Design And Implementation of A Home Power Distribution Board

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Abstract—**This project presents a practical demonstration board to simulate domestic electrical wiring. It focuses on secure wiring, component integration, and educational value. The study bridges theoretical learning with hands-on implementation, covering meters, breakers, switches, and loads. It validates electrical principles through real-world observations and highlights opportunities for innovation in smart and green technologies**

Aims and Objectives of the Work

To design and construct a functional domestic electrical wiring board.

To implement secure and clear wiring practices for educational use.

To analyze the power distribution and component behavior under load.

To demonstrate practical knowledge of switches, sockets, meters, and breakers.

INTRODUCTION

Domestic and Industrial electrical wiring is essential for safe and functional electricity distribution. This project aims to simulate a real-life wiring board for educational demonstration. It also:

- Helps learners understand the connections among breakers, energy meters, switches, and loads (bulbs/sockets).
- Enables hands-on experience in identifying, installing, and operating basic electrical components.
- Demonstrates proper safety procedures and cable management techniques.
- Offers a cost-effective, reusable, and modular approach to practical lab experiments.
- Encourages problem-solving by enabling fault diagnosis and troubleshooting on the board.
- Bridges the gap between theoretical coursework and real-world electrical practices.

LITERATURE REVIEW

Scope:

This review explores recent advancements in home and smart power distribution systems.

Objective:

To synthesize existing literature to identify trends, technological developments, and current limitations.

Significance:

The analysis highlights research gaps, establishing the pedagogical and technical rationale for a modular, educational demonstration board

IoT-Enabled Distribution Board (Egonwa et al., 2024)

- Designed a 60A smart board with IoT integration using ESP32.
- Features: Real-time monitoring, fault alerts, remote access.
- Application: Residential and industrial smart grid systems.
- Identified Gap: High complexity and cost reduce educational accessibility.

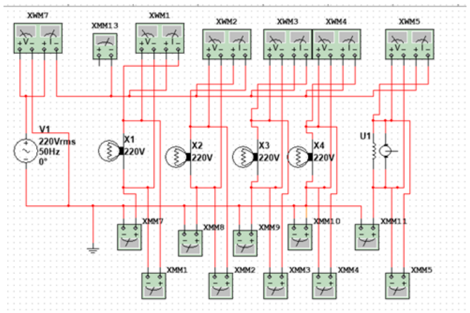
Intelligent Home Systems (Parihar et al., 2024)

- Uses Arduino with ACS712 and ZMPT101B sensors.
- Incorporates automated overload/leakage protection.
- Focus on real-time sensor feedback and logic control.
- Identified Gap: Requires programming; not focused on practical wiring education.

Comparative Analysis and Research Justification

- Egonwa et al. (2024): Industrial IoT board – Complex and costly.
- Parihar et al. (2024): Smart home system – Focus on automation, limited for training.
- Current Study: Educational demo board – Bridges theoretical and practical training effectively.
- BNBC Code-Color code

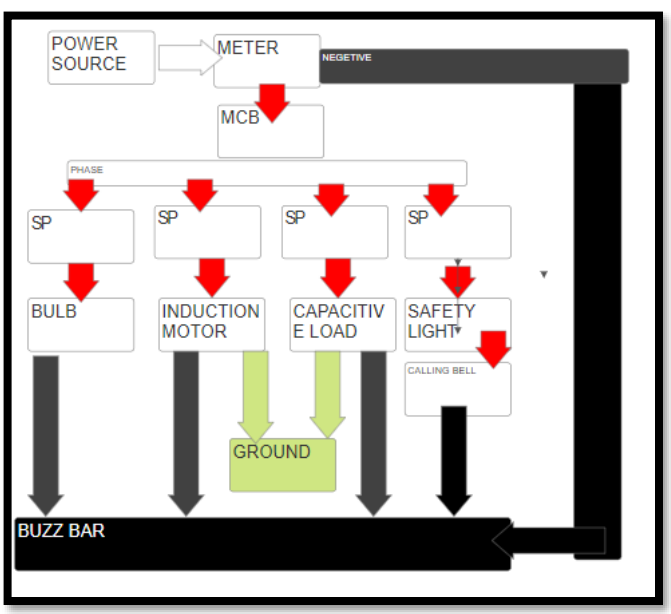
CIRCUIT DIAGRAM



WORKING METHOD

1. Create a project board simulating a household wiring system.
2. **Install and connect**:
   - Energy meter
   - MCBs (circuit breakers)
   - Distribution busbar
   - Switches
   - Sockets (6-pin, 3-pin)
   - Light holders
   - Fuse holders
3. Wire all components using red (phase), black (neutral), and green (earth) wires.
4. Follow wiring codes for safety and clarity.

