Design Of Energy-Efficient Switch-Mode DC-DC Converters For Mobile Applications

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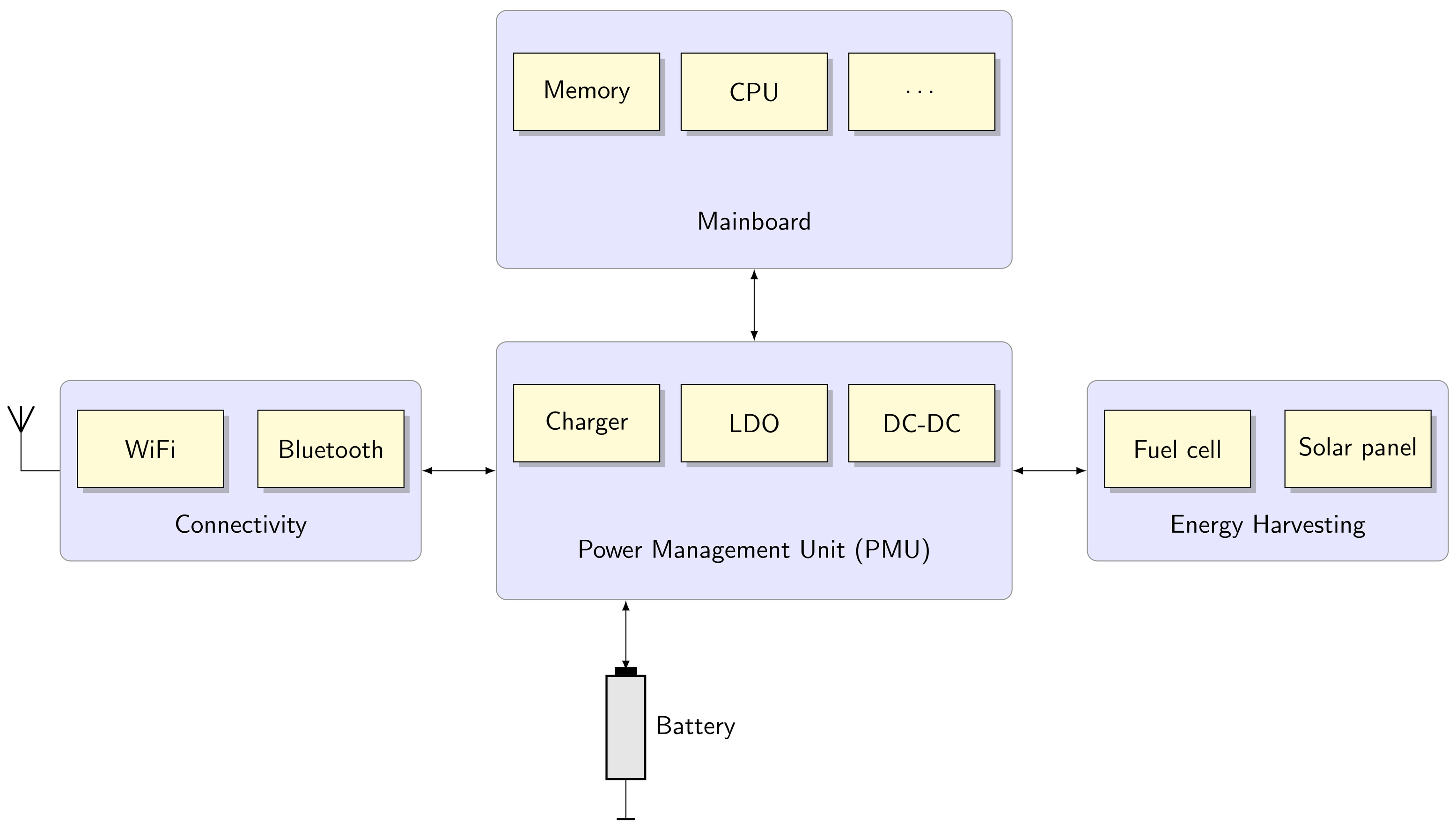
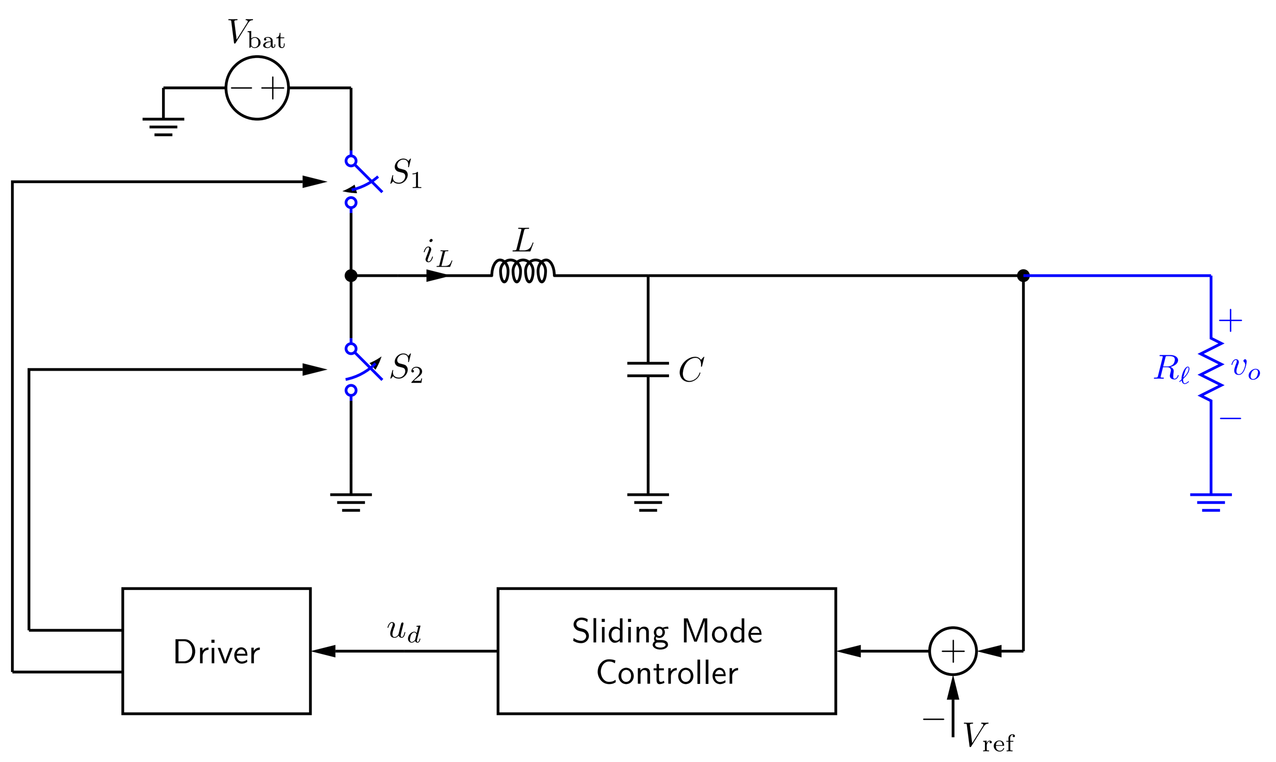
Motivation

