

Precision Temperature Data Logger

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Contents

1	Introduction	3
2	System Overview	3
2.1	System Specifications	3
3	Hardware Setup	4
3.1	Hardware Components	5
3.2	Hardware Setup Procedure	5
4	Graphical User Interface (GUI) Setup	6
4.1	GUI Installation	6
4.2	GUI Operation	7
4.3	Digital Filtering	7
4.4	GUI Features Summary	7
5	Calibration Procedure	8
5.1	GUI Settings During Calibration	8
5.2	Zero-Point (Offset) Calibration	8
5.3	Gain Calibration	8
6	Troubleshooting	8
7	Conclusion	9
8	Major Specifications	9

1 Introduction

The Two-Channel Precision Temperature Data Logger provides highly accurate temperature measurements for laboratory and industrial applications. Using platinum resistance sensors (PT100), the system ensures high linearity, repeatability, and stability.

The system integrates precision amplification, high-resolution analog-to-digital conversion, STM32 microcontroller processing, and a Python-based GUI for real-time monitoring, calibration, and data logging. This manual guides the user through hardware setup, GUI installation, calibration, and troubleshooting to ensure accurate operation.

2 System Overview

The system comprises two PT100 sensors, each forming one arm of a Wheatstone bridge. The differential voltage is amplified using AD620 instrumentation amplifiers, digitized by ADS1256 24-bit ADC, and processed by STM32F103 MCU. Data is transmitted to a PC via FT232 USB-UART for GUI operation.

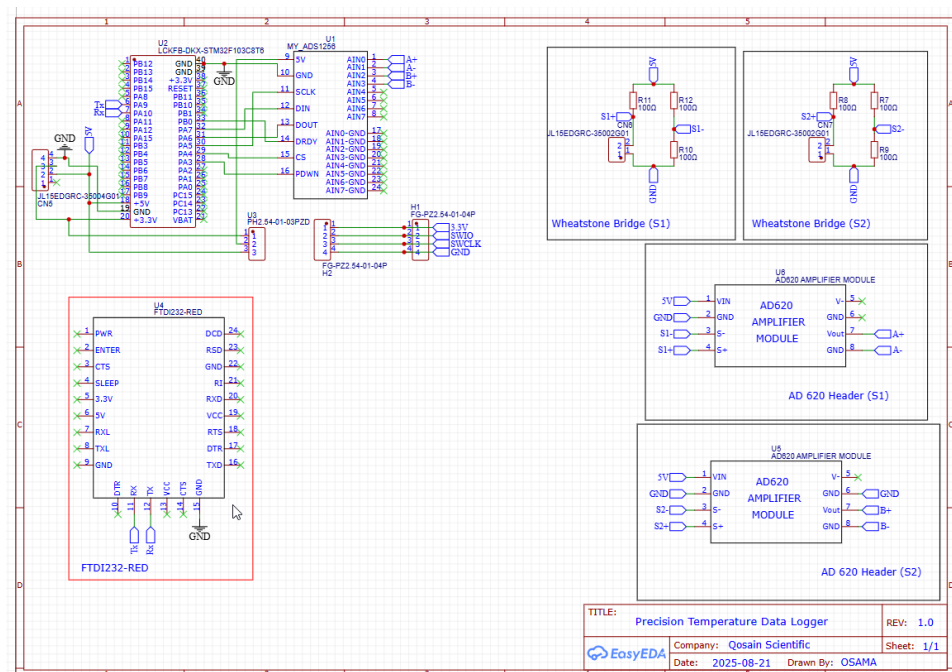


Figure 1: System Overview of Precision Temperature Data Logger.

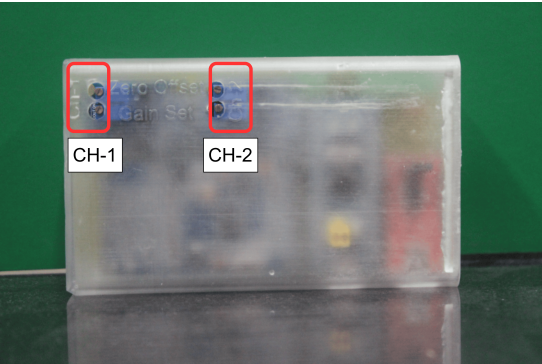
2.1 System Specifications

The system supports a wide range of sampling frequencies, allowing adaptation to slow or dynamic temperature processes.

