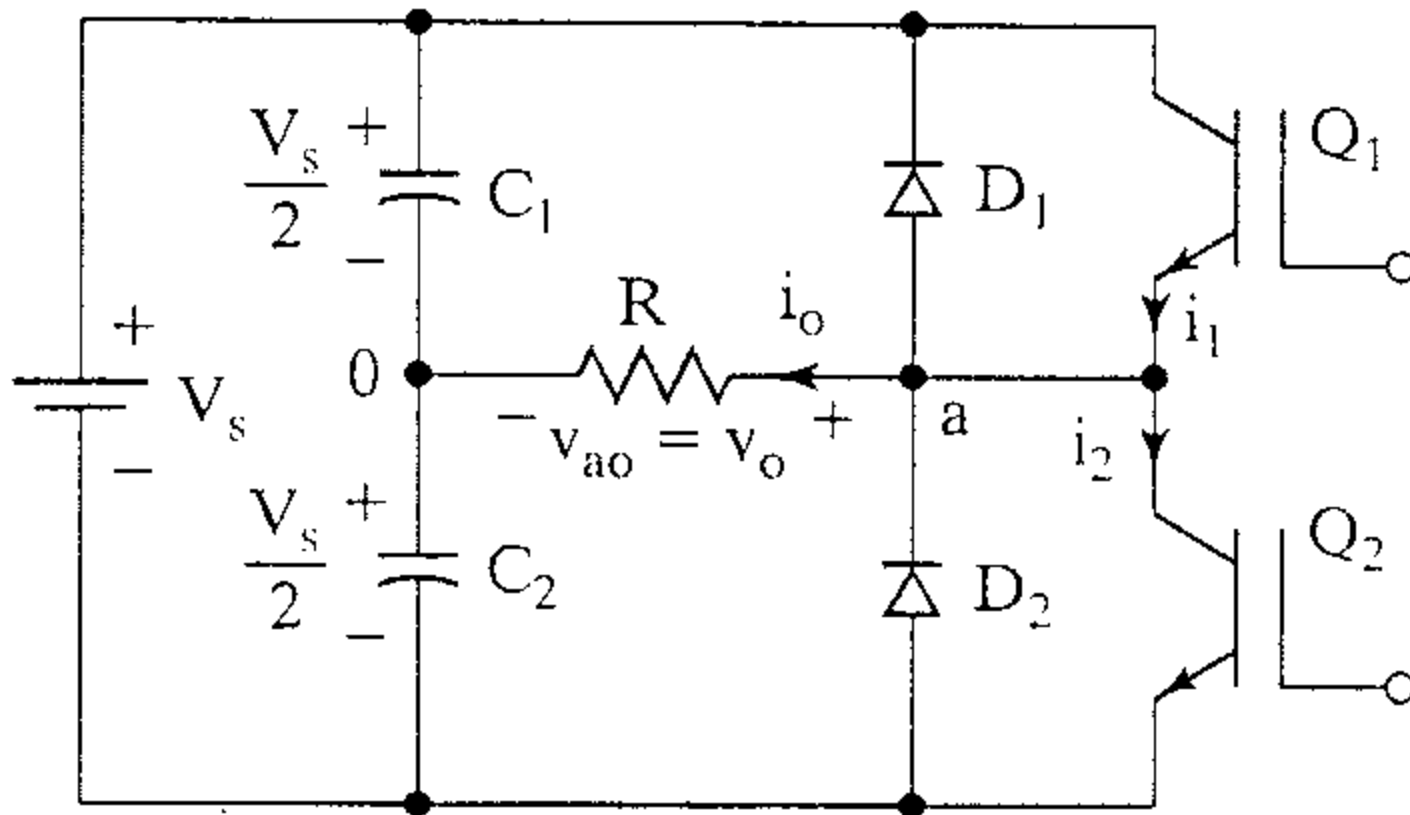
