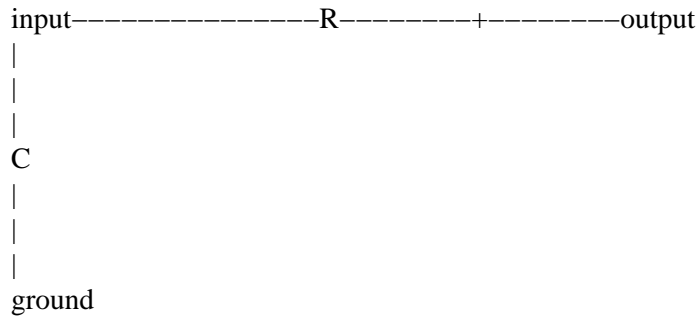


Re: Poles and Zeros

expresses the transfer function as a polynomial, using the complex variable "S". You'll have to read up on the theory to understand what S really is.

But if you express a transfer function as a polynomial on S, and factor it out nicely, and sweep S, the polynomial has "zeroes" where the numerator hits zero, and "poles" where the denominator hits zero. With a little practice, one can eyeball the equation, spot the poles and zeroes, and guess the frequency response.

Take this circuit:



which is a simple "single-pole" resistor-capacitor lowpass filter. If $R = 1$ ohm and $C = 1$ farad, it has a pole at radian frequency $\omega = 1$, namely at 0.16 Hertz.

The transfer function is

$$1 / (S+1)$$

and

$$\text{Output} = \text{Input} * 1 / (S+1)$$

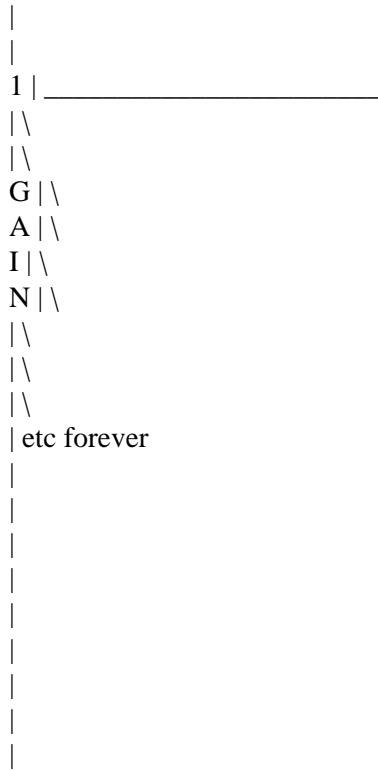
so has a pole at $S = -1$, sort of. (S is actually a complex variable... dig into the theory for gory details.)

You estimate the frequency response by pretending that S is the input frequency, in radians/second. Ignore the sign!

For very small S, very low frequencies, $1/(S+1) = 1$, so frequency response is flat, unity gain. At high frequencies, S is big, so $1/(S+1)$ is almost the same as $1/S$, so the output is dropping off inverse with frequency.

If you graph the frequency response, it will look close to...

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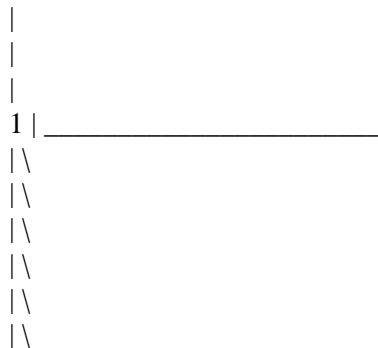


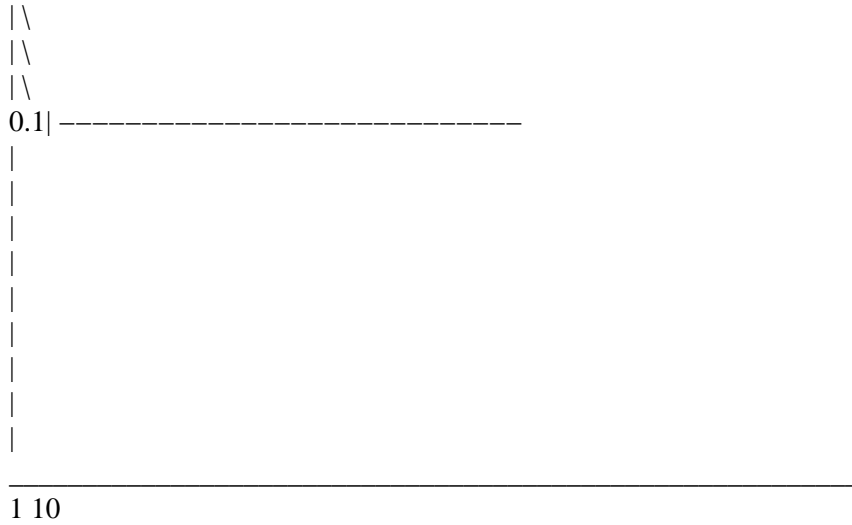
radian freq 1

where the gain is 1.00 at low frequencies up until 0.16 Hz, where it starts to roll off as $1/f$, namely at -6 dB per octave. Engineers casually say that this frequency plot "has a pole at $\omega = 1$ " because the Laplace polynomial really does.

(Because S is actually a complex number, the rolloff region has a 90 degree phase shift. A 90 degree phase lag is associated with a 6 dB/octave rolloff in simple networks like this one.)

Now if you add a small resistor in series with that cap, say 0.1 ohms, it adds a zero. That looks like...





where the second break is at $\omega=10$, namely 1.6 Hz. Phase is 0 in the flats and 90 lag on the slopey part.

I find it helpful to start with a rough, practical explanation of stuff like this before I hit the books for the formal stuff.

John

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