CubiSens™ TS100
Wireless Temperature Sensor

User Manual

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Introduction

CubiSens™ TS100 Wireless Temperature Sensor (TS100 in short) is a millimeter-scale wireless sensor for accurate, real-time temperature measurement. Measuring only 7.5 x 7.5 x 4.2 mm, the TS100 is capable of transmitting up to 100m in distance and last up to 2 years in sensing operation. The device is packaged in bio-compatible epoxy and coated with parylene, making it ideal for implanting in animal models. The TS100 Communication Kit includes a Windows-compatible GUI software, which allows the user to start operations, stop operations, and view the received data. This document serves as the user manual for the TS100, as well as an installation manual for setting up the TS100 Communication Kit.

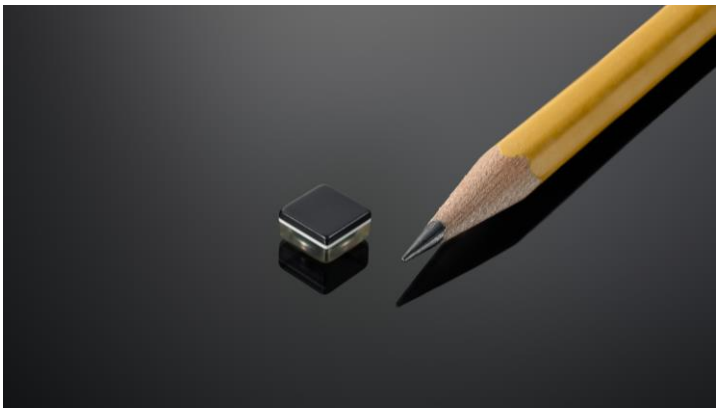


Figure 1. CubiSens™ TS100 Wireless Temperature Sensor

Important Notes before Using the TS100

- **Abrupt Temperature Change During Measurement**: Measurement interval must be set to ensure <20°C change between successive measurements. For example, if the TS100 needs to be abruptly dropped into a hot or cold liquid during measurement resulting in a rapid temperature change of 40°C, the measurement interval should be set to no more than 5 seconds, which is about 1/2 the thermal response time of the unit.
- **Battery Life**: The TS100 operation lifetime varies significantly depending on the exposed temperature and measurement interval. Before starting measurement operation, please refer to Figure 1 of "TS100 Technical Datasheet" to select the appropriate measurement interval.
- **Temperature Exposure**: The TS100 is designed for indoor environments and animal implants (10-55˚C). Optical communication must be performed at room temperature (20-30˚C) in an indoor environment. Please refer to Technical Specifications section for details on other temperature limits. Please allow at least 5 minutes for the unit to acclimate to a new temperature environment before initiating optical communication in case of an abrupt temperature change.
- **Manual Handling**: Each unit is coated to protect the electronics from manual handling. However, directly grabbing the unit in certain ways can temporarily shift radio frequency of the integrated antenna and hamper wireless communication. Also, handling with sharp objects that can compromise the coating should be avoided.

TS100 Communication Kit

1. What's in the Box

The TS100 Communication Kit consists of:

1. CSG100-A9 CubiSens™ Gateway
2. Gateway Antenna
3. CubiSens™ Optical Programmer
4. USB to Ethernet adapter
5. Ethernet cable
6. Micro USB cable
7. 5V power adapter

Figure 2. TS100 Communication Kit Example Setup

2. User System Requirements

For proper operation of the TS100 Communication Kit, user needs access to a Windows computer with 2 available USB ports. Details on minimum system requirements is shown below.

Minimum User System Requirements	
Operating System	Windows 7, 8, 10
Memory	1GB
Processor	1GHz
Software Framework	Microsoft .NET 4.7.2
Storage	500MB available disk space
Ports	2 available USB 2.0 (or higher) ports

