TEAM 004

Smart Traffic Light System for Emergency Vehicle Clearance

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ICS EE 3 ME

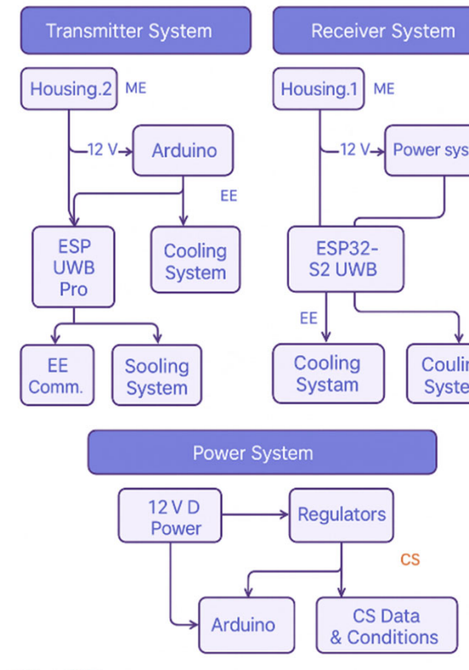
Background

- Traffic lights operate on fixed cycles and cannot respond to approaching emergency vehicles, causing delays and safety risks. This project develops a smart UWB-based detection and signal-control system that clears intersections automatically, improving response times and overall traffic safety. The design provides a reliable, cost-effective solution suitable for real-world smart-city deployment.

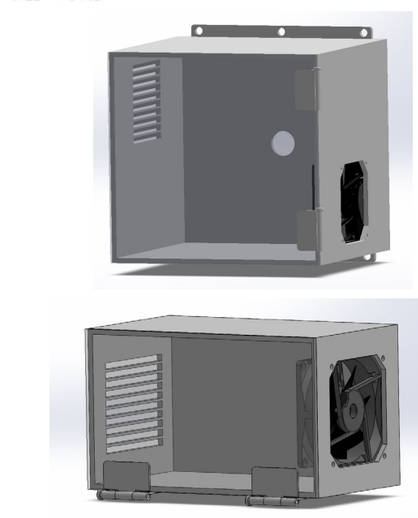
Problem Statement

- Emergency vehicles are frequently delayed at intersections because traditional traffic lights cannot identify or prioritize them in real time. This leads to longer response times, increased accident risk, and unsafe driver behavior as vehicles try to make way manually. A reliable, fast, and low-cost system is needed to detect approaching emergency vehicles and automatically clear intersections to ensure safe and efficient passage.

Prototype



EE ME



Constraints

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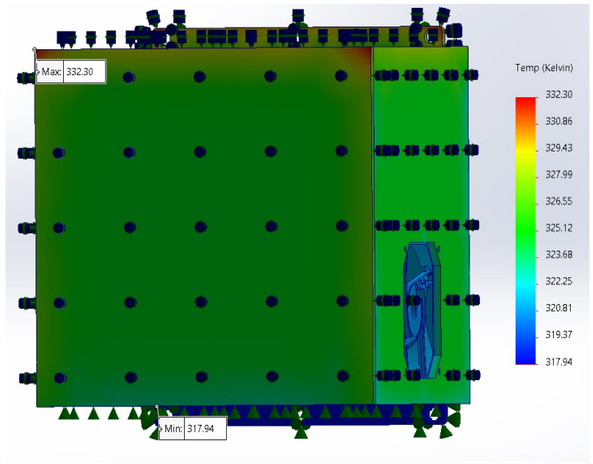
The system must detect emergency vehicles within a range of 175 meters.
The system must switch the traffic light to green within 8 seconds of detecting an emergency vehicle.
The housing must be designed to withstand environmental conditions, including temperatures from -10°C to 55°C, rain, and dust, to ensure long-term outdoors.
The system must comply with local traffic regulations and safety standards.
The simulation shall be designed to run efficiently on non-specialized consumer hardware to ensure accessibility and usability for testing and demonstration.
The system should employ commercially available ESP32 UWB Pro modules for Wi-Fi-based distance measurement.
The signal affected by the path loss

Tests & Validations



Specifications

The ESP32 UWB Pro communication system shall measure the distance to an emergency vehicle with an accuracy of ±0.5 meters
The system must restore the traffic light to its original state within 10 seconds after the emergency vehicle passes.
The protective enclosure shall maintain an internal temperature no more than 10 °C above the external ambient temperature, and shall not exceed an absolute maximum of 60 °C
The simulation shall model at least 3 distinct emergency routing scenarios involving varying traffic light coordination paths across multiple intersections.
The traffic control shall process sensor input and update the traffic light state with a latency of no more than 200 milliseconds
The virtual simulation shall model emergency vehicle clearance scenarios with a minimum frame rate of 30 FPS and a resolution of at least 720p
The system must be withstanding difficult wind conditions (40 km/h).
The system will provide a warning indication on the traffic light for 3 seconds before it turns red.
The system must integrate the Wi-Fi-based distance measurement with the traffic light control mechanism
The integrated system shall enable real-time synchronization between physical traffic light system and the virtual simulation with a maximum latency difference of 100 ms, ensuring coherent performance across all subsystems under varying traffic conditions
The system must be able to operate continuously for 24 hours without failure.
The total cost of the device should not exceed 4000 Saudi Riyals

Conclusion

- The system reliably detects emergency vehicles and clears intersections automatically, reducing delays and improving safety. Its UWB-based design offers fast response, simple integration, and strong potential for real smart-city deployment.