Greenhouse Controller Project Documentation Group 2

ARM-Processors and Embedded Operating Systems

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Contents

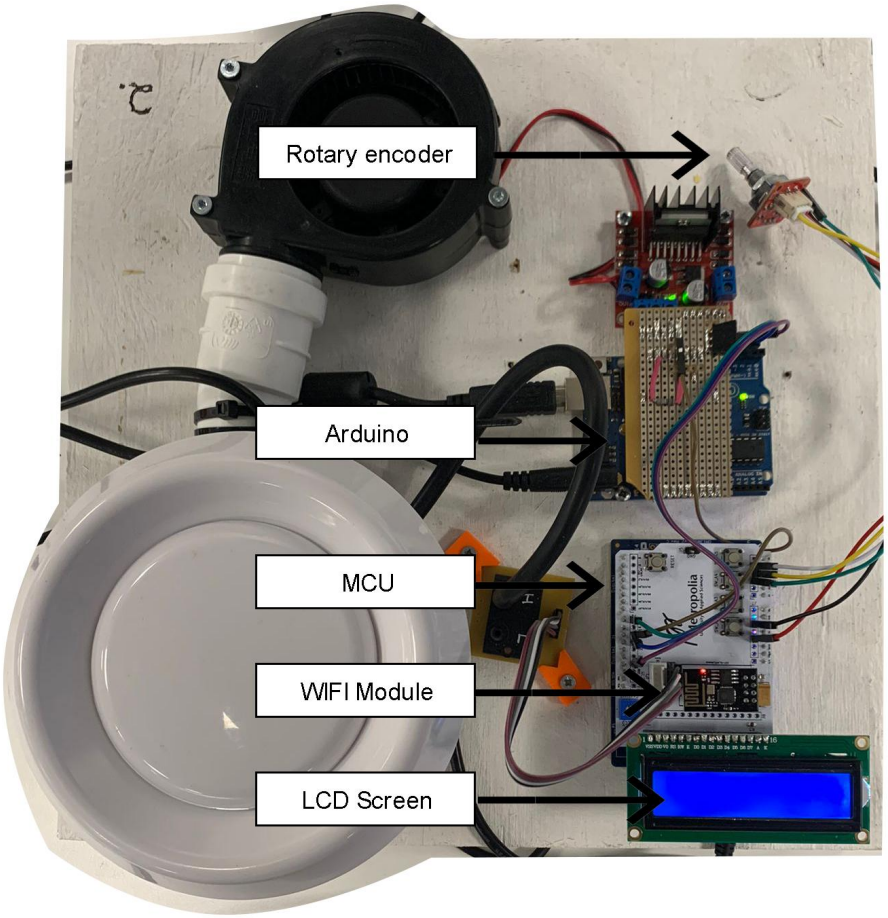
1. Concept

Carbon Dioxide (CO_2) is an essential component for photosynthesis (also called carbon assimilation), a process of extreme importance for life as food is made with this process which is the ultimate source of energy for organisms on this planet. The goal of the project is to control CO2 level in an artificial greenhouse where the CO2 level can be read and set on a LCD attached to the control system. Additionally, data on temperature and humidity of the environment are also gathered and displayed on the local UI, the LCD.

2. User manual

2.1 Product specifications

The hardware used during the project development is shown in the picture below:



Ventilation System

The system consists of following modules:

- LPC1549 (MCU)

LPC1549, an ARM-cortex M3 based microcontroller was used in this project, which features a rich peripheral set with very low power consumption. The LPC1549 operates at CPU frequencies of up to 72 MHz. The LPC1549 includes up to 256 kB of flash memory, 32 kB of ROM, a 4 kB EEPROM, and up to 36 kB of SRAM. Among the features, mainly, GPIO interrupts, communication protocols: I2C, Modbus, and UART, were used for this project.

- LCD Screen

  The LCD (Liquid Crystal Display) screen is an electronic display module and has a wide range of applications. A 16x2 LCD display is a very basic module which is very commonly used in various devices and circuits, as it can display 16 characters per line and there are 2 such lines. The LCD, used in this project, displays co2, temperature, and humidity readings from the sensor and also lets us set a certain co2 level as 'setpoint'.

