Digital Regulated Power Supply

Shantanu Joshi[1], Sakshi Kahandal[2], Vaishnavi Lachake[3], Mr. V. R. Wadekar[4]

[1, 2, 3]BE Students, [4]Project guide
[1, 2, 3, 4]Dept. of ENTC, MCOERC, Nashik, Maharashtra, India

Abstract

This project presents the design and implementation of a Digital Dual Variable Power Supply with an integrated ESP32-based smart protection circuit. The proposed system delivers two independent and adjustable voltage outputs, making it ideal for powering diverse electronic components, development boards, and prototyping systems. A key innovation lies in the incorporation of an ESP32 microcontroller for real-time monitoring and control, which enhances the safety and functionality of the power supply.Users can define threshold values for both voltage and current via a keypad interface or remotely using IoT-based connectivity. The ESP32 continuously monitors these parameters and, upon detecting any violation of predefined thresholds, activates a relay-based protection mechanism to disconnect the supply, thereby preventing overvoltage, overcurrent, or short-circuit damage.The dual-channel architecture allows simultaneous delivery of different voltages, with digital displays providing real-time feedback on power levels. This makes the system particularly suitable for electronics laboratories, hardware testing environments, and embedded system development. Additionally, the IoT-enabled control offers remote configurability and monitoring, increasing the system's flexibility and usability.

Keywords: Digital Variable Power Supply, ESP32 Microcontroller, Iot-Based Power Protection, Dual-Channel Power System, Overcurrent Protection, Overvoltage Protection, Relay-Based Safety, Real-Time Monitoring, Embedded Systems, Electronics Lab Equipment, Smart Power Supply, Remote Control Power Supply

INTRODUCTION

Power supplies are fundamental components in the field of electronics, providing the necessary voltage and current required to operate various electronic circuits and systems. In laboratory and prototyping environments, especially those involving sensitive and dynamic loads, the need for variable and dual-channel power supplies becomes critical. These devices must not only deliver precise and adjustable outputs but also include robust protection mechanisms to ensure the safety of both the equipment and the user.Traditional analog power supplies often lack real-time feedback and intelligent protection features, making them less reliable for modern electronic applications. With the increasing integration of smart technologies and Internet of Things (IoT) capabilities, there is a growing demand for power supplies that can be digitally controlled, monitored, and remotely accessed. In response to these needs, this survey investigates the design and development of a Digital Dual Variable Power Supply equipped with an ESP32-based smart protection system.The proposed system utilizes the ESP32 microcontroller, known for its high processing power, low energy consumption, and built-in Wi-Fi/Bluetooth support. This allows the power supply to perform real-time monitoring of voltage and current parameters, implement user-defined protection thresholds, and enable remote configuration via network-connected devices. In the event of

parameter violations, a relay-based cutoff mechanism is triggered to prevent damage due to overvoltage, overcurrent, or short circuits.

Moreover, the system supports two independent output channels, providing flexibility in powering multiple circuits simultaneously. Real-time data visualization through digital displays, along with local keypad input and IoT remote control, enhances the user interface and system reliability.

This survey explores existing systems, compares conventional and digital power supplies, and highlights how the integration of microcontrollers and IoT enhances safety, flexibility, and performance. It also discusses the practical applications of such systems in electronics laboratories, embedded development setups, and educational institutions.

LITERATURE SURVEY

Sr no	Title of paper	Author name	IEEE journals/conference
1	A Dual-Output Single-Stage Regulating Rectifier With PWM and Dual-Mode PFM Control for Wireless Powering of Biomedical Implants	Reza Erfani; FatemehMarefat; PedramMohseni	20 November 2020
2	Control of a GaN-Based High-Power-Density Single-Phase Online Uninterruptible Power Supply	Danish Shahzad	17-20 June 2019
3	A Dual-Rail Hybrid Analog/Digital Low-Dropout Regulator With Dynamic Current Steering for a Tunable High PSRR and High Efficiency	Xiaosen Liu; Harish K. Krishnamurthy	03 November 2020
4	A practical and unique control technique to enhance efficiency of dual-stage DC-AC power inverter	Akshat Jain; Ranajay Mallik	25-29 February 2024

FUTURE SCOPE

The proposed digital dual variable power supply system holds significant potential for future enhancements. Integration with cloud platforms can enable remote data logging and analysis, while the development of a dedicated mobile application can further improve user accessibility. Expanding the system to support

additional output channels and incorporating intelligent load detection can enhance its versatility for complex applications. Features such as automated calibration, voice or gesture control, and battery or solar power support can make the system more adaptive and energy-efficient. Additionally, modular design approaches and tailored versions for industrial or educational use can broaden its applicability across diverse user environments.

