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Greenhouse CO_2 Controller

User Manual

Third Year IOT Project
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Contents

1. Introduction

Greenhouse CO_2 Controller is a controlled environment that automatically keeps the right levels of carbon dioxide in your greenhouse with intelligent ventilation and CO_2 injection control. The system reads environmental conditions continuously and adjusts CO_2 levels to your chosen settings, leading to maximum plant growth.

1.1 Key Features

- Automatic CO_2 level control up to 1500 ppm.
- Real-time environmental monitoring (CO_2, temperature, humidity).
- Storage of permanent settings (not deleted in case of power loss).
- Safety override at 2000 ppm.
- Cloud connectivity for remote monitoring.
- Local display with simple controls.

2. System Overview

2.1 What the System Does

The controller adjust your set CO_2 level by:

- **Monitoring:** Ongoing CO_2 level and environmental monitoring
- **Injecting:** Opening a CO_2 valve when levels are below target
- **Ventilating:** Fan speed control for distributing excess CO_2
- **Reporting:** Sending data to the cloud for remote access

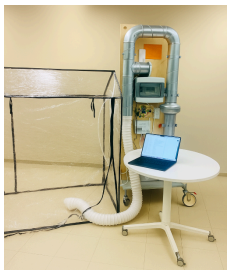
2.2 System Components

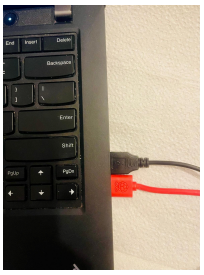
- **CO_2 Sensor (Vaisala GMP252):** CO_2 concentration measurement inside the greenhouse
- **Temperature & humidity sensor (Vaisala HMP60):** Monitors climate conditions
- **Ventilation Fan:** Variable speed (0-100%) controlled by Produal MIO 12-V
- **CO_2 Injection Valve:** Solenoid valve for controlled CO_2 release
- **Local Display:** OLED screen showing current status
- **Control Interface:** Rotary encoder and buttons for settings adjustment

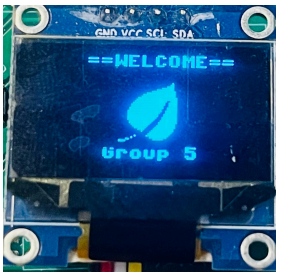
3. Getting Started

3.1 Initial Setup

1. Power On the System
    - Connect the controller to power
    - Wait for the system to initialize (approximately 5 seconds)
    - The display will show the welcome screen







2. Verify Sensor Readings
    - Check that CO_2, temperature, and humidity readings appear on the display
    - Readings should be within expected ranges:
        - ❖ CO_2: 400-600 ppm (typical ambient level)
        - ❖ Temperature: Current greenhouse temperature
        - ❖ Humidity: Current greenhouse humidity %

3. Set Your Desired CO_2 Level
    - Use the rotary encoder to navigate to the CO_2 setpoint setting
    - Rotate to select your desired level (minimum 400 ppm -maximum 1500 ppm)
    - Press the button to confirm
    - Settings are automatically saved

3.2 Recommended CO_2 Levels

- Ambient: 400-450 ppm (no enrichment)
- Light enrichment: 600-800 ppm
- Standard enrichment: 1000-1200 ppm
- Maximum enrichment: 1200-1500 ppm

⚠️ **Note**: Never set CO_2 above 1500 ppm and below 400 ppm. The system will not accept values above/below these limits.

4. Operating the Local User Interface

4.1 Display Screens Overview

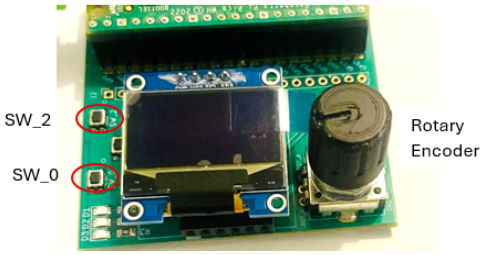
The system uses an OLED display with the following screens:

1. **Welcome Screen** - Initial startup screen
2. **Idle Mode** - Main monitoring display (default)
3. **Menu** - Navigation to system settings
4. **Set CO_2** - Adjust CO_2 target level
5. **Network** - Configure WiFi settings
6. **Warning -** CO2 level above 2000 ppm

