Design and Development of Embedded Systems and IoT Applications Using PCB Design Techniques

Prof. C.H. Mallareddy[1], Ms. Prerana Bulbule[2], Prof. J. B. Patil[3], Prof. A. L. Barkhade[4]

[1,2,3,4] *Department Of Electrical Engineering, Nagesh Karajagi Orchid College Of Engineering & Technology, Solapur, Maharashtra, India.*

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Abstract - *Embedded systems and Internet of Things (IoT) technologies are playing an important role in modern electronic and automation applications. Printed Circuit Boards (PCBs) are essential components that provide compact design, reliable electrical connections, and efficient hardware integration in embedded systems. This paper presents the design and development of embedded systems and IoT applications using PCB design techniques during an industrial internship at Pantech Prolabs India Pvt Ltd. The internship focused on understanding embedded system fundamentals, microcontroller programming, communication protocols, hardware interfacing, and PCB development using EasyEDA software. Practical activities such as LED blinking circuits, ESP32-based home automation systems, and regulated power supply PCB designs were carried out to gain hands-on industrial knowledge. The PCB design process included schematic creation, component placement, routing, design rule checking, and Gerber file generation for manufacturing. The study also highlights the importance of PCB technology in reducing circuit complexity, improving reliability, and enhancing system performance in embedded and IoT applications. The internship experience improved technical skills related to debugging, hardware integration, and real-time system development. Overall, the work demonstrates the significance of PCB-based embedded system design in modern electronic applications and industrial training programs.*

Key Words: Embedded Systems, Internet of Things (IoT), PCB Design, EasyEDA, ESP32, and Hardware Interfacing.

1. INTRODUCTION

Embedded systems and Internet of Things (IoT) technologies are widely used in modern electronic and automation applications. Printed Circuit Boards (PCBs) play an important role in providing reliable electrical connections, compact circuit design, and efficient hardware integration in embedded systems. PCB technology helps in reducing wiring complexity, improving system performance, and increasing circuit reliability in electronic devices. This paper presents the design and development of embedded systems and IoT applications using PCB design techniques during an industrial internship at Pantech Prolabs India Pvt Ltd. During the internship, practical knowledge was gained in embedded programming, hardware interfacing, communication protocols, ESP32-based applications, and PCB development using EasyEDA software. Various activities such as LED blinking circuits, home automation systems, schematic design, routing, and Gerber file generation were performed to understand real-time electronic product development. The main objective of this paper is to study the implementation of PCB design techniques in embedded and IoT systems and to understand their importance in modern electronic applications.

2. METHODOLOGY

During the internship, the work was mainly focused on understanding embedded systems, IoT applications, and PCB design techniques used in modern electronic systems. The study started with learning the basic concepts of embedded systems, microcontrollers, and Embedded C programming. Simple programs such as LED blinking and switch control were implemented to understand the working of microcontrollers and hardware interfacing techniques. Communication protocols such as UART, SPI, and I2C were also studied for device communication and data transfer between electronic components.

The internship also included the development of IoT-based applications using ESP32 microcontrollers. Practical activities such as home automation systems were performed to understand real-time monitoring and control systems. Sensors, LEDs, and peripheral devices were interfaced with the controller to study hardware integration and embedded application development. These practical implementations helped in improving programming knowledge, debugging skills, and understanding of real-time embedded systems.

For PCB development, EasyEDA software was used to perform schematic design, component placement, routing, and PCB layout preparation. The PCB design process started with creating circuit schematics and assigning component footprints. After schematic creation, components were placed properly on the PCB board and electrical connections were established using copper traces. Design Rule Checking (DRC) was carried out to identify design errors and improve PCB reliability. Gerber files were then generated for manufacturing and testing purposes.

The internship also involved designing PCB layouts for DC power supply and regulated power supply circuits. Throughout the training period, the PCB layouts and embedded projects were analyzed and modified to improve circuit organization, electrical connectivity, and system performance. This methodology provided practical exposure to embedded system development, IoT applications, hardware interfacing, and industrial PCB design techniques used in modern electronic product development.

3. MODELING AND ANALYSIS

The modeling and analysis of embedded and IoT applications were carried out during the internship using practical hardware implementation and PCB design techniques. Different embedded circuits and IoT-based applications were developed to understand the working of microcontrollers, communication systems, and hardware interfacing. The practical activities mainly included LED blinking circuits, switch control applications, and ESP32-based home automation systems. These projects helped in understanding the operation of embedded systems and the interaction between hardware and software components.

