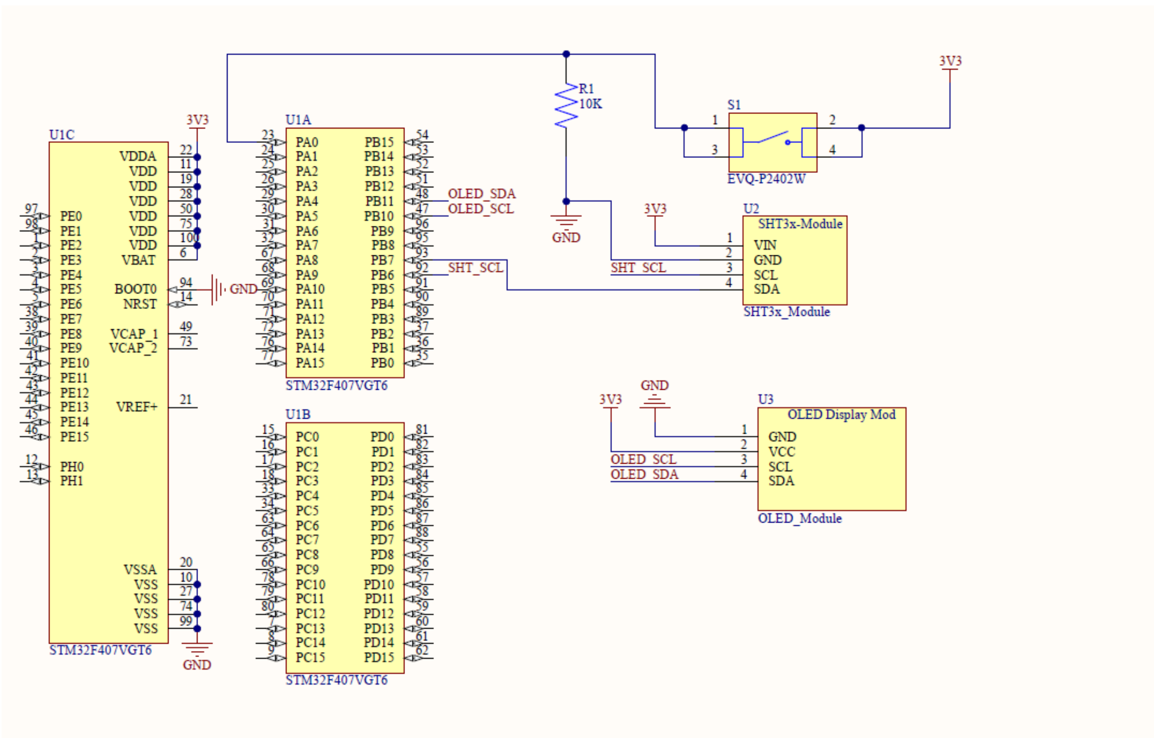
Environmental Monitoring Project

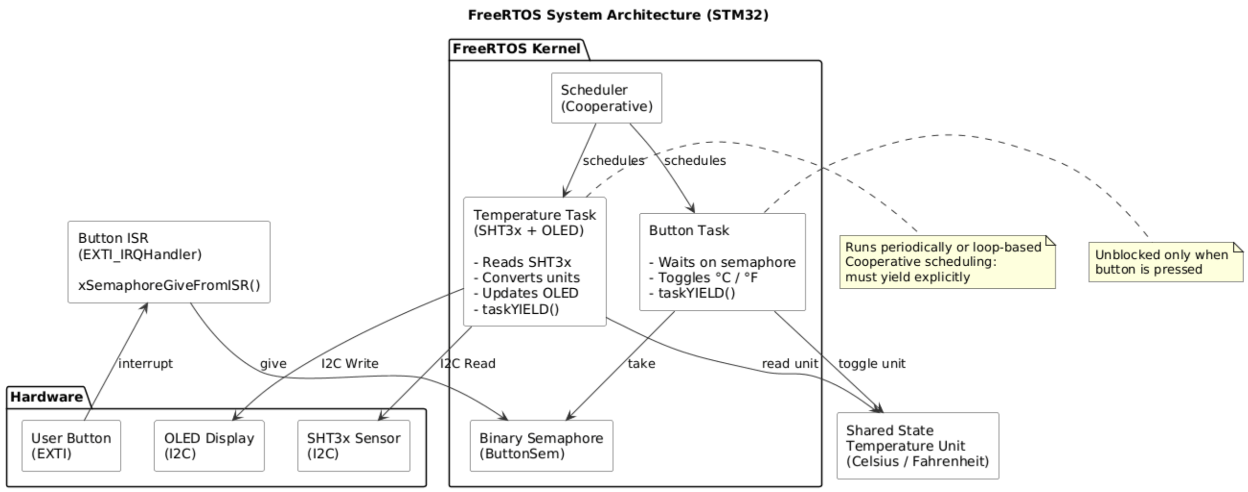
ABSTRACT

The project uses a STM32F407 that is an ARM Cortex M4f and uses STM32CUBEIDE as firmware development environment. The project uses FREERTOS(cmsis_V2) in cooperative scheduling policy to run multiple threads.
The project has an SHT30 sensor that reads Temperature and humidity values over I2C protocol. It also has an oled 0.96 display on I2C that is used to display the readings of SHT30 sensor. The project also has a button that is configured on an interrupt. This will let the user toggle between Temperature readings from Celsius to Fahrenheit and vice versa. For this demonstration, the project uses oled display modules and sht3x modules. The pull-ups are already mounted on the modules.
Below is the schematic/ wiring up.



System Diagram

Below is a high level system diagram. The project uses FREERTOS(cmsis_V2) Co-operative scheduling for managing threads and performing the system tasks to achieve parallelism. The diagram is generated using PLANTUML.



There are two tasks in the system.

Task-1 (Sensor Monitoring Thread)

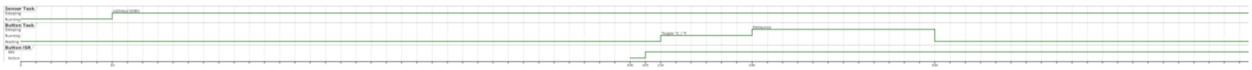
This thread reads the data from the SHT3x module (SHT-30) periodically, makes a conversion and writes the data to the OLED display. It then yields itself to give the next scheduled task to run as shown in the diagram above.
The thread shows the reading of temperature in C/F and the humidity in percentage. The thread also checks for system errors or sensor errors and prints the “Sensor ERR” in case sensor initialization fails.

Task-2 (Button Thread)

This task waits for the semaphore to be available. The user button is configured on the external button interrupt. Whenever a user presses the button; a binary semaphore is released from the ISR.
The button task starts its execution and also checks for the debouncing of the button. It then toggles the unit of Temperature from Celsius to Fahrenheit or Fahrenheit to Celsius depending on current configuration.

