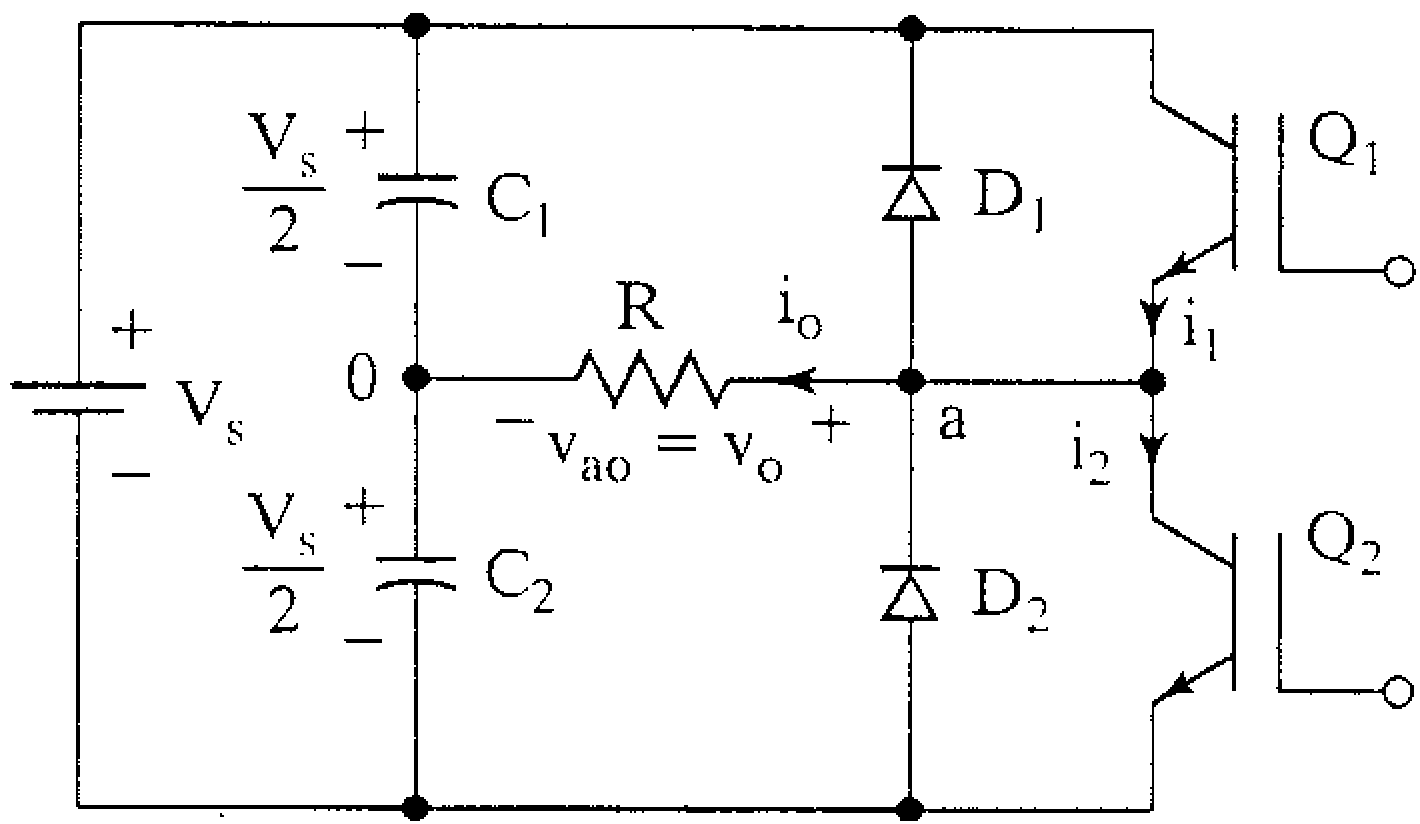
