

Chapter 3. Bridge Circuits and Pulse-Width Modulation (PWM)

1. Switch mode converter example - DC/DC converter with resistive load

- 1) Make a new project.
- 2) Set step size as 1us in the simulation profile .

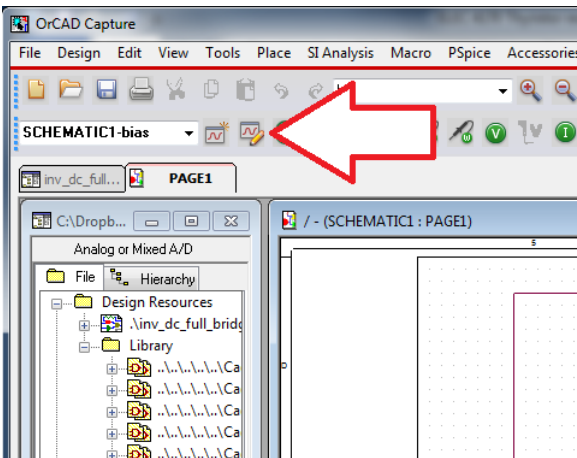


Figure 1

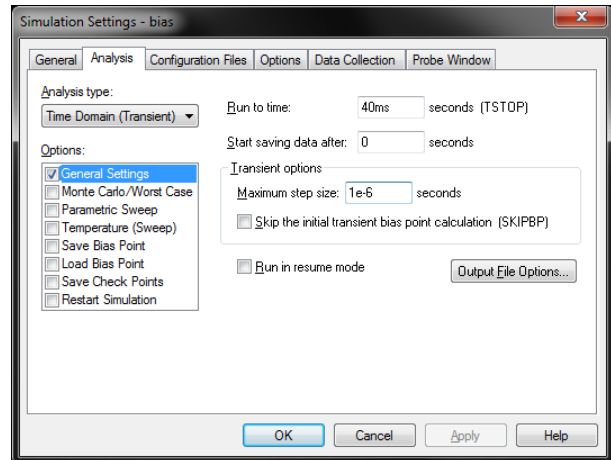


Figure 2

- 3) Open schematic page and build the following switch mode dc/dc converter using ADIODE, AIGBT, PWM, and TRIWAV module (Figure 3). PORTNO-L and PORTNO-R are used to connect gate signal and PWM output (Figure 4). Also use DC voltage sources and resistor under “Place – Pspice components...”.

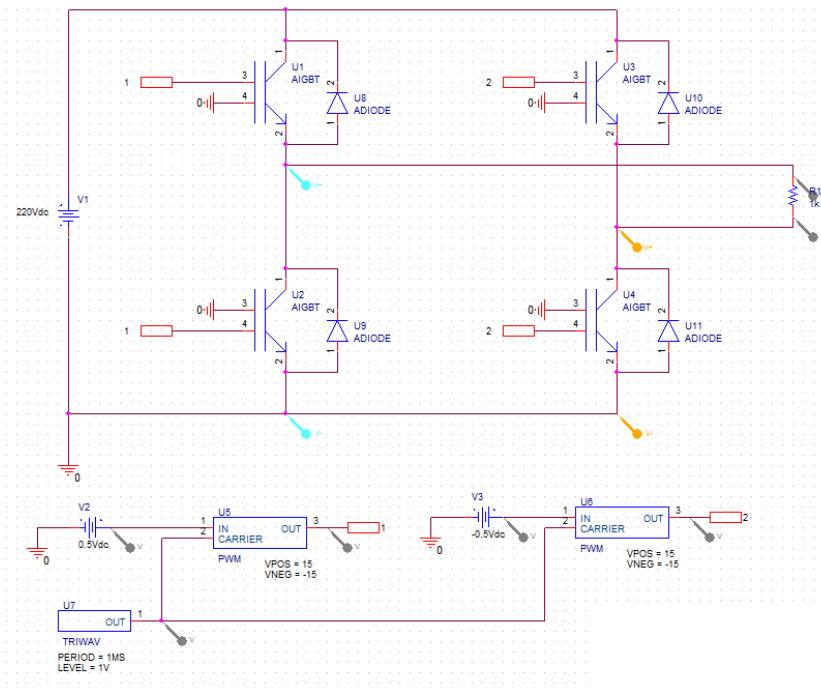


Figure 3

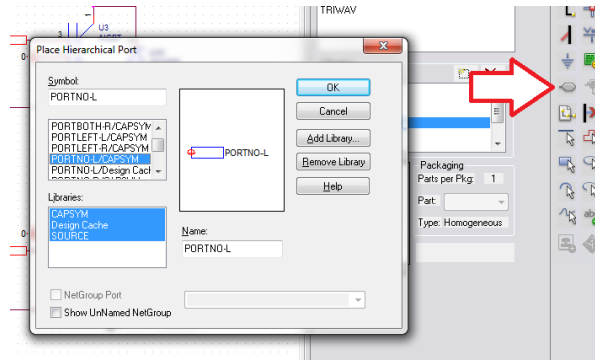


Figure 4

- 4) AIGBT and ADIODE are ideal devices.
- 5) TRIWAV generates a triangular carrier wave with the parameters shown. In this case, the period is 1ms (i.e., 1kHz) and the level is -1V to 1V. The reference signals are set to -0.5V and 0.5V to generate 50% duty ratio gate pulses. Note the carrier is bipolar (i.e., no ½ in the duty ratio expression).

$$v_o = v_{aN} - v_{bN}$$

$$v_{aN} = d_a V_d, v_{bN} = d_b V_d$$

- 6) PWM module compares signals of IN and CARRIER and generates outputs defined in parameters (VPOS and VNEG).
- 7) Reproduce Figure 5. Average output voltage is 110V and the duty ratio is 50%.

