
You can notch out more frequencies by adding more roots to the poly command. What is plotted by the bottom figure?



The frequency response can be plotted by using the freqz VI. What should the frequency response look like?

## Redo Tone Removal Step 2: Using Poles and Zeros

Now that you've seen how to position zeros where you want them, you'll see that it is also easy to position poles. For example, let's place some poles right near the zeros from above. Like this:



The poles are at  $0.9e^{\pm j\pi/4}$  and  $0.9e^{\pm j\pi/2}$ . In LabVIEW use what's shown above.

Notice the frequencies between the zero'ed frequencies are not attenuated as much. In fact, they are amplified slightly (times 1.2). The only problem left is for you to figure out how to create a filter that amplifies by 1 rather than 1.2. How do you do this?

## The Assignment

Redo the tone removal project using poles behind the zeros. Plot the frequency response for both approaches **on the same axis**<sup>1</sup>. Describe how the sound has changed. Can you tell what the DC gain of your filter will be based on the  $a$  and  $b$  coefficients? How?

## What's Due

For this mini-project you are to work on your own. You may discuss your ideas with others, but you may not share LabVIEW files. The policy stated on the Homework Procedures handout under "Responsibility" applies to this and other mini-projects.

What is due:

1. A .wav file containing your cleaned-up Sunshine Square voice clip.
2. A one-page (or so) memo describing what you did. Your memo should include:
  - a. An introduction telling what the project is about. (One or two sentences should be enough.)
  - b. A brief summary of what you did. Include
    - i. a table listing your pole and zero locations in polar form.
    - ii. a spectrogram of the cleaned-up signal.
    - iii. the frequency response plot of both the old and new approach.
    - iv. Answers to all questions in this memo.
    - v. Highlight any **extras** you've added.

This part should take no more than a page or so.

- c. Give your judgment on the effectiveness of this project in reinforcing the class. Justify your opinion. Only a sentence or two is expected.
- d. Provide a brief conclusion. Again, a sentence or two should be plenty.
- e. Use a memo format.

<sup>1</sup> Hint: Use the **Build Array** block to concatenate the output of the two **freqz** VIs. Make sure you right-click on **Build Array** and select *Concatenate Inputs*.

3. Print out your LabVIEW code. Selecting File→Print will start a print wizard. When you reach the “Print Contents” window, select “Icon, description, panel, and diagram.” This will print out the whole works in a compact format.

Zip (i.e. rar) up the .wav file and place it in the Angel drop box. Be sure that your name is contained in the file name. Hard copy of the memo, PeZ worksheet and LabVIEW printout are to be handed in at the start of class on the due date.