EM labs

OPERATION MANUAL

FP Series Fabry-Perot resonator

EM LABS INC.

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Contents

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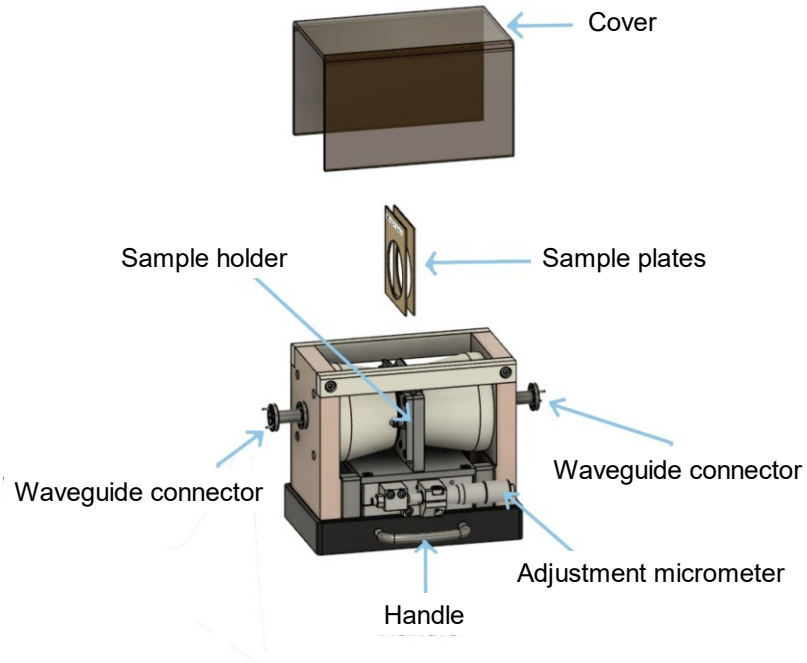
1. Product Overview

This section provides an overview of the product.

FP Series Fabry-Perot resonators are designed to be connected to a network analyzer and measure complex relative permittivity of dielectric materials. To accurately measure low permittivity and low loss materials, the loss of the resonator is designed and manufactured extremely low. You can efficiently measure samples with the instructions of the permittivity measurement software, which enables automatic measurement to obtain the frequency characteristics within a band.

Appearance and structure of resonator

(Refer to the FP-MA operation manual for the operation of each part.)



Cover: Set on the resonator body during measurement.
Sample Plates: Set the sample between two sample plates.
Sample holder: Insert the sample plates into the sample holder.
Waveguide connector: Connect to the network analyzer.
Adjustment micrometer: Use to adjust the position of the sample holder after sample insertion.
Handle: hold the handle when lifting the resonator body.

CAUTION

1. When lifting the resonator body, be sure to hold the handle.
   Holding the waveguide connector may damage the resonator.
2. Treat the sample plates carefully. Bending due to external pressure may cause measurement errors.

Product Specifications

model	Resonance characteristics			Connector type
	Frequency*	Mode	Un-loaded Q	
FP-BB	Broadband (25-110 GHz)	TEM	>100,000	1mm(f)
FP-E	E-band (60-90 GHz)			WR12
FP-W	W-band (75-110 GHz)			WR10
FP-D	D-band (110-170 GHz)			WR 6.5
FP-G	G-band (140-220 GHz)			WR 5.1
FP-J	J-band (220-330 GHz)			WR 3.4

*Permittivity is measured at approximately every 2.5 GHz.

Operating temperature : 10 to 40℃ (non-condensing)

Accessories

FP-TB　waveguide connection tables and clamps (2 each)
: Accessories required for waveguide connection

Appropriate cables are required depending on the network analyzer. For the E/W band coaxial cable connection, coaxial-waveguide adapters are required.

2. Measurement

This section describes what you need to know about how to proceed with the measurement, focusing on precautions for handling the resonator and samples to ensure correct measurements.

Sample Preparation

The sample must be processed into a plate shape to fit the resonator. Since the thickness of the sample is used to calculate permittivity, it is important to know the accurate thickness. Ideally, the sample should be flat and uniform in order to accurately determine the thickness. Also, a wavy sample can cause significant errors in the permittivity measurement results. Proper sample preparation is the first step for accurate measurements.

About sample size

It is important to prepare samples of the appropriate thickness for accurate measurements. The appropriate thickness depends on the dielectric properties and the resonator used, but 100 μm is a good rule of thumb. The higher the frequency and the higher the dielectric constant, the thinner the sample needs to be.
Refer to Appendix 1 for the relationship between thickness, dielectric constant and measurement frequency band. Note that thinner samples may be required for samples with high loss ($\tan\delta > 0.01$).

The recommended sample size is shown in the table below. Larger sample will not fit into the sample plates. Smaller sample will not adequately cover the measurement area, resulting in measurement errors. (See "Sample Plate Shape" below.)

