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Research Article

Microcontroller based DC Drive with Power Factor Correction

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Abstract

In order to improve the performance of conventional AC/DC converter the proposed system presents a microcontroller based triggering circuitry for converter with power factor correction. Microcontroller with Zero crossing detectors and ADC are used to generate triggering pulses for semi converter to obtain controlled DC output. Special IC La6561 is used for power factor correction. The main aim is to achieve controlled dc drive output with variable voltage range and power factor correction. Proposed system is specially used for Domestic applications and small scale industries.

Keywords: *Firing angle control; Optoisolator; Semi converter; ZCD; ICL6561; PFC*

1. Introduction

Now a day there is large demands of electronics devices such as computer, TV etc. These all are required a controlled DC power supply. But due to the nonlinear behavior of the ac to dc converter current distortion occurs at the output and causes low power factor.

Power factor =Actual Power/Apparent Power

The actual power is the power being used in a circuit and apparent power is the power being drawn from the mains. But some additional reactive power is required to perform particular work, and causes power losses. So as to reduce the power losses and to improve the power factor this system proposes Microcontroller based power factor correction by using IC L6561. In proposed system two control methods are used i.e. Borderline current control & Firing angle control. The Microcontroller based triggering circuitry operates on firing angle control mechanism and generating pulses for semi converter. Power factor correction IC L6561used to correct the power factor value based on borderline current control method. Gate driver and opto isolator circuitry makes proper isolation in between triggering circuit and power circuit. The proposed system gives controlled DC output with wide output voltage range.

2. Literature Survey

To obtain controlled power output Shashikant V. Lahade describes a microcontroller based digital triggering circuitry for converter. In this system a firing angle control mechanism has been used for the control of output power. Triggering pulses are generated in desired sequence as output of microcontroller. This system gives reliable, affordable and accurate power control, but this system does not work on power factor correction. Nagaranjan M *et.al.* Proposes PIC Microcontroller based power factor correction by using PWM control method. This involves measuring the power factor value from the load using the microcontroller and sensors proper algorithm is used to determine and trigger sufficient switching capacitors in order to reduce reactive components, thus obtaining low power factor near to unity and also monitoring the power factor changes in LCD. This system results acquires higher efficiency and better quality AC output power factor correction. But PWM control method fails to reduce current harmonic distortion.

R.Seyezhai *et.al.* Describes comparison of various current control methods for a bridgeless boost converter to improve the power quality such as peak current, average current mode and borderline current control. This system results input current waveform close to sinusoidal implying high power factor and reduced harmonics for borderline current control. Nonlinear load such as rectifier distort the current drawn from the system and causes low power factor. So Suja C Rajappan *et.al*. describes a bridgeless power factor correction circuitry for boost converter which results in improved power factor and reduced harmonics content in input line currents as compared to conventional boost converter topology. This system eliminates the line-voltage bridge rectifier in conventional boost power factor correction converter,

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so that the conduction loss is reduced. In this system a PWM technique is used for power factor correction.

Abhinav Sharma *et.al*. Presents design and development of a single phase TRIAC based Static VAR Compensator for reduction of reactive power and power factor correction using PIC micro-controlling chip. This system is based on firing angle control method for generating the triggering pulses by using PIC microcontroller. Sridevi J. presents active power factor correction controller using boost converter. IC L6561is used for power factor correction. IC L6561 operated on Borderline current control mechanism for generating the triggering pulse. This system gives better power factor correction. Sanjay N. Patel *et.al*.Proposes a conceptual design of microcontroller based automatic power correction by using firing angle control method for 1 – ø and 3 - ø circuit for nonlinear loads. Proposed system uses Firing angle control method for getting variable controlled output voltage and borderline current control method for power factor correction by using IC L6561.

3. Proposed System

A scheme that address on building up system as a mention above is presented here as the single phase power factor correction for nonlinear loads with wide output voltage range. The following figure 3 shows the hardware details of the proposed system

3.1 Zero Crossing Detectors

The zero crossing detectors provide the zero crossing reference of the line frequency to the trigger circuit.