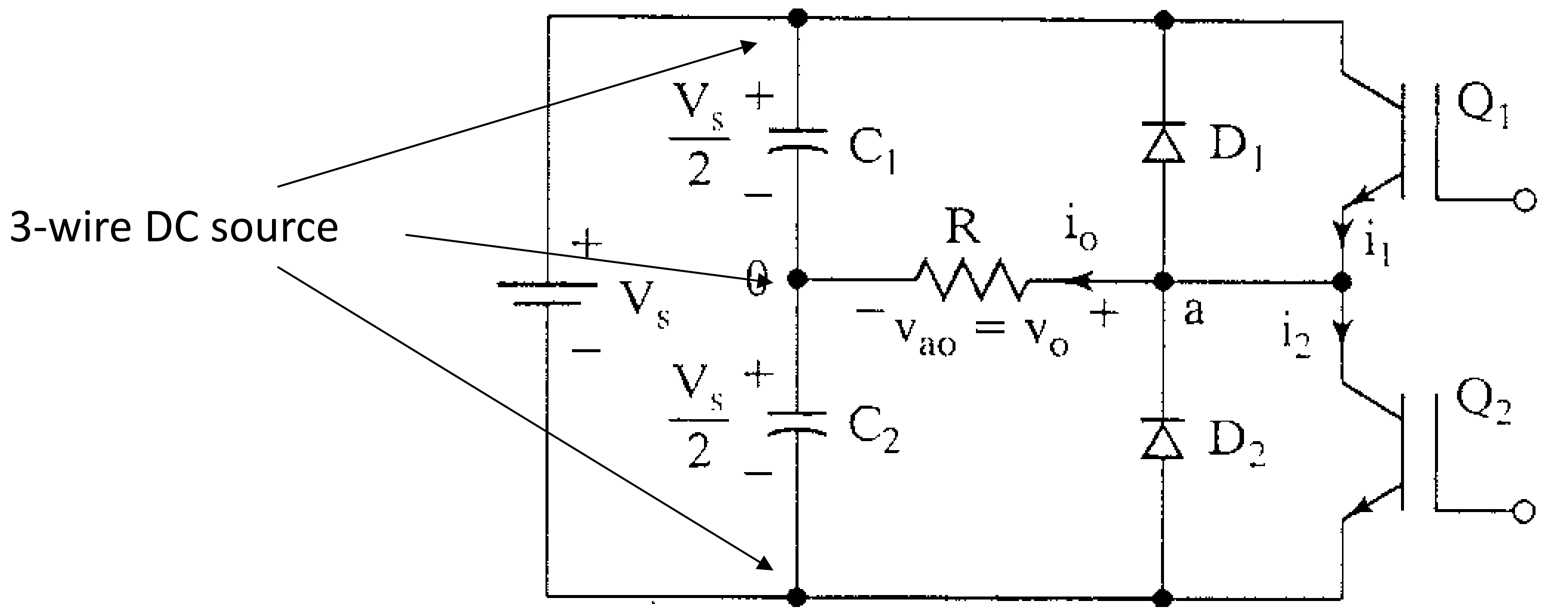
Single-phase half-bridge inverter

