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MULTILEVEL RECTIFIER/PFC TOPOLOGIES: A REVIEW

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Abstract*— The conventional DC-DC converter topologies such as buck, boost, buck-boost converter, Cuk, Sepic and Luo converters and their controlling techniques for specific applications have been analysed in this Paper. The voltage regulator has to maintain a constant output voltage irrespective of the change in line voltage or load current. Hence a range of controlling techniques classified as linear and non-linear controllers are being designed to control the converters for dynamic changes in the system. The linear controllers such as Proportional (P), Proportional-Integral (PI) and Proportional-Integral-Derivative (PID) control were widely used to control the active performance of the converter. However the linear control of converter is not sufficient to face the changes in line voltage or load current. Hence non-linear controlling techniques such as Fuzzy Logic Control (FLC), Neuro-Fuzzy Logic Control (NFLC), Adaptive Neural Network (ANN) and Genetic algorithm (GA) controlling techniques are implemented to increase the performance of the converter. This section discusses various controlling techniques employed to control the said converters and their hardware implementation with microcontroller, Digital Signal Processor (DSP) and Very Large Scale Integrated (VLSI) chips in detail as a Review

1. LITERATURE SURVEY

Stefanutti et. al., (2005) A PID auto-tuning technique was proposed by [64] for control of DC-DC boost converters using relay feedback technique. Controller parameter tuning is obtained introducing small perturbations on the output voltage by including a relay in the control feedback and ensuring closed-loop operation during the auto-tuning procedure. The controller parameter is tuned as PID regulator is connected to relay feedback loop based on the dynamic requirement of the converter.

(Liping, et. al., 2009) [47] introduced a PID and fuzzy controller for DC-DC converter which was implemented in Digital Signal Processor (DSP) achieved fast transient response and stable steady state response for various load variations. To reduce the effect of parasitic resistance and inductance of the output capacitor of a DC-DC converter, which induces noise in the output is reduced by a PID controller proposed by (Kapat, et. al., 2010) [38]. It integrates a load current feed-forward and inductor current dynamic controller to improve the bandwidth and phase margin of the system.

Elshaer, et. al., (2010) [16], Elshaer, et. al., (2011) [17] proposed a PID controller for DC-DC boost converter of a PV system to meet dynamic load variation. The PID controller was tuned by genetic algorithm (GA) to regulate the output voltage and a Fuzzy-PID controller was implemented to tune the proportional, derivative and integral gains yielding a minimum overshoot and low ripple content. The smart controller adapts the duty cycle of the boost converter based on input voltage and loading conditions such that it produces a constant output voltage. A fixed frequency non-linear controller is proposed by Agostinelli et. al., (2011) [2] for controlling a four- switch non inverting Buck-Boost converter based on the sliding mode control strategy which is used for power amplifiers. The main advantage of this controller is the increase the dynamic performance of the system and energy efficiency of the converter.

Fumio et. al., (1991) [20] designed a Fuzzy controller to regulate a Cuk converter whose operation was verified by simulation. The output of Fuzzy and PID controllers are compared for various aspects like output transient, line and load regulation. The Fuzzy controller output shows reduced settling time. A detailed study of fuzzy logic controller is carried out (Lin, et. al., 1993) [44] for DC-DC power converters operating at finite switching frequency using several control methods for buck and boost converters to obtain dynamic performance and less steady state error. A Fuzzy controller was proposed by De Azevedo et. al.,(1993) [14] for DC-DC PWM Buck ZVZCS converter to regulate the output of the converter. Simulation results for a switching frequency of 50 KHz show good load and line regulation from no-load to full-load condition and from full-load to no- load condition.

Fang et. al.,(1995) A new fuzzy control algorithm for feedback control of Fuzzy-PID was proposed for quasilinear DC-DC buck-boost converter model which performs better than ordinary Fuzzy control technique. The result obtained from the output of the converter depicts performance improvement of the converter when it is subjected to load variation and input disturbances. [18] proposed a Fuzzy Controller for a Buck Converter, Boost Converter and a Buck-Boost Converter to control start-up transients and load regulation. Simulation was performed in PSPICE and the variation in output voltage for start-up transient and load current variation were observed. It was inferred that the Current-Mode Controlled Buck Converter has an advantage over the Fuzzy Controller due to fast response and provided good regulation under step changes in load whereas Fuzzy

Controller for Boost and Buck- Boost Converter show less steady-state error and improved transient response under load variations over the Current-Mode Control method.