Tools Used: Screwdrivers, pliers, wire strippers, multimeter, etc.



Energy Meter (Watt-hour Meter)

- **Purpose:** Measures electrical energy usage in Kilowatt-hours (kWh).
- **Types:** Analog and Digital/Smart.
- **Features:** Can display voltage, current, power factor, and instantaneous load.
- **Working Principle:**
- Energy (kWh)=Power (kW)×Time (h)

MCBDP (Miniature Circuit Breaker Distribution Panel)

- **Purpose:** Distributes electricity from the main energy meter to individual circuits.
- **Components:** MCBs, neutral and earth busbars, incoming terminals.
- **Used in:** Homes, small offices/buildings.
- **Function:** Protects circuits from overload and short circuits.

Busbar (Buz Bar)

- **Purpose:** Distributes electrical power within a panel.
- **Material:** Copper or Aluminum.
- **Types:** Single, Double, Insulated/Non-insulated.
- **Function:** Enables efficient and clean distribution, helps in load balancing.

Switch

- **Purpose:** Controls power flow by opening or closing a circuit.
- **Types:**
- SPST, DPST
- Two-way/Three-way
- Momentary (push button), Toggle, Rocker, Dimmer, Smart
- **Application:** Light, fan, appliances, automation.

Socket (Outlet)

- **Purpose:** Provides access to power for electrical devices.
- **Voltage/Current Ratings:** 220–240V, 6A–16A.
- **Pin Configurations:** 2-pin or 3-pin.
- **Application:** Used for plugging in various appliances.
- **Safety Tips:** Use sockets with shutters, surge protection, and proper grounding.

METHODOLOGY OF THE WORK

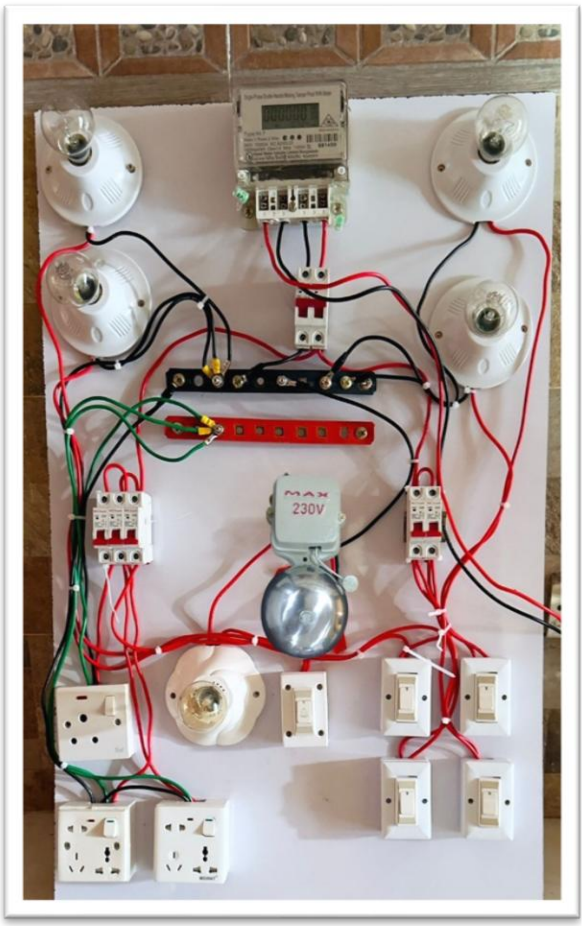
Power Supply to Energy Meter

The system begins with the **main supply** feeding into the **energy meter**, which records the total electricity consumed in **kilowatt-hours (kWh)**.