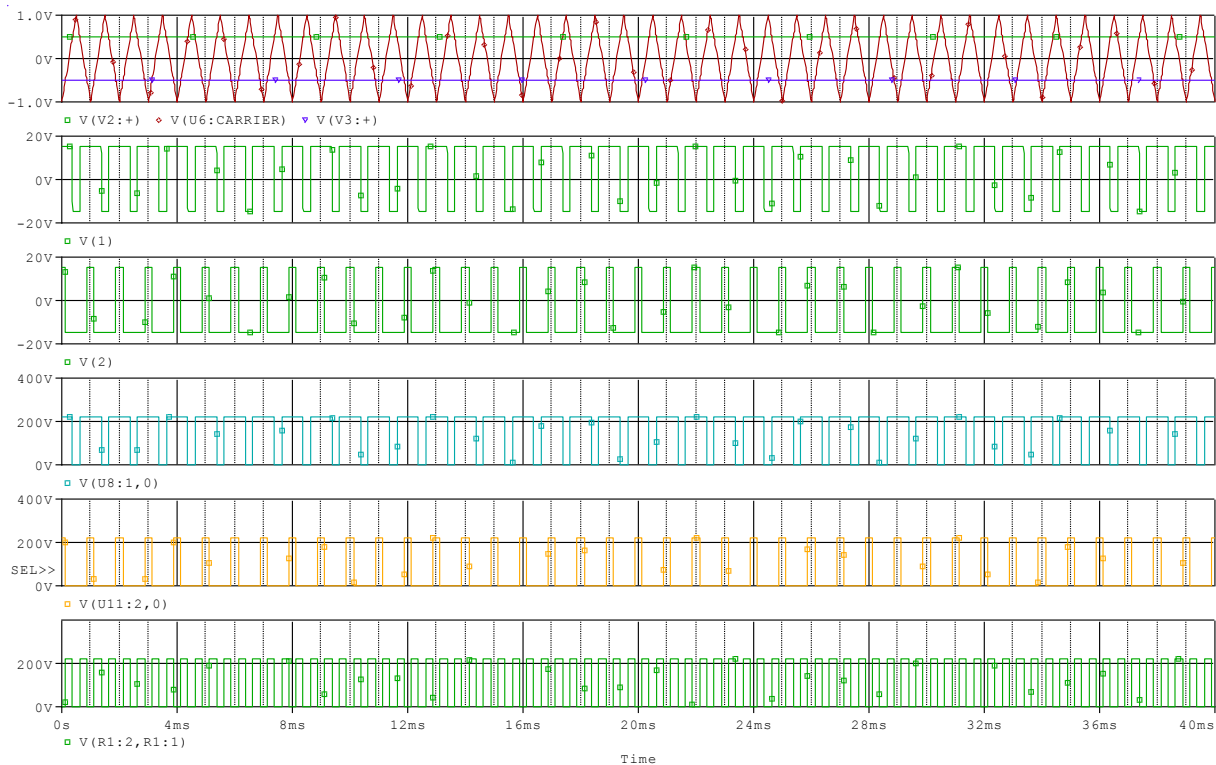


Figure 5

Task 1: DC/DC bridge circuit with series RL load

1. Make a new project. Use same simulation set up with the previous example.
2. Build a DC/DC bridge circuit with series RL load ($R = 10\Omega$, $L = 10\text{mH}$, $V_{dc} = 220\text{V}$) using ideal devices in ELEC4170_x.olb. Set reference signals for 50% duty ratio and output level of the PWM module as $\pm 15\text{V}$.
3. Plot signals in Figure 5 as well as load current. Reproduce Figure 6.
4. Include the schematic and output waveforms in your report and explain the result. Calculate the peak-to-peak ripple current and see it matches with simulation.