Jordi, et. al.,(1996) [36] created a Fuzzy Controller to regulate the output voltage of a Buck Converter whose model included inductor and capacitor resistive losses whereas transistor and diode were considered as ideal; and the IF-THEN rules were obtained heuristically describing the control action for each state. Simulations for both start-up transient and load regulation are performed for a switching frequency of 50 kHz. The method exhibited the importance of converter dynamics knowledge and this design procedure can be applied to other DC-DC Converters.

Wing-Chi, et. al., (1996) A Fuzzy controller designed by [73] for regulating DC-DC converters such as buck, boost and buck-boost converters whose simulation results prove the feasibility of the algorithm and proved that the rule base predominated performance of the controller. Implementation was performed with a Texas instrument Digital Signal Processor TMS 320C50 and all the three converters were operated at a finite switching frequency of 100 kHz. The output voltage of converter was sampled within the off-interval of the switching cycle to prevent the unwanted noise of the converter.

Gupta, et. al.,(1997) A Fuzzy logic controller proposed by [22] for control of buck and boost converter was developed with a common algorithm for both the converters. Implementation was carried out in an 8-bit microcontroller. Experimental results for load transient and settling time were observed. The Fuzzy logic controller exhibited a steady state output and regulation over load disturbances with better settling time in both the buck and boost converter with an inexpensive microcontroller.

Mattavelli, et. al.,(1997) A general purpose Fuzzy controller for a Buck-Boost converter and Sepic converter was designed by [51] which afford an improved performance in terms of output voltage overshoot and sensitivity to line and load disturbances. The simulation results of Buck-Boost and Sepic

Raviraj, et. al.,(1997) [55] converters confirmed the validity of the proposed control methodology. A linear PI controller, sliding mode controller and a Fuzzy controller were developed by for a buck converter. The load transient and line transient analysis conducted for a switching frequency of 20 KHz for the said controllers proved that the Fuzzy controller produced efficient results than the other controllers.

(Lin, et. al., 1997) A detailed study [46] is carried out for fuzzy logic implementation in controlling DC-DC converters for nonlinear loads of buck, boost and buck-boost converters which exhibit better dynamic performance of the system with less steady-state error. Wong, et. al.,(1997) [75] designed and implemented an analog

Fuzzy controller for boost converter to enhance the performance of the converter against load and line disturbances. The robust operation of the converter and its controller is validated by simulation and experimental results. The results have shown the regulation of the converter against variation in load and the line regulation is checked with input voltage variations.

(Gomariz, et. al., 1998) A Fuzzy logic controller [21] is implemented with VLSI chip in mixed mode for controlling a bidirectional DC-DC converter. The approximation technique implemented for nonlinear control takes a minimum time control for the converter by combining the features of digital and analog control alternatives. A Fuzzy controller developed by Smyej, et. al., (1999) [63] for a buck converter output voltage regulation was initially designed and simulated in Matlab/Simulink environment and implemented with Electrically Programmable Read Only Memory (E-PROM). The results show the robust performance of the buck converter for variations in load resistance and changes in input voltage with an operating frequency of 10 KHz.
Sung-hoe et. al.,(1999)An adaptive Fuzzy controller is designed by [65] for a boost converter operating at 200 KHz. In this controller a feed-forward Fuzzy logic control is employed with adaptive learning algorithm with a back propagation network. The simulation performed in time domain analysis yielded better load transient with steady- state performance of the converter and a better load regulation was achieved with the adaptive Fuzzy controller.

Asumadu, et. al.,(2000) [6] designed and implemented an intelligent fuzzy logic inference pipeline for the control of DC-DC buck- boost converter using a semi-custom VLSI chip. The fuzzy linguistics describing the switching topologies of the converter were mapped into a look-up table which is synthesized by a set of Boolean equations and implemented in a Field Programmable Gate Array (FPGA) to obtain robust performance of the converter.
Rafael, et. al., (2000A Fuzzy controller was developed by) [54] for a DC-DC buck converter operating at 50 KHz and implemented with a high speed Field Programmable Gate Array (FPGA). The experimental results for load variation from half load to full load is observed and line variation analysis is observed for change in input voltage and the converter with Fuzzy controller exhibit an improved performance along with reduced peak overshoot and fast settling time.

