MPower Boards: Revolutionizing Power Grid Education and Research

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Project Vision:

Vision:

- MPower Boards aims to create an interactive, physical representation of power grids that blends 3D printing, LED technology, and real-time simulations to revolutionize power systems education and research.

Key Objectives:

- Teach complex concepts like the per-unit system with a hands-on, visual approach.
- Provide a dynamic platform for testing and visualizing grid operations and optimizations.

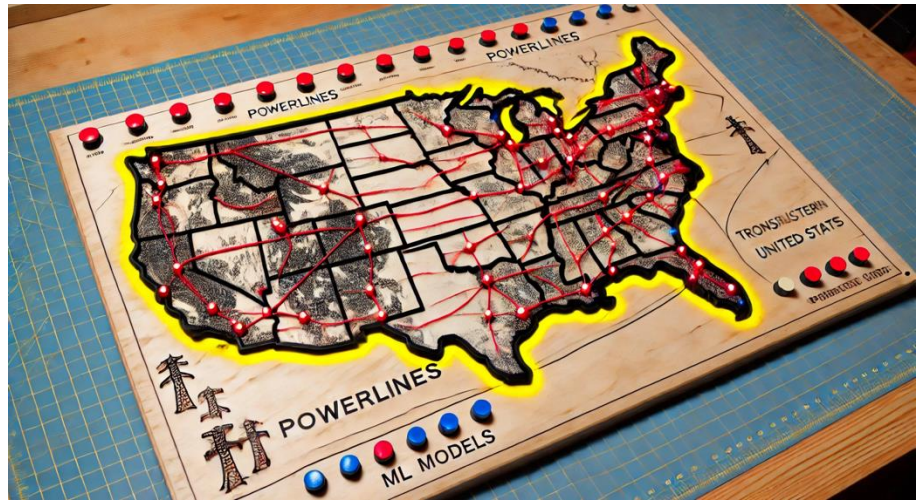

Fig.1. MPB Prototype V1

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Notes on the Design Direction

Hardware and Layout

- Gather all necessary components.
- Ensure the **ESP32** can be placed on a **black PCB** and merges seamlessly with it.
- Include the **GT logo** in one corner.
- Position the **12V battery jack** in the corner for easy access.
- Add **standoffs for the OLED display** (a smaller OLED may be required).
- Source the **ESP32 circuit design** from *Techeism (YouTube channel)*.

Display and Functionality

- Display the **total number of violations** and the **maximum violation count**.
- Show **DC → AC violations** to visualize how design approximations affect power flow results.
- Aim to develop both **DCOPF** (DC Optimal Power Flow) and **ACOPF** (AC Optimal Power Flow) representations — or display both.
- Use the display to **illustrate violations of the inequality constraints** observed during the optimization or market clearing process.

Network Diagram to Physical Implementation

•**Objective:** Transitioning from a network diagram to a physical implementation using an LED matrix.

- **ML Model Application:** We will discuss how machine learning models could identify and replicate patterns from grid simulations, which could then be visualized using LEDs. Highlight potential techniques such as supervised learning or reinforcement learning.
- **Automation vs. Manual Coding:** We will explore the feasibility of using automated processes for setting up the network on the LED matrix, potentially by using existing software /custom scripts.

Key Component	Details
Objective	Transitioning from network diagram to physical implementation using an LED matrix.
ML Model Integration	Can an ML model learn grid simulation patterns and transfer them to an LED matrix?
Manual vs. Automation	Do we need to code each network component individually, or can this be automated?

Fig.4. MPB Prototype V3: Mapping network diagram directly

MPBs Physical Representation

•**Simple Grid (Point-Based):** This LED matrix offers flexibility and versatility, allowing it to be reconfigured to represent various geographic locations or network structures. Its ability to morph into different shapes makes it ideal for dynamic visualizations where the network/location might change frequently.

•**Complex Network Structure:** This setup involves a 3D printed map of the USA with LEDs embedded within it. The LEDs can light up to represent different network structures across the country. While less flexible than the simple grid, this option provides a detailed and realistic representation, making it particularly effective for visualizing fixed network layouts.

Representation Type	Description
Simple Grid (Point-Based)	A matrix of LEDs that is highly malleable, capable of morphing into any country, state, or network.
Complex Network Structure	A fixed 3D printed USA map with embedded LEDs that can morph into various network structures.

