TITLE : Automatic Wiring System for Panel Boards

Introduction

In the electrical and electronics industry, panel boards are an essential component used to control and distribute electricity safely and effectively. These panels consist of various components such as switches, relays, circuit breakers, wiring terminals, and control modules, which are interconnected through complex wiring arrangements. Traditionally, the wiring process in panel boards is performed manually by skilled technicians, involving repetitive tasks such as cutting wires, stripping insulation, identifying terminal points, and securing connections. Although reliable, manual wiring is often time-consuming, error-prone, and subject to human fatigue or inconsistency.

As industries move towards automation and smart manufacturing, there is a growing need for efficient, accurate, and time-saving solutions in all aspects of production — including wiring. One such area of advancement is the automatic wiring system for panel boards, where machines, robotic arms, and microcontroller-based systems are used to perform the tasks that were previously done by human hands. Automating panel wiring not only speeds up the production process but also ensures uniform quality, reduces errors, and increases safety.

Objectives of the Project

This project aims to design and develop a prototype of an Automatic Wiring System for Panel Boards that demonstrates the feasibility of automating key wiring processes. The proposed system focuses on wire measurement, cutting, placement, and terminal connection with minimal human input.

The main objectives of the project are:

1. To Minimize Manual Effort:

Develop a system that automates the routine tasks involved in panel board wiring — such as measuring wire length, cutting, routing, and connection — thus reducing reliance on human labor.

2. To Improve Wiring Accuracy and Uniformity:

Ensure that wires are cut to exact lengths and placed in the correct terminal blocks as per a programmed layout, improving overall system reliability and redTo Reduce Time Consumption:

3.To Reduce Time Consumption:

Design the system to work faster than traditional manual wiring methods, thus To Enhance Safety:

4. To Enhance Safety:

By automating repetitive wiring tasks, the system can reduce risks associated with electric shock, hand fatigue, or improper terminal connections.

5.To Create a Scalable Model:

Build a basic prototype using microcontrollers and motors, which can later be scaled up using robotic arms, CAD interpretation, and integration with industrial software tools like EPLAN or AutoCAD.

6. To Lower Production Costs in the Long Run:

Though initial development costs may be high, automation will lead to cost savings by reducing rework, labor expenses, and error correction over time.

7. To Serve as an Educational and Training Model:

Provide an academic model that can be used in technical institutions for demonstrating the principles of automation in electrical engineering.

Problem Statement

In today’s fast-growing industrial environment, electrical panel boards are central to every facility's control and power distribution. Despite technological advancements in design, software, and component manufacturing, wiring of panel boards continues to be a manually performed task in most places. This manual wiring process, although traditional and well-understood, suffers from several limitations that hinder productivity, quality, and cost-effectiveness.

Manual wiring is labor-intensive requiring skilled technicians who must interpret complex wiring diagrams, measure and cut wires precisely, and ensure correct routing and connections. In large-scale production environments or high-volume projects, this becomes extremely time-consuming. Even with skilled labor, there is always a risk of human errors — such as wrong connections, loose terminals, or wire mix-ups — which can lead to serious system failures or safety hazards.

Moreover, the demand for custom-made panel boards is increasing, requiring rapid configuration and wiring changes. Manual rework or adjustments in such cases can cause significant delays. In addition, companies face challenges in training and retaining experienced panel wiring technicians, further contributing to inefficiencies.

Due to these limitations, there's a clear need for an automatic system that can perform wiring operations efficiently, consistently, and accurately with minimal human intervention. A programmable, automated wiring system can drastically improve the speed and quality of panel board assembly while reducing labor costs and errors.

Methodology

The methodology outlines the structured approach used to develop the Automatic Wiring System for Panel Boards. This chapter describes the system architecture, key components, design steps, working procedure, and the technologies used to bring the project to life. The focus is on building a prototype using low-cost components like microcontrollers, motors, and sensors to demonstrate automatic measurement, cutting, and placement of wires within a control panel.

WORK PLAN

6-Month Work Plan (With Outcomes)

Project Title: Automatic Wiring System for Panel Boards

Month 1: Research & Problem Definition

Activities:

Study existing manual wiring processes in panel boards.