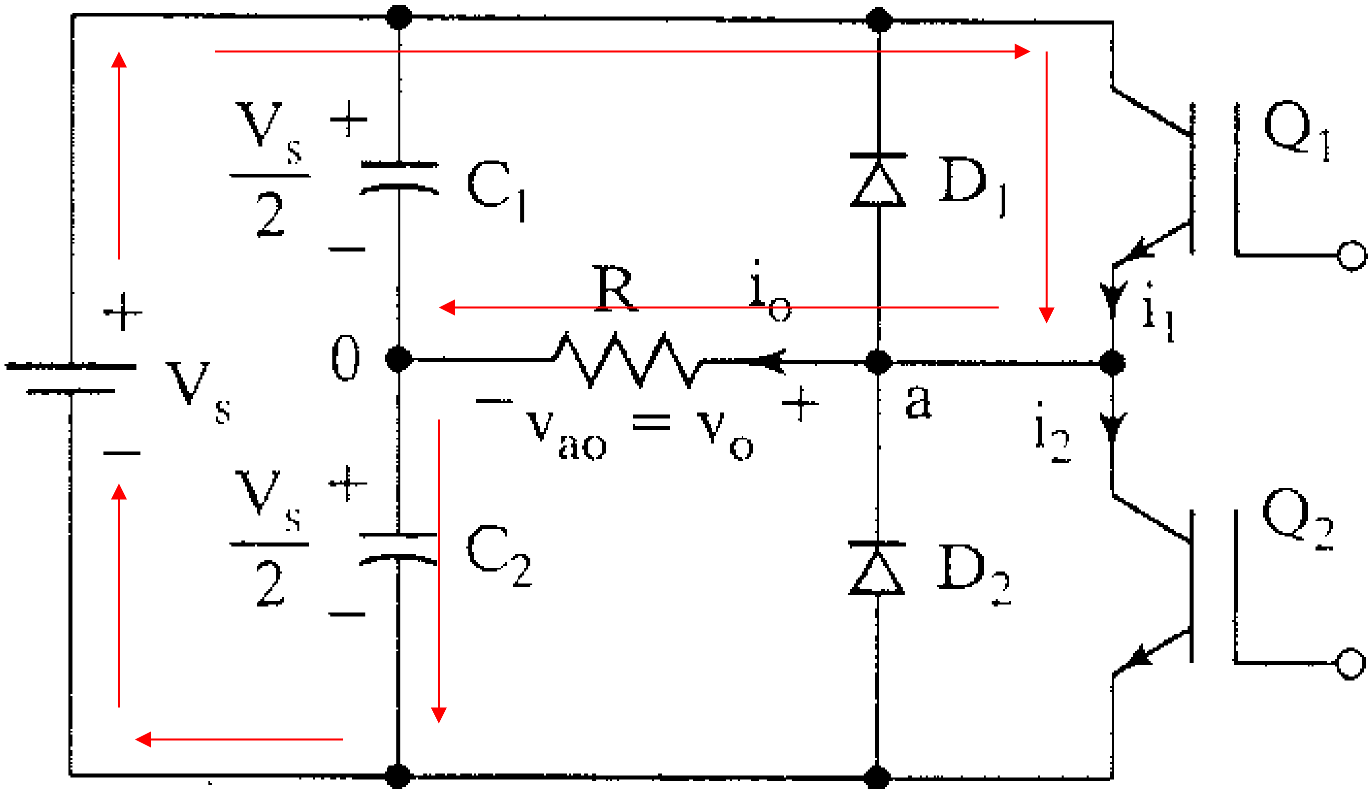


Operational Details



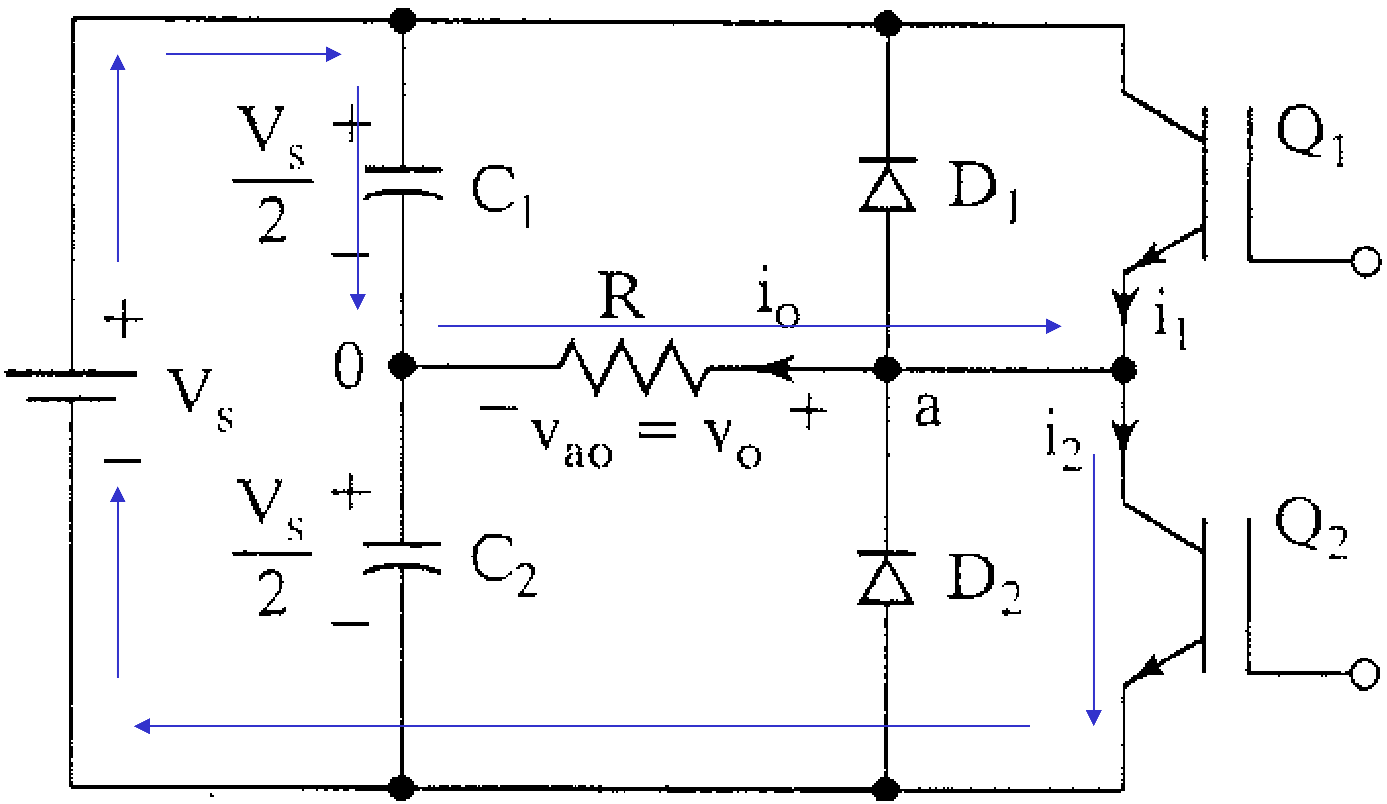
- Consists of 2 choppers, 3-wire DC source
- Transistors switched on and off alternately
- Need to isolate the gate signal for Q_1 (upper device)
- Each provides opposite polarity of $V_s/2$ across the load

