

ABSTRACT

In this thesis, design and control of hybrid buck-SEPIC two-input DC-DC converter topologies and its application in power management is investigated. The hybrid converter topologies are evolved with the aim to realize extreme step-down conversion ratios. The hybrid converters formulated in this work are: (i) Switched Inductor Hybrid Buck SEPIC two-input Converter (SIHBSTIC), (ii) Sixth-order Quadratic Buck-SEPIC two-input DC-DC Converter (QBSTIC), and (iii) Switched Capacitor-cell with Hybrid Buck-SEPIC two-input converter (SCHBSTIC) topology-1 and topology-2. All these topologies exhibit step-down voltage conversion features and are functions of two different pulse width modulated (PWM) controlling inputs. Further, they also draw power from two different voltage sources along with load sharing on the input dc-sources. All of these topologies offer the benefit of more bucking at lower duty ratios while some of the topologies exhibit quadratic bucking behavior. The topologies are evolved to not only give the benefit of more bucking but to also give the feature of lower ripple content in their source currents.

An extensive steady-state analysis of these proposed topologies is carried-out so as to understand the nature of these hybrid-buck converters. To further investigate the nature of these topologies, dynamic analysis is done and state-space models are formulated. As all these topologies belongs to multi-input multi-output (MIMO) systems and are primarily evolved for two-input applications, the transfer functions indicating the dependency of load voltage, source current on the controlling duty ratios are formulated. On the basis of these transfer functions controlling and controlled quantities dependency is identified and then their pairing is done for judicious power management.

After having enough understanding of the hybrid topologies evolved in this thesis, attention has been paid in designing the controller for achieving reliable power transfer. Though many multi-variable control strategies are possible for these hybrid buck topologies but this work primarily focuses on the Individual Channel Design (ICD), multi-variable quantitative feedback theory (QFT) based design so as achieve controllers. By the virtue of multi-input structure, existence of interactions within the converter system are inevitable. For designing the diagonal controllers, the plant interactions dependent transfer functions needs to be reflected on to the diagonal transfer functions. Although such transformation is possible but it would lead to ineffective handling of the high frequency dynamics. Thus to avoid all such transformation relevant issues and to accommodate the dynamics of the plant for the entire frequency range, a full-order or non-diagonal controller strategy design using MIMO-QFT is attempted.

Having done thorough investigations on steady-state, dynamics as well as the MIMO-controller design of all the proposed hybrid buck-SEPIC topologies, their validity is tested in the simulation platform. In all the topologies formulated, the effectiveness of the non-diagonal controller is seen both in steady-state as well as during dynamics. It clearly indicated that the resultant MIMO-controller takes into account the plant interactions effectively thus avoiding instability issues. To also test MIMO-controller effectiveness, several different disturbances are created and in all these cases the proposed topologies are stable and ensures power management indicating the designed controllers robustness.