

High Efficiency Three-phase Power Factor Correction Rectifier using Wide Band-Gap Devices

Improving the conversion efficiency of power factor correction (PFC) rectifiers has become compelling due to their wide applications such as adjustable speed drives, uninterruptible power supplies (UPS), and battery chargers for electric vehicles (EVs). The attention to PFCs has increased even more since grid regulations have become stricter in terms of injected harmonic and power quality. Therefore, improving the efficiency and the power quality of PFCs are the main objectives of this PhD work.

Increasing the conversion efficiency requires optimizing of all the components employed in the converter, such as switches and filter parameters. To minimize the loss in the switches, it is reasonable to use power semiconductor devices which (1) have a low on-resistance and (2) have a good transient performance. Wide band gap (WBG) power devices present relatively good switching performance in comparison with the alternative silicon devices. This advantage yields to lower switching loss and possibly higher switching frequency. Therefore, in this thesis, WBG devices are used because of their better performance.

Modeling of the losses in the reactive components regardless of the switching frequency is vital for designing an optimum converter. In this thesis, a comprehensive model for designing the filter parameters is proposed. The model is based on analyzing the converter waveforms and generalizing their behavior to find the required filter parameters. The proposed method yields to an optimized filter.

The controller is also an important part of PFCs. In this research work, the aim of studying the controller is to investigate the impact of the controller on the efficiency. Finally, a 5 kW three-phase PFC using WBG devices is designed using the proposed model and the prototype is built. The measured efficiency of the converter is 98.95% at full load and 99.1% at half of the nominal load.

The major contributions of this work are as follows:

- A complete model for designing the filter parameters is proposed.
- A high efficiency 5 kW three-phase PFC with the efficiency of 98.95% at full load is achieved. The achieved efficiency is greater than the efficiencies most recently reported in the literature representing the state of the art.
- The conversion efficiency is substantially flat for a wide range of loads.