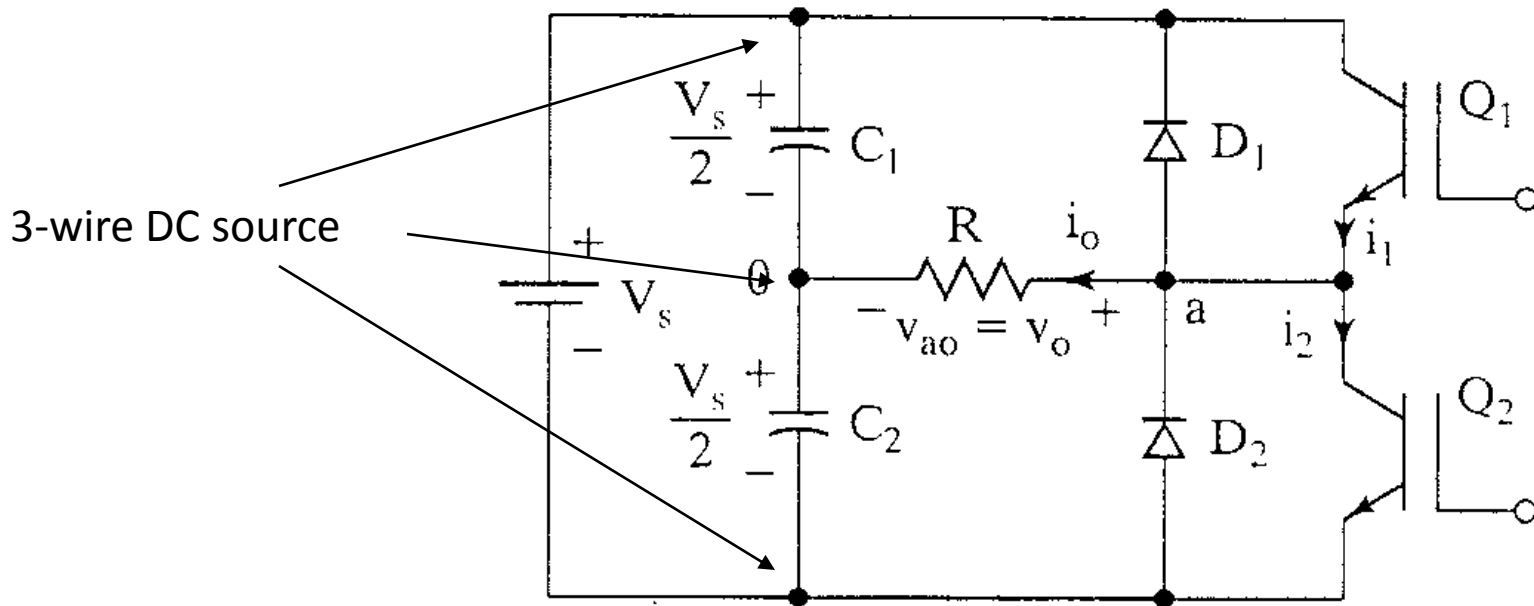


