OPERATION MANUAL

FC Scanner

KFM2151

KIKUSUI
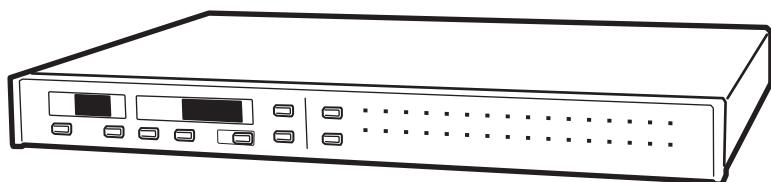
Use of Operation Manual

Please read through and understand this Operation 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.

Power Reqiorements of this Product

Power reqirements of this product have been changed and relevant sections of the Operation Manual should be revised accordingly.

 (Revision should be applied to items indicatedby a check mark .)

☐ **Input voltage**

The input voltage of this product is _____ VAC,
and the voltage range is _____ to _____ VAC. Use the product within this range only.

☐ **Input voltage**

The rating of this product's input fuse is _____ to _____ VAC, and _____ .

⚠ WARNING
- **To avoid electrical shock, always disconnect the power cord or turn off the switchboard before attempting to check or replace the fuse.**
- **Use a fuse element having a shape, rating, and characteristics suitable for this product. The use of a fuse with a different rating or one that short circuits the fuse holder may result in fire, electric shock, or irreparable damage.**


☐ **Power cord**

The product is provided with power cords described below. If the cord has no power plug, attach a power plug or crimp-style terminals to the cord in accordance with the wire colors specified in the drawing.


⚠ WARNING
- **The attachment of a power plug or crimp-style terminals must be carried out by qualified personnel.**

☐ **Without a power plug**

Blue (NEUTRAL)
Brown (LIVE)
Green/Yellow (GND)

☐ **Without a power plug**

White (NEUTRAL)
Black (LIVE)
Green or Green/Yellow (GND)
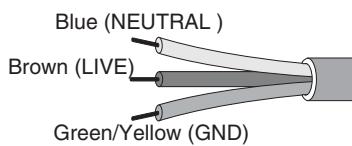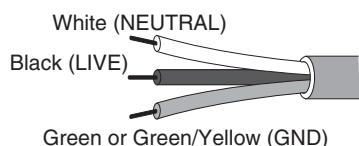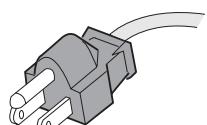
☐ **Plugs for USA**

☐ **Plugs for Europe**
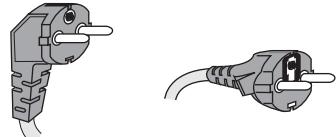
☐ **Provided by Kikusui distributor/agent**
Kikusui agents can provide you with suitable power cord.
For further information, contact Kikusui distributor/agent.

⚠ **Safety Symbols**

For the safe use and safe maintenance of this product, the following symbols are used throughout this manual and on the product. Note the meaning of each of the symbols to ensure safe use of the product. (Not all symbols may be used.)
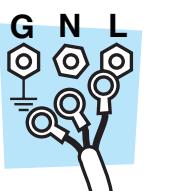
⚡ or ⚠	Indicates that a high voltage (over 1000 V) is used here. Touching the part causes a possibly fatal electric shock. If physical contact is required by your work, start work only after you make sure that no voltage is output here.
DANGER	Indicates an imminently hazardous situation which, if ignored, will result in death or serious injury.
⚠ WARNING	Indicates a potentially hazardous situation which, if ignored, could result in death or serious injury.
⚠ CAUTION	Indicates a potentially hazardous situation which, if ignored, may result in damage to the product and other property.
🚫	Shows that the act indicated is prohibited.
⚠	Indicates a general danger, warning, or caution. When this symbol is marked on the product, see the relevant sections in this manual.
⏚	Protective conductor terminal.
⎏	Chassis (frame) terminal.
I	On (supply)
O	Off (supply)
▬	In position of a bi-stable push control
▭	Out position of a bi-stable push control
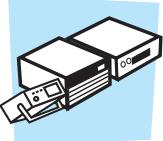
⚠ Safety Precautions

The following safety precautions must be observed to avoid fire hazards, electric shock, accidents, and other failures. Keep them in mind and make sure to observe them.

Using the product in a manner that is not specified in this manual may impair the protection functions provided by the product.

Users	• This product must be used only by qualified personnel who understand the contents of this operation manual. • If unqualified personnel is to use the product, be sure the product is handled under the supervision of qualified personnel (those who have electrical knowledge). This is to prevent the possibility of personal injury. • Do not use the tester if you have a heart problem such as heart disease, if you are or may be pregnant, or if you wear a medical device such as pacemaker.
Purpose of use	• Never use the product for purposes other than the product's intended use. • This product is not designed or manufactured for general home or consumer use.
Input power **Line Voltage**	• Use the product within the rated input power voltage range. • For applying power, use the power cord provided. For details, see the respective page in the operation manual. • This product is designed as an equipment of IEC Overvoltage Category II (energy-consuming equipment supplied from the fixed installation).
Cover	• Some parts inside the product may cause physical hazards. Do not remove the external cover.
Grounding **G N L**	• This product is an IEC Safety Class I equipment (equipment with a protective conductor terminal). To prevent the possibility of electric shock, be sure to connect the protective conductor terminal of the product to electrical ground (safety ground).

| Installation | • This product is designed for safe indoor use. Be sure to use it indoors. |
| | • When installing this product, be sure to observe the description in section 2.2, "Precautions Concerning Installation Location" in this manual. |

| Relocation | • Turn off the POWER switch, and disconnect all cables before relocating the product. |
| | • When relocating the product, be sure to include the manual. |

Operation	• Before using the product, be sure to check the input power voltage and that there is no abnormality in the appearance of the power cord. Be sure to remove the power plug from the outlet before checking it.
	• If a malfunction or abnormality is detected on the product, stop using it immediately, and remove the power plug from the outlet. Make sure the product is not used until it is completely repaired.
	• Use cables or wires with sufficiently large current capacity for output wires and load cables.
	• Do not disassemble or modify the product. If you need to modify the product, contact your Kikusui distributor/agent.

Maintenance and inspection	• To prevent the possibility of electric shock, make sure to unplug the power plug before carrying out maintenance or inspection.
	• Do not remove the external cover during maintenance or inspection.
	• To maintain the performance and safe operation of the product, it is recommended that periodic maintenance, inspection, cleaning, and calibration be performed.

| Service | • Kikusui service engineers will perform internal service on the product. If the product needs adjustment or repairs, contact your Kikusui distributor/agent. |

How to Read This Manual

Preface

Thank you for purchasing the KFM2151 FC Scanner.

This manual is intended for first-time users of the KFM2151. It gives an overview of the impedance measurement system and describes various settings, measurement procedure, SCPI commands, maintenance, safety precautions, etc.

Read this manual thoroughly to use the functions of the KFM2151 effectively. You can also review this manual when you are confused about an operation or when a problem occurs.

For details on the individual instruments making up the impedance measurement system such as the PLZ-4W Series and KFM2150 FC Impedance Meter, see the respective operation manuals.

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 the KFM2151 for the first time.

Related manuals

Only the basic aspects of the KFM2150 are described as part of the impedance measurement system. For details, see the operation manual of the KFM2150.

Intended readers of this manual

This manual is intended for operators that control the impedance measurement system and use the KFM2151 FC Scanner or persons teaching other users on how to operate the KFM2151.

It assumes that the reader has knowledge about fuel cells and electrical aspects of impedance measurement.

Information on SCPI commands is provided with the premise that the reader has sufficient knowledge about controlling instruments using a personal computer.

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 KFM2151.

Chapter 2   Installation and Preparation

This chapter describes the procedures from unpacking to installation.

Chapter 3   Operation

This chapter mainly describes various setup procedures.

Chapter 4   Remote Control

This chapter describes the procedure for connecting the interface and the procedure for transmitting commands to the KFM2151 using SCPI commands.

Chapter 5   Maintenance

This chapter covers maintenance of the KFM2151 including cleaning, inspecting, calibrating, and troubleshooting.

Chapter 6   Specifications

This chapter contains the electrical and mechanical specifications of the KFM2151.

Notations used in the manual

- The KFM2151 FC Scanner is also simply referred to as KFM2151 in this manual.

- The KFM2150 FC Impedance Meter is also simply referred to as KFM2150 in this manual.

- The word computer used in the text is a collective term for personal computers and workstations.

- The following markings are used in the explanations in the text.

⚠ WARNING

Indicates a potentially hazardous situation which, if ignored, could result in death or serious injury.

⚠ CAUTION

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.

DESCRIPTION

Explanation of terminology or operation principle.

See

Indicates reference to detailed information.

>

Indicates menu settings that you select. Menu items to the left of the greater-than sign is are higher level menus.

SHIFT+key name (marked in blue)

Indicates an operation in which a switch marked in blue is pressed while holding down the SHIFT key.

Contents

Chapter 1 General Description

Chapter 2 Installation and Preparation

Chapter 3 Operation

Chapter 6 Specifications

Index

Contents by Function

Panel control

Situation		Heading	
Switch between impedance scanning and voltage scanning		Switching the monitor display (impedance/voltage).	3-3
Impedance scanning	Setting	Setting the Channels.	3-4
	Scanning	Impedance Scanning.	3-14
Voltage scanning	Setting	Setting the Channels.	3-4
	Scanning	Voltage scanning.	3-15

Basic operations

Situation	Heading	
Want to change the SENSING terminal	Logical Channel Configuration.	3-9
Forgot the SENSING terminal number		
Want to scan manually	Manual scanning.	3-14
Want to detect voltage drop and overvoltage	Voltage protection (only for voltage scanning), Alarms.	3-5 3-16

Front panel
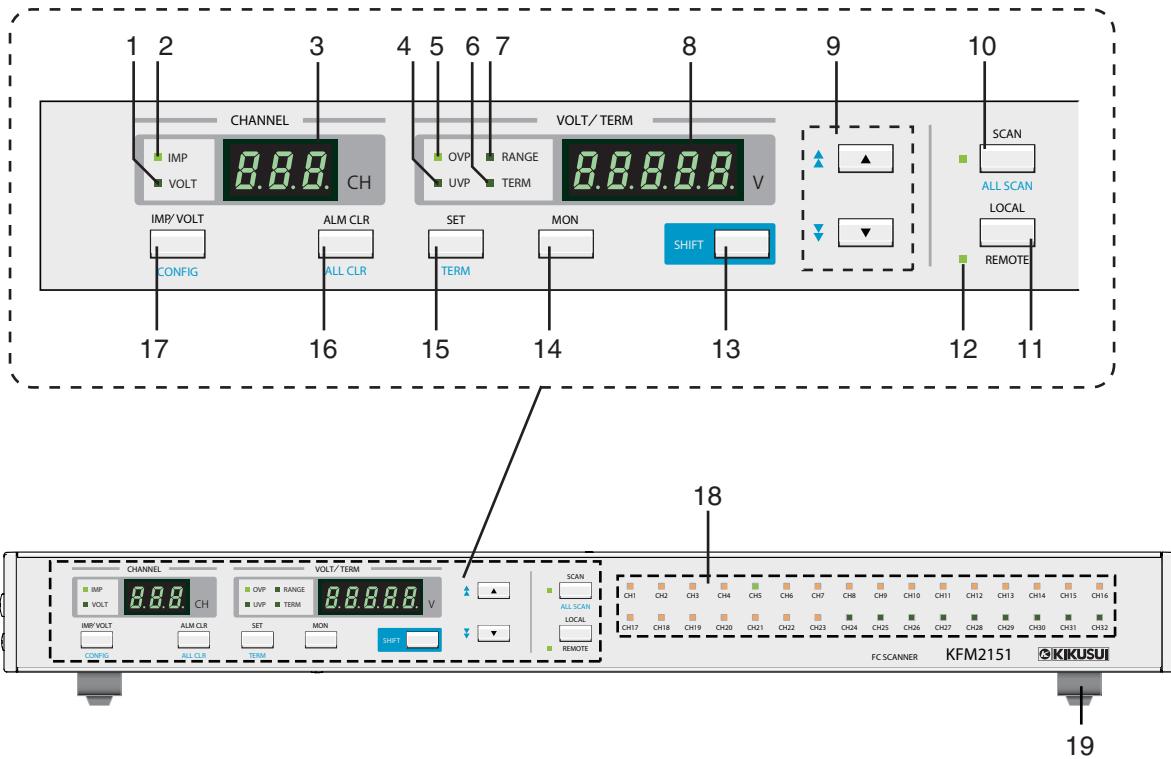
No.	Name	+SHIFT	Description	See Page
1	VOLT LED		Illuminates when scanning voltage.	3-3
2	IMP LED		Illuminates when scanning impedance.	
3	CHANNEL		Displays the selected channel.	–
4	UVP LED		When setting the UVP for voltage scanning: Illuminates in green. When an alarm is occurring: Illuminates in red.	3-5 3-16
5	OVP LED		When setting the OVP for voltage scanning: Illuminates in green. When an alarm is occurring: Illuminates in red.	
6	TERM LED		Illuminates when setting the SENSING terminal.	3-9
7	RANGE LED		Illuminates when setting the voltage scanning range.	3-5
8	VOLT/TERM		Displays the voltage, SENSING terminal number, etc.	–
9	▲ ▼		Up/Down key. Resolution: 1	–
		▲▲ ▼▼	Up/Down key that changes settings by a great amount. Resolution: 10 times the ▲ and ▼ keys unless specified otherwise.	–
10	SCAN		Scanning start/stop key. The LED to the left of the key illuminates while scanning.	3-14
		ALL SCAN	Scanning start/stop key for all channels when the channels are expanded. The LED to the left of the key illuminates while scanning.	3-15
11	LOCAL		Local mode switch key.	3-18
12	REMOTE LED		Illuminates in remote control mode.	
13	SHIFT		Shift key.	–
14	MON		Monitor status switch key.	3-2
15	SET		Set key.	3-4
		TERM	SENSING terminal setting key.	3-9
16	ALM CLR		Clears the alarm on the selected channel.	3-17
		ALL CLR	Clears the alarm on all channels.	3-17
17	INP/VOLT		Impedance scanning/voltage scanning switch key.	3-3
		CONFIG	Configuration setting key.	3-12
18	Monitor LED.		Channel (CH1 to CH32) monitor LED. Not scanned: Not illuminated. Pause: Illuminates in green. Scanning: Illuminates in orange. When an OVP or UVP alarm is occurring: Illuminates in red.	3-11 3-16
19	Feet		Four locations on the bottom.	–

Rear panel
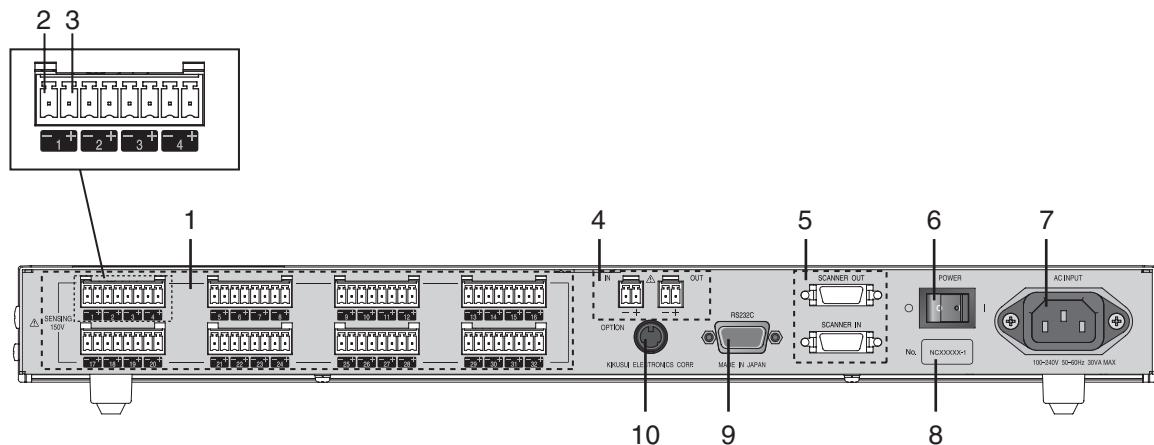
No.	Name	Description	See Page
1	SENSING	SENSING terminal. 32 channels total. Isolated from the chassis electric potential (withstand voltage of 250 V). Rated input voltage: ±150 V (±200 Vpeak maximum). Input impedance: Approx. 1 MΩ.	3-9
2	TERM-	Low potential terminal of the SENSING terminal.	
3	TERM+	High potential terminal of the SENSING terminal.	
4	IN/OUT	Scanning I/O signal terminal for impedance measurement.	2-5
5	SCANNER IN/OUT	Channel expansion terminal.	2-7
6	POWER	POWER switch. Press the (I) side to turn the power on and the (O) to turn the power off.	3-2
7	AC INPUT	AC inlet connector for the power cord.	
8	Serial number	The serial number of the KFM2151.	–
9	RS232C	RS232C cable connector for remote control.	–
10	OPTION	Terminal for connecting to the KFM2150.	2-5
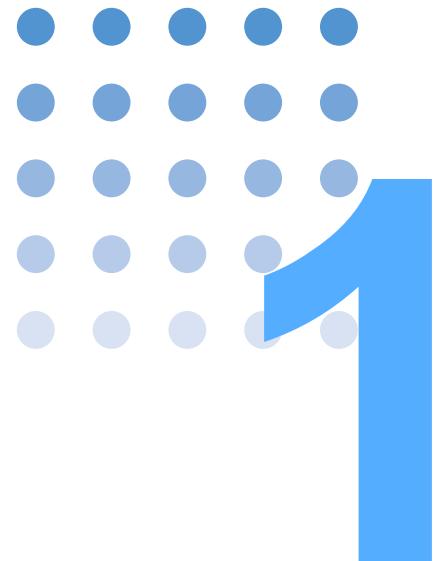
General Description

This chapter gives a general description and introduces the features of the KFM2151.

1.1   About This Manual

This manual describes the KFM2151 FC Scanner.

Impedance of fuel cells is measured using a system that combines the KFM2151, KFM2150 FC Impedance Meter, and the PLZ-4W Series Electronic Load Unit.

For a description of the KFM2150 FC Impedance Meter and the PLZ-4W Series Electronic Load Unit, see the operation manuals of the respective products.

Firmware version of the product to which this manual applies

This manual applies to KFM2151s with firmware version 1.0X.

When making an inquiry about the product, please provide us with the following information.

- Model (written on the front cover of this manual)
- Firmware version
- Serial number (indicated at the lower section on the rear panel)

1.2   Overview

The KFM2151 is a channel selector for the 32-channel voltmeter and impedance meter. It is used as a component instrument of the impedance measurement system as shown in Fig.1-1. By combining with the KFM2150 FC Impedance Meter, the voltage and impedance of each stack of the fuel cell can be measured.

If it is not used in combination with the KFM2150 FC Impedance Meter, it can be used as a multi-channel voltmeter.

The role of the scanner in the impedance measurement system is described in the next section.

