PROJECT#3: HVDC

ELC 470: Power Systems

Kevin Cao & Dhruvit Naik

Problem: Familiarize ourselves with three-phase circuits and high-voltage dc transmission.

The first task was to connect the different pieces of the system. The three-phase generator was connected to the diode rectifier. That subsystem was connected to the dc transmission line. Finally, the three-phase inverter and resistive load was connected. We then calculated the undefined values. Below is PSpice Schematic.

Step #3: PSpice Circuit

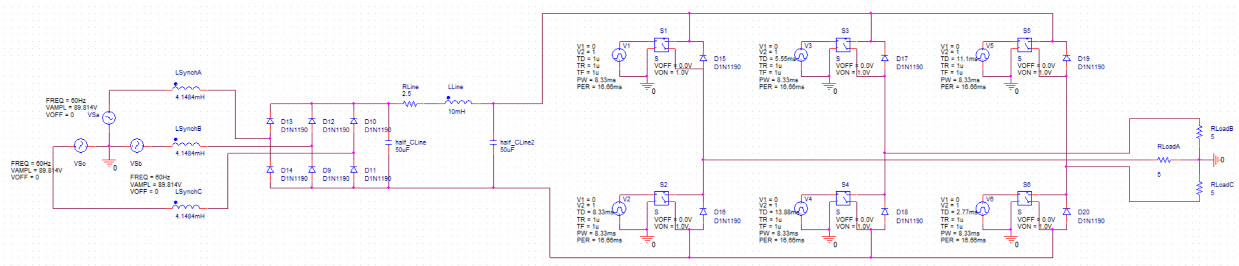


Figure 1: Circuit of HVDC Transmission System

Step #4: Transient Analysis of Terminal Voltages

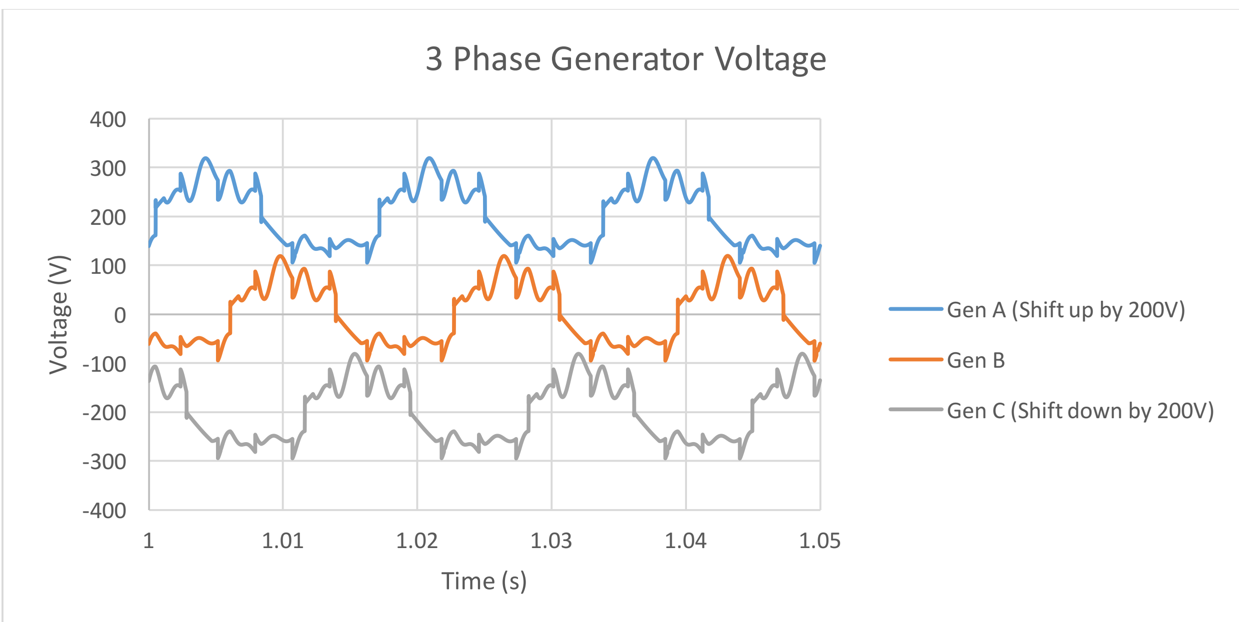


Figure 2: Three-Phase Generator Terminal Voltages (A, B, C) vs. Time

Step #5: Calculate the RMS of Phase a Generator Terminal

$$RMS\left(V_{GenA}(t)\right) = 61.032$$