- Rotary Encoder

  A rotary encoder is a type of position sensor, they measure rotary movements and displacement and can either be absolute or incremental. Rotary Encoder lets users toggle between menu items and set certain reading on the LCD (co2 / temp / rh). Users can select co2_setpoint and set a certain co2 level as they click on the button present in the encoder module.

- Arduino Uno

  Arduino is an open hardware development board that is used to design and build devices that interact with the real world. In the simulator, Arduino Uno has been used to simulate input from the temperature, humidity and CO2 sensors and its purpose is to serve for basic testing of the software. When the real system is flashed, the software behaves in the same way as with the simulator without the Arduino Uno.

- ESP8266-01 Wifi Module

  The ESP8266 WiFi Module is a self contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network. Therefore, this module brings to the system the possibility to connect to the internet, which is a key factor in the data transmission.

The sensors used to collect data in the embedded system are the following:

- GMP252 co2 probe

  Vaisala's GMP252 co2 probe was used to measure and collect information on the co2 concentration. GMP252 is designed for CO2 measurement in demanding applications that require reliable and accurate performance. The measurement range is 0 - 10 000 ppmCO2 (measurements can be carried out in the 10 000 - 30 000 ppmCO2 range with reduced accuracy). It is an intelligent, stand-alone, ppm-level probe. It's intended for measuring CO2 in greenhouses, among other places.

GMP252 co2 probe

- HMP60

  Another one from Vaisala, HMP60 Humidity and Temperature Probe measures temperature and humidity readings. HMP60 series probes use the interchangeable Vaisala INTERCAP® sensor. No recalibration is required after sensor replacement. It is a simple, durable and cost-effective humidity probe suitable for greenhouses.

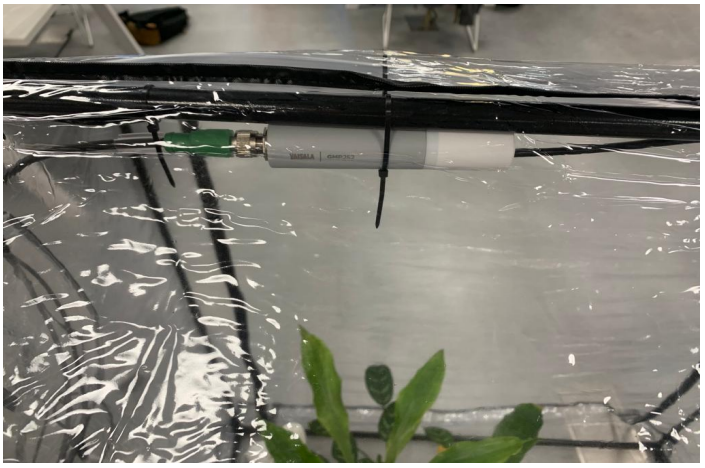
HMP60 Humidity and Temperature Sensor

2.2 Process description

The software's purpose is to be used in a greenhouse environment shown below:

Greenhouse environment

The site designated to create the ecosystem must contain the sensors described above: GMP252 co2 probe and HMP60. These are constantly collecting information about humidity, temperature, and the C02 concentration in the greenhouse.



GMP252 co2 probe in the Greenhouse

As the user interacts with the system by adjusting the CO2, if the actual CO2 value is lower than the desired value, the valve will open to increase the amount of CO2. However, the timer would close the valve in 2 seconds. If the user sets the desired CO2 value lower than the actual value, the valve remains closed and perhaps the system blows out the excess co2 (out of the scope of this project to control the fan).

