

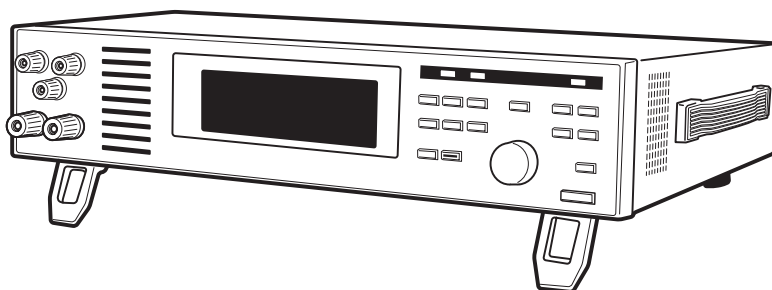
Part No. Z1-003-072, IB008803

Dec. 2009

User's Manual

FC Impedance Meter

KFM2030



Operation Manual

The operation manual for the KFM2030 is consisting of the User's Manual (this manual) and the Communication Interface Manual. In addition, the operation manual for the Fuel Cell Load & Impedance Measurement Software (accompanying application software) is available.

The manual is intended for users of the product or persons teaching other users on how to operate the product. The manual assumes that the reader has knowledge about electronic measuring instrument.

- KFM2030 User's Manual (this manual)

This manual is intended for first-time users of the KFM2030. It gives an overview of the KFM2030, connecting procedures, safety precautions, etc. Read through and understand this manual before using the product.

- KFM2005/KFM2030 Communication Interface Manual (HTML, PDF)

The interface manual explains the remote control by using SCPI commands. It is provided on the accompanying CD-ROM. The interface manual is written for readers with sufficient basic knowledge of how to control instruments using a personal computer.

The HTML manual can be viewed using the following browsers.

Operating environment: Windows 98 or later

Browser: Microsoft Internet Explorer 5.5 or later

- Fuel Cell Load & Impedance Measurement Software Operation Manual (PDF)

This manual explains the remote control by using the Fuel Cell Load & Impedance Measurement Software. It is provided on the accompanying CD-ROM.

You can view the PDF manual using Adobe Reader 6.0 or later.

Operation 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. If the operation 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 page.

After reading, always keep the manual nearby so that you may refer to it as needed.

The newest version of the operation manual can be downloaded from Download service of Kikusui website (<http://www.kikusui.co.jp/en/download/>).

How to read this manual

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

Waste Electrical and Electronic Equipment (WEEE)

Disposing of used Kikusui products in the EU

Under a law adopted by member nations of the European Union (EU), used electric and electronic products carrying the symbol below must be disposed of separately from general household waste.



This includes the power cords and other accessories bundled with the products. When disposing of a product subject to these regulations, please follow the guidance of your local authority, or inquire with your Kikusui distributor/agent where you purchased the product.

The symbol applies only to EU member nations.

Disposal outside the EU

When disposing of an electric or electronic product in a country that is not an EU member, please contact your local authority and ask for the correct method of disposal.

Trademarks

Microsoft, Windows and Visual Basic are registered trademarks of Microsoft Corporation in the United States and/or other countries.

Other company names and product names used in this manual are generally trademarks or registered trademarks of the respective companies.

Copyright

The contents of this manual may not be reproduced, in whole or in part, without the prior consent of the copyright holder.











The specifications of this product and the contents of this manual are subject to change without prior notice.

Copyright© 2005-2009

Kikusui Electronics Corporation

Safety Symbols

For the safe use and safe maintenance of this product, the following symbols are used throughout this manual and on the product. Understand the meanings of the symbols and observe the instructions they indicate (the choice of symbols used depends on the products).

 or 	Indicates that a high voltage (over 1 000 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.
	Is placed before the sign “DANGER,” “WARNING,” or “CAUTION” to emphasize these. When this symbol is marked on the product, see the relevant sections in this manual.
	Protective conductor terminal.
	Chassis (frame) terminal.
	On (supply)
○	Off (supply)
	In position of a bi-stable push control
	Out position of a bi-stable push control

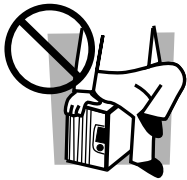
Safety Precautions

The following safety precautions must be observed to avoid fire hazard, electrical shock, accidents, and other failures. Keep them in mind and make sure that all of them are observed properly. Using the product in a manner that is not specified in the operation manual may impair the protection functions provided by the product.



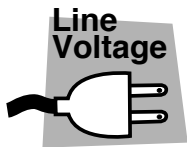
Users

- This product must be used only by qualified personnel who understand the contents of this operation manual.
- If it is handled by disqualified personnel, personal injury may result. Be sure to handle it under supervision of qualified personnel (those who have electrical knowledge.)



Purposes of use

- Do not use the product for purposes other than those described in the operation manual.
- This product is not designed or manufactured for general home or consumer use.



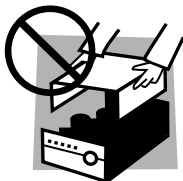
Input power

- Use the product with the specified input power voltage.
- For applying power, use the power cord provided. Note that the provided power cord is not use with some products that can switch among different input power voltages or use 100 V and 200 V without switching between them. In such a case, use an appropriate power cord.



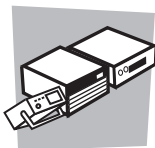
Fuse

- With products with a fuse holder on the exterior surface, the fuse can be replaced with a new one. When replacing a fuse, use the one which has appropriate shape, ratings, and specifications.



Cover

- There are parts inside the product which may cause physical hazards. Do not remove the external cover.



Installation

- When installing products be sure to observe section 1.2, "Precautions Concerning Installation" described in this manual.
- To avoid electrical shock, connect the protective ground terminal to electrical ground (safety ground).
- When connecting the power cord to a switchboard, be sure work is performed by a qualified and licensed electrician or is conducted under the direction of such a person.
- When installing products with casters, be sure to lock the casters.



Relocation

- Turn off the power switch and then disconnect all cables when relocating the product.
- Use two or more persons when relocating the product which weights more than 20 kg. The weight of the products can be found on the rear panel of the product and/or in this operation manual.
- Use extra precautions such as using more people when relocating into or out of present locations including inclines or steps. Also handle carefully when relocating tall products as they can fall over easily.
- Be sure the operation manual be included when the product is relocated.



Operation

- Check that the AC input voltage setting and the fuse rating are satisfied and that there is no abnormality on the surface of the power cord. Be sure to unplug the power cord or stop applying power before checking.
- If any abnormality or failure is detected in the products, stop using it immediately. Unplug the power cord or disconnect the power cord from the switchboard. Be careful not to allow the product to be used before it is completely repaired.
- For output wiring or load cables, use connection cables with larger current capacity.
- Do not disassemble or modify the product. If it must be modified, contact Kikusui distributor/agent.



Maintenance and checking

- To avoid electrical shock, be absolutely sure to unplug the power cord or stop applying power before performing maintenance or checking.
- Do not remove the cover when performing maintenance or checking.
- To maintain performance and safe operation of the product, it is recommended that periodic maintenance, checking, cleaning, and calibration be performed.



Service

- Internal service is to be done by Kikusui service engineers. If the product must be adjusted or repaired, contact Kikusui distributor/agent.

Contents

Safety Symbols	i
Safety Precautions	ii

Preface	P-1
----------------	------------

Overview	P-1
Firmware version to which this manual applies	P-1
Functions	P-1
KFM2030 Configuration	P-2
Rack Mounting Option	P-3

Chapter 1 Setup	1-1
------------------------	------------

1.1 Checking the Package Contents	1-1
1.2 Precautions Concerning Installation	1-2
1.3 Precautions to Be Taken When Moving the Product	1-3
1.4 Connecting the Power Cord	1-4

Chapter 2 Names and Functions of Parts	2-1
---	------------

2.1 Front Panel	2-1
2.2 Rear Panel	2-7

Chapter 3 Operation	3-1
----------------------------	------------

3.1 Power On Procedure	3-1
3.2 Connecting to the Fuel Cell	3-2
3.3 Operation	3-4
3.3.1 Setting the Current on the Internal Load Device	3-4
3.3.2 Measuring the Impedance	3-5
Setting the range and frequency	3-5
Setting the average count	3-6
Setting the measurement item to be displayed on the LCD	3-8
3.3.3 Turning the Load On/Off	3-9
3.4 Protection Function	3-11
3.5 Memory	3-12
Store	3-12
Recall	3-13
3.6 External Control	3-14
Connecting the wire	3-15
3.6.1 Controlling the load current using an external voltage	3-16
3.6.2 Turning the load current on/off	3-17
3.6.3 Switching the load device range	3-18
3.6.4 Voltage monitor output	3-19
3.6.5 Current monitor output	3-19
3.6.6 Alarm output	3-20
3.6.7 LOAD ON/OFF status output	3-20

Chapter 4 Remote Control **4-1**

4.1	Selecting the Communication Interface	-4-1
4.2	Operating the KFM2030 with SCPI commands	-4-4
4.3	Using the Accompanying Application Software	-4-5
4.3.1	Product Overview	4-5
	System Requirements	-4-5
	VISA Driver	-4-6
	Notes on use	-4-7
4.3.2	Opening the Menu Program Window	4-7
4.3.3	Installing the KI-VISA	-4-8
4.3.4	Installing the Fuel Cell Load & Impedance Measurement Software	-4-9
	Starting the application software	-4-10
	Viewing the application software User's Manual	-4-10

Chapter 5 Maintenance and Calibration **5-1**

5.1	Cleaning	-5-1
5.2	Inspection	-5-1
5.3	Calibration	-5-1
5.4	Replacing the Fuse	-5-2
5.5	Replacing the Backup Battery	-5-2
5.6	Malfunctions and Causes	-5-3

Chapter 6 Specifications **6-1**

6.1	Electrical Performance	-6-1
	Impedance Measurement Section	-6-1
	DC Voltage and Current Measurement Section	-6-2
	Electronic Load Section	-6-2
	Protection Function	-6-2
	Communication Interface	-6-3
	Miscellaneous	-6-3
6.2	Outline Drawing	-6-4

Appendix **A-1**

A.1	Overview of the Fuel Cell	A-1
A.2	Impedance Measurement Method of the KFM2030	A-2
A.3	Concerning the GUARD Terminal	A-3

Index **A-4**



Preface

Overview

The KFM2030 has been developed to easily test the impedance characteristics of the fuel cell under loaded conditions using the AC impedance method.

Because a DC load device that can handle up to 60 W is built in, fuel cell tests can be performed while applying up to 20 V or supplying up to 30 A of DC load current.

Firmware version to which this manual applies

This operation manual applies to products with firmware version 1.0x.

The version can be confirmed on the opening screen immediately after the power is turned on or by using the *IDN? command. For details on the *IDN? command, see “Communication Interface Manual”.

When contacting us about the product, please provide us the version number and the manufacturing number that is attached to the rear panel.

Functions

■ DC load function

The KFM2030 is equipped with a constant current (CC) mode load device with two load current ranges.

The load device can be switched between two ranges: 30 A maximum and 5 A maximum.

■ AC impedance measurement function

AC impedance from 10 mHz to 10 kHz can be measured on the fuel cell under test under loaded conditions.

The KFM2030 can display the real resistance R , reactance X , absolute value $|Z|$, and phase angle θ of the impedance.

■ DC voltage measurement function

Measures the DC voltage at the sensing terminal. Two full scale ranges are available: 2 V and 20 V.

■ Load current read back function

The current flowing through the load device can be read back.

■ External control of the load current

The load device current can be controlled using an external voltage.

■ Remote control function

The KFM2030 can be controlled through the port on the rear panel from a PC, etc.

KFM2030 Configuration

As shown in Fig. P-1, the KFM2030 is equipped with the necessary functions for testing fuel cells on a single unit. It consists of an electric load device, voltmeter, ammeter, and impedance meter. In addition, it is equipped with useful functions such as external load current control and communication interface that facilitate the synchronization with the fuel cell control system.