Hyo-Sik, et. al.,(2001) A Fuzzy controller designed by [28] for a buck converter and boost converter was designed and implemented with Digital Signal Processor (DSP) TMS320C32 operating with a switching frequency of 10 KHz. The performance of buck and boost converter for various load and line disturbances were found to be better with a Fuzzy controller. An integrated Fuzzy controller designed by Criscione, et. al.,(2001) [12] for a boost converter control was designed with current-mode control technique. Simulation results for supply voltage variation yield stable output and the load regulation analysis yielded better performance of the converter for an output voltage of 12V corresponding to the input value of 5V.

Jose Alvarez, et. al.,(2001)The stability of a Boost converter operating at 200 KHz is studied by [37]. The load and line disturbances were experimented in time domain analysis and the results validate the stability of boost converter. A PI and Fuzzy controller designed by Lam, et. al., (2001) [43] based on Sugeno Fuzzy model for a boost converter was experimented with analog circuit to study the characteristics of the converter for dynamic changes in load. Experimental results have proved the Fuzzy controller produce robust performance rather than a PI controller for dynamic load changes and for disturbance in line variation.

Viswanathan, et. al.,(2002) A novel Fuzzy controller designed by [70] for a Boost converter operating at 25 V with a switching frequency of 50 KHz was simulated and the results obtained for peak overshoot and settling time in time domain analysis exhibit superior performance of Fuzzy controller over the conventional linear PI controller. An Adaptive Fuzzy logic controller designed by Feng, et. al.,(2002) [19] for a DC-DC boost converter operating at 48 V output was subjected to dynamic load changes and input voltage disturbances with due change in circuit parameters. The current mode control applied with Fuzzy logic control had yielded robust performance of the converter for dynamic changes in line and load. A Buck- Boost converter control topology was designed with Fuzzy

Viswanathan, et. al.,(2004) The fuzzy logic controller implemented [71] applied an approximated single non-linearity technique for control of power electronic converters. The simplified Non-Linear Function Controller (NLFC) was applied in proportionate-integral fuzzy logic controller to obtain good dynamic performance of a DC-DC boost converter. An Adaptive Network based Fuzzy controller for buck and buck-boost converter designed by Abdul, et. al., (2004) [1] was implemented with a PIC microcontroller. The experimental results for dynamic load variation for the buck and buck-boost converter reveal better load transient. The stability of the converter is checked with change in input voltage and the output verified the robust operation of the buck and buck-boost converter.

Rubaai, et. al., (2004) [58] successfully implemented a fuzzy controller for controlling DC-DC converters with two different fuzzy logic control techniques for buck, boost, buck-boost and Sepic converters. The results exhibit robustness around the operating point and good performance of transient responses under varying load conditions and varying input voltage with invariant dynamic performance of the system for varying operating conditions.

Weidong, et. al., (2004) [72] proposed a Fuzzy logic auto-tuning controller for a 50V/24V buck converter operating at 20 KHz. The auto-tuning algorithm efficiently handles the non-linear characteristics of the buck converter under drastic load variations. The results proved improvement in transient response of the converter for load variation and produce very low output ripple when a Fuzzy controller is implemented with the auto-tuning algorithm. A Multivariable Fuzzy Logic Controller (MFLC) was proposed by Johnson, et. al., (2004) [35] to control a buck converter operating at 12V/6V. The output voltage regulation for varying load conditions are checked from half load to full load and the output demonstrate enhanced performance of the converter when compared with conventional control strategies.

Kayalvizhi, et. al., (2004) [39] developed a fuzzy logic controller for positive output Luo self-lift DC-DC boost converter to produce a constant output voltage. The converter exhibit dynamic performance for load regulation and line regulation. A two-loop control strategy employing sliding mode control and fuzzy logic control was devised by Vidal, et. al., (2004) [68]. An 8 bit microcontroller was used for Fuzzy logic control and an analog circuit for sliding mode control was designed and the experimental results depict a dynamic performance of the system when compared with other conventional analog two-loop control strategies.

