CHAPTER-II

LITERATURE REVIEW

2.1 GENERAL

Electrical power is discovered as a product with some uniqueness that can be calculated, expected and improved. However it has developed into a fundamental part of our existence. The fact that power quality has become a subject recently doesn’t mean that it was not significant in the past. In the recent years, users of electric power have found an increased number of disadvantages because of variations in electric power quality. These aspects in terms of variations previously presented in the electrical system but recently they are causing many crucial problems. Due to this fact that end user equipment have become more responsive to disturbances that occur both of the supplier as well as the utility side. To enhance power quality with sufficient solutions, it is now required to know what kinds of disturbances take place in the electrical system. The raised attention in power quality has resulted in important advances in designing and monitoring equipment that can be employed for the characterization of disturbances and power quality variations.

Electrical power system is facing objectionable poor power quality problems due to various categories of linear/non-linear loads on supply system. The power quality issues comprise current waveform deformation, excessive VAR power burden, phase unbalancing, extreme neutral current, voltage related issues i.e. sag and swell, flicker and notching etc. Power converter based non-linear loads are also playing a key role in power quality related problems. Power quality is a combination of two subset one is voltage quality another is current quality. Voltage quality in an electrical system depends on multi-aspects of the network disturbances and the quality of power approaching from the other nearby network; on the other hand, current quality typically depends upon the nature of loads associated with the circuit.

Rectification process of electric power is needed in various type of load configuration like variable-speed drives (VSDs), switch-mode power supplies (SMPSs), uninterrupted power supplies (UPSs), arc furnaces, welding systems and utility interface with other non-conventional energy sources. One of the foremost key point causing power quality issues lies in the AC-DC uncontrolled converters.
The selection of IPQC depends upon the following aspects

1. Type of the supply applicable (single-phase and three-phase)
2. Level of power quality correction at input side (permitted PF, CF and THD)
3. Depends on type of output DC voltage needed (constant and variable)
4. Direction of Power-flow (unidirectional and bi-directional)
5. Nature of quadrants operation required (one, two or four)
6. Prerequisite of DC output (buck, boost and buck-boost)

Most of the time active power factor correction (PFC) techniques are used for improving power factor in an AC-DC converter. Sometimes reactive power compensators and harmonic filters are also incorporate for PQI. A review on different improved power quality AC–DC converters for PFC and decline of harmonics level at the front-end side are presented in various literature which explain control techniques, selection of circuit elements and selection of appropriate converters such as buck, boost and buck–boost etc for particular applications. These days Multi-pulse AC–DC converters (MPC) are also popular for improving the power quality by reducing THD at the 3-phase AC supply and high grades of ripples in dc output. It is generally used in the drive applications.

The application of power converters are increased due to its precise control strategy, economic operation and high efficiency. On the other part the increased number of these converters increases voltage and current harmonics contents in the power system. In some cases passive and active power filters are used to overcome the power quality problems. Many research scholars discuss the categorization of active and passive filters, their combinations and applications as solutions to various power quality problems.

2.2 OVERVIEW OF DIFFERENT TOPOLOGIES IN SRM DRIVE

This section is a review of all the research paper discussing the converter configuration for Switched Reluctance Motor Drive.
Power quality improvement at the supply side of the SRM drive can be achieved using various improved power quality converter (IPQC). This converter operates in discontinuous conduction mode (DCM), continuous conduction mode (CCM) or boundary condition mode (BCM).

Various possible solutions for power quality improvement for SRM drive has been reported in the literature, which includes IPQC, multi-pulse converters, active and passive compensation, hybrid formation of active and passive compensation. SRM require a machine converter for its proper operation. Most of the researchers have discussed the various type of machine converter for the SRM. They have been discussed the circuit configuration, component count, working mechanism and control techniques of various proposed converter like C-dump converter, asymmetric half-bridge converter, MOSFET switch based converter, zero-current switching converter, ZETA converter in CCM, (n+1) switch converter, soft-switching based converter, energy efficient converter, new split source type converter, 2(n+1) switch converter and many more [2-9, 11-14, 16-20]. To improve the performance of the SRM drive in terms of accurate torque estimation, loss calculation and its reduction, torque ripple minimization lot of research has been reported [10, 21-23, 36].

