CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION

Modern electronic equipment operating at lower voltages with higher currents requires an efficient power conversion. Power converters provide a highly efficient means to deliver a regulated voltage from a standard power source. However, circuit trends need voltage/current requirements outside the efficient range of most classical converters and therefore new converter topologies must be developed.

This literature survey gives an account of the various research works carried out in the design of converters to reduce the component stresses and the switching losses, while achieving high power density and improved performance. The existing methods in the design of converters, applications of Artificial Neural Network (ANN), Fuzzy controller and their related works are summarized in this chapter.

The survey reported in this chapter proceeds in the following fashion:

- Converter schemes
- Application of ANN
- Fuzzy controller
2.2 CONVERTER SCHEMES

The switched mode DC-DC converters are some of the simplest power electronic circuits which convert one level of voltage into another level by switching action. These converters have received an increasing deal of interest in many areas. This is due to their wide range applications like power supplies for personal computers, office equipments, appliance control, telecommunication equipments, automotive, aircraft, etc. The literature survey for design, modeling and application of variety of converters is presented in this section.

Herman Wiegman (1992) discussed the analysis and implementation of a resonant pulse gate drive based on a simple charge pulse circuit. The pulse charging and discharging instances are controlled by the user, hence their circuit is applicable to pulse width modulation schemes as well as resonant converters.

Guichao Hua and Fred Lee (1995) proposed a number of soft switching techniques aiming at combining the desirable features of both the conventional PWM and resonant converters while avoiding their respective limitations. They reviewed three types of zero voltage soft switching PWM converters and two types of zero current soft switching PWM converters with their merits and limitations.

Poon and Pong (1996) introduced a Zero Voltage Switching (ZVS) based DC-DC converter. Amplitude modulated square wave train is generated in their work and the output is controlled by the amplitude of this square wave train. Energy is directly transferred to the output and it results in simple configuration and inherent ZVS characteristics.
Robert Watson, Fred Lee and Guichao Hua (1996) analyzed the behaviour of the ZVS active clamp fly back converter operating with unidirectional magnetizing current and presented the design equations. They concluded that fly back derived topologies are attractive because of their relative simplicity compared with the other topologies used in low power applications. Incorporation of the active clamp circuit, the fly back topology serves to recycle the transformer leakage energy while minimizing the switch voltage stress.

Mariodi Bernardo et al (1998) analyzed the nonlinear phenomena in closed loop pulse width modulated DC-DC converters. They obtained the analytical conditions for the occurrence of the periodic orbits and flip bifurcations and derived the necessary conditions for infinite local stretching on the phase plane.

Rais Miftakhutdinov et al (1999) proposed a modification in the asymmetrical zero voltage switched half bridge DC-DC converter topology that substantially changes the static transfer function and the voltage stress distribution within the converter power mesh. This modification allows the converter circuit to be optimized for higher efficiency and power density. They also postulated that the modification with its corresponding benefits can be utilized in other complementary driven topologies. Although the asymmetrical half bridge converter is inherently capable of ZVS switching, only the proper choice of parameters can ensure ZVS in all modes of operation.

Marcelo Lobo Heldwein et al (2000) presented a simple clamping circuit for the ZVS PWM asymmetrical half bridge DC-DC converter. This clamping circuit reduces the oscillations caused by the reverse recovery of the output diodes and thus increasing the efficiency of the converter.
Trevor Smith et al (2000) presented a control technique for DC-DC converters using an improved resonant switch model. The model recognizes that a converters power switch has a finite resistance in its ON state. If MOSFET is used, then this resistance will be variable. A switch that has a finite resistance has a voltage across it when the current passes through it. This voltage can be compared to a threshold voltage of an inverter which determines when the switch changes in its state. This method provides self oscillation and inherent overload protection for a converter. The variable resistance of a MOSFET can be utilized to change the time taken by the switch voltage to reach the inverter threshold voltage. This changes the ON time and provides a regulation mechanism for variable output power and input voltage.

Xunwei Zhou, Mauro Donati et al (2000) implemented a methodology that utilizes the duty cycle signal to improve light load efficiency. Since current sensors are not required, high density and high efficiency can be achieved. This makes the whole circuit suitable for integration. For low voltage high current applications synchronous rectifier technologies are widely used. It was suggested that in order to improve the performance at light load, the converters have to operate in discontinuous conduction mode to reduce its conduction loss and at lower switching frequency to reduce the gate drive loss.

Peng Xu et al (2001) proposed a family of DC-DC converters which employs an innovative interleaving concept by using series primary windings and interleaved parallel secondary sides. The advantages of their converters include reduced filter size, improved transient response and increased efficiency.