OBJECTIVE

1. To design and implement a digital dual variable power supply capable of delivering two independent and adjustable voltage outputs.
2. To integrate an ESP32 microcontroller for real-time monitoring and control of voltage and current levels.
3. To provide a user-friendly interface through a local keypad and digital display for setting and viewing voltage/current values.
4. To ensure protection against overvoltage and overcurrent conditions using a relay-based automatic cutoff mechanism.
5. To enable remote monitoring and configuration via IoT connectivity, enhancing system flexibility and usability.
6. To develop a reliable and safe power supply solution suitable for electronics laboratories, embedded system development, and prototyping environments.
7. To explore the combination of traditional power supply functionality with smart, modern digital control features.

PROPOSED SYSTEM

The proposed system is a Digital Dual Variable Power Supply integrated with an ESP32-based smart protection mechanism. It is designed to provide two independent and adjustable voltage outputs suitable for powering a variety of electronic circuits. The ESP32 microcontroller continuously monitors the output voltage and current in real-time, allowing users to set safety thresholds via a local keypad or remotely through IoT connectivity. When abnormal conditions such as overvoltage or overcurrent are detected, the system automatically triggers a relay to disconnect the power supply, ensuring the safety of connected devices. A digital display provides real-time feedback, and the system's IoT capability allows remote monitoring and control, making it a smart, efficient, and user-friendly solution for modern electronics and embedded applications.

FLOW CHART

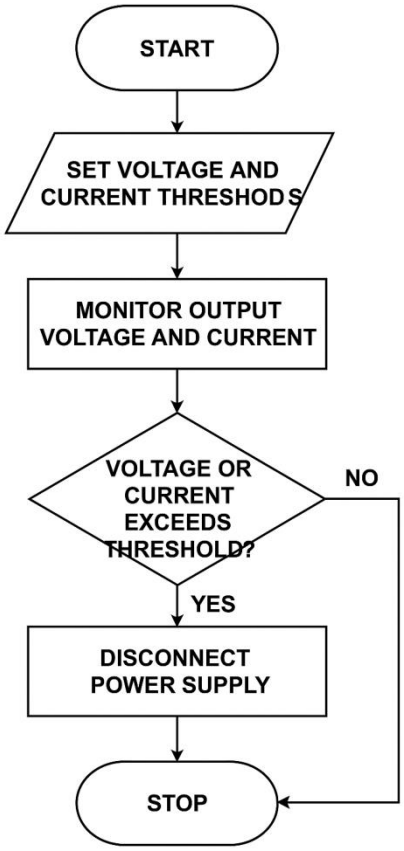

Fig: Flowchart

FUNCTIONAL REQUIREMENTS

1. Voltage Output Control
    - The system shall allow users to adjust
    - two independent voltage outputs within a specified range.
2. Current Monitoring
    - The system shall continuously monitor the output current for both channels.
3. Threshold Configuration
    - The system shall enable users to set voltage and current threshold limits via a keypad interface or remotely via IoT.
4. Relay-Based Protection
    - The system shall trigger a relay to disconnect power when voltage or current exceeds the defined thresholds.
5. Digital Display Interface

- The system shall display real-time voltage and current readings on a digital screen for both channels.

6. IoT Connectivity
   - The system shall support remote access and configuration using Wi-Fi through the ESP32 microcontroller.
7. Dual Channel Operation
   - The system shall operate both channels simultaneously with independent settings.

NON-FUNCTIONAL REQUIREMENTS

1. Reliability
   - The system should operate continuously and safely under normal laboratory and prototyping conditions.
2. Accuracy
   - Voltage and current readings should be precise and reflect real-time values accurately.
3. Usability
   - The system should provide an intuitive interface for local and remote users.
4. Performance
   - The response time for detecting and reacting to threshold violations should be minimal to prevent device damage.
5. Maintainability
   - The system should be easy to maintain, with modular components for easy replacement and upgrades.
6. Security
   - Remote access should be secured to prevent unauthorized modifications to the threshold settings.
7. Portability
   - The hardware design should be compact and lightweight for easy use in various environments.

APPLICATION

1. Electronics Prototyping and Development
2. Embedded Systems Development
3. Electronics Labs and Workshops
4. IoT Device Testing and Evaluation
5. Battery-Powered System Testing

CONCLUSION

The development of a Digital Dual Variable Power Supply integrated with an ESP32-based smart protection system presents a significant advancement in power management for electronics applications. By combining adjustable dual voltage outputs with real-time monitoring, relay-based safety mechanisms, and IoT connectivity, the system ensures both flexibility and protection for sensitive devices. It addresses the limitations of traditional power supplies by introducing smart control features, remote accessibility, and automated safeguards against overvoltage and overcurrent. This intelligent design makes it highly suitable for electronics laboratories, embedded systems development, and educational setups. The project successfully demonstrates how the integration of microcontrollers and IoT can enhance the efficiency, safety, and user experience of conventional power systems, paving the way for future enhancements and broader industrial applications.

REFERENCES

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