Bridgeless Critical Conduction Mode Boost Power Factor Correction Converter Using ANFIS

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***Abstract*— Critical mode boost power factor corrector converters are widely used because of its low switching loss and simple control. In this paper, power factor correction of boost converter has been obtained using a quantitative analysis and the advantage of the digital control (ATMEGA8 controller). Also, in order to improve the efficiency and power factor in a high input and light load condition, circulating currents are reduced in the inevitable dead angle with a gate turning-off technique using (ANFIS) technology.**

***Keywords*— Additional on time, critical mode (CRM) boost power factor corrector (PFC).**

I. INTRODUCTION

The input current shape of an offline power supply should be in-phase with the input voltage for a high power factor (PF) and a low total harmonic distortion (THD). This is because an effective power delivery and minimizing unfavorable effects on the other electronic devices using the same ac line are required. For these reasons, boost power factor corrector (PFC) converters are widely used, due to its input-current-control capability.

The control methods for boost PFC converters can be divided according to its output power. In high power applications, continuous conduction mode (CCM) PFC is used to reduce the ripple currents and the conduction losses. However, in low-to midpower applications, critical conduction mode (CRM) boost PFC is widely used although it has a large ripple current, because of its low switching losses and simple constant on-time control. Nowadays, the digital control of power converters comes into the spotlight, because of its flexible control, reduced components, and no aging problems. For these reasons, a digital control of the CRM boost PFC has also been studied by many researchers. Fig. 1 shows a schematic diagram of a digitally controlled CRM boost PFC. As shown in Fig. 1, the input and output voltages are sensed by two analog-to-digital converter (ADC) modules and the zero current detection (ZCD) can be implemented by using an analog comparator in the digital controller. The on-time of the main switch (*T*on) is determined by a digital compensator using the output voltage (V_{out}). The ZCD enables the switch to be turned on when the voltage across the switch (v_{ds}) is the minimum value, to minimize the switching losses. However, this valley switching results in negative currents of the boost inductor and a delay time in a switching period, causing a distortion of the input current especially near the zero crossing of the ac input voltage.

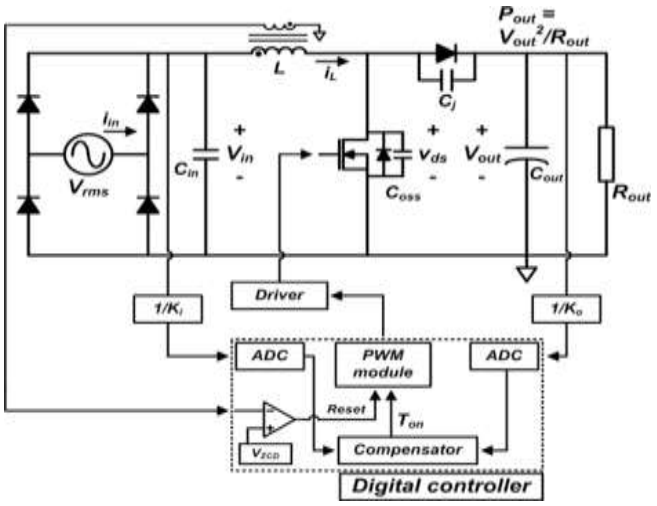


Fig.1 Digitally Controlled CRM Boost PFC

The additional on-time methods can cancel out the effect of the delayed switching period and negative inductor current, because it allows the inductor current to build up more. Because the distortion factors become larger when the input voltage of the boost PFC (*V*in) is smaller, the methods use a larger additional on time as *V*in decreases. Also, the additional on-time methods prevent the switching frequency from increasing near the zero crossing of the ac input voltage. However, many previous research studies use only the input voltage to obtain the additional on time. Since the distortion factors are dependent on not only the input voltage but also the output power, only considering the input voltage cannot provide an optimized additional on time. Despite the fact that the optimized on time considering both the input voltage and output power is not studied yet, it is impossible to obtain high PF in the entire input voltage and load conditions. Because the proposed research provides the optimal additional on time according to both the input voltage and the output power, the CRM boost PFC converter with the proposed control can have a high PF in the entire input and load conditions.

II. CONCEPT OF ANFIS

Artificial neuro-fuzzy interface system (ANFIS) is The general idea Control (ANFIS) is to create a closed loop controller with parameters that can be updated to change the response of the system. The output of the system is compared to a desired response from a reference model. The control parameters are update based on this error. The goal is for the parameters to converge to ideal values that cause the plant response to match

the response of the reference model. For example, you may be trying to control the position of a robot arm naturally vibrates. You actually want the robot arm to make quick motions with little or no vibration. Using ANFIS, we could choose a reference model that could respond quickly to a step input with a short settling time.

