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Industrial Power Control by Integral Cycle Switching Without Generating Harmonics

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Abstract: This project aims to achieve vital cycle switching, a technique that removes complete cycles or fractions of cycles from an AC signal. This technique is used to manage AC power in linear loads, such as heaters in electric ovens. The project uses a comparator for zero crossing detection, fed as an interrupt to a microcontroller of the 8051 family, to generate triggering pulses. These pulses are then driven by opto-isolators to trigger the TRIAC, achieving integral cycle control as per the input switches interfaced to the microcontroller. A series motor or lamp can be used to verify the output, but this may cause an imbalance in the input current or voltage waveform as the cycles are switched on and off across the load. A lamp is provided in the project for demonstration purposes, but the real objective is to verify whether the load switches on at zero cross of the waveform during random switching. The power supply consists of a step-down transformer 230/12V, which steps down the voltage to 12V AC, converts it to DC using a Bridge rectifier, removes ripples using a capacitive filter, and regulates it to +5V using a voltage regulator 7805. The project can be enriched by using a feedback mechanism to automatically maintain the desired output to the load by appropriate cycle stealing. Integral cycle switching is achieved by using a microcontroller of the 8051 family programmed in assembly/C language, ensuring that the actual time-average voltage at the load is proportionately lower than the whole signal. A comparator is used for zero crossing detection, and the microcontroller produces output based on the received interrupt and generates triggering pulses. These pulses drive opto-isolators to trigger the TRIAC, achieving integral cycle control as per the input switches interfaced to the microcontroller.

Keywords: microcontroller, Bridge rectifier, current

I. INTRODUCTION

Ac phase-controlled switching is used for the speed control of single-phase induction motors but it introduces large high-order harmonics. Alternatively, an integral cycle control method is also available but it introduces sub-harmonics in the line and the output voltage is adjustable in steps only. To mitigate these situations, a discontinuous phase-controlled switching technique is proposed. The voltage control is done by a combination of the phase control and the integral-cycle switching. Fine voltage and step voltage are controlled by the former and the latter methods respectively.
Rotor fan-type loads, performance of the proposed controller improves when this technique is applied to control the main winding voltage only. In case of constant-torque loads, conventional voltage controllers including ac regulators offer a very limited speed control range. The strong sub-harmonics of the controlled voltage due to integral-cycle controller are used for such loads. The rotor is forced to lock at any desired sub-synchronous speed. Different types of motors operate smoothly over a wide range for fan-type loads and near various sub- synchronous speeds at aerated conditions for constant- torque loads.

Objectives:

- This project is intended to attain vital cycle switching.
- It is a renowned and aged technique of managing AC power.
- In this project, we are using a comparator for zero crossing detection.
- A lamp is provided in this project in place of a motor for demonstration purpose.

Problem Definition:

The below mentioned hardware and software requirement of the project is useful to construct the circuit. Forgetting integral cycle switching for controlling AC power in linear loads like heaters used in electric furnace.

Scope of Study:

- The world is becoming autonomous. By automating this project, efficiency can be increased.

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- This can be done by using a sensor programmed with the microcontroller. Once the sensor receives the data, the cycle switching automatically takes place. We can make an automatic temperate control using this method.
- Temperature sensor senses the temperature and when the temperature goes beyond the set limit, the intensity will be controlled by using the cycle switching method.

II. LITERATURE REVIEW

After going through the papers published by different authors on the topic of industrial power control by cycle switching, we can conclude that a microcontroller has increased the efficiency of this method by a large margin but still these are losses that are not yet mitigated. Also, all these papers focus on the power control of linear devices and but for nonlinear devices the research is still going on. Losses are greater in case of nonlinear devices which makes them unfit for use in control schemes. But with the advent and advancement of FACTS devices, the control of nonlinear devices will be more easy without encountering losses. The development of FACTS devices like UPQC, DSTATCOM, DVR, have changes the scenario of power system stability and control.

Our project is also based on power control of a linear device, but we have used a nonlinear device to showcase the difference of losses encountered. We also have used high quality Arduino programmer and high quality opto isolators which have eliminated the ripple up to greater extend. This is the reason we do not see any flicker in ac linear bulb. Apart from that we have developed a MATLAB simulation which was also presented by different papers. We have further perfected the design and reduced the THD up to 0.78% only.

