



USER MANUAL

FP-CND-MA Conductivity Measurement Software

EMLABS.INC

Table of Contents

1. Product Overview.....	2
2. System Requirements	2
3. Installation and Uninstallation	3
Installation	3
Uninstallation.....	3
4. Measurement Procedures.....	4
Terminology list.....	4
Measurement Procedures	5
1 . Starting the Measurement.....	5
2 . Sample Settings.....	8
3 . Selecting Measurement Frequency	12
4 . Reference Measurement	13
5 . Sample Measurement.....	15
6 . Exporting Results	17
Other Functions	18
Re-calculation.....	18
Re-notification for Reference Measurement	18
When Drift Does Not Stabilize	18
Switching Detailed Functions	19
5. Troubleshooting	20

First Edition: February 7, 2025

1. Product Overview

The CP-CND-MA Conductivity Measurement Software (hereinafter referred to as "the software") is designed to efficiently measure the conductivity of samples using a Fabry-Perot resonator for conductivity measurement. It controls a Keysight Technologies network analyzer to automatically acquire the necessary parameters and output the surface conductivity.

2. System Requirements

This section describes the operating environment required to use the software.

- Windows 10 or later
- .NET Framework 4.5 or later
- Keysight IO Libraries 2020, ver. 18.3.29517.2 or later

Compatible Measurement Devices:

- Keysight E5080B Network Analyzer
- Keysight PNA Series Network Analyzer
- Keysight Streamline Series USB Network Analyzer

3. Installation and Uninstallation

This section explains the detailed steps for installing and uninstalling the software.

Installation

Use the installer (FPCMASetup_vxx.xx.xx.msi, hereafter referred to as "FPCMASetup.msi") and the 16-digit product key provided at the time of purchase. Run FPCMASetup.msi on a Windows PC and follow the on-screen instructions to proceed with the installation.

Uninstallation

Similar to the installation process, use FPCMASetup.msi to uninstall the software. Run FPCMASetup.msi on a Windows PC and follow the on-screen instructions to proceed with uninstallation.

Note:

You can also uninstall the software using the "Uninstall an app" feature provided by Windows. In such cases, follow the standard Windows procedure.

4. Measurement Procedures

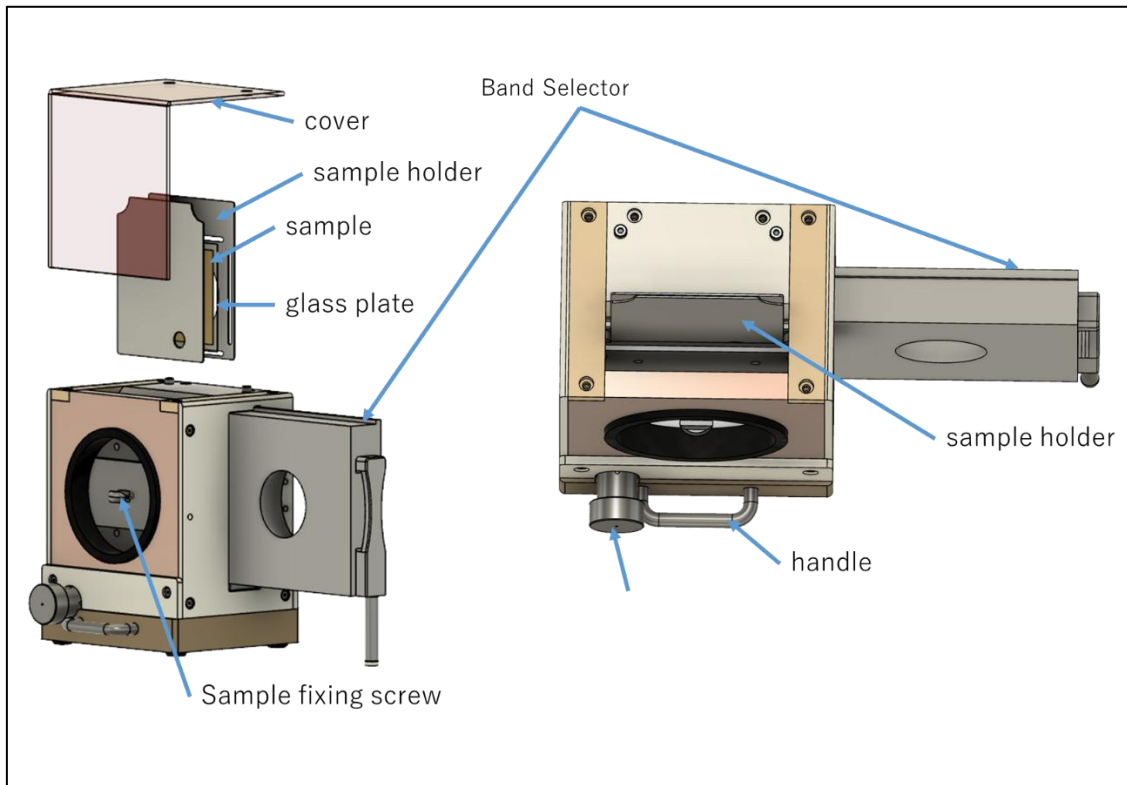
This section explains the overall procedure for starting the software and completing conductivity measurements, divided into individual steps. For preparation of measurement samples and handling of hardware, refer to the manual for the "FP-CND Series Conductivity Measurement Fabry-Pérot Resonator."

