

1. For a four-level NPC converter, find all the available switching states. Let the total dc link voltage be 8.0kV.
 - a. List the switching states in a table showing the voltage across each switch and the components of a space vector representation thereof. You may work in a per unit system of your choice if you prefer.
 - b. Create a plot similar to what was presented in class. Plot all the vectors. Label each vector in the first hexant; that's plenty. You can check your plot using Prof. Corzine's reference.

2. Find and plot one cycle of the dc current that accompanies a three-level space vector PWM that yields a vector of $0.60 V_{dc} \angle 40^\circ$ Volts. The load current is 200 Amps with a power factor of 1.00. A number for V_{dc} is not necessary, but if you want one, make one up and declare it.

3. For a four-level NPC, apply sine-triangle modulation at a 5kHz:50Hz frequency ratio between triangle and sine wave frequencies. Set the sine wave's amplitude at $\frac{3}{4}$ of the sum of the applied triangle wave. Let the dc link voltage be 8kV.
 - a. Plot the triangle waves superimposed on a three phase sine wave.
 - b. Show one (sine) cycle of the resulting pulse width modulation.
 - c. Show a harmonic spectrum that reveals at least the first half dozen nonzero voltage harmonics.

4. For a Multimodal Multilevel Converter (MMC) with four-modules in each leg and balanced capacitor voltages of 2kV for each switch and diode,
 - a. Determine the voltage stair step waveform with the ~~same switching losses as the NPC converter of problem 3.~~ **2kV / switch.** Use a fundamental output frequency of 50 Hertz.
 - b. Identify the fundamental and lowest nonzero harmonic output line-to-neutral voltage, magnitude and frequency. Assume the inductors have no voltage drop.
 - c. For a machine load that is modeled as a 50 Hz voltage source of the same amplitude as the fundamental component of the terminal voltage, but lagging three degrees, behind a reactance of 0.35 Ohms at 50 Hz, find the fundamental current and the lowest nonzero current harmonic, magnitude and frequency.