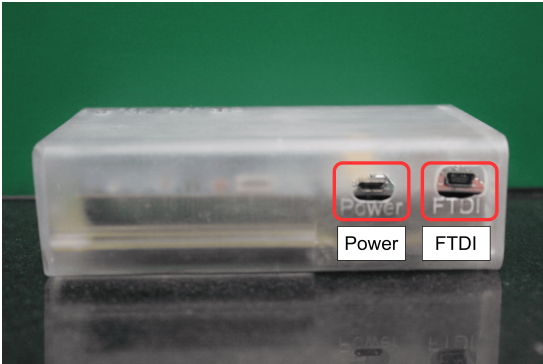
Channel	1 Hz	5 Hz	10 Hz	20 Hz	50 Hz	100 Hz	250 Hz	500 Hz	850 Hz
1	✓	✓	✓	✓	✓	✓	✓	✓	✓
2	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 1: Number of Channels and Sampling Frequencies.

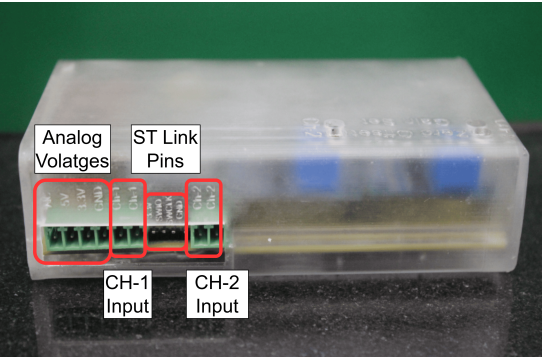
3 Hardware Setup



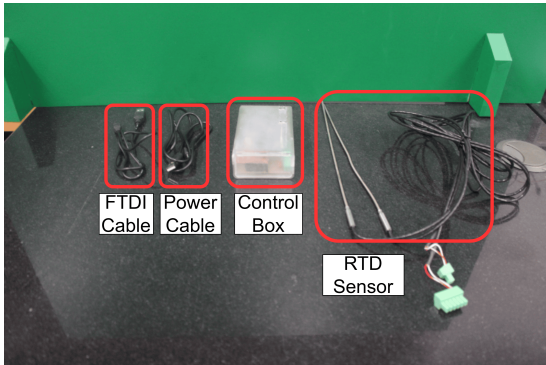
(a) Control knobs for PT100 sensors.



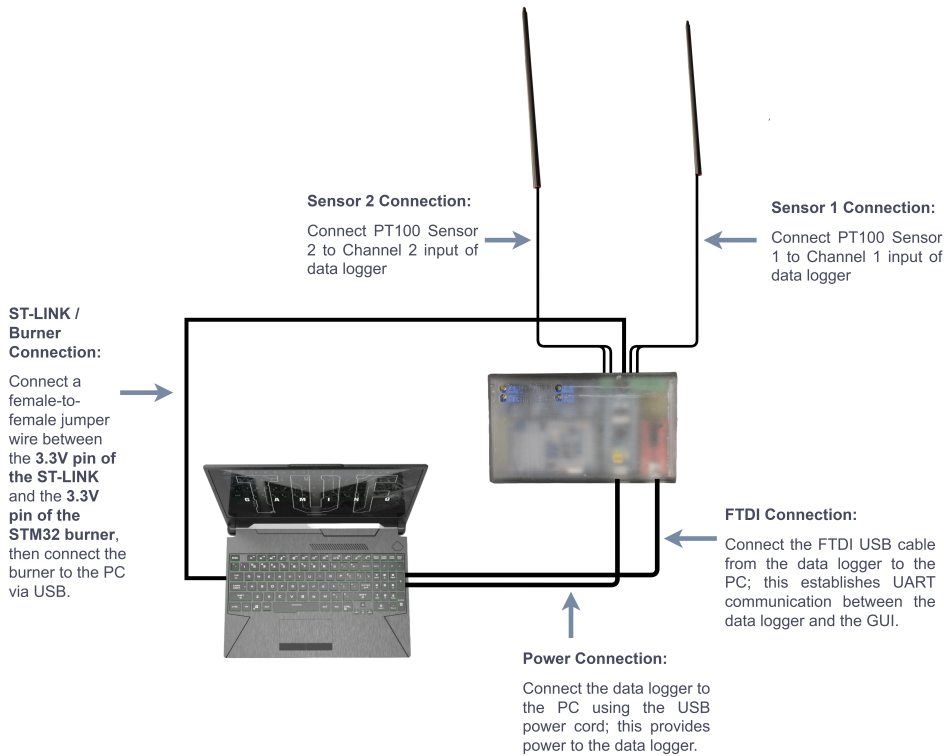
(b) Power and FTDI port.



(c) RTD inputs.



(d) Complete hardware setup with USB connections.



(e) Connection diagram of Precision Temperature Data Logger.

