IMPROVEMENT OF POWER QUALITY BY INRLEAVED BOOST CONVERTER WITH FUZZY LOGIC CONTROLLER

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Abstract—In many converter applications Interleaving control schemes are widely used to reduce input current ripples and volume to increased processed power capacity of converters. The presence of ripple and harmonics in current and voltage has sparked the research in power quality of the system. AC- DC power conversion equipment distorts power factor due to distortion in input current. In this paper Interleaved Boost Converter with Average Current Control technique is compared with Variation tolerant Phase Shifting(vtps) Technique to improve power quality. Hysterisis current controller is used to generate Switching Signals for converters. The proposed VTPS Circuit fed by Fuzzy logic controller is modeled and simulated using matlab to reduce total harmonic distortion (THD).

Keywords—Power Factor Correction (PFC), Interleaved Boost Converter Control, Average current control model, Variation-Tolerant Phase Shifting technique (VTPS), Fuzzy Controller

1. INTRODUCTION
In this modern era many appliances requires DC power supply. To obtain this DC power an interface must be provided between the AC power line and the load requiring DC voltage. In general diode rectifiers are used for AC-DC conversion. Diode rectifier rectify input line voltage to get DC output voltage. But this DC voltage oscillates between zero to peak. A filter capacitor is used to reduce ripple from DC output voltage. By using filter capacitor power factor problem and THD arises. Capacitor maintains DC voltage at a constant value but it draws non sinusoidal current from supply. So the input current becomes pulsating which results poor power factor and high THD. To improve power factor, power factor correction techniques are used. There are two types of power factor correction techniques are used.
1. Passive power factor correction
2. Active power factor correction

Passive power factor correction method has a disadvantage that it cannot control output voltage and also have resonance problem. As a result active power factor correction method is used. In this paper power factor correction and THD minimization is done by interleaved boost converter. Interleaved Boost converter with average current control technique is compared with Variation Tolerant Phase Shifting Technique (VTPS). Average current control based PI controller is compared with VTPS PI and fuzzy logic controllers. The simulation of interleaved boost converter with PI and fuzzy logic controllers are shown. Finally hysterisis current control is used to control the switching of converters.

2. INTERLEAVED BOOST CONVERTER
This converter is suitable for current sharing and stepping up the voltage on high power applications. Ripple is produced due to rise and fall of the inductor current. To eliminate this problem interleaved boost converter is used. Interleaved Boost converter is shown in fig 1. In Interleaved boost converter two boost converters are operate in 180° out of phase. The input current can be calculated by adding two inductor currents. Because two inductor currents are out of phase they cancel each other reduces the input ripple that the boost converter cause.

Fig 1: Interleaved Boost Converter

When the switch Sm is on and switch Ss is off
\[
d\text{im}/dt = \text{Vin}/Lm \tag{1}
\]
\[
d\text{is}/dt = (\text{Vo-Vin})/Ls \tag{2}
\]

When the switch Sm is off and switch Ss is on
\[
d\text{im}/dt = (\text{Vin})/LS \tag{3}
\]
\[
d\text{is}/dt = (\text{Vo-Vin})/Lm \tag{4}
\]
The two inductor currents will be out of phase and cancel out the ripple of each other.
\[
\text{Vin}/Lm = (\text{Vo-Vin})/Ls \tag{5}
\]
\[
(\text{Vo-Vin})/Lm = (\text{Vin})/Ls \tag{6}
\]
The above two equations i.e. equation (5) and (6) will be satisfied \( Lm = Ls \)
\[
\text{Vo}= 2\text{Vin}
\]
3. AVERAGE CURRENT CONTROL MODEL

The average current control mode is one of the different current control techniques. To manipulate continuous input current obtain from boost converter. In average current control mode using PI controller as shown in fig (2). In this mode current control and voltage control loop are used. Input current is compared with reference current can be obtained by scaling factor K and it multiplying with actuating signal is obtained by comparing the output voltage with reference voltage and passing voltage error through PI controller. Comparison of $I_a$, $I_{ref}$ gives error. Error is the input of Hysteresis current controller, which provides signal for the switches. PI controller consists of proportional gain and Integral gain. Proportional gain produces an output proportional to input error and an integrator to make steady state error zero. When the inductor current $I_a$ rises, the error current $I_{error}$ increases. When output voltage $V_o$ decreases, error current $I_{error}$ decreases on the contrary $I_{error}$ increases.

4. VARIATION IN TOLERANT PHASE SHIFTING TECHNIQUE

In this mode voltage control and two current control Loops are used. Input current is compared with reference current can be obtained by scaling factor K and it multiplying with actuating signal is obtained by comparing the output voltage with reference voltage and passing voltage error through PI controller. Comparison of $I_a$, $I_{ref}$ gives error. Error is the input of Hysteresis current controller, which provides signal for the switches.

PI controller consists of proportional gain and Integral gain. Proportional gain produces an output proportional to input error and an integrator to make steady state error zero. In this technique mutual inductance is used in the place of inductance. To form the closed loop by using the secondary ends of the inductance. The Zero Crossing Detector (ZCD) is used to form closed loop. Whenever the voltage or current crosses the zero than ZCD detects the short pulses. If the phase difference between two ZCD pulses is zero then phase difference between two converters is 1800. Whenever the phase difference between two ZCD pulses is $\alpha$, then that $\alpha$ will be added to the upper switch of the boost converter. so VTPS ensures 1800 phase difference between two converters.