A new converter concept for driving the SRM which has only one switching apparatus per phase, returns back all the intent energy to the supply and no need of bifilar windings; it is also known as C-dump converter [2,6-7,11,22,29,32]. A narrative converter circuit for the four phases SRM. The circuit is designed on the basis of asymmetric half bridge, but uses only one switch/phase. The switches in the converter have the same voltage rating as the motor they are connected to unlike any previous converter with one switch per phase. It saves the requirement of number of switches. The number of switches should be kept minimum for improved performance of the proposed drives [3, 14, 19, 27, 33].

A 2(n+1) switch converter circuit for 4-phase SRM drive have been suggested [27] where two active-clamp resonant tanks have been added. All chopping transistors and auxiliary transistors are run under high switching frequency. Soft-switching condition can be imparted to these transistors by this circuit for on and off switching. Active-clamp circuit can clamp resonant voltage of the transistors to lower voltage rating of the transistors.
An investigation and comparison on different switching circuit topologies for linear SRM are presented. In order to achieve the most advantageous converter configuration five topologies are studied in detail and compared based on their overall performance [37]. The mathematical modeling, simulation and new control technique of SRM for the high-speed operations [38]. The model is designed on the basis of three dimensional relationships among rotor position, excitation currents and flux linkage. The relationship creates electromagnetic torque, which depends on two components, one is excitation currents and another is rotor position. Therefore, it is intricate to high performance control operations for SRM. In order to decrease torque ripple of the drive, the Torque Distribution Function is proposed.

A new topology which offers a high rate of current discharge and simple control technique for a SRM drive circuit [39]. In the proposed circuits, a capacitor is associated in series with the motor winding. An energy recovery circuit is used. The stored magnetic energy that falls to trap on resonant capacitor in due discharge period recovered from this energy recover circuit by the single quadrant chopper circuit. The chopper comprising of one transistor, capacitor and diode sent to the dc source. The new drive circuits use a capacitor in the phase discharge path in order to reduce the discharging time.

There are several research papers on the design and analysis of various power converter circuits for SRM. In these papers [38-43] they have presented the procedure for calculating volt-amp requirement and the component ratings of the converters for SRM drive. The modeling and performance analysis of SRM drives under steady state has been included in the publication [44-50]. They have demonstrated that switched reluctance motor provide the basis for fully controllable variable speed systems, which are seen to be superior to conventional system in many aspects. The basic modes of operation, design consideration and experimental results for various converter based SRM drive have been included.

2.3 APPROACH FOR POWER FACTOR CORRECTION IN SRM DRIVE

From last half decade, power quality improvement (PQI) has become a significant feature in designing PFC AC-DC converter for SRM drive applications. As a consequence, new approaches have been acknowledged for the design of PFC converter with compact input current harmonics and enhanced efficiency. Most of the
researchers are targeting and embryonic new techniques to design an appropriate converter which should draw almost pure sinusoidal input current while providing stiff regulated DC output voltage at a preferred power rating. Most of the PFC converters topologies and their implementations in SRM drive system have been explained in detail in the review. Low THD of input AC current does not guarantee high input power factor (HPF), as it governed by two factors, one is displacement pf (DPF) and other is distortion factor (DF). Even if the input current is not in phase with AC mains voltage, sinusoidal input current does not guarantee HPF. Therefore, for HPF operation both factor i.e. DPF and DF should be almost unity. The generally used PFC techniques are recognized as active and passive PFC techniques. Amongst these techniques, passive techniques are frequently used for retrofit application, which result in high value inductors and capacitors with supplementary power losses. An efficient and improved power quality solution, however, can be achieved by the use of active or hybrid arrangement of active and passive PFC techniques.