3.1 Hardware Components

Component	Description
PT100 Sensors	Platinum resistance temperature sensors ($100\ \Omega$ at $0\ ^\circ\text{C}$) for precise measurement.
Wheatstone Bridge	Converts PT100 resistance change to differential voltage.
AD620 Instrumentation Amplifier	Amplifies the bridge signal. Gain controlled via R_G : $G = 1 + \frac{49.4\ \text{k}\Omega}{R_G}$
ADS1256 ADC	24-bit high-resolution delta-sigma ADC.
STM32F103 MCU	Manages acquisition, filtering, and UART communication.
FT232 USB-UART	Converts UART data to USB for PC GUI.

Table 2: Hardware Components Used in the System.

3.2 Hardware Setup Procedure

1. **Prepare the Hardware:** Ensure all components are powered off before making any connections. Verify that PT100 sensors, Wheatstone bridges, AD620 amplifiers, ADS1256 ADC, STM32 MCU, and FT232 module are properly assembled on the PCB.
2. **Connect PT100 Sensors:** Connect the PT100 sensors to their respective Wheatstone bridge inputs (Sensor 1 $\rightarrow$ Channel 1, Sensor 2 $\rightarrow$ Channel 2). Check for correct polarity and secure connections.
3. **Connect to PC:** Take a female-to-female jumper wire and connect one end to the 3.3V pin on the ST link pin (as labeled) and the other end to the PC USB port using the STM32 burner. Ensure the correct pin labels are followed.
4. **Connect Power and FTDI Cords:** Connect the data logger main power cord to the PC usb port. Then, connect the FTDI USB cord to the PC for UART communication. Ensure both connections are secure before powering on the system.
5. **Verification:** Verify that the STM32 board and FTDI module LEDs indicate proper operation. The system is now ready to communicate with the GUI.

4 Graphical User Interface (GUI) Setup

The Python-based GUI shown in Fig. 3 provides real-time monitoring and user control. Features include:

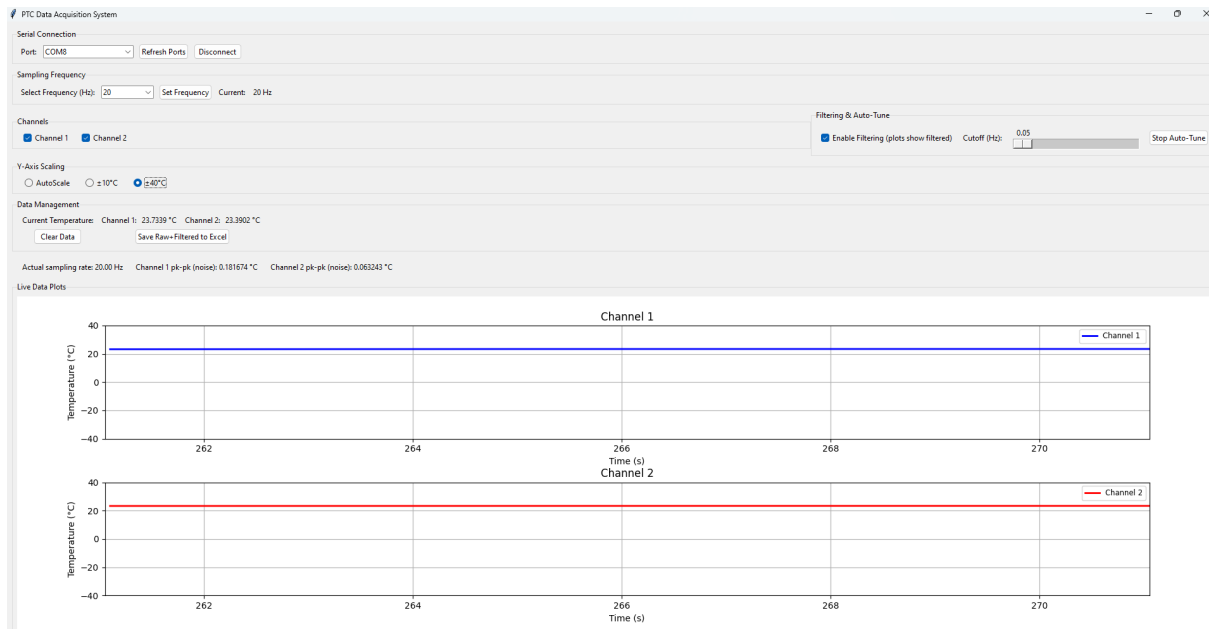


Figure 3: Graphical User Interface for live data acquisition and analysis.

