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Title : THREE-PHASE AC-DC CURRENT INJECTION HYBRID RESONANT CONVERTER (CIHRC) WITH WIRELESS POWER TRANSFER FUNCTION

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In this thesis, the three-phase AC-DC current injection hybrid (series-parallel) resonant converter (CIHRC) is proposed to achieve a high power factor by injecting high-frequency currents into the three-phase diode bridge rectifier, producing a high frequency modulation signal with only two soft-switched active devices. The hybrid configuration resonant converter has the desirable characteristics of both series and parallel configurations. As such, the resonant current dependency problem of the typical series configuration circuit topology can be overcome, allowing the control of the output voltage at no-load or small load conditions. With an appropriate design of hybrid resonant circuit and a suitable switching frequency selection, the devices is capable to operate under virtually lossless zero voltage switching (ZVS) conditions allowing reduction in the size of inductive and magnetic components with high frequency operation. The early stage of the research work involved the derivation of detailed description of the steady-state analysis and characteristics of the proposed CIHRC. The test-rig of 1 kW operating at 20 kHz is developed and tested to be in good agreement with the prediction and simulation results. Next, the small-signal model is developed to design the compensator for the output voltage regulation, in which the derivation of a small-signal model is done by considering the converter to consist of two stages; the line-frequency rectifier and high-frequency resonant circuit. The analysis of line-frequency of the three-phase PWM AC-DC converter is based on the standard method. The resulting circuit equations that are expressed in state-space form are then averaged to remove the ripple. The direct and quadrature (d-q) transformation method is adopted to eliminate the time variance in the equations. In order to model the high-frequency resonant stage, the fundamental frequency methods are adopted. To match the line frequency equations of the three-phase PWM AC-DC converter with the high-frequency resonant stage equations, the power balanced relationship for the DC link methods are employed. Then, by considering small perturbations in all variables, the resulting non-linear model is linearised. The small-signal model is used to design the closed loop controller for the proposed three-phase AC-DC CIHRC. Such closed loop controller of the converter is designed based on the classical techniques of linear network and control theory. In addition, the compensator for the output voltage regulation is designed based on the open-loop control-to-output frequency response, the location of poles and also the trade-off between reducing the output voltage ripple and maintaining the high quality input line current. Design of this controller is verified under small signal change in the load, which is implemented by increasing and decreasing the parameters of the load resistor. With the successful application of the small-signal model in the closed-loop control, the output voltage regulation of the CIHRC is achieved. The proposed converter is further modified to operate wirelessly to provide wireless power transfer feature as an example of one of the salient application of CIHRC. High power transfer efficiency of 92 % is obtained showing the feasibility of the converter implementation in the wireless power transfer application whilst maintaining high input power factor. An experimental test-rig is constructed to verify the operation of the proposed system.