SpoilSense

ECE 445
Senior Design Laboratory
Final Demonstration
Team 25

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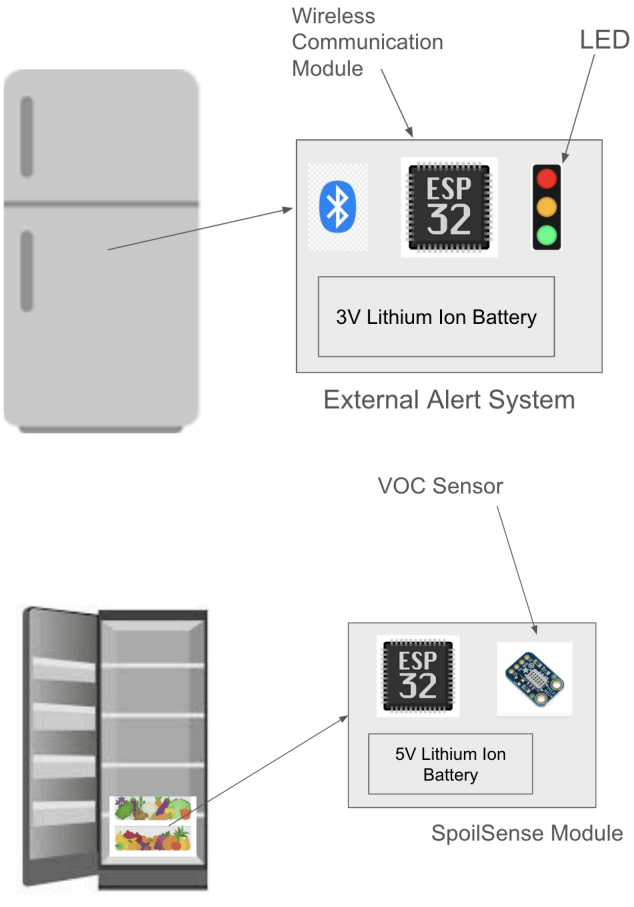
Problem and Solution

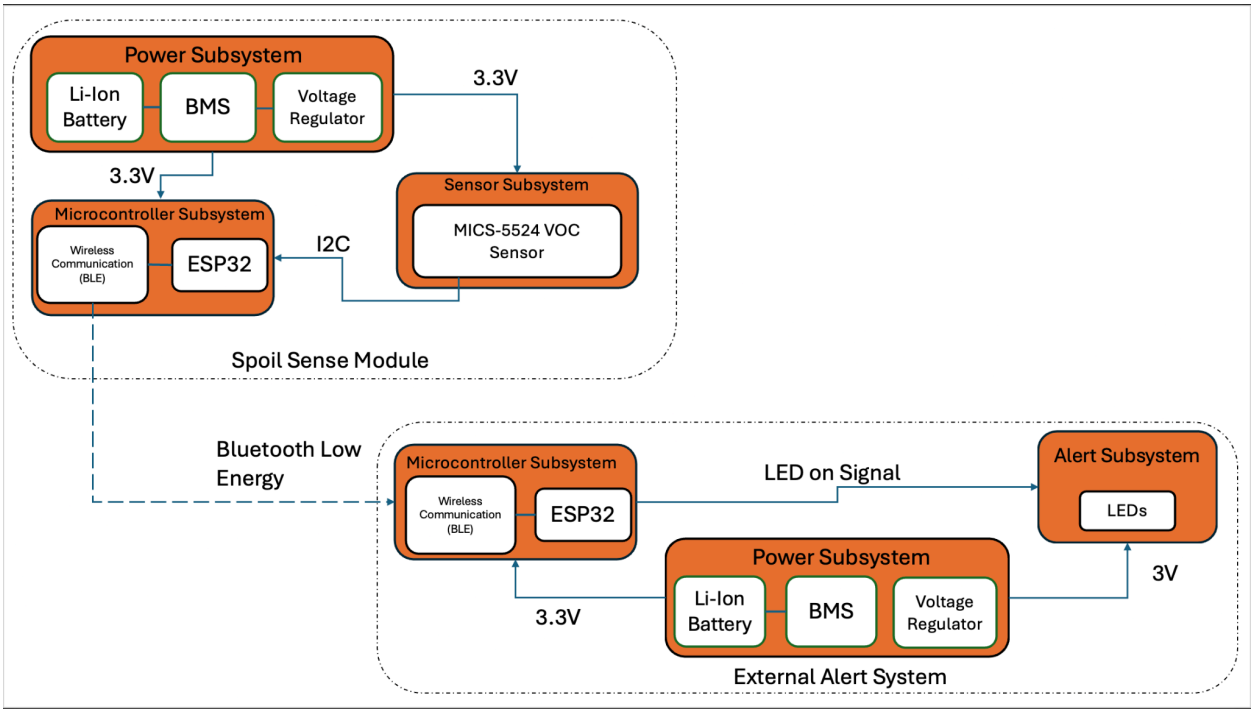
Maintaining the freshness of produce in household refrigerators is a persistent challenge faced by many individuals and families. Fruits and vegetables often go unnoticed at the back of the fridge until they become overripe or rotten, leading to unnecessary food waste, financial loss, and unpleasant odors that permeate the entire refrigerator. Spoiled produce emits various gasses that foster the growth of mold and bacteria, accelerating the decay of nearby fresh items and compromising the overall quality and safety of other stored foods. In the U.S. alone, an estimated 133 billion pounds of edible food—worth over $161 billion—goes to waste every year. Alarmingly, more than 80 percent of Americans discard perfectly good, consumable food simply because they misunderstand expiration labels (UNEP).

