Module integrated converters (MIC), also called micro inverter, in single phase have witnessed recent market success due to unique features (1) improved energy harvest, (2) improved system efficiency, (3) lower installation costs, (4) plug-N-play operation, (5) and enhanced flexibility and modularity. The MIC sector has grown from a niche market to mainstream, especially in the United States. Due to the fact that two-stage architecture is commonly used for single phase MIC application. A DC-DC stage with maximum power point tracking to boost the output voltage of the Photovoltaic (PV) panel is employed in the first stage, DC-AC stage is used for use to connect the grid or the residential application. As well known, the cost of MIC is key issue compared to convention PV system, such as the architecture: string inverter or central inverter. A high efficiency and density DC-DC converter is proposed and dedicated for MIC application.

Assuming further expansion of the MIC market, this dissertation presents the micro-inverter concept incorporated in large size PV installations such as MW-class solar farms where a three phase AC connection is employed. A high efficiency three phase MIC with two-stage ZVS operation for grid tied photovoltaic system is proposed which will reduce cost per watt, improve reliability, and increase scalability of MW-class solar farms through the development of new solar farm system architectures. This dissertation presents modeling and triple-loop control for a high efficiency three-phase four-wire inverter for use in grid-connected two-stage micro inverter applications. An average signal model based on a synchronous rotation frame for a three-phase four-wire inverter has been developed. The inner current loop consists of a variable frequency bidirectional current mode (VFBCM) controller which regulates output filter inductor current thereby achieving ZVS, improved system response, and reduced grid current THD. Active damping of the LCL output filter using filter inductor current feedback is discussed along with small signal modeling of the proposed control method. Since the DC-link capacitor plays a critical role in two-stage micro inverter applications, a DC-link controller is implemented outside of the two current control loops to keep the bus voltage constant. In the end, simulation and experimental results from a 400 watt prototype are presented to verify the validity of the theoretical analysis.