Exercise 13 – Fourier Series I

Procedure

1. Use the Octave/MATLAB function `fs_trig1` and the code below to plot the sum of the first three harmonic terms in the Fourier series expansion of a full-wave rectified sine over the interval $0 \leq t \leq 8$ ms. Refer to Table 17.3 to find the coefficients. The rectified sine we want to approximate has an amplitude of $A = 1$ and a period of $T = 1$ ms. Notice that (due to symmetry) all of the $b_n$ coefficients are zero. Here is template code to get you started. You will need to complete the lines of code for the $a_0$ and $a_n$ coefficients ($a$ is an array of coefficients).

   ```matlab
   N = 3;
   A = 1, T = 1e-3;
   n = 1:N;
   a0 = TO BE FILLED IN BY STUDENT
   % Use the n array to calculate the corresponding array of a coefficients
   % You will want to use only element operations (not matrix)
   a = TO BE FILLED IN BY STUDENT
   b = zeros(size(n));
   % Plot from 0 to 8 ms (8 periods)
   t = [0:0.01:8]*T;
   y = fs_trig1(a0, a, b, T, t);
   plot(t, y, 'linewidth', 2);
   ylim([0 1.2])
   grid on
   ```

   `$N$` is the number of terms to include in the series. `$n$` is an array of length `$N$` containing integer values between 1 and `$N$`. `$a$` and `$b$` are the coefficient arrays of length `$N$`. The `$t$` array contains the time values at which to compute the Fourier series sum. The length of the `$a$` and `$b$` arrays determines the number of terms to include in the FS sum. The arguments to `fs_trig1` are `$a_0$, $a$, $b$, $T$, and $t$`. From the equation above, this function has a fundamental frequency of 1000 Hz ($2000 \pi$ rad/s) and a period of $T = 1$ ms.

2. Use transient analysis and LTspice to plot the sum of the first three harmonic terms (and the DC term) by connecting (four) voltage sources in series. (The LTSpice sinusoidal source generates a sine wave add a +90° phase shift to produce a cosine wave.) Each voltage source should produce a voltage equal to a corresponding term in the series. Plot the total voltage over the interval $0 \leq t \leq 8$ ms. Adjust the vertical scale of the plot and resize the windows so that the plot is similar to the one produced in MATLAB/Octave.

3. Use `fs_trig1` to plot the sum of the first 10 harmonics and then the first 100 harmonics in the series. How many harmonic terms appear to be necessary to obtain a good approximation to $v(t)$.

Deliverables

Copy-and-paste all four plots (three from MATLAB/Octave and one from LTSpice) into a single page document. All graphs should be approximately the same size. Add appropriate captions to the figure. Turn in only the single page document. Your name(s) should be included at the top of the document.