SMART SURGE PROTECTOR

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TRIMLIGHT

Intro/Abstract

Trimlight designs and installs permanent outdoor lighting throughout North America. The lights are meant to last 50,000 hours, yet severe weather events pose a persistent challenge. Surges and electromagnetic activity from storms frequently damage these systems, leading to costly repairs and downtime. An autonomous device is needed, to provide surge protecting capabilities while acting on real-time weather data to protect lighting infrastructure.

Problem Statement

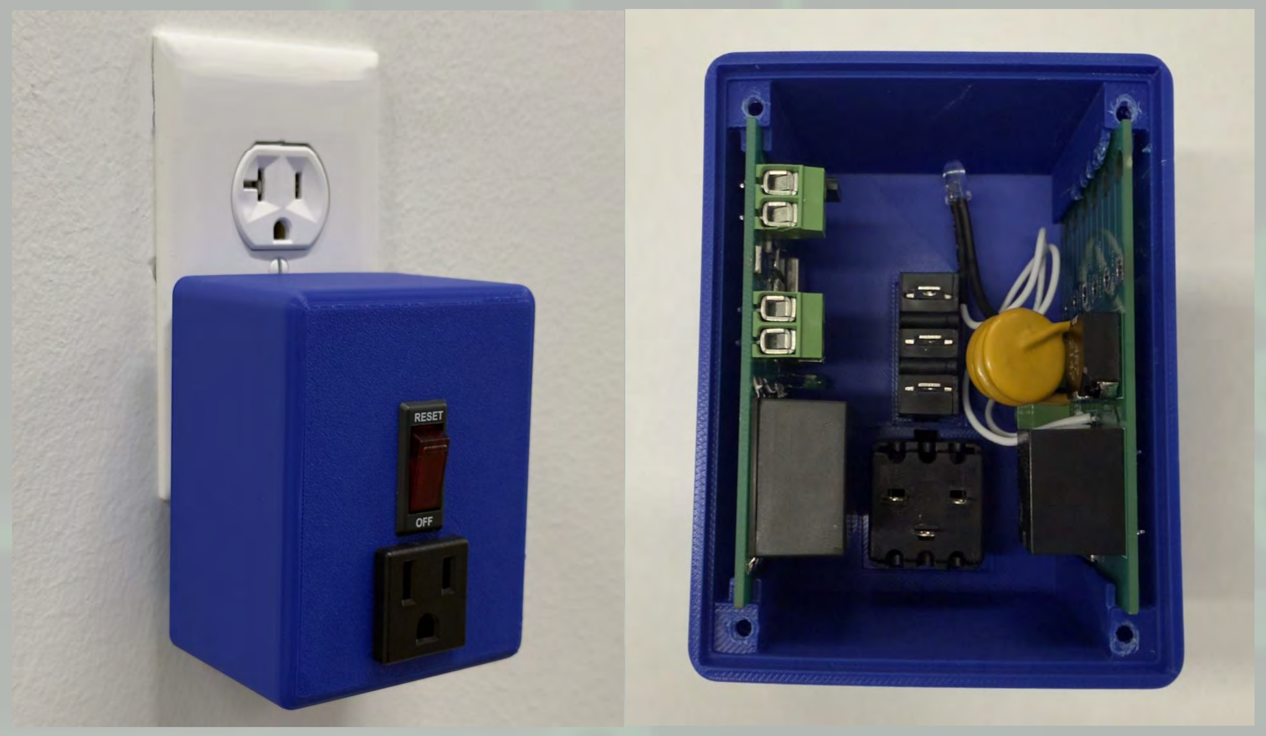
The objective was to design a device that will toggle lights on and off in response to storm activity. To enhance durability and reliability, a mechanical switch and passive surge protection were incorporated. This device is meant to plug directly into home outlets and act as an outlet, to provide power to other electronic devices.

Receives wireless signals	Yes
Connects and disconnects electronics	Yes
Protects against voltages above 200 V	Yes
Current Rating	15A
Voltage Rating	120V

Device and operating specifications

Design Overview

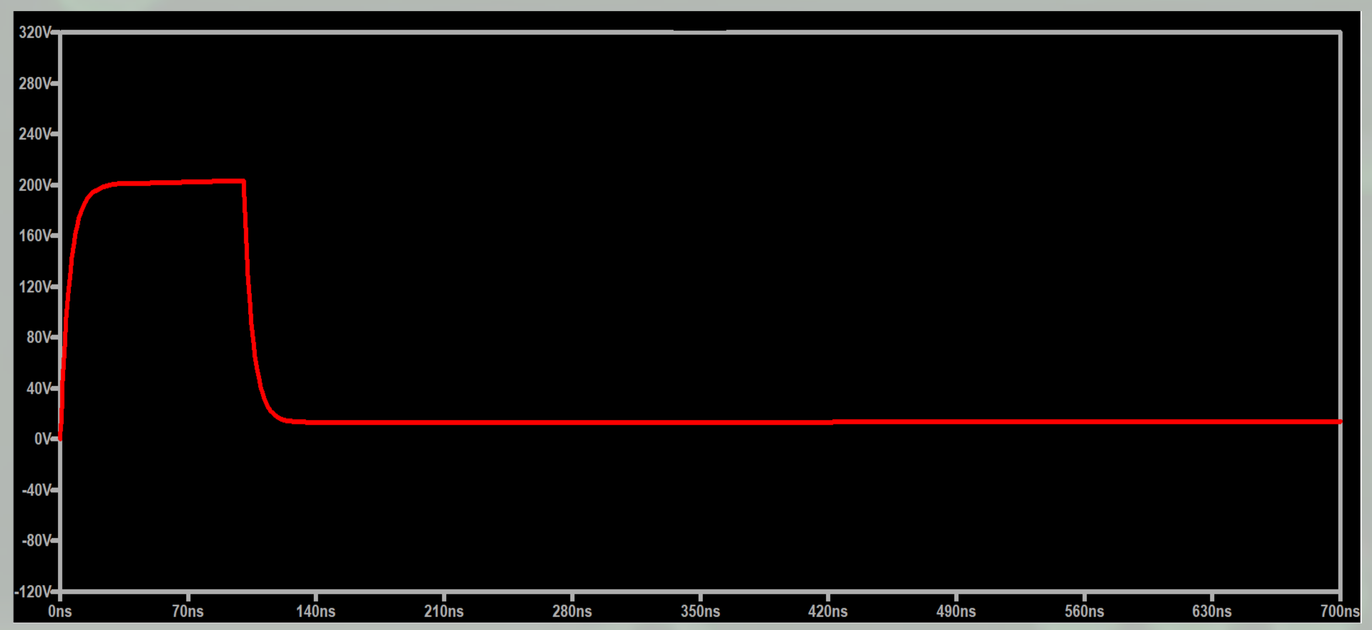
The circuit includes surge protection and wireless communication components. Surge protection is provided by a circuit breaker, thermal MOVs, an inductor, and a relay. If the current spikes, the breaker trips while MOVs divert excess voltage. Wireless functionality is enabled via a Wi-Fi module and power converter, allowing remote control through Trimlight's server. During storms, the Wi-Fi module triggers the relay, cutting power to connected electronics.



