IB011513 Oct 2018



User's Manual

KFM Series Application Software

FCTester Ver. 1.1





Use of This Manual

Please read through and understand this User's Manual before operating the product. After reading, always keep the manual nearby so that you may refer to it as needed. When moving the product to another location, be sure to bring the manual as well.

If you find any misplaced or missing pages in this manual, they will be replaced. If the manual gets lost or soiled, a new copy can be provided for a fee. In either case, please contact Kikusui distributor/agent, and provide the "Kikusui Part No." given on the cover.

This manual has been prepared with the utmost care; however, if you have any questions, or note any errors or omissions, please contact Kikusui distributor/agent.

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A For Safe Use

Before starting tests using this application software, please thoroughly read the following operation manuals describing the hardware. Use extreme caution to make correct connections and handle the components of the system properly. Improper connections or handling may cause serious accidents such as damage or fire.

- Fuel Cell Impedance Measurement System KFM2150SYSTEM
- FC Scanner KFM2151 (when using the scanner)

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Preface

Thank you for purchasing the FCTester application software for the KFM2150 FC Impedance Meter.

This manual is intended for first-time users of the application. It describes installation procedures, various settings, basic operations, safety precautions, etc.

Read this manual thoroughly to use the functions of the application software effectively. You can also review this manual when you are confused about an operation or when a problem occurs.

For details on the hardware of the impedance measurement system, read the operation manual of the respective product.

How to read this manual

This manual is designed to be read from beginning to end. We recommend that you read the manual thoroughly from the beginning before using this application software for the first time.

Related manuals

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For details on the impedance measurement system, see the respective operation manual of the impedance measurement system.

Intended readers of this manual

This manual is intended for operators that control the impedance measurement system using the KFM2150 or persons teaching other users on how to operate the system.

Structure

Below is the structure of the manual. A summary of each chapter is provided.

Chapter 1 General Description

This chapter gives a general description and introduces the features of the FCTester.

Chapter 2 Setup

This chapter describes the procedures from unpacking to preparation before use.

Chapter 3 System Configuration

This chapter describes the FCTester Configuration Tool (system configuration program).

Chapter 4 Creating Test Conditions

This chapter describes the FCTester Condition Editor (test condition editing program).

Chapter 5 Executing Tests

This chapter describes the FCTester Executive (test execution program).

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Notations

- The word "PC" indicates a personal computer in this manual.
- The KFM2150 FC Impedance Meter is also simply referred to as KFM2150 in this manual.
- The PLZ-4W Series Electronic Load Unit is also referred to as the PLZ-4W or the PLZ-4W Series in this manual.
- The following markings are used in the explanations in the text.

Indicates a potentially hazardous situation which, if ignored, may result in damage to the product and other property.

NOTE

Indicates information that you should know or convenient tips.

See

Indicates reference to detailed information.

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General Description

This chapter gives a general description and introduces the features of the FCTester.

1.1 Overview

FCTester is a application software used to retrieve measured data from the KFM2150 FC Impedance Meter.

Integrating the FCTester in the KFM2150 impedance measurement system allows additional measurements to be made such as Cole-Cole plot measurements and I-V characteristics measurements. This feature streamlines the fuel cell evaluation tests.

FCTester Version to Which This Manual Applies

This manual applies to FCTester version 1.1X.

You can check the version in the Help menu of the FCTester Condition Editor or Executive.

Main Features

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Possible test modes

- I-V measurement
- V-I measurement
- I-V + AC impedance measurement
- I-V + Cole-Cole plot measurement
- Cole-Cole plot measurement
- AC impedance measurement
- Current interrupt measurement
- · Constant current test
- · Constant voltage test

Startup operation of the fuel cell

- Startup sequence
- Shutdown sequence

Sequence operation of the measurement mode

• Up to 15 sequences

Structure

FCTester consists of the following three programs.

Program	Description
FCTester Configuration Tool (system configuration program)	Configures the FC impedance measurement system. The program is used only when configuring the system for the first time or when you change the system configuration.
FCTester Condition Editor (test condition editing program)	Creates test conditions.
FCTester Executive (text execution program)	Loads test conditions, executes tests, and saves and displays the measurement data.

1.2 System Requirements

The following hardware and software are required to use FCTester.

PC system

- 1 GHz or faster 32-bit (x86) or 64-bit (x64) processor
- 1 GB or more RAM (32-bit) or 2 GB or more RAM (64-bit)
- 16 GB or more available hard disk space (32-bit) or 20 GB or more (64bit) (additional free space is required to save data)
- DirectX 9 graphics device with Windows Display Driver Model (WDDM) 1.0 or higher driver
- Microsoft Windows 7
- SVGA resolution or higher (800×600 dots or higher).
- CD-ROM drive.
- Mouse or pointing device.
- Microsoft Excel (required for data analysis).
- VISA library NI-VISA3.0 or later, Agilent I/O Library M01.00 or later, or KI-VISA 2.5 or later.
- GPIB board (only when using the GPIB)
 A GPIB board made by National Instruments, Agilent Technologies, Contec Co.,LTD., or Interface Corporation.

Handling precautions

The application software retrieves the measurement data of the KFM2150 into the PC. To ensure that the measurement data is retrieved, disable the following operations on the PC while the test is in progress.

- Power-saver mode
- Screen saver
- · Execution of memory-resident programs

In addition, do not operate other application softwares while the test is in progress.

FC Impedance Meter

• KFM2150 with firmware version 1.1X

The firmware version is shown on the display when the KFM2150 is turned on.



Setup

This chapter describes the procedures from unpacking to preparation before use.

2.1 Installing FCTester

1 Load the CD-ROM containing the program in the CD-ROM drive. The installation program automatically starts.



Fig.2-1 Startup window

2 Click Install the Fuel Cell Tester.



Fig.2-2 Setup startup window

3 Continue with the installation according to the instructions on the window.

When the installation is complete, the following window appears.

📸 Kikusui Fuel Cell Tester	
Installation Complete	
Kikusui Fuel Cell Tester has been successfully installed.	
Click "Close" to exit.	
Cancel < <u>B</u> ack	<u>C</u> lose

Fig.2-3 Finish window

4 Click **Close** to finish the installation.

2.2 Installing the VISA Driver

2.2.1 Preparation

You must install a VISA driver to use FCTester.

The VISA driver that is required varies depending on the I/O interface that is to be used. See Table 2-1, and select the appropriate VISA driver.

Do not install different VISA drivers on a single PC. Each VISA driver may not operate correctly.

- VISA (Virtual Instrument Software Architecture) is a specification for standard software for connecting instruments that was defined by the VXIplug&play Systems Alliance.
- A VISA driver is a software driver implemented according to the VISA Specifications.
- KI-VISA is Kikusui original VISA driver compatible with VXIplug&play VISA Specifications 2.2.

I/O interface		Required VISA driver
RS232C ^{*1} , ^{*2}		KI-VISA Ver2.2.x or later
USB ^{*1}		Agilent IO Libraries M01.00 or later
GPIB *4	By Interface Corporation ^{*3}	KI-VISA Ver2.2.x or later
	By Contec Co., LTD.*3	
	By National Instruments	NI-VISA Version 3.0 or later
	By Agilent Technologies	Agilent IO Libraries M01.00 or later

Table 2-1 Required VISA drivers

- *1 Any VISA driver will work when using the RS232C or USB. However, be sure to check the licensing information of the respective VISA driver.
- *2 For the RS232C, communication ports that come standard with the PC and virtual serial communication ports using USB-to-RS232C adapters are supported. However, virtual communication ports using adapters or the like may not operate properly depending on the device driver that is provided.
- *3 KI-VISA supports the following GPIB models.

Manufacturer	Model name	Notes
Contec Co., Ltd.	GP-IB(PCI)L, GP-IB(PM), GP-IB(PCI)F, and GP- IB(CB)F (API-GPIB Driver Version 4.01 or later recommended)	When using a GPIB board by Contec, use the normal API-GPIB driver, not the API-GPLV driver (compatible with LabVIEW and NI-488.2M API).
Interface Corporation	PCI-4301 LabVIEW version (GPC-4301N Driver Version 1.21 or later recommended)	When using a GPIB board by Interface, use the GPC-4301N driver (compatible with LabVIEW and NI- 488.2M API), not the normal GPC- 4301 driver.

*4 If you are using the GPIB, you must use the correct VISA driver. Otherwise, the GPIB will not work.

VISA driver	How to obtain the driver
KI-VISA	CD-ROM for this product or KIKUSUI Website.
NI-VISA	CD-ROM that comes with the GPIB or National Instruments Website.
Agilent IO Libraries	CD-ROM that comes with the GPIB or Agilent Technologies Website.

Table 2-2 Obtaining the VISA driver

2.2.2 Installing KI-VISA

If you are going to use KI-VISA, install it using the setup program (kivisa_ x_x .exe) on the CD-ROM. ("x" varies depending on the KI-VISA version.) For a description of the installation of other VISA drivers, see the documentation of the respective driver.

1 Load the CD-ROM containing the program in the CD-ROM drive.

The installation program automatically starts. The window shown in Fig.2-1 opens.

If KI-VISA is already installed, **Install the KI-VISA library (Version x.x.x)** is unavailable. Because no installation is necessary, close the window. If you move the cursor over **VISA library setup**, an explanation appears at the bottom of the dialog box.

If KI-VISA is not installed, **Install the KI-VISA library (Version x.x.x)** is available. Proceed to the next step.

2 Click Install the KI-VISA Library (Version x.x.x).

The installation startup window appears.



Fig.2-4 Installation startup window

3 Click Next.

The Program Maintenance window appears.

🙀 Kikusui KI-	VISA 3.0.4 – InstallShield Wizard
Program Main Modify, repair	tenance , or remove the program.
	Change which program features are installed. This option displays the Custom Selection dialog in which you can change the way features are installed.
O Repair	Repair installation errors in the program. This option fixes missing or corrupt files, shortcuts, and registry entries.
O <u>R</u> emove	Remove Kikusui KI-VISA 3.0.4 from your computer.
InstallShield ———	< <u>B</u> ack <u>N</u> ext > Cancel

Fig.2-5 Program Maintenance window

4 Select the **Modify**.

5 Click Next.

The Custom Setup window appears.



Fig.2-6 Custom Setup window

6 Click the programs you need.

7 Click Next.

The installation start window appears.



Fig.2-7 Installation start window

8 Click Install.

9

If the program already exists, the dialog box opens.

Question	
?	VISA32.DLL does exist in the C:\WINDOWS\system32\ directory! Existing version is 3.2.0.19 Replacement KI version to be installed is 3.0.4.171 The VISA32.DLL will be overwriten if the replacement KI version is newer than the existing. Would you like to continue?

Fig.2-8 Dialog box that opens when the program exists

To overwrite the program, click **Yes**. Otherwise, click **No**. When the installation is complete, the following window appears.



Fig.2-9 Finish window

10 Click **Finish** to finish the installation.



System Configuration

This chapter describes the FCTester Configuration Tool (system configuration program).

3.1 About the FCTester Configuration Tool

The FCTester Configuration Tool (hereafter referred to as the Configuration Tool) is a program used to configure the FC impedance measurement system. The program is used only when configuring the system for the first time or when you change the system configuration.

When the Configuration Tool is run, connection to each measuring instrument is checked when the system is being configured. Connection between the PC and the instrument as well as the installation of the VISA library (also the GPIB driver if you are using the GPIB) must be completed before you start the Configuration Tool.

The Configuration Tool cannot be used while the FCTester Condition Editor or the FCTester Executive program is running.

Items that are set using the Configuration Tool

- Impedance meter selection.
- Impedance meter and VISA resource selection.
- Scanner option selection.

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- Scanner option and VISA resource selection.
- Scanner channel configuration.

Connecting the KFM2150 Impedance Meter to the KFM2151 Scanner

The KFM2150 is equipped with two VOLTAGE SENSING input terminals on the rear panel. The voltage sensing terminal is switched depending on wether the scanner option is used or not.

- When using the scanner option, the voltage sensing terminal is fixed to VOLTAGE SENSING 2 on the FCTester application software. Connect the VOLTAGE SENSING 2 terminal to the OUT terminal of the KFM2151 Scanner. Impedance cannot be measured if connected to the VOLTAGE SENSING 1 terminal.
- When not using the scanner option, the voltage sensing terminal is fixed to VOLTAGE SENSING 1. Impedance cannot be measured if connected to the VOLTAGE SENSING 2 terminal.

3.2 Starting the Configuration Tool

1 On the taskbar, click the Start button, and then select **Programs** > kikusui Fuel Cell Tester 1.1 > Configuration Tool.

The Configuration Tool starts.

🗟 Introduction 🛛 🔀		
The Configuration Tool is a program used to configure the FC impedance measurement system. The program is used only when configuring the system for the first time or when you change the system configuration. When the Configuration Tool is run, the connection to each measuring instrument is checked while the system is being configured. The connection between the PC and the instrument and the installation of the VISA library (also the GPIB) driver if use the using the GPIB) must be completed before you start the Configuration Tool		
The Configuration Tool cannot be used while the FCTester Condition Editor or the FCTester Executive program is running. Configuration Tool sets the following items. "Impedance meter selection "VISA resource selection "Scanner option selection		
*Scanner channel configuration		
< <u>B</u> ack <u>N</u> ext > Finish Cancel Help		



2 Click Next.

🚳 System Configuration		×		
Impedance Meter Selection	Impedance Meter (KFM series)	*		
~VISA				
Select the interface connec	ting Impedance Meter to the PC for the VISA resource.			
If the interface is set to seria Baud rate: 19200 bps, Dat	If the interface is set to serial, set Impedance Meter as follows (default settings): Baud rate: 19200 bps, Data bits: 8, Stop bits: 2, and Acknowledge: OFF			
VISA Vender (Version)	National Instruments (Version 3.6.0)			
VISA Resource	visa://192.168.10.29/USB0::0x0B3E::0x1008::12345678::INSTR	~		
	Example of VISA resource setup: "ASRLn::INSTR" = Serial port n "GPIBn::m::INSTR" = GPIB n Address m			
Impedance Meter				
Check the Impedance Mete button, check that Impedar connection with the PC.	er connection. Before clicking the Check Check Check Check Check Check			
Impedance Meter	KFM2150			
Version	1.10			
	< Back Next > Finish Cancel He			

Fig.3-2 System Configuration

On the System Configuration window, select the impedance meter, select the VISA resource, and check the connection to the impedance meter.

Selecting the impedance meter

Select an impedance meter (KFM Series).

Selecting the VISA resource

Select or type the VISA resource.

The selectable VISA resources are shown. Click **Find Resource** to search the VISA resource again.

Туре	Syntax	VISA resource example	Description
GPIB	GPIB Board :: PrimaryAddress :: INSTR	GPIB0 :: 3 :: INSTR	Measuring instrument connected to GPIB0 with a primary address set to 3
Serial	ASRL Board :: INSTR	ASRL1 :: INSTR	Measuring instrument connected to serial port COM1
USB	USB0 :: VendorID :: ProdutID :: SerialNumber :: INSTR	USB0 :: 0x0B3E :: 0x1008 :: ABC12345 :: INSTR	USBTMC measuring instrument with vendor ID: 2878 (Kikusui), product: ^{*1} ID1008 (KFM2150), and serial number: ABC12345.

Table 3-1 VISA resource expression example

*1. The PLZ-4W Series is ID1004.

Checking the connection to the impedance meter

After selecting the impedance meter and VISA resource, click **Check** to check the connection.

If the connection is detected correctly, the impedance meter name and version appear, and the **Next** button becomes available.

