**BACHELOR OF SCIENCE IN ELECTRONIC AND TELECOMMUNICATION ENGINEERING**

# Design and Implementation of Cycle Switching By Controlling TRIAC for Industrial Load


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# Certificate Of Approval

A project entitled "DESIGN AND IMPLEMENTATION OF CYCLE SWITCHING BY CONTROLLING TRIAC FOR INDUSTRIAL LOAD" is presented by Robiul Hossain, Md Kaies, Oli Ahammad Bhuiyan bearing Matric ID. T171035, T-171040, T-171019 session of Spring 2020, to the Department of Electronic and Telecommunications Engineering (ETE), International Islamic University Chittagong (IIUC). In partial fulfillment of the degree of Bachelor of Science in Engineering criteria, it was approved as satisfactory and accepted for the review conducted on October 2021.

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# Declaration

It is thus stated that we have completed this project and that no part of it has been submitted elsewhere to grant a degree or certificate in any other institution.

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# Abstract

The project aims to implement integral cycle switching, which is a method that erases the cycles in AC signals. Controlling AC electricity is essential. Many AC systems use phase angle control to provide control, generating additional harmonics in the system. For example, heaters are commonly found in linear loads such as furnaces. This approach uses a mechanism to make up for less distortion in load. But utilizing a microcontroller, integral cycle control is achievable in Programmed C. The load's voltage is lower than what the total voltage would indicate since it has an additional applied load. When a linear load isn't available, an alternative source of linear movement might be used to validate the output. With each turn-on and turn-off cycle, this system produces a random voltage or current. To help with zero-crossing detection, we've implemented a comparator attached to the Arduino UNO, which sets off an interrupt when it receives zero input. The microcontroller uses the interrupt to transmit the output to generate the timing signal (trigger) that acts as a reference. To assist with zero-crossing detection, we installed a comparator to the Arduino UNO, which will signal when it has received zero input and cause an interrupt. When giving a timing signal (trigger), the microcontroller transmits the output through an interrupt to produce the reference. Input signals turn on optocoupler via exploiting input switch settings on microcontrollers, including cycles. A lamp or a motor has been chosen for the machine to be exhibited. For the success of this project, a feedback system is critical.

# Table of Contents

# List of Figures

# List of Tables

# List of Abbreviation

| | |
|---|---|
| AC | Alternating  Current |
| BIT | Binary Digit |
| CCD: | Charged Coupled Device |
| DC | Direct Current |
| LED | Light Emitting Diode |
| LCD | Liquid Crystal Display |
| LDR | Light Dependent Resistor |
| LED | Light Emitting Diode |
| IIC | Integral Cycle Control |
| PCS | Phase Controlled Switching |
| PDIP | Plastic Dual Inline Package |
| PWM | Pulse Width Modulation |
| RFI | Radio Frequency Interference |
| USB | Universal Serial Bus |
| VDD | Voltage Drain Drain |
| SMPS | Switching mode power Supplies |
| TRIAC | Triode For Alternating Current |
| ZCD | Zero Crossing Detector |
| SSR | Solid State Relay |
| TTL | Transistor -Transistor Logic |

# Chapter 1
# Introduction

## 1.1 Introduction

To reduce the amount of energy wasted, organizations can install power controllers to take advantage of new and efficient power management strategies, including developing a tailored power profile [1]. Voltage controllers transform a steady, alternating ac voltage into a changeable alternating voltage by bypassing the changes in frequency, all without using any moving parts [2]. The Phase Controlled Switching (PCS) direct conversion technology is frequently used in the [1] for adjustable conversion from ac to ac and ac to dc. A significant inrush of inrush current is generated when heat controllers that regulate resistive loads (R) are powered up from a cold state because the control circuits generate additional harmonics and Radio Frequency Interference (RFI). To increase signal strength, large, expensive line filters are required [3]. These filters are hefty. Integral cycle control is a direct conversion technique that integrates cycle control into the whole conversion process. On-off control, often known as zero switching or cycle selection, can be described as one of these options. Several seconds is needed for the mechanical time constant or thermal time regular in situations where it is used. No noticeable temperature changes occur if the load is connected to the source but is turned off during alternating cycles. It operates by applying a load to the connected supply and then cycling the power supply on and off an integral number of times, followed by the load applying power to the connected supply for a different number of cycles. It is repeated in a constant cycle. The duty cycle is for altering the output power. It is like an on-off control, which operates on zero voltage and zero current switching thyristor, although similar to thermostatic switches [4]. Phase controlled AC voltage controller: The phase-controlled AC voltage controller comprises two parallel inverse thyristors. The regulator may be built with a single TRIAC and a single gate input signal for low power applications; however, thyristors are utilized for high power applications. Inexpensive phase-controlled-based regulators [5] are available. Thyristors T1 and T2 regulate the output voltage using the phase control approach. When the firing angle is altered, the output voltage's RMS value changes. It is possible to use unidirectional or bidirectional AC voltage controllers for single-phase and three-phase systems. Thyristor line commutation eliminates the need for additional commutation circuitry when using an

AC input source. Low-cost and straightforward circuits are also available for AC voltage regulators.

A unidirectional AC voltage controller has one thyristor and one diode anti-parallel to the power source and the load. To regulate the load voltage, adjust the firing angle of the thyristor. The reason it's a half-wave controller is that one thyristor can only regulate half of the input signal's cycle; the other half stays at the controller's output.

A bidirectional AC voltage controller has two thyristors anti-parallel to each other between the supply and the load. The load voltage may be adjusted by varying the thyristor firing angles. A thyristor gate current is varied to provide positive and negative input signal cycles, making it a full-wave controller.

Integrated DCDC converters are a critical component in power management. They control the output voltage quickly based on changes in external parameters and are easily adjusted to suit various external components [1]. Such needs arouse considerable interest in the deployment of DCDC converters on a digital basis. Analog designs provide substantial benefits over digital control for power dc-dc converters [2]. It presents easy-to-learn approaches for mastering more complex controls. The same hardware design may be used with a different output power by simply altering the register configuration values. In integrated circuit design, digital flow's automated tools and well-structured high-level verification methods enable rapid development. Circuits may be tested on an FPGA board without the need for a separate test chip for digital circuits. Digital control mode converters, on the other hand, have drawbacks. The digital pulse width modulator (DPWM), which determines duty cycle duration and directly affects the static properties, is one of the most prevalent sources of problems. The limit-cycle oscillation effect can't be avoided without using a PWM with high resolution [6]. This problem was addressed using a variety of architectural designs. A tapped string of delay cells commonly referred to as delay lines are used in most proposals to achieve high-resolution time quantization [7]. This type of circuit uses linear propagation, which is dependent on several time delays. When the duty cycle is set to n bits, the multiplexer determines the delay. The disadvantage of this strategy is the need for a multiplexer and many individually controlled delay cells. Using a mix of counter and delay line methods, a different solution may be found. A duty cycle digital word is used to regulate counter and delay-based components correspondingly in such systems. You have a choice of using analog buffers or digital cells to build the delay-line in this sort of design. The fundamental drawback of analog buffers is their inability to maintain design stability under varying process, voltage, and temperature conditions. Using DPWM based on second-order sigma-delta [8] is one method for removing the output voltage's limit-cycle oscillation effect. Due to the requirement for separate computing units, this design can impose some additional total loop latency and degrade the dc-dc converter's output dynamics. Therefore, increasing the firing angle increases overall harmonic distortions. As a result, the lower the firing angle, the better the power system performs since it has less THD. Since the converter generates nonlinearities and distortions, they directly impact the input system, degrading its overall performance. For this reason, many businesses supply converters with their supplies so that no other loads are disrupted. Furthermore, only odd harmonics were present in the settings of the bidirectional AC voltage controller since half-wave symmetry was respected there as well. Half-wave balance was not discovered in the case of unidirectional waves, and the findings showed both even and odd harmonics. When used in motor applications, harmonics may wreak havoc because of the potential for noise. As a result, electrical drives, AC motors, and power systems benefit from a bidirectional AC voltage controller. However, a unidirectional AC voltage controller is used for welding, heating, and melting applications. With the Phase Control technique, the firing angle of the thyristor is used to regulate the phase connection between starting load current and the input supply voltage. For a certain number of integral cycles, the AC input supply is turned ON; then, it is turned OFF for another number of integral cycles. Most often, integral cycle control is employed when the mechanical or thermal time constants are rather large. Many speed control drives have mechanical time constants or thermal time constants that are relatively large, for example, heating loads. Using this method, there will be essentially little change in speed or temperature since the load is connected to the source only during certain on-cycles and then disconnected during certain off-cycles. Controlling power is done by comprehensive cycle control. Instead of using a preset voltage to drive the load, an alternate-current voltage controller or regulator utilizes the load's actual RMS voltage to drive it. An induction motor speed controller, an ac power magnetic controller, and on-load transformer tap change may all be done with the same device since the output frequency is identical to the input frequency.

Additionally, it is employed in the management of reactive power. Using an AC switch is the most straightforward technique to regulate the AC voltage going to a load. An antiparallel pair of TRIACS or SCRs will be used as this switch's bidirectional counterpart. The usage of bidirectional switches is not limited to thyristors. The effect of the control is independent of the switch utilized for the majority of functions. When using TRIACS for very high power applications, the practical constraints of the currently available TRIAC ratings typically necessitate the use of SCRs instead [5]. The load can be controlled using either power integral cycle control or power integral cycle control, both of which only alter the voltage level of the signal, not the frequency, of the waveform they produce. Using the first approach is more suited to systems that have a large time constant, such as temperature control systems. It is possible to connect the load power to the source and run it for several full cycles before removing the source and running the load again. The relative duty cycle duration d is changed to fulfil a certain aim regarding the average power provided to the load during on and off periods. Ideal conditions call for a range of 0 to 100% control over the average power delivered to the load Loads with a short time constant do not require integral cycle control. It's possible to employ phase control in these circumstances. The load is linked to the supply for n cycles and then detached from the supply for "m" cycles of the integral cycle in phase control. To change the voltage delivered to the load, adjust the firing angle halfway through a period. In this case, the output voltage is set to its highest possible value (=0). Whenever = is used, the output voltage is reduced to its smallest value. Because of this, the output voltage may be set anywhere between zero and the voltage from which it came. This method generates a phase-controlled alternating output that's ideal for things like lightning and motor speed control. The project's goal is integral cycle switching, which is a technique for removing the entire cycle, or cycles, or segments of an AC signal cycle. For linear loads like electric furnace heaters, it is a tried-and-true way of managing AC power. As long as you use an assembly or C program, you may get the same results as you would with a microcontroller. As a result, the time-average voltage at the load is less than half of the total signal delivered. It is possible to test the output with a series motor or light instead of a linear load. As the cycles are turned on and off throughout the load, one side consequence of using this approach is an imbalance in the input current or voltage waveform. An interrupt is generated by an microcontroller when a comparator register crosses zero. Here, the microcontroller generates triggering pulses based on the interrupt is received. Through the use of these pulses, the optoisolators are driven to trigger the TRIAC, allowing us to control the integral cycle using the microcontroller's input switches alone. Instead of using a motor to demonstrate the concept, a light is included in this project. Additionally, a feedback system may be included in this project to automatically maintain the desired output to the load by proper cycle stealing.

## 1.2 Objectives of the Study

An ac load can be controlled using integral cycle control (ICC), which allows a few full cycles of power to flow to the load before turning the power off. This is done cyclically. By adjusting the duty cycle, the output power may be adjusted to suit the situation. An integral number of cycles is passed here instead of a discrete number of times like with thermostatic switches. ICC is also known as On-Off control, Burst firing, Zero Voltage Switching (ZVS), Cycle Selection, and Cycle Syncopation in the scientific literature. Exponentially increasing from a low during the Nth cycle till the Nth cycle ends, speed or temperature grows exponentially when electricity is turned on. Assume N is the number of complete cycles that have been completed for every M cycle of the source voltage. According to this theory, the duty cycle is D=N/M. The disturbance is defined as an increase or decrease in one temperature over another. The AC voltage controller is a power electronic circuit that converts fixed ac to variable ac while keeping the frequency constant. SCR switches serve as switches in the converter circuit, which supplies varying ac to the load. The converter circuitry.

AC magnet controls, industrial heating and lighting, on-load tap changing transformers, soft starting induction motors, and speed control of induction motors are just some of the things you can do with them. The most typical power electronic circuit regulating ac voltage includes two anti-parallel SCRs linked between the source and the load as a voltage regulator. It all comes down to the gate pulse supplied to the SCRs when designing the control strategy. It is possible to convert AC to AC in two ways: directly and indirectly. It's also an indirect AC-DC converter since it uses a DC-link (also known as a DC bus) as an intermediary step. Direct conversion involves converting the ac input waveforms straight into the desired output waveforms without any intermediate processing. As an example of a straightforward conversion technique, consider phase-controlled switching (PCS). There are several applications where PCS may convert power between different voltages and currents, such as AC to AC and DC to DC. While switching from cold, phase control circuits in heat controllers for resistive loads (R) induce higher-order harmonics, radio frequency interference (RFI), and large inrush currents. To decrease RFI at high power levels, significant and costly line filters are required [2]. RMS output voltage (V o) and power factor (PF) are provided by [3] for PCS devices. Figure 1 (a) depicts the phase control circuit's switching configuration.

