North South University

Department of Electrical and Computer Engineering

CSE331L: Microprocessor Interfacing and Embedded System Lab

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Section: 7

Assignment Type: Project Report

Project Name: The Mini Weather & Safety Station

Submitted To:

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Abstract:

The Mini Weather & Safety Station is a compact embedded system developed using the STM32F103C8T6 microcontroller to monitor indoor environmental conditions and provide timely safety alerts. It continuously collects data from three primary sensors: a DHT11 for temperature and humidity, a YL-69 for soil moisture, and a PIR-based infrared (IR) motion sensor. Sensor readings are evaluated against predefined thresholds to determine safe, cautionary, or hazardous conditions. Real-time information is displayed on a 0.96" OLED module, while LEDs and a buzzer provide immediate visual and auditory feedback. By integrating sensing, decision-making, and multimodal alerts in a single platform, the Mini Weather & Safety Station demonstrates practical applications of microcontroller-based monitoring for safety-critical environments.

Introduction:

Embedded systems are essential in modern automation, enabling real-time monitoring, data processing, and decision-making across diverse applications [9]. The Mini Weather & Safety Station applies these principles to provide an indoor monitoring solution that observes environmental conditions and delivers alerts for safety management. The system is built on the STM32F103C8T6 microcontroller, a low-power ARM Cortex-M3 device widely employed for sensor interfacing and control tasks [1].

The station integrates multiple sensors to gather environmental data: the DHT11 sensor measures temperature and humidity [3], the YL-69 sensor monitors soil moisture levels [4], and a PIR-based IR sensor detects human presence or motion [6]. Sensor data is processed in real time and displayed on a 0.96-inch OLED display via the I^2C protocol [5]. To enhance user awareness, the system provides multimodal feedback: LEDs indicate safe, warning, and danger states, while a buzzer alerts users to hazardous conditions.

The objectives of this project include designing a cost-effective and reliable monitoring station, interfacing multiple sensors with the STM32 platform, evaluating sensor data against defined thresholds, and delivering results through clear multimodal feedback. These objectives reinforce key embedded system concepts such as microcontroller programming, sensor interfacing, real-time data processing, and actuator control [7], [8].

Components and Their working:

- STM32F103C8T6 (Blue Pill):
  - ARM Cortex-M3 microcontroller.
  - Handles data acquisition, decision-making, and controlling outputs.
- ST-LINK V2 Programmer
  - Used to flash and debug STM32.
  - Connects via SWD (Serial Wire Debug).
- OLED Display (0.96" I2C)
  - Displays sensor values and warnings.
  - Communicates with STM32 via I2C protocol.
- DHT11 Sensor
  - Measures temperature (°C) and humidity (%).
  - Communicates via single-wire digital protocol.
- Soil Moisture Sensor (YL-69)
  - Detects soil wetness using analog output.
  - Helps determine whether watering is required.
- IR Motion Sensor
  - Detects movement in the environment.
  - Provides HIGH (no motion) / LOW (motion detected).
- LED Indicators (Green, Yellow, Red)
  - Green → Safe
  - Yellow → Caution
  - Red → Danger
- Buzzer
  - Provides audible emergency alerts.

Pin Configurations:

ST-LINK V2 to STM32:

ST-LINK Pin	STM32 Pin	Description
3.3V	3.3V	Power
GND	GND	Ground
SWDIO	PA13	Serial Wire Debug I/O
SWCLK	PA14	Serial Wire Clock
RST	NRST	MCU Reset

STM32 to OLED (I2C):

OLED Pin	STM32 Pin	Description
VCC	3.3V	Power
GND	GND	Ground
SDA	PB7	I2C Data
SCL	PB6	I2C Clock

STM32 to DHT11:

DHT11 Pin	STM32 Pin	Description
VCC	3.3V	Power
GND	GND	Ground
DATA	PA1	Single-wire data line

STM32 to Soil Moisture Sensor (YL-69):

Sensor Pin	STM32 Pin	Description
VCC	3.3V	Power
GND	GND	Ground

AO	PA0	Analog soil moisture output

STM32 to IR Motion Sensor:

IR Pin	STM32 Pin	Description
VCC	3.3V	Power
GND	GND	Ground
OUT	PB0	Motion signal (LOW → Motion detected)

STM32 to LEDs & Buzzer:

Device	STM32 Pin	Function
Green LED	PC13	SAFE indicator
Yellow LED	PB1	CAUTION indicator
Red LED	PB10	DANGER indicator
Buzzer	PA8	Audible alert