Identify problems: time-consuming, error-prone, labor-intensive, safety issues.

Research existing automation in wiring (if any).

Define clear project objectives and scope.

Expected Outcome:

Problem statement finalized**.**

Project plan created.

Clear understanding of automation needs and industry relevance.

Month 2: Design & Planning

Activities:

Design mechanical layout (wire feeder, cutter, panel holder).

Develop electrical block diagram and wiring logic.

Design system architecture using microcontroller/PLC.

Prepare flowchart and working logic.

Select components: motors, sensors, microcontroller, drivers, relays, etc.

Expected Outcome:

Complete system design (mechanical and electrical).

Bill of Materials (BoM) prepared.

Planning for procurement and development completed

Month 3: Procurement & Initial Assembly

Activities:

Purchase and collect all required components.

Fabricate or 3D-print the mechanical setup.

Assemble structure for panel holder and wiring mechanism.

Mount motors, sensors, and wire routing components**.**

Expected Outcome:

Mechanical setup assembled.

All components available.

Ready for electrical integration.

Month 4: Circuit Integration & Programming

Activities:

Wire the components to microcontroller (Arduino/PLC).

Connect motor drivers, relays, and power supply.

Code logic for motor control, wire feeding, cutting, and placement.

Interface sensors for length detection and endpoint identification.

Expected Outcome:

Circuit integration completed.

First-level working code uploaded.

Basic motor/sensor control tested.

Month 5: Testing & Troubleshooting

Activities:

Run system tests with sample wiring layouts.

Fix errors in logic, motor control, or placement accuracy.

Improve speed, grip mechanism, and wire accuracy.

Add safety features (emergency stop, fault detection).

Expected Outcome:

Fully working prototype developed.

System performance optimized.

Bugs/errors resolved.

Month 6: Finalization, Documentation & Presentation

Activities:

Final testing and demonstration.

Prepare detailed project report (introduction to conclusion).

Include circuit diagrams**,** flowcharts, and source code.

Prepare for college/industry demo or patent filing.

Document novelty and real-time applications.

Expected Outcome:

Complete and demonstrable working project.

Final report and documentation ready.

Prepared for exhibition, industry visit, or patent filing.

Project Budget: Automatic Wiring System for Panel Boards

This estimate assumes a prototype for demonstration purposes.

S/ NO	**COMPONENT**	**QUANTITY**	**UNIT COAST**	**TOTAL COAST**
1	Microcontroller(Arduino UNO/ESP32)	1	600	**600**
2	Motor Drives/Relays	2	150	**300**
3	Servo or stepper Motors	2	500	**1000**

4	Power supply(12v/5v adapter+ battery)	1set	500	**500**
5	Sensors	3	150	**450**
6	Wiring tools (cutter Soldering kit)	1set	800	**800**
7	Frame/structure(wood/Metal/3d Printed)	1set	1000	**1000**
8	Control panel(switches wires)	-	500	**500**
9	PCBDesign/ Breadboard/Connectors	-	300	**300**
10	Miscellaneous	-	200	**200**
	Total	**=**		**5650**

Note:

This is a basic prototype budget for industry grade systems costs will be significantly higher.

System Overview

1. Wiring Layout Selection – A predefined wiring configuration is stored in the microcontroller.

2. Wire Measurement – The system measures the required wire length using a motor-driven feeder and sensor.

3. Wire Cutting – After measuring, a cutting mechanism slices the wire.

4. Wire Routing (optional in prototype) – In advanced versions, the wire is placed or routed to terminals.

5. Crimping or Termination (optional) – Future upgrades may include terminal connection.

Hardware Components Used

Component Specification / Function

Arduino UNO - Controls the overall logic and motor operations

DC Gear Motor -Feeds wire to a measured length

IR Sensor - Detects length of wire fed

Solenoid or Blade Cuts the wire automatically

L298N Motor Driver - Drives the motor from Arduino signals

LCD Display - Shows system status, length, and progress

Power Supply Unit - Provides required voltages

Push Buttons - Start/stop input, select wire length

Software Tools Used

Arduino IDE – For writing and uploading code

Fritzing / Tinkercad Circuits – For circuit simulation and prototyping

Proteus (optional) – For testing logic before hardware implementation.