# Single-phase half-bridge inverter

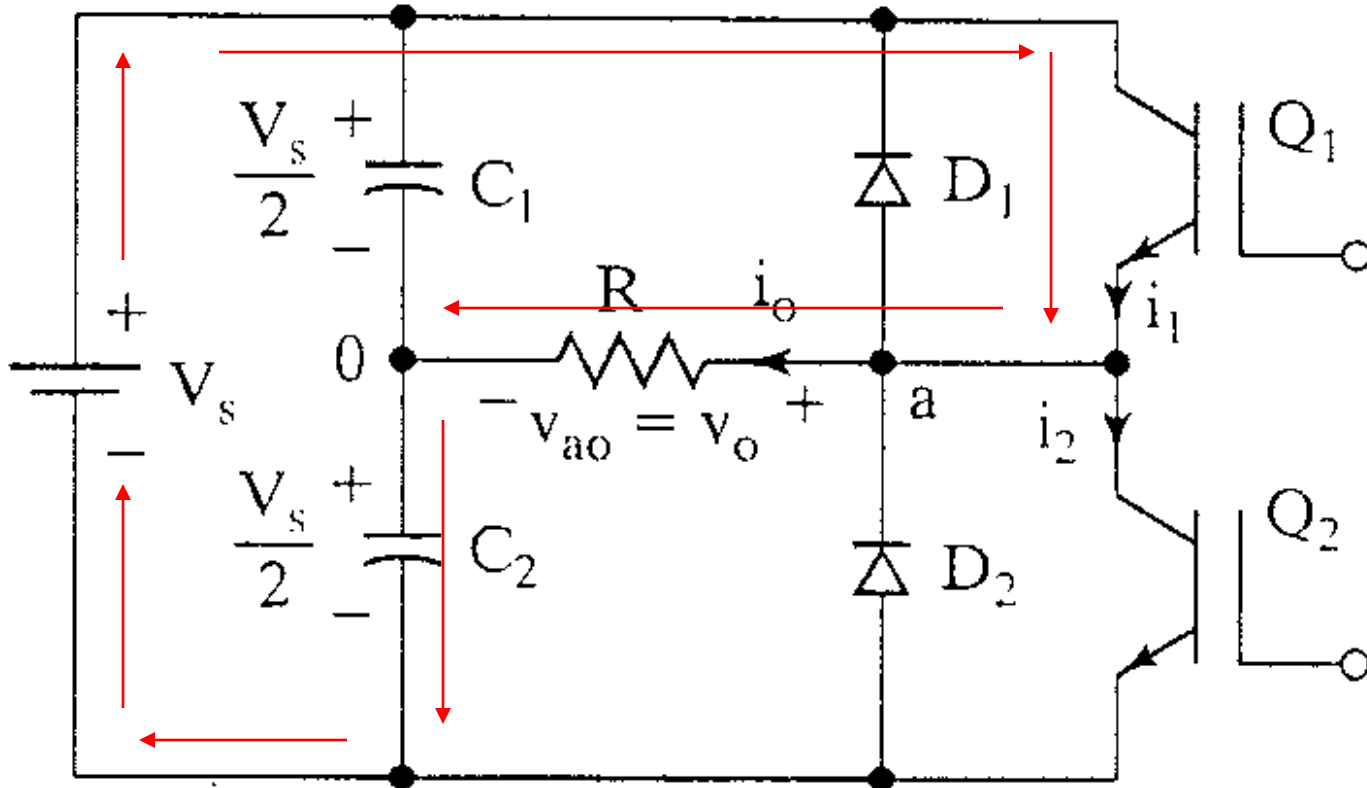


# Operational Details



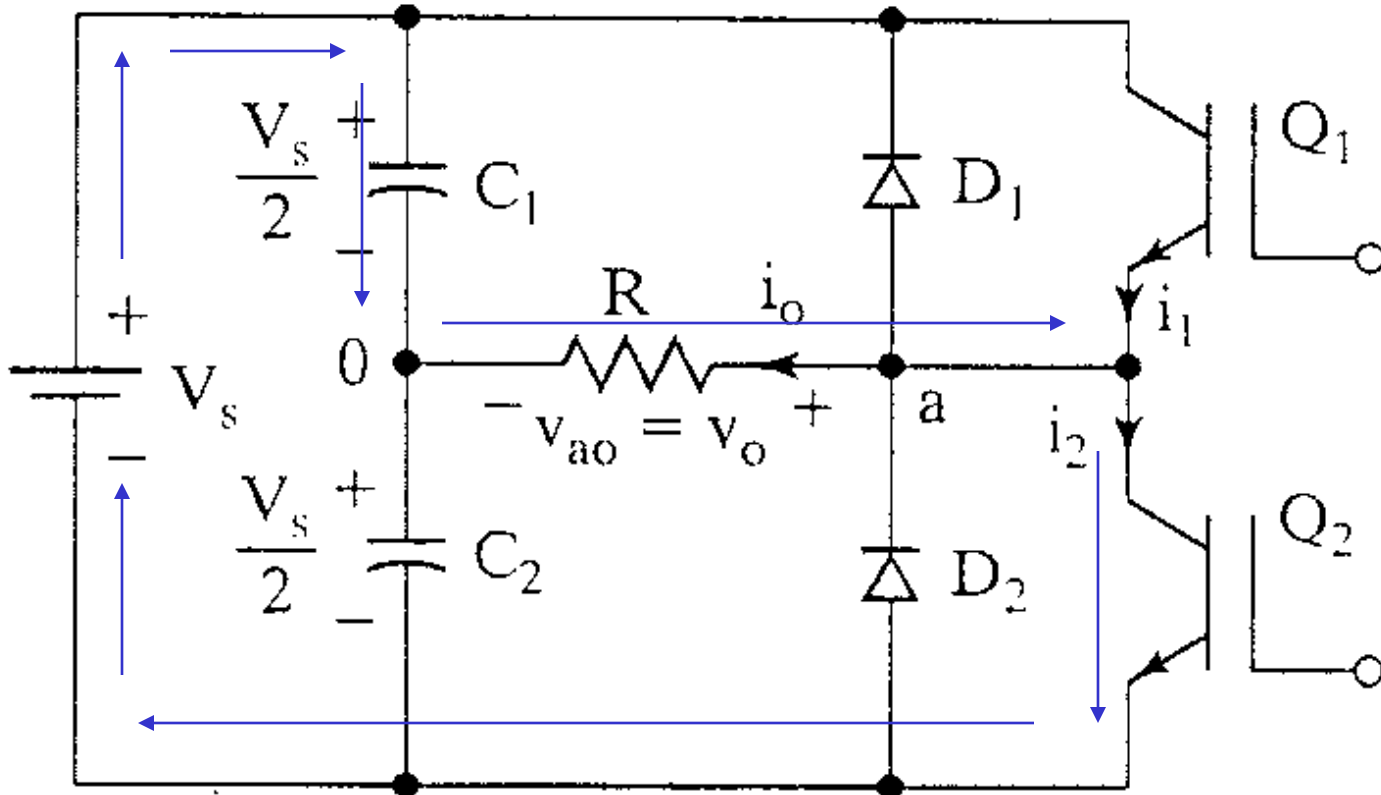
- Consists of 2 choppers, 3-wire DC source
- Transistors switched on and off alternately
- Need to isolate the gate signal for  $Q_1$  (upper device)
- Each provides opposite polarity of  $V_s/2$  across the load

