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TITLE PAGE

- Problem Statement ID – **SIH1572**
- Problem Statement Title- **Design/Development of an efficient Energy Storage System (ESS) to integrate intermittent Renewable Energy sources and to support/stabilize the grid.**
- Theme- **Renewable / Sustainable Energy**
- PS Category- **Hardware**
- Team ID- **7668**
- Team Name- **TEENAGE ENGINEERING**

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IDEA TITLE
INTELLIGENT ENERGY STORAGE SYSTEM

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Proposed Solution / IDEA

Intelligent Energy Storage System

Our approach for *renewable* energy storage with grid integration (Powered by ESP32). It uses advanced technologies and intelligent **control algorithms** to **optimize energy storage**, **utilization**, **grid stability** with **real-time dashboard.**

Unique Value Propositions

- A ***real-time dashboard*** for **control** and **insights** into ***energy*** **flows**, ***grid*** **status and system performance.**
- Achieves **87%** **peak conversion *efficiency*.**
- Reduces **fossil fuel reliance** by up to **40%.**
- Increases grid **resilience** up to **99%** under stress.
- Stabilize the grid with frequency regulation **(50Hz)**, ***voltage*** **support**, and **peak *load* reduction**.

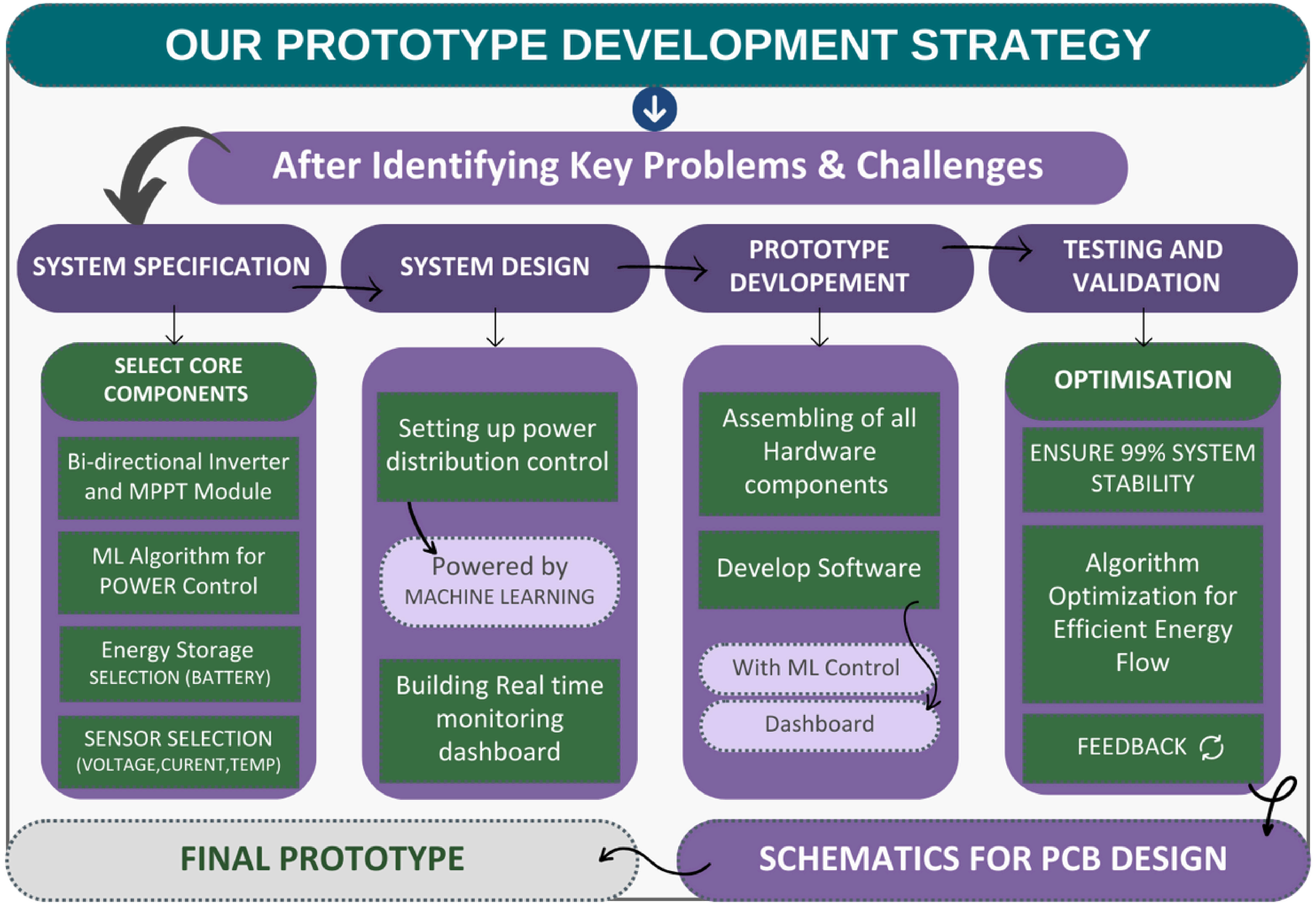

FIGURE.1:- STRATEGY FLOW CHART OF OUR PROPOSED SYSTEM

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TECHNICAL APPROACH

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TECHNOLOGIES & PLATFORMS TO BE USED