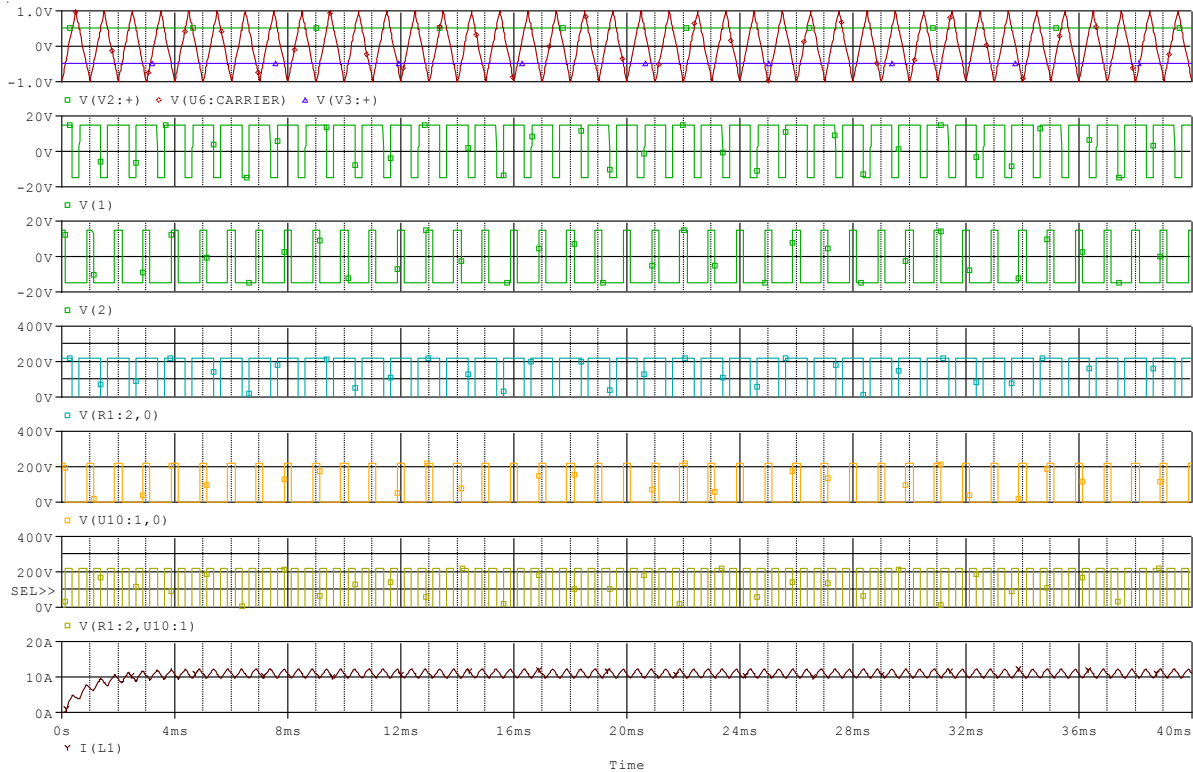


Figure 6

Task 2: Single-Phase DC/AC inverter with resistive load

1. Make a new project. Use same simulation set up with the previous example.
2. Build a DC/DC bridge circuit with series RL load ($R = 1k\Omega$, $V_{dc} = 220V$) using ideal devices in ELEC4170_x.olb. Set output level of the PWM module as $\pm 15V$.
3. Set reference signals for 198V peak, 60Hz output voltage. Make $v_{aN} = -v_{bN}$ so that $v_o = 2v_{aN}$.

$$v_{aN} = d_a \frac{V_d}{2}$$

4. Plot reference voltages, carrier wave, gate signals, and load voltage. Reproduce Figure 7.
5. Include the schematic and output waveforms in your report and explain the result.

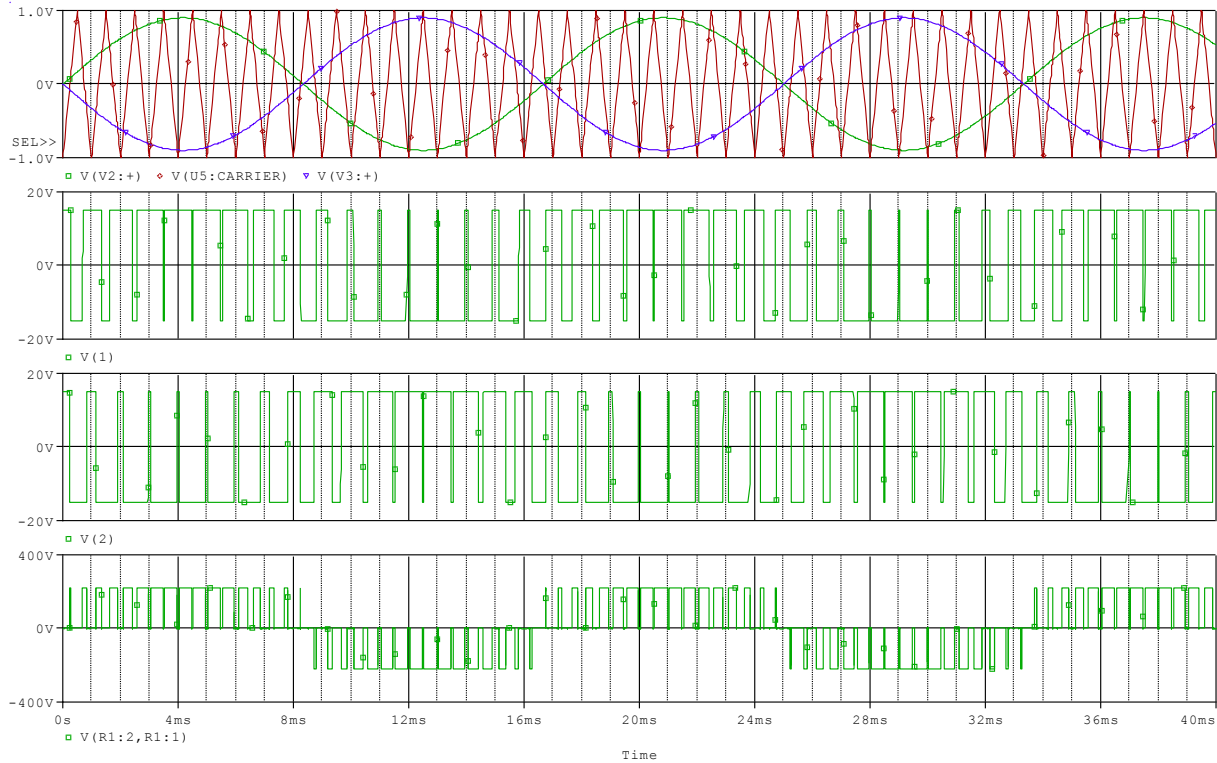


Figure 7

Task 3: Single-Phase DC/AC inverter with series RL load

1. Make a new project. Use same simulation set up with the previous example.
2. Build a DC/DC bridge circuit with series RL load ($R = 0.5\Omega$, $L = 10\text{mH}$, $V_{dc} = 220\text{V}$) using ideal devices in ELEC4170_x.olb. Set output level of the PWM module as $\pm 15\text{V}$.
3. Set reference signals for 198V peak, 60Hz output voltage.
4. Plot reference voltages, carrier wave, gate signals, load voltage and current. Reproduce Figure 8.
5. Include the schematic and output waveforms in your report and explain the result.

