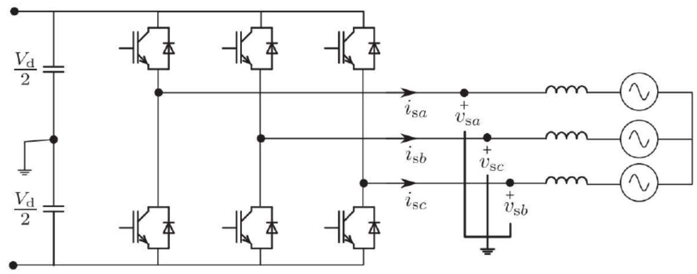
- Simulate a three-phase DC/AC converter.

Data:

- Vdc = 800 V
- Load : R=10 and L=10mH



a) Build the circuit using ideal switches and define the switching sequence

b) Add a filter between the inverter and the load, to obtain an almost sine waveform

c) Plot the AC voltages and currents and comment the results

Question 1: Build the circuit using ideal switches and define the switching sequence

Answer 1:

Inverters are direct converters that transform direct current (DC) into alternating current (AC). They utilize powerful fully-controlled electronic switches, typically transistors, MOSFET or IGBT. Inverters connect two energy systems with different frequencies — one with zero frequency (DC) and the other with frequency f (where f > 0). The power flows from the DC side to the AC side.

Inverters also play a significant role in connecting renewable energy sources (such as solar photovoltaic panels, wind turbines, etc.) and modern energy storage systems (like battery storage) to the grid, known as grid-tie inverters. The output of these inverters is characterized by a constant frequency (50 Hz or 60 Hz) and output voltage (220 V / 400 V). Their operation and connection to the grid are defined by technical connection requirements and various grid codes.

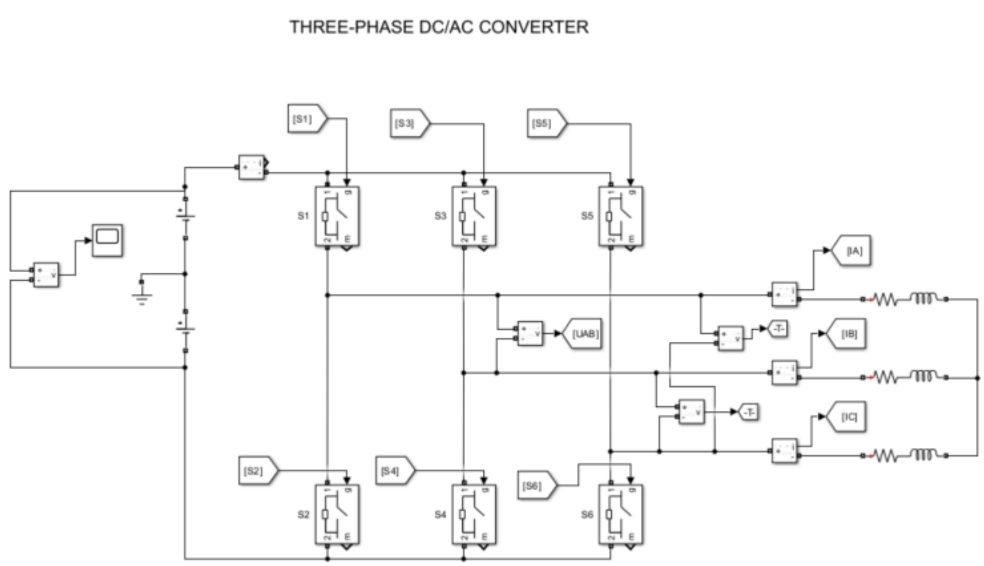


Figure 1. Inverter Circuit

Defining a switching sequence for a three-phase inverter is crucial for generating the desired AC output from a DC source. We are using pulse generators with specific delays for each switch and complementary NOT blocks for the opposing switches.