Step #6: Transient Analysis of Sending and Receiving-End Line

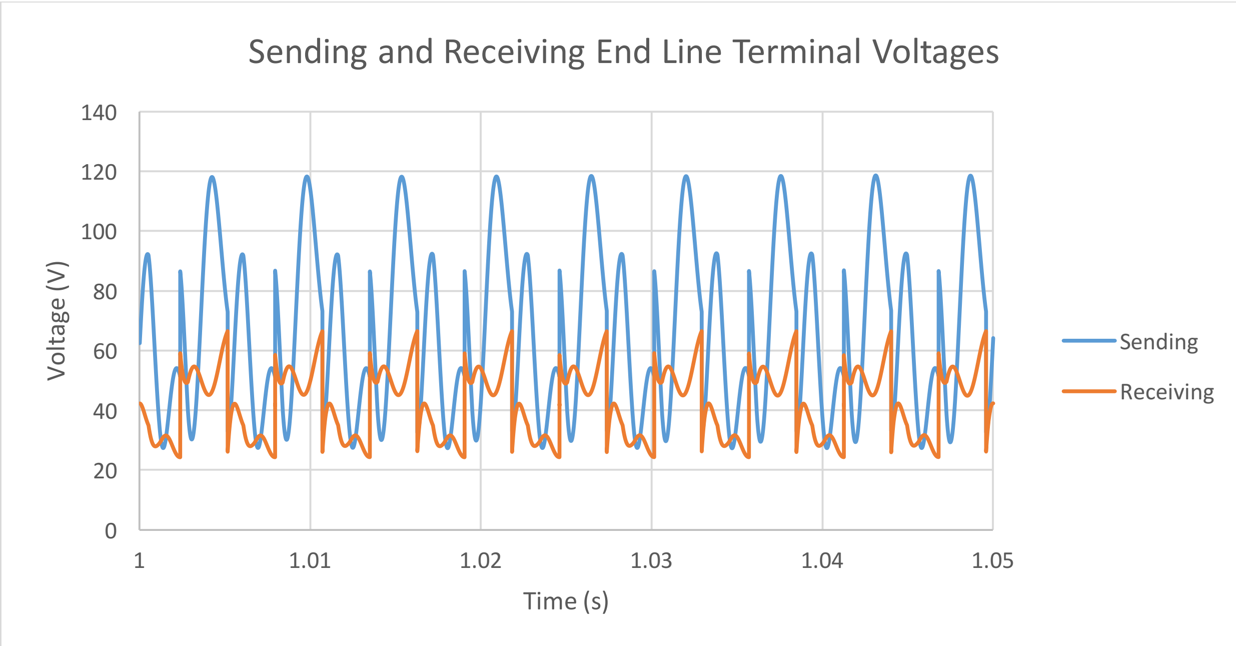


Figure 3: Sending and Receiving-End Line Terminal Voltages vs Time

Step #7: Calculate the ripple in the Sending and Receiving

$$\Delta V_{Send} = 118.59 - 27.28 = 91.31\ V$$

$$\Delta V_{Rec} = 66.52 - 24.32 = 42.19\ V$$

Step #8: Calculate the average in the Sending and Receiving

In order to calculate the average, we found the sum of voltage * time step and divided the result by the period (0.005).

$$avg\left(V_{Send}(t)\right) = \frac{3.326}{0.05} = 66.52\ V$$

$$avg\left(V_{Rec}(t)\right) = \frac{2.111}{0.05} = 42.22\ V$$

Step #10: Next Page
Step #11:

When the resistive load is increased, the generator terminal voltages resemble a pure sinusoidal wave. In addition, more current is being drawn to the load. Also the sending and receiving voltages are identical waves. There is no loss between them.