Pit Leong Wong et al (2001) proposed integrated coupling inductors in multichannel interleaving voltage regulator modules. Coupling inductors have
different equivalent inductances for steady state and transient responses. With a proper design, the inverse coupling inductors reduce the steady state current ripple while maintaining the same transient response. The conduction losses in the MOSFET can thus be reduced. The air gap in the centre leg more evenly distributes the flux, which can reduce the core loss of the center leg. They concluded that the coupling inductor core structures make the manufacture of the cores easier and improve the mechanical stability of the cores.

Tso Min Chen and Chern Lin Chen (2002) proposed the converter, which is attractive because of its simple capacitive output filter when compared with the other converters used in the multiple output and cost sensitive applications. They analyzed the detailed circuit behavior of the asymmetrical half bridge fly back converter. Several practical issues including the specific relationships between the duty cycle and the different types of energy in the energy storage elements and the zero voltage switching conditions of the power switches were examined.

Jianhong Zeng et al (2002) presented the analysis, design and optimization of a DC-DC converter used for battery input applications.

Joe Liu et al (2002) proved that the current driven synchronous rectifier with current sensing energy recovery are suitable for high frequency switching topologies. The synchronous rectifier can be driven ON and OFF automatically according to the current direction. It can be taken as an active diode with very low power dissipation.

Khalid Rustom et al (2002) described a single stage power factor correction converter with direct energy transfer feature. They used an asymmetric half bridge topology as a DC-DC cell for its inherent ZVS
capability. Direct energy transfer power factor correction cell is introduced to improve the conversion efficiency.

Alou et al (2002) designed a low power DC-DC converter with wide input voltage range. They analyzed several topologies and selected the flyback with active clamp converter circuit because it presents a good tradeoff between simplicity and efficiency. Their topology provides a wide regulation capability even at no load, ZVS capability and soft turn OFF in the rectifier diode.

Masakazu Takagi et al (2002) considered the theoretical limitations in the efficiency of DC-DC converters used in telecom applications. They compared the theoretical limitations of the efficiency in single stage topology with two stage topology. They concluded that buck half bridge topology is suitable for high output current and low output voltage DC-DC converters.

Vitor Fernao Pires and Jose Fernando Silva (2002) illustrated a method to obtain nonlinear switched mode state space model of power converters suited for simulation and control design. They simulated the state space models of the electronic power converters with its associations and electromechanical devices with various types of control systems. They concluded that the MATLAB software provides the powerful simulation and control tool for power converters.

Jose Eduardo Baggio et al (2003) presented an isolated DC-DC zero voltage switching converter composed of two half bridge converters operating at constant frequency. It can be seen as an alternative to the ZVS phase shift full bridge DC-DC converter for high voltage applications. They proposed a command strategy named interleaved phase shift which allows equalization of the input capacitor voltage where each capacitor shares one quarter of the total input voltage.
Zoran Mihajlovic et al (2004) used the state space averaging methods to derive time invariant models that bounded the envelope of trajectories of pulse width modulated DC-DC converters. They compared the results to conventional averaging methods used in power electronics and it was shown that designing a DC-DC converter based on the averaged output of a converter can be ineffective because peak output values sometimes significantly deviate from the averaged output. They quantified the deviation by using both small signal transfer functions and non linear models to form the maximum and minimum values of outputs of PWM converters.

Hong Mao et al (2004) presented a simple and effective PWM control method known as duty cycle shifted PWM to reduce switching losses and transformer leakage inductance related losses in half bridge DC-DC converters. By employing this control scheme, ZVS is achieved for one of the two switches without adding extra components and without asymmetric penalties of the complementary control. Based on the control scheme, they analyzed two ZVS half bridge topologies.

Xinyu Xu et al (2004) presented the analysis and design of an asymmetrical half bridge fly back DC-DC converter which can minimize the switching power loss by realizing the Zero Voltage Switching (ZVS) during the transition between the two switches and the Zero Current Switching (ZCS) on the output diode. As a result, it achieved high efficiency. They concluded that in order to ensure the realization of ZVS, the required interlock delay time between the gate signal of the two switches, the transformer leakage inductance and the ZVS range of the output current variation should be properly calculated.

Yuhui Chen et al (2004) presented a resonant MOSFET gate drive circuit having characteristics that make it suitable for high frequency PWM applications. These characteristics included reduced gate drive loss, fast
driving speed, clamped gate voltage, cycle to cycle dynamics and immunity to false trigger. They achieved the loss reduction by increasing the resonant inductance at the cost of slower driving speed and decreasing the forward voltage drop of the clamping diodes by using Schottky diodes. The leakage current does not cause a substantial drift at the operating frequency and by reducing the gate resistance of the power MOSFET.

