

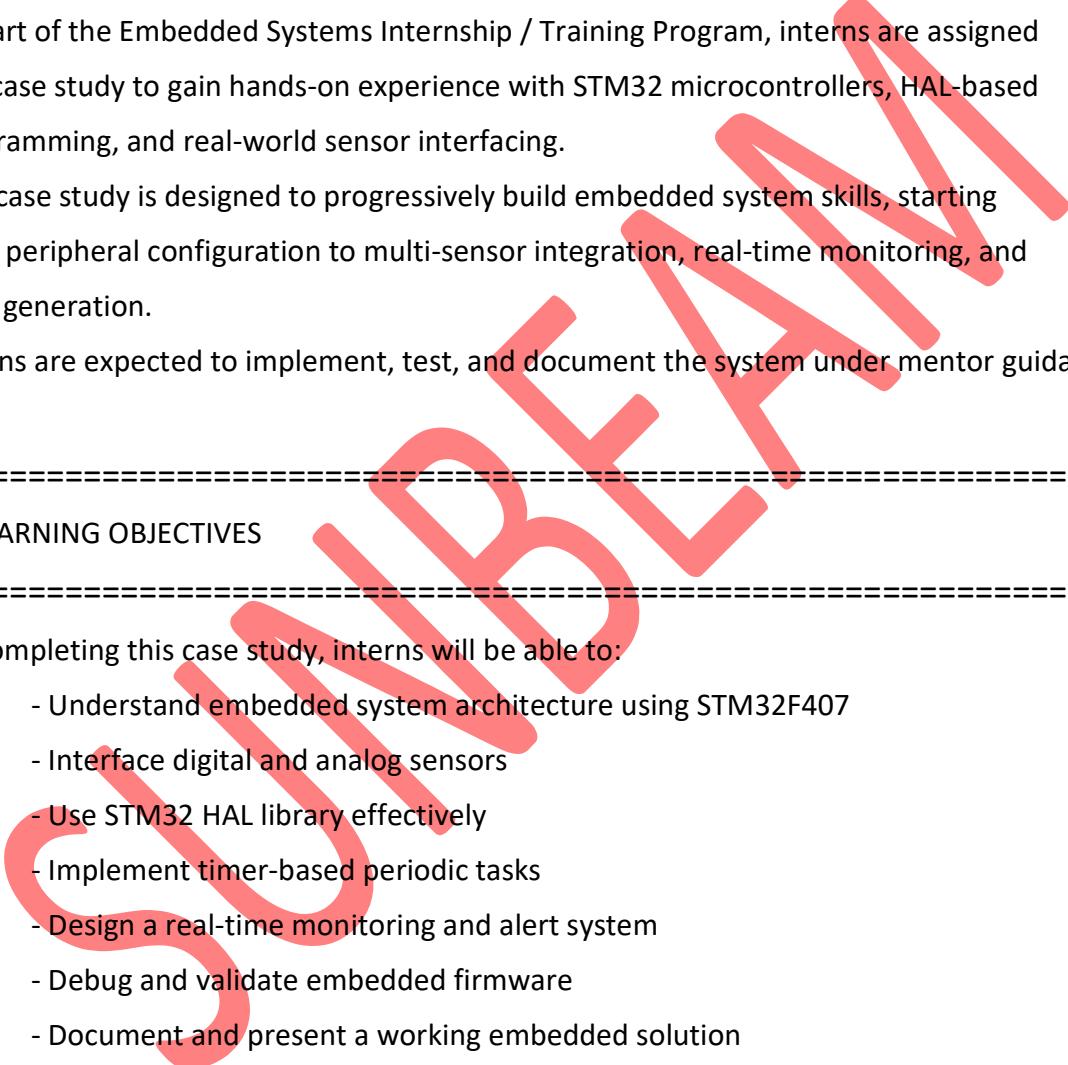
SMART ENVIRONMENTAL MONITORING AND ALERT SYSTEM USING STM32F407

1. CASE STUDY OVERVIEW

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.