He, et. al., (2005) [23] implemented a microcontroller based fuzzy logic Average Current Mode Control (ACMC) for DC-DC converter using a PIC16C782 microcontroller using look-up table and other techniques in the fuzzy logic algorithm which demonstrate the performance of the said controller. An 8-bit microcontroller based fuzzy logic Peak Current Mode Controller (PCMC) (He, et. al., 2005) [23] is carried out with an algorithm using rule-based description of converter operation. Implementation is carried out by rule-based look-up tables and other techniques. Results indicate successful operation of fuzzy logic PCMC power converter system.

Ping, et. al., (2005) [53] devised a Type-2 Fuzzy Controller to regulate a 10V Buck converter against load and line voltage uncertainties. A PC based experimental analysis was carried out and the results for load regulation were taken in time domain analysis by varying the load dynamically and line regulation analysis was carried out by varying the input voltage and the results show better response of the converter against the uncertainties.

Alexander, et. al., (2005) [3] devised a Fuzzy logic control technique for a buck converter integrating the stability analysis of the controller and to simplify the small signal design. A frequency domain analysis is carried out for Fuzzy logic controller and a digital PI controller. The experimental results depict the performance of Fuzzy logic controller which showed better response than the digital PI controller for variation in line conditions.

Nagaraj, et. al., (2006) [52] designed and implemented a microcontroller based fuzzy logic technique controller for DC-DC buck and boost converters. An Analog-to-Digital Converter (ADC) and a PWM generator were used to control the converter. The duty cycle is varied according to the requirement of the converter to produce stable responses.

Arulselvi, et. al., (2006) A Fuzzy controller developed by [5] for Zero Voltage Switching (ZVS) Quasi-Resonant buck-boost converter was implemented with Digital Signal Processor (DSP) and operated at 100 KHz. A time domain analysis was carried out with MATLAB environment and the simulation results depict better load regulation. Experimental results performed with DSP validate the simulation result of the Fuzzy controller.

Anil, et. al., (2006) A Fuzzy controller based on Sliding Mode Control (SMC) technique was devised by [4] for a buck converter operating in Continuous Conduction Mode (CCM). The parameters of the converter such as settling time, peak overshoot and load regulation were performed in MATLAB environment. The simulation results exhibit dynamic performance of the system for load regulation and peak overshoot is reduced to much extent with faster settling time.

Jenica, et. al., (2007) A Fuzzy logic controller designed by [34] was integrated with a current mode control technique and implemented for a boost converter and the experimental results show the improved performance of the non-linear controller over variations in load dynamically and the results show faster response of the system.

Shamim-Ul-Alam, et. al., (2010) [60] developed a sliding mode controller based on fuzzy logic for a boost DC-DC converter in which a proportional-integral type current mode control is employed with the sliding mode controller based on fuzzy logic principles. The system performance ensures robustness against input variation and load variation and the fuzzy logic reduces the chattering phenomenon of the sliding controller which minimises the error thereby increasing the efficiency of the system. A Self- Scheduled Fuzzy Control (SSFC)

(El Beid, et. al.,2010) [15] was designed to control the duty cycle of a DC-DC converter. The Takagi-Sugeno (TS) model of fuzzy logic control technique is designed to control the output voltage by varying the duty cycle of the buck-boost converter using control law of Parallel Distributed Compensation (PDC) and Linear Quadratic Regulator (LQR) techniques.

Chaoui, et. al., (2010) [9] developed an adaptive fuzzy logic controller for a DC-DC boost converter under load uncertainties. The control strategy aims to track output voltage accurately under dynamic load variations without inner current control loop. The performance of the converter with this controller shows robustness with reduced sensors due to lack of current control loop. A fuzzy logic controller was designed in (Sahin, et. al., 2011) [59] for a buck-boost DC-DC converter used in solar-battery systems enhanced the performance of the converter for various conditions such as load regulation and line regulation.

Diordiey, et. al., (2003) [13] presented a hybrid PID-Fuzzy controller for a DC-DC converter which is intrinsically a non-linear plant. A Fuzzy system is used for gain control of PID controller. The performance for load regulation, line regulation and integratral component defect compensation of the PID is found better. (Shen, et. al., 2006) [61] proposed a double closed loop control strategy for a Zero Voltage Zero Current Switching (ZVZCS) PWM DC-DC converter. The double closed loop controller comprises an inner loop of PI controller and an outer loop of fuzzy logic with integrator control technique. This control strategy yield better performance in stability, control precision and dynamic performance of the converter is found on a 3KW prototype.

