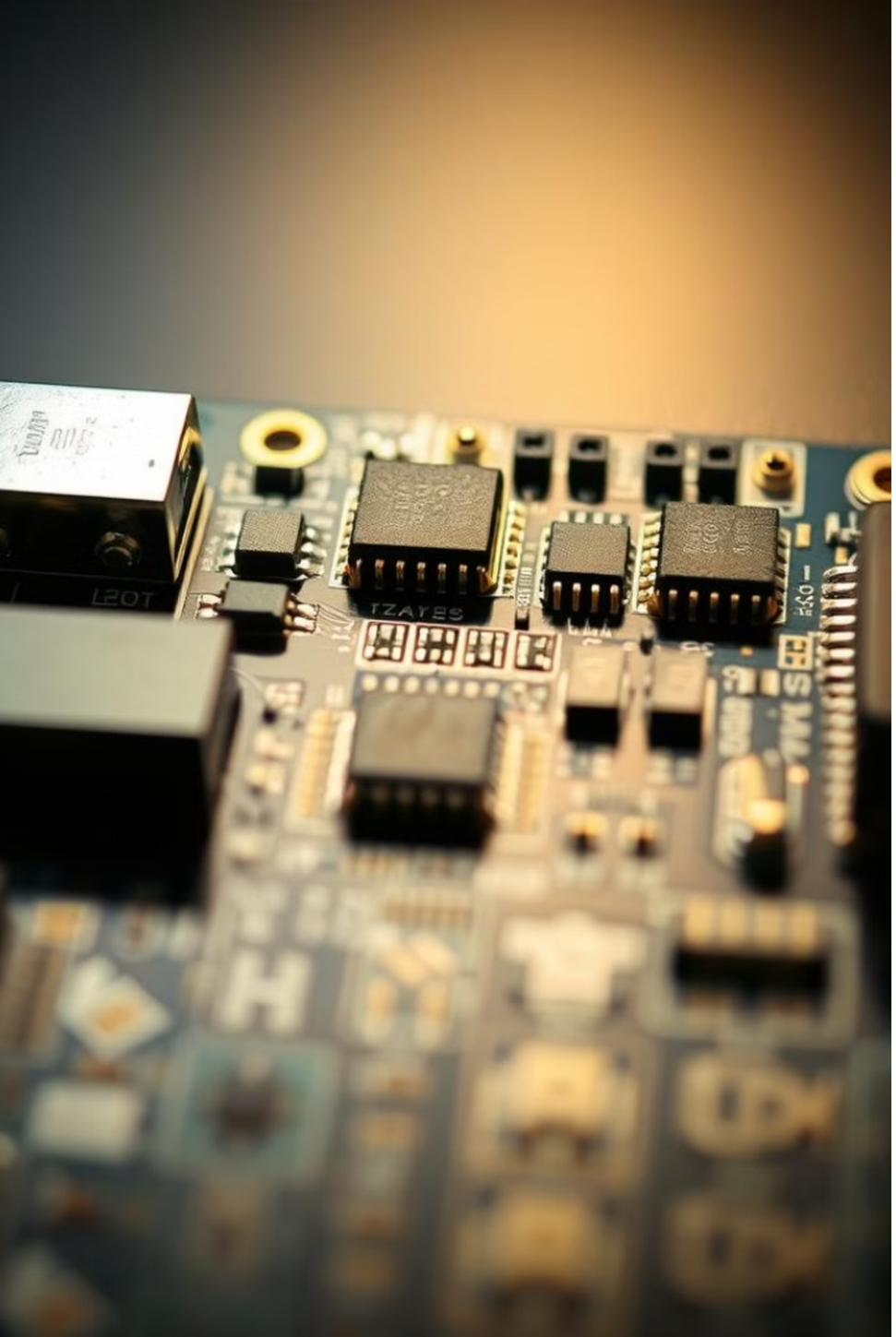

RTOS-Based Environmental Monitoring System

This project outlines the development of an RTOS-based environmental monitoring system designed to display time, temperature, and humidity data in real-time.

