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FUZZY LOGIC BASED POWER FACTOR CORRECTION SINGLE STAGE AC/DC CONVERTER

[1]THIMMAPURAM MERCY GRACE, [2]Mr.M.S.SHIVA KUMAR,
[3]DR K .CHITHAMBARAIASETTY
[1]M.Tech Student, [2]Assistant Professor, [3]Assosciate Professor
Department of Electrical & Electronis Engineering
ST.JOHNS COLLEGE OF ENGINEERING & TECHNOLOGY,
YERRAKOTA,YEMMIGANUR, KURNOOL

Abstract:

A DC-link voltage is widely used in industrials and domestic's application. Simple diode rectifier's bridges are used to create dc voltage link. A diode rectifier has a high distortion input currents wave form and low power factor. A single phase AC–DC boost converter is realized to replace the conventional diode bridge rectifier. Fuzzy logic and hysteresis control techniques is implemented to improve the performance of the boost converter. The current loop is being controlled by using a PI, and hysteresis controllers. The fuzzy controller is applied to DC voltage loop circuit to get better performance. The results show that the fuzzy controller gives well controller. The controller is verified via MATLAB/Simulink.

I. INTRODUCTION

Power factor corrected AC-DC power supplies are increasingly important as many more electronic loads are using the AC grid.

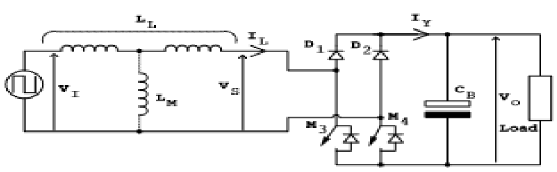

Fig 1. Simplified circuit model of the power supply

There is much research on power factor correction in general and active power factor correction using modern power electronics techniques are now commonly deployed. For many applications such as electric vehicle chargers, portable inverter welders and plasma cutters, light weight is an important consideration. The single stage architecture in is based on using a single magnetic core for a transformer whose leakage inductance is used in a step up (boost) configuration. However, the design in requires hard switching of the switches in the secondary side active rectifier.

II. LITERATURE SURVEY:

i. Single phase power factor correction:

New recommendations and future standards have increased the interest in power factor correction circuits. There are multiple solutions in which line current is sinusoidal. In addition, a great number of circuits have been proposed with non sinusoidal line current. In this project, a review of the most interesting solutions for single phase and low power applications is carried out. They are classified attending to the line current waveform, energy processing, number of switches, control loops, etc. The major advantages and disadvantages are highlighted and the field of application is found.

ii. State of the art, single phase active power factor correction techniques for high power applications an overview:

A review of high-performance, state-of-the-art, active power-factor-correction (PFC) techniques for high-power, single-phase applications is presented. The merits and limitations of several PFC techniques that are used in today's network-server and telecom power supplies to maximize their conversion efficiencies are discussed.

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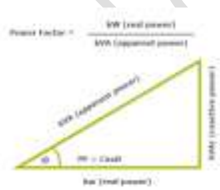
These techniques include various zero-voltage-switching and zero-current-switching, active snubber approaches employed to reduce reverse-recovery-related switching losses, as well as techniques for the minimization of the conduction losses. Finally, the effect of recent advancements in semiconductor technology, primarily silicon-carbide technology, on the performance and design considerations of PFC converters is discussed.

III. PFC CONVERTER

How does Power Factor Correction work?

Power Factor is a measure of how effectively incoming power is used in your electrical system and is defined as the ratio of Real to Apparent (total) power where:

- Real Power is the power that actually powers the equipment and performs useful, productive work.
- Reactive Power is required by some equipment (eg transformers, motors and relays) to produce a magnetic field for operation; however it does not perform any real work.
- Apparent Power is the vector sum of Real and Reactive Power and corresponds to the total power required to produce the equivalent amount of real power for the load.



Power Factor Correction may be required where a system has a power factor of less than 90% (or 0.9). A poor power factor can contribute to equipment instability and failure, as well as significantly higher than necessary energy costs since it means that more current is required to perform the same amount of work. By optimising and improving the power factor, power quality is improved, reducing the load on the electricity distribution system.

PFC equipment achieves a decrease in the total amount of electrical demand by using a bank of capacitors to offset an inductive load (or reactors if the load is capacitive).

The boost converter can operate in three modes: continuous conduction mode (CCM), discontinuous conduction mode (DCM), and critical conduction mode (CrCM). Figure 3.1 shows modeled waveforms to illustrate the inductor and input currents in the three operating modes, for the same exact voltage and power conditions. By comparing DCM among the others, DCM operation seems simpler than CrCM, since it may operate in constant frequency operation; however DCM has the disadvantage that it has the highest peak current compared to CrCM and also to CCM, without any performance advantage compared to CrCM. For that reason, CrCM is a more common practice design than DCM, therefore, this document will exclude the DCM design.

