DC−AC Converter (PE_1ph_VSI_4.sqproj)

Question: A single phase full−bridge voltage source inverter (VSI) is shown in Fig 1. It is controlled by using pulse−width modulation (PWM) technique with one pulse per half cycle. The desired fundamental frequency is 50 Hz. Determine

(i) the required approximate pulse−width so that the fundamental RMS component of the output voltage is 70% of the dc input voltage. Find the corresponding RMS output voltage.

(ii) the required pulse width so that the fifth harmonic in the output voltage waveform is eliminated.

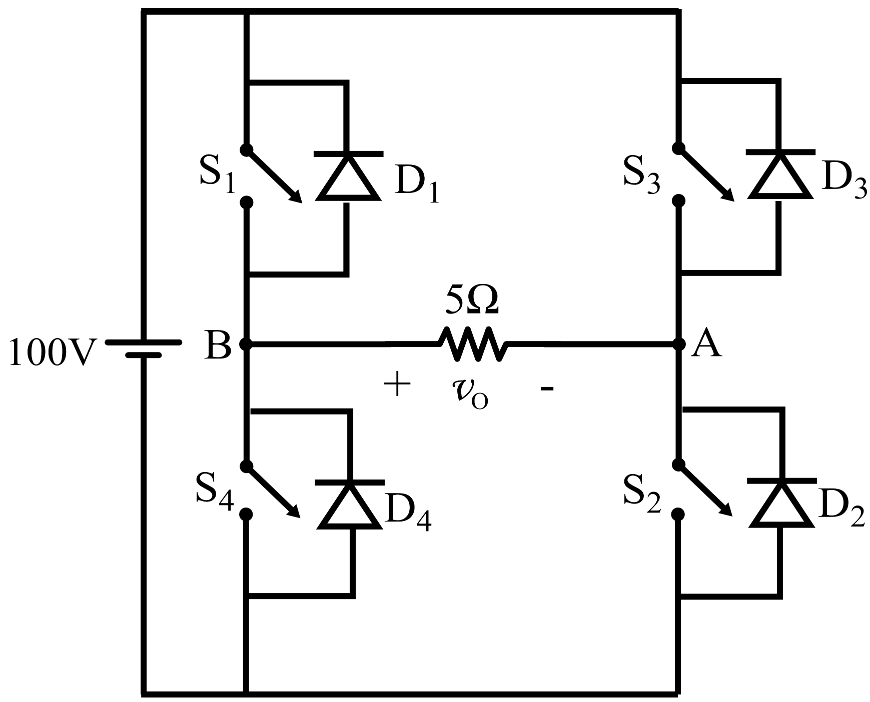

Figure 1: Full bridge inverter

Solution :

PWM techniques are employed for the control of output voltage. In PWM method, width of the output voltage gets modulated while maintaining amplitude as constant.

Operation : For a resistive load, when the switches S_1, S_2 are ON, the voltage across load (v_o) is positive and hence the current (i_o) is positive. Similarly, when the switches S_3, S_4 are ON, the voltage across load (v_o) is negative and hence the current (i_o) is negative. Diodes will not conduct in this case. The width of the output pulse can be controlled by varying the ON and OFF duration of switches.