Q_1 on, Q_2 off, $v_o = V_s/2$

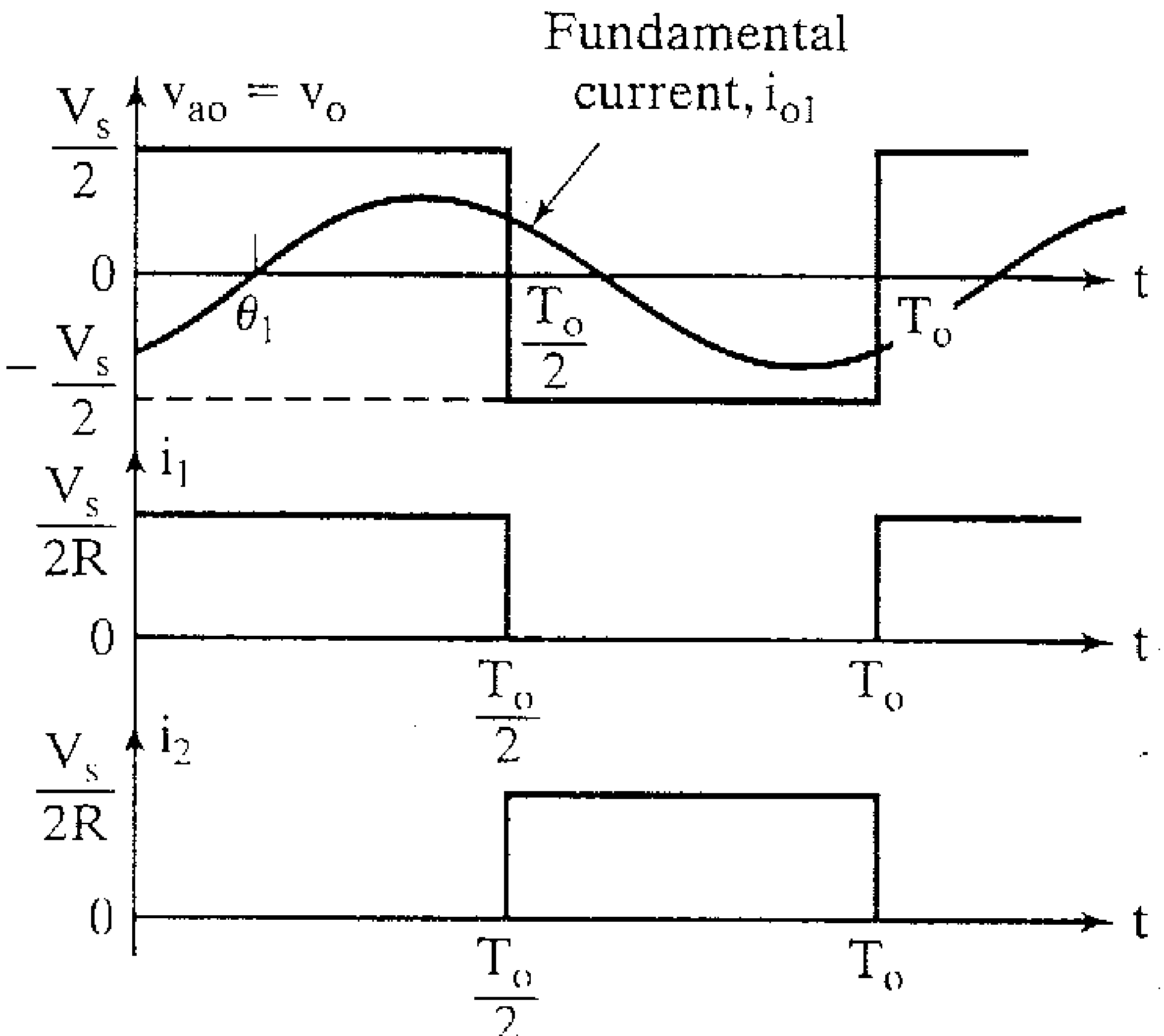


Peak Reverse Voltage of $Q_2 = V_s$

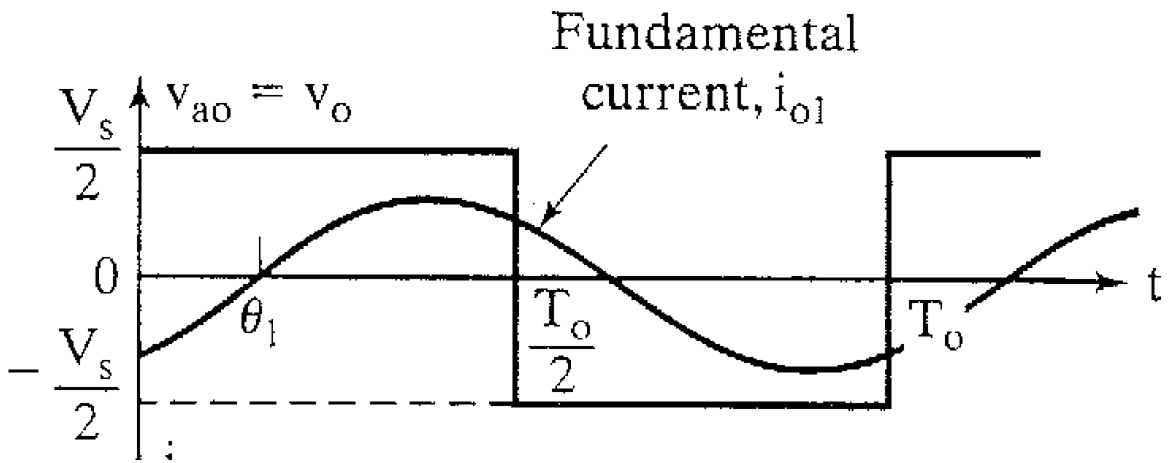
Q_1 off, Q_2 on, $v_o = -V_s/2$



Waveforms with resistive load



Look at the output voltage



rms value of the output voltage, V_o

$$V_o = \left(\frac{2}{T_o} \int_0^{\frac{T_o}{2}} \frac{V_s^2}{4} dt \right)^{\frac{1}{2}} = \frac{V_s}{2}$$

Fourier Series of the instantaneous output voltage

$$v_o = \frac{a_o}{2} + \sum_{n=1}^{\infty} \left(a_n \cos(n\omega t) + b_n \sin(n\omega t) \right)$$

$$a_o, a_n = 0$$

$$b_n = \frac{1}{\pi} \left[\int_{-\pi}^{0} \frac{-V_s}{2} \sin(n\omega t) d(\omega t) + \int_{0}^{\pi} \frac{V_s}{2} \sin(n\omega t) d(\omega t) \right]$$

