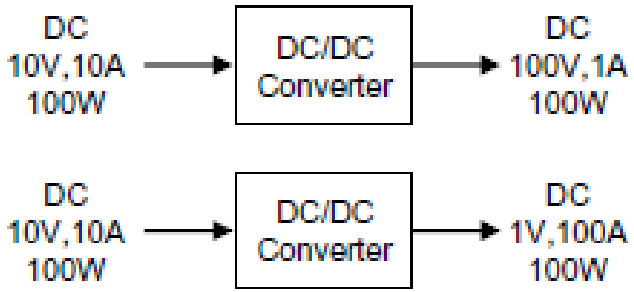
DC to DC Converters

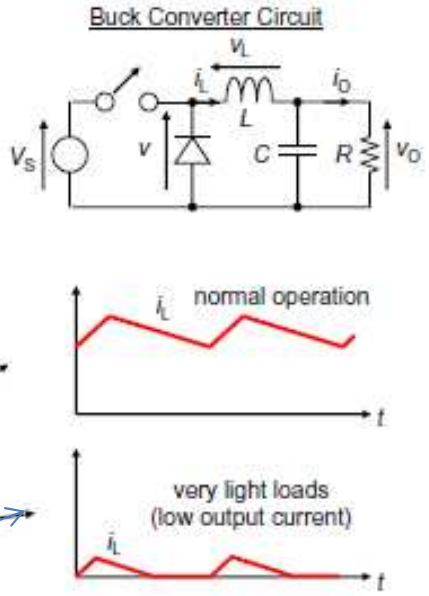
Usually use transistors as switches

Act as a DC transformer



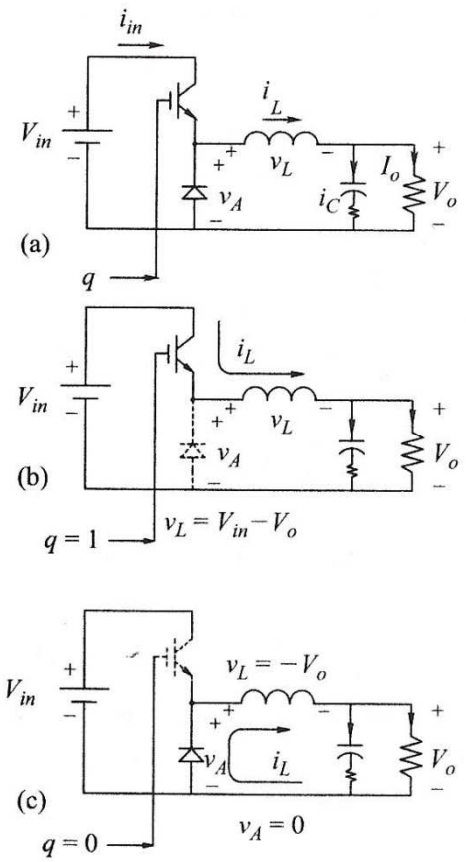
Buck Converter

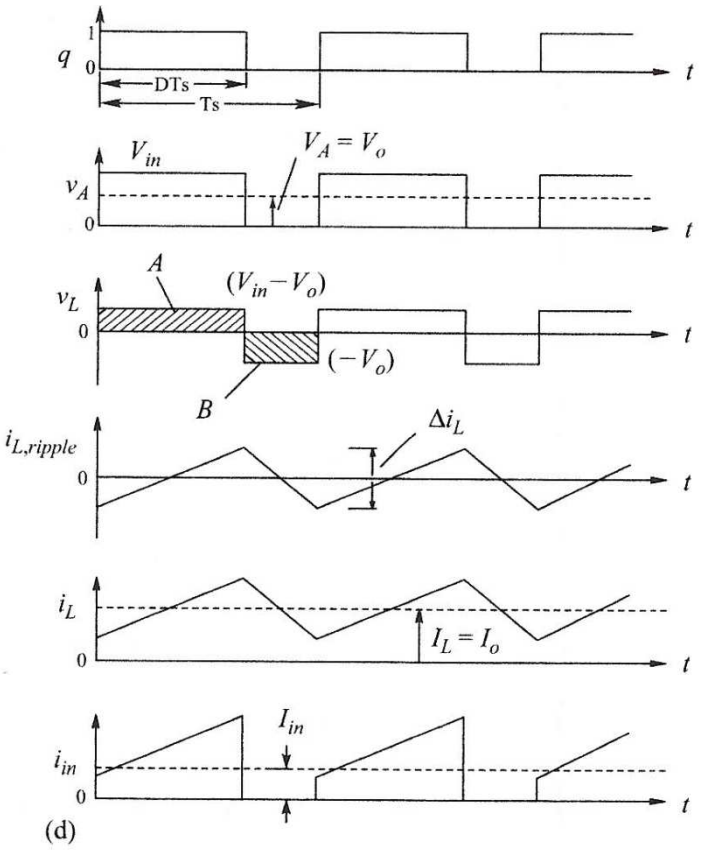
- Step down converter
- Switch
- Low-pass LC filter
- Diode
- Continuous conduction
- Discontinuous current



Buck Converter Analysis