CrCM may be considered a special case of CCM, where the operation is controlled to stay at the boundary between CCM and DCM. CrCM usually uses constant on-time control; the line voltage is changing across the 60 Hz line cycle, the reset time for the boost inductor is varying, and the operating frequency will change as well in order to maintain the boundary mode operation. CrCM dictates the controller to sense the inductor current zero crossing in order to trigger the start of the next switching cycle.

The inductor current ripple (or the peak current) in CrCM is twice of the average value, which greatly increases the MOSFET RMS currents and turn-off current. But since every switching cycle starts at zero current, and usually with ZVS operation, turn-on loss of MOSFET is usually eliminated.

Also, since the boost rectifier diode turns off at zero current as well, reverse recovery losses and noise in the boost diode are eliminated too, another major advantage of CrCM mode. Still, on the balance, the high input ripple current and its impact on the input EMI filter tends to eliminate CrCM mode for high power designs unless interleaved stages are used to reduce the input HF current ripple.

A high efficiency design can be realized that way, but at substantially higher cost. That discussion is beyond the scope of this application note. The power stage equations and transfer functions for CrCM are the same as CCM.

The main differences relate to the current ripple profile and switching frequency, which affects RMS current and switching power losses and filter design. CCM operation requires a larger filter inductor compared to CrCM. While the main design concerns for a CrCM inductor are low HF core loss, low HF winding loss, and the stable value over the operating range (the inductor is essentially part of the timing circuit), the CCM mode inductor takes a different approach. For the CCM PFC, the full load inductor current ripple is typically designed to be 20-40% of the average input current.

This has several advantages: Peak current is lower, and the RMS current factor with a trapezoidal waveform is reduced compared to a triangular waveform, reducing device conduction losses. Turn-off losses are lower due to switch off at much lower maximum curren The HF ripple current to be smoothed by the EMI filter is much lower in amplitude.

On the other side, CCM encounters the turn-on losses in the MOSFET, which can be exacerbated by the boost rectifier reverse recovery loss due to reverse recovery charge, Qrr. For this reason, ultra-fast recovery diodes or silicon carbide Schottky Diodes with extreme low Qrr are needed for CCM mode.

In conclusion, we can say that for low power applications, the CrCM boost has the advantages in power saving and improving power density. This advantage may extend to medium power ranges, however at some medium power level the low filtering ability and the high peak current starts to become severe disadvantages.

IV. PROPOSED CONVERTER

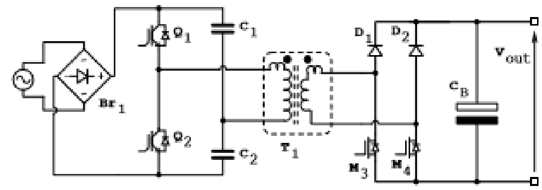


Fig 2 Circuit diagram of the power supply architecture

A simplified model for the power supply operation is shown in Fig. 4.1 viewed from the secondary side of the transformer and the magnetizing inductance LM is assumed sufficiently large to be ignored. The scaled input voltage to the transformer model (VI) is a square wave at the switching frequency fs with magnitude 1 2 Ns Np √ 2VAC sin(2πfAC kT) , with VAC the line input rms voltage, fAC the line frequency, k an index integer and T = 1/fs being the switching period.

The transformer turns ratio is Ns Np and the half bridge configuration accounts for the additional factor of 1.2 The active rectifier D1, D2, M3 and M4, allows the transformer secondary to be shorted by turning on both switches M3 and M4.The inductance LL is then operated as boost type converter and the input current is controlled to achieve input power factor correction.

A discontinuous conduction mode (DCM) and continuous conduction mode (CCM) can be identified dependent on whether the inductor current IL returns to zero in each half period T /2 as detailed in. The discontinuous conduction mode inherently provides for zero current switch on of the shorting switches M3 and M4 and no recovery losses in the diodes D1 and D2, but the continuous conduction mode requires switch on with non-zero current values and hard turn off of the diodes with the associated recovery loss.