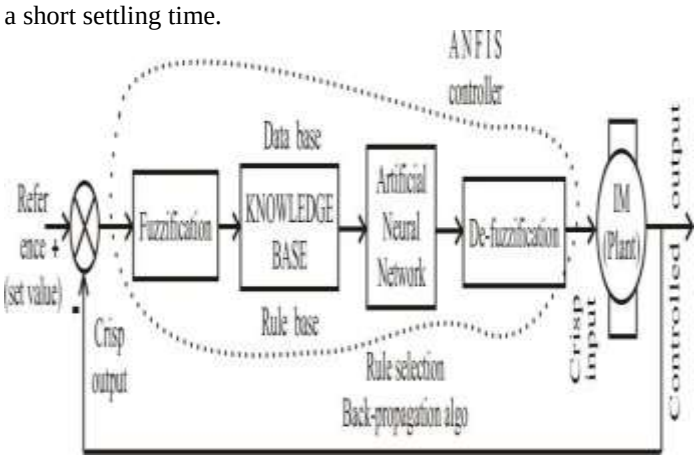


Fig.3 ANFIS process

The fuzzification unit converts the crisp data into linguistic variables, which is given as inputs to the rule-based block. The set of 49 rules is written on the basis of previous knowledge or experiences. The rule-based block is connected to the neural network block. Back-propagation algorithm is used for NN training in order to select the proper set of rule base. For developing the control signal, training is a very important step in the selection of the proper rule base. Once the proper rules are selected and fired, the control signal required to obtain the optimal outputs is generated.

These fuzzy-based controllers develop a control signal that yields on the firing of the rule base, which is written on the previous experiences, which is random in nature. Thus, the outcome of the controller is also random and optimal results may not be obtained. Selection of the proper membership functions and in turn selecting the right rule base depending on the situation can be achieved by the use of an ANFIS controller, which becomes an integrated method of approach for control purposes and yields excellent results, which is the highlight of this chapter. In the designed ANFIS scheme, neural network techniques are used to select a proper rule base, which is achieved using the back-propagation algorithm. This integrated approach improves the designed controller's performance in many ways in terms of cost-effectiveness and reliability.

III. PROPOSED SYSTEM

Boost converter, diode rectifier is replaced by bridgeless rectifier. This paper presents a single-phase Bridgeless critical conduction mode (CRM) power factor correction boost converter with ANFIS.

- In this method we using ANFIS controller, so it helps to improve the PF nearly to 0.99
- And we using output feedback closed loop method. So, there is constant voltage maintenance and ripple reduction in output

By using Matlab and proteus software the proposed system is simulated. This paper introduces a new bridgeless rectifier for AC-DC conversion. The rectifier reduces the primary side conduction loss by eliminating the four bridge diodes to increase efficiency This PFC controller with the proposed boost converter has high power factor of 9.9.

A. Block Diagram of Proposed System

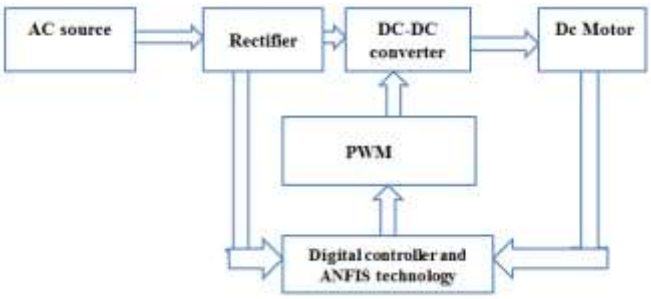


Fig.4 Block Diagram of Proposed System

In this block diagram 230V AC supply is given to the bridge less rectifier circuit, which converts AC input voltage into DC. DC to DC converter steps up the output voltage. Output of the dc converter is given to the motor load. By measuring the voltage and current digital controller produces the pulses for mosfet to maintain the power factor of the system.

B. Circuit Diagram of Proposed System

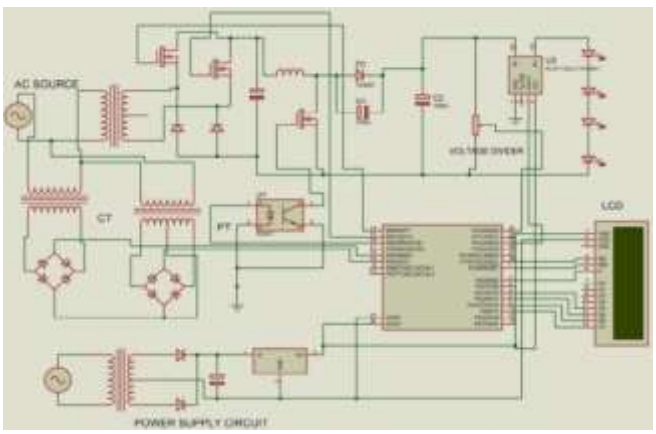


Fig.5 Circuit Diagram of Proposed System

230V AC supply is stepped down by using step down transformer and given to the bridgeless rectifier circuit. Where the rectifier converts the AC input voltage into DC voltage. DC to DC converter steps up the output voltage. Output of the dc converter is given to the motor load. Inductor is used to reduce the ripples and the diode is used to avoid the return supply from load to the supply.