3. Hardware Assembly

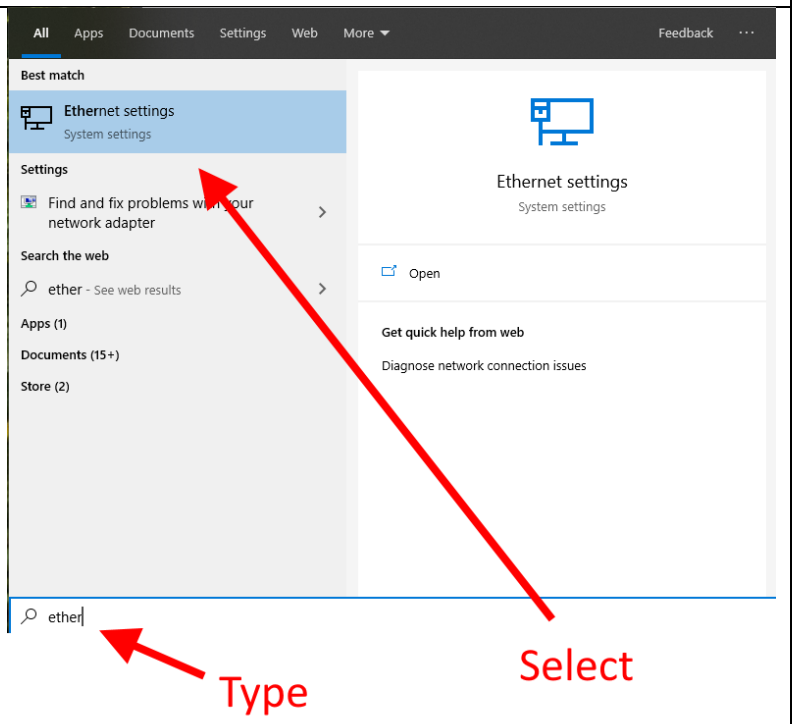
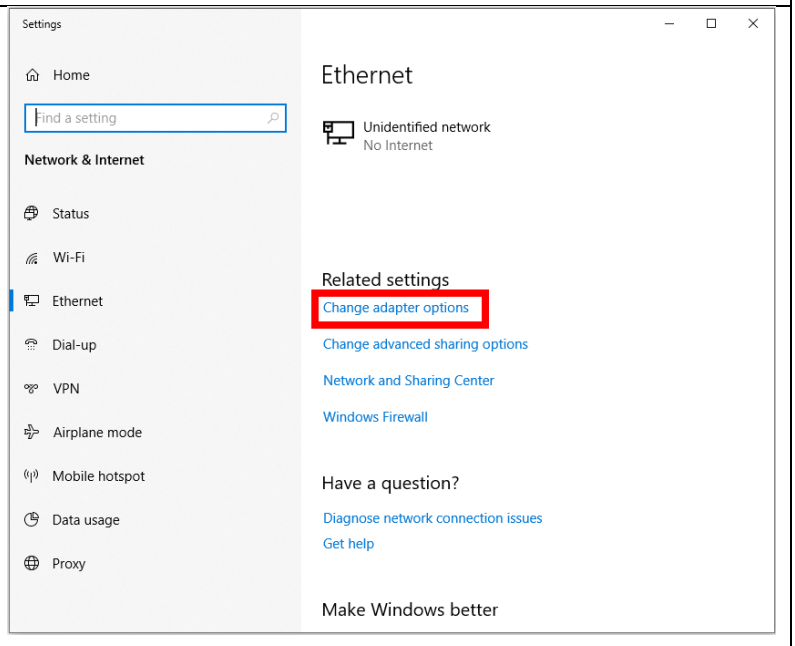
Figure 5. TS100 Communications Kit Hardware Connections