If the connection is not correct, a dialog box shown in Fig.3-3 opens. Check that the POWER switch of impedance meter (KFM2150) is turned on and that the interface connection is correct.

After checking and correcting the connection, click **OK** to proceed to the next step.







When not selecting the scanner option

To select the scanner option, see $\stackrel{1}{\times}$ When selecting the scanner option $\stackrel{1}{\leftarrow}$ on page 3-6.

3 Click Next.

Clear the **Use the scanner option** check box.

Use the scanner option.		
Select the interface conne	cting the scanner to the PC for the VISA resou	rce.
Set the scanner unit as fol Baud rate: 19200 bps, Da	lows (default settings): ta bits: 8, Stop bits: 2, and Acknowledge: OFF	
VISA Vender (Version)	VXIplugplay Alliance (Version 3.0.0)	
VISA Resource	ASRL1::INSTR	×
	Example of VISA resource setup: "ASRLn::INSTR" = Serial port n	Eind Resource
Scanner		
Check the scanner conne check that the scanner is	ction. Before clicking the Check button, turned on and the connection with the PC.	Check
Scanner Name		
Version		
	< Back Next > Finish	Cancel Heb

Fig.3-4 Scanner Configuration

4 Click Next.

S Configuration Complete		
Press the Finish button to save the configuration data and close the Configuration Tool.		
-Note- There are two voltage sensing terminal inputs on the KFM2150 (terminals on the rear panel). However, the terminal is fixed to VOLTAGE SENSING 1 on the FCTester application when the scanner option is disabled. Note that you will not be able to perform impedance measurements if you connect to VOLTAGE SENSING 2.		
< <u>B</u> ack <u>N</u> ext> Finish Cancel Help		

Fig.3-5 Configuration Complete

5 Click **Finish**.

The configuration data is stored, and the Configuration Tool closes.

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When selecting the scanner option

3 Click Next.

Scanner Configuratio	in	
Use the scanner option.		
VISA		
Select the interface conne	ecting the scanner to the PC for the VISA resour	rce.
Set the scanner unit as fol Baud rate: 19200 bps, Da	lows (default settings): ita bits: 8, Stop bits: 2, and Acknowledge: OFF	
VISA Vender (Version)	National Instruments (Version 3.2.0)	
VISA Resource	ASRL1::INSTR	~
	Example of VISA resource setup:	Find Resource
Commer		
Check the scanner conne check that the scanner is	ction. Before clicking the Check button, turned on and the connection with the PC.	<u>C</u> heck
Scanner Name	KFM2151	
Version	1.01	
r		
l	< <u>B</u> ack Next> Finish	Cancel Help

Fig.3-6 Scanner Configuration

On the Scanner Configuration window, select the scanner usage and VISA resource, and check the connection to the scanner.

Scanner usage

Select the Use the scanner option check box.

Selecting the VISA resource

Select or type the VISA resource.

The selectable VISA resources are shown. Click **Find Resource** to search the VISA resource again.

Checking the connection to the scanner

After selecting the scanner usage and VISA resource, click **Check** to check the connection.

If the connection is detected correctly, the scanner name and version appear, and the **Next** button becomes available.

If the connection is not correct, a dialog box shown in Fig.3-7 opens. Check that the POWER switch of scanner (KFM2151) is turned on and that the interface connection is correct.

After checking and correcting the connection, click **OK** to proceed to the next step.



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FCTester Configuration Tool		
⚠	Unable to open VISA. Check the VISA resource, or check that the measuring instrument is turned on.	
	ОК	

Fig.3-7 Incorrect connection

4 Click Next.

	ai ceil cari be measureu.	
Channel Number	els. Channel Name	Terminal Number [-+]
001	Channel 001	1.1
002	Channel 002	1-1
003	Channel 003	1-1
✓ 004	Channel 004	1-1
005	Channel 005	1-1
006	Channel 006	1-1
007	Channel 007	1-1
008	Channel 008	1.1
009	Channel 009	1.1
010	Channel 010	1 - 1
011	Channel 011	1.1
012	Channel 012	1-1 🔍

Fig.3-8 Scanner Channel Configuration

Information such as the Number of Scanners and Channel Number are displayed according to the system configuration.

If you select the **Enable all channels** check box, all the channels are enabled, and the check boxes of all channel numbers are selected.

If you clear the **Enable all channels** check box, all channels except channel 032 are disabled.

Select the check box of a given channel to enable that channel. Clear the check box to disable it.

NOTE

• As the number of channels increases in the Scanner Channel Configuration window, the time it takes to retrieve the voltage data also increases. We recommend that you select only the channels that you need.

5 Click Edit.

Channel Configura	tion	×
Channel <u>S</u> election	003 💌	
Enable the cha	Innel	
Channel <u>N</u> ame	Channel 003	
Terminal Number	Negative 3	Positive 3
		ОК



Selecting the channel

Select the channel number.

Enabling the channel

To enable the selected channel, select the **Enable the channel** check box. Otherwise, clear the check box.

If you enabled the channel, specify the channel name (up to 64 characters) and the terminal number.

Configure all other necessary channels in the same manner.

Channel 032 on the FCTester is a special channel used to measure the stack. Connect this channel so that the stack is measured. This channel cannot be disabled.

FCTester Configuration Tool			
⚠	Channel 032 on the FCTester is a special channel used to measure the total cell. Therefore, this channel cannot be disabled.		
	OK		

Fig.3-10 Channel 032 cannot be disabled.

6 Click **OK**.

The Scanner Channel Configuration window (Fig.3-8) appears.

7 Click **Next** and then click **Finish**.

The configuration data is stored, and the Configuration Tool closes.



Creating Test Conditions

This chapter describes the FCTester Condition Editor (test condition editing program).

4.1 About the FCTester Condition Editor

The FCTester Condition Editor (hereafter referred to as the Condition Editor) is a program used to edit test conditions.

You can combine up to 15 sequences of test modes in one cycle of a test condition file.

The Condition Editor allows you to set the following items.

- Fuel cell information
- Protection
- Cycle

4-2

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- Startup sequence
- Shutdown sequence
- Sequence 1 to 15 (select from nine test modes for each sequence)
- Test mode (9 modes)
 - I-V measurement I-V + AC impedance measurement I-V + Cole-Cole plot measurement V-I measurement Cole-Cole plot measurement AC impedance measurement Current interrupt measurement Constant current test Constant voltage test

4.2 Starting the Condition Editor

1 On the taskbar, click the Start button, and then select **Programs** > kikusui Fuel Cell Tester 1.1 > FCTester Condition Editor.

The Condition Editor starts.



Fig.4-1 Startup window

The startup window consists of two panes.

Pane	Description
Test Conditions Item Pane	The test condition items are divided into sheets. The sheet names are shown in a tree structure. You select the sheet that you want to edit on this pane.
Test Conditions Edit Pane	Shows the contents of the sheet that is selected in the Test Condition Item Pane. You edit the condition items of each sheet on this pane. The input range of an item is shown by moving the pointer over the corresponding box.

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4.3 Creating and Saving Test Conditions Files

Creating a test conditions file

Creating a new file

From the File menu, select New.

A file with the name Untitled opens. The startup window opens. Specify the settings by referring to the subsequent sections.

Opening an existing file

- 1 From the **File** menu, select **Open**. The Open window opens.
- 2 Select the file you want to open.

The extension of the test conditions file is .fcct.

Saving the test conditions file

1 From the File menu, select Save.

The test conditions file that is currently open is saved. If you are saving the current file the first time, the Save As dialog box opens. Specify the save destination and the file name. The extension of the test conditions file is .fcct. To save the file with another name, select **Save As**. The Save As dialog box opens. Specify the save destination and file name.

Setting the default file

From the File menu, select Default.

You can set the current file to be the default file when a new file is created.

• The test data files that the FCTester Executive generates are placed in the same location as the test conditions file. Many test data files are created in a single test. If you want to place the test conditions file on the desktop, we recommend that you create a dedicated folder on the desktop and place the file in the folder.

4.4 Fuel Cell Information

1

This window is used to enter information concerning the sample (fuel cell).

In the Test Condition Item Pane, click Fuel Cell Information.

Test Conditions	Enter the fuel co	ll informat	tion.				
Startup	Sample Name						V
Shutdown Sequence 1	Membrane	5					~
Sequence 2	⊆atalyst						Y
Sequence 4	Width	N.N	[mm]	Weight	n.nn	[kg]	
Sequence 6	Height	n.n	[mm]	Electrode Area	0.00	[rm2]	
Sequence 8	Depth	0.0	[mm]	Nominal Voltage	0.00	[V]	
Sequence 10 Sequence 11 Sequence 12 Sequence 13 Sequence 14 Sequence 15	Mem <u>n</u>						0
		<u><</u>					3

Fig.4-2 Fuel Cell Information

Item	Input range			
Sample Name	Up to 64 arbitrary characters. You can enter more than			
Membrane	64 characters, but they are discarded. Text entered in the past are stored and displayed in the dron-down list			
Catalyst	when you click the arrow.			
Dimensions (W, H, and D)	0.0 to 10000.0 [mm]			
Weight	0.00 to 1000.00 [kg]			
Electrode Area	0.00 to 100000.00 [cm ²]			
Nominal Voltage	-2.00 to 150.00[V]			
Memo	Up to 256 arbitrary characters.			

NOTE

- The electrode area is used when displaying the current on the graph scale of the FCTester Executive in current density.
- The nominal voltage is used as the maximum value when the voltage on the graph scale of FCTester Executive is fixed.

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4.5 Protection

This window is used to set the protection function of the impedance meter, electronic load unit, and scanner.

1 In the Test Condition Item Pane, click **Protection**.

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Test Conditions Fuel Cell Information Protection Startup Shutdown Sequence 1 Sequence 3 Sequence 3 Sequence 3 Sequence 3 Sequence 4 Sequence 5 Sequence 6 Sequence 6 Sequence 7 Sequence 8 Sequence 10 Sequence 11 Sequence 11 Sequence 13 Sequence 13 Sequence 14 Sequence 14 Sequence 14	Set the protection. T Impedance Me UVP -2.00 Scanner Settings for Channel Stact Scanner Channel Settings Octannel Number 001 002 003 004 005 006 007 008 009 010 011 012 013 n14	In e setup items that ter [V] Mask Time r the Stack Cell (Ch s ings Channel 001 Channel 002 Channel 002 Channel 002 Channel 003 Channel 005 Channel 005 Channel 005 Channel 007 Channel 007 Channel 007 Channel 009 Channel 010 Channel 011 Channel 012 Channel 012 Channel 012 Channel 013 Channel 013	you can set vary	depending on the m E-Load VVP 0.00 OVP OVP	easuring instrument mod	
					Vour computer mic	ght be at risk

Fig.4-3 Protection

Common settings

Item		Description	Input range	
Impedance meter	UVP	Select the check box to enable the undervoltage protection (UVP) function of the impedance meter.	-2.00 to 150.00 [V]	
	Mask Time	Select the check box to set the time (mask time) until the undervoltage protection (UVP) of the impedance meter is to be activated.	0 to 10 [s]	
E-Load	UVP	Select the check box to enable the undervoltage protection (UVP) function of the electronic load unit.	0.00 to 150.00 [V]	
	OPP	Select the check box to enable the overpower protection (OPP) function of the electronic load unit.	*1	
Stack channel settings (channel 032) of the scanner	OVP	Select the check box to enable the overvoltage protection (OVP) function of the scanner.	-2.00 to 200.00 [V]	
	UVP	Select the check box to enable the undervoltage protection (UVP) function of the scanner.	-2.00 to 200.00 [V]	

*1. Depends on the capacity of the electronic load unit that is being used.

Settings of each scanner channel



You must select the scanner option on the Configuration Tool in advance to use the channel settings of the scanner.

Click Edit.

1



Fig.4-4 Scanner Protection Settings

Select the scanner channel on which you want to set the protection.

The settings are displayed in **Scanner Channel Settings** in the Test Condition Edit Pane.

Item	Description	Input range
Channel selection	Select the channel you want to set.	Depends on the
		number of scanners ^{*1}
OVP	Select the check box to enable the overvoltage protection (OVP) function of the scanner.	-2.00 to 200.00 [V]
UVP	Select the check box to enable the undervoltage protection (UVP) function of the scanner.	-2.00 to 200.00 [V]
Set all channels to the same settings.	Select the check box to set the OVP and UVP values to the same values on all channels.	Same as OVP and UVP

*1. 001 to 031 for 1 unit, 101 to 132 for 2 units, 201 to 232 for 3 units, 301 to 332 for 4 units, and 401 to 432 for 5 units.

4.6 Cycle

A cycle consists of multiple sequences (up to 15) that can be tested repetitively (Fig.4-5). You can set one test mode in a sequence and combine the sequences to perform various tests in a cycle. Startup and shutdown sequences, which define the startup and shutdown operations of the fuel cell, can be executed at the start and end of the cycle test.



Fig.4-5 Concept of cycles

Turning the load on/off (turning the load current on/off)

If the current range or voltage range between two adjacent sequence sheets is the same, the cycle continues with the load turned on. If not, the load is turned off instantaneously at the start of the sequence, and the current range or voltage range is switched.

OCV (Open Circuit Voltage)

If you are turning the load off to measure the OCV (Open Circuit Voltage) before a sequence, the load is turned off once regardless of whether the voltage range or current range is the same. You can set the load off period.

Setting the recording conditions

You can set the recording conditions of the voltage and current data for each sequence. You can select the points to be recorded in the recording conditions to reduce the number of recorded data values.

You can select multiple items in each recording condition. If you clear all the recording condition check boxes, voltage and current are not recorded in the test data file.

All of the recording data of the impedance meter are recorded regardless of the conditions.

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 Test Conditions Fuel Cell Information Protection Startup Shutdown Sequence 1 Sequence 2 Sequence 3 Sequence 4 Sequence 5 Sequence 6 Sequence 6 Sequence 7 Sequence 7 Sequence 9 Sequence 10 Sequence 11 Sequence 12 Sequence 13 Sequence 14 Sequence 15 	Set the test cycle. Normally, a common However, you can se at the start of a sequ Current Range Test Cycle Sequence 1 Sequence 2 Sequence 3 Sequence 5 Use the startup se Use the startup se Use the shutdown Cutoff Voltage	current range is in t different curren rence, switch the voltage range fo 200.0 • 1 times 1 times 1 times 1 times 1 times 1 times 1 times 1 times 1 times 1 times	n a test cycle even a ht ranges for each s current range, and r each sequence. [A] Voltage V Sequence 6 V Sequence 7 V Sequence 8 V Sequence 9 V Sequence 10 [V]	among different equence sheet I turn the load b Range 150.0 1 times 1 times 1 times 1 times 1 times	sequence sheets. by instantaneously to ack on. Sequence 11 Sequence 12 Sequence 13 Sequence 14 Sequence 15 Sequence 15	In times times times times times times times
	Turn the load off	when the load cu	rrent is set to 0 A.			
						NUM
						NUM

1 In the Test Condition Item Pane, click Cycle.

Fig.4-6 Cycle

•
Itom	Description	
Item	Description	input range
Set the current/voltage range for each sequence.	If you select the check box, the Voltage Range and Current Range of the electronic load unit become unavailable. The voltage and current settings are enabled in each sequence. If you select the check box, you can set the current and voltage ranges of the electronic load unit. The ranges are set to the same ranges in all sequences. Settings in each sequence is not allowed (the Current Range and Voltage Range boxes become unavailable).	(No relevant values)
Current Range	The current range of the electronic load unit that is set by clearing the check box. The range is set to the specified range in all sequences.	*1
Voltage Range	The voltage range of the electronic load unit that is set by clearing the check box. The range is set to the specified range in all sequences.	15.0 [V] or 150.0 [V]
Test Cycle Sequence 1 to 15	Select the check box to enable that sequence. Specify the number of times to repeat each sequence.	1 to 10
Cycle	Specify the number of times to repeat the cycle.	1 to 100
Use the startup sequence.	Select the check box to execute the startup sequence before executing the first cycle. If the startup sequence is enabled, the load is automatically turned on even if the load is not on before starting the test. If the startup sequence is disabled, you must manually turn the load on before starting the test. ^{*2}	(No relevant values)
Use the shutdown sequence.	Select the check box to execute the shutdown sequence after the last cycle is executed. If the shutdown sequence is disabled, you must manually turn the load of after the test. ^{*3}	(No relevant values)
Cutoff Voltage	This item is enabled if you select the Use the shutdown sequence check box. If the voltage falls below the Cutoff voltage during a test cycle, the present sequence is terminated, and transition is made to the shutdown sequence.	-2.00 to 150.00 [V]
Turn the load off when the load current is set to 0 A.	Select the check box to turn the load off when the load current is set to 0 A. This setting is applied only to the I-V measurement, I-V + current impedance measurement, and I-V + Cole- Cole plot measurement.	(No relevant values)

*1. Depends on the capacity of the electronic load unit that is being used.
*2. For the operating procedure, see section 5.3.2, X Not Using the Startup Sequence."