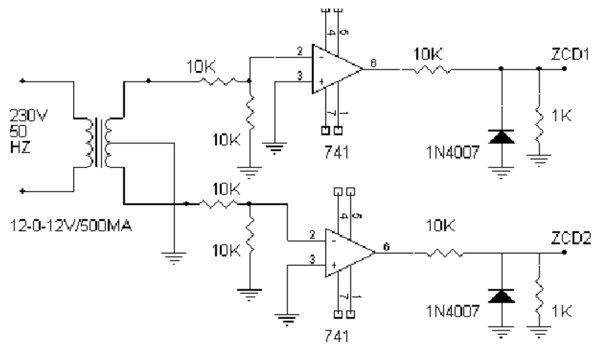

Fig 1 Zero crossing detectors module

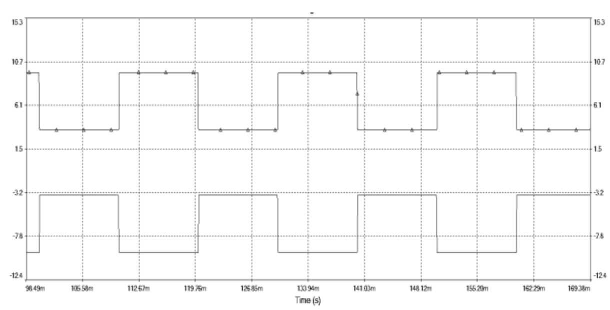

Fig 2 Zero Crossing Detectors Output

It consists of comparator block using op-amp (OP07). Its output swings to either positive saturation or negative saturation and given as interrupt to the microcontroller as shown in following figure1 and 2.

3.2 Analog to Digital Converter

The ADC is connected to the variable potentiometer for changing the analog voltage form 0 to 5v. Here an 8 bit code values are assign for proportional analog voltage and according to the voltage value the ADC generate the digital count and given to the microcontroller as a reference signal.

3.3 Microcontroller

The microcontroller 89s52 gets interrupted by ZCD outputs and ADC reference signal and according to that the microcontroller generates the firing angle and display on the LCD. According to the firing angle the interrupt signal are converted in to firing pulses which controls the semi converters. The microcontroller generates triggering pulse between firing angles 8^0 to 172^0.

3.4 LCD

The LCD displays the firing angle of Triggering pulses.

3.5 Buffer Signals

The Octal buffer offers asynchronous two way data communication between the control and power circuitry.

3.6 Opto isolator and Gate Driver

It isolates the control circuitry from the power circuitry. Signal amplifier (TIP-122) darling tone pair transistor is used for current boosting.

3.7 Semi converter

In semi converter two MOSFETs are connected in parallel operating for both positive and negative half cycle respectively. According to the firing angle control the semi converter gives the controlled output with variable voltage range.

3.8 Automatic Power Factor Correction IC L6561

IC L6561 based on borderline current control method used for power factor correction. IC L6561controls the power MOSFET according to the reference signal getting from microcontroller.

3.9 Software Used

The software of the whole system was developed using embedded 'C'.