Terminology list

The terms used in this manual are defined below.

Term	Description
Reference Plate	A soft copper foil used for reference measurements.
Reference Measurement	Measuring the included reference plate.
Sample Measurement	Measuring the sample you want to evaluate.
Dk	The real part of the complex relative permittivity, equivalent to ϵ' .
Df	Dielectric loss tangent, equivalent to $\tan \delta$ or ϵ''/ϵ' .
Dielectric Constant	Complex relative permittivity, representing both Dk and Df.
Surface Conductivity	The conductivity of the sample surface being measured.
Relative Surface Conductivity	The value of surface conductivity normalized to that of soft copper (5.8×10^7 S/m, set to 1).
Conductivity	A general term encompassing both surface conductivity and relative surface conductivity.

The names of the hardware components are as follows.

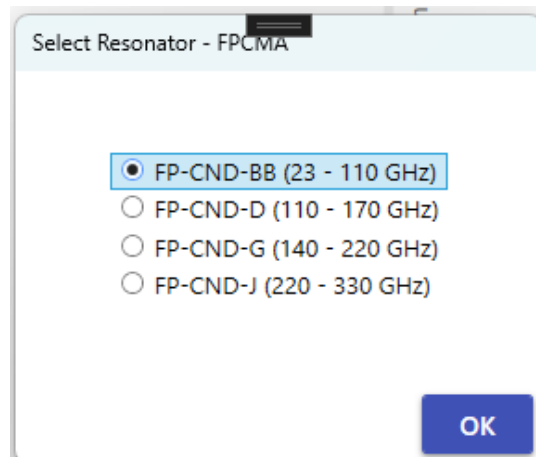


Measurement Procedures

Follow the steps below to proceed with the measurement while referring to the software screen display.

1. Starting the Measurement

Launch the software and the instrument selection screen will be displayed. Please select the connected fixture.

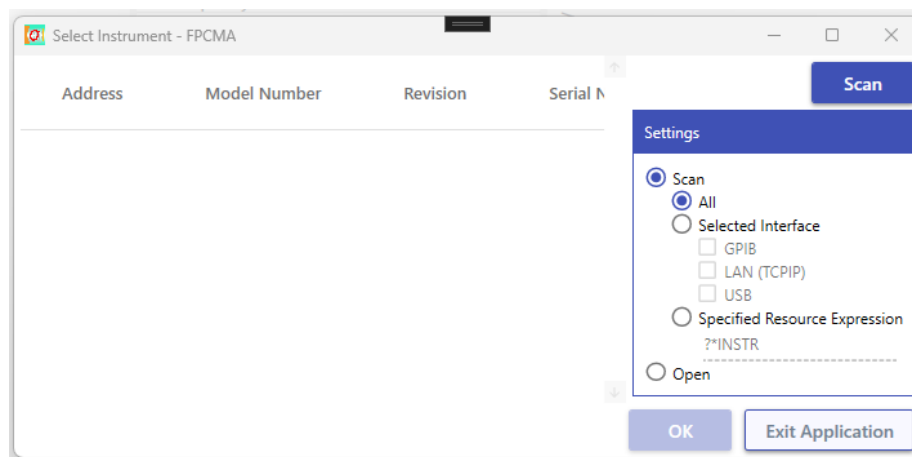


NOTE (SWITCHING THE RESONATOR)