$$b_n = \frac{2V_s}{n\pi} \rightarrow n = 1, 3, 5, \ldots$$

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

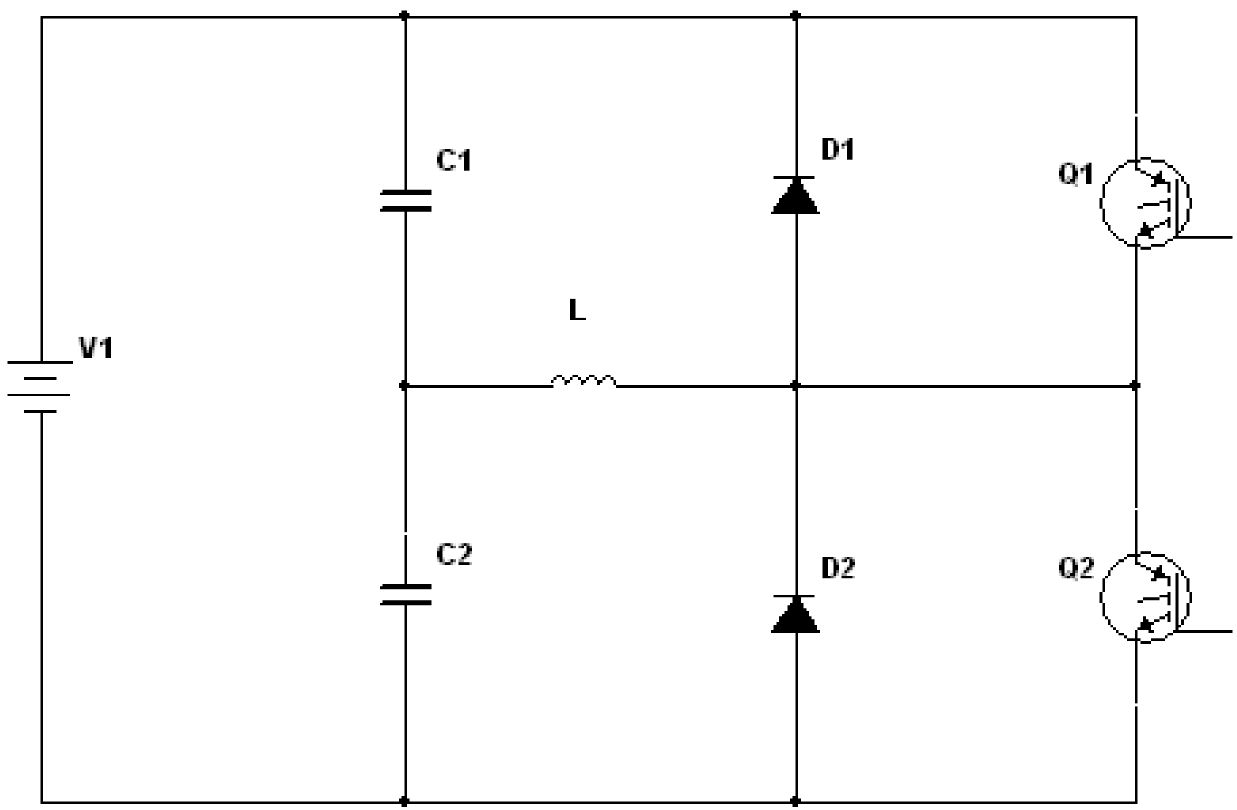
rms value of the fundamental component

$$v_o = \sum_{n=1,3,5,..}^{\infty} \frac{2V_s}{n\pi} \sin n\omega t$$

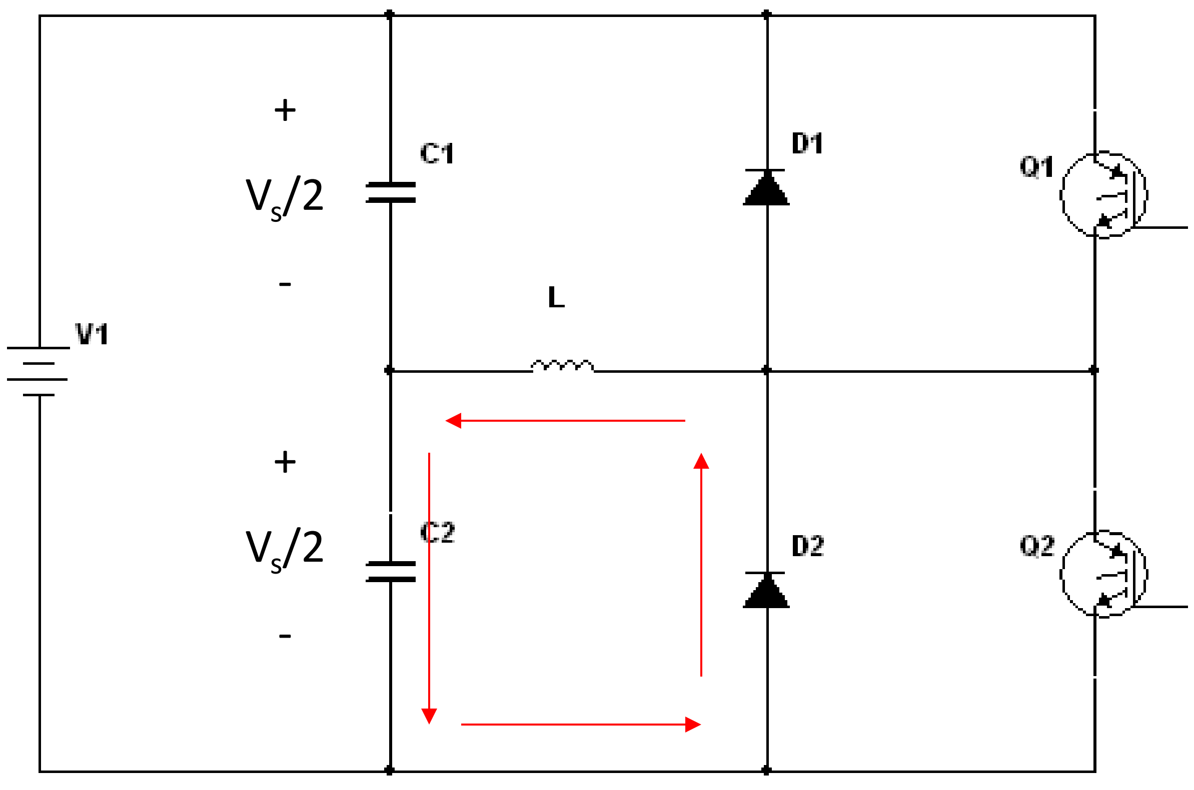
$$V_{o1} = \frac{1}{\sqrt{2}} \frac{2V_s}{\pi}$$