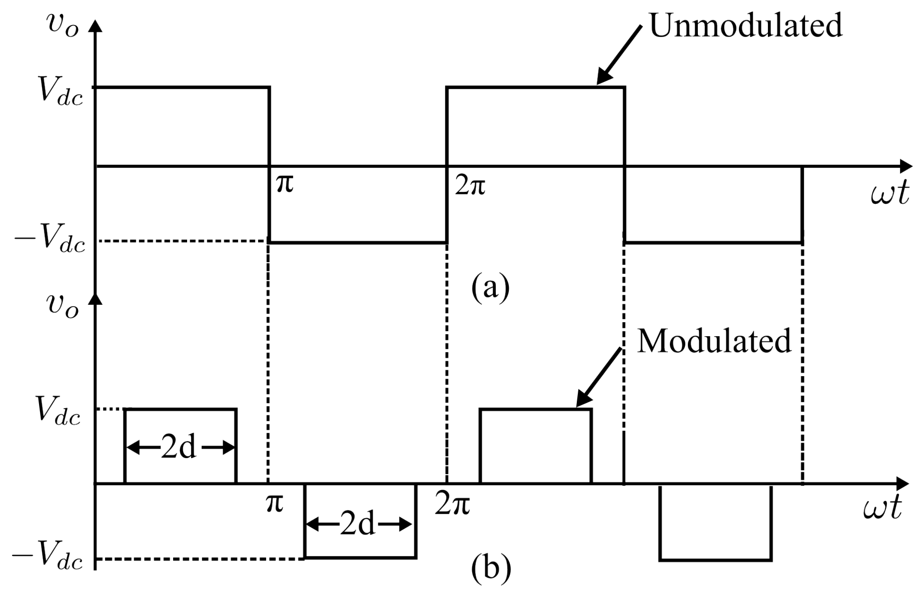

Figure 2: Output voltage waveforms (a) Unmodulated (b) Modulated

RMS value of output voltage is given by

$$V_o^{\text{rms}} = \sqrt{\frac{1}{\pi} \sum_{\pi/2-d}^{\pi/2+d} V_{dc}^2 \, d\,(\omega\, t)}$$

$$\therefore (V_o^{\text{rms}})^2 = \frac{V_{dc}^2 \; 2d}{\pi} \qquad \Longrightarrow \qquad V_o^{\text{rms}} = \sqrt{\frac{V_{dc}^2 \; 2d}{\pi}}$$

The modulated voltage waveform is shown in Fig. 2 (b). The waveform has half-wave symmetry. Hence the Fourier series consists of odd harmonic terms alone. Also, the waveform is an odd periodic signal, i.e., only the sine terms of the Fourier series exist.

Therefore, the trigonometric Fourier series representation of the waveform is given by the eqn. 1.

$$v_o\,(\omega t) = \sum_{n=1,3,5....}^{\infty} \left[\frac{4\,V_{dc}}{n\,\pi}\sin\frac{n\pi}{2}\sin nd\right]\sin n\omega t \tag{1}$$

$\therefore$ RMS value of the fundamental component,

$$V_{01}^{\text{rms}} = \frac{\left[\dfrac{4\,V_{dc}}{\pi}\sin\dfrac{\pi}{2}\sin d\right]}{\sqrt{2}}$$

(i) $$V_{01}^{\text{rms}} = \frac{4\,V_{dc}}{\sqrt{2}\,\pi}\sin d = 0.7\,V_{dc} \qquad \Longrightarrow \qquad d = 51.05^{\circ}$$

$$\therefore \text{Pulse-width } 2d = 102^{\circ} \qquad , \qquad V_o^{\text{rms}} = \sqrt{\frac{100^2 \times (102^{\circ} \times \dfrac{\pi}{180^{\circ}})}{\pi}} = 75.27\,\text{V}$$

(ii) By properly selecting the width of the pulse, one of the harmonic in output waveform can be eliminated. It is possible only when amplitude of waveform becomes zero for that value of 'n'.

$$\text{i.e., } \sin nd = 0 \Longrightarrow nd = \pi \Longrightarrow d = \frac{\pi}{n}$$

To eliminate the fifth harmonic, $d = \dfrac{180^{\circ}}{5} = 36^{\circ}$ $\qquad \therefore$ Pulse width $2d = 72^{\circ}$

SequelApp Exercises:

(1) A single phase full−bridge VSI has input voltage of 50 V and load resistance of 10 Ω. It is controlled by using PWM with one pulse per half cycle. If the 3rd harmonic is to be eliminated, find the fundamental RMS component of the output voltage. The desired fundamental frequency is 50 Hz.

Verify your answer using SequelApp.