International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 10 | Oct - 2026 SJIF Rating: 8.659 ISSN: 2582-3930

Automatic Standby Generator Changeover Simulator Using Delta DVP12SA2 PLC.

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Abstract - The Automatic Standby Generator Changeover Simulator is a PLC-based automation system designed to demonstrate the automatic transfer of a simulated electrical load between the main power supply and a standby generator. The proposed system addresses the need for reliable power continuity by replicating common supply failure and restoration conditions in a controlled, low-voltage environment. A Programmable Logic Controller (PLC) acts as the central processing unit, monitoring inputs from mains availability switches, generator-ready switches, and Auto/Manual mode selectors. Based on predefined control logic, the PLC executes the changeover sequence, activates appropriate relay interfaces, and updates visual and audible indicators to communicate system status. The simulator incorporates start, stop, and reset controls, status LEDs, indicator lamps, and an optional LCD display for improved monitoring and user interaction. Interlocking logic prevents simultaneous selection of the simulated power sources, while alarm functions help identify abnormal operating conditions. The proposed prototype provides a cost-effective platform for understanding PLC programming, industrial control logic, relay interfacing, and power supply management. It is particularly suitable for Diploma-level Electronics and Telecommunication engineering laboratories, where students can investigate automation principles without exposure to hazardous mains voltages. The system offers a practical foundation for studying automatic changeover mechanisms and developing more advanced power management applications.

Key Words: Programmable Logic Controller (PLC), Automatic Changeover, Standby Generator, Power Supply Management, Industrial Automation, Relay Interlocking.

1.INTRODUCTION

Electrical power continuity is essential for residential, commercial, industrial, and institutional applications. Interruptions in the main power supply can affect equipment operation, production activities, communication systems, and overall operational efficiency. Standby generators are commonly used as alternative power sources during supply failures. To ensure a reliable transition between the main supply and a standby generator, an automatic changeover mechanism is required. Such systems detect the failure of the primary source and initiate a predefined sequence for transferring the load to the available backup source.

The **Automatic Standby Generator Changeover Simulator** is a PLC-based educational project developed to demonstrate the operating principles of an automatic power source transfer system. A Programmable Logic Controller (PLC) monitors the simulated mains status and generator readiness through digital input devices. According to the programmed logic, it controls relay interfaces and visual indicators to represent the selection of the appropriate power source. The system also incorporates Auto/Manual mode selection, Start/Stop controls, fault indication, and an optional LCD display for improved monitoring.

The proposed simulator emphasizes sequential control, input-output interfacing, interlocking logic, and fault indication. It provides a cost-effective platform for studying industrial automation and control system design. By using low-voltage switches and indicators to represent electrical supply conditions, the prototype enables students to understand changeover operations without directly handling hazardous mains voltage.

This project is particularly suitable for Diploma-level Electronics and Telecommunication engineering laboratories. It helps develop practical skills in PLC programming, relay interfacing, troubleshooting, and automation system implementation. Furthermore, the simulator can serve as a foundation for future development involving generator monitoring, programmable time delays, and advanced power management techniques.

2. Body of Paper

2.1 Overview of Automatic Changeover Systems

Automatic changeover systems are designed to maintain the continuity of electrical supply by transferring a load from a primary power source to an alternative source when the primary supply becomes unavailable. In a typical standby power arrangement, the main utility supply acts as the primary source, while a generator serves as the backup source. The system monitors the availability of both sources and executes the transfer according to predefined operating conditions.

Conventional changeover systems may use electromechanical relays, contactors, timers, and voltage-monitoring devices. Although these arrangements can perform basic switching operations, complex control sequences may require additional hardware and wiring. A Programmable Logic Controller (PLC) provides a flexible alternative because its control logic can be modified through programming. The proposed simulator demonstrates these principles using low-voltage switches, indicator lamps, and relay interfaces instead of actual power-source switching.

2.2 Review of Existing Approaches

Automatic power transfer can be implemented using relay-based circuits, microcontroller-based controllers, or PLC-based control systems. Relay-based systems are generally suitable for simple applications but may require extensive wiring when additional operating conditions and fault-handling functions are introduced.

Microcontroller-based systems offer compact implementation and can support digital monitoring, timing, and communication features. However, their development requires suitable electronic interface circuits and appropriate software design.

PLC-based systems are widely used in industrial automation because they provide programmable logic, modular input-output interfacing, and convenient troubleshooting. Changes in operating sequences can be implemented by modifying the program rather than extensively redesigning the hardware. For educational purposes, a PLC-based simulator allows students to study industrial control concepts through a practical, repeatable demonstration.

The suitability of each approach depends on application complexity, reliability requirements, available equipment, maintenance considerations, and cost. The proposed project focuses on demonstrating the PLC-based approach at a low-voltage prototype level.

2.3 Proposed System Architecture

The proposed system consists of input devices, a PLC controller, an output interface, and status indicators. Input devices provide information about the simulated mains supply, generator readiness, operating mode, and operator commands. The PLC processes these signals according to the programmed control sequence.

The output section includes relay interfaces, indicator lamps, LEDs, and an optional buzzer or LCD display. These components represent the operating status and simulated selection of the available power source.

The system can be divided into four functional sections:

1. **Input section:** Includes mains simulation, generator-ready, Auto/Manual, Start, Stop, and Reset switches.
2. **Processing section:** Uses the PLC to execute the programmed control logic and timing sequence.
3. **Output section:** Uses compatible relay interfaces and indicators to represent the selected source.
4. **Monitoring section:** Displays operating status and indicates simulated faults through LEDs, lamps, a buzzer, or an LCD.

This modular architecture simplifies testing, troubleshooting, and future modification.

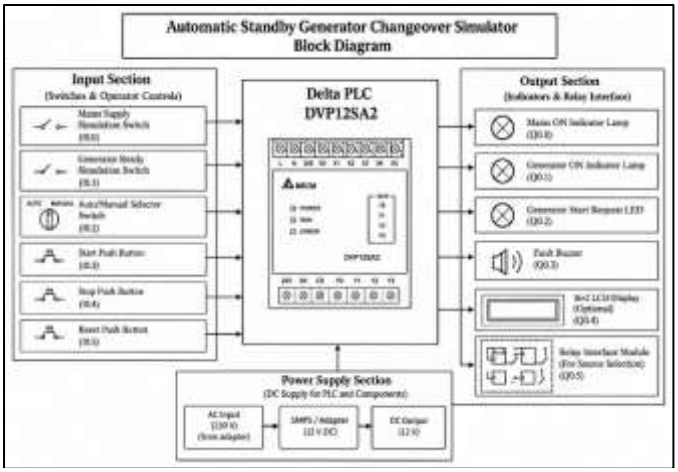


Fig: Block Diagram

2.4 Hardware Components and Their Functions

1. PLC (Programmable Logic Controller



Fig: PLC

The PLC is the main control unit of the Automatic Standby Generator Changeover Simulator. It continuously monitors the input signals from the mains supply simulation switch, generator-ready switch, and operating-mode selector. Based on the programmed logic, the PLC determines whether the simulated load should receive power from the mains or standby generator. It also provides interlocking to prevent both sources from being selected simultaneously. The PLC offers reliable operation, flexible programming, and easy troubleshooting. A PLC with at least four digital inputs and four digital outputs is suitable for this low-voltage educational prototype.

2. 12 V DC Power Adapter



Fig: 12V DC Power Adapter

The 12 V DC power adapter supplies regulated low-voltage power to compatible components in the simulator. It can power indicator lamps, relay modules, and other 12 V devices, depending on their electrical ratings. The adapter converts AC input into DC output suitable for the control circuit. Its current capacity must be sufficient for the combined load of all connected devices. Proper polarity, insulation, and overcurrent protection should be considered during installation. The PLC must be powered according to its manufacturer's specified voltage requirements, as some PLC models require a separate 24 V DC supply.

3. Mains Supply Simulation Switch



Fig: Mains Supply Simulation Switch

The mains supply simulation switch represents the availability or failure of the primary electrical supply. In the prototype, operating the switch generates a digital input signal for the PLC without connecting the circuit directly to actual mains electricity. When the switch indicates that mains power is available, the PLC keeps the simulated load connected to the primary source. When the switch indicates a mains failure, the PLC initiates the programmed standby-generator sequence. This component provides a simple and safe method for testing supply-failure conditions and demonstrating automatic changeover logic in an educational environment.

4. Generator-Ready Simulation Switch



Fig: Generator-Ready Simulation Switch

The generator-ready simulation switch represents the condition in which a standby generator has started and is ready to supply the load. In an actual system, generator readiness may be determined by voltage, frequency, and engine-status monitoring. In this educational simulator, a low-voltage switch provides the corresponding signal to the PLC. When mains power fails, the PLC waits for the generator-ready input before transferring the simulated load to the generator source. This component helps demonstrate generator-start delay, readiness verification, and changeover sequencing. It does not start or monitor a real generator.

5. Auto/Manual Selector Switch



Fig: Auto/Manual Selector Switch

The Auto/Manual selector switch allows the operator to select the operating mode of the simulator. In automatic mode, the PLC performs the programmed changeover sequence based on the simulated mains and generator conditions. In manual mode, the operator can initiate permitted control actions using push buttons or other designated inputs. The PLC program should maintain essential interlocking and prevent unsafe simultaneous source selection in both modes. This selector improves flexibility during demonstrations, troubleshooting, and testing. A suitable maintained-contact selector switch can be connected to a PLC digital input, provided its voltage and current ratings match the control circuit.

6. Start/Stop Push Buttons.



Fig: Start/Stop Push Buttons.

Start and Stop push buttons provide manual control over the simulator's operation. The Start button sends a command to the PLC to begin the programmed sequence, while the Stop button requests the system to stop or enter a defined safe state. The PLC reads these commands through its digital inputs and processes them according to the control program. Push buttons make the prototype easier to operate during laboratory demonstrations and testing. Normally open contacts are commonly used for Start, while Stop-button contact selection depends on the design. The software should define the Stop function clearly and retain necessary interlocking protections.

7. Reset Push Button



Fig: Reset Push Button

The Reset push button is used to clear a recoverable fault or return the simulator to its initial operating state after the relevant condition has been checked. When pressed, it sends a digital signal to the PLC, which executes the programmed reset sequence. This may include clearing an alarm indication, resetting a fault flag, or preparing the system for another test. Resetting should not automatically bypass interlocks or initiate an unsafe transfer. The PLC should first verify that the required operating conditions are satisfied. A reset button improves system usability and helps students test fault-handling and recovery procedures.

8. Relay Interface Module



Fig: Relay Interface Module

The relay interface module allows PLC output signals to control external low-voltage loads, such as indicator lamps or simulated contactor coils, when the module is compatible with the PLC. It provides an electrical switching interface and may offer isolation between the PLC output circuit and the controlled load. The relay coil voltage, contact ratings, and PLC output type must be checked before installation. In this project, relays can represent the selection of mains and generator sources without switching actual power supplies. Electrical interlocking or equivalent control logic should ensure that both source-selection relays cannot operate simultaneously.

9. 12 V DC Indicator Lamps



Fig: 12 V DC Indicator Lamps

The 12 V DC indicator lamps visually represent the availability of mains and generator supplies. One lamp can indicate that the simulated mains source is available, while another can indicate that the generator is ready or selected. The PLC or relay interface controls the lamps according to the system's operating conditions. These indicators help users understand the changeover sequence without needing additional monitoring instruments. Before connecting the lamps, their rated voltage, current consumption, and polarity requirements should be checked. Using low-voltage indicator lamps makes the educational prototype easier to demonstrate and reduces the risks associated with high-voltage electrical equipment.

10. Red, Green, and Yellow LED Indicators

LED indicators provide compact visual feedback about the simulator's operating status. A green LED may indicate normal mains availability, a yellow LED may represent generator operation or changeover in progress, and a red LED may indicate a simulated fault or supply failure. The exact meaning of each colour should be clearly labelled in the project. LEDs consume relatively little power and can be controlled through suitable PLC outputs or driver circuits. If bare LEDs are used, appropriate current-limiting resistors are required. The indicator logic should be designed so that the displayed status accurately reflects the programmed system conditions.



Fig: Red, Green, and Yellow LED Indicators

11. Buzzer



Fig: Buzzer

The buzzer provides an audible alert when a specified event occurs in the simulator. For example, it may sound when the mains supply is simulated as failed, when the generator is not ready within a programmed time, or when a fault condition is detected. The PLC activates the buzzer through a compatible output or relay interface. An audible alarm helps users identify abnormal conditions without continuously observing the control panel. The buzzer's voltage and current ratings must match the supply and switching circuit. The PLC program should include suitable alarm-reset logic to prevent unnecessary or continuous alarms after a fault has been acknowledged.

12. 16×2 LCD Display

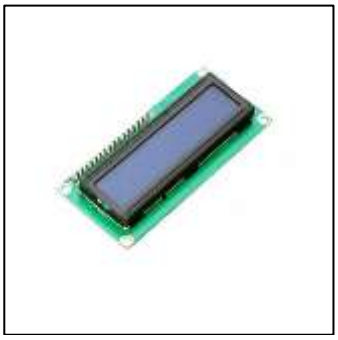


Fig: 16×2 LCD Display

A 16×2 LCD display can show the operating status and messages generated by the PLC or an associated controller. Example messages include “Mains Available,” “Mains Failure,” “Generator Ready,” and “Load on Generator.” The display improves the user interface by presenting system information in text rather than relying only on indicator lamps. Communication may require a compatible PLC interface, an expansion module, or an external microcontroller, depending on the hardware selected. The display must be powered and connected according to its specifications. Although optional, it can make the prototype more informative and useful for project demonstrations.

13. Terminal Blocks



Fig: Terminal Blocks

Terminal blocks provide secure and organized connection points for the electrical wiring of the simulator. They connect PLC inputs and outputs, push buttons, selector switches, relay modules, indicator lamps, and the power supply. Using terminal blocks simplifies circuit assembly, maintenance, testing, and troubleshooting. Each terminal should be labelled according to the wiring diagram to reduce connection errors. The terminal blocks must be suitable for the conductor size, rated voltage, and expected current. For an educational prototype, clearly arranged terminals also help students understand signal routing and control-circuit organization.

14. General-Purpose PCB

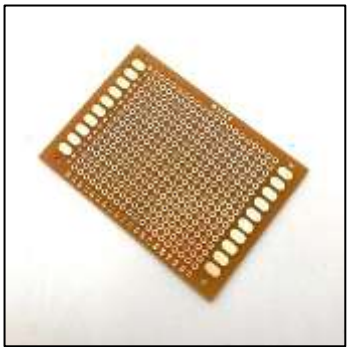


Fig: General-Purpose PCB

A general-purpose printed circuit board (PCB) or breadboard can be used to assemble low-voltage interface circuits and organize small electronic connections. A breadboard is suitable for temporary testing and demonstration, whereas a general-purpose PCB provides a more permanent arrangement. The board may hold LED resistors, connectors, and simple interface circuitry, depending on the design. The PLC itself and higher-current components should be mounted and wired according to their manufacturers' instructions. Proper insulation, spacing, and secure connections are important to minimize short circuits and loose wiring. The choice depends on the prototype's complexity and durability requirements.

15. Connecting and Jumper Wires

Connecting and jumper wires carry electrical signals and power between the PLC, switches, relays, indicators, and other components. They form the physical wiring network required for the simulator to operate. Wires should be selected according to the circuit current, voltage, conductor size, and installation method. Different colours can be used to distinguish supply, common, input, and output connections, provided a consistent wiring convention is followed. Connections should be secure and protected against accidental disconnection. Organizing and labelling the wiring makes the prototype easier to inspect, troubleshoot, and modify during project development.



Fig: Connecting and Jumper Wires

16. Acrylic Mounting Board

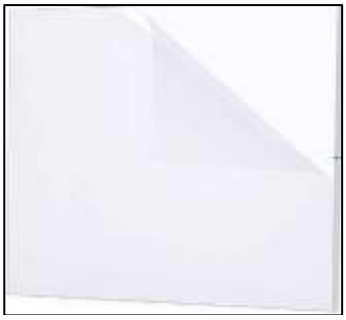


Fig: Acrylic Mounting Board

The mounting board provides a stable base for installing the PLC, switches, indicator lamps, relay module, terminal blocks, and display. Acrylic or plywood can be used for a low-cost educational prototype, depending on the required strength and finish. The board helps keep components arranged in a clear and accessible layout, making demonstrations and maintenance easier. Mounting holes, labels, and suitable cable-routing provisions can improve the overall appearance. Components should be fixed securely, and exposed conductive parts must be avoided or properly protected. The mounting board is intended for a low-voltage demonstration system, not as an enclosure for live mains wiring.

17. Labels and Wiring Accessories



Fig: Labels and Wiring Accessories

Labels and wiring accessories improve the safety, organization, and presentation of the simulator. Labels identify switches, indicator lamps, terminals, power supplies, and operating modes, helping users understand the control panel. Accessories such as cable ties, wire markers, mounting clips, insulating sleeves, and suitable fasteners keep wiring neat and reduce the risk of accidental disconnection. Proper labelling also supports troubleshooting and makes the prototype easier to maintain. The wiring diagram and physical labels should use consistent names for each input and output. These inexpensive items contribute significantly to the professional appearance and usability of the completed project.

2.5 Working Principle of the System

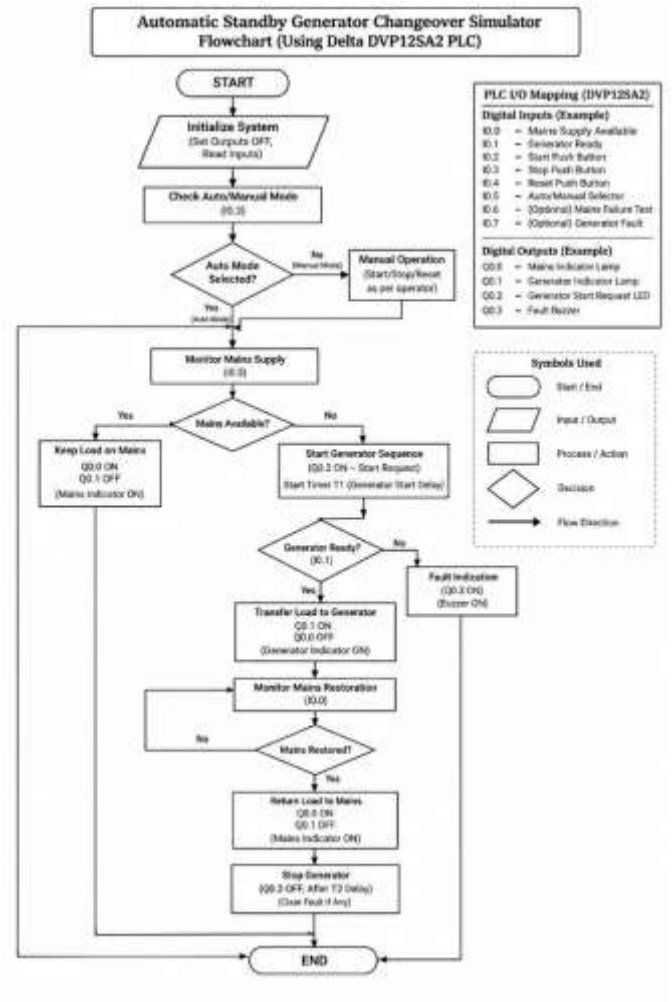


Fig: Flowchart

Under normal conditions, the mains simulation switch indicates that the primary supply is available. The PLC processes this input and activates the corresponding status indication. The simulated load is represented as being connected to the mains source.

When a mains failure is simulated, the PLC detects the changed input condition. It then initiates the programmed backup sequence and indicates that the generator is required. The generator-ready switch is operated to represent the availability of the standby source.

After receiving the generator-ready signal and satisfying any programmed delay or interlocking conditions, the PLC activates the generator-source indication. The simulator therefore represents the transfer of the load from the mains source to the standby generator.

When the mains supply is restored, the PLC detects the restoration signal and executes the programmed return sequence. Depending on the selected operating logic, the simulated load can be returned to the mains source after the required conditions are satisfied. The generator-source indication is then deactivated.

If the generator-ready signal is absent, the simulator can activate a fault indication and prevent the simulated transfer. The exact timing, alarm, and recovery behaviour depend on the PLC program.

2.6 PLC Control Logic and Interlocking

The PLC program forms the foundation of the simulator. It evaluates input conditions and determines which outputs should be activated. The control logic must consider mains availability, generator readiness, operating mode, operator commands, and fault conditions.

A basic control sequence can be represented as follows:

1. Initialize the system and verify the selected operating mode.
2. Monitor the mains simulation input.
3. If mains power is available, maintain the simulated mains-source selection.
4. If mains failure is detected, initiate the generator-required sequence.
5. Check the generator-ready input and any programmed delay.
6. If the generator is ready, select the simulated generator source.
7. If the generator is not ready, activate the appropriate fault indication.
8. When mains power is restored, execute the programmed return-to-mains sequence.
9. Update the status indicators and continue monitoring the inputs.

Interlocking is essential to prevent the mains-source and generator-source selection outputs from being activated simultaneously. The PLC program should incorporate mutually exclusive output conditions and a defined transition sequence. In actual power-transfer equipment, software logic alone is not a substitute for properly rated electrical and mechanical interlocking.

2.7 Testing and Performance Evaluation

The simulator can be evaluated by testing different operating conditions and observing the resulting PLC outputs. A test plan should include normal mains availability, simulated mains failure, generator readiness, generator-not-ready conditions, restoration of the mains supply, Auto/Manual mode selection, and fault-reset operation.

The observations should include the response of the status indicators, correctness of the changeover sequence, operation of the interlocking logic, and activation of fault alarms. Any timing delay programmed into the PLC should be measured and compared with the intended setting.

A test-results table can be included in the review paper with the following headings: *Test condition, expected response, observed response,* and *result*. Actual observations should be recorded during prototype testing rather than assumed in advance. Response time, sequence correctness, and fault handling can then be used to assess the effectiveness of the simulator.

2.8 Advantages of the Proposed System

The proposed simulator provides a practical way to understand automatic power changeover and PLC programming. Its principal advantages include programmable control logic, clear visual indication, simplified testing, and flexible modification of operating sequences. The use of simulation switches and low-voltage indicators reduces the hazards associated with direct exposure to mains voltage during laboratory demonstrations.

The modular arrangement also helps students understand input-output interfacing, relay operation, sequential control, and fault indication. Because the prototype can be developed using a PLC available in the institution's laboratory, the additional hardware cost can be reduced.

2.9 Limitations

The proposed prototype represents supply conditions through switches rather than measuring actual voltage and frequency. Similarly, the generator-ready condition is simulated and does not confirm the real generator's mechanical or electrical status.

The simulator therefore cannot independently verify generator starting performance, load capacity, voltage stability, or actual power-transfer safety. Its behaviour also depends on the correctness of the PLC program, wiring, and selected interface components.

A practical installation would require suitable voltage-monitoring devices, generator-start controls, rated transfer equipment, protective devices, and appropriate electrical and mechanical interlocking. These requirements are outside the scope of the low-voltage educational model.

2.10 Future Scope

The simulator can be enhanced by integrating voltage sensors, frequency monitoring, programmable transfer delays, and more detailed fault-detection logic. An LCD or human-machine interface could provide additional information about operating status and fault history.

Further development could include data logging, communication-based monitoring, and remote status reporting. Energy monitoring and automated event recording could also be explored to support advanced power-management studies.

These enhancements would extend the project's educational value and provide a foundation for studying more sophisticated industrial automation systems. Any development toward a real generator-transfer application would require a separate engineering design, suitable protection, and qualified installation.

2.11 Discussion

The proposed PLC-based simulator demonstrates how programmable control can coordinate the detection of supply conditions, simulated generator readiness, source selection, and fault indication. Compared with a basic manually operated arrangement, it provides a structured method for demonstrating repeatable changeover sequences and testing different operating scenarios.

Its primary contribution is educational rather than the direct provision of backup power. The project connects theoretical concepts of digital control and automation with practical hardware interfacing. The effectiveness of the prototype should ultimately be established through documented tests of sequence correctness, interlocking behaviour, and response to simulated faults.

3. CONCLUSIONS

The Automatic Standby Generator Changeover Simulator using the Delta DVP12SA2 PLC provides an effective platform for understanding automatic power transfer and industrial automation principles. The system demonstrates how a PLC monitors simulated mains supply conditions, verifies generator readiness, and controls source-selection indicators according to predefined logic. The integration of input switches, relay interfaces, indicator lamps, and fault alarms supports practical learning of PLC programming, sequential control, and input-output interfacing. The simulator offers a cost-effective and safer alternative for laboratory demonstrations because it represents power-source conditions using low-voltage components. Its modular design also allows future enhancements, including voltage monitoring, programmable time delays, event logging, and remote status indication. Overall, the project strengthens practical engineering skills and provides a foundation for studying advanced automatic transfer systems.

ACKNOWLEDGEMENT

We would like to express our sincere gratitude to our **Project Coordinator, Mr. M. N. Waghmode**, for his valuable guidance, continuous encouragement, and technical support throughout the preparation of this review paper on *"Automatic Standby Generator Changeover Simulator Using Delta DVP12SA2 PLC."*

We are also thankful to **Mr. N. E. Bhutekar, Head of the Electronics and Telecommunication (E&TC) Department**, for his valuable suggestions, academic guidance, and support.

We extend our sincere thanks to our respected Principal, **Dr. P. T. Kale**, Vice Principal, **Dr. M. S. Yadav**, and Academic Dean, **Dr. V. S. Dabhade**, for their encouragement and academic support.

We are grateful to all faculty members of the E&TC Department for their cooperation, technical assistance, and constructive suggestions. Finally, we thank **JSPM Bhivrabai Sawant Polytechnic, Wagholi, Pune**, for providing the necessary facilities and a supportive learning environment to complete this review paper successfully.

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