

## Lecture 3: Volt-Second and Capacitor Charge Balance; Converter Examples

ECE 481: Power Electronics

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## 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:

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

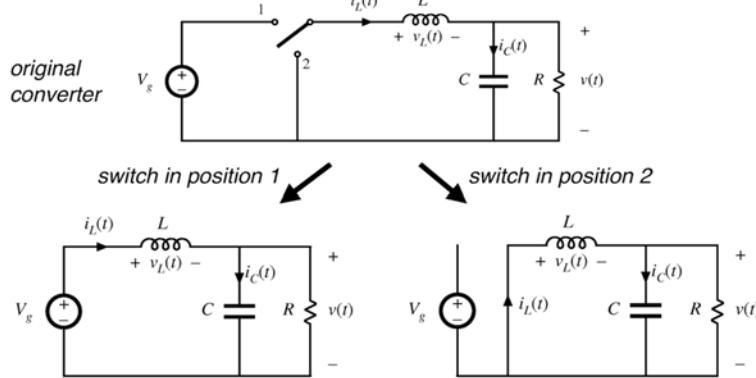
*Hence, the total area (or volt-seconds) under the inductor voltage waveform is zero whenever the converter operates in steady state.*

An equivalent form:

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

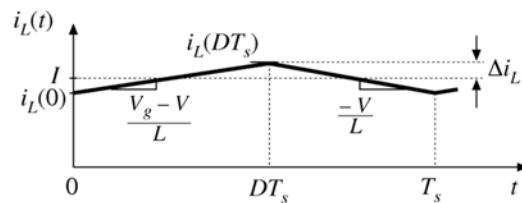
*The average inductor voltage is zero in steady state.*

## Volt-Second Balance: Direct Application



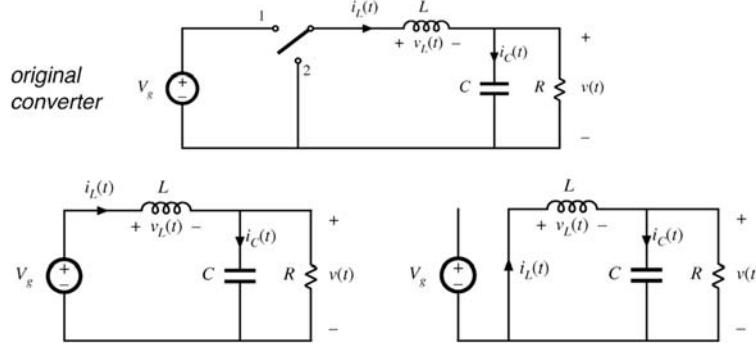
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## Current Ripple Magnitude



$$(change \ in \ i_L) = (slope)(length \ of \ subinterval)$$

## Capacitor Charge Balance



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## 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:

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

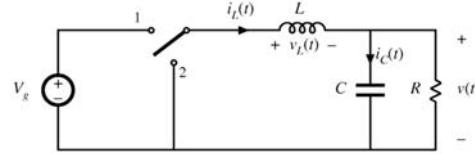
Hence, the total area (or charge) under the capacitor current waveform is zero whenever the converter operates in steady state. The average capacitor current is then zero.

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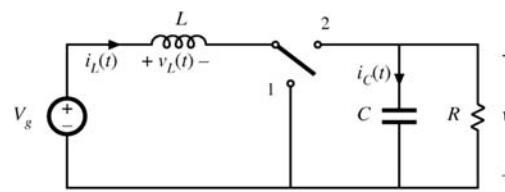
## Buck Cap Charge Balance



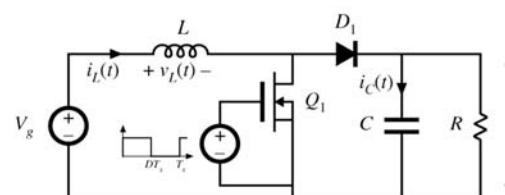
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## The Boost Converter

