Industrial Power Control by Integral Cycle Switching Without Generating Harmonics

Rutuja B Shinde, Akshay S Chaudhary, Mayuri M Gophan,
Vaibhav S Sonatakke,

Prof. Tamboli K.S. Department of electrical Engineering,
S.B.Patil College of Engineering Indapur

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Abstract - The proposed research seeks to implement integral cycle switching for the regulation of ac power in linear loads such as electric furnace heaters. Integral cycle switching generally involves eliminating the entirety of a cycle or certain cycles from an AC signal. At328 family devices programmed in assembly/C language are used to achieve this, ensuring that the real-time average voltage at the load is proportionately lower than the total signal whenever the signal is applied to the load. For zero-crossing detection, a comparator is employed, and an interrupt is sent from it to the AT 328. Hence, the AT 328 generates triggering pulses and output in accordance with the interrupt that was received.
The integral cycle is therefore accomplished in accordance with the input switches interfaced to the AT 328. Instead of using a motor, a lamp is used to check the output. Yet, the idea of using an Arduino to cycle-switch the voltage waveform may be executed with great precision thanks to a software written in assembly language, resulting in a time- average voltage or current at the load that is proportionately less than the total signal sent to the load. To validate the output, a series motor or lamp can be utilized in place of the linear load that will be employed in the output. When using this method, the input current or voltage waveform may become unbalanced when the cycles are cycled on and off throughout the load. For zero crossing detection in this project, a comparator is used, and the output is delivered as an interrupt to an Arduino processor.

Key Words: discontinuous-phase control, integral-cycle control, speed control, single-phase induction motors.

1. INTRODUCTION

Numerous modern technologies, such leds and DC motors, have trained makers and designers to employ fairly straightforward techniques for the partial transfer of energy on the load (e.g. LED dimming or brushless speed control). When a load is powered by AC rather than DC, it loses some of its conceptual and practical simplicity. Several inductive loads, such as lamps, AC motors, and heating components, exhibit this property. The majority of household electrical items need AC electricity to function. Via the action of some power electronic switches, this AC power or AC is provided to the appliances. Controlling the AC power supplied to the loads is essential for their smooth operation. Controlling the switching behavior of power electronic switches, such as an SCR, is then used to achieve this. We can therefore draw the conclusion that controlling ac power is more complex than controlling DC power. This encouraged us to focus on ac power control with the fewest losses. Only when blended and controlled with a reliable microcontroller is industrial power control via cycle switching an effective method of managing ac power. PWM-based technology aids in reducing losses that were sustained by a large margin.
Ac phase-controlled switching is used to control the speed of single-phase induction motors, although this technique produces a lot of high-order harmonics. The integral cycle control method is an alternative, however it only permits step- by-step changes in output voltage and adds sub-harmonics to the line. To address these issues, a discontinuous phase- controlled switching technique is proposed. The voltage is managed by combining integral-cycle switching and phase control. Fine voltage and step voltage are controlled by the first and second methods, respectively. The proposed controller performs better with rotor fan-type loads when this technique is employed to manage the main winding voltage alone.

2. WHAT IS INTEGRAL CYCLE SWITCHING?

AC voltage regulators and other power electronic equipment use integral cycle switching as a power control strategy. In this method, the AC waveform is sampled on a regular basis, and the control circuit determines the waveform's average value over a predetermined time, or the "integral cycle." The regulator's output voltage is then modified in accordance with the estimated average value of the input waveform.
Integral cycle switching has the benefit of accurate output voltage control without adding harmonics to the AC waveform. This is because only zero-crossing points of the input waveform are switched at since the switching frequency is synced with the AC waveform. The output waveform is consequently free of the harmonic distortion that is typically produced by other power management strategies, such as pulse width modulation (PWM).

3. PROPOSED SYSTEM

The proposed system for industrial power control by means of integral cycle switching without generating harmonics is a power electronics device that provides precise regulation of the output voltage without producing any harmonic distortion in the AC waveform. This system employs the integral cycle control technique to control the output voltage of the device. The system comprises a rectifier, filter, and voltage regulator. The rectifier converts the AC input voltage to DC, which is then filtered to eliminate any ripples in the DC waveform. The filtered DC voltage is subsequently fed to the voltage regulator, which controls the output voltage utilizing the integral cycle switching approach. The voltage regulator uses a control circuit that samples the input waveform at regular intervals and calculates the average value of the waveform over a fixed period. The output voltage of the regulator is adjusted based on the computed average value of the input waveform. The switching of the regulator is synchronized with the input waveform to ensure that the switching only occurs at the zero-crossing points of the waveform. This produces a smooth and undistorted output waveform that is free from any harmonic.