$$V_{o1} = 0.45V_s$$

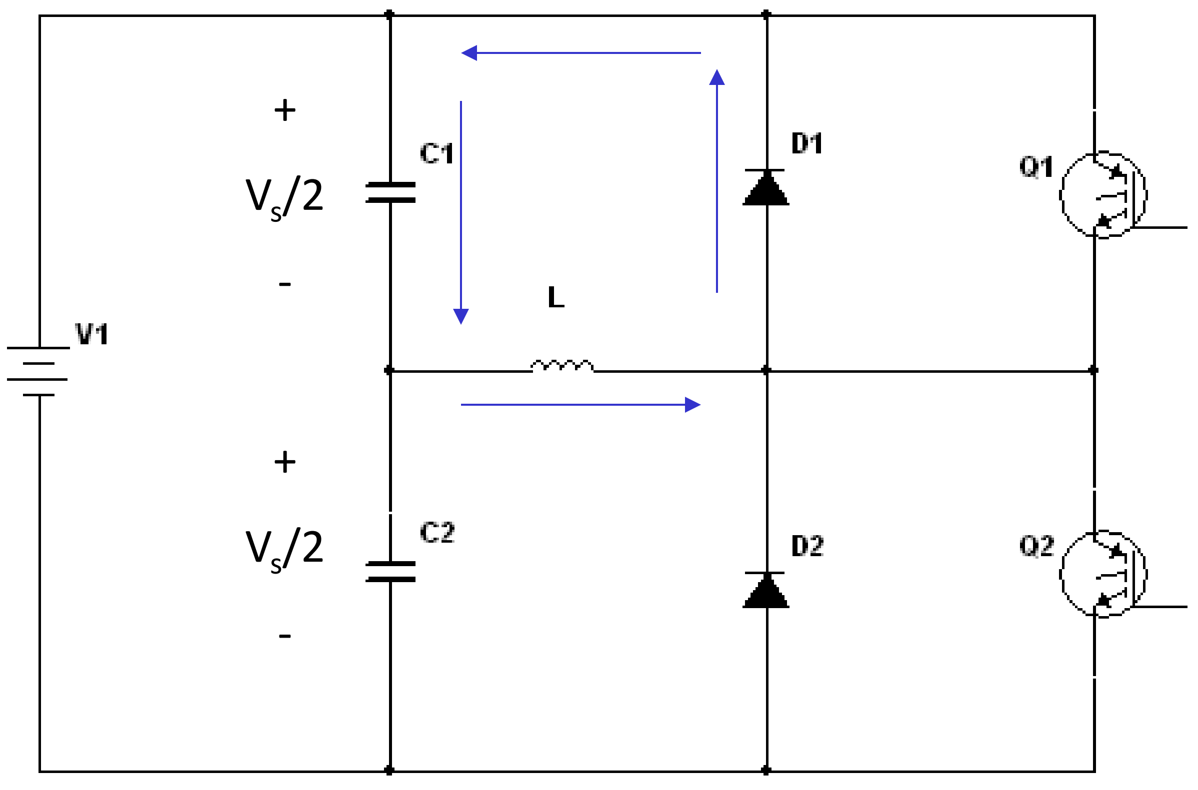
When the load is highly inductive



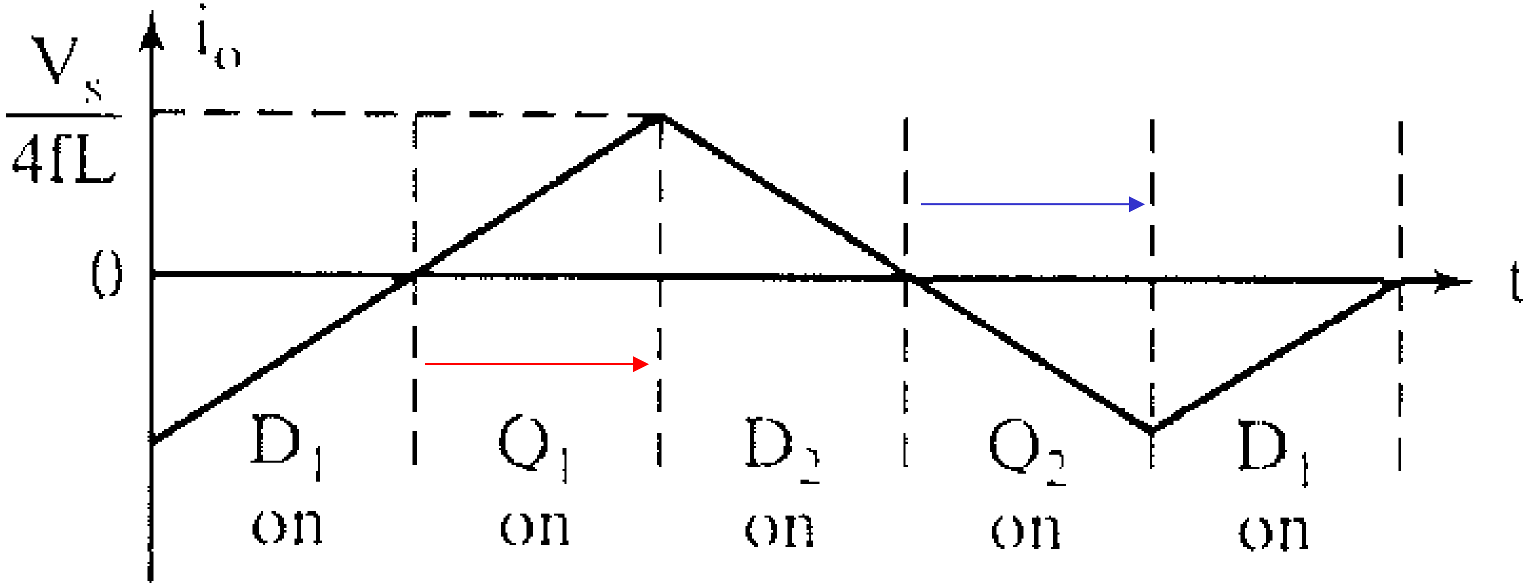
Turn off Q_1 at $t = T_o/2$
Current falls to 0 via D_2, L, $V_s/2$ lower



Turn off Q_2 at $t = T_o$
Current falls to 0 via D_1, L, $V_s/2$ upper



Load Current for a highly inductive load



Transistors are only switched on for a quarter-cycle, or 90°

Fourier Series of the output current for an RL load

$$i_o = \frac{v_o}{Z} = \frac{v_o}{R + jn\omega L} = \sum_{n=1,3,5,\ldots}^{\infty} \frac{2V_s}{n\pi\sqrt{R^2 + (n\omega L)^2}} \sin(n\omega t - \theta_n)$$

$$\theta_n = \tan^{-1}\left(\frac{n\omega L}{R}\right)$$

Fundamental Output Power
In most cases, the useful power

$$P_{o1} = V_{o1} I_{o1} \cos\theta_1 = I_{o1}^2 R$$

$$P_{o1} = \left[\frac{2V_s}{\sqrt{2}\pi\sqrt{R^2 + (\omega L)^2}} \right]^2 R$$

DC Supply Current

- If the inverter is lossless, average power absorbed by the load equals the average power supplied by the dc source.

$$\int_0^T v_s(t) i_s(t) dt = \int_0^T v_o(t) i_o(t) dt$$

- For an inductive load, the current is approximately sinusoidal and the fundamental component of the output voltage supplies the power to the load. Also, the dc supply voltage remains essentially at V_s.