Protection via Double Pole MCB (63A)

Electricity from the energy meter flows into a **Double Pole Miniature Circuit Breaker (MCB)** rated at 63A. This breaker disconnects both the **phase and neutral lines** during an overload or short circuit, ensuring complete system isolation

- **Distribution through Busbars**
  From the MCB, power is distributed using **busbars**:
- **Red for Phase (Live)**
- **Black for Neutral**
- **Green for Ground (Earth)**
  These busbars act as the central points for further circuit branching.
- **Branch Circuit Protection with SP MCBs (20A)**
  Each outgoing load line is protected by a **Single Pole MCB** rated at 20A, which disconnects only the **phase wire** in case of a fault in that specific branch.



EQUATIONS

- **Current Calculation:** $I = \frac{P}{V}$
- **Total Load Current :** $I_{Total} = \frac{P_{TOTAL}}{V}$
- **Energy Consumption:** $E=P \times t$

MATHEMATICAL MODEL

For,

Voltage = 240 Volt

Supply Voltage = 233 Volt

Bulbs Quantity = 04

Each Bulb Power = 100 Watt

Total Power = (100*4)= 400 Watt

NOW, Total Current (I),

$I = \frac{400}{240}$ **= 1.67Amp (Therotical)**

$I = \frac{400}{233}$ **= 1.71 Amp(Measured)**

For KCL(Throtical) ,

I1 +I2+I3 +I4= I(Total)

Each load(Bulbs) current ,

$I = \frac{1.67}{4}$ **= 0.42 Amp**

Now, KCL(Proved)

I1 +I2+I3 +I4= I(Total)

0.42+0.42+0.42+0.42= 1.67 Amp
For KCL(Measured) ,

I1 +I2+I3 +I4= I(Total)

Each load(Bulbs) current ,

$I = \frac{1.71}{4}$ **= 0.43Amp**

Now, KCL(Proved)

I1 +I2+I3 +I4= I(Total)

0.43+0.42+0.41+0.43= 1.70 Amp

For Power Calculation

t= 1 Hour for 4 bulbs (100 W each)

And an Induction Motor (1HP=745W) using

t= 1Hour(60 min)

Total Energy Consumption :

E = P×t = [(400 × 1)+(745 × 1)] = 400+745 = 1145 Wh = 1.1145 kWh

OUTCOMES

🔌 Test Components	✅ Expected Outcome	📈 Observed Outcome	📝 Remarks
Energy Meter	Measure power usage	Meter reading displayed power usage accurately	Functioning properl
MCB (1-Phase)	Cut off power in overload	Tripped successfully on fault	Circuit protection v
Switches	Control individual loads	Controlled lights & sockets smoothly	Smooth operation,
Sockets (Plug Points)	Supply power to devices	Provided correct voltage (230V)	Suitable for applian
Lamp Loads (Bulbs)	Illuminate when switch on	Lights illuminated as per switch	Normal operation c
Color Coding (R-N-E)	Correct wiring scheme	Phase (Red), Neutral (Black), Earth (Green)	Wiring safety stand followed
System Testing	Whole system works	All components worked together as intended	System verified as f

RESULTS

From this experiment, we confirmed theoretical calculations with practical values. We demonstrated how to calculate individual and total currents and verified these using KCL.We also calculated energy usage over time, which is critical for understanding electricity consumption and billing in real-world applications.

we also observe the following precise outcomes:

1.Theoretical vs Practical Current:

Ideal current with 240V: 1.67 A

Actual current with 233V: 1.71 A, confirming voltage drop affects current draw

2. KCL Validation:

Individual bulb currents measured ≈ 0.42 A,

Their total value is near to the calculated overall current, proving KCL in a parallel load setup.

3. Energy Consumption Accuracy:

Total energy consumption calculated as 1.1145 kWh over one hour, Demonstrating the combined effect of lighting and motor loads on overall power usage. These results validate the application of Ohm's Law, KCL, and energy consumption principles in practical electrical circuits."**

DISCUSSION

Our project to build a model of a home's electrical wiring was a success! We successfully showed how to connect all the important parts, like the main **energy meter**, **circuit breakers (MCBs)**, **switches**, and **sockets**.

We were very careful to keep the wiring neat and followed the standard color code: **red for the live (phase) wire, black for the neutral wire, and green for the safety (earth) wire**. This makes the board safe and easy for anyone to understand.

Our math was also correct. We calculated that four 100-watt bulbs would draw about 1.67 amps of current. The **20-amp circuit breakers** we used were the right choice for this load, proving our design was solid. For safety, we made sure every part was grounded to prevent electric shocks.

