FACULTY OF ELECTRICAL AND ELECTRONIC ENGINEERING TECHNOLOGY

BVI3114

TECNOLOGY SYSTEM OPTIMIZATION II

HARDWARE DOCUMENTATION

LECTURE:

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1. Hardware overview

The hardware for this project is designed to support real-time environmental data collection using a simple and reliable IoT architecture. At the core of the system is an ESP32 microcontroller, which acts as the main control unit responsible for reading sensor data and transmitting it to the cloud through a Wi-Fi connection.

Two sensors are connected to the ESP32. The BME280 sensor is used to measure environmental parameters such as temperature, humidity, and atmospheric pressure, while the HC-SR04 ultrasonic sensor is used for distance measurement. All components are assembled use jumper female-female, allowing easy troubleshooting and modification during development. The overall hardware design focuses on stable operation, minimal wiring complexity, and compatibility with cloud-based data processing systems.

2. List of Hardware Components

No	Component	Quantity	Description
1	ESP32	1	Microcontroller used to acquire sensor data, process information, and communicate with cloud services via Wi-Fi
2	BME280 Sensor	1	Environmental sensor that measures temperature, humidity, and atmospheric pressure using I^2C communication
3	HC-SRC04 Ultrasonic Sensor	1	Sensor used to measure distance based on ultrasonic wave reflection
4	Jumper Wires (Female – Female)	As required	Used to connect the ESP32 with sensors and power lines
5	Micro USB Cable	1	To power up ESP32

3. Circuit Diagram

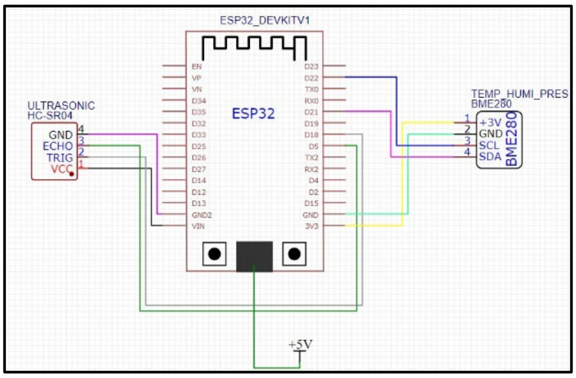

Figure 1: Schematic Circuit Diagram

The circuit diagram represents the physical connections between the ESP32 microcontroller and the connected sensors. The BME280 sensor is connected using the I²C communication protocol, which reduces the number of required pins while ensuring reliable data transmission. The HC-SR04 ultrasonic sensor is connected through dedicated digital input and output pins. Power for both sensors is supplied directly from the ESP32, with appropriate grounding to ensure stable operation. The circuit design follows standard practices to prevent voltage mismatch and communication errors.

4. Pin Configuration

The pin assignments used in this project are selected to avoid conflicts and ensure stable communication between the ESP32 and the sensors.

ESP32 to BME280 (I^2C):

- 3.3V → VCC
- GND → GND
- GPIO22 → SCL
- GPIO21 → SDA

ESP32 to HC-SR04 Ultrasonic Sensor:

- VIN → VCC
- GND → GND
- GPIO25 → TRIG
- GPIO26 → ECHO

This configuration allows the ESP32 to communicate efficiently with both sensors while maintaining reliable power distribution.

5. Sensor Integration

The BME280 sensor is integrated using the I^2C interface, enabling the ESP32 to read temperature, humidity, and pressure data through a single communication channel. Appropriate software libraries are used to initialize the sensor and ensure consistent and accurate readings.

The HC-SR04 ultrasonic sensor operates using digital signals. The ESP32 sends a short trigger pulse to the TRIG pin, and the time taken for the echo signal to return on the ECHO pin is measured to calculate distance. Basic validation is applied in the software to reduce noise and improve measurement reliability.

Sensor readings are taken at one-minute intervals. To improve data stability, the system calculates the average value over a five-minute period before transmitting the data to the cloud platform.

6. Hardware Assembly

All hardware components are assembled using direct jumper wire connections without the use of a breadboard. The ESP32 is positioned at the centre of the setup, while the sensors are placed nearby to minimise wiring length and reduce potential signal interference.

Female-to-female jumper wires are used to connect the power supply, ground, and signal pins between the ESP32 and each sensor according to the defined pin configuration. This direct wiring approach provides a compact setup and reduces loose connections that may occur during long-term operation.

Each sensor is tested individually after wiring to ensure correct connections and proper functionality before being integrated into the complete system.

7. Hardware Testing and Verification

Hardware testing is carried out in stages to ensure reliable system operation. Initially, each sensor is tested separately to verify correct readings and stable performance. The BME280 sensor outputs are checked against expected environmental values, while the HC-SR04 sensor is tested using known distances.

Once individual testing is completed, the full system is tested under continuous operation. Data is monitored to confirm stable power supply, consistent sensor readings, and reliable communication between components. Any wiring or connection issues identified during testing are corrected before extended use.