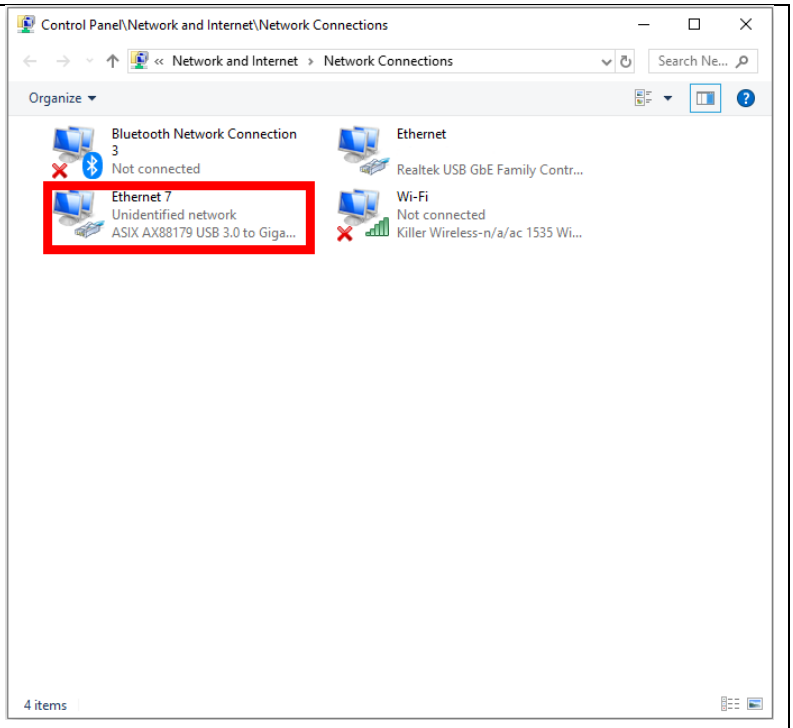
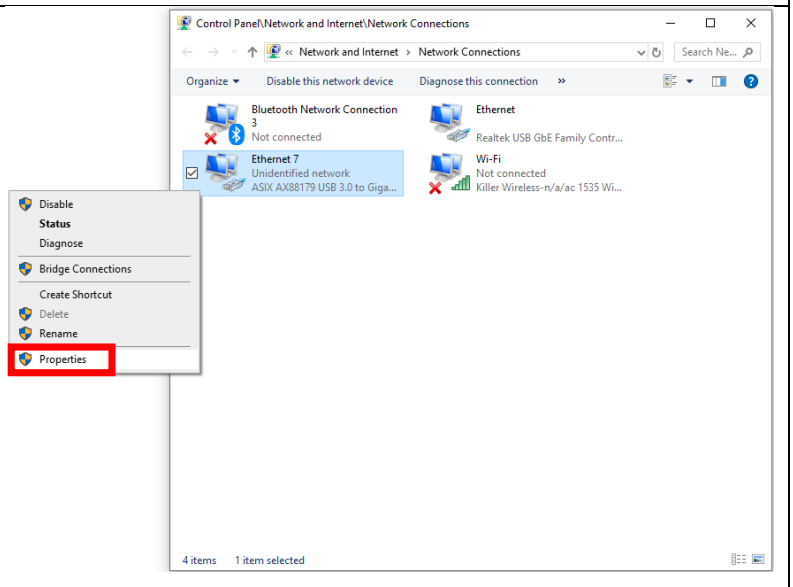
1. Screw in the antenna to the CSG100-A9 CubiSens™ Gateway as shown in Figure 5.
2. Connect the 5V power adapter to the CSG100-A9 Gateway and plug it into a power outlet.
3. Connect the ethernet cable to the CSG100-A9 Gateway and to the ethernet-to-USB adapter.
4. Connect the ethernet-to-USB adapter into a computer's USB port.
5. Verify that the Power light is lit on the gateway, and that the Activity light is blinking.
6. Connect the CubiSens™ Optical Programmer to the same computer that the CSG100-A9 Gateway is connected to with the provided micro-USB cable.
7. Verify that two blue LEDs light up in the programmer, and that one starts blinking, as shown in Figure 5.
8. The kit is now ready for ethernet configuration and software installation.