- $V_o = V_A = DV_{in}$; D = switch duty ratio
- $\Delta_{iL} = \frac{1}{L}(V_{in} - V_o)DT_s = \frac{1}{L}V_o(1-D)T_s$
- $I_L = Io = \frac{Vo}{R}$



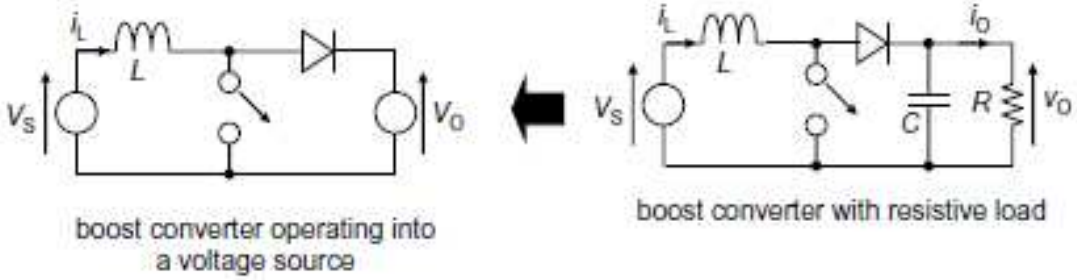


Example

- In **Buck** converter, L = 24μF (steady-state): V_{in} = 20V; D = 0.6; P_o = 14V; f_s = 200 kHz. Calculate and draw the waveform.

Boost Converter

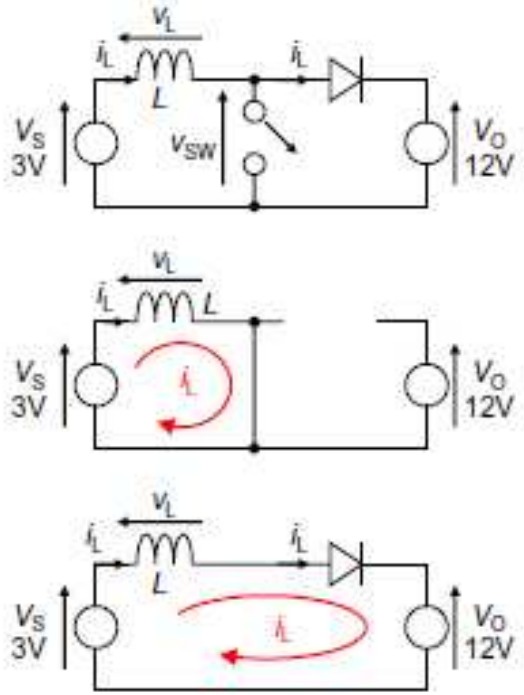
- Step-up
- Same components
- Different topology!



