TRANSITION FROM TO ECE 307

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In ECE 109 we learned how to analyze linear resistor circuits for attenuating signals. In ECE 207 we saw how controlled sources can be used to model transistors and op amps that amplify signals. And we saw how capacitors and inductors affect the transient responses of circuits. And finally in ECE 209 we saw how circuits containing linear resistors, controlled sources, capacitors and inductors can be used in frequency selective circuits - circuits we refer to as filters.

As we went through this analysis we developed a number of tools and made a number of basic observations. First of all in ECE 109 we found that voltage and current division work great for simple series and parallel circuits but node analysis is usually best for more general circuits. We then found that circuits containing linear resistors and controlled sources have equivalent resistances, transfer functions and Thevenin Equivalents - all very helpful in analysis.

In ECE 207 we found that the complete responses of linear RLC circuits can be expressed as the sums of natural and forced responses. We saw that the natural responses of our 2nd order circuits decayed to zero - were transient - being either overdamped, underdamped or critically damped depending on the circuit and its element values. In the circuits we worked with, the transient responses decayed to zero leaving us with just the forced responses as follows

$$v_o(t) = v_n(t) + v_f(t) \rightarrow v_f(t)$$

We also observed in ECE 207 that sinusoids are **magical** signals - that the forced response of a linear RLC circuit to a given sinusoid is a sinusoid of the same frequency. So the problem of finding the sinusoidal steady state responses of such circuits reduces to that of only having to find magnitudes and phases. This was tedious to do in ECE 207 with differential equations but much easier with the aid of complex numbers and phasors in ECE 209.

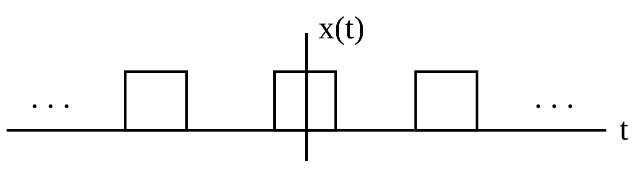
The key result of ECE 209 is that complex numbers - in particular Euler's Relation as follows

$$re^{j\theta} = r\cos(\theta) + j\sin(\theta)$$

makes the calculation of sinusoidal steady state responses much easier because it allows us to express sinusoids as the real parts of complex exponentials as follows

$$v_o(t) = A\cos(\omega t + \theta) = \mathrm{Re}\left[Ae^{j\theta}e^{j\omega t}\right] = \mathrm{Re}\left[V_o(j\omega\, e^{j\omega t}\right]$$

Once we became proficient in sinusoidal steady state analysis and the calculating of frequency responses we introduced the idea of **frequency domain analysis** for finding the steady state responses of linear circuits to periodic signals like the following pulse train



The basic idea of this scheme was to

(1) Make use of Fourier Series to express x(t) as a sum of sinusoids

(2) Make use of phasors, transfer functions and other tools from ECE 209 to find the steady state responses to the individual sinusoids
(3) Make use of superposition to find the circuit's steady state response to x(t) by adding up the responses to each of the sinusoids

We then made use of this Fourier analysis to show that even though the steady state response of a linear RLC circuit to a periodic input may not closely resemble its input, it will still be periodic with the same frequency as the input.

Our main goal in ECE 307 is to extend our frequency domain methods from ECE 209 - methods we really like for the analysis of linear RLC circuits because they turn differential equation problems into algebra problems with complex numbers. But, of course, not all the work goes away - we still have to do the algebra and we still have to do the math to get the Fourier Coefficients and such in the first place.

We begin ECE 307 by expressing our Fourier Series results in terms of complex exponentials. We then show how Fourier techniques can be used to find the responses of linear circuits to inputs that don't repeat like single pulses. Next we'll develop the LaPlace Transform to simplify the calculating of transient responses. We'll then finish off the course with an introduction to convolution which is actually a time domain technique - but has a useful connection with the frequency domain. And finally, as neat as all these methods are, they of course have their limitations as we'll indicate.