4.1 GUI Installation

The Graphical User Interface (GUI) can be used in two ways: either through the pre-compiled `Application.exe` file or by running the Python source code (if provided).

Option 1: Using the Executable File

1. Copy the provided `Precision_Temperature_Data_Logger.exe` file to your PC.
2. Double-click the `Precision_Temperature_Data_Logger.exe` to launch the program.
3. Connect the USB cable from the data logger to the PC and confirm COM port detection in Device Manager.
4. Select the correct COM port in the application window to establish communication.

Option 2: Using the Python Source Code (if available)

1. Install Python (version 3.8 or later).
2. Install the required Python packages:

```
pip install pyqt5 matplotlib pyserial
```

3. Connect the USB cable from the data logger to the PC and confirm COM port detection in Device Manager.
4. Open the terminal/command prompt, navigate to the folder containing the source code, and run:

```
Precision_Temperature_Data_Logger.py
```

5. The GUI will launch and operate in the same way as the executable version.

4.2 GUI Operation

1. Select the COM port corresponding to FT232 module.
2. Choose sampling frequency and filtering options.
3. Press *Start* to begin live data acquisition.
4. Use *Clear* to reset data buffer.
5. Adjust *Auto/Manual Scaling* to view signals properly.
6. Save data in CSV format using *Data Saving* option.

4.3 Digital Filtering

2nd-order Butterworth filter reduces noise, adjustable from 0.05–5 Hz:

Filter Type	Order	Cutoff Frequency (Hz)
Butterworth	2nd	0.05 - 5

Table 3: Digital Filter Parameters.

4.4 GUI Features Summary

Feature	Description / Options
Live Plot	Real-time plotting of channel data
Scaling	Auto and Manual scaling options
Filtering	Auto and Manual filter tuning
Data Saving	Save data in CSV format
Clear Data	Clear current acquisition data
Actual Sample Rate	Displays real-time sampling frequency
Channel 1 Noise	Peak-to-peak noise measurement
Channel 2 Noise	Peak-to-peak noise measurement

Table 4: GUI Features and Capabilities.

5 Calibration Procedure

5.1 GUI Settings During Calibration

For better visualization during calibration, configure the software as shown in Table 5.

Parameter	Setting
Sampling Frequency	20 Hz
Enable Filtering (Plot)	Unchecked (show raw signal)
Autotune	Disabled
Y-Axis Scaling	Auto Scaling

Table 5: GUI settings for calibration procedure

5.2 Zero-Point (Offset) Calibration

1. Place PT100 sensors in ice bath (0 °C).
2. Adjust AD620 offset potentiometer until output reads 0 V.
3. Verify symmetry by slightly raising and lowering temperature.

5.3 Gain Calibration

1. Place PT100 sensors in stable reference temperature (25 °C).
2. Adjust gain potentiometer until GUI reading matches reference.
3. Verify linearity at multiple temperature points.

6 Troubleshooting

Issue	Solution
No data on GUI	Check FT232 USB connection and COM port. Ensure correct COM port is selected and drivers are installed.
Incorrect temperature reading	Repeat zero-offset and gain calibration. Verify PT100 connections and reference temperatures.
Noise in signal	Ensure shielding, proper grounding, and secure amplifier connections.

Table 6: Common Issues and Solutions.

7 Conclusion

The Precision Temperature Data Logger provides reliable, high-resolution temperature measurements. Proper hardware setup, calibration, and GUI operation ensure precise and accurate results suitable for laboratory experiments, industrial monitoring, and research applications.

8 Major Specifications

Parameter	Specification
Number of Channels	2 (independent PT100 inputs)
Sensor Type	PT100 Platinum Resistance Thermometer
Resolution	24-bit (ADS1256 ADC), $\pm 0.001^{\circ}\text{C}$ (with digital filtering)
Sampling Frequencies	1 Sample/s, 5 S/s, 10 S/s, 20 S/s, 50 S/s, 100 S/s, 250 S/s, 500 S/s, 850 S/s
Input Configuration	4-wire RTD connection
Amplifier	AD620 instrumentation amplifier (programmable gain)
Microcontroller	STM32F103 (ARM Cortex-M3, 72 MHz)
Communication Interface	USB 2.0 via FT232 UART-USB bridge
PC Software	Precision_Temperature_Data_Logger.exe (standalone) or Python source code (if provided)
Filter	2nd-order digital Butterworth (0.05–5 Hz)
Power Supply	5 V DC (USB powered)
Enclosure	Desktop laboratory module
Operating Environment	-40°C to 40°C
Dimensions	118.30 mm $\times$ 70 mm $\times$ 36.15 mm

Table 7: Major Specifications of the Precision Temperature Data Logger.