Impedance measurement system (scanner system)

Fig.1-1 shows an impedance measurement system consisting of the KFM2150, PLZ-4W Series, and KFM2151. The load current of the fuel cell and impedance measuring AC current flows through the PLZ-4W Series. The current signal is passed from the PLZ-4W Series to the KFM2150. The KFM2151 scans the voltage signal for the impedance measurement and passes it to the KFM2150 where the impedance is measured.
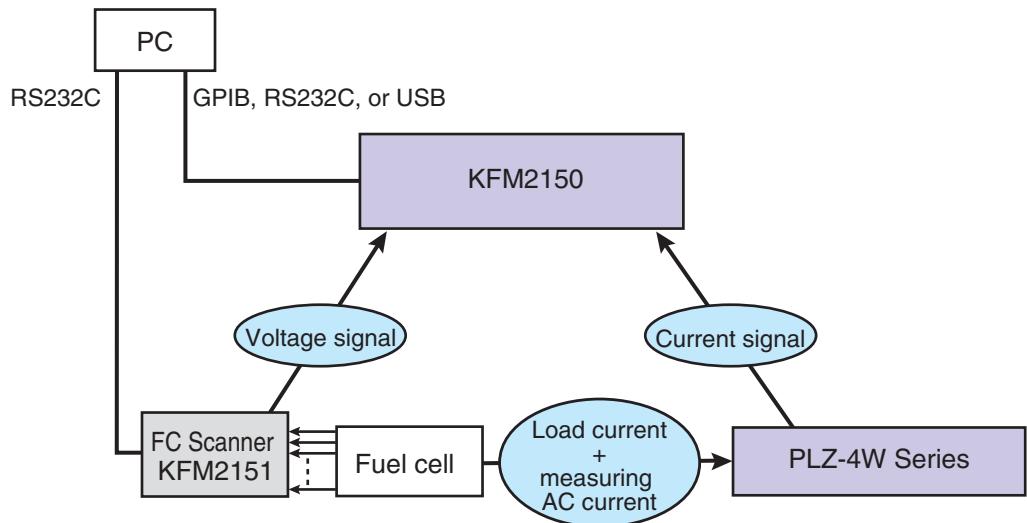
Fig.1-1   Impedance measurement system employing the KFM2151

1.3   Features

● 32 channel input, expandable up to 160 channels.

The input section consists of 32 channels per unit. The number of channels can be expanded to 160 by using five KFM2151s. This feature is best suited to the monitoring of each cell of the fuel cell.

● Best for impedance measurement

By combining with the KFM2150 FC Impedance Meter, an impedance measurement system for fuel cells can be configured.

● DC voltage measurement function

Equipped with a DC voltage measurement function. Input voltage up to 200 V can be measured.

● Change the measurement point without changing the wiring

The KFM2151 allows arbitrary SENSING terminal numbers to be assigned to channels (logical channels). Because the channels are logical channels, measurement points can be changed without having to change the wiring. The same SENSING terminal number can also be assigned to multiple logical channels.

● Scan speed

A scan speed of 32 channels/second is achieved through efficient internal processing.

● Protection functions

Overvoltage protection (OVP) and undervoltage protection (UVP) can be set.

● Remote control interface

Equipped with RS232C as standard.

1.4   Rack mounting option

The following rack mounting options are available.

For details, contact your Kikusui agent or distributor.

Table 1-1   Rack mounting options

Product	Model	Applicable Model	Note
Rack mount bracket	KRB1-KFM [B9-000-055]	KFM2151	Compatible with the Inch rack EIA standard and the milli rack JIS standard

Unit: mm
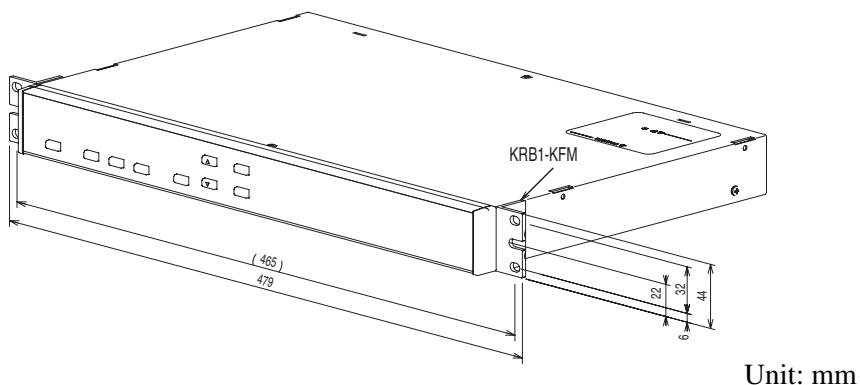
Fig.1-2   Rack mount bracket
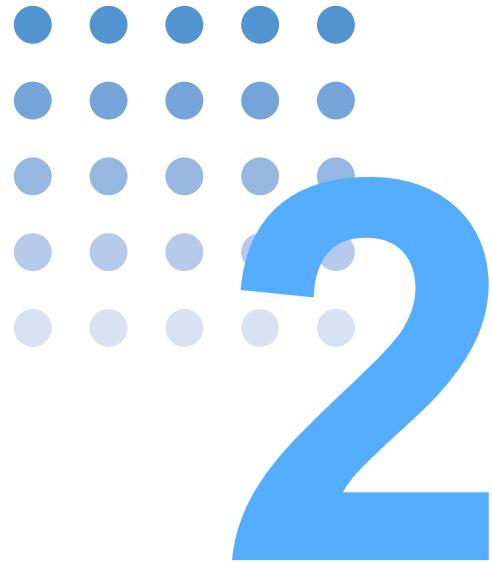
Installation and Preparation

This chapter describes the procedures from unpacking to installation.

2.1   Checking the Package Contents

When you receive the product, check that all system component instruments and all accessories are included and that the product and accessories have not been damaged during transportation.

If any of the accessories are damaged or missing, contact your Kikusui agent or distributor.

We recommend that all packing materials be saved, in case the product needs to be transported at a later date.

Accessories

May vary depending on the shipment destination.

[85-AA-0003]

☐ Power cord (1 pc.)

☐ Metal fittings (4 pcs.)
[D3-100-166]

☐ Screwless terminal connector 2 poles (2 pcs.)
[84-63-6201]

☐ Screwless terminal connector 8 poles (8 pcs.)
[84-63-6811]

☐ KFM2150 connection cable: 1 m (1 pc.)
[85-50-0130]

M3 screws

☐ Metal fitting screws (4 pcs.)
[M3-000-041]

☐ Operation manual (this manual, 1 pc.)
[Z1-003-382]
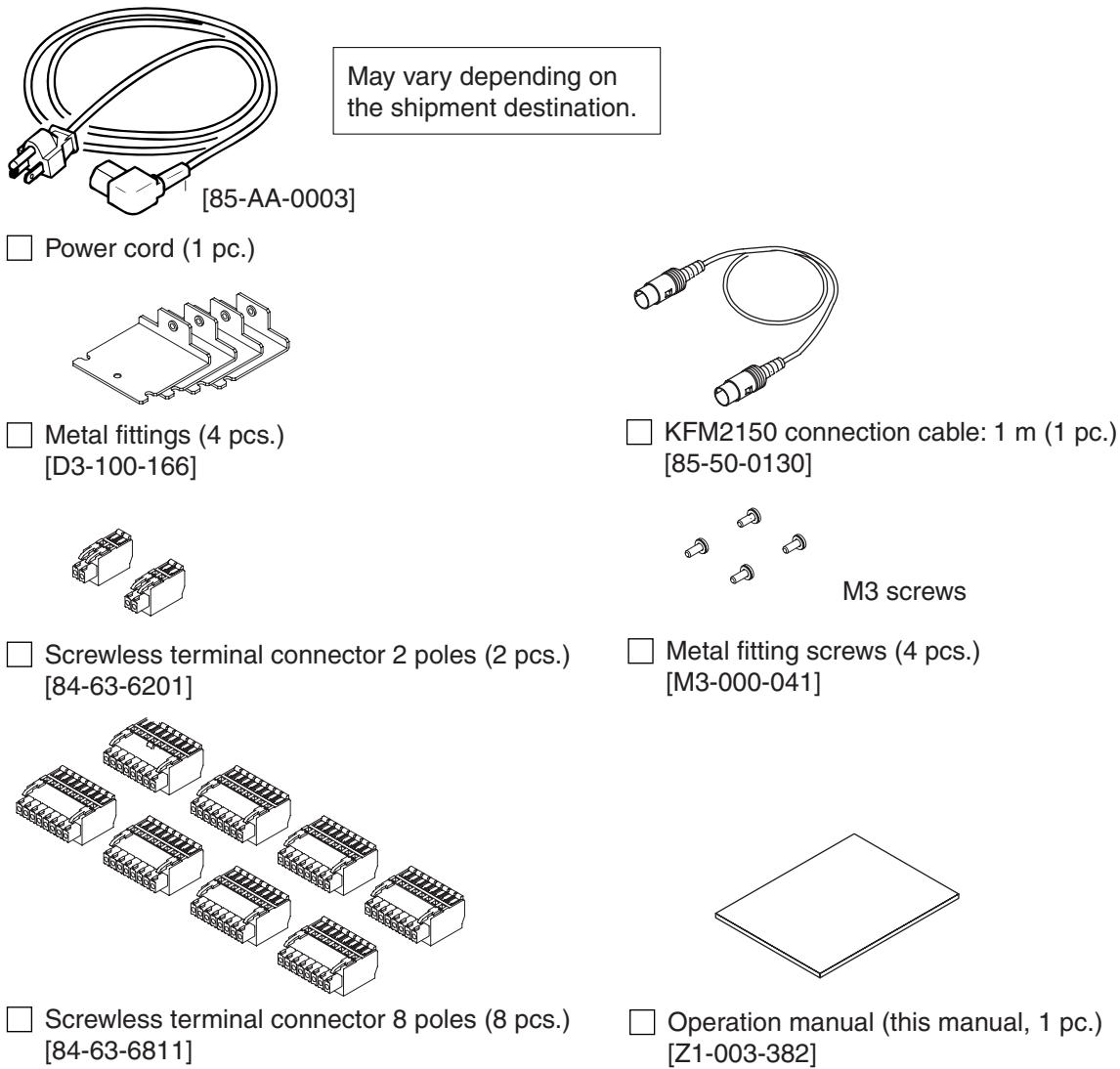
Fig.2-1   Accessories

2.2   Precautions Concerning Installation Location

Be sure to observe the following precautions when installing the KFM2151.

● Do not use the product in a flammable atmosphere.

To prevent the possibility of explosion or fire, do not use the product near alcohol, thinner or other combustible materials, or in an atmosphere containing such vapors.

● Avoid locations where the product is exposed to high temperature or direct sunlight.

Do not place the product near a heater or in areas subject to drastic temperature changes.

Spec guaranteed temperature range: +20 °C to +30 °C

Storage temperature range: -20 °C to +70 °C

● Avoid humid environments.

Do not install the product in high-humidity locations near a boiler, humidifier, or water supply.

Spec guaranteed relative humidity range:

20 % to 85 % (no condensation)

Storage relative humidity range: 0 to 90 % (no condensation)

Condensation may occur even within the spec guaranteed humidity range. If this occurs, do not use the product until the condensation dries up completely.

● Be sure to use it indoors.

This product is designed for safe indoor use.

● Do not place the product in a corrosive atmosphere.

Do not install the product in a corrosive atmosphere or in environments containing sulfuric acid mist, etc. This may cause corrosion of various conductors and bad contacts of connectors inside the tester leading to malfunction and failure, or in the worst case, a fire.

● Do not place the product in a dusty location.

Accumulation of dust can lead to electric shock or fire.

● Do not use the product where ventilation is poor.

Secure adequate space around the product so that air can circulate around it.

● Do not place objects on the product.

Placing heavy objects on top of the product may cause failures.

● Do not install the product on an inclined surface or location subject to vibrations.

The product may fall or tip over causing damages and injuries.

● Do not use the product in a location where strong magnetic or electric fields are nearby or a location where large amount of distortion and noise is present on the input power supply waveform.

The product may malfunction.

2.3 Precautions to Be Taken When Moving the Product

Note the following points when moving or transporting the product to the installation location.

● Turn off the POWER switch.

Moving the product while the power is turned on can cause electric shock or damage to it.

● Remove all wiring.

Moving the product with the cables connected may cause wires to break or injuries due to the product falling over.

● When transporting the product, be sure to use the original packing materials.

Otherwise, damage may result from vibrations or from the product falling during transportation.

● Be sure to include this manual.

2.4 Connecting the KFM2151 to the FC Impedance Meter

Use AWG24 wires. The recommended amount of covering to be stripped is approximately 10 mm. Using the strip gauge shown in Fig.2-2 will ensure proper work.

When using a single KFM2151
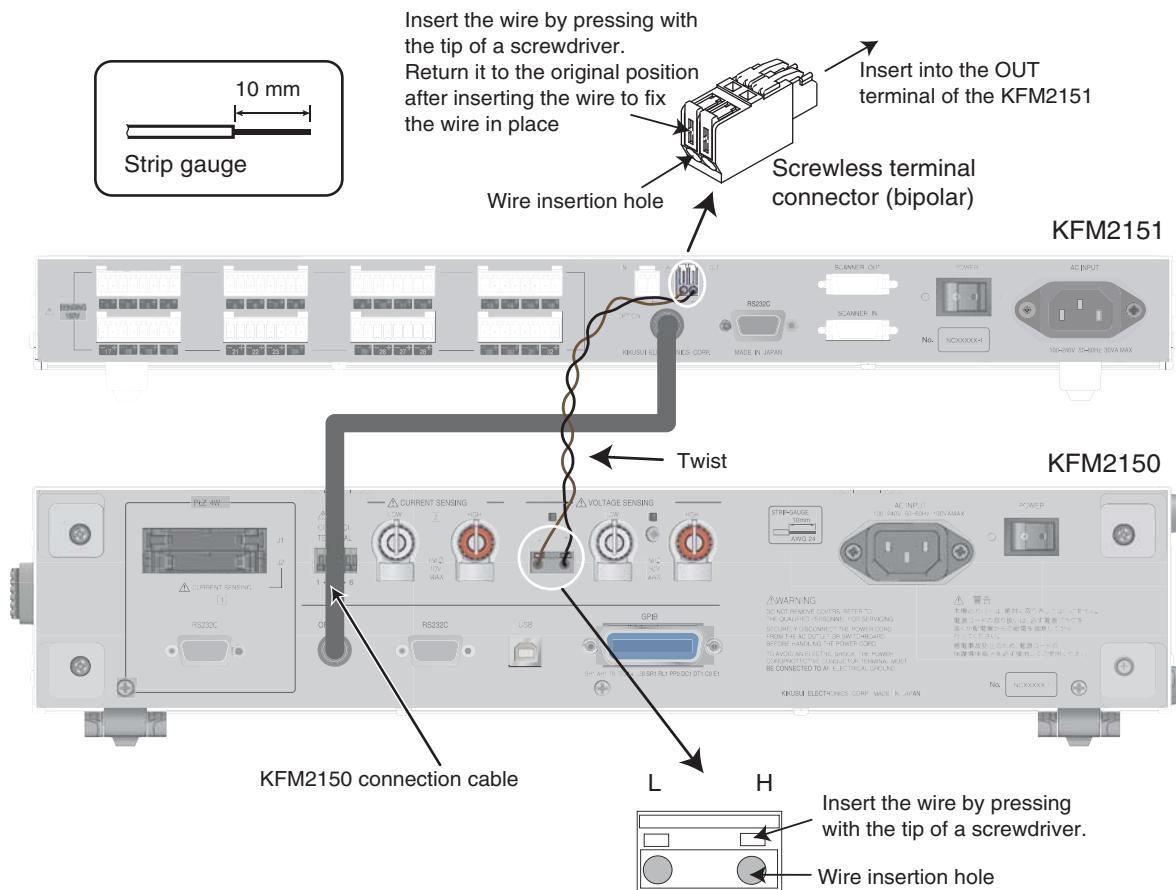
Fig.2-2   Connection of one KFM2151 to the KFM2150

Use channel 2 of the KFM2150 VOLTAGE SENSING terminal. Select Setup > Input Select > Voltage Sensing from the KFM2150 menu and select channel 2. For details on KFM2150 menu, see the operation manual of the KFM2150.

1. Check that the POWER switch is turned off on the KFM2151 and KFM2150.

2. Using a screwdriver, insert the wire into the screwless terminal connector (bipolar) provided as shown in Fig.2-2.

3. After you insert the two wires, twist the wires together.

4. Insert the screwless terminal connector (bipolar) to the OUT terminal of the KFM2151.

5. Connect the other end of the wires to the VOLTAGE SENSING terminal (channel 2) of the KFM2150 as shown in Fig.2-2.

Table 2-1 shows the polarity of the connection.

Table 2-1   Polarity of the connection

KFM2151	KFM2150
OUT+	VOLTAGE SENSING terminal 2-H
OUT−	VOLTAGE SENSING terminal 2-L

6. Using the KFM2150 connection cable provided, connect the OPTION terminal of the KFM2151 to the OPTION terminal of the FC Impedance Meter.

Then, enable the KFM2150 scanner function. Select Configuration > Option> Scanner from the KFM2150 menu and select Enable. Turn the KFM2150 POWER switch off and then turn it back on. The scanner display (▣) appears on the KFM2150 as shown in Fig.2-3 enabling the use of the KFM2151.
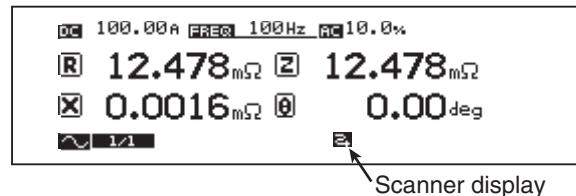
Fig.2-3   KFM2150 scanner display

If you disconnect the KFM2151 from the KFM2150, be sure to disable the scanner function. Otherwise, the KFM2150 will not operate.

For details on KFM2150 menu, see the operation manual of the KFM2150.

When using multiple KFM2151s (channel expansion)

Up to five KFM2151s (one master and four slave units) can be connected.

An example in which two KFM2151s are connected to the KFM2150 is given below. If you are connecting three or more KFM2151s, connect them in the same manner as the connection between the KFM2151 master unit and the slave unit shown in Fig.2-4.