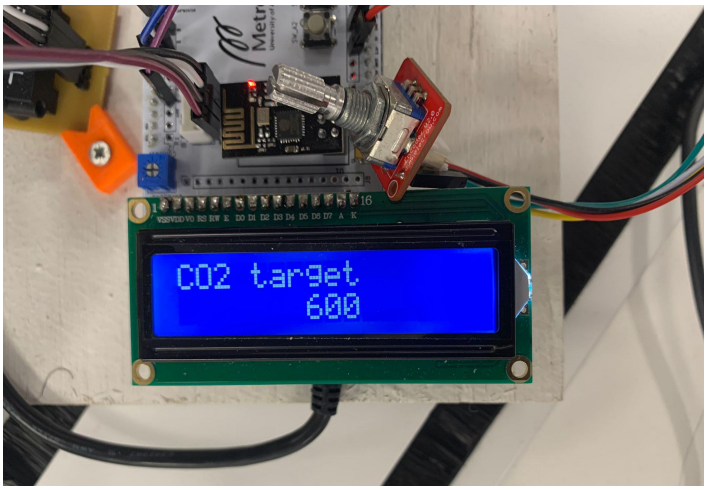
2.3 How to operate the system?

The system has a LCD screen displaying a menu. The menu has the following options:

[1] CO2, [2] CO2 target, [3] Temperature, [4] Humidity.

All the settings, except the second one (CO2 target), are used to display the current readings from the sensors installed in the greenhouse. The rotary encoder shown in the picture switches the menu options. Rotating the lever, you can switch between the different menu items.

The second menu option, CO2 Target, is the one that allows setting a value. Upon clicking on the button (press the tip of the lever), it sets focus on the number and lets user set a



LCD menu

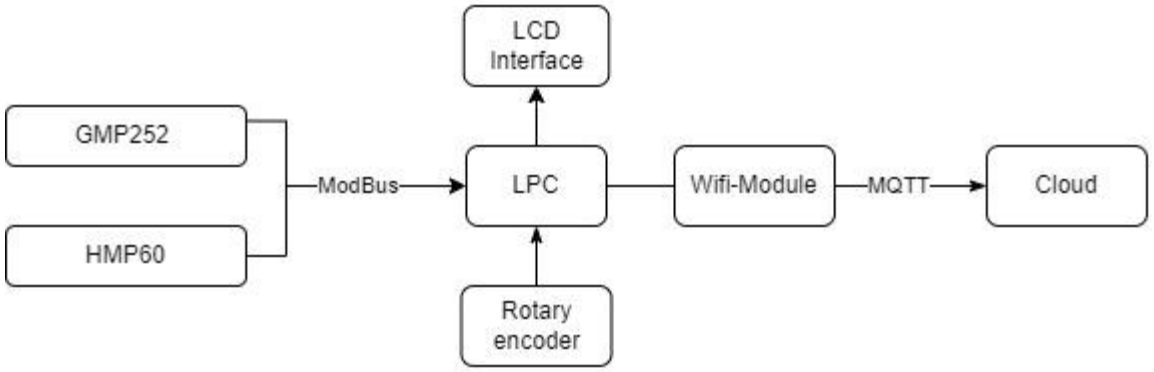
certain values. This value is read by the LCD task and sends it to a queue. MQTT task is blocking on the same queue event that upon receiving, publishes to the defined topic. The data can be visualized real-time on the Thingspeak browser interface.

3. Documentation

3.1 System description

The greenhouse system consists of a LPC1549 microcontroller, rotary encoder, a LCD Screen, Vaisala's humidity & temperature probe, and a CO2 probe (more information on User Manual). The data is read from the sensors via Modbus protocol and displayed on the LCD. Also, the setpoint for co2 is read/displayed to/from the LCD. The system communicates with the Thingspeak cloud through a Wifi-Module (ESP8266-01) attached to the LPC. The cloud hosts a MQTT broker where the LPC publishes messages every 5 minutes (as specified in the project requirements).