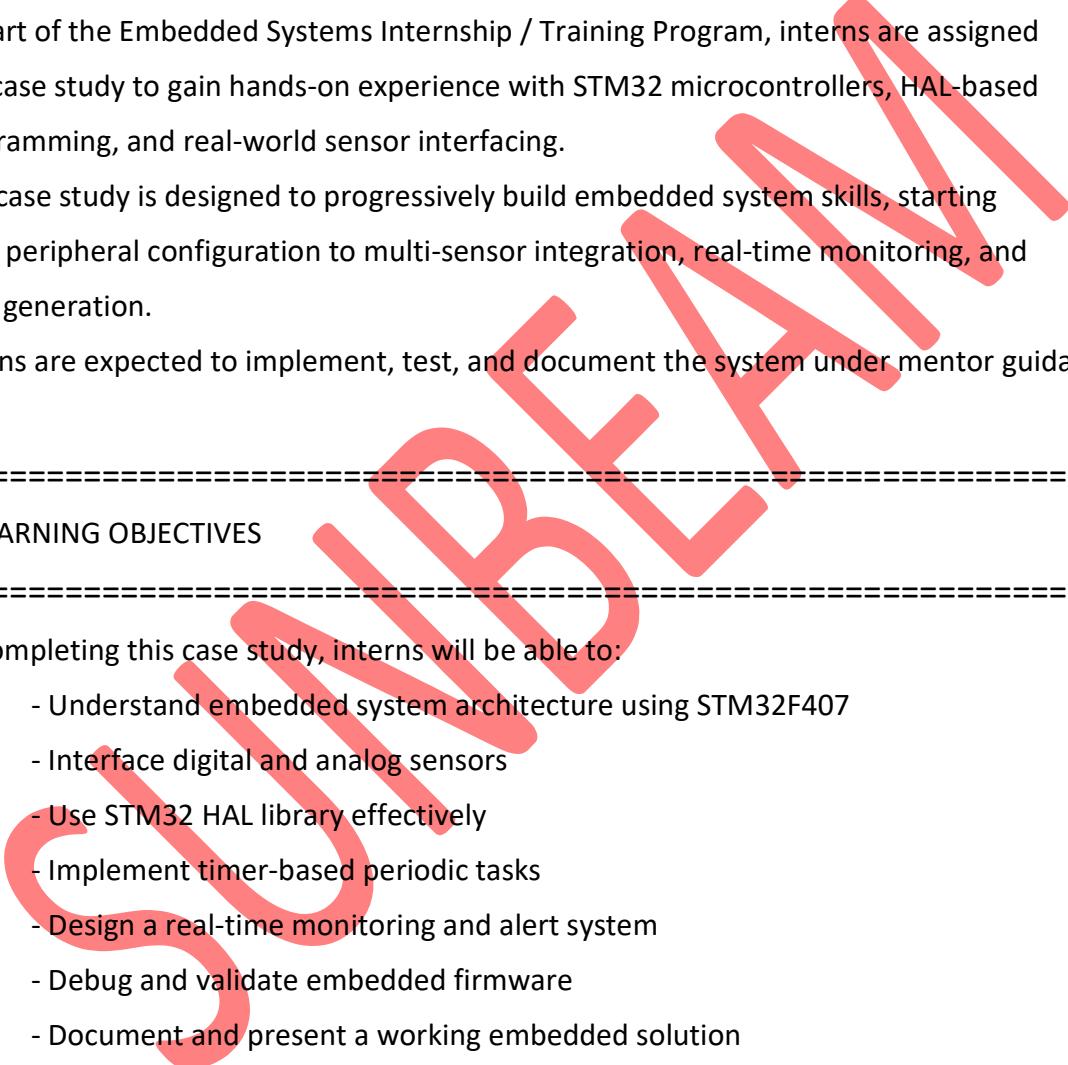
This case study is designed to progressively build embedded system skills, starting from peripheral configuration to multi-sensor integration, real-time monitoring, and alert generation.

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



2. LEARNING OBJECTIVES

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)

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

4. HARDWARE ASSIGNED FOR THE CASE STUDY

- 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

5. PERIPHERALS & INTERFACES TO BE USED

- 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.

6. FUNCTIONAL EXPECTATIONS (TASK REQUIREMENTS)

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

7. IMPLEMENTATION GUIDELINES (MENTOR INSTRUCTIONS)

- 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

8. EXPECTED DELIVERABLES FROM INTERNS

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

9. EVALUATION CRITERIA

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

10. OPTIONAL EXTENSION TASKS

Advanced interns may:

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

11. CONCLUSION

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.