KFM2151 master unit

Channel expansion cable

Wire (twist)

KFM2151 slave unit

Wire (twist)

KFM2150 connection cable
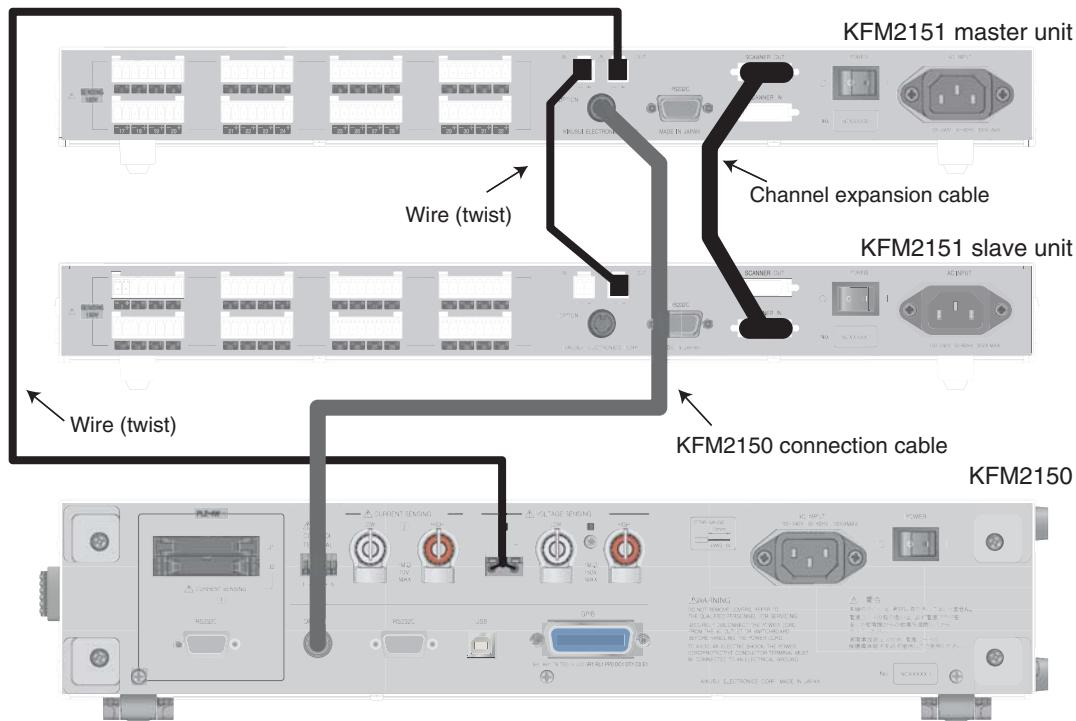
KFM2150

Fig.2-4   Connection of two KFM2151s to the KFM2150

The optional channel expansion cable is not included in the package. If you are connecting multiple KFM2151s, contact your Kikusui agent.

[91-80-9901]
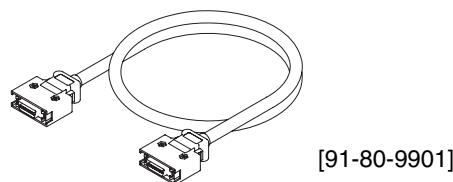
Fig.2-5   Channel expansion cable (option)

1. Check that the POWER switch is turned off on the KFM2151 and KFM2150.

2. Connect the KFM2150 and the KFM2151 master unit.

3. Use the channel expansion cable (option) to connect the SCANNER OUT terminal of the master unit to the SCANNER IN terminal of the slave unit.

4. Connect the IN terminal of the master unit to the OUT terminal of the slave unit using the screwless terminal connector (bipolar).

Joining the KFM2151 and the KFM2150

Use the metal fittings provided to join the KFM2151 and KFM2150. It is also possible to join multiple KFM2151s.

1. Remove the four feet from the bottom of the KFM2151.

   The screws that you removed will be used in the next step.

2. Attach the metal fittings to where the feet were attached using the screws that you just removed (four locations).

3. Use the screws for the metal fittings provided to join the KFM2151 and KFM2150.

   Insert the metal fittings in the rectangular holes in the top cover of the KFM2150.

Metal fittings (4 locations)
Align the convex section with the hole.

Screws used on the feet (4 locations)
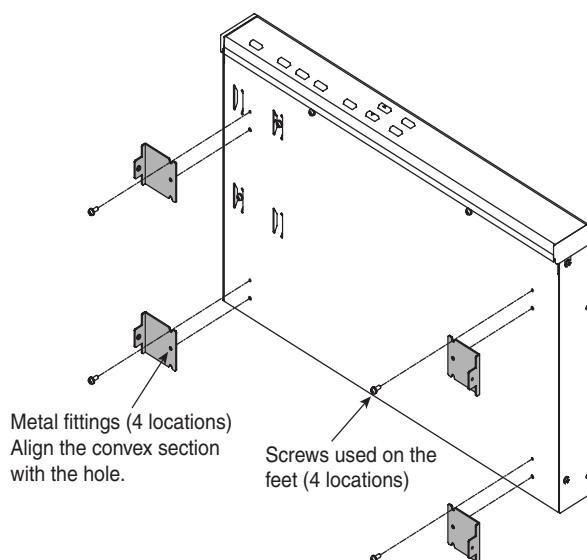
Fig.2-6   Attaching the metal fittings

Metal fitting
Each side (4 locations)

Metal fitting screws
Each side (4 locations)
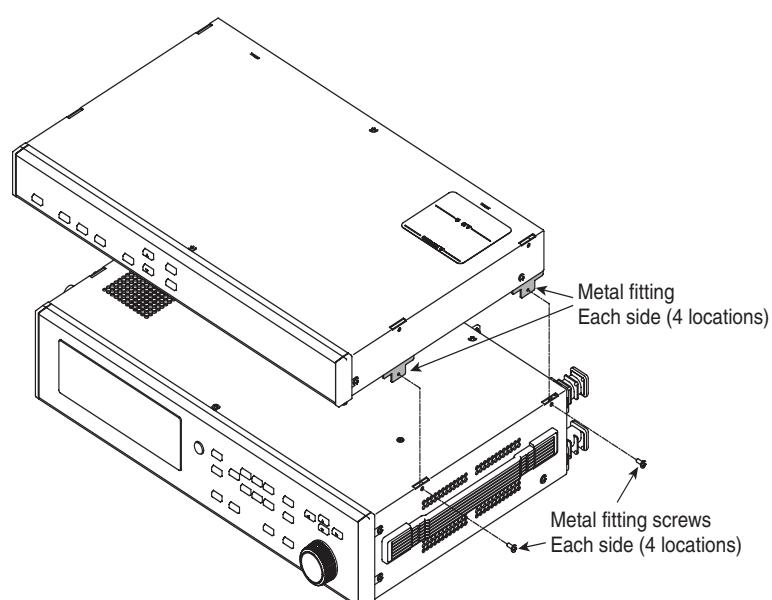
Fig.2-7   Joining with the KFM2150 FC Impedance Meter

2.5 Connecting the SENSING terminal and the fuel cell

Use the screwless terminal connector (8 poles) provided. One block contains four channels of terminals. Connect the SENSING terminal directly to the separator in order from cell 1.
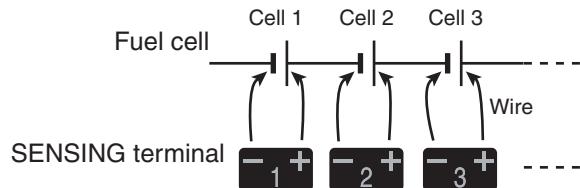
Fig.2-8   Wiring the SENSING terminal

If you want to measure the performance at the electrode terminal, connect to it.

Use AWG24 wires. The recommended amount of covering to be stripped is approximately 10 mm. Using the strip gauge shown in Fig.2-9 will ensure proper work.

NOTE
- Check the rated temperature of the wires that you are using. Pay close attention for fuel cells that operate at high temperatures. Even for fuel cells that run at relatively low temperatures such as a PEFC, the collecting electrode where the wire is connected may be hot.
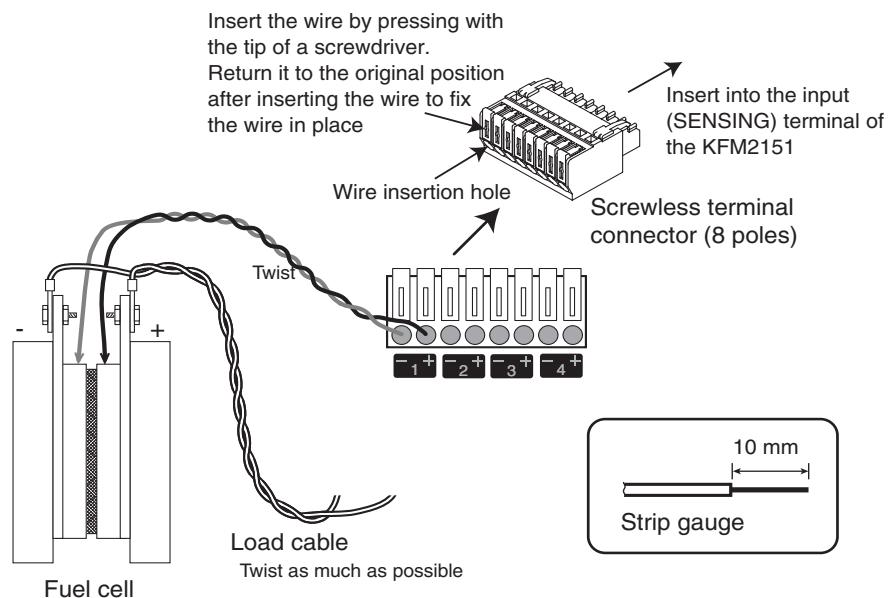
Fig.2-9   Connection to the fuel cell

1. Using a screwdriver, insert the wire into the screwless terminal connector (8 poles) provided as shown in Fig.2-9.

2. Twist the wires after inserting the positive and negative wires.

   This completes the wiring of one channel. Insert and twist the wires for as many channels as necessary.

3. Insert the screwless terminal connector (8 poles) to the SENSING terminal of the KFM2151.

4. Connect the other end of the wires to the fuel cell by aligning the polarity.

2.6   Connecting the Power Cord

This product is designed as an equipment of IEC Overvoltage Category II (energy-consuming equipment supplied from the fixed installation).

NOTE
- Use the supplied power cord to connect to the AC line.
- If the supplied power cord cannot be used due to the rated voltage or the plug shape, have a qualified engineer replace it with an appropriate power cord of length 3 m or less. If obtaining a power cord is difficult, consult your Kikusui agent or distributor.
- The power cord with a plug can be used to disconnect the KFM2151 from the AC line in an emergency. Connect the plug to an easily accessible power outlet so that the plug can be removed from the outlet at any time. Be sure to allow enough space around the power outlet.
- Do not use the supplied power cord on other instruments.
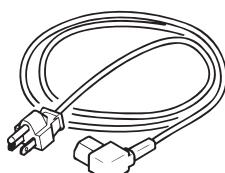
The rated voltage and rated current of this power cord is 125 VAC and 10 A, respectively.

[85-AA-0003]
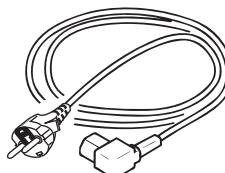
Fig.2-10   Supplied power cord

Kikusui provides a 200-V system power cord with a plug for purchase separately (see the figure on the left).

The rated voltage and rated current of this power cord is 250 VAC and 10 A, respectively.

[85-AA-0005]

Fig.2-11   200 V system power cord

1. Check that the AC power line complies with the input rating of the KFM2151.

   The voltage that can be applied is any of the nominal power supply voltages in the range of 100 VAC to 120 VAC or 200 VAC to 240 VAC. The frequency is 50 Hz or 60 Hz.

2. Check that the POWER switch is turned off.

3. Connect the power cord to the AC INPUT connector on the rear panel.

4. Insert the power plug to an outlet.

2.7 Precautions Concerning Grounding (Earth)

> **⚠ WARNING**
> - **This product is an IEC Safety Class I equipment (equipment with a protective conductor terminal). To prevent electric shock, be sure to ground (earth) the unit.**
> - **Be sure to connect the protective ground terminal to an appropriate earth ground.**
>
> **⚠ CAUTION**
> - If you do not ground the KFM2151, malfunction may occur due to external noise, or the noise generated by the KFM2151 may become large.

Connect the power cord to a three-prong power outlet with proper grounding.

Three-prong outlet with
proper grounding
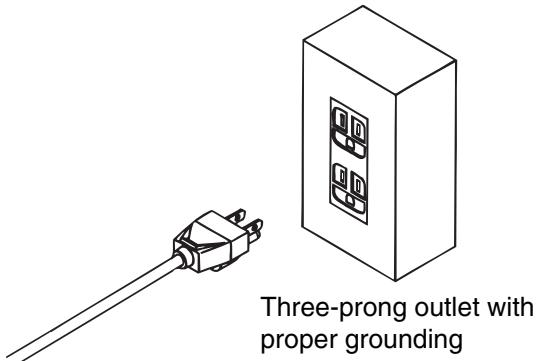
Fig.2-12   Grounding method
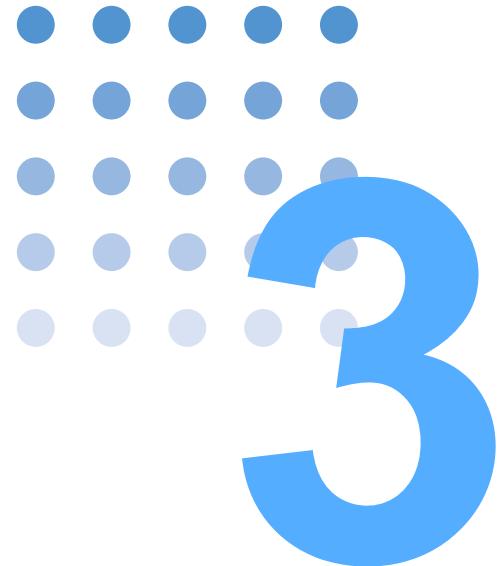
3 Operation

This chapter mainly describes various setup procedures.

3.1 Powering Up

For the power-up procedure of the impedance measurement system that includes the PLZ-4W Series, see the operation manual of the KFM2150 FC Impedance Meter.

Turning on the POWER switch

1. Check that the POWER switch on the rear panel is turned off (O).

2. Check all wiring connections.

3. Push the (I) side of the POWER switch to turn the KFM2151 on.

   If you are using multiple KFM2151s, turn the POWER switch of the slave units first and then the POWER switch of the master unit.

   The KFM2151 starts up in the condition in which the power was turned off the previous time.

Checking the firmware version

When the power is turned on, all LEDs illuminate for approximately 1 second. The VOLT/TERM display section shows the firmware version for approximately 2 seconds.
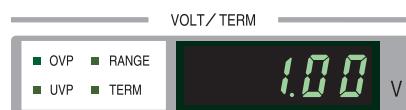
Fig.3-1   Firmware version display (example for 1.00)

3.2 Monitor

The KFM2151 has two modes: monitor and setup.

When in monitor mode, the KFM2151 scans the voltage at all times. Voltage scanning stops when setting various conditions.

■ Monitor (MON)

Pressing the MON key causes the KFM2151 to enter monitor mode.

Set the KFM2151 to monitor mode to check the active channels and start/stop the impedance scanning. Pressing the MON key when the KFM2151 is in monitor mode causes the buzzer to sound.

■ Setup (CH, OVP, UVP, RANGE, and TERM)

Sets the logical channels, SENSING terminals, range, and protection function.

Operation

3.3   Switching the monitor display (impedance/voltage)

Select impedance or voltage when scanning or when setting the scanning conditions. When impedance is selected, the IMP LED of the display section illuminates. When voltage is selected, the VOLT LED illuminates.

1. **Check that the KFM2151 is in monitor mode.**

   If the CHANNEL display or VOLT/TERM display is blinking, press the MON key.

2. **Press the IMP/VOLT key.**

   Select impedance scanning (IMP) or voltage scanning (VOLT).

   The IMP LED and VOLT LED illuminate alternately each time you press the IMP/VOLT key, and the monitor LED of the channels on which the respective scanning is turned on illuminates in green.
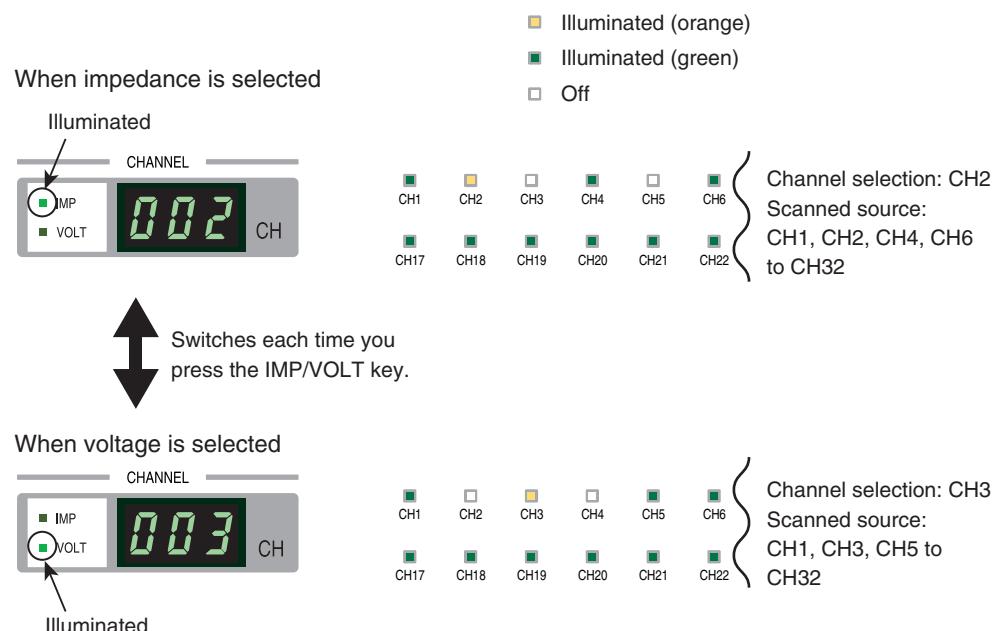
Fig.3-2   Switching the monitor display

3.4   Setting the Channels

The KFM2151 allows voltmeter and impedance channels to be configured (two system configuration). The voltage measurement and the impedance signal selector operate independently.

By factory default, the SENSING terminal numbers and logical channel numbers match as shown in Fig.3-3. If the SENSING terminal is connected as shown in Fig.2-8, the KFM2151 scans in order from cell 1.