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Overview

Project Goals

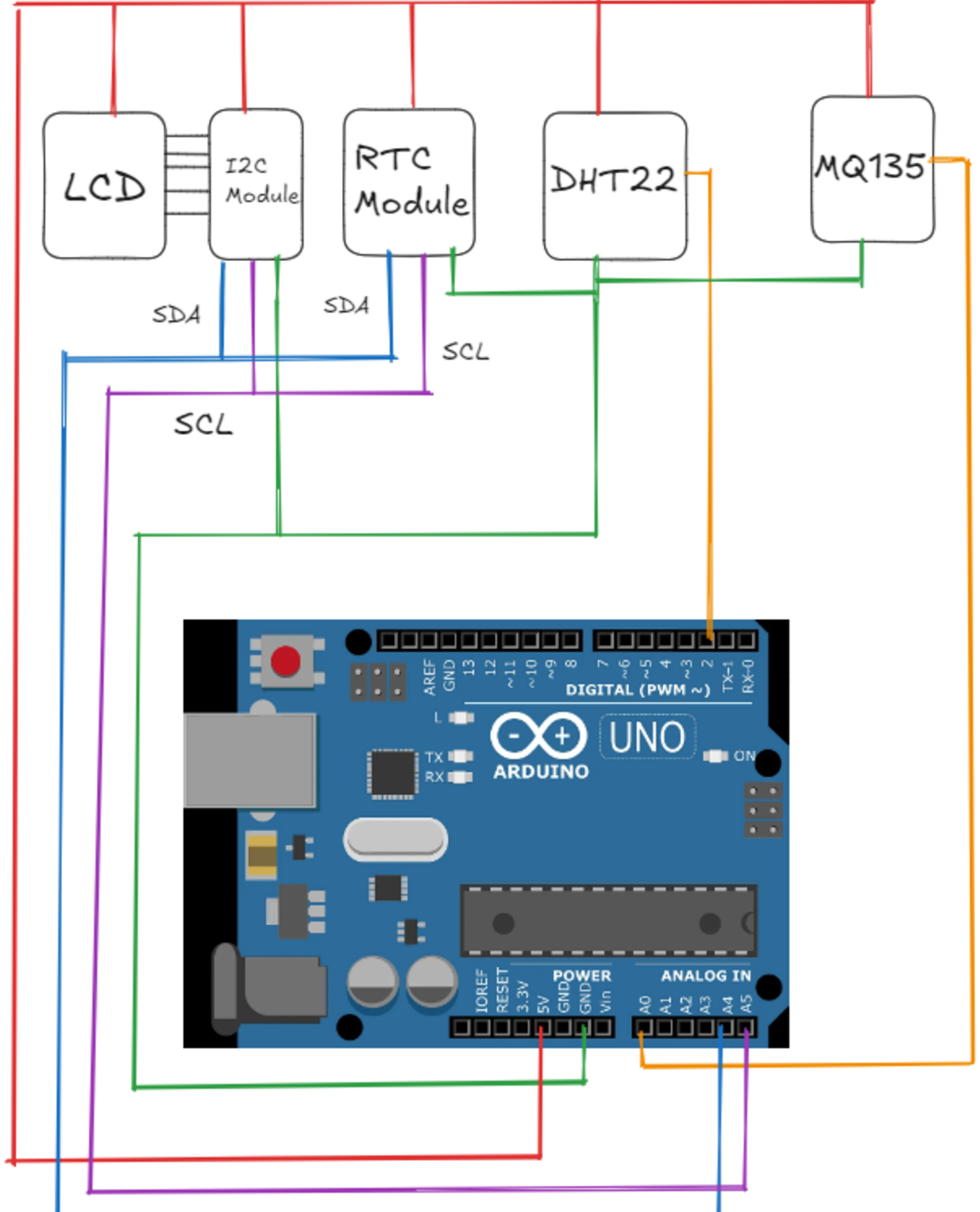
- Environmental Monitoring
- Timekeeping

Technical Highlights

- RTOS Integration
- Sensors
- Resource Management

System Benefits

- Reliable



System Architecture

RTOS	Real-time operating system for task management and scheduling.
Sensors	DHT22, DS3231 RTC, MQ-135
Board	Arduino UNO

Software Design

1

RTOS

FreeRTOS was chosen for its efficiency, reliability, and support for real-time applications.

