

## Abstract for thesis initiation

DC-DC power converters are widely used in many industrial and commercial applications, such as computers, electric vehicles and renewable energy generation systems, to name a few. In the past decade, due to the various requirements of practical applications, a lot of new dc-dc power converters has been proposed. In particular, the transformer-less high-gain dc-dc converter is of interest since it is capable of boosting a lower level voltage to a very high level without an extreme duty ratio. Besides, these converters have high transfer efficiency and small power losses. However, since the high-gain converters are generally high-order systems, there are many state variables that can be used for the feedback purposes. Hence, developing the controllers for these converters using the least number of system state variables and the most suitable state variables are still open questions which need to be addressed. The objective of this thesis is to investigate the control aspect of high-order transformer-less dc-dc boost converters. The details are described in the following.

Based on the studies of using the least number of state variables to regulate high-order converter systems, some output feedback control laws for various high-order boost-type dc-dc converters have been proposed. In these control laws, only the output voltage is required for feedback purposes. This feature results in control laws that are very suitable for applications where there are power density constraints to accommodate the current sensor.

Firstly, a voltage-mode controller for a dc-dc multilevel boost converter was investigated. Unlike some existing voltage-mode controllers for the high-order dc-dc converters, the selection of the controller gains mainly relies on a trial and error approach. Since the proposed controller uses a new structure, it permits the frequency domain method to be directly used to select the appropriate values for the controller gains to ensure system stability. As such, it is easier to achieve the desired control performance.

Secondly, the development of a novel output feedback control strategy for the super-lift re-lift Luo converter was investigated. The main feature of this controller is that, despite the non-minimum phase behavior of the converter, the output voltage is regulated directly. Apart from this, the structure of the proposed controller is such that there is no risk of saturation in the control law due to division by zero, and the “remaining dynamics” for the controlled converter has only one equilibrium point which is always stable. The stability analysis of the closed-loop controlled system was carried out and the feasibility of the proposed controller was shown. Finally, some simulation and experimental results were obtained to validate the theoretical conclusions.

Thirdly, an improved voltage-mode controller for the quadratic boost dc-dc converter was addressed. A new structure for the integral action was adopted in this controller. Since the time derivative of the adopted integral action is bounded by a user-defined constant, the extreme changes in the control signal can be avoided. As such, the proposed controller provides better control performance as compared to its counterparts using the traditional integral action.

Besides the work on how to regulate high-order converters using only the output voltage for the feedback purposes, the study on how to select the most suitable state variable to control the high-order dc-dc boost converters was also addressed in the thesis. For the current-mode control techniques, the measurement of the inductor current for feedback purpose is necessary. However, for some of the high-gain dc-dc converters, such as the hybrid-type high-order dc-dc boost converter, they contain two or more inductors. Which inductor current is more suitable

for the design of the controller is an issue that should be answered. To address this issue, a comparative study of the adaptive current-mode controllers for the hybrid-type high-order dc-dc boost converter was carried out. The root-locus method was used to determine the most suitable inductor current for the controller design. Some simulation as well as experimental results were obtained to verify the theoretical conclusions.