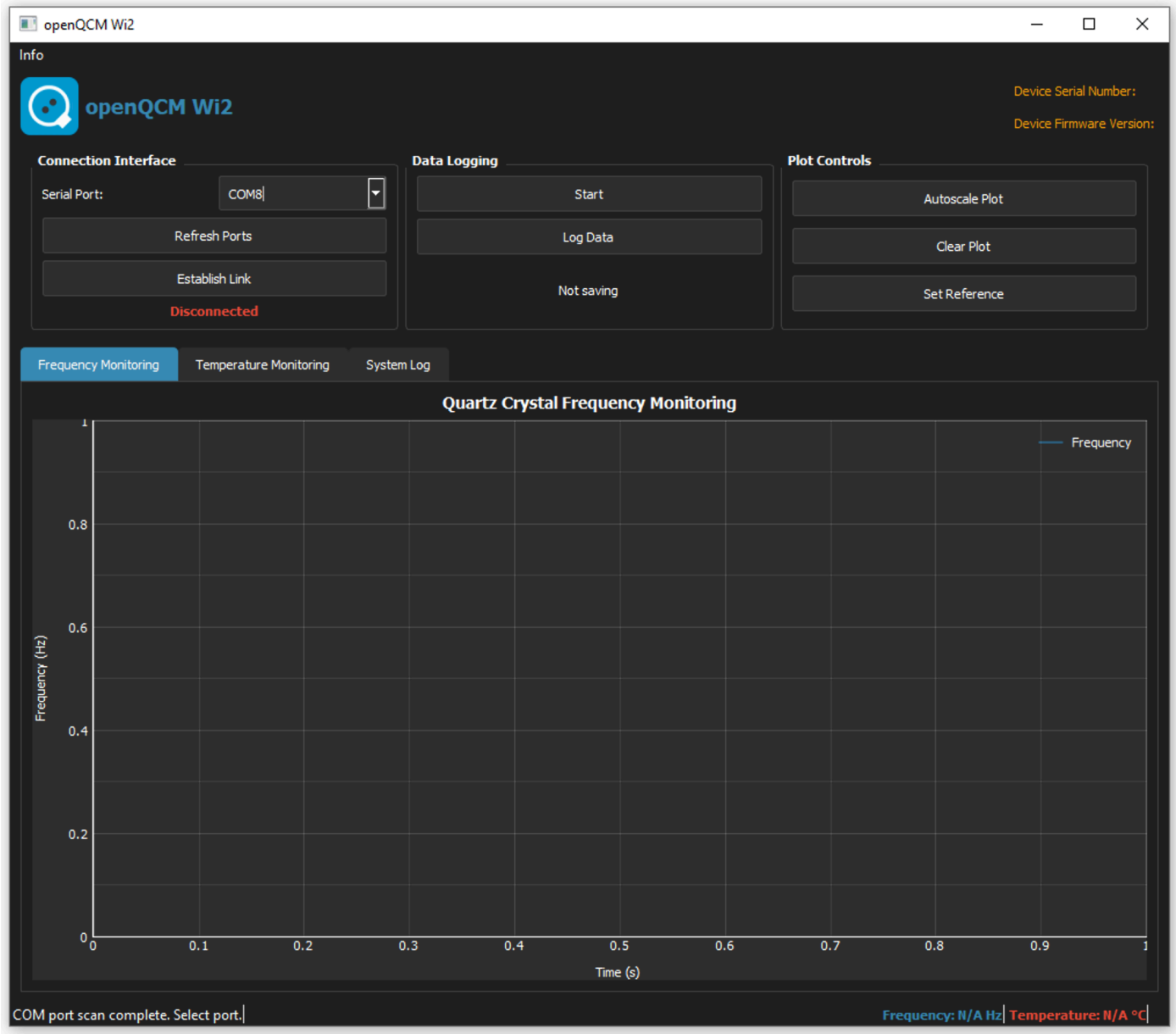
openQCM Wi2 Software - User Manual



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Introduction

Overview

The openQCM Wi2 Python Software is a professional application for real-time monitoring and data acquisition from the openQCM Wi2 device. The software interfaces with the openQCM Wi2 hardware to provide high-precision frequency and temperature measurements from Quartz Crystal Microbalance (QCM) systems.