An ac load can be controlled using integral cycle control (ICC), which allows a few full cycles of power to flow to the load before turning the power off. This is done cyclically. By adjusting the duty cycle, the output power may be adjusted to suit the situation. Essentially, it's an on-off switch but with an integral cycle number instead of a discrete value. ICC is also known as On-Off control, Burst firing, Zero Voltage Switching (ZVS), Cycle Selection, and Cycle Syncopation [4]. The integral cycle controller output voltage waveform is shown in Fig. 3. Exponentially increasing from a low during the Nth cycle till the Nth cycle ends, speed or temperature grows exponentially when electricity is turned on. It is stated to have a duty cycle of = N / (N + M), where N is the number of complete cycles per M cycles of the source voltage that has passed.

The disturbance is defined as an increase or decrease in one temperature over another. It's modelled after an AC voltage or current source connected to a load by a network of switches, and it works the same way. There are no on-state losses and no restrictions on the voltage or current that a switch or diode can carry. The analysis and criteria for evaluating the converter's performance are simplified. There are four types of steady-state converter performance measures: voltage transfer ratio (VTR), current reflection ratio (CRR), harmonic profile, and component stresses. Forward Voltage Transfer Ratio: The forward voltage transfer ratio is the RMS voltage output voltage ratio to the RMS input voltage. A Solid State Power Controller (SSPC) is used in the class of ac power controllers to connect and detach the load from the supply based on the amount of power required. Phase Control Switching (PCS) and Integral Cycle Control (ICC) are two fundamental voltage control techniques often used in ac power controllers for controlling heating power (ICC). PCS can create higher-order harmonics and large inrush current when switched on in a cold start with resistive load. The design of a feedback-controlled digital circuit for ICC power measurement in R-L loads is discussed.

Among the circuit's most notable features are its ability to quickly and automatically alter PSD firing angle to minimize the RL load's undesired DC component. In addition, the circuit's first conduction is begun with a firing angle of = 90°, resulting in suppressed conduction burst early peaks. After that, the feedback takes over to make the firing angle equal to the power factor angle, causing conduction to start at zero volts in each outbreak. Motor loads with rapidly changing power factors will benefit significantly from the auto-dc offset removal approach described here. The circuit is simple, low-cost, and easy to put together with readily accessible commercial components. With the new approach, the drawback of using phase-controlled is eliminated. This study presents simulated findings, design approach, and implementation of the ICC technique for R-L load welding.

In AC power distribution networks, harmonics are generated due to distortions in conventional current waveforms caused by nonlinear loads. Computers, laser printers, copiers, fax machines, battery chargers and UPSs are examples of nonlinear loads. Switch-mode power supplies are also nonlinear. [5]. This device generates harmonics by pulsing the current rapidly. Preferentially, the brief pulses cause current waveforms to be distorted, which then causes current to flow back into the system. Harmonic currents in non-sinusoidal currents generate voltage distortion, impacting the distribution system's equipment and associated loads. To regulate the power from AC circuits more easily, users generally use phase angle control. However, this results in poor levels of harmonics. This approach has resulted in a regulation technique utilizing integral cycle switching, which will lead to fewer harmonics [6].

## 1.3 Motivation

By utilizing power controllers, which are devices for controlling the load's power, it is possible to achieve higher efficiencies, precise power consumption, and preservation. The disadvantage of AC Voltage Control in the On – Off-Cycle Control method is that the control is not continuous. On the other hand, this problem is solved in the Integral Cycle

Switching Method. In Comparison with the Phase angle control method, the Integral-Cycle control method reduces the electromagnetic interference can processes all the advantages of zero-voltage switching techniques. Typical regulators cannot control accurately, while the Integral Cycle Switching Method can control accurately at any portion of the cycle at any time. The Integral Cycle Switching Method can prevent devices from damaging due to sudden overheat production if it occurs in the application of Induction Heating & Domestic Heating. As well as the distribution system equipment, this distortion may impact loads linked to it. We came up with a solution to the harmonics issue. These are the essential aspects that researchers found while looking at this issue.

## 1.4 Objective

1. This project's primary aim was to establish an integral cycle switching control which can control accurately at any portion of the cycle at any time.
2. To build a system Using C programming that can find zero crossing pulses.
3. To control the speed of an induction motor using cycle switching.
4. To establish a control system that controls AC output by increasing the firing angles of the thyristor and allowing the push of a button to set different levels.

## 1.5 Thesis Outline

Chapter 1: Includes introduction, motivation and thesis outline.

Chapter 2: Outlines the previous works done in the field of air pollution.

Chapter 3: Describes the methodology of the proposed model including the specific components and their description.

Chapter 4: Describes result and discussion.

Chapter 5: Concludes the paper stating the challenges were found and the future work of the project.

# Chapter 2
# Literature Review

## 2.1 Paper Review

[1] Wadah EEB, Huang Shen C, Albert FYC, “Simulation and Experimental Validation of AC to AC Converter Waveform and Power Consumption using the Integral Cycle PWM Technique", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE), vol. 4, issue 8, August 2015.

The PWM AC to AC converter waveform and power consumption were successfully simulated and confirmed by experiment. There is a strong correlation between the generated waveforms and the experimental waveform. BJT transistor and Optocoupler gate drives were employed. It was found that when BJT was utilized, the experimental waveform differed significantly from the simulated one. Using an Optocoupler solved this issue. Highest power and the smallest discrepancy between simulation and experiment among different switching frequencies: 100 Hz Tiva C Launchpad and Code Composer Studio (CCS) tools were used to produce the integral cycle PWM for the application. In comparison to other topologies, this one has the lowest THD and the highest power factor in terms of efficiency.

Increasing efficiency, producing particular power usage, and implementing conservation by employing power controllers is possible. Engineers in the past employed transformer tap altering and resistive control to regulate the power. AC waveform modification is a tremendous benefit for controllers. However, this is not a universally accepted method for controlling power flow. DC to DC converters, DC to AC converters, AC to DC converters, and AC to AC converters are all forms of power controllers or power converters. The AC to AC converter is the cheapest of the power converters in terms of the overall cost. If you have an AC supply, you may use either an integral cycle or a phase angle to obtain a variable output voltage. Dimming, heating, and induction motor speed control are the sole uses for this technology because of the waveform distortion at low cyclic pulse rates or large delay angles.

[2] Ajeigbe, O., Munda, J., & Hamam, Y. (2018). ’’Characterisation of Voltage Distortions Produced by Small Domestic Back-Up Generators’’. 2018 IEEE PES/IAS PowerAfrica.

Recently, there has been a growing focus on the quality of electricity being provided to companies, commercial facilities and residential properties. This is owing to the increased use of harmonic-creating non-linear loads such as adjustable-speed drives, switching mode power supply, arc furnaces, electronic fluorescent bulb ballasts, etc. Defining power quality as the process of powering and grounding electronic equipment in such a way as to preserve the integrity of the power delivered to the system is a broad definition. In the IEEE 1159 standard, power quality is defined as: The notion of powering and grounding sensitive equipment in a way appropriate for the functioning of that equipment. The IEEE 100 Authoritative Dictionary of IEEE Standard Terms defines power quality as, p. 855): The notion of powering and grounding electronic equipment in a way that is suitable to the functioning of that equipment and compatible with the premise wiring system and other connected equipment. Even if the high power quality is not easy to define, what is acceptable for a refrigerator motor can fall short of what is sufficient for a computer or other sensitive load. Small (less than 5%) changes in the r.m.s line voltage are the result of voltage fluctuations. For example, cyclo converters and other devices that draw current in a non-synchronized manner might create these fluctuations. A phenomenon is known as "flicker" can be observed by the end-user as a result of such oscillations in illumination intensity. Voltage/current distortion can be quantified in either the time or frequency domain. Distorted waveform values are compared to their reference sinusoidal counterparts to determine variances in time. This approach of describing differences is rarely utilized since it is difficult to measure them. The frequency-domain description of distortion is widely recognized.

[3] Zbigniew Hanzelka Andrzej Bien "Power Quality Application Guide " AGH University of Science and Technology (www.lpqi.com) July 2004.

Much further research is being performed about power systems and possible treatment methods. These are primarily due to increased power system instability, nonlinear loads, and power device improvements. It is essential to employ inductive load modeling in the design phase to prevent unwanted issues like voltage dips, surges, and outages. Voltage controllers regulate power. Voltage regulators may trace their heritage over the last two hundred years to the construction of the first electric battery by Alessandro Volta (Italy) in 1800, which sparked more than a century of innovation and invention during which the finest computerized systems of today have emerged. At first, DC converters were utilized to regulate voltage. Still, when electricity usage expanded and transmission distances expanded, DC voltage control became an expensive and ineffective undertaking, causing AC to be adapted. Transformers were utilized to adjust the high voltage levels to what was needed. Engineer management of electricity is generally done through transformers that tap into different electrical currents and resistive control.

[4] M. Narayanan, R. Vidhya, Implementation of integral switching cycle control using pic 16F877A, International Journal of Research in Electrical Engineering (IJREE) Volume 3, Issue 04 2016, print ISSN: 2349-2503.

It is only through the introduction of simple items to use that customers will be able to meet their needs. In order to meet these demands, businesses are compelled to keep up with the latest technological advancements. Using variable ac or dc injection, we may increase the efficiency of the loads while also reducing their overall power consumption. As a result, the first consideration should be the availability of the energy input in the desired form. It is common practice to run applications at varying voltages and frequencies in order to meet varying load requirements and save energy. All of these criteria necessitate the study of electrical circuits that execute the necessary conversion and control operations. Since the introduction of power electronic equipment, it has been easier and more dependable to perform energy conversions. The conversion of energy from one form to another, such as AC to DC, AC to AC, DC to DC, and DC to AC, can be accomplished without the need for spinning machines. This reduces costs, losses, and maintenance issues and thereby enhances the system's efficiency. Variable air conditioning (VAC) is needed in several household and commercial applications. By changing the voltage supplied to the ceiling fan, for example, the fan's speed may be altered. AC voltage controllers are electrical circuits that change a constant ac supply voltage and frequency to a variable ac supply voltage and frequency. It is possible to change the RMS voltage output from the converter circuit by adjusting the timing of the SCRs.

An output voltage can be controlled using any of these methods. Choosing the best may be done by considering the application and the proportion of Total Harmonic Distortion that is present (THD). Any converter circuit has to be verified before it is implemented in the physical world. Costs, labor, and overall time are all reduced as a result of this. Using simulation software, the same model or architecture may be evaluated with real-time hardware ratings and device specs, resulting in the same results. MATLAB and PROTEUS are two examples of software that may be used to test power electronic converter circuits. Through their use in the actual world, these software show to be invaluable. Various AC voltage controller control mechanisms are presented in this study in order to manage the output voltage. In ON-OFF cycle control, even though the percent THD is lower, a broad range of voltage control is not achievable, whereas in phase angle control, smooth voltage fluctuation can be obtained, but the percent THD is large. Integral Switching cycle control (ISCC) may be used to smooth voltage variations by setting duty cycle constant and adjusting firing angle, thereby eliminating the aforementioned two problems.

[5] Bhagyashri S. Patil1, Prof. V.S.Pawar, "A Review on Conditioning and Monitoring of NonLinear Load Electrical Load in the View of Power Quality", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE), vol. 5, issue 4, April 2016.

To transfer power between various devices, various power controllers can convert different power sources into multiple configurations. These power controllers can be classified into four categories: power converters that transform DC to DC, DC to AC, AC to DC, and AC to AC. The lowest-cost power converter is the AC to AC converter. Nonetheless, power controllers are a significant benefit since they can regulate the power flow by editing the AC waveform. The variable output voltage is produced when utilizing AC input with either integral cycle or phase angle.

There is a great deal of cutting-edge study being done on the subject of power quality and solutions. Each of these factors has a part in the overall problem. Dynamic loads can cause voltage or current variations, such as voltage dips and fluctuation periods, interruptions, and oscillatory transients, resulting in power quality issues. Managing electricity requires voltage controllers. Voltage regulators have been around for over two centuries, starting with Alessandro Volta's invention of the first electric battery in 1800 and continuing through today's solid-state computerized systems. Initially, DC converters were employed to regulate the voltage in the system. The usage of energy and transmission lengths increased, however, and DC became unreliable and expensive, leading to the adaptation of AC. Consequently, to reduce the greater voltages, engineers utilized transformers.

Electricity flow was previously controlled by engineers using resistive control or changing the transformer tap. Power controllers can change the AC waveform and regulate power flow, which is a critical benefit. AC to AC (sometimes referred to as power adapters) converters are available in three flavors: converters, converters, and converters (also known as power inverters). One of the most cost-effective power converters is an AC to AC converter. An alternating current source can provide a variable output voltage using either an integrated or a phase angle method.