III. SYSTEM DESIGN

In this project, when a AC signal is applied to the bridge rectifier circuit, it is converted in to pulsating DC signal. This output is given to the opto-coupler. And whenever voltage is being detected only then the opto-coupler conducts.

Proposed System:

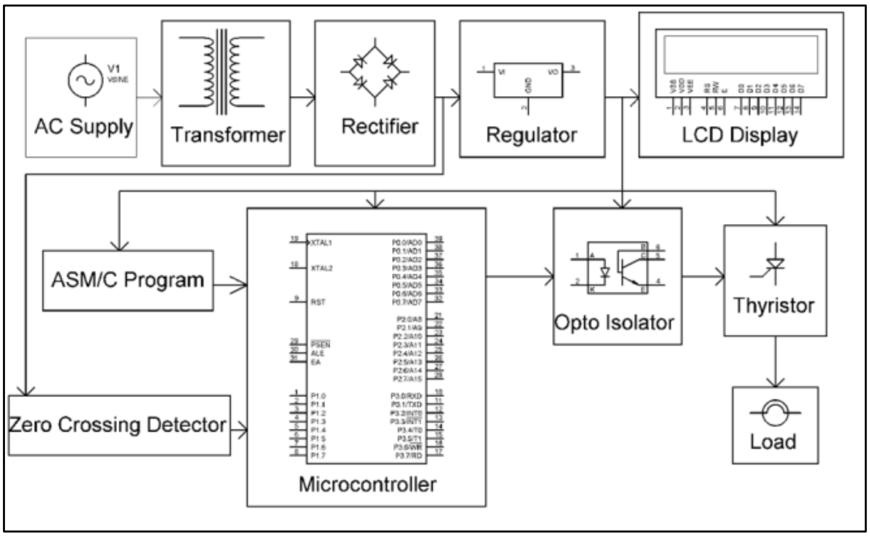

Figure 1: System Design

A. Constructional Details:

Hardware Required

- Transformer
- Voltage Regulator
- Rectifier
- Microcontroller
- LCD
- Zero crossing detectors
- Opto-isolators
- TRIAC
- Capacitive filter

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Software Required:

- Eagle
- Proteus

B. Working:

In this project, when a AC signal is applied to the bridge rectifier circuit, it is converted in to pulsating DC signal. This output is given to the opto-coupler. And whenever voltage is being detected only then the opto-coupler conducts. So, when zero cross over voltage is detected this input is given to the Microcontroller. We power up the chip when the power is high. Now the TRIAC is being triggered with desired value. And MOC 3021 chip is connected to the TRIAC gate because microcontroller cannot directly handle more voltage from AC to DC communication device. So, after the opto-coupler receives the desired value it will fire the gate, according to the angle and the TRIAC will be allowed to rotate the motor. Four switches are required to read the input values and four connections are made as shown in the code of microcontroller. Resistor is connected for switch concept, because it has to shift from low to high positions. The bulb is being connected to the power supply and the code from the ARDUINO is uploaded. Now the switch is being turned ON and the operation is performed. A lamp is provided in this project in place of a motor for demonstration purpose. The project output is shown with an AC single phase motor.

Hardware Description:

- Voltage Transformer:

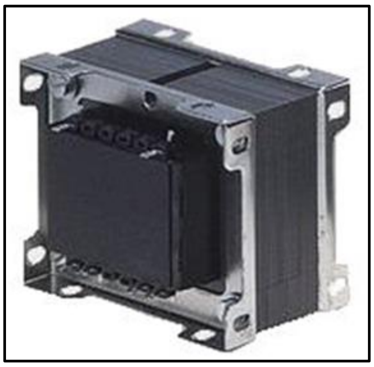

Figure 2: Voltage Transformer

One of the main reasons that we use alternating AC voltages and currents in our homes and workplace's is that AC supplies can be easily generated at a convenient voltage, transformed (hence the name transformer) into much higher voltages and then distributed. The reason for transforming the voltage to a much higher level is that higher distribution voltages implies lower currents for the same power and therefore lower I2R losses along the networked grid of cables. These higher AC transmission voltages and currents can then be reduced to a much lower, safer and usable voltage level where it can be used to supply electrical equipment in our homes and workplaces, and all this is possible thanks to the basic.

