Derivation of Volt-second Balance

Inductor defining relation:

$$v_L(t) = L\frac{di_L(t)}{dt}$$

Integrate over one complete switching period:

$$i_L(T_s) - i_L(0) = \frac{1}{L}\int_0^{T_s} v_L(t)\,dt$$

In periodic steady state, the net change in inductor current is zero:

$$0 = \int_0^{T_s} v_L(t)\,dt$$

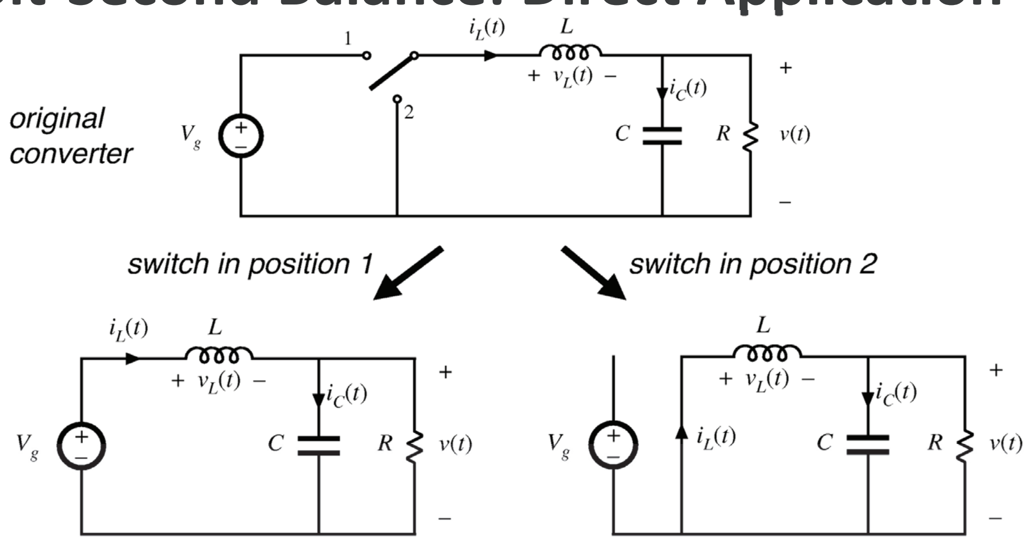
Hence, the total area (or volt-seconds) under the inductor voltage waveform is zero whenever the converter operates in steady state.

An equivalent form:

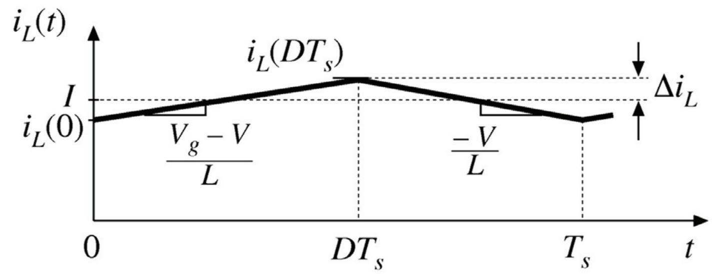
$$0 = \frac{1}{T_s}\int_0^{T_s} v_L(t)\,dt = \langle v_L \rangle$$

The average inductor voltage is zero in steady state.

Volt-Second Balance: Direct Application

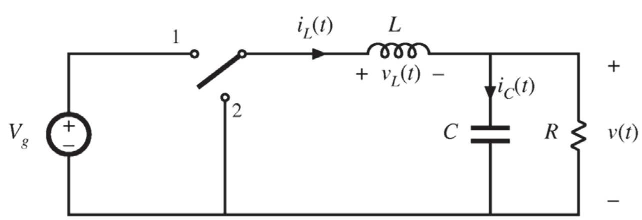


Current Ripple Magnitude



(*change in* i_L) = (*slope*)(*length of subinterval*)