Gate timing for zero current switch on of M3/M4

In this letter, zero current switches on of M3 and M4 is achieved in the CCM mode by delaying the switch on time to a period T0 after the transformer primary voltage changes polarity. Fig 3 shows the detailed CCM mode waveforms. At t = 0, the scaled transformer primary voltage changes polarity from −VI to +VI with the transformer secondary having a current of −IE and M3 and D2 are conducting. The transformer secondary current flowing through the inductance LL, decays to 0 over the period T0. With the output voltage

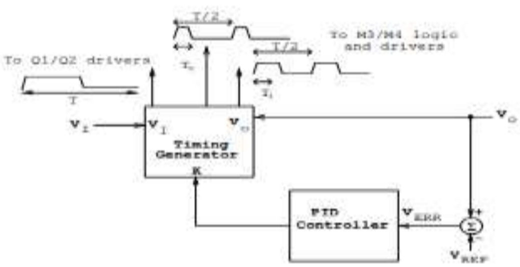


Fig.3 Output voltage control and timing generation for Q1/Q2 and M3/M4

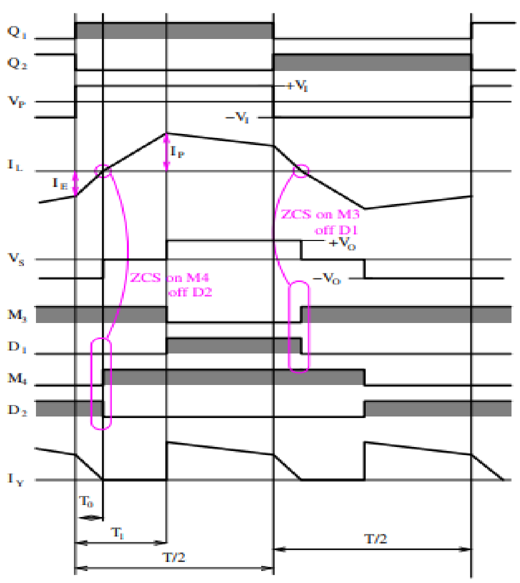


Fig 4 Waveforms for continuous conduction mode with zero current switching on M3 and M4.

V. FUZZY LOGIC

In recent years, the number and variety of applications of fuzzy logic have increased significantly. The applications range from consumer products such as cameras, camcorders, washing machines, and microwave ovens to industrial process control, medical instrumentation, decision support systems, and portfolio selection. To understand why use of fuzzy logic has grown, you must first understand what is meant by fuzzy logic.

Fuzzy logic has two different meanings. In a narrow sense, fuzzy logic is a logical system, which is an extension of multivalve logic. However, in a wider sense fuzzy logic (FL) is almost synonymous with the theory of fuzzy sets, a theory which relates to classes of objects with un sharp boundaries in which membership is a matter of degree. In this perspective, fuzzy logic in its narrow sense is a branch of FL. Even in its more narrow definition, fuzzy logic differs both in concept and substance from traditional multivalve logical systems.

What is fuzzy logic?

Fuzzy logic is all about the relative importance of precision is how important is it to be exactly right when a rough answer will do?

You can use Fuzzy Logic Toolbox software with MATLAB technical computing software as a tool for solving problems with fuzzy logic. Fuzzy logic is a fascinating area of research because it does a good job of trading off between significance and precision something that humans have been managing for a very long time. In this sense, fuzzy logic is both old and new because, although the modern and methodical science of fuzzy logic is still young, the concept of fuzzy logic relies on age old skills of human reasoning.

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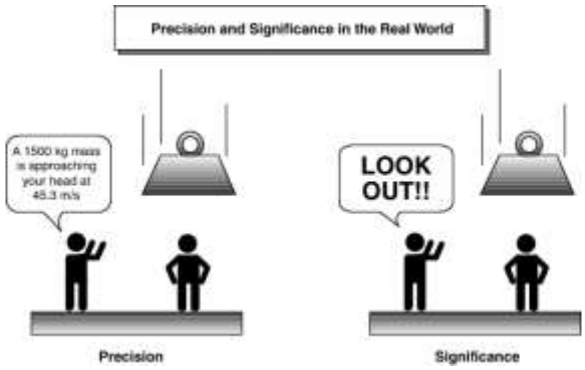

Fig.5. Fuzzy descriptions

Building a fuzzy inference system

Fuzzy inference is a method that interprets the values in the input vector and, based on user defined rules, assigns values to the output vector. Using the GUI editors and viewers in the Fuzzy Logic Toolbox, you can build the rules set, define the membership functions, and analyze the behavior of a fuzzy inference system (FIS). The following editors and viewers are provided.