You can also arbitrarily assign the SENSING terminal numbers to channels and perform scanning.
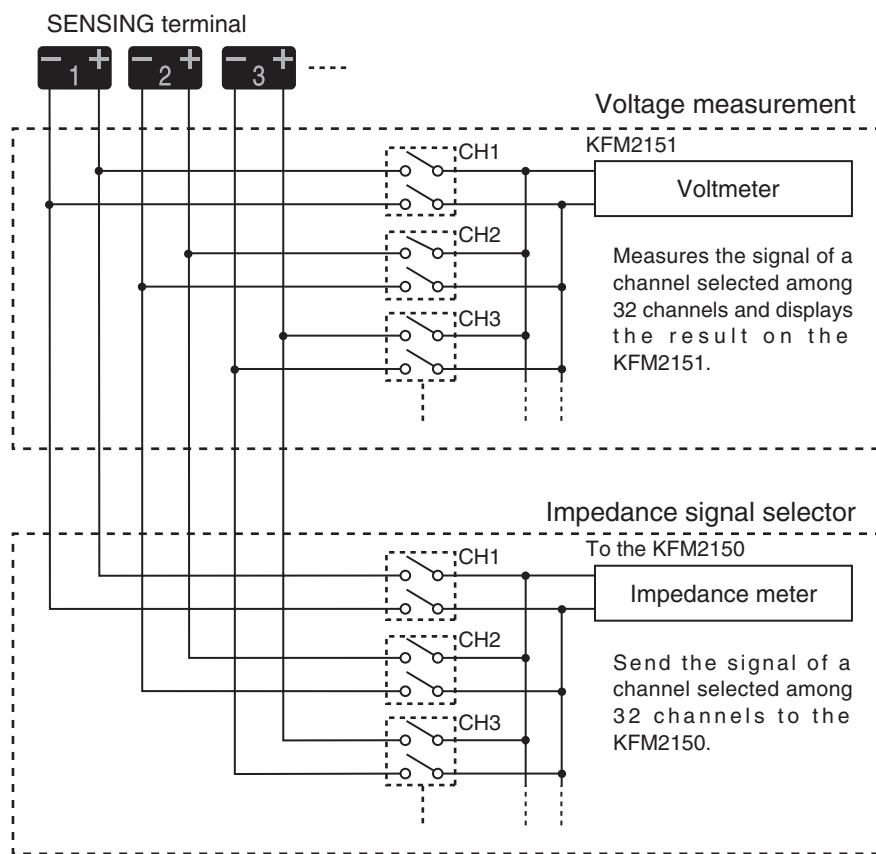
Fig.3-3   Two system configuration (factory default example)

When setting an impedance channel, select the desired channel and set the scanned source (ON/OFF).

When setting a voltage channel, select the desired channel and set the scanned source (ON/OFF), voltage protection, and range.

Channel number

The highest digit of the channel number of the master unit shows zero. The highest digit for slave units shows a number between 1 and 4 (unit number). The unit numbers are set in the CONFIG settings.

Value: 1 to 32

A buzzer sounds if the selectable range is exceeded.

Scanned source

Scanning is performed in order from the smallest channel number. In the example of Table 3-1, scanning progresses from left to right. Scanning is performed on channels whose scanned source turned ON (enabled). Scanning is skipped for channels that are turned OFF (disabled). In this example, CH3 is skipped and continues to CH4.

Table 3-1   Scanning operation (example)

Logical channel number	CH1	CH2	CH3	CH4
Scanned source	ON	ON	OFF	ON
Scanning	Executed ➤	Executed		➤ Executed

The VOLT/TERM display blinks.

Value:	ON	Scanned
	OFF	Not scanned

Voltage protection (only for voltage scanning)

Set the overvoltage protection (OVP) and undervoltage protection (UVP).

Value: -2.00 V to 200.00 V

Resolution: ▲ When using the ▼ key   10 mV

When using SHIFT+▲ ▼   1 V

A buzzer sounds if the selectable range is exceeded.

Range setting (only for voltage scanning)

Set the range.

Value: 2 V, 20 V, 200 V, or AUTO

Table 3-2   Measurement Range and Auto Range

Range	Measurement Range	Auto Range	
		Range Down	Range Up
200 V	-199.99 to 199.99	10 V or less	None
20 V	-19.999 to 19.999	1 V or less	20 V or higher
2 V	-1.9999 to 1.9999	None	2 V or higher
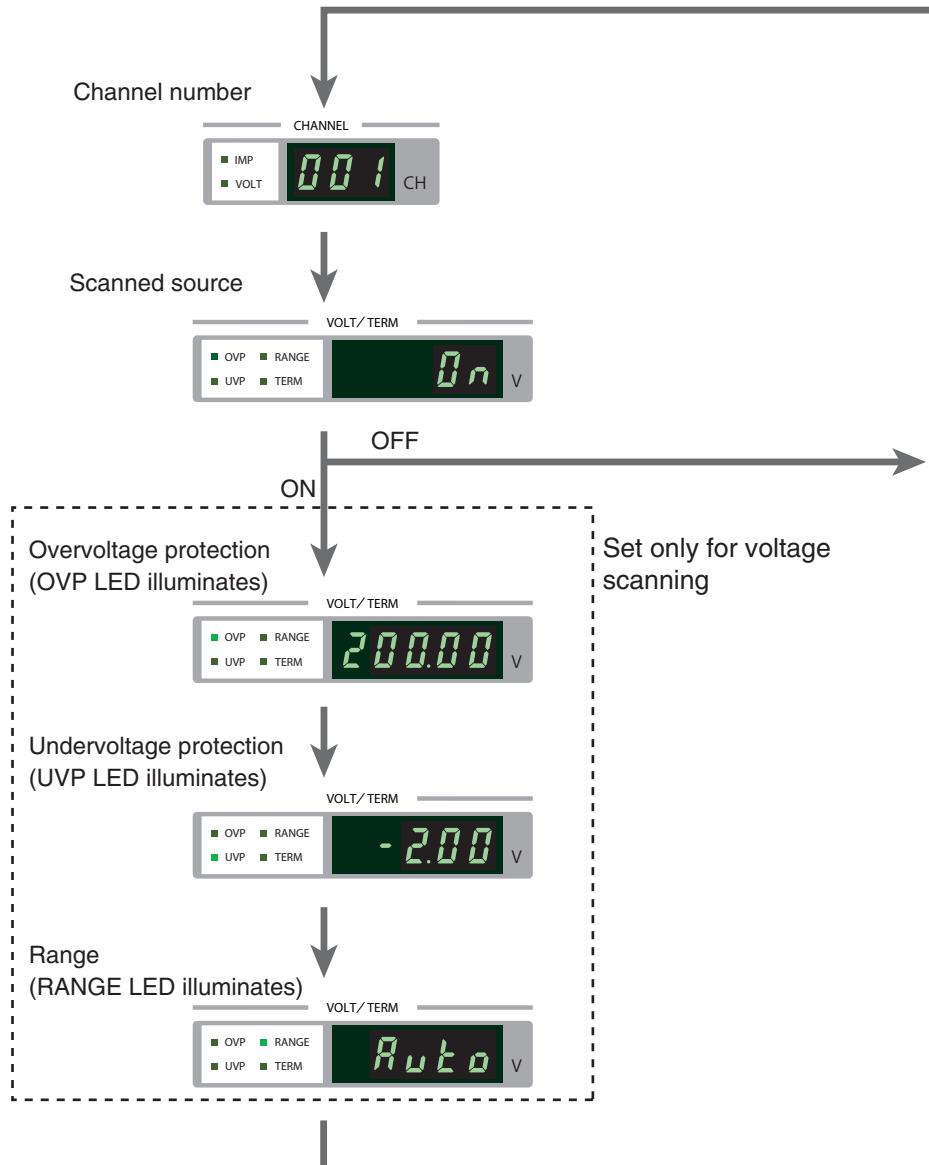
Fig.3-4   Channel setting

The procedure on how to use a single KFM2151 is explained in the following pages.
If you are using multiple KFM2151s, set the channel expansion in advance.

Setting the impedance channels

1. Check that the KFM2151 is in monitor mode.

   If the CHANNEL display or VOLT/TERM display is blinking, press the MON key.

2. Press the IMP/VOLT key.

   Select IMP.

   The IMP LED and VOLT LED illuminate alternately each time you press the IMP/VOLT key.

3. Press the SET key.

   The CHANNEL display blinks.

4. Press the ▲ and ▼ keys or SHIFT+▲ and ▼ keys to select the channel.

5. Press the SET key.

   The VOLT/TERM display blinks.

6. Press the ▲ and ▼ keys to select the scanned source (ON/OFF).

7. Press the SET key.

   The CHANNEL display blinks.

8. To set other channels, repeat steps step 4 to 7 . To finish, press the MON key.

Setting the voltage channels

1. Check that the KFM2151 is in monitor mode.

   If the CHANNEL display or VOLT/TERM display is blinking, press the MON key.

2. Press the IMP/VOLT key.

   Select VOLT.

   The IMP LED and VOLT LED illuminate alternately each time you press the IMP/VOLT key.

3. Press the SET key.

   The CHANNEL display blinks.

   The settings switch in order each time you press the SET key.

4. Press the ▲ and ▼ keys or SHIFT+ ▲ and ▼ keys to select the channel.

5. Press the SET key.

   The VOLT/TERM display blinks.

6. Press the ▲ and ▼ keys to select the scanned source (ON/OFF).

7. Press the SET key.

   If you set the scanned source to ON in step step 6 , the OVP LED illuminates, and the VOLT/TERM display blinks. If you select OFF, the CHANNEL display blinks.

   If you set the scanned source to OFF, proceed to step step 14 .

8. Press the ▲ and ▼ keys or SHIFT+ ▲ and ▼ keys to set the overvoltage protection (-2.00 V to 200.00 V).

9. Press the SET key.

   The UVP LED illuminates, and the VOLT/TERM display blinks.

10. Press the ▲ and ▼ keys or SHIFT+ ▲ and ▼ keys to set the undervoltage protection (-2.00 V to 200.00 V).

11. Press the SET key.

    The RANGE LED illuminates, and the VOLT/TERM display blinks.

12. Press the ▲ and ▼ keys to select the range (2, 20, 200, or AUTO).

13. Press the SET key.

    The CHANNEL display blinks.

14. To set other channels, repeat steps step 4 to 13 . To finish, press the MON key.

3.5   Logical Channel Configuration

Logical channels and SENSING terminal

The channels on the KFM2151 are logical channels. You can assign arbitrary SENSING terminal numbers to be assigned to channels (logical channels). Up to 32 logical channels can be set separately for impedance and voltage.

On the SENSING terminal, TERM+ is high potential and TERM- is low potential. Isolated from the chassis electric potential (withstand voltage of 250 V). The input impedance is approximately 1 MΩ.

Because the channels are logical channels, channel numbers can be changed without having to change the connection to the measurement point. It is also possible to assign the same SENSING terminal number to multiple logical channels.

By factory default, the SENSING terminal numbers and logical channel numbers match. In the connection shown in Fig.3-5, channel 1 scans cell 1.
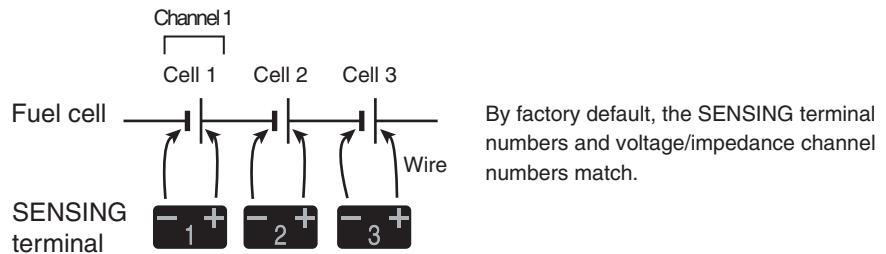
Fig.3-5   Logical channel configuration (factory default condition)

Here, we change the configuration of channel 1. The SENSING terminals are assigned to the voltage and impedance logical channels as shown below.

Assign TERM+3 and TERM-2 to voltage channel 1. The negative terminal of cell 2 and the positive terminal of cell 3 are assigned, and the series voltage of cells 2 and 3 is scanned.

Assign TERM+2 and TERM-1 to impedance channel 1. The negative terminal of cell 1 and the positive terminal of cell 2 are assigned, and the series impedance of cells 1 and 2 is scanned.
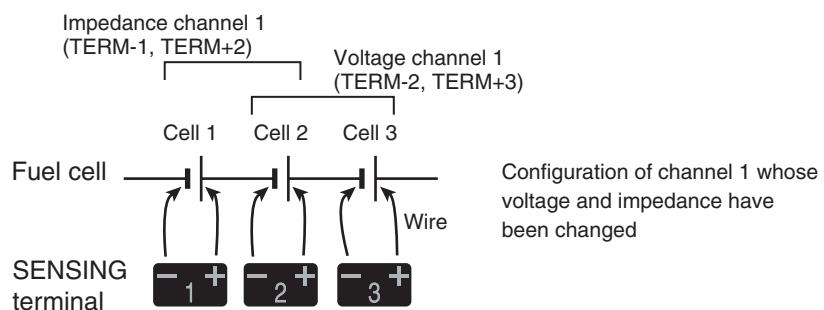
Fig.3-6   Logical channel configuration (example in which channel 1 is changed)

Setting the channel assignments
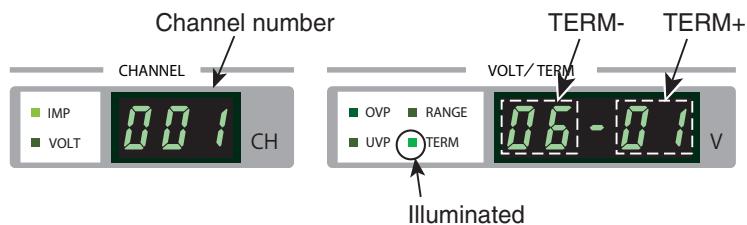
Fig.3-7   Example of the display shown when assigning channels

1. Check that the KFM2151 is in monitor mode.

   If the CHANNEL display or VOLT/TERM display is blinking, press the MON key.

2. Press the IMP/VOLT key.

   Select impedance (IMP) or voltage (VOLT).

   The IMP LED and VOLT LED illuminate alternately each time you press the IMP/VOLT key.

3. Press the ▲ and ▼ keys or SHIFT+▲ and ▼ keys to select the channel number.

4. Press SHIFT+TERM to make TERM- blink.

   The TERM LED illuminates in green. The left two digits of the VOLT/TERM display correspond to TERM-, and the right two digits correspond to TERM+.

   TERM+ and TERM- blinks alternately each time you press SHIFT+TERM.

5. Press the ▲ and ▼ keys or SHIFT+▲ and ▼ keys to select the terminal number (1 to 32).

   A buzzer sounds if the selectable range is exceeded.

6. Press SHIFT+TERM to make TERM+ blink, and set it in the same manner.

7. Press SHIFT+TERM to confirm.

   TERM- blinks again.

8. Press the MON key.

   The KFM2151 enters monitor mode. To set other channels, repeat steps step 2 to step 7 .

3.6   Checking the Channels

Press the ▲ and ▼ keys or SHIFT+ ▲ and ▼ keys in monitor mode to select the channel number (1 to 32). Channels whose scanned source is turned OFF are skipped. The monitor LED shows the channel status.

Selected channel: CH2
Scanned channel: CH1, CH2, CH4, CH6 to 32

□ Illuminated (orange)
■ Illuminated (green)
□ Off
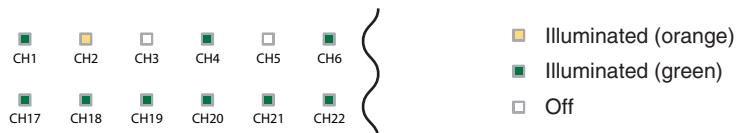
Fig.3-8   Monitor LED

Table 3-3   Channel status shown on the monitor LED

LED Status		Description
On	Green	Scanned source channel not currently selected.
	Orange	Selected channel.
	Red	OVP or UVP alarm is activated.
Off		Channel that is not scanned.

■ **Impedance scanning**

The VOLT/TERM display shows "-----". The impedance is shown on the KFM2150.

If all channels are not scanned, the CHANNEL display shows "x--". (x is the unit number.)
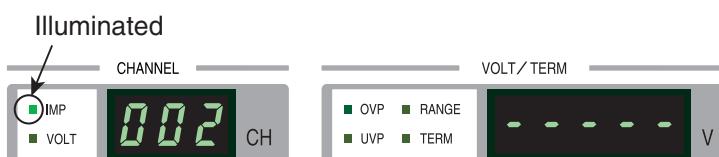
Fig.3-9   Impedance meter scanning

■ **Voltage scanning**

The VOLT/TERM display shows the voltage of the selected channel. If the range is exceeded or the measurement is not possible, "-----" is shown.
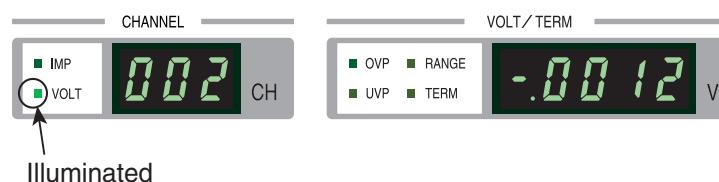
Fig.3-10   Voltmeter scanning

3.7   CONFIG Settings

This section explains how to set the CONFIG parameters for using the KFM2150. The CONFIG parameter number and condition are displayed as shown in Fig.3-11.
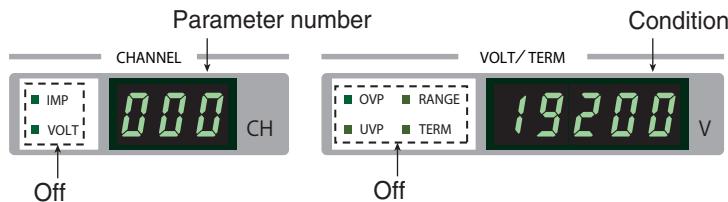
Fig.3-11   Example of a CONFIG setting display

Parameters and conditions

Table 3-4   Parameter and settings

Parameter Number	Parameter		Condition
000	RS232C	Baud rate	19200 bps/9600 bps/4800 bps/2400 bps
001		Data length	7 bits/8 bits
002		Stop bit	1 bit/2 bits
003		Acknowledge message	ON/OFF
010	Unit number		00: Master unit 01/02/03/04: Slave unit

1. Check that the KFM2151 is in monitor mode.

   If the CHANNEL display or VOLT/TERM display is blinking, press the MON key.

2. Press SHIFT+CONFIG.

   The CHANNEL display blinks, and parameter number 000 is shown.

3. Press the ▲ or ▼ key to select the parameter number.

4. Press the SET key.

   The VOLT/TERM display blinks, and the conditions are shown.

5. Press the ▲ or ▼ key to select the condition.

6. Press the SET key to confirm.

   The CHANNEL display blinks. To set other conditions, repeat steps step 3 and 6 .

7. Turn the POWER switch off and then turn it back on.

   The specified conditions are activated.

3.8   Channel Expansion

Up to four slave units can be connected to a single master unit.
The number of channels can be expanded to 160 by using five KFM2151s.

For the connection between the KFM2151 and the KFM2150 FC Impedance Meter, see "2.4 Connecting the KFM2151 to the FC Impedance Meter."

Table 3-5 shows the channel numbers when multiple KFM2151s are used.

If you are using a single KFM2151, set it to be the master unit.
Channel verification works correctly only when the master unit is operating.

Table 3-5   Channel numbers of the master unit and slave units

Master/Slave	Unit Number	Channel Number
Master unit (factory default)	0	001 to 032
Slave unit	1	101 to 132
	2	201 to 232
	3	301 to 332
	4	401 to 432

Setting the master unit or slave unit (unit number)

Set one KFM2151 to be the master unit (unit number: 0) and other KFM2151s to be slave units (unit number: 1 to 4).