Buck Cap Charge Balance



Derivation of Capacitor Charge Balance

Capacitor defining relation:

$$i_C(t) = C\frac{dv_C(t)}{dt}$$

Integrate over one complete switching period:

$$v_C(T_s) - v_C(0) = \frac{1}{C}\int_0^{T_s} i_C(t)\,dt$$

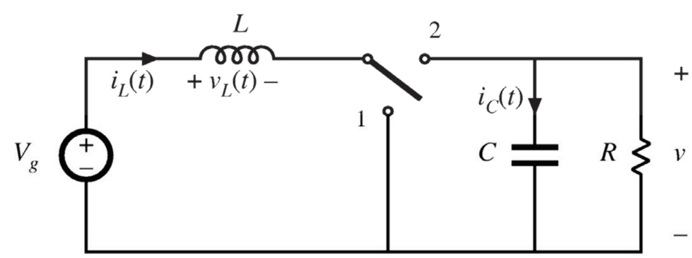
In periodic steady state, the net change in capacitor voltage is zero:

$$0 = \frac{1}{T_s}\int_0^{T_s} i_C(t)\,dt = \left\langle i_C \right\rangle$$

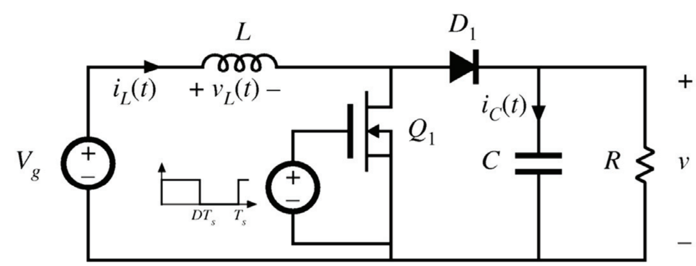
Hence, the total area (or charge) under the capacitor current waveform is zero whenever the converter operates in steady state. The average capacitor current is then zero.

The Boost Converter

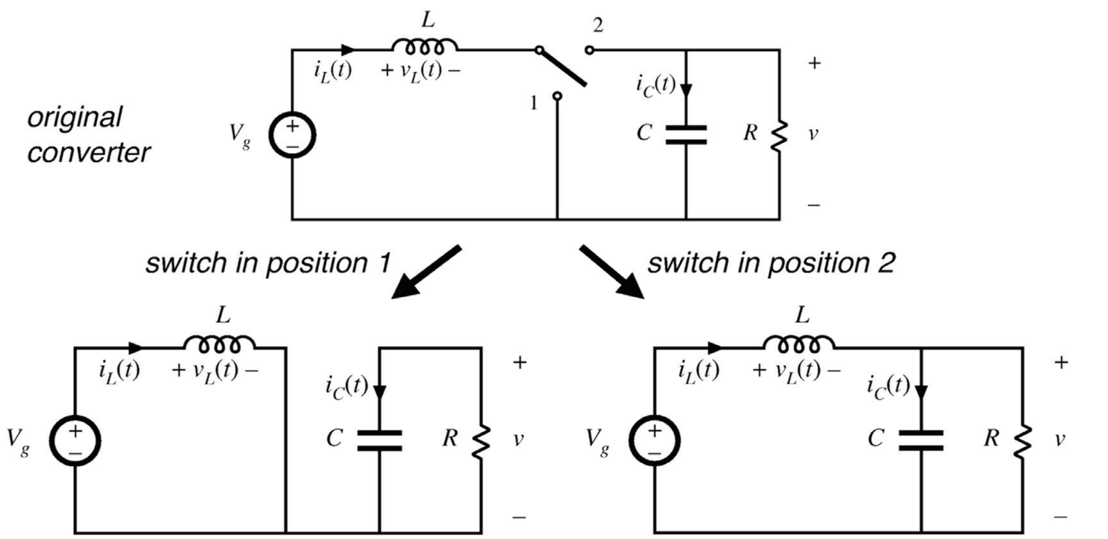
Boost converter with ideal switch



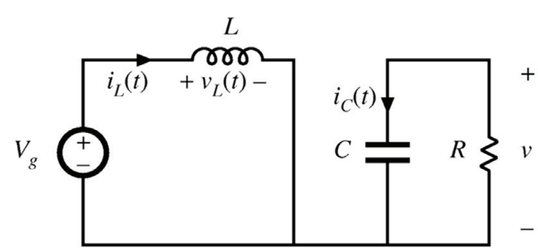
Realization using power MOSFET and diode