Navigation Controls

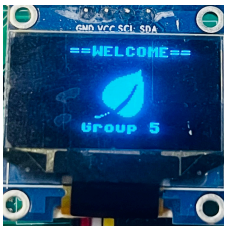
Rotary Encoder

- **Rotate Clockwise:** Move down in menu / Increase values
- **Rotate Counter-Clockwise:** Move up in menu / Decrease values
- **Press (Button):** Select current option / Confirm changes
- **Button SW_0(used in Network screen):** confirm/save Network SSID and password to EEPROM
- **Button SW_2 (used in Network screen)**: delete character



4.1.1 Welcome Screen

What You See:



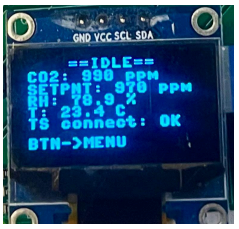
Behavior:

- Appears automatically when system powers on
- Displays for 10 seconds
- Automatically transitions to Idle Mode
- Press encoder button to skip to Idle Mode immediately

Purpose: Initial system startup indication.

4.1.2 Idle Mode Screen

What You See:



Information Displayed:

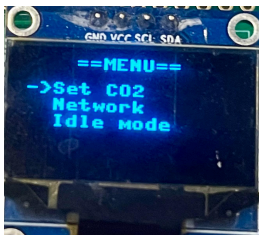
- **CO2:** Current CO_2 concentration in parts per million
- **SETPNT:** Your target CO_2 setpoint
- **RH:** Relative humidity percentage
- **T:** Temperature in Celsius
- **TS:** Wifi Connection status (OK = connected, -- = disconnected)
- **BTN->MENU:** Reminder to press encoder button for menu access

How to Use:

- This is the default monitoring screen
- Updates continuously with live sensor data and key system information such as ThingSpeak connectivity status and current CO2 setpoint
- Press the encoder button once to access the Menu
- System automatically returns to Idle Mode after 10 seconds of inactivity from any other screen

4.1.3 Menu Screen

What You See:



Menu Options:

1. **Set CO2 -** Adjust CO_2 target setpoint
2. **Network -** Configure WiFi credentials
3. **Idle mode -** Return to idle display

How to Navigate:

1. Rotate encoder clockwise to move down the list
2. Rotate encoder counter-clockwise to move up the list
3. The arrow (→) indicates your current selection
4. Press encoder button to select highlighted option

Auto-Return: If no input detected for 10 seconds, returns to Idle Mode automatically

4.1.4 Set CO_2 Screen

What You See:

How to Set CO_2 Level:

1. **Access:** Select "Set CO2" from Menu and press button
2. **Adjust Value:**
    - Rotate clockwise to increase setpoint (+10 ppm per each encoder edge)
    - Rotate counter-clockwise to decrease setpoint (-10 ppm per each encoder edge)
3. **Value Range:**
    - Minimum: 400 ppm
    - Maximum: 1500 ppm
4. **Save Setting:** Press encoder button to confirm and save
5. **Confirmation:** System returns to Idle Mode
6. **Implementation:** New setpoint takes effect immediately
7. **Persistence:** Setting is saved to EEPROM (survives power loss) and sent to Cloud

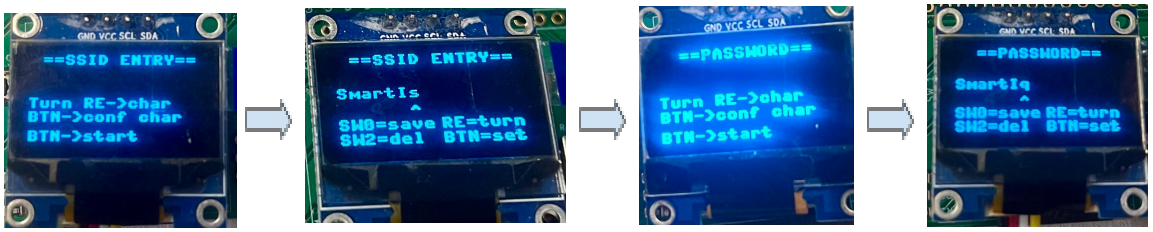
Example Sequence:

- **Current display:** "SET CO2: 500"
- **Rotate clockwise 5 times** → "SET CO2: 550"
- **Rotate counter-clockwise 2 times** → "SET CO2: 530"
- **Press button** → Saved! Returns to Idle Mode

Tip: Make small adjustments (50-100 ppm) and observe system response before making larger changes

4.1.5 Network Screen

What You See:



Configuring Network Settings:

The Network screen allows you to configure WiFi credentials using the rotary encoder and an ASCII character table.

