
School of Electrical and Computer Engineering
University of Newcastle, Australia

# ELEC3251
# Assignment 2

## Analysis of Switching Harmonics, Grid Connected Inverters and Space Vector Control System Design

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# 1 PV Voltage and Switching Harmonics

## 1.1 Method

To determine the correct switching output, a test was performed at the H-bridge output to confirm that both switching strategies can be achieved. This test involved setting a constant sinusoid input at the H-bridge controller.

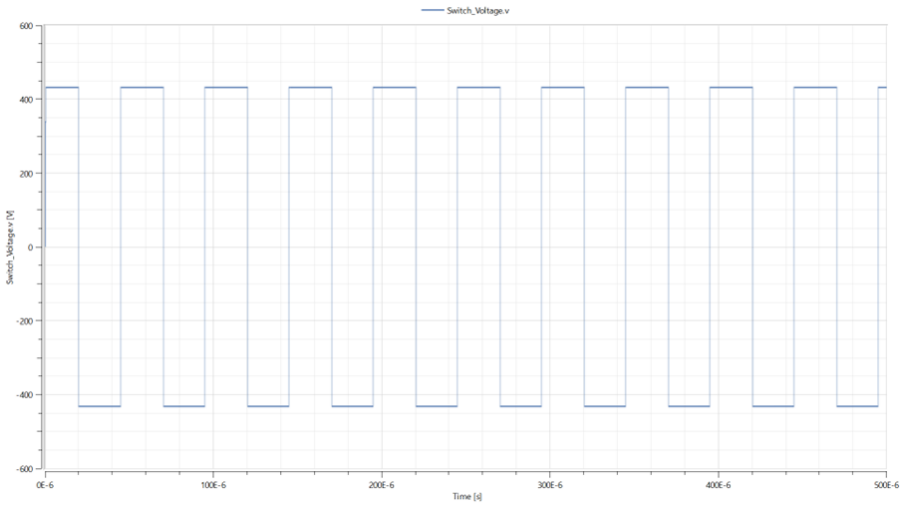


Figure 1: Bipolar Switching Test

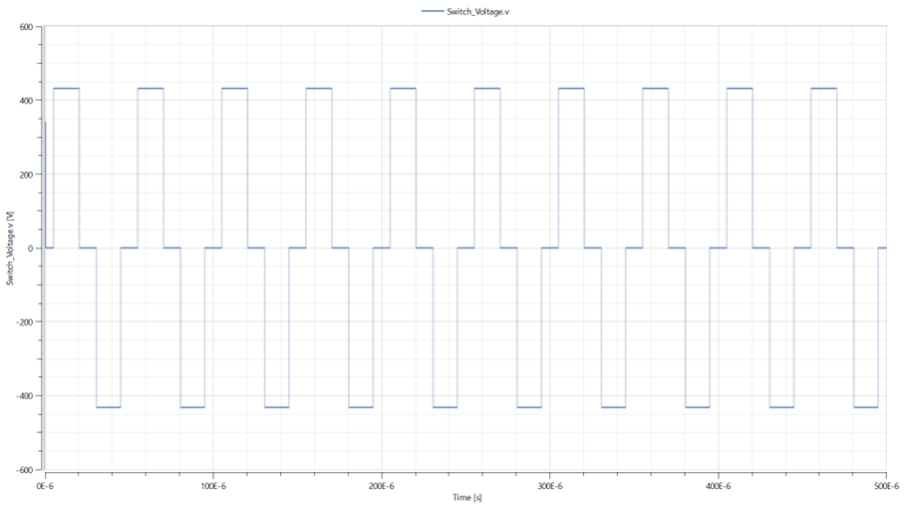


Figure 2: Unipolar Switching Test

The switching frequency was set to $20kHz$. The current sensor, Ic was added to measure current through the capacitor. The voltage sensor for the capacitor was named Vc. The simulation was run twice, at 0.2 s and at 10 s. This allows the viewing of different frequency components. The numbers of cells in series for the solar cell was 850. The capacitance was set to 56 mF. The some experimentation, it was found that the input supply was 5kW.

