Lecture 2: Volt-Second and Capacitor Charge Balance

ECE 481: Power Electroncis

Prof. Daniel Costinett
Department of Electrical Engineering and Computer Science
University of Tennessee Knoxville
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Announcements

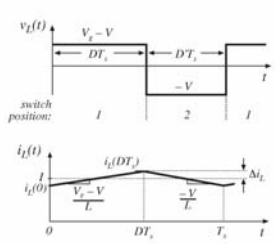
- HW #1 due Friday (8/29)

Part I: Converters in Equilibrium

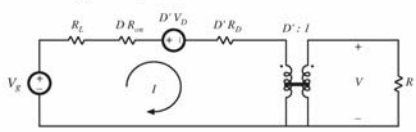
2. Principles of steady state converter analysis
3. Steady-state equivalent circuit modeling, losses, and efficiency
4. Switch realization
5. The discontinuous conduction mode
6. Converter circuits

Part I: Converters in Equilibrium

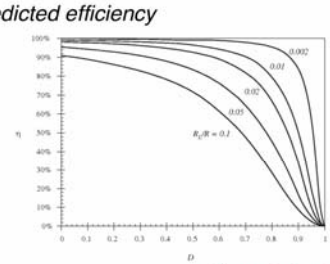
Inductor waveforms



Averaged equivalent circuit



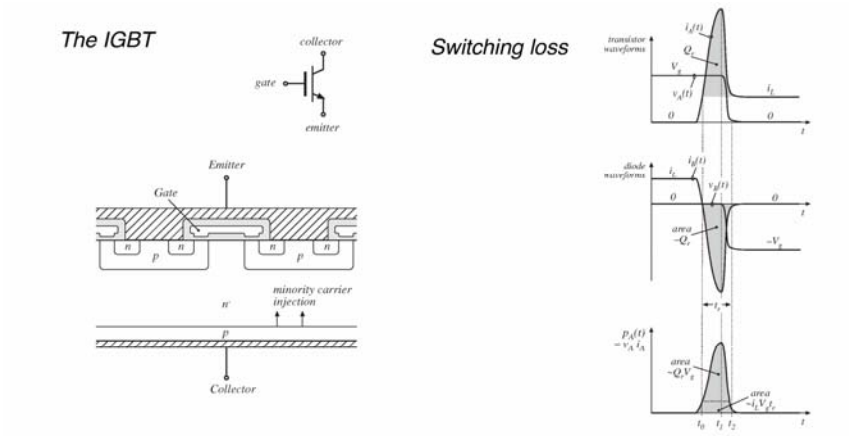
Predicted efficiency



Discontinuous conduction mode

Transformer isolation

Switch Realization: Semiconductor Devices

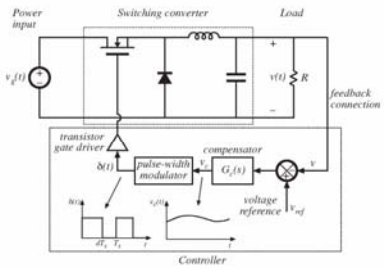


Part II: Converter Dynamics and Control

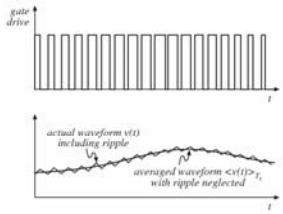
7. Ac modeling
8. Converter transfer functions
9. Controller design
10. Input filter design
11. Ac and dc equivalent circuit modeling of the discontinuous conduction mode
12. Current-programmed control

Part II: Converter Dynamics and Control

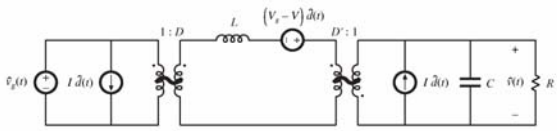
Closed-loop converter system



Averaging the waveforms



Small-signal averaged equivalent circuit

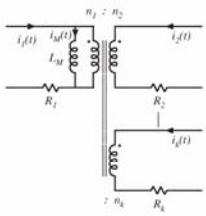


Part III: Magnetics

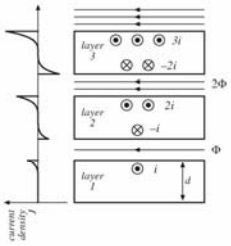
13. Basic magnetics theory
14. Inductor design
15. Transformer design