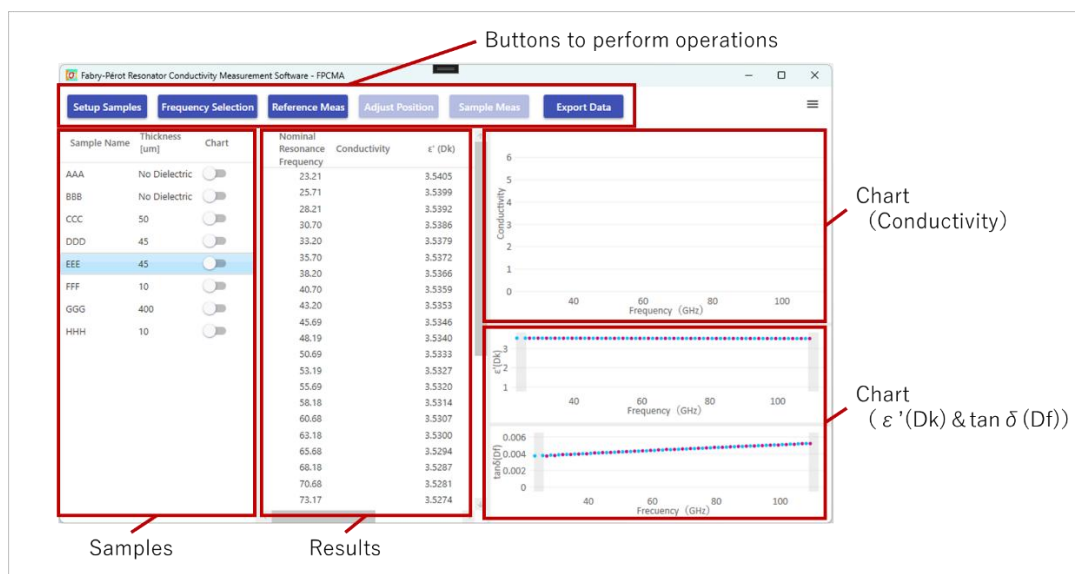
After clicking **OK** for resonator selection, if you need to reselect the resonator, exit the software and restart from the beginning.

NOTE (THE NETWORK ANALYZER IS NOT FOUND):

If the window shown below opens, the network analyzer is not properly connected to the PC. Check the connection and click **Scan**.



After selecting resonator, Main Window will be displayed. The contents of the main window are as follows:



For the functions of each button, refer to the respective sections below:

- Setup Samples: Section 2, Sample Settings
- Frequency Selection: Section 3, Selecting Measurement Frequencies
- Reference Meas: Section 4, Reference Measurement
- Adjust Position & Sample Meas: Section 5, Sample Measurement
- Export Data : Section 6, Exporting Results

2. Sample Settings

Press **Setup Samples** to register the sample information for measurement. In the newly displayed popup, enter the sample name. If the sample has a dielectric attached, also enter the dielectric thickness and permittivity information. Once settings are complete, press **OK**. Below are details about optional features for entering dielectric constant information.

NOTE (OPTIONAL FEATURES FOR ENTERING PERMITTIVITY INFORMATION)

These options can be added later. Please contact the supplier if you wish to enable this feature.

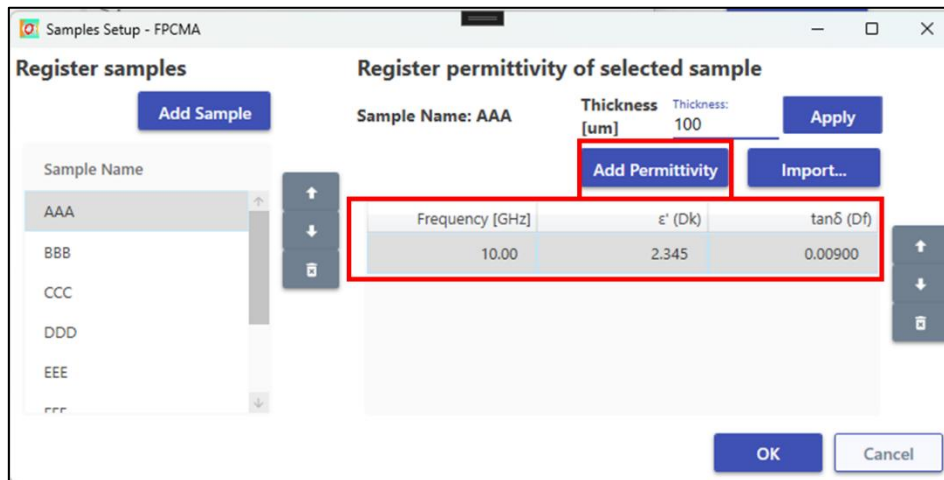
When measuring the conductivity of a sample with a dielectric, entering the dielectric constant information in advance allows the software to calculate the conductivity by incorporating the dielectric parameters. To input the dielectric constant information:

1. First, enter the dielectric thickness in the upper-right corner of the screen and press **Apply**.
2. You can add permittivity information via **Add Permittivity**. Enter the frequency and the corresponding Dk and Df values for that frequency.