To address this pervasive issue, our project SpoilSense aims to develop a monitoring device that detects when produce inside a refrigerator is going bad. The system will utilize sensors to monitor volatile organic compound (VOC) gases emitted by spoiling fruits and vegetables. Once spoilage is detected, it will alert the user via wireless communication to an external LED indicator magnetically attached to the refrigerator's exterior. This solution automates the process of monitoring produce freshness, allowing households to take timely action to reduce food waste, maintain food quality, and save costs.

Visual Aid



Block Diagram



High-level Requirements

1. The module should be accurate in detecting the presence of VOCs (volatile organic compounds) up to a threshold of 3000 PPM for CH4 (Methane) and 50 PPM for NH3 (Ammonia) in order to trigger an alert.
2. The design should be capable of withstanding standard refrigerator temperatures (3-5 Degrees Celsius) and should maintain a form factor that is at most dimensions of 5 in x 4 in x 2 in.
3. The system must respond to detected gas concentration changes and trigger an alert within 30 seconds of the threshold being met to ensure timely responses.

SpoilSense Module

Sensor

Requirements	Verification
The VOC sensor should be able to accurately	To verify the VOC sensor's accuracy up to the

detect the presence of CH4 up to 3000 PPM with an accuracy of ±5% as well as NH3 up to 50 PPM with an accuracy of ±5%	thresholds listed with ±5% precision, set up a controlled test environment with some sort of spoiled food. We will conduct incremental tests at various concentrations, recording the sensor's readings to a serial console. Once we find a resistance value that indicates spoilage, that value will be our threshold for the microcontroller.

Microcontroller

Requirements	Verification
Must process sensor data and trigger alerts within 30 seconds of spoilage detection.	Create a controlled test environment where spoilage conditions are simulated and detected by the sensors. Initiate the spoilage event and start timing simultaneously, then record the exact time when the alert is triggered by the system. Repeat this test multiple times to ensure reliability and account for any variations in processing time. Analyze the collected data to confirm that the system consistently processes the sensor input and issues alerts within the 30-second threshold, thus meeting the specified design requirement.
Must maintain a wireless communication through the door of the fridge with the external alert system, using BLE	Set up a controlled environment where the device and the alert system are placed at varying positions on either side of the metal barrier. At each position, conduct communication tests to assess successful pairing, data transmission reliability, signal strength, and latency, while recording any instances of dropped connections or errors. Ensure that external factors such as interference from other wireless devices, obstacles, and environmental conditions are minimized or kept consistent to accurately evaluate the BLE performance. Analyze the collected data to confirm that the device consistently maintains a stable and reliable BLE connection with the external alert system at a distance of 2 meters, thereby meeting the

	specified design requirement.

External Alert System

Alert

Requirements	Verification
Must be able to accurately light the LED based on detecting a certain amount of VOCs (based on the threshold) or not in the subsystem. LED off: no spoilage detected LED on: spoilage detected	To verify that the system accurately changes LEDs based on the detected gas concentrations, conduct controlled tests by introducing known spoiled food. Pay special attention to the transition thresholds to confirm that the LED changes precisely at the specified points without delay. Document the testing procedures, observations, and results to confirm that the system reliably and consistently meets the design requirement of lighting the LED accurately based on the presence of spoiled food or not.

Microcontroller

Requirements	Verification
Must maintain a wireless communication range across the door of the fridge.	To verify that the device maintains wireless communication through the fridge door, set up a controlled environment where the device and its corresponding receiver are placed at various positions on either side of the metal door. We will then conduct communication tests at each position, recording any instances of dropped connections or errors. We will ensure that external factors such as interference, obstacles, and environmental conditions mimic that of a standard refrigerator.
Must trigger alerts from the LED within 30 seconds of receiving signal from the internal module microcontroller.	To verify that the device triggers alerts from the LED within 30 seconds of receiving a signal from the internal module microcontroller, we will set up a controlled test environment where the microcontroller is

	programmed to send activation signals to the LED at predetermined times. We will use precise timing logs to measure the elapsed time between the microcontroller's signal transmission and the LED's alert activation. Multiple trials will be done to account for any variability, ensuring consistent refrigerator environmental conditions during testing. Analyze the recorded times to confirm that the LED consistently triggers alerts within the 30-second requirement, thereby validating compliance with the design specification.