ABSTRACT

This thesis focusses on developing buck-boost dc-dc converter topologies by utilizing a switching-capacitor cell offering a variety of voltage gains. Firstly, a switching-capacitor cell buck-boost converter (SCBBC) which has gain same as that of conventional buck-boost converter (CBBC) is evolved. Though its gain is same as that of CBBC i.e. $D/(1-D)$, it overcomes many limitations such as non-inverted load voltage polarity, common ground and non-pulsating source current. The degree of freedom associated with two controllable switches is utilized to enable multi-mode operation offering stand-alone buck as well as standalone boost functionality along with the transition from buck mode to boost mode and vice-versa. Despite being operational under multi-mode, it exhibits low source current ripple. Detailed steady-state as well as small-signal analysis of the converter in all modes of operation are formulated and it is observed that the proposed converter exhibits minimum-phase behavior. Exhaustive simulations with supporting experimental measurements have also been made.

The voltage gain exhibited by SCBBC topologies varies highly non-linearly with duty ratio and this pose controlling issues particularly at higher duty ratios. In order to minimize this non-linear trend in gain variation, the duty ratio range for bucking operation is increased by replacing the switching capacitor with a split capacitor cell. This cell embedded SCBBC topology is named as modified switching-capacitor cell buck-boost converter (MSCBBC). Extensive mathematical analysis is established for three MSCBBC topologies. Though these topologies are effective in extending the duty ratio range however they need more number of components.

With an attempt to increase the voltage gain in the bucking range with reduced number of components, an alternative topologies named as extended switching-capacitor based buck-boost converter (ESCBBC) topologies are evolved. This evolution is formulated by utilizing the switching-capacitor cell with an addition of a charge-pump cell to it. Two topologies are identified under this ESCBBC family i.e. ESCBBC Type-1 and Type-2. Both of them have identical voltage gain$(1/2(1-D))$. Due to this, these converters offer fine-tuned feature in bucking range. A comparison of ESCBBC Type-1 and Type-2 converter showed that ESCBBC Type-2 inherits the features of ESCBBC Type-1 converter but exhibits reduction in source current ripple close to 50 %. The converter also exhibited minimum-phase behaviour. Steady-state analysis is followed by state-space model formulations and the analytical findings are validated with experimental observations.