The screenshot shows the 'Samples Setup - FPCMA' window. On the left, under 'Register samples', there is a list of sample names: AAA, BBB, CCC, DDD, EEE, and FFF. 'AAA' is selected. On the right, under 'Register permittivity of selected sample', the 'Sample Name' is 'AAA'. There is a 'Thickness (um)' input field with the value '0'. The 'Thickness (um)' field and the 'Apply' button are highlighted with a red rectangle. Below the input fields, there is a note: 'First, enter the thickness of the dielectric in the sample. If the sample has no dielectric, enter '0.''. Another note states: 'Note: If the thickness is set to '0,' any entered permittivity data will be cleared.' At the bottom right, there are 'OK' and 'Cancel' buttons.

Note (Regarding Dielectric Thickness)

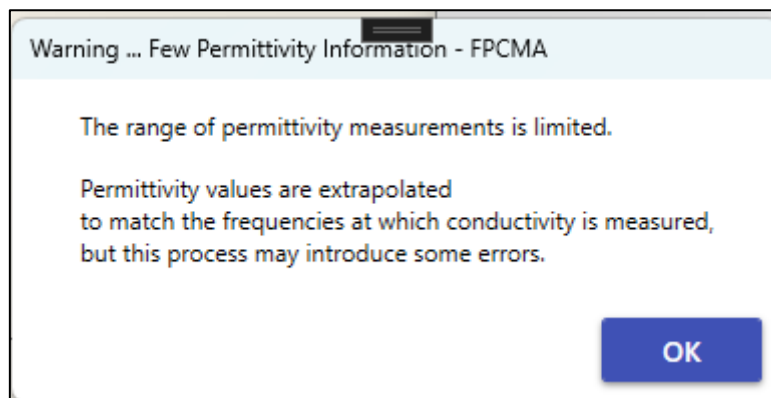
If $Dk \times Df \times \text{Thickness}$ exceeds 1, there is a possibility that conductivity cannot be measured accurately. When using high-Dk materials, reduce the thickness of the dielectric.



Additionally, if you own an EM Labs Fabry-Perot resonator and FP-MA Permittivity Measurement Software (hereafter referred to as the FP series), you can import measurement data exported from the FP series into this software and register it as permittivity information. Press **Import** and select the measurement data (Excel format) obtained from the FP series.

NOTE (EXTRAPOLATION OF PERMITTIVITY)

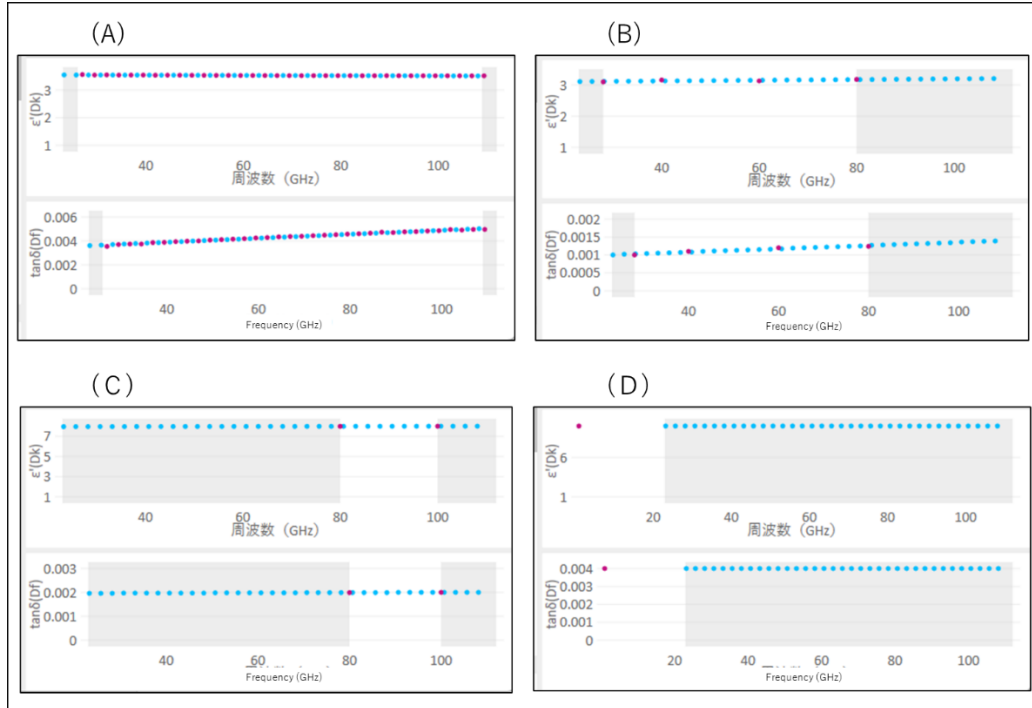
The permittivity at the frequency used for conductivity measurement is estimated based on the entered permittivity data. The closer the frequency of the entered permittivity data is to the measurement frequency, the higher the accuracy. Additionally, having multiple data points helps reduce errors. If a significant error is expected, the following popup will appear.



