High Performance Predictive Digital Current Mode Controller for DC-DC Converters

Dc-dc converters are widely used in battery chargers, chargers for electrical vehicles, power-factor-correction applications, solar power systems and power supplies. Due to dynamic performance requirements and control frequencies ranging from tens of kHz to Mhz, dc-dc converters have traditionally been controlled using analog circuitry. With improved processing speed and capabilities of digital controllers in recent years, interest in digital control of dc-dc converters has increased. Although digital control of dc-dc converters have significant advantages such as increased immunity to noise and environmental changes and use of advanced, flexible and adaptive controllers, they also have inherently lower bandwidth due to sampling and processing delays. Since bandwidth is directly related with performance, maximizing performance of digital control is essential. The main objective of this PhD project is therefore to optimize the control performance of digital current controlled dc-dc converters.

This project proposed a predictive digital current control method for isolated and non-isolated dc-dc converters. The control method is based on estimating the converter inductor current to control and predict the converter current under varying converter load and operating conditions.

The research project also include:

- Improve bandwidth for predictive digital current control using adaptive slope compensation.
- Digital estimating and control of transformer magnetizing current in isolated full-bridge forward converters.
- Predictive digital current control with built-in magnetizing current balancing for isolated full-bridge forward converters.
- A new concept for verification and analysis of digital control strategies for dc-dc converters.

The proposed predictive digital current control method has been experimental verified on a 450 W buck converter and a 2.4 kW isolated full-bridge forward converter. The experimental results demonstrate the achievement of a high performance predictive digital current controller for both converter topologies.