*3. For the operating procedure, see section 5.3.7, X Test Completion."

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4.7 Startup

1 In the Test Condition Item Pane, click Startup.

The startup sequence is a sequence for the fuel cell that is executed before starting the test cycle.







Fig.4-8 Conceptual diagram of startup

Item	Description	Input range
Operation Mode	Specifies the operation mode of the startup sequence.	Constant current or constant voltage
Use the soft start function.	Select the check box to enable the soft start function. The current increases from the present value to the load current along a slope over the specified rise time. If this function is enabled, the generating time is the elapsed time since the load current is reached.	(No relevant values)
Rise Time	The load current is changed step-wise at 1 second interval. The current rises from 0 A to the load current over the specified time.	0 to 2 [h] 0 to 59 [min]
Current Range	Sets the current range of the electronic load unit.	*1
Current	Sets the load current.	*1
Generating Time	Sets the generating time of the startup sequence (the time after the preset current is reached).	0 to 8 [h] 0 to 59 [min]
Voltage Range	Sets the voltage range of the voltage for switching to constant voltage mode. This item is unavailable if the operation mode is constant current.	15.0 [V] or 150.0 [V]
Voltage	Sets voltage for switching to constant voltage mode. This item is unavailable if the operation mode is constant current.	0 to 157.5 [V] or 0 to 15.75 [V]
CC Time	This item is unavailable if the operation mode is constant current. The CC Time sets the time from the point when the load current is reached. If the current falls below the load current within the specified time, the specified time is reset.	0 to 8 [h] 0 to 59 [min]
Time Interval	Sets the time interval of measurements.	1 to 3600 [s]
Delta Voltage	Continues the measurement in the period where the voltage change is greater than or equal to the specified delta voltage when the operation mode is constant current.	0.001 to 1.000 [V]
Delta Current	Continues the measurement in the period where the current change is greater than or equal to the specified delta current when the operation mode is constant current.	The minimum resolution of the current range to 10 % of the current range ^{*1}

 $^{\ast}1.~$ Depends on the capacity of the electronic load unit that is being used.

4.8 Shutdown

1 In the Test Condition Item Pane, click Shutdown.

The shutdown sequence is a sequence for the fuel cell that is executed after the end the test cycle.



Item	Description	Input range
Operation Mode	Specifies the operation mode of the shutdown sequence.	Constant current or constant voltage
Current Range	Sets the current range of the electronic load unit.	*1
Current	Sets the load current.	*1
Generating Time	Sets the generating time of the shutdown sequence (the time after the preset current is reached).	0 to 8 [h] 0 to 59 [min]
Voltage Range	Sets the voltage range of the voltage for switching to constant voltage mode.	15.0 [V] or 150.0 [V]
Voltage	Sets voltage for switching to constant voltage mode.	0 to 157.5 [V] or 0 to 15.75 [V]
Cutoff Current	If the current falls below the preset value when the operation mode is constant voltage, the shutdown sequence is terminated, and the load is turned off.	
Use the soft start function.	Select the check box to enable the soft start function. The current decreases from the present value to 0 A along a slope over the specified fall time. If this function is enabled, the generating time is the time that passes after the load current is reached.	(No relevant values)
Fall Time	The load current is changed step-wise at 1 second interval. The current falls from the load current to 0 A over the specified time.	0 to 2 [h] 0 to 59 [min]
Time Interval	Sets the time interval of measurements.	1 to 3600 [s]
Delta Voltage	If the difference between the previous voltage data and the present voltage data is greater than or equal to the delta voltage, the data is recorded.	0.001 to 1.000 [V]
Delta Current	The data before the load current value is changed is recorded.	The minimum resolution of the current range to 10 % of the current range ^{*1}

 $^{\ast}1.~$ Depends on the capacity of the electronic load unit that is being used.

4.9 Sequence Sheets 1 to 15

Sequence sheets are used to define each sequence that make up the cycle. The Test Conditions Pane has the Measurement and Scanner tabs. The scanner tab only corresponds to test modes in which impedance measurements are performed.

Measurement tab

The following test modes are available. The items that you can set vary depending on the test mode.

- I-V measurement
- I-V + AC impedance measurement
- I-V + Cole-Cole plot measurement
- V-I measurement
- Cole-Cole plot measurement
- AC impedance measurement
- · Current interrupt measurement
- · Constant current test
- · Constant voltage test

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Test Conditions Fuel Cell Information Protection Cycle Startup Stutdown Sequence 1 Sequence 2 Sequence 3 Sequence 4 Sequence 5 Sequence 6 Sequence 7 Sequence 7 Sequence 7 Sequence 1 Sequence 11 Sequence 11 Sequence 11 Sequence 13 Sequence 14 Sequence 14	Measurement Scanne Test Mode Comment Comment Current Range Start Qurrent Gable current/ Fold-back Current Fold-back Voltage Final Current Step Current Step Time Regt Time Change the cur next sequence	r Image: Constraint of the sequence. before starting the sequence. Image: Constraint of the sequence. 200.0 Image: Constraint of the sequence. 200.0 Image: Constraint of the sequence. 0.00 [A] -2.00 [V] 0.10 [A] -2.00 [V] 0.10 [A] 0.05 [A] 0 [h] 1 [min] rent to the current value of the along a slope over the rest time	Cutoff Condition Repeat Count Cutoff Voltage -2.00 Record Condition I Delta Yoltage 1.000 Delta Current	s] times (V] [s] (V]
				NUM

Fig.4-11 Measurement tab

You can set the recording conditions of the voltage and current data for each sequence. You can select the points to be recorded in the recording conditions to reduce the number of recorded data values.

You can select multiple items in each recording condition. If you clear all the recording condition check boxes, voltage and current are not recorded in the test data file.

All of the recording data of the impedance meter are recorded regardless of the conditions.

Scanner tab

Scanning is supported only for the following test modes that perform impedance measurement.

- I-V + AC impedance measurement
- I-V + Cole-Cole plot measurement
- Cole-Cole plot measurement
- AC impedance measurement
- Current interrupt measurement

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Test Conditions Fuel Cell Information Protection Startup Startup Startup Startup Startup Sequence 1 Sequence 2 Sequence 3 Sequence 3 Sequence 3 Sequence 4 Sequence 4 Sequence 6 Sequence 6 Sequence 7 Sequence 7 Sequence 8 Sequence 10 Sequence 11 Sequence 11 Sequence 13 Sequence 13 Sequence 14 Sequence 14	Measurement Scannels of You can select the channels of You can select multip number. V Enable all channel Channel Number V 001 V 002 V 003 V 004 V 005 V 006 V 007 V 008 V 009 V 010 V 011 V 012 V 013 V 013 V 014	ar construction of the second	dance. t scanning is performed in order from t e: Stack]	he smallest channel
	014	Channel 014 Channel 015		

Fig.4-12 Scanner tab

If you select one of the test modes above, you will be able to select channels on the **Scanner** tab.

Select the check box of a given channel to enable the channel as a channel on which impedance measurement will be performed. Clear the check box to disable the channel.

You can arbitrarily select the channels to be measured, but scanning is performed in order from the smallest channel number.

- If you select the **Stack Cell Channel (Channel 032/Channel Name: Stack)** check box, channel 032 is enabled. If you select the **Enable all channels** check box, channel 032 is automatically enabled.
- If you select the **Enable all channels** check box, all the channels are enabled, and the check boxes of all channel numbers are selected. If you clear the check box, all channels are disabled.

- You must select the scanner option on the Configuration Tool to use the **Scanner** tab.
- The voltage data of a channel that is enabled using the Configuration Tool is enabled even if the channel is not selected in the Scanner tab of Fig.4-12.

NOTE

4.9.1 I-V Measurement

This test mode varies the load current in steps and measures the voltage.

1 In the Test Condition Item Pane, click **Sequence (1 to 15)**.

You can select any of the sequences from 1 to 15 in the Test Conditions Item Pane. Select the sequence considering the cycle order.

2 In the Test Mode box, select I-V measurement.

Test Conditions Fuel Cell Information Protection	Measurement Scanne Test Mode	er I-V Measurement		~		
E Cycle	Comment			~		
Shutdown	Measure the OCV	before starting the	sequence.	Load Off Period 2	[8]	
Sequence 2	Current <u>R</u> ange	200:0	[A]	Cutoff Condition	1	1.0
Sequence 4 Sequence 5 Sequence 5 Sequence 6	Start <u>C</u> urrent	0.10	[A]	Repeat Count	1	times
	Enable current,	/voltage t <u>o</u> ld back		Cuton vojtage	-2.00	[V]
	Fold-back Current	0.00	[A]	Record Condition		
Sequence 8	Fold back Voltage	-2.00	[V]	🗹 jime Interval	1	[5]
Sequence 9	Final Current	0.10	[A]	Delta Yoltage	1.000	[V]
Sequence 10	Step Current	0.05	[A]	Delta Current		
Sequence 12	Step lime	U [min] 2	[5]			
Sequence 13						
Sequence 15	Rest Time	0 [h] 1	[min]			
	Change the cur next sequence	rrent to the currer along a slope ove	nt value of the r the rest time.			

Fig.4-13 I-V measurement



Fig.4-14 Conceptual diagram of I-V measurement

Ite	em	Description	Input range
Comment		You can enter up to 16 arbitrary characters. You can but they are discarded. Past comments are stored an when you click the arrow.	enter more than 16 characters, d displayed in the drop-down list
Measure the OCV before starting the sequence.		Select the check box to set the fuel cell to no load condition (open circuit) and measure the cell voltage. The load is turned off, and the OCV (Open Circuit Voltage) is measured before starting each sequence.	(No relevant values)
Load Off Pe	riod	Sets the OCV measurement time.	1 to 60 [s]
Current Rar	nge	Selects the current range.	*1
Start Currer	nt	Sets the current at which the load current sweep is started.	*1
Enable curr fold back	ent/voltage	Select the check box to fold back the current sweep.	(No relevant values)
Fold-back C	Current	Sets the current at which the current sweep is folded back.	*1
Fold-back Voltage		Sets the voltage at which the current sweep is folded back. If the cell voltage is less than or equal to the fold-back voltage when the current sweep is increasing, the current sweep is folded back.	0 to 157.5 [V] or 0 to 15.75 [V]
Final Current		Sets the current at which the load current sweep is stopped.	*1
Step Current		Sets the step current for sweeping the load current in steps.	*1
Step Time		Sets the time for each step.	0 to 59 [min] 0 to 59 [s]
Rest Time		Sets the rest time after the sequence sheet is completed.	0 to 12 [h] 0 to 59 [min]
Change the current to the current value of the next sequence along a slope over the rest time.		The current is changed from the value at the end of the sequence sheet to the start current of the next sequence sheet during the rest time. The load current is changed in steps at 1 second interval.	(No relevant values)
Cutoff Condition	Repeat Count	Sets the number of times to repeat the I-V test.	1 to 999 times
	Cutoff Voltage	The sequence is terminated if the cell voltage falls to or below the cutoff voltage.	-2 to 150 [V]
Record Condition	Time Interval	Sets the time interval for acquiring data.	1 to 3600[s]
	Delta Voltage	If the difference between the previous voltage data and the present voltage data is greater than or equal to the delta voltage, the data is recorded.	0.001 to 1.000[V]
	Delta Current	The data before the load current value is changed is recorded.	(No relevant values)

*1. Depends on the capacity of the electronic load unit that is being used.

4.9.2 I-V + AC Impedance Measurement

This test mode varies the load current in steps and measures the AC impedance after the step time elapses.

1 In the Test Condition Item Pane, click Sequence (1 to 15).

You can select any of the sequences from 1 to 15 in the Test Conditions Item Pane. Select the sequence considering the cycle order.

2 In the **Test Mode** box, select I-V + AC Impedance Measurement.

Test Conditions	-					
Fuel Cell Information	Measurement					
S Protection	Test <u>M</u> ode	I-V + AC Impedanc	e Measuremen	t 🗸		
Cycle Cycle Startup	Comment			Y		
Shutdown	Measure the OCV	before starting the	sequence.	Load Off Period 2	[s]	
Sequence 2	Current Bange	200.0		Impedance Measur	ement Condition	
Sequence 3	Start Current	0.10	[A]	Frequency	20k 🗸	[Hz]
Sequence 5	Enable current	voltage fold back		Measuring AC	10.0	1%]
Sequence 6	Fold-back Current	0.00	[A]	Measure Range	AUTO 🗸	
Sequence 7	Fold back Voltage	-2.00	[V]	Moving Average	32 😽	times
Sequence 9	Final Current	0.10	[A]	C. A. C. C. Mar		2109 0.110 O.
Sequence 10 Sequence 11	Step Current	0.05	[A]	Repeat Count	1	timer
Sequence 12	Step lime	U [min] 2	[s]	Cutoff Voltage	-2.00	EV1
Sequence 13	Measure Rest Time	5	[\$]	- Vecord (opdition -		11.41
Sequence 15	Pact Time	0 0.1	1	Time Interval	1	F-1
	Change the cu	rent to the curren	_ [min] it value	Delta Voltage	1.000	151
	of the next sec	juence along a sloj	be over	Dolta Current	11000	IV1:

Fig.4-15 I-V + AC impedance measurement



Fig.4-16 Conceptual diagram of I-V + AC impedance measurement

Iter	n	Description	Input range
Comment		You can enter up to 16 arbitrary characters. You can enter but they are discarded. Past comments are stored and disp when you click the arrow.	nore than 16 characters, layed in the drop-down list
Measure the OCV before starting the sequence.		Select the check box to set the fuel cell to no load condition (open circuit) and measure the cell voltage. The load is turned off, and the OCV (Open Circuit Voltage) is measured before starting each sequence.	(No relevant values)
Load Off Perio	d	Sets the OCV measurement time.	1 to 60 [s]
Current Range		Selects the current range.	*1
Start Current		Sets the current at which the load current sweep is started.	*1
Enable current back	/voltage fold	Select the check box to fold back the current sweep.	(No relevant values)
Fold-back Curr	rent	Sets the current at which the current sweep is folded back.	*1
Fold-back Volta	age	Sets the voltage at which the current sweep is folded back. If the cell voltage is less than or equal to the fold-back voltage when the current sweep is increasing, the current sweep is folded back.	0 to 157.5 [V] or 0 to 15.75 [V]
Final Current		Sets the current at which the load current sweep is stopped.	*1
Step Current		Sets the step current for sweeping the load current in steps.	*1
Step Time		Sets the time for each step.	0 to 59 [min] 0 to 59 [s]
Measure Rest Time		Sets the rest time after the AC impedance measurement.	0 to 59 [s]
Rest Time		Sets the rest time after the sequence sheet is completed.	0 to 12 [h] 0 to 59 [min]
Change the current to the current value of the next sequence along a slope over the rest time.		The current is changed from the value at the end of the sequence sheet to the start current of the next sequence sheet during the rest time. The load current is changed in steps at 1 second interval.	(No relevant values)
Impedance Measurement	Frequency	Sets the frequency at which the AC impedance measurement is performed.	10m to 20k [Hz]
Condition	Measuring AC Current	Sets the measuring AC current used to measure the AC impedance.	0 to 10 [%] of the load current
	Measure Range	Sets the measurement range at which the AC impedance measurement is performed.	AUTO
	Moving Average	Sets the moving average count of the AC impedance measurement.	1 to 256 (1, 2, 4, 8, 16, 32, 64, 128, or 256)
Cutoff Condition	Repeat Count	Sets the number of times to repeat the AC impedance measurement.	1 to 999 times
	Cutoff Voltage	The sequence is terminated, if the cell voltage falls to or below the cutoff voltage.	-2 to 150 [V]
Record Condition	Time Interval	Sets the time interval for acquiring data.	1 to 3600[s]
	Delta Voltage	If the difference between the previous voltage data and the present voltage data is greater than or equal to the delta voltage, the data is recorded.	0.001 to 1.000 [V]
	Delta Current	The data before the load current value is changed is recorded.	(No relevant values)

*1. Depends on the capacity of the electronic load unit that is being used.