- Single Phase Voltage Transformer:

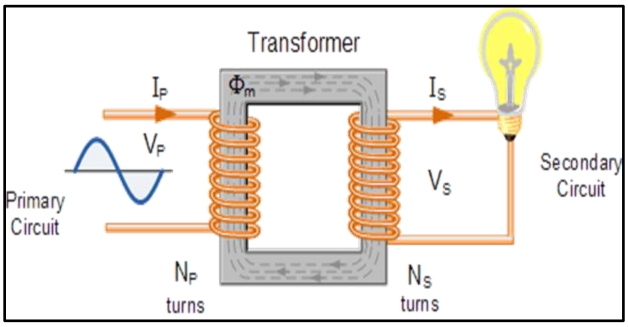

Figure 3: Single Phase Votg. Transformer

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In other words, for a transformer there is no direct electrical connection between the two coil windings, thereby giving it the name also of an Isolation Transformer. Generally, the primary winding of a transformer is connected to the input voltage supply and converts or transforms the electrical power into a magnetic field. While the job of the secondary winding is to convert this alternating magnetic field into electrical power producing the required output

- Bridge Rectifier:

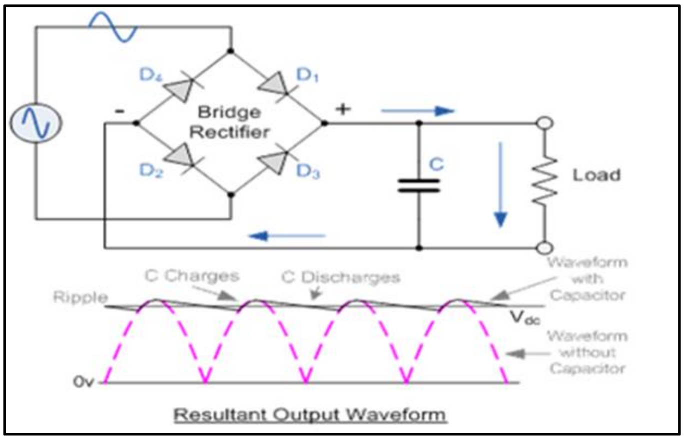

Figure 4: Bridge Rectifier

A Bridge rectifier is an Alternating Current (AC) to Direct Current (DC) converter that rectifies mains AC input to DC output. Bridge Rectifiers are widely used in power supplies that provide necessary DC voltage for the electronic components or devices. They can be constructed with four or more diodes or any other controlled solid state switches. Depending on the load current requirements, a proper bridge rectifier is selected. Components' ratings and specifications, breakdown voltage, temperature ranges, transient current rating, forward current rating, mounting requirements and other considerations are taken into account while selecting a rectifier power supply for an appropriate electronic circuit's application.

- Microcontroller IC: (89C51) :

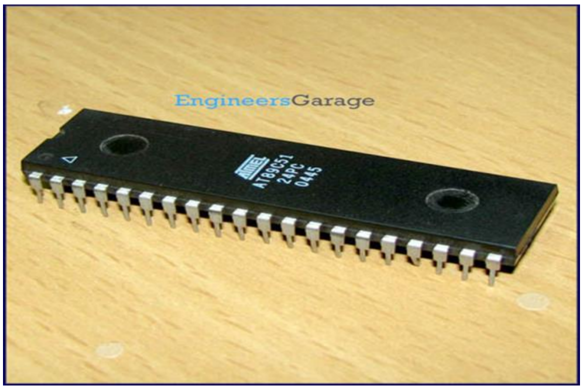

Figure 5: Microcontroller

The AT89C51 is a low-power, high-performance CMOS 8-bit microcomputer with 4 Kbytes of Flash Programmable and Erasable Read Only Memory (PEROM). The device is manufactured using Atmel's high density nonvolatile memory technology and is compatible with the industry standard MCS-51 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C51 is a powerful microcomputer which provides a highly flexible and cost effective solution to many embedded control applications.

