

Digital Electronics 2B (EEDE226) - Formative
Project 2

Interrupt-Driven Environmental Sensing System

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0.1 Introduction

The objective of this project was to implement an **interrupt-driven sensing system** utilizing an STM32 microcontroller to acquire real-time temperature, humidity, and ultrasonic distance data. The core requirement was to manage the sensor readings and display modes on a 16x2 I2C LCD using external interrupts from push-button switches.

This report details the hardware configuration, the software design focused on peripheral initialization (I2C, TIM, GPIO), and the robust, non-blocking interrupt handling logic developed to manage four distinct display modes, including a bonus continuous dual-display feature.

0.2 Hardware Implementation and Interfacing

The system utilizes an STM32 development board (e.g., STM32F401RE Nucleo or similar) interfaced with three primary external components.

0.2.1 Component Connections

The following connections were established using a breadboard and jumper wires:

Table 1: Component Interfacing and Pin Assignments

Component	STM32 Pin / Peripheral	Function
16x2 I2C LCD	I2C1 (SCL, SDA)	Display output
DHT22 Sensor	GPIO (e.g., PA5)	One-wire bi-directional data transfer
HC-SR04 (Trig)	GPIO Output (e.g., PA6)	Initiates ultrasonic burst
HC-SR04 (Echo)	TIM1 Channel 1 (e.g., PA8)	Input Capture for time-of-flight
Button 1 (Temp)	GPIO Input (PA0)	External Interrupt 0 (EXTI0)
Button 2 (Dist)	GPIO Input (PA1)	External Interrupt 1 (EXTI1)

0.3 Software Design and Configuration

The software was developed using STM32CubeIDE and the HAL library, focusing on precise peripheral and interrupt configuration.

0.3.1 Peripheral Configuration

1. **I2C1**: Configured in standard mode to communicate with the 16x2 LCD module.
2. **TIM1 (IC)**: Configured as a high-resolution, free-running timer with the **Input Capture (IC)** mode enabled on Channel 1 (Echo pin). This allows for accurate measurement of the ultrasonic pulse width, critical for distance calculation.
3. **GPIO (EXTI)**: Pins PA0 and PA1 were configured as GPIO inputs with internal pull-up resistors and set to trigger an **External Interrupt (EXTI)** on the **falling edge** (button press).