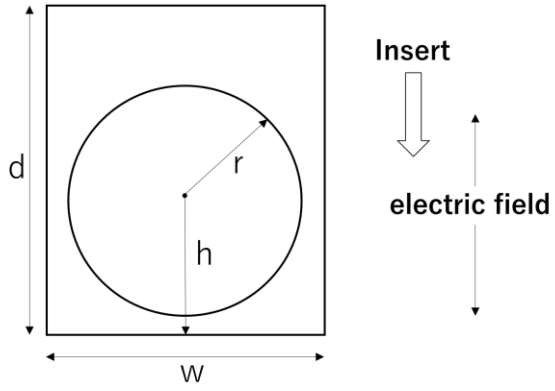
Recommended sample size	Broadband model: 65 mm square on each side Other models: 50 mm square on each side

Note that it is possible to evaluate anisotropy by using a square sample. As a vertical electric field in the resonator is used to measure the permittivity, anisotropy can be evaluated by rotating the sample by 90 degrees. It is recommended to mark the sample so that its orientation can be identified.

Measurement of sample thickness

In the measurement procedure, you need to input the sample thickness according to the measurement software instruction. It is recommended to measure the sample thickness in advance. Since the error of the input value causes the error of the permittivity measurement, accurate measurement is necessary.
Although it depends on the processing conditions of the sample, it is generally recommended to measure about five locations with a micrometer, etc. and use the average value. It is important to measure the thickness of the area used for the measurement. Refer to the sample plate shape below for the specific location of the part to be used.

Sample plate shape



	FP-BB(High/Low)	FP-BB(High only)	FP-E/W/D/G/J
r	30 ㎜	22.5 ㎜	21.5 mm
h	39 ㎜		25.0 mm
d	107 ㎜		63.0 mm
w	94 ㎜		55.0 mm

Two types of sample plates for FP-BB are provided, one with a guide and the other without a guide. When using the sample plates with guide, the sample should be processed 6 mm smaller than the width (w) so that it fits into the sample plates.

NOTE

Refer to the Appendix for details on the use of sample plates for FP-BB with/without guide.

Before starting measurement

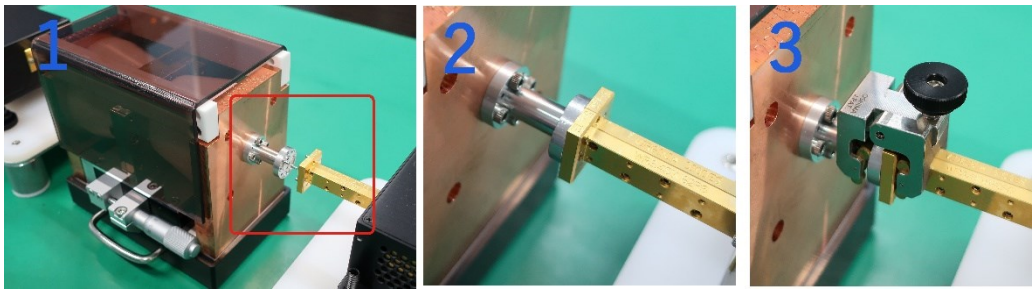
Before starting the measurement software, make sure that the following preparation has been completed.

- The temperature of the resonator should be stable. It is recommended to start measurement at least 60 minutes after setting the fixture in the actual measurement environment.
- The network analyzer should be sufficiently warmed up (in accordance with the recommended time for each network analyzer).
- The size of the sample must be measured and recorded.
- A torque wrench and spanner for connector connection must be prepared if coaxial cables are used. Tweezers and gloves for handling samples are prepared, if necessary.

Instrument connection

Connect the resonator to the network analyzer with a waveguide/cable. The connector type varies depending on the frequency band. The connector type is described in the product specifications.

Connecting waveguide connectors



1. Align the height of the connector between the resonator and the waveguide. (Use the waveguide connection tables for millimeter wave modules.)
2. Connect the connectors.
3. Clamp them and tighten the knobs firmly by hand.

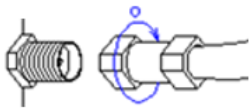
Connecting coaxial connectors

Connect the resonator to the network analyzer using appropriate cables.

NOTE

It is important to use a torque wrench to apply proper torque when tightening the connector. Excessive torque can damage the connector. Torque shortage causes measurement errors and rotation of the center

conductor, which can damage the connector. Also, be careful to rotate only the nut of the male connector. Rotating the center conductor leads to wear and damage of the connector.



For accurate measurements

The Fabry-Perot resonator is designed and manufactured to measure permittivity with high accuracy. There are some key points in order to make full use of its performance.

About the Cover

Keep the dedicated cover on the fixture except when loading and unloading samples. This will stabilize the measured values.