boost converter operating into a voltage source

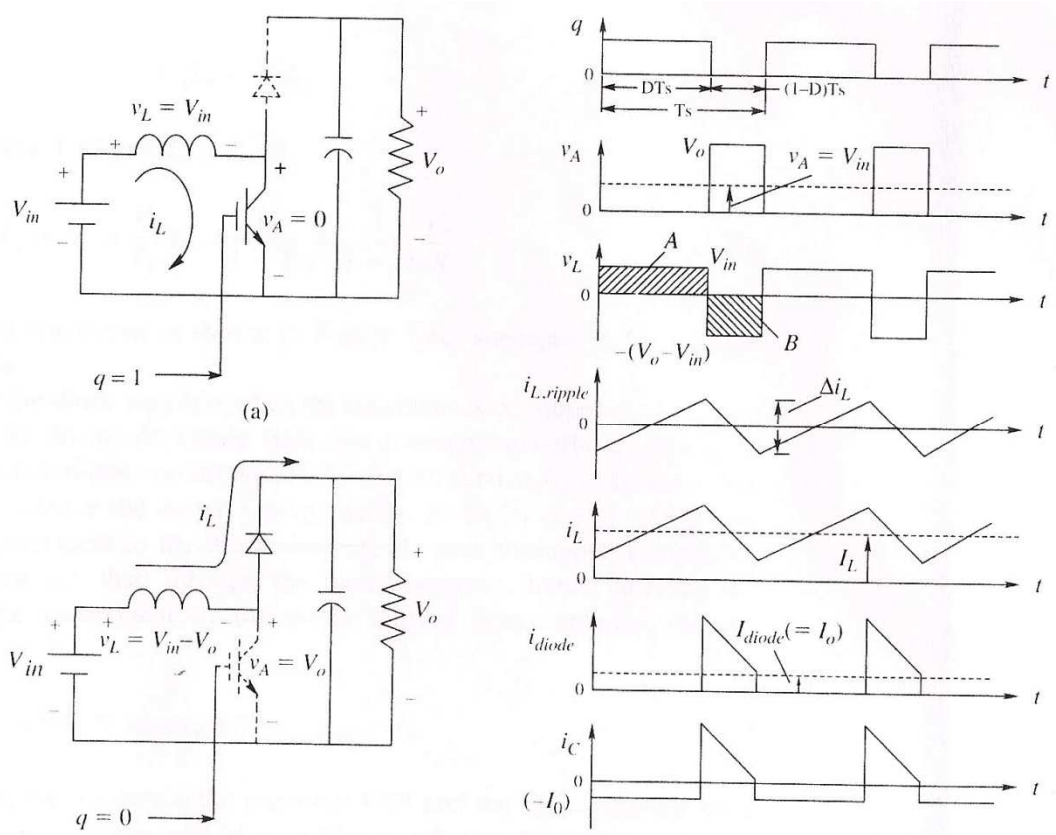
boost converter with resistive load

- See stages of operation



Boost Converter

- $\Delta_{iL} = \frac{1}{L}(V_{in})DT_s = \frac{1}{L}(V_o - V_{in})(1-D)T_s$
- $\frac{V_o}{V_{in}} = \frac{1}{1-D}$

