Ph.D Thesis Title: Analysis, Modeling and Control of Quadratic Type Wider Step-Down Gain DC-DC Converters

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ABSTRACT

Low voltage, high current functionalities are rapidly proliferating in modern point-of-load applications like microprocessors, battery chargers, LED ballasts, automotive drive trains, portable electronic gadgets etc. To meet these supply requirements, traditional DC-DC buck converter suffers from switch under-utilization, constricted range of control, high device power stress and associated ripple current losses. Isolated DC-DC step-down converter topologies can provide wider conversion ratios, but they make substantial compromise on switching voltage/current surges, system volume, cost, transformer magnetizing losses and efficiency. As a result, development of non-isolated higher-order step-down converter topologies has garnered significant attention in recent years.

Through this thesis, such advanced transformerless topologies namely: sixth-order step-down converter, fifth-order step-down converter and fourth-order step-down converter, are introduced for point-of-load applications. Having quadratic type of wider voltage gain, these topologies facilitate an optimal trade-off between system order, switching elements and imposed voltage/current stress on the components. Their time domain analysis is carried out to anticipate steady-state behaviour and establish *L-C* design equations. State-space averaged model for each topology is obtained and linearized transfer functions are evaluated, to subsequently design a fixed-frequency indirect sliding mode controller. The equivalent control law presented in this scheme is duly constituted from source side inductor current dynamics and load voltage error information, thus it provides simple realization as well as better transient response. Salient operational characteristics of the proposed topologies are analytically studied with simulation tools and subsequently validated using experimental outcomes of laboratory prototypes.