Setting WiFi SSID (Network Name):

1. Select "Network" from Menu and press button
2. System prompts for SSID entry
3. Use rotary encoder to scroll through ASCII characters:
    - Rotate to select characters (A-Z, a-z, 0-9, special characters)
    - Press button to confirm each character
4. Continue until complete network name is entered
5. Press button (SW_2) to delete a character.
6. Press button (SW_0) on final character to confirm SSID

Setting WiFi Password:

1. After SSID entry, system prompts for password
2. Use same method as SSID:
    - Rotate through ASCII character table
    - Press button to select each character
3. Password characters may be masked for security
4. Press button (SW_2) to delete a character.
5. Press button (SW_0) on final character to confirm password

Saving Network Settings:

- After both SSID and password are entered, settings save to EEPROM
- System must be reset, after which it attempts connection automatically
- Connection to ThingSpeak updates on Idle Mode display

Checking Connection Status:

- Return to Idle Mode to view connection status
- "TS connect: OK" = Successfully connected
- "TS connect: --" = Not connected or connection failed

Returning to Menu:

- Pressing button SW_2 after entering the password returns the system to Menu
- Or wait 10 seconds for automatic return to Idle Mode

Note: Network settings are stored persistently. You only need to configure once unless the network changes.

5. Remote Operation via Cloud

5.1 ThingSpeak Integration

The system automatically sends data to ThingSpeak cloud service at regular intervals (typically every 16 seconds).

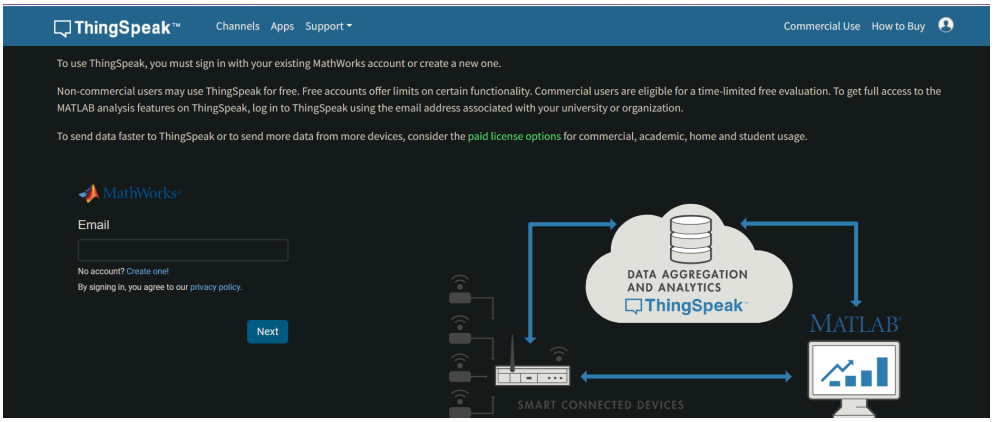
Monitored Parameters

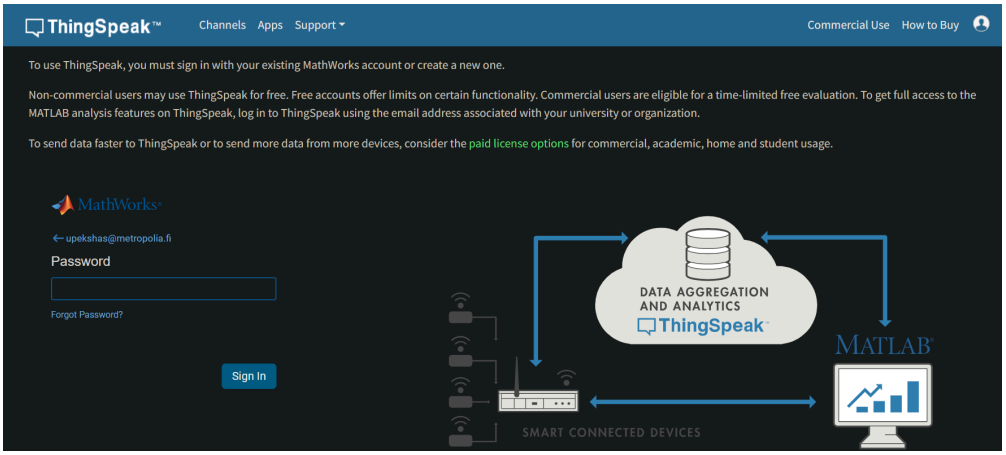
The following data is sent to the cloud:

1. **Field 1**: CO_2 level (ppm)
2. **Field 2**: Relative humidity (%)
3. **Field 3**: Temperature (°C)
4. **Field 4**: Ventilation fan speed (%)
5. **Field 5**: CO_2 setpoint (ppm)

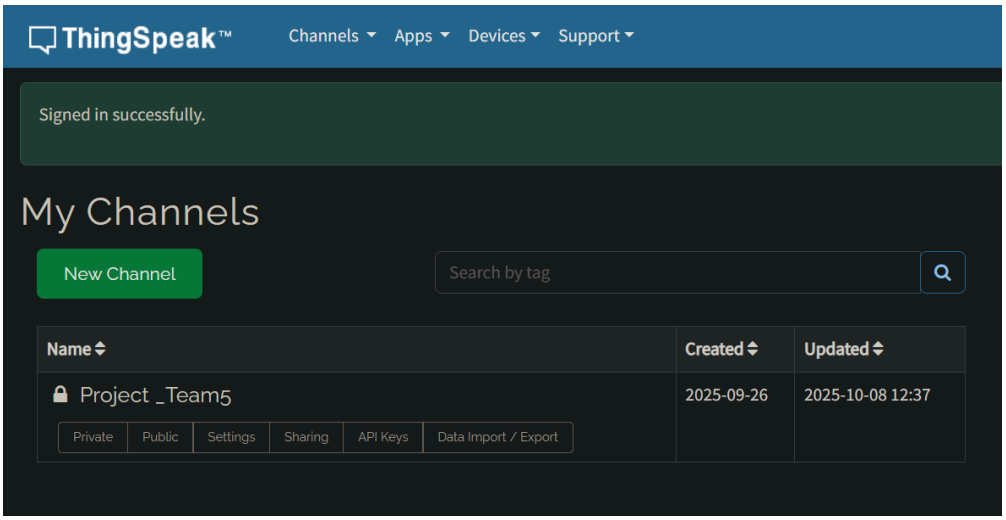
Accessing Your Data

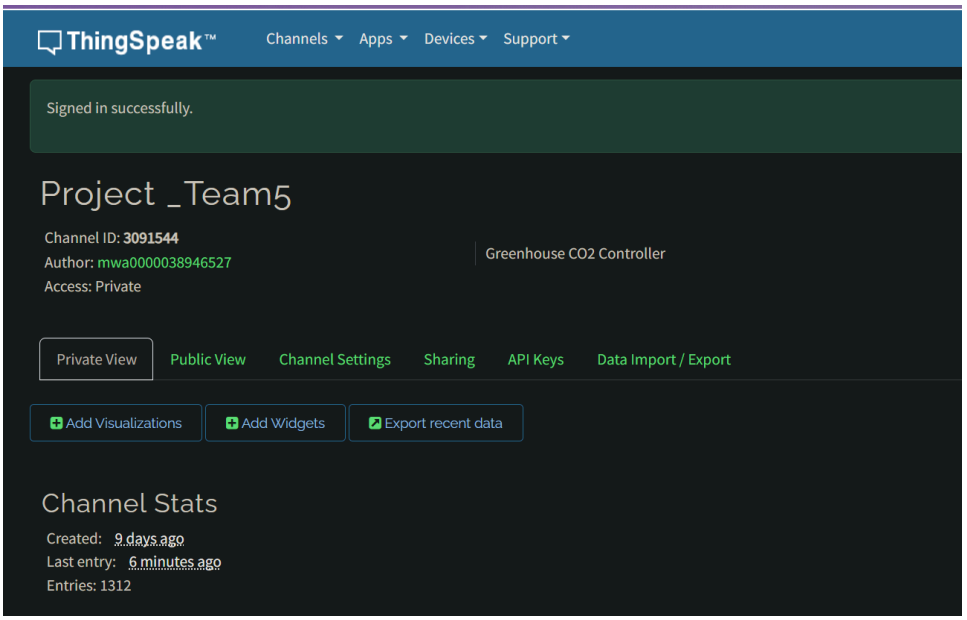
1. Log in to your ThingSpeak account at https://thingspeak.com



