Power Saving Techniques for DC-DC Converters

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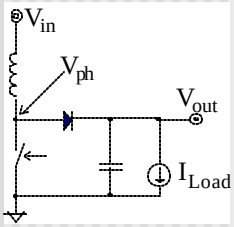
Abstract

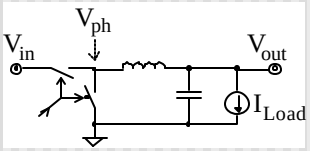
This project is focused on developing new system-based power-saving techniques for DC-DC Converters. As a part of this project, existing power saving techniques are researched and assessed. Converter efficiency and some existing power-saving techniques are the focus of this poster presentation.

Overview

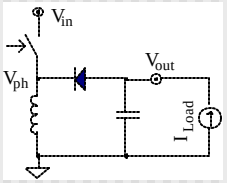
Boost Converter



Buck Converter



Buck-Boost Converter →

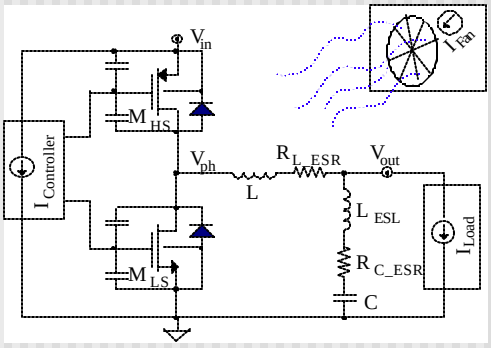


Why increase efficiency?

- Longer battery life (laptops, cell phones, etc.)
- Smaller size and less weight → No heat sinks and single battery operation

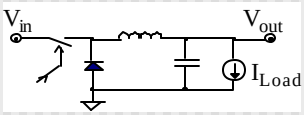
Power Losses

- Where is power lost?
  - Conduction Losses (DC)
    - Diode/Transistors
    - Capacitor ESR, Inductor ESR
  - Switching Losses (AC)
    - Voltage/Current Overlap
    - Capacitive Losses
  - Thermal Losses
    - Fan current

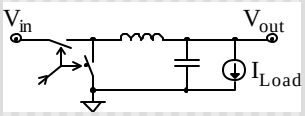


Asynchronous vs. Synchronous

Asynchronous



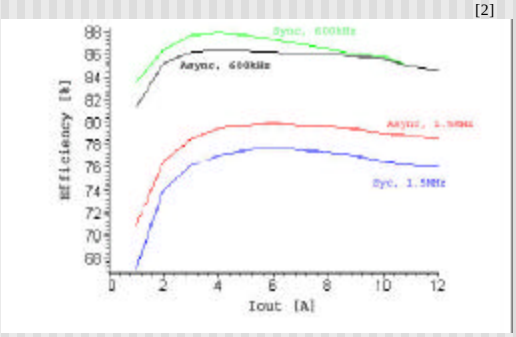
Synchronous



Efficiency Perspective

- High frequency -> Async
- Low frequency, low output current -> Sync

[2]

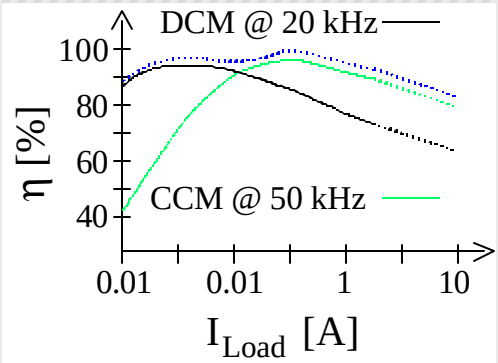


[2] Djekic, Ognjen and Brkovic, Miki. *Synchronous Reectifiers vs. Schottky Diodes in a Buck Topology for Low Voltage Applications.* Power Electronics Specialists Conference, 1997.

DCM vs. CCM

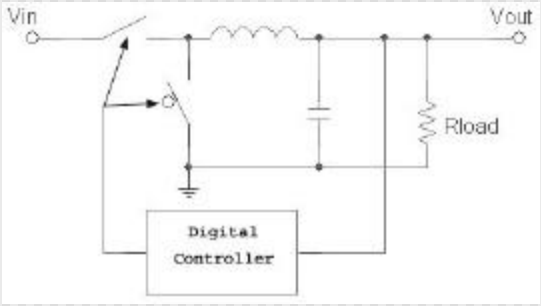
- Operating Modes
  - CCM -> Inductor current never goes to zero
  - DCM -> Inductor current goes to zero between cycles
- Efficiency Perspective
  - Light loads -> Operate in DCM and Async Mode
  - Heavy loads -> Operate in CCM and Sync Mode

[1]



[1] Prodic, Aleksandar and Maksimovic, Dragan. *Digital PWM Controller and Current Estimator for A Low-Power Switching Converter.* 7th IEEE Workshop on Computers in Power Electronics, 2000.

Digital PWM Controller[1]



- Example Technique: Mode-Hopping
  - Operate in either CCM/Sync or DCM/Async, depending on load characteristics
  - Increases efficiency for wide range of loading

Summary

- Major Power Losses
  - Switching Losses
    - At high frequencies
    - Light loads
  - Conduction Losses
    - At higher loads
  - Thermal Losses
- Modes
  - Synchronous
    - Heavy Loads
    - Low-Mid Frequencies
  - Asynchronous
    - Light Loads
    - High Frequencies
  - DCM/Async
    - Light Loads
  - CCM/Sync
    - Heavy Loads
  - Mode Hopping
    - For wide range of loads
    - High Complexity

Present Status/Goals

- Presently, completing research on existing power saving techniques
- Goals
  - Suggest new techniques
  - Verify with simulations
  - Verify with hardware
  - Publish results