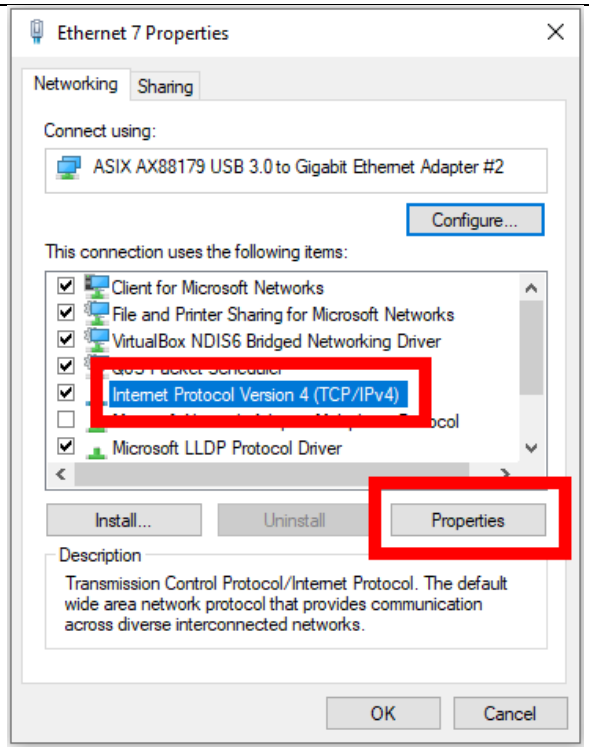
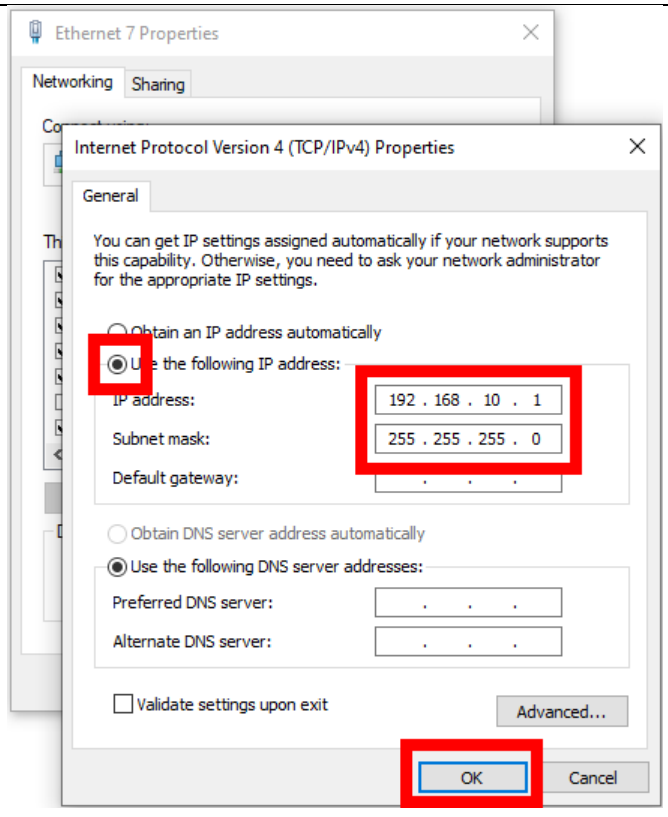
Note: The gateway will become warm to the touch. Please keep the top and sides clear when it is powered to allow proper ventillation.

4. Ethernet Configuration

The USB-to-Ethernet adapter needs to be configured as follows (Windows 10 shown as example):

1. Verify that the USB to Ethernet adapter is connected to the computer using an available USB port.	
2. Press the windows key on the keyboard, then start typing “ethernet” until you see the option for “Ethernet settings”. Select that and press enter or click on it.	
3. A new window, “Ethernet” will open. Click on “Change adapter options”, which may appear below or to the right of the identified networks.	

4. In the “Network Connections” window look for connections labeled “Ethernet”. If there are multiple ethernet connections find the one with the subtitles “ASIX AX88179…” or “Realtek USB..” Right click on that connection to bring up another menu.	
5. In the context menu which appears choose “Properties”.	

6. In the new window that opens click on text “Internet Protocol Version 4(TCP/IPv4)” to select that line. Be careful not to click on any checkboxes. With “Internet Protocol Version 4(TCP/IPv4)” selected click on the button “Properties”.	
7. Choose “Use the following IP address:” and set the IP address to 192.168.10.1. The subnet mask should automatically set itself to 255.255.255.0, but if not then set it to that value. Verify that the settings are as follows, then click “OK”. 8. Click “OK” in the ethernet properties window, then close all the windows opened during this process. The ethernet configuration for the CubiSens™ Gateway is now complete.	

5. Driver & GUI Software Installation

The GUI software is used to communicate with the TS100 through the optical programmer and gateway, providing a user interface for controlling the device and downloading its data. The software and driver need to be installed as follows:

1. Run “CDM21228_Setup.exe” in the installation kit and follow its installation instructions. This will allow the computer to send commands to the TS100 via the optical programmer.