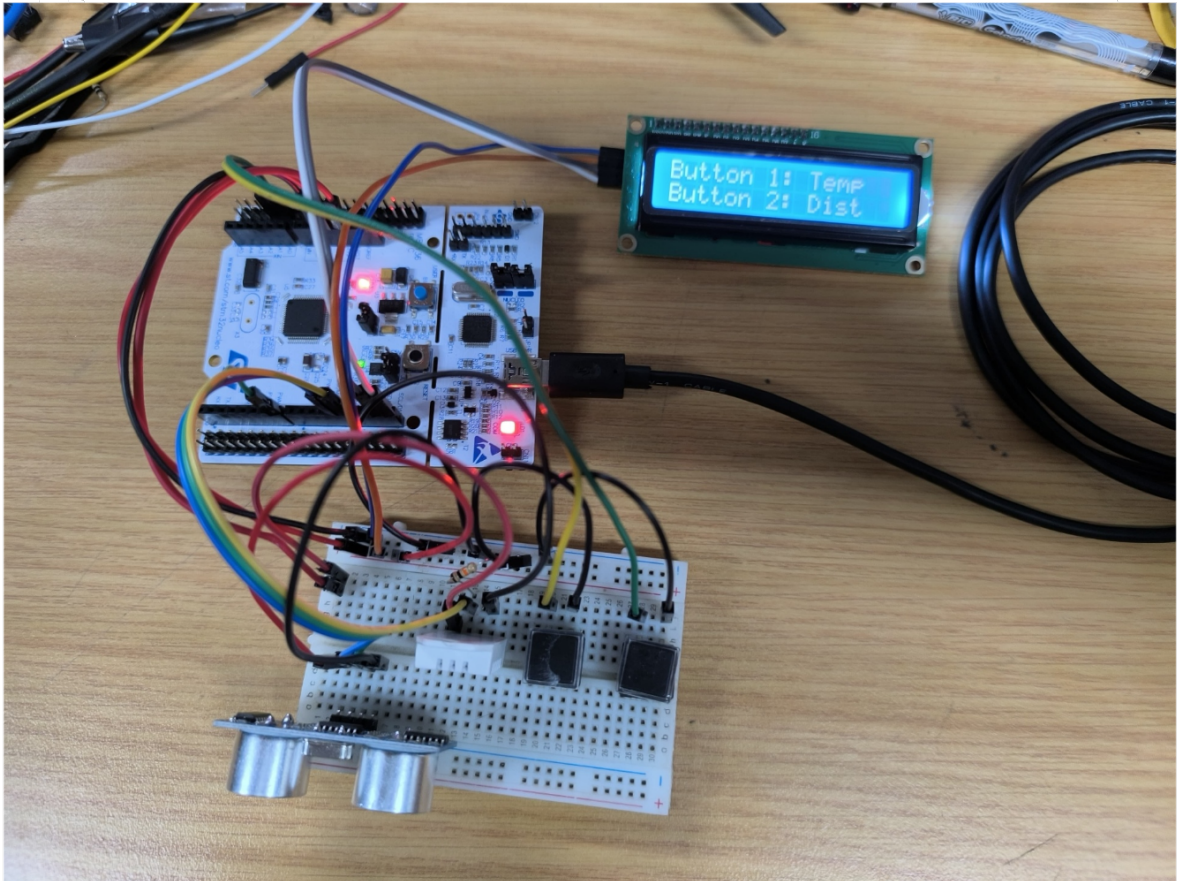


Figure 1: Hardware schematic showing the interconnection between the STM32, the LCD (I2C), the HC-SR04 sensor, the DHT22 sensor, and the two push buttons (PA0 and PA1).

0.3.2 Interrupt Handling and Mode Switching Logic

The interrupt logic was divided between the `HAL_GPIO_EXTI_Callback` and the `main()` loop to handle debouncing and complex mode-switching logic effectively.

A. EXTI Callback (`HAL_GPIO_EXTI_Callback`)

The interrupt handler's role is to debounce the event and set a flag, signaling the main loop without performing time-consuming calculations inside the ISR:

```
void HAL_GPIO_EXTI_Callback(uint16_t GPIO_Pin)
{
    // Debounce check ensures only one trigger per 50ms
    if ((HAL_GetTick() - last_exti_trigger) < DEBOUNCE_TIME) return;
    last_exti_trigger = HAL_GetTick();

    // Signal the main loop that an EXTI event occurred
    exti_triggered = 1;
}
```

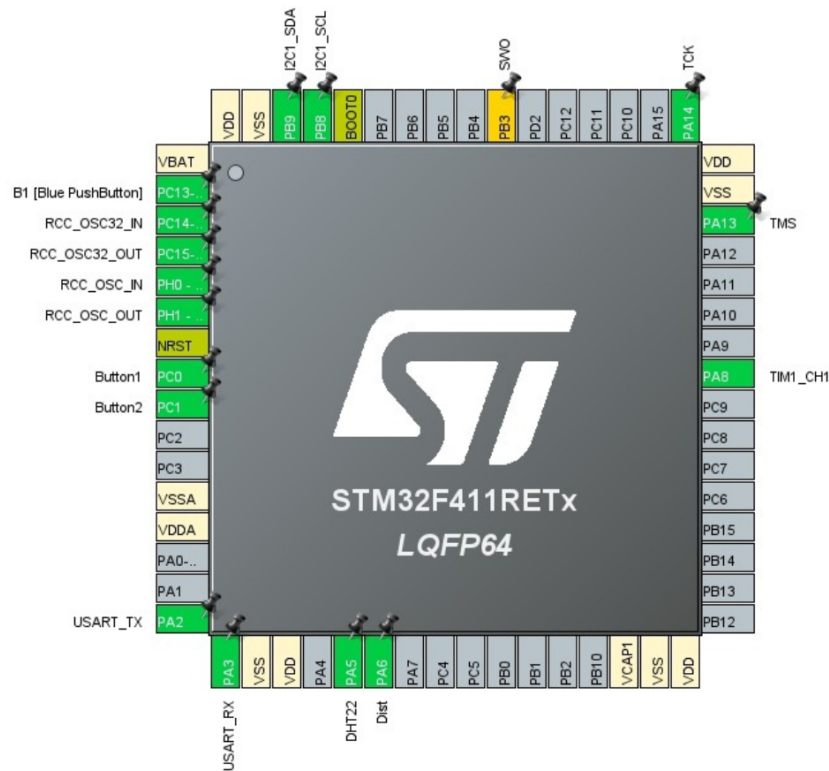


Figure 2: Figure 2: STM32CubeIDE Pinout showing PA0 (EXTI0), PA1 (EXTI1), I2C1, and TIM1 (IC) configurations.

B. Main Loop Polling (State Check)

When `exti_triggered` is set, a critical **50ms delay** is introduced in `main()` to allow dual-press signals to register. The main loop then polls the state of both PA0 and PA1 pins simultaneously to determine the desired mode.

0.3.3 Display Modes and Bonus Feature

The system supports four operational modes, managed by the `current_display_mode` state machine:

The `DUAL_MODE` is a latching bonus feature that toggles between continuous display and `NORMAL_MODE` upon successive dual-press events.

Table 2: System Operational Modes

Mode	Trigger	Action
NORMAL_MODE	Default, or after an interval	Prompts the user to press a button.
TEMP_MODE	Single Press of Button 1	Reads DHT22 and displays Temperature
DIST_MODE	Single Press of Button 2	Triggers HC-SR04 and displays Distance
DUAL_MODE (Bonus)	Simultaneous Press of Button 1 + 2	Displays T/H and D continuously. Latch

0.4 Results and Demonstration

The implemented solution successfully manages sensor data acquisition and mode switching without blocking the system outside of the necessary polling/read delays.