Man Siu et al (2006) presented the end point prediction scheme for voltage mode buck regulators. The settling time of the regulator can therefore be significantly reduced for faster dynamic responses even with the dominant pole compensation. Fast reference tracking feature is very important for systems powered up by adaptive supply voltages. Voltage mode PWM power converters compensated by a dominant pole approach have a slow dynamic response which is mainly limited by the large off chip compensation capacitor. They solved the problem by the end point prediction scheme in which the simplicity and the robustness of a voltage mode buck converter with dominant pole compensation is retained, while the dynamic response is greatly improved by an adder circuit.

Sung Sae Lee et al (2006) presented an active clamp ZVS PWM forward converter using a secondary synchronous switch control suitable for low voltage and high current applications. Their structure is same as in the case of conventional active clamp forward converter. However, since it controls the secondary synchronous switch to build up the primary current during a very short period of time, the ZVS operation is easily achieved without any additional conduction losses of the magnetizing current in the transformer and the clamp circuit. There are no additional circuits required for the ZVS operation of power switches. Therefore, their converter can achieve high efficiency with low EMI noise resulting from soft switching without any additional conduction losses.
Yongseok Choi et al (2007) considered the problem of energy minimization with the consideration of the characteristics of power consumption of the DC-DC converters. They analyzed the effects of the efficiency variation of DC-DC converters on a single task execution in a dynamic voltage scaling scheme.

Vahid Yousefzadeh et al (2008) introduced an approach to near time optimal control in a synchronous buck DC-DC converter using a simple digital controller realization. They proposed a proximate time optimal digital controller in association with a constant frequency pulse width modulation and a linear switching surface controller.

Hong Mao et al (2008) proposed an active resonant tank cells to achieve zero voltage switching and eliminate body diode conduction in DC-DC converters with synchronous rectifiers. In low output voltage DC-DC converters, synchronous rectifiers are widely utilized to reduce rectifier conduction loss and improve converter efficiency. However, during the transition of switches, parasitic body diodes of the rectifier unavoidably carry load current which decreases conversion efficiency because voltage drops across body diodes is much higher than that of the voltage drops across synchronous rectifiers. Moreover, reverse recovery of the body diodes leads to increased switching losses and electromagnetic interference. The body diode conduction of the synchronous rectifier is eliminated during the switching transition from a rectifier to an active switch and thus body diode reverse recovery related switching and ringing losses are reduced by active resonant tank.

Pattnaik et al (2008) implemented the concepts of zero voltage switching in synchronous buck converter. In their converter, the additional voltage and current stresses on the main devices do not take place and the
auxiliary devices are subjected to allowable voltage and current values. Moreover, the converter has a simple structure, low cost and ease of control.

Ehsan Adib and Hosein Farzanehfard (2009) introduced a family of zero current transition PWM converters which employs a simple auxiliary circuit composed of a switch and capacitor. They concluded that the auxiliary circuit can be applied to other isolated converters such as forward, half bridge and full bridge converters. In this family of converters, zero voltage switching condition is attained for the main and rectifier switches. Also zero current switching is achieved for the auxiliary switch. In addition, the applied ZVS technique can eliminate the reverse recovery losses of the rectifier switch.

Thomas Baginski and Keith Thomas (2009) discussed the fabrication and characterization of a high voltage shock switch. The structure was designed to operate a device with low impedance. They also suggested that the switch is a planar structure that allows direct integration into the strip line geometries used in a conventional capacitive discharge unit. High voltage switches are capable of operating at high speeds over a wide range of voltages.

Wu Chen Xinbo Ruan et al (2009) investigated the DC-DC conversion systems constructed from connecting multiple converter modules in series and parallel at both the input and output sides. They studied the control strategies aiming to achieve proper sharing of the voltage and current at the input and output sides. They also presented the relationship between sharing of input voltages/currents and output voltages/currents. In particular, the inherent stability of control operations applied at the input side and the output side is analyzed in their work.

Panda et al (2009) proposed an improved active auxiliary circuit that allows the power switch in the pulse width modulated synchronous buck
converter to operate with zero voltage switching. The designed zero voltage transition PWM synchronous buck converter is operating at low output voltage and high efficiency, typically required for portable systems. To make the DC-DC converter efficient at low voltages, synchronous converter is an obvious choice because of its lower conduction loss. The main feature of the auxiliary circuit is that the auxiliary switch can operate with zero current switching turn ON and turn OFF without increasing the peak current stresses of the main switch.