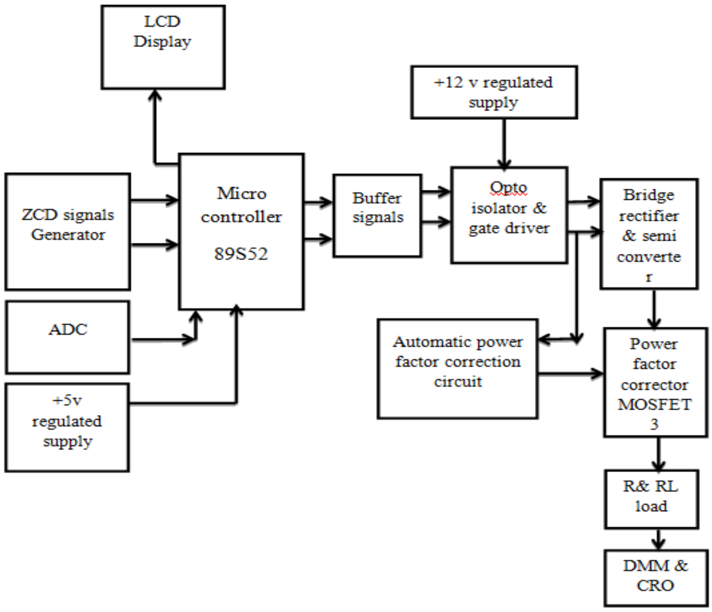

Fig 3 Block diagram

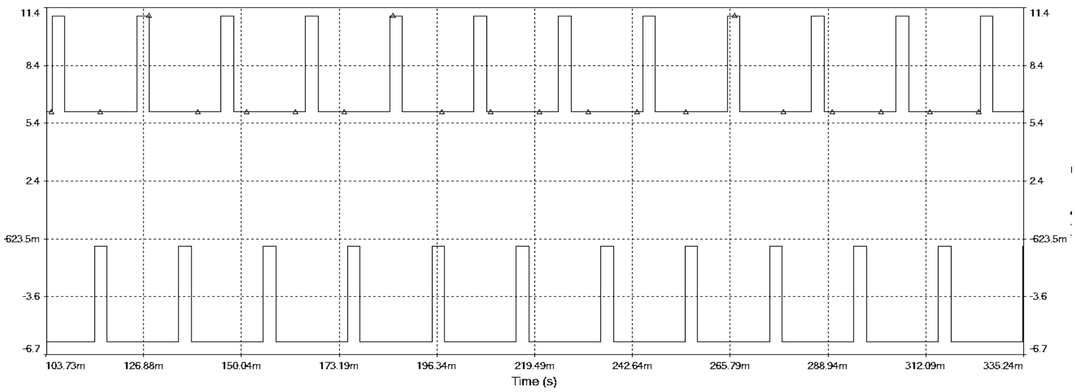

Fig 4: Triggering Pulses for Semi converter

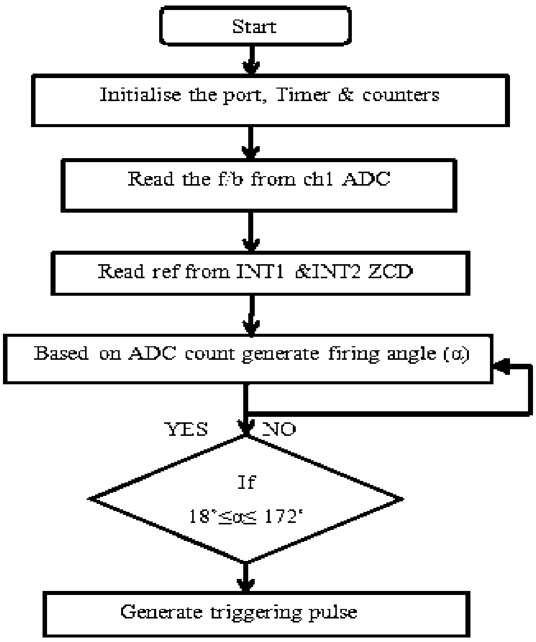

Fig 5: Flow Chart of Triggering Pulse Generation

Table 1 Theoretical and Practical Calculation for RL Load

S.No.	Triggering angle	Conduction period (n)	Total period(p)	V_{dc}	α=n/p*180	PF= cos α
1	18°	0.2	4.8	6.8	9°	0.985
2	40°	1	4.8	51.5	37.5°	0.793
3	55°	1.2	4.8	81.3	45°	0.707
4	60°	1.6	4.8	120.7	60°	0.5
5	80°	2	4.8	201	75°	0.258
6	100°	2.6	4.8	240.3	97.5°	0.130
7	120°	3.1	4.8	269	110°	0.5
8	140°	3.7	4.8	273	140.5°	0.79
9	172°	4.6	4.8	274	170.5°	0.9814

3.10 Generation of Triggering Pulse for Semi Converter

The microcontroller gets interrupted by zero crossing detectors (falling edge of Square wave) and the latest value of ADC output. According to the ADC reference value the triggering pulses are generated. The ADC output value range in between 0 to 5v count which is used to control firing angle 0˚-180˚. Suppose 'p' is latest output value of ADC and 'α' is the firing angle the relationship in between the firing angle and the ADC output is given in equation 1.

$$\alpha = p/0.0277 \quad (1)$$

At firing angle 90˚the following diagram 4 shows the triggering pulses generated by the microcontroller for both MOSFET 1& MOSFET 2.The total time equals to on time plus off time for triggering pulse is 10 msec. Following figure 6 shows the flow chart of triggering pulse generation.

4. Result & Discussion

The hardware and software part of the proposed system is fully tested and demonstrated. For the application purpose RL load i.e. 60 watt bulb with 0.25 HP DC shunt motor. Proposed system is fully operated on firing angle above 8˚ and below 172˚.The output is tested here according to the brightness value of the bulb and speed of motor to its rated value.

The power factor correction automatically starts from firing angle 90˚. The CRO shows a waveform which is varying according to firing angle across the load. The firing angle can be calculated theoretically from the waveform shown by the CRO. For power factor calculation following formula is used.

$$\text{Power factor} = \cos \alpha, \quad (2)$$

Where $\alpha = n/p * 180$

The following table shows the theoretical and practical calculations for the RL load.

Figure 5 shows the Simualtion results of the ac/dc converter with power factor correction circuitry.