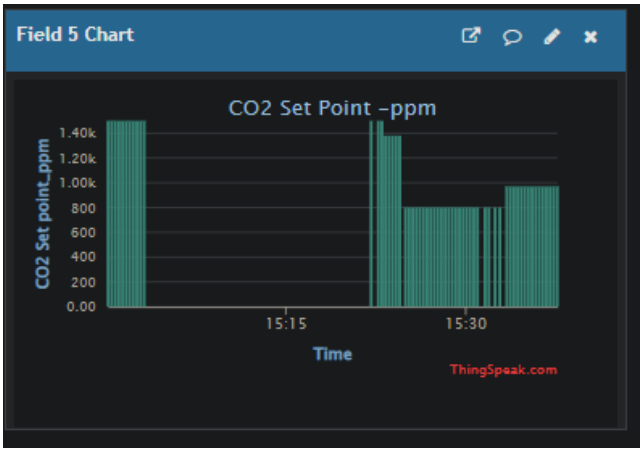


2. Navigate to your channel (credentials provided separately)





3. View real-time and historical data in graphs



4. Set up custom alerts for abnormal conditions

5.2 Remote Control (Advanced Feature)

you can remotely adjust the CO_2 setpoint:

1. Access ThingSpeak TalkBack feature
2. Send command with new setpoint value
3. System checks for new commands periodically
4. New setpoint is applied and confirmed in next data update

6. Safety Features

6.1 Automatic Safety Override

Critical Safety Feature: If CO_2 level exceeds 2000 ppm at any time:

- System automatically increases ventilation to maximum
- CO_2 injection valve is closed
- System will not resume normal operation until CO_2 drops below 2000 ppm
- Safety override cannot be disabled
- A warning message appears on the display

6.2 Sensor Error Detection

If CO2 sensor provides invalid readings:

- An error message appears on the display (CO2: -1)
- System may enter safe mode (maximum ventilation, no CO_2 injection)
- Contact technical support if sensor CO2 errors persist

6.3 Power Loss Protection

- All settings are stored in EEPROM (Co2 setpoint and Network SSID and password)
- After power restoration, system resumes with previous settings
- System performs sensor check before resuming operation

7. Troubleshooting

Common Issues and Solutions

7.1 CO_2 Level Not Reaching Target

Symptoms: CO_2 remains below setpoint despite valve operation

Possible Causes:

- CO_2 supply depleted or valve blocked
- Excessive ventilation preventing buildup
- Greenhouse leakage too high

Solutions:

- Check CO_2 supply
- Verify injection valve operates (check display status)
- Reduce ventilation fan speed temporarily to test
- Inspect greenhouse for air leaks

7.2 CO_2 Level Too High

Symptoms: CO_2 exceeds setpoint significantly

Possible Causes:

- Ventilation fan not operating
- Fan blocked or obstructed
- Setpoint too high for greenhouse size

Solutions:

- Verify fan is running (check fan speed on display)
- Check for physical obstructions
- Reduce CO_2 setpoint
- If reading exceeds 2000 ppm, safety mode activates automatically

7.3 No Cloud Connection

Symptoms: Data not updating on ThingSpeak

Possible Causes:

- Network settings incorrect
- WiFi connection lost
- Internet outage
- Invalid API credentials

Solutions:

- Verify network settings in menu
- Check WiFi router operation
- Verify API key is correct
- System continues local operation during connection loss

7.4 Settings Not Saving

Symptoms: Settings revert after power cycle

Possible Causes:

- EEPROM write failure
- Confirmation step skipped

Solutions:

- Ensure you press button to confirm settings
- Wait for "Settings Saved" confirmation
- If problem persists, contact technical support

8. Technical Specifications

8. 1 Operating Ranges

Parameter	Range	Accuracy
CO_2 Control	400-1500 ppm	±10 ppm
Safety Override	2000 ppm	Fixed threshold
Temperature Monitoring	-40 to +60°C	±0.5°C (10-30°C), ±0.6°C (other)
Humidity Monitoring	0-100% RH	±3% RH (0-90%), ±5% RH (90-100%)
Fan Speed Control	0-100%	1% increments

8.2 Communication

- Modbus RTU: 9600 bps, 8N1
- I²C: Standard mode (100 kHz)
- WiFi: 2.4 GHz 802.11 b/g/n
- Cloud API: HTTPS RESTful

8.2.1 Control and I/O

- GPIO27: CO_2 injection valve control

8.3 Environmental Conditions

- Operating Temperature: 0-50°C
- Storage Temperature: -20 to 70°C
- Humidity: 10-90% RH (non-condensing)