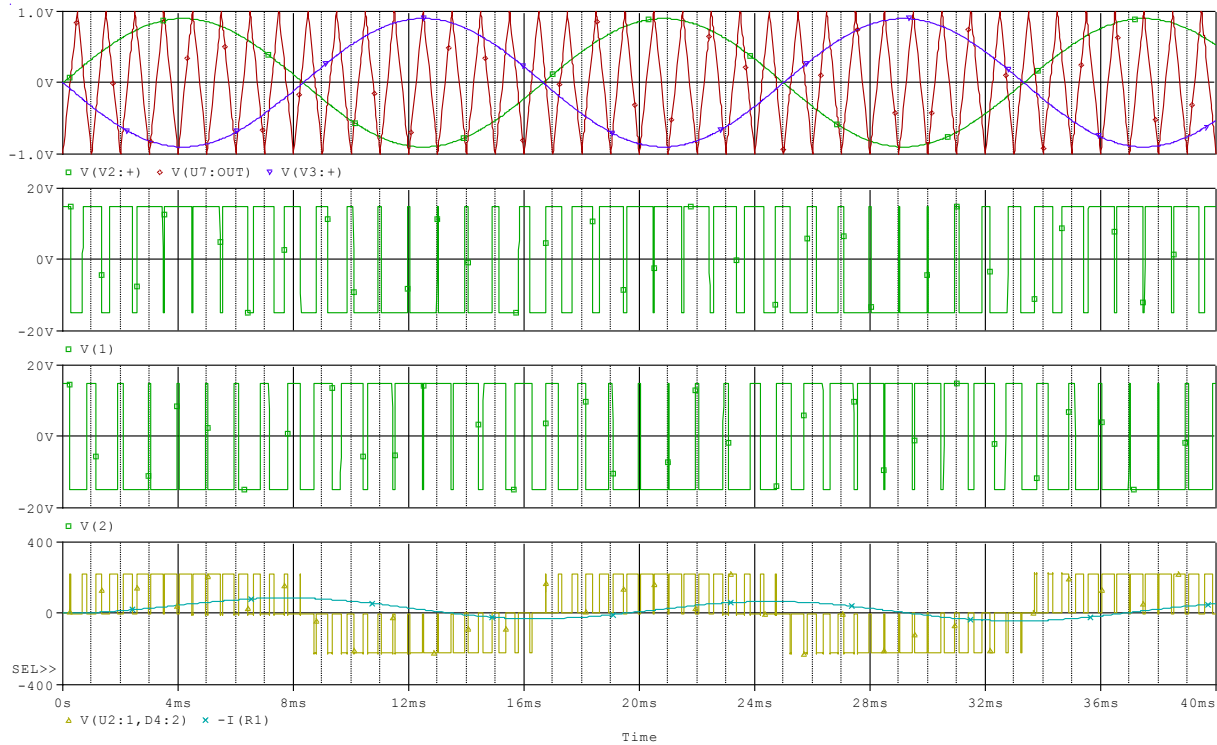


Figure 8

Task 4: Three-Phase DC/AC inverter with resistive load

1. Make a new project. Use same simulation set up with the previous example.
2. Open the schematic page and enlarge the page size to “B” (Figure 9, Figure 10).

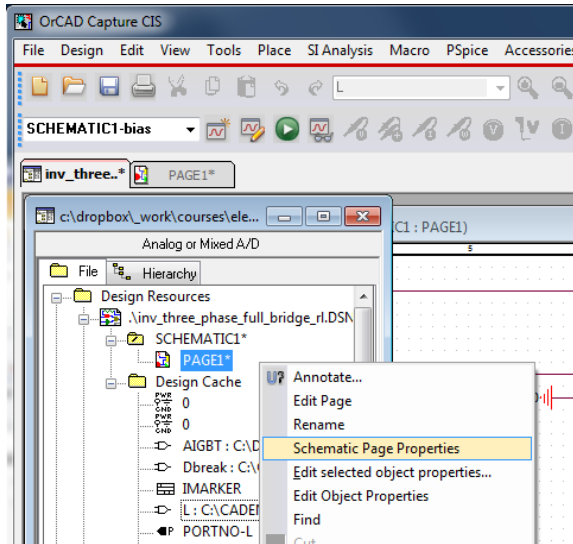


Figure 9

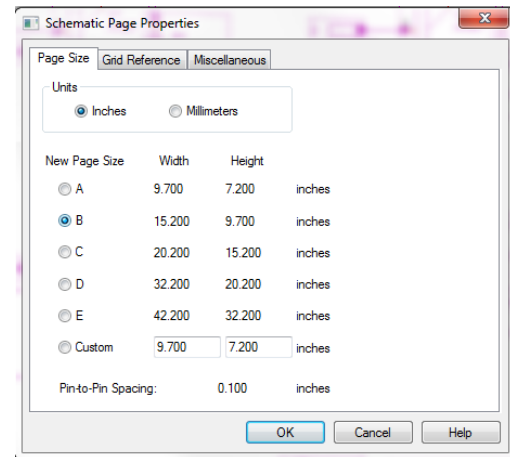


Figure 10

3. Build a DC/DC bridge circuit with three-phase balanced Y-connected resistive load ($R = 0.5\Omega$, $V_{dc} = 220V$) using ideal devices in ELEC4170_x.olb. Set output level of the PWM module as $\pm 15V$.
4. Set reference signals for 198V peak, 60Hz (phase-to-neutral) voltages.