0.4.1 Functional Demonstration

The system successfully performs:

1. Temperature and humidity reading from the DHT22.
2. Accurate distance calculation using TIM1 Input Capture.
3. Smooth switching between single-value display modes that correctly revert to the prompt after 5 seconds.
4. Reliable detection of simultaneous dual-press events for the bonus feature.

0.5 Conclusion

This project successfully met all core objectives outlined in the project brief. The use of external interrupts (EXTI) for mode selection provided an efficient, event-driven architecture, and the implementation of Input Capture (IC) ensured high precision for the ultrasonic distance sensor.

The key challenge of resolving simultaneous button presses was overcome by implementing a time-delayed polling mechanism within the `main` loop, subsequent to the EXTI trigger. Furthermore, the bonus feature—a latching Dual Display Mode triggered by the dual press—enhances the utility of the system, demonstrating a well-structured and highly reliable interrupt-driven embedded solution.

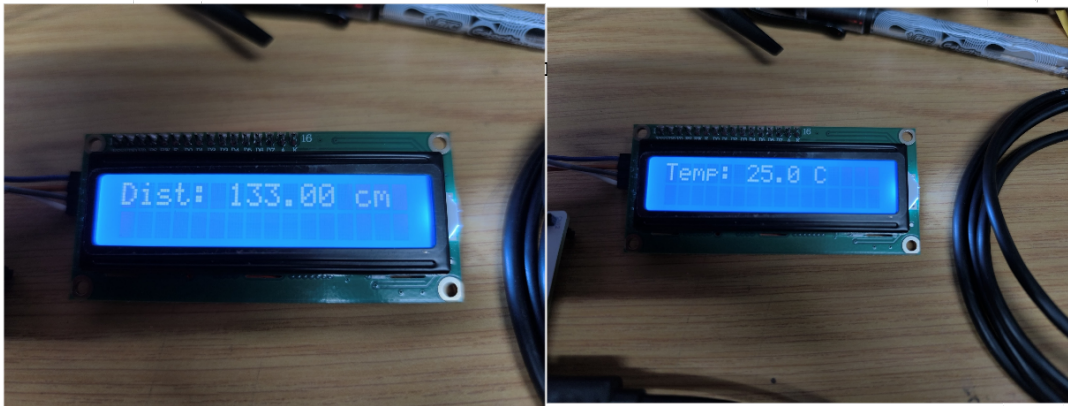
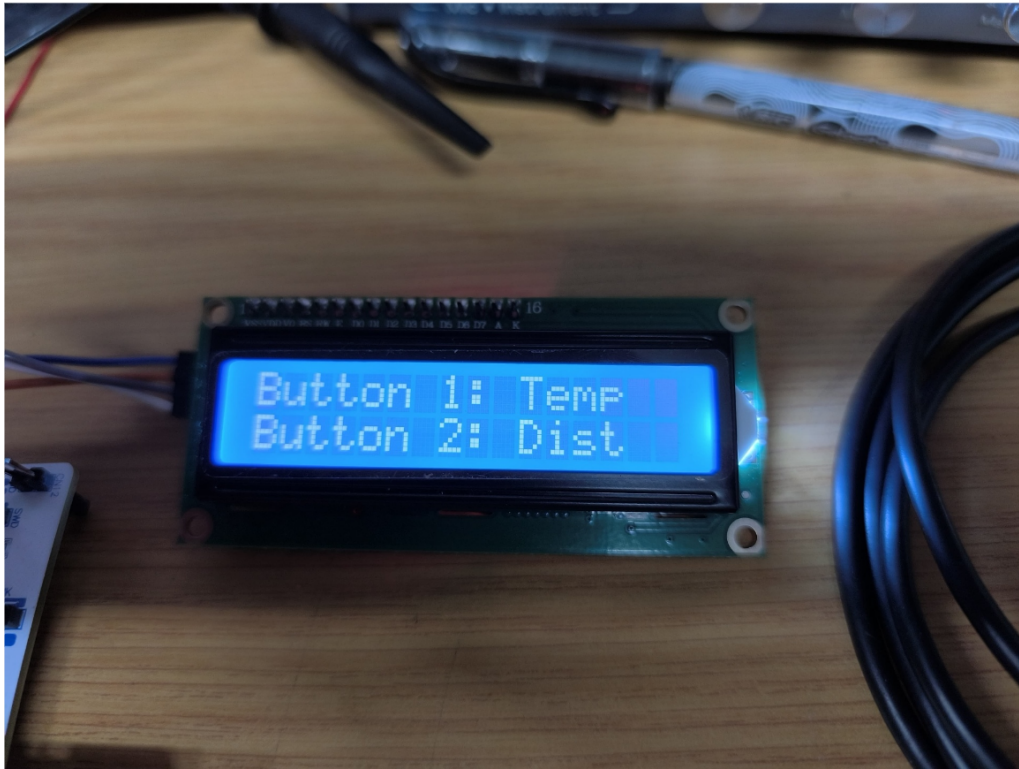


Figure 3: Figure 3: LCD display in NORMAL_MODE, showing the user prompts for single-button functionality.



Figure 4: Figure 4: LCD display in DUAL_MODE (Bonus Feature), showing both temperature/humidity and distance simultaneously. This mode is activated and deactivated by a simultaneous dual-button press.