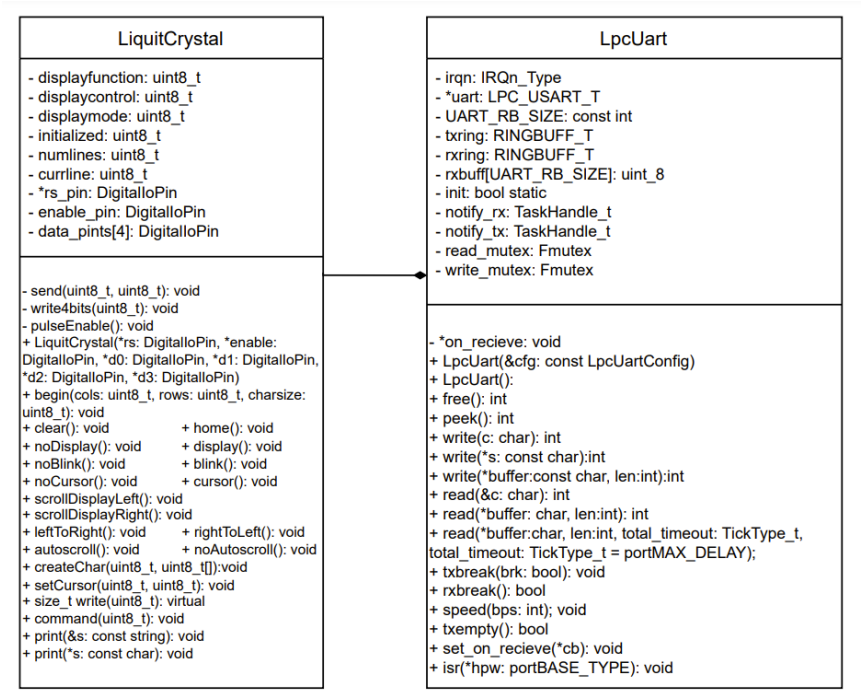
The following diagram describes the overall system architecture, that includes the components mentioned above, in the abstract form.



3.2 Software architecture

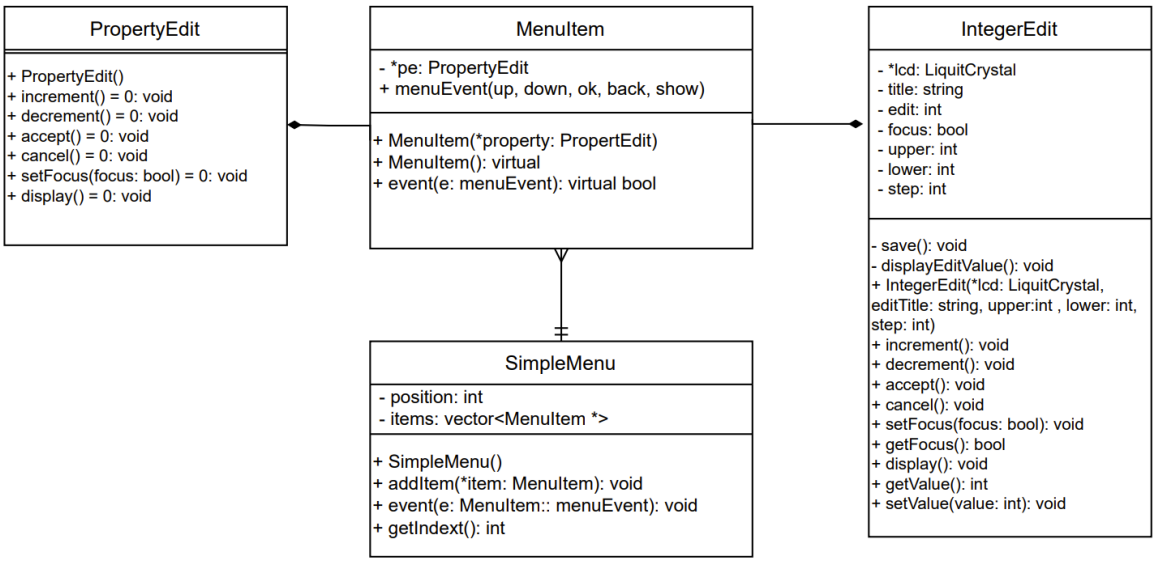
The organization of the system will be presented through class diagrams. Each class interacts with multiple other classes to achieve the implementation of an effective system.

The LCD screen contains the following classes:



LCD classes diagram

On the other hand, the menu available on the LCD with which the user interacts is made possible by the classes shown below. A SimpleMenu class can contain multiple MenuItems, and consequently, each MenuItem has a PropertyEdit where the numbers can be modified.