Zhiliang Zhang et al (2009) proposed a non isolated ZVS asymmetrical buck converter with direct energy transfer. They used the transformer to extend the low duty cycle of a conventional buck converter. The turn OFF losses can be significantly reduced due to the extension of duty cycle and there is no turn ON losses owing to the zero voltage turn ON condition. At the same time, the voltage stress over the synchronous rectifier can also be reduced. Therefore, the reverse recovery loss of the body diode is reduced. Furthermore, they used MOSFET with lower voltage rating and lower ON state resistance to reduce the conduction losses.

Vasic et al (2009) presented the optimization of a synchronous buck DC-DC converter that is used to regulate the variable power source to a constant voltage for the load. Higher switching frequency leads to smaller components and low weight.

Jeong (2010) presented the analysis and design of an asymmetrical half bridge fly back converter using a voltage driven synchronous rectifier. They analyzed the circuit behaviour and the steady state characteristics of the converter. The synchronous rectifier that is used in the circuit covers a universal input voltage range. It also conducts under zero voltage switching condition with a discontinuous conduction mode.
Qian and Lehman (2010) proposed a concept of connecting two stage DC-DC converters in an input series connection having reduced voltage stress. A single second stage is a half bridge converter and is able to regulate the charge balance of the first stage. The benefits of their topology include reduced primary switch voltage stress, simple self synchronous rectification for wide range of input voltage, self voltage balancing on intermediate bus capacitors and simple housekeeping power supply. Further, they concluded that the topology exhibits an unusual ripple match concept that can be utilized to suppress the current ripple of the second stage.

Miao and Yuan Bing (2011) proposed the circuit for counteracting part of the slope current to solve the problem of low dropout operation with heavy loads. They achieved adjustable slope current and low dropout operation during clamp state, which extends the battery life and suits for portable applications.

Yahaya et al (2011) presented a synchronous rectifier buck converter having the capability of ZVS in its operation. In addition, the traditional forward ON state drain voltage of the switch is reduced. Their comparative assessments on the drain current of switches and load current show a small difference in margin.

Hamid Daneshpajooh et al (2011) dealt with finding the optimum operating points of a soft switched dual half bridge bidirectional DC-DC converter. In their work, the soft switching range and efficiency of the converter are highly improved by recruiting duty cycle as the important control parameter.

Jian Min Wang et al (2011) proposed a control technology that enables a synchronous rectified buck converter to realize zero voltage switching in light load condition. The synchronous rectifier control technique is applicable
to low voltage output because the replacement of output rectifier diode by MOSFET can minimize the conduction losses and increase the efficiency of the whole circuit.

Jaehong Kim et al (2011) investigated a method to address the voltage unbalance problem in the secondary side of the dual half bridge converter. The decoupling term and its compensation control were derived from the power equations of the converter.

Mor Mordechai Peretz and Shmuel Ben Yaakov (2012) developed the time domain design method for the digital controller of pulse width modulation DC-DC converter. The approach is based on the fact that the closed loop response of a digitally controlled system is largely determined by the first few samples of the compensator. This concept is used to fit a digital PID template to the desired response. They also investigated the possible realistic closed loop performance obtained from a system that is controlled by a PID template controller as well as the stability boundaries of the time domain controller.

Lin and Hou (2012) proposed the analysis, design and implementation of a DC-DC converter with two series connected half bridge converters without an output inductor. In the high voltage side, two half bridge converters with the asymmetric pulse width modulation are adapted to achieve zero voltage switching for all switching devices. The voltage stress of power switch is clamped at one half of input voltage. Thus, active switches with low voltage stress can be used for high input voltage application. At low voltage side, the secondary sides of two half bridge converters are connected in parallel to share load current. For each half bridge converter, two transformers are connected in series at the primary and secondary sides. They concluded that as each transformer can be operated as an inductor, no output inductor is needed in each half bridge converter.
Chien et al (2012) presented a zero voltage switching converter in which two circuit modules with the interleaved pulse width modulation are adapted to share the load current. In each circuit module, series resonant converters with two transformers that are series connected in primary side and parallel connected in secondary side are used to achieve load current sharing and reduce the current stresses of rectifier diodes and transformer secondary windings. Based on the series resonant behaviour, power metal oxide semiconductor field effect transistors are turned ON at ZVS and rectifier diodes can be turned OFF at zero current switching. Therefore the switching losses of power semiconductors are reduced.

