Notes on ECEN220 Signals and Systems Lab 2

Part 1 Fourier Series

We have learnt in our Lectures that a perfect Fourier Series will have many terms that go from negative infinity to positive infinity, i.e. the more terms that we have in the Fourier Series, the better we can "get back" the original waveform. However, sometimes it is impossible to retain that many terms, and a decision has to be made to truncate (cut) the series after $\pm K$ terms.

In this part, we wish to investigate effect of different numbers of K has on the reconstruction of the original waveform.

Given $x(t)$ stated in the lab sheets, we can represent it in Fourier Series as:

$$x(t) = \sum_{k=-\infty}^{+\infty} a_k e^{jk\omega_0 t} = \sum_{k=-\infty}^{+\infty} a_k e^{jk(2\pi/T)t}$$

In this part, we want to compute the Fourier coefficients a_k, given by

$$a_k = \frac{1}{T}\int_T x(t)e^{-jk\omega_0 t}dt = \frac{1}{T}\int_T x(t)e^{-jk(2\pi/T)t}dt$$

In order to compute a_k, we need Matlab to do integration for us. This will require "symbolic computing" (remember, document 3 of Introduction to Matlab?). Read that document together with Lab 2's hints on how to conduct a symbolic computing with Matlab. Remember, the a_k are in general complex in nature. So, there will be real and imaginary part to every a_k. If you want to see the magnitude use *abs( )*; to see the phase, use *angle( )*.

Once you have the a_k (remember, the k runs from $-K$ to K), we can get back an "estimate" of the original $x(t)$ with this equation:

$$\hat{x}(t) = \sum_{k=-K}^{K} a_k e^{jk\omega_0 t}$$

Compare the plots of different K with the original waveform, what do you observe?

Part 2 Parseval's Theorem

In this part, we want to verify Parseval's theorem, which states that the energy of the signal $x(t)$ is equal to the sum of the Fourier coefficients a_k squared. Remember the energy formula for a given signal? (Go find it out yourself) It involves integration, so again use symbolic computing in Matlab.

To sum the squared of a_k, we will want to use as many K terms as we can so that it is a fair comparison. Try to see if 30 terms is enough or not, otherwise, increase the K further, maybe ~ doubling it?

You should find that the energy of the signal $x(t)$ is equal to the sum of the Fourier coefficients a_k squared (up to a certain decimal places).