Vibration

Be careful not to touch the resonator, millimeter-wave modules, or cables during measurement sweep. Vibration or mechanical stress may affect the measured values. It is not necessary to use a vibration isolator.

Measurement Procedure

Start the FP-MA software and follow the on-screen instructions to perform the measurement. Refer to the FP-MA software manual for detailed instructions.

3. Maintenance and Repairs

This section explains daily maintenance and simple troubleshooting.

Health check with stable samples

It is recommended to periodically measure samples with stable characteristics and check the condition of the measurement system.

Daily cleaning

The Fabry-Perot resonator is basically maintenance free. If the sample plates become contaminated due to transfer from the sample etc., wipe them clean with a non-woven cloth with a small amount of alcohol.

> NOTE
>
> Do not disassemble the fixture for cleaning as it may cause malfunction. Especially, do not touch the inside of the resonator. Performance may deteriorate greatly.

If you think something is wrong...

This section describes how to respond to abnormal measurement values. First, check that the connectors are firmly connected. Clean the surface of the sample insertion space according to Daily cleaning. If the problem persists, repair is necessary.

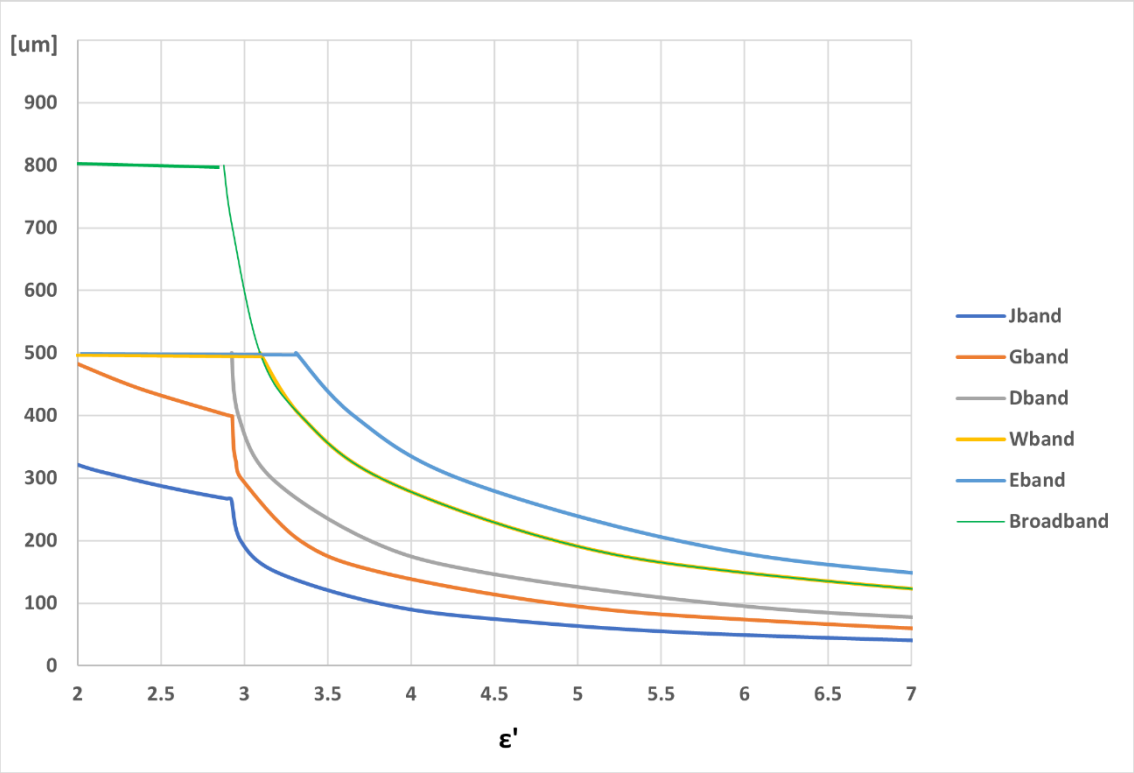
Repair

Please contact us directly through our Web site for repair.

https://www.emlabs.jp

Appendix 1. Chart: Relation between Sample Thickness and Dielectric Constant

The relationship between the sample thickness, dielectric constant, and frequency band is shown in the charts below. The maximum sample thickness that can be measured correctly throughout the entire measurement frequency band of each device is shown in the chart.



Appendix2. Sample Plates for the Broadband Model

Use accordingly based on the following characteristics.

NOTE

Be very careful that the sample does not slide off the sample plates and into the sample holder. If a sample falls into the sample holder, it may not be removed. In this case, the repair will be required.

Guided plates

Basically, use this sample plates. Guides on the sample plates prevent the sample from slipping off.

Plates without guide

The above guides may get in the way of placing thin film samples flat on the sample plates. Use the plates without guide in such cases. The bottom edges of the sample plates may be secured together with thin tape.