Below are examples of ideal and error-prone cases for registering permittivity information.

Red: Permittivity entered by the user.

Blue: Predicted Permittivity at the conductivity measurement frequency, based on the user's input.



A) Most Ideal Case

Measurement data is registered near the frequency at which conductivity is to be measured. Additionally, for many materials, the permittivity exhibits frequency-dependent characteristics. This data sufficiently reflects those characteristics, making it ideal. Importing data from the FP series allows for this type of interpolation.

B) Case with Minor Errors

Multiple data points of permittivity information are registered within the frequency range where conductivity measurement is intended. This interpolation can be achieved by inputting data measured using EM Lab's split-cylinder resonator series.

C) Prone to Errors

Two data points are registered within the frequency range of the conductivity measurement. However, a significant discrepancy exists between the registered permittivity information and the frequency at which conductivity is measured, resulting in a high potential for extrapolation errors.

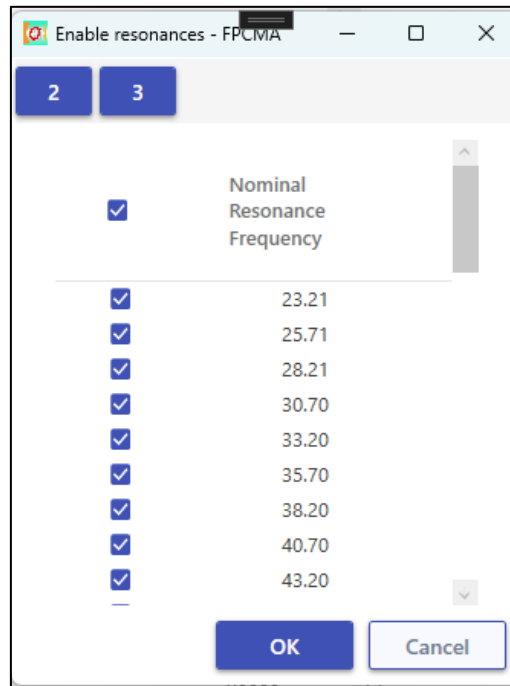
D) Prone to Errors

Only one measurement point outside the frequency range of conductivity measurement is registered. In this case, the permittivity information from this single point is applied across all frequencies to estimate the permittivity at the conductivity measurement frequency.

However, since frequency characteristics are not reflected at all, significant errors are likely.

3. Selecting Measurement Frequency

From the main screen's **frequency selection**, you can choose the desired measurement frequency. Check the frequency you wish to measure and press **OK**.



NOTE

Pressing "2" at the top of the screen will automatically set the frequencies at 2-point intervals, and pressing "3" will set them at 3-point intervals.

4. Reference Measurement

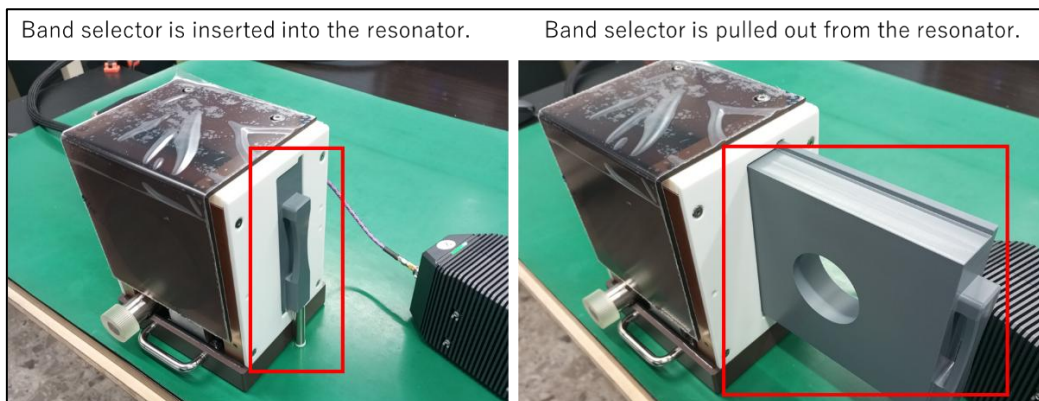
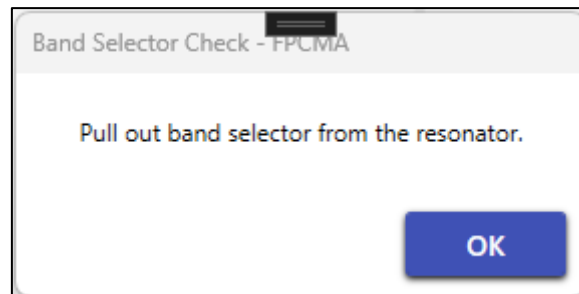
The conductivity of a Fabry-Perot resonator is calculated from the difference in Q values observed for the reference plate and the test sample. This section explains the procedure for reference measurement.