[6] D Velmurugan, S Siva , M Narayanan , R Vidhya (January, 2016), ''A Review of All Possible Control Strategies for AC Voltage Controller'' ( IJET) An International Journal of Engineering & Technology | Volume 3, Number 1, January, 2016 (19-25)

In an AC voltage controller, a fixed ac is transformed into variable ac without altering the frequency. Using SCR switches, a variable ac output is provided to the load. A wide range of applications can benefit from an ac voltage controller: industrial heating and lighting, on-load tap changing transformers, soft-starting induction motors, etc. AC voltage is often controlled by a power electronic circuit consisting of two SCRs placed in anti-parallel between their respective points of origin and load destinations. The SCRs' gate pulses determine the control method. These two SCRs are anti-parallel to one other. It is also possible to employ a 400Hz TRIAC-based voltage controller if the voltage and current ratings of the individual TRIACs are high enough. Using a line commutation approach, several control techniques, including phase angle control, on-off cycle control, and integral cycle switching control, can employ SCRs as power electronic switches. PWM control, Section control, Sector control, and other integrated approaches necessitate the on/off operation of IGBT switches. Consequently, it has been determined that IGBTs should not be utilized since power switches without harmonic filters, as doing so will simply lead to huge amounts of distortion in the input voltage to the induction motors, potentially causing instability in the drive system.

Since DC drives are more expensive and fragile, induction motors have replaced them in several applications. It may be used for anything from washing machines, pumps, and freezers to industrial robots, electric cars, and elevators. Pace control is utilized instead of running machinery at a constant speed to save energy. Mechanical wear and tear, regular maintenance, inefficient and bulky are some of the drawbacks of conventional speed control techniques. When it comes to enhancing the aforesaid aspects, power electrical devices and controllers play an important role. The AC voltage controller is linked between the input ac supply and the load to construct this simple and compact power electronic controller circuit (single-phase induction motor). In order to manage the supply voltage to the load, the controller has two antiparallel SCRs. There are several ways to adjust the output voltage of this converter, including changing its firing angle. Controlling the output voltage may be done in two ways. Phase angle control, often known as "firing angle control," is the second type. In the On–Off cycle control technique, the input AC supply is turned on for n cycles and off for m cycles. Power electrical devices and loads must be able to handle abrupt voltage fluctuations during OFF periods. So the firing angle control is employed in this study to regulate the induction motor's speed. Speed control is the way of adjusting the machine's speed to meet the demands of the load and increase the drive's efficiency. For speed control of an induction motor, both the supply voltage, frequency, and number of poles may be varied, and external resistance linked in the rotor circuits can be varied. By adjusting the supply voltage, speed control of induction may be achieved in this study. Single phase induction motors benefit from voltage changing techniques whereas three phase induction motors suffer greatly from them.

Phase angle method SCRs T1 and T2 are used to regulate the output voltage in this manner. When the firing angle is changed, the rms output voltage is changed. Harmonics will be injected into the system when the sine wave pattern changes, increasing the percent THD. However, harmonics will be injected into the system as a result of the changing pattern of the input waveform, which is a drawback.

[7] André L. A. da Fonseca, Msc.; José A. Lambert, *Dr.*; Raul V. A. Monteiro, Esp.; Arnulfo B. de Vasconcellos, *Dr.*; Bismarck C. Carvalho, *Dr.* -Faculty of Architecture, Engineering and Technology. Federal University of Mato Grosso – UFMT. Cuiabá – MT, Brazil, “Behavioral and Statistical Analysis of Voltage Distortion of a Triggering an Industrial Fan: A Case Study” 2014 16th International Conference on Harmonics and Quality of Power (ICHQP), IEEE.

Domestic and industrial single-phase induction is the preferred method of generating modest amounts of electricity (less than 2 kW). The supply (single-phase) is also easily accessible even in rural regions. As a result, the winding of the single-phase induction motor has to be separated into two separate windings: the primary winding and the secondary winding. Single-phase induction motors come in three varieties. a) Split phase induction motor b) Capacitor induction motor c) Shaded pole induction motor. The capacitor start induction motor is the first split-phase induction motor. Suppose a capacitor is connected in series with the secondary winding of the split-phase motor. In that case, the result is a capacitor-start induction motor, The starting torque and power factor of the induction motor can be improved with this setup. Compressors, fans, air conditioners, grinders, and blowers are all examples of applications for capacitor-start motors.

Like welding, much of the load requires controlled or variable ac power. If you have a heating furnace, you'll need an adjustable ac supply. To drive such loads, ac voltage controllers are employed. It typically uses the main supply as an input and outputs a variable ac to the load as an output. It is possible to convert an ac source to an ac sink using either direct or indirect conversion. Conversion from direct ac to direct ac uses an intermediary dc stage known as the dc-link or dc bus and a converter known as a dc-link.

Direct conversion involves converting the ac input waveforms straight into the desired output waveforms without any intermediate processing.

Voltage distortion occurs when an AC output has a clean sinewave frequency but a tiny amount of voltage harmonics. This low degree of voltage distortion can be difficult to perceive on an oscilloscope and requires a harmonics analyzer to measure. The influence of non-linear loads can contribute to voltage distortion in a number of ways, including a decrease in voltage. Even so, it is preferable to evaluate AC power sources using pure resistive loads to minimize the impact of loads on power source performance. Only the intrinsic voltage distortion of the AC power supply is left to be considered. At each voltage zero crossing, switch mode AC power sources (aka Class D amplifiers) suffer from crossover distortion, which is the primary cause of distortion. Since the H-Bridge FETs or IGBTs in a switch-mode AC source are constantly switching between on and off, there can be no overlap between the positive and negative halves of the H-switching Bridge's cycles, Creating a direct current channel between the positive and negative DC rails of the H-Bridge would cause excessive current to flow through power devices if this was possible. The H-Bridge or power amplifier output stage will always fail if this circumstance occurs. To avoid this, a 'dead-time must be established between turning one side of the H bridge off and the other on. Deadtime causes the output sine wave to halt just short of zero, causing the voltage to bounce from one side to the other for a brief duration.

[8] Wadah Elgack, C. Huang Shen, F.Y.C. Albert, M. N. Mohd Fuad, “Analysis of Total Voltage Distortion and Power Consumption in Ac to Ac Voltage Convertor using Integral Cycle PWM Control” 2015 IEEE 2015 International Conference on Computer, Communication, and Control Technology (I4CT 2015), April 21 - 23 in Imperial Kuching Hotel, Kuching, Sarawak, Malaysia.

When it comes to induction motor driving systems, AC voltage converters are commonly employed. As a result of their detrimental impact on supply power factor degradation and high line current harmonic content, these drive methods are generally avoided. In many applications, phase-angle control line commutated voltage controllers and integral-cycle thyristor control have been widely used. Simpleness and cost-effectiveness are two of the benefits of using these methods to manage big amounts of power. Inherent drawbacks include trailing input power factor, particularly at large firing angles, and significant low-order harmonic content on both the load and supply sides due to the firing angle retardation. It's also worth noting a power flow discontinuity on both sides. There is a low input power factor and a drop in firing angle power factor when using the typical phase angle control approach.

A squirrel cage induction motor, on the other hand, is most efficient at its rated load. The machine is inefficient at low loads because the phase of the stator current is trailing, resulting in a low power factor. An explanation for this behavior is that the machine's internal impedance becomes mostly reactive when supplied with a constant supply voltage, which is the case in most applications.

Choosing the optimal approach for controlling ac voltage is, thus, quite complex. By today's standards, the power factor is receiving more and more attention from utility companies. Electronic variable transformers are often the result of a trade-off between efficiency and power factor that can be reached only via compromise. Using simple ac voltage converters to try to solve this conundrum would be an exercise in futility. On the other hand, installing a complicated controller that costs several times the cost of the motor is an unattractive alternative. Various ways of adjusting the operating stator voltage of an induction machine under light load have been studied. For each load situation, some applied voltages produce the lowest input power and the highest efficiency, according to one of these new research.

Furthermore, optimizing the input power factor leads to a performance that falls short of optimal efficiency. Here, we will provide a simple method to create variable ac voltage straight from the line using power factor enhancement strategies and compare these techniques. The secondary purpose is to apply these control approaches to the commonly used single-phase induction motor and provide comparative findings on motor speed, power, power factor, displacement factor, and overall system efficiency for comparison. Controlling the firing and extinction angles is the goal of this research, which uses a combination of modified phase angle control (PAC), extinction-angle control (EAC), and pulse width modulation (PWM) approaches to achieve this goal. An ac voltage converter with two controlled switches and a two diode bridge rectifier is being designed. Reducing the number of controlled switches is critical for control simplicity, cost, reliability, and switching losses, which improves the converter efficiency.

[9] Y. Renny Rakhmawati, "Implementation of AC-AC Voltage Controller for Reduce Transient Current at Three Phase Induction Motor", International Seminar *on* Application for Technology of Information and Communication (iSemantic), 2019.

In order to prevent commutation issues, a dead time is created, and a bypass capacitor Cb is added in parallel to the load in order to provide a channel for the current during the dead period when both switches are closed. For this purpose, an Rb bleeding resistor is connected in series with the supply voltage's bypass capacitor Cb when the forward switch S1 has been activated. The bypass circuit consists of both the capacitor Cb and the resistance Rb. The operating modes are classified into three categories: active, dead time, and freewheeling. Conducting current flows across both sides of the circuit, delivering energy to the load during the active mode, freewheeling through the freewheeling channel during the freewheeling mode, and bypassing during the dead time mode. Single-phase AC-AC voltage regulators have been compared in power factor enhancement research. The EAC approach was discovered to be superior from a utility AC side power factor improvement point of view since the utility supply power factor not only increased from the load power factor, but it became leading when the extinction angle exceeded the load angle. It was largely owing to the considerable increase in the displacement factor that led to this improvement. Using a PWM approach, harmonic material is shifted to higher frequencies, making it easier to meet filtering requirements. IGBT's with reverse blocking capabilities should be investigated and debated in the future.

One of the direct conversion methods, Phase Controlled Switching (PCS), is widely utilized for tunable ac-to-ac and ac-to-dc power conversion. While switching from cold, phase control circuits in heat controllers for resistive loads (R) emit higher-order harmonics, generate Radio Frequency Interference (RFI), and cause large inrush currents. To reduce RFI at high power levels, extensive and costly line filters are required. Another approach to direct conversion is known as integral cycle control. Zero switching or cycle selection are other names for on-off control. Depending on the application, mechanical or thermal time constants might be many seconds long. By attaching the load to the source and then detaching it for a few off cycles, there is almost no temperature difference detected when controlling it this way. That is to say; it involves turning on and then turning off the supply to the load for an arbitrary number of integral cycles. It is cyclically repeated. The duty cycle regulates the output power, which operates in the same way as thermostatic switches but with an integral number of cycles. It's because of the thyristors' zero-voltage/zero-current switching.

[10] D.V.Khakhkhar, "Design and Simulation of Novel Integral Switching Cycle Control for Heating Load", International Journal of Emerging Trends in Electrical and Electronics (IJETEE – ISSN*:* 2320-9569), vol. 5, no. 1, -2013, 2013.

The Solid State Power Controller (SSPC) connects and disconnects the load based on the amount of power required. Phase-control switching and integral-cycle-control are two of the most used methods for heating power in an ac power controller (ICC). When PCS is used to power a resistive load, it can generate high-order harmonics and a significant amount of inrush current when turned on cold. Consistent and smooth voltage control is impossible in ICC, and output voltage control cannot be continuously maintained. Integral Switching Cycle Control (ISCC) was developed as a novel way to overcome the drawbacks of both systems and gain the advantages of both methods for heating applications. The design and simulation results of the ISCC approach for heating applications with resistive loads have been presented in this study, along with the method's strengths and weaknesses.

When welding and heating, most of the load demands variable ac power, which necessitates a variable ac supply. AC voltage controls power such loads. In most cases, it uses the mains supply and delivers a variable ac output to its load. There are two ways to convert AC to AC: direct and indirect. In indirect acac conversion, a dc link or dc bus is used as an intermediary dc stage, and the converter is referred to as a dc link converter. The ac input waveforms are immediately transformed into the required output waveforms during direct conversion. One of the direct conversion methods, PCS, is widely used for tunable ac-to-ac and dc power conversion. PCS is one of the direct conversion methods. Phase control circuits in heat controllers of resistive load (R) create higher-order harmonics and Radio Frequency Interference (RFI) and significant inrush currents when switching on from cold. To prevent RFI at high power levels, heavy and costly line filters are required. Direct conversion can also be achieved with the use of integral cycle control. Zero switching, cycle selection, and on-off control can be used to describe it. It is possible to establish temperature control for several applications where the mechanical or thermal time constants are a few seconds long by connecting and then disconnecting the load for a number of on and off cycles, respectively. As a result, it switches on the supply for an equal number of cycles, then switches it off for an equal number of cycles. This happens repeatedly. To control the output power, the duty cycle is regulated in a manner similar to that of thermostatic switches, except that an integral number of cycles are traversed. Due to thyristor zero voltage and zero current switching, switching harmonics are decreased. ICC's output voltage waveforms. As soon as the power is turned on, the temperature or speed grows exponentially from low to high. D= n/M is a duty cycle if n is the number of complete cycles passed per M full cycles of the source voltage. It's termed a differential when the temperature difference between the highest and lowest temperature is more than zero. Harmonic frequencies in the ICC are at their lowest, and switching losses are minimal. Hence there is less EMI and RFI. Zero-voltage switching (ZVS) reduces inrush current, but continuous voltage control is not attainable, and the frequency included in the ICC is changeable.

[11] M.R.Tanvir Hossain et al., "Performance Analysis of Modified Three-Phase Buck AC Voltage Regulator", *2019* International Conference on Electrical, Computer and

Communication Engineering *(*ECCE*)*, 7-9 February, 2019, 2019. Available: 978-1-5386-9111-3/19/$31.00 ©2019 IEEE.