1.   Select parameter number 010 in the CONFIG settings.

2.   In the condition setting, set the master unit to 00 and slave units to 01, 02, 03, or 04.

3.   Turn the POWER switch off and then turn it back on.

3.9 Performing the Scanning Operation

The procedure to perform the impedance scanning and voltage scanning is explained below.

3.9.1 Impedance Scanning

Scanning is performed on the channels on which scanning is enabled. The scanned input signal is transmitted to the KFM2150 FC Impedance Meter. The impedance is shown on the KFM2150.

There are two impedance scanning modes: manual scanning and auto scanning.

Manual scanning

Press the ▲ and ▼ keys or SHIFT+ ▲ and ▼ keys in monitor mode to select the channel number (1 to 32). The impedance is shown on the KFM2150.

Auto scanning

Scanning is performed on channels that are set to scanned source. Scanning is performed in order from the smallest channel number. When the scanning of the last channel is complete, the scanning operation returns to the smallest channel number. This operation is repeated until the scanning operation is aborted.

If the measuring frequency on the KFM2150 is low, the scanning speed is slow.

You can switch to the voltage monitor by pressing the IMP/VOLT key during auto scanning. Impedance scanning continues even while you monitor the voltage. You cannot stop the impedance scanning while monitoring the voltage. If you want to do so, press the IMP/VOLT key again and then stop it.

Scanning when using a single KFM2151

The procedure to scan when using a single KFM2151 is given below.

1. Check that the KFM2151 is in monitor mode.

   If the CHANNEL display or VOLT/TERM display is blinking, press the MON key.

2. Press the IMP/VOLT key to select impedance.

   The IMP LED illuminates. The monitor LED of the channel whose scanning is enabled illuminates in green. The IMP LED and VOLT LED illuminate alternately each time you press the IMP/VOLT key.

3. **Press the SCAN key to start the scanning operation.**

   The SCAN LED illuminates while auto scanning is in progress. The minimum hold time is fixed to 1000 ms.

4. **Press the SCAN key to stop the scanning operation.**

   The scanning operation stops, and the SCAN LED turns off. You can also press the ▲ and ▼ keys or SHIFT+▲ and ▼ keys to stop the scanning operation.

Scanning when the channels are expanded

The procedure to scan when using multiple KFM2151s is given below.

Scanning is performed on channels that are set to scanned source in order from the smallest channel number. When the scanning on the master unit is complete, the scanning starts on the slave units. When the scanning of the last channel is complete, the scanning returns to the master unit. This operation is repeated until the scanning operation is aborted.

1. **Check that the KFM2151 is in monitor mode.**

   If the CHANNEL display or VOLT/TERM display is blinking, press the MON key.

2. **Press the IMP/VOLT key to select impedance.**

   The IMP LED illuminates. The monitor LED of the channel whose scanning is enabled illuminates in green. The IMP LED and VOLT LED illuminate alternately each time you press the IMP/VOLT key.

3. **While holding the SHIFT key down, press the SCAN key on the master or slave unit.**

   The SCAN LED of units that are scanning illuminates in orange.
   The minimum hold time is fixed to 1000 ms.

4. **Press the SCAN key on a unit that is scanning to stop the scanning operation.**

   The scanning operation stops, and the SCAN LED turns off.

To scan on a single unit, press the SCAN key on the desired unit.

3.9.2   Voltage scanning

See │ Page 3-2

Voltage scanning starts when you switch the KFM2151 to monitor mode after setting the channels. There is no need to operate the SCAN key as in the impedance scanning.

Voltage scanning stops while setting various conditions.

3.10   Alarms

This section describes the display when alarms occur, and the procedure to clear alarms.

Alarm display

When an alarm occurs while scanning voltage, the monitor LED illuminates as shown in Table 3-6.

Table 3-6   LED display when alarms occur

LED	Alarm Description	LED Display
Monitor LED	There are channels on which alarms are occurring.	The corresponding channels illuminate in red.
OVP LED	There are channels on which OVP alarms are occurring.	Illuminates in red.
UVP LED	There are channels on which UVP alarms are occurring.	Illuminates in red.

If an alarm occurs while monitoring the impedance, the OVP LED or UVP LED and the corresponding monitor LED illuminate in red. The LEDs illuminate even when the corresponding channel is not scanning the impedance.

The LED remains illuminated until the alarm is cleared. If you do not eliminate the cause of the alarm, the alarm will occur again when you clear the alarm and perform scanning.

Clearing alarms

This section explains the procedure to clear the alarm on each channel and the procedure to clear the alarms collectively on all channels.

The procedure on how to clear an alarm on a single KFM2151 is explained below. Clear the alarms on each unit also when using multiple KFM2151s.

If the alarms of all channels are cleared, the OVP LED and UVP LED turn off. If you do not eliminate the cause of the alarm, the alarm will occur again when you perform scanning.

Clearing the alarm by selecting the channel

1. Check that the KFM2151 is in monitor mode.

   If the CHANNEL display or VOLT/TERM display is blinking, press the MON key.

2. Press the IMP/VOLT key to select voltage.

   The VOLT LED illuminates. The IMP LED and VOLT LED illuminate alternately each time you press the IMP/VOLT key.

3. Check the channel number on which the alarm occurred.

   The monitor LED of the corresponding channel is illuminated in red.

4. Press the ▲ and ▼ keys or SHIFT+ ▲ and ▼ keys to select the channel number.

5. Press the ALM CLR key.

   The alarm on the selected channel is cleared. The monitor LED turns green.

Clearing the alarm on all channels

1. Check that the KFM2151 is in monitor mode.

   If the CHANNEL display or VOLT/TERM display is blinking, press the MON key.

2. Press the IMP/VOLT key to select voltage.

   The VOLT LED illuminates. The IMP LED and VOLT LED illuminate alternately each time you press the IMP/VOLT key.

3. Press the SHIFT+ALM CLR key.

   All alarms are cleared. The monitor LEDs of all channels on which alarms occurred turn to green.

3.11   Initializing to Factory Default Settings

This section explains factory default settings of the KFM2151 and how to initialize to factory default settings.

■ **Factory default settings**

Table 3-7 shows the factory default settings of the KFM2151.

Table 3-7   factory default settings

Parameter			Factory default setting
CONFIG	RS232C	Baud rate	19200 bps
		Data length	8 bits
		Stop bit	2 bits
		Acknowledge message	OFF
	Unit number		0 (master)
Setting (Channels 1 to 32)	VOLT	Scanned source	ON (scanned)
		OVP	200.00 V
		UVP	-2.00 V
		RANGE	AUTO
		TERM+	The SENSING terminal numbers and logical channel numbers match.
		TERM-	
	IMP	Scanned source	ON (scanned)
		TERM+	The SENSING terminal numbers and logical channel numbers match.
		TERM-	
Monitor	IMP/VOLT selection		VOLT
	VOLT		1 CH
	IMP		1 CH

■ **Initializing to factory default settings**

The KFM2151 stores the settings entered from the panel through the backup function.

To initialize to factory default settings, turn the POWER switch on while holding the SHIFT key down. The buzzer sounds, and the KFM2151 powers up. The parameters in Table 3-7 are initialized to factory default settings.

3.12   Switching from Remote to Local Mode

Pressing the LOCAL key when the KFM2151 is being controlled remotely causes the KFM2151 to switch to panel operation (local mode). The REMOTE LED illuminates when the KFM2151 is being controlled remotely.

3.13 Channel and SENSING Terminal Assignment Table

Unit number	0	1	2	3	4
Channel number	001 to 032	101 to 132	201 to 232	301 to 332	401 to 432

Impedance scanning			
Channel No.	Enable Disable	TERM –	TERM+
□ 01			
□ 02			
□ 03			
□ 04			
□ 05			
□ 06			
□ 07			
□ 08			
□ 09			
□ 10			
□ 11			
□ 12			
□ 13			
□ 14			
□ 15			
□ 16			
□ 17			
□ 18			
□ 19			
□ 20			
□ 21			
□ 22			
□ 23			
□ 24			
□ 25			
□ 26			
□ 27			
□ 28			
□ 29			
□ 30			
□ 31			
□ 32			

□ : 1, 2, 3, or 4

Voltage scanning					
Channel No.	Enable Disable	OVP (V)	UVP (V)	Range (V)	TERM –	TERM+
□ 01						
□ 02						
□ 03						
□ 04						
□ 05						
□ 06						
□ 07						
□ 08						
□ 09						
□ 10						
□ 11						
□ 12						
□ 13						
□ 14						
□ 15						
□ 16						
□ 17						
□ 18						
□ 19						
□ 20						
□ 21						
□ 22						
□ 23						
□ 24						
□ 25						
□ 26						
□ 27						
□ 28						
□ 29						
□ 30						
□ 31						
□ 32						

□ : 1, 2, 3, or 4

Remote Control

This chapter describes the procedure for connecting the interface and the procedure for transmitting commands to the KFM2151 using SCPI commands.

4.1   Overview

In addition to using the front panel, the KFM2151 can be controlled remotely using the RS232C interface.

The remote interface complies with IEEE 488.2 std 1992 and SCPI Specification 1999.0.

Use the SCPI commands only after you have understood the SCPI command syntax for the KFM2151.

4.2   Instrument Interface Standards

The KFM2151 conforms to the following standards.

- IEEE Std 488.2-1992 IEEE Standard Codes, Formats, Protocols, and Common Commands For Use With IEEE Std 488.1-1987
- Standard Commands for Programmable Instruments (SCPI) version 1999.0

4.3   Interface Setup

The remote control interface is RS232C.

RS232C connection

Turn off the POWER switch on the KFM2151 and the computer.

Connect the KFM2151 to the PC using an RS232C cable. The RS232C cable is not included in the package.

If you are using the KFM2151 as an impedance measurement system in combination with the KFM2150, connect the KFM2150 and the KFM2151 to the PC. We recommend that the KFM2150 be connected to the PC using USB or GPIB. If you are using the RS232C, you must use a PC that has two RS232C ports.

■ RS232C cable

Use a D-sub 9-pin female-to-female AT type cross cable for the RS232C cable. Fig.4-1 shows the connector pin assignments.

Because the KFM2151 does not use hardware handshaking, DTR(4)/DSR(6) and RTS(7)/CTS(8) connections are not required.

Facing the KFM2151 rear panel   Cross cable example
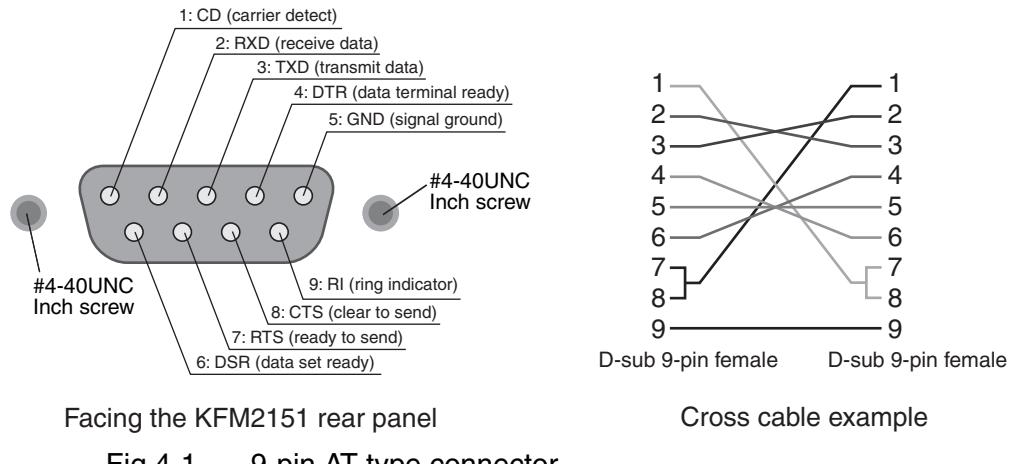
Fig.4-1   9-pin AT type connector

Protocol

Table 4-1 shows the RS232C protocol. Underline indicates factory default condition.

The settings are changed in the CONFIG settings.

Table 4-1   RS232C protocol

Parameter	Setting
Connector	9-pin D-sub terminal on the rear panel
Baudrate	2400 bps, 4800 bps, 9600 bps, or 19200 bps
Data (data length)	7 bits or 8 bits
Stop (stop bit)	1 bit or 2 bits
Parity	Fixed to none
Ack (acknowledge)	ON or OFF

RS232C communication

Use X-Flow control or acknowledge function for RS232C communication.

Transmission/reception may not work correctly through unilateral transmission.

■ X-Flow control

The transmission/reception on the KFM2151 can be controlled using Xon/Xoff. DC (device control) codes are used to carry out control.

Table 4-2   DC codes

Code	Function	ASCII Code
DC1	Transmission request	11H
DC3	Transmission stop request	13H

After receiving DC3, the KFM2151 pauses transmission within 3 characters.
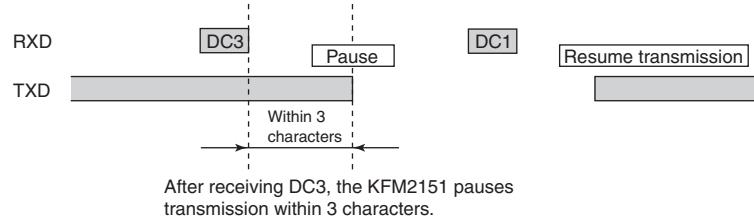
Transmission control from KFM2151 to the RS232C terminal

The RS232C terminal must pause transmission within 10 characters after receiving DC3.
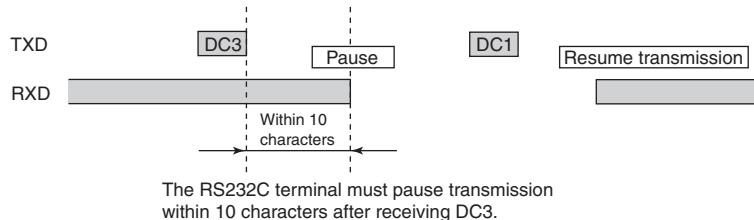
Fig.4-2   RS232C terminal and transmission control of the KFM2151

■ Acknowledge message

An acknowledge message is information sent from the KFM2151 to the controller. It notifies that the processing of the program message has been completed.

The acknowledge message is an ASCII code string consisting of only the header. The following two types are available.

- OK: Normal completion
- ERROR: Syntax error or other errors

To use acknowledge messages, set Acknowledge to On in the CONFIG settings.

On the controller, the RS232C configuration must be set to full-duplex operation.

4.4   Overview of Messages

The information that is exchanged between the controller (computer) and the device (KFM2151) is called a message.

The KFM2151 uses the SCPI language for the messages.

There are two types of messages, commands that are sent from the computer to the KFM2151 and responses that are sent from the KFM2151 to the computer.

Command hierarchy

SCPI commands are ASCII-based commands designed for test and measurement devices. The command hierarchy is structured around the common root or node, which is the construction block of the SCPI sub system. A command consists of a program header, parameters, and punctuations.

The hierarchy is explained using the CHANnel subsystem as an example.

Program header	Parameter	Node hierarchy
CHAN		Root node
:VOLT		2nd level
:DC		3rd level
:TERM	<NR1>,<NR1>,<NR1>,<boolean>	4th level
:NSEL	<NR1>	4th level
:ROUT		2nd level
:TERM	<NR1>,<NR1>,<NR1>,<boolean>	3rd level
:NSEL	<NR1>	3rd level

A higher node is separated from a lower node using a colon (:).

4.4.1　Command Syntax

This manual denotes SCPI commands using the following format.

```
[SENSe:]VOLTage[:DC]:RNAGe:AUTO
```

SCPI commands can be issued using the short form. The short form of an SCPI command is the section of the command written in uppercase.

SCPI commands can be sent in the long form or short form. Since SCPI commands are not case-sensitive, VOLT, Volt, and volt are all accepted as the short form of VOLTage. In the long form, VOLTAGE, Voltage, and voltage are all acceptable.

- A space is required between the program header section and the parameter section.

- Multiple parameters, when available, are concatenated using commas.

- Commands are concatenated using semicolons (complex command).

```
VOLTage:PROTection:UPPer 200;LOWer 100
```

In the second command, the root node VOLTage:PROTection: is omitted. This is because the path is set to VOLT:PROTection by the first command VOLTage:PROTection:UPPer.

This compound command is the same as entering the following commands.

```
VOLTage:PROTection:UPPer 200
```

```
VOLTage:PROTection:LOWer 100
```

An error occurs if a node that is not defined in the current path is designated.

Commands of different subsystems can be concatenated using colons and semicolons.

```
CHANnel:VOLTage:NSELect 1;:MEASure:VOLTage?
```

This compound command contains two root nodes, CHANnel and MEASure.

When the second or subsequent command starts with a colon, the path specified by the previous command is cleared.

- The maximum number of characters that can be transmitted in a single line is 255.

Special symbols

Special symbols used in this manual to describe SCPI commands are defined below.

- Characters and numbers delimited by "|" in braces indicate that one of the items is to be selected.
  Do not include the braces in the actual program.

- The characters < > indicate program data.
  Do not write < > in the actual program.

- Brackets indicate option data.
  When option data is not sent with the program, the default value is applied.
  Do not write [] in the actual program.

Query

The device settings or status can be queried.

To make a query, add a question mark at the end of the program header section.

If a query has parameters, enter a space after the question mark followed by the parameters.

```
VOLTage:PROT? MIN
```

■ Response

A response returned as an answer to a query. It is a message that is always sent from the device to the computer. The status of the device or measured values is transmitted to the computer.

NOTE
- When transmitting two queries in separate lines, read the response to the first query before transmitting the second line. When two query lines are sent at once, an incomplete response may be received for the first query followed by a complete response for the second query.

String termination

All commands must be terminated using a valid terminator.

The available terminators are <new line> (ASCII 0x0A) and EOI (end-or-identify). Either one can be used as a terminator.

EOI is not available on the RS232C. Be sure to use <new line>.

When a command string is terminated, the path is reset to the root level.

NOTE
- CR (ASCII 0x0D) is not a terminator.

Common commands

The IEEE-488.2 and SCPI standards contain a set of common commands for reset, self-test, and other functions. These common commands always start with an asterisk. The commands may have one or multiple parameters.

4.4.2   Parameters

The parameter format of SCPI is derived from the program parameter format defined in IEEE 488.2.

The representation system of the program data that the KFM 2151 handles is indicated below.

Non-numeric parameters

■ String data

String data is used when a series of ASCII characters are requested.

Enclose a string in single quotations or double quotations. The start and end quotation marks must match.

If you wish to use a quotation mark as a part of the string, enter two quotation marks consecutively (with no characters in between).

■ Boolean data

Boolean data expresses a 1 or 0 condition or an ON or OFF condition. Responses are returned as 1 or 0.

```
VOLTage:RANGe:AUTO ON
```

Numeric parameters

■ NR1

Represents an integer.

Details are given in the IEEE 488.2 Standard Digital Interface for Programmable Instrumentation.

■ NR3

Represents a real number (exponential).

Details are given in the IEEE 488.2 Standard Digital Interface for Programmable Instrumentation.

The value +5.20000+E01 is returned for the response data 52.0. The number of digits to the right of the decimal is 5.

