CHAPTER 1

INTRODUCTION

Power electronics has grown rapidly in recent years because of advances in power semiconductor devices, new power converter circuit topologies, the use of advanced control techniques, and improvements in packaging and manufacturing. Industrial applications, flourished, are adjustable speed drives, uninterruptible power supplies and industrial power supplies for welding, materials processing and a host of other applications. These advances in technology and design techniques provide opportunities for improvement in product performance and cost and for new products and features previously not economically feasible.

The energy conversion using power converters can classify as:

a. DC to DC (direct current) converters,
b. DC to AC (alternative current) converters,
c. AC to DC converters, and
d. AC to AC converters.

These converters make it possible to deliver high performance, lower cost drives for a wide range of commercial, vehicular, military, utility and residential applications, there by contributing to efficient operation of electric power systems, enhance the efficient use of electricity, and thus contribute to environmental protection and sustainable developments around the world.

It is no longer possible to ignore the implications of the reliability and overall quality of our electrical power supply. Without dramatic changes in the quality of electric power coming into homes and businesses, everyone on the grid, from residential to industrial customers, is vulnerable to significant damage and loss. Interruptions and disturbances in supply voltage can shut down, damage, or even destroy the equipment it is attempting to run. The imbalance of supply and demand for energy in California led to rolling blackouts in 2001; facing challenges meeting energy needs with their current power supply. With the deregulation of power industry, it is expected that power electronics will be more active in energy generation and distribution as well.

Thus the market is largely driven by the need for uninterrupted, high-quality power, as companies are anxious to avoid both the inconvenience and potential financial losses caused by sudden power failures. Rising awareness about environmental concerns and unpredictability of conventional energy prices prompt the Government to emphasize the need for alternative sources of energy.

Converters are going to play increasingly important roles in the future energy intensive economy. Therefore, it is essential that we have efficient methodologies for their control, which will also help to improve their design and achieve the optimal, minimalist structures resulting in cost reduction, efficient improvement and reduction of the space they occupy. The control of these converters is a study, which involves a deep understanding of modulation schemes, and the mathematical methodologies that can be applied to determine various combinations for switching the power devices ON or OFF in order to synthesize the desired reference output. Even under fault conditions it is very valuable in designing converters with self-repair and reconfiguration capabilities.

Industry modulation standards for DC/AC or AC/DC high power converters primarily comprise of two techniques in digital implementation,

a. Comparison of modulating signal with triangle to generate pulse-width modulation (PWM), this can be continuous PWM (CPWM) or discontinuous PWM (DPWM) schemes.

b. Calculation of the switching times for the devices also known as space vector (SVPWM) technique

The choice of modulation schemes selected for particular applications depends on desired requirements such as good waveform quality, high dynamic performance, low switching loss and implementation simplicity. While traditional pulse-width and space vector modulation schemes result in converters with low-harmonic distortion waveform characteristics and implementation simplicity, the switching losses can be relatively high, making them unacceptable, especially for high power applications.

Discontinuous pulse-with (DPWM) and generalized (GDPWM) space vector modulations are known to be better than traditional versions in that waveform quality is improved, modulation linearity range can be increased, and – important for high power applications - reduced switching loss of converters.

Chapter 3 discusses the following modulation schemes in three-phase voltage source inverters.

i. Continuous PWM scheme

ii. Discontinuous PWM scheme

for balanced and unbalanced conditions. It also gives a mathematical insight in developing the theory for the carrier based GDPWM and SVPWM modulation schemes to be used in three-phase voltage source inverter. The developed theory is validated via experimental results.

Chapter 4 discusses the method of applying the developed PWM schemes in voltage source inverters to current source inverters. The switching states generated in voltage source inverters are recombined and processed to generate switching possibilities for a current source inverter. Over-modulation of these schemes is also discussed. This method developed is validated via experimental results.

Chapter 5 discusses the following modulation schemes in three-phase four wire voltage source inverters or four legged inverters.

i. Continuous PWM scheme
ii. Discontinuous PWM scheme

under balanced and unbalanced conditions. Here the theory developed in chapter 3 is extended and applied to three-phase four wire voltage source inverters or four legged inverter. A rigorous mathematical proof for exploring enormous possibilities of modulating the top devices is discussed. The developed theory is validated via experimental results.

Chapter 6 explains the modeling and control of a four- legged inverter. Comprehensive design of the controller using feedback-linearizing technique is discussed and supported with simulation results.

Chapter 7 explains the modeling and control of a four- legged active power filter. Comprehensive design of the controller is discussed supported with simulation results.

Chapter 9 discusses about the DSP source codes developed for the practical realization of the above converters. It deals with the various routines and subroutines called to synthesize the reference voltages. Comprehensive explanation of each routine is described in order to assist further modifications and progressive developments.

Finally Chapter 10 concludes the project objective and brings forward the scope for future research.

This dissertation will address the following issues of unbalanced load/source and nonlinear load in power electronics system with special attention to motor drive applications, utility power generation applications as in UPS systems and active Power Filters:

- Pulse width modulation techniques for 3 phase VSI and CSI.
- Pulse width modulation techniques for four legged power converters for unbalanced and nonlinear load.
- Modeling and control of power converter as an inverter and an active filter for unbalanced and nonlinear load
- Power converter system to handle unbalanced and nonlinear load