4. CIRCUIT DIAGRAM

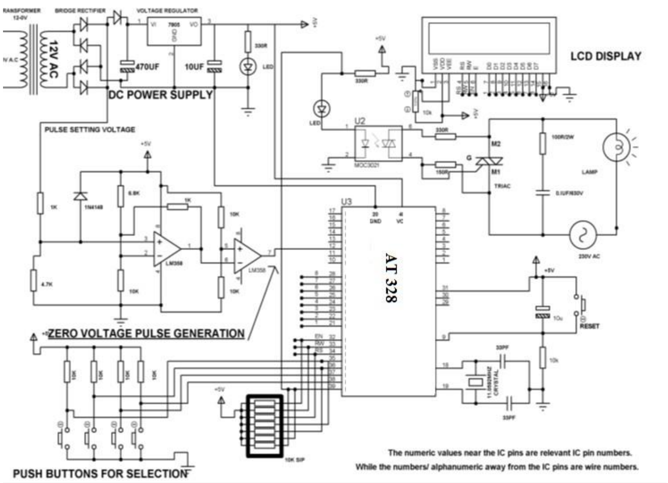


Fig -1: Circuit diagram

5. Block diagram

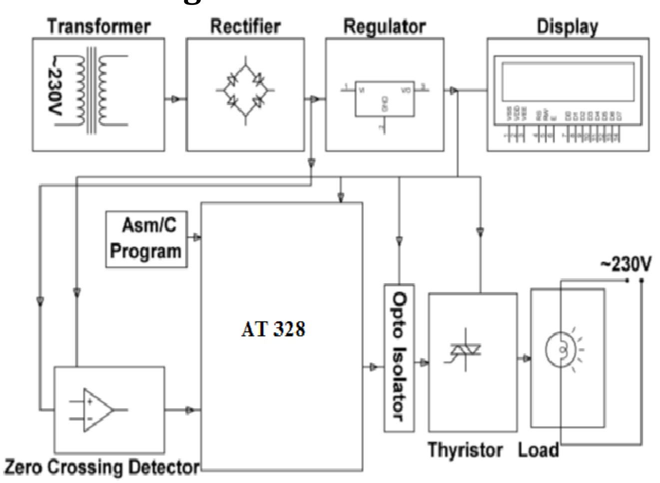


Fig -2: Block diagram

6.PCB ARTWORK

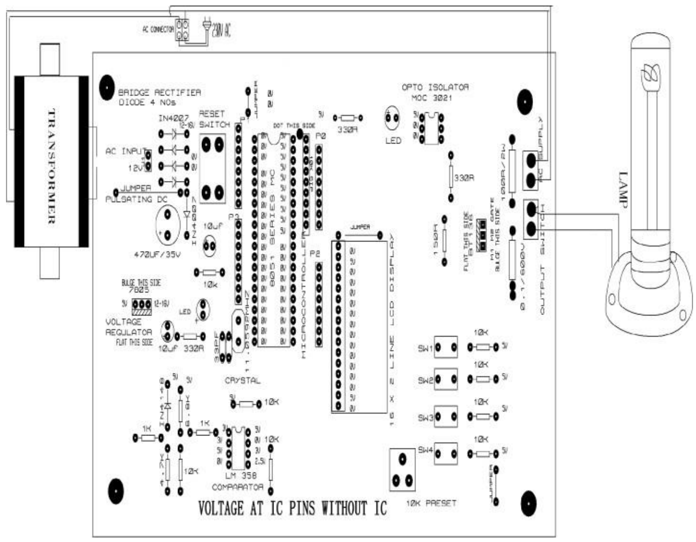


Fig -3: PCB artwork

7. WORKING PRINCIPLE

The project is based on a bridge rectifier circuit that converts the AC signal into a pulsating DC signal. The opto-coupler is connected to the output of the rectifier circuit and conducts only when a voltage is detected. The zero-crossing voltage is detected by the opto-coupler and this signal is sent to the microcontroller. The microcontroller is powered up when the power is high and it triggers the TRIAC with the desired value. The MOC 3021 chip is connected to the TRIAC gate to handle the high voltage from the AC to DC communication device. The opto-coupler fires the gate of the TRIAC according to the angle, and the TRIAC allows the motor to rotate. Four switches are required to read the input values, and four connections are made as shown in the code of the ARDUINO AT328 microcontroller. A resistor is connected for the switch concept to shift from low to high positions. For demonstration purposes, a bulb is connected to the power supply, and the code from the ARDUINO AT328 is uploaded. The switch is turned on, and the operation is performed. A lamp is provided in this project instead of a motor for demonstration purposes. The project output is shown with an AC single-phase motor.