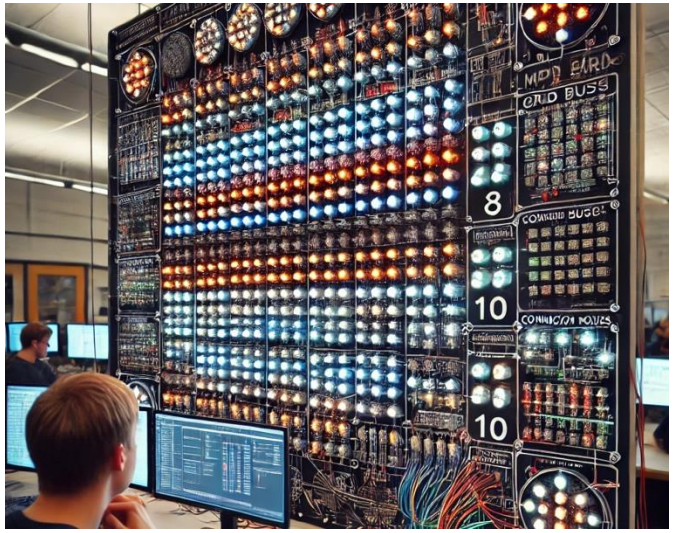

Fig.5. MPB Prototype V7, with LED matrix

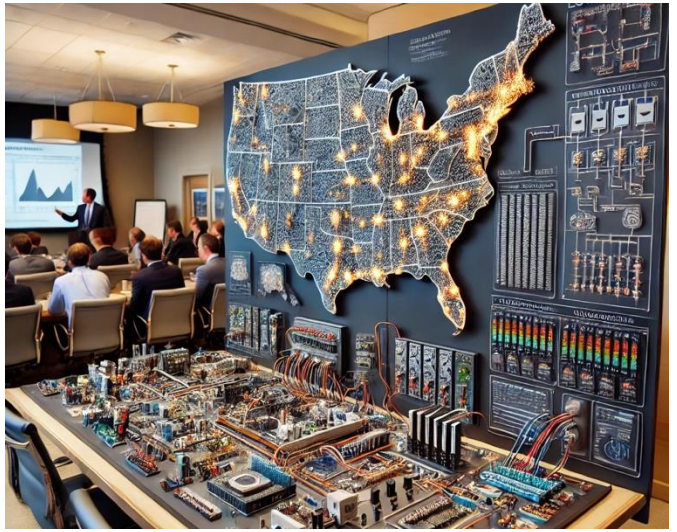

Fig.6. MPB Prototype V6, with 3D print

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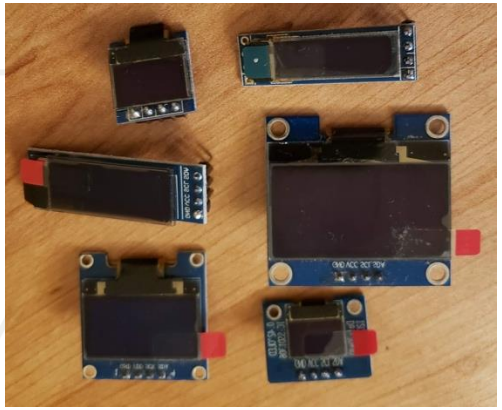
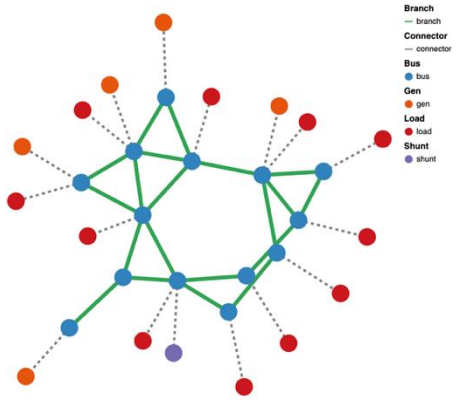
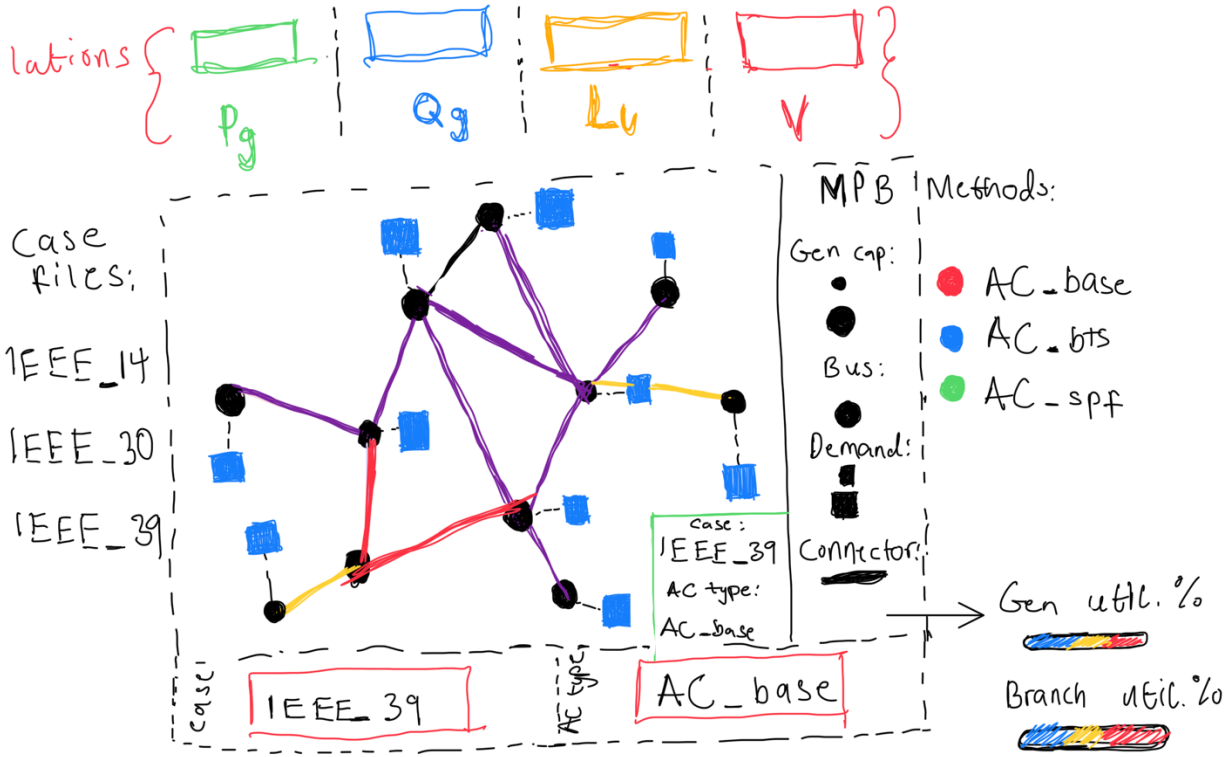
MPB v1