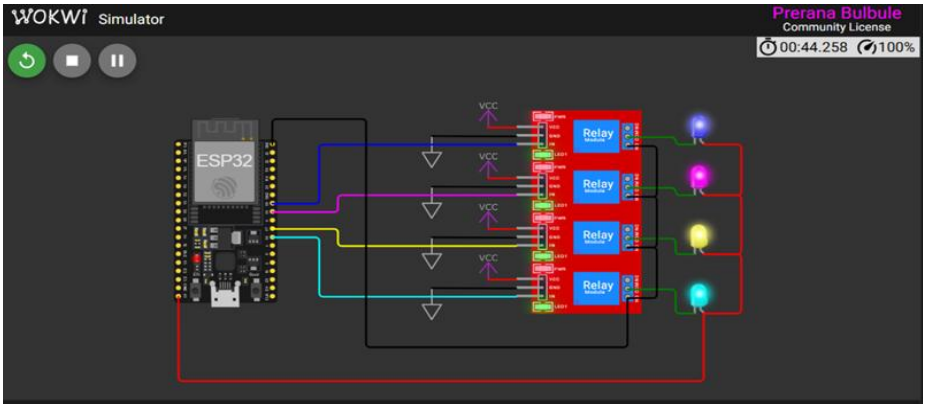

Fig -1: Home automation system using Esp32

PCB modeling was performed using EasyEDA software for designing electronic circuit layouts and preparing PCB boards for embedded applications. The design process included schematic creation, footprint assignment, component placement, routing, and Gerber file generation. Proper placement of components and routing of copper tracks were carried out to achieve organized circuit layouts and reliable electrical connections. Design Rule Checking (DRC) was also performed to reduce layout errors and improve PCB quality before manufacturing.
The internship also involved the design and analysis of DC power supply and regulated power supply PCB layouts. Different electronic components such as resistors, capacitors, diodes, voltage regulators, connectors, and LEDs were arranged according to circuit requirements. The PCB layouts were analyzed for proper electrical connectivity, compact size, and efficient routing paths. Through-hole and surface mount design concepts were studied to understand modern PCB manufacturing techniques used in electronic industries.

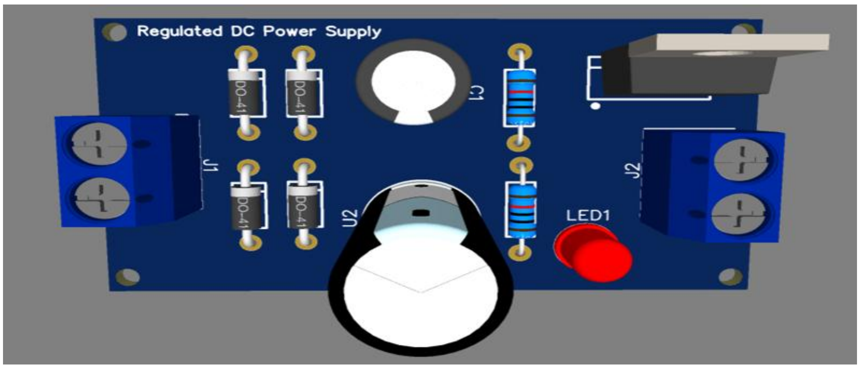

Fig -2: PCB design of Regulated Power Supply

The use of PCB design software improved circuit visualization, design accuracy, and ease of modification compared to conventional manual circuit design methods. The analysis of embedded projects and PCB layouts provided practical understanding of hardware integration, debugging techniques, and real-time electronic system development. The internship demonstrated that PCB-based embedded systems offer better reliability, reduced wiring complexity, and improved performance in modern IoT and electronic applications.

4. RESULTS AND DISCUSSION

During the internship, practical knowledge regarding embedded systems, Internet of Things applications, and PCB design techniques was successfully gained. Various embedded projects such as LED blinking circuits, switch control systems, and ESP32-based home automation systems were implemented to understand real-time hardware and software interaction. These activities improved understanding of microcontroller programming, communication protocols, and hardware interfacing methods used in modern electronic systems.

The PCB design process using EasyEDA software helped in understanding schematic creation, component placement, routing, and Gerber file generation. PCB layouts for DC power supply and regulated power supply circuits were successfully designed and analyzed. Proper routing of copper tracks and organized component placement improved electrical connectivity, compactness, and circuit reliability. Design Rule Checking (DRC) also helped in identifying layout errors and improving overall PCB quality before manufacturing.

The internship provided practical exposure to debugging techniques, real-time system development, and embedded hardware integration. Communication protocols such as UART, SPI, and I2C were studied for data transfer between electronic devices. The ESP32-based home automation project demonstrated the practical implementation of IoT technology for monitoring and controlling electronic devices. The integration of sensors, LEDs, and peripheral devices improved understanding of real-time automation systems.

It was observed that PCB-based embedded systems provide better performance, reduced wiring complexity, improved reliability, and easier maintenance compared to conventional circuit connections. The use of modern PCB design software simplified circuit development, improved design accuracy, and reduced manual design errors. Overall, the internship experience enhanced technical knowledge, practical skills, and industrial understanding related to embedded systems, IoT applications, and PCB-based electronic product development.

3. CONCLUSIONS

The internship provided valuable practical knowledge and industrial exposure in the fields of embedded systems, Internet of Things applications, and PCB design techniques. During the training period, various activities such as embedded programming, hardware interfacing, communication protocol study, ESP32-based home automation, and PCB layout development were successfully carried out using EasyEDA software. The internship improved understanding of schematic design, component placement, routing, and Gerber file generation used in modern PCB development. It also enhanced technical skills related to debugging, real-time system implementation, and electronic circuit design. The study concludes that PCB-based embedded systems provide reliable performance, compact design, and efficient hardware integration for modern electronic and IoT applications. Overall, the internship experience was highly beneficial in developing practical engineering skills and understanding industrial PCB design and embedded system development processes.

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