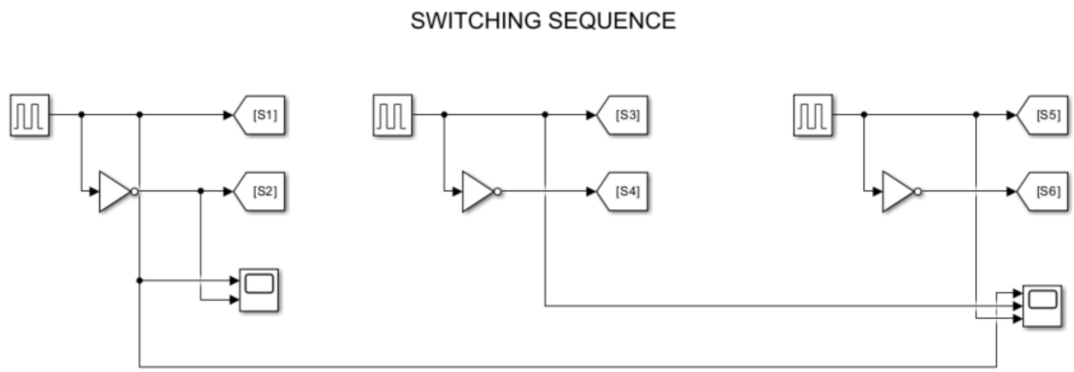


Figure 2. Invertor Switching Sequence

Configuring the "Pulse Generator" blocks for S1, S3, and S5 as follows:

- **S1**: Set the delay to 0.
- **S3**: Set the delay to 0.02 / 3.
- **S5**: Set the delay to 0.04 / 3.

Setting the pulse period to match desired switching frequency and setting the duty cycle to 50% for each pulse to ensure symmetrical switching.

Use the **NOT** block to control the complementary switches:

- **S2** as the complement of S1.
- **S4** as the complement of S3.
- **S6** as the complement of S5.

This setup ensures preventing short circuits across the DC bus.

Without a filter, the output waveform will include high-frequency switching harmonics. This raw, unfiltered output has a stepped waveform that approximates a sin wave but includes significant high-frequency harmonics.