Quartz Crystal Microbalance Technology

The Quartz Crystal Microbalance measures mass changes by monitoring the resonant frequency of a quartz crystal resonator. Mass deposition or removal causes frequency shifts proportional to the mass change according to the Sauerbrey equation. This enables nanogram-level mass detection for studying surface interactions, thin film deposition, adsorption kinetics, and biomolecular binding events.

QCM applications include materials science research, biotechnology studies, environmental monitoring, and industrial process control. The technique provides real-time mass sensitivity measurements essential for characterizing surface processes and molecular interactions.

Key Features

The openQCM Wi2 Python Software provides real-time frequency and temperature monitoring with 1 Hz sampling rate and automated data logging to CSV format. The software features dual-channel visualization, moving average calculations for noise reduction, and reference mode for differential measurements.

The updated software includes enhanced features and improvements for the openQCM Wi2 Quartz Crystal Microbalance. Key features include 60-minute rolling data buffer, automated file management, device diagnostics, and multi-process architecture for system stability. The software operates as a standalone Windows executable requiring no additional installations.

- **Real-time monitoring** of frequency and temperature
- **High-precision data acquisition** with 1 Hz sampling rate
- **Moving average calculations** for noise reduction
- **Automatic data logging** to CSV files
- **Advanced visualization** with interactive plots
- **Native Windows support**

Quick Start Guide

Firmware Compatibility Check

⚠️ **Requirement**: Before using the software, verify your device firmware compatibility:

- **Serial number < 1840**: Firmware update required
- **Serial number ≥ 1840**: Ready to use

Quick Installation

1. Download the latest version of the standalone Windows executable software: **openQCM Wi2 software Version 2.1**
2. Extract and run `openQCM Wi2 v2.1.exe`
3. No installation required - standalone executable

Device Connection

1. Connect openQCM Wi2 device via USB cable
2. Launch software
3. Click **"Refresh Ports"** to scan for device
4. Select device from **Serial Port** dropdown
5. Click **"Establish Link"**
6. Verify connection status shows **"Connected"** in green.

Basic Operation

1. **Start measurement**: Click **"Start"**
2. **Data logging**: Click **"Log Data"** to save data
3. **Reference mode**: Optional - click **"Set Reference"** for relative measurements

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Installation and Setup

System Requirements

Component	Minimum	Recommended
Operating System	Windows 10	Windows 11
Processor	Intel Core i3	Intel Core i5 or higher
RAM	4 GB	8 GB
Disk Space	300 MB	1 GB
Resolution	1280x720	1920x1080
USB	USB 2.0 port	USB 3.0 port

Software Installation

1. **Download**: openQCM Wi2 Software v2.1
2. **Extract**: Unzip file to dedicated folder
3. **Run**: Double-click `openQCM Wi2 v2.1.exe`
4. **Permissions**: Confirm execution if prompted by Windows

> **Note**
>
> *The software is completely standalone and requires no Python or additional library installation.*

Firmware Compatibility

Serial Number Check

> **Warning**
>
> *openQCM Wi2 Python Software v2.1 requires firmware version 1.2.T4 or higher. Devices with serial numbers below 1840 require firmware update before software operation. Check device serial number on device label*

- **Serial < 1840**: Firmware update required
- **Serial ≥ 1840**: Compatible firmware, ready to use

Firmware Update Procedure

Only for devices with serial number < 1840:

1. Connect openQCM Wi2 device to computer
2. **Download** the firmware update package: firmware_tool_wi2_1.2.T4
3. Launch **TyUploader.exe** (provided in firmware package)
4. Click **"Upload"** in TyUploader interface
5. Select firmware file: **openQCM_Wi2_FW_1_2_T4.ino.hex**
6. Wait for upload completion confirmation
7. Disconnect and reconnect device

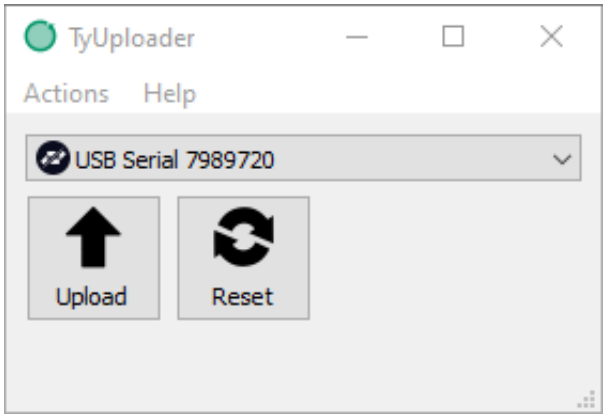

Figure 1: *TyUploader.exe interface for openQCM Wi2 firmware update. The tool displays the detected USB device and provides Upload/Reset functionality for installing firmware version 1.2.T4 on compatible devices.*

User Interface

Interface Overview

The openQCM Wi2 Python Software interface consists of four main sections: header section, control panel, tabbed display area, and status bar.

