Abstract

Applications like electric vehicle, LED drivers, and portable devices are moving towards miniaturization. The power management unit of these applications operating from single voltage source demand better efficiency, compactness, longer battery life and regulated voltages. To achieve these requirements many single-input multiple-output (SIMO) DC-DC converters have been proposed in the literature. This research work focuses on coupled inductor single-input dual-output (CI-SIDO) converters. The CI-SIDO converter utilizes coupled inductors on one magnetic core and hence reduces the number of magnetic components. The use of an inversely coupled inductor offers benefits of reduced current ripple and improved efficiency. However, due to the coupling of inductor currents, the outputs are coupled and CISIDO converters suffer from cross coupling and cross-regulation problems. These issues affect the converter performance and stability. Thus, designing an appropriate control technique is a fundamental challenge for achieving desired performance and stability. Hence converter dynamics need to be analyzed and predicted accurately.

The dynamics of CI-SIDO converters are analyzed by developing the small-signal model using the state-space averaging method. It is inferred that the steady-state behaviour of CI-SIDO converters is the same as that of single-input single-output (SISO) dc-dc converters. However, the CI-SIDO converter's dynamic characteristic is affected by choice of the coefficient of coupling *k*. The derived small-signal transfer functions reveal that complex poles and zeros of the converter, cross-coupling and cross-regulation are affected by choice of *k*. As a result, with tight coupling (high value of k), the converter leads to instability with sever cross-coupling and cross-regulation effects. Therefore, the moderate coupling is preferred for CI-SIDO converters.

For CI-SIDO converters, achieving independent regulation of output voltages and maintaining good dynamic performance are difficult due to cross-regulation and cross-coupling problems. Therefore, this thesis proposes a decoupled voltage mode control (VMC) and decoupled average current mode (ACC) control for CI-SIDO buck converter to address the issues of cross-coupling. The proposed decoupled method ensures good dynamic performance and is validated using experimental and simulation results.

To further suppress the cross-regulation, peak current mode (PCM) control is introduced for CI-SIDO converter in this thesis. Compared to the conventional PCM control of SISO converter, the

PCM control of CI-SIDO converter has more complex structure and stability issues. Therefore, a unified small-signal model is developed for PCM controlled CI-SIDO converter to predict the instability and dynamic characteristics. Moreover, using the unified small-signal model, the design procedure for slope-compensation and controller is proposed for PCM controlled CI-SIDO buck converter. The proposed PCM control suppresses the cross-regulation, cross-coupling of the CI-SIDO buck converter with good dynamic performance and is verified through simulation and experimental results.