By using the current and potential transformer input current and voltages are measured. Output current is measured by the current sensor, which are given to the ATMEGA8 controller. The DC supply for the controller is taken from the voltage regulator circuit (5V DC).

Gate driver circuit used for the MOSFET is opto coupler. Depends upon the intensity of the light signal the MOSFET will be turned off and on for the purpose of power factor correction.

IV. CODING FOR POWERFACTOR CORRECTION

```
#include <mega8.h>
#include <delay.h>
// Alphanumeric LCD Module functions
#include <alcd.h>
#include<math.h>

// Declare your global variables here

void main(void)
{
// Declare your local variables here

PORTB=0x00;
DDRB=0x0F;

PORTC=0x00;
DDRC=0x00;

PORTD=0x01;
DDRD=0x00;
int i,v,d,p;

lcd_init(16);
lcd_clear();
while (1)
    {


      lcd_puts("PF:");
      V=adc_read(5);
      i=adc_read(4);
      p[d]=v*i;
      z=exor(v,i);
      pf=cos(z);
      num(pf);
      OCA1A=100;
      PORTB=0x03;
      delay_ms(z*10);
      PORTB=0;
      delay_us(500);
      PORTB=0x0C;
      delay_ms(z*10);
      PORTB=0;
      delay_us(500);
     }
    }

}
```

V.SIMULATION DIAGRAM

Matlab simulation diagram of power factor factor correction of boost converter is given in Fig 5. The input and output voltages are sensed by two analog-to-digital converter (ADC) modules and the zero current detection (ZCD) can be implemented by using an analog comparator in the digital controller. The on-time of the main switch (T_{on}) is determined by a digital compensator using the output voltage (V_{out}). The ZCD enables the switch to be turned on when the voltage across the switch (v_{ds}) is the minimum value, to minimize the switching losses.