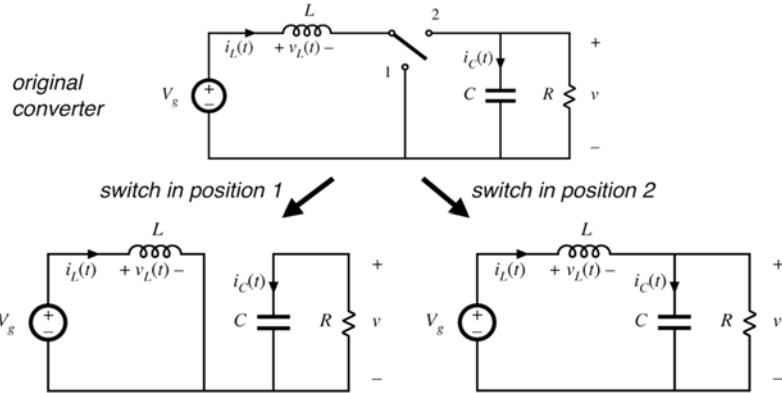
*Boost converter  
with ideal switch*



*Realization using  
power MOSFET  
and diode*



## Boost Subintervals

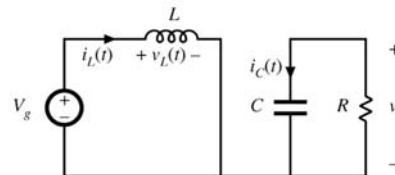


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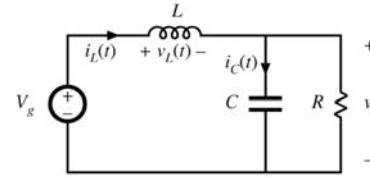
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## Boost: Subinterval 1

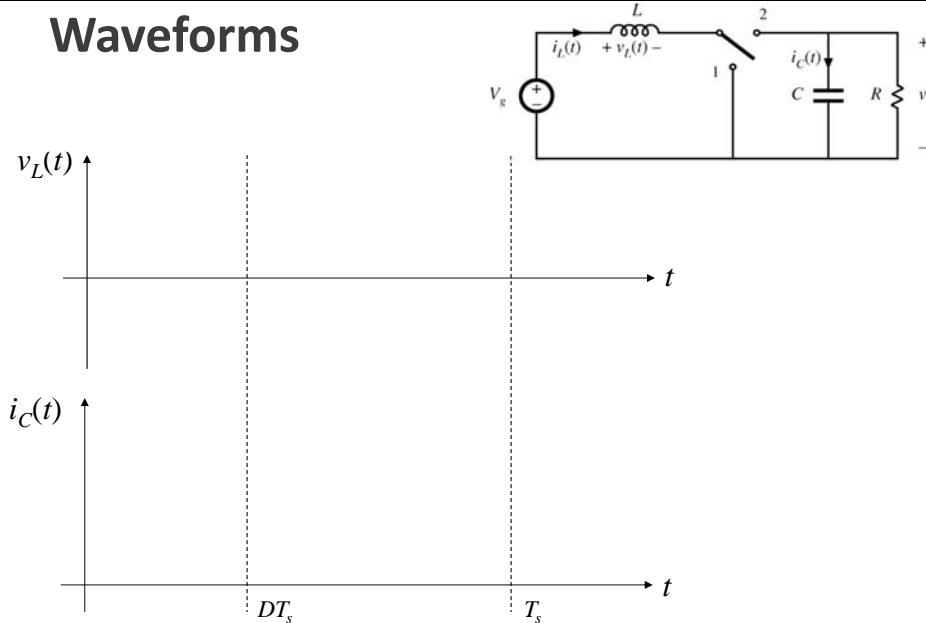


## Boost: Subinterval 2



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## Waveforms

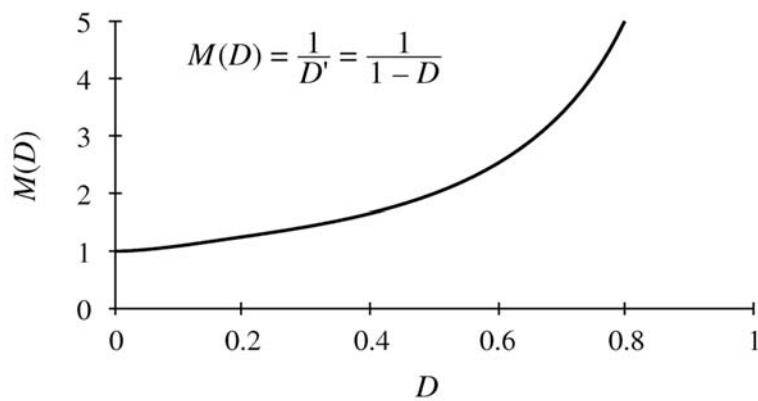


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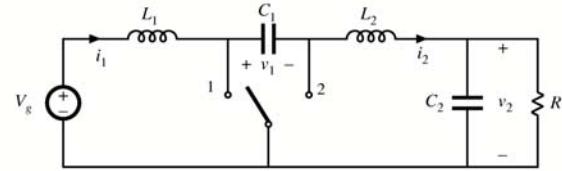
## Steady State Solution



## Boost: Conversion Ratio



## Cuk Converter



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