1. Place the reference plate on the sample holder.
2. Insert it into the resonator, tighten the sample fixing screws securely, and install the cover.
3. Press **Reference Meas.**
4. A confirmation popup for measurement start will appear. Review its content and press **OK**.

A drift check of the sample will be performed immediately after the measurement begins. Please do not touch the resonator during the process.

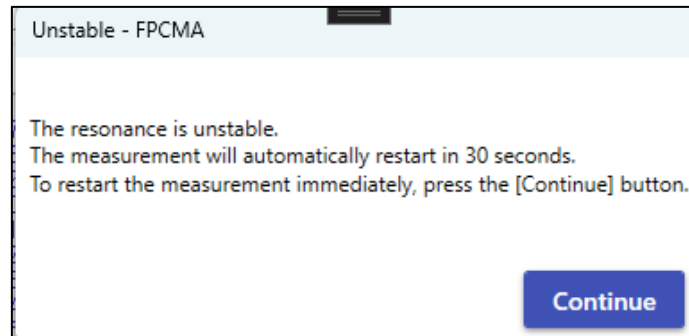
NOTE (FOR FP-CND-BB)

After starting the measurement, a popup like the one below may appear. Follow the instructions in the popup to operate the band selector. Examples of the pulled-out and pushed-in states of the band selector are shown below.

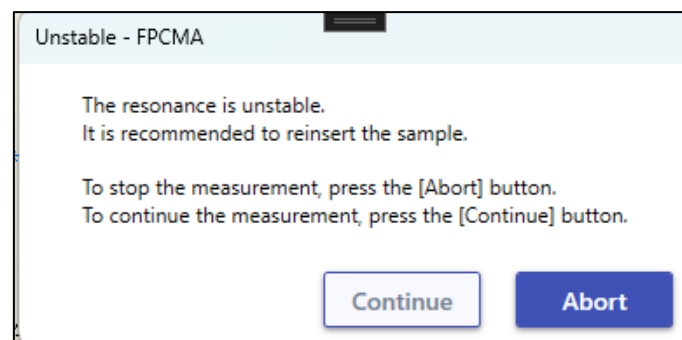


NOTE (FOR UNSTABLE SAMPLES)

If the sample is unstable after starting the measurement, a popup like the one below may appear. This occurs because the inserted sample has shifted slightly, causing fluctuations in the measurement values. The system will wait for the duration displayed in the popup to allow the movement to stabilize.



If instability is detected three times in a row, another popup will appear. It is recommended to reinsert the sample as instructed in the popup. However, you may choose to continue the measurement by pressing **Continue**. Please note that the measurement will proceed in an unstable condition.



5. Sample Measurement

This section explains the procedure for measuring a sample.

1. Place the test sample on the sample holder.
2. Insert it into the resonator, tighten the sample fixing screws (if any), and install the cover.
3. The subsequent process will vary depending on whether the hardware requires "Sample Position Adjustment."