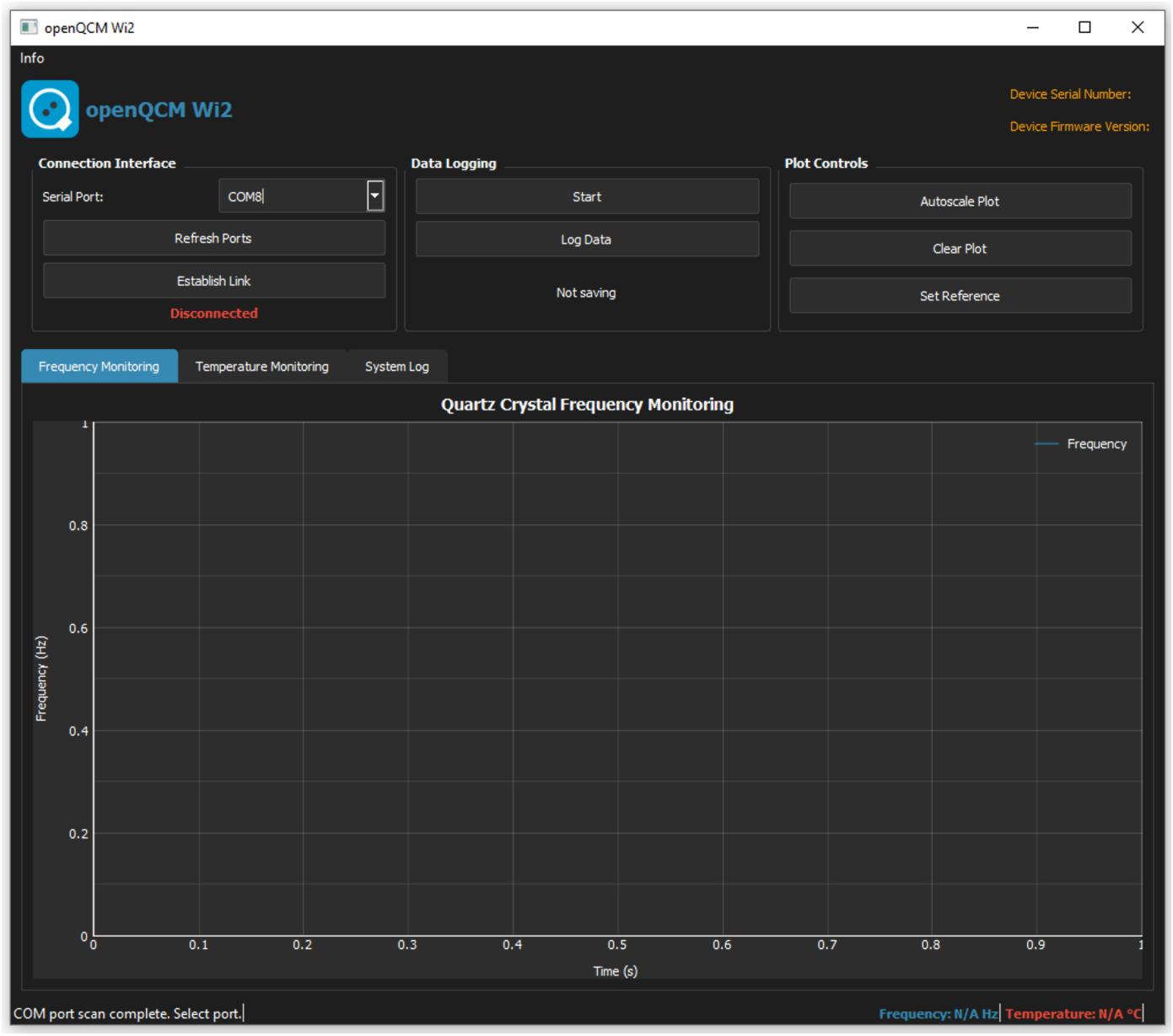

Figure 2: openQCM Wi2 software main interface in intial state state with frequency monitoring plot and available control panels for device connection, data logging, and plot management.