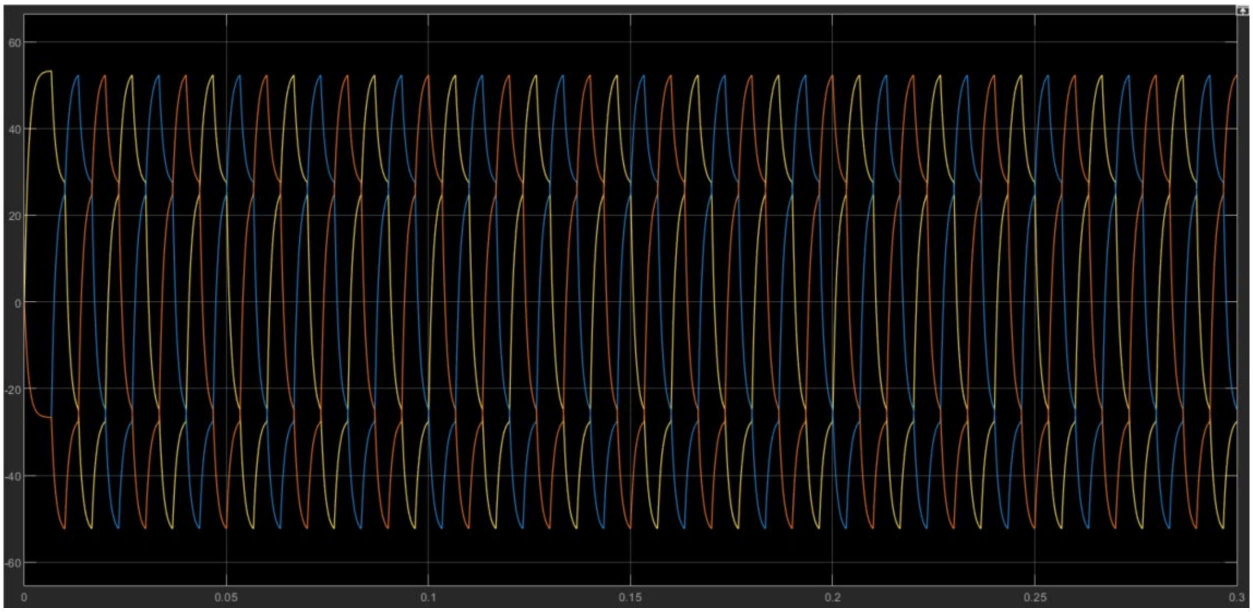


Figure 3. Current Output No Filter

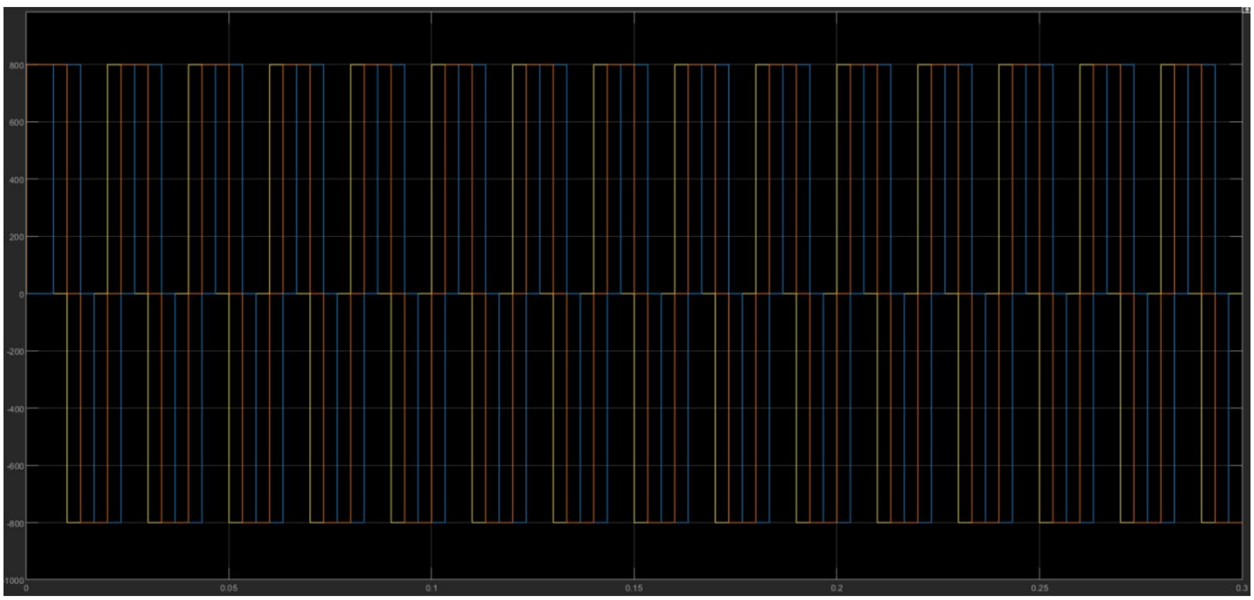


Figure 4. Output Voltage

Question 2: Add a filter between the inverter and the load, to obtain an almost sine waveform

Answer 2:

To design a filter for a DC/AC inverter to achieve a smooth sinus wave form, we need to focus on filtering out the high-frequency components created by the switching process and allow the fundamental frequency (50 Hz) to pass through. The most common type of filter used in inverters is the LC low-pass filter.

- **The switching frequency** is the frequency at which the inverter's transistors switch on and off, generating a high-frequency signal.
- **The output frequency** (50 Hz) is the frequency of the desired AC waveform.
- **Cutoff Frequency** of the filter determines the range of frequencies that will be allowed to pass through. To filter out high-frequency components generated by the switching process and ensure a smooth 50 Hz output, you want the cutoff frequency to be low enough to reject those high-frequency harmonics but high enough to allow the 50 Hz fundamental component to pass through.