Qing Du et al (2012) proposed a high power input, parallel output series half bridge converter. The circuit achieves complete decoupling from the input so that the mutual effects between modules are eliminated and thus oscillations are avoided. They analyzed the circuit structure, operating principles and basic relations. The inconformity of the transfer functions and the discontinuity caused by the switching time delay and the disturbance of input voltage are also analyzed. They described the combinational control strategy and the compensation methods in order to achieve effective control at steady state, smooth transition at mode change and reduction of the adverse effect caused by the disturbance of input voltage.

Zhe Zhang et al (2012) proposed the converter that consists of push pull forward half bridge circuit and a high frequency transformer. This structure minimizes the number of the switching transistors and their associate gate driver components. With phase shift control strategy, all the switches are operated under zero voltage switching condition. In order to optimize the converter performance and increase the efficiency, they investigated the optimal design methods and criteria including coupled inductors design, power flow analysis, harmonics analysis and ZVS range extension.
2.3 APPLICATION OF ANN

The power converters are susceptible to various disturbances from the source and the connected load. These disturbances, if not controlled, may damage or shutdown the devices attached to the converter. In this stream, various control strategies are proposed to achieve high performance and a bridge is made between automatic control and power electronic converters. The detailed review and application of Artificial Neural Network (ANN) controller is described in this section.

Chin Teng Lin and George Lee (1991) proposed the general neural network model for decision diagnosis systems. This connectionist model, in the form of feed forward multilayer network, combines the idea of fuzzy logic controller and neural network structure with its learning abilities integrated into a neural network based decision system. A decision network is constructed automatically by learning the training examples itself. The learning algorithm for this network combines unsupervised learning and supervised gradient descent learning procedures to build the rule nodes and train the membership functions. Their proposed model introduces the low level learning power of neural networks into the fuzzy logic system and provides high level human understandable meaning to the normal connectionist architecture.

Hush and Horne (1993) summarized the theoretical results concerning the capabilities and limitations of network models and discussed some of their extensions. The network models are partitioned into two basic categories as static networks and dynamic networks. Static networks, of which the multi layer perceptron is the most widely used, are characterized by node equations that are memory less. That is, their output is a function of only the current input not of past or future inputs or outputs. Another static model that has gained a great deal of notoriety is the radial basis function network. Dynamic
networks, on the other hand are systems with memory. Their node equations are typically described by differential equations. They can be categorized into three different groups as networks with feed forward dynamics, networks with output feedback and networks with state feedback. They discussed the networks from each of these groups with the greatest emphasis placed on networks with state feedback.

Penman and Yin (1994) demonstrated the feasibility of using an artificial network for identifying faults in induction motors. They used the network as a learning and pattern recognition device and were able to successfully associate the input signal patterns with appropriate machine states. The used neural network is the multilayered perceptron trained by the back propagation algorithm. It was concluded that because of the parallel architecture of neural networks, they are suited to the use of multiple transducer inputs which can greatly enhance the reliability of decisions made regarding the state of machine performance and condition.

Kim, Simoes and Bose (1996) demonstrated the validity of feed forward neural network for the estimation of power electronic waveforms. They concluded that neural network based estimation is very fast and it is simultaneously giving response for all the inputs. Neural network was trained to function as a calculator for estimation of the outputs with the input variables such as firing angle and load for the controller. They used the pattern of the waveforms characterized by the width and height to train the estimator networks.

Jin Tsong Jengt and Tsu Tain Lee (1999) developed an approximate equivalent neural network for the feed forward neural network. The approximate equivalent neural network not only has the same capability of universal approximator but also has a faster learning speed than the conventional feed forward neural networks. They also derived the relationship
between the single layered neural network and multi layered perceptron
neural network based on the approximate transformable technique.

Mona Eskander and Baha Bahawodin (2001) investigated the use of
neural networks for identification and control of quasi resonant converters.
They implemented the model of the DC-DC switching converter by means of
a neural network emulator to identify the converter dynamics. They obtained
the accurate identification of a fly back quasi resonant converter using a three
layer neural network emulator with four input layer neurons, four hidden layer
neurons and one output layer neuron.

Jose Quero et al (2002) proposed a neural controller implementing an
energy feedback control law as an alternative to classic control of resonant
converters. They analyzed the properties of the energy feedback control and
particularly the optimal trajectory control law. The state space is divided into
two subspaces that correspond to different states of the switches in the
converter. An analog neural network learns to classify these two classes by
means of a learning algorithm. They concluded that their design can be
generalized to other power converters also.