Part III: Magnetics

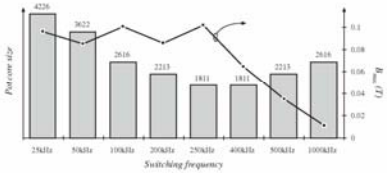
transformer design



the proximity effect



transformer size vs. switching frequency



Fundamentals of Power Electronics 30 *Chapter 1: Introduction*

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Chapter 2: Converters in Equilibrium

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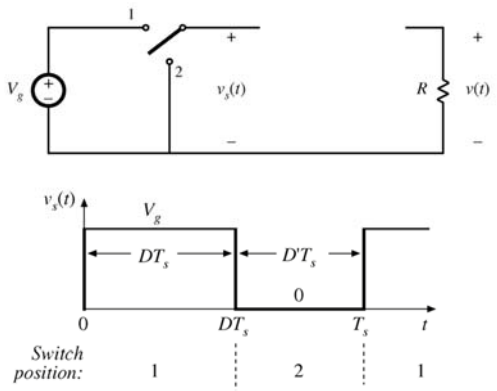
Buck Converter Review

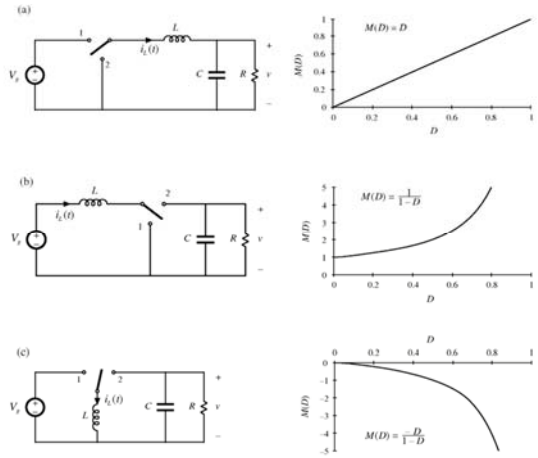


Three Basic DC-DC PWM Converters

Buck

Boost

Buck-boost



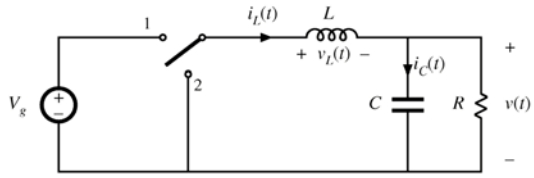
Chapter 2: Goals

- Develop techniques for easily determining output voltage of an arbitrary converter circuit
- Derive the principles of *inductor volt-second balance* and *capacitor charge (amp-second) balance*
- Introduce the key *small ripple approximation*
- Develop simple methods for selecting filter element values
- Illustrate via examples

Buck Output Voltage Ripple

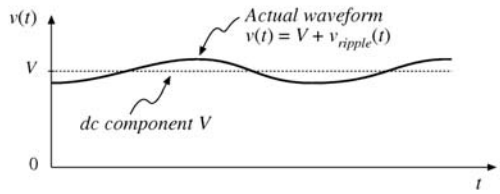
Actual output voltage waveform, buck converter

Buck converter containing practical low-pass filter



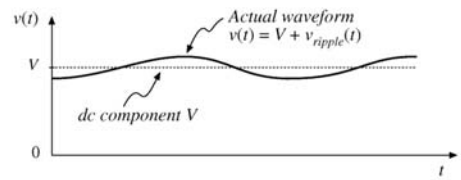
Actual output voltage waveform

$v(t) = V + v_{ripple}(t)$



The Small Ripple Approximation

$$v(t) = V + v_{ripple}(t)$$

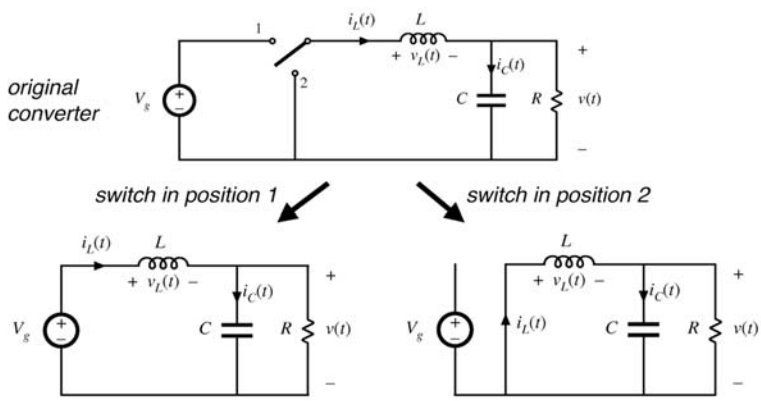


In a well-designed converter, the output voltage ripple is small. Hence, the waveforms can be easily determined by ignoring the ripple:

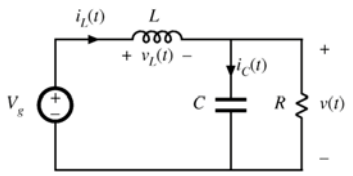
$$\left| v_{ripple} \right| \ll V$$

$$v(t) \approx V$$

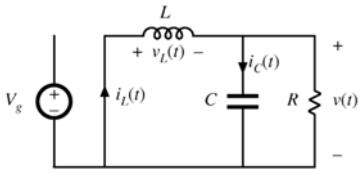
Buck Switching Intervals: Inductor Current



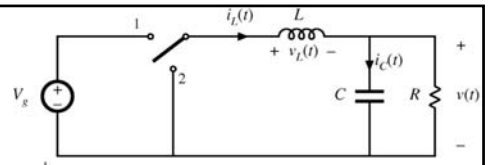
Subinterval 1

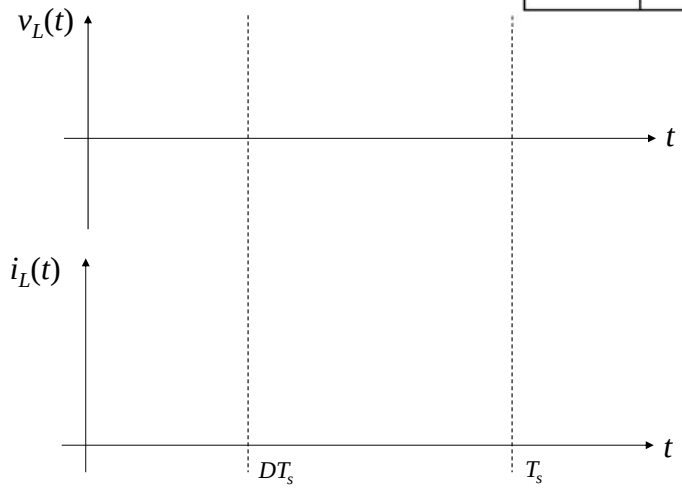


Subinterval 2

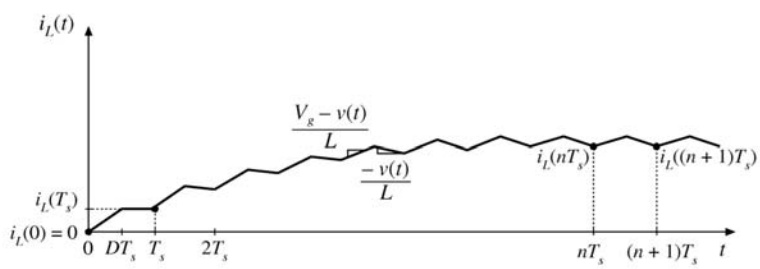


Current Waveform



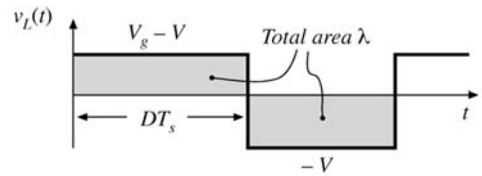


Transient vs. Steady-State Operation

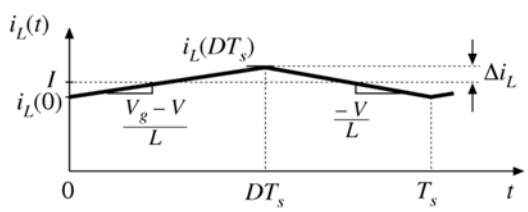


Fundamentals of Power Electronics *Chapter 2: Principles of steady-state converter analysis*

Volt-Second Balance



Current Ripple Magnitude



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

Capacitor Charge Balance