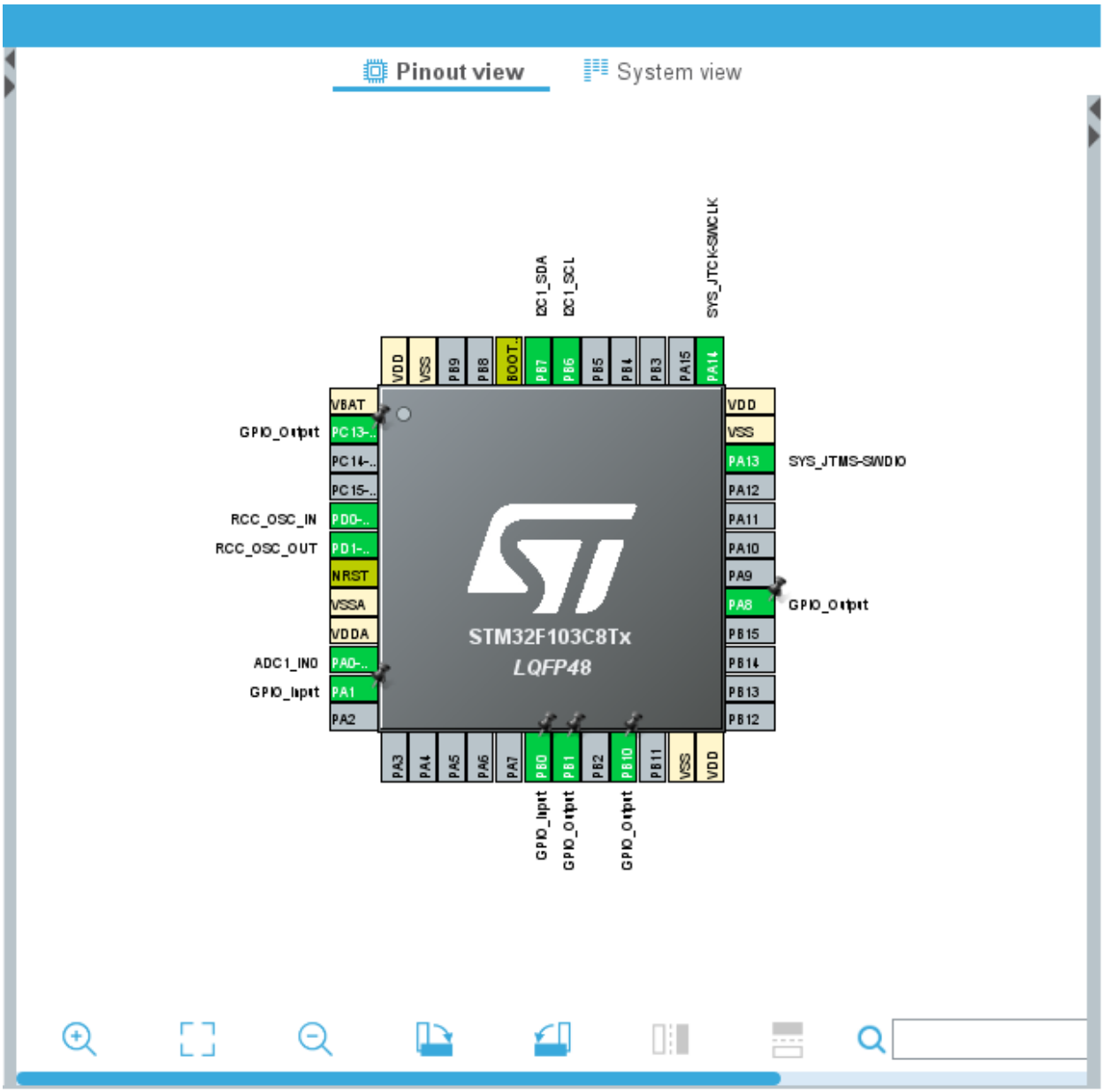


Figure: Pin Configuration on STM32CubeMX

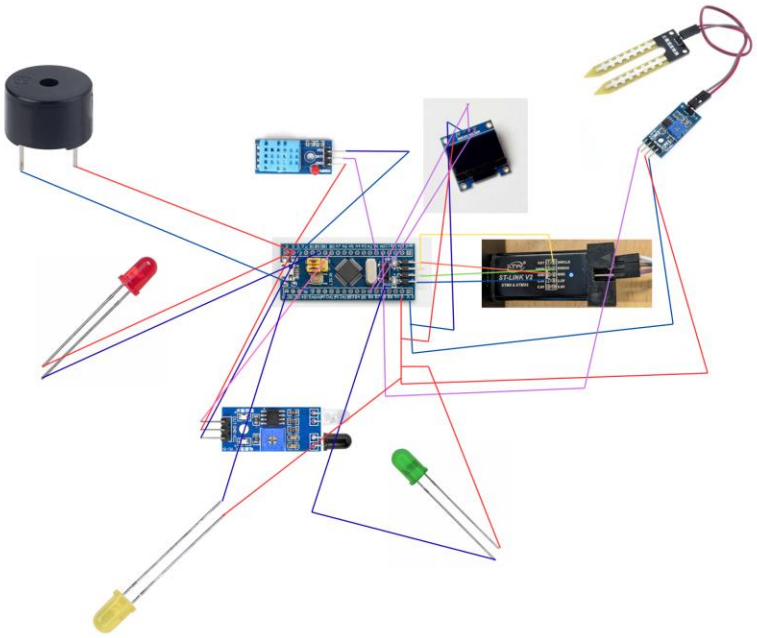


Figure: Pin diagram of Project (Zoom for Better Visualization)

Threshold Values:

Parameter	Threshold	Action Taken
Temp ≥ 33°C	Danger	Red LED + Buzzer + OLED "High Temp!"