Kumarawadu, et. al., (2006) [41] developed an intelligent controller with adaptive fuzzy logic technique for high performance power electronic converter. It implements an Adaptive Neuro Fuzzy Inference System (ANFIS) controller whose membership functions are fine tuned by neural networks. The results show robust performance of the DC-DC buck converter against input voltage variation and load resistance variations.

(Wong, et. al., 1995) A Neuro-Fuzzy controller [74] was developed to control the duty cycle of the PWM switch for controlling the DC-DC Cuk power converter. An offline training algorithm is used to train the ANFIS of the controller whose inputs are voltage and change in error and the output being duty cycle control signal. Results show better performance of the said converter.

Jawahar, et. al., (2006) [33] designed a Neuro-Fuzzy controller to improve the performance of a power electronic boost converter. The system exhibits fine performance over worst conditions of maximum load and minimum line condition.A Neuro controller designed for a buck converter and a boost converter operating at 50 KHz and tested in time domain for change in line and load variations. Simulations results show the robustness of the buck and boost converter for variations in load and line conditions and the results depict faster settling time and reduced peak overshoot.
(Vasile, et. al., 2016) A Fuzzy and Neuro- Fuzzy controller [67] are designed to control the duty cycle of the controller to linearize the nonlinear external characteristics of a boost converter that supplies DC motors. This controller is additionally introduced in high precision speed control system. A Fuzzy-Neural Sliding- Mode (FNSM) control system

(Kuo, et. al., 2017) [42] is developed to control power electronic converters. The FNSM control system comprises a neural controller and a compensation controller. In the neural network controller, an asymmetric fuzzy neural network is utilized to mimic an ideal controller. The compensation controller is designed to compensate for the approximation error between the neural controller and the ideal controller. An online training methodology is developed in the Lyapunov sense; thus, the stability of the control system is guaranteed. Experimental results of a DC- DC converter show that the FNSM control system is found to achieve favourable regulation performances even under input-voltage and load-resistance variations.

(Chen, et. al., 2018) A T-S fuzzy controller [10] is developed to control a buck-boost converter by adopting PDC control scheme. The controller produces reliable output that exhibit the stability of the system.

Janagiraman, et. al., (2018) A Neuro controller designed by [32] for a Zero Current Switching (ZVS) Quasi-Resonant Luo converter to perform a closed loop control against load disturbances was implemented with a Digital Signal Processor (DSP) and simulation was carried out with MATLAB environment. The simulation results exhibit faster response of the converter for changes in load and the experimental results validate the simulation results.

(Bourdoulis, et. al., 2019) [8] designed a Neuro-Fuzzy controller to regulate the converter. The ANFIS is trained to produce control signal to regulate the PWM signal dynamically according to the need of the converter. The controller guarantees stability of the closed loop system.

(Utomo, et. al., 2019) [66] proposed a neural network control algorithm for the control of a DC-DC buck-boost converter using online learning method. In this technique a back propagation algorithm is utilized. The controller was designed for output voltage stabilization and to improve the performance of the buck-boost converter during transient operations and variation in reference voltage. The result shows improvement in the performance of the converter for voltage stabilization.

Rong, et. al., (2019) [57] developed an Adaptive Fuzzy Neural Network Control (AFNNC) for the tracking control of a conventional DC-DC boost converter. The AFNNC online learning algorithms are derived in the sense of Lyapunov stability theorem and projection algorithm to ensure the stability of the controlled system without the requirement of auxiliary compensation. AFNNC produces a duty cycle control signal for PWM generation which exhibit effective control of the system against uncertainties.

2. CONVENTIONAL PFC TECHNIQUE

It is a technique of counteracting the undesirable effects of electric loads that create a power factor less than 1.When an electric load has a PF lower than 1, the apparent power delivered to the load is greater than the real power which the load consumes. Only the real power is capable of doing work, but the apparent power determines the amount of power that flows into the load, combining both active and reactive components.