■ NRf

NRf is a generic term that includes NR1 and NR3.

■ Numeric

A numeric parameter such as a decimal point, option symbol, or measurement unit.

The syntax as a numeric representation is the same as NRf.

MINimum, MAXimum, and DEFault are available as substitutes for declaring certain values.

Units such as V, A, and W can also be used in a numeric parameter.

If a value that cannot be assigned is entered, the device rounds the value to the closest possible value.

```
VOLTage:RANGe 250
```

Because the range setting is 2 to 200, 200 is returned in response to VOLT:RANG?.

Special form numeric parameters

The special form numeric parameters MINimum, MAXimum, and DEFault can be used as substitutes for limit values when the parameter is numeric.

In the example below, the voltage protection (UVP) is set to the minimum value.

```
VOLTage:PROTection:LOWer MINimum
```

The minimum and maximum values can be inquired for most parameters using queries.

```
VOLTage:PROTection:LOWer? MIN
```

```
VOLTage:PROTection:LOWer? MAX
```

Measurement unit

Below are the default measurement units.

- V (voltage)

The following optional prefixes are supported.

- M (milli)
- K (kilo)
- U (micro)

NOTE
- The unit symbols in the International System of Units contain lowercase characters. The IEEE standard uses uppercase characters. SCPI commands are not case sensitive.
- Commands are accepted even if a measurement unit are not specified.
- To enter "μ" in the data, use "U" instead.

4.4.3   Default Conditions

Table 4-3 shows the default conditions when *RST, CONF:VOLT, CONF:VOLT:ALL, or MEAS? is sent and when the KFM2151 is shipped from the factory. When the power is turned on, the parameters in Table 4-3 are set to the settings that existed when the POWER switch was turned off.

Table 4-3   Default conditions

Setting	Value		Unit	Note
	*RST Factory Default	CONF[1] MEAS?		
CHAN:VOLT:TERM	[2]	No change	–	Sets the channels on which to perform voltage scanning.
CHAN:VOLT:NSEL	1	No change	–	Specify the channel on which to perform voltage scanning.
CHAN:ROUT:TERM	[3]	No change	–	Sets the channels on which to perform impedance scanning.
CHAN:ROUT:NSEL	1	No change	–	Specify the channel on which to perform impedance scanning.
VOLT:RANG	200	[4]	–	
VOLT:RANG:AUTO	ON	[4]	–	
VOLT:PROT	200	200	V	
VOLT:PROT:LOW	-2.00	-2.00	V	

*1.   When CONF:VOLT or CONF:VOLT:ALL is sent.
*2.   Chan: 1, term±: 01, voltage scanning: on
*3.   Chan: 1, term±: 01, impedance scanning: on
*4.   Range specified by CONF:VOLT, CONF:VOLT:ALL, and MEAS?

4.5   SCPI Commands

The SCPI commands below are those that are used on the RS232C interface.

4.5.1   IEEE 488.2 Common Commands

*CLS

Clears all event registers including the status byte, event status, and error queue.

Command

    *CLS

*ESE

Sets the event status register that is counted by the event summary bit (ESB) of the status byte.

Command

    *ESE <NR1>

    *ESE?

Parameter

Value: 0 to 255

An SCPI error (-222, "Data out of range") occurs if outside the range.

(Example)   When *ESE 16 is transmitted, bit 4 of the event status enable register is set. Each time the execution error bit (bit 4) of the event status register is set, the event summary bit (ESB) of the status byte is set.

Response

Returns the value of the event status enable register in the <NR1> form in response to *ESE?.

*ESR

Queries the event status register. This register is cleared when it is read.

Command

    *ESR?

Response

Returns the value of the event status register in the <NR1> form in response to *ESR? and clears the register.

*IDN

Queries the manufacturer name, model, serial number, and firmware version.

Command

```
*IDN?
```

Response

The response to *IDN? is indicated below.

(Example) For KFM2151 with a serial number AB123456 and firmware version 1.00

```
Returns KIKUSUI,KFM2151,AB123456,1.00.
```

NOTE • When using a compound command in which multiple commands are concatenated, include *IDN? as the last message unit. Otherwise, An SCPI error (-440, "Query UNTERMINATED after indefinite response") occurs.

*OPC

The KFM2151 does not support asynchronous I/O operation.

When the *OPC command is transmitted, the Operation Complete bit (bit 0) of the standard event status register is set.

Command

```
*OPC
*OPC?
```

Response

See

IEEE 488.2-1992
Section 12.5.3

Returns the ACII character "1" in the output queue in response to *OPC?.

*RST

Resets the device to factory default settings. For the commands that are affected, see Table 4-3.

Command

```
*RST
```

*SRE

Sets the service request enable register bits.

The service request enable register is used to select the summary messages in the status byte register that will be able to perform service requests.

To clear the service request enable register, send *SRE 0. If the register is cleared, service requests cannot be generated by status information.

Command

```
*SRE <NR1>
*SRE?
```

Parameter

Value: 0 to 255

An SCPI error (-222, "Data out of range") occurs if outside the range.

(Example) Sending *SRE 8 sets bit 3 of the service request enable register. Each time the summary bit (bit 3) of the QUEStionable status register in the status byte is set, a service request message is generated.

Response

Returns the value of the service request enable register in the <NR1> form in response to *SRE?.

*STB

Queries the contents of the status byte register and the MSS (master summary status) message.

The response is the same as that of serial polling only with the exception that the MSS message appears in place of the RQS message in bit 6.

Command

```
*STB?
```

Response

Returns the value of the status byte register and the MSS message (bit 6) in <NR1> form in response to *STB?.

*TRG

Because there is no trigger function built into the KFM2151, *TRG results in a command error.

Command

```
*TRG
```

*TST

Since there is no self-test function built into the KFM2151, an ASCII character 0 is always returned in the output queue in response to this query.

Command

```
*TST?
```

Response

Returns 0 in response to *TST?.

*WAI

Prevents the KFM2151 from executing subsequent commands or queries until all operations in standby are complete.

Command

```
*WAI
```

4.5.2   Channel Commands

■ <chan>

The logical channel number of the KFM2151 represents the unit number (0 to 4) in the hundredths unit and the channel number (1 to 32) of the specified unit with the lower two digits.

For example, the third channel of the master unit (unit number = 0) is 003 (or 3), and the 32nd channel of the second unit (unit number = 1) is 132.

In this manual, the channel setting is denoted as <chan>.

Refer to the list below, and replace <chan> with the required setting.

<chan> is in the <NR1> form.

Value: Unit number 0   1 to 32 (001 to 032)

Unit number 1   101 to 132

Unit number 2   201 to 232

Unit number 3   301 to 332

Unit number 4   401 to 432

CHAN:VOLT:TERM

Specify the logical channel for voltage scanning and set the terminal and the scanned source (on/off).

Command

```
CHANnel:VOLTage[:DC]:TERMinals
<chan>,<term+_NR1>,<term-_NR1>,{ON|OFF|1|0}

CHANnel:VOLTage[:DC]:TERMinals? <chan>
```

Parameter   `<term+_NR1>, <term-_NR1>`

Value: 1 to 32   The lower two digits of the specified logical channel by default.

Parameter   `{ON|OFF|1|0}`

Value: ON(1)   Scan the specified channel (default)

OFF(0)   Not scan the specified channel

The settings after sending *RST are indicated in Table 4-3.

Response

Returns TERM+ and TERM- of the specified logical channel and the scanned source (on/off) in the <NR1>,<NR1>,<NR1> form in response to CHAN:VOLT:TERM? <chan>.

(Example)   If channel 1 of unit number 0 is term+7 and term-8 and is set as a scanned source, the following is returned in response to CHAN:VOLT:TERM? 1.

```
7,8,1
```

CHAN:VOLT:NSEL

Specifies the logical channel for voltage scanning. However, the logical channel cannot be specified, if the specified channel is not a scanned source.

Command

```
CHANnel:VOLTage[:DC]:NSELect <chan>

CHANnel:VOLTage[:DC]:NSELect?
```

Parameter   `<chan>`

The default value is 1.

If the specified channel is not a voltage measurement source, an SCPI error (-221, "Settings conflict") is returned.

The settings after sending *RST are indicated in Table 4-3.

Response

Returns the logical channel of the specified voltage scanning in the <NR1> form in response to CHAN:VOLT:NSEL?.

CHAN:ROUT:TERM

Specify the logical channel for impedance scanning and set the terminal and the scanned source (on/off). Auto scanning cannot be executed in remote mode.

Command

```
CHANnel:ROUTe:TERMinals
<chan>,<term+_NR1>,<term-_NR1>,{ON|OFF|1|0}

CHANnel:ROUTe:TERMinals? <chan>
```

Parameter   `<term+_NR1>, <term-_NR1>`

Value: 1 to 32   The lower two digits of the specified logical channel by default.

Parameter   `{ON|OFF|1|0}`

Value: ON(1)   Scan the specified channel (default)

OFF(0)   Not scan the specified channel

The settings after sending *RST are indicated in Table 4-3.

Response

Returns TERM+ and TERM- of the specified logical channel and the scanned source (on/off) in the <NR1>,<NR1>,<NR1> form in response to CHAN:ROUT:TERM? <chan>.

(Example)   If channel 1 of unit number 0 is term+7 and term-8 and is set as a scanned source, the following is returned in response to CHAN:ROUT:TERM? 1.

7,8,1

CHAN:ROUT:NSEL

Specifies the logical channel for impedance scanning. However, the logical channel cannot be specified, if the specified channel is not a scanned source.

Command

CHANnel:ROUTe:NSELect <chan>

CHANnel:ROUTe:NSELect?

Parameter   <chan>

The default value is 1.

If the specified channel is not a scanned source, an SCPI error (-221, "Settings conflict") is returned.

The settings after sending *RST are indicated in Table 4-3.

Response

Returns the logical channel of the specified impedance scanning in the <NR1> form in response to CHAN:ROUT:NSEL?.

VOLT:RANG

Sets the voltage range of the channel specified by CHAN:VOLT:NSEL.

Command

[SENSe:]VOLTage[:DC]:RANGe[:UPPer]
{<numeric>|MIN|MAX|DEF}

[SENSe:]VOLTage[:DC]:RANGe[:UPPer]? [{MIN|MAX}]

Parameter

Value: 2, 20, or 200 The default value is 200.

Table 4-3 shows the settings when *RST, MEAS?, CONF:VOLT, or CONF:VOLT:ALL is sent.

Response

Returns the present range setting in the <NR1> form in response to VOLT:RANG?.

VOLT:RANG:AUTO

Sets the voltage range of the channel specified by CHAN:VOLT:NSEL to auto.

Command

```
[SENSe:]VOLTage[:DC]:RANGe:AUTO {ON|OFF|1|0}
```

```
[SENSe:]VOLTage[:DC]:RANGe:AUTO?
```

Parameter

Value:	ON(1)	Auto range on (default)
	OFF(0)	Auto range off

Table 4-3 shows the settings when *RST, MEAS?, CONF:VOLT, or CONF:VOLT:ALL is sent.

Response

Returns the auto range setting in the <NR1> form in response to VOLT:RANG:AUTO?.

VOLT:PROT

Sets the voltage protection (OVP) of the channel specified by CHAN:VOLT:NSEL.

Command

```
[SENSe:]VOLTage[:DC]:PROTection[:UPPer]
{<numeric>|MIN|MAX|DEF}
```

```
[SENSe:]VOLTage[:DC]:PROTection[:UPPer]? [{MIN|MAX}]
```

Parameter

Value:	-2 to 200	The default value is 200.
Unit:	V	

Table 4-3 shows the settings when *RST, MEAS?, CONF:VOLT, or CONF:VOLT:ALL is sent.

Response

Returns the voltage protection (OVP) in the <NR3> form in response to VOLT:PROT?.

VOLT:PROT:LOW

Sets the voltage protection (UVP) of the channel specified by CHAN:VOLT:NSEL.

Command

```
[SENSe:]VOLTage[:DC]:PROTection:LOWer
{<numeric>|MIN|MAX|DEF}

[SENSe:]VOLTage[:DC]:PROTection:LOWer? [{MIN|MAX}]
```

Parameter

Value: -2 to 200   The default value is -2.

Unit: V

Table 4-3 shows the settings when *RST, MEAS?, CONF:VOLT, or CONF:VOLT:ALL is sent.

Response

Returns the voltage protection (UVP) in the <NR3> form in response to VOLT:PROT?.

4.5.3   Releasing the Protection Function

INP:PROT:CLE

Releases the alarm.

Command

```
INPut:PROTection:CLEar
```

4.5.4 Configuration Function

CONF:VOLT

Sets the voltage range of the channel specified by CHAN:VOLT:NSEL and sets the voltage protection (OVP and UVP) to default.

Command

```
CONFigure[:SCALar]:VOLTage[:DC]
[{<numeric>|MIN|MAX|DEF}]
```

Parameter   <numeric>Voltage range setting

Value: 2, 20, or 200The default value is AUTO.

This command is the same as sending the following commands.

```
[SENSe:]VOLTage[:DC]:RANGe <numeric>
[SENSe:]VOLTage[:DC]:PROTection[:UPPer] DEFault
[SENSe:]VOLTage[:DC]:PROTection:LOWer DEFault
```

CONF:VOLT:ALL

Sets the voltage range of all logical channels that are set as scanned sources for voltage scanning and sets the voltage protection (OVP and UVP) to default.

Command

```
CONFigure[:SCALar]:VOLTage[:DC]:ALL
[{<numeric>|MIN|MAX|DEF}]
```

Parameter   <numeric>Voltage scanning range setting

Value: 2, 20, or 200The default value is AUTO.

This command is the same as sending the following commands to all channels set as scanned sources.

```
[SENSe:]VOLTage[:DC]:RANGe <numeric>
[SENSe:]VOLTage[:DC]:PROTection[:UPPer] DEFault
[SENSe:]VOLTage[:DC]:PROTection:LOWer DEFault
```

CONF

Queries the voltage range setting, resolution setting, and voltage protection (OVP and UVP) of the channel specified by CHAN:VOLT:NSEL.

Command

```
CONFigure[:SCALar]?
```

Response

Returns the following in the <String> form in response to CONFigure[:SCALar]?.

(Example) When the voltage range setting is AUTO, the resolution is 0.001, UVP is 0, and OVP is 20.

```
Returns "VOLT AUTO,1.0000E-03,0,2.00000E01".
```

4.5.5   Trigger Function

INIT

Initiates the voltage scanning. INIT discards the measured data that is already being held immediately before performing the measurement. If an FETC? query is sent immediately after INIT, measured data is returned after waiting for the measurement to complete.

Command

```
INITiate[:IMMediate][:ALL]
```

ABOR

Aborts the scanning currently in progress. Does nothing if the measurement is not in progress.

The condition of the KFM2151 after the power is turned on or immediately after switching from local to remote mode is the same as the condition after ABOR is sent. If ABOR is sent while measurement is in progress, the measured data remains void. If ABOR is sent when the status has not be initialized and the measured data being held is valid, the measured data is never discarded.

Command

```
ABORt
```

*RST

Aborts voltage scanning and discards the measured data being held. Therefore, *RST;:FETC:VOLT? results in an SCPI error (-230, "Data corrupt or stale"), because a query is being made when there is no valid measured data and acquisition of new data cannot be expected.

Command

```
*RST
```

4.5.6   Measurement Function

■ Difference between SCALar and ARRay

The second level node of FETC?, READ?, and MEAS? can be [SCALar] or ARRay.

[SCALar] is the default node that can be omitted and returns the measured data of the channel specified by CHAN:VOLT:NSEL.

ARRay returns the measured data of all logical channels that are set as scanned sources for voltage scanning in comma-separated format.

■ Difference between FETC, READ, and MEAS

FETC acquires data that has been measured already without starting the measurement operation. If you use the FETC? query without initiating the voltage scanning operation after the measured data has been discarded, an SCPI error (-230, "Data corrupt or stale") occurs. This is because there is no valid measured data, and the acquisition of measured data cannot be expected. Be sure to use this command with the INIT command.

READ starts a new measurement operation and acquires the resultant data. The READ command is a combination of INIT and FETC.

MEAS resets the settings to default, starts a new measurement operation, and acquires the resultant data. The MEAS command is a combination of ABOR, CONF, and READ.

FETC
FETC:ARR

Queries the voltage measurement data.

Command

```
FETCh[:SCALaar][:VOLTage[:DC]]?
FETCh:ARRay[:VOLTage[:DC]]?
```

Response

Returns the measured data in the <NR3> form in response to FETC?.

Returns the measured data in the <NR3>, <NR3>... form in response to FETC:ARR?.

Unit: V

READ
READ:ARR

Performs voltage scanning and queries the voltage measurement data.

Command

```
READ[:SCALaar][:VOLTage[:DC]]?
READ:ARRay[:VOLTage[:DC]]?
```

Response

Returns the measured data in the <NR3> form in response to READ?.

Returns the measured data in the <NR3>, <NR3>... form in response to READ:ARR?.

MEAS:VOLT
MEAS:ARR:VOLT

Resets the settings to default (the range can be set), performs voltage scanning, and queries the voltage measurement data.

Command

```
MEASure[:SCALaar]:VOLTage[:DC]?
[{<numeric>|MIN|MAX|DEF}]
MEASure[:SCALaar]:VOLTage[:DC]?[{<numeric>|MIN|MAX}]
```

Parameter   `<numeric>`

Value: 2, 20, or 200   If default is specified or the parameter is omitted, the range of all channels is set to AUTO.

4.5.7　Other Commands

SYST:ERR

Reads the error message from the error queue. The error queue can store up to 255 error messages.

Command

```
SYSTem:ERRor[:NEXT]?
```

Response

Returns the current error message in response to SYST:ERR?.

(Example)　When there is no error.

```
Returns 0, "No error".
```

(Example)　When there is a command error.

```
Returns -100, "Command error."
```

SYST:VERS

Queries the SCPI version to which the KFM2151 conforms.

Command

```
SYSTem:VERSion?
```

Response

Below is an example of the response to SYST:VERS?.

(Example)　When conforming to 1999.0

```
Returns 1999.0.
```

SYST:FORM:INST:COUN

Queries the number of KFM2151s that are connected.

Command

```
SYSTem:FORMation:INSTruments:COUNt?
```

Response

Returns the number of KFM2151s in the <NR1> form in response to SYST:FORM:INST:COUN?.

4.6 Status Registers and Status Report Function

IEEE488.2 and SCPI registers are used for the status registers.

In each SCPI status register, there are sub registers, CONDition register, EVENt register, ENABle register, PTRansition filter, and NTRansition filter.

Fig. 4-3 shows the SCPI status register structure. The character "+" represents the logic sum of the register bits. Table 4-6 to Table 4-4 describe the bit number, bit weight, and the meaning of each bit.

CONDition register

The transition of the CONDition register is automatic and reflects the condition of the KFM2151 in real-time. Reading this register does not affect the contents.

EVENt register

The EVENt register bits are automatically set according to the changes in the CONDition register. The rule varies depending on the positive and negative transition filters (PTRansition and NTRansition). The EVENt register is reset when it is read.