1. Header Section

Logo and Title: openQCM Wi2 software identification

Device Information:

- Device serial number
- Firmware version
- Not available when disconnected

2. Control Panel

The control panel contains three functional groups for device operation:

Connection Interface

- **Serial Port**: Dropdown menu for port selection
- **Refresh Ports**: Scan available ports
- **Establish Link**: Connect/disconnect device
- **Status**: Connection status (red: disconnected, green: connected)

Data Logging

- **Start**: Start/stop real-time monitoring
- **Log Data**: Start/stop CSV file recording
- **Status**: Recording status and active filename

Plot Controls

- **Autoscale Plot**: Automatic plot range adjustment
- **Clear Plot**: Clear data from display and memory
- **Set Reference**: Enables relative frequency measurement mode

3. Display Area (Tabs)

Three tabs provide access to different visualization and monitoring functions:

Frequency Monitoring Tab

Real-time frequency plot with blue trace. Displays frequency values in Hz with time axis in seconds.

- **Y-axis**: Frequency in Hz
- **X-axis**: Time in seconds
- **Blue trace**: Moving average of frequency measurements
- **Buffer**: 60 minutes of data (rolling window)

Temperature Monitoring Tab

Real-time temperature plot with red trace. Displays temperature values in °C with time axis in seconds.

- **Y-axis**: Temperature in °C
- **X-axis**: Time in seconds
- **Red trace**: Moving average of temperature measurements
- **Synchronization**: Aligned with frequency measurements

System Log Tab

- **System messages**: Operational and diagnostic information
- **Device communication**: Command and response logs
- **Errors**: Problem notifications and solutions

4. Status Bar

- **Main status**: Current system messages
- **Frequency**: Real-time value in Hz (blue text)
- **Temperature**: Real-time value in °C (red text)
- **Reference**: Reference value when active (orange text)

Plot Interactive Controls

Plot Navigation

- **Pan**: Click and drag to move view
- **Zoom**: Mouse wheel or rectangular area selection
- **Context menu**: Right-click for additional options
    - Auto-scale (fit all data)
    - Reset Zoom (default view)
    - Pan Mode (pan mode)
    - Select Mode (selection mode)

Basic Operations

Device Connection

1. **Physical Connection**
   - Connect openQCM Wi2 device to computer via USB cable
   - Verify device power indicator is illuminated
2. **Port Selection**
   - Click **"Refresh Ports"** to scan available ports
   - Select device from **Serial Port** menu
   - Port naming conventions: Windows (COM3, COM4), macOS (/dev/cu.usbmodem*), Linux (/dev/ttyUSB*)
3. **Establish Connection**
   - Click **"Establish Link"**
   - Connection status changes from "Disconnected" (red) to "Connected" (green)
   - Button text changes from "Establish Link" to "Disconnect"
   - Device information appears in orange in header
4. **Connection Verification**
   - Verify serial number and firmware version display
   - Use **Info** menu for manual device information requests

Data Monitoring

Starting Monitoring

1. Ensure device is connected
2. Click **"Start"** in Data Logging section
3. Button text changes to **"Stop"**
4. Real-time data appears in frequency and temperature plots

> **Tip**
>
> **Frequency Baseline Stability**: *Stable frequency indicates equilibrium conditions. Frequency variations < 2 Hz indicate good baseline stability for measurement initiation and loggin..*
>
> **Temperature stability**: *Stable temperature required for accurate mass measurements. Temperature drift or variations > 1.0 °C may introduce frequency artifacts.*

> **Note**
>
> **Drift - variation values** *are indicative and represent typical operating conditions. Actual values may vary significantly based on specific experimental conditions, quartz crystal characteristics, experimental setup configuration, and laboratory environmental conditions. Users should establish acceptance criteria based on their system specifications and experiment precision requirements.*

Data Logging

Starting Recording

1. Ensure monitoring is active
2. Click **"Log Data"**
3. Select save location and filename in dialog
4. Default filename format: `openQCM_data_YYYYMMDD_HHMMSS.csv`
5. Click **"Save"** to begin recording

CSV File Format

The data file contains four columns:

Column	Description	Format
Date and Time	Absolute timestamp	YYYY-MM-DD HH:MM:SS
Relative Time(s)	Time relative to start	1 decimal place
Avg Frequency(Hz)	Moving average frequency	2 decimal places
Avg Temperature(°C)	Moving average temperature	2 decimal places

File Management

- **Continuous writing**: Data written real-time during acquisition
- **File size**: Approximately 150 bytes per minute of recording
- **Default location**: "logs" subfolder in program directory

Stopping Recording

- Click **"Stop Logging"** to end recording
- CSV file automatically closed and saved
- Recording status returns to "Not saving"

Plot Controls

Autoscale Plot

Click "Autoscale Plot" to automatically adjust both frequency and temperature plot ranges to display all collected data. Function applies to both axes simultaneously and operates on both plot tabs. Use after manual zoom or pan operations to restore full data view.

- Automatically adjusts both plot ranges
- Displays all collected data
- Useful after manual zoom or pan operations

Clear Plot

Click "Clear Plot" to remove all data from memory buffer and plot display. Operation resets time axis to zero and clears 60-minute data buffer. Use when starting new experiment or after baseline establishment.

- Removes all data from memory and display
- Resets time axis to zero
- Clears 60-minute data buffer
- Deactivates reference mode if active

Reference Mode

Reference mode enables differential frequency measurements by establishing baseline frequency as zero reference point. Function applies only to frequency monitoring - temperature display remains absolute values.

Setting Reference:

1. Start monitoring and establish stable baseline
2. Click **"Set Reference"** when baseline is stable
3. Current frequency value becomes reference point (0 Hz)
4. Plot shows frequency changes relative to reference
5. Button changes to **"Unset Reference"**

Using Reference Mode:

- All frequency values show changes from reference
- Status bar displays "Frequency Shift" instead of absolute value
- Reference value shown in orange in status bar

Clearing Reference:

- Click **"Unset Reference"** to return to absolute values
- Plot returns to showing actual frequency values
- Reference mode automatically cleared with "Clear Plot"

Advanced Features

System Standby Prevention

The software automatically prevents Windows system from entering sleep mode during active monitoring. Standby prevention activates when monitoring starts and restores normal power settings when monitoring stops.

> **Note**
>
> **Windows Implementation**: Uses SetThreadExecutionState API to maintain system and display active state. Prevents interruption of long-term measurements due to power management.

Multi-Process Architecture

The software employs separate processes for critical functions to ensure system stability and data integrity during extended measurements.

- **Serial Process**: Handles device communication independently of user interface. Maintains consistent 1 Hz sampling rate regardless of GUI activity or system load.
- **Data Processor**: Performs moving average calculations and data validation in dedicated process. Isolates signal processing from display operations.
- **CSV Writer**: Manages file operations in separate process to prevent data loss during intensive disk operations or system resource constraints.
- **GUI Process**: User interface operates independently, ensuring responsive controls during data acquisition and file operations.

Process isolation prevents single-point failures and maintains data acquisition continuity during system stress conditions.

Data Buffer System

- **Circular Buffer**: Implements 60-minute rolling data buffer for continuous visualization. Oldest data automatically replaced when buffer capacity exceeded.
- **Memory Management**: Fixed buffer size prevents memory growth during extended monitoring sessions. Buffer operates at constant memory footprint regardless of measurement duration.
- **Thread Safety**: Buffer access synchronized across multiple processes using mutex locks. Prevents data corruption during concurrent read/write operations.
- **Auto-scroll Function**: Plot display automatically scrolls to show most recent data when buffer exceeds display window. Manual zoom/pan operations temporarily disable auto-scroll.

Signal Processing

- **Moving Average Filter**: Implements 10-sample moving average for both frequency and temperature measurements. Reduces high-frequency noise while preserving signal dynamics.
- **Sampling Rate Validation**: Monitors actual sampling intervals and generates warnings when deviations exceed ±0.2 seconds from target 1 Hz rate. Irregular sampling alerts displayed in System Log.

Troubleshooting

Connection Problems

Device Not Detected

Symptoms:

- No device in Serial Port menu
- "No serial ports found" error

Solutions:

1. Verify USB cable connection to device and computer
2. Check device power indicator
3. Try different USB port
4. Click **"Refresh Ports"** for new scan
5. Restart device by disconnecting and reconnecting USB

Connection Fails

Symptoms:

- Status remains "Disconnected" after "Establish Link"
- Connection error message

Solutions:

1. Verify correct port selection from menu
2. Ensure no other software is using the port
3. Check Windows Device Manager for port status and drivers
4. Close and reopen software
5. Restart computer if driver problems persist

Data Acquisition Problems

No Data Display

Symptoms:

- Plots remain empty despite successful connection
- No data in status bar

Solutions:

1. **Verify firmware compatibility**:
    - Check device serial number
    - Devices <1840 require firmware update
    - Verify firmware version 1.2.T4 or higher
2. Restart monitoring (Stop → Start)
3. Disconnect and reconnect device
4. Check System Log for error messages

Irregular Data

Symptoms:

- Interruptions in data display
- Irregular sampling warnings

Solutions:

1. Verify stable USB connection
2. Check system resources (CPU, memory)
3. Close unnecessary applications
4. Verify USB cable integrity
5. Try different USB port

File Recording Problems

Cannot Save File

Symptoms:

- Error during recording start
- File not created in specified location

Solutions:

1. Verify write permissions for destination folder
2. Ensure sufficient disk space
3. Avoid special characters in filename
4. Use shorter file path
5. Try different folder

Performance Problems

Slow or Unresponsive Software

Symptoms:

- Slow user interface
- Button response delays

Solutions:

1. Verify minimum system requirements
2. Close other applications
3. Restart software
4. Check available disk space
5. Check Windows Task Manager for intensive processes

Memory Errors

Symptoms:

- Memory error messages
- Unexpected software closure

Solutions:

1. Restart software

2. Check available RAM
3. Use "Clear Plot" to free memory
4. Restart computer if problem persists

Advanced Diagnostics

Using System Log

The **System Log** tab provides detailed information for diagnostics:

- **Connection messages**: Device communication status
- **Data validation**: Signal quality notifications
- **Process errors**: Multi-process architecture issues
- **File operations**: Recording and writing status

Technical Specifications

Data Acquisition

Parameter	Specification
Sampling frequency	1 Hz (1 sample/second)
Communication	USB Serial at 115200 baud
Data format	CSV with timestamps
Serial timeout	0.5 seconds
Data buffer	60 minutes (3600 samples)

Measurement Ranges

Parameter	Range	Resolution
Frequency	Device-dependent (typical MHz)	< 1 Hz
Temperature	-40°C to +85°C	0.01°C
Time	Unlimited	1 second
Time precision	±0.2 seconds	-

Firmware Requirements

Parameter	Specification
Minimum version	1.2.T4
Compatible devices	Serial number ≥ 1840
Update required	Serial number < 1840
Communication protocol	Serial 115200 baud

File Specifications

Parameter	Specification
Output format	CSV (UTF-8)
Buffer size	8192 bytes
Flush frequency	2 seconds
Typical size	150 bytes/minute

Software Architecture

Component	Implementation
Language	Python 3.7+
GUI Framework	PyQt5
Plotting	pyqtgraph
Data processing	numpy
Serial communication	pyserial
Distribution	PyInstaller (standalone exe)

System Performance

Parameter	Specification
GUI update interval	500ms
Process check interval	5 seconds
Typical memory usage	50-100 MB
Typical CPU usage	1-3%

Support and Contact

Technical Support

Website: https://openqcm.com/
Email: info@openqcm.com

Support Requests

When contacting support, include:

1. **Software information**:
    - openQCM Wi2 software version
    - Windows operating system version
    - Device serial number
2. **Problem description**:
    - Observed symptoms
    - Steps to reproduce problem
    - Error messages (if any)
3. **Log files**:
    - System Log tab contents
    - Problematic CSV files (if applicable)

Software Updates

Software updates available through:

- Direct download from openQCM website
- Integrated update check (future versions)

License and Warranty

Glossary

Term	Definition
QCM	Quartz Crystal Microbalance - Mass measurement technique based on quartz frequency changes
Sauerbrey	Equation relating frequency changes to mass changes in QCM
Baseline	Stable reference frequency before sample introduction
Circular buffer	Data structure maintaining fixed size by overwriting oldest data
Moving average	Filter calculating average of N previous samples to reduce noise
Firmware	Low-level control software in openQCM Wi2 device
Baud rate	Serial communication speed (115200 symbols/second)
CSV	Comma-Separated Values - Data file format