Ahmed Rubaai (2003) demonstrated the design of a neural network
based device that can be used to detect and classify generic railroad operating
conditions as normal and abnormal. The intended neural network is trained
online to capture the nonlinear mapping that transforms a specific location,
time of the day and direction of travel into a quantitative statement. They
concluded that artificial neural networks are versatile, robust and it can be
effectively used for the task of monitoring the railroad track system in a real
time transportation environment.

Sabura Banu et al (2004) used the neural networks for the
identification of behaviour of power converter. They obtained the accurate
identification of a quasi resonant converter using three layer neural network emulator with ten neurons in the input and hidden layer and one neuron in the output layer.

Javad Mahdavi et al (2005) proposed an output feedback neural controller for the implementation of sliding mode control using state space averaging method. They trained the neural network so that it is to be robust for large variations of system parameters and state variables.

Hsu et al (2006) developed a supervisory intelligent control system comprising a neural controller and a supervisory controller. They developed an online parameter training methodology based on the gradient descent method.

Chun Fei Hsu et al (2006) successfully demonstrated the effectiveness of the adaptive recurrent fuzzy neural network control system for a forward DC-DC power converter. They investigated the control design method based on the Lyapunov stability theorem so that the stability of the system can be guaranteed. They also designed a compensation robust controller to recover the residue of the approximation error.

Murphey et al (2006) presented a model based fault diagnostics system using a machine learning technology for detecting and locating multiple classes of faults in an electric drive. They developed a robust diagnostic system that has the capability of accurately detecting the state of the drive and correctly locating faults as soon as they occur. A machine learning approach is used to train a diagnostic system and fault diagnostic neural network detects and locates the faulty switch. They concluded that model based fault diagnostics approach is found to be very effective in detecting multiple classes of faults and it is elaborate to make the resulting diagnostic system accurate and robust.
Weiming Li and Xiao Hua Yu (2007) selected the neural network to improve the efficiency and response of a DC-DC converter for dynamic system changes. They used multi layer feed forward neural network controller because of its learning ability. It also can work under the situation when the input voltage and load current fluctuates.

Tsu Tian Lee, Chun Fei Hsu and Kun Neng Hung (2007) presented a wavelet neural network controller for DC-DC power converters. They designed the system that can track the output voltage reference and cope with the load resistance variations to ensure the stability while providing faster response.

Kuo Hsiang Cheng, Chun Fei Hsu and Chih Min Lin (2007) proposed a fuzzy neural sliding mode control system to control the power electronic converters comprising a neural controller and a compensation controller. In the neural controller, an asymmetric fuzzy neural network is utilized to mimic like an ideal controller. The compensation controller is designed to compensate for the approximation error between the neural controller and the ideal controller. They achieved favourable regulation performances even under input voltage and load resistance variations.

Xianghui Huang et al (2007) reported a method for the detection of rotor eccentricity faults in a closed loop drive connected using induction motor. They used an artificial neural network to learn the complex relationship between the eccentricities related harmonic amplitudes and the operating conditions. The neural network can estimate a threshold corresponding to an operating condition and then it can be used to predict the motor condition. They concluded that the neural network based detection method is feasible over the whole range of operating conditions.
Hua Su and Kil To Chong (2007) proposed an analytical redundancy method using neural network modeling of the induction motor for machine fault detection and diagnosis. Condition monitoring is desirable for increasing machinery availability, reducing consequential damage and improving operational efficiency.

Xinggui Wang, Bing Xu and Lei Ding (2008) integrated neural network incorporating the traditional PID controller and designed a single neuron PID controller. They concluded that the system has a good dynamic performance and robustness because of excellent knowledge extraction of neural network and its learning ability.

Tomohisa Hayakawa et al (2008) developed a neuro adaptive control framework for adaptive stabilization of continuous and discrete time nonlinear systems. Their proposed framework guarantees an asymptotic stability with respect to the part of closed loop system states associated with the plant.

Yu Zhao and Chien Chern Cheah (2009) proposed an adaptive neural network jacobian controller for multi fingered robot hands with unknown kinematics, dynamics and Jacobian matrices. They presented a Lyapunov function with sufficient conditions for the stability analysis of the multi fingered robot control system.

Chen, Qin, Sun and Fang (2011) analysed the problem of global adaptive stabilization for a class of uncertain non linear systems in which the uncertainty may not be parameterized. They also obtained the global approximation of a function with the help of the partition technique. They concluded that the proposed design method is able to ensure boundedness of all the signals in the closed loop.
Alma Alanis et al (2011) proposed a nonlinear discrete time neural observer for discrete time unknown nonlinear systems in the presence of external disturbances and parameter uncertainties. It is based on a discrete time recurrent higher order neural network trained with an extended kalman filter based algorithm and it includes the stability proof based on the Lyapunov approach.