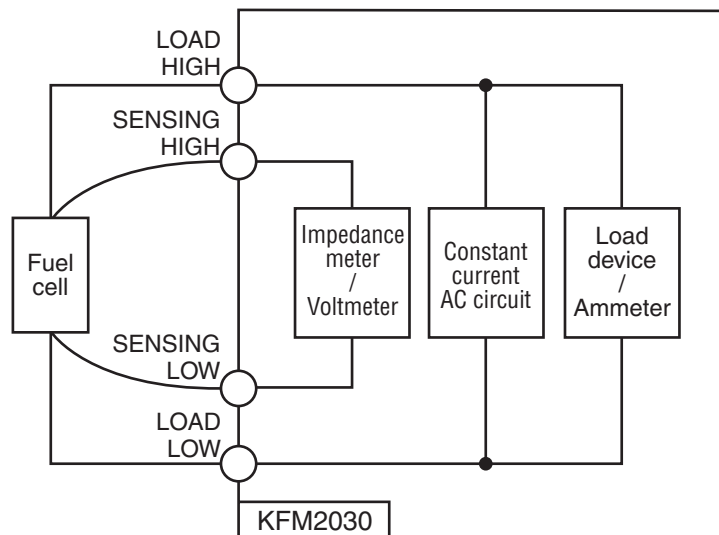


Fig.P-1 KFM2030 configuration

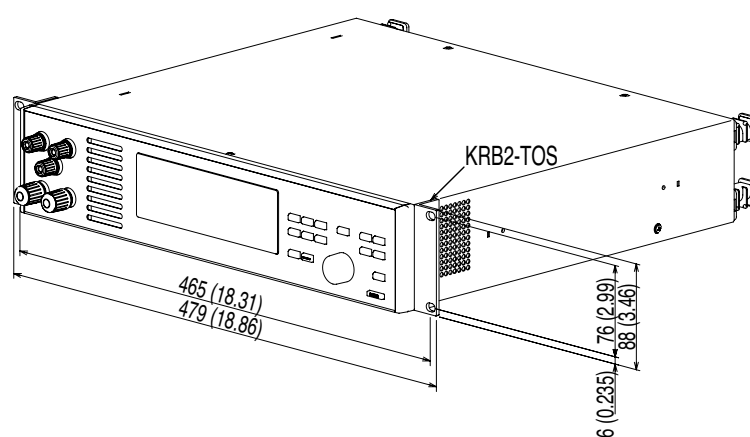
The KFM2030 incorporates a high performance constant current AC circuit that enables a given AC current (measuring AC current) to be supplied to the fuel cell. By connecting sensing wires to the output terminals of the fuel cell, the KFM2030 samples the AC voltage to calculate the impedance. Therefore, highly accurate measurements can be made even when resistance or inductance components in the wires or contact resistance exist.

The power that the fuel cell generates is absorbed by allowing DC current to flow through the load device from the LOAD terminal. A measuring AC current is supplied by the constant current AC circuit through the LOAD terminal to the fuel cell. The measuring AC current does not flow through the load device in the process. The impedance is calculated using the AC voltage that is measured by the SENSING terminal and the measuring AC current. Also see section A.2, "Impedance Measurement Method of the KFM2030."

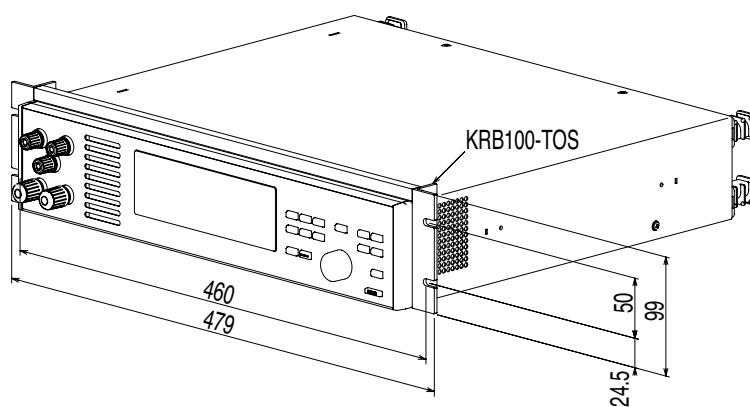
Rack Mounting Option

The following rack mounting options are available.
For details, contact your Kikusui agent or distributor.

Item	Model	Note
Rack mount bracket	KRB2-TOS	Inch rack EIA standard
	KRB100-TOS	Milli rack JIS standard



Unit: mm (inch)



Unit: mm

Fig. P-2 Rack mount bracket



This chapter describes unpacking procedures and basic precautions to be taken before using the FC Impedance Meter.

1.1 Checking the Package Contents

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

If any of the accessories are damaged or missing, contact Kikusui distributor/agent as soon as possible.

NOTE

- It is recommended that all packing materials be saved, in case the product needs to be transported at a later date.

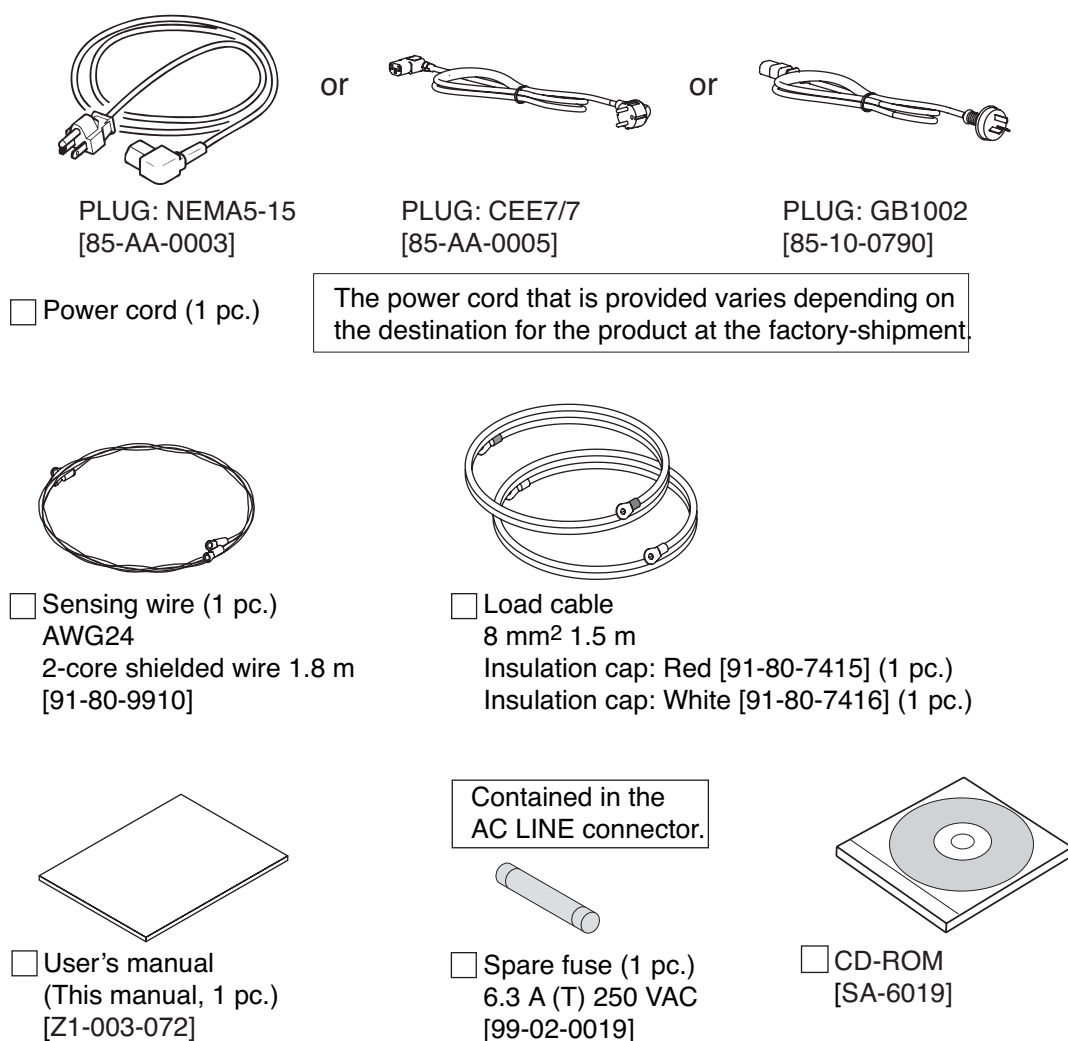


Fig.1-1 Accessories

1.2 Precautions Concerning Installation

This section describes the precautions to be taken when installing the product. Make sure to observe them.

■ 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.

Operating temperature range: 0 °C to +40 °C (32 °F to 104 °F)

Storage temperature range: -10 °C to +60 °C (14 °F to 140 °F)

■ Avoid humid environments.

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

Operating relative humidity range: 20 % to 85 % (no condensation)

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

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

■ 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 product 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.

This product employs a forced air cooling system. Air is taken in from intake ports located on panels other than the rear panel and exhausted from the ports on the rear panel. Install the product so that the vent ports are at least 20 cm from the wall to prevent the possibility of fire caused by accumulation of heat. In addition, do not place objects within 20 cm.

■ Do not place objects on top of the product.

Placing objects on top of the product can cause failures (especially heavy objects).

■ Do not place 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 subject to strong magnetic or electric fields.

The product may malfunction and cause electric shock or fire.

■ **Do not use the product near highly sensitive measuring instruments or transceivers.**

The noise generated by the product may affect them.

Using the Stand

The stand is used to tilt the front panel for easier viewing of the screen and improving the operability of the keys.

Pull the stand until it clicks in place.

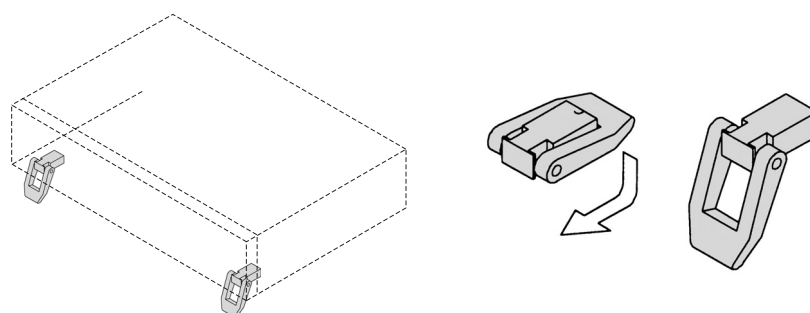


Fig. 1-2 Using the stand

⚠ CAUTION • When using the stand, do not place objects on top of the unit or apply downward force from the top of the unit.

1.3 Precautions to Be Taken When Moving the Product

When moving the product to the installation location or when transporting it, note the following points.

■ **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 can cause wires to break or injuries if the product is dropped.

■ **Put away the stand.**

The stand may break if the unit is moved with the stand pulled out.

■ **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.

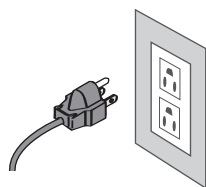
1.4 Connecting the Power Cord

-
- ⚠ 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.
 - This product is grounded through the ground wire of the power cord. Be sure to connect the power plug to an outlet with an appropriate earth ground.
-

- 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 the cord replaced with an appropriate power cord of length 3 m or less by a qualified engineer. If obtaining a power cord is difficult, consult your Kikusui agent or distributor.
 - In an emergency, the power cord with a plug may be used to disconnect the product 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.
-

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

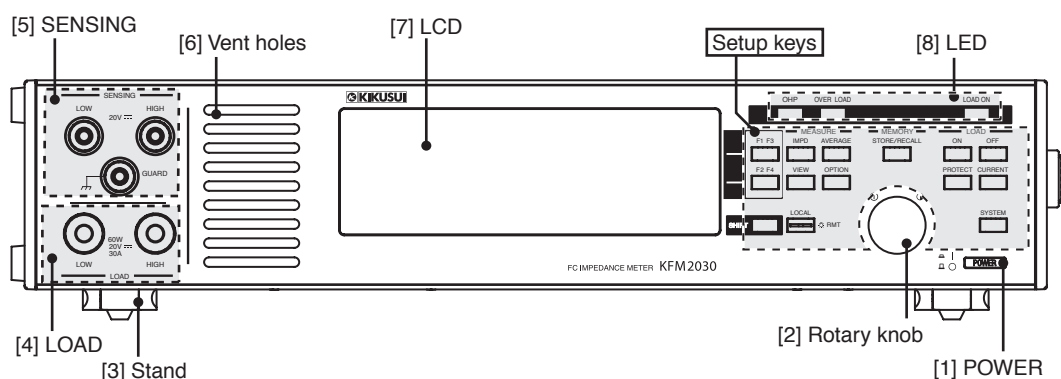
1. Turn the POWER switch off.
2. Check that the AC power line complies with the input rating of the KFM2030.
The voltage that can be applied is any of the nominal power supply voltages in the range of 90 VAC to 132 VAC or 180 VAC to 250 VAC. The frequency is in the range of 45 Hz to 65 Hz.
3. Connect the power cord to the AC inlet (AC LINE) on the rear panel, and connect the power cord plug to an outlet with proper grounding.