$$v_{an} = v_{aN} = d_a \frac{V_d}{2}$$

5. In case you encounter convergence error, turn on the autoconverge option (Figure 11) and click “OK”. Then restart the simulation.

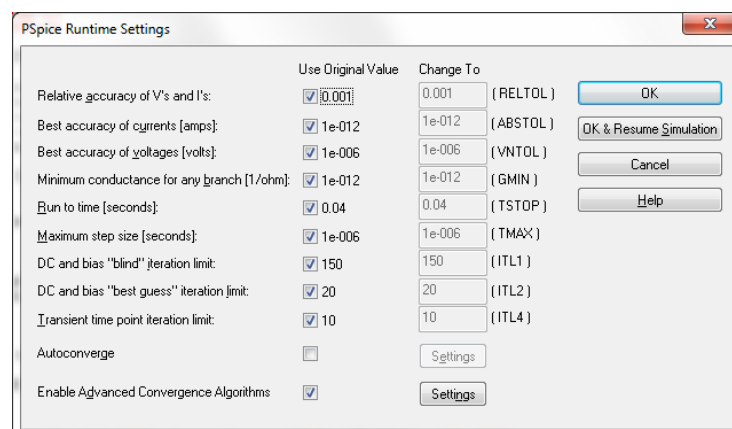


Figure 11

6. Plot reference voltages, carrier wave, gate signals, phase-to-neutral and line-to-line load voltages. Reproduce Figure 12, Figure 13 and Figure 14.
7. Include the schematic and output waveforms in your report and explain the result.