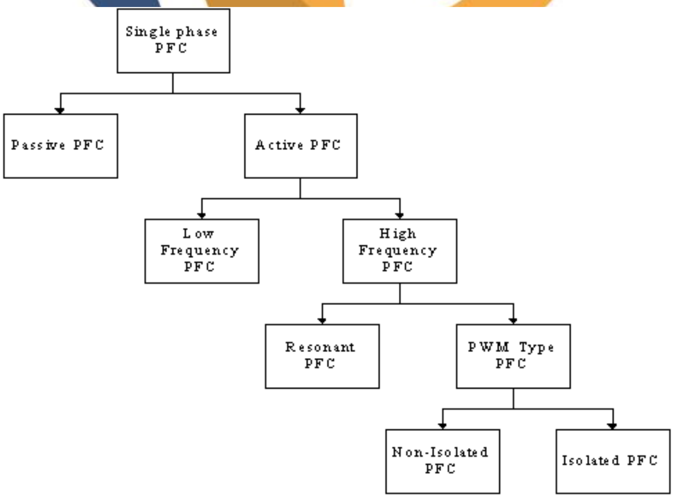


Figure 1: Classification of Power Factor Correction Controllers for single phase system

The purpose of the power factor correction circuit is to minimize the input current waveform distortion and make it in phase with the voltage one. Most of the research on PFC for nonlinear loads is actually related to the reduction of the harmonic content of the line current. ". Figure 1 shows the classification of all type PF PFC in single phase system. There are several methodologies to achieve PFC but depending on whether active switches (controllable by an external control input) are used or not, they can be categorized as "Passive" or "Active.

3. LINEAR BOOST CONVERTER CONTROL

There are varieties of control methods, among which any one method can be used in PFC application. In general, for any control strategy for PFC, two basic feedback compensating loops are required shown in figure 3.2. Voltage feedback compensating loop is used as the outer loop to keep the bus voltage to a fixed DC (predefined reference) value. An inner loop, known as current loop is to control the inductor current to a specific level and to shape the inductor current with the aim to be as alike as possible to the rectified input DC voltage keeping almost unity PF. The PFC power supplies with control loops implementation is employed to achieve a stable system with a tolerable dynamic behavior irrespective of the system loading conditions.

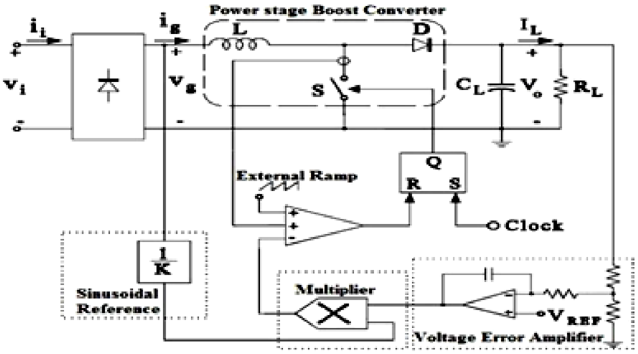
Basically, PFC control strategy is divided into two categories:
1. Active Control Method
2. Automatic Control of line current

For CCM, active control method is used whereas automatic control method is related to the DCM operation of the converter. In the active control method the main control scheme is peak current control method and average current control method is generally used.

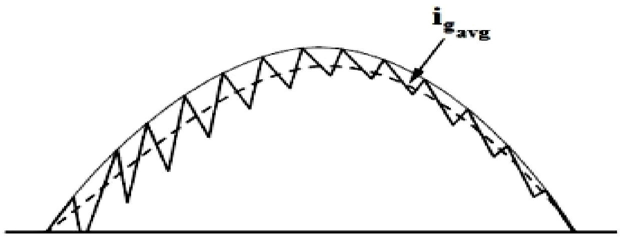
Peak Current Control Method
The switch turns on with a constant frequency and it can turn off uphill inductor current reaches a level set by the outer loop. Therefore, instant over-current switch protection is easier, but there is very noise sensitive control.

A compensating ramp is always required to add, when the duty cycle exceeds 0.5, otherwise the control is inherently unstable.

