6

CONCLUSION AND FUTURE SCOPE

In this chapter, general conclusion of the thesis has been presented in section 6.1 and some further future scope of the research are also drawn in the section 6.2.

6.1 Conclusion

The general conclusions are divided in several sub sections according to different converters presented in this thesis. The high gain converter is essential in several renewable energy resources such as small roof-top solar PV and fuel cell application. These renewable energy sources used in microgrid application generally generate low voltages which are to be converted into high dc-dc or dc-ac output voltage or as demanded by the distribution system. In order to take care of the issues related to the low voltage generation of renewable resources, several converters are proposed. The proposed converters are as 1) minimum phase quadratic boost hybrid converter, 2) two quadratic boost derived hybrid multi-output converter, and, 3) three switched-boost modified ZSI topologies. The detailed conclusions of individual proposed converters are as follows.

1) Minimum phase quadratic boost hybrid converter

The conventional boost, buck-boost derived inverters/converter topologies as well as impedance source inverters found in the literatures prominently display RHPZ in the control-to-output transfer function and therefore, make the system non-minimum phase. The presence of RHPZ causes the controller design complex. Presence of RHPZ in the system also poses problem of lower bandwidth of the system (slower system) and gives difficulty in achieving adequate phase margin (less relative stability). The proposed minimum phase quadratic boost hybrid inverter is derived from the quadratic boost converter therefore, for relatively low duty ratio; high voltage gain can be achieved for dc output. The hybrid inverter is developed by coupling the filter inductors of quadratic boost converter with an insertion of damping network in the circuit and replacing load side main switch of the quadratic boost converter by the H-bridge inverter. This circuit arrangement facilitates the simultaneous dc and ac output for the hybrid inverter and helps in complete elimination of RHPZ thereby making it a minimum phase system. The detailed mathematical modeling and dynamic analysis for the proposed concept is carried out. A comparative analysis between the proposed inverter and other classical inverters is presented to bring out the advantages of the proposed inverter. Steady state analysis, design of hybrid PWM techniques, and detailed analysis about no RHPZ property of the proposed hybrid inverter are carried out. The proposed concept is also validated through simulation and experimental results.

2) Quadratic boost derived hybrid multi-output converter

In microgrid application multi-output converters are required for different power requirements. So, in this work multiple ac outputs and one dc output, two (series mode and parallel mode) quadratic boost derived hybrid multi-output converters are proposed.

The proposed converters are derived by replacing the main switch of the quadratic boost converter with n- number of H Bridge inverters connected either in series or parallel. The topology which is developed from n-series connected H-bridges give series mode of the proposed converter and it is capable of giving n-number of ac outputs with variable voltages and same currents (to all the ac loads) along with one dc output. Moreover, the topology which is developed from n-parallel connected H-bridges give parallel mode of the proposed converter and it is capable of giving n-number of ac outputs with same voltages (to all the ac load) and variable currents along with one dc output. In this way, the proposed hybrid converter topologies are capable of directly meeting out more than one different ac load demands directly (without any extra regulator or adaptor) unlike the conventional existing hybrid converters. Due to quadratic behaviour relatively (compared to the classical hybrid converters) small shoot-through duty is required to achieve high voltage gain therefore, the proposed multi-output hybrid converters are capable of operating on a wide range of shoot-through duty cycle ($0 < D < 1$). Moreover, the proposed topologies (series mode and parallel mode) have higher power density and improved reliability (due to inherent shoot-through protection property) which make them suitable to be used in compact systems with multiple ac and one dc loads. Steady state analysis, small signal modelling, and design of hybrid pulse width modulation (PWM) technique are carried out for the proposed converters (for two ac and one dc outputs) in the thesis. The proposed hybrid converters (series and parallel mode) are validated for two ac and one dc outputs through simulations and experimental results.

3) Switched-boost modified ZSIs topologies

The proposed modified ZSIs topologies give high voltage gain at low D as compared to the traditional ZSIs. The proposed ZSIs can be applied to dc-dc and dc-ac

power conversion for renewable energy sources where low voltage input and high voltage gain is required. Since for the proposed ZSIs, $M + D \leq 1$, operating at low D gives flexibility to operate with wide ranges of M. This enables the proposed topologies to give higher ac voltage gain compared to traditional ZSIs. To validate the proposed ZSIs, simple boost pulse width modulation (PWM) control technique has been used to verify the operation of the proposed three-phase inverter. By extending the proposed CC-qZSI to n- number of stages, the boost capability can further be increased. Detailed analysis and comparison in terms of voltage gain, voltage stress, current stress, stored energy analysis, power loss, total harmonic distortion (THD), and efficiency analysis are carried out to show the advantages of the proposed three-phase inverters as compared to the conventional ZSIs. Moreover, proposed CC-qZSI has lesser stored energy in the passive components and lesser peak SDP to output power ratio as compared to conventional qZSI when operating at $B \geq 2$. Simulation and experimental studies are presented to validate the performance of the proposed three-phase CC-qZSI.

6.2 Future scope of the research

The future scopes of the proposed work are as follows:

1) A simple boost PWM control technique is used for the proposed converters. The simple boost PWM techniques has a constraint that addition of modulation index and duty cycle is always be less than 1. However, PWM control techniques such as maximum boost, maximum constants boost, modified space vector has relaxed limit between modulation index and duty cycle which results into higher gain of the output voltage at same duty cycle. The performance of the proposed converters with the maximum boost, maximum constants boost, and modified space vector technique may be tested in future extension of this work.

2) To further enhance the boost factor in the proposed converters, inductors and capacitors are replaced with switched inductors and switched capacitor techniques.

3) Coupled inductor is also an effective technique to compact the sizing of the inductor. However, transformer based technique suffers from decreased efficiency. So, proper energy recycling techniques may be used to increase the efficiency of the proposed converters.

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