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

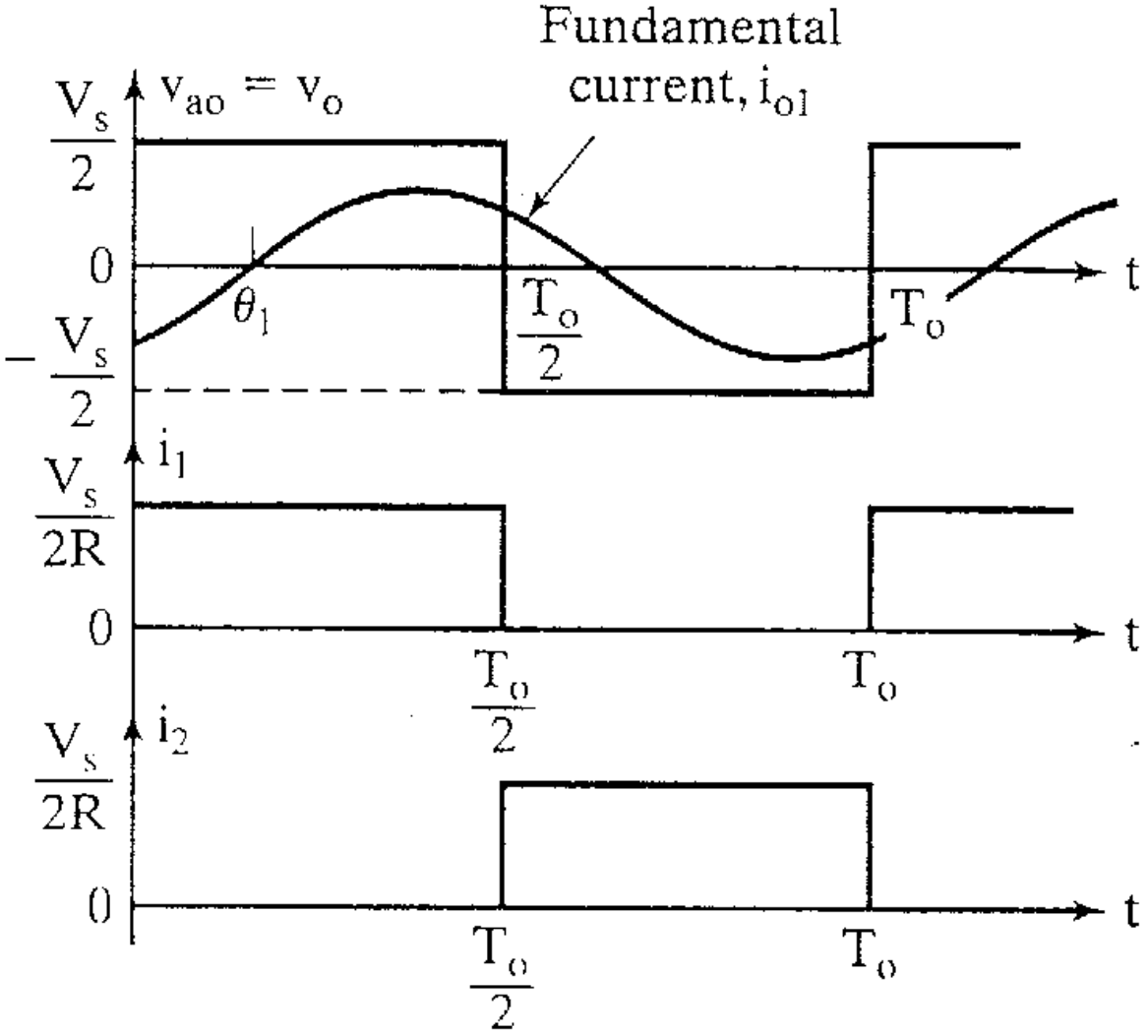


Peak Reverse Voltage of  $Q_2 = V_s$

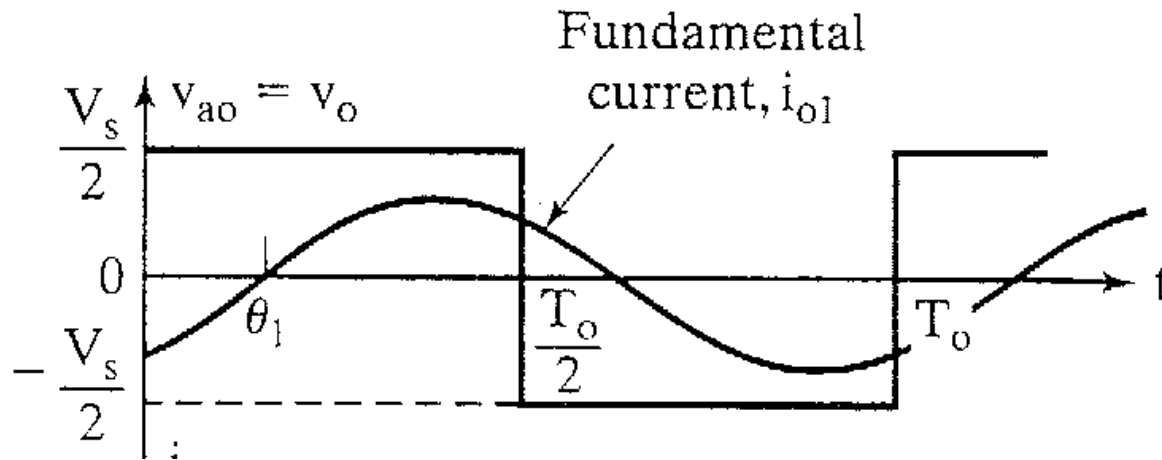
$Q_1$  off,  $Q_2$  on,  $v_o = -V_s/2$



# 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

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

$$a_o, a_n = 0$$

$$b_n = \frac{1}{\pi} \left[ \int_{-\pi}^0 \frac{-V_s}{2} \sin(n\omega t) d(\omega t) + \int_0^{\pi} \frac{V_s}{2} \sin(n\omega t) d(\omega t) \right]$$