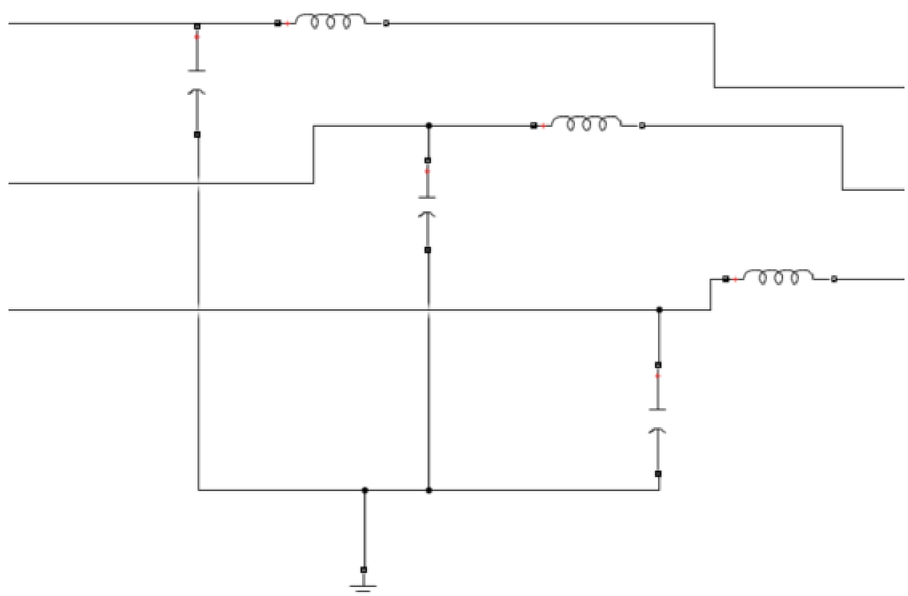


Figure 5. Filter 1

First filter tried to get sinus form of output voltage an current has one L = 7 mH and one C = 141 uF in every phase.