Three-prong power outlet
with proper grounding

This chapter describes the names and functions of parts such as switches and connectors.

2.1 Front Panel



[1] POWER I / O

A switch used to turn on/off the KFM2030 power. The power toggles on (I) and off (O) each time the switch is pressed.

[2] Rotary knob

Turn the rotary knob when changing values and settings.

You can press the rotary knob to switch between coarse adjustment and fine adjustment.

Turn the rotary knob while holding down the SHIFT key to adjust the LCD contrast. The LCD contrast varies depending on the viewing angle and ambient temperature. Adjust it to your liking.

[3] Stand

The stand is used to tilt the front panel for easier viewing of the screen and improving the operability of the keys.

[4] LOAD

Load input terminal.

Connect between the same polarities of the LOAD connector and fuel cell.

For details, see section 3.2, “Connecting to the Fuel Cell.”

[5] SENSING

Sensing terminals for impedance measurement and voltage readout.

For making accurate measurements, be sure to connect the HIGH terminal to the positive terminal of the fuel cell.

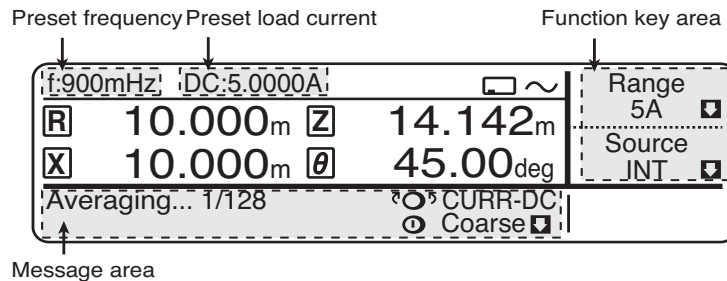
The GUARD terminal is connected to the chassis. Never connect the HIGH or LOW sensing terminal to the GUARD terminal. The KFM2030 does not operate if voltage exceeding 10 V is applied between the sensing terminal and chassis.

[6] Vent holes

Vent holes for internal cooling.

[7] LCD

Displays various information such as settings and measured values.














[7-1] Preset frequency value

Displays the preset frequency value.

[7-2] Preset load current value

Displays the preset load current value.

[7-3] Icons

-  Displays the measured value of sensing voltage V.
-  Displays the measured value of load current I.
-  Displays the measured value of real resistance R of the impedance.
-  Displays the measured value of reactance X.
-  Displays the measured value of the absolute value of the impedance |Z|.
-  Displays the measured value of impedance phase angle θ.
-  An icon indicating the measurement range.
-  An icon indicating the AC current used to make measurements (referred to as "measuring AC current" hereafter).
-  An icon indicating that the value or status can be changed by turning the rotary knob.
-  An icon indicating that the status can be switched by pressing the rotary knob.
-  An icon indicating that the value or status can be changed by pressing a key repeatedly.

[7-4] Function key area

The item shown in the function key area can be set using the F1 (F3) and F2 (F4) keys.

Press the CURRENT, IMPD, AVERAGE, or VIEW key to switch the function key area.

[7-5] Message area

- OVER Range

If the measured value exceeds the measurement range, the LCD shows "OVER Range."

If this happens, increase the range by one level.

- Averaging

Displayed while processing the moving average.

The icon disappears when the specified count is reached.

- ALM:

Displayed when an alarm occurs.

ALM:OVP	overvoltage protection
ALM:UVP	undervoltage protection
ALM:OHP	overheat protection
ALM:OCP	overcurrent protection
ALM:OPEN	disconnection detection
ALM:OPP	overload protection

[8] LED

[8-1] Alarm LED

- OHP

If the internal temperature rises abnormally due to some problem such as in the ventilation of the fan, ambient temperature, or installation condition, the load is turned off for safety reasons. Then, the OHP LED lights to warn the user.

- OVER LOAD

If the power consumption at the load exceeds the rated power by 5% (63 W), the OVER LOAD LED lights to warn the user.

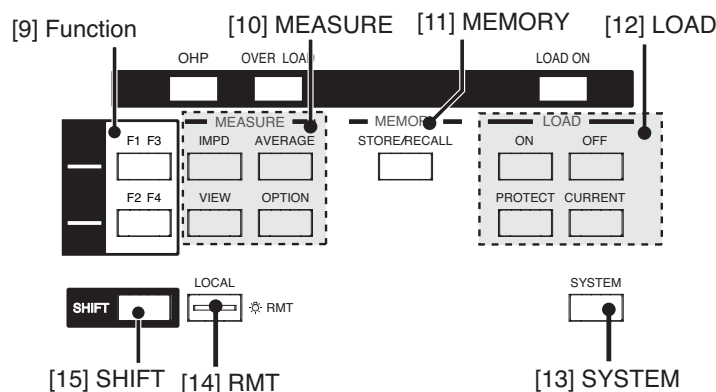
If the power consumption increases further and exceeds the rated power by approximately 8% (65 W), the current setting is automatically changed to suppress the power down to approximately 65 W.

[8-2] Load on LED

- LOAD ON

Lights when the load is turned on.

Setup keys



[9] Function

[9-1] F1/F3

Press this key to perform the function of F1.

Pressing this key with the SHIFT key held down performs the function of F3.

[9-2] F2/F4

Press this key to perform the function of F2.

Pressing this key with the SHIFT key held down performs the function of F4.

[10] MEASURE

A group of keys used to configure the impedance measurement.

[10-1] IMPD

Used to switch the frequency in impedance measurement.

• RANGE

Press the IMPD key followed by the F1 key to switch the impedance measurement range.

• CURR-AC

Press the IMPD key followed by the F2 key to switch the AC current used to measure the impedance.

[10-2] AVERAGE

Used to set the average count.

• INTEGRATION

Press the AVERAGE key followed by the F1 key to enable INTEGRATION setup mode in which the number of cycles used to integrate the measured frequency can be specified. Turn the rotary knob to change the setting.

• MOVING

Press the AVERAGE key followed by the F2 key to enable MOVING setup mode, which takes the moving average of the measured result to be displayed. Turn the rotary knob to change the setting.

[10-3] VIEW

Used to set the items displayed on the LCD and their positions.

Press this key followed by one of the F1 to F4 keys to select the position on the LCD where real resistance R, reactance X, absolute value $|Z|$, and phase angle θ of the impedance as well as load current I and sensing voltage V are displayed.

Press the VIEW key followed by the F1, F2, F3, or F4 key to select upper left, lower left, upper right, or lower right, respectively.

Press each key repeatedly to switch the displayed item.

[10-4] OPTION

This key is used to control the optional unit when it is connected.

[11] MEMORY

Stores/Recalls panel settings.

[11-1] STORE/RECALL

Press this key followed by the F1 or F2 key to store or recall panel settings.

Three sets of memories are available: A, B, and C.

• STORE

Press the STORE/RECALL key followed by the F2 key to enter STORE mode in which panel settings can be saved. Turn the rotary knob to select the memory, and press the rotary knob to store the settings.

• RECALL

Press the STORE/RECALL key followed by the F1 key to enter RECALL mode in which panel settings that have been saved before can be recalled. Turn the rotary knob to select the memory to be recalled, and press the rotary knob to recall the settings.

Factory default settings can be recalled by selecting default.

[12] LOAD

A group of keys used to configure the internal load device.

[12-1] ON

Press this key to turn the load on. The specified load current flows through the KFM2030.

However, the load does not turn on if the external load on/off control is turned off or if an alarm is occurring.

For details, see section 3.3.3, “Turning the Load On/Off” and section 3.4, “Protection Function.”

[12-2] OFF

Press this key to turn the load off and cut off the current flowing through the KFM2030. This key also clears the alarm when an alarm is activated.

[12-3] PROTECT

Used to set the detection voltage for protecting the fuel cell from abnormal voltage.

- UVP

Press the PROTECT key followed by the F1 key to enter UVP setup mode. If the fuel cell voltage falls below the specified value and this condition lasts for time longer than the UVP Mask Time, the load is turned off.

- Mask Time

Press the PROTECT key followed by the F2 key to enter Mask Time setup mode. Turn the rotary knob to set the time until the undervoltage protection is activated.

[12-4] CURRENT

Used to set the current of the internal load device.

- RANGE

Press the CURRENT key followed by the F1 key to select the current range of the internal load device.

- SOURCE

Press the CURRENT key followed by the F2 key to select whether to set the current of the internal load device by operating the KFM2030 (INT) or by using an external voltage (EXT).

[13] SYSTEM

Press the SYSTEM key to display INTERFACE in the F1 area.

Press the SYSTEM key followed by the F1 key to set or display communication parameters. The menu switches to RS232C, USB, and GPIB each time the F1 key is pressed.

RS232C If RS232C is selected, the RS232C parameters can be configured. Turn the POWER switch off and then back on to activate the settings and enable RS232C.

USB USB settings cannot be changed. Select USB and turn the POWER switch off and back on to enable USB.

GPIB If GPIB is selected, the GPIB address can be changed. Turn the POWER switch off and then back on to activate the settings and enable GPIB.

[14] RMT/LOCAL

Remote mode is enabled while the keycap LED is lit.

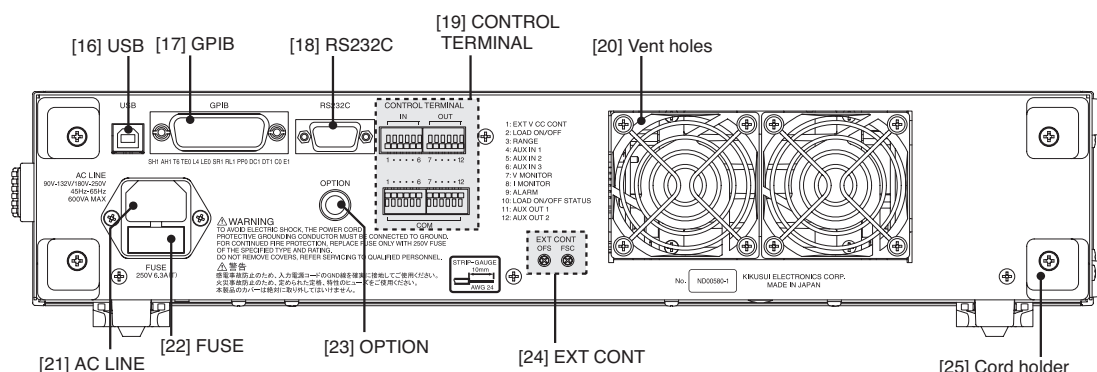
Press this key in remote mode to switch to local mode.

[15] SHIFT

Pressing the F1/F3 key with the SHIFT key held down performs the function of F3. Pressing the F2/F4 key with the SHIFT key held down performs the function of F4.

Turn the rotary knob while holding this key down to adjust the LCD contrast.

2.2 Rear Panel



[16] USB

A connector for the USB cable.

USB, GPIB, and RS232C cannot be used simultaneously.

[17] GPIB

A 24-pin connector for the GPIB cable. Conforms to the IEEE-488-1978 GPIB Standard.

USB, GPIB, and RS232C cannot be used simultaneously.

[18] RS232C

A connector for the RS232C cable.

For details on the cable, see Fig. 4-1.

USB, GPIB, and RS232C cannot be used simultaneously.

[19] CONTROL TERMINAL

[19-1] 1: EXT V CC CONT

An input terminal for controlling the current supplied to the internal load device using an external voltage.

[19-2] 2: LOAD ON/OFF

An input terminal for controlling the on/off of the internal load device using an external signal.

[19-3] 3: RANGE

If the internal load device is set to external control, the load device range can be controlled through this terminal.

[19-4] 4 to 6: AUX IN 1 to 3

Reserved input terminals for future expansion. Do not connect anything to these terminals.

[19-5] 7: V MONITOR

A monitor terminal for the DC voltage applied to the sensing terminal.