8. RESULT AND DISCUSSION

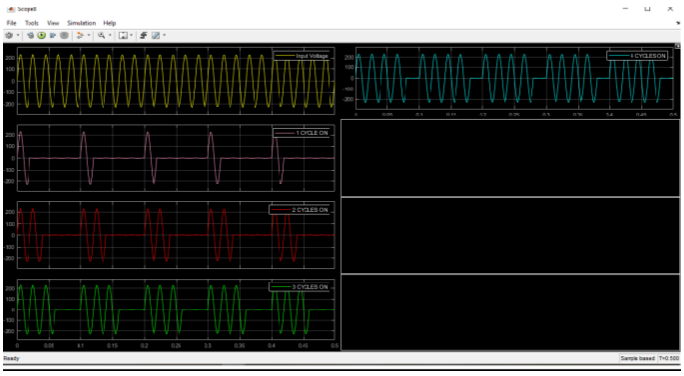


Fig -4: Signal a

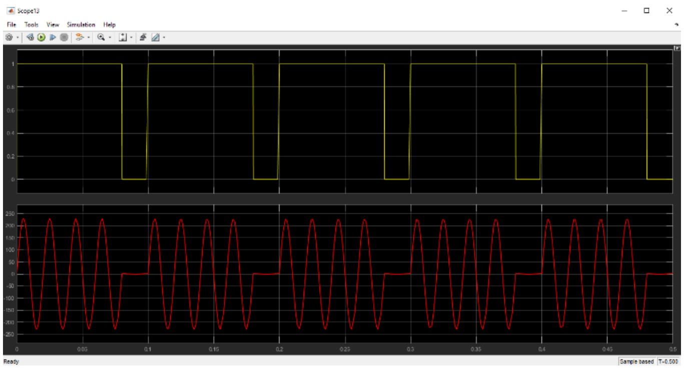
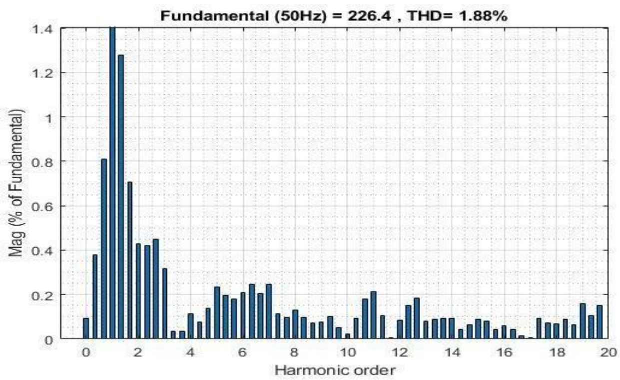


Fig -5: Result b

Chart (Harmonic order vs mag)



The concept behind this project is to improve the lifespan of a lamp by implementing the Zero Voltage Switching (ZVS) technique using a TRIAC. Typically, a lamp draws more current while switched on at peak voltages, resulting in a shorter lifespan. Therefore, the proposed project aims to extend the life of the lamp by switching it precisely at the zero crossing point of the voltage waveform.

The project achieves this by utilizing a TRIAC in such a way that the switched-on time is precisely controlled by firing it only after detecting the zero-cross point of the supply voltage waveform.

It is important to note that the ZVS technique can also be used in other applications where precise control of the switching time is necessary to prevent damage or extend the lifespan of electrical components. The proposed project is a significant improvement over traditional methods of controlling lamps. It utilizes the Zero Voltage Switching (ZVS) technique to ensure that the lamp is switched on and off at the precise moment when there is no voltage across the TRIAC. This minimizes the stress on the lamp and extends its lifespan. One of the advantages of the project is its cost- effectiveness and ease of implementation. The necessary components are widely available and relatively inexpensive, and the code used to control the system can be easily modified to suit different applications.

Furthermore, the project showcases the potential of the ZVS technique for precise and efficient control of electrical components. It has applications in a variety of industries, including lighting, motor control, and power electronics.

9. CONCLUSION

In conclusion, the proposed project demonstrates the effectiveness of using the Zero Voltage Switching (ZVS) technique to control electrical components such as lamps. By switching the lamp on and off precisely at the zero-crossing point of the voltage waveform, the project is able to extend the lifespan of the lamp and improve its efficiency. The project is also cost-effective and easy to implement, making it a viable option for a variety of industries. With potential applications in lighting, motor control, and power electronics, the ZVS technique has great potential to improve the performance and lifespan of a wide range of electrical components. Overall, the success of this project highlights the importance of innovative and efficient control techniques in the field of electrical engineering, and encourages further research and development in this area.

10. FUTURE SCOPE

The proposed project has a significant scope for future research and development. Here are some potential areas of focus for future work:

1. Integration with Iot The project can be extended by integrating it with iot (Internet of Things) technology, which would enable remote monitoring and control of the lamps. This would have a significant impact on energy efficiency and could potentially lead to reduced energy consumption.

2. Application in motor control: The ZVS technique used in this project can also be applied to motor control systems, which would have a positive impact on their efficiency and lifespan.

3. Implementation of feedback control: The project can be further improved by implementing a feedback control system, which would enable real-time monitoring of the lamp and adjust the switching frequency to optimize its performance. This would improve the efficiency and reliability of the system.

4. Use of advanced switching devices: The project can be enhanced by using advanced switching devices such as igbts (Insulated Gate Bipolar Transistors) or mosfets (Metal Oxide Semiconductor Field Effect Transistors) instead of the TRIAC. These devices have a higher switching speed and can operate at higher frequencies, resulting in improved performance and efficiency.

5. Overall, the proposed project has a significant scope for future research and development, and these potential areas of focus can lead to further advancements in the field of electrical engineering.

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