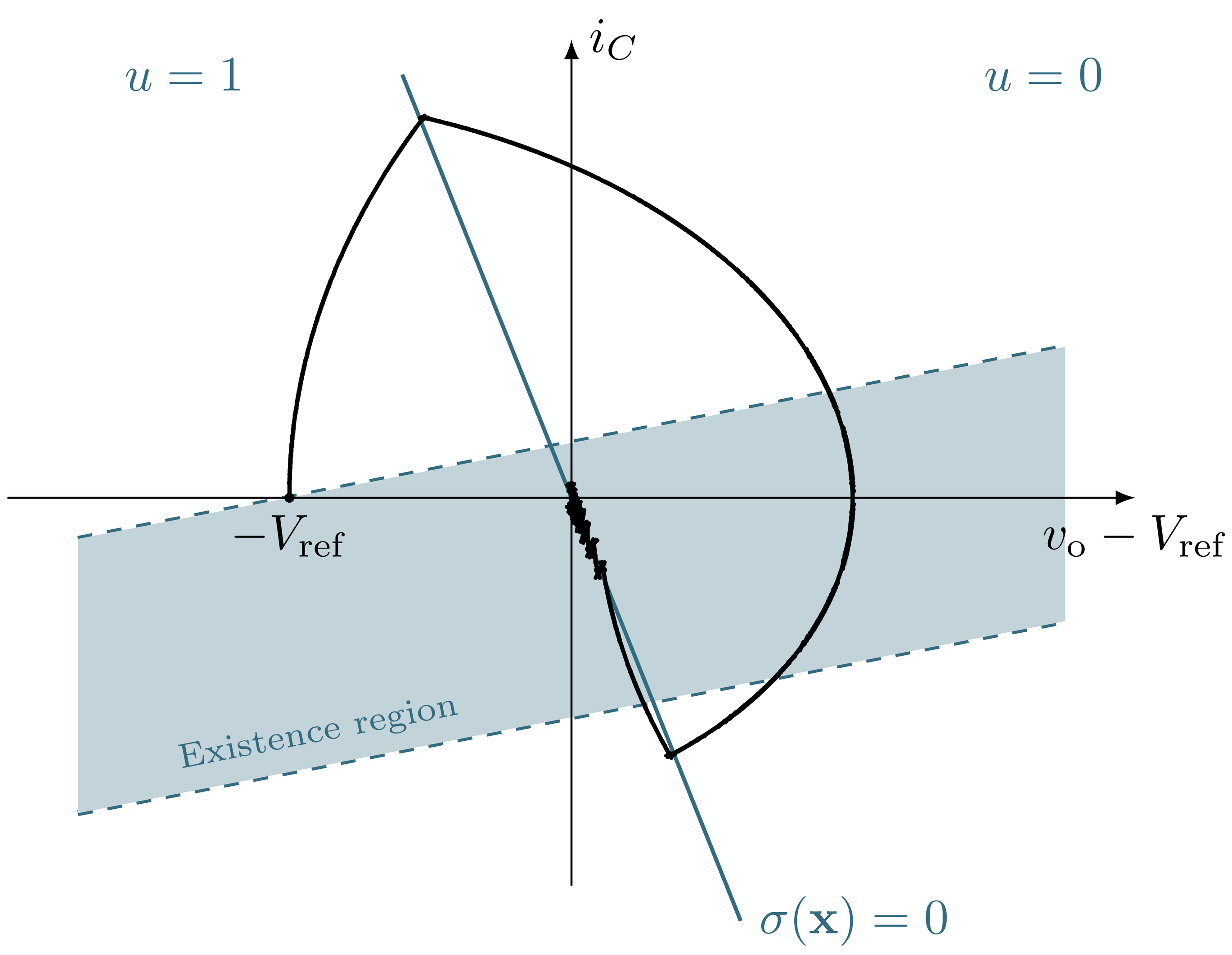


- Different components require different (stable) supply voltages
- Several DC-DC converters are typically necessary to convert the battery voltage into the different required levels
- Power conversion should be as efficient as possible
  - ▷ Resource savings
  - ▷ Extend lifetime of battery-powered devices