[19-6] 8: I MONITOR

A monitor terminal for the load current.

[19-7] 9: ALARM

A high signal is output if an abnormal condition occurs in the internal load device such as OHP, OVER LOAD, and OCP.

[19-8] 10: LOAD ON/OFF STATUS

Outputs the on/off status of the internal load device.

[19-9] 11 and 12: AUX OUT1 and 2

Reserved output terminals for future expansion. Do not connect anything to these terminals.

[20] Vent holes

Allow at least 20 cm of space between the vent holes and the wall to avoid disruption in the air flow. In addition, do not place objects within 20 cm.

[21] AC LINE

A connector for the power cord.

⚠ WARNING • Improper handling can lead electric shock. Be sure to follow the procedures given in section 1.4, "Connecting the Power Cord."

[22] FUSE

Fuse holder for the input power supply.

⚠ WARNING • Improper handling can lead electric shock. Be sure to follow the procedures given in section 5.4, "Replacing the Fuse."

[23] OPTION

A reserved terminal for future expansion. Do not connect anything to this terminal.

[24] EXT CONT

[24-1] OFS

A variable resistor for fine tuning the offset current when controlling the internal load device externally.

[24-2] FSC

A variable resistor for fine tuning the full scale current when controlling the internal load device externally.

[25] Cord holder

A holder for winding the power cord for storage.

This chapter describes the procedure to connect the fuel cell and the external device, the basic operations of the KFM2030, precautions, etc.

3.1 Power On Procedure

1. Check that the POWER switch is turned off.
2. Connect the power cord provided to the AC LINE connector on the rear panel.
3. Connect the plug to an appropriate power line.
4. Turn on the POWER switch.

The front panel settings are set to the condition that existed immediately before the power was turned off the previous time.

3.2 Connecting to the Fuel Cell

-
- ⚠ CAUTION** To prevent damage to the KFM2030 and the fuel cell,
- Pay attention to the polarities of the fuel cell. If the polarity is reversed, overcurrent may flow.
 - The maximum input voltage of the LOAD terminal is 20 V. Do not apply the voltage exceeding 20V.

To prevent damage to the load wire and the sensing wire,

- Be sure to use a wire with a diameter that can handle at least the maximum load current (30 A) and strong sheath that is frame resistant. It is recommended that the cable be at least AWG8 or 8 mm².
 - The rated temperature of the sensing wire provided is 80°C. Therefore, the fuel cell with the activation temperature exceeding 80°C can not be used.
 - Even for fuel cells that run at relatively low temperatures such as a PEFC, the cable cannot be connected to a location where the collecting electrode or ambient temperature is 75°C or higher.
-

- NOTE**
- Connect the sensing wire to the point where you wish to measure the impedance or voltage on the fuel cell. If wish to eliminate the effects of the electrode plate, you must connect the sensing terminal directly to the separator. If you wish to measure the performance at the electrode terminal, you must connect it to the electrode terminal.
-

1. Check that the POWER switch is turned off.
2. Connect the electrode plate of the fuel cell to the LOAD terminal using the load cable provided as shown in Fig. 3-1.
Connect the positive and negative polarities of the fuel cell to the HIGH and LOW terminals of the LOAD, respectively. It is recommended that the cables be stranded to eliminate the effects of magnetic flux.
3. Connect the desired sensing point of the fuel cell to the SENSING terminal of the KFM2030 using the sensing wires provided.
Connect the shield to the GUARD terminal.
Connect the positive and negative polarities of the fuel cell to the HIGH and LOW terminals of the SENSING, respectively.

■ Further information for the GUARD terminal

See A.3, “Concerning the GUARD Terminal.”

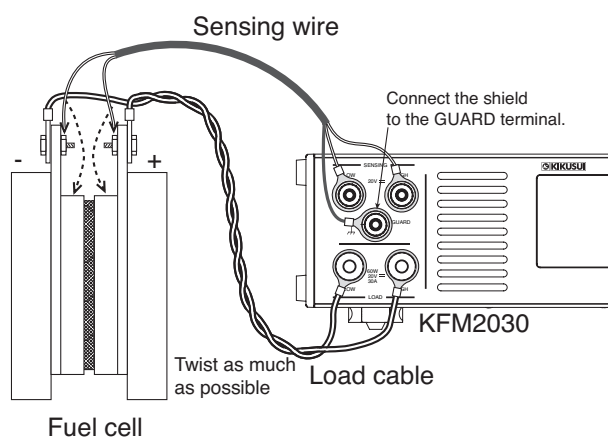


Fig.3-1 Connecting to the fuel cell

Table 3-1 Nominal cross-sectional area of cables and allowable currents

Nominal cross-sectional area [mm ²]	AWG	(Reference cross-sectional area) [mm ²]	Allowable current(*) [A] (Ta = 30 °C)	Current recommended by Kikusui [A]
2	14	(2.08)	27	10
3.5	12	(3.31)	37	-
5.5	10	(5.26)	49	20
8	8	(8.37)	61	30
14	5	(13.3)	88	50
22	3	(21.15)	115	80
30	2	(33.62)	139	-
38	1	(42.41)	162	100
50	1/0	(53.49)	190	-
60	2/0	(67.43)	217	-
80	3/0	(85.01)	257	200
100	4/0	(107.2)	298	-
125	-	-	344	-
150	-	-	395	300
200	-	-	469	-

* Excerpts from Japanese laws related to electrical equipment.

3.3 Operation

3.3.1 Setting the Current on the Internal Load Device

1. Press the CURRENT key.
The LCD changes as shown in Fig. 3-2.
2. Select the current setting control (Source).
Press the F2 key to select the current setting control. The setting changes each time the F2 key is pressed.
INT: KFM2030 control
Ext: External control
If you select external control, skip step 3.
3. Set the load current (only when the KFM2030 control is selected for setting the current) .
Turn the rotary knob to set the load current.

Fine / Coarse

Press the rotary knob to switch between Coarse and Fine.

Range switching

Press the F1 key to switch the range.

5 A or 30 A

If the range is switched, the load is turned off to prevent unintended current from flowing through the circuit.

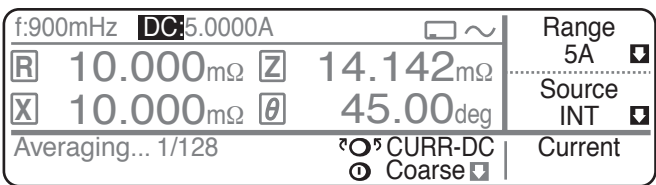


Fig. 3-2 Setting the load current

DESCRIPTION • Difference between 0 A setting with the load turned on and the load turned off

With 0 A setting with the load turned on, the KFM2030 tries to set the load current to 0 A, but the actual current is not 0 A. This current is called an offset. The offset in the specifications of the KFM2030 is 10 mA or less. On the contrary, the load current is electronically cut off when the load is turned off. If you wish to set the current exactly to 0 A, turn the load off.

3.3.2 Measuring the Impedance

Setting the range and frequency

The measurement range can be assigned to each setting of the measuring AC current.

For example, assume that a measurement range of 100 mΩ and 30 mΩ are assigned to the measuring AC current of 500 mA and 165 mA, respectively. If the measuring AC current is changed from 500 mA to 165 mA, the measurement range switches from 100 mΩ to 30 mΩ.

1. Press the IMPD key.

The LCD changes as shown in Fig. 3-3.

2. Select the measurement frequency.

Turn the rotary knob to select the measurement frequency.

3. Select the AC current used to make measurements.

Press the F2 key to change the measuring AC current.

The icon indicating the measuring AC current on the LCD also changes.

Icon \sim → \sim → —
500 mA → 165 mA → OFF

The OFF setting does not allow the measuring AC current to flow. Select OFF if not measuring the impedance such as when using only the load device.

If you select OFF, skip step 4.

4. Select the measurement range (only when the AC current setting other than OFF is selected).

Press the F1 key to switch the measurement range.

The measurement range switches according to the measuring AC current setting as shown below. The measurement range 10 mΩ cannot be selected when the measuring AC current is 165 mA, and the measurement range 300 mΩ cannot be selected when the measuring AC current is 500 mA.

The icon indicating the measurement range on the LCD also changes.

If Auto is selected, selectable measurement ranges are used for the respective measuring AC current, and the selected measurement range icon appears.

Icon □ → □ → □ → □
At 165 mA: 30 mΩ → 100 mΩ → 300 mΩ → Auto
At 500 mA: 10 mΩ → 30 mΩ → 100 mΩ → Auto

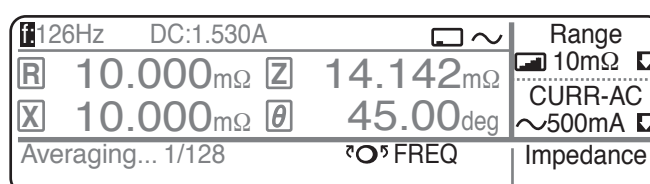


Fig. 3-3 Setting the range and frequency

Setting the average count

The averaging functions below can be used to stabilize the measured result such as when the signal source contains high level of noise or when the measured value fluctuates.

DESCRIPTION • Difference between integral average (Integration) and moving average (Moving).

The KFM2030 determines the impedance by supplying a measuring AC current and measuring the AC voltage that results. Therefore, the influence from the electromotive force (DC voltage) of the fuel cell itself must be removed.

The KFM2030 is equipped with an offset adjustment function for correcting the DC voltage of the fuel cell.

In the impedance measurement, the offset adjustment is performed first. Then, the AC voltage is measured. The number of times the AC voltage is to be measured is referred to as the cycle count.

In integral average, the cycle count can be specified, and impedance is determined from the averaged AC voltage. In moving average, the impedance is determined from a single measurement of the AC voltage. The count specified for moving average is the number of times the impedance is averaged.

The idea of averaging the measured values to obtain a stable measured result is the same for integral average and moving average. However, the time when offset adjustment is carried out differs between the two.

In integral average (INTEGRATION), offset adjustment is carried out before starting the measurement, and readjustment is not made until the specified number of cycles elapses. In moving average (MOVING), however, offset adjustment is carried out every measurement cycle.

It is recommended that INTEGRATION be used when you wish to cut down the time needed to make the offset adjustment and shorten the total measurement time. MOVING should be used when you wish to obtain a more stable result even if the measurement takes longer.

INTEGRATION is highly effective when measuring at high frequencies.

However, if the electromotive force of the fuel cell is fluctuating gradually (this is called a drift), the drift affects the measurement if INTEGRATION is used. This is due to the long interval between offset adjustments. In such case, MOVING must be used.

Integral average and moving average can be used in combination.

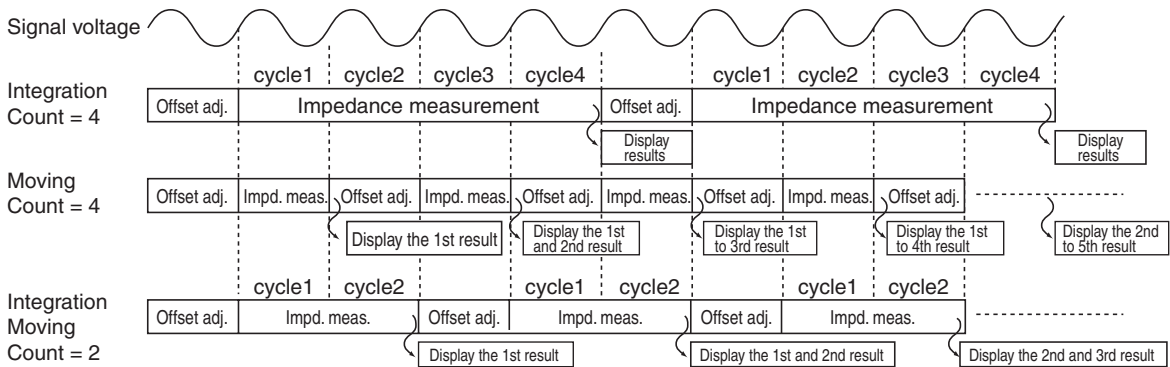


Fig. 3-4 INTEGRATION and MOVING

Setting the integral average

1. Press the AVERAGE key.

The LCD changes as shown in Fig. 3-5.

2. Select the integral average count.

Press the F1 key to select Integration, and the LCD function area switches from ○ to ●.