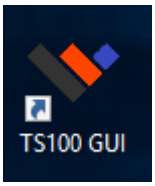
2. Run “TS100GUI_Setup.exe” in the installation kit and follow its installation instructions. When asked “Do you want to allow this app from an unknown publisher to make changes to your device?” select “Yes”.

3. Start the TS100 GUI application by doing one of the following:

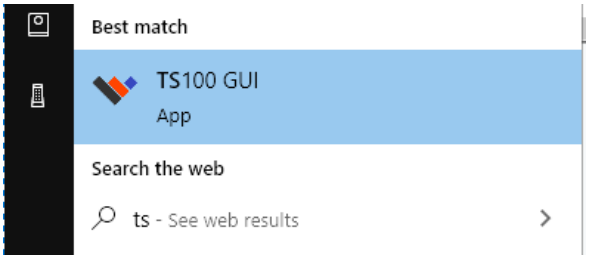
- Double-click the desktop icon
- Click the Windows menu button, scroll to “CubeWorks”, click on it, then click on “TS100 GUI”
- Click the Windows menu button and type “TS100” in the search bar until it appears, then click on it.

Note: The installer might prompt for installation or update of Microsoft .NET software. This will only happen once, please follow the prompts to download and install the update.

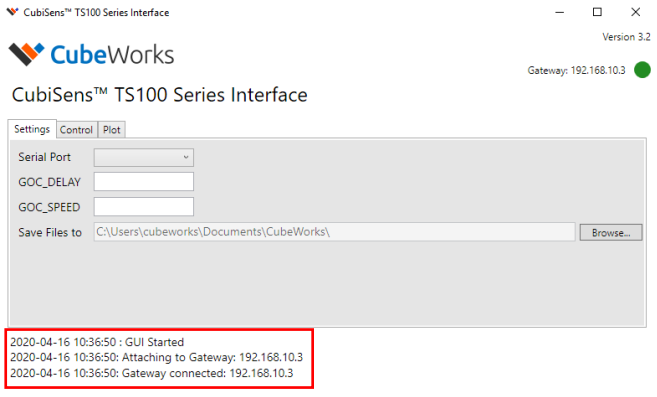
Desktop shortcut:

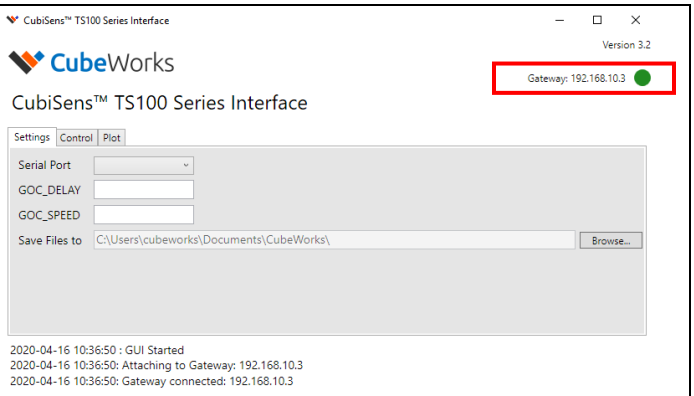
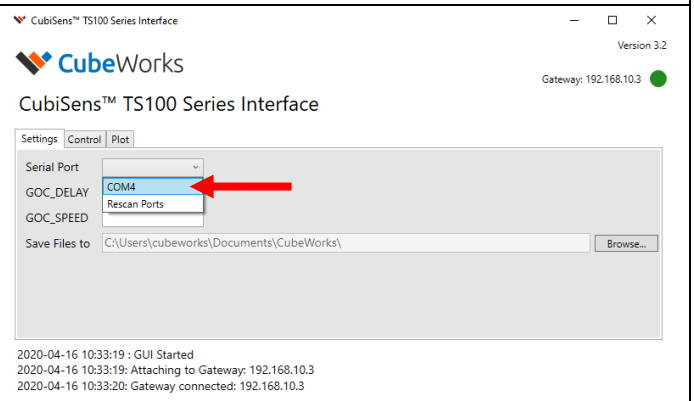
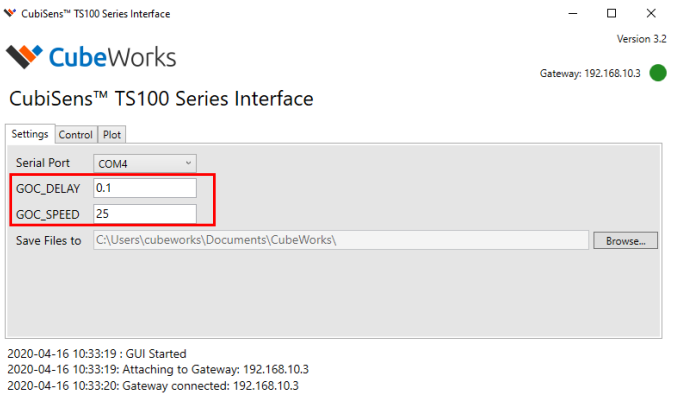