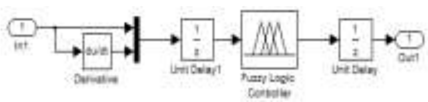

Fig.6 Fuzzy interference system

Fig.7 The primary GUI tools of the fuzzy logic toolbox

VI. SIMULATION RESULTS

PROPOSED CIRCUIT:

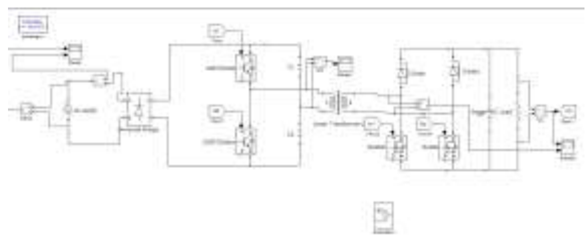

Fig.8 Proposed circuit of fuzzy logic ontroller

CONTROL DIAGRAM WITH FID AND FUZZY LOGIC ONTROLLER:

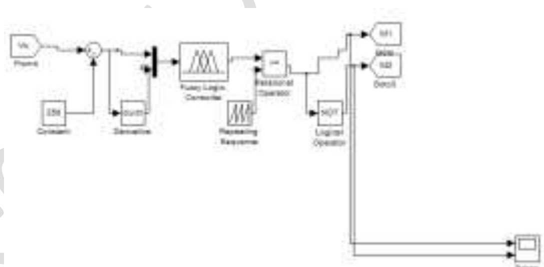

Fig.9 control diagram with FID and fuzzy logic controller

OUTPUT SOURCE VOLTAGE CURRENT WAVEFORM:

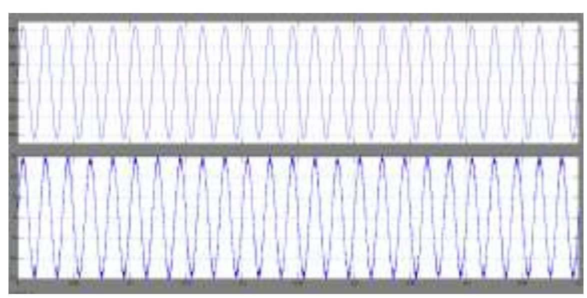

Fig.10 Vs and IS (SOURE VOLTAGE CURRENT)

6.4 TRANSFORMER PRIMARY VOLTAGE:

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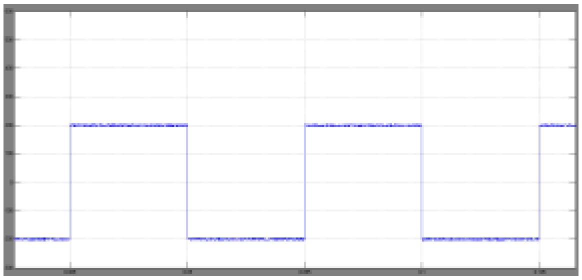

Fig.11 Transformer primary voltage

OUTPUT VOLTAGE:

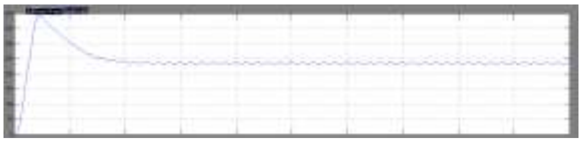

Fig 12 output voltage

6.6 TRANSFORMER SECONDARY VOLTAGE:

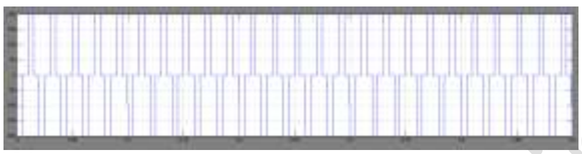

Fig 13 Transformer Secondary voltage

VII. APPLICATIONS AND FUTURE SCOPE

APPLICATIONS:

INDUSTRIAL APPLICATIONS

- Railway and transportation system
- Industrial motion control
- Information displays
- Factory automation and power generation systems

DOMESTIC APPLICATIONS

- Power supplies for radio
- Television and computer equipment
- In variable speed drives and almost of domestic electrical equipment

ADVANTAGES

- Small distortion input currents waveform
- Power factor near to unity
- Controlling the output DC voltage

VIII. FUTURE SCOPE

A single phase PFC converter dc voltage loop has been analysed with fuzzy logic based controller techniques implemented to improve the performance of the PFC converter this is reboost and efficient for single phase. These zero switching and soft switching techniques substantially eliminated the switching loss. However these techniques also used for three phase PFC converter dc voltage techniques with fuzzy logic based techniques.

XI. CONCLUSION

In this project, a single-phase PFC converter DC voltage loop has been analyzed. The fuzzy logic controller technique is implemented to improve the performance of the PFC converter, it is robust and efficient. Matlab/Simulink has been used to simulate the proposed techniques with successful result. In the same time, high efficiency is obtained. The proposed controller applied to the unity power factor give better results a reduced harmonic distortion, and robustness control during parameter variations.

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