Working Procedure

Step 1: Wiring Configuration

The user selects a predefined wiring layout (or enters desired wire length) through push buttons or pre-coded settings.

Step 2: Wire Feeding

The microcontroller activates the motor to feed wire from a spool.

The IR sensor counts the wire as it passes, measuring length in real-time.

Step 3: Wire Cutting

Once the desired length is reached, the motor stops

The cutting mechanism (solenoid or servo blade) is triggered to cut the wire cleanly.

Step 4: Display Output

The LCD shows "Wire Cut: 30 cm" or similar confirmation messages.

Advantages of the Method

Time-Saving: Automates wire measurement and cutting quickly.

Error-Free: Eliminates human error in length estimation.

Cost-Effective: Uses affordable components suitable for academic projects.

Expandable: Can be upgraded with routing and crimping features.

This methodology ensures a logical and cost-effective development of an automatic wiring system. The project successfully implements the key aspects of automation: sensing, control, motion, and action. It demonstrates how panel board wiring can be semi-automated using accessible technology, offering a foundation for further innovation.

Implementation

The implementation phase of the project involves translating the design and methodology into a working hardware prototype. This stage includes assembling the components, coding the microcontroller, interfacing the motor and sensors, and testing the overall functionality of the automatic wiring

system. The goal is to create a model that accurately performs wire measurement and cutting automatically, as per user-defined input.

Hardware Assembly

The hardware setup is structured to handle the following sequence:

1. Wire Feed Mechanism

A DC gear motor is mounted to rotate the wire spool and feed the wire through a guiding channel.

The speed of the motor is controlled using the L298N Motor Driver, which is connected to the Arduino.

2. Length Detection

An Infrared (IR) Sensor is used to detect the passing of the wire and count revolutions or length.

A basic calibration is done to relate sensor pulses to wire length in centimeters.

3. Cutting Mechanism

A solenoid-based blade or servo-operated cutter is attached after the measuring point.

Once the desired length is reached, Arduino sends a signal to activate the cutter.

4. User Interface

A 16x2 LCD Display shows the current operation: status, selected length, or error messages.

Push buttons are used to select length and start the process.

5. Power Supply

A 12V adapter powers the motor and solenoid.

Arduino is powered via USB or 9V adapter.

Software / Programming

The Arduino UNO is programmed using the Arduino IDE.

The code includes:

Motor speed control via PWM

IR sensor interrupt for measuring length

Solenoid activation via digital pin

LCD output display for user interaction

Debounce logic for buttons

Sample Arduino Logic (simplified):

```
if (startButtonPressed) {
  activateMotor();
  while (lengthMeasured < targetLength) {
    updateLengthFromIR();
  }
  stopMotor();
  activateCutter();
  displaySuccessMessage();
}
```

Automation in Electrical Industry

Automation in the electrical industry has taken various forms, such as programmable logic controllers (PLCs), SCADA systems, automatic testing equipment, and robotic assembly lines. However, wiring — especially internal wiring in control panels — remains largely manual. With advancements in robotics, sensors, and embedded systems, it is now feasible to design an automatic wiring setup that can:

Measure and cut wires precisely

Route wires through predefined paths

Identify and connect to correct terminal points

Perform tasks such as insulation stripping or terminal crimping

The integration of such systems marks a significant evolution in electrical manufacturing processes. Technologies like Arduino, stepper motors, servo-based arms, machine vision systems, and computer-aided wiring layout software (e.g., EPLAN) support the implementation of such automated systems.

Manual Wiring Process – Limitations

Historically, panel wiring has been a manual process. Skilled technicians interpret electrical schematics, measure wire lengths using tools like tape and cutters, and insert wires into terminal blocks using screwdrivers or crimpers. While this method is effective, it presents the following issues:

Human error: Miswiring, incorrect length estimation, or improper routing can lead to failures. Inconsistency: Different workers may produce slightly varied results.