## 1.2 Results

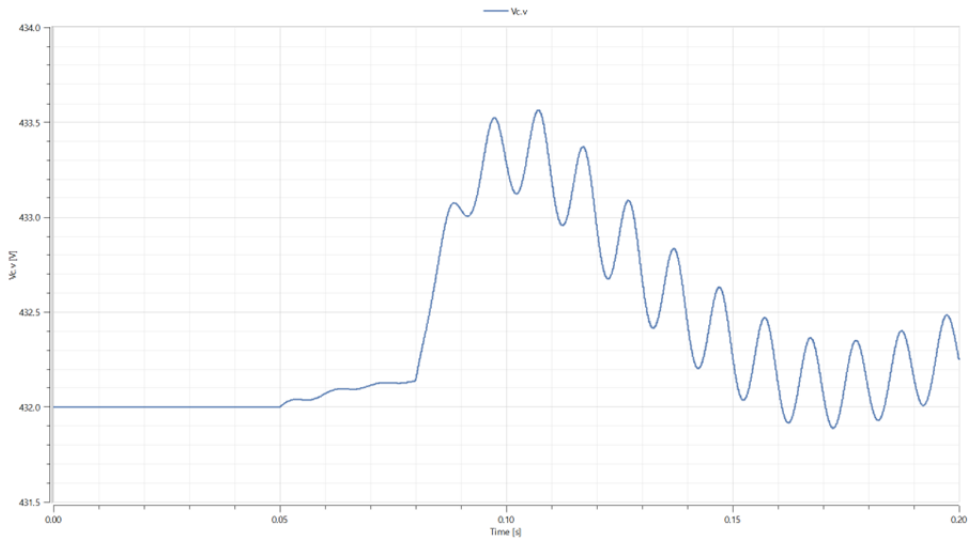


Figure 3: Bipolar $V_c$, capacitor voltage (PV to GND), Sim Time = 0.2 s

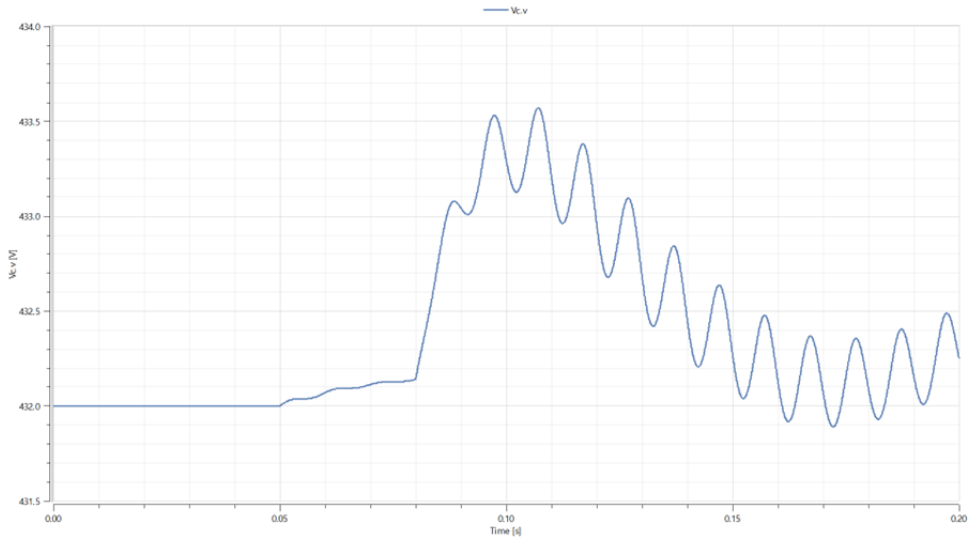


Figure 4: Unipolar $V_c$, capacitor voltage (PV to GND), Sim Time = 0.2 s

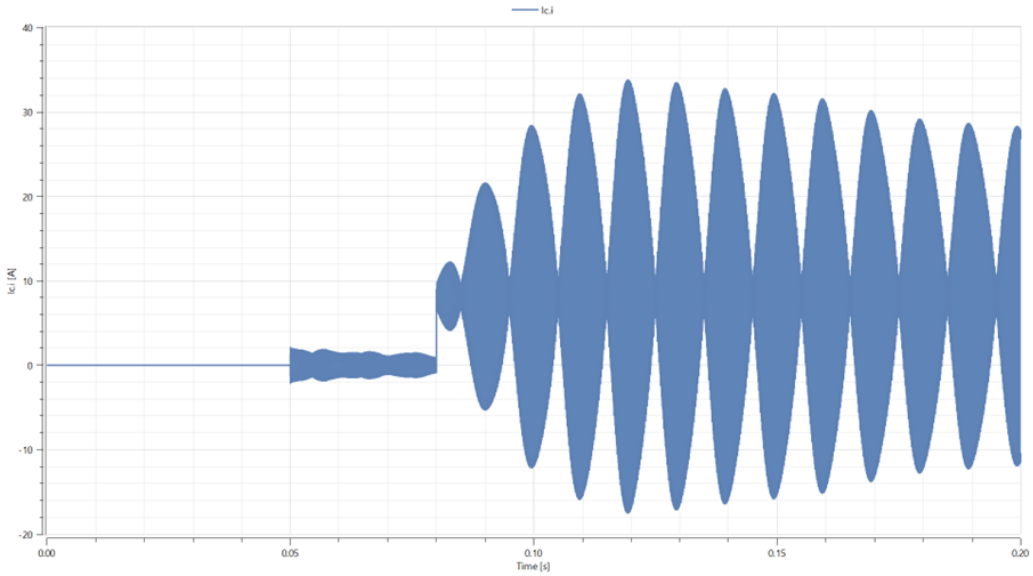


Figure 5: Bipolar $I_c$, current through capacitor, Sim Time = 0.2 s

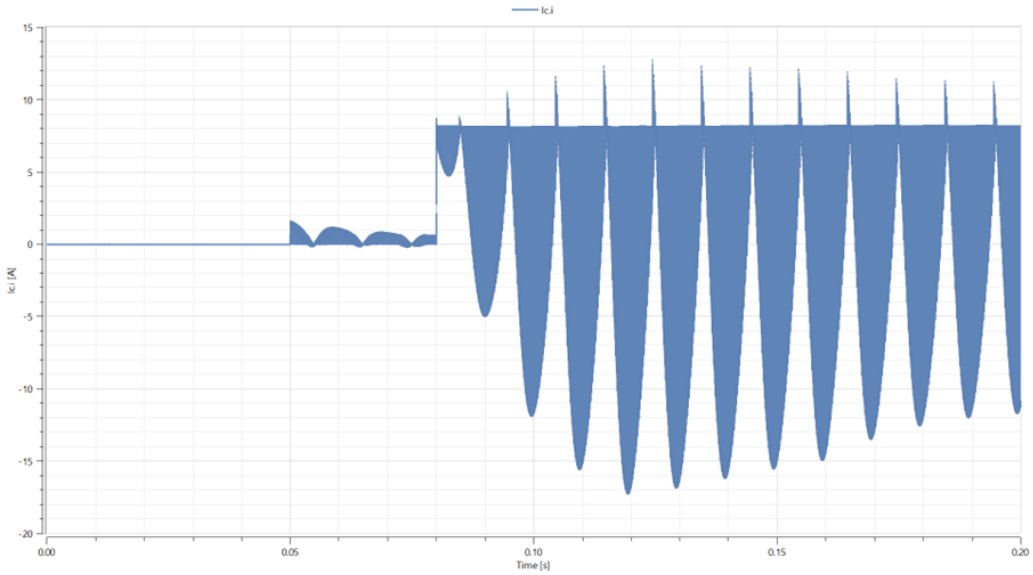


Figure 6: Unipolar $I_c$, current through capacitor, Sim Time = 0.2 s

### 1.3 Discussion

In both switching methods, the capacitor voltage (PV) were equal, see Figure 4 & 5 at 3. At time 0.05 s the H-bridge starts switching to produce a current. There are noticable harmonics. This frequency component can calculated by measuring its period, which inferred from Figure 3 is about 0.01 s. For wave relationship,

$$f = \frac{1}{T} \tag{1}$$

Therefore the frequency, $f$, is 100 $Hz$. This comes from the grid connected voltage. This is 50 $Hz$, that makes this signal, the second harmonic. The same frequency can be seen from the current plots, Figure 5. There is a distinct difference between the plots, due to the differnet switching modes, see Figure 6. This is expected, as harmonic disturbance should be less under unipolar switching. The greatest piece of evidence, can be inferred from the magnitudes of the current plots. As the magnitude of the harmonics is from 40 to -20 for bipolar and from 15 to -20 for unpolar.

## 2 Grid Connected Inverters

## 3 Space Vector Control System Design

# References