Windows search:



4. Once the GUI software launches and if the ethernet setting was configured correctly according to the instructions in Section 4, the connection to the CubiSens™ Gateway will automatically established. “Gateway connected” message will be displayed.



5. The green blinking status light next to the IP address of the gateway indicates connection status to the gateway.	
6. The opening screen shows the settings. The COM Port of the Optical Programmer must be selected by clicking on the Serial Port selection dropdown menu. **Note:** If multiple ports are available, disconnect the micro USB cable from the Optical Programmer, select “Rescan Ports” from the selection box, and see which port disappears. Then reconnect the USB cable to the Optical Programmer, select “Rescan Ports” from the selection box, and see which new port is available. Select the port that appears.	
7. The GUI is now ready to be used. **Note:** The GOC_DELAY and GOC_SPEED values will be automatically filled with suitable settings, and do not need to be adjusted.	

Using the TS100

1. Overview

TS100 Wireless Temperature Sensor uses optical communication for receiving commands from the user and for RF communication transmitting data and status. The optical communication is intended for short-range configuration and command, whereas the RF communication can be received from up to 100m line-of-sight. When implanted or operated in an environment with obstructions, RF communication distance can be significantly reduced.

2. Optical Communication

To send a command to a TS100, TS100 device should be placed on the communication slot of the CubiSens™ Optical Programmer with the clear side facing down, as shown in Figure 7. This ensures that the TS100's optical sensor faces the LED of the programmer. Each time a command button is clicked on the GUI, an optical packet is transmitted, which takes 1-2 seconds. The buttons on the GUI will be disabled during the optical transmission.

Important: The TS100 should be placed with the **clear side facing down**, as shown in Figure 7.

Important: The TS100's core temperature should be at room conditions (20°C - 30°C) for communication. If it has been exposed to extreme temperatures, please allow at least **5 minutes** for it to acclimate to room temperature before attempting communication.

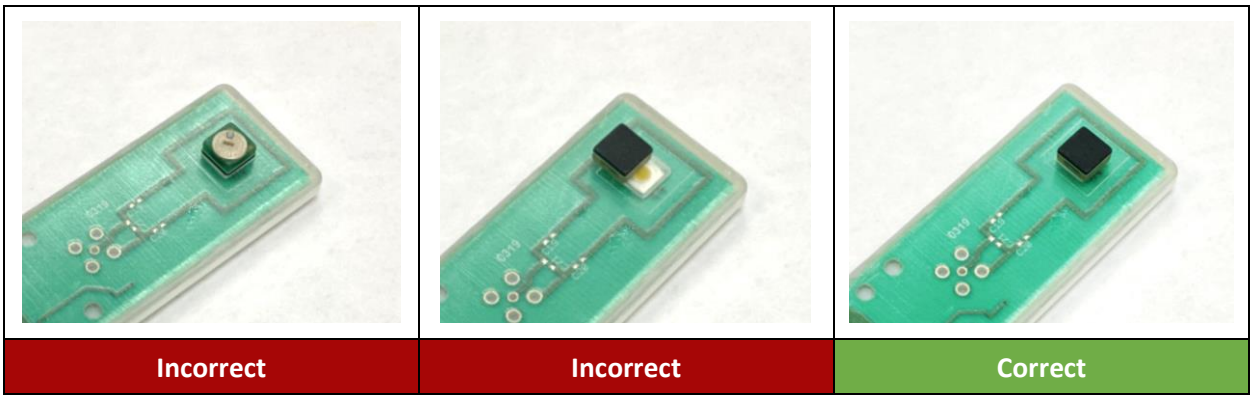


Figure 7: Orientation & Placement of TS100 for Optical Communication

3. Starting Measurement

To command the TS100 to start measuring temperature with a desired measurement interval:

1. Place the TS100 on the optical programmer.
2. Select the tab “Control” in the TS100 GUI.
3. Set the measurement interval.
4. Click the “Start Measurement” button.
5. After 3-4 seconds, the TS100 will reply with a “Measurement Started” message, the current battery state, and starts measuring at the set interval.
6. The measured data will be displayed as a “Check-in” message from the particular TS100 unit, identified by its “Chip ID”.

Note: The TS100 will start measuring temperature values until the user stops it using optical communication. Refer to the TS100 Technical Datasheet for details on battery life.

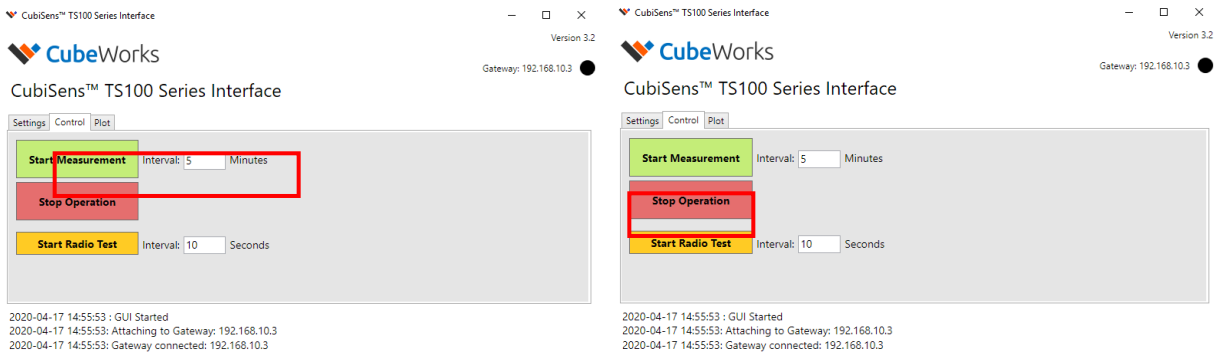


Figure 8: Starting & Stopping Measurement

4. Stopping Measurement

1. Place the TS100 on the optical programmer.
2. Click on “Stop Operation” to stop ongoing measurement operation and the TS100 will report its current battery state.

Note: This command can also be used when the TS100 is not in measurement mode, for instance, to check what the battery state is or to identify its Chip ID.

5. Viewing Measured Data Real-Time

Any measurement data from the TS100 received by the Gateway will be displayed in real-time on the GUI log as part of the "Check-in" message, and also as a datapoint in the "Plot" tab of the GUI, as shown in Figure 9. The plot may be used to examine measurement data. User can click on the plot to control it. After clicking, zooming can be accomplished with the mouse scroll wheel or Page Up and Page Down buttons on the keyboard. The arrow keys or the right mouse button can be used to move the graph and examine areas of interest.

The received data is also saved in CSV format under "My Documents\CubeWorks\" folder with a file name corresponding to the TS100 device ID. The file location can be configured in the "Settings" tab. The CSV formatted data file includes the device ID, timestamp, raw data, and converted data.