Housing unit with circuit breaker and outlet

Methods - Simulation

LTSpice was used to model the protective circuit. A surge was simulated according to UL 1449. The simulation tests MOV clamping voltage, demonstrating protection.



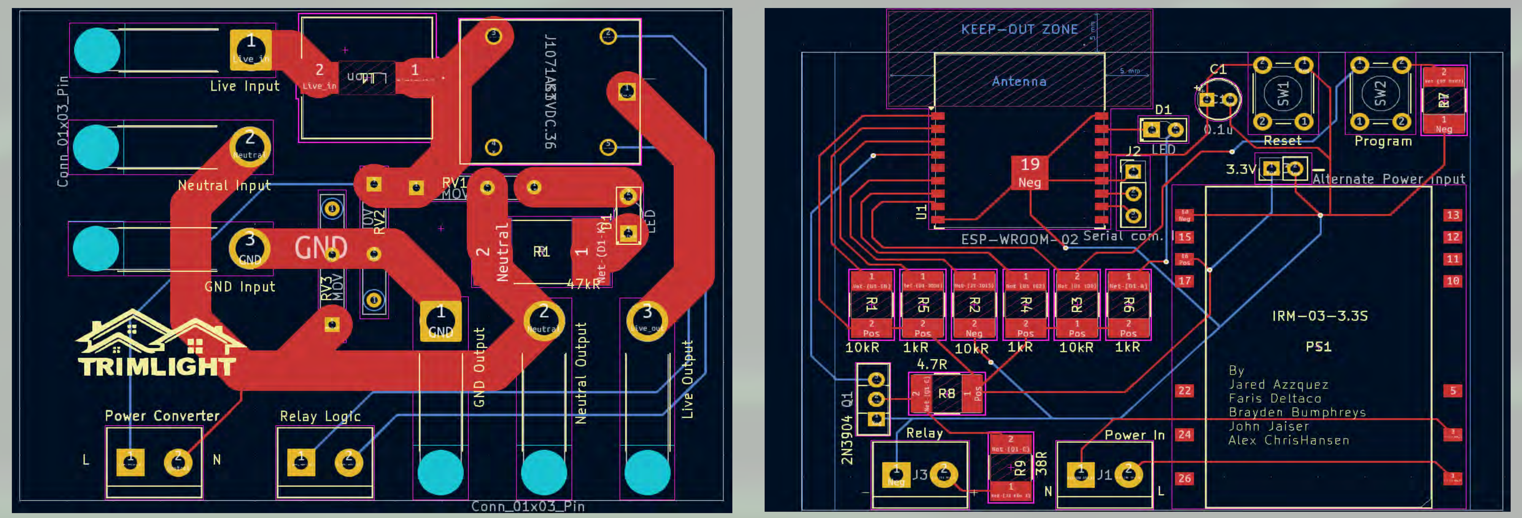
Simulation results documenting clamping voltage

Simulation Results

The best UL Voltage Protection Rating (VPR) is 330, which corresponds to a clamping voltage of 330V. In the simulation, the system yielded a clamp voltage of approximately 200V, representing the maximum voltage allowed through. As a result, the connected electronics will experience this lower clamp voltage instead of the full surge voltage, effectively providing protection.

Methods – Physical Testing and Modeling

Custom PCBs were designed alongside a housing unit to support the overall system. A NOT gate was developed to control the activation of the relay. Additionally, a server was programmed to communicate with the Wi-Fi module, enabling wireless control functionality.



Dual custom PCB's which enable surge protecting and wireless communication

Physical Testing Results

The Wi-Fi module receives wireless inputs from a server and remains in a dormant state when idle. In this dormant state, the relay sees a current of 60 mA, which keeps the circuit closed. However, when the Wi-Fi module receives a signal, it activates and sends current through a NOT gate. This action reduces the current reaching the relay, causing the circuit to open.

Conclusion

The smart surge protector designed will work as intended based on the physical and simulated tests. Thermal MOVs will provide the necessary protection against surges that will be occur from lightning storms. The relay can switch on/off via the Wi-Fi module when a storm is in the vicinity. Future work is to implement brownout protection in the device. This will allow the device to protect electronics from damages due to low voltage conditions.