Abstract

Grid connected converters are widely used as front end rectifiers, interface between renewable energy and grid, and power quality applications. Popular control techniques to generate gating signals for active devices, reported in literature are voltage-oriented control, direct power control and one cycle control. In literature, one cycle control has also been reported as scalar resistive emulation or unified constant frequency integration control. The above-mentioned control techniques has been collectively addressed as conventional one cycle control (C-OCC). Light load instability and steady state dc offset phenomenon are the major concerns with of the conventional one cycle control reported in literature. These issues were addressed in the liter-ature by treating them independently. This thesis proposes a common solution to address the light load instability and steady state dc offset phenomenon of conventional one cycle control.

C-OCC employs peak detection comparison method, hence the peak of the current always confines with the grid voltage. Therefore, the average current will differ by the ripple error. This results in the steady state dc offset, which is more severe at light load. Further in C-OCC, since the valley of current is not controlled a localized sub-harmonic instability occurs when slope of the falling current is greater than that of the slope of carrier. This thesis proposes a method to control both peak and valley of current, such that the converter changes its state when the expected value of current has been attained. Valley of current in each carrier cycle is decided such that the current has no steady state dc offset in current. To control peak and valley of current, this comparison is necessitated once more. This results in two comparisons in a carrier cycle, hence the name dual comparison one cycle control (DC-OCC). A generalized approach for controlling average current in a carrier cycle for grid connected converter has

been proposed. Stability of the inherent current loop in DC-OCC, using propagation dynamics of small disturbance, showed that the proposed control strategy did not suffer from localized sub-harmonic instability.

In a converter controlled by C-OCC and DC-OCC, the current lags the grid voltage. The reason for this has been discovered to be the inductive drop across the boost inductor. A novel method to compensate for the inductive drop is proposed in this thesis. The sensed input current is modified by adding a 90°phase shifted current with appropriate gain and is used for comparison to generate gating signals for active devices.

The sensed input current is added with a fictitious current, generated from gating signal of the active devices, to enable bi-directional power ow in converters controlled by DC-OCC. A second order band pass filter (BPF) is used to generate the fictitious current from the gating signal. Effects of BPF corner frequency in quality of current drawn or injected into the grid is used during the design of the filter.

The sum of sensed input current and fictitious current, is further modified by adding a 90°phase shifted current with appropriate gain. This modification enabled the converter to draw or inject power at an adjustable displacement power factor. Moreover, this modification also enables the converter to operate as a STATCOM. The gain of the phase shifted current determines the phase of the current drawn or injected. The current loop showed a tendency to become unstable when the gain of the phase shifted current approached 0.5. Small signal model of the converter is used to analyze this instability.

Average modeling technique is used to derive the model of the converter controlled by DC- OCC. Further, the non-linear average model is linearized using small signal analysis. The small signal model shows the presence of an inherent current loop with a proportional controller. Gain of the proportional controller is the effective resistance seen by the current loop. As the gain of the phase shifted current loop approaches 0.5, the closed poles of the inherent current loop crosses over to the right half of s-plane, causing an instability in the current loop. Design of voltage loop controller parameters is also presented in this thesis.

All of the above modifications are validated in simulations and experiments. Simulation and experimental results are presented in this thesis for converters in the range from 600 W to 2 kW.