ENABle register

The ENABle register enables the reports to the summary bit or status bit of the event bit.

Transition filter

Use the PTRansition (positive transition) filter to report events when the condition changes from false to true.

Use the NTRansition (negative transition) filter to report events when the condition changes from true to false.

If both the positive filter and the negative filter are set to true, events can be reported each time the status changes.

If both of these filters are cleared, event reporting is disabled.
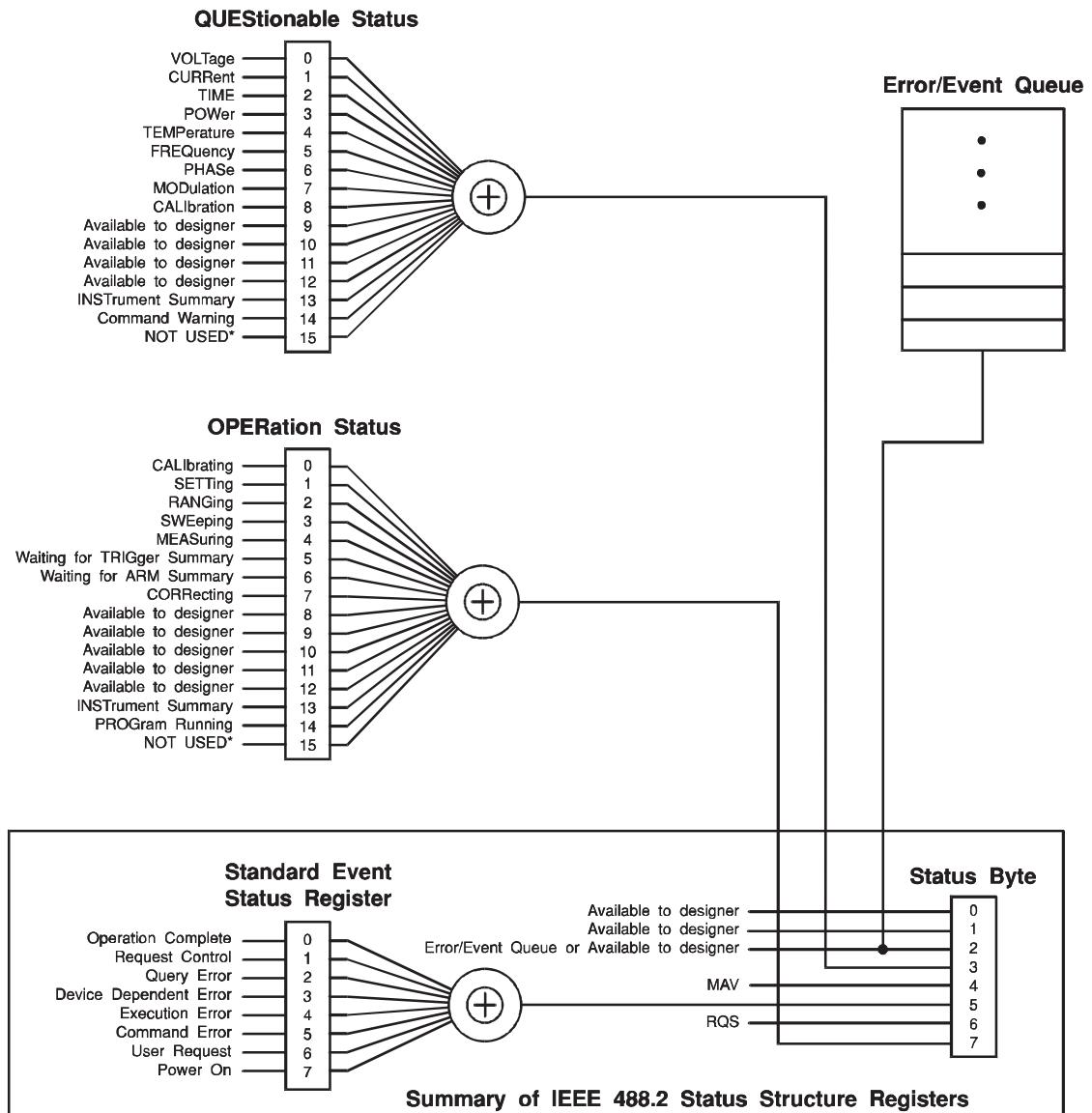
SCPI Standard 1999.0 Volume1 fig.9-1

Fig.4-3   Status register

4.6.1 IEEE488.2 Register Model

Status byte register

The status byte register stores STB and RQS (MSS) messages as defined by the IEEE488.1 standard. The status byte register can be read using IEEE488.1 serial polling or IEEE488.2 common command *STB?.

When serial polling is carried out, bit 6 responds with the request service (RSQ). The status byte value is not changed by serial polling.

The *STB? query makes the device transmit the contents of the status byte register and the master summary status (MSS) summary message.

The *STB? query does not change the status byte, MSS, and RQS.

Table 4-4   Status byte summary register

Bit	Bit Weight	Bit Name	Description
0	1	Reserved	Reserved for future use by the IEEE. The bit value is notified as zero.
1	2	Reserved	
2	4	Error/Event Queue (EEQ)	If data exists in the error or event queue, this bit is set to true.
3	8	Questionable Status Register (QUES)	This bit is set to true when a bit is set in the QUEStionable event status register and the corresponding bit in the QUEStionable status enable register is true.
4	16	Message Available (MAV)	This bit is set to true when a request is received from the digital programming interface and the KFM2151 is ready to output the data byte.
5	32	Standard Event Status Bit Summary (ESB)	This bit is set to true when a bit is set in the event status register.
6	64	Request Service (RQS)	This bit is set to true when a bit is set in the service request enable register, and the corresponding bit exists in the status byte.
		Master Status Summary (MSS)	Set by one of the following: Status byte bit 0 and service request enable register bit 0. Status byte bit 1 and service request enable register bit 1. Status byte bit 2 and service request enable register bit 2. Status byte bit 3 and service request enable register bit 3. Status byte bit 4 and service request enable register bit 4. Status byte bit 5 and service request enable register bit 5. Status byte bit 7 and service request enable register bit 7.
7	128	Operation Status Register (OPER)	This bit is set to true when a bit is set in the OPERation event status register and the corresponding bit in the OPERation status enable register is set.
8-15		Not Used	–

IEEE 488.2 status event command

See "4.5.1 IEEE 488.2 Common Commands."

Standard event status register

The event status register bits are set when certain events occur during KFM2151 operation. All bits of the event status register are set by the error event queue.

The register is defined by the IEEE488.2 standard. IEEE488.2 common commands *ESE, *ESE?, and *ESR? are used to control the register.

Table 4-5   Standard Event Status Resister

Bit	Bit Weight	Bit Name	Description
0	1	Operation Complete (OPC)	Set when an *OPC command is received and all operations in standby are complete. Event-800 Operation Complete message is loaded in the error/event queue.
1	2	Request Control (RQC)	Not used.
2	4	Query Error (QYE)	Set when an attempt is made to read data from the output queue when there is no output or the error queue is in wait status. Indicates that there is no data in the error queue.
3	8	Device Dependent Error (DDE)	Set when there is a device-specific error.
4	16	Execution Error (EXE)	Set when the KFM2151 evaluates the program data following the header is outside the formal input range or does not match the performance of the KFM2151. This indicates that a valid SCPI command may not be executed correctly depending on the conditions of the KFM2151.
5	32	Command Error (CME)	Set when an IEEE 488.2 syntax error is detected, when an unidentifiable header is received, or when a group execution trigger enters the internal IEEE 488.2 SCPI command input buffer.
6	64	User Request (URQ)	Set when the bit is unmasked and the instrument wishes to respond to the 488.2 user request event. When the instrument detects the activation of the user request local control, an event is generated. Event-600 User Request message is loaded in the error/event queue.)
7	128	Power ON (PON)	Not used.
8-15		Reserved	Not used.

4.6.2   SCPI Register Model

OPERation status register

The OPERation status register is a 16-bit register which contains information about conditions which are part of the KFM2151 normal operation.

Table 4-6   OPERation status register (STATus:OPERation)

Bit	Bit Weight	Bit Name	Description
0	1	NOT USED	–
1	2	NOT USED	–
2	4	NOT USED	–
3	8	NOT USED	–
4	16	Measuring	Indicates whether measurement is in progress on the KFM2151.
5	32	NOT USED	–
6	64	NOT USED	–
7	128	NOT USED	–
8	256	NOT USED	–
9	512	NOT USED	–
10	1024	NOT USED	–
11	2048	NOT USED	–
12	4096	NOT USED	–
13	8192	NOT USED	–
14	16384	NOT USED	–
15	32768	NOT USED	Always zero.

STAT:OPER

Queries the event of the OPERation status register.

A query clears the contents of the register.

Command

```
STATus:OPERation[:EVENt]?
```

Response

Returns the event of the OPERation status register in the <NR1> form in response to STAT:OPER?.

STAT:OPER:COND

Queries the condition of the OPERation status register.

A query does not clear the contents of the register.

Command

```
STATus:OPERation:CONDition?
```

Response

Returns the condition of the OPERation status register in the <NR1> form in response to STAT:OPER:COND?.

STAT:OPER:ENAB

Sets the enable register of the OPERation status register.

Command

```
STATus:OPERation:ENABle <NR1>
STATus:OPERation:ENABle?
```

Parameter

Value: 0 to 32767

Response

Returns the enable register of the OPERation status register in the <NR1> form in response to STAT:OPER:ENAB?.

STAT:OPER:PTR

Sets the positive transition of the OPERation status register.

Command

```
STATus:OPERation:PTRansition <NR1>
STATus:OPERation:PTRansition?
```

Parameter

Value: 0 to 32767

Response

Returns the positive transition of the OPERation status register in the <NR1> form in response to STAT:OPER:PTR?.

STAT:OPER:NTR

Sets the negative transition of the OPERation status register.

Command

```
STATus:OPERation:NTRansition <NR1>
STATus:OPERation:NTRansition?
```

Parameter

Value: 0 to 32 767

Response

Returns the negative transition of the OPERation status register in the <NR1> form in response to STAT:OPER:NTR?.

QUEStionable status register

The QUEStionable status register is a 16-bit register that stores information related to the questionable events and status during KFM2151 operation.

These register bits may indicate problems with the output of the KFM2151.

Table 4-7   QUEStionable status register (STATus:QUEStionable)

Bit	Bit Weight	Bit Name	Description
0	1	VOLTage	The voltage measurement data is questionable.
1	2	Not Used	–
2	4	Not Used	–
3	8	Not Used	–
4	16	Not Used	–
5	32	Not Used	–
6	64	Not Used	–
7	128	Not Used	–
8	256	Not Used	–
9	512	UVP	Undervoltage protection is activated (on some channel).
10	1024	OVP	Overvoltage protection is activated (on some channel).
11	2048	Not Used	–
12	4096	Not Used	–
13	8192	Not Used	–
14	16384	Not Used	–
15	32768	Not Used	Always zero

STAT:QUES

Queries the event of the QUEStionable status register.

Command

```
STATus:QUEStionable[:EVENt]?
```

Response

Returns the event of the QUEStionable status register in the <NR1> form in response to STAT:QUES?.

STAT:QUES:COND

Queries the condition of the QUEStionable status register.

Command

```
STATus:QUEStionable:CONDition?
```

Response

Returns the condition of the QUEStionable status register in the <NR1> form in response to STAT:QUES:COND?.

STAT:QUES:COND:LIST:OVP
STAT:QUES:COND:LIST:UVP

Queries the condition of bit 9 (UVP) or bit 10 (OVP) of the QUEStionable status register.

Command

```
STATus:QUEStionable:CONDition:LIST:OVP?
```

```
STATus:QUEStionable:CONDition:LIST:UVP?
```

Response

Returns the current condition in the <String> form in response to STAT:QUES:COND:LIST:OVP?.

Returns the current condition in the <String> form in response to STAT:QUES:COND:LIST:UVP?.

(Example) If OVP is activated on CH31, CH122, and CH205, and UVP is not activated, the following is returned in response to STAT:QUES:COND:LIST:OVP?;UVP?.

"31,122,205";"".

STAT:QUES:ENAB

Sets the enable register of the QUEStionable status register.

Command

```
STATus:QUEStionable:ENABle <NR1>
```

```
STATus:QUEStionable:ENABle?
```

Parameter

  Value: 0 to 32767

Response

Returns the enable register of the QUEStionable status register in the <NR1> form in response to STAT:QUES:ENAB?.

STAT:QUES:PTR

Sets the positive transition of the QUEStionable status register.

Command

```
STATus:QUEStionable:PTRansition <NR1>

STATus:QUEStionable:PTRansition?
```

Parameter

Value: 0 to 32767

Response

Returns the positive transition of the QUEStionable status register in the <NR1> form in response to STAT:QUES:PTR?.

STAT:QUES:NTR

Sets the negative transition of the QUEStionable status register.

Command

```
STATus:QUEStionable:NTRansition <NR1>

STATus:QUEStionable:NTRansition?
```

Parameter

Value: 0 to 32767

Response

Returns the negative transition of the QUEStionable status register in the <NR1> form in response to STAT:QUES:NTR?.

Preset Status

STAT:PRES

Specific events are reported at a higher level by constructing status data and using the status reporting mechanism. These events are summarized in the required structures, OPERation status register, and QUEStionable register.

STAT:PRES only affects the ENABle register and the transition filter register of the status data structure.

STAT:PRES does not clear any event registers or any items from the error/event queue.

To reset all event registers and the queue within the device status reporting mechanism, use *CLS.

For status data required by SCPI, the STAT:PRES command sets the transition filter registers so that only positive transitions are detected and sets the ENABle register to all zeroes. The settings of the service request enable register, parallel poll enable register, output queue, and power on status clear flag are not affected by this command.

For the device-dependent status data structure, STAT:PRES sets the ENABle register to all 1s and sets the transition filter registers so that only positive transitions are reported.

Table 4-8   Preset values of registers that can be set by the user

Register	Filter/Enable	Preset Value
Required status data Operation QUEStionable	Enable register	All 0s
	Positive transition filter	All 1s
	Negative transition filter	All 0s
Device-dependent status data	Enable register	All 1s
	Positive transition filter	All 1s
	Negative transition filter	All 0s

Command

```
STATus:PRESet
```

4.7   A List of Error Messages

Command errors

An error/event number in the range [-199, -100] indicates that an IEEE 488.2 syntax error has been detected by the instrument's parser. The occurrence of any error in this class shall cause the command error bit (bit 5) in the event status register to be set.

Table 4-9   Command errors

Error Code		Error Message Description
-100	Command error	Generic syntax error.
-101	Invalid character	A syntactic element contains a character which is invalid.
-102	Syntax error	An unrecognized command or data type was encountered.
-103	Invalid separator	The parser was expecting a separator and encountered an illegal character.
-104	Data type error	The parser recognized a data element different than one allowed.
-105	GET not allowed	A Group Execute Trigger was received within a program message.
-108	Parameter not allowed	More parameters were received than expected for the header.
-109	Missing parameter	Fewer parameters were received than required for the header.
-110	Command header error	An error was detected in the header.
-120	Numeric data error	Generated when parsing a data element which appears to be numeric, including the nondecimal numeric types.
-130	Suffix error	Generated when parsing a suffix.
-131	Invalid suffix	The suffix does not follow the syntax, or the suffix is inappropriate for the KFM2151.
-134	Suffix too long	The suffix contained more than twelve characters.
-138	Suffix not allowed	A suffix was encountered after a numeric element which does not allow suffixes.
-140	Character data error	Generated when parsing a character data element.
-141	Invalid character data	Either the character data element contains an invalid character, or the element is not valid.
-144	Character data too Long	The character data element contains more than twelve characters.
-148	Character data not allowed	A legal character data element was encountered where prohibited by the KFM2151.
-150	String data error	Generated when parsing a string data element.
-160	Block data error	Generated when parsing a block data element.
-170	Expression error	Generated when parsing an expression data element.
-180	Macro error	Generated when defining a macro or executing a macro.

Execution errors

An error in the range [-299, -200] indicates that an error has been detected by the instrument's execution control block. The occurrence of any error in this class shall cause the execution error bit (bit 4) in the event status register to be set.

Table 4-10   Execution errors

Error Code		Error Message Description
-200	Execution error (generic)	A generic error for the KFM2151.
-203	Command protected	Password protected program or query command cannot be executed.
-210	Trigger error	A trigger error occurred.
-211	Trigger ignored	A trigger was received but discarded.
-213	Init ignored	Measurement initiate operation was ignored because measurement is in progress.
-214	Trigger deadlock	Dead lock occurred because a query was received before the software trigger.
-220	Parameter error	A program data element related error occurred.
-221	Settings conflict	Received a command that cannot be executed in the current condition of the KFM2151.
-222	Data out of range	Parameter value was outside the legal range.
-223	Too much data	Too many parameters were received than the requirements.
-224	Illegal parameter value	Received an invalid parameter data.
-230	Data corrupt or stale	Received a data query before the measurement was completed.
-241	Hardware missing	Cannot be executed because the optional hardware is not installed.

Query errors

An error in the range [-499, -400] indicates that the output queue control of the instrument has detected a problem with the message exchange protocol described in IEEE 488.2, chapter 6. The occurrence of any error in this class shall cause the query error bit (bit 2) in the event status register to be set.

Table 4-11   Query errors

Error Code		Error Message Description
-400	Query error (generic)	A generic query error of the KFM2151 that is used when other types of errors do not apply.
-410	Query INTERRUPTED	An INTERRUPTED query error as defined by IEEE488.2 (6.3.2.3) occurred.
-420	Query UNTERMINATED	An UNTERMINATED query error as defined by IEEE488.2 (6.3.2.2) occurred.
-430	Query DEADLOCKED	A DEADLOCKED query error as defined by IEEE488.2 (6.3.1.7) occurred.
-440	Query UNTERMINATED after indefinite response	Another query was specified after a query that generates an indefinite response in a same program message. (Example: when SYST:ERR? is received after a *IDN? query and a semicolon separator)

Operation complete event errors

An error in the range [-899, -800] is used when the instrument wishes to report an IEEE488.2 operation complete event. This event occurs when the instrument's synchronization protocol, having been enabled by an *OPC command, completes all selected pending operations.

This event also sets the operation complete bit (bit 0) of the standard event status register.

Table 4-12   Operation complete event errors

Error Code		Error Message Description
-800	Operation complete	All selected pending operations in accordance with the IEEE 488.2, 12.5.2 synchronization protocol has completed.

4.8 A List of Messages

SCPI command: Full command name in long form (lowercase characters can be omitted)

Affected commands: Commands that are set to their default values as a result of the *RST, *RCL, MEAS:VOLT?, and CONF commands are indicated as Yes.

R and W denote query command (R) and set command (W), respectively.

*: Values 1, 2, and 3 indicate SCPI standard command, command in review, and KIKUSUI original command, respectively.