DC Supply Current (continued)

$$\int_0^T i_s(t)dt = \frac{1}{V_s}\int_0^T \sqrt{2}V_{o1}\sin(\omega t)\sqrt{2}I_o\sin(\omega t-\theta_1)dt = I_s$$

$$I_s = \frac{V_{o1}}{V_s}I_o\cos(\theta_1)$$

Performance Parameters

- Harmonic factor of the nth harmonic (HF_n)

$$HF_n = \frac{V_{on}}{V_{o1}} \qquad \text{for } n>1$$

V_{on} = rms value of the nth harmonic component

V_{01} = rms value of the fundamental component

Performance Parameters (continued)

- Total Harmonic Distortion (THD)
- Measures the “closeness” in shape between a waveform and its fundamental component

$$THD = \frac{1}{V_{o1}} \left(\sum_{n=2,3,\ldots}^{\infty} V_{on}^{2} \right)^{\frac{1}{2}}$$

Performance Parameters (continued)

- Distortion Factor (DF)
- Indicates the amount of HD that remains in a particular waveform after the harmonics have been subjected to second-order attenuation.

$$DF = \frac{1}{V_{o1}}\left[\sum_{n=2,3,\ldots}^{\infty}\left(\frac{V_{on}}{n^2}\right)^2\right]^{\frac{1}{2}}$$

$$DF_n = \frac{V_{on}}{V_{o1}n^2} \qquad \text{for } n>1$$

Performance Parameters (continued)

- Lowest order harmonic (LOH)
- The harmonic component whose frequency is closest to the fundamental, and its amplitude is greater than or equal to 3% of the amplitude of the fundamental component.