Example: A single-phase inverter shown in figure (3.1a) supplies a 10 ohm resistance with inductance 50 mH from a 340 V dc source. If the bridge is operating at 50 Hz, determine the load rms voltage and steady-state current waveforms with

(a) a square-wave output.

(b) a quasi-square-wave output with a 50 percent on time.

Solution

(a)

$$V_{Lrms} = +V_s = 340\ V$$

$$I_1 = -I_o = \frac{V_s}{R}\,\frac{1-e^{-\frac{R}{L}t_1}}{1+e^{-\frac{R}{L}t_1}}$$

$$f = 50\ Hz \Rightarrow t_2 = \frac{1}{f} = \frac{1}{50} = 20ms$$

$$t_1 = 0.5 t_2$$

$$= 0.5 \times 20m = 10\ msec$$

$$\therefore I_1 = -I_o = \frac{340}{10}\,\frac{1-e^{-\frac{10}{50\times10^{-3}}\times10\times10^{-3}}}{1+e^{-\frac{10}{50\times10^{-3}}\times10\times10^{-3}}}$$

$$= 34\,\frac{1-e^{-2}}{1+e^{-2}}$$

$$= 25.9\ A$$

$$t_x = \frac{L}{R}\ln\left(1-\frac{I_oR}{V_s}\right)$$

$$= \frac{50\times10^{-3}}{10}\ln\left(1-\frac{-25.9\times10}{340}\right)$$

$$= 2.83\ msec$$

when $v_L = V_s = 340$: $i_L = \frac{V_s}{R} - \left(\frac{V_s}{R} - I_o\right)e^{-\frac{R}{L}t}$

$$\therefore i_L = \frac{340}{10} - \left(\frac{340}{10} + 25.9\right)e^{-200t} = 34 - 59.9\,e^{-200t}$$

When $V_L = -V_s = -340V$: $i_L = -\frac{V_s}{R} + (\frac{V_s}{R} + I_1)e^{-\frac{R}{L}t}$

$\therefore i_L = -\frac{340}{10} + (\frac{340}{10} + 25.9)e^{-200t} = -34 + 59.9\,e^{-200t}$ A

The mean power delivered to load $= P_L = \frac{1}{t_1}\int_0^{t_1} V_s\, i_L\, dt$

$$\therefore P_L = \frac{1}{10\times10^{-3}}\int_0^{10m} 340\times(34 - 59.9e^{-200t})\,dt$$

$$= \frac{340}{10\times10^{-3}}\left(34t + \frac{59.9e^{-200t}}{200}\right)_0^{10\times10^{-3}}$$

$$= \frac{340}{10\times10^{-3}}\left(34\times10\times10^{-3} + \frac{59.9e^{-200\times10\times10^{-3}}}{200} - \frac{59.9}{200}\right)$$

$= 2755$ W

(b)

Since the operation is with 50 percent on-time hence:

$t_o = \frac{50}{100}\times t_1 = 0.5\times 10m = 5msec$

$\alpha = \frac{\pi}{2}$

$V_{Lrms} = V_s\sqrt{1-\frac{\alpha}{\pi}} = V_s\sqrt{1-\frac{0.5\pi}{\pi}} = V_s\sqrt{\frac{1}{2}} = \frac{V_s}{\sqrt{2}} = \frac{340}{\sqrt{2}} = 240.4\,V$

The steady-state load current is reached after few cycles:-

First 5 ms on-period when $V_L = 340V$:-

$i_L = \frac{V_s}{R} - (\frac{V_s}{R} - I_o)e^{-\frac{R}{L}t}$, $I_o = 0 \Rightarrow i_L = \frac{V_s}{R} - \frac{V_s}{R}e^{-\frac{R}{L}t}$

$\therefore i_L = 34 - 34e^{-200t}$ and at $t = 5ms \Rightarrow i_L = 34 - 34e^{-200\times5m} = 21.5$ A