Step #10:
We increased the resistive load from 50Ω to 500kΩ per phase. Then reexamined the generator and sending & receiving terminal voltages.

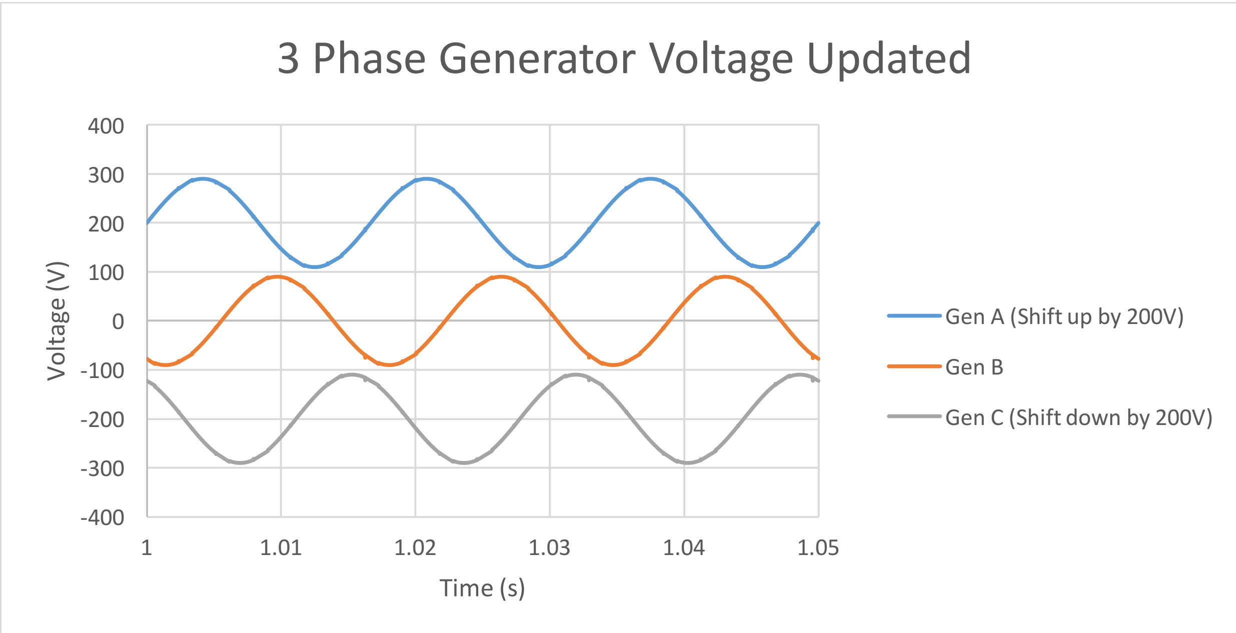


Figure 4: Three-Phase Generator Terminal Voltages (A, B, C) vs. Time with 500kΩ load