The switch is getting turned on with a fixed frequency by a clock signal as in figure.3.3 (a) and is turned off when the sum of the positive ramp of the inductor current (i.e. the switch current) and an external ramp (i.e. compensating ramp) touches the sinusoidal current reference as in figure 3.3(b). Usually, this reference can be attained by multiplying a scaled replica of the rectified line voltage, Vo times the output of the voltage error amplifier, which sets the current reference amplitude. This is way for natural synchronization of the reference signal and hence reference is always proportional to line voltage, which is the condition to acquire unity power factor.A figure 3.3 show, the converter is in continuous inductor current mode operation, which implies that the devices current stress as well as reduction in input filter requirement. Furthermore, with continuous input current, the diode of the bridge can be slow devices (they operate at line frequency). On the contrary, the hard turn-off of the freewheeling diode increases losses and switching noise, calling for a faster device.



(a)



(b)

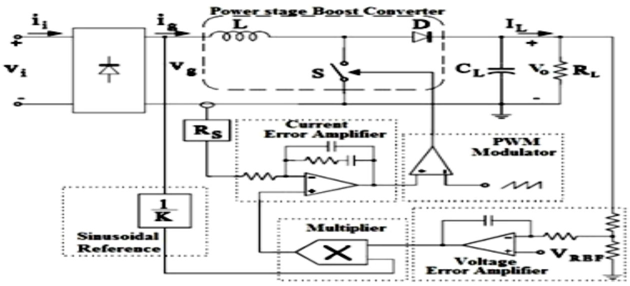
Figure 3: Peak Current Control Method for Boost Converter based PFC

Advantage of Peak Current control Method

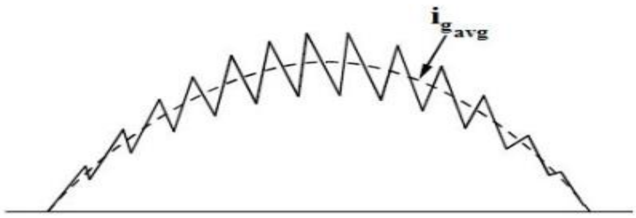
- ➢ Fixed Switching Frequency
- ➢ In this method only switch current is sensed so it accomplished by a current transformer, thus it avoid the loss due to sensing resister.
- ➢ In this method we use current error amplifier so compensation network is not required.
- ➢ Due to presence of instantaneous current limiter its reliability and speed of response get improved.
- ➢ Disadvantage of Peak current control method
- ➢ At duty cycle 0.5 sub-harmonics are presents so a compensating ramp is required.
- ➢ Due to presence of ramp compensating system input current distortion increase at high line voltage.
- ➢ This method is more sensitive to commutation noise.

Average Current Control Method

Each control method has its own qualities and drawbacks based on the topology of the DCDC converter employed in PFC converter. Now a day's average current control method is taken as a standard strategy in the industry for the boost AC-DC PFC converter, since it has merits of less THD with improved noise and easy to shape input current waveform.



(a)



(b)

Figure 4: Average Current Control Method for Boost Converter Based PFC

This control method also allows a better improved input current waveform. A current error amplifier is there as in the figure 3.4, which filters the inductor current sensed. The output of the current error amplifier drives a PWM modulator. The inner current loop tends to reduce the error between the average input current, ig and its reference. The latter is obtained as the peak current control. Same considerations can be realized with respect to this control technique because the converter works in a continuous inductor current mode. This method overpowers the complications of the peak current control method by introducing a high gain integrating current error amplifier (CA) into the current loop.

Advantage of Average Current Control Method

- ➢ This method is based on fixed switching frequency.
- ➢ In this method there is no requirement of external compensating ramp circuit.
- ➢ Due to presence of current filtering system this method is less sensitive with communication noise.
- ➢ This method has better input current waveform than peak current control method.

Disadvantage of Average Current Control Method

- ➢ Inductor current must be sensed
- ➢ Due to presence of inductor current error amplifier is necessary for compensating network must be design for different converter operating point during the line cycle.

4. CONCLUSION

The PFC converter always needs extensive operating conditions and fast response, which is satisfactorily impossible by conventional PWM current mode controller. The nonlinear controllers offer control backing in this regard. In comparison to the conventional current mode controllers the nonlinear controller is able to provide in the further modelling work the following desires can be achieved in simulation in MATLAB.

This paper deals with all the existing PFC techniques in a review

- ➢ Fast dynamic responses
- ➢ Inherent robust features with fixed operating frequency
- ➢ Stable for large operating range
- ➢ Least deviation of settling time over wide operating range
- ➢ Low overshoots voltage relatively over wide operating range

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