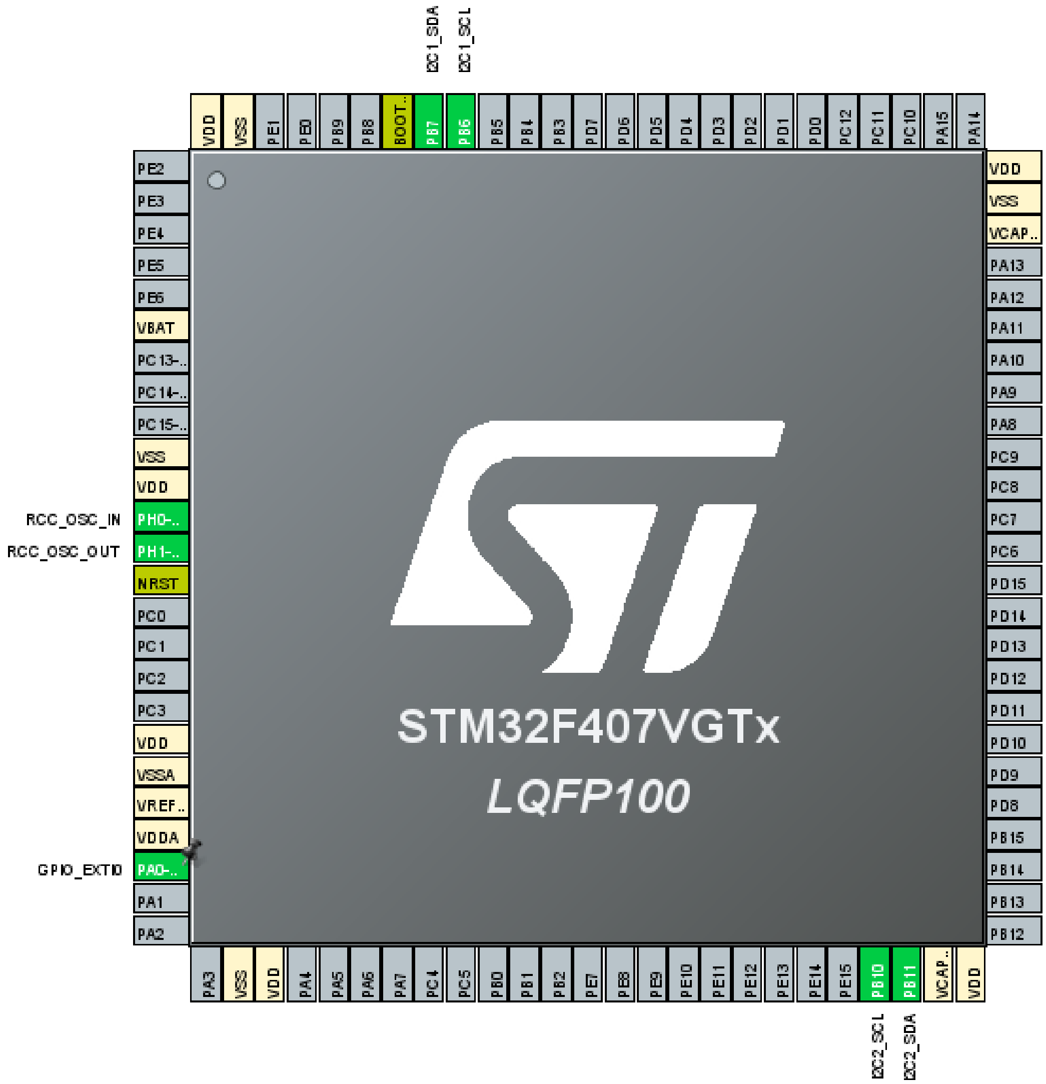
Timing Diagram

Below is the timing diagram of the system generated using plantuml. The image can also be found alongside the image for proper viewing.



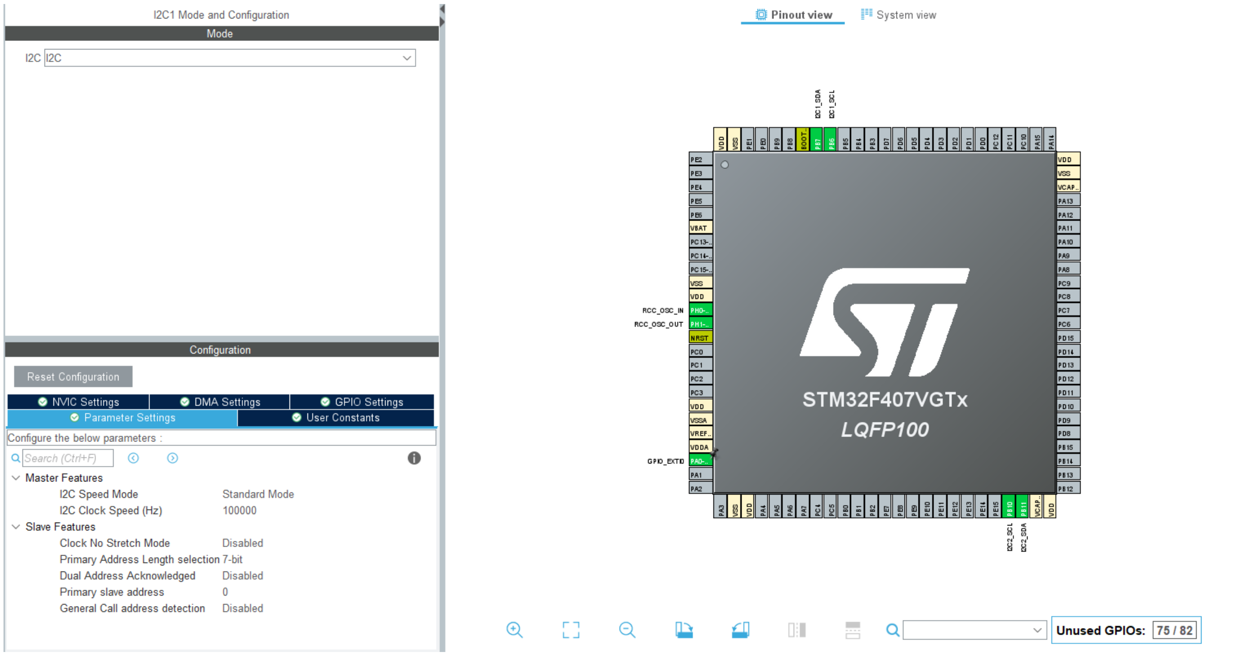
Configuration

This section describes the overall process of configuration done for this project. The below is the pinout of STM32CUBEMX to describe the peripheral configuration.



