

**EE 207 - Lab #9**  
**Constructing Waveforms from Fourier Series using MATLAB**  
**(thanks to Dr. Nehrir for this lab)**

**Objective:** In this experiment we will use MATLAB to construct waveforms using Fourier series.

**Pre-lab:** Document your pre-lab and lab work in your lab notebook. Find the Fourier series expression for the sawtooth waveform, shown below, and for a square wave, a full-wave rectified sine wave and a half-wave rectified one, all having the same peak and period as the sawtooth waveform (see Chapter 15 of your text.)

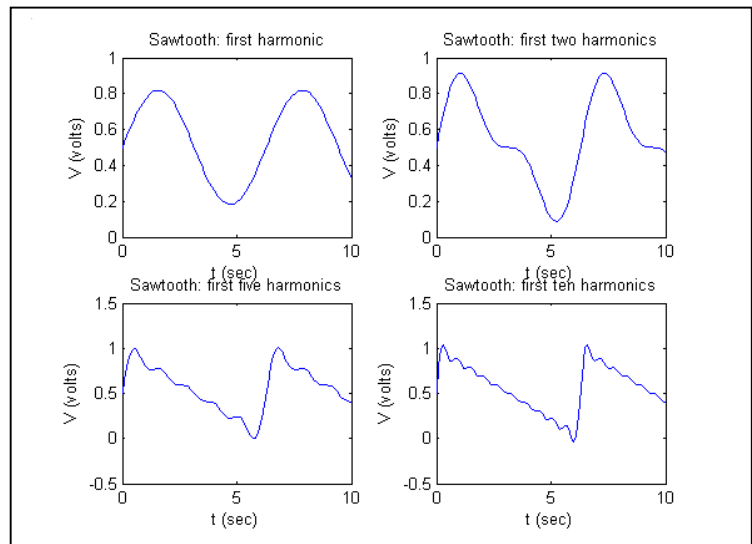
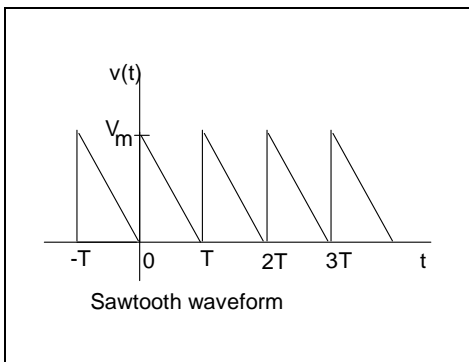
**Laboratory:** Bring a USB stick with you to the computer lab to save your work, or plan to make use of a shared drive that you can access later.

We can use MATLAB “sin ( )” function to construct the Fourier series of a waveform with as many terms as we care to include. Construct plots of the first harmonic, the sum of the first two, the first five, and the first ten harmonics of the sawtooth waveform. A listing of the M-file that computes the Fourier series for this sawtooth waveform is given on the next page, where  $V_m$  is set to 1. As noted from the listing, a radian frequency of 1, equivalent to a period  $T = 2\pi = 6.28$  sec. is chosen. A time span of 0-10 seconds is specified so that slightly less than two periods of the waveform can be examined. You can divide the screen into different subplots, as shown below, and use these plotting windows to show the graphs of the developing waveforms when different number of harmonics of the waveform are used.

Edit the M-file to generate different combinations of the harmonic components and see how many terms must be included before a near-ideal sawtooth waveform is obtained. Harmonics can be added to the program by adding equations for additional harmonics, or a “for loop” with a generalized equation can be written to achieve the same.

Use the M-file as a template to generate a square wave, a half wave rectified sine wave and a full-wave rectified sine wave (with period  $T = 6.28$  sec. and  $V_m = 1$ ) from their Fourier series.

**Report:** You will turn in a single report for labs 9 and 10. You should include your theoretical Fourier series analysis, the Matlab results of reconstructed waveforms based on your Fourier series coefficients, and the measured Fourier magnitude coefficients using the function generator and the oscilloscope FFT capability. As usual you need to describe your procedure, results, how your measurements relate to your theory and draw conclusions about the exercise.



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% The Fourier series expansion for a sawtooth-wave is made up of a sum
% of harmonics.

t = 0:.1:10;
y = 0.5 + sin(t)/pi;    % The fundamental frequency
subplot(2,2,1), plot(t,y, 'k')
title('Sawtooth: first harmonic')
xlabel('t (sec)')
ylabel('V (volts)')

% Add the next harmonic to the fundamental
y = 0.5 + sin(t)/pi + sin(2*t)/(2*pi);
subplot(2,2,2), plot(t,y, 'k')
title('Sawtooth: first two harmonics')
xlabel('t (sec)')
ylabel('V (volts)')

% The first five harmonics:
y = 0.5+sin(t)/pi+sin(2*t)/(2*pi)+sin(3*t)/(3*pi);
y = y + sin(4*t)/(4*pi)+sin(5*t)/(5*pi);
subplot(2,2,3), plot(t,y, 'k')
title('Sawtooth: first five harmonics')
xlabel('t (sec)')
ylabel('V (volts)')

% The first ten harmonics (illustrating the use of a for loop):
y = 0.5;

for m=1:10;
    y=y+sin(m*t)/(m*pi);
end;

subplot(2,2,4), plot(t,y, 'k')
title('Sawtooth: first ten harmonics')
xlabel('t (sec)')
ylabel('V (volts)')

```