the number of circuit elements is minimized, because as the number of devices reduces the associated amount of switching reduces and so the losses are minimized.

Proliferation of nonlinear loads, such as three-phase rectifiers, adjustable speed drives and uninterruptible power supplies are prone to high harmonic injection into the utility, which powers them [1]. To reduce harmonic injections, improvement in displacement factor is considered and so power factor correction equipment like capacitors and filters are installed in the system. Harmonic currents cause resonance between utility and harmonic–producing loads or among multiple harmonic producing loads. These harmonic related phenomena result in de-rating of the system equipment such as transformers, higher transmission line loss and reduced system stability margin. Since electrical motors consume around 56% of the total consumed electrical energy the improvement in power factor of electrical drives as seen by the utility connection has been of major concern. Another consideration is the need to increase the VA capacity of motor drives, so that the full utilization of the isolated real power is possible [2].

In order to solve some of these problems, a large variety of control techniques and converter topologies have appeared in the literature [3]. Since good quality power factor systems are becoming more and more mandatory, power factor improvement is one of the key issues in designing a system.

Several methods have been attempted in order to obtain a satisfactory power quality from the supply mains. The use of terminal capacitors across the machine windings is very common, due to its low cost and simplicity. However, this method is often not often recommended for the adjustable speed drives employing inverters which are PWM operated, as the capacitor may draw high harmonic currents due to the harmonics present in the PWM terminal voltages, and the motor may experience self-excitation, which might cause over-voltages in its terminals [4].

In rural electric system

embedded control of the line and the load can be achieved. The superiority of static converters is further reinforced with the advances in power semiconductor devices and their control logic.

Previous work on static single-phase converters involves the use of thyristors in combination with L, C components, as in [6]. The disadvantage of this scheme is the limited control range and the L-C values must be matched with the load impedances. Moreover the circuit topology is bulky due to the reactor used with the input. In [5] a number of reduced switch count converter topologies for generating high quality three-phase voltages from single-phase mains have been presented, in which the converters were classified as active input current shaping feature ones and those without the active input current shaping feature. The converters, which do not employ the input current shaping feature have reduced number of switches when compared to ones in which this feature was included, but in both types the converter size is large due to the inductor, in series with the single-phase supply.

In [7] a new single-phase to three phase converter for low cost ac motor drive was presented, which employed only six switches and incorporates an active input current shaping feature that results in sinusoidal input current close to unity power factor. This converter has the capability of bidirectional power transfer, an improvement on all the previously proposed converters. In [8] new topologies for single to three-phase power conversion was proposed in which the zero sequence voltage was used to control the supply side parameters. This allowed the integration of the load and supply control, and with this class of converters unity power factor operation was possible.

Low power drive systems typically in the range of fractional horse-power (hp) to 1 hp, due to their massive emerging applications in appliances and in industrial processes have been of great interest for researchers to explore their performance while improving the same. For these low power drives it is very common to use the single-phase to three-phase type of converter to drive the motor. The usual approach for these adjustable speed drives is to implement the power factor correction (PFC) feature in the power converter itself, which normally requires additional circuitry and controls. Some analysis has been done in order to evaluate the impact of these PFC schemes in the drive system in terms of performance and costs. It was concluded that, though a good system input power factor improvement can be achieved, the used of additional PFC control feature may not be very attractive for induction motor drives, due to cost and packaging factors. Hence, in order to make this scheme more cost effective, it is important to develop power converters with PFC schemes using a reduced number of components and more integrated controls.

The use of digital signal processor (DSP) as a way to integrate multiple control functions in a motor drive system is becoming more and more common now-a days. In this thesis an approach to work on the concept of integrating motor and PFC controls with reduced number of switches in the converter topologies has been presented with detailed analysis of dynamic model and control scheme.

Due to the variety of the topologies and control strategies, the converter topologies have been differentiated as Conventional converters and Sparse converters. In Conventional circuits the number of switching devices are sufficient enough to achieve independent control of both the converter and the three-phase inverter. In sparse t enough to

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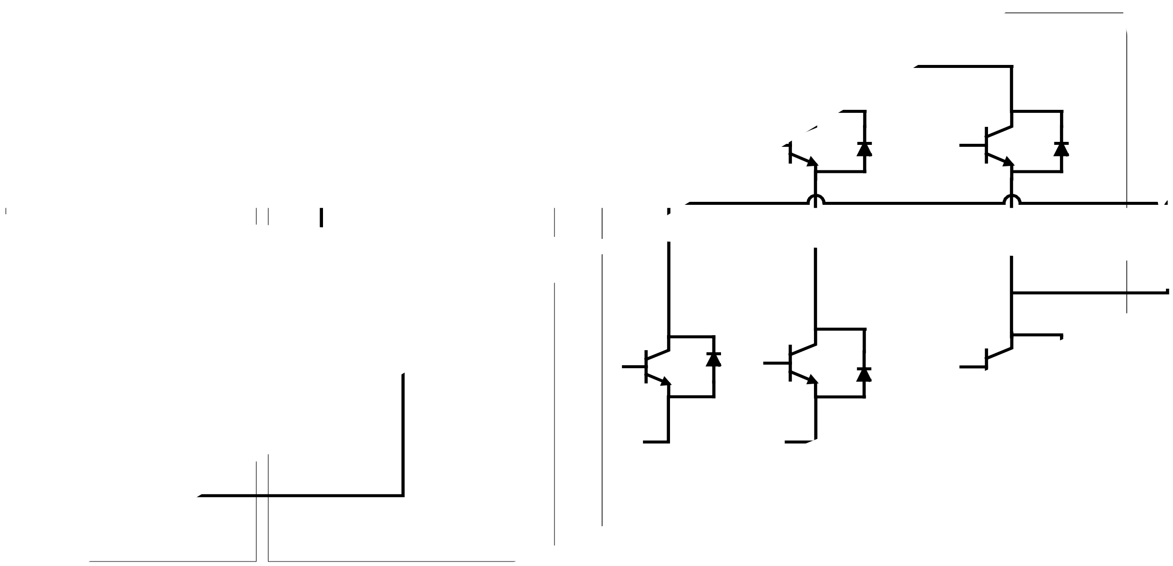
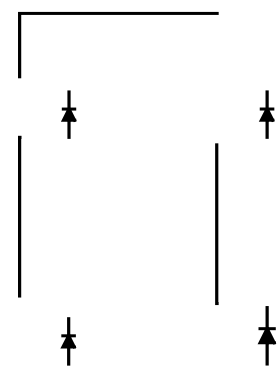




Due to the inherent voltage vector limitation in the four-switch inverter, three-phase 120 balanced currents profiles can only be obtained by using 60 phase shifted PWM control strategy. In order to properly utilize the four-switch inverter topology in a certain application, it is very important to understand its operational limitations. The main limitations are lower voltage utilization and higher harmonic components. Consequently, it can result in an increased harmonic copper losses and torque pulsations. Therefore, the four-switch inverter cannot be an alternative to the six-switch inverter configuration in all application areas, but can be a good choice in middle power range application, in which a certain harmonic level can be tolerated. For this circuit to be more effectively utilized advanced PWM control strategies should be developed for wide application in industry.

Applying the component minimization concept of the four switch inverter to the conventional three-phase to three-phase PWM converter system, we can reduce the number of switches from the conventional configuration and come up with the eight switch based configuration. One topology of the conventional circuits is shown in Figure 1.3, in which the power factor is typically about 0.6, and the input harmonic distortion is large. This highly distorted input current can be smoothed by the use of series ac side inductances, with the disadvantages in cost, size and losses. Since the converter fed loads are the most common type of non-linear load for the ac mains, there are various guidelines, such as in the IEEE-519, and are given in [1], which lists the allowed amount of harmonic current injection in the utility system.

The desirable functions of an active power factor correction scheme are line voltage rectification, bus voltage regulation and line current wave shaping. To perform these tasks an additional circuitry, based on a dc-dc converter, is added to the front-end rectifier. Among a number of dc-dc topologies proposed in the literature, the use of a boost converter has been considered very appropriate for many applications due to the following reasons.

1) The dc bus voltage is higher than the conventional diode bridge rectified ac voltage. This is very convenient to increase the range of operation of single-phase to three phase motor drive inverters.

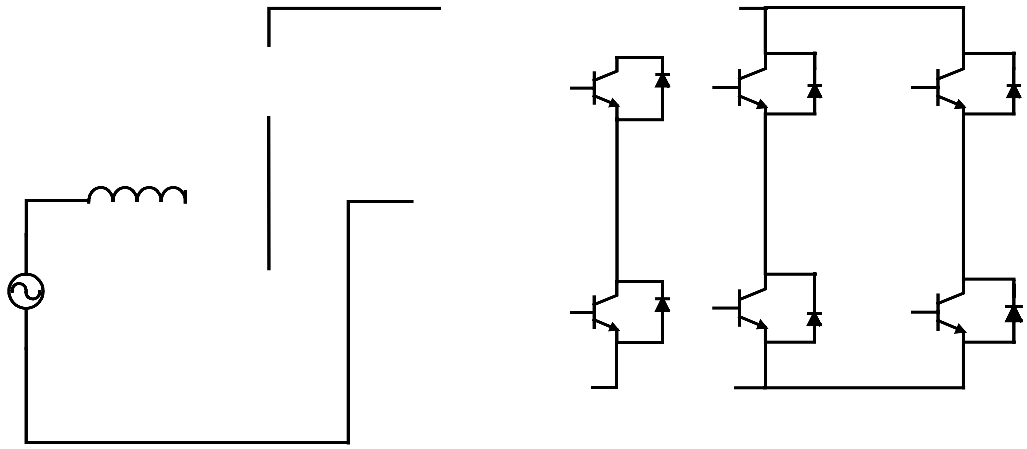
2) It has an inductor in the input and a capacitor at the output, which is very convenient for filtering.

Figure 1.3 shows the conventional active power factor correction scheme based on the boost converter. The input current shaping is done by the boost action of the inductor and the switch ‘s’.

This configuration does not provide bi-directional power flow between the dc bus and the ac mains, which is a very desirable feature for ac motor drives. Moreover, though the boosted dc bus improves the drive operating range, when compared to the conventional system, still there is a limitation for the system speed range. Several single-phase to three-phase topologies were proposed in [7] with bidirectional power flow and input current shaping capabilities and with reduced component count.

1.3 Research Objective

Recently, improved developments in DSP technology and the need for more compact motor drive systems, with reduced costs has emphasized research on drive systems, with more reduced component count and or more integrated controls. The conventional single-phase to three-phase circuit as shown in Figure 1.4, consists of a single-phase full bridge ac-to-dc converter and a three-phase inverter. This circuit has five legs each being a series connection of two switching devices. A reactor is connected in series with the single-phase power supply and the input is applied between the central points of the full bridge ac-to-dc converter legs. The single phase supply voltage us converter to dc voltage across the capacitor and then the dc voltage is converted to the required number of phase voltages here in this case three phase voltages across the load, which if the motor.

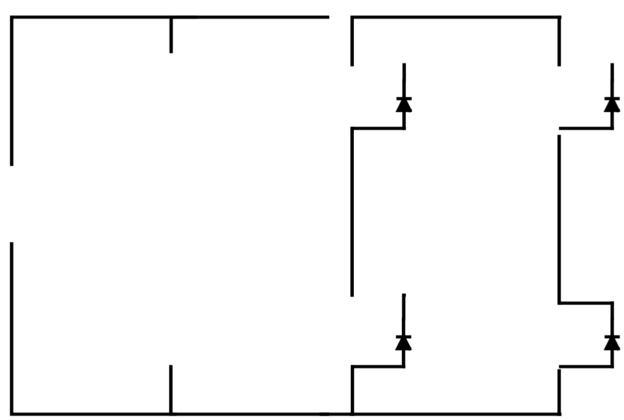


$$v_o \quad \frac{Vd}{2}$$ when all the top devices are on

$$v_o \quad \frac{Vd}{2}$$ when all the bottom devices are on

Therefore the neutral point voltage of the load can be controlled by a proper use of the zero vectors. The model for the sparse converters is as shown in Figure 1.5. It consists of a motor, a three-phase inverter and an additional leg having the functionality of the ac-to-dc converter. The power supply is directly connected between the neutral point of the load, in doing so the input reactor as in conventional circuits becomes redundant as its purpose is served by the leakage inductance of the motor.

Since the power supply is connected directly to the load, power supply current and the output voltage control actions are no longer independent as in the case of the conventional circuits. Owing to the connection of the power supply the load currents carry an additional amount of the current, which is one third of the supply current, and this current is the zero phase sequence current.



The zero-phase sequence current flowing in to the stator windings does not generate any torque and so therefore may

1.4. Thesis Organization

In this thesis first an introduction is presented, where some important issues regarding the development of ac motor drives with improved power quality are addressed, along with literature review. Chapter 2 deals with single-phase inverter and some of the associated modulation schemes, like the unipolar, bipolar and the modified bipolar modulation schemes and lays out the functionality of these schemes along with a comparative study.

Chapter 3 gives a brief introduction on the operation and dynamic modeling of induction machine as it was used as the load in testing the functionality of the given converter topologies. In Chapter 4 the model for a three-phase inverter was presented along with the derivation of the switching functions for the devices.

In Chapter 5 the control scheme for the induction machine has been explored in great depth and also an introduction to