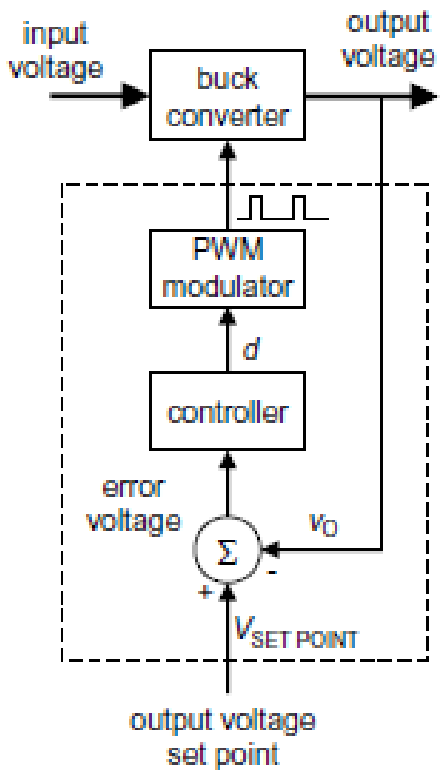


Example

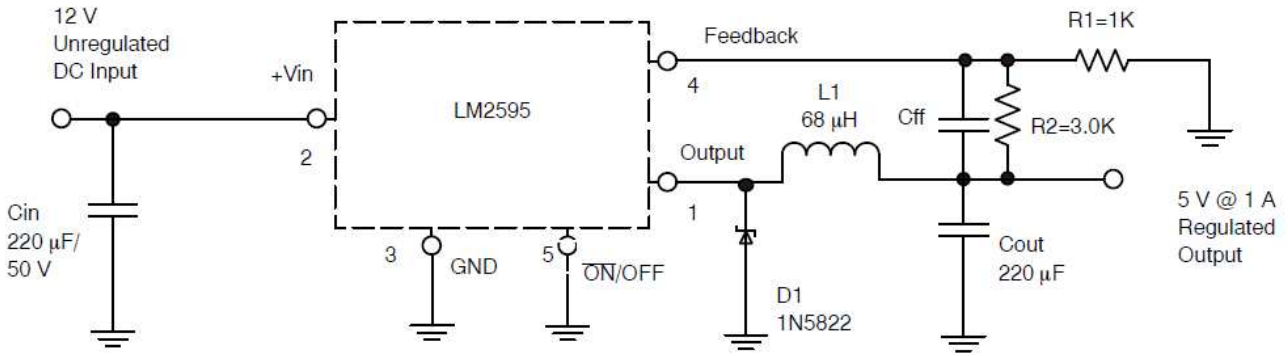
- Consider a boost converter, the inductor current has Δi_L=2 A. V_{in} = 5 V, V_o = 12 V, P_o = 11 W, f_s = 200 kHz. Calculate L and draw the waveform.

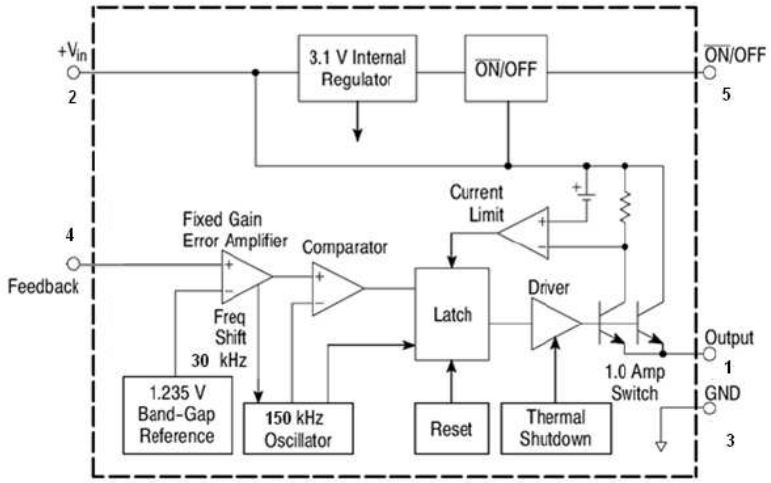
Control of DC to DC Converter

- **Error voltage = desired – actual**
- **Controller: Control duty cycle (PID)**
- **Modulator**
- **Entire controller is available as an IC.**