Energy Source and Storage Design

- Solar Panel (100W, 18V) / Power Supply (Simulation)
- MPPT Charge Controller (12V, 10A)
- LEFOPE4 Battery (3S, 12V, 20Ah)

Power Management (Dynamic energy distribution)

- Bidirectional Inverter (12V to 240V AC)
- Relays, DC-DC Buck & Boost Converters for voltage regulation (step-down and step-up)

Sensors & Feedback

- INA219 Sensors for Precision ADC Measurements
- Temperature sensors for safety.

Monitoring - Automation - Control

- ESP32 Microcontroller: for control, monitoring, data logging, power routing, and Wi-Fi-based dashboard communication.
- LCD Menu Interface and Control switches for feedback and stats.

Programming: Embedded C++, Arduino cloud & IDE

Algorithms & Logic

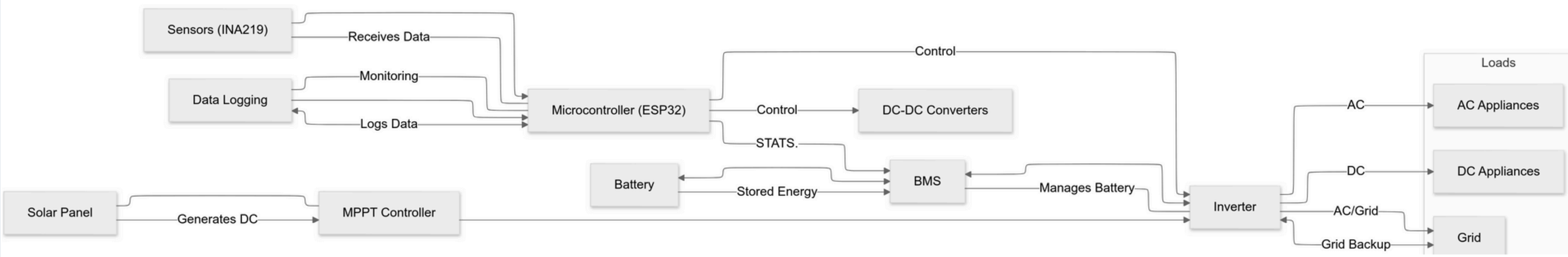
- Power Distribution Algorithm
- MPPT Perturbed Algorithm With CC-CV & PWM
- Battery Management and protection Logic
- Fault Detection & Alerts

Other

- MOSFETs, Diodes, Voltage Regulators, Relays etc.

METHODOLOGY [CLICK HERE]

FIGURE.3:- METHODOLOGY AND WORKFLOW CHART OF OUR PROPOSED SYSTEM



Prototype Status: Currently, the prototype is in the testing phase, with the dashboard fully operational for monitoring stats, Circuit designs are in progress, with some completed (see Figure 2).