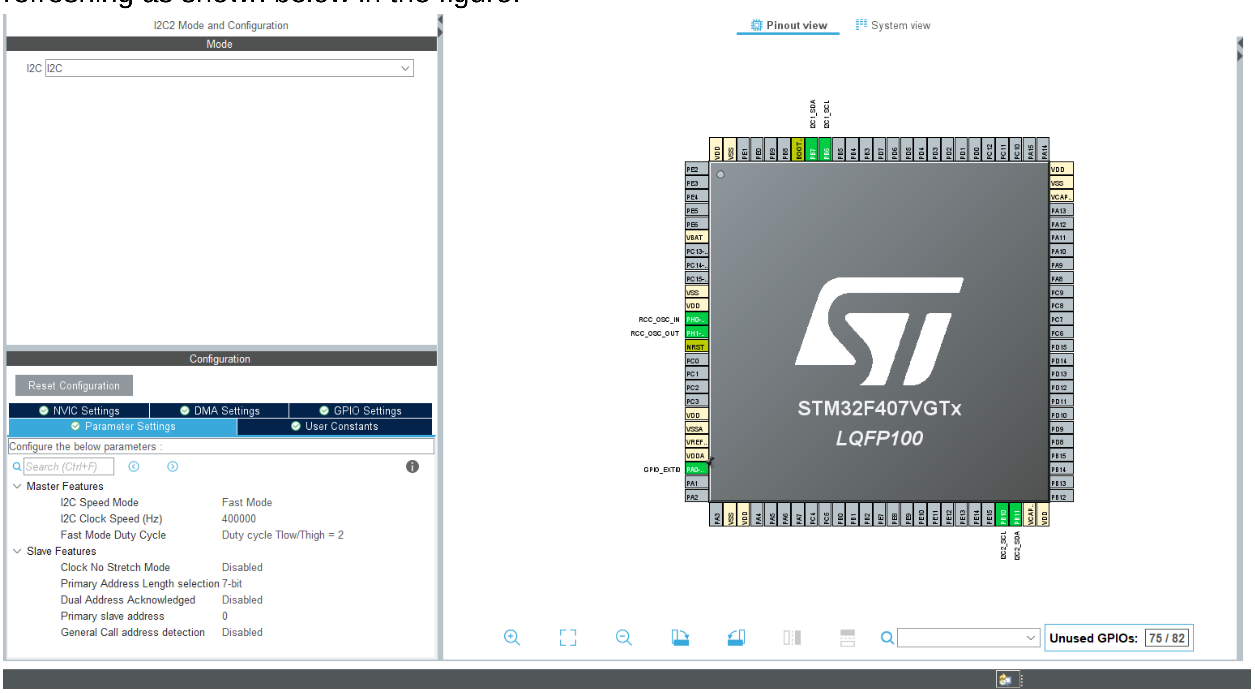
SHT3x_I2C_Configuration

The SHT3x is configured on Standard I2C clock speed i.e. 100KHz as shown below in the figure.



OLED_I2C_Config

The OLED Display is configured on Fast I2C clock speed i.e. 400KHz to eliminate visible refreshing as shown below in the figure.



Button Configuration

The button is configured on PA0 as shown in the schematic figure. The button is configured as EXTERNAL interrupt with priority of 10 as the FREERTOS functions can be called from interrupts whose priority is higher than 5 according to the FREERTOSConfig file.

Power Considerations

The embedded devices often have power constraints. In our system, the power consumption can be minimized by using below considerations.

1. Sensor Reading time.
    a. The sensor reading is set to 1 second. Increasing the reading time will decrease the power consumption.
    b. The sensor can be shut-down in case of a waiting state. Currently, we do not have that capability in the modules; therefore, we cannot use this one.
    c. Configuring the STM32 Clock on a lower frequency. This STM32F407 can run upto 180 MHz. More frequency consumes more power; lowering it to an optimal level that is sufficient for the application significantly reduces the power. We are currently using it for 100 MHz.
2. OLED Display
    a. Refreshing more can increase the power consumption. Currently, the device is refreshing the OLED Display every 1 second. Increasing the periodic refresh rate can decrease the power consumption.
3. STM32 Sleep mode
    a. Another consideration could be sleep mode. The device can go into sleep mode when there is nothing happening in the system. In our case, there is nothing happening in the 1 second interval.

Setup Image

Below is the setup image for reference.