Turn the rotary knob to change the integral average count.

1, 2, 4, 8, 16, and 32

Setting the moving average

If moving average is set to a value greater than or equal to 2, the LCD displays the progress of the moving average as in “Averaging... 2/128.” This indicates that the count is set to 128, and the second moving average is being performed. The display disappears when the specified count is completed.

1. Press the AVERAGE key.

The LCD changes as shown in Fig. 3-5.

2. Select the moving average count.

Press the F2 key to select Moving, and the LCD function area switches from ○ to ●.

Turn the rotary knob to change the moving average count.

1, 2, 4, 8, 16, 32, 64, 128, and 256

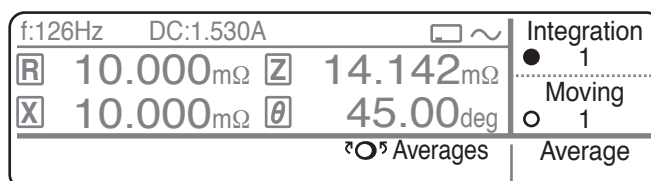


Fig. 3-5 Setting the average count

Setting the measurement item to be displayed on the LCD

The measurement items displayed on the LCD can be changed by pressing the VIEW key.

1. Press the VIEW key.

The LCD changes as shown in Fig. 3-6.

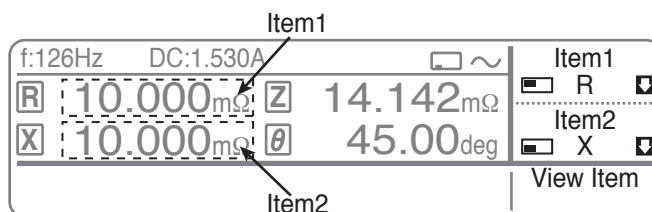
2. Switch the display at the upper left section of the LCD.

Press the F1 key to switch the display.

Press the F1 key repeatedly to switch the display in the following order.

R (real resistance of the impedance), X (reactance), Z (absolute value of the impedance), θ (phase angle of the impedance), V (sensing voltage), and I (load current)

3. Likewise, press the F2, F3(SHIFT+F1), and F4(SHIFT+F2) keys to switch the display at the lower left, upper right, and lower right sections of the LCD.



If the SHIFT key is pressed:

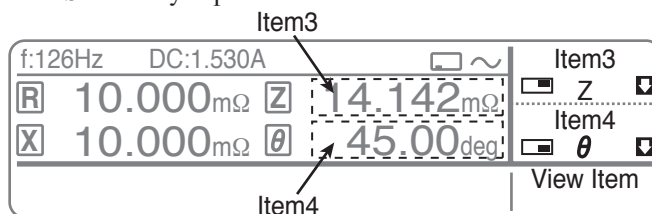


Fig. 3-6 Setting the VIEW

3.3.3 Turning the Load On/Off

“Turning the load on” refers to the operation of enabling the current to flow. “Turning the load off” refers to the operation of cutting off the current. Press the ON key to turn the load on; press the OFF key to turn the load off.

If the load current on/off of external control is set to off, the load does not turn on. The relationship of load on/off between the panel, remote, and external control is shown in Table 3-2.

Table 3-2

		Instruction through the panel or remote control	
		ON	OFF
Instruction through external control	ON	ON	OFF
	OFF	OFF	OFF

NOTE

- Be sure that the setup such as the current setting, the connection to the fuel cell, and the polarity are correct before turning the load on.
- If the cell voltage fluctuates during the measurement and the KFM2030 cannot distinguish the measuring AC current from the fluctuating voltage, the measurement may become unstable or the measurement may not be possible. When measuring the impedance, be sure that the cell voltage is stable and free from the effects of external noise.
- The fuel cell noise and the voltage fluctuation tend to increase in proportion to the load current.
If the load current is large, a more stable result can be obtained using a measuring AC current of 500 mA rather than 165 mA in the same measurement range.

Relationship between the measuring current and minimum load current

- DESCRIPTION** • The measuring AC current of 165 mA and 500 mA are in terms of peak-to-peak values (see Fig. 3-7). In other words, a current of 165 mA corresponds to an AC current with 82.5 mA_{peak} and -82.5 mA_{peak} (+250 mA_{peak} and -250 mA_{peak} for 500 mA).

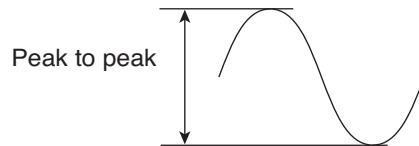


Fig. 3-7

Because the current that is supplied from the fuel cell to the load device is a DC current, the actual current that flows through the fuel cell is as shown in Fig. 3-8 depending on the load current setting.

For case A, the load current is small and a section of the measuring AC current does not flow. In this case, the impedance cannot be measured (over range, etc. is indicated).

For case B, the load current is at the minimum level that allows the impedance to be measured (82.5 mA for the 165 mA range and 250 mA for the 500 mA range).

For case C, the load current is sufficiently greater than the minimum load current, and the impedance can be measured.

In this way, the impedance cannot be measured depending on the load current setting. If over range, etc. appears frequently, supply a current greater than or equal to the minimum load current to achieve the condition of case B or case C.

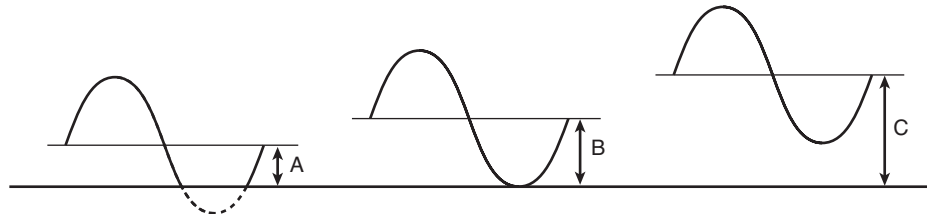


Fig. 3-8

3.4 Protection Function

The protection function automatically turns the load off or places a limit to protect the fuel cell.

When a protection function trips, an alarm is activated. When an alarm occurs, the load is turned off (or is limited), and the ALARM pin (pin 9) of CONTROL TERMINAL OUT on the rear panel is set to a high TTL level signal.

At the same time, the bit corresponding to the alarm in the status register is set. Thus, you can check the details of the alarm through the interface.

There are two types of protection functions: those that allow you to set the trip point and those with a fixed trip point.

Overvoltage protection (OVP)

An overvoltage is detected when a voltage greater than or equal to 21 V is applied. If this happens, “ALM:OVP” is displayed on the LCD.

If a voltage greater than or equal to 21 V is applied for more than 4 seconds or if a voltage greater than or equal to 24 V is applied, the load is automatically turned off for safety reasons.

Undervoltage protection (UVP)

An undervoltage is detected when the voltage falls to or below the specified voltage. If this happens, “ALM:UVP” is displayed on the LCD. You can set a time (delay) until the undervoltage protection (UVP) is activated. If the condition lasts for a time longer than the specified UVP Mask Time, the load turns off.

■ Setting the UVP

1. Press the PROTECT key.
2. Set the detection voltage.

Press the F1 key to select UVP, and the LCD function area switches from ○ to ●.

Turn the rotary knob to set the voltage at which the internal load device is turned off.

NOTE

- You can specify a voltage down to -2.0 V to allow UVP operation at a cell voltage of 0 V. Increase the setting for use.

■ Setting the UVP Mask Time

1. Press the PROTECT key.
2. Set the UVP Mask Time.

Press the F2 key to select Mask Time, and the LCD function area switches from ○ to ●.

Turn the rotary knob to set the time until the undervoltage protection is activated.

Overheat protection (OHP)

An overheat is detected when the temperature of the internal power unit exceeds 95 °C. If this happens, the OHP alarm LED lights. In addition, “ALM:OHP” is displayed on the LCD, and the load is turned off.

Turn the power off, and turn it back on after the KFM2030 has cooled down.

Overload protection (OPP)

The overload protection of the KFM2030 is activated at two stages.

If the power consumption at the load exceeds the rated power by 5% (63 W), the OVER LOAD LED lights to warn the user.

If the power consumption increases further and exceeds the rated power by approximately 8% (65 W), the current setting is automatically changed to suppress the power down to approximately 65 W.

Overcurrent protection (OCP)

If a load current greater than or equal to 31.5 A flows, “ALM:OCP” is displayed on the LCD, and the load is turned off.

Disconnection detection (OPEN)

If the load current does not flow such as when the load cable is not wired or is loose, “ALM:OPEN” is displayed on the LCD, and the load is turned off.

If OPEN is detected even when the cable is connected properly, the protection fuse in the load device is blown. If this happens, repair/inspection is necessary.

■ Resetting alarms

You can press the OFF key when an alarm is activated to reset the alarm. However, note that the alarm will be activated again, if the cause of the alarm is not corrected.

3.5 Memory

The current panel settings of the KFM2030 can be stored to internal memories A, B, and C.

Store

1. Press the STORE/RECALL key.
The LCD changes as shown in Fig. 3-9.
2. Select the memory to store the settings.
Press the F2 key to select Store, and the LCD function area switches from ○ to ●.
Turn the rotary knob to select the memory address (A, B, or C) for storing the settings.
Press the rotary knob to execute.

Recall

1. Press the STORE/RECALL key.

The LCD changes as shown in Fig. 3-9.

2. Select the memory to recall the settings.

Press the F1 key to select Recall, and the LCD function area switches from ○ to ●.

Turn the rotary knob to select the memory address (A, B, C, or default) for recalling the settings. If default is selected, the KFM2030 is reset to factory default settings.

Press the rotary knob to execute.

Factory default settings

Load current	Load current setting	DC: 0.0000 A
	Current setting control	INT: KFM2030 control
	Range	5 A
	Load	Off
Measurement frequency		10 kHz
	Measuring AC current	500 mA
	Range	Auto
Moving average		1
Integration cycle		1
LCD display	Upper left	R: Real resistance of the impedance
	Lower left	X: Reactance
	Upper right	Z: Absolute Value of the impedance
	Lower right	θ: Phase angle of the impedance
Under voltage protection (UVP)	Voltage value	-2.0 V
	Delay time	4.0 s

f:126Hz DC:1.530A		Recall	
R	10.000mΩ	Z	14.142mΩ
X	10.000mΩ	θ	45.00deg
Address		STR/RCL	
Recall			

Fig. 3-9 Storing/Recalling panel memory (a recall example)

3.6 External Control

The KFM2030 allows the internal load device to be controlled not only from the panel or through the communication interface but also using external signals. The settings in each operation mode normally use the internal reference signal. In external control, this reference signal is supplied externally. The external signal is applied using a voltage (voltage control).

External control allows the range to be controlled between 0 % and 100 %.

This section describes the procedures to connect, adjust, and use the external control function.

Table 3-3 CONTROL TERMINAL arrangement

Terminal #	Name	Signal name	Description	Name	Signal name	Description
1	IN	EXT V CC CONT	Load current control input using external voltage (Vext < 11 V)	COM	COMMON	Common for EXT V CC CONT
2		LOAD ON/OFF	Load on/off control input for the internal load device (0 V: OFF and 5 V: ON)		COMMON	Common for LOAD ON/OFF
3		RANGE	Range switch of the internal load device (0 V: 5 A range and 5 V: 30 A range)		COMMON	Common for RANGE
4		AUX IN1	Reserved terminal. Do not connect anything to this terminal.		COMMON	Common for AUX IN1
5		AUX IN2	Reserved terminal. Do not connect anything to this terminal.		COMMON	Common for AUX IN2
6		AUX IN3	Reserved terminal. Do not connect anything to this terminal.		COMMON	Common for AUX IN3
7	OUT	V MONITOR	Outputs half of the sensing terminal voltage.		COMMON	Common for V MONITOR
8		I MONITOR	Monitor output for the load current. Outputs 10 V when the load current is 30 A.		COMMON	Common for I MONITOR
9		ALARM	A high signal is output if an abnormal condition occurs in the internal load device such as overheat, overpower, and burnout fuse.		COMMON	Common for ALARM
10		LOAD ON/OFF STATUS	Outputs the on/off status of the internal load device. Set to high when the load is on; set to low when the load is off.		COMMON	Common for LOAD ON/OFF STATUS
11		AUX OUT 1	Reserved terminal. Do not connect anything to this terminal.		COMMON	Common for AUX OUT 1
12		AUX OUT 2	Reserved terminal. Do not connect anything to this terminal.		COMMON	Common for AUX OUT 2

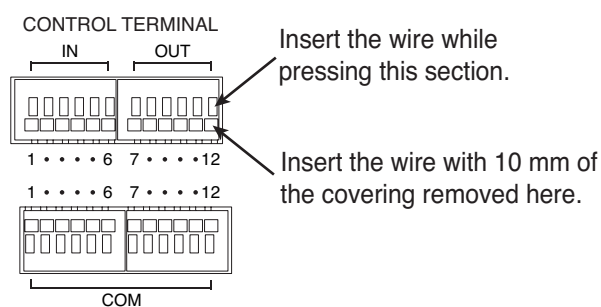


Fig. 3-10 CONTROL TERMINAL

Wires that can be used

Single wire: $\phi 0.32$ to $\phi 0.65$
(AWG28 to AWG22)

Stranded wire: 0.08 mm^2 to 0.32 mm^2
(AWG28 to AWG22)

Connecting the wire

⚠ WARNING • Never connect wires to the CONTROL TERMINAL while the POWER switch is turned on. Doing so can cause electric shock or damage to the internal circuitry.