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

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

rms value of the fundamental component

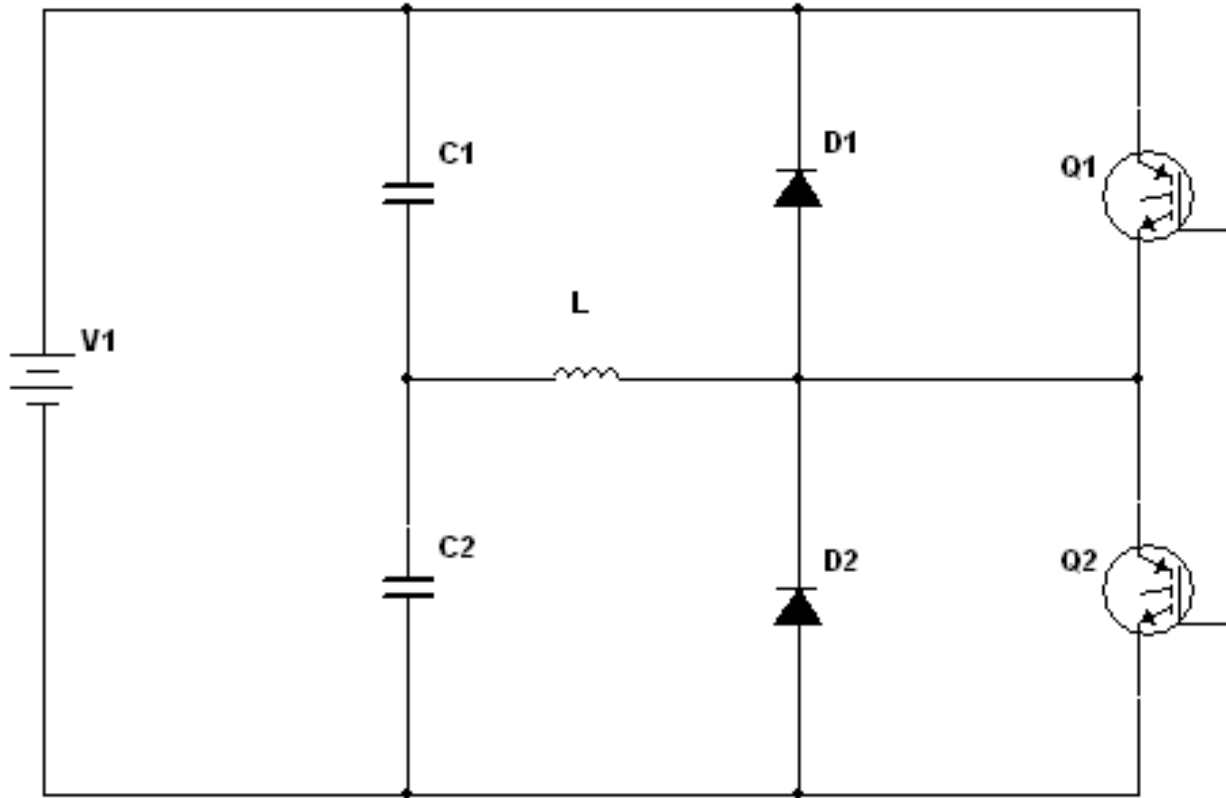
$$v_o = \sum_{n=1,3,5,\dots}^{\infty} \frac{2V_s}{n\pi} \sin n\omega t$$