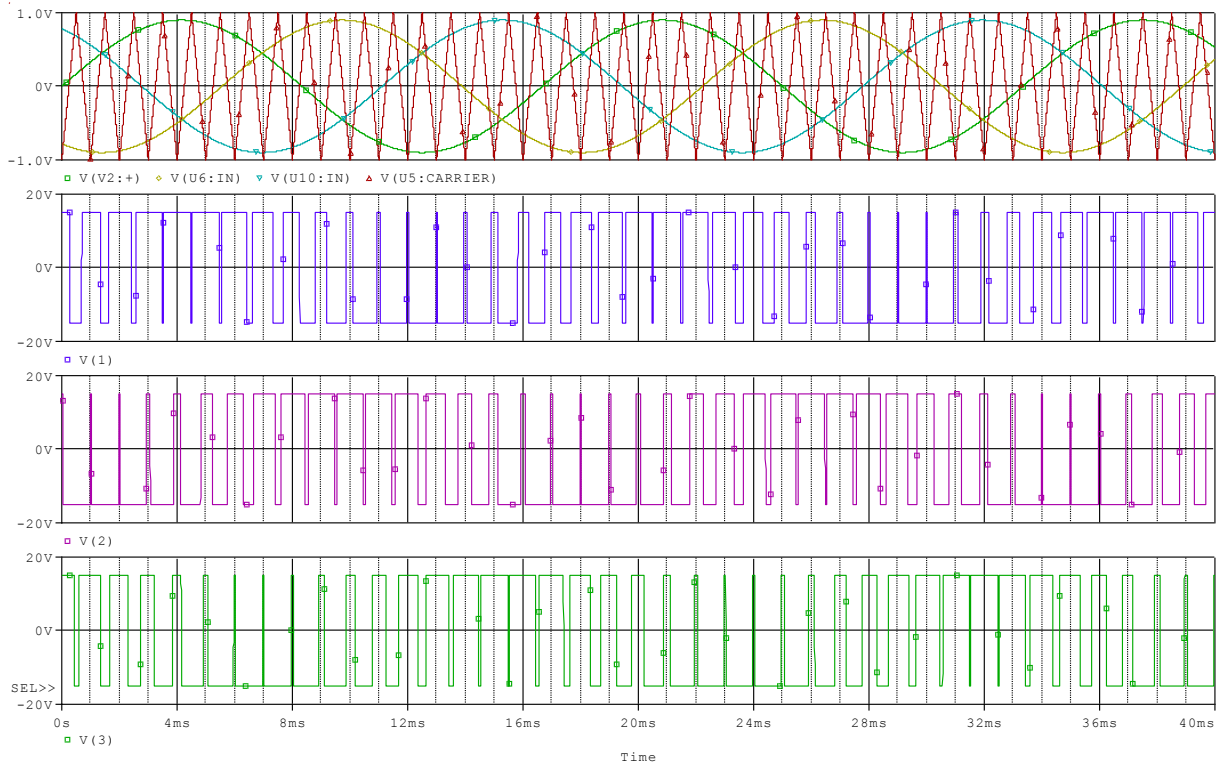


Figure 12

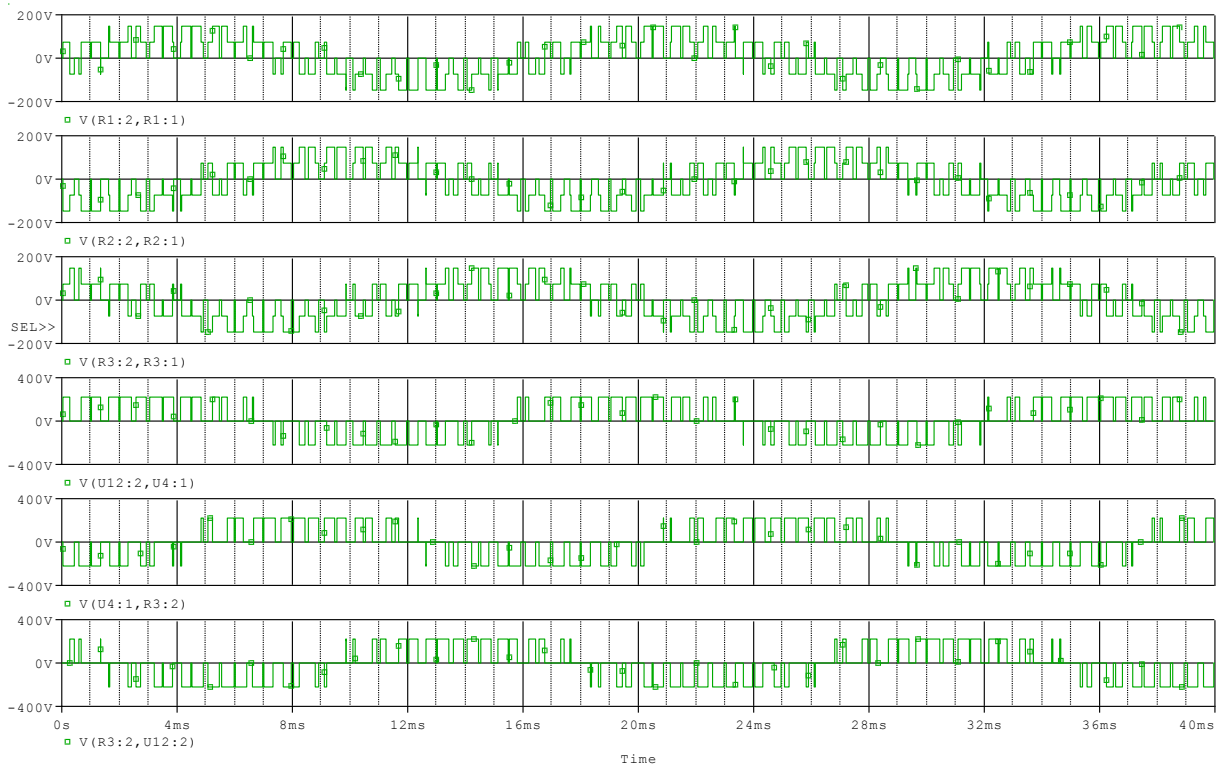


Figure 13

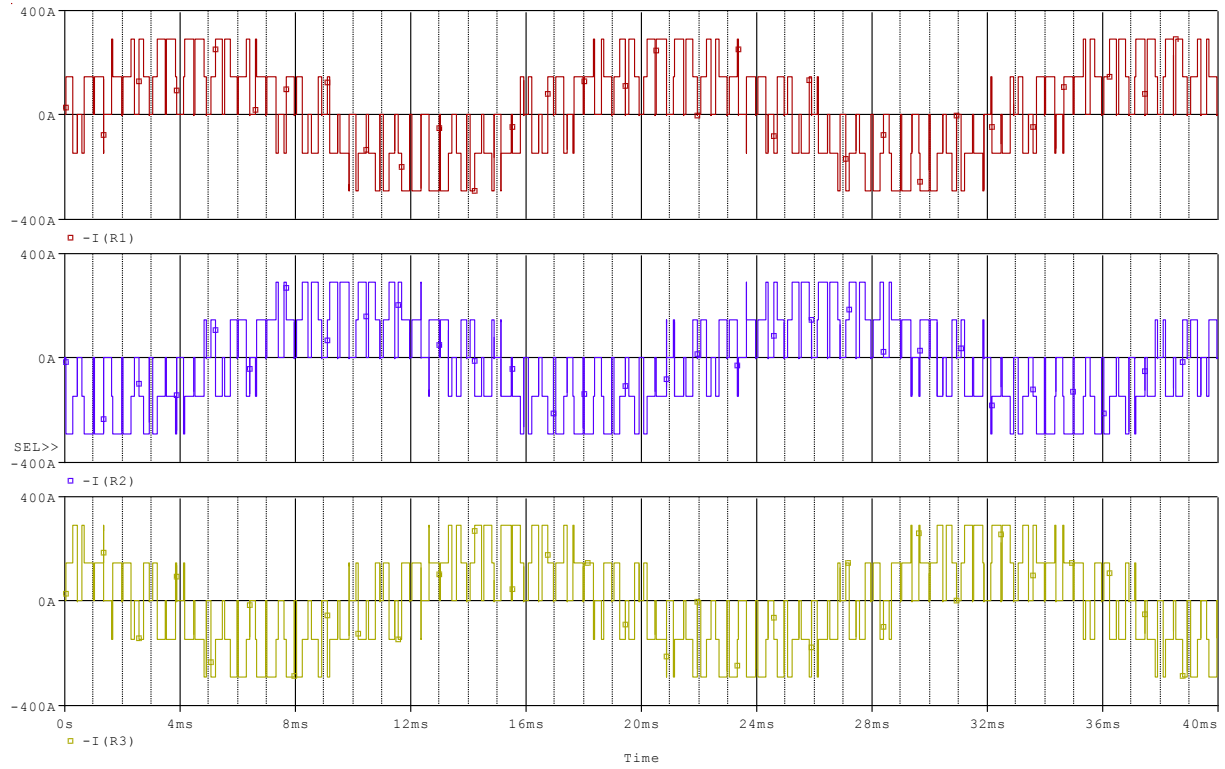


Figure 14

Task 5: Three-Phase DC/AC inverter with series RL load

1. Make a new project. Use same simulation set up with the previous example.
2. Build a DC/DC bridge circuit with three-phase balanced Y-connected resistive load ($R = 0.5\Omega$, $L = 10\text{mH}$, $V_{dc} = 220\text{V}$) using ideal devices in ELEC4170_x.olb. Set output level of the PWM module as $\pm 15\text{V}$.
3. Set reference signals for 198V peak, 60Hz (phase-to-neutral) voltages.

$$v_{an} = v_{aN} = d_a \frac{V_d}{2}$$

4. Plot reference voltages, carrier wave, gate signals, phase-to-neutral and line-to-line load voltages, and line current. Reproduce Figure 15, Figure 16, and Figure 17.
5. Include the schematic and output waveforms in your report and explain the result.