Control theory

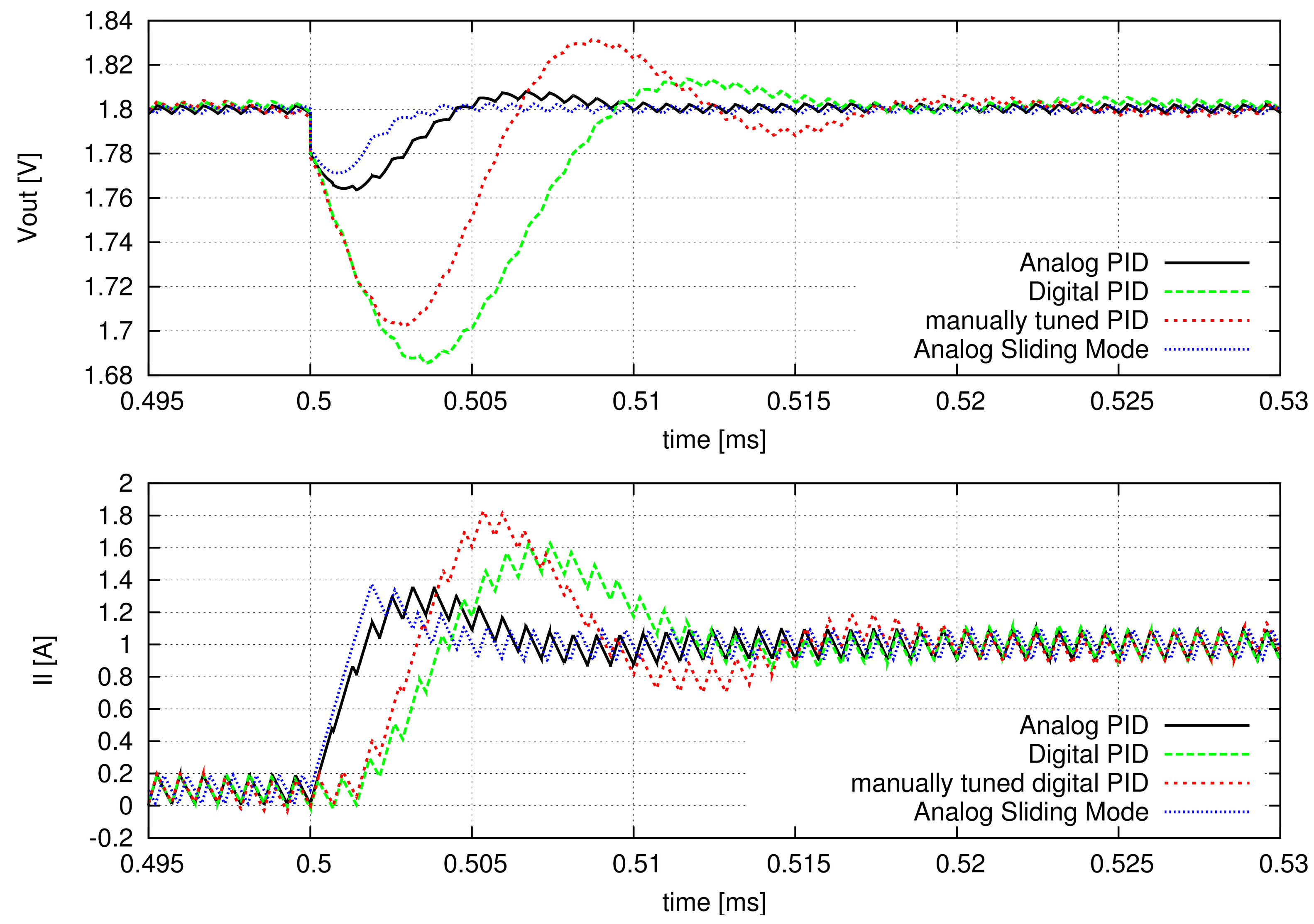


- Needed to tightly regulate the output voltage of a DC-DC converter
- Can play a key role in the efficiency
  - ▷ Reduce the switching activity (e.g. DCM, PFM)
  - ▷ Reduce under- and overshoots during transient ⇒ reference value can be reduced
- Alternative and modern structures alternative to linear PID worth exploring, e.g. Sliding Mode:
  - ▷ Improved dynamic performance (e.g. load transient)
  - ▷ Improved efficiency
  - ▷ Robustness to parameter variations



Implementation

- Choice between analog and digital should be made with care
- Digital implementation gives more flexibility
  - ▷ Power consumption of the additional ADC must be evaluated
  - ▷ Particularly critical at high switching frequencies
- Analog implementation generally offers faster dynamic response and lower power consumption



Challenges

- Maximize efficiency
- Optimize the control structures
  - ▷ Use innovative control techniques (especially with digital implementations)
    - Sliding mode
    - H_∞ control
    - Fuzzy logic
    - Predictive control
  - ▷ Auto-tuning of the control coefficients
- Fully integrated DC-DC converters
  - ▷ Output filter integrated on-chip
  - ▷ Requires extremely high switching frequencies
- Energy harvesting

Application example – Buck-Boost converter for mobile devices

- Capable of stepping up and down the input (battery) voltage
- Analog implementation for high-performance and low-power
- 0.13 µm CMOS technology
- Efficiency improvement via control algorithm (efficient operating mode selection)

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