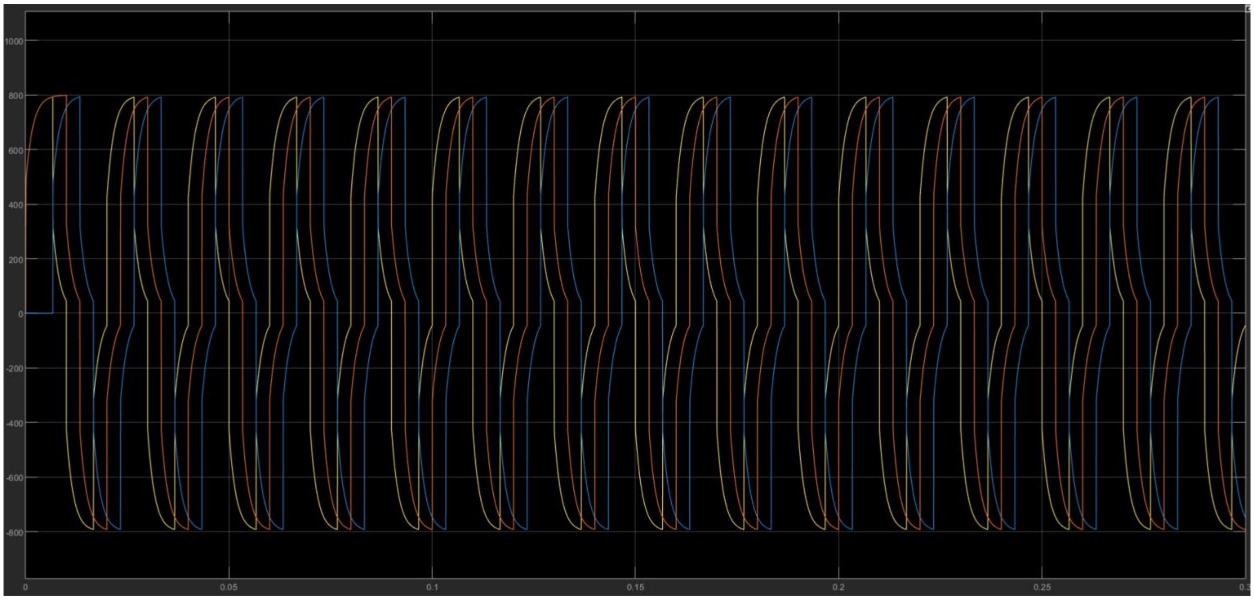


Figure 6 Output Voltage Filter 1

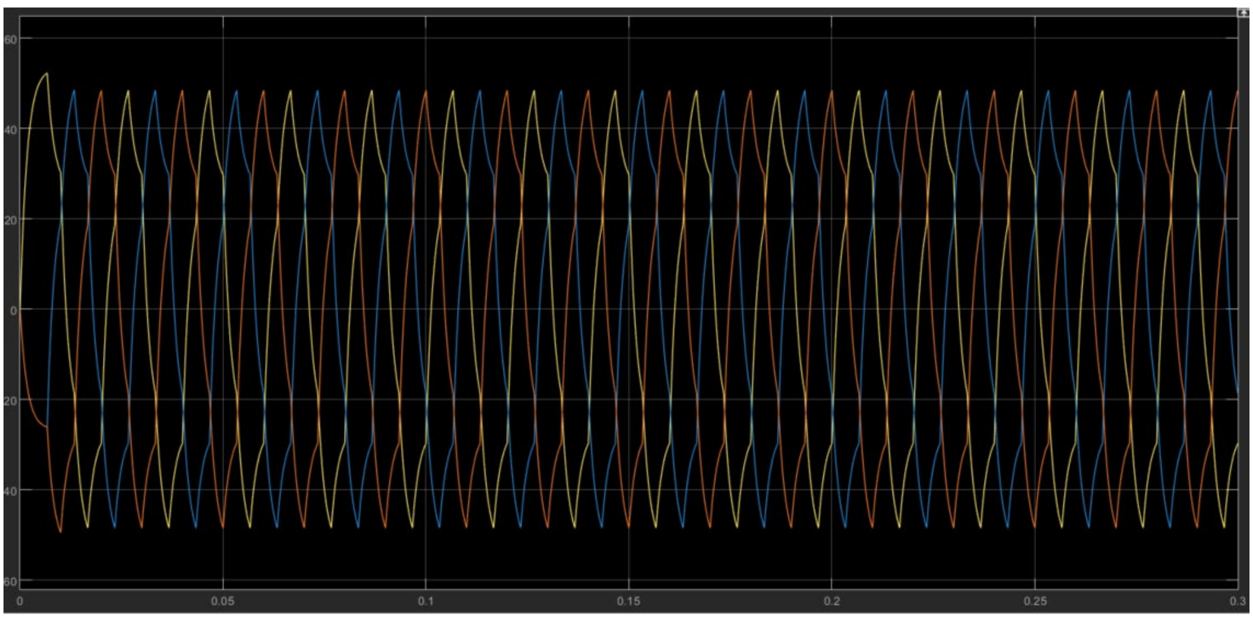


Figure 7 Output Current Filter 1

It’s obvious from this graph that this is not a sinus. This filter is not good enough.

