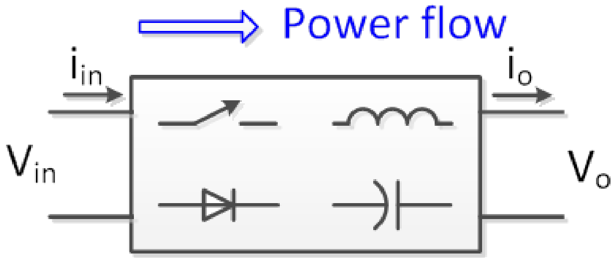
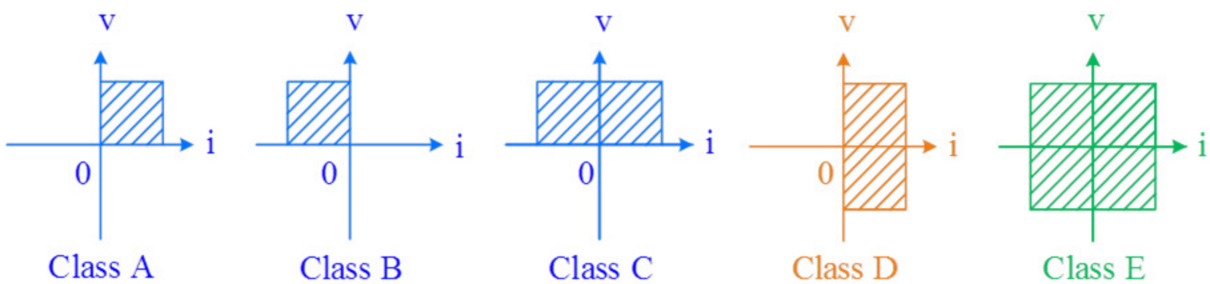
Basic DC-DC converter



The DC-DC converters illustrated in the figure above is used to interface two DC systems and control the flow of power between them. Their basic function in a DC environment is similar to that of transformers in AC systems. Unlike transformers, the ratio of the input to the output, either voltage or current, can continuously be varied by the control signal and this ratio can be higher or lower than unity. The DC-DC converters are constructed of electronic switches and sometimes include inductive and capacitive components, all of which are normally followed by a low-pass filter.

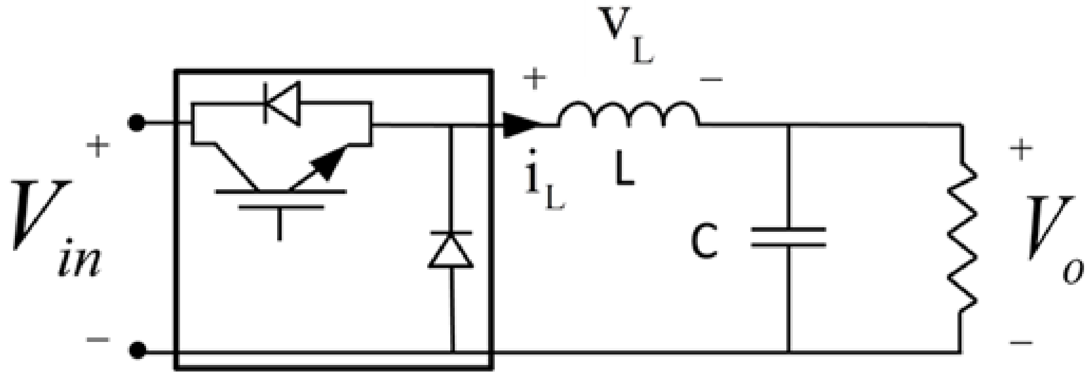


Depending upon the direction of the output current and voltage, the converters can be classified into five classes as shown in the figure. One-quadrant (classes A and B), two-quadrant (classes C and D) and four-quadrant operation can be realized.

Bidirectional power flow (2 quadrant converter) is required in automotive applications. Let us assume that voltage V_{in} is the voltage of the DC link (500 V) and voltage V_{out} is voltage of the battery (200V). The battery has to be charged during slowing down (decelerating) the vehicle and discharged during driving and accelerating (speeding up). Both voltages do not change their polarity. What is changing polarity is the current. We need a converter working as a class C (Figure).

Key equations for a buck converter

Now that you have an understanding of how the simple DC-DC buck converter works, we summarize the main equations for the converter here. These equations are for continuous conduction mode, where the current always flows through the inductor. Discontinuous conduction mode is out of the scope of this course. You can find the equations on the next page.



$V_0 = DV_{in}$

$T = 1/f$

$D = T_{on}/(T)$

$T = T_{on} + T_{off}$

Where

V_0 is the output voltage

D is the duty cycle of the switch

V_{in} is the input voltage

f is the switching frequency of the semiconductor switch

T is the time period of the semiconductor switch

T_{on} is the ON time of the semiconductor switch

T_{off} is the OFF time of the semiconductor switch