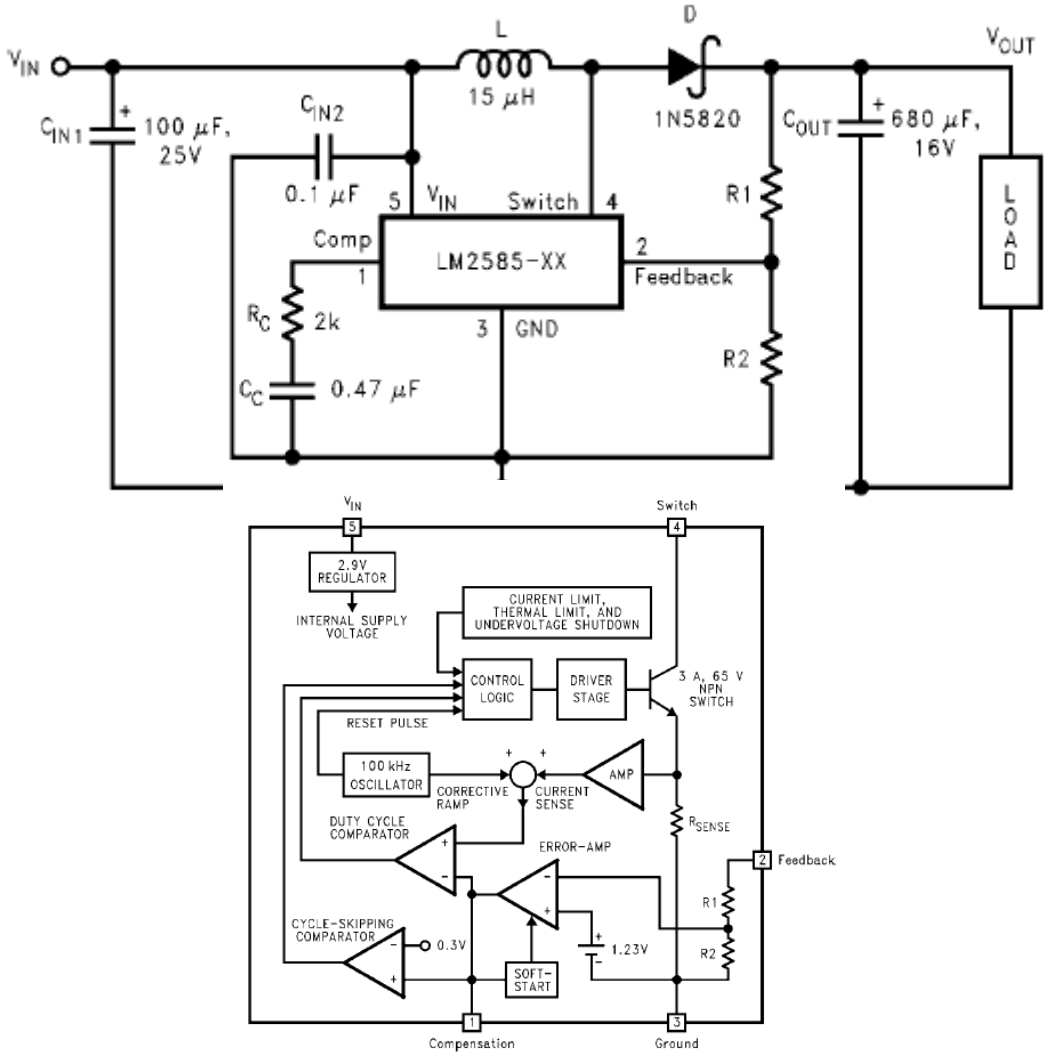
Switch, PWM, Electronics, Reference, and Buck Converter (LM2529: *Courtesy of National Semiconductors*)