Muhammad Sheraz and Mohammed A. Abido (2012) trained the neural network to track the maximum power from the photo voltaic system. They concluded that neural network based approach can track maximum power more accurately and much faster than the conventional methods.

2.4 FUZZY CONTROLLER

The controller design has become an attractive topic in automatic control applications because of the type of nonlinearity in the mathematical model of DC-DC converters. In the recent years, the use of digital control schemes has become increasingly popular in control of these converters. These digital control schemes analyze the input signal and produce the appropriate output signal. Fuzzy control has emerged as one of the most active and fruitful area for research in the applications of fuzzy set theory.

Fuzzy logic control is much closer in spirit to human thinking and natural language than the traditional logical systems. Fuzzy logic control provides a method of nonlinear control using piece wise linear functions to apply varying gains depending on the error signal between the desired output and the actual output. The survey of different types of fuzzy logic controllers are presented in this section.

Bor Ren Lin and Richard (1993) presented a DC-DC converter operating at finite switching frequency using the fuzzy logic control method.
Their simulations show that the fuzzy control methods have better dynamic performance and less steady state error. They used state space averaging method for analyzing the low frequency small signal performance of switching circuits when the power switching period is short compared to the response time of the output. They concluded that fuzzy control is related to linguistic rules so this control can be combined with expert systems to create more knowledge based control systems.

Wing Chi So et al (1996) proposed a simple fuzzy controller for closed loop regulation of DC-DC converters. They presented the derivation of the fuzzy linguistic rules and verified its function by computer simulations and experimental measurements of the closed loop performance of simple DC-DC converters in respect of line and load regulation.

Rahim et al (1997) described the fuzzy logic controller technique applied to the DC-DC buck converter. The converter is modeled using state space averaging technique. Due to the nonlinear behaviour of the power converter, the fuzzy logic controller is designed to simplify the compensation of the converter. They demonstrated the dynamic response of the controller.

Paolo Mattavelli et al (1997) presented a general purpose controller for DC-DC converters using fuzzy logic. Based on a qualitative description of the system to be controlled, fuzzy controllers are capable of providing good performance even for those systems whose linear control techniques fail i.e., when a mathematical description is not available or in the presence of wide parameter variations. It also provides improved performance in terms of overshoot limitation and sensitivity to parameter variations when compared to standard controllers. Since fuzzy logic control rules can be assigned separately for various regions resulting in effective small signal operation. They also concluded that the controller implementation is relatively simple and can guarantee a small signal response as fast and stable.
Johnson et al (2000) designed an intelligent fuzzy logic inference for the control of a DC-DC buck-boost converter. They mapped the fuzzy linguistics describing the switching topologies of the converter into a look up table and that was synthesized into a set of Boolean equations. Being independent of number of rules in the knowledge base and having faster response are the important features of their control.

Aldo Balestrino et al (2002) proposed a low cost PI fuzzy controller for a DC-DC cuk converter. They explained their results for variable output voltages in the presence of changes in the load resistance. They also obtained a good dynamic performance in the face of input voltage variations and the variable output operating point via a suitable variation of the scaling factors related to the input variables of the fuzzy controller.

Kanakasabai Viswanathan et al (2004) approximated the rule table of most of the two input fuzzy logic controllers used with power converters into a single non linearity. This allows the controller to be easily realized using simple, fast and inexpensive circuits. The simplified nonlinear function controller developed in this manner, was shown to be equivalent in performance to the original fuzzy logic controller. The superior dynamic performance of the controller against with linear PI controller was demonstrated.

Abdul Ofoli and Ahmed Rubaai (2006) implemented a fuzzy logic controller structure using a small number of rules for a special class of hard switching DC-DC converters. They determined the optimum topology of the fuzzy controller using a dynamics of the DC-DC converter. They concluded that the fuzzy controller structure is capable of reducing the effect of different disturbances such as load changes, input voltage variations and provide a considerable control performance over a wide range of operating conditions.
Radhi et al (2006) proposed a DC-DC converter control in which the fuzzy logic was implemented with reduced number of rules. The reduction of rules are done by the elimination of those belonging to the far from the set point area and directly feeding the membership values of the corresponding fuzzy labels into the defuzzification stage. The controller generates a duty ratio control signal through the addition of weighted part of the input voltage and of the low pass filtered signal of the inductor current to that of the fuzzy. The controller was added significant improvements to the dynamic performance of the well known PI like fuzzy controller which uses the output voltage error and its rate of change as inputs. The controlled DC-DC converter exhibits excellent performances under small and large disturbances of the input voltage and output load resistance and also showed good reference tracking ability.