- No 3D printed parts
- Connections are shown using standard LEDs. They are large and more prominent.
- Violations will be shown at the top of the board and will use more rectangular OLED displays.







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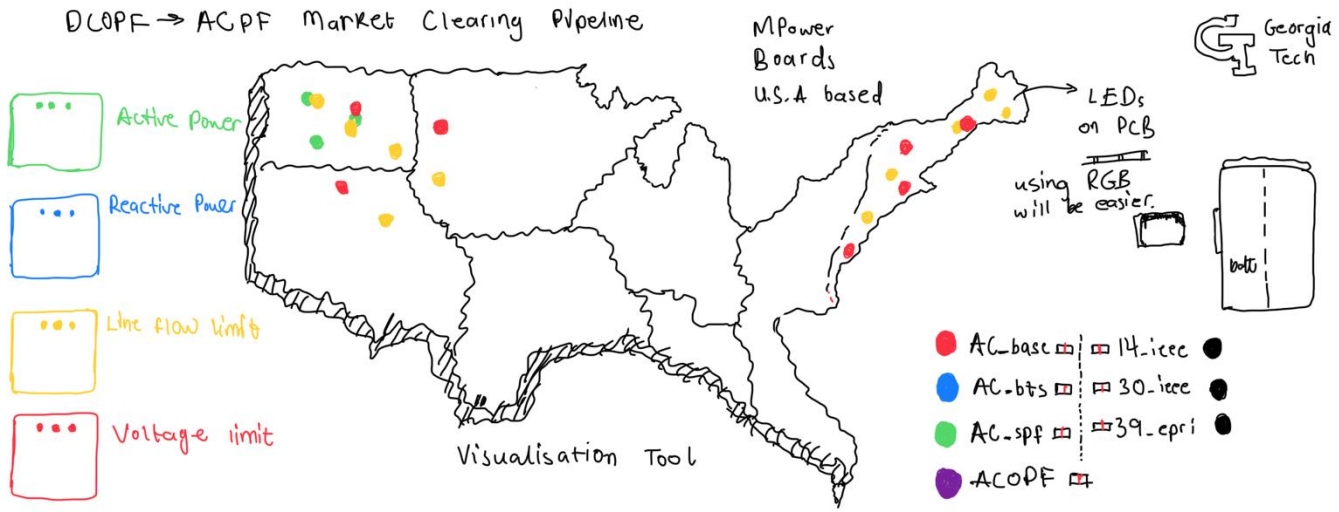
MPB v2

- 3D printed U.S. Map
- Connections will be shown using PCB LEDs (much smaller and can show more complex connections).
- Violations will be shown at the left side of the board. This time on a more square-shaped display.



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