Abstract

The factors like increasing population, improvement in the standard of living around the world, and depletion in conventional sources of energy have led to an imminent energy crisis situation. Renewable energy sources like solar and wind have been accepted by industries, governments, and the public at an unprecedented rate. The major problem with renewable energy sources is their intermittent and stochastic nature of availability. As solar and wind power availability is complementary chronologically and topologically, it makes them the perfect candidate for developing a hybrid system. Moreover, as renewable energy resources have DC power generation and end-to-end efficiency of DC to DC power delivery is higher. Thus, this hybrid power is designed to feed a local DC microgrid, which can operate in the islanded as well as in grid-connected mode. Here, two different converter topologies for PV generation system and a single stage three-phase AC to DC converter topology is presented to deal with associated problems with solar and wind generation systems.

An interleaved, highly efficient, high-gain modified boost converter is presented. High gain and transformerless converter operation make the converter suitable for integrating photovoltaic (PV) power to a standalone DC microgrid. A coupled inductor is used with two diodes and one switch per phase with a common clamping capacitor to modify the conventional boost converter. The common clamping capacitor and coupled inductor reduce the converter's component count and size; thus, high efficiency is achieved at a low cost. The proposed converter achieves a high step-up gain and low voltage stress on switches. Interleaved converters are deemed ideal for PV power extraction as they exhibit low input current ripple. A 900 W prototype of a two-phase interleaved modified boost converter is designed and developed to verify the working principle of the converter and performance testing.

An interleaved, high-gain quadratic boost converter with a continuous input current is presented in this Thesis. The current ripple is eliminated in the designed two-phase interleaved converter by operating the input side switches at the fixed duty of 0.5. The transformerless converter operation with high gain makes the converter suitable for integrating photovoltaic (PV) power to standalone DC microgrid. The common intermediate capacitor reduces the component count and voltage stress on the input side switches; thus, achieving high efficiency at a lower cost. The Proposed topology of the interleaved quadratic boost converter is ideal for PV power extraction as it exhibits no input current ripple and has high input current handling capability. A 1000 W two-phase interleaved prototype of the converter is designed, developed, and analyzed to verify its working principle. The performance testing is done with the laboratory prototype with a DC microgrid of 230 V connected to the converter's output.

The prevalent use of the DBR in three-phase Wind Energy Conversion Systems (WECS) decreases power generation efficiency. In standalone wind energy generation, bridgeless converters can address this problem by eliminating the front-end DBR. Thus, a novel single-stage three-phase bridgeless AC to DC cuk converter for WECS is presented. The proposed converter is designed to work in Discontinuous Inductor Current Mode (DICM) because of its inherent Power Factor Correction (PFC) and less harmonic distortion. In this converter, component reduction per phase is achieved by using body-diodes of the MOSFETs. A unique MPPT technique is developed for this converter using Three-phase voltages and currents instead of the DC link states. A Wind Energy Emulation system using a DC motor and SEIG is used to test the laboratory prototype of the proposed converter. Furthermore, a permanent magnet synchronous generator (PMSG) based WECS system is developed and analysed.

A comparison of hybrid solar-wind power generation system fed DC microgrid connected to a battery and single-phase grid is presented. The battery is feeding the DC microgrid through a bidirectional quadratic buck/boost converter. Alternatively, the single-phase grid connection to the DC microgrid through an H-bridge inverter. A detailed discussion of the control technique for single-phase grid to DC microgrid is presented as well.