NOTE • Remove 9 mm to 10 mm (10 mm recommended) of the covering. You can perform the work accurately by using the strip gauge indicated on the KFM2030 rear panel.

1. Check that the POWER switch is turned off.
2. Use a wire stripper to remove the covering from the wires.
3. Insert the wires in the CONTROL TERMINAL as shown in Fig. 3-10.
4. Pull on the wires gently to check that they do not come loose.

3.6.1 Controlling the load current using an external voltage

An external voltage is used to control the current supplied to the internal load device.

If LOAD CONTROL is set to EXT, the load current is controlled by the voltage applied across pin IN1 and pin COM1.

1. Connect to the CONTROL TERMINAL.

Connect the voltage source to pin 1 as shown in Fig. 3-11.

2. Set the load current control to external voltage.

Press the CURRENT key, and then the F2 key to set SOURCE to EXT.

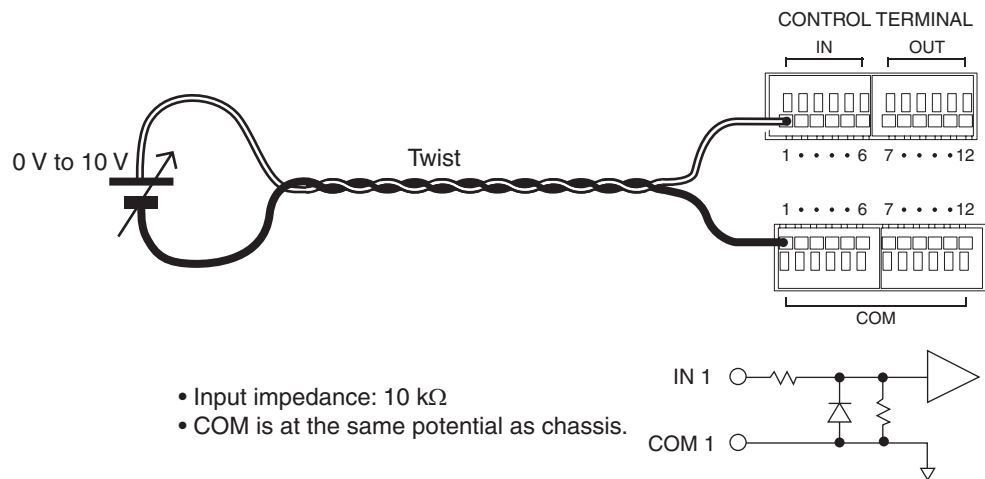


Fig. 3-11 Controlling the load current using an external voltage

NOTE

- Use a stable voltage with small ripple noise for the external voltage. If the voltage contains high level of ripple noise, the ripple noise also appears in the load current. If this occurs, the impedance measurement may be unstable or may not be possible.

Adjusting the offset and full scale

The KFM2030 allows the offset and full scale to be adjusted so that the load current control using an external voltage is as accurate as possible.

First, adjust the offset with the EXT CONT OFS variable resistor on the rear panel so that 0 A is obtained when 0 V is applied. Next, adjust the full scale with the EXT CONT FSC variable resistor so that the full scale value of the specified range (5 A or 30 A) is obtained when 10 V is applied.

3.6.2 Turning the load current on/off

The internal load device can be turned on/off using an external signal.

The load current is turned on when the terminal is opened or is set to 5 V and turned off when the terminal is shorted or is set to 0 V. However, for this function to work, the load must be turned on on the panel or through remote control.

The relationship of load on/off between the panel, remote, and external control is shown in Table 3-4.

Table 3-4

		Instruction through the panel or remote control	
		ON	OFF
Instruction through external control	ON	ON	OFF
	OFF	OFF	OFF

1. Connect to the CONTROL TERMINAL.

Connect the contact or signal source to pin 2 as shown in Fig. 3-12.

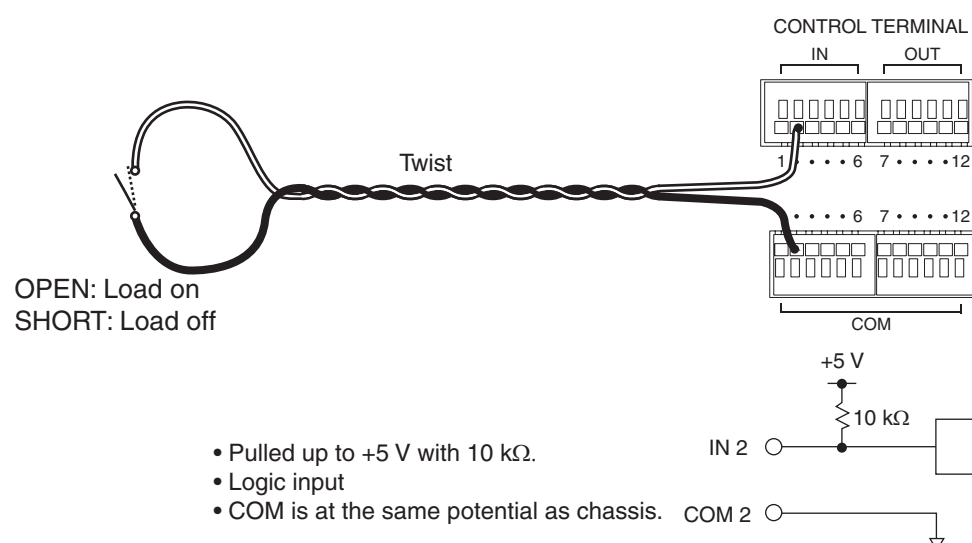


Fig. 3-12 Turning the load current on/off

NOTE

- If the load does not turn on/off using external control, this is because the internal load status in the KFM2030 is turned off as indicated in Table 3-4. In this case, set the external signal to the off condition, and turn on the internal load status by pressing the ON panel key or through remote control. Because the status is stored internally, current flows as soon as the external control is turned on.

If the load has been turned off by a protection function, the internal load status is off. To turn the load on again, you must remove the cause, reset the alarm, and then turn the internal load status on from the panel or through remote control.

3.6.3 Switching the load device range

If the internal load device is set to external control, the load device range can be controlled through pin IN3.

The range is set to 30 A when the terminal is opened or is set to 5 V and 5 A when the terminal is shorted or is set to 0 V.

1. Connect to the CONTROL TERMINAL.

Connect the contact or signal source to pin 3 as shown in Fig. 3-13.

2. Set the load current control to external voltage.

Press the CURRENT key, and then the F2 key to set SOURCE to EXT.

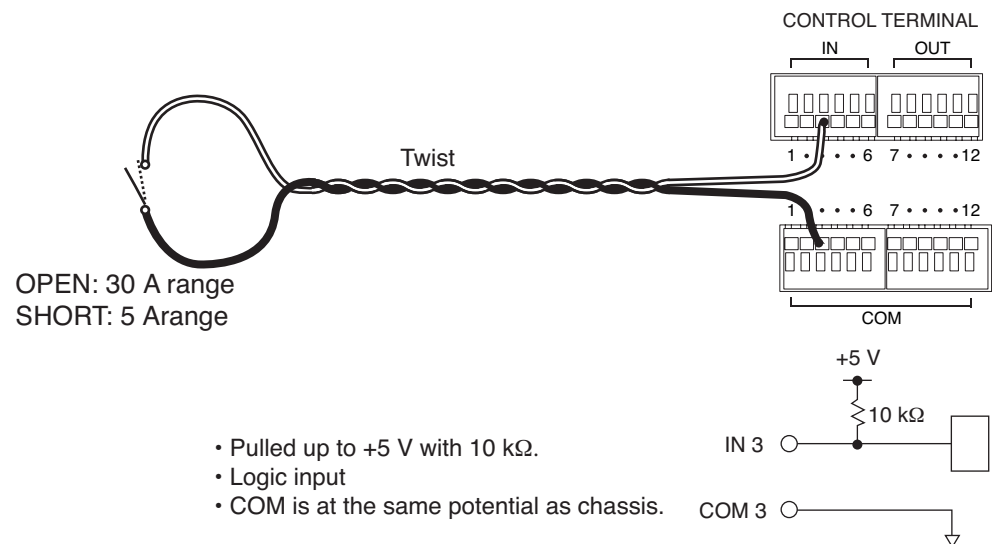


Fig. 3-13 Switching the current range

NOTE

- The load device range cannot be switched while the load is turned on. Turn the load off before switching the range.

If the range is switched, the internal load status is turned off. Therefore, you must turn the internal load status on from the panel or through remote control before you can turn the load on/off using external control again.

3.6.4 Voltage monitor output

A monitor terminal for the DC voltage applied to the sensing terminal. This terminal outputs half of the sensing terminal voltage.

1. Connect to the CONTROL TERMINAL.

Connect a voltmeter to pin 7 as shown in Fig. 3-14.

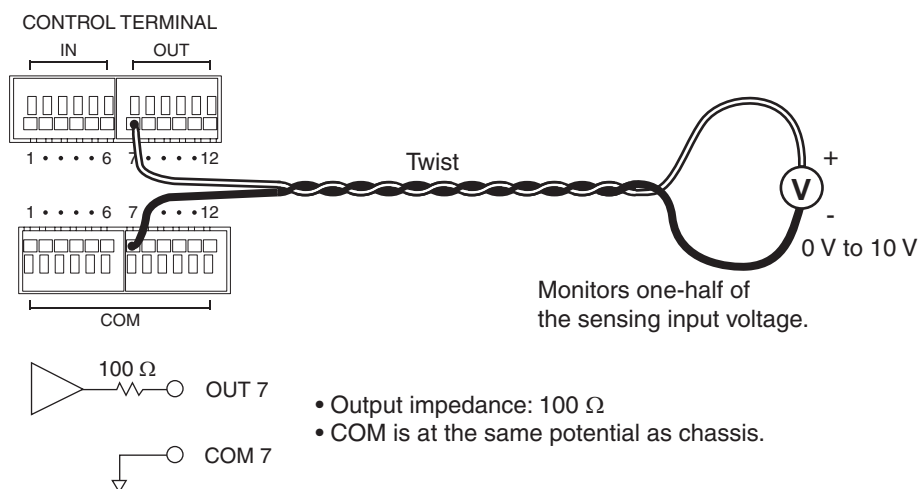


Fig. 3-14 Voltage monitor output

3.6.5 Current monitor output

A monitor terminal for the load current. The terminal outputs 10 V at 30 A regardless of the preset current range.

1. Connect to the CONTROL TERMINAL.

Connect an ammeter to pin 8 as shown in Fig. 3-15.