2

Tasks

Separate tasks were created for time display, temperature and humidity monitoring, AQI reading.

3

Inter-Task Communication

Using a common resource combined with semaphore to avoid race condition.

Implementation

1 Libraries Used

- DHT22.h
- Arduino_FressRTOS.h
- semphr.h
- RTClib.h

2 Integration

- Defined data type to save sensors data
- Using multiple tasks to read sensor data and the display task

```
#include <DHT22.h>
// Define the digital pin for DHT22 temperature and humidity sen
#define pinDATA 2
DHT22 dht22(pinDATA);

// Sensor Data Structure:
// This struct encapsulates all sensor readings and timestamp
struct SensorData {
  DateTime time; //DateTime class from RTC module defined in the
  // uint8_t yOff; ///< Year offset from 2000
  // uint8_t m;    ///< Month 1-12
  // uint8_t d;    ///< Day 1-31
  // uint8_t hh;   ///< Hours 0-23
  // uint8_t mm;   ///< Minutes 0-59
  // uint8_t ss;  ///< Seconds 0-59
  float temperature; // Temperature reading from DHT22
  float humidity; // Humidity reading from DHT22
  int mq135_value; // Air quality/gas concentration from MQ135 s
};
SensorData sensorData; // Global instance of sensor data structu

// Global instance of sensor data structure
RTC_DS3231 rtc;
// Mutex for thread-safe access to shared sensor data
// Prevents race conditions when multiple tasks access the same
SemaphoreHandle_t xsensorDataMutex;

// Task Handles: Allow tracking and management of individual Fre
TaskHandle_t dhtTaskHandle;
TaskHandle_t rtcTaskHandle;
TaskHandle_t mq135TaskHandle;
TaskHandle_t printvalHandle;
```

Results

Output Specifications

- Time calculated through RTC, using rtc.now() API
- DHT22 returns a 40bit data
  - 8 bit integral RH data
  - 8 bit decimal RH data
  - 8 bit integral T data
  - 8 bit decimal T data
  - 8 bit check-sum
- MQ135 (requires calibration)
  - Approx 5-10 minutes for calibration as it’s heating element needs to be heated

```
--------------------
2024/11/28 11:13:52
h=63.5  t=23.4
33 PPM
--------------------
2024/11/28 11:13:54
h=63.5  t=23.4
42 PPM
--------------------
2024/11/28 11:13:56
h=63.5  t=23.3
44 PPM
--------------------
2024/11/28 11:13:58
h=63.5  t=23.3
41 PPM
```

Challenges Faced and Solutions

Sensor calibration	MQ-135 takes 5minutes to calibrate to environment.
Memory	Utilized FreeRTOS to schedule tasks and manage resource allocation efficiently.
Race Conditions	Maintained a struct with a semaphore for optimal resource sharing
Interfacing different hardware components	Leveraged libraries and documentation to ensure proper communication and data exchange between components.
I2C noise between I2C Module and RTC	-

Project Specifications

1 Operating Voltage

- 3-5V

2 Detection Range

- Humidity 0-100%RH
- Temperature -40 - 80 C
- AQI 10 - 1000ppm(NH3, NOx, Alcohol, Benzene, Smoke, CO2.)

3 Accuracy

- Humidity +-2%RH(Max +-5%RH)
- Temperature <+-0.5Celsius
- +-1 PPM (gives an approximate value for PPM not the correct one)

4 Sensing Period

- Temperature and humidity - 2s
- AQI - <1s

5 Calibration time

- DHT22 - <1s
- MQ135- 5-10 minutes

Conclusion

Key Points

Developed a reliable and accurate environmental monitoring system.

Achievements

Successfully implemented real-time data acquisition and Serial display.

Future Work

implement User request for historical data, data analysis, LCD display correction.