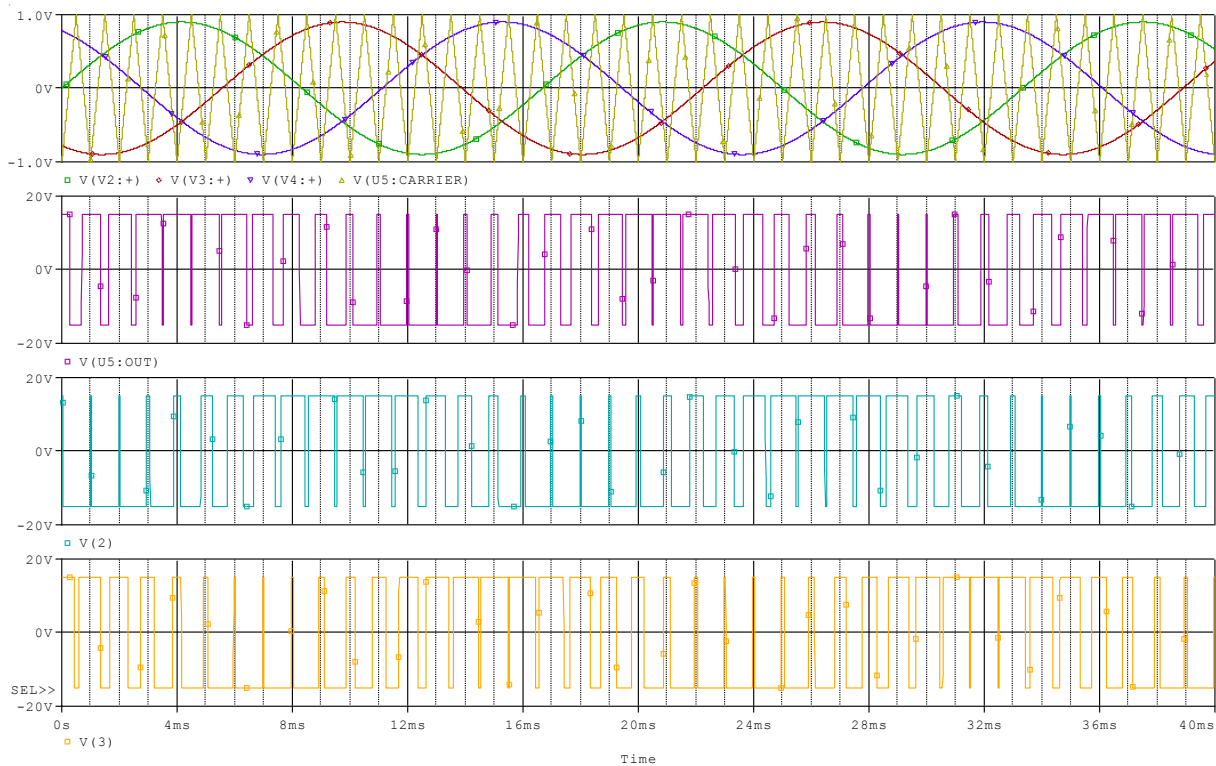


Figure 15

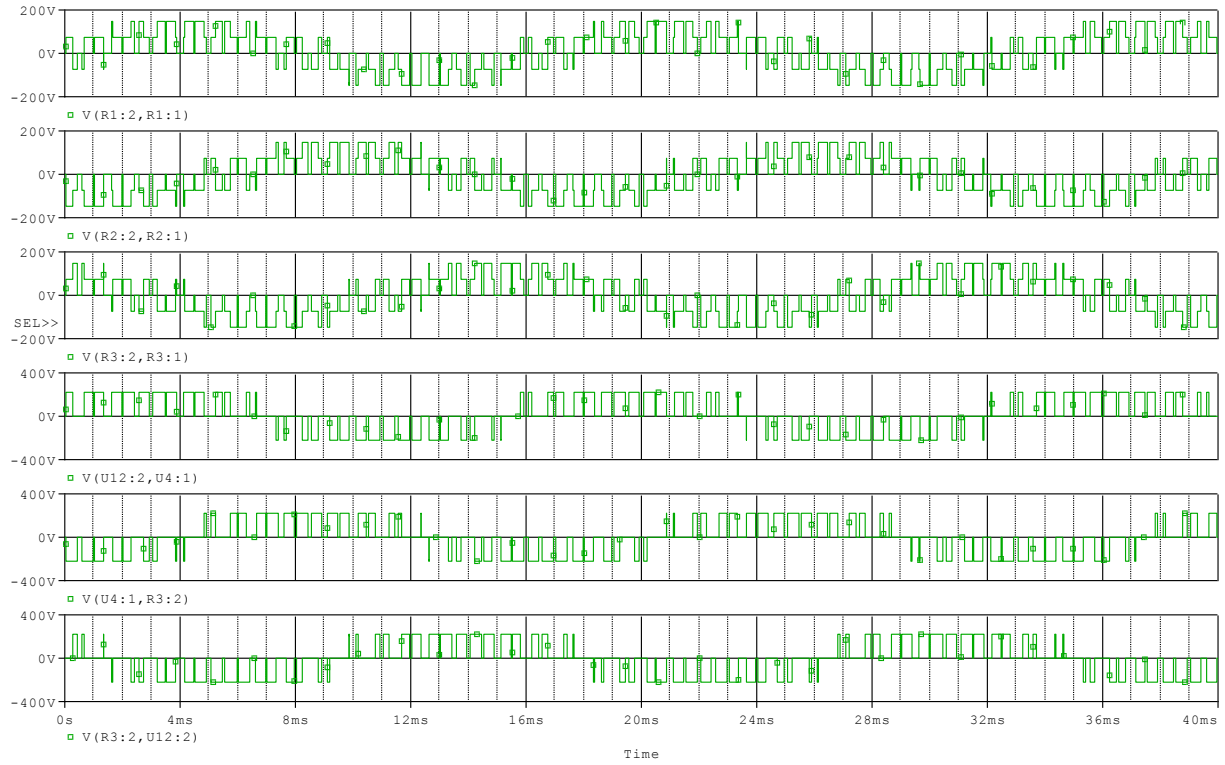


Figure 16

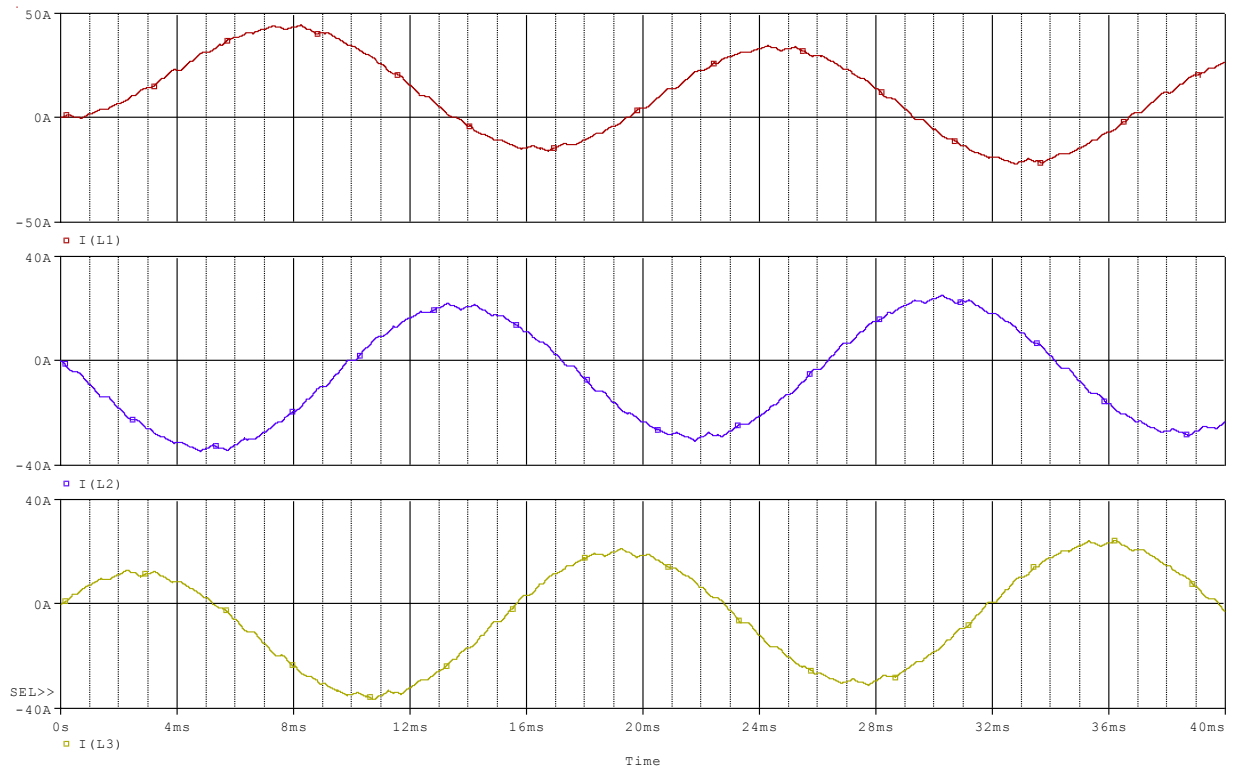


Figure 17