$\Rightarrow I_1 = 21.5$ A

First 5ms zero period when $v_L = 0\,V$:-

$$i_L = I_1 e^{-\frac{R}{L}t} = 21.5\, e^{-200t} \quad \text{ending with } i_L = 21.5\, e^{-200\times 5m} = 7.9\,A$$

i.e $I_2 = 7.9\,A$

Second 5ms on period when $v_L = -340\,V$:-

$$i_L = -\frac{V_s}{R} + \left(\frac{V_s}{R} + I_2\right) e^{-\frac{R}{L}t} = -34 + (34 + 7.9)\, e^{-200t}$$

$$= -34 + 41.9\, e^{-200t} \quad \text{ending with } i_L = -34 + 41.9\, e^{-200\times 5m} = -18.6\,A$$

Second 5 ms zero period when $v_L = 0\,V$:-

$$i_L = I_1 e^{-\frac{R}{L}t} = -18.6\, e^{-200t} \quad \text{ending with } i_L = -18.6\, e^{-200\times 5m} = -6.8\,A$$

$\therefore I_o = -6.8\,A$

Third 5 ms on period when $v_L = 340\,V$:-

$$i_L = \frac{V_s}{R} - \left(\frac{V_s}{R} - I_o\right) e^{-\frac{R}{L}t} = 34 - (34 + 6.8)\, e^{-200t} = 34 - 40.8\, e^{-200t}$$

ending with $i_L = 19\,A$ i.e $I_1 = 19\,A$

Third 5ms zero perid when $v_L = 0\,V$:-

$$i_L = I_1 e^{-\frac{R}{L}t} = 19\, e^{-200t} \quad \text{ending with } i_L = 19\, e^{-200\times 5m} = 7\,A$$

Fourth 5ms on period when $v_L = 340\,V$:-

$$i_L = -34 + (34 + 7)\, e^{-200t} \quad \text{ending with } i_L = -18.9\,A$$

fourth 5ms zero period when $v_L = 0\,V$:-

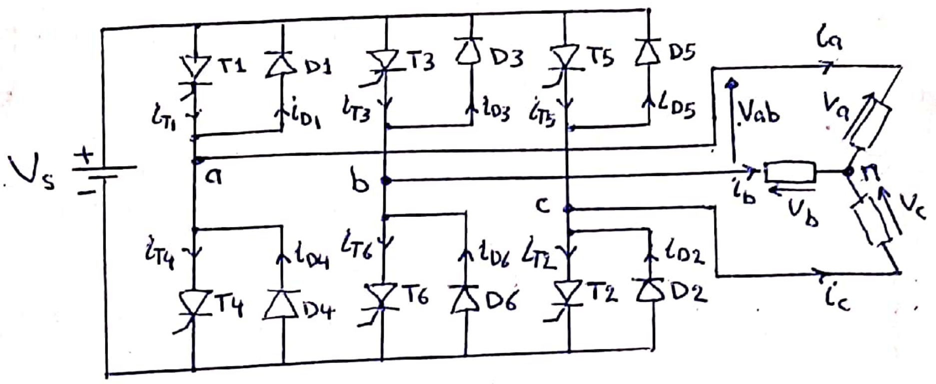
$$i_L = -18.9\, e^{-200t} \quad \text{ending with } i_L = 7\,A$$