Menu class diagram

3.3 Communication protocols

3.3.1 MQTT

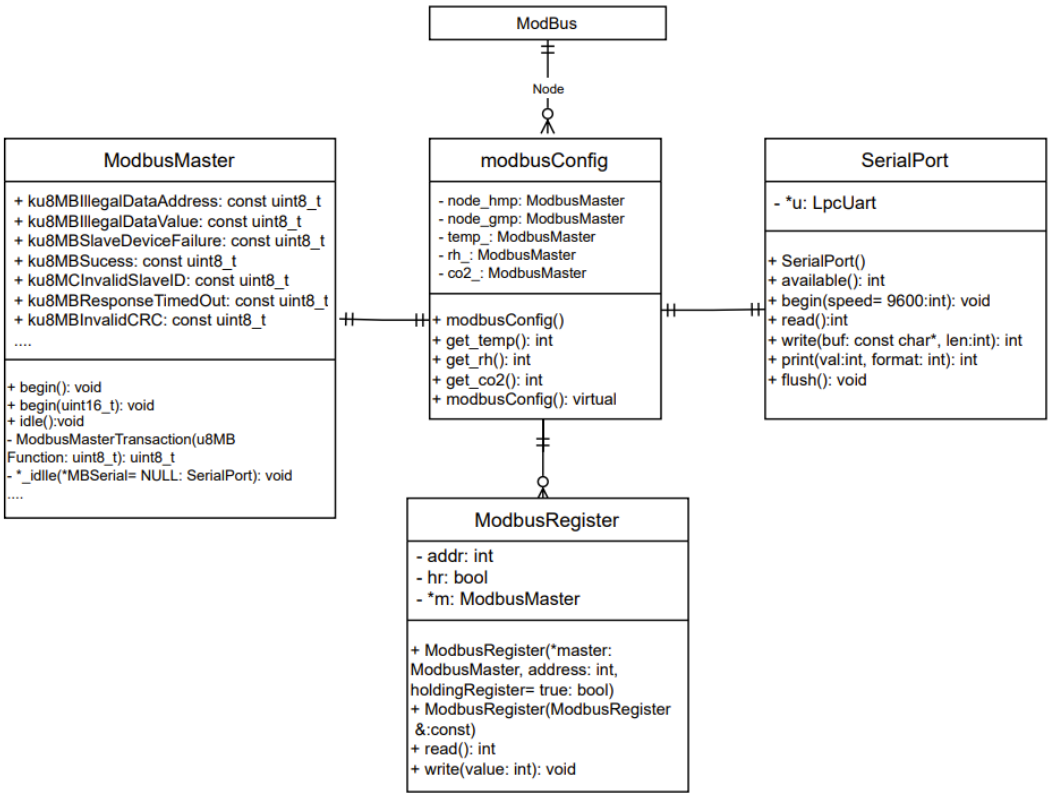
MQTT is a standards-based messaging protocol, or set of rules, used for machine-to-machine communication. It is designed as an extremely lightweight publish/subscribe messaging transport that is ideal for connecting remote devices, and in this particular case, the LPC board both publish and subscribe to MQTT messages from the topic "channels/1955513/publish" and the information is structured and published every 5 minutes:

<CO2-level>=<00>&<relative-humidity>=<00>&<temperature>=<00>&<valve-opening-percentage>=<00>&<CO2-set-point>=<00>

[Where 00 is just an example and changes according to the current reading from the sensors.]

3.3.2 Modbus

Vaisala's HMP60, relative humidity and temperature sensor, (modbus address 241) the GMP252 co2 probe (modbus address 240), both interact via Modbus RTU protocol with the LPC board. THe sensors store data in certain registers that the Lpc can access via Modbus.



Modbus Class Diagram

4. Bibliography

CO_2 Probe GMP252

HMP60 Humidity and Temperature Probe

Carbon Dioxide In Greenhouses

Embedded Systems - Ventilation Project - Group 5

What Is Mqtt?

5. Conclusion

The project requirements were accomplished, since at the end we were able to read from the sensors, display it on the LCD, and more importantly, set the co2 level and control the valve as per the setpoint. Due to the tight schedule for developing the project, eeprom for memory management was implemented the following day.