**A Basic Fire Alarm System: A Study in Embedded Security**

**Introduction**

My project is a foundational embedded system designed to perform a single, critical function: the local detection and alerting of a fire. Using a low-cost yet powerful ESP32 microcontroller, I have built a system that combines sensor input with simple actuator outputs to provide an immediate and effective security measure. This essay details the project's topic, its industrial application, the specific challenges it addresses, and the technical implementation of the solution.

**Topic and Industry**

The topic of this project is the use of embedded systems for **security monitoring**. Specifically, it focuses on fire detection as a core component of a security protocol. The system's target industry is the broad field of **physical security**, which encompasses applications in residential, commercial, and industrial environments. While my project is a basic prototype, the same principles are at the heart of more advanced fire detection systems found in modern buildings. By creating a functional, self-contained alarm, this project serves as a practical demonstration of how embedded technology forms the first line of defense in protecting lives and assets.

**Challenges Solved**

This project addresses a fundamental challenge in security: the need for a reliable, immediate, and local fire alert. A traditional fire alarm system is often expensive and complex, but my solution demonstrates that effective security can be achieved with a minimal set of components. The main problem it solves is providing an unmistakable warning to anyone within earshot or eyesight of the device. The system's use of both a loud audible alarm (the buzzer) and a clear visual signal (the flashing LED) ensures that the alert is effective even in noisy or visually impaired conditions. It provides an accessible and affordable entry point into embedded security systems, offering a viable alternative to more costly commercial products for small-scale applications.

**Technical Description of the Solution**

The fire alarm system is built around the **ESP32 microcontroller**, which serves as the brain. The system's operation is based on a simple control loop:

1. **Sensing:** The primary input is a **two-terminal flame sensor**. This sensor's electrical resistance changes when it detects infrared radiation from a flame. To make this resistance change readable by the ESP32's analog input, the sensor is integrated into a **voltage divider circuit** with a 10k Ohm resistor. The ESP32's analog-to-digital converter (ADC) reads the voltage at the midpoint of this divider, which correlates directly to the presence of a flame.
2. **Logic:** The ESP32's firmware, written in Arduino C++, continuously reads the analog value from the sensor. This value is compared against a pre-calibrated flameThreshold. If the sensor's value exceeds this threshold, the ESP32's control logic determines that a fire has been detected.
3. **Actuation:** Upon detection, the ESP32 triggers two outputs. It sends a digital HIGH signal to **GPIO 26** to activate the **buzzer**, creating a loud, audible warning. Simultaneously, it sends a digital HIGH signal to **GPIO 27**, which, through a **220 Ohm resistor**, illuminates the **LED**, providing a crucial visual alert. This dual-output strategy ensures that the alarm is highly noticeable. When the sensor value drops below the threshold, the ESP32 turns off both the buzzer and the LED, indicating that the threat has passed.

In summary, my project successfully integrates core embedded systems concepts to create a functional and practical security device. It showcases how simple circuits and straightforward programming logic can be combined to build a system that addresses a fundamental safety need in a cost-effective and accessible manner.