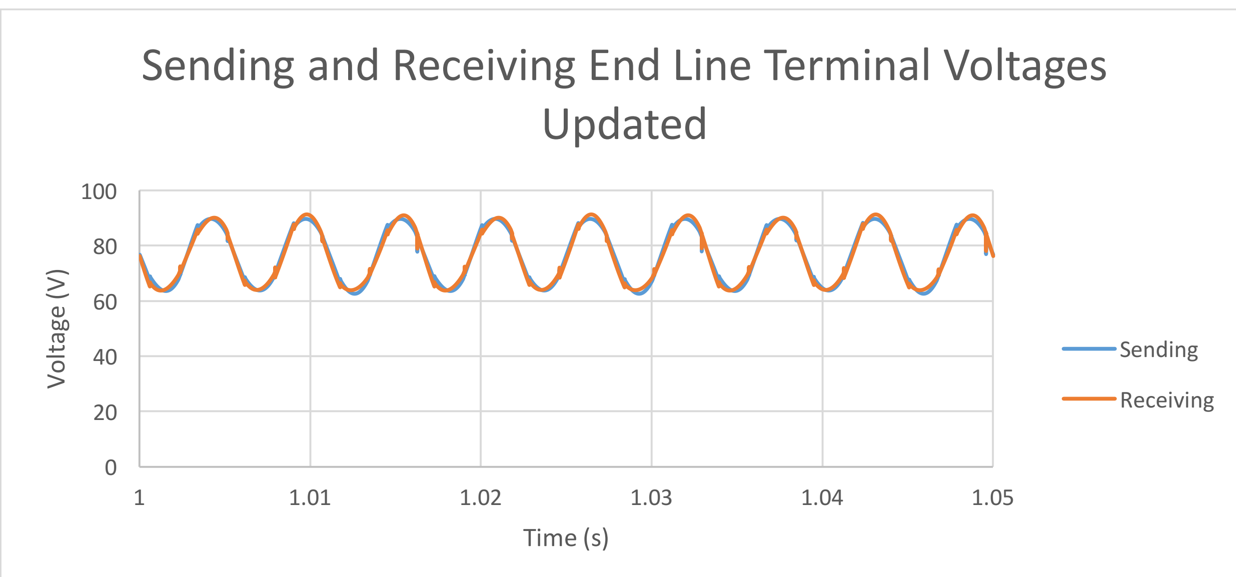


Figure 5: Sending and Receiving-End Line Terminal Voltages vs Time with 500kΩ load

Step #13:

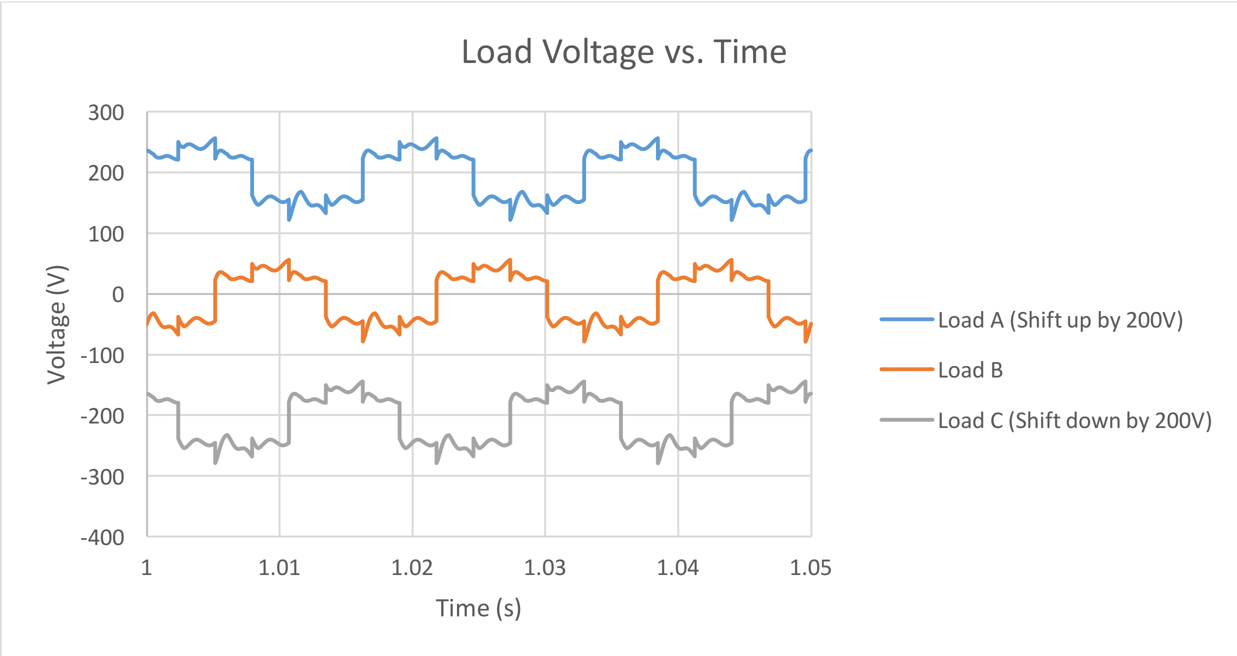


Figure 6: Load Voltages (A, B, C) vs. Time

Step #14:

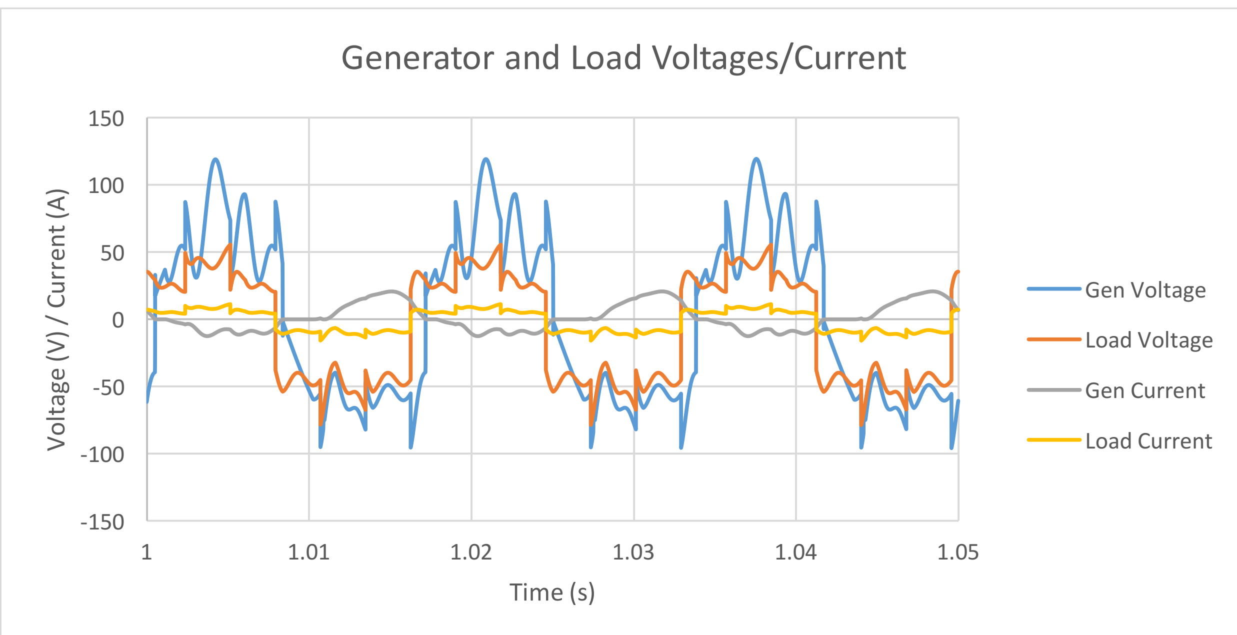


Figure 7: Generator and Load Voltages/Currents for Phase A vs. Time

Step #15: RMS magnitude of voltages and currents below.

$$RMS\left(V_{GenA}\,(t)\right) = 61.032$$

$$RMS\left(V_{LoadA}\,(t)\right) = 41.845$$

$$RMS\left(I_{GenA}\,(t)\right) = 10.364$$

$$RMS\left(I_{LoadA}\,(t)\right) = 8.369$$

Step #16: Read Power output of generator and load.

$$|P_{GenA}| = 506.85\,Watts$$

$$|P_{LoadA}| = 305.20\,Watts$$

Step #17: Efficiency of transmission system.

$$efficiecy\,(\%) = 69.1\%$$

Step #18:

For the HVDC transmission line, as resistivity increases the efficiency follows a negative log trend. While the 3-Phase system resistivity increase the efficiency decreases linearly. Thus the HVDC is much more stable in terms of efficiency vs line resistivity.

