SMART ENVIRONMENTAL MONITORING AND ALERT SYSTEM USING STM32F407

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1. CASE STUDY OVERVIEW

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As part of the Embedded Systems Internship / Training Program, interns are assigned this case study to gain hands-on experience with STM32 microcontrollers, HAL-based programming, and real-world sensor interfacing.

This case study is designed to progressively build embedded system skills, starting from peripheral configuration to multi-sensor integration, real-time monitoring, and alert generation.

Interns are expected to implement, test, and document the system under mentor guidance.

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2. LEARNING OBJECTIVES

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By completing this case study, interns will be able to:

- Understand embedded system architecture using STM32F407
- Interface digital and analog sensors
- Use STM32 HAL library effectively
- Implement timer-based periodic tasks
- Design a real-time monitoring and alert system
- Debug and validate embedded firmware
- Document and present a working embedded solution

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3. SYSTEM DESCRIPTION (WHAT INTERNS WILL BUILD)

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Interns will design a system that:

- Measures temperature and humidity using DHT11

- Monitors air quality using MQ135 gas sensor
- Displays sensor values on a 16x2 I2C LCD
- Generates an audible alert using a buzzer when thresholds are crossed
- Uses a hardware timer for periodic data acquisition
- Optionally logs data via UART for debugging

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4. HARDWARE ASSIGNED FOR THE CASE STUDY

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- STM32F407 Discovery Board
- DHT11 Temperature & Humidity Sensor (GPIO based)
- MQ135 Gas / Air Quality Sensor (ADC based)
- 16x2 LCD with I2C Interface
- Buzzer (GPIO Output)
- Breadboard, jumper wires, USB cable

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5. PERIPHERALS & INTERFACES TO BE USED

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GPIO : DHT11 data pin, Buzzer control
ADC : Reading analog output from MQ135
I2C : Communication with LCD
TIMER : Periodic sensor sampling
UART : Optional debugging and logging

NOTE:

Interns must use STM32 HAL APIs only, unless instructed otherwise by the mentor.

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6. FUNCTIONAL EXPECTATIONS (TASK REQUIREMENTS)

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Interns must ensure the system performs the following:

1. Periodically read temperature and humidity from DHT11
2. Read air quality level from MQ135
3. Display real-time values on LCD
4. Compare sensor values against predefined thresholds
5. Activate buzzer on abnormal conditions
6. Maintain non-blocking execution using timers
7. Demonstrate stable and repeatable operation

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7. IMPLEMENTATION GUIDELINES (MENTOR INSTRUCTIONS)

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- Use STM32CubeIDE and HAL library
- Organize code in modular structure
- Avoid long blocking delays in main loop
- Use timers or flags for periodic execution
- Add meaningful comments
- Validate each sensor individually before integration

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8. EXPECTED DELIVERABLES FROM INTERNS

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- Working STM32CubeIDE project
- Live or recorded demonstration of system
- Circuit connection diagram
- Short documentation explaining system design
- Ability to explain implementation during evaluation

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9. EVALUATION CRITERIA

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Interns will be evaluated based on:

- Correct sensor interfacing
- Proper use of HAL APIs
- System stability and timing accuracy
- Code readability and modularity
- Understanding of peripherals used

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10. OPTIONAL EXTENSION TASKS

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Advanced interns may:

- Add UART-based data logging
- Add DAC-based analog output
- Modify alert thresholds dynamically
- Add additional sensors with mentor approval

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11. CONCLUSION

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This case study bridges theoretical concepts with practical embedded development. Successful completion indicates readiness to work on real-world embedded firmware projects involving sensors, displays, and real-time control.