5. CONCEPT OF FUZZY SYSTEM

L. A. Zadeh presented the first paper on fuzzy set theory in 1965. Since then, a new language was developed to describe the fuzzy properties of reality, which are very difficult and sometime even impossible to be described using conventional methods. Fuzzy set theory has been widely used in the control area with some application to power system [5]. A simple fuzzy logic control is built up by a group of rules based on the human knowledge of system behavior. Matlab/Simulink simulation model is built to study the dynamic behavior of converter. Thus, fuzzy logic controller has been potential ability to improve the robustness of converters. The basic scheme of a fuzzy logic controller is shown in Fig 6 and consists of four principal components such as: a fuzzy fication interface, which converts input data into suitable linguistic values; a knowledge base, which consists of a data base with the necessary linguistic definitions and the control rule set; a decision-making logic which, simulating a human decision process, infer the fuzzy control action from the knowledge of the control rules and linguistic variable definitions; a defuzzification interface which yields non fuzzy control action from an inferred fuzzy control action [10].

Rule Base: the elements of this rule base table are determined based on the theory that in the transient state, large errors need coarse control, which requires coarse input/output variables; in the steady state, small errors need fine control, which requires fine input/output variables. Based on this the elements of the rule table are obtained as shown in Table 1, with "Vdc" and "Vdc-ref" as inputs.
6. SIMULATION RESULTS

Here simulation is carried out in several cases, in that 1). Improvement of Power factor using Interleaved Boost converter. 2). Interleaved Boost Converter Operated Under Average Current Control Technique. 3). Interleaved Boost Converter Operated under Variable Tolerant Phase Shifted Technique. 4). Interleaved Boost Converter Operated under Fuzzy Controller.

Case 1: IMPROVEMENT OF POWER FACTOR USING INTERLEAVED BOOST CONVERTER

Case 2: INTERLEAVED BOOST CONVERTER OPERATED UNDER AVERAGE CURRENT CONTROL TECHNIQUE

Fig 6: Matlab/Simulink Model Of Improvement Of Power Factor Using Interleaved Boost Converter

Fig 7: Output Voltage Of Interleaved Boost Converter

Table 1: FUZZY RULES

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Fig 8: Source Side Voltage & Current

Fig 9: Input Current

Fig 10: FFT Analysis Of Source Current

Fig 11: Matlab/Simulink Model Of Interleaved Boost Converter Operated Under Average Current Control Technique

Fig 12: Matlab/Simulink Model Of Interleaved Boost Converter Operated Under Average Current Control Technique using Matlab/Simulink software package.

Fig 8 shows the Source Side Voltage & Current of Proposed Power Factor Correction using AC/DC Single Stage Conversion Operated using Interleaved Boost Converter. Which represents the both voltage & current would be placed in in-phase condition, get unity power factor.
Case 3: INTERLEAVED BOOST CONVERTER OPERATED UNDER VARIABLE TOLERANT PHASE SHIFTING TECHNIQUE

Fig 16: Matlab/Simulink Model Of Interleaved Boost Converter Operated Under Variable Tolerant Phase Shifting Technique

Fig 16 shows the Matlab/Simulink Model of Interleaved Boost Converter Operated under Variable Tolerant Phase Shifted Technique using Matlab/Simulink software package.

Fig 17: Output Voltage

Fig 17 shows the Output Voltage of Interleaved Boost Converter Operated under Variable Tolerant Phase Shifting Technique.

Fig 18: Source Side Voltage & Current

Fig 18 shows the Source Side Voltage & Current of Interleaved Boost Converter Operated under Variable Tolerant Phase Shifting Technique, which represents the both voltage & current would be placed in in-phase condition, get unity power factor.

Fig 19: Input Current

Fig 19 shows the Input Current of Interleaved Boost Converter Operated under Variable Tolerant Phase Shifting Technique.
Fig 20: FFT Analysis Of Source Current
Fig 20 shows the FFT analysis of source current of Interleaved Boost Converter Operated under Variable Tolerant Phase Shifting Technique, get 5.32%.

Case 4: INTERLEAVED BOOST CONVERTER WITH FUZZY CONTROLLER.

Fig 21: Matlab/Simulink Model Of Interleaved Boost Converter Operated Under Variable Tolerant Phase Shifting Technique With Fuzzy Controller
Fig 21 shows the Matlab/Simulink Model of Interleaved Boost converter Operated under Variable Tolerant Phase Shifting Technique with Fuzzy Controller using Matlab/Simulink software package.

Fig 22 shows the Output Voltage of interleaved Boost Converter Operated under Variable Phase Shifted Technique with Fuzzy Controller.

Fig 23: Source Side Voltage & Current
Fig 23 shows the Source Side Voltage & Current of Interleaved Boost Converter Operated under Variable Phase Shifted Technique with Fuzzy Controller, which represents the both voltage & current would be placed in in-phase condition, get unity power factor.

Fig 24: Input Current
Fig 25: FFT Analysis Of Source Current
Fig 25 shows the FFT analysis of source current of Interleaved Boost Converter Operated under Variable Phase Shifted Technique with Fuzzy Controller, get 3.85%.

TABLE II: RIPPLE CURRENT AND THD COMPARISON FOR VARIOUS TECHNIQUES

<table>
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<tr>
<th>TOPOLOGY</th>
<th>RIPPLE CURRENT(A)</th>
<th>THD (%)</th>
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<td>Interleaved Boost Converter</td>
<td>24</td>
<td>24.90</td>
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<td>Interleaved Boost Converter with Average Current control model</td>
<td>2.8</td>
<td>7.03</td>
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<td>Interleaved Boost Converter with Variation Tolerant Phase Shifting</td>
<td>0.9</td>
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7. CONCLUSION
This proposed model is implemented using Matlab Simulink software and the obtained resultant waveforms were evaluated and the effectiveness of the system stability and performance of converter topology have been established. The input current ripple is reduced with the proposed phase shifter compared with the conventional phase shifting techniques. Fuzzy logic controllers have given better results than conventional strategy in terms of reduction in THD and also ripple in input current.

REFERENCES