Question 3: Plot the AC voltages and currents and comment the results

Answer 3:

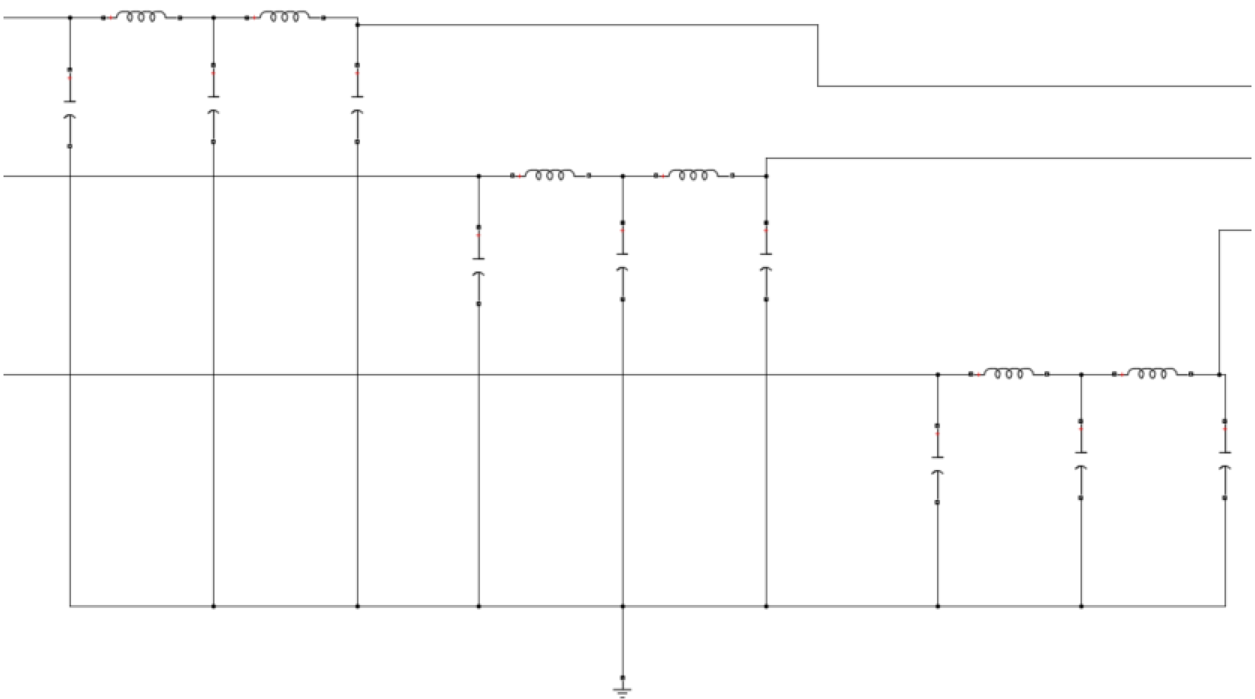


Figure 8. Filter 2

In second filter tried, in every phase I use two series inductors: L1= 17 mH, L2 = 9 mH, and three shunt Capacitors: C1 = 154 uF, C2 = 137 uF, C3 = 31 uF.