All the PFC converter are mainly using three control techniques namely first as a current multiplier approach (CMA), second voltage follower control(VFC) and third one as feed forward current control (FFC). The first and third scheme yield high-quality results as compared to the second one particularly for the input voltage variations. However, the second technique, VFC requires only one control loop, which reduces control complexity. The VFC topology has wide suitability with a diversity of applications such as SMPS, small rating fans and compressor drives, due to intrinsic power factor correction and its simple execution. The VFC topology is frequently used with discontinuous conduction mode (DCM) of operation, whereas, the CMA is used in continuous conduction mode (CCM) of operation. FFC is used in boundary conduction mode (BCM) of operation. In BCM operation, PF\textsubscript{C} converters and many other control techniques are also taken in consideration by many researchers [52-66].

2.3.1 Two Stage PFC Converter Based Technique

In two-stage active PFC based SRM drive, HPF can be obtained by using two stages power processing. Pre-regulation of power factor is the first stage, which performs rectification of AC mains. In second stage the chopping action will be performed. Beside the advantage of having more flexibility, the two stage PFC suffers from two drawbacks- one is more component count and second is cost.
Two-stage approach offers tight regulated output and good input power factor with a smaller amount ripples in solid state drive. However, life expectancy of electrolytic capacitor as well as of SRM drive decreases due to more ripples in output voltage which in turn induces ripples in SRM current. Sometimes it is also ambiguous that more components invite more cost, which is not always true. Thus two-stage technique is preferred over single-stage in few applications such as green and clean lightening.

2.3.2 Single Stage PFC Converter Based Technique

In single stage active PFC SRM drive, single switch is used for the purpose of PFC and it also takes part in DC-AC transformation stage. In single-stage approach, the complexity of control technique increases and simultaneously the degree of freedom decreases. Beside these the other advantages are decline in number of circuit component and the required number of active switches as compared to two stage approach.

2.4 IDENTIFIED RESEARCH AREAS

On the basis of comprehensive literature reviews, some of the new research fields have been identified to be explored to acquire power quality improvement for SRM drive applications.

1. The necessity of appropriate PFC converter based SRM drive for improvement of power quality at AC mains operational under variable voltage input.

2. The requirement of energy efficient and economical PFC converter based SRM drive for low, medium & high power application.

3. The requirement of regulating the desired output voltage with minimum number of harmonics ripples with the variation of supply AC mains.

On the basis of above points the attractive features of this research proposal are investigated as mentioned in following aspects.

- A structured analysis of various power converter based SRM drive is carried out and each converter technique is investigated on the basis of control mechanism employed and it is also classified on the basis of circuit configuration used for power quality enhancement at AC mains.
The various type of power converters are explained for SRM drive with single phase & three phases AC mains. The performances of converters are compared on the basis of power quality parameters i.e. THD, PF, DPF, DF etc. with the variation of AC mains with various control techniques.

Design, analysis and simulation of switched reluctance motor for universal purpose drive applications.

Execution of various PFC converter based SRM drive & the performance of the proposed PFC converter is carried out through MATLAB-SIMULINK simulation with three-phase & single-phase AC mains supply.

Various PFC converter techniques under each structured category are analyzed, designed, modelled and simulated for SRM drive. The performance analysis is carried to observe their effectiveness in terms of power quality improvement at extensive range of input AC voltage.

2.5 CONCLUSIONS

A comprehensive literature review indicates the latest trend in the field of electrical machine drives which is largely intense towards the economical operation and energy efficient PFC converter with extensive range of input AC mains. Presently researchers are working meticulously to attain power quality improvement in SRM drive for wide range of power applications. The proposed PFC converter based SRM drive has been utilized in sinking the system losses, improving power quality at AC mains, increasing overall efficiency and adequacy to various power quality international standards like IEC 61000-3-2.

Therefore, this research work is majorly paying attention on the expansion of appropriate PFC converter based techniques for SRM drive with improved power quality, economic operation of the drive and energy efficient which can function at wide range of input AC mains voltage.