4.9.3 I-V + Cole-Cole plot measurement

This test mode varies the load current in steps and performs Cole-Cole plot measurement (AC impedance) after the step time elapses.

1 In the Test Condition Item Pane, click **Sequence (1 to 15)**.

You can select any of the sequences from 1 to 15 in the Test Conditions Item Pane. Select the sequence considering the cycle order.

2 In the **Test Mode** box, select **I-V + Cole-Cole Plot Measurement**.



Fig.4-17 I-V + Cole-Cole plot measurement





Item	Description	Input range		
Comment	You can enter up to 16 arbitrary characters. You can enter more than 16 characters, but they are discarded. Past comments are stored and displayed in the drop-down list when you click the arrow.			
Measure the OCV before starting the sequence.	Select the check box to set the fuel cell to no load condition (open circuit) and measure the cell voltage. The load is turned off, and the OCV (Open Circuit Voltage) is measured before starting each sequence.	(No relevant values)		
Load Off Period	Sets the OCV measurement time.	1 to 60 [s]		

Current Range		Selects the current range.	*1
Start Current		Sets the current at which the load current sweep is started.	*1
Enable current/voltage fold back		Select the check box to fold back the current sweep.	(No relevant values)
Fold-back Curr	ent	Sets the current at which the current sweep is folded back.	*1
Fold-back Volta	age	Sets the voltage at which the current sweep is folded back. If the cell voltage is less than or equal to the fold-back voltage when the current sweep is increasing, the current sweep is folded back.	0 to 157.5 [V] or 0 to 15.75 [V]
Final Current		Sets the current at which the load current sweep is stopped.	*1
Step Current		Sets the step current for sweeping the load current in steps.	*1
Step Time		Sets the time for each step.	0 to 59 [min] 0 to 59 [s]
Measure Rest	Time	Sets the rest time after the AC impedance measurement.	0 to 59 [s]
Rest Time		Sets the rest time after the sequence sheet is completed.	0 to 12 [h] 0 to 59 [min]
Change the current to the current value of the next sequence along a slope over the rest time		The current is changed from the value at the end of the sequence sheet to the start current of the next sequence sheet during the rest time. The load current is changed in steps at 1 second interval.	(No relevant values)
Impedance Measurement	Start Frequency	Sets the start frequency at which the AC impedance measurement is performed.	10m to 20k [Hz]
Condition	Stop Frequency	Sets the stop frequency at which the AC impedance measurement is performed.	10m to 20k [Hz]
	Use the frequency option	Select the check box to click the button. Press the button to set the frequency in detail (Fig.4- 19).	Frequency option
	Measuring AC Current	Sets the measuring AC current used to measure the AC impedance.	0 to 10 [%] of the load current
	Measure Range	Sets the measurement range at which the AC impedance measurement is performed.	AUTO
	Moving Average	Sets the moving average count of the AC impedance measurement.	1 to 256 (1, 2, 4, 8, 16, 32, 64, 128, or 256)
Cutoff Condition	Repeat Count	Sets the number of times to repeat the AC impedance measurement.	1 to 999 times
	Cutoff Voltage	The sequence is terminated, if the cell voltage falls to or below the cutoff voltage.	-2 to 150 [V]
Record Condition	Time Interval	Sets the time interval for acquiring data.	1 to 3600[s]
	Delta Voltage	If the difference between the previous voltage data and the present voltage data is greater than or equal to the delta voltage, the data is recorded.	0.001 to 1.000[V]
	Delta Current	The data before the load current value is changed is recorded.	(No relevant values)

 $^{\ast}1.~$ Depends on the capacity of the electronic load unit that is being used.

Frequency option

Frequency Option				
You can arbitrary set the freque	encies at wh	ich the impedance	is measured.	
Start Frequency 316	[Hz]	Stop Frequency	20k	🖌 [Hz]
Frequency [Hz]	Moving Av	/erage		~
316	256			
400	256			
500	256			
600	256			
630	256			
700	256			
800	256			
900	256			
🔽 1k	256			
1 26k	256			<u>×</u>
		ОК	Can	cel

Fig.4-19 Frequency Option

Select the check box to select the frequency individually. The start and stop frequencies are interlinked to the frequency selected using the check boxes.

The moving average shows the value specified for moving average in the impedance measurement condition.

4.9.4 V-I Measurement

This test mode varies the load voltage in steps and measures the current.

1 In the Test Condition Item Pane, click Sequence (1 to 15).

You can select any of the sequences from 1 to 15 in the Test Conditions Item Pane. Select the sequence considering the cycle order.

2 In the **Test Mode** box, select **V-I measurement**.

Sections Fuel Cell Information	Measurement					
Protection	Test Mode	V-I Measurement		~		
Startup	Comment			~		
5hutdown	Measure the OCV	before starting the	equence.	Load Off Period 2	[5]	
Sequence 2	Voltage Range	150.0	na.	Cutoff Condition		
Sequence 0	Start Voltage	0.00	[v]	Repeat Count	1	times
Sequence 5	Enable voltage	fold back	ral	Cutoff Current	0.00	LAJ
Sequence 6	Fold-back Voltage	0.00	EV1	Record Condition		
Sequence 7 Sequence 8	Final Voltage	0.00	[V]	Jime Interval	1	[5]
Sequence 9	Step Voltage	0.05	[V]	Delta Voltage	111	
Sequence 10 Sequence 11	Step Time	0 [min] 2	[5]	Delta Current	0.30	[4]
Sequence 12 Sequence 13	Current Bange	200.0	[A]			
Sequence 14 Sequence 15	Limit Current	0.10	[A]			
	Rest Time Change the cu of the next see the rest time.	0 [h] 1 rent to the curren juence along a slop	[min] : value e over			

Fig.4-20 V-I measurement





Time [s]

Fig.4-21 Conceptual diagram of V-I measurement

lte	em	Description	Input range
Comment		You can enter up to 16 arbitrary characters. You can enter but they are discarded. Past comments are stored and dis when you click the arrow.	r more than 16 characters, played in the drop-down list
Measure the OCV before starting the sequence.		Select the check box to set the fuel cell to no load condition (open circuit) and measure the cell voltage. The load is turned off, and the OCV (Open Circuit Voltage) is measured before starting each sequence.	(No relevant values)
Load Off Pe	riod	Sets the OCV measurement time.	1 to 60 [s]
Voltage Rar	nge	Selects the voltage range.	15.0 or 150.0 [V]
Start Voltag	е	Sets the voltage at which the voltage sweep is started.	0 to 157.5 [V] or 0 to 15.75 [V]
Enable volta back	age fold	Select the check box to fold back the voltage sweep.	(No relevant values)
Fold-back Voltage		Sets the voltage at which the voltage sweep is folded back.	
Cutoff Voltage		Sets the voltage at which the voltage sweep is stopped.	
Step Voltage		Sets the step voltage for sweeping the voltage in steps.	
Step Time		Sets the time for each step.	0 to 59 [min] 0 to 59 [s]
Current Range		Selects the current range.	*1
Limit Currer	nt	Sets the limit current.	
Rest Time		Sets the rest time after the sequence sheet is completed.	0 to 12 [h] 0 to 59 [min]
Change the current to the current value of the next sequence along a slope over the rest time.		The current is changed from the value at the end of the sequence sheet to the start current of the next sequence sheet during the rest time. The load current is changed in steps at 1 second interval.	(No relevant values)
Cutoff Condition	Repeat Count	Sets the number of times to repeat the V-I test.	1 to 999 times
	Cutoff Current	The sequence is terminated if the current falls to or below the cutoff current when the operation mode is constant voltage.	
Record Condition	Time Interval	Sets the time interval for acquiring data.	1 to 3600[s]
	Delta Voltage	The data before the voltage is changed is recorded.	
	Delta Current	If the difference between the previous current data and the present current data is greater than or equal to the delta current, the data is recorded.	*1

*1. Depends on the capacity of the electronic load unit that is being used.

4.9.5 Cole-Cole Plot Measurement

This test mode sweeps the frequency in steps and measures the impedance.

The graph shows a Cole-Cole plot.

1 In the Test Condition Item Pane, click Sequence (1 to 15).

You can select any of the sequences from 1 to 15 in the Test Conditions Item Pane. Select the sequence considering the cycle order.

2 In the **Test Mode** box, select **Cole-Cole plot measurement**.

Test Conditions	Measurement				
Protection Cycle	Test <u>M</u> ode Comment	Cole-Cole Plot Measurement	*		
Shutdown	Measure the OC	V before starting the sequence.	Load Off Period 2		[\$]
Sequence 2	Current <u>R</u> ange	200.8	Impedance Measur	ement Cond	lition
Sequence 4	Current	0.10 [A]	Start Freguency	316	[Hz]
Sequence 5			Stop Frequency	20k.	2 [l lz]
Sequence 6	Change the r	Unit (min)	Measuring AC	10.0	For 1
Sequence 8	uf the next s	equence along a slope over	Current Measure Ranne	ALITO	[/o]
Sequence 9 Sequence 10	and rest and	•	Moving <u>A</u> verage	32	💙 times
Sequence 11 Sequence 12			Cutoff Condition		
Sequence 13 Sequence 14			Cutoff Voltage	0.00	[V]
Sequence 15			Record Condition -		
			☑ <u>T</u> ime Interval ☐ Delta <u>V</u> ultage	1	[>] [V]

Fig.4-22 Cole-Cole plot measurement



Fig.4-23 Conceptual diagram of Cole-Cole plot measurement

Iter	n	Description	Input range
Comment		You can enter up to 16 arbitrary characters. You can e but they are discarded. Past comments are stored and when you click the arrow.	enter more than 16 characters, d displayed in the drop-down list
Measure the OCV before starting the sequence.		Select the check box to set the fuel cell to no load condition (open circuit) and measure the cell voltage. The load is turned off, and the OCV (Open Circuit Voltage) is measured before starting each sequence.	(No relevant values)
Load Off Perio	d	Sets the OCV measurement time.	1 to 60 [s]
Current Range)	Selects the current range.	*1
Current		Sets the load current.	*1
Rest Time		Sets the rest time after the sequence sheet is completed.	0 to 12 [h] 0 to 59 [min]
Change the current to the current value of the next sequence along a slope over the rest time.		The current is changed from the value at the end of the sequence sheet to the start current of the next sequence sheet during the rest time. The load current is changed in steps at 1 second interval.	(No relevant values)
Impedance Measurement	Start Frequency	Sets the start frequency at which the AC impedance measurement is performed.	10m to 20k [Hz]
Condition	Stop Frequency	Sets the stop frequency at which the AC impedance measurement is performed.	10m to 20k [Hz]
	Use the frequency option.	Select the check box to click the button. Press the button to set the frequency in detail (Fig.4- 19).	Frequency option
	Measuring AC Current	Sets the measuring AC current used to measure the AC impedance.	0 to 10 [%] of the load current
	Measure Range	Sets the measurement range at which the AC impedance measurement is performed.	AUTO
	Moving Average	Sets the moving average count of the AC impedance measurement.	1 to 256 (1, 2, 4, 8, 16, 32, 64, 128, or 256)
Cutoff Condition	Cutoff Voltage	The sequence is terminated, if the cell voltage falls to or below the cutoff voltage.	-2 to 150 [V]
Record Condition	Time Interval	Sets the time interval for acquiring data.	1 to 3600[s]
	Delta Voltage	If the difference between the previous voltage data and the present voltage data is greater than or equal to the delta voltage, the data is recorded.	0.001 to 1.000[V]

*1. Depends on the capacity of the electronic load unit that is being used.

4.9.6 AC impedance measurement

This mode measures the impedance at arbitrary frequency points continuously during the generating time.

1 In the Test Condition Item Pane, click Sequence (1 to 15).

You can select any of the sequences from 1 to 15 in the Test Conditions Item Pane. Select the sequence considering the cycle order.

2 In the **Test Mode** box, select **AC Impedance Measurement**.

Test Conditions	Measurement				
Rotection	Test <u>M</u> ode	AC Impedance Measurement	~		
C Startup	Comment		*		
Shutdown	Measure the OC	V before starting the sequence.	Load Off Period 2	[5]	
Sequence 3 Sequence 3 Sequence 4 Sequence 5 Sequence 6 Sequence 7 Sequence 8 Sequence 10 Sequence 10 Sequence 11 Sequence 12	Current <u>R</u> ange <u>C</u> urrent Regt Time Change the of the next s the rest time	200.0 [A] 0.10 [A] 0 [h] 1 [mn] current to the current value requence along a slope over	Impedance Measur Freguency Measuring AC Current Measure Range Moving Average Cutoff Condition Generating Time Cutoff Voltage	ement Condition 20k • 10.0 • AUTO • 32 • 0 [h] 10 -2.00 • •	[H7] [%] times [min] [V]
Sequence 14 Sequence 15			Record Condition	1.000	[5] [V]

Fig.4-24 AC impedance measurement



Fig.4-25 Conceptual diagram of AC impedance measurement

Iter	n	Description	Input range
Comment		You can enter up to 16 arbitrary characters. You can e but they are discarded. Past comments are stored and when you click the arrow.	enter more than 16 characters, d displayed in the drop-down list
Measure the OCV before starting the sequence.		Select the check box to set the fuel cell to no load condition (open circuit) and measure the cell voltage. The load is turned off, and the OCV (Open Circuit Voltage) is measured before starting each sequence.	(No relevant values)
Load Off Period	d	Sets the OCV measurement time.	1 to 60 [s]
Current Range		Selects the current range.	*1
Current		Sets the load current.	*1
Rest Time		Sets the rest time after the sequence sheet is completed.	0 to 12 [h] 0 to 59 [min]
Change the current to the current value of the next sequence along a slope over the rest time.		The current is changed from the value at the end of the sequence sheet to the start current of the next sequence sheet during the rest time. The load current is changed in steps at 1 second interval.	(No relevant values)
Impedance Measurement	Frequency	Sets the frequency at which the AC impedance measurement is performed.	10m to 20k [Hz]
Condition	Measuring AC Current	Sets the measuring AC current used to measure the AC impedance.	0 to 10 [%] of the load current
	Measure Range	Sets the measurement range at which the AC impedance measurement is performed.	AUTO
	Moving Average	Sets the moving average count of the AC impedance measurement.	1 to 256 (1, 2, 4, 8, 16, 32, 64, 128, or 256)
Cutoff Condition	Generating Time	Sets the generating time during which power is generated in the sequence.	0 to 8 [h] 0 to 59 [min]
	Cutoff Voltage	The sequence is terminated, if the cell voltage falls to or below the cutoff voltage.	-2 to 150 [V]
Record Condition	Time Interval	Sets the time interval for acquiring data.	1 to 3600[s]
	Delta Voltage	If the difference between the previous voltage data and the present voltage data is greater than or equal to the delta voltage, the data is recorded.	0.001 to 1.000[V]

*1. Depends on the capacity of the electronic load unit that is being used.

4.9.7 Current Interrupt Measurement

This mode measures the internal resistance using the current interrupt method. The measurement is repeated by the specified repeat count.

1 In the Test Condition Item Pane, click Sequence (1 to 15).

You can select any of the sequences from 1 to 15 in the Test Conditions Item Pane. Select the sequence considering the cycle order.

2 In the Test Mode box, select Current Interrupt Measurement.

	1				
Fuel Cell Information Protection	Measurement Test <u>M</u> ode	Current Interrupt Measurem	ient 🔽		
E 🔛 Cycle	Comment		V		
Shutdown	Measure the OCV	before starting the sequence	e. Load Olf Period 2	\$]	
Sequence 2 Sequence 3 Sequence 3 Sequence 5 Sequence 5 Sequence 6 Sequence 8 Sequence 8 Sequence 9 Sequence 10 Sequence 11 Sequence 12	Current <u>R</u> ange <u>C</u> urrent Regt Time Change the cu of the next se the rest time. Cutoff Condition Repeat Count Cutoff Vollage	200.0 (A) 0.10 (A) 0 [h] [mm] rrent to the current value quence along a slope over 1 1 times U.UU [V]	Impedance Measurn Pulse Width Pulse Depth Transition Time Sampling Position Sampling Region Muving <u>Average</u>	1.0 1.0 5.00 0.510 32	[ms] [%] [ms] [ms] [ms] times
Sequence 13 Sequence 14 Sequence 15	Record Condition	1 [5] 1.000 [√]	Show Waveform Trigger Point Display Data	n Data U.UUU 0.100	[5] [5]

Fig.4-26 Current interrupt measurement



Time [s]



• The waveform shows the voltage and current data of the last current interrupt.

•

Iter	n	Description	Input range
Comment		You can enter up to 16 arbitrary characters. You can e but they are discarded. Past comments are stored and when you click the arrow.	enter more than 16 characters, d displayed in the drop-down list
Measure the OCV before starting the sequence.		Select the check box to set the fuel cell to no load condition (open circuit) and measure the cell voltage. The load is turned off, and the OCV (Open Circuit Voltage) is measured before starting each sequence.	(No relevant values)
Load Off Perio	d	Sets the OCV measurement time.	1 to 60 [s]
Current Range	9	Selects the current range.	*1
Current		Sets the load current.	*1
Rest Time		Sets the rest time after the sequence sheet is completed.	0 to 12 [h] 0 to 59 [min]
Change the current to the current value of the next sequence along a slope over the rest time.		The current is changed from the value at the end of the sequence sheet to the start current of the next sequence sheet during the rest time. The load current is changed in steps at 1 second interval.	(No relevant values)
Impedance Measurement	Pulse Width	Sets the pulse width of the current interrupt method.	0.1 to 10.0 [ms]
Condition	Pulse Depth	Sets the pulse depth of the current interrupt method.	0 to 100 [%]
	Transition Time	Sets the transition time of the current interrupt method.	0.00 to 10.00 [ms]
	Sampling Position	Sets the sampling start position of the current interrupt method.	0.00 to 9.99 [ms]
	Sampling Region	Sets the sampling region of the current interrupt method.	0.002, 0.006, 0.014, 0.030, 0.062, 0.126, 0.254, or 0.510 [ms]
	Moving Average	Sets the moving average count of the AC impedance measurement.	1 to 256 (1, 2, 4, 8, 16, 32, 64, 128, or 256)
Cutoff Condition	Repeat Count	Sets the number of times to repeat the current interrupt method.	1 to 999 times
	Cutoff Voltage	The sequence is terminated, if the cell voltage falls to or below the cutoff voltage.	-2 to 150 [V]
Record Condition	Time Interval	Sets the time interval for acquiring data.	1 to 3600[s]
	Delta Voltage	If the difference between the previous voltage data and the present voltage data is greater than or equal to the delta voltage, the data is recorded.	0.001 to 1.000[V]
Show Wavefor	m Data	Select the check box to show the voltage and current waveforms of the current interrupt method.	(No relevant values)
Trigger Point		Sets the point to start the waveform acquisition.	0.000 to 0.100 [s]
Display Data		Sets the time for displaying the waveform.	0.000 to 0.100 [s]

*1. Depends on the capacity of the electronic load unit that is being used.

4.9.8 Constant Current Test

This mode performs constant current measurement during the generating time.

1 In the Test Condition Item Pane, click **Sequence (1 to 15)**.

You can select any of the sequences from 1 to 15 in the Test Conditions Item Pane. Select the sequence considering the cycle order.

2 In the Test Mode box, select Constant Current Test.

🚉 Untitled - FCTester Conditio	on Editor	
Untitled - FCTester Condition Ele Edit View Tools Help Test Conditions Test Conditions Fuel Cell Information Protection Cycle Startup Shutdown Sequence 1 Sequence 2 Sequence 2 Sequence 3 Sequence 5	on Editor Measurement Scanner Test Mode Constant Current Test Comment Measure the OCV before starting the sequence. Load Off Period 2 [s] Current Bange 200.0 [A] Current Current (A) Current (A) Cutoff Condition Generating Time 0 [h] 10 [Cutoff Voltage 0.00 [c]	[min] [V]
Sequence 3 Sequence 3 Sequence 4 Sequence 5 Sequence 5 Sequence 7 Sequence 7 Sequence 7 Sequence 10 Sequence 10 Sequence 11 Sequence 13 Sequence 14 Sequence 15	Rest Time 0 [h] 1 [min] Change the current to the current value of the next sequence along a slope over the rest time.	x] s] x]
		NUM

Fig.4-28 Constant current test



Fig.4-29 Conceptual diagram of constant current test

Ite	em	Description	Input range			
Comment		You can enter up to 16 arbitrary characters. You can e but they are discarded. Past comments are stored and when you click the arrow.	You can enter up to 16 arbitrary characters. You can enter more than 16 characters, but they are discarded. Past comments are stored and displayed in the drop-down list when you click the arrow.			
Measure the OCV before starting the sequence.		Select the check box to set the fuel cell to no load condition (open circuit) and measure the cell voltage. The load is turned off, and the OCV (Open Circuit Voltage) is measured before starting each sequence.	(No relevant values)			
Load Off Pe	eriod	Sets the OCV measurement time.	1 to 60 [s]			
Current Ra	nge	Selects the current range.	*1			
Current		Sets the load current.	*1			
Rest Time		Sets the rest time after the sequence sheet is completed.	0 to 12 [h] 0 to 59 [min]			
Change the current to the current value of the next sequence along a slope over the rest time.		The current is changed from the value at the end of the sequence sheet to the start current of the next sequence sheet during the rest time. The load current is changed in steps at 1 second interval.	(No relevant values)			
Cutoff Condition	Generating Time	Sets the generating time during which power is generated in the sequence.	0 to 12 [h] 0 to 59 [min]			
	Cutoff Voltage	The sequence is terminated, if the cell voltage falls to or below the cutoff voltage.	-2 to 150 [V]			
Record Condition	Time Interval	Sets the time interval for acquiring data.	1 to 3600[s]			
	Delta Voltage	If the difference between the previous voltage data and the present voltage data is greater than or equal to the delta voltage, the data is recorded.	0.001 to 1.000[V]			

 $^{\ast}1.~$ Depends on the capacity of the electronic load unit that is being used.

4.9.9 Constant Voltage Test

This mode performs constant voltage measurement during the generating time.

1 In the Test Condition Item Pane, click **Sequence (1 to 15)**.

You can select any of the sequences from 1 to 15 in the Test Conditions Item Pane. Select the sequence considering the cycle order.

2 In the Test Mode box, select Constant Current Test.

Test Conditions					
Fuel Cell Information Protection Cycle Startup Shutdown Sequence	Measurement	Constant Voltage Test V before starting the sequence.	Load Off Period 2		[\$]
Sequence 2 Sequence 3 Sequence 4 Sequence 5 Sequence 5 Sequence 6 Sequence 8 Sequence 8 Sequence 10 Sequence 11 Sequence 12 Sequence 12 Sequence 14 Sequence 15	Current <u>R</u> ange <u>C</u> urront Voltage <u>R</u> ange <u>V</u> oltage Regt Time Change the c ☐ of the next s the rest time	Current Range 200:0 [A] Qurrent 0.10 [A] Voltage Range 0.00 [V] Yoltage 0.00 [V] Regt Time 0 [h] 1 Change the current to the current value of the next sequence along a slope over the rest time.	Cutoff Condition Generating Time CC Time Cutoff Current Cutoff Voltage Record Condition Time Interval Delta Yoltage	0 [h] 0 [h] 0.00 -2.00 1 1.000 0.30	10 [min] 0 [min] [A] [V] [S] [V] [V] [A]

Fig.4-30 Constant voltage test



Fig.4-31 Conceptual diagram of constant voltage test

Ite	em	Description	Input range
Comment		You can enter up to 16 arbitrary characters. You can e but they are discarded. Past comments are stored and when you click the arrow.	enter more than 16 characters, I displayed in the drop-down list
Measure the OCV before starting the sequence.		Select the check box to set the fuel cell to no load condition (open circuit) and measure the cell voltage. The load is turned off, and the OCV (Open Circuit Voltage) is measured before starting each sequence.	(No relevant values)
Load Off Pe	eriod	Sets the OCV measurement time.	1 to 60 [s]
Current Rai	nge	Selects the current range.	*1
Current		Sets the upper limit of the load current.	*1
Voltage Rar	nge	Selects the voltage range.	15.0 [V] or 150.0 [V]
Voltage		Sets the voltage.	0 to 157.5 [V] or 0 to 15.75 [V]
Rest Time		Sets the rest time after the sequence sheet is completed.	0 to 12 [h] 0 to 59 [min]
Change the current to the current value of the next sequence along a slope over the rest time.		The current is changed from the value at the end of the sequence sheet to the start current of the next sequence sheet during the rest time. The load current is changed in steps at 1 second interval.	(No relevant values)
Cutoff Condition	Generating Time	Sets the generating time during which power is generated in the sequence.	0 to 12 [h] 0 to 59 [min]
	CC Time	Sets the time from the point when the limit current is reached. If the current falls below the limit current within the specified time, the specified time is reset.	0 to 8 [h] 0 to 59 [min]
	Cutoff Current	The sequence is terminated if the current falls to or below the cutoff current when the operation mode is constant voltage.	*1
	Cutoff Voltage	The sequence is terminated, if the cell voltage falls to or below the cutoff voltage.	-2 to 150 [V]
Record Condition	Time Interval	Sets the time interval for acquiring data.	1 to 3600[s]
	Delta Voltage	If the difference between the previous voltage data and the present voltage data is greater than or equal to the delta voltage, the data is recorded.	0.001 to 1.000[V]
	Delta Current	If the difference between the previous current data and the present current data is greater than or equal to the delta current, the data is recorded.	*1

 $^{\ast}1.~$ Depends on the capacity of the electronic load unit that is being used.

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Executing Tests

This chapter describes the FCTester Executive (test execution program).

5.1 About the FCTester Executive

FCTester Executive executes the tests according to the test conditions that you create with the Condition Editor.

The FCTester Executive provides the following functions.

- Load test conditions and display a brief summary of the conditions
- Execute tests
- Display and save the measured data

Starting the FCTester Executive

On the taskbar, click the Start button, and then select **Programs > kikusui Fuel Cell Tester 1.1 > FCTester Executive**.

The following window opens.



Fig.5-2 Toolbar

5.2 Window Description

Window	Description
Test Conditions and Test Data Tree Pane	Displays the current test conditions and the status of the test data in a tree structure.
Graph and Data Pane	Displays the item selected in the Test Conditions and Test Data Tree Pane.
Monitor and Event Log Pane	Displays the monitored value of the voltage and impedance. The Event Log displays the operation log such as test start and abort.
Toolbar	Items that are used often are indicated as icons. The following icons are available: Open, Close, Stop, Alarm Reset, Panel, Monitor Start, Option, Test Conditions, Manual, and Emergency Stop.
Status monitor	Displays the main information of the KFM2150 (load on, operation mode of the electronic load unit, voltage, and current).

Table 5-1 Window structure

5.2.1 Test Conditions and Test Data Tree Pane

When the FCTester Executive is started, only the Test Conditions and Test Data are displayed.

Test condition items

When you load test conditions by choosing **Open** from the **File** menu, a tree similar to the one in the Condition Editor is displayed.

- The sequence sheets (1 to 15) whose check box is selected in the test cycle sequence in the Condition Editor cycle are displayed.
- Startup and Shutdown are displayed even if it is disabled in the cycle setting of the Condition Editor.

Test data items

Items such as life and cycle are displayed as the test progresses.





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5.2.2 Graph and Data Pane

Test conditions display

When you select a test condition item on the Test Conditions and Test Data Tree Pane, the contents in Table 5-2 are shown.

Table 5-2 Test conditions

	Item	Displayed contents
Tes	st conditions	Test conditions created using the FCTester Condition
	Fuel Cell Information	Editor
	Protection	(displays the settings of each sheet item).
	Cycle	
	Startup	
	Shutdown	
	Sequence 1 to 15	

For the procedure to change the test conditions, see section 5.3.4, \checkmark Changing Test Conditions during the Test.

Test data display

When you select a test data item on the Test Conditions and Test Data Tree Pane, the contents in Table 5-3 are shown.

Table 5-3 Test data

			lte	em	Displayed contents
Tes	t Dat	a			Real-time graph of the test currently in progress.
	Life				Displays the result after each sequence is completed. (Finished By, Test Mode, Elapsed Time, Start Time, Start Voltage, Start Current, Start Resistance, Start Reactance, Start Impedance, Start Phase, Finish Voltage, Finish Current, Finish Resistance, Finish Reactance, Finish Impedance, and Finish Phase)
	C	ycle	n		Displays the result after each sequence is completed.
		Se	equ	ence n (m)	Without the scanner option: Displays the graph of this sequence.
					With the scanner option: Displays the graph of the stack channel of this sequence.
			So	canner	With the scanner option: Displays the graphs of multiple channels of this sequence (excluding the stack channel).
				Channel (n)	With the scanner option: Displays the graph of channel n of this sequence.

Test data

Displays the real-time graph of the test currently in progress. The graph is shown in the format corresponding to the test mode and sequence.

The graph displays up to 64 data values. For current interrupt measurement, the last waveform data during the current interrupt measurement is displayed. If the scanner option is enabled, the last waveform data of the first selected channel is displayed.



Fig.5-4 I-V measurement example

Life

Displays a simple result of the finished sequence.

A portion of the data such as OCV (Open Circuit Voltage) is displayed for the sequence that is in progress. Startup and shutdown sequences are not displayed.

FCTester Executive												. 🖻 🔀
Elle View Test Graph Tools	Help											
er					ſ]1		?				
Open Start	Stop	Alarm Reset	Panel	Monitor	Graph	Option	Condition Editor	Manu	Jal E	Emergency Stop		
Fest Conditions (rest.int) Fest Conditions (rest.int) Fordection Protection Protection Sequence 1 Sequence 1 Sequence 3 Sequence 3 Sequence 3 Sequence 3 Sequence 1 Sequence 1	Cy 10 10 10 10 10 10 10 20 20 20 20 20 20 20 20 20 20 20 20 20	cle Termination (1)] Test End (2)] Test End (Time) (3)] Test End (Time) (4)] Test End (Time) (2)] Test End (Time) (2)] Test End (Time) (4)] Test End (Time)	Test Mode 1-V Cole Cole Plot Impedance (Cole Plot Impedance (Cole Plot Impedance (Cole Plot Impedance (CV I-V Cole Cole Plot Impedance (CV I-V I-V Cole Cole Plot Impedance (CV I-V I-V Impedance (CV I-V I-V Impedance (CV I-V Impedance I-V Impedance I-V I-V Impedance I-V I-V I-V I-V I-V I-V I-V I-V	Elspeed [0:3:24.17] [0:1:070] [0:1:070] [0:1:050] [0:1:0541 [0:1:0541] [0:1:1051] [0:1:1051] [0:1:1054] [0:1:0.641] [0:1:0.641] [0:1:0.64] [0:1:0.64] 	OCV [V]	Start Tim 9/19/2000 9/19/2000 9/19/2000 9/19/2000 9/19/2000 9/19/2000 9/19/2000 9/19/2000 9/19/2000 9/19/2000	e [httmis] 5 11:29:17 AM 5 11:29:42 AM 5 11:30:42 AA 5 11:30:24 AA 5 11:30:20 AM 5 11:41:52 AM 5 11:41:52 AM 5 11:41:52 AM 5 11:41:52 AM 5 11:41:53 AM 5 11:51:44:53 AM 5 11:55:46 AM 5 11:55:48 AM	Start V 12,2174 11,9732 11,9517 12,0243 12,1633 11,9248 12,0044 12,01044 12,01044 11,9295 11,18894 11,9892 12,1198	Start -0.0138 9.0450 4.7104 -0.0063 -0.0189 11.0016 4.5503 -0.0189 -0.0064 11.0914 4.9450 -0.0123 -0.0035	Start R 5.8186 8.6679 5.8892 9.0892 9.0892 9.0732 9.1701 	Start R 0.9344 24.7500 0.9344 24.7277	Start Im 5.8908 25.6475 5.9445 26.3631 6.0458 26.3733
Sequence3 (1)	~ <											>
Channel Number Channel Name	Cycle	Status Test Mod	Time [h:min:] Voltage [V] Current	[A] Pow	er [W] Time [h:min:s]	Frequency	y [Hz] Resist	ance [mOhm] Reacta

Fig.5-5 Result display of the finished sequences

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Cycle n

Displays a simple result of the sequences in the cycle.

😪 FCTester Executive												. 🕫 🔀
Eile ⊻iew Test Graph Iools Help	p				_							
		0			ſ	1		1				
Open Start	Stop	Alarm Reset	Panel	Monitor	Graph	Option	Condition Editor	Man	Jal E	imergency Stop		
Test Conditions (test.fcct)	Cycle	Termination	Test Mode	Elapsed	OCV [V]	Start Tir	me [h:min:s]	Start V	Start	Start R	Start R	Start Imp
Protection Cycle Startup	1 [1(1) 1 [2(1) 1 [3(1) 1 [4(1)	I] Test End] Test End] Test End (Time)] Test End (Time)	I-V Cole Cole Plot Impedance CV	[0:3:24.17] [0:2:40.56] [0:1:0.70] [0:1:0.51]		9/19/20 9/19/20 9/19/20 9/19/20	06 11:29:17 AM 06 11:32:42 AM 06 11:36:24 AM 06 11:37:26 AM	12.2174 11.9732 11.9517 12.0243	-0.0138 9.0450 4.7104 -0.0063	5.8186 8.6879	0.9199 24.1312 	5.8908 25.6475
Shutdown Sequence 1 Sequence 2 Sequence 3												
Sequence 4												
Sequence1 (1) Sequence2 (1) Sequence3 (1) Sequence3 (1)												
Cycle 2 Cycle 2 Sequence1 (1) Sequence2 (1)												
Sequence3 (1) Sequence4 (1) Cycle 3 Sequence1 (1)												
Sequence2 (1)												
Sequence3 (1)	~ <)						>

Fig.5-6 Result display of cycles 1 to 5

Sequence n (m) (without the scanner option)

Displays the graph of the measured sequence.



Fig.5-7 Graph display of the sequence

Sequence n (m)

••••

Displays the graph of the stack channel of the measured sequence.



Fig.5-8 Display example of a stack channel graph



_____ Sequence number

Scanner (with the scanner option)

Displays the multiple channel graph of the measured sequence.



Fig.5-9 Display example of a multiple channel graph

....

Channel n (with the scanner option)

Displays the channel graph of the measured sequence.



Fig.5-10 Channel graph display example

5.2.3 Monitor and Event Log Pane

If the **Monitor** tab is selected, the monitored values of the voltage and impedance of the test currently in progress are displayed.

If **Monitor** is enabled, the voltage and current are monitored even when the test is not in progress.

Channel Number	Channel Name	Cycle	Status	Test Mode	Time [h:min:s]	Voltage [V]	Current [A]	Power [W]	Time [h:min:s]	Frequency [Hz]	Resistance [mOhm]	Reactar
KFM2150	Voltage Sensi	4[1(1)]	Testing	I-∀	[0:2:28.11]	11.8849	5.4662	64.9656				
<												>
🥥 Monitor 🔄 I	Event Log											

Fig.5-11 Real-time monitor

If the **Event Log** is selected, the operation log from when the application is started is displayed.



Fig.5-12 Event log

••••

5.3 **Executing Tests**

5.3.1 Using the Startup Sequence

If the **Use the startup sequence** check box is selected in the Cycle setting of the test conditions using the Condition Editor.

Starting the test

Start the test according to the procedure below.

🔩 FCTester Executive 1 File View Test Graph Tools Start... 2 Open 3 Test C 0 🛒 Panel Control... Pre Monitor Shutdown Sequence 1 2 Sequence 2 Sequence 3 2 📉 Sequence 4

Fig.5-13 Test menu

- 1 From the **File** menu, select **Open**.
- 2 Select the test conditions file you want to load from the Open window.

When the file is loaded, the test condition items are displayed in a tree structure on the Test Conditions and Test Data Tree Pane.

3 From the **Test** menu, select **Monitor**.

You can start the test only when the monitor is started.

You can check whether the monitor has started on the **Monitor** tab on the Monitor and Event Log Pane. If the voltage and current are updated on the Pane, the monitor is running.

4 Select **Start** from the **Test** menu or click Start on the toolbar.

The Start dialog box opens.

Start	×	
•	The test will start. (test mode: Startup and maximum current 10.0A)	If Start is not available, see "Starting the test without the startup sequence" on
	Use a startup sequence. Restart the test from the aborted sequence.	the next page.
<u> </u>	anel Control Start Cancel	

Fig.5-14 Start

5 Click Start.

When the test starts, the windows shown in Fig.5-15 appears.



••••

Test Data is selected automatically on the Test Conditions and Test Data Tree Item Pane, and the Graph and Data Pane displays the real-time graph of the test currently in progress.

The status monitor displays TEST.



Fig.5-15 Test data display

5.3.2 Not Using the Startup Sequence

If the **Use the startup sequence** check box is cleared in the Cycle setting of the test conditions using the Condition Editor. Load on/off, load current setting, and soft start function are controlled from the Panel Control.

This is useful if you want to start the test after checking the status of the fuel cell operation. You can set the load current from the Panel Control and check the operation status before starting the test using sequences.

Starting the test

1 Carry out steps 1 to 4 in section 5.3.1, X Using the Startup Sequence." The **Start** button in the Start dialog box is unavailable.

⚠	The load is not turned on. The load must be turned on to start the test. Use the panel control to turn the load on, or use the startup sequence.
	Use a startup sequence. Restart the test from the aborted sequence.

Fig.5-16 When Start is unavailable
2 In the Start dialog box, click **Panel Control**.

The Panel Control dialog box appears.

anel Control	
Electronic Load Measur	urement Test Data Protection
Load Current Range 200 <u>C</u> urrent 0.00	Image: [A] Load <u>0</u> n Image: [A] Load 0[f
0	Limit 200.00 😂 [A]
Current Sweep Current sweep is perfo current value.	ormed from the present load Start the Sweep. 0.00 [A1 Step Current 0.10 [A1
Final Current	0.00 [A] Step Time 0 [min] 1 [s]
Turn the load off wi	when the load current is set to 0 A.
Soft Start <u>R</u> ise 0	(h) 1 (min) Fall
	Close

Fig.5-17 Panel Control

If you want to start the test from a specific load current (not 0 A), carry out the procedure below in the **Electronic Load** page.

- 3 Select the load current range of the electronic load unit.
- 4 Type the load current value.

When not using the soft start function

5 Click Load On.

The load of the electronic load unit turns on, and the load current flows. Click **Load Off** to turn the load off.

6 Click Close.

The Start dialog box shown in Fig.5-16 appears.

7 Click Start.

The test starts.

When using the soft start function

- 5 Select the Soft Start check box.
- **6** Type in values of **Rise** Time and **Fall** Time.

7 Click Load On.

The load of the electronic load unit turns on, and the soft start function starts.

8. Click Close.

The Start dialog box shown in Fig.5-16 appears. The **Start** button is unavailable until the rise time elapses.

9 When the Start button becomes available, click it.

The test starts.

5.3.3 Adding a startup sequence at the start of the test

You can add a startup sequence to start the test even if the startup sequence is disabled in the loaded test conditions.

- 1 Carry out steps 1 to 4 in section 5.3.1, X Using the Startup Sequence. The **Start** button in the Start dialog box is unavailable.
- 2 In the Start dialog box of Fig.5-16, select the **Use a startup sequence**. check box.

The **Start** button becomes available.

3 Click Start.

The test starts.

5.3.4 Changing Test Conditions during the Test

From the **Tools** menu, select **Options**. If you select the **Change the test conditions during the test** check box, the test conditions file that is currently loaded in the Test Executive is reloaded after the current sequence is finished.

If you edit and overwrite the current test conditions, the new test conditions are applied from the next sequence.

Options 🛛
Test Condition
If you select the "Change the test conditions during the Test" check box and you edit and overwrite the test conditions file that is currently loaded in the Test Executive, the new test conditions are applied from the next sequence.
Change the test conditions during the Test
OK Cancel

Fig.5-18 Options Window



5.3.5 Stopping the Test

The following two methods are available to stop a test in progress.



Fig.5-19 Stop and Emergency Stop on the toolbar

Emergency Stop

Select Emergency Stop if you want to stop the test immediately.

1 Select **Emergency Stop** from the **Test** menu or click **Emergency Stop** on the toolbar.

The test stops, and the load of the electronic load unit is turned off.

Stop

Select **Stop** if you want to stop the test under a given condition.

If you select Stop, the load of the electronic load unit does not turn off automatically. You must manually turn the load off.

If the test conditions include the shutdown sequence or if you enable **Use the startup sequence** in the Start dialog box, the load of the electronic load unit turns off when the test stops.

Select Stop from the Test menu or click Stop on the toolbar.

The Stop dialog box opens.

itop	2 2
Stop Action Stop immediately. Stop after the pre] esent gequence is completed. esent cycle is completed.
Use the shutdowr	n sequence.
	OK Cancel
Fig E O	0 Stan

Fig.5-20 Stop

2 Select the stop action and click **OK**.

If the loaded test conditions do not include the shutdown sequence, you can enable it by selecting the **Use the shutdown sequence** check box in the Stop dialog box. In this case, the shutdown sequence is executed after the selected stop action. Then, the test stops, and the load of the electronic load unit is turned off.

5.3.6 Alarm Occurrence

If a protection function is activated during a test, an alarm occurs, and the test stops. The status display of the Monitor and Event Pane indicates the word Alarm.

Channel Number	Channel Name	Terminal Number	Cycle	Status	Test Mode	Time [h:min:s]	Voltage [V]	Current [A]	Power [W]	Time
KFM2150	Voltage Sensin		1 [2(1)]	Alarm (UVP)			0.0270	-0.0250	-0.0007	
032	Stack	[0][1-1]		💽			0.0001			
001	Channel 001	[0][1-1]					-0.0004			
002	Channel 002	[0][1-1]		\			0.0007			
003	Channel 003	[0][3-3]		\			0.0000			
004	Channel 004	[0][1-1]		\			0.0002			
005	Channel 005	[0][1-1]		\			-0.0009			
006	Channel 006	[0][1-1]					-0.0013			
007	Channel 007	[0][1-1]					-0.0006			
800	Channel 008	[0][1-1]					0.0006			
009	Channel 009	[0][1-1]					0.0011			
<										>

Fig.5-21 Alarm occurrence



Fig.5-22 Reset Alarm on the toolbar

To reset an alarm, carry out the procedure below.

1 Select **Reset Alarm** from the **Test** menu or click **Reset Alarm** on the toolbar.

The alarm is reset, and you can execute the test again. Eliminate the cause of the alarm before you execute the test again.

5.3.7 Test Completion

The test is complete when all the cycles specified in the test conditions are finished.

The status monitor switches from TEST to IDLE.

If you want to execute the test again using the same test conditions, you can simply start the test.

If you want to change the test conditions, load a new test conditions file. Because the monitor is already started, you can immediately start the test after the test conditions are loaded.

Load off

The load remains on if the shutdown sequence is not used. To turn the load off, carry out the procedure below.

1 From the **Test** menu, select **Panel Control**.

The Panel Control dialog box opens. Carry out the following steps in the Electronic Load page.

2 Click Load Off.

The load of the electronic load unit turns off.

3 Click Close.

5-14

5.4 Panel Control

Panel Control consists of the Electronic Load, Measurement, Test Data, and Protection pages. It allows you to carry out operations equivalent to the operations on the KFM2150. In addition, you can perform current sweep (I-V measurement) and frequency sweep (Cole-Cole plot measurement). Panel Control cannot be used if a test is being executed according to the procedure given in section 5.3, % Executing Tests."

Basic operation

- From the Test menu, select Panel Control.
- There is no need to set test conditions using the Condition Editor.
- Press the up and down keys for the setup items with spin control to change the value. The value is immediately applied.
- If you enter the value directly in the text box, the value is applied when you press the Enter key in the text box.
- If you do not press the Enter key, the value is not applied to the KFM2150. However, it is applied if you move to another tab page or if you press the Close button.

5.4.1 Electronic Load page

Load current

Set the current range and load current. If you set the current limit, you will not be able to set a current higher than the limit. This prevents you from setting an incorrect load current. You can also set the current using the slider control. Resolution specifies the resolution in which the load current is changed when you press the up and down keys.

Current Sweep

Click **Start the sweep** to perform a load current sweep from the present preset current by the specified step unit. The operation is equivalent to the I-V sequence. If you want to stop the current sweep, click **Stop the sweep**. The test stops in that condition. Operation on other pages is prohibited while the current sweep is in progress.

Soft Start

You can use the soft start function of the KFM2150 by select the **Soft Start** check box and turning the load on/off.

If you change the rise or fall time during the soft start operation, the rise or fall time changes. If you set the rising or falling time to 0 s, the load turns on/off.

Panel Control
Electronic Load Measurement Test Data Protection
Load Current Load <u>On</u> Range 200 ♥ [A] urrent 0.00 ♀ [A] Load <u>On</u> Load Off
0 Line 200.00 (A)
Current Sweep Current sweep is performed from the present load Current value. Fold-back Current O.00 [A] Step Current O.10 [A]
Final Current 0.00 [A] Step Time 0 [min] 1 [s]
Turn the load off when the load current is set to 0 A.
Soft Start <u>B</u> ise 0 \$ [h] 1 \$ [min] Fall 0 \$ [h] 1 \$ [min]
Close Cancel

Fig.5-23 Electronic load page

5.4.2 Measurement page

Set the conditions for the AC impedance and current interrupt measurements.

Click **Start the sweep** to perform a measuring frequency sweep from the present preset frequency to the stop frequency. If you want to stop the frequency sweep, click **Stop the sweep**. The test stops in that condition. Operation on other pages is prohibited while the current sweep is in progress.

mpedance Measu	irement		
Erequency Measuring AC Current	20k 🔽 [Hz 10.0 🛟 [%]	:]	
Sweep from the p frequency.	resent frequency to	the stop	Start the <u>s</u> weep
Stop Frequency	10 🔽 (Ha	:]	
Current Interrupt			
Pulse <u>W</u> idth	10.0 🔅 [ms	Sampling	
<u>P</u> ulse	100 🔅 [%]	Start Position	6.00 🗘 [ms]
Transition	10.00 💲 [ms] P <u>e</u> riod	0.510 💉 [ms]

Fig.5-24 Measure page



5.4.3 Test Data page

The measured data is saved according to the record conditions from the time you select the **Start Recording** check box until you clear the check box. If you start a current or frequency sweep, a test conditions file is created automatically according to the specified record conditions.

The data file of the simplified measurement on the Panel Control is created in the test data folder.

Panel Control		×
Electronic Load	Measurement Test Data Protection	
The measured (the Start Record If you start a cu according to the	data is saved according to the record conditions from the time you select ding check box until you clear the check box. rrent or frequency sweep, a test conditions file is created automatically e specified record conditions.	
■ Start <u>R</u> ec → Record Cond	ording	
🔽 Delta <u>T</u> im	e 10 [s]	
📃 Delta <u>V</u> oli	age 0.100 [V]	
Delta <u>C</u> un	ent	
<u>N</u> ominal Voltage	e 1.00 [V]	
Destination Fold	ler for Saving the Test	
C:\\Program Fi	es\Kikusui\Fuel Cell Tester 1.1\	
	Modify	
	Close	

Fig.5-25 Test Data page

5.4.4 Protection page

Set the KFM2150 protection. If clear a check box, the protection function is turned off. If you clear the Impedance UVP check box, the voltage is set to -2 [V].

Panel Control			
Electronic Load Measurement	Test Data	Protection	
☐ Impedance UVP ☐ E-Load <u>O</u> PP ✔ E-Load <u>U</u> VP	-2.00 1100.0 0.00	[V]	
			Close Cancel

Fig.5-26 Protection page

5.5 Setting the Graph Display

You can set the graph display even while a test is in progress. The display items include graph options, copy to clipboard, zoom, move, cursor, and default.

5.5.1 Graph Options

From the **Graph** menu, select **Graph Options**. Scale, Pattern, View, and 3D pages appear.

Scale

For the scale, you can select Manual, Auto, or Fixed.

If you select manual scale, you can arbitrarily set the maximum and minimum values of the scale. If you select auto scale, the scale is automatically set from the measured data. If you select fixed scale, fixed scale values are set from the test conditions. This setting is available for time, voltage, and current (density). The fixed scale set from the test conditions is indicated in Table 5-4.

X/Y/Z Axes	Scal	e	Mini	num			Max	amum	
<u>T</u> ime	Auto	*	0	[h]	0	[min]	0	[h]	1 [min]
<u>V</u> oltage	Auto	*	0.00		[V]		1.23		[V]
<u>C</u> urrent	Auto	*	0.00		[A]		10.0	0	[A]
<u>F</u> requency	Auto	*	0.000	0	[Hz]		0.00	00	[Hz]
<u>R</u> esistance	Auto	*	0.000		[Ohm]		1.00	00	[Ohm]
R <u>e</u> actance	Auto	*	0.000		[Ohm]		1.00	00	[Ohm]
<u>I</u> mpedance	Auto	¥	0.000	0	[Ohm]		1.00	00	[0hm]
<u>P</u> hase	Auto	*	-180.0)0	[deg]		180.0	00	[deg]
View the curr Term ar	rent <u>d</u> ensity. ea 1.00	[ci	m2]						

Fig.5-27 Scale page example

Table 5-4	Fixed	scale se	et from the	e test o	conditions

Scale	Minimum value	Maximum value
Time	0 s	Generating time and rest time
Voltage	Impedance meter UVP	Nominal voltage
Current	0 A (the minimum current for I-V)	Current (the maximum current for I-V)
Frequency	The frequency specified here or the stop frequency, whichever is smaller.	The frequency specified here or the stop frequency, whichever is greater.

If you select the **View the current density** check box, the current density is calculated from the electrode area that is specified in the Fuel Cell Information of the test conditions. If the test conditions file is not loaded in the FCTester Executive, the electrode area is set to 1.00 [cm^2].

Pattern

You can set the color and width of the Y-axis line and the marker style and color. You can also set the color of the graph grid lines and the graph/frame background.

Scale Pattern View Set the color and width color of the graph grid I	3D of the Y-axis line ines and the grap	and the marker sty h/frame backgrour	le and color. You ca nd.	an also set the
-Y-Axis Line and Mark	er Width	Color	Marker Style	Color
⊻oltage	~			
Current	~	·····	 ✓ 	
<u>R</u> esistance			0 🗸	
R <u>e</u> actance			× •	
Impedance			+ •	····
<u>P</u> hase			• •	
Grid Lines	Color		Plot Area/Graph	Frame
<u>M</u> ajor			Plot <u>A</u> rea	
Minor			Graph <u>F</u> rame	
			01	

Fig.5-28 Pattern page example

View

Set the display format of the graph.

Graph Option					× • • • • • • • • • • • • • • • • • • •
Scale Pattern View	v 3D				
You can select the ty Y-axis, and whether t In addition, you can s	pe of X- and o display the elect separa	d Z-axes to be grid lines for e ate Y-axis and	displayed on each test moo grid line displ	the graph, Je. ay for each	the item displayed on the type of X- and Z-axes.
Test <u>M</u> ode IV Me	asurement	¥	🗖 Multi (Sca	i-channel vi Inner Optior	iew n)
∑-Axis O Time ⊙	Current () Resistance) [^[] <u>Z</u> -Ax O Cur	rent OF	Frequency O Channel
∽ Selection of view —	X/Y/Z Axis	Right Axis	Major Grid Line	Minor Grid Line	Consolidate the scale on the resistance axis
Time					
Voltage	✓		~		
Current			v		
Frequency					
Resistance					
Reactance					
Impedance					
Phase					
					OK Cancel

Fig.5-29 View page example

Select the X- and Z-axes type for each test mode. You can select the item to be assigned to the Y-axis, and turn on/off the scale line of each axis.

- You can select the Z-axis type depending on the test mode. Test modes on which the Z-axis is selected are displayed using a 3D graph. For 3D graphs, you can only select one item to be displayed on the Y-axis.
- Selecting the multi-channel view

You can select the multi-channel view if the scanner option is being used. If you select the multi-channel view, select the X-axis type and the item displayed on the Y-axis. The Z-axis type is fixed to channel.

· Consolidate the scale on the resistance axis

If you select this check box, the resistance and reactance are displayed consolidated on the resistance axis. The scale and pattern items of the resistance axis are used.

Test mode	X-axis type	Display selection
I-V measurement	Current	Voltage
V-I measurement	Current	Voltage
I-V + AC impedance measurement	Current	Voltage, resistance, or reactance
I-V + Cole-Cole plot measurement	Resistance	Reactance
Cole-Cole plot measurement	Resistance	Reactance
AC impedance measurement	Time	Voltage, current, resistance, or reactance
Current interrupt measurement	Time	Voltage, current, or resistance
Constant current test	Time	Voltage or current
Constant voltage test	Time	Voltage or current

Table 5-5 Default display format

3D

Sets the drawing method of the 3D graph. The setting becomes the default value of the 3D graph display.

Graph Option	
Scale Pattern View 3D	
The 3D settings set the default values of the 3D	graph display.
C Plot	
Plot Style Surface	
Color Map Style Shaded 🛛 💉	
Iransparency 20 [%]	
View Direction	Projection
OXY	X-Y Plane
O×₂	X-Z Plane
OYZ	Y-Z Plane
O User Defined	Only Show Projections
Latitude 45	
L <u>o</u> ngitude 45	
	OK Cancel

Fig.5-30 3D display page example



Plot

Plot Style	Drawing method
Point	Point
Line	Line
Line + Point	Lines and points
Hidden line	Hides lines that are located in places where they cannot be seen.
Contour	Contour
Surface	Surfaces
Surface + Line	Lines and surfaces
Surface + Contour	Contours and surfaces
Surface + Normal	Vector space and surfaces
Color Map Style	Drawing method
Shaded	Shaded
Color Spectrum	Rainbow
Gray Scale	Grayscale
Transparency	Drawing method
0 % to 100 %	Transparency
View direction	Drawing method
X-Y	X-Y, two dimensional
X-Z	X-Z, two dimensional
Y-Z	Y-Z, two dimensional
User Defined	X-Y-Z, three dimensional Latitude: Viewing angle (pitch angle) Longitude: Rotation angle (yaw angle)
Projection	Drawing method
X-Y Plane	X-Y surface
X-Z Plane	X-Z surface
Y-Z Plane	Y-Z surface
Only Show Projections	Displays only the projection surface

5.5.2 Zoom, Pan, and Cursor of the Graph

Zoom function

• 2D graph

From the **Graph** menu, select **Zoom** to expand the graph. Click the start point on the graph you want to zoom and drag the mouse to the end point.

The area shown with a dotted frame is expanded.



Fig.5-31 Zoom window of the 2D graph

• 3D graph

Hold down the Alt key and left-click on the graph. Then, drag the mouse up or down to expand or reduce the graph.

You can also scroll the mouse wheel to expand or reduce the graph.



Hold down the Alt key and left-click on the graph. Then, drag the mouse up or down.

Fig.5-32 Zoom window of the 3D graph

Pan

• 2D graph

From the **Graph** menu, select **Pan** to move the graph.

Click on the graph and drag the mouse to move the graph.



Fig.5-33 Panned window of the 2D graph

3D graph

Hold down the Shift key and left-click on the graph. Then, drag the mouse to move the graph.



Hold down the Shift key and left-click on the graph. Then, drag the graph to the desired position.

Fig.5-34 Panned window of the 3D graph

Cursor

• 2D graph

From the **Graph** menu, select **Cursor** to display a cursor. Drag the cursor to display the value at the point as a tool tip.

Currently, this function is not supported on the 3D graph.



Fig.5-35 Cursor window of the 2D graph

Rotate

• 3D graph

Click on the graph and drag the mouse to rotate the graph.



Fig.5-36 Rotated window of the 3D graph

5.6 Test Data Files

A test data file is created each time a sequence is completed. A test data file is created even if you abort the test using Emergency Stop or Stop for the data up to that point.

The test data files are created in the same location with the test conditions file (.fcct extension), and the file names are assigned as follows:



FCTester

5.6.1 File Description

The following is an example of a sequence data file opened with Excel or other spreadsheet application. The file consists of two parts: test condition data created with Condition Editor and test result data.

-Fuel Cell Information- Sample Name Membrane Catalyst W/H/D Weight [kg] Electrode Area [cm2] Nominal Voltage [V] Memo	sample1 ABC Pt-sample 30 0.1 4 1.2 sample1 TEST	5	30	Fuel Cell Information
-Protection- Impedance UVP [V]/Mask Time [s] E-Load UVP [V] E-Load OPP [W]	-2 0 300	4	_	Protection
-Test condition- Test Mode Comment Measure OCV/Load Off Period [s] Current Range [A] Current [A] Rest time [h:min:s] Start Frequency [Hz] Stop Frequency [Hz] Measuring AC Current [%] Measure Range Moving Average Cutoff Voltage [V]	Cole Cole Plot Enable 132 1 0:0:0 20000 100 100 AUTO 32 0	2	-	Test condition
-Result- Cycle Termination Factor Elapsed Time OCV [V] Start Time Start Voltage [V] Start Current [A] Start Resistance [m Ohm]	1 (2-1) Test End 0:1:25 5.1632 25/07/2018 16:59:12 25/07/2018 17:00:38 4.6788 1.1403 352.5087			

Result

Start Reactance [m Ohm]	-14.3541									
Start Impedance [m Ohm]	352.8008									
Start Phase	-2.33									
Finish	4.7627									
Finish	1 0008									
Current [A] Finish	1.0000									
Resistance [m Ohm] Finish	584.2146									
Reactance [m Ohm]	-96.1729									
Finish Impedance	592.0776									
[m Ohm] Finish Phase [deg]	-9.35									
Time1			TimeO	Frequency	Desistance	Desetance	Impodonoo	Dhasa	Cuala	Cuala
[h:min:s]	Voltage [V]	Current [A]	[h:min:s]	[Hz]	[m Ohm]	[m Ohm]	[m Ohm]	[deg]	Voltage [V]	Cycle Current [A]
0:00:00	4.6691	1.1624	0:00:02	20000	352.5087	-14.3541	352.8008	-2.33	4.6865	1.1219
0:00:02	4.6814	1.1324	0:00:04	15800	350.371	-7.3746	350.4486	-1.21	4.6877	1.1224
0:00:04	4.6727	1.1422	0:00:06	12600	350.6058	-6.4502	350.6651	-1.05	4.6856	1.1232
0:00:06	4.6737	1.1762	0:00:09	10000	352.4903	-6.811	352.5561	-1.11	4.6849	1.1227
0:00:09	4.6912	1.1597	0:00:11	9000	354.4401	-4.9448	354.4746	-0.8	4.6853	1.1226
0:00:11	4.6531	1.2066	0:00:13	8000	353.918	-5.5286	353.9611	-0.89	4.6866	1.1223
0:00:13	4.6627	1.168	0:00:15	7000	353.9027	-3.83	353.9234	-0.62	4.6862	1.1234
0:00:15	4.65	1.1742	0:00:18	6300	355.2192	-3.1122	355.2329	-0.5	4.6865	1.1219
0:00:18	4.6811	1.1235	0:00:20	6000	356.2516	-3.1987	356.2659	-0.51	4.6849	1.1235
0:00:20	4.6975	1.1079	0:00:22	5000	355.193	-0.8921	355.1941	-0.14	4.6855	1.1228
0:00:22	4.66	1.1754	0:00:24	4000	352.6647	2.0959	352.671	0.34	4.6855	1.1236
0:00:25	4.66	1.1793	0:00:27	3160	345.2523	2.3007	345.26	0.38	4.6864	1.1233
0:00:27	4.6825	1.1371	0:00:29	3000	343.639	1.3415	343.6416	0.22	4.686	1.1234
0:00:29	4.6323	1.266	0:00:32	2510	337.2833	-3.784	337.3045	-0.64	4.6855	1.1227
0:00:31	4.6591	1.2087	0:00:34	2000	332.069	-14.457	332.3836	-2.49	4.6856	1.122
0:00:33	4.7266	1.0088	0:00:37	1580	330.0544	-27.4793	331.1964	-4.76	4.6864	1.1225
0:00:36	4.6972	1.0972	0:00:40	1260	331.9672	-42.9418	334.733	-7.37	4.6874	1.1221
0:00:38	4./116	1.0359	0:00:43	1000	337.092	-59.9793	342.3865	-10.09	4.6858	1.1223
0:00:40	4.7253	0.9768	0:00:47	900	340.7608	-00.003	347.2241	-11.07	4.0845	1.1231
0:00:42	4.6446	1.2561	0:00:50	800	345.7149	-/6.6/21	354.1149	-12.5	4.6862	1.1223
0:00:45	4.7076	1.0559	0:00:54	700	352.6788	-85.1012	362.801	-13.57	4.6849	1.1228
0:00:47	4.089	1.1190	0:00:58	600	309.4180	-95.1058	3/1./000	-14.82	4.0844	1.123
0:00:49	4.0430	1.2000	0:01:01	500	303.7203	-97.5474	3/0.5/39	-15.01	4.0841	1.1231
0:00:51	4./12/	0.9919	0:01:05	500	377.9028	-111.915	394.1202	-10.5	4.0843	1.1227
0:00:54	4.6248	1.2707	0:01:08	400	402.4252	-130.113	422.9367	-17.92	4.6845	1.1225
0.00.50	4.0051	1.093	0.01.10	200	431.9790	-142.499	404.0760	10.20	4.0044	1.1227
0.00.30	4.700	0.0050	0.01.12	251	440.0005	-144.52	404.0702	-17.71	4.0040	1.1223
0.01.00	4.7083	1 0250	0.01.13	200	503 8861	-140.000	525 9662	-16.66	4.6844	1 1 2 2 8
0.01.05	4.7000	1.0233	0.01.17	158	536 5321	-130.795	554 2610	-14.53	4.6852	1 1220
0.01.00	4 6622	1 2221	0.01.20	126	567 5908	-123 806	580 9366	-12.3	4 6849	1 1225
0.01.07	4.0022	1.2221	0.01.22	100	584 2146	-96 1729	592 0776	-12.5	4 6851	1 1225
0.01.12	4 6141	1 2346	0.01.20		507.2140	50.1723	552.0770	0.00	1.0001	
0.01.14	4 6521	1 2104								
0.01.14	4 7533	1 0048								
0.01.18	4 7559	0.9719								
0:01:21	4,7331	1.0192								
0:01:23	4.668	1.1045								

Result (continued)

0:01:25

4.5964

1.2699

Description of each part

-Fuel Cell	
Information-	
Sample Name	sample1
Membrane	ABC
Catalyst	Pt-sample
W/H/D	30 5 30
Weight [kg]	0.1
Electrode Area [cm2]	4
Nominal Voltage [V]	1.2
Memo	sample1 TEST

The information entered from the screen on the right is recorded.

File Edit View Tools Hel					
: D 📽 🖬 D 📾 🛛					
Test Conditions Cucle Cel Information Protection Cucle	Enter the fuel o	ell information.			
- Startup	Sample Name	sample 1			
Shutdown	Membrane	ABC			
Sequence 2	Catalyst	Pt-sample			
Sequence 3 Sequence 4 Sequence 5 Sequence 6 Sequence 7 Sequence 8 Sequence 10 Sequence 11 Sequence 11 Sequence 13 Sequence 14 Sequence 15	<u>w</u> idth Height Depth Memg	30.0 [mm] 5.0 [mm] 30.0 [mm] sample1 TEST <	Weight Electrode Area <u>N</u> ominal Voltage	0.10 [kg] 4.00 [cm 1.20 [V]	2]

-Protection-

Impedance UVP [V]/	-2	Δ
Mask Time [s]	2	-
E-Load UVP [V]	0	
E-Load OPP [W]	300	

The information entered from the screen on the right is recorded.

Cyde	UVP -2.00	ter [V] Mask Time 4 [s]	E-Load		g instrument model	[w/
Shutdown Sequence 1 Sequence 2 Sequence 3 Sequence 4 Sequence 5	Scanner Settings fo Channel Char	r the Stack Cell (Channel 032)	QVP 0.00	[٧]	UVP 0.00	[V]
Sequence 6 Sequence 7 Sequence 8 Sequence 10 Sequence 11 Sequence 11 Sequence 12 Sequence 13 Sequence 15	Channel Number	Channel Name	OVP		UVP	

-Test condition-

Test Mode	Cole Cole Plot
Comment	
Measure OCV/Load Off Period [s]	Enable 2
Current Range [A]	132
Current [A]	1
Rest time [h:min:s]	0:0:0
Start Frequency [Hz]	20000
Stop Frequency [Hz]	100
Measuring AC Current [%]	10
Measure Range	AUTO
Moving Average	32
Cutoff Voltage [V]	0

The information entered from the screen on the right is recorded.

le <u>E</u> dit <u>V</u> iew <u>T</u> ools <u>H</u> el	p			
Test Conditions Fuel Cell Information Fuel Cell Information Cycle Startup Sequence 1 Sequence 2 Sequence 3 Sequence 4 Sequence 5 Sequence 5 Sequence 5 Sequence 6 Sequence 7 Sequence 7 Sequence 7 Sequence 10 Sequence 11 Sequence 11 Sequence 13 Sequence 13 Sequence 13 Sequence 14 Sequence 15	Measurement Test Mode Cole-Cole Plot Measurement Comment	Load Off Period 2 Impedance Measure Start Freguency Stop Frequency Use the fin Measuring AC Current Measure Range Moving Average Cutoff Condition Cutoff Voltage Record Condition	[5] ement Condition 20k ~ 100 ~ equency option 10.0 AUTO ~ 32 ~ 0.00	[Ptz] [Ptz] [Ptz] [%] [%] [%]

The "Time1" voltage and current indicated on the next page are recorded using these conditions.

-Result-	•
----------	---

Cycle	1 (2-1)
Termination Factor	Test End
Elapsed Time	0:1:25
OCV [V]	5.1632
Start Time	25/07/2018 16:59:12
Finish Time	25/07/2018 17:00:38
Start Voltage [V]	4.6788
Start Current [A]	1.1403
Start Resistance [m Ohm]	352.5087
Start Reactance [m Ohm]	-14.3541
Start Impedance [m Ohm]	352.8008
Start Phase [deg]	-2.33
Finish Voltage [V]	4.7627
Finish Current [A]	1.0008
Finish Resistance [m Ohm]	584.2146
Finish Reactance [m Ohm]	-96.1729
Finish Impedance [m Ohm]	592.0776
Finish Phase [deg]	-9.35

The measurement results at the start and end of the test are recorded.

adata_ex.fcct - FCTester Condition	Editor					_			×
File Edit View Iools Help	Set the test cycle. Normally, a common c However, you can se at the start of a sequ	current range is i t different currer ience, switch the	n a test cycle even a nt ranges for each s current range, and	among d equence turn the	ifferent e sheet b e load ba	sequence sheets. vy instantaneously ti vck on.	urning t	the load o	off
Station Shutdown Sequence 1 Sequence 2	Set the current/voltage range for each sequence. Current Bange 132.0 [A] Voltage Range 150.0 [V]								
Sequence 3 Sequence 4 Sequence 5 Sequence 6 Sequence 7 Sequence 8 Sequence 8 Sequence 9 Sequence 10	Test Cycle Sequence 1 Sequence 2 Sequence 3 Sequence 4 Sequence 5	1 times 1 times 1 times 1 times 1 times 1 times	Sequence 6 Sequence 7 Sequence 8 Sequence 9 Sequence 10	1 1 1 1	times times times times times	Sequence 11 Sequence 12 Sequence 13 Sequence 14 Sequence 15	1 1 1 1 1 1	times times times times times	
Sequence 12						Cyde	1	times	
Sequence 14 Sequence 15	Use the startup se Use the sh <u>u</u> tdown Cutoff Voltage	equence. sequence. -2.00 when the load cu	[V] rrent is set to 0 A.					NUM	

Time1: The amount of time that has elapsed since the test started when voltage and current are recorded according to the recording conditions on the sequence screen. The condition in this example is 2 second time interval.

> Time2: The amount of time that has elapsed since the test started when the impedance measurement results of each frequency are recorded.

	Instant value	aneous			Impedance measurement result			Average voltage and average current per cycle		
Time1 [h:min:s]	Voltage [V]	Current [A]	Time2 [h:min:s]	Frequency [Hz]	Resistance [m Ohm]	Reactance [m Ohm]	Impedance [m Ohm]	Phase [deg]	Cycle Voltage [V]	Cycle Current [A]
0:00:00	4.6691	1.1624	0:00:02	20000	352.5087	-14.3541	352.8008	-2.33	4.6865	1.1219
0:00:02	4.6814	1.1324	0:00:04	15800	350.371	-7.3746	350.4486	-1.21	4.6877	1.1224
0:00:04	4.6727	1.1422	0:00:06	12600	350.6058	-6.4502	350.6651	-1.05	4.6856	1.1232
0:00:06	4.6737	1.1762	0:00:09	10000	352.4903	-6.811	352.5561	-1.11	4.6849	1.1227
0:00:09	4.6912	1.1597	0:00:11	9000	354.4401	-4.9448	354.4746	-0.8	4.6853	1.1226
0:00:11	4.6531	1.2066	0:00:13	8000	353.918	-5.5286	353.9611	-0.89	4.6866	1.1223
0:00:13	4.6627	1.168	0:00:15	7000	353.9027	-3.83	353.9234	-0.62	4.6862	1.1234
0:00:15	4.65	1.1742	0:00:18	6300	355.2192	-3.1122	355.2329	-0.5	4.6865	1.1219
0:00:18	4.6811	1.1235	0:00:20	6000	356.2516	-3.1987	356.2659	-0.51	4.6849	1.1235
0:00:20	4.6975	1.1079	0:00:22	5000	355.193	-0.8921	355.1941	-0.14	4.6855	1.1228
0:00:22	4.66	1.1754	0:00:24	4000	352.6647	2.0959	352.671	0.34	4.6855	1.1236
0:00:25	4.66	1.1793	0:00:27	3160	345.2523	2.3007	345.26	0.38	4.6864	1.1233
0:00:27	4.6825	1.1371	0:00:29	3000	343.639	1.3415	343.6416	0.22	4.686	1.1234
0:00:29	4.6323	1.266	0:00:32	2510	337.2833	-3.784	337.3045	-0.64	4.6855	1.1227
0:00:31	4.6591	1.2087	0:00:34	2000	332.069	-14.457	332.3836	-2.49	4.6856	1.122
0:00:33	4.7266	1.0088	0:00:37	1580	330.0544	-27.4793	331.1964	-4.76	4.6864	1.1225
0:00:36	4.6972	1.0972	0:00:40	1260	331.9672	-42.9418	334.733	-7.37	4.6874	1.1221
0:00:38	4.7116	1.0359	0:00:43	1000	337.092	-59.9793	342.3865	-10.09	4.6858	1.1223
0:00:40	4.7253	0.9768	0:00:47	900	340.7608	-66.683	347.2241	-11.07	4.6845	1.1231
0:00:42	4.6446	1.2561	0:00:50	800	345.7149	-76.6721	354.1149	-12.5	4.6862	1.1223
0:00:45	4.7076	1.0559	0:00:54	700	352.6788	-85.1012	362.801	-13.57	4.6849	1.1228
0:00:47	4.689	1.1196	0:00:58	630	359.4185	-95.1058	371.7886	-14.82	4.6844	1.123
0:00:49	4.6436	1.2656	0:01:01	600	363.7203	-97.5474	376.5739	-15.01	4.6841	1.1231
0:00:51	4.7127	0.9919	0:01:05	500	377.9028	-111.915	394.1262	-16.5	4.6843	1.1227
0:00:54	4.6248	1.2707	0:01:08	400	402.4252	-130.113	422.9367	-17.92	4.6845	1.1225
0:00:56	4.6651	1.093	0:01:10	316	431.9798	-142.499	454.8764	-18.26	4.6844	1.1227
0:00:58	4.708	1.0187	0:01:12	300	440.8685	-144.92	464.0762	-18.2	4.6846	1.1223
0:01:00	4.7396	0.9959	0:01:15	251	465.2571	-148.555	488.3983	-17.71	4.6851	1.1213
0:01:03	4.7083	1.0259	0:0+:17	200	503.8861	-150.795	525.9662	-16.66	4.6844	1.1228
0:01:05	4.6233	1.2534	0:01:20	158	536.5321	-139.067	554.2619	-14.53	4.6852	1.1217
0:01:07	4.6622	1.2221	0:01:22	126	567.5908	-123.806	580.9366	-12.3	4.6849	1.1225
0:01:09	4.7334	1.004	0:01.25	100	584.2146	-96.1729	592.0776	-9.35	4.6851	1.1227
0:01:12	4.6141	1.2346								
0:01:14	4.6521	1 2104	Tim	e1 and Time	e2 are the ar	nount of tim	e elapsed fr	om the star	t of a single t	test. They
0:01:16	4.7533	1.0048	are	not recorded	d as times o	f separate t	ests.		0	,
0:01:18	4.7559	0.9719	Taki	ng the times	s enclosed i	n frames as	an example	, the voltag	e and currer	nt values
0:01:21	4.7331	1.0192	are	recorded at	0:01:14 acc	ording to th	e 2 second t	ime interva	l. Next, an in	npedance
0:01:23	4.668	1.1045	mea	asurement a	t 251 Hz is (completed a	and the mea	sured value	is recorded	at
0:01:25	4.5964	1.2699	0:01:15. Then, the voltage and current values are recorded again at 0:01:16							

according to the 2 second time interval.

NOTE

- The voltage and current at Time1 are instantaneous values. When values are to • be recorded according to the recording conditions, if the relevant values are in the middle of a measurement, the values may appear as blanks.
- The FCTester uses the PC clock. Even when the recording condition is set to • Time Interval, the specified time interval may not be achieved depending on the performance of the PC or other running applications. Errors accumulate.
- If you set the recording condition to Delta Voltage, values will be recorded whenever there is a voltage change, so the time interval will not be inconsistent.

5.7 A List of Menus

Menu		Description						
File	Open	Opens the test conditions file created using the Condition Editor.						
	Exit	Closes the application. You cannot close the application while the test is in progress.						
View	Toolbar	Shows or hides the toolbar.						
		Shows or hides the status monitor.						
	Status Bar	Shows or hides the status bar.						
Test	Start	Starts the test. If the startup sequence is enabled, the load is automatically turned on. If the startup sequence is disabled, you must turn the load on before starting the test.						
	Stop	Stops the test. Select an item in the dialog box.						
	Reset Alarm	Resets the alarm when an alarm occurs.						
	Emergency Stop	Stops the test, and turns off the load of the electronic load unit.						
	Panel Control	Allows you to carry out operations equivalent to the operations on the KFM2150. Set items in the dialog box. The dialog box consists of the Electronic Load, Measurement, Test Data, and Protection pages.						
	Monitor	Start the voltage/current monitor. You must start the monitor to start the test.						
Graph	Graph Options	Set the graph scale, pattern, view, and 3D items.						
	Copy to Clipboard	Copies the graph to the clipboard.						
	Zoom	Zooms the graph.						
	Pan	Moves the graph.						
	Cursor	Shows the cursor.						
	Default	Sets the graph functions back to default.						
Tools	Start the Condition Editor	Starts the Condition Editor. This is used to set test conditions.						
	Options	This is used to change the test conditions during the test.						
Help	View the FCTester User's Manual	Shows the FCTester User's Manual.						
	About	Shows the FCTester version and the system information while executing the Configuration Tool.						

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KIKUSUI ELECTRONICS CORP.

1-1-3 Higashiyamata, Tsuzuki-ku, Yokohama, 224-0023, Japan Tel: +81-45-482-6353 Fax: +81-45-482-6261

www.kikusui.co.jp/en