Time-consuming: Wiring a complex panel may take several hours or even days.

Lack of scalability: Manual methods struggle to keep pace with large-scale or urgent production demands.

Studies such as Automation in Electrical Panel Manufacturing (Singh et al., 2018) highlight that manual wiring consumes over 40% of the total panel assembly time.

Need for Automation

As industry demands shift toward speed, accuracy, and digital manufacturing, automation becomes crucial. Automatic wiring systems aim to minimize the effort of humans while improving throughput and quality. According to a report by ResearchGate on Smart Automation (2021), industries using automation in panel assembly saw:

25–30% reduction in wiring time

60% improvement in fault detection

50% reduction in labor cost over 2 years

This data supports the viability of automated wiring as a solution to modern industrial challenges.

Existing Technologies

1.Robotic Wire Assembly Systems

Several commercial robotic systems exist for automatic wire cutting, stripping, and crimping. These systems, like the Komax Zeta 640 and Schleuniger WirePro, are used in automotive and aerospace industries for wire harness production. However, they are:

Highly expensive

Designed for mass production of wire harnesses

Not tailored for custom electrical panel boards

This presents a gap where low-cost, programmable systems are needed for custom or educational applications.

2.Microcontroller-Based Automation

Microcontrollers such as Arduino, Raspberry Pi, and STM32 are widely used for prototyping automatic wiring systems. They control motors for wire feeding and cutting, and can be programmed to follow a wiring sequence. Projects like “Arduino-Based Wire Cutter and Measurer” by Jain (2019) demonstrate successful implementation of precision wire handling using IR sensors, stepper motors, and LCD displays.

3.Use of CAD Software in Wiring

EPLAN and AutoCAD Electrical are popular tools used to design wiring layouts. These layouts can be exported into coordinates and command sets for robotic systems to follow. Some companies have started integrating CAD-to-wire systems, allowing machines to read wiring diagrams and execute physical connections.

4. Panel Wiring Simulation Tools

Simulation tools such as Proteus, Tinkercad Circuits, and PLC simulators are now used to train students in wiring techniques before implementing them physically. These simulations reduce errors in real-life applications and help plan wiring paths efficiently.

Scope of the Project

This project aims to fill that gap by creating a low-cost, microcontroller-based automatic wiring system prototype, suitable for both educational purposes and s The goal of this project is to develop a prototype of an Automatic Wiring System for Panel Boards, which can mimic human operations such as cutting, routing, and connecting wires. The system will be based on microcontrollers

and controlled through programmable logic to perform repeated wiring tasks accurately. While the project focuses on developing a simplified model suitable for educational and small-scale industrial use, it can be scaled up for advanced operations with robotic arms and AI-based layout detection.

Key features of the proposed system include:

- Automated wire length measurement and cutting
- small-scale industrial applications.
- Wire routing through predefined duct paths

- Identification of terminal points using sensor-based or programmed coordinates
- Automatic insertion or placement of wire ends into terminal blocks
- Optional extensions like wire crimping or soldering units

This project presents a blend of mechanical automation and electrical control, requiring knowledge in microcontrollers, motor drivers, wiring layouts, sensor integration, and software development.

Applications and Use Cases

This prototype model can serve as a base for future commercial products in:

- Electrical panel board manufacturing companies.
- Industrial automation assembly lines.
- Educational institutions for training in automation.
- Small workshops looking to semi-automate their wiring tasks.

Conclusion

In conclusion, the Automatic Wiring System is a promising step toward smart automation in electrical engineering. It addresses one of the most basic yet time-consuming tasks in panel board fabrication, offering a scalable and

customizable solution. With advancements in sensor technology, embedded systems, and industrial design, this project can evolve into a full-fledged automation module that fits well into modern smart manufacturing workflows.

This project serves as a foundation for innovation — encouraging further exploration into the digitization and automation of everyday electrical and mechanical tasks.

The “Automatic Wiring System for Panel Boards” project demonstrates a successful attempt at minimizing manual labor involved in the repetitive task of wire cutting and measuring, especially in electrical panel board manufacturing.