Ultimately, this project was a great hands-on experience that helped us connect our classroom learning to a real-life electrical system

CULTURAL CONSIDERATION

In Bangladeshi culture, visiting friends and family is a very common and important social practice. The calling bell is the standard and expected way for guests to announce their presence. It is a symbol of hospitality, signaling the arrival of visitors to be welcomed into the home.

It is not considered a luxury but a basic, essential component of a modern home in the region. Its inclusion in your project, as shown in your block diagram and final design , makes the "Home Power Distribution Board" a more authentic and relatable simulation of a typical local residence.

CONCLUSIONS

The Basic Electrical Wiring Project effectively showcased the practical implementation of a single-phase domestic wiring setup on a demonstration board. This hands-on experience deepened our understanding of crucial components such as the energy meter, miniature circuit breakers (MCBs), switches, sockets, and electrical loads. By adhering to standard wiring practices and proper color coding—Red for Phase, Black for Neutral, and Green for Earth—we ensured that all connections were both safe and systematically organized.

Throughout the project, we gained valuable skills in electrical wiring, safe troubleshooting methods, and collaborative teamwork. The system underwent successful testing, with all components operating correctly. Additionally, this project highlighted areas for future enhancement, such as incorporating RCCB/ELCB protection devices, integrating smart monitoring systems, and expanding the setup for more advanced applications.

In summary, this project serves as a strong foundation for understanding real-life electrical installations. It significantly contributed to our technical development, improved our safety awareness, and enriched our practical knowledge in the field of electrical engineering.

FUTURE SCOPES

The Basic Electrical Wiring Project lays a strong foundation for future innovation, real-world application, and community impact. With further development, it can evolve into a highly educational, safe, and sustainable model. Potential areas of advancement include:

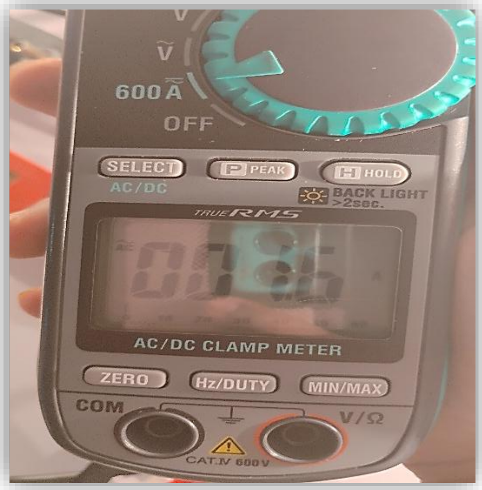
Integrated Smart Protection: Use advanced protection devices like RCCB, RCBO, and smart circuit breakers that can detect overloads, short circuits, and leakage currents, with real-time alerts via mobile apps.

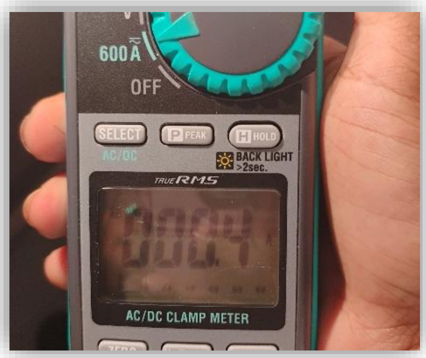
IoT and Automation Integration: Add smart home capabilities such as voice-controlled switches, automated lighting, and energy usage tracking through cloud-based dashboards to modernize the electrical setup.

Green Power Solutions :**Incorporate** solar PV systems with inverters and battery backups to create hybrid energy systems, promoting the use of clean, renewable energy.

Three-Phase System Expansion: Extend the model to include three-phase wiring systems, preparing learners for industrial and commercial electrical environments..
Enhanced Safety Features: Include surge protectors, lightning arresters, visual indicators (such as LEDs for live/fault detection), proper grounding techniques, and insulation testing for added safety awareness.
Disaster-Resilient Wiring: Design wiring setups suitable for extreme environments such as flood-prone or cyclone-hit areas using water-resistant materials and elevated cabling.
Research and Innovation Opportunities: Encourage experimentation with energy-efficient layouts, smart grid integration, eco-friendly materials, and cost-effective electrical solutions to address global challenges..

APPENDIX





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