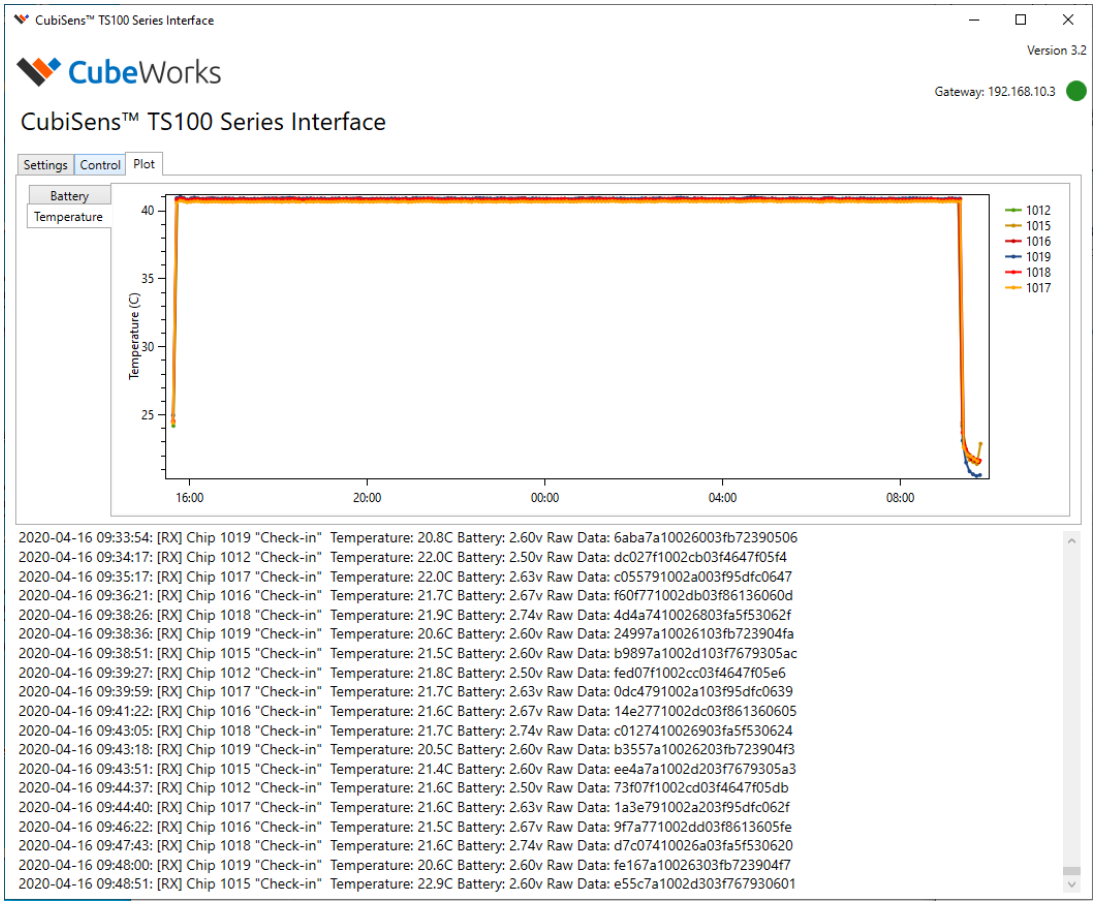


Figure 9: "Plot" Tab of the GUI Showing Real-time Data from Multiple TS100 Devices

Technical Specifications

1. TS100 Technical Specifications

Please refer to the "TS100 Technical Datasheet" for full details on the technical specifications. Below are key specifications for TS100.

TS100 Device Specifications	
Dimensions (W x L x H)	7.5 x 7.5 x 4.2 mm
Weight	0.5g
Thermal Reaction Time	τ: 11.7 ($1-e^{-t/\tau}$)
Thermal Mass	TBD
Operation Temperature	10˚C - 55˚C
Optical Interface Temperature	20˚C - 30˚C
Storage Temperature	10˚C - 30˚C
Battery Lifetime	1 min interval: 5 weeks 5 min interval: 26 weeks 30 min interval: 2 years
Storage Lifetime	1 Year
Wireless Communication	Optical RX, RF TX
Packaging Material	Biocompatible Epoxy and Parylene Coating

TS100 Temperature Sensor Specifications	
Resolution	0.05°C
Inaccuracy, 25-45°C	±0.1°C
Inaccuracy, 10-55°C	±0.2°C
Measurement Interval	5s to 1 Hour (Configurable)
Measurement Timing Accuracy	1%

2. CSG100-A9 CubiSens™ Gateway Tech Specs

The CSG100-A9 CubiSens™ Gateway receives the RF transmissions from the TS100 sensors, interprets them, and provides them to the software.

CSG100-A9 CubiSens™ Gateway

CSG100-A9 CubiSens™ Gateway Specifications	
RF Receiving Frequency	915 ±10MHz
Size	141 x 81 x 33mm
Weight	400g
Power Source	5V DC
Power Consumption	10W