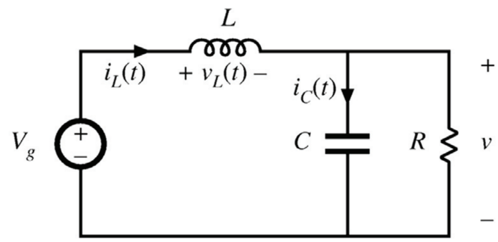
Boost Subintervals



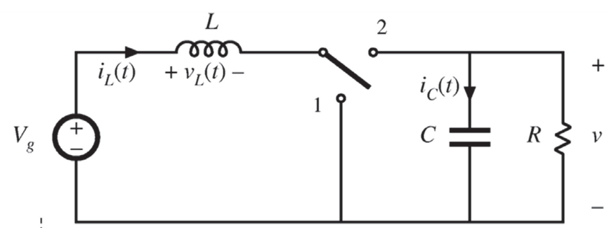
Boost: Subinverval 1

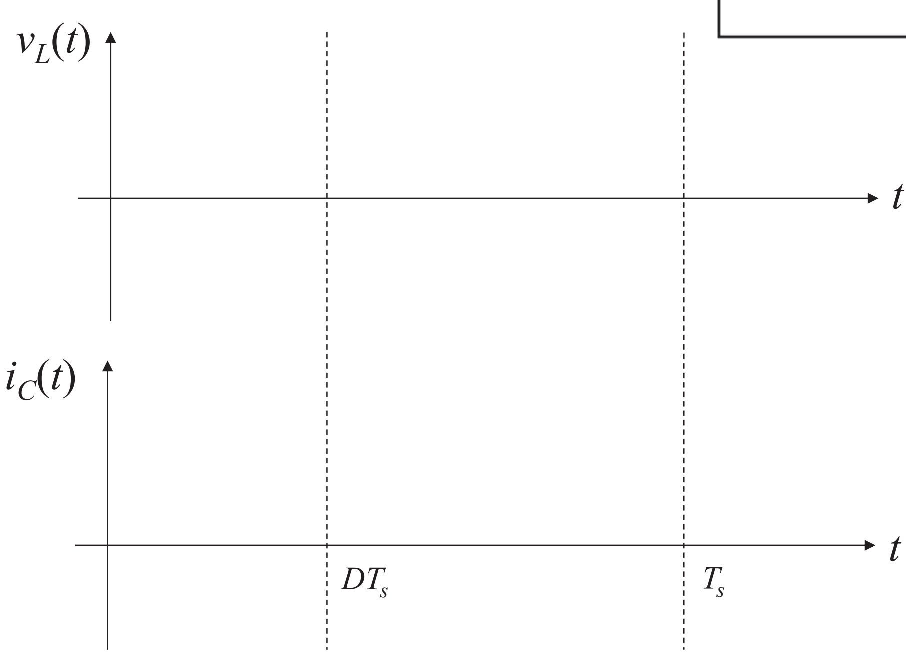


Boost: Subinterval 2



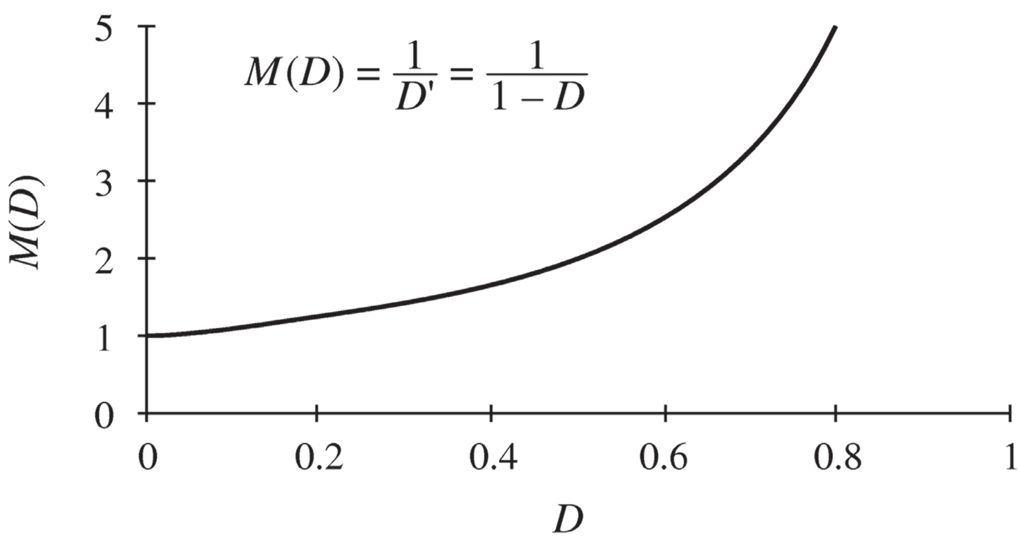
Waveforms





Steady State Solution

Boost: Conversion Ratio



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