The AT89C51 provides the following standard features: 4 Kbytes of Flash, 128 bytes of RAM, 32 I/O lines, two 16-bit timer/counters, five vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator and clock circuitry. In addition, the AT89C51 is designed with static logic for operation down to zero frequency and supports two

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software selectable power saving modes. The idle mode stops the CPU while allowing the RAM, timers/counters, serial port and interrupt system to continue functioning. The power down mode saves the RAM contents but freezes the oscillator disabling all other functions until the next hardware reset.

PIN DAIGRAM:

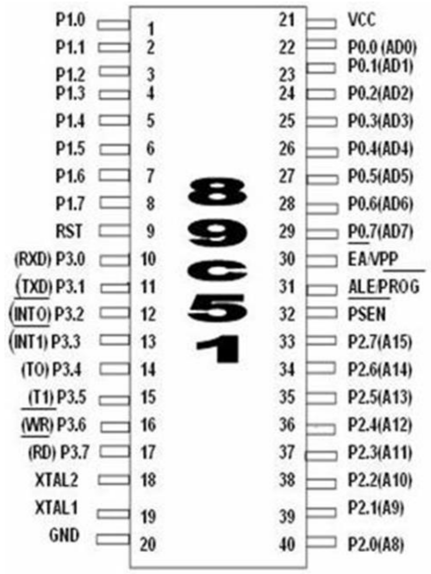

Figure 6: Pin Diagram

LCD Display:

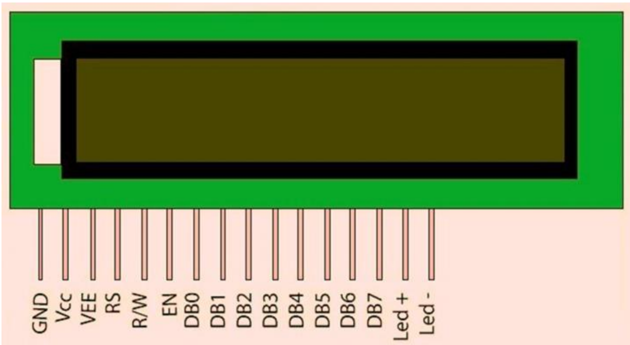

Figure 7: LCD Display

Advantages:

- It reduces harmonics.
- It is more efficient than convention firing angle modulation method.
- Load operates safely.
- This method is easy and less costly.

Disadvantages:

Power can be delivered with percentages 20% 60% 80% and 100% in between power delivering required modification on the circuit.

Application:

- This method is used in industry for controlling power.
- This method is also used in house such as fan, motor, water pumping etc.
- It is used to control the power in linear loads.
- Where we have to control the speed, intensity and power then this method is applicable.

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IV. RESULT AND DISCUSSION

In this Project, voltage is controlled through integral cycle switching, and controlling AC power is used. Less AC power losses. So better in this system. The two main management ways of AC voltage management accustomed control the output voltage is mentioned during this paper. In Integral cycle management (ICC) even though the Doctor of Theology is a smaller amount big selection of voltage management isn't possible wherever as in point in time management swish voltage variation are often achieved however Doctor of Theology is high. So to eliminate higher than drawbacks the integral change cycle control(ICC) technique is often employed in that by setting duty cycle constant and ranging firing angle will cause get each swish voltage variation and reduced Doctor of Theology. For a similar power output, a hundred and twenty-fifth reductions in THD are discovered. The change of the switches has been done at zero voltage and current thus voltage stresses are reduced. This paper additionally discusses the simulation study of AC voltage management control strategy exploitation LT SPICE. It is concluded that ICC is a lot of economical than PCS in terms of proportion THD.

V. FUTURE SCOPE

So many techniques square measure used for the ability management in the system however this techniques square measure used as a result of during these techniques harmonics absent. It's used in the washer, compressors. In future Scope, the commercial masses thought of within the gift work square measure variable incessantly with relevancy time thence the planning of potency. In the future we will develop voltage is controlled through integral cycle switch and dominant ac power is employed. Through integral cycle sign, we tend to get pure undulation therefore it reduces harmonics and up power issue. It's low price and simple to control, less Ac power losses.

VI. CONCLUSION

We can control the power by using integral cycle switching. We understand how to remove cycle from main input. We get output without any distortion. This model also reduces the harmonic content while controlling the power and since we are providing zero cross switching so the probability of sparking is also reduced. The setup can also be used to control the speed of induction motor or fan.

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