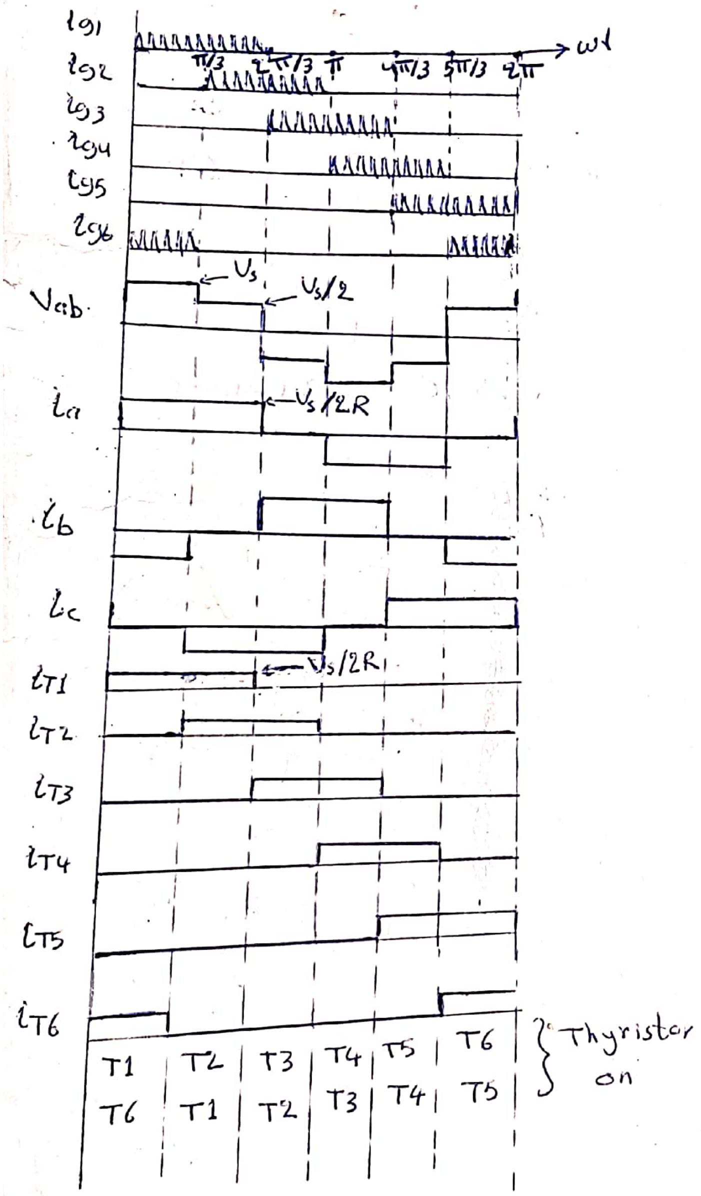
steady-state load current have been reached.

$$P_L = \frac{1}{t_1}\int_0^{t_0} V_s\, i_L\, dt = \frac{1}{0.01}\int_0^{0.005} 340\,\{340 - 41\, e^{-200t}\} = 1378\,W$$

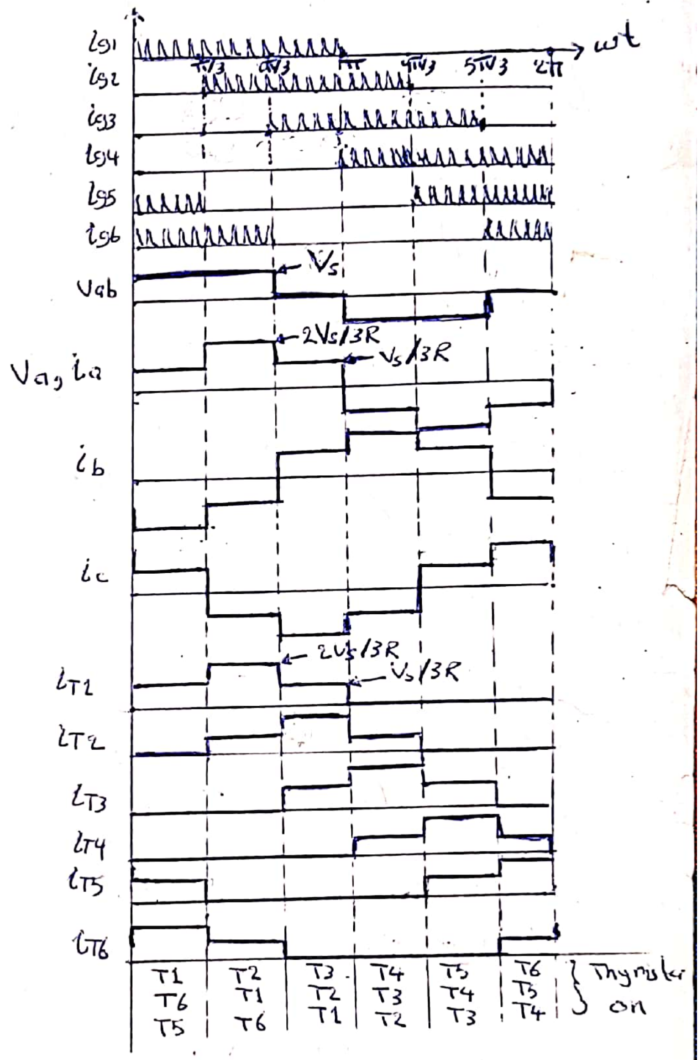
3.3 Three-phase bridge inverter

(a)





(b)
waveforms for 120° conduction & resistive load



(c)
waveforms for 180° conduction & resistive load

Figure (3-2)