Diagram of the circuit to regulate the single-phase ac voltage. There are two SCRs in an anti-parallel connection. A TRIAC-based voltage controller can be employed if TRIACs are available with the voltage and current ratings needed for a specific application. Several control approaches employ online commutation, such as phase angle control, on-off cycle control, and integral cycle switching control. So SCRs may be used as a power electronic switch. On the other hand, PWM control, Section control, Sector control, and different integrated approaches need on/off IGBT switches. IGBTs shouldn't be utilized as power switches without harmonic filters because doing so leads to significant distortion in the input voltage to induction motors, leading to driving system instability. The research supports this conclusion.

Today's power system must enhance the power electronics' reactive power, eliminate harmonic generation, and boost power. Switching devices produce harmonics in the electrical grid and harm overall system performance. Hence they should be avoided whenever possible. Many scientists have been working on ways to enhance the efficiency of all electrical power devices apart from the grid in recent years. Grid-connected switching equipment needs to reduce reactive power consumption, remove created harmonics, and improve total harmonic distortion. Three rectifiers are being used more frequently now that they offer certain advantages. For example, electric motor drives and DC power systems both use rectifiers. Input current harmonic distortion is low, power factor is high (typically near one), dc-link voltage quality is excellent. The input and output filters are compact in this type of converter. Various control strategies are available for this sort of Ac-to-DC converter. To control the three-phase rectifier, we can use any one of many approaches. A high power factor and input current with a sinusoidal form is among these types of control goals. The only thing that separates the two control strategies is the way they go about things. It's possible to divide these techniques into many subcategories. Included in this category are active and reactive power controls and current loop controllers Voltage-oriented control (VOC) is a well-known technique for indirectly controlling reactive power. This kind of control can change the power factor up the value of the unit. Variable frequency drives employ the frequency direct torque control technique as a further means of managing three-phase rectifiers. This approach is based on controlling reactive and functional power simultaneously (DTC). Due to the switching table's design, the DPC approach does not include an internal current control loop. According to this approach, an instantaneous discrepancy between the estimated and measured active power is used to create a converter switching state. The primary difficulty with this approach is that it requires a high sampling frequency. A technological solution to this problem is to combine the predictive method with the DPC method.

It is possible to start a three-phase induction motor in a variety of methods. TRIAC, which is placed in each phase of the three-phase power system, may provide the motor with three different voltage settings. The approach used to start this three-phase motor was chosen since an uncontrolled starting motor can generate a variety of issues. It can lead to a variety of problems with the electrical system that's linked to the engine. High start current is a common concern since it can cause voltage flickering and a relay trip on overload or Undervoltage. There is a solution to this problem that uses an AC-AC Voltage Controller to establish the starting voltage and then use a TRIAC component to regulate the motor's power supply by adjusting the ignition angle on each phase of the induction motor's windings. So that all three ignition angles are changed simultaneously, a proper synchronization signal is required to ensure that each TRIAC has the same ignition angle. To deal with high start flow issues, this voltage control approach is frequently employed. It's possible to classify this approach as either a VFD or an AC-AC Voltage Controller. Compared to Variable Frequency Drives (VFD), using an AC-AC Volt Controller is more common since it is an affordable solution to three-phase induction motor starting difficulties. With the help of an AC-AC Voltage Controller, a three-phase induction motor's input voltage may be regulated until it achieves its nominal voltage, and the system's current sensor detects decreasing currents caused by the slip value. As soon as the voltage reaches the trim value, the system may then use the sensor's feedback to lower the beginning currently.

In every electric charging scenario, linear and nonlinear charging types are commonly used. A linear load has a constant impedance throughout the voltage cycle it is operating at. Loads classified as linear include those that are resistive, inductive, and capacitive. Unlike a linear load, a nonlinear load changes impedance according to the voltage cycle.

SCR/IGBT devices and UPS systems are examples of nonlinear categories, as are SMPS and other electrical equipment. To complicate matters, while harmonics don't change the fundamental nature of an electric current's waveform, they modify the waveform of the nonlinear loads that feed it. When a harmonic current flows through a system, it increases heat losses and decreases efficiency. Harmonic currents can have a substantial impact on the electric distribution system and feed into it. To power the computer's internal hardware, every computer has an SMPS to convert the utility's AC electricity to a regulated low voltage DC. Using these nonlinear power sources produces significant distortions in electric current and voltage waveforms, which is measured as total harmonic distortion (THD). The distortion may return to the power supply, where it might affect other devices linked to it. When harmonics make up a considerable portion of the overall load, most power systems have problems handling harmonic currents. As harmonic currents flow through the grid, they can cause problems such as large load currents in the neutral wires of a three-phase system, high neutral voltages (often more significant than 2 volts), communication errors, heating and hardware damage, and overheating of electric distribution equipment, cables, transformers, and standby generators. High voltage and circulating currents are caused by harmonic resonance and device malfunction due to extreme voltage distortion.

Electronics for power conversion and control is what power electronics is all about. Among the several types of power converters available, the most affordable is the AC-AC converter. Phase angle (firing angle) and integral cycle control (zero-crossing) regulate the AC supply for a variable output voltage. With high delay angles or intense cyclic pulses, waveform distortion limits the use of this technology to industrial heat applications such as motor starting or low range controls. Zero detection control is commonly used in temperature control systems to avoid actual frequency spectrum content at and around the fundamental frequency. As a result, it's critical to use RC filters on the load. Because of supply interruptions at low demand, zero detection control is unsuitable for engine or lighting control. The advantage of switching controls is that they don't have to be synchronized with the power supply and that voltage fluctuation across the load is faster since the switch may be turned on and off throughout the AC cycle. Because the switching frequency is exceptionally high, the total power factor is larger than in other controller topologies. The waveform is a sinewave. PWM modulates the output voltage to produce a sinusoidal wave instead. In the terahertz range, harmonics have a negligible influence. Simplistic capacitive wire films are effective in smoothing the output voltage. In addition, the voltage is low. Instead, the switching regulator's disadvantages include harmonic filtering at low power needs, greater size and price owing to more accurate control and electrical circuitry, and increased production of radio frequency interference due to the switching occurring many times each cycle.

[12] A. V. Kudryashov, "Experimental PWM Controlled Device", *2019 International* Conference on Industrial Engineering, Applications and Manufacturing (ICIEAM), 2019. Available: 978-1-5386-8119-0/19/$31.00 ©2019 IEEE.

The most popular methods for converting DC to AC power are direct, indirect, and matrix converters. It is vital to regulate voltage and frequency, which is why indirect and matrix converters are utilized. Direct PWM AC–AC voltage converters employ power semiconductor devices to modify the RMS voltage delivered to the AC load and use a constant AC supply voltage as the input. Different studies have indicated that AC voltage regulators are used in many applications such as light dimmers, motor starters, AC motor speed controllers, voltage regulators, and battery chargers that need regulated AC voltage. There are several drawbacks to using transformer-based AC voltage regulators. They're bulkier, heavier, and have sluggish reaction times and distortions. Therefore many switches are required to improve voltage control. The harmonic content and power factor must be controlled with extensive filters, which are also required. Autotransformers and tap-changing transformers can be replaced by simple, low-cost, dependable thyristor phase-controlled circuits or TRIAC circuits. The drawback is that they lead to low power factors and voltage and current waveform distortion.

The advancement of power semiconductor research and the use of high frequency, efficient, and low loss switching devices leads to several alternatives for the topology of the AC voltage controller. It was hypothesized in that better AC voltage controller topologies functioning on boost mode might be found. There is no converter in because safe commutation prevents it from working correctly. Utilizes a three-phase system in which each phase operates separately. It is, therefore, possible to attain a flexible operation even under asymmetrical situations. To implement either of these topologies, you'll need six switches and three phases of passive components. Two 3-phase semi-bi-directional switches were used in the AC voltage converters developed by F. Z. Peng et al. Structures for AC voltage controllers proposed in utilized a similar switching architecture. The imbalanced load voltages occur in these converters due to the lack of a load/source neutral. The authors proposed two 3-phase AC bi-directional switches in to alleviate this problem. The AC bidirectional switch was modified in with fewer diodes while keeping the neutral connection on the source/load side. Modified boost converter analysis revealed reduced complexity, easier control, and improved system dependability. A three-phase buck AC-AC converter with modified bidirectional switches is introduced and examined in this work by the authors. Since the suggested converter uses more miniature semiconductor diodes and switches, the power quality indices have been evaluated. Comparisons with a semi-bidirectional switch-based buck converter have been made to confirm the improved performance of the proposed converter under unbalanced load situations. When the converter's input voltage and load fluctuated rapidly, voltage-mode feedback control assessed how well the converter performed.

For LED lights, the most frequent topologies of switching power supply are boost, buck, buck-boost, flyback. Control chips are available from a wide range of vendors. The microcontroller and the driver may create the control signals and intervals required by the system. When using a more complex microcontroller, it is possible to reduce brightness in various ways: by adjusting the voltage or resistance, the current regulating resistor, or the fill factor of the PWM signal from the microcontroller [6]. PWM control is popular because light intensity depends more linearly on the fill factor than on current. Additionally, an increase in current influences the deterioration of LEDs throughout the manufacturing process, reducing LED usability overall. The light-emitting diode's spectrum properties are also altering. There is a shift in colour temperature for white LEDs and colour distortion for colour LEDs. To sum it up, the existing control scheme is cumbersome to use. A microcontroller can generate PWM signals in a wholly digital system and be utilized to operate the drives. PWM may be used to turn the driver on and off. Flickering should not be noticeable to the human eye if control is done by pulse-width modulation (PWM). When used at high frequencies, LEDs may be highly energy-efficient, with light intensities approaching or equal to the maximum permissible for the current they are running at.

[13] E.A.Qasmi et al, "Power Quality Analysis of Phase Controlled Bidirectional and Unidirectional AC Voltage Controllers and their impacts on input power system.", 2019 International Conference on Computing, Mathematics and Engineering Technologies, 2019. Available: 978-1-5386-9509-8/19/$31.00 ©2019 IEEE.

Pulse-switching on current maximum with brightness control via duty ratio change is more efficient. The PWM control system may be used in conjunction with a digital DALI control system. DALI converters on the market receive the signal and convert it to PWM and DALI compliant drivers, that is, drivers that have a built-in converter. Lighting control devices such as converters and LED drivers to control light sources by converting DALI signals into PWM and delivering that power to LEDs. A variety of loads require different ac supply voltages, including driller machines and induction motors. Transformers may convert a constant-voltage AC source to an adjustable-voltage supply using autotransformers. To make matters even worse, they are more costly to operate, have higher energy costs, suffer from increased heating losses, and have lower system efficiency. Altering the supply of gate currents without changing the frequency is how an AC voltage controller converts fixed AC into variable AC. Power electronic devices, including MOSFETs, IGCTs, MCTs, SCRs, and GTOs, among others, have made this discussion more efficient and precise. Included among the methods for controlling the output AC supply are phase angle and integral cycle control. Electrical motor speed control, transformer tap switching, industrial and home heating, induction heating and AC magnet controls are just a few of the many uses for phase regulated AC voltage controllers. Load changes in AC voltage controllers can cause voltage sag, affecting residential, commercial, and industrial users. For efficiency and uninterruptible system supply, several devices now include built-in power controllers. There are two types of ac voltage controllers available: one for low power home uses and another for industrial ones. The impact of harmonics on power quality variables are being studied by researchers who are working on better converter topologies. Using unidirectional and bidirectional controllers with resistive and inductive loads, this research looks at how distortions behave at the single-phase input power supply. Most loads are RL type. Hence this is taken into consideration when designing ac voltage regulators RL load.

# Chapter 3
# Methodology

## 3.1 Introduction

This chapter explains the design, implementation, testing, and validation used to achieve its objectives.

## 3.2 Interpretation and Analysis of Data

The purpose was to use qualitative and quantitative analytical approaches to build the system and understand all the acquired data to extract all needs the research project evaluated the results based on the primary outcomes. A literature analysis was conducted to manufacture integral switching and control voltage distortion without the pulse width method, and the study revealed that data refers to the understanding.

## 3.3 Integral cycle switching

This project aimed to eliminate the entire cycle or cycles of an AC signal through a technique known as cycle switching. It is an established and proven approach for regulating AC power and has been used chiefly to manage electric ovens (for example, through heaters). However, getting the voltage cycle to shift using Arduino may be made precisely according to the software written in assembly language. Since the applied voltage is distributed among the load, the voltage at the load is more minor. The project incorporates a comparator and a connection to the Arduino's interrupt to accomplish the zero-crossing detection. The Arduino gives output using interrupt signals as the basis for producing pulses that serve as reference points. To integrate cycle control, we activate the TRIAC using the optocoupler that the Arduino drives. It's possible to verify the outcome by using a series motor or light in place of a linear load in the output. The other potential consequence of implementing such a system is an inconsistency in the input current or voltage cycle when the cycles are manipulated throughout the load. This idea uses a light in place of a motor for visual purposes. It looks like a project on flickering lamps, but it may be more sophisticated. The disadvantage of AC Voltage Control in the On–Off Cycle Control method is that the control is not continuous. On the other hand, this problem is solved in the Integral Cycle Switching Method. Typical regulators cannot control accurately, while the Integral Cycle Switching Method can control accurately at any portion of the cycle at any time. In Comparison with the Phase angle control method, the Integral-Cycle control method reduces the electromagnetic interference can processes all the advantages of zero-voltage switching techniques. Typical regulators cannot control accurately, while the Integral Cycle Switching Method can control accurately at any portion of the cycle at any time.

## 3.4 Proposed Model block diagram

The power supply comprises a 230/12V step-down transformer, which reduces the voltage to 12V alternating current. A Bridge rectifier is used to convert this from an AC signal to a DC signal. We reduce the noise by using a capacitive filter. Then we regulate to +5V, which is needed for the microcontroller and other components to work properly. We utilized an Optoisolator as an input and a zero-crossing detector as an output in this Arduino UNO project. The Zero-crossing detector in the TRIAC will be used to regulate the load. We'll have a visual representation of the voltage level on display.

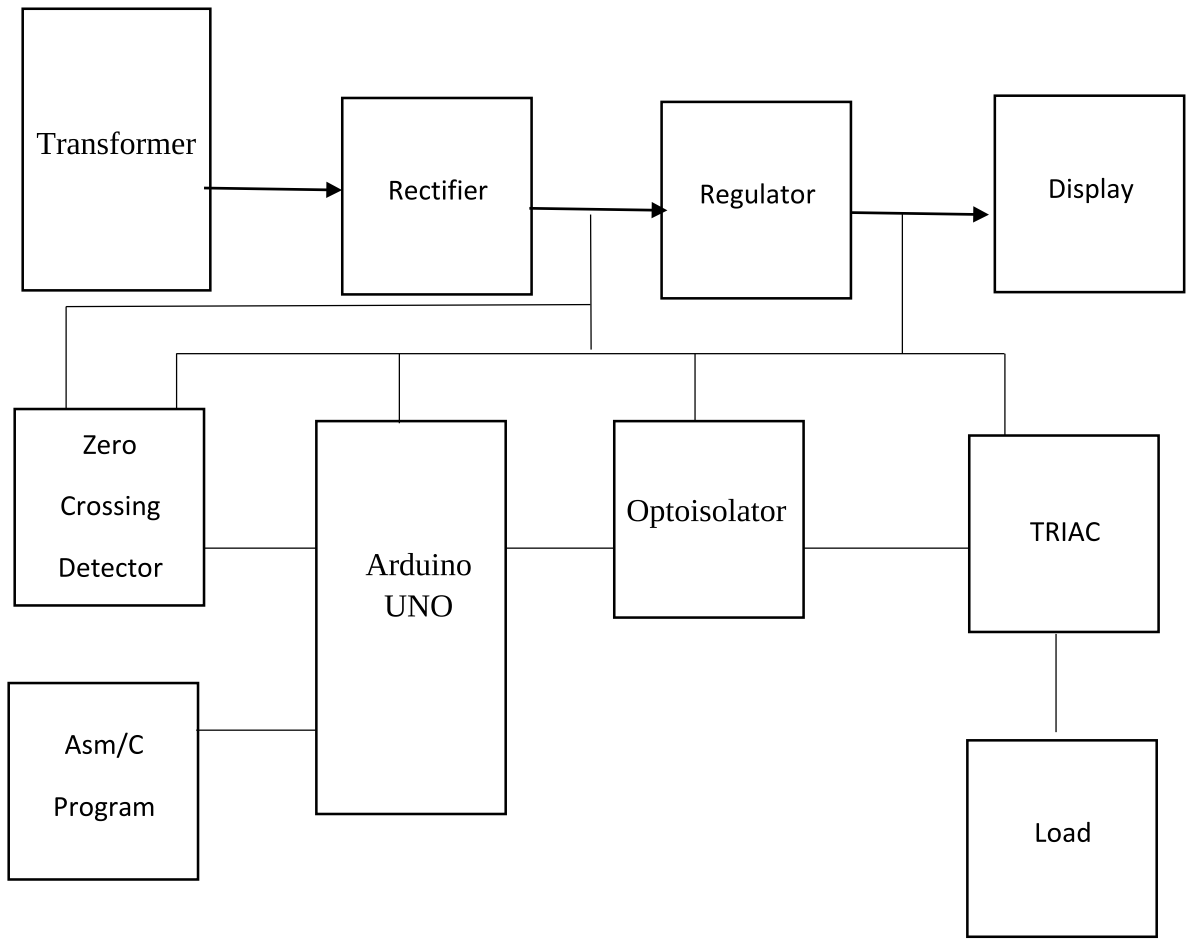



**Figure. 3.1: Block diagram for proposed model of the system.**

## 3.5 Flow Chart of Proposed System

After starting the program, first of all, we will be check the voltage distortion at Lad. If any distortion is detected, then we will control the AC output with the Zero-Crossing detector through the TRIAC. Then we monitored the voltage level on display, changing the stage by push switches.

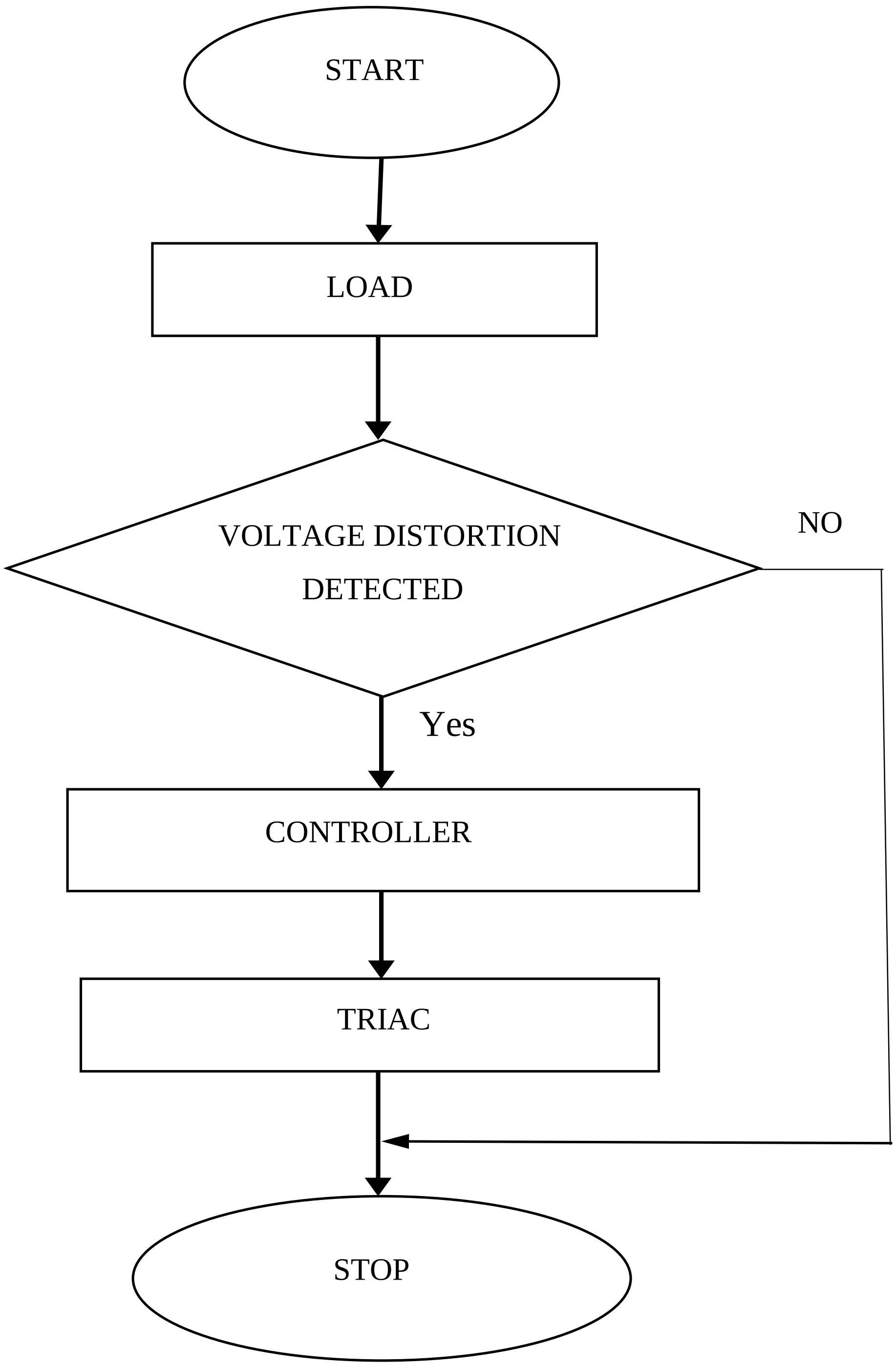



**Figure. 3.2: Flow Chart for proposed model of the system.**

## 3.6 Circuit Diagram of Proposed System

After converting the AC voltage source to 12V, we used two 47k ohm resistors to reduce the Voltage flow. Then we build up a full-wave bridge rectifier by the diode, which rectifies it by converting AC to DC. Then, the positive part of the full-wave bridge rectifier is connected to the Optoisolators Anode Pin and Negative to the cathode pin. The collector pin of Optoisolator is associated with two no pin of Arduino UNO as input, and pin no four is grounded. The ten no pin of Arduino UNO, which is used as output pin of it. That is connected to the Anode pin of MOC3021. Here, The MOC3021 is used as a Zero-Crossing detector. The 6 & 4 no pin are connected with the Gate and Terminal 1 pin of TRIAC, respectively. Then terminal 2 pin of TRIAC is connected to the load. We will control the AC output with the Zero-Crossing detector through the TRIAC. Then we monitored the voltage level on display, changing the stage by push switches.

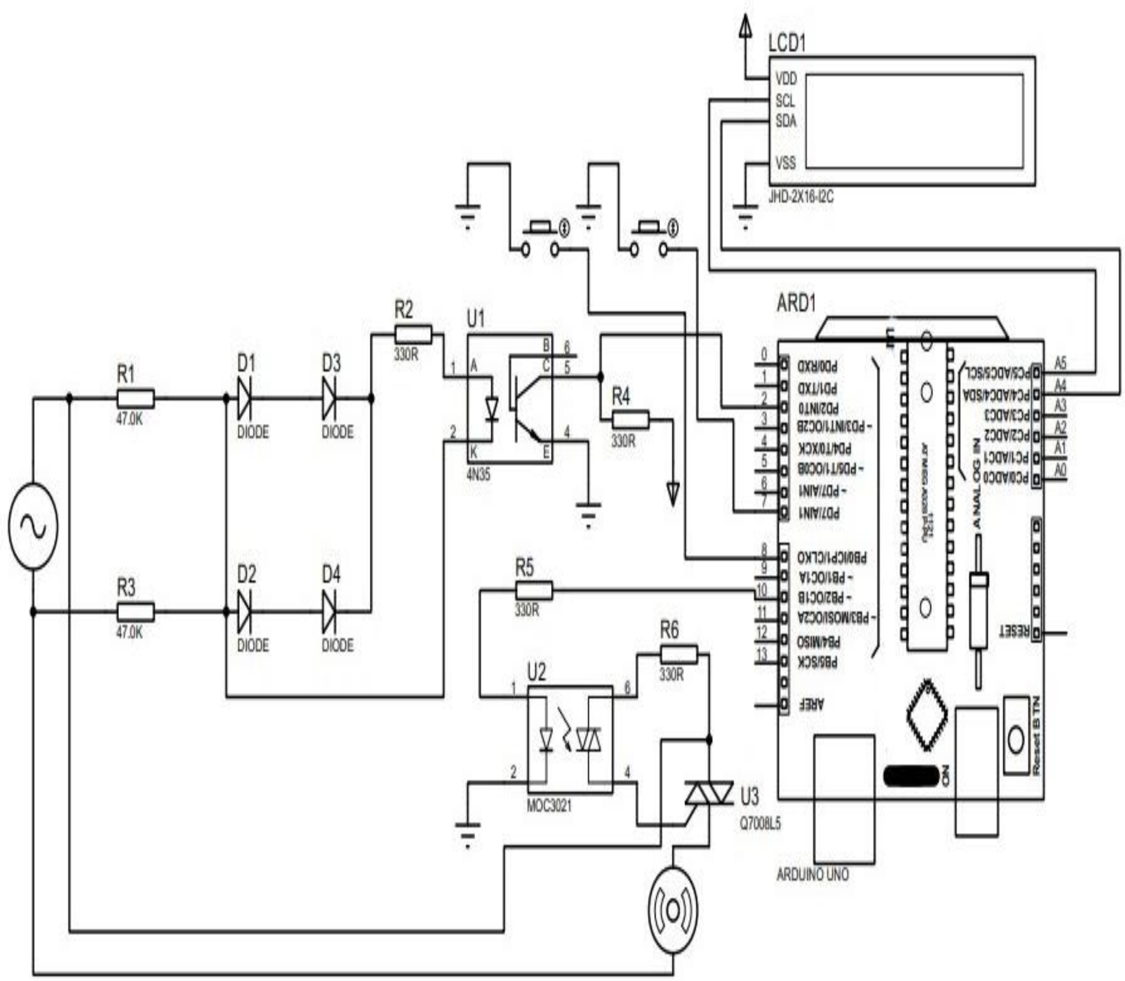



**Figure.3.3: Circuit diagram for proposed model of the system.**

## 3.7 Proposed Model in Real Life

This is the Initial project layout. Here we monitored the different voltage stages by changing push switches. We used two push buttons; one is for high to the low, and the second one is for low to high.

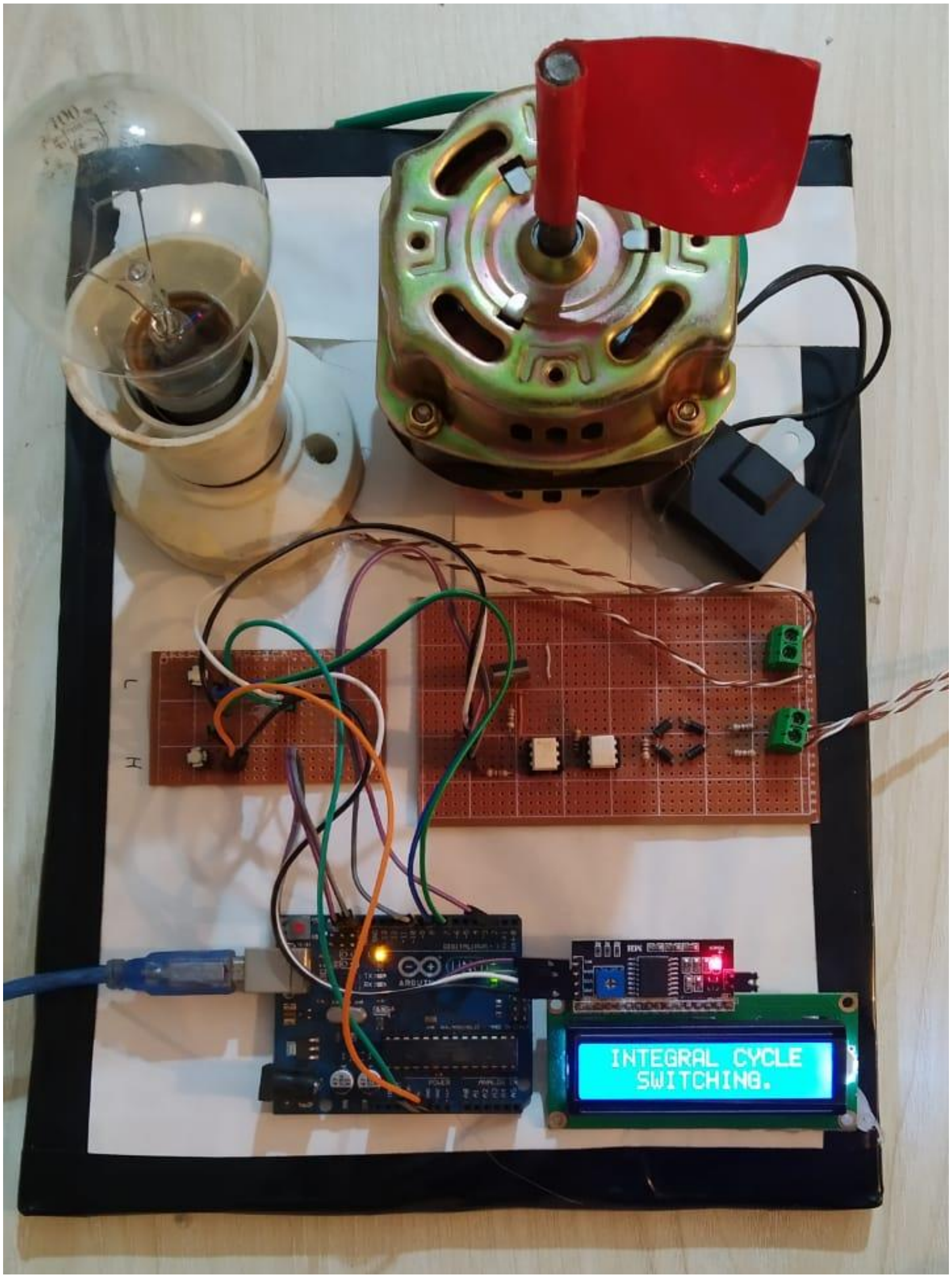



**Figure 3.4: Proposed Model in Real Life.**

## 3.8 Components of the Device

**Component List**

- Diode
- Resistor 47k ohm
- Resistor 330 ohm
- MOC3021 IC (Opto-isolator)
- 4N35 IC
- BT 136 TRIAC
- Arduino uno
- Lcd display
- I2C module
- Motor & light
- Push switch

### 3.8.1 Diode

The electrical component is known as a diode, only conducts current in one direction. It may be described as a two-terminal device (so long as it is operated within a specified voltage level). In a perfect diode, it has zero resistance going one way and infinite resistance going the other. While a diode cannot attain zero or infinite resistance in reality, in theory, it can. Instead, a diode will have minimal resistance to current in one direction (since it allows current to flow) and a massive amount of resistance in the other way (which keeps the current flowing in one direction alone) (to prevent current flow). A diode is an instrument that lets one-way current flow, which prohibits current from moving in the other direction. This is done via an internal electric field. In the early days, red-hot wires passed through the center of a metal cylinder situated within a glass vacuum tube.

**Figure:3.5: Diode.**

### 3.8.2 Resistor

A resistor is a type of passive electrical component that may increase the amount of electrical resistance. Almost all networks and circuits contain these. The measurement for the resistance is in ohms (Ω). Resistance occurs in a circuit with a decrease of one volt when one ampere (A) of current flows through a resistor. Such resistance is referred to as an ohm (Ω). The voltage is related to the amount of current in the circuit. This is how Ohm's law expresses the ratio: R=V/I. Several applications use resistors. For example, some options include cutting the electric current, reducing voltage, producing heat, matching and loading circuits, gaining control, and choosing a time constant. Resistant varieties may be bought commercially and vary in several magnitudes more resistance. They can be used as an electric brake for trains or be one-hundredth of a square millimeter or smaller for electronics.


**Figure. 3.6: 47k ohm Resistor. & Figure. 3.7: 330 ohm Resistor.**

### 3.8.3 MOC3021 IC (Opto-isolator)

With a built-in voltage regulator, the MOC3021 TRIAC driven zero-crossing optocoupler may be used. A TRIAC is linked to an LED in the device's inside, which emits infrared light. The TRIAC is activated in tandem with the LED.

With an Optoisolator like the MOC3041, you may regulate an AC or DC load by controlling another switching device (such a TRIAC, MOSFET or SCR). An external device can be turned on using the MOC3041's maximum peak current of 1A. To switch a load, an external switch should be used rather than merely the TRIAC. AC loads are often controlled using the MOC3041 since it has a built-in Zero crossing detector. Using a Zero Cross Detector will ensure that the TRIAC will only fire when the voltage is zero, and the TRIAC will not fire otherwise. This will protect the LOAD from harmful voltage peaks. [14].

**MOC3021 Pin Configuration**

**Table 1: MOC3021 Pin Configuration**

| Pin Number | Pin Name | Description |
|---|---|---|
| 1 | Anode (A) | Anode pin of the IR LED. Connected to logic input |
| 2 | Cathode (C) | Cathode pin of the IR LED |
| 3 | NC | No Connection - Cannot be used |
| 4 | Triac Main Terminal 1 | One end of the Triac which is present inside the IC |
| 5 | NC | No Connection – Cannot be used |
| 6 | Triac Main Terminal 2 | Other end of the Triac which is present inside the IC |

**MOC3041 Features and Specifications**

- Opto-isolator with Zero-Crossing Triac Driver
- Input LED Diode Forward Voltage: 1.3V
- LED Forward Trigger Current: 15mA
- TRIAC output terminal voltage: 400V (max)
- TRIAC peak output current: 1A
- Available as 6-pin PDIP with and without M-suffix


**Figure 3.8: MOC3021**


**Figure 3.9: MOC3021 Pinout**

### 3.8.4 Zero crossing Detector

A Zero Crossing Detector Circuit makes extensive use of an Op-amp as a comparator. When the Zero voltage is crossed, it's utilized to watch how the sinus form changes from positive to negative or vice versa. It may also be used as a generator of Square Wave. The Zero Crossing Detector has numerous uses such as a generator time marker, phase meter, frequency counter etc. A Zero Crossing Detector is possible in various methods, such as a transistor, op-amp or optocoupler IC. In this post, Op-amp is used to construct a Zero Crossing Detector Circuit. Op-amp works as a comparator as described above. Essentially, a Zero-Crossing Detector (ZCD) is a comparator with the reference level set at zero. It is used to detect zero AC signals crossing. This means it is the sort of voltage comparator that can detect the transition of a sine waveform from the i/p to the zero voltage state. This might be manufactured from an operational amplifier with a positive input voltage. The output is sent to Arduino Uno through this null-circuit detector.

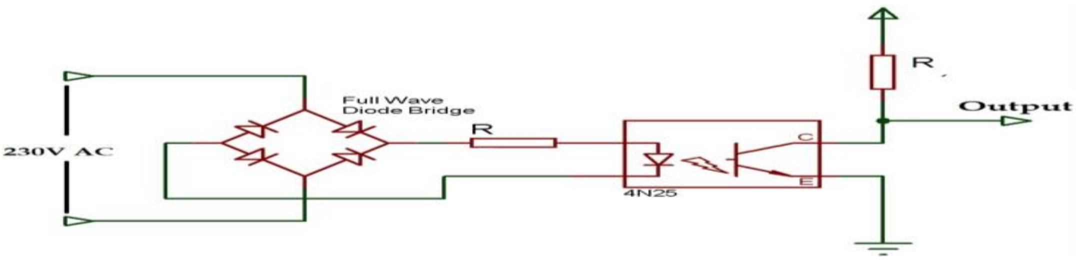



**Figure 3.11: The zero crossing detector circuit.**

### 3.8.5 4N35 IC

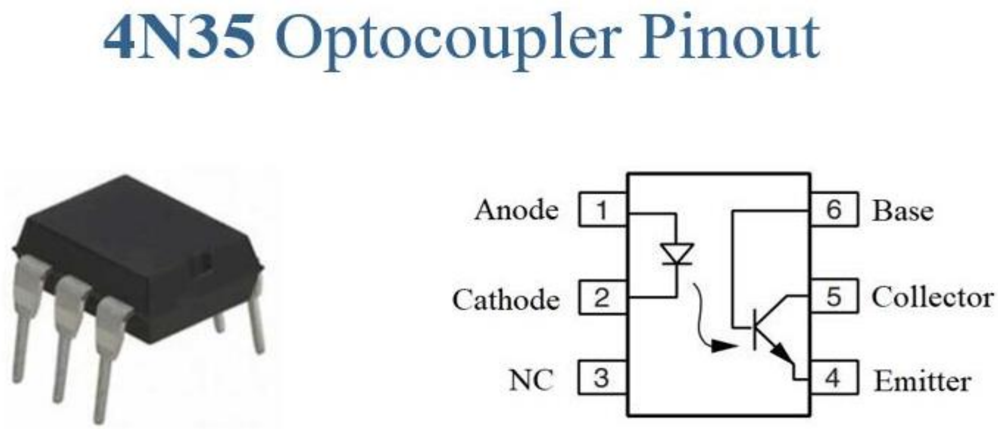



**Figure 3.10: 4N35 Optocoupler.**

**Features and Specifications [15]**

This section discusses the optocoupler IC's key features and specs.

- Number of Channels: 1 Channel
- Maximum Collector-Emitter Voltage: 30V
- Forward Current: 100mA
- Forward Voltage: 1.5V
- Reverse Voltage: 6V
- Isolation Voltage: 5300 Vrms
- Operating Temperature: -55 to 100 Degree C
- Power dissipation: 250 mW

**4N35 Pinout Configuration**

**Table 2: 4N35 Pinout Configuration.**

| Pin Number | Pin Type | Pin Description |
|---|---|---|
| 1 | A | Anode |
| 2 | C | Cathode |
| 3 | NC | Not Connected |
| 4 | E | Emitter |
| 5 | C | Collector |
| 6 | B | Base |

### 3.8.6 BT136 TRIAC

As previously stated, the maximum terminal current of the BT136 is four amps. The BT136's ability to be controlled by digital circuits may be viewed as a benefit. Because of its ability to work in both directions, TRIACs are often employed to control AC systems. In such a case, BT136 might be an appropriate solution for a project if you need to transfer control of a 6A+ load to a microcontroller or microprocessor. [16]

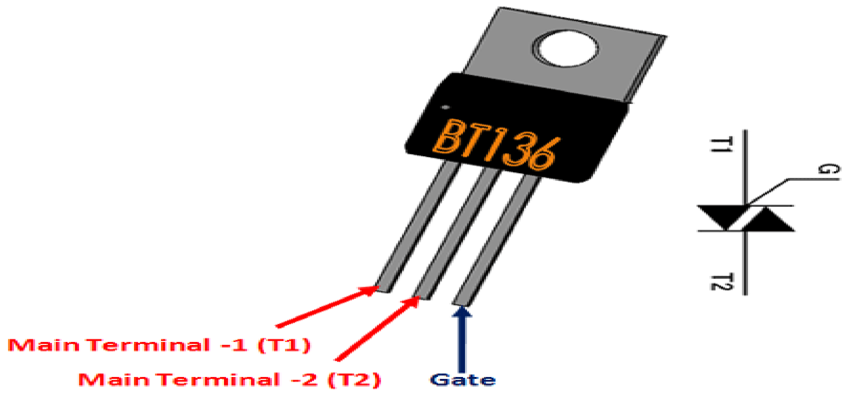



**Figure 3.12: BT136 TRIAC**

**Pin Configuration**

**Table 3: Pin Configuration of BT136 TRIAC**

| Pin Number | Pin Name | Description |
|---|---|---|
| 1 | Main Terminal 1 | Connected to Phase or neutral of AC mains |
| 2 | Main Terminal 2 | Connected to Phase or neutral of AC mains |
| 3 | Gate | Used to trigger the SCR. |

**Features**

- Maximum Terminal current: 4A
- On-state Gate voltage: 1.4V
- Gate trigger current: 10mA
- Max Terminal Voltage is 600 V
- Holding current: 2.2mA
- Latching current: 4mA
- Available in To-220 Package

### 3.8.7 Arduino UNO

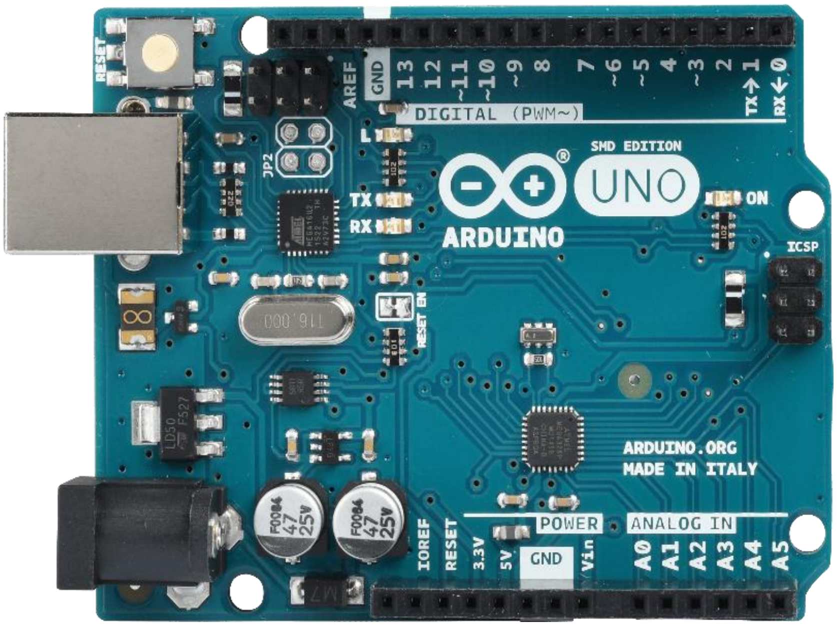



**Figure. 3.13. Arduino UNO.**

Arduino UNO is an open-source microcontroller board based on the ATmega328P chip. Several circuit components work together to provide the microcontroller with its unique powers. UNO has six PWM outputs, 14 digital input/output pins, and a USB connection. It also has an AC power connector and an ISP header. There's also an ICSP header. [17].

**Arduino UNO Technical Specifications**

**Table 4: Arduino UNO Technical Specifications.**

| **Microcontroller** | **ATmega328P -8 bit AVR family microcontroller** |
|---|---|
| Operating Voltage | 5V |
| Recommended Input Voltage | 7-12V |
| Input Voltage Limits | 6-20V |
| Analog Input Pins | 6 (A0 – A5) |
| Digital I/O Pins | 14 (Out of which 6 provide PWM output) |
| DC Current on I/O Pins | 40 mA |
| DC Current on 3.3V Pin | 50 mA |
| Flash Memory | 32 KB (0.5 KB is used for Bootloader) |
| SRAM | 2 KB |
| EEPROM | 1 KB |
| Frequency (Clock Speed) | 16 MHz |

**Arduino UNO Pinout Configuration**

**Table 5: Arduino UNO Pinout Configuration.**

| Pin Category | Pin Name | Details |
|---|---|---|
| Power | Vin,<br>5V,<br>3.3V,<br>GND | **Vin:** Input voltage to Arduino when using an external power source.<br>**5V:** Regulated power supply used to power microcontroller and other components on the board.<br>**3.3V:** 3.3V supply generated by on-board voltage regulator. Maximum current draw is 50mA.<br>**GND:** ground pins. |
| Reset | Reset | Resets the microcontroller. |
| Analog Pins | A0 – A5 | Used to provide analog input in the range of 0-5V |
| Input/Output Pins | Digital Pins 0 - 13 | Can be used as input or output pins. |
| Serial | 0(Rx),<br>1(Tx) | Used to receive and transmit TTL serial data. |
| External Interrupts | 2, 3 | To trigger an interrupt. |
| PWM | 3, 5, 6, 9, 11 | Provides 8-bit PWM output. |
| SPI | 10 (SS),<br>11(MOSI),<br>12 (MISO) and<br>13 (SCK) | Used for SPI communication. |
| Inbuilt LED | 13 | To turn on the inbuilt LED. |
| TWI | A4(SDA),<br>A5(SCA) | Used for TWI communication. |
| AREF | AREF | To provide reference voltage for input voltage. |

### 3.8.8 Lcd display

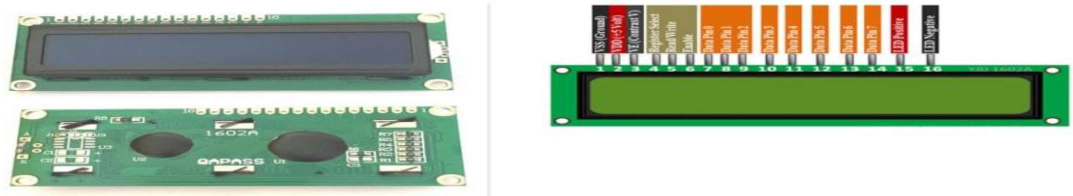


**Figure 3.14: 16x2 LCD Module**

**16x2 LCD Pinout Configuration [18]**

**Table 6: 16x2 LCD Pinout Configuration.**

| Pin No: | Pin Name: | Description |
|---|---|---|
| **1** | Vss (Ground) | Ground pin connected to system ground |
| **2** | Vdd (+5 Volt) | Powers the LCD with +5V (4.7V – 5.3V) |
| **3** | VE (Contrast V) | Decides the contrast level of display. Grounded to get maximum contrast. |
| **4** | Register Select | Connected to Microcontroller to shift between command/data register |
| **5** | Read/Write | Used to read or write data. Normally grounded to write data to LCD |
| **6** | Enable | Connected to Microcontroller Pin and toggled between 1 and 0 for data acknowledgement |
| **7** | Data Pin 0 | Data pins 0 to 7 forms a 8-bit data line. They can be connected to Microcontroller to send 8-bit data. These LCD's can also operate on 4-bit mode in such case Data pin 4,5,6 and 7 will be left free. |
| **8** | Data Pin 1 | |
| **9** | Data Pin 2 | |
| **10** | Data Pin 3 | |
| **11** | Data Pin 4 | |
| **12** | Data Pin 5 | |
| **13** | Data Pin 6 | |
| **14** | Data Pin 7 | |
| **15** | LED Positive | Backlight LED pin positive terminal |

**LCD Features and Technical Specifications**

- Operating Voltage is 4.7V to 5.3V
- Current consumption is 1mA without backlight
- Alphanumeric LCD display module, meaning can display alphabets and numbers
- Consists of two rows and each row can print 16 characters.
- Each character is build by a 5×8 pixel box
- Can work on both 8-bit and 4-bit mode
- It can also display any custom generated characters
- Available in Green and Blue Backlight

### 3.8.9 I2C Serial Interface Adapter Module for LCD

The control of an LCD screen might be difficult due to the few pins in a microcontroller/microprocessor. Serial to parallel adapters like the PCF8574 chip I2C serial adjuster facilitate the job with just two pins. The serial interface adaptor may be attached to a 16x2 LCD and offers two output signal pins (SDA and SCL) for MCU/MPU communications [19].

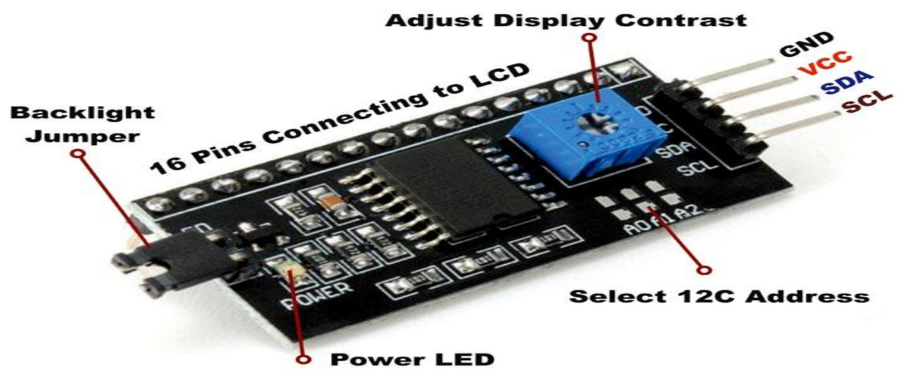



**Figure 3.15: I2C Serial Interface Adapter Module for LCD.**

**Features and Specifications of I2C Serial Interface Adapter Module**

This section mentions some of the features and specifications of the I2C Serial Interface Adapter Module.

- Operating Voltage: 5V DC
- 2C control using PCF8574
- Can have eight modules on a single I2C bus
- 2C Address: 0X20~0X27 (the original address is 0X20, you can change it yourself via the onboard jumper pins)

**Pin Configuration of I2C Serial Interface Adapter Module**

The module has multiple pins onboard for communication with the MCU/MPU via the I2C protocol. The table below shows the pin name, type, and their functions.

**Table 7: Pin Configuration of I2C Serial Interface Adapter Module.**

| Pin Name | Pin Type | Pin Description |
|---|---|---|
| GND | Power | Ground |
| VCC | Power | Voltage Input |
| SDA | I2C Data | Serial Data |
| SCL | I2C Clock | Serial Clock |
| A0 | Jumper | I2C Address Selection 1 |
| A1 | Jumper | I2C Address Selection 2 |
| A2 | Jumper | I2C Address Selection 3 |
| Backlight | Jumper | Control Backlight of panel |

### 3.8.10 Push Switch

Open push buttons frequently use tactile switches. Push buttons make connecting or power a circuit simply by pressing a button on the device. When pushed, it joins the circuit; when released, it disjoins it. A pushbutton may be utilized to turn on the SCR from the gate terminal as an additional option. These are the most often used controls on the electronic devices we use on a daily basis. A list of many applications for the Pushbutton may be found at the article's conclusion. [20].

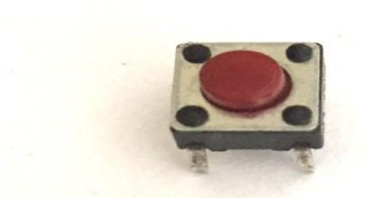
**Push Button Features**

- Prevent flux rise by the insert-molded terminal
- Snap-in mount terminal
- Contact Bounce: MAX 5mS
- Crisp clicking by tactile feedback
- Dielectric Withstanding Voltage 250V AC for 1 minute

**Technical Specifications**

- Mode of Operation: Tactile feedback
- Power Rating: MAX 50mA 24V DC
- Insulation Resistance: 100Mohm at 100v
- Operating Force: 2.55±0.69 N

➢ Contact Resistance: MAX 100mOhm
➢ Operating Temperature Range: -20 to +70 ℃
➢ Storage Temperature Range: -20 to +70 ℃



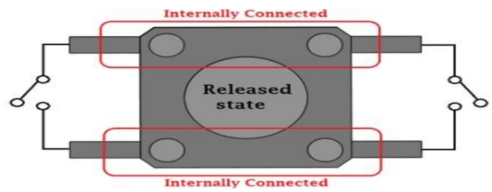



**Figure 3.16: Push Switch.**

### 3.8.11 INDUCTION MOTOR

An induction engine is a common electric AC motor (also known as an asynchronous motor). In an induction motor, the electric current required for the torque in the rotor comes from the spinning magnetic field winding of the stator by electromagnetic induction. A motor induction always operates slower than synchronous since the spinning magnetic field created in the stator generates a flow in the rotor that rotates the rotor.

**Figure 3.17: Induction Motor.**

### 3.8.12 Light

A device that converts energy into light consisting of a light source (an electric filament or one or more LEDs) contained within such a made of transparent shell, generally spherical and intended to fit into a socket on a lamp.

**Figure 3.18: Light.**

## 3.9 Software Requirements

➢ Arduino Software (IDE)

# Chapter 4
# Result And Discussion

## 4.1 Introduction

This chapter is all about our devices experiment and its results. We put our device in different situations to get data as much as possible.

## 4.2 Continuity Test

A continuity test was performed to determine if there was current flow in the project circuit and to discover electrical opening routes in the circuit after the soldering and configuration had been completed. A multimeter was used to evaluate the circuit continuity by measuring the electric current flow. A multimeter has been maintained in diode mode. The ground terminal of the multimeter is connected then to the ground Finally, both terminals are connected through the way to be monitored, and continuity exists inside the path. Test power was carried out to ascertain whether or not the voltage at different terminals complies with the criteria. A multimeter was switched in the voltage mode; notice that this analysis was conducted without the Arduino to ensure that high voltages did not harm the Arduino.

## 4.3 Displaying data in LCD Display

**Stage 1→ 80%**

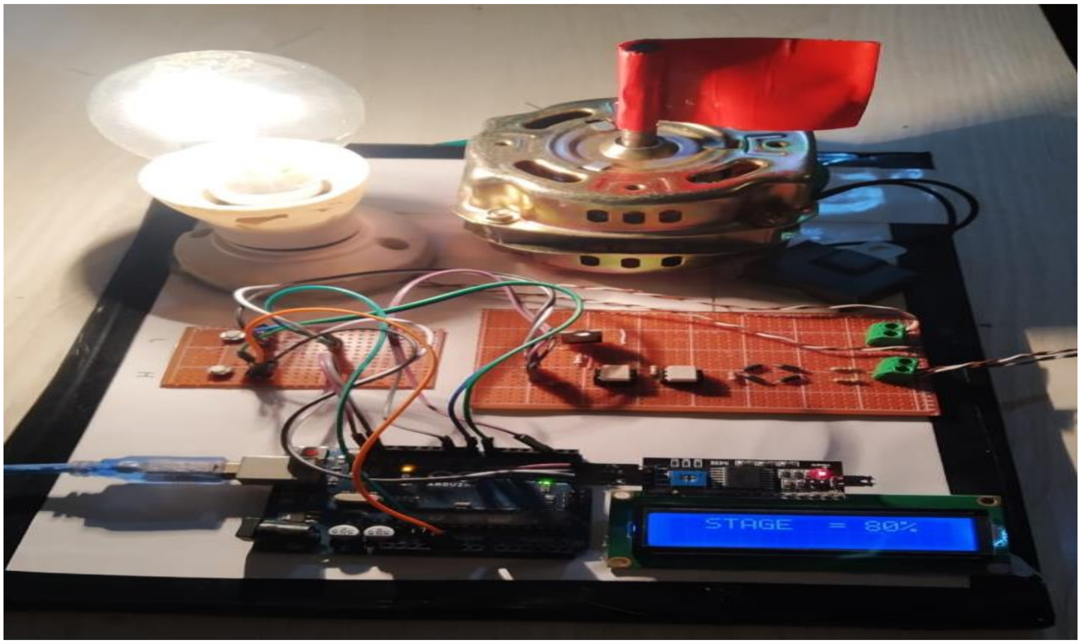



**Figure 4.1: Stage 1 → 80%.**

**Stage 2→ 60%**


**Figure 4.2: Stage 2→ 60%**

**Stage 3→ 40%**


**Figure 4.3: Stage 3→ 40%**

**Stage 4→ 20%**

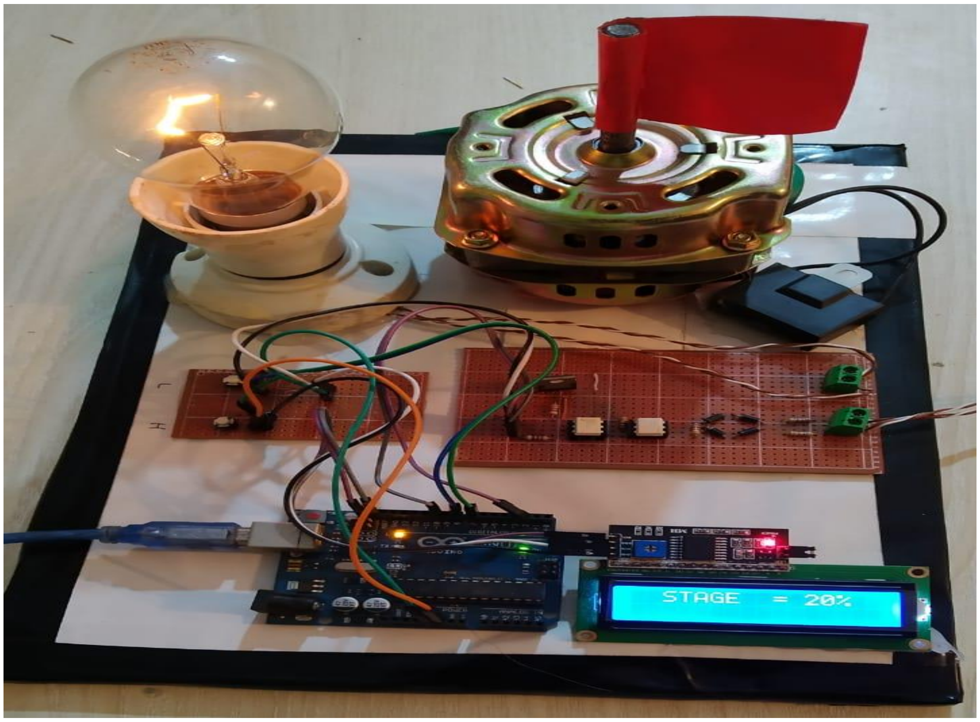



**Figure 4.4: Stage 4→ 20%**

**Stage 5→ 0%**

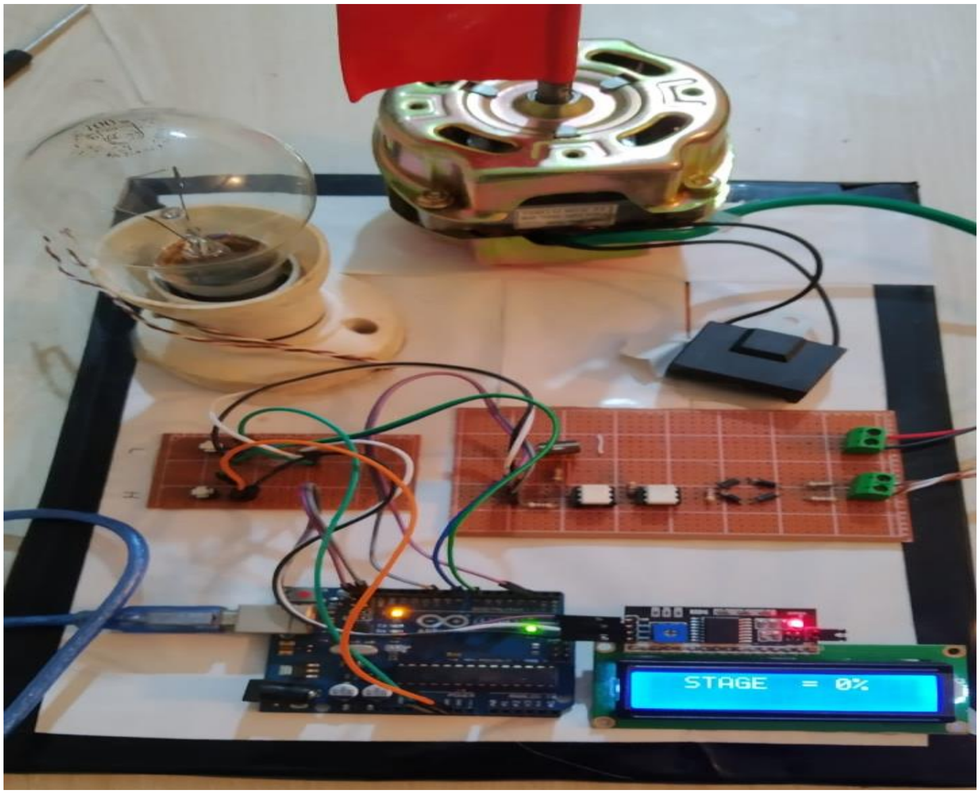



**Figure 4.5: Stage 5→ 0%**

## 4.4 Result

**Table 8.1: Push Switch 1: High to Low.**

| **PUSH Switch Position (1)** | **PUSH Switch Position (2)** | **PUSH Switch Position (3)** | **PUSH Switch Position (4)** | **PUSH Switch Position (5)** |
|---|---|---|---|---|
| It puts the voltage level at maximum value: 80%. | It puts the voltage level below higher value: 60%. | It puts the voltage level at middle condition: 40% | It Puts the voltage level at lower: 20% | It Shows the minimum voltage value: 0% |

**Table 8.2: Push Switch 2: Low to High.**

| **PUSH Switch Position (1)** | **PUSH Switch Position (2)** | **PUSH Switch Position (3)** | **PUSH Switch Position (4)** | **PUSH Switch Position (5)** |
|---|---|---|---|---|
| It Shows the minimum voltage value: 0% | It Puts the voltage level at lower: 20% | It puts the voltage level at middle condition: 40% | It puts the voltage level below higher value: 60%. | It puts the voltage level at maximum value: 80%. |

## 4.5 Cost Analysis

**Table 9: Cost Analysis of the Project**

| **Equipment name** | **Quantity** | **Price (BDT)** |
|---|---|---|
| Arduino UNO | 1 | 700 |
| Motor | 1 | 375 |
| Lcd Display | 1 | 215 |
| I2C Serial Interface Adapter Module for lcd. | 1 | 90 |
| BT 136 TRIAC | 1 | 25 |
| 4N35 IC | 1 | 20 |
| Diode | 4 | 20 |
| Push Switch | 2 | 10 |
| Resistor | 2 | 2 |
| | **Total** | **1457** |

## 4.6 Discussion:

AC voltage controller is a power electronic circuit in which fixed ac is converted to variable ac without changing the frequency. The converter circuit consists of TRIAC as switches and provides variable ac to the load. The most load needs variable or regulated ac power like welding, and a heating furnace requires variable ac supply. Ac voltage controllers are used to drive such loads. Usually, it takes the main supply as the inputs and provides variable ac to the load. While conventional regulators cannot accurately control AC voltage, the Integral Cycle Switching Method does so at any point during the cycle. The disadvantage of using AC Voltage Control in conjunction with On – Off-Cycle Control is that the control is not continuous. The Integral Cycle Switching Method, on the other hand, resolves this issue. In comparison to phase angle control, the integral-cycle control method minimizes electromagnetic interference and can process all of the benefits of zero-voltage switching techniques. Additionally, the cost of developing such a regulator is less for our project. The Integral Cycle Switching Method can protect devices from damage caused by sudden overheating in applications such as Induction Heating and Domestic Heating.

# Chapter 5
# Conclusion And Future Works

## 5.1 Conclusion:

An improved system is designed and implemented to control industrial power by using the Integral Cycle Switching method, which can continuously control any desired portion of the cycle at any time. The components of the industrial power system usually work at a much higher watt, and if the system is controlling rapidly, components can be affected. Through this Integral Cycle Switching Method, that problem can be handled smoothly. Furthermore, the proposed system eliminates the distortion of the controlling cycle of load from the primary input due to the use of a programmable ARDUINO UNO system. While typical regulators cannot control accurately, the Integral Cycle Switching Method can control accurately without harming the system devices. It can be applicable for controlling various types of power system in industries.

## 5.2 Future work:

This project can be modified by automatically adding system sensors to all actions. It could decrease and increase depending on the output temperature (load). In the future, we can implement it with an IoT system and operate it with a robotic system. Cycle modifications can also be observed directly on the CRO screen.

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# Appendix A

## Arduino Code of the proposed model:

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27,16,2);
#include <RBDdimmer.h>//https://github.com/RobotDynOfficial/RBDDimmer
//Parameters
const int zeroCrossPin  = 2;
const int acdPin  = 10;
int MIN_POWER  = 0;
int MAX_POWER  = 100;
int POWER_STEP  = 20;
const int button1 = 7;
const int button2 = 8;
int button1_state = 0;
int button1_last_state = 0;
int button2_state = 0;
int button2_last_state = 0;
int count=0;
bool bpress = false;
//Variables
int power  = 0;
//Objects
dimmerLamp acd(acdPin);
void setup(){
   lcd.begin();
  lcd.backlight();
  pinMode(button1,INPUT_PULLUP);
  pinMode(button2,INPUT_PULLUP);
//Init Serial USB
Serial.begin(9600);
```

```
Serial.println(F("Initialize System"));
acd.begin(NORMAL_MODE, ON);
lcd.setCursor (0,0);
lcd.print(" INTEGRAL CYCLE ");
lcd.setCursor (3,1);
lcd.print("SWITCHING.");
delay(3000);
}
void loop(){
  testDimmer();
}
void testDimmer(){/* function testDimmer */
////Sweep light power to test dimmer
button1_state = digitalRead(button1);
button2_state = digitalRead(button2);
if(button1_state != button1_last_state)
{
if(button1_state == LOW)
{
 if(power<=MAX_POWER){
 power+=POWER_STEP;
      acd.setPower(power); // setPower(0-100%);
      Serial.print("lampValue -> ");
      Serial.print(acd.getPower());
      Serial.println("%");
      delay(100);
      lcd.clear();
      lcd.setCursor(2,0);
      lcd.print("STAGE  = ");
      lcd.print(acd.getPower());
      lcd.print("%");
```

```
     bpress = true;
    power = power;
 }}
  else{
    } delay(50);
}
button1_last_state = button1_state;
if(button2_state != button2_last_state)
{
if(button2_state == LOW)
{
  if(power>=MIN_POWER){
    power-=POWER_STEP;
    acd.setPower(power); // setPower(0-100%);
     Serial.print("lampValue -> ");
     Serial.print(acd.getPower());
     Serial.println("%");
    delay(100);
       lcd.clear();
     lcd.setCursor(2,0);
     lcd.print("STAGE  = ");
     lcd.print(acd.getPower());
     lcd.print("%");
       bpress = true;
       power = power;
  }}
  else{
    }
    delay(50);
}
button2_last_state = button2_state;
}
```