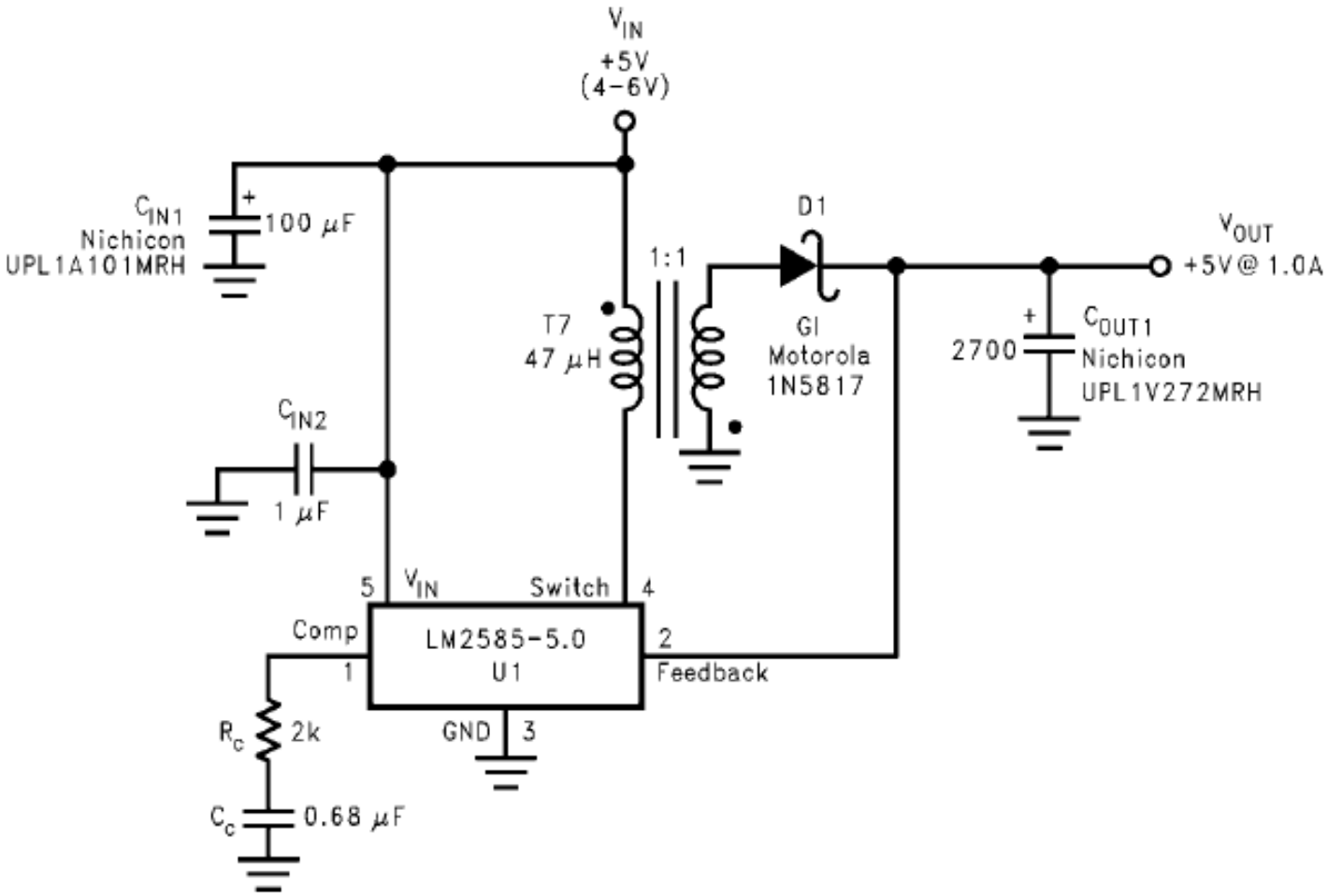
LM2585 with Boost Regulator

National Semiconductors