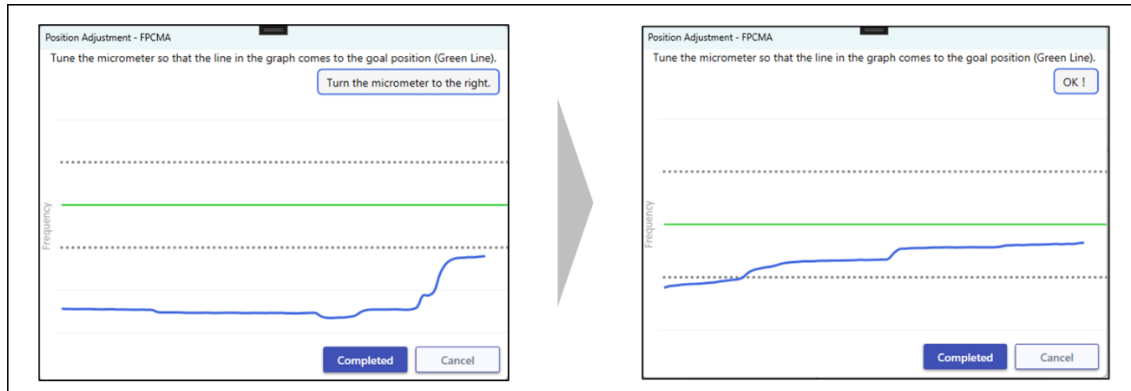
- For non-FP-CND-BB devices

1. Select the sample you want to measure.
2. Press **Sample Meas.**
3. A confirmation popup for measurement start will appear. Review its content and press **OK**.
4. A drift check of the sample will be performed immediately after the measurement begins.
5. Wait for the sample to stabilize without touching the resonator.
6. The measurement will proceed automatically.

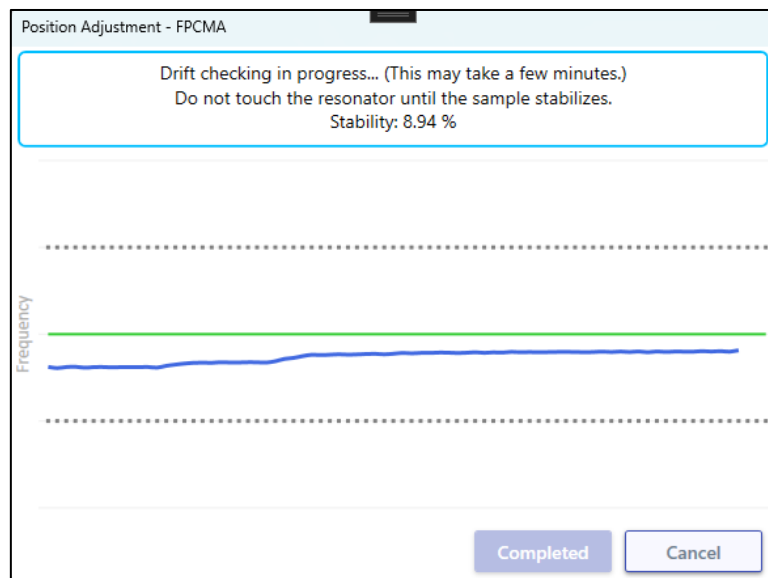
- For FP-CND-BB devices

For FP-CND-BB, slight misalignment of the sample position caused by replacing the test sample can affect the measurement results. Adjusting the sample position corrects this impact. Follow the steps below

1. Place the test sample on the sample plate.
2. Insert it into the sample holder, tighten the sample fixing screws securely, and install the cover.
3. Select the sample you want to measure and press **Adjust Position**.
4. When the adjustment begins, markers will appear on the network analyzer screen. A new popup will appear in the software. Follow the instructions displayed at the top-right of the screen. Turn the adjustment micrometer slightly to the left or right according to the direction indicated at the top-right. Continue until the blue measured line approaches the green target line, and then press **Completed**.
5. After pressing **Completed**, an automatic drift check will begin. Please wait until it is finished.



After pressing **Completed**, an automatic drift check will begin. Please wait until it is finished.



If the system is set to "Perform sample position adjustment and sample measurement consecutively," it will automatically proceed to sample measurement once the position adjustment is complete. If this setting is disabled, press **Sample Meas** to initiate the measurement. It will then proceed automatically. For details about the "Perform sample position adjustment and sample measurement consecutively" setting, refer to "Other Functions."

As the measurement progresses, the measurement values will be displayed in the table in the center of the main screen. The graph area in the upper-right corner will display the plotted results. Data from previously measured samples can also be overlaid in the graph area. Use the graph toggle in the sample list on the left side of the screen to show or hide data. Results for the currently selected sample are displayed in light blue with a slightly larger plot size.

6. Exporting Results

Press **Export Data** to output the measurement results for the selected sample. Choose a save location and save the data.

Measurement data will be deleted upon performing specific operations. These operations are listed below:

- Re-measuring the sample.
- Re-performing reference measurements.
- Updating the measurement frequency on the frequency selection screen.
- Deleting the target sample on the sample settings screen.
- Updating the sample's dielectric thickness or permittivity information on the sample settings screen.
- Switching to Precise mode.
- Exiting the software.

Examples of Data Deletion:

After completing reference measurements, switching to Precise mode before performing sample measurements.

→ Reference measurements will need to be redone.

After completing sample measurements, modifying the registered thickness for the sample.

→ The sample measurement results will be deleted.

Examples Where Data is Not Deleted:

After completing sample measurements, adding a new sample in the sample settings screen and entering the sample name, thickness, and dielectric information.