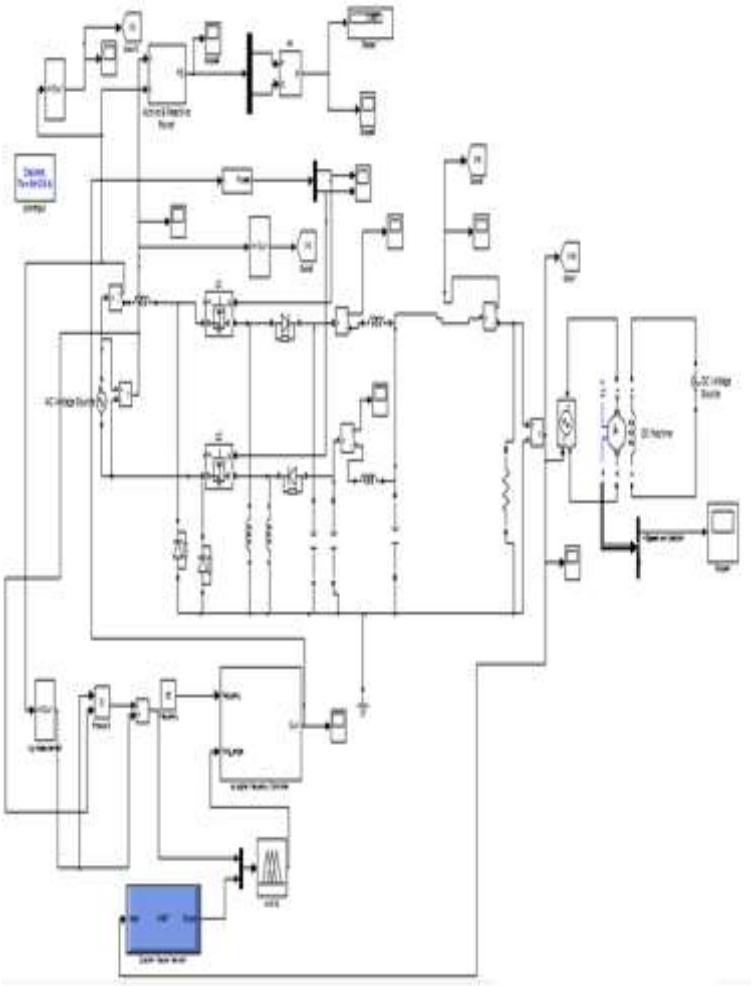


Fig .6 Simulation Of Flyback Converter

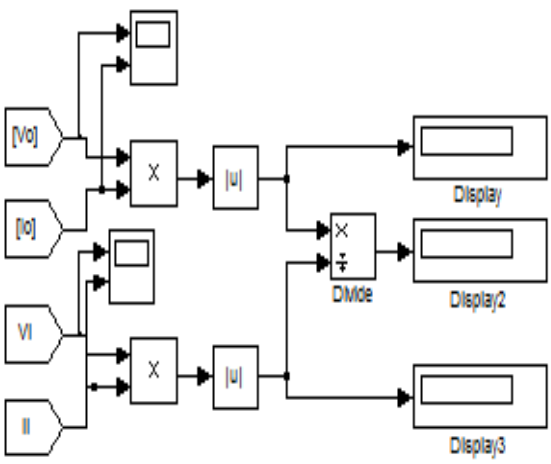


Fig.7 Efficiency calculation block

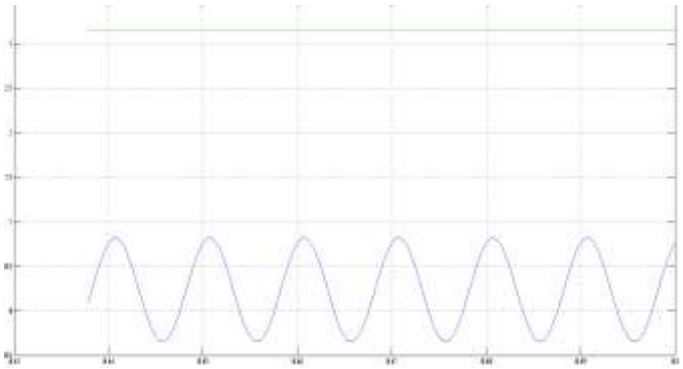


Fig.8 Real and reactive power

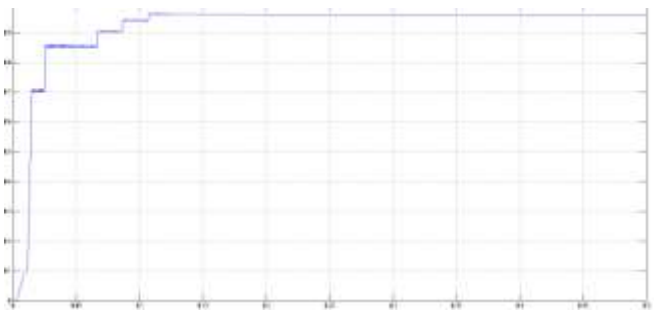
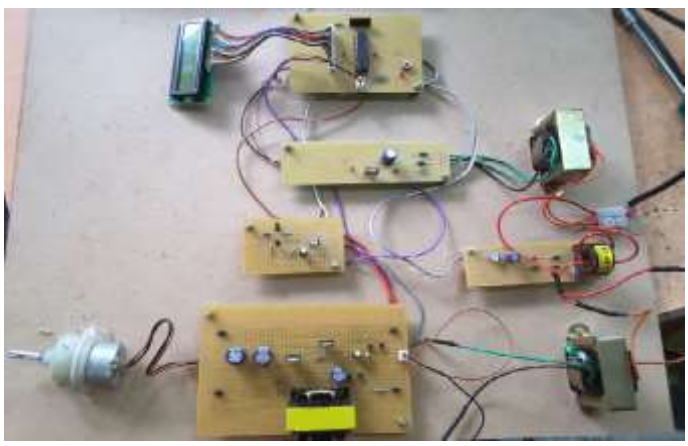


Fig.9 Efficiency

A. Hardware circuit



V. CONCLUSION

In this paper, an explicit form of the optimal additional on time for a CRM boost PFC is analyzed and verified. which allows using a cost effective digital controller. Both methods show a high PF and low THD in the entire input and output conditions. The proposed additional on-time method is powerful because of the following reasons:

1) The proposed method does NOT use additional sensing network. The required sensing variables are only the input and output voltage of the CRM PFC.

2) NO optimization procedure is required and implementation is also easy. It only requires the fixed variables of the PFC.

Also, the gate turning-off technique is presented so that the efficiency in a high input voltage-low output power condition can be improved without degrading the input current shape by reducing circulating losses in an inevitable dead angle.

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