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

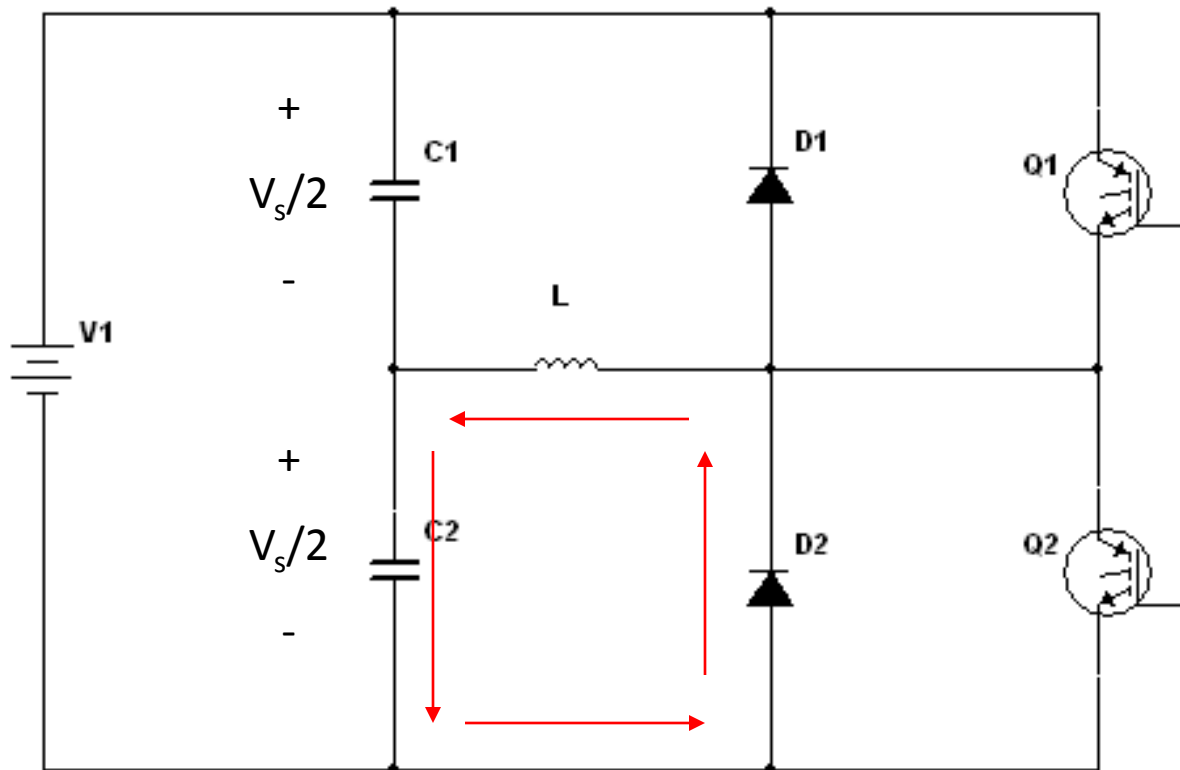
$$V_{o1} = 0.45V_s$$



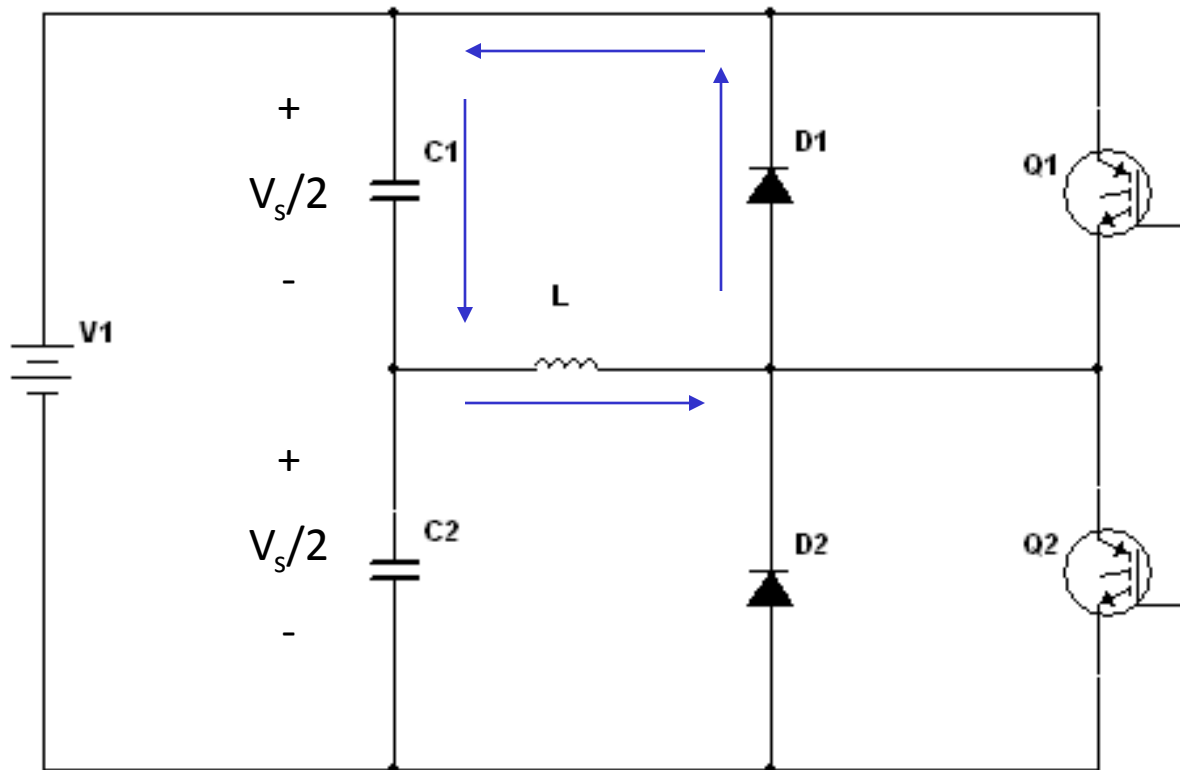
# When the load is highly inductive



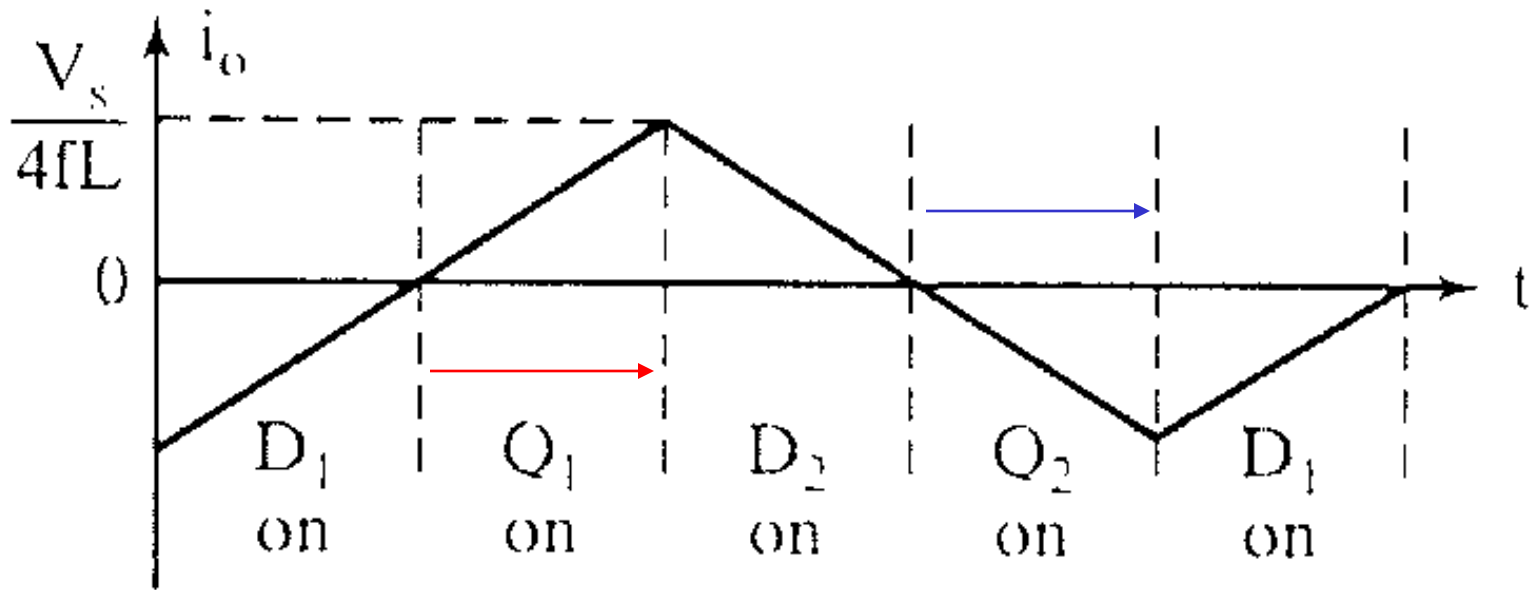
Turn off  $Q_1$  at  $t = T_o/2$   
Current falls to 0 via  $D_2$ ,  $L$ ,  $V_s/2$  lower



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  $90^\circ$

# Fourier Series of the output current for an RL load

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

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

# 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 ( $HF_n$ )

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

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

$V_{o1}$  = 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

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

# 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.

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

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

# 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.