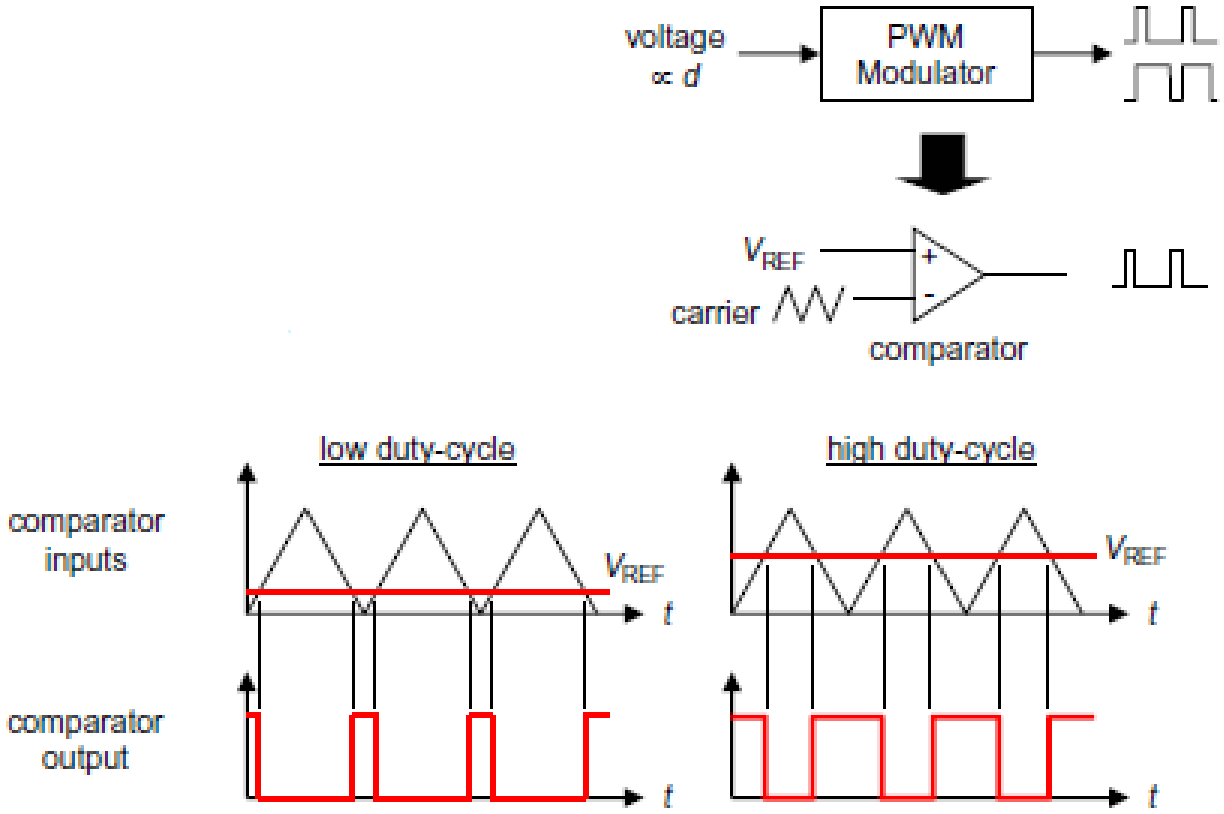


Flyback Converter

(Isolated Power Converter)