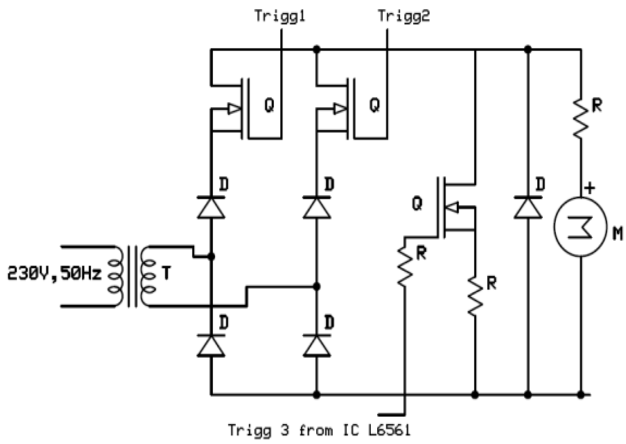

Fig 6 Power circuitry of proposed System

Figure 7 and 8 shows the voltage and current wave form for R and RL load.

4.1 For R load

For R load Power Factor = 98.99%

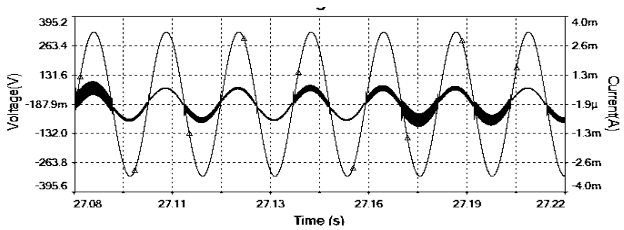

Fig 7: Input Voltage and Current for R Load

4.2 For R-L Load

Power Factor =97.89%

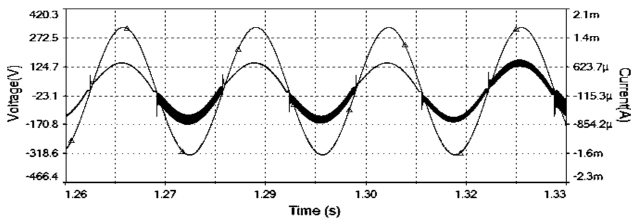

Fig 8: Input Voltages and Current for R-L Load

Following figure 9 shows the hardware circuitry and its setup for R load at 170° firing angle and figure 10 shows the conduction angle of load on CRO.

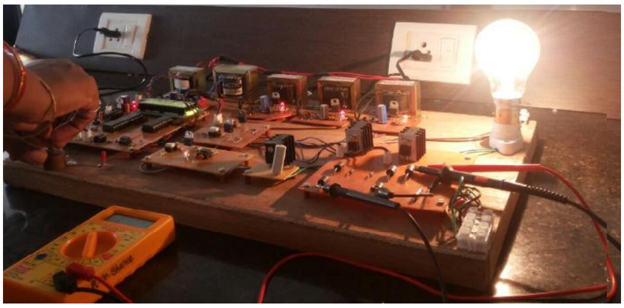

Fig 9: Complete hardware circuitry

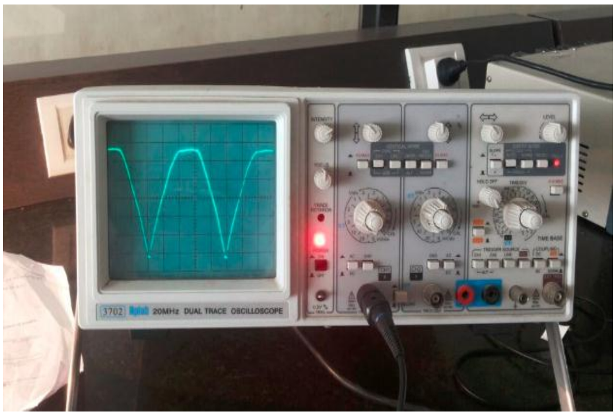

Fig 10: Observation on CRO

5. Relevance of Project

Proposed system can be used in Industry. Proposed system reduces the size and cost required to maintain the power factor value and also this system is useful in home appliances.

Conclusion

The proposed system presents two methods to achieve controlled converter output with power factor correction. Microcontroller operates on firing angle control mechanism to give soft start switching for semi converter so that it improves the performance of the non-linear load. And also increases the life of equipment. IC La 6561based on Borderline current control method used to correct the power factor value so that the system gives controlled output with improved power factor. The system design requires components which are very cheap and easily available & it fulfils all the requirement of power factor correction. This system gives power factor correction up to 0.99.

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