DC−AC Converter `(PE_1ph_VSI_2.sqproj)`

Question: A single-phase half−bridge voltage source inverter (VSI) shown in Fig. 1 drives an RL series load with $R = 3\,\Omega$ and $L = 5\,\text{mH}$. The input dc voltage $V_{dc} = 100\,\text{V}$ and the desired fundamental frequency is 50 Hz. Determine

(i) % THD of the output voltage waveform.

(ii) RMS output current at fundemental frequency

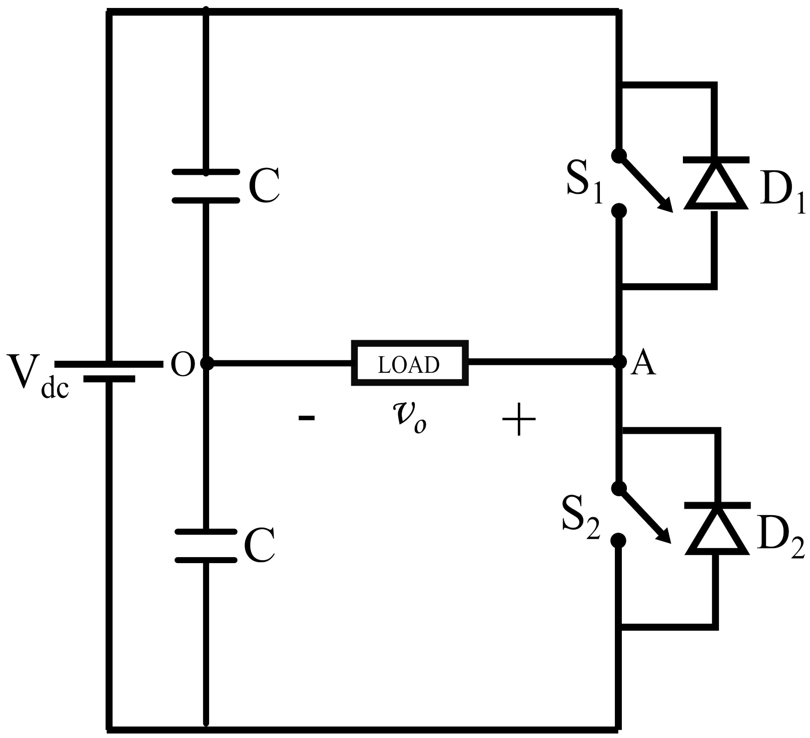

Figure 1: Half−bridge inverter

Solution :

For an unmodulated voltage source inverter, the v_o waveform is half wave symmetrical square, irrespective of the type of load. Therefore, the pattern of conduction of switches and diodes should be as follows.

	v_o	i_o
S_1	$+$	$+$
D_1	$+$	$-$
S_2	$-$	$-$
D_2	$-$	$+$

Assume that the inductor has some stored energy initially.

Operation: When the diode D_1 is ON ($0 < t < t_1$) and when the switch S_1 is ON ($t_1 < t < \frac{T}{2}$), the output voltage is positive. The inductor is storing energy from $0 < t < \frac{T}{2}$. Similarly, when the diode D_2 is ON ($\frac{T}{2} < t < t_2$) and when the switch S_2 is ON ($t_2 < t < T$), the output voltage is negative. The inductor is releasing energy from $\frac{T}{2} < t < T$.

(i) v_o waveform as shown in Fig. 2 (a).

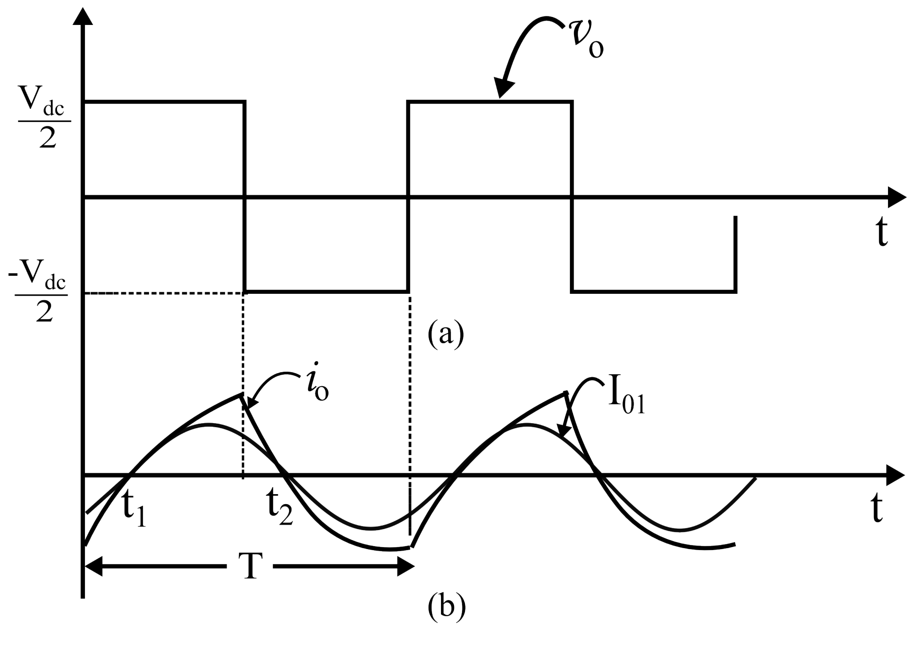

Figure 2: Output voltage and current waveforms

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.

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

The RMS output voltage at the fundamental frequency $(\mathrm{V}_{01}) = \dfrac{4}{\sqrt{2}\pi} \times \dfrac{100}{2} = 45\,\mathrm{V}$

For a square waveform, the RMS value and the magnitude of waveform are equal.

$$\therefore V_o^{\text{rms}} = V_{dc} = 50\,\mathrm{V}$$

The total harmonic distortion (THD) is a measurement of the harmonic distortion present in a signal and is given by

$$\%\text{THD} = \sqrt{\frac{(V_o^{\text{rms}})^2 - V_{01}^2}{V_{01}^2}} = 48.43\%$$

NB : % THD of a square waveform is always 48.43% irrespective of magnitude.

(ii) The load current waveform (i_o) is shown in Fig. 2 (b). The desired fundamental frequency is 50 Hz and therefore the fundamental load impedance (Z_{L1}) is given by

$$Z_{L1} = \sqrt{R_1^2 + (2\pi f_1 L)^2} = 3.386\,\Omega$$

The fundamental load current (I_{01}) component is given by

$$I_{01} = \frac{(4\,.\frac{V_{dc}}{2\pi})\,\sin\,(\omega_1 t - \Phi_1)}{Z_{L1}} \quad , \quad \text{where} \quad \Phi_1 = \tan^{-1}\left(\frac{X_{L1}}{R}\right)$$

$$= \frac{\frac{400}{2\pi}\,\sin\,(\omega_1 t - \Phi_1)}{3.386}$$

$\therefore$ The fundamental RMS output current is given by

$$I_{01}^{\text{rms}} = \frac{400}{2\sqrt{2}\pi \times 3.386} = 13.29\,\mathrm{A}$$

SequelApp Exercises:

(1) In a half-bridge VSI, with series RL load, if $R = 2\,\Omega$, find the value of inductor such that fundamental RMS output current is 20 A. The desired fundamental frequency is 50 Hz. (Take $V_{dc} = 120\,\mathrm{V}$)

Verify your answer using SequelApp.