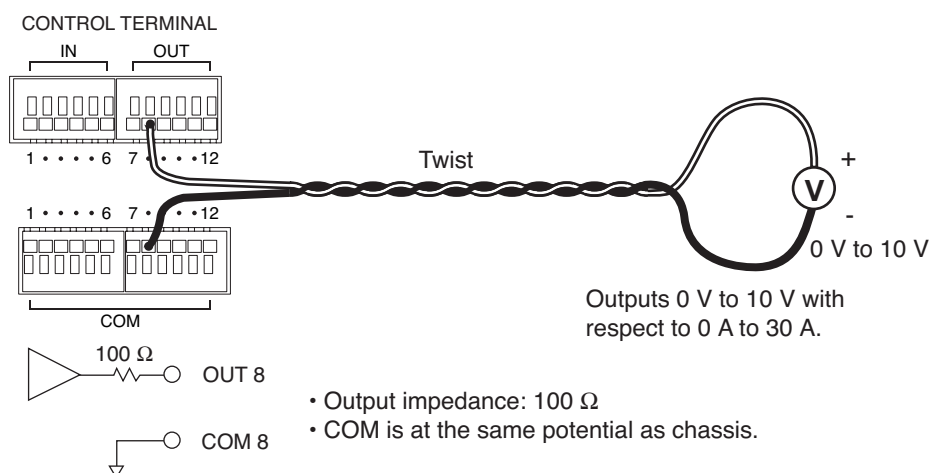


Fig. 3-15 Current monitor output

3.6.6 Alarm output

If an abnormal condition exists in the internal load device such as OHP, OVER LOAD, or OCP, the terminal outputs 5 V (high signal). Otherwise, the terminal outputs 0 V (low signal).

1. Connect to the CONTROL TERMINAL.

Acquire the alarm signal from pin 9 as shown in Fig. 3-16.

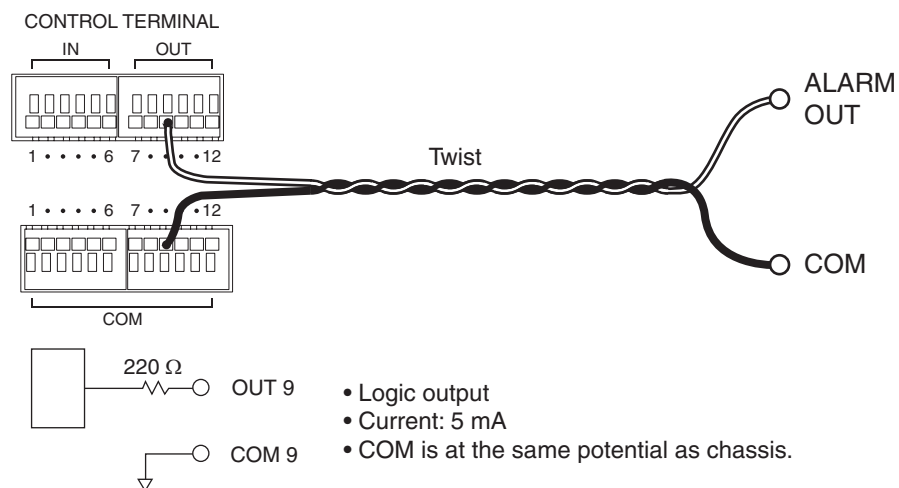


Fig. 3-16 Alarm output

3.6.7 LOAD ON/OFF status output

This terminal outputs the on/off status of the internal load device. The load is on when the terminal is 5 V (high) and off when the terminal is 0 V (low).

1. Connect to the CONTROL TERMINAL.

Acquire the status signal from pin 10 as shown in Fig. 3-17.

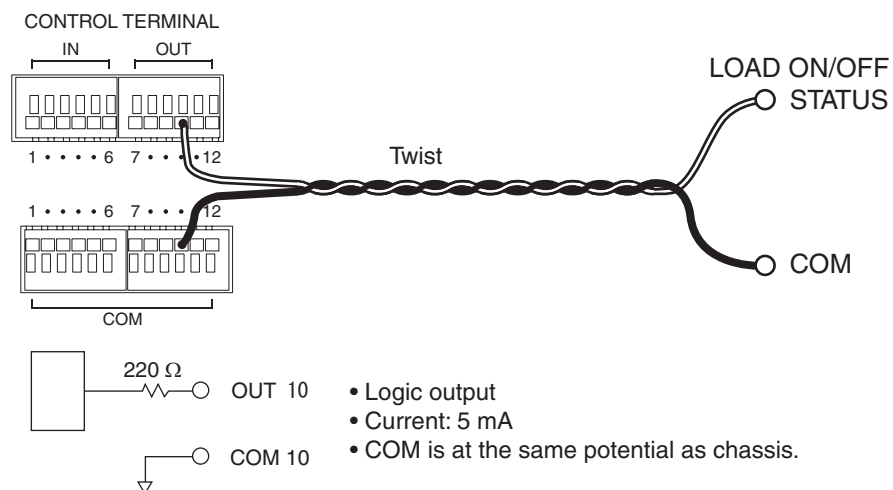


Fig. 3-17 Load on/off status output

This chapter describes the selection of interfaces and the installation of the application software included as a standard accessory.

4.1 Selecting the Communication Interface

The operation besides front panel key operation, the KFM2030 can be remotely operated from the PC with SCPI commands through the communication interface or by using the application software included as a standard accessory.

- RS232C interface
- GPIB interface
- USB interface

The factory default remote control interface setting is RS232C. USB, GPIB, and RS232C cannot be used simultaneously.

The KFM2030 conforms to the following standards.

- IEEE Std 488.2-1992 IEEE Standard Codes, Formats, Protocols, and Common Commands For Use With IEEE Std 488-1987
- IEEE Std 488.1-1987 IEEE Standard Digital Interface for Programmable Instrumentation
- Standard Commands for Programmable Instruments (SCPI) version 1999.0
- Universal Serial Bus Specification Rev 2.0
- Universal Serial Bus Test and Measurement Class Specification (USBTMC) Rev 1.0
- Universal Serial Bus Test and Measurement Class, Subclass USB488 Specification (USBTMC-USB488) Rev 1.0

To operate the KFM2030 remotely, it is necessary to select the communication interface to be used. The interface is selected from the front panel of the KFM2030.

- 1. Press the SYSTEM key.**

"System" is displayed on the function key display area.

- 2. Select the communication interface to be used.**

The setting (GPIB/USB/RS232C) changes each time the F1 key is pressed.

The following describes the settings of each interface. The selected interface becomes valid by turning on the POWER switch again.

■ When RS232C interface is selected.

To set the protocol, press the rotary knob repeatedly, the mark "●" moves in the circle check box "○" displayed on the front of item description, it is selected when the circle check box is shown as "●".

Set each item by turning the rotary knob.

Table4-1 Protocol setting

Item	Choices
Baudrate (Bit rate)	2400 bps, 4800 bps, 9600 bps, or 19200 bps ^{*1}
Databits	7 bit or 8 bit ^{*1}
Acknowledge	ON or OFF ^{*1}
Parity	Fixed to NONE
Stopbits	Fixed to 2

*1. When the Fuel Cell Load & Impedance Measurement Software as included as a standard accessory is used through by RS232C interface, select "19200 bps", "8 bits", and "OFF".

The RS232C port on the KFM2030 is a standard D-sub 9-pin male connector.

Check that the POWER switches of the KFM2030 and the PC are off, and connect the KFM2030 to the PC using a standard cross cable (null modem cable).

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

The KFM2030 does not use hardware handshaking. The cable shown in the "Cross cable example 2" can be also used.

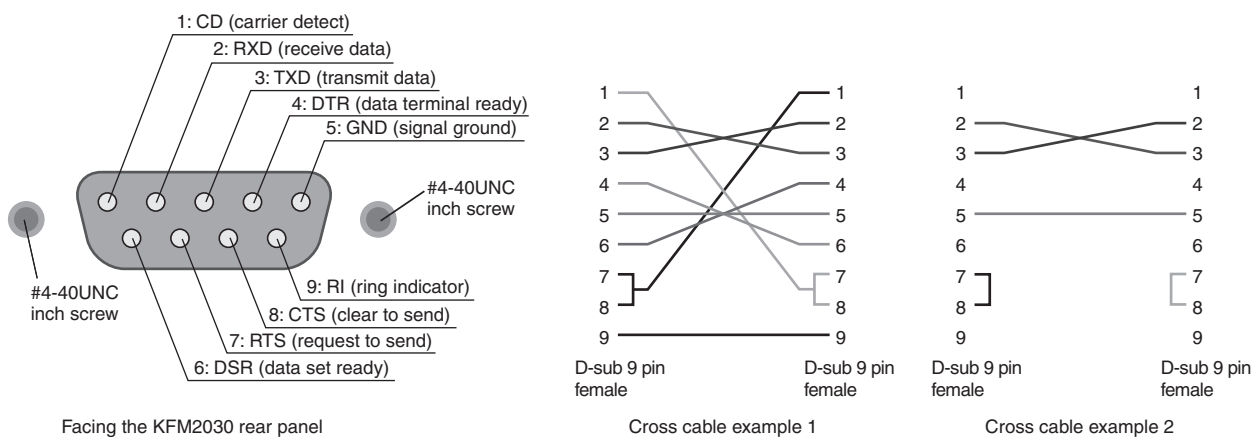


Fig.4-1 9-pin AT type connector

■ When GPIB interface is selected.

Turn the rotary knob to set the GPIB address (1 to 30).

■ When USB interface is selected.

"Vendor ID (0x0B3E)", "Product ID (0x1007)", and "Serial/No." are displayed on the LCD.

Data rate is 12 Mbps maximum (full speed).

3. Power cycle the KFM2030.

The settings are updated.

4.2 Operating the KFM2030 with SCPI commands

The required SCPI commands are specified in the "Communication Interface Manual" (CD-ROM) as included as a standard accessory.

The communication interface manual is in HTML format. The HTML manual can be viewed using the following browsers.

Operating environment: Windows 98 or later

Browser: Microsoft Internet Explorer 5.5 or later

The list of messages of interface manual is provided in a PDF file. Adobe Reader 6.0 or later is required to view the file.

NOTE

A device driver supporting USB T&M Class (USBTMC) is required to control the KFM2030 through the USB interface. The USBTMC driver is automatically installed by one of the VISA drivers below.

- KI-VISA 2.2.x or later
(included with the software CD-ROM, or downloadable from KIKUSUI Website)
 - NI-VISA 3.0 or later
(downloadable from National Instruments Website)
 - Agilent VISA (Agilent I / O Libraries) M01.00 or later
(downloadable from Agilent Website)
-

4.3 Using the Accompanying Application Software

4.3.1 Product Overview

The accompanying application software "Fuel Cell Load & Impedance Measurement Software" for measuring the impedance of fuel cell under loaded conditions can be used to control the KFM2030 from a PC and perform tests on fuel cells, etc. The application software achieves the following functions.

I-V characteristics test

Performs a current sweep on the load unit in constant current mode and retrieves the I-V characteristics. At the same time, fuel cell impedance can be measured at a certain frequency, and the result can be saved to a text file.

Cole-Cole plot test

Measures the impedance by performing a frequency sweep and generates a Cole-Cole plot with a given load current flowing through the fuel cell. The result can be saved to a text file.

CC mode test

Logs the fuel cell voltage and impedance with a given load current flowing through the fuel cell. The result can be saved to a text file.

System Requirements

Below are the hardware and software requirements for using the Fuel Cell Load & Impedance Measurement Software.

- PC running Windows 2000, Windows XP, or Windows Vista
- At least 256 MB of memory
- 1024 x 768 dots or higher resolution
- 100 MB or more free hard disk space
- CD-ROM drive
- Mouse or other pointing device
- VISA library
NI-VISA 3.0 or later; Agilent IO Libraries Suite M01.00 or later; or KI-VISA 2.2.x or later
- USB cable (when using USB)
- IEEE488 cable (when using GPIB)
- Cross serial cable (when using RS232C)

VISA Driver

⚠ CAUTION • Do not install multiple different VISA drivers, because they may not operate properly.

VISA (Virtual Instrument Software Architecture) is a standard developed by the VXI-plugin&play Systems Alliance that defines software specifications for communicating with instruments from a PC. A VISA-compliant driver software is the VISA driver.

The KI-VISA is Kikusui original VISA driver compatible with VXIplugin&play VISA 3.0. You must install a VISA driver to use the Fuel Cell Load & Impedance Measurement Software.

The VISA driver that is required varies depending on the I/O interface that you will be using. See below to select the appropriate VISA driver.