Alexander Perry et al (2007) presented a design procedure of proportional and integral like fuzzy logic controller for DC-DC converters that integrates linear control techniques with fuzzy logic. By exploiting the fuzzy logic structure of the controller, they incorporated the heuristic knowledge in the design which results in a nonlinear controller with improved performance over linear PI controllers. Their design procedure allowed the small signal model of the converter and linear control techniques to be applied in the initial stages of the fuzzy controller design. This made assessing the performance and stability of the fuzzy controller easy. It also allowed linear design techniques to be exploited.

Jenica Ileana Corcau et al (2007) proposed a fuzzy logic controller using an inductor current feedback for significantly improving the dynamic performance of DC-DC converters. Inductor current plays an important role in high performance DC-DC converter control and fuzzy logic controller is
suitable to deal with time varying nonlinear nature of power converters. Their approach is general so it can be applied to any converter topology.

Ahmed Rubaai et al (2008) presented a genetic based hybrid fuzzy proportional integral derivative controller for industrial motor drives. They used genetic optimization technique to determine the optimal values of the scaling factors of the output variables of the controller. They concluded that the proposed controller based genetic optimization produces better control performance than the conventional PID controllers particularly in handling nonlinearities and external disturbances.

Eric Meyer et al (2008) presented a control method which utilizes the concept of capacitor charge balance to achieve optimal dynamic response for buck converters undergoing a rapid load change. They implemented the charge balance method with analog components which is cheaper and more effective than its digital counterparts since complex arithmetic and sampling delay is eliminated. Their controller consistently causes the converter to recover from an arbitrary load transient with the smallest possible voltage deviation in the shortest possible settling time.

Benjamin et al (2010) presented a computationally tractable genetic algorithm based procedure for estimating regions of asymptotic stability of nonlinear systems. Their procedure incorporates constraints on the state variables and was applied successfully to power electronic system models. They executed numerous time domain simulation studies as a confidence check for the region of asymptotic stability estimates. They concluded that the approach comparing the estimates of region of asymptotic stabilities using different Lyapunov functions; however, the computational efficiency of the procedure can be affected by the complexity of the Lyapunov function.
Anas et al (2011) introduced the method of intelligent regulation to control the power electronic buck DC-DC converter using a developed small signal model of the pulse width modulation switch. The hierarchical intelligent control uses the fuzzy-PID controller to counteract the existence and effect of high amplitude disturbances. Their control method minimizes the effect of noise even when noise is higher by the buck converter generated output signal by several folds.

Feshki Farahani (2011) designed a controller for a DC-DC converter using the fuzzy conceptions. In order to evaluate the designed controller efficiency, they investigated the responses of fuzzy controller for different parameters such as output inductor value and output voltage.

Hari Prasad et al (2012) discussed the design of a fuzzy logic controller for buck/boost converters. They proposed the synthesis of a control system using a fuzzy inference for switching regulators. The fuzzy controller is evaluated for closed loop performance of buck/boost converters in respect of line and load regulation.

Nittala et al (2012) presented the reduction of ripples by the use of fuzzy logic controller in a single phase buck converter. In electrical science, ripple means the unwanted residual periodic variation of the direct current output of a power supply which was derived from an alternating current source. The ripple is due to incomplete suppression of the alternating current waveform within the power supply. As the ripple causes reduction in resolution of the measuring instruments, it should be reduced up to the possible extent. When comparing with the other control techniques available for a DC-DC buck converter like sliding mode control, current mode control and voltage mode control, they concluded that fuzzy logic control is the better one as it is mainly based on heuristic knowledge of the system.
Zahra Malekjamshidi et al (2012) presented a fuzzy controlled welding machine current source used in mobile welding industries. The fuzzy controller is applied to the welding machine to solve the problems of welding process. The intelligent controller guarantees a constant current during welding to improve welding quality. It also provides some features such as hot start, anti stuck function and a standby mode for energy saving.

2.5 SUMMARY

A detailed literature survey is made in the areas of converter schemes, application of artificial neural networks and fuzzy logic controllers. From the review, it is evident that the asymmetrical pulse width modulated half bridge converter has many advantages over the other converters. The voltage stress on the power switch is also confined to the input voltage. In addition, the simple structure and small output filter make this converter be attractive to a low cost production.

In this work, the asymmetric half bridge isolated DC-DC converter is proposed to achieve zero voltage switching for the two switches without adding extra components and the artificial neural network and fuzzy logic controllers are used to improve its performance.