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Design and Implementation of a Microcontroller based Automatic Changeover Switch

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Abstract— *Power-instability and phase-failure have presented a severe danger to India's economic progress. Many businesses, whether corporate, retail, or residential, rely on public power supplies that are irregular, such as phase-failure, phase-imbalances, or complete power outage, because of one or more technical problems during generation of power, transmission of power, or during distribution of power. Moreover, the manually replacement operation would take a long time. This indicates that the duration and procedure required for changing the phase can cause major damage to machinery and sometimes even products, as well as posing a hazard to the human's life when transitioning through one-phase to a better suited one. As a result, automating of phase-transition during phase-failure or total power loss is required to protect customer devices from erratic electrical supply. The following goals have been met: to create a better low-cost device designed to relieve the predominate responsibility confronted by sensitive industry sectors and organization's electrical equipment, to decrease the harm done to our home appliances, and to eliminate the loss of an individual life because of electric shocks from the conventional procedure of the manual selection of three-phases during high-voltage supply. If there is an electricity loss or extremely low-voltage in the phases whereby the load is attached, the system automatically shifts to the alternate phases that has voltage without turning off the electricity. The selector connects the loads to another phases and relays-switches, enabling use of the other-phases in the event of a power failure neither disrupting or stopping the loads. It ensures a stable energy source to overall workload by dynamically engaging the phases as needed. The proposed Automatic-Three-Phase Selector has the following specifications for power output, frequencies, voltage levels, and power output: power output=500W, frequencies=50Hz, voltage levels=12Vdc, and power output=18Vac. If consumers attach an electrical device to it, the equipment reduces the likelihood of electricity being entirely off in the event of an electricity outage in any particular-phase and reduces the latency required to transfer from one-phase to another-phase. Furthermore, it is advised that a software simulation of the architecture is created and simulated in order to facilitate additional study to evaluate the overall system performance.*

Keywords—*Power,Electrical, high-voltage,Automatic Three Phase Selector, frequency*

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I. INTRODUCTION

In India nowadays, the issues with electricity outages between phases are so prevalent that many delicate devices and electronics become redundant; this might occasionally be the reason for one phase to go out with regard to the other. It may surprise some to learn that so many inexperienced energy consumers have recently turned to some primitive methods of switching between phases to receive power in an effort to overcome these challenges. This conduct has resulted in the loss of so many people. Customers find this to be an unattractive situation, hence a system that can dynamically choose between the phase and ensure electricity supply accessible at the customer's interface has to be designed. This project, known as a three-phase automated phase selector, has been developed with the aim of resolving the issues mentioned above. Nevertheless, this can only be done if one has a three-phase meter or and there is selection supply from either of the service line or the complete line. The contactor arrangement, which serves as an example of electro magneto-dynamics, served as the foundation for the design and construction.A stop-by-step guide to the project's functioning is provided, and additional components include timers, small electrical systems, switching devices, and indicator lamps. The ease of use of the gadget has been carefully considered to guarantee simplicity. No project is without limitations and applications, thus we have also devoted a portion of this article to discussing these. In the event that there is a fault, to make it easier for specialists to restore the equipment. The gadget presents faults and how to fix them, however as there are no user-serviceable parts, all operation should be left to skilled electrical staff. This circuit will provide a resolution in this system if one or two-phases of a three-phase supply are interrupted or become low and you need your equipment to operate at normal levels. This method is made to keep track of the three-phases supply and to show the state of each-phase on an LCD. The project discussed here is a microcontroller-based automated phase changer project. In this project, a microcontroller is used to store, process, and modify data in accordance with user requirements. Because the CPU, memory, I/O ports, timers, counters, ADC/DAC, serial ports, interrupt logic, oscillator circuits, and many other functional blocks are all integrated into a single chip, the microcontroller, this is made feasible. As a result, hardware costs are decreased.

Additionally, no external RAM connection is required for memory storage. The microcontroller's most crucial characteristic is this. There are many different kinds of microcontrollers on the market. Examples include the IntelMCS-51, Microchip's PIC series, and the Atmel 89cxx and 89cxx51. Atmel's 89c52 microcontroller is the one utilized in this project. Nowadays, one out of every three-phases will frequently cut out, causing the circuit breaker to trip. In these situations, the MSEB Operator must manually reset the circuit breaker by turning on the during business hours, at which point the hooter will sound and inform us. We made the decision to create a system that would ultimately resolve these problems and aid in reducing human effort while also taking into account human daily life and the conditions that arise as a result of power instability problems. Second, to resolve the numerous phase transition problems and prevent harm to automation systems, hospitals, and airports.

II. LITERATURE SURVEY

A three-phase supply contains three power-generating coils linked together, either in a Y (star) arrangement or a delta design, with each coil physically offset by 120 degrees (Wong, 2016). Alternating current is the name given to three-phase electricity. Due to the fact that it is a less expensive and simpler means to carry electricity from one location to another, it is the most used distribution technique globally. Most households only utilize single-phase electricity, despite the fact that this kind of electrical transmission is common in institutional, commercial, and industrial power systems. When the current and voltage oscillate sinusoidally, there is a phase of alternating current. A phase is the up-and-down variations in voltage across a power producing coil over a certain time while the coil spins. One live wire travels to the load, and one return wire (neutral) returns to the power source, in a single-phase power supply (Wong, 2016).

Numerous negative consequences of voltage variations are brought on by loose and rusted interconnections on the phases. The voltage may be too low as a consequence of overloading, faulty connections, or electric shock. Voltage dips may thus happen when there is a decrease in the delivery of electrical energy and then it returns after a certain amount of time, and this could also be due to a defect. Due to the ability to transition to the subsequent phase in microseconds even before interrupted phase is restored, the phase selector is helpful in this situation. When there is a power failure on a line or phase, there is a high likelihood that there will be very brief interruptions. In these cases, the Automatic-Phase-Selector comes in handy because it also lessens the difficulties and problems and risks associated with unapproved workforce interference during a manual changeover. This may lead to electrocution, serious injuries, or even death. (Amol, 2015).

Oduobuk (2014) used an LM324 Quad Integrated Circuit to design and build an autonomous three-phase changer. When the three phase A.C inputs from the public utility supply—red, yellow, and blue phases—were fed to the system, the system compared the inputs with regard to phase imbalances, and the input with the highest voltage appeared across the output. The system was designed and simulated using the program (Multisim), and the results showed that. Additionally, it switches from one phase to another as soon as the circuit detects a new phase imbalance.

In 2017 (Ofualagba G.), conceived of and mimicked a 3-Phase Supply Automatic Phase Selector and ChangeoverSwitch. It offered a way to transition from one phase of the AC mains to another in the event that the current phase failed, and it also switched to a generator supply in the event that all three phases of the AC mains failed. The circuit also detects the return of any one of the three mains and changeover phases without any prior warning of a power interruption. One of four analog multiplexers (CD4052), an analog to digital converter (ADC0804), an AT89C51 microcontroller, and relay switches were used to create the system.

(Iwu, 2015), Designed and built an Automatic Three Phase Power System Selector that, in the event of a power loss or very low current in the phase to which the load is connected—even if the power is still on—automatically changes to the alternate phase with current. When there is a mains supply loss, the selector connects the load to the other phases and relay switches enable the use of the other phases without disturbing or halting the load. By automatically triggering the phases as needed, it keeps the load's power supply constant. This protects the electronics system against damage or burnout brought by voltage instability, collapse, and persistent outages, all of which are critical in emerging and underdeveloped nations.

In 2016 (Mr. LalitPatil), used an 89C52 microcontroller to design an automatic phase selector. The system suggested that three phase input lines (R, Y, and B) should utilize an appropriate rated fuse if the supply voltage is low. When the appropriate voltage is present, it seamlessly transitions to the next phase. Transformer and a relay comparator made up the circuit.

(NwaforChukwubuikem M., 2012) created a changeover system with a low-cost strategy. Using the solid-state relay (SSR), which completely removes the noise, arching, wear, and tear associated with electromechanical relays, the study analysed the techniques of establishing changeover systems and provided a better and more cost-effective solution. Microcontrollers and digital integrated circuits were employed to increase the system's speed while reducing the number of components. Along with other desired characteristics, the system contains a liquid crystal display (LCD) that makes it user-friendly, a generator failure warning system, an automated phase selector that chooses the best phase, and over-voltage and under-voltage level monitoring.

The researchers' system was restricted to obvious failure modes, such as heating problems inherent in solid-state solutions, as proposed by Nwafor (2012), and system instability problems inherent in the solution proposed by oduobuk (2014) because phase imbalances are a common occurrence in Nigeria, as confirmed by iwu (2015). As a result, the developed system will be switching too frequently, making it difficult for a user to fully utilize the power. This research was thus started in order to provide a straightforward method to switch to a new technology without having to deal with complicated phase imbalance management or heating issues in solid state solutions. A 3-phase automated change over with generator control mechanism was developed by Ezema et al. (2012) to choose between two available sources of power, providing priority to one of the two sources. This system was primarily concerned with seamlessly switching from the mainsto the generator and back again. The three phase supply's available phases were selected with little consideration.

A phase selector with options for a solar inverter and generator supply input was created by Ashish et al. (2015). Although multiple power sources were permitted, there was no way to identify the power source or the voltage of the three phases in this work. It took into account power accessibility rather than necessarily the quantity or caliber of available power.

Ezirim et al. (2015) developed an automatic phase selector using a relay with a contact that can carry 5 amps of current at 240 volts at 50 Hz and three-pole contactors with ratings of 50Hz, 240 volts each. The voltage present in these phases was not taken into consideration when designing the phase selector system; rather, it was only concerned with the availability of phases. Phase drop problems were not resolved because it will continue to supply a low phase even when higher phases are present. Instead of a microcontroller, this system relied on logic gates.

An automatic three-phase selector with improved power factor was built by Ajith et al. This technology was created to serve as an automated phase selector and as a tool to assess how efficiently electricity is being utilized in a power system. The highest phase was used for selection since the system had no fixed switching range. One of these voltages will be chosen and delivered to the load if the voltages of the three phases should fall below the voltage needed by the load. Electrical equipment may sustain harm as a result of this.

The continuous AC mains supply was obtained in the model created by Himadri and Sayan (2016) by automatically switching the load from the absent phase to the next available phase. The actual voltage delivered by the chosen phase was not taken into account in this study; just the availability of the phase was.

A PIC16F628 microcontroller was used in the design of a three-phase voltage selector by Lawal et al. (2017). Although the three-phase selector functions of this work were achieved, the switching range of selection is set at 180-220V, making range selection flexibility impossible without reprogramming the system.

In 2017 saw the design and simulation of an automatic phase selector and change-over switch for three-phase supply by Ofualagba and Udoha. This design was able to show the voltages that were available graphically, but it was unable to address the problem of an overvoltage supply since the microcontroller selects the highest phase, which may be greater than what is needed.

III. AUTOMATIC THREE PHASE SELECTOR

The Automatic-Three-Phase-Selector is a device that switches from the public supply to a generator if the other two phases' voltages are not available after being compared using a comparator circuit. It is an electrical circuit that can compare three phases and switch between them on its own. The automated three phase selector was not immediately put to action. In the past, users of electricity have always operated these stages manually. without knowing if the supply on theother-phases has a high voltage. The requirement for an automated phase selection of the phases then arose. An electrical gadget was conceived and built to execute the task swiftly and dependably so that this choosing or changing from one-phase to another could be done automatically and promptly. The tool gained the moniker "automated three-phase selection." Because it analyses input or phase-voltage and chooses the one with the best voltage value for supply and has the ability to switch to another-phase automatically if the current phase turns off, it is also known as a "intelligent phase selector." It consists of a transformer, a switching device (relays and relay drivers), a monitoring unit, a control unit, and the transformer. This transformer is a step-down kind that reduces 240 volts to 12 volts. It is supplied with various phase voltage, rectified, and smoothed before being fed into a voltage regulator with a positive output. The microcontroller was linked to the regulator outputs. In addition to controlling the result that flows from the generator, the monitoring unit also analyzes the three-phases and produces a single output. A control device that manages the circuit's functioning, relay drivers required to operate the relays used to switch on and off the generator and alternate among the two power sources.

A. Design of Automatic Phase Selector

A power supply application specific phase-selector is the automated phase-selector (APS). Automatic switching among the utility power source and an additional power supply is part of the system (generator). Its design made use of a variety of electrical components. Figure 1 depicts the overall architecture diagram of the built-in microcontroller-based automated three phase selector.

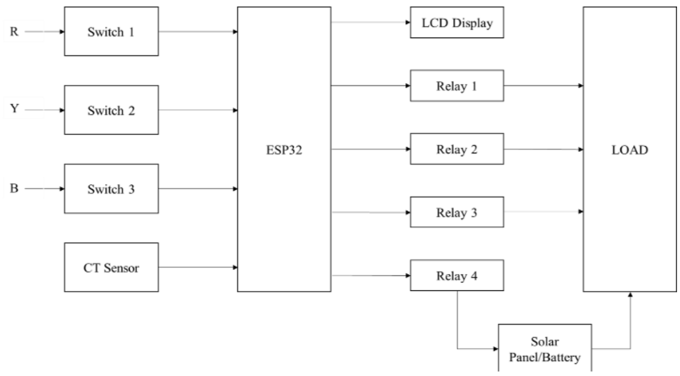

Figure 1: Architecture of the proposed Automatic Three Phase Selector

This picture shows how the system's many components have been put into practice. All of the modules are interconnected among themselves and are not reliant on external loads. The hardware and software make up the system's two main components. Phase-sensing, control-logic, a power supply, a display unit, a relay driver, and DC relays make up the hardware architecture. To perceive the availability of R, Y, and B phases, respectively, the phase-sensing circuit comprises sensors for R, Y, and B phases. For one of the three phases, the control logic circuit selects the phase priority [8]. Phase sensors, the control logic unit, and the relay driver sections are all powered by the power supply, and the relay is driven by the relay-driver section in accordance with the signalreceived from the control logic unit. Through the connections that are supplied from all three phases, the relay links the load to the best available phase. The rms voltage of the phase that is linked to the load is shown on the display unit.

The following is a quick summary of each part of the system:

a) Power Source: Alternating current makes up the majority of the supply supplied into the system (AC). In this module, the voltage level is reduced to the necessary level using a step-down transformer, and the alternating current must be converted into direct current using a rectifier (DC). The power supply also controls the D.C voltage needed by the integrated circuit and other system components. In order to power this device, a 50Hz ac signal from the main supply is fed into a 12V step-down transformer, which is then rectified and regulated into 5V and 12V DC supplies, respectively, for the microcontroller and a backup generator. By doing so, 230V AC is sent to the 5Vdc relay, which then powers the load. Additionally, a rectified step-down 5V DC is sent into the microcontroller in order to operate the relay module.

b) Phase detection unit: This component contains sensors that can detect the existence of the R, Y, and B phases of the supply, respectively. Which of the phases has supply is determined by this module. Potential dividing networks and a step down transformer (230V-12V) are employed to sense the phase voltage. In order to reduce the output voltage of the transformers to levels that the signal processor can safely handle, voltage division networks made of series-connected resistors are utilized (microcontroller). Here, the voltage divider circuit's output (Vo) is estimated to be simply 5 volts, therefore it is fed into the ARDUINO module's ADC section.

c) Control logic circuit: The control logic circuit primarily consists of a microcontroller, a processor with all of its support functions (clocking and reset), memory (both program storage and RAM), and I/O (including bus interfaces) incorporated into the gadget. For one of the three phases, the module determines the phase priority. The choice of the ATMEGA328P was made for its dependability, efficiency, affordability, and tiny footprint. The microcontroller has also been designed to function as a voltmeter, which measures voltages. This acts as the circuit's control component. With a power supply that is available, it looks for an active phase, signals it with the LCD and individual LEDS, and then sends a signal to the relay driver to turn on the individual relays. The circuit's distinctive feature is how the microcontroller and the relay driver synchronize the generator and each individual phase. Only output is linked to the load, regardless of the phase with the power source.

d) Switching Circuit: A relay module with four NPN transistors and a 5V DC configuration serves as the switching circuit. Relay-driver output is delivered to the interlocked relay, which switches the desired phase to the load while leaving the others unaffected since their terminals are not linked. Relay drivers have internal diodes built in to prevent inductive spikes from damaging the transistors in the relay driving circuits. According to the signal received from the control logic circuit, the relay module circuit operates the relay. The system links a normal phase to the load and primarily monitors a three-phase alternating current power supply. The microprocessor runs the relay and shuts its typically open contacts to connect any one of the three phases. In order to avoid short circuits on any of the phases in the event that any of the electrical components has a malfunction, three relays are supplied for phase switching. These relays are tightly interconnected.

e) Active phase indicator: This shows the phase when a power supply is available using three different coloured LEDs. There are red, yellow, and blue LEDs in it.

f) Display unit: To make it user-friendly, a liquid crystal display (LCD) is supplied to show all the measured electrical values to the connected load. A phase indicator is also offered to show the linked phase. The system primarily keeps an eye on the utility power supply and the generator while connecting the loads to the available supply.

g) Firmware: To create an embedded system for mains phase monitoring, load switching between phases, and the display of the voltage at the device's output, this study employed the C++ programming language on an ARDUINO module with an ATMEGA328P microcontroller.

Initially, PROTEUS simulation software was used to run the simulation. Both on a computer system and using the Arduino programming software, the microcontroller was programmed. An Electronic Design Automation (EDA) program called the PROTEUS design suite includes schematic capture and simulation PCB layout modules.

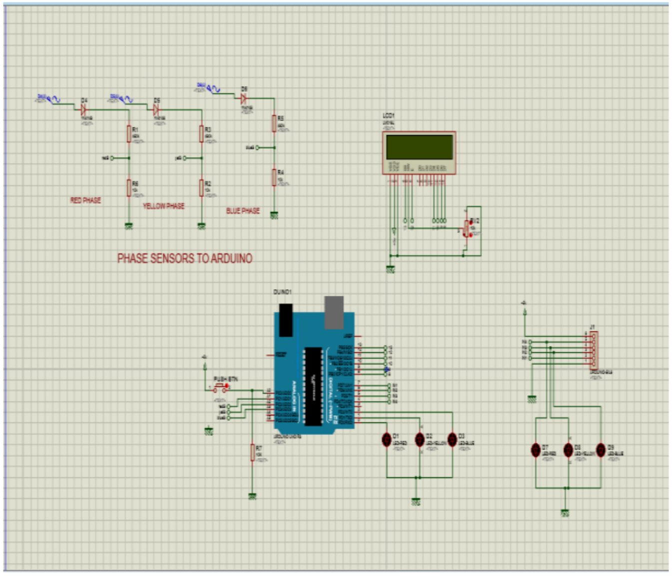

Figure 2. Circuit Diagram in Proteus

B. Flowchart

Figure 3 depicts the flowchart of the suggested model.

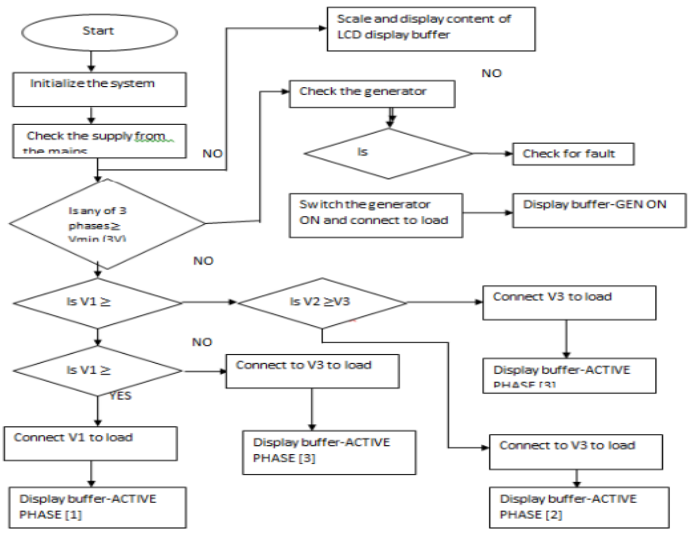

Figure 3. Automatic-Three-Phase-Selector Flowchart

IV. RESULTS AND DISCUSSION

The results have been showed below in the table.

Table 1. Output

R	Y	B	Output/Load Status
1	1	1	1
1	0	1	1
0	1	1	1
0	0	1	1
1	1	0	1
1	0	0	1
0	0	0	0

1→ON
0→OFF

0 →In this case Relay 4 will turn ON (Solar/Battery)

V. CONCLUSION AND FUTURE WORK

It is necessary to physically shift from the mains supply to the generators or vice versa after the power has been restored. The need for emergency operations in hospitals and airports to save lives as quickly as possible from generators makes it crucial to develop and build an automated change-over switch that would address the issue of the required manpower and potential hazard during the change-over. The electronic control keeps track of the voltage of the arriving electrical supply and notices when it falls below the point at which electrical devices may still operate. If voltage drop is accessible in any one phase of a three-phase system and we need our equipment to operate at standard voltage, our issue will be solved. As a result, it was intended to automatically choose any one phase while keeping the load constant.This automated three phase selector's development was engaging, fascinating, and difficult, but the true success of the project can only be gauged by how well it works and how consistently it does so. The work's utility values make it attractive to be built utilizing three stages, notably in all small residential facilities. In addition to assuring automated and effective household electrical load balancing from the consumer end, it also saves resources such as time, energy, and even lives.

The use of automatic phase changers is widespread nowadays. In the past, we had to manually switch to the available phase whenever one of the three phases had a power outage. Automatic phase changers automatically shift the phase to the accessible location for the current voltage. Hence, in future an Automatic-Phase-Changer can be built as a future work.

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