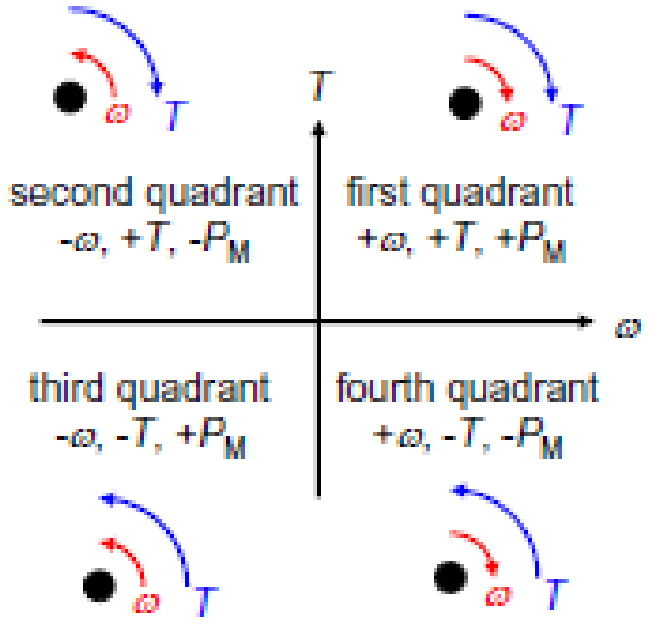


Pulse Width Modulator



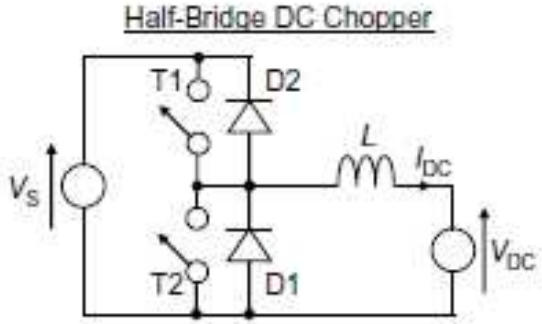
DC Motor Quadrant

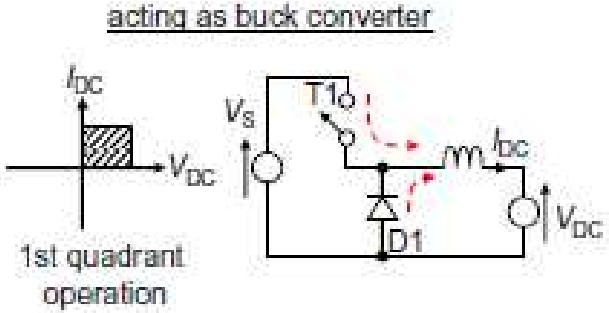
- **First:** Steady-State forward driving.
- **Fourth:** Regenerative breaking; machine trying to slow down; like breaking for traffic light.
- **Third:** Reverse steady-state driving.
- **Second:** Regenerative breaking.

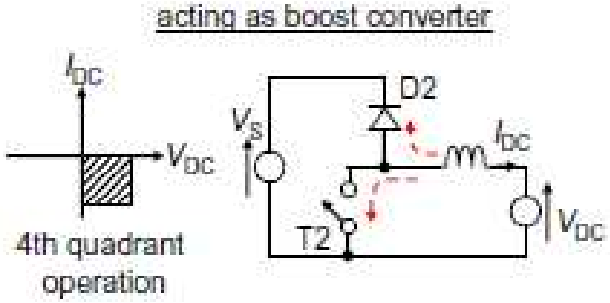


Half-Bridge DC Chopper

- **Buck converter:** Motoring
- **Boost Converter: Generating**
- Two quadrant operating capability

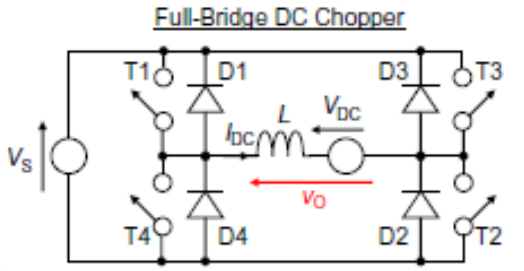


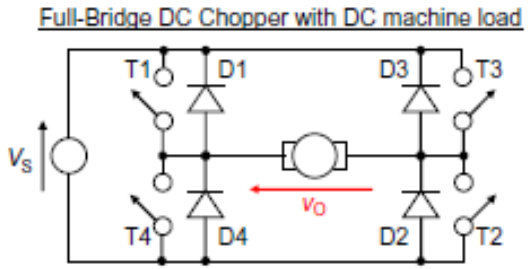


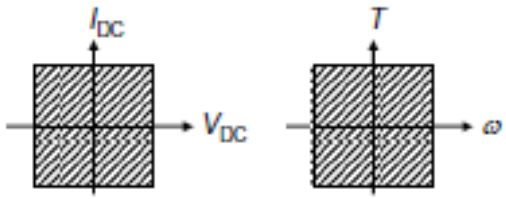


Full-Bridge DC Chopper

- Full-Quadrant Operation
- **T1 and T2 ON:** + Output voltage
- **T3 and T4 ON:** - Output voltage
- **DC current and torque:** + and –
- **DC voltage and speed:** + and –
- All quantities can be positive or negative







Summary of DC Choppers

- One Quadrant
- Half Bridge
- Full Bridge