8. Hardware Photographs

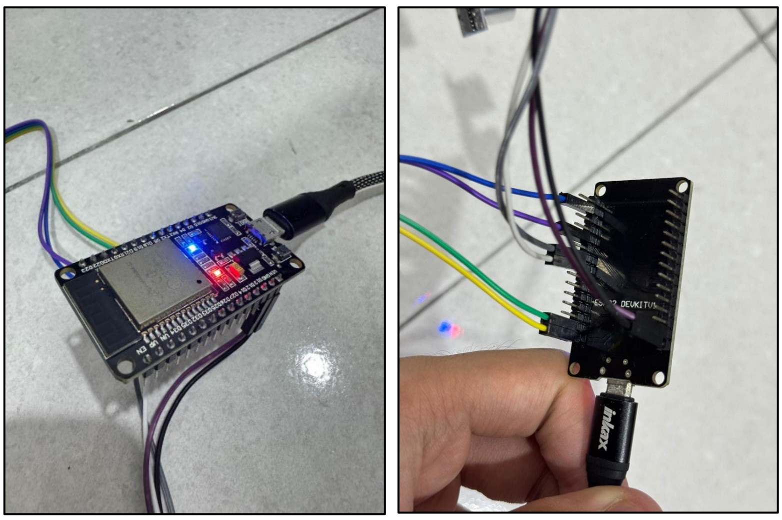

Figure 2: ESP32

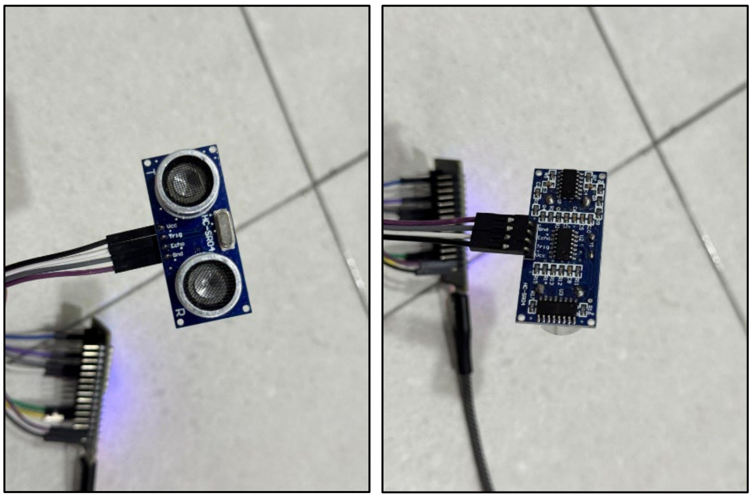

Figure 3: HS-SRC04

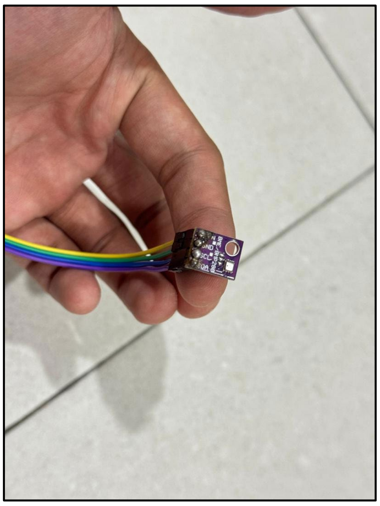

Figure 4: BME 280

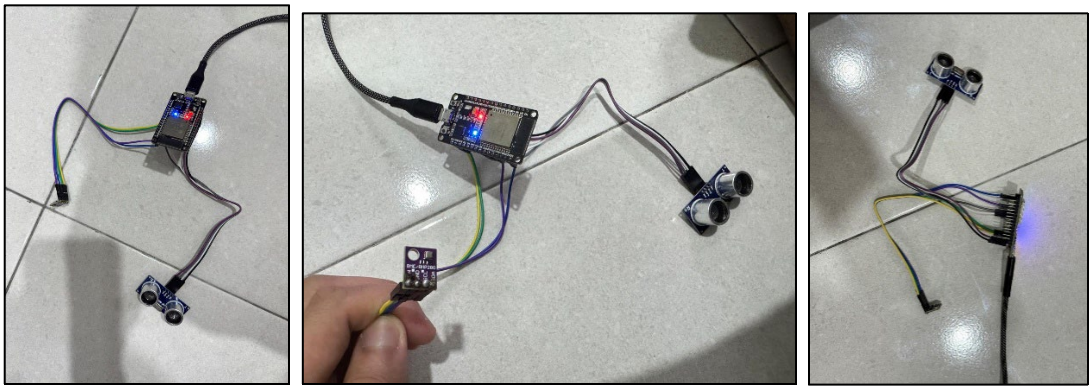

Figure 5: Overall Project Connection