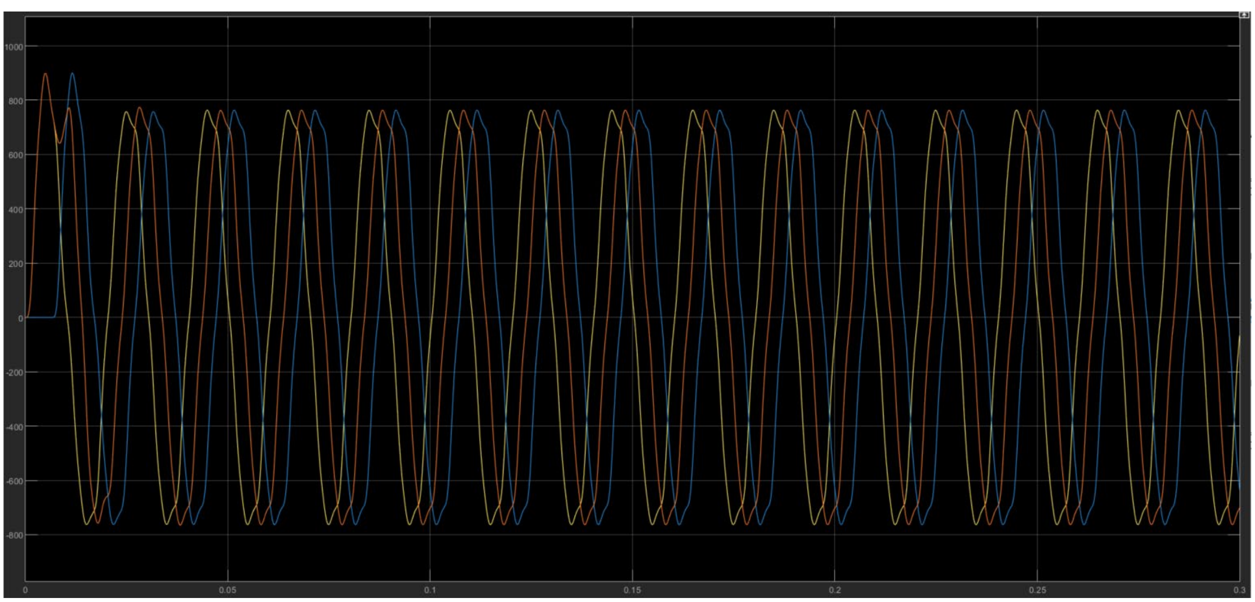


Figure 9. Output Voltage Filter 2

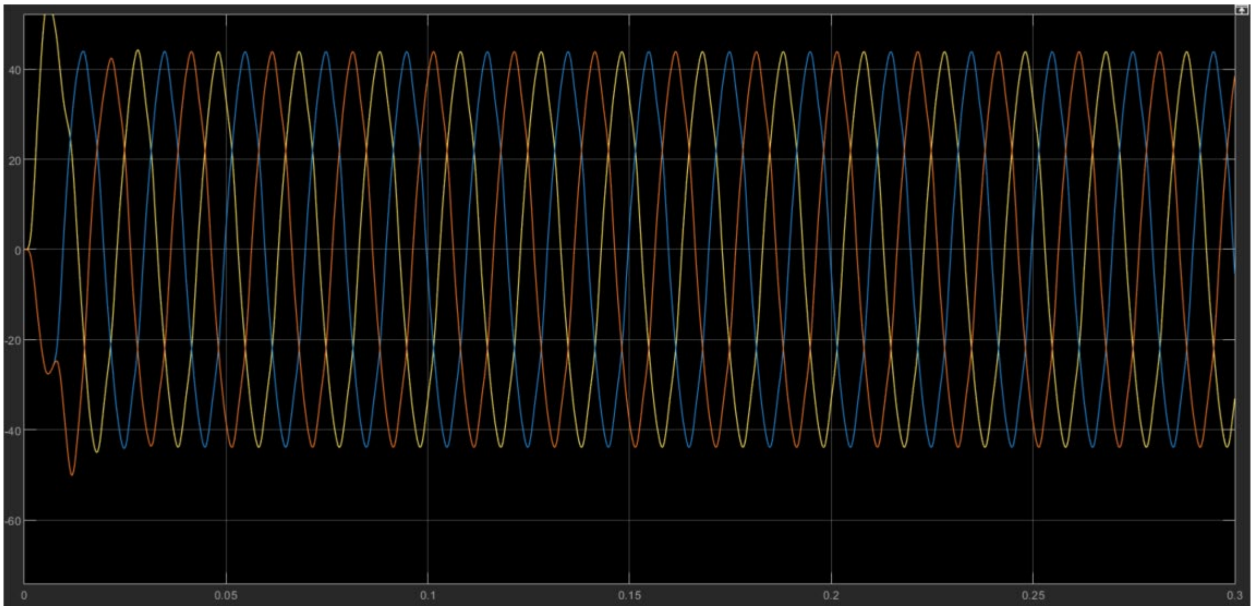


Figure 10. Output Current Filter 2