Step #19: Fourier Analysis

$$Gen\ V = \frac{-0.5}{2} + [-19.05\cos(\omega t) + 77.85\sin(\omega t)]$$

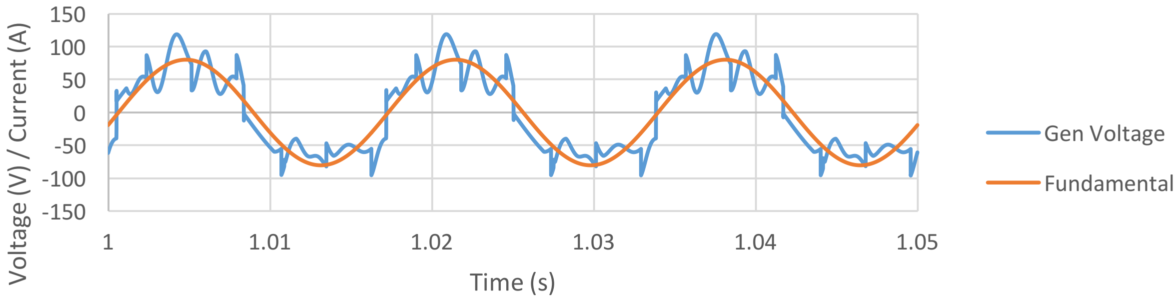
$$Gen\ I = \frac{3.14}{2} + [7.52\cos(\omega t) - 11.10\sin(\omega t)]$$

$$Load\ V = \frac{-15.75}{2} + [9.66\cos(\omega t) + 52.4\sin(\omega t)]$$

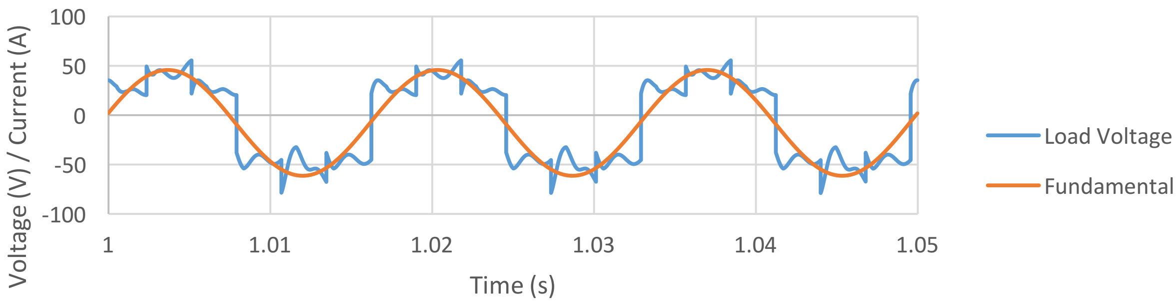
$$Load\ I = \frac{-3.15}{2} + [1.93\cos(\omega t) + 10.48\sin(\omega t)]$$

Next Page:
Figure 8-11: Comparison of Waveforms and Fundamental Components of Generator and Load Terminal Voltages/Currents for Phase A vs. Time

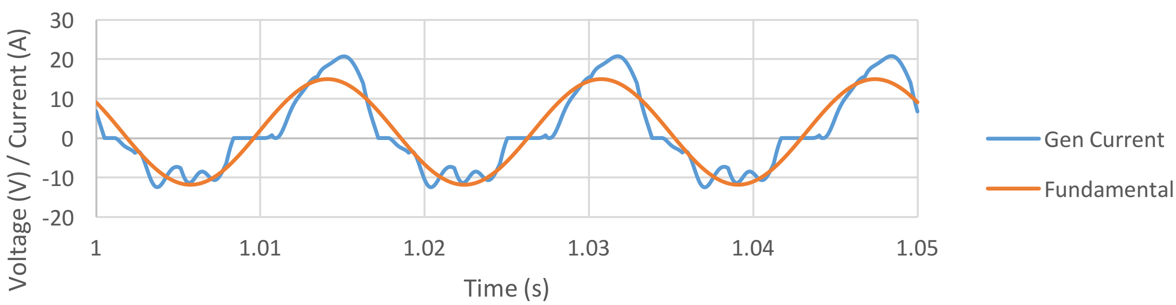
Generator Voltage vs. Fundamental Component



Load Voltage vs. Fundamental Component



Generator Current vs. Fundamental Componenet



Load Current vs. Fundamental Component