ECE31033 Project #2– Due April 3, 2024

1) Create a Matlab function named *fourseries* that is invoked to provide the coefficients of the fourier series up to the user-defined Nth value. Specifically, the function header should have a form

function [avg,ak,bk, rcon, err] = *fourseries*(t,x,T,N)

where t is time, x is the waveform that is being analyzed, T is its fundamental period of the waveform, and N is the number of terms of the fourier series that is desired. ak and bk are the Fourier coefficients you should obtain by performing an approximate Reimann sum of the coefficient integrals. Note the avg is the average value of x. rcon is a reconstructed approximation of the function x, obtained using your Fourier coefficients. err is to be calculated by taking the rms of the difference between the reconstructed waveform and the waveform x that it is intended to represent.

2) Prove your function works by inputting time and function values of the waveform:

x = 15-30cos(2π40t) + 20sin(2π40t) +8cos(2π800t) + 2sin(2π1600t) - 5cos(2π2000t)

and verifying your error is small and that the coefficients match what you expect. In addition to calculating the error, you should plot x and the reconstruction of the waveform obtained using your Fourier series on top of each other to demonstrate they match.

3) Assume a single-phase inverter operating is operating under 180 switching. Assume the load is an rl load with $r = 0.5\ \Omega$ and $L = 1mH$ and the desired fundamental component of AC voltage is $V_{as} = -\frac{200}{\pi}\cos(\theta_{ac})$ where $\theta_{ac} = 120\pi t$. Analytically determine the steady state AC current waveform, DC current waveform, the transistor and diode currents you would expect to observe over a single period. Plot these (you can do so by hand) versus θ_{ac}.

4) Simulate the system of problem 3 using a forward Euler integration algorithm. Your simulation should be performed in a While loop, similar to project 1, where tend is used to end the loop. Run the system to steady-state and use the results to obtain a plot of all transistor and diode voltages and currents and output voltage and current and dc current over 1 cycle to validate the model is correct. These should be plotted versus θ_{ac} (in degrees). Within the simulation a mod function should be used to keep θ_{ac} between 0 and 360 degrees. Use the spectrum analyzer developed in Problem 1 to plot the

frequency spectrum of the output voltage from 0 to 1200 Hz. Validate the waveforms, and spectrum matches the values expected.

5) Using Matlab simulate use a forward Euler integration routine to simulate a single-phase inverter operating under sine-triangle PWM. Assume the load is an rl load with $r = 1.0\ \Omega$ and $L = 1mH$ and the desired ac voltage has a fundamental frequency of 400 Hz and a phase angle of $\phi_v = -\frac{\pi}{2}$. Assume the dc voltage is 100 V. Assume a switching frequency of 7600 Hz. For the case in which m = 1, plot the transistor and diode voltages and currents and output voltage and current over 1 cycle of the fundamental to validate the model is correct. Similar to Problem 4, these should be plotted versus θ_{ac} (in degrees).

6) Using the model in 5) vary the amplitudes of m from 0, 0.2, 0.4, 1.0, 1.3, 1.6, 2.0, 3.0, 4, 5. For each value of m, use the spectrum analyzer of problem 1 to determine the amplitude of the fundamental frequency component of the output voltage. Then plot the amplitude as a function of the duty cycle. Validate that the amplitude versus duty cycle is what you would expect.

7) Using Matlab, simulate (using a Forward Euler algorithm) a 3-phase inverter operating under sine-triangle PWM. Assume the load is an rl load with $r = 1.0\ \Omega$ and $L = 1mH$ and the desired ac current has a fundamental component at 50 Hz. Assume you would like to have the phase-a current be $I_{as} = 20\cos(\theta_{ac})$ (b- and c-phases are equal and amplitude and displaced by 120 degrees) and that you operate with the minimum dc voltage you can to obtain the necessary current without low frequency harmonics. Assume a switching frequency of 3100 Hz. Plot the transistor and diode voltages and currents and output voltage and current over 1 cycle of the fundamental to validate the model is correct. Similar to Problem 4, these should be plotted versus θ_{ac} (in degrees). Use the spectrum analyzer to determine the amplitude of the fundamental frequency component of the output voltage.

Write a report that documents the key results of the project, focusing on what was expected versus what was obtained.