Table 4-2 VISA driver that is required and how to obtain the driver

I/O interface		VISA driver that is required
RS232C ^{*1, *2}		KI-VISA Ver2.2.x or later
USB ^{*1}		NI-VISA Ver3.0 or later Agilent IO Libraries M01.00 or later
GPIB ^{*3}	Interface Corporation ^{*4}	KI-VISA Ver2.2.x or later
	CONTEC CO., LTD. ^{*4}	
	National Instruments	NI-VISA Ver3.0 or later
	Agilent	Agilent IO Libraries M01.00 or later

VISA driver	How to obtain the driver
KI-VISA	From the software CD-ROM or from the KIKUSUI Website ^{*5}
NI-VISA	From the CD-ROM provided with the GPIB card or from the National Instruments Website
Agilent IO Libraries	From the CD-ROM provided with the GPIB card or from the Agilent Technologies Website

*1. If you are using RS232C or USB, any VISA driver can be used. However, for details on licensing, refer to the license terms of the respective VISA driver.

*2. RS232C supports standard communications ports on a personal computer and virtual serial communication ports through a USB-RS232C converter or other similar converters. However, virtual communication ports may not work properly depending on the device driver that is provided.

*3. If you are using GPIB, you must use the appropriate VISA driver; otherwise, it will not work.

*4. KI-VISA supports the following GPIB models.
 CONTEC CO., LTD. GP-IB(PCI)L, GP-IB(PM), GP-IB(PCI)F, GP-IB(CB)F. API-GPIB driver VER4.01 or later recommended.
 When using GPIB cards by Contec Co., Ltd, use the ordinary API-GPIB driver, not the API-GLV driver (LabVIEW compatible and NI-488.2M API compatible).
 Interface Corporation PCI-4301 LabVIEW compatible version (GPC-4301N driver version 1.21 or later recommended)
 When using GPIB cards by Interface Corporation, use the GPC-4301N driver (LabVIEW compatible and NI-488.2M API compatible), not the ordinary GPC-4301 driver.

*5. It can be downloaded by "DOWNLOAD" site (<http://www.kikusui.co.jp/en/download/index.html>) at KIKUSUI Website. To install the KI-VISA Ver.4.2.2 or later, the Windows 2000 SP4 or later version is required.

Notes on use

The Fuel Cell Load & Impedance Measurement Software is used to retrieve KFM2030 test data to your PC. To ensure that test data is retrieved, disable the following features on your PC during testing.

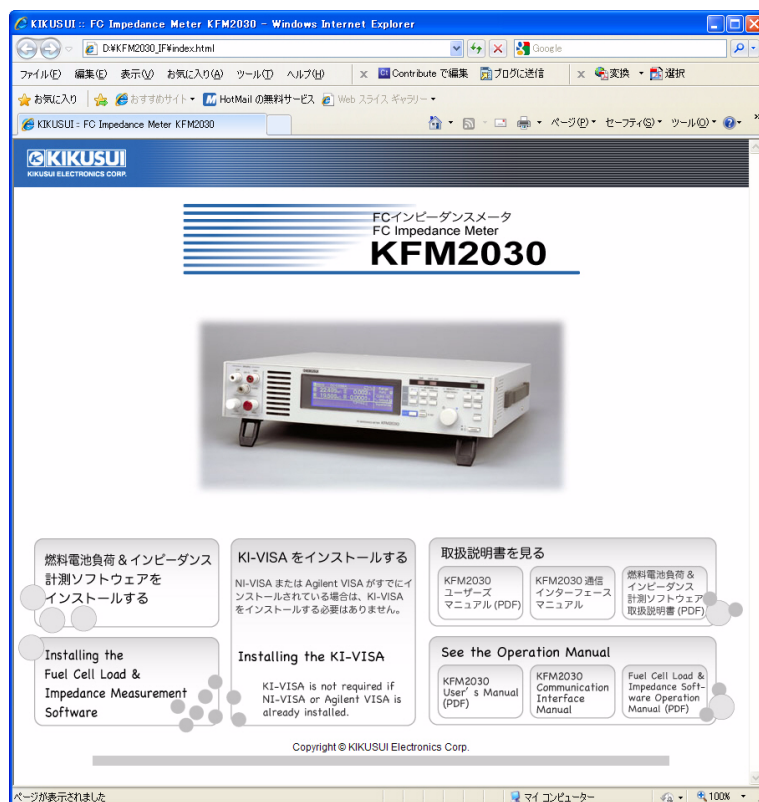
- Windows power save mode
- Screen saver
- Memory-resident programs

Do not run other software applications during testing.

4.3.2 Opening the Menu Program Window

Insert the program CD-ROM in the drive. After a short time, the menu program window opens.

If the menu program window does not open, browse the CD-ROM with Windows Explorer, and double-click index.htm. The menu program will start.



4.3.3 Installing the KI-VISA

CAUTION • Do not install multiple different VISA drivers, because they may not operate properly.

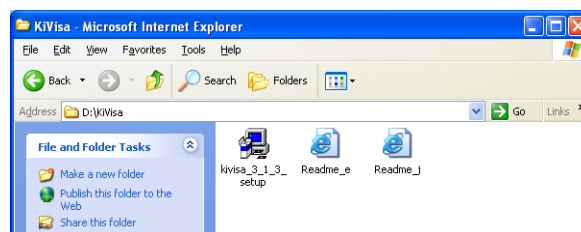
To use "Fuel Cell Load & Impedance Measurement Software", it requires to install the VISA driver, however, it is not necessarily to install the KI-VISA.

To use an NI-VISA or Agilent Technologies VISA driver, refer to the manual of the respective product.

If you are not installing KI-VISA, proceed to 4.3.4, "Installing the Fuel Cell Load & Impedance Measurement Software."

1. On the menu program window, click Installing the KI-VISA.

The Kivisa_3_x_x.exe file on the CD-ROM appears in the window.



2. Double-click Kivisa_3_x_x.exe.

Then, follow the instructions on the screen.

The IVI Shared Components will be installed prior to the installation of KI-VISA.

3. When the KI-VISA driver installation is complete, the following dialog box opens. Click Finish.

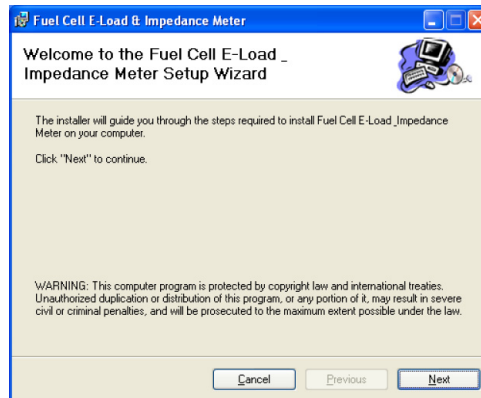
To back the menu program window, click Back in the browser window.



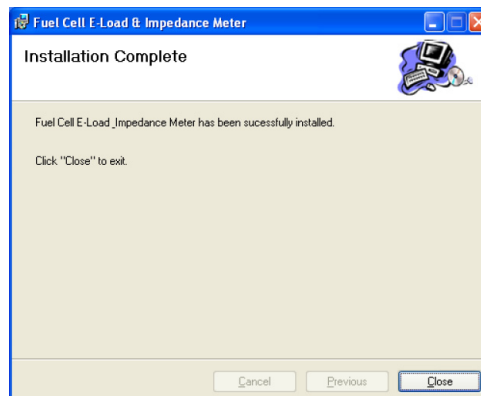
4.3.4 Installing the Fuel Cell Load & Impedance Measurement Software

1. On the menu program window, click Installing the Fuel Cell Load & Impedance Measurement Software.

Then, follow the instructions on the screen.

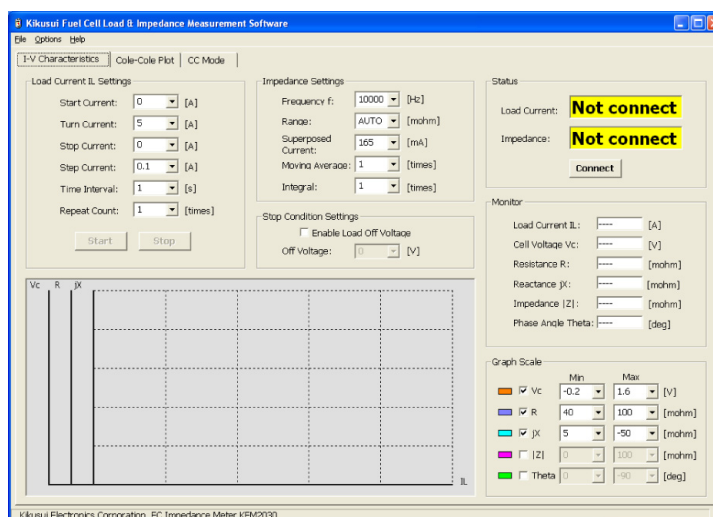


2. When the installation is complete, the following window appears. Click Close.



Starting the application software

1. Setting the communication interface of the KFM2030.
2. Connect the KFM2030 to the PC with the interface cable.
3. Click Start on the task bar, point to Programs > Kikusui KFM2030, and then click Fuel Cell Load & Impedance Measurement Software.
4. Fuel Cell Load & Impedance Measurement Software starts.



NOTE

- To use Fuel Cell Load & Impedance Measurement Software, it should be recognized that the application software is connected with the KFM2030. For details, see the Fuel Cell Load & Impedance Measurement Software operation manual.

Viewing the application software User's Manual

The Fuel Cell Load & Impedance Measurement Software operation manual details the instructions on how to use the application software.

On the menu program window, choose Fuel Cell Load & Impedance Measurement Software operation manual. Or click Start on the task bar, point to Programs > Kikusui KFM2030, and then click Manual.

This chapter describes maintenance and calibration of the KFM2030. Conduct periodic maintenance, inspection, and calibration to maintain the initial performance as long as possible.

5.1 Cleaning

-
- ⚠ CAUTION**
- Be sure to turn off (O) the power switch before cleaning.
 - Do not use volatile chemicals such as benzene or thinner. They may discolor the surface or erase the printed characters.
-

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

5.2 Inspection

Power cord

Check that the insulation coating is not broken and that the plug is not cracked or falling apart.

-
- ⚠ WARNING**
- Breaks in the insulation coating or wire may cause electric shock. If a break is found, stop using it immediately.
-

To purchase accessories, contact Kikusui distributor/agent.

5.3 Calibration

The KFM2030 is calibrated at the factory before shipment. However, periodic calibration is necessary due to changes that occur after extended use.

To have your KFM2030 calibrated, contact Kikusui distributor/agent.

5.4 Replacing the Fuse

-
- ⚠ WARNING**
- To prevent the possibility of electric shock, make sure to unplug the power cord before replacing the fuse.
 - Use a fuse of shape, rating, and characteristics that conform to the KFM2030.
- Using a fuse of a different rating or shorting the fuse holder is dangerous. Never carry out such acts.
-

1. Turn the POWER switch of the KFM2030 and remove the power cord plug.
2. Remove the power cord from the AC LINE connector on the rear panel.
3. Remove the fuse holder using a tool such as a flat-blade screwdriver as shown in Fig. 5-1.

Fuse rating: 250 VAC, 6.3 A (T)

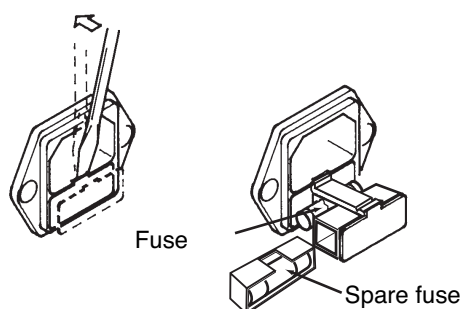


Fig.5-1 Removing the fuse holder

5.5 Replacing the Backup Battery

The KFM2030 backs up panel settings and other information with the internal battery even when the power is turned off. If the panel settings are different at the time the power is turned off and at the time the power is turned on again, the battery is already dead.

The battery life depends on the operating conditions. Three years after purchase is a good estimation.

To replace the battery, contact Kikusui distributor/agent.

5.6 Malfunctions and Causes

This section describes remedies for malfunctions encountered during the use of the KFM2030. Typical symptoms are listed. Check whether any of the symptoms below apply to your case. In some cases, the problem can be solved quite easily.

If the remedy does not solve the problem, contact your Kikusui agent or distributor.

■ Nothing appears on the display when the POWER switch is turned on.

Check Item		Possible Cause	Remedy
Location and Status of the Object	Check Result		
Is rated voltage applied for the input power supply (AC)?	No	Broken power cord or bad connection at the AC LINE connector on the rear panