



Article Title: Automatic Phase Adaptation in Three Phase Supply for Online Inverter Systems

Automatic Phase Adaptation in Three Phase Supply for Online Inverter Systems

A. Geetha^{1,*}, R. Dinesh Kumar², K. Murali Krishna³, M. A. Vignesh⁴

^{1,*}Assistant Professor, Department of Electrical and Electronics Engineering, P. S. R. Engineering College, Sivakasi, India.

^{2,3,4}Student, Department of Electrical and Electronics Engineering, P. S. R. Engineering College, Sivakasi, India.

ABSTRACT

The project titled "Automatic Phase Adaptation in Three-Phase Supply for Online Inverter" introduces a novel solution for ensuring uninterrupted power supply, particularly in critical applications like medical equipment. Utilizing MATLAB function blocks, the system is designed to seamlessly manage phase transitions and control battery charging. In a three-phase four-wire supply system, the project comprises several essential components. The "AC Supply Sensing Block" continuously monitors the voltage levels of the three-phase supply, providing real-time data on power quality. The "MATLAB Function Block" interprets the data from the sensing block to control circuit breakers, regulating the online inverter's battery charging process. The "Online Inverter Battery Charging Block" effectively charges the battery using a buck converter, guaranteeing a stable and dependable power source. The "Circuit Breaker Block" selects the most reliable power source, receiving commands from the MATLAB function block, ensuring seamless transitions. Meanwhile, the "SoC (State of Charge) Block" manages the battery's state of charge to maintain safe operating levels. The "Inverter Block" converts DC power into AC power, making it suitable for powering high-priority medical equipment, thus ensuring a consistent and uninterrupted power supply. This project's integrated approach aims to provide a robust and intelligent solution that automatically adapts to varying power conditions, addressing the critical need for reliable, uninterrupted power in the medical field, ultimately contributing to enhanced patient care and potentially saving lives.

Keywords: MATLAB Function Block, SoC (State of Charge) Block, Inverter Block, DC power, AC power.

1 Introduction

In today's digital and technology-driven world, the reliable and uninterrupted supply of electricity is paramount, particularly in critical sectors such as healthcare. The need for continuous and high-quality power sources has become increasingly evident with the proliferation of life-saving medical equipment and devices. The project "Automatic Phase Adaptation in Three-Phase Supply for Online Inverter" seeks to address this vital requirement by developing an intelligent and autonomous power management system. By utilizing



Article Title: Automatic Phase Adaptation in Three Phase Supply for Online Inverter Systems

advanced MATLAB function blocks; this project endeavors to create a seamless and dependable power supply solution for applications that cannot afford even the briefest power interruptions.

In a three-phase four-wire supply system, the project integrates several key components to achieve its objectives. These components include the "AC Supply Sensing Block," which constantly monitors the voltage levels of the incoming three-phase supply. This real-time monitoring provides essential data on the quality and reliability of the power source. The "MATLAB Function Block" then interprets the data from the sensing block, making real-time decisions and controlling the circuit breakers to manage the online inverter's battery charging circuit. The "Online Inverter Battery Charging Block" plays a crucial role in efficiently and effectively charging the battery with the assistance of a buck converter. This ensures a stable and dependable power source, particularly for life-critical applications. The "Circuit Breaker Block" further enhances system reliability by selecting the most dependable power source, responding to commands from the MATLAB function block, and facilitating seamless transitions as needed. Managing the state of the battery, the "SoC (State of Charge) Block" ensures that the battery operates within safe and optimal levels. Finally, the "Inverter Block" converts DC power into AC power, making it suitable for powering high-priority medical equipment without disruption, ensuring continuous patient care.

This project aims to provide an integrated and intelligent solution for automatically adapting to varying power conditions, offering a reliable and uninterrupted power supply. The healthcare sector, in particular, stands to benefit significantly from this innovation, as it ensures the continuous operation of life-saving medical devices, potentially saving lives and improving patient outcomes. This project is a significant step towards enhancing power reliability in critical applications, addressing a fundamental need in our modern society.

In our modern world, the uninterrupted supply of electricity is a fundamental necessity, especially in sectors where even the slightest power interruption can have life-threatening consequences. The healthcare industry, in particular, relies heavily on a continuous and high-quality power source to ensure the seamless operation of life-saving medical equipment. The project titled "Automatic Phase Adaptation in Three-Phase Supply for Online Inverter" is designed to meet this critical need by developing an intelligent and autonomous power management system. Leveraging the advanced capabilities of MATLAB function blocks, this project aims to create a comprehensive and reliable power supply solution for applications where power continuity is non-negotiable.

2 Related Work

This section presents the review of similar work done and highlighted different approaches that have been adopted to achieve automatic phase selection for three-phase power supply. Kyereh, et al [1] reported that the ability to supply reliable power to consumer loads is a



Article Title: Automatic Phase Adaptation in Three Phase Supply for Online Inverter Systems

major aim of the utility company. Based on technological advancement, various theories have been implemented to design different kinds of means to attain automatic means of healthy phase selection in times of fault. Therefore, a real-time automatic phase selector was designed using logic gates and power electronic devices. Miniaturization of digital circuits and scalability of other electronic circuits are, therefore, recommended to improve upon the designs and development. Oduobuk, et al [2] reported that, the automatic phase changer was made from several electronic components which include; operational amplifiers, diodes, resistors, capacitors, Zener diodes transformers, relays and fuses. Results obtained during the test showed that whenever the system senses a higher voltage across at least one of the three inputs, it then engages the load. The system was designed to handle low power load and not high power loads. Also, system reliability, compatibility, and durability in this work were not considered. Nweke et al [3] noted that the automatic three phase power system selector was designed and constructed to automatically switch over to the alternative phase that has current when there is power outage or extremely low current in the phase which the load is connected without the power being off. The selector links the load and the other phases and relay switches allowing the usage of the remaining phases where there is outage on the mains source without disturbing or interrupting the load. It maintains constant power supply to the load by automatically activating the phases when the need arises. This safeguards the electronics system from being damaged and burnout as a result of voltage instability, collapse, insistent outages which are paramount in under developed and developing countries. Bhise et al [4] observed that in many cases we have three phase supply where only single phase is used to run the equipment such as load of Operation Theater in hospitals, commercial Internet servers. By the use of proper relay logic, available phase can be automatically selected and avoid the short circuit condition between the different phases. This could be realized by using electrical component such as transformer, under voltage, overvoltage protection and relay switches. As reported by Lawal et al [5], the variation in voltage level per phase in a three-phase supply circuit posed challenges in industrial power system. Hence, the need for the design of a system to check the availability of any live phases, and connects the load to the available live phase only. This feat was achieved with microcontroller (PIC16F628). Ofualagba, et al [6] proposed the design and construction of automatic phase selector and changeover switch for 3-phase power supply to provide a means of switching from one phase of AC mains to another in the case of failure in the existing phase. It also change over to generator if there is failure in all the three phases of the AC mains. The circuit also senses the restoration of any or all the three phases of the mains and changeover without any notice of power outage. The project was aimed at improving on the existing types of electromechanical device that has being in use over the years. The proposed system was realized by the use of 1- of - 4 analogue multiplexers (CD4052), analogue to digital converter (ADC0804), AT89C51 microcontroller and relay switches.



Article Title: Automatic Phase Adaptation in Three Phase Supply for Online Inverter Systems

Dowuona et al [7] found out that emergency power systems were used as early as World War II on naval ships. In combat, a ship may lose the function of its steam engines which powers the steam driven turbines for the generator. In such situations, one more diesel engine was used to drive backup generators. Early changeover switches relied on manual operation: two switches would be placed horizontally in line and the “ON” position facing each other, with a rod placed in between them. In order to operate the changeover switch, one source must be turned OFF, the rod moved to the other side and the other turned on. The “Automatic Voltage Regulator” system developed by Steven. M Hietpas [8] using ac voltage – voltage convertor which load great flexibility in the voltage regulation for power distribution systems but had high complexity. Gua-kiang Huang, Chih-Chang Chang [9] then developed a system named as Automatic Phase Shift Method for finding Detection of Grid Connected Photo Voltaic inverter using photo-voltaic inverter but the statistical analysis were complicated to achieve in single detection.

Another system named as “Grid Current Regulation of a three Phase Voltage Source Inverter with LC Input Filter” in 2003 developed by Twining. Erikan [10] may use simple series inductor as the filter interface between VSI and Grid network but due to harmonic distortion it does not proved to be more advantageous. Then the next system was proposed by Mariuz Malinowkshi et al [11] named as “Simple Direct Power Control Of Three Phase PWM Rectifier Using Space Vector Modulation(DPC-SVM) in April 2004 but due to variable switching frequency and violation in polarity there was a need to design such a system which would overcome all of above system drawbacks.

3 Proposed Methodology

The proposed system, "Automatic Phase Adaptation in Three-Phase Supply for Online Inverter," represents a cutting-edge solution designed to tackle the critical issue of uninterrupted power supply, with a particular emphasis on the healthcare sector. In healthcare facilities, where even the briefest power interruption can have life-threatening consequences, this system offers a robust and autonomous power management solution. Its core strength lies in its ability to seamlessly adapt to varying power conditions, including phase variations, voltage fluctuations, and power outages, all while taking into account the unpredictable impact of adverse weather events. This system integrates an array of hardware components, including the AC Supply Sensing Block and MATLAB Function Block, to continuously monitor power quality and make real-time decisions based on the data received. It incorporates adaptive phase control algorithms, enabling it to swiftly and intelligently respond to phase variations without any disruptions. Moreover, the system is equipped with weather-responsive features, proactively anticipating and responding to adverse weather conditions, such as storms, by switching to alternative power sources like backup generators or energy storage systems.



Article Title: Automatic Phase Adaptation in Three Phase Supply for Online Inverter Systems

Efficient battery charging, facilitated by buck converters, ensures that the battery remains charged and ready to step in during power interruptions, guaranteeing a stable power supply. The integration of MATLAB Function Blocks empowers the system with real-time monitoring, control, and decision-making capabilities. It also manages the battery's state of charge effectively, prolonging battery life and optimizing its performance. Furthermore, the system explores the integration of smart grid and microgrid technologies, automatically switching to alternative power sources during grid outages and adverse weather events.

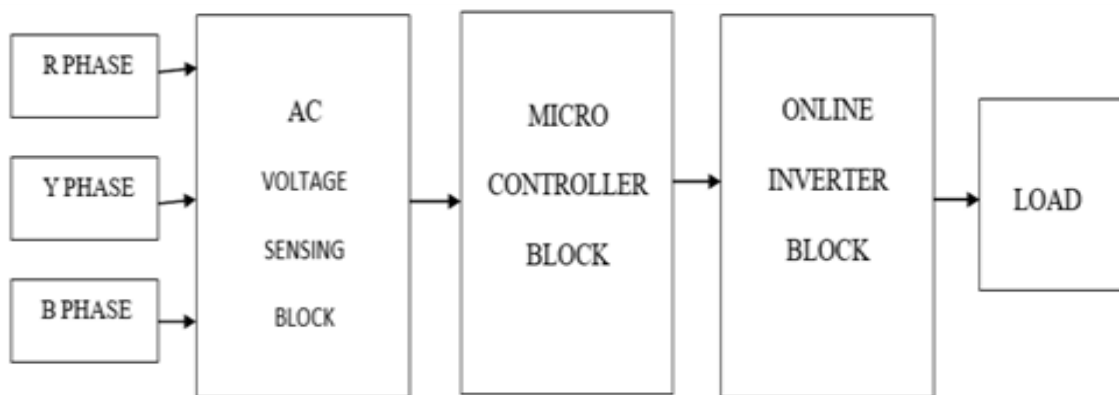


Figure 1: Block diagram of the proposed methodology

The block diagram for the "Automatic Phase Adaptation in Three-Phase Supply for Online Inverter" project offers a detailed representation of the system's architecture and how its components interact to ensure a seamless and uninterrupted power supply, especially in healthcare settings. At the core of the system is the MATLAB Function Block, which serves as the central control unit. This block receives real-time data from the AC Supply Sensing Block, which continuously monitors the voltage levels of the incoming three-phase supply. The MATLAB Function Block processes this data using advanced algorithms to make instantaneous decisions based on the quality and stability of the power supply. It then sends control commands to other components in response to changing conditions, ensuring a swift and adaptive system response. The Online Inverter Battery Charging Block is pivotal for maintaining a stable power source. It efficiently charges the battery with the assistance of a buck converter, which optimizes the battery's charging process, making it ready to provide power during any disruptions in the main power supply. The Circuit Breaker Block acts as a crucial component for seamless transitions between power sources. It receives commands from the MATLAB Function Block, allowing it to select the most reliable source of power. This is particularly vital during power outages or fluctuations, where a swift change to an alternative power source can prevent downtime in critical applications. The State of Charge (SoC) Block manages the battery's state of charge, ensuring it remains within safe operating levels. This optimized SoC management prolongs the battery's lifespan and



Article Title: Automatic Phase Adaptation in Three Phase Supply for Online Inverter Systems

guarantees its consistent performance. Finally, the Inverter Block converts the DC power supplied by the battery in to AC power. This AC power is essential for driving high-priority medical equipment, ensuring uninterrupted patient care. The interconnected lines and arrows in the block diagram signify the flow of information and control signals between these components, demonstrating how they work harmoniously to create an intelligent and autonomous power management system. This system is engineered to adapt to changing power conditions, including phase variations, voltage fluctuations, and power interruptions, offering an uninterrupted and dependable power supply. In critical applications like healthcare, where patient care and safety depend on the reliability of power, this system represents a significant advancement in ensuring continuous and reliable energy supply. At the core of the system is the MATLAB Function Block, which serves as the central control unit. This block receives real-time data from the AC Supply Sensing Block, which continuously monitors the voltage levels of the incoming three-phase supply. The MATLAB Function Block processes this data using advanced algorithms to make instantaneous decisions based on the quality and stability of the power supply. It then sends control commands to other components in response to changing conditions, ensuring a swift and adaptive system response.

3.1 Circuit operation and working

The operation and working of the "Automatic Phase Adaptation in Three-Phase Supply for Online Inverter" system can be explained in detail. The AC Supply Sensing Block continuously monitors the voltage levels of the incoming three-phase supply. It senses variations, fluctuations, and phase imbalances in the power supply. The MATLAB Function Block serves as the central decision-making unit of the system. It receives real-time data from the AC Supply Sensing Block. Based on this data, it assesses the quality and stability of the power supply. If it detects any anomalies, such as phase variations or voltage fluctuations, it makes immediate decisions and sends control commands to other system components. When the MATLAB Function Block identifies power supply issues or adverse weather conditions, it may instruct the Online Inverter Battery Charging Block to activate the buck converter. The buck converter efficiently charges the battery, ensuring it remains at an optimal state of charge. This step is crucial to maintain a stable power source for critical applications. The Circuit Breaker Block receives commands from the MATLAB Function Block. If the system detects a power outage, unstable power supply, or phase variations, it can command the Circuit Breaker Block to switch to an alternative power source, such as a backup generator or an energy storage system. This quick response ensures that the power supply remains uninterrupted and stable. The State of Charge (SoC) Block manages the battery's state of charge. It ensures that the battery operates within safe and optimal levels, preventing overcharging or discharging. Maintaining the battery's SoC at the

Article Title: Automatic Phase Adaptation in Three Phase Supply for Online Inverter Systems

right level is essential for prolonged battery life and consistent performance. The Inverter Block plays a crucial role in converting the DC power supplied by the battery into AC power. This AC power is used to drive high- priority medical equipment and other critical loads. The Inverter Block ensures that these devices receive a continuous and uninterrupted power supply.

In summary, the system operates by continuously monitoring the incoming power supply through the AC Supply Sensing Block. The MATLAB Function Block acts as the system's brain, making real-time decisions based on the power conditions it detects and instructing other components to adapt as needed. This adaptation includes efficient battery charging, circuit breaker control, SoC management, and DC to AC power conversion. The system's ability to respond to changing power conditions and its weather-responsive features make it a reliable and adaptive solution for ensuring uninterrupted power supply in critical applications.

4 Results and Discussion

4.1 Simulation Diagram

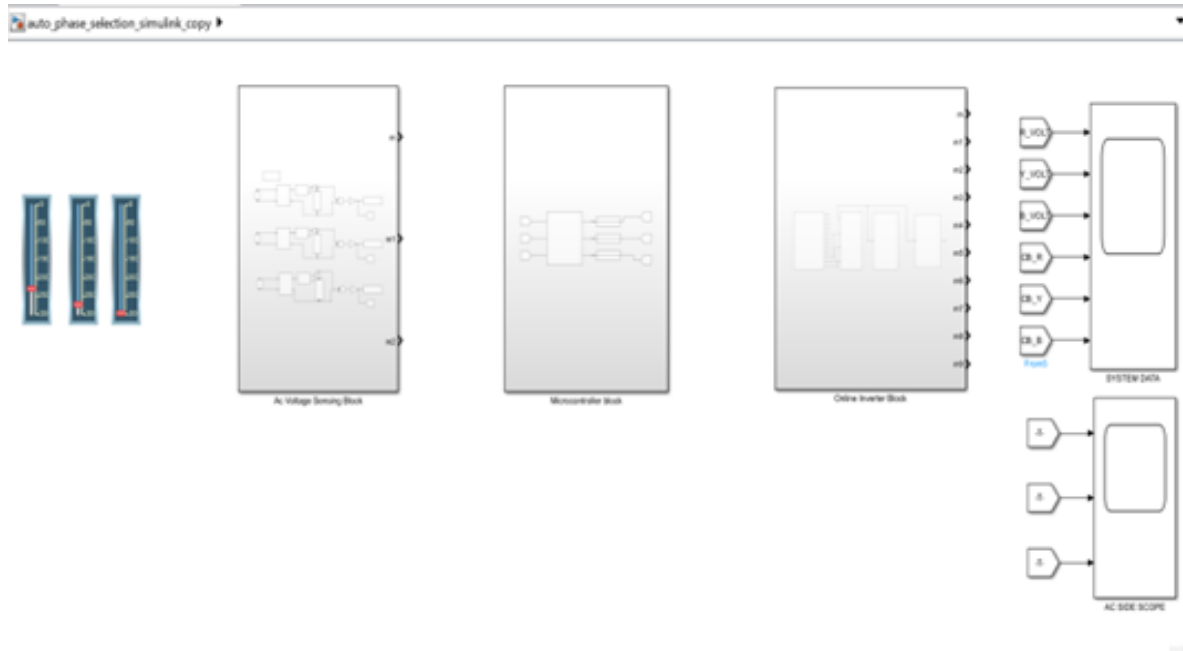


Figure 2: Simulation Diagram



Article Title: Automatic Phase Adaptation in Three Phase Supply for Online Inverter Systems

4.2 Auto Phase Selection Simulation Block

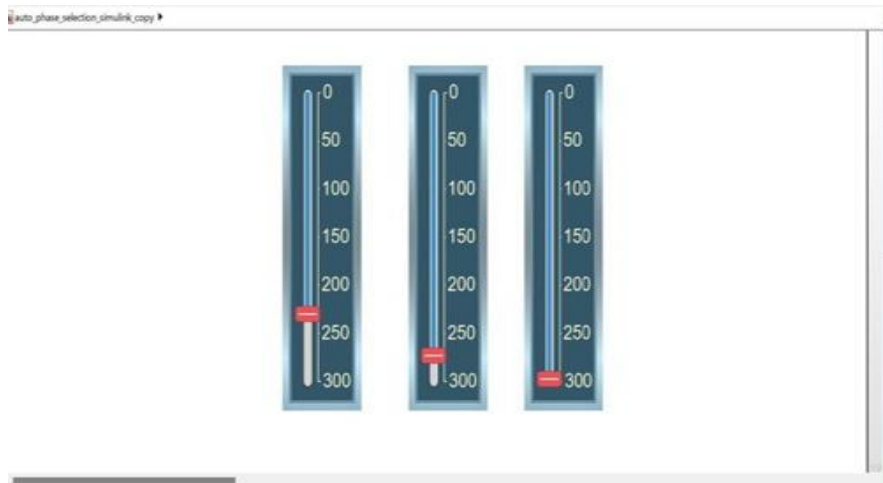


Figure 3: Auto phase selection block

4.3 AC Voltage Sensing Block

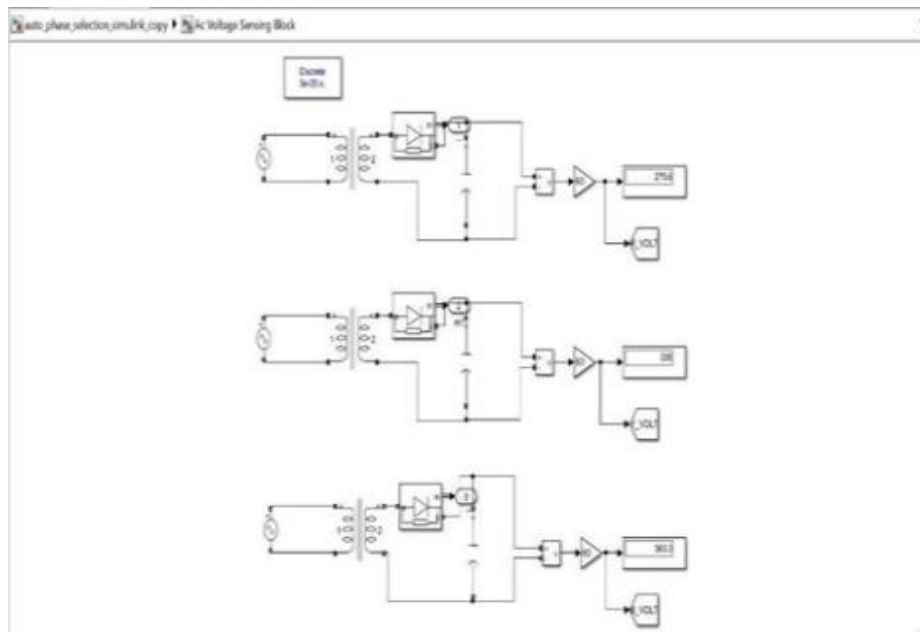


Figure 4: AC voltage sensing block



Article Title: Automatic Phase Adaptation in Three Phase Supply for Online Inverter Systems

4.4 Microcontroller Block

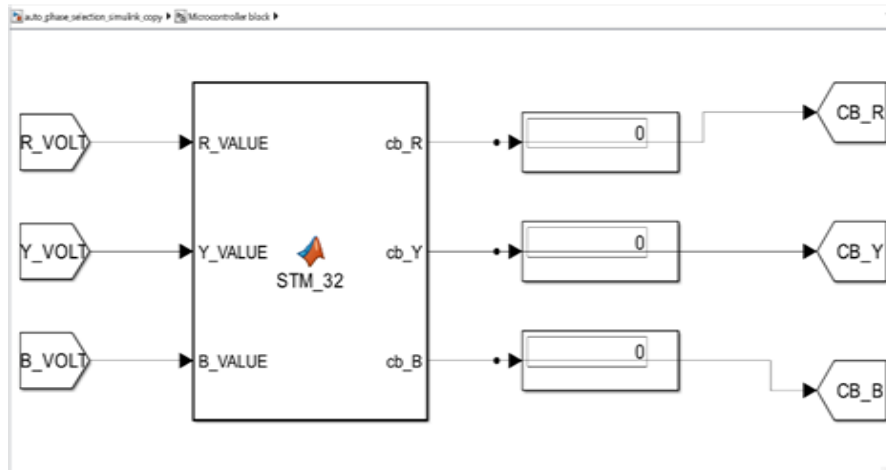


Figure 5: Microcontroller Block

4.5 Microcontroller Code

```

1
2 function [cb_R,cb_Y,cb_B] = STM_32(R_VALUE,Y_VALUE,B_VALUE)
3
4 if(R_VALUE >= 200 && R_VALUE <= 240)
5
6     cb_R=1;
7     cb_Y=0;
8     cb_B=0;
9
10
11 elseif (Y_VALUE >= 200 && Y_VALUE <= 240)
12
13     cb_R=0;
14     cb_Y=1;
15     cb_B=0;
16
17
18 elseif (B_VALUE >= 200 && B_VALUE <= 240)
19
20     cb_R=0;
21     cb_Y=0;
22     cb_B=1;
23
24 else
25
26     cb_R=0;
27     cb_Y=0;
28     cb_B=0;
29
30
31 end
    
```

Figure 6: Microcontroller code

Article Title: **Automatic Phase Adaptation in Three Phase Supply for Online Inverter Systems**

4.6 Online inverter block

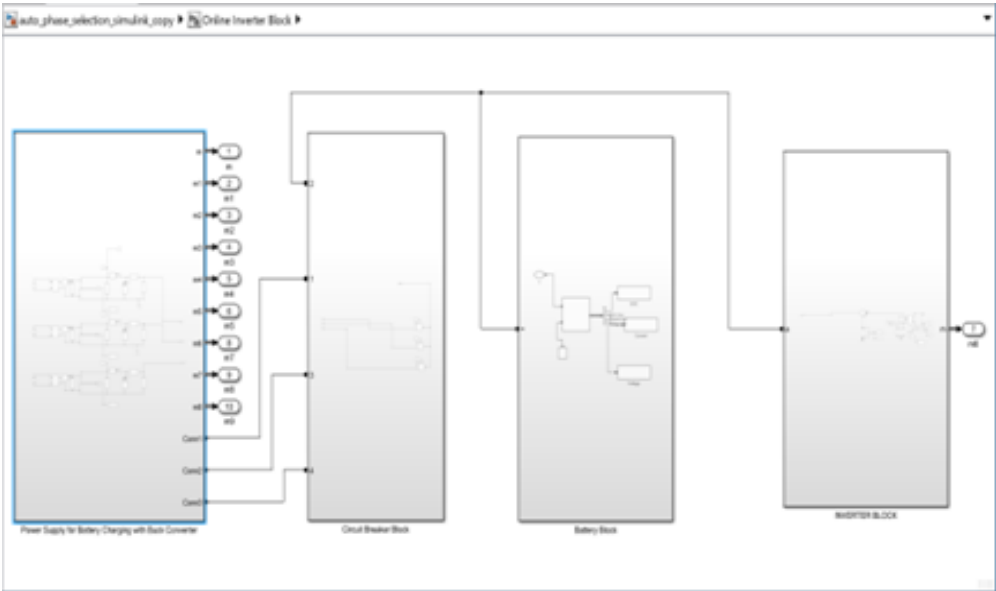


Figure 7: *Online Inverter Block*

4.7 Power Supply for Battery Charging with Buck Converter

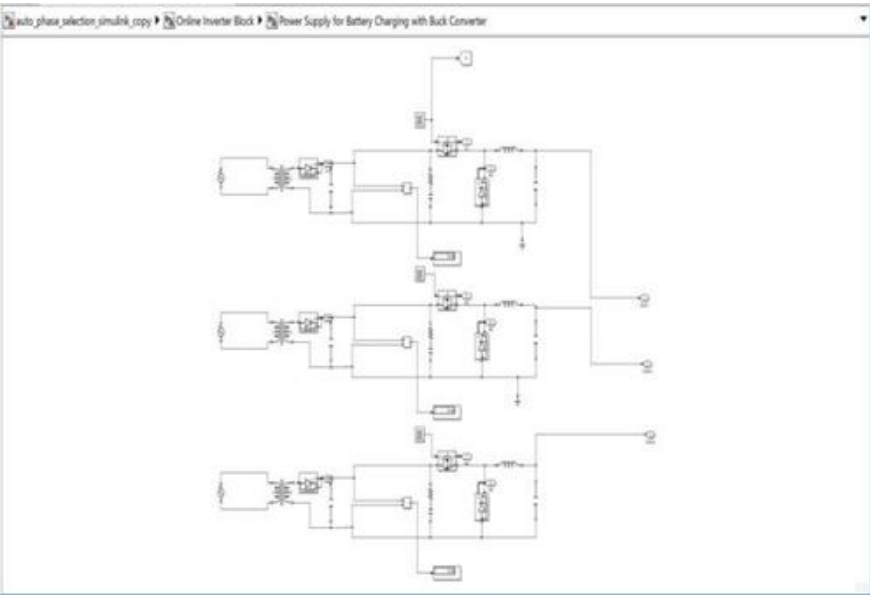


Figure 8: *Power supply for battery charging with buck converter*



Article Title: Automatic Phase Adaptation in Three Phase Supply for Online Inverter Systems

4.8 Circuit Breaker Block

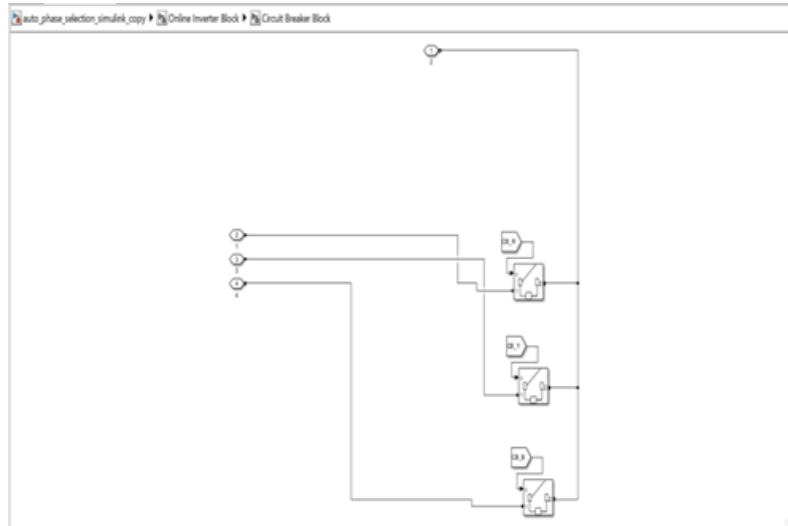


Figure 9: *Circuit Breaker block*

4.9 Battery block

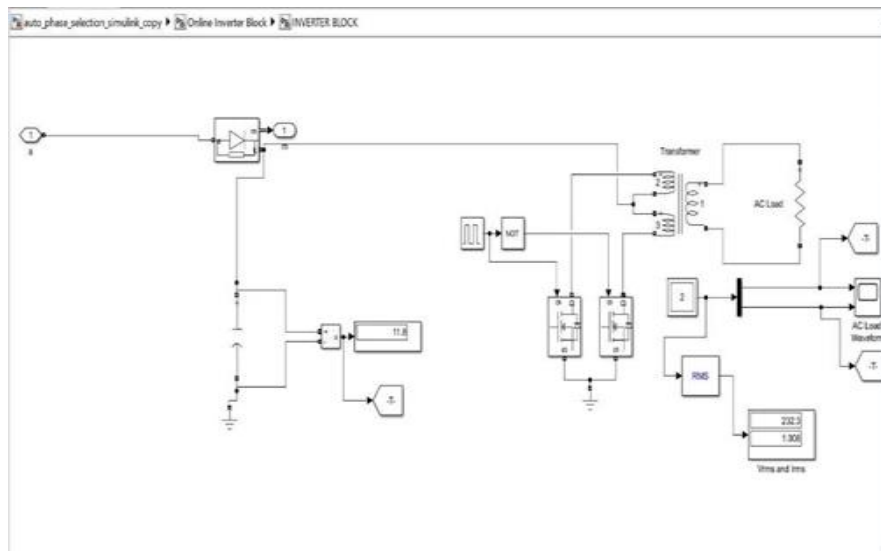


Figure 10: *Battery block*

4.10 Inverter block

The heart of the Inverter Block is the inverter unit. This unit typically includes power electronics and semiconductor devices, such as insulated gate bipolar transistors (IGBTs) or metal-oxide-semiconductor field-effect transistors (MOSFETs). These components are responsible for converting DC power into AC power.

Article Title: Automatic Phase Adaptation in Three Phase Supply for Online Inverter Systems

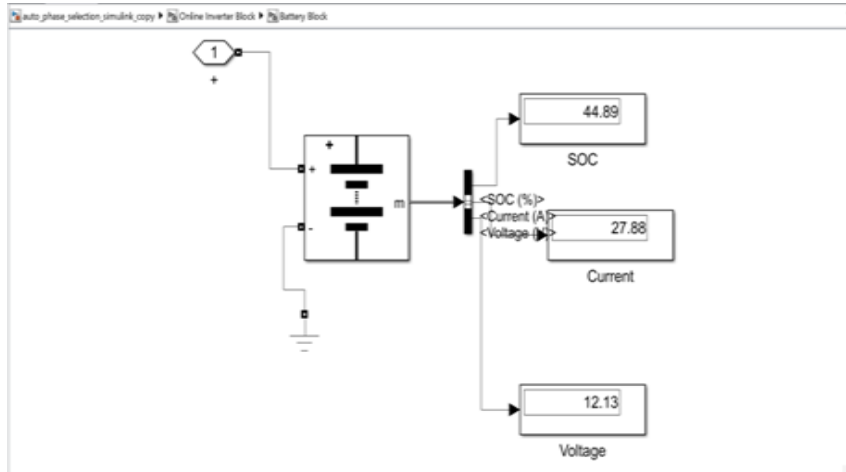


Figure 11: Inverter block

4.11 Output Waveform

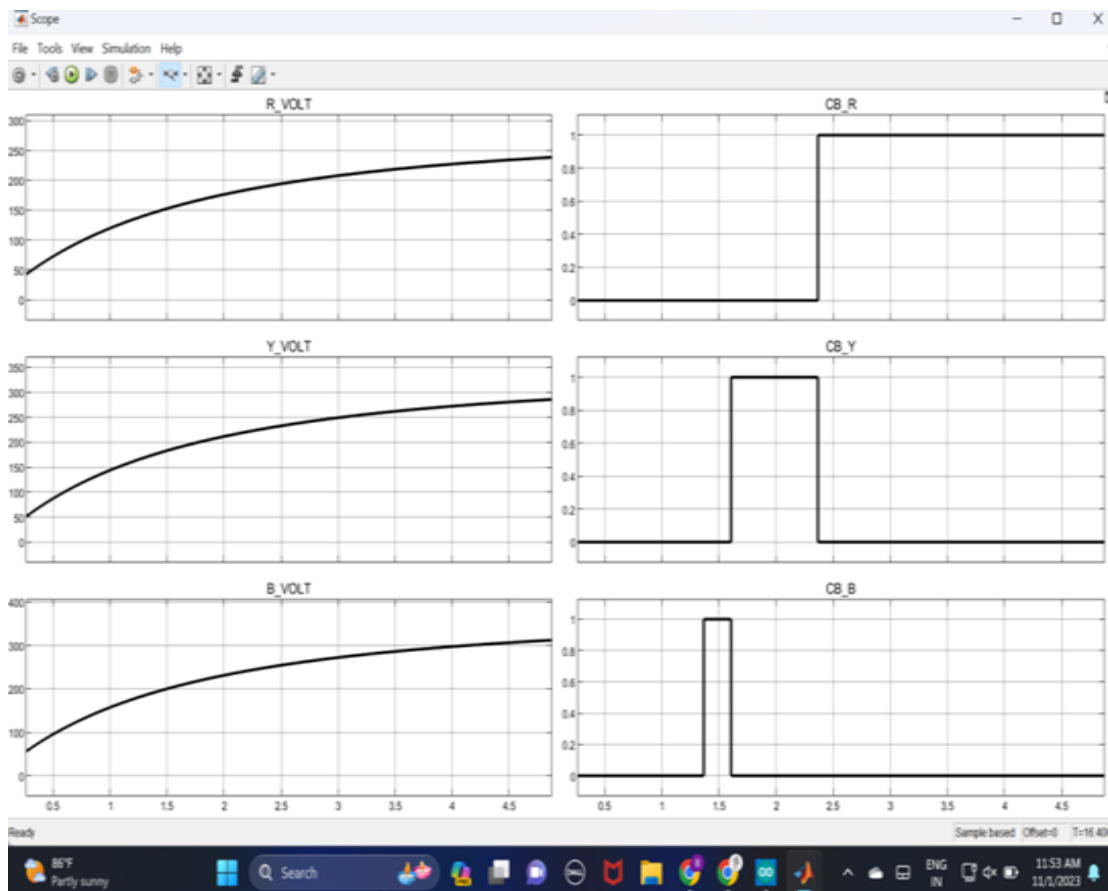


Figure 12: Output waveform



Article Title: Automatic Phase Adaptation in Three Phase Supply for Online Inverter Systems

Figure 3 provides a controlled environment for testing and optimizing the system's ability to adapt to varying power conditions. It plays a crucial role in ensuring that the power management system can autonomously and rapidly select the correct power phase, contributing to uninterrupted power supply in critical applications. Figure 4 serves as the first line of defense in monitoring the power supply's health. By continuously assessing the voltage levels of the three phases, it plays a critical role in providing the system with the essential data needed to make real-time decisions and ensure uninterrupted and reliable power supply, particularly in applications where power continuity is of paramount importance. Figure 5 serves as the central intelligence of the system, coordinating and controlling various functions to ensure the uninterrupted and reliable supply of power. Its ability to process data in real-time, run control algorithms, and facilitate communication is crucial for adapting to changing power conditions and responding to anomalies in the power supply, particularly in critical applications like healthcare where power continuity is paramount. Figure 7 is a crucial component that ensures the availability of stable AC power to drive high-priority. Its capacity to convert DC power from the battery into clean and reliable AC power is essential for maintaining an uninterrupted power supply, particularly in applications where a consistent power source is critical, such as in healthcare settings. Figure 8. A buck converter, often referred to as a step-down converter, is a vital component in the realm of power electronics and DC-DC voltage conversion. Its primary function is to reduce the voltage level of a direct current (DC) power source while simultaneously increasing the current, thus facilitating the transformation of electrical energy. The buck converter achieves this by employing a switching element, often a MOSFET or transistor, which alternates between open and closed states to control the flow of current. During the on-state, the input voltage flows through an inductor, storing energy in the form of a magnetic field. When the switching element transitions to the off-state, the inductor releases this stored energy, effectively reducing the output voltage. A diode and output capacitor further smooth and stabilize the output voltage. Crucially, a feedback loop and control circuitry continuously monitor the output voltage, adjusting the duty cycle of the switching element to maintain a consistent output voltage level, even in the face of varying input voltage or load conditions. Buck converters are highly efficient and are widely utilized in various electronic devices and systems, such as power supplies and battery charging circuits, to provide a stable and regulated output voltage. Figure 9. Instrumental in maintaining uninterrupted power supply by making intelligent decisions when faced with power disruptions or anomalies. Its ability to assess the status of multiple power sources and select the most reliable one ensures that essential loads, like high-priority medical equipment, receive a continuous and stable power supply, making it a critical component in systems where power continuity is paramount. Figure 10. Ensuring power continuity in critical applications. It stores electrical energy and is equipped with management and protection features to deliver power



Article Title: Automatic Phase Adaptation in Three Phase Supply for Online Inverter Systems

when needed, making it a key element in maintaining a stable power supply, especially in environments like healthcare facilities where uninterrupted power is essential for patient care and safety. Figure 11. Typically includes power electronics and semiconductor devices, such as insulated gate bipolar transistors (IGBTs) or metal-oxide-semiconductor field-effect transistors (MOSFETs). These components are responsible for converting DC power into AC power.

5 Conclusion

In conclusion, the "Automatic Phase Adaptation in Three-Phase Supply for Online Inverter" project represents a significant advancement in the field of power management, particularly in applications where uninterrupted and stable power supply is of utmost importance, such as healthcare settings. This innovative system leverages a range of crucial components and functions, which have been explained in detail throughout this project description. The project begins with the "AC Supply Sensing Block," which continuously monitors the three-phase power supply, providing real-time data on voltage levels and phase conditions. This information is pivotal in the system's decision-making process. The "Microcontroller Block" serves as the central intelligence, coordinating the system's functions, and ensuring real-time adaptability to changing power conditions. It runs control algorithms and facilitates communication among system components. The "Online Inverter Block" plays a central role in transforming DC power from a battery in to clean and stable AC power. This is essential for powering high-priority equipment, and its efficiency is paramount for effective power management. The "Power Supply for Battery Charging with Buck Converter Block" ensures efficient battery charging, maintaining the backup power source's readiness. It plays a crucial role in prolonging battery life and ensuring it is ready to provide power when needed. The "Circuit Breaker Block" is a key component that selects and controls the availability of reliable power sources, seamlessly transitioning to alternative sources during power disruptions. The "Battery Block" is the backbone of the system's backup power. It stores electrical energy, monitors its state of charge, and ensures the availability of power when primary sources face issues. The "Inverter Block" is responsible for converting DC power into AC power, serving as the final link in delivering power to high-priority equipment. In healthcare and other critical applications, this system ensures that essential equipment receives a stable and uninterrupted power supply, even in the face of power outages, phase variations, or adverse weather conditions. The ability to adapt to changing power conditions is vital for patient care and safety. This project represents an important step in addressing the need for continuous and reliable power supply, and its applications extend beyond healthcare to any environment where power continuity is critical. The integration of advanced control, monitoring, and power conversion technologies showcased in this project promises to enhance the reliability and resilience of power management systems.



Article Title: Automatic Phase Adaptation in Three Phase Supply for Online Inverter Systems

References

1. A. Kyereh; G. Kopri, Year: 2017, "Automatic Phase Selector for Multisource Power Supply", STU International Journal of Technology, Vol: 1, no: 3.
2. E. Oduobuk; E. Ettah; E. Ekpenyong, Year: 2014, "Design and implementation of automatic three phase changer using LM324 quad integrated circuit", International journal of engineering and technology research, Vol: 2, no: 4, pp.1 – 15.
3. F. U. Nweke; R. C. Iwu, Year: 2015, "Construction of Automatic Three Phase Power System Selector", IOSR Journal of Applied Physics (IOSR-JAP), Vol: 7, no: 6, pp. 11 – 14.
4. C. P. Bhise; Ananta A. Nare; N. M. Wankhade, Year: 2017, "Automatic Phase Selector International Journal in Advance Research in Science and Engineering", Vol: 6, no. 9.
5. A. O. Lawal; A. A. Jimoh; O. A. Lawal; A. K. Tihamiyu, Year: 2017, "Design and Implementation of Three-Phase 6KVA Automatic Phase Selector in Three Phase Supply Circuit", Journal of Research and Development Studies; Vol: 5, no: 1.
6. Godswill Ofualagba; E. E. Udoha, Year: 2017, "Design and Simulation of Automatic Phase Selector and Changeover Switch for 3-Phase Supply", International Journal of Novel Research in Electrical and Mechanical Engineering, Vol: 4, no: 2, pp. 28 – 35.
7. Sara Yazdani; Mehdi Ferdowsi; Pourya Shamsi, Year: 2020, "Internal model based smooth transition of a three-phase inverter between islanded and grid-connected modes", IEEE Transactions on Energy Conversion, Vol: 35, pp. 405 – 415.
8. Sara Yazdani; Mehdi Ferdowsi; Masoud Davari; Pourya Shamsi, Year: 2020, "Advanced current-limiting and power-sharing control in a pv-based grid-forming inverter under unbalanced grid conditions", IEEE Journal of Emerging and Selected Topics in Power Electronics, Vol: 8, pp. 1084 – 1096.
9. Abrez Mondal; Mahesh S. Illindala; Amrit S. Khalsa; David A. Klapp; Joseph H. Eto, Year: 2016, "Design and operation of smart loads to prevent stalling in a microgrid", IEEE Transactions on Industry Applications, Vol: 52, pp. 1184 – 1192.
10. Abrez Mondal; Mahesh S. Illindala, Year: 2018, "Improved frequency regulation in an islanded mixed source microgrid through coordinated operation of DERs and smart loads", IEEE Transactions on Industry Applications, Vol: 54, pp. 112 – 120.
11. Year: 2011, "American National Standard for Electrical Power Systems and Equipment—Voltage Rating (60 Hz)". ANSI C84.1-2011 Std.



Article Title: Automatic Phase Adaptation in Three Phase Supply for Online Inverter Systems

12. Kai Zhang; Yong Kang; Jian Xiong; Jian Chen, Year: 2003, “Direct repetitive control of SPWM inverter for UPS purpose”, IEEE Transactions on Power Electronics, Vol: 18, pp. 784 – 792.
13. Gerardo Escobar Valderrama; Aleksandar M. Stankovic; Paolo Mattavelli, Year: 2003, “Dissipativity-based adaptive and robust control of UPS in unbalanced operation”, IEEE Transactions on Power Electronics, Vol: 18, pp. 1056 – 1062.
14. Paolo Mattavelli, Year: 2005, “An improved deadbeat control for UPS using disturbance observers”, IEEE Transactions on Industrial Electronics, Vol: 52, pp. 206 – 212.
15. Hasan Komurcugil, Year: 2015, “Improved passivity-based control method and its robustness analysis for single-phase uninterruptible power supply inverters”, IET Power Electronics, Vol: 8, pp. 1558 – 1570.
16. Dong Dong; Timothy Thacker; Rolando Burgos; Fei Wang; Dushan Boroyevich, Year: 2011, “On zero steady-state error voltage control of single-phase PWM inverters with different load types”, IEEE Transactions on Power Electronics, Vol: 26, pp. 3285 – 3297.