

# Re: Poles an Zeros

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- *From:* Tim Wescott <[tim@xxxxxxxxxxxxxxxxxxxx](mailto:tim@xxxxxxxxxxxxxxxxxxxx)>
  - *Date:* Thu, 28 Feb 2008 21:55:08 -0800
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Rob wrote:

Hello,

Could someone explain to me Poles and Zeros.  
What does a Pole do and what does a zero do and how they interact together.  
How does phase, gain, and delays relate to them?

If a book or a link could be recommended along with a what math needs to be used. (maybe a course outline to work from)

I am right now working on systems which I have an good idea on how they work but I don't seem to have the underlying understanding or how to calculate.

Some fully worked out examples I can look at would also be helpful. I just seem to be missing parts. I have found information. But I am having some issues putting it all together. A number of fields all converge and I am not able to find a path and seem to be jumping around and not getting anywhere.  
The area I am interested in are digitally controlled power converters (DC/AC and DC/DC power supplies).

Thank you,  
Rob

This is too big a subject for a news group reply. Read what John said, and read this: <http://www.wescottdesign.com/articles/zTransform/z-transforms.html>.

If you're really interested in digital control, check out my book: <http://www.wescottdesign.com/actfes/actfes.html>. You will have to wrap your brain around some mathematics, but I tried to make it as accessible as I could, and keep the discussion rooted in the real world at all times.

Basically, you can express the behavior of a linear, continuous-time, time-invariant system with a mathematical construct called a "transfer function". The transfer function is a consequence of analyzing a system using the Laplace transform (do a web search, or check Wikipedia).

## Re: Poles and Zeros

Most such transfer functions (at least those that you don't run away from, screaming) are rational ratios of polynomials in  $s$ , the Laplace domain 'frequency' variable. So, I may have a PID controller whose transfer function is

$$H(s) = \frac{(s + 250)(s + 1000)}{s(s + 5000)}$$

This guy has zeros at  $s = -250$  and  $s = -1000$ , and poles at  $s = 0$  and  $s = -5000$ .

It turns out to be very easy to calculate the response of such a system to a continuous sine wave at a particular frequency — in this case the poles of a system will tend to make the system gain go down as the frequency is increased, and the zeros will make the gain go up.

You can also use the transfer function concept in the digital domain. Here the system has to be linear and shift-invariant, the analysis method is called the 'z transform', and the 'frequency domain' variable is  $z$  (instead of  $s$ ).

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"Applied Control Theory for Embedded Systems" gives you just what it says.  
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