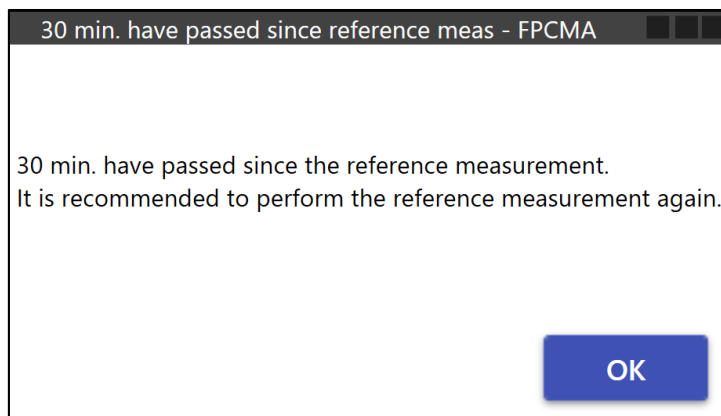
Other Functions

Re-calculation

After the sample measurement is complete, updating the permittivity information (thickness or Dk/Df) will trigger a recalculation of the conductivity results.

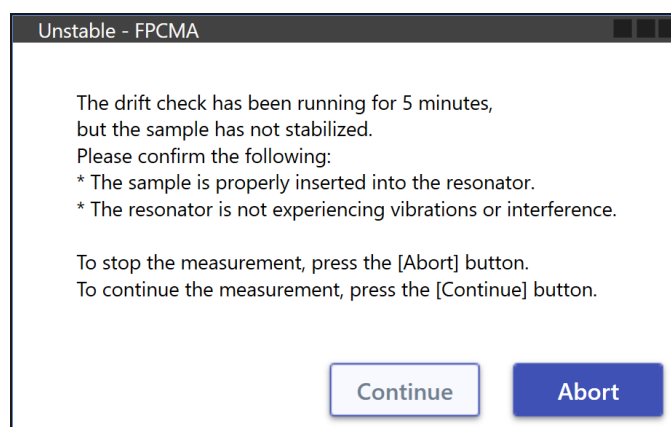
Re-notification for Reference Measurement

To minimize changes in the device environment since the last reference measurement, it is recommended to perform reference measurements every 30 minutes. When 30 minutes have passed since the last reference measurement, the following pop-up will appear. When this notification is displayed, press **OK** and perform the reference measurement again. Note that performing a reference measurement will delete all previously measured data. If you have any unexported data, please export it first.



When Drift Does Not Stabilize

A drift check is performed before the measurement. If the drift does not stabilize within 5 minutes, the following pop-up will appear. Possible causes include issues with sample insertion or vibrations affecting the resonator. Press **Abort**, reinsert the sample, and try again. If the issue persists, check whether vibrations are being transmitted to the measuring device and address the problem before reattempting the measurement. However, you can choose to proceed with the measurement by pressing **Continue**, but please note that the results may be unstable under these conditions.



Switching Detailed Functions

From the hamburger menu in the upper-right corner of the main screen, you can open the **Settings** screen to configure various features. Details of each function are explained below:

1. **Precise Mode**

This software is configured to balance measurement time and accuracy. If you prioritize accuracy and do not mind longer measurement times, select the Precise mode. Measurement time will increase by approximately three times. By default, this setting is OFF, balancing accuracy and speed.

2. **Notification Sound at the End of Measurement**

Reference and sample measurements, including stability checks, may take several minutes for all points. To notify users of measurement completion, a beep sound can be enabled after the measurement ends. This feature is ON by default. If unnecessary, turn it OFF or mute your PC. The sound volume can be adjusted through your PC's volume settings.

3. **Switching Between Surface Conductivity and Relative Surface Conductivity Display**

By default, the software displays relative surface conductivity, standardized to $5.8 \times 10^7 \text{ S/m}$. This setting is ON by default (displaying relative surface conductivity). To switch to surface conductivity display, turn this setting OFF.

4. **Configuring Actions After Sample Position Adjustment**

You can set whether the system automatically proceeds to sample measurement after completing sample position adjustment. This setting is ON by default, meaning sample measurement starts automatically once position adjustment is completed. Note that for hardware without a sample position adjustment feature, changing this setting will not affect the software's operation.

5. Troubleshooting

If you encounter issues such as unsuccessful installation or sudden operational failures, please contact us directly via our website:

<https://www.emlabs.jp>

When making an inquiry, providing the following information will help us respond effectively:

- Version information of this software.
- PC OS version information.
- Version information of Keysight IO Libraries.
- Model and firmware version of the network analyzer.