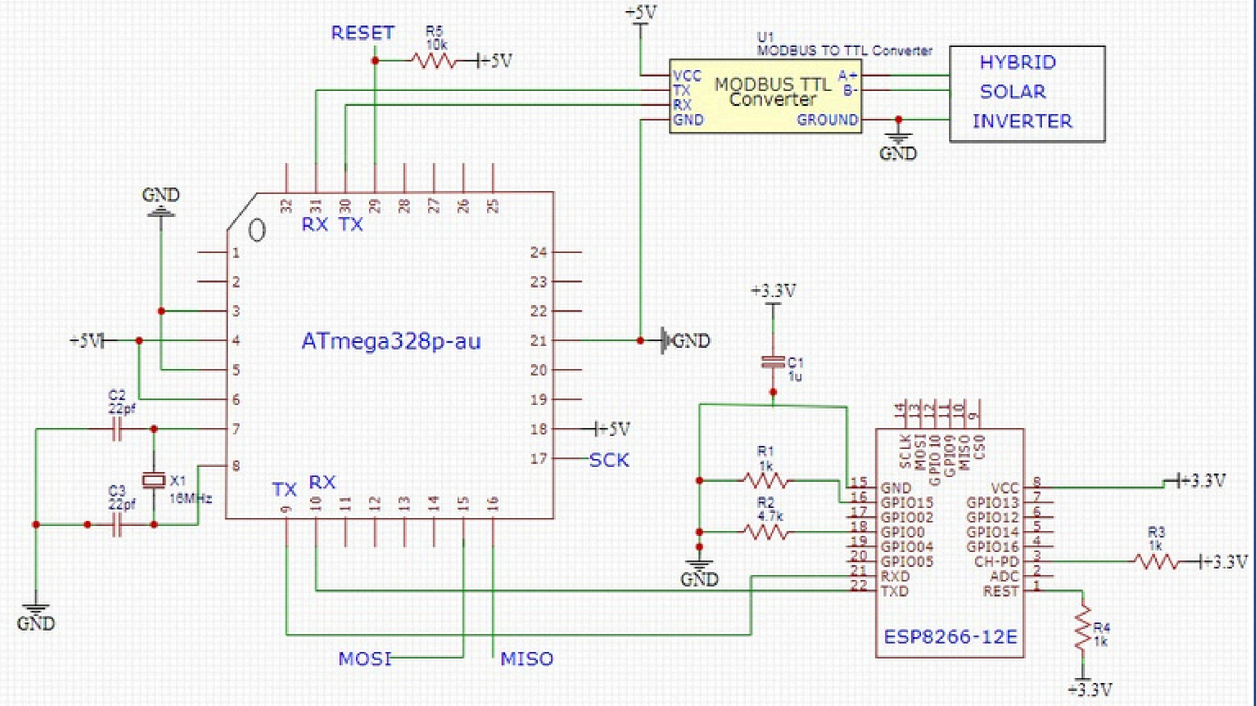


FIGURE.2:- PROTOTYPE CICRUIT - SCHEMATICS (DASHBOARD)

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FEASIBILITY AND VIABILITY

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Feasibility Analysis of the Idea:

- India's **supportive policies** towards renewable energy commitment. [REFERENCE LINK]
- **Environmental benefits** include **reducing** carbon emissions and promoting sustainability. [LINK]
- **Market Demand:** The growing demand for energy storage solutions, driven by the increasing adoption of renewable energy, presents a market opportunity.

Technical Feasibility

Current Status: Prototype is operational with the dashboard integration (FIGURE - 4) and partial circuit designs. Feedback-based testing is ongoing.

Strategies that we are considering:

- Conducting iterative feedback-based testing to resolve integration issues.
- Validating each component's performance through detailed testing.
- Refining design based on test results and feedback.

[DRIVE LINK] FOR MORE DETIALS

Our challenge involves optimizing energy flow among solar panels, batteries, and loads by integrating MPPT, BMS, and inverters.
We aim for ensuring seamless automation, overheating prevention, real-time monitoring validation, and battery health maintenance under variable loads for long-term reliability.

FIGURE 4. PROTOTYPE – DASH BOARD

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IMPACT AND BENEFITS

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The target audience includes:

TO End Users:
Homeowners and businesses with renewable energy sources will experience enhanced energy reliability and reduced dependency on the grid with **reduced bills.**

TO Government:
achieves renewable energy targets, reduced emissions, energy security, and economic growth.

Environmental benifits:

- Reduced Emissions: Supports India's target of reducing emission intensity by **45**% by 2030 through enhanced renewable integration.

Economical benifits:

- Cost Savings: Decreases reliance on expensive fossil fuels and grid electricity, potentially lowering energy bills for users.
- Job Creation: this lead to new job opportunities

Sustainable Energy:
Contributes to the goal of achieving 50% installed capacity from non-fossil fuel-based resources by 2030.

[REFERENCE LINK] [POLICIES]

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RESEARCH AND REFERENCES

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Advancements:

Our **solution** combines **advanced energy management** with renewable sources through a **flexible** hybrid system. Unlike traditional batteries, it optimizes **efficiency**, enhances **performance**, and integrates seamlessly with **solar energy** and the grid. **Intelligent automation** enables real-time **decision-making**, improving adaptability, reducing waste, and promoting sustainability.

Overall, it delivers superior performance and efficiency with renewable integration, making it as a standout (ESS).

Primary Sources

Government Publications & Reports:

National Electricity Plan (NEP) 2023 by Central Electricity Authority (CEA)

Ministry of Power notifications on Energy Storage Obligations (ESO)

[DRIVE LINK]

Academic Research Papers:

IoT Integration in Renewable Energy:

- Panda et al., 2017. Wireless Power Transfer... Home Automation. ICPEDC.
- Adhya et al., 2016. An IoT Based Smart Solar... Monitoring and Control unit. CIEC.
- Lokesh Babu et al., 2018. IoT Enabled Solar Power Monitoring System. IJET.

Solar Monitoring & Control:

- Patil et al., 2017. Solar Energy Monitoring System Using IoT. Indian Journal of Scientific Research
- Sarswat et al., 2019. Real Time Monitoring of Solar PV Parameter Using IoT. IJITEE
- Ambadkar & Junghare, 2018. Solar Tracking System With Iot. ICEMESM.

Advanced Control & Optimization:

- Saranya et al., 2019. Web Monitoring And Speed Control Of Solar Based Bldc Motor With Iot. ICACCS

[EXPLANATION VIDEO]