Humidity ≤ 20% or ≥ 85%	Caution	Yellow LED + OLED "Humidity Alert"
Soil Moisture ≤ 20%	Caution	Yellow LED + OLED "Soil Dry! Water"
Motion Detected (IR=LOW)	Caution	Yellow LED + OLED "Motion Detected"
Normal Case	Safe	Green LED + OLED "Soil Normal, No Need"

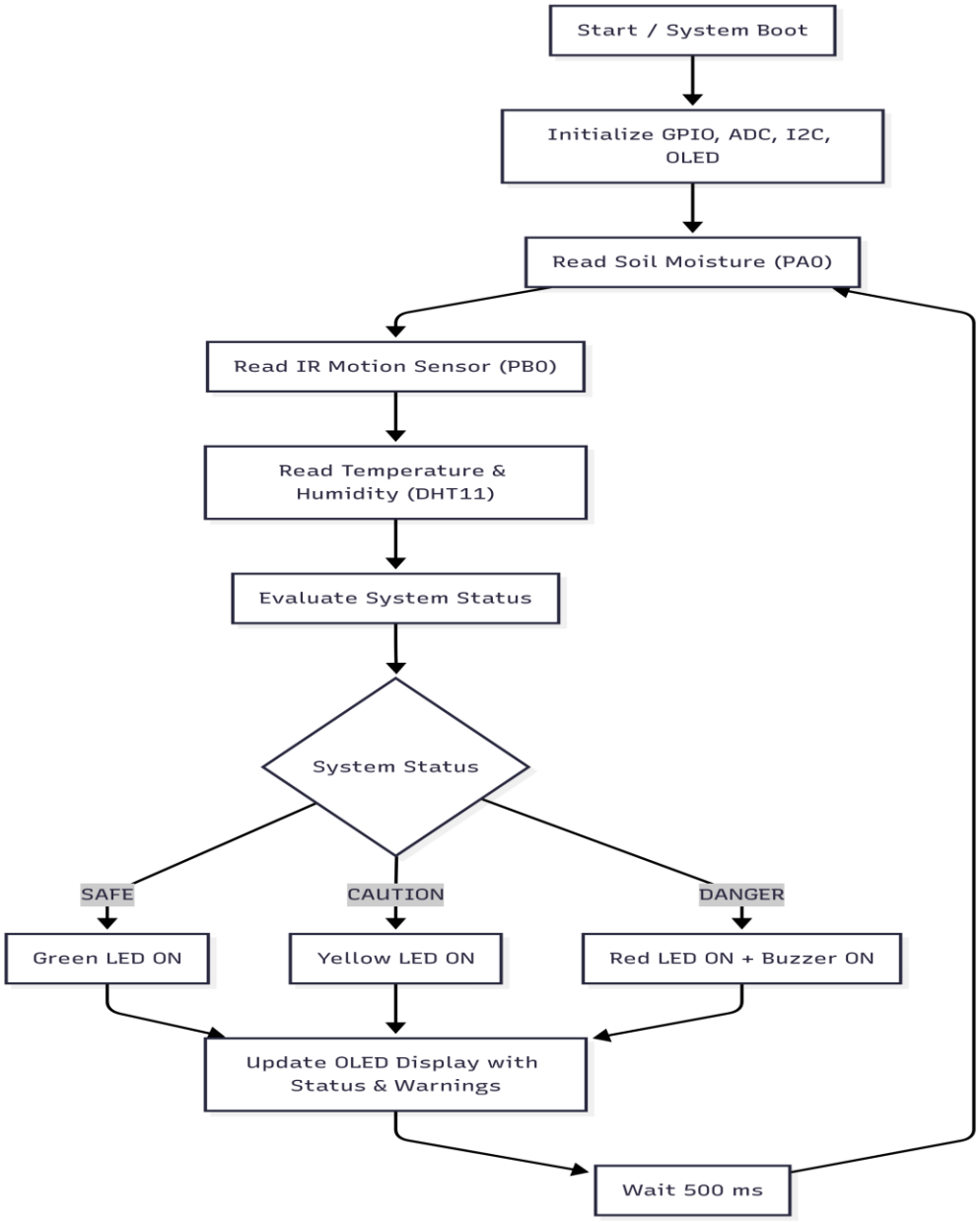
Methodology:

The Mini Weather & Safety Station is a small system that works together to check the environment and keep indoor areas safe. The STM32F103C8T6 microcontroller is the main part that connects with different sensors and devices. It gets temperature and humidity data from the DHT11 sensor using a simple connection. It reads soil moisture levels as analog signals from the YL-69 sensor using the STM32's ADC. At the same time, the IR sensor checks for movement by sending a digital signal when it detects motion.

After collecting the data, the microcontroller checks if the readings are within safe limits. If the temperature is above 33°C, it is considered dangerous. Humidity below 20% or above 85% and soil moisture below 20% are warning signs. Motion detection also triggers a warning. These checks result in a system status of SAFE, CAUTION, or DANGER. Based on this status, the controller uses lights and sounds to alert users: green, yellow, or red lights show safe, warning, or critical conditions, and the buzzer sounds only in dangerous situations.

All current readings and alerts are shown on a small OLED screen, giving users clear information. The system runs continuously, updating sensor data, checking conditions, controlling alerts, and refreshing the display every half second. This setup ensures smooth data collection, decision-making based on limits, alert

signals, and real-time monitoring, showing key principles of embedded systems in a small and effective design.



Results:

Sample Output & Input:

Temp	Humidity	Soil Moisture	IR	OLED Output (Line by Line)	LED	Buzzer
29°C	55%	40%	No	T:29C H:55% Soil:40% IR:NO Status: SAFE Soil Normal, No Need	Green	OFF
32°C	60%	15%	No	T:32C H:60% Soil:15% IR:NO Status: CAUTION Soil Dry! Water	Yellow	OFF
30°C	90%	40%	No	T:30C H:90% Soil:40% IR:NO Status: CAUTION Humidity Alert	Yellow	OFF
29°C	55%	40%	Yes	T:29C H:55% Soil:40% IR: YES Status: CAUTION Motion Detected	Yellow	OFF
36°C	50%	40%	No	T:36C H:50% Soil:40% IR:NO Status: DANGER High Temp!	Red	ON

- System successfully reads and processes all sensor data.
- OLED correctly displays values and warnings.
- Threshold-based decisions work as expected.
- LEDs and buzzer provide clear multimodal alerts.

Discussions:

This project illustrates a practical application of embedded system design by integrating multiple sensors and actuators with the STM32 platform to develop a

compact weather and safety monitoring station. The successful implementation underscores key concepts such as sensor interfacing, real-time data acquisition, threshold-based decision-making, and multimodal feedback. The Mini Weather & Safety Station thus serves as a dependable prototype for applications in smart agriculture, home automation, and indoor safety management.

Future Work:

Looking ahead, the system can be enhanced in several ways. Adding wireless modules such as the ESP8266 would enable IoT-based remote monitoring and real-time data sharing. Incorporating an SD card interface could allow long-term data logging for trend analysis and predictive insights. Upgrading to more accurate sensors, such as the DHT22 for temperature and humidity and capacitive soil moisture sensors, would improve precision and reliability. These enhancements would transform the current prototype into a scalable, feature-rich environmental and safety monitoring solution suitable for practical, real-world applications.

References:

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