Table 4-13   CHANnel subsystem

SCPI Command			Setting	Response	Affected Command			R/W	*
					*RST	MEAS?	CONF		
CHANnel									
	:VOLTage[:DC]								
		:TERMinals	<NR1>,<NR1>,<NR1>,<boolean>	<NR1>,<NR1>,<NR1>,<boolean>	Yes			R/W	3
		:NSELect	<NR1>	<NR1>				R/W	3
	:ROUTe								
		:TERMinals	<NR1>,<NR1>,<NR1>,<boolean>	<NR1>,<NR1>,<NR1>,<boolean>	Yes			R/W	3
		:NSELect	<NR1>	<NR1>				R/W	3

Table 4-14   INPut subsystem

SCPI Command		Setting	Response	Affected Command			R/W	*
				*RST	MEAS?	CONF		
INPut								
	:PROTection							
		:CLEar						W	1

Table 4-15   [SENSe] and CONFigure subsystem

SCPI Command				Setting	Response	Affected Command			R/W	*
						*RST	MEAS?	CONF		
[SENSe:]										
	VOLTage[:DC]									
		:RANGe								
			[:UPPer]	{<numeric>|MIN|MAX|DEF}	<numeric>	Yes	Yes	Yes	R/W	1
			:AUTO	<boolean>	<boolean>	Yes	Yes	Yes	R/W	1
		:PROTection								
			[:UPPer]	{<numeric>|MIN|MAX|DEF}	<numeric>	Yes			R/W	3
			:LOWer	{<numeric>|MIN|MAX|DEF}	<numeric>	Yes			R/W	3
	CONFigure:									
		[:SCALar]			"<configuration_info>"				R	1
			:VOLTage [:DC]	[<numeric>]					W	1
				:ALL	[<numeric>]				W	3

Table 4-16   MEASure & TRIGger subsystem

SCPI Command	Setting	Response	Affected Command			R/W	*
			*RST	MEAS?	CONF		
FETCh							
[:SCALar]		<volt>				R	1
[:VOLTage[:DC]]		<volt>				R	1
:ARRay		<volt>,<volt>,<volt>...				R	1
[:VOLTage[:DC]]		<volt>,<volt>,<volt>...				R	1
READ							
[:SCALar]		<volt>				R	1
[:VOLTage[:DC]]		<volt>				R	1
:ARRay		<volt>,<volt>,<volt>...				R	1
[:VOLTage[:DC]]		<volt>,<volt>,<volt>...				R	1
MEASure							
[:SCALar]		<volt>				R	1
:VOLTage[:DC]		<volt>				R	1
:ARRay		<volt>,<volt>,<volt>...				R	1
:VOLTage[:DC]		<volt>,<volt>,<volt>...				R	1
ABORt						W	1
INITiate[:IMMediate]						W	1

Table 4-17   SYSTem subsystem

SCPI Command	Setting	Response	Affected Command			R/W	*
			*RST	MEAS?	CONF		
SYSTem							
:VERSion		<scpi_version>				R	1
:ERRor[:NEXT]		<code>,"<description>"				R	1
:FORMation:INSTruments:COUNt		number of scanning units				R	3

Table 4-18   STATus subsystem

SCPI Command	Setting	Response	R/W	*
STATus				
:OPERation				
[:EVENt]		<event>	R	1
:CONDition		<condition>	R	1
:ENABle	<numeric>	<numeric>	R/W	1
:PTRansition	<numeric>	<numeric>	R/W	1
:NTRansition	<numeric>	<numeric>	R/W	1
:QUEStionable				
[:EVENt]		<event>	R	1
:CONDition		<condition>	R	1
:LIST				
:OVP		"<channel list>"	R	3
:UVP		"<channel list>"	R	3
:ENABle	<numeric>	<numeric>	R/W	1
:PTRansition	<numeric>	<numeric>	R/W	1
:NTRansition	<numeric>	<numeric>	R/W	1

Table 4-19   IEEE488.2 common commands

IEEE488.2 common commands	Setting	R/W
*CLS	Clears the status data structures.	W
*ESE	Sets the standard event status enable register bits.	R/W
*ESR?	Queries the standard event status register.	R
*IDN?	Queries the identification string. (Manufacturer information)	R
*OPC	Causes the device to generate the operation complete message in the standard event status register when all pending selected device operations have been finished.	R/W
*RST	Performs a device reset. Configures the device to a known condition independent from the usage history of the device.	W
*SRE	Sets the service request enable register bits.	R/W
*STB?	Reads the status byte and the master summary status bit.	R
*TRG	Command error	W
*TST?	Since there is no self-test function built into the KFM2151, an ASCII character "0" is always returned in the output queue in response to this query.	R
*WAI	Prevents the device from executing subsequent commands or queries until the No Operation Pending flag becomes true. (*OPC?)	W

4.9   Tutorial

This section describes the procedures to make voltage measurements through remote control on the KFM2151.

4.9.1   Simple measurement procedure (MEASure)

For simple measurement procedures, use the MEASure:VOTLage? query. When you use the MEASure:VOLTage? query, all measurement conditions except the range setting are set to default, and the measured data can be retrieved easily.

Example:
```
CHAN:VOLT:NSEL 1 ' Select logical channel 1.

MEAS:VOLT?       ' Start voltage scanning on all
                   activated channels, and query the
                   measured data of the selected
                   channel.
```

Response example: 1.72000E00

Example 2:
```
MEAS:ARR:VOLT?   ' Start voltage scanning on all
                   activated channels, and query the
                   measured data of all activated
                   channels.
```

Response example: 1.72000E00,1.69000E00,2.92000E00

Because the MEASure:VOLT? query inherently calls the CONFigure command, the voltage measurement range is set as shown in Table 4-20.

Table 4-20   Voltage measurement range set by MEAS

Setting	command	Value
Voltage measurement range	VOLT:RANG	Specified value (AUTO when omitted)
Voltage protection (OVP)	VOLT:PROT	200
Voltage protection (UVP)	VOLT:PROT:LOW	-2

The MEAS:VOLT? and CONF commands have parameters (can be omitted).
```
MEASure:VOLT? [<numeric>]

CONFigure:VOLT [<numeric>]
```

Specify the estimated range of the measured data in <numeric>.

If <numeric> is set to DEFault or is omitted, AUTO range is used.

The MEAS:VOLT? allows you to easily make measurements even if you do not have a detailed knowledge of the KFM2151. The down side is that all the settings related to the measurement functions are set to default. This prohibits you from setting detailed measurement conditions. To make measurements using setup conditions with a little more detail, use the CONF:VOLT command and READ? query.

The MEAS:VOLT? query is equivalent to combining the CONF:VOLT command and READ? query.

4.9.2　Measurement procedure with a little more flexibility (CONFigure and READ)

The measurement procedure using the CONF:VOLT command and READ? query separates the measurement condition setup from the measurement start and data acquisition procedures. This enables you to specify detailed conditions between the setup and measurement start procedures. For the default settings set by the CONF:VOLT command, see Table 4-20.

You can set the settings to default using the CONF:VOLT command, specify other settings, and then start the measurement using the READ? query.

Example:

```
CHAN:VOLT:NSEL 1              ' Select logical
                               channel 1.

CONF:VOLT                     ' Set voltage scanning
                               to default.

SENS:VOLT:RANG 20V            ' Set the selected
                               channel to 20 V range

SENS:VOLT:PROT:UPP 16;LOW 2   ' Set the selected
                               channel to OVP 16 V and
                               UVP 2 V.

READ?                         ' Start voltage
                               scanning on all
                               activated channels, and
                               query the measured
                               data.
```

(Read the response)

To abort the measurement after it is started, use the ABORt command. You can also use the *RST command or break signal to abort the measurement. The *CLS command does not abort the measurement. Once the measurement starts, you cannot enter settings related to the test conditions. You can specify the settings again after the test is completed or aborted.

The measurement procedure using the CONF:VOLT command and READ? query is flexible in that the measurement conditions can be specified in detail. However, because the READ? query itself contains the function of the measurement start command, it is still inflexible in terms of specifying the measurement timing. This is because, measurement is started every time the READ? query is issued. To program the measurement timing in detail, the measurement start and data acquisition procedures must be separated. The commands that allows you to do this are INIT and FETC?. The READ? query is equivalent to combining the INIT command and FETCh? query.

4.9.3　Measurement procedure with flexibility (INITiate and FETCh)

Because the measurement procedure using the INIT command and FETC? query separates the measurement start and data acquisition procedures, it enables the most detailed control. INIT is used to start the measurement, and FETC? is used to query the data of a measurement that has been completed.

Example:
```
CHAN:VOLT:NSEL 1          ' Select logical channel 1.

SENS:VOLT:RANG 20         ' Set the selected channel
                            to 20 V range

CHAN:VOLT:NSEL 2          ' Select logical channel 2.

SENS:VOLT:RANG 2          ' Set the selected channel
                            to 2 V range

INIT                      ' Start voltage scanning on
                            all activated channels.

CHAN:VOLT NSEL 1;:FETC?   ' Query the measured data
                            of Ch1.
```
(Read the response)
```
CHAN:VOLT:NSEL 2;:FETC?   ' Query the measured data
                            of Ch2.
```
(Read the response)

The INIT command measures all voltage measurement channels. After sending the INIT command, you can query the data by specifying an individual channel with the FETC? query.

5 Maintenance

This chapter covers maintenance of the KFM2151 including cleaning, inspecting, calibrating, and troubleshooting.

5.1　Cleaning and Inspection

Periodic maintenance and inspection are essential to maintain the initial performance of the KFM2151 over an extended period.

⚠ WARNING
- **Be sure to turn off the POWER switch and remove the power cord plug or turn off the switchboard. If you do not, death or injury may result from electric shock.**

Cleaning the panels

If the panel needs cleaning, gently wipe using a soft cloth with water-diluted neutral detergent.

⚠ CAUTION
- Do not use volatile chemicals such as benzene or thinner as they may discolor the surface, erase printed characters, cloud the display, and so on.

Inspecting the power cord

Check the power cord for breaks in the insulation and cracks or rattling of the plug.

5.2　Calibration

The KFM2151 is shipped after carrying out appropriate calibrations. We recommend periodic calibration to maintain the performance. For details, contact your Kikusui agent.

5.3   Malfunctions and Causes

This section describes check items and remedies for malfunctions encountered during the use of the KFM2151. Typical symptoms are listed.

In some cases, the problem can be solved quite easily. If you find an item that corresponds to your case, follow the remedy for the item. If you do not, we recommend that you initialize the KFM2151. If the remedy does not correct the problem, contact your Kikusui agent or distributor.

■ Does not power up.

Symptom	Check Items	Remedy	See Page
The KFM2151 does not operate when the POWER switch is turned on.	• Is the power cord disconnected from the power outlet? • Is the power cord inserted correctly into the AC INPUT connector on the rear panel?	• Connect the power cord correctly.	2-11

■ Keys do not work correctly.

Symptom	Check Items	Remedy	See Page
Panel key operations are not accepted.	• Is the RMT LED illuminated?	• The KFM2151 is being remotely controlled via the external interface. Press the LOCAL key to release remote control.	–
Unable to stop auto scanning.	• Is the VOLT LED illuminated?	• Press the IMP/VOLT key.	3-14

■ Does not operate according to the settings.

Symptom	Check Items	Remedy	See Page
The settings entered from the CONFIG are not applied.	• Did you turn off the POWER switch after changing the settings?	• Turn off the POWER switch after you change the settings. The settings are applied when the power is turned back on.	3-12
Settings are not applied.	• Did you press the SET key when you were done with the settings?	• Enter the settings again and press the SET key.	3-4 3-5
The OVP LED is illuminated in red.	• Is the OVP for the channel on which the monitor LED is illuminated in red set appropriately? • Is the fuel cell voltage high?	• The overvoltage protection (OVP) is activated. Check that the OVP for the channel on which the monitor LED is illuminated in red set appropriately or check the fuel cell.	3-16
The UVP LED is illuminated in red.	• Is the UVP for the channel on which the monitor LED is illuminated in red set appropriately? • Is the fuel cell voltage low?	• The undervoltage protection (UVP) is activated. Check that the UVP for the channel on which the monitor LED is illuminated in red set appropriately or check the fuel cell.	3-16

6
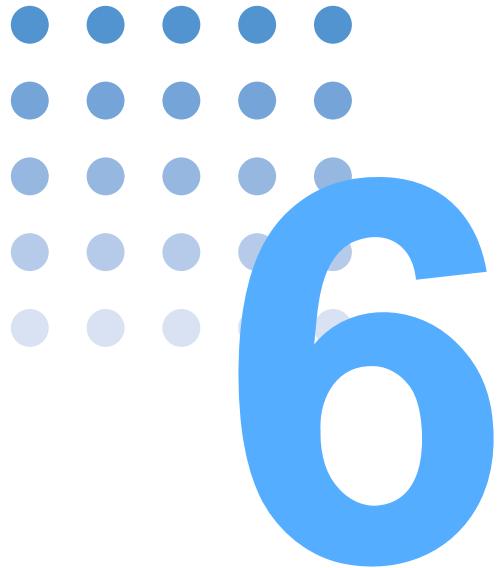
Specifications

This chapter contains the electrical and mechanical specifications of the KFM2151.

6.1   Specifications

Unless specified otherwise, the specifications are given for the following settings and conditions.

- The warm-up time is 30 minutes (with current flowing).
- Temperature: 20 °C to 30 °C
- Relative humidity: 20 % to 85 %
- rdng: Indicates the read value.
- rng: Indicates the range.

6.1.1   Scanning Function

		KFM2151
SENSING terminal	Number of inputs	32 pairs/unit (expandable to 160 pairs with 5 units)
	Rated input voltage	±150 V (±200 Vpeak maximum).
Voltage measurement section	Number of channels	32. A SENSING terminal can be assigned to each channel.
	Range	2 V, 20 V, 200 V, and auto range
	Scanning speed	32 channels/s
	OVP	Selectable range	-2 V to 200 V. Can be set for each channel.
		Resolution	0.01 V
	UVP	Selectable range	-2 V to 200 V. Can be set for each channel.
		Resolution	0.01 V
	Voltmeter	Maximum display	19999
		Accuracy	±(0.1 % of rdng + 0.1 % of rng)
Impedance measurement switching section	Number of channels	32. A SENSING terminal can be assigned to each channel.
	Output terminal	Number of outputs	1 pair
		Output voltage	Input voltage × 1/10
		Accuracy	±1 %: For DC
	Scanning		Auto[*1] or manual
	Frequency characteristics (value to be added to the measurement accuracy of the KFM2150)[*2]	126 Hz or less	2 %
		158 Hz to 3 kHz	2 %
		3.16 kHz to 9 kHz	3 %
		10 kHz to 20 kHz	5 %
Interface	Remote control	RS232C
	For connecting the FC Impedance Meter	Dedicated interface
	For channel expansion	

*1. If the measuring frequency on the KFM2150 is low, the scanning speed is slow.

*2. The basic measurement accuracy when combined with the KFM2150 FC Impedance Meter is obtained by adding a percentage indicated for a specific frequency range to the percentage of the |Z| reading on the KFM2150. ±((percentage of the |Z| reading) + 3 mΩ) for the 10 mΩ range.

6.1.2   Communication Function

		KFM2151	
RS232C	Connector	9-pin D-sub terminal on the rear panel	
	Baud rate	2400 bps/ 4800 bps/ 9600 bps/ 19200 bps	
	Data length	7 bits or 8 bits	
	Stop bit	1 or 2 bits	
	Parity	Fixed to none	
	Acknowledge	ON/OFF	
	Command language	SCPI Specification 1999.0	

6.1.3   General Specifications

	KFM2151	
Storage temperature and relative humidity range	-20 °C to 70 °C, 0 % to 90 % (no condensation)	
Operating temperature and relative humidity range	0 °C to 40 °C, 20 % to 85 % (no condensation)	
Spec guaranteed temperature and relative humidity range	20 °C to 30 °C, 20 % to 85 % (no condensation)	
Nominal input power rating	100 VAC to 240 VAC, 50 Hz to 60 Hz	
Maximum power consumption	30 VAmax	
Insulation resistance: Between the primary circuit and chassis	500 VDC, 30 MΩ or more.	
Withstand voltage: Between the primary circuit and chassis	No abnormalities at 1500 VAC for 1 minute.	
Dimensions	See outline drawing.	
Weight	Approx. 3.5 kg	
Accessories	KFM2150 connection cable (1 m)	1
	Screwless terminal connector (8 poles)	8
	Screwless terminal connector (2 poles)	2
	Metal fitting	4
	Metal fitting screws	4
	Power cord	1
	Operation Manual	1

6.2 Outline Drawing
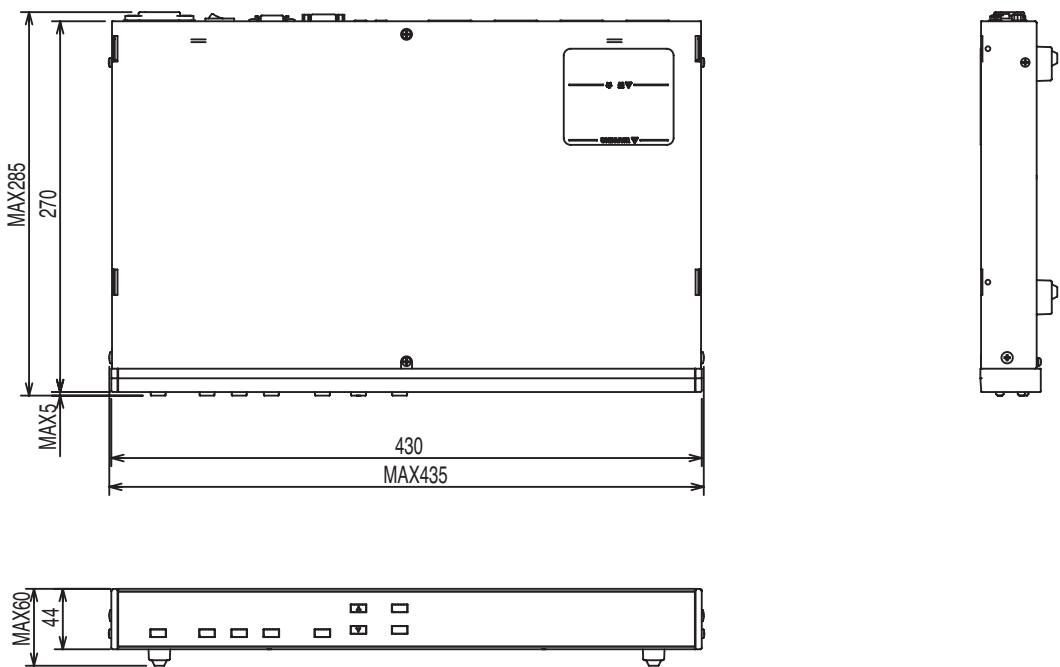
Unit: mm

Fig.6-1　KFM2151 outline drawing

Index

String 4-8

T

terminator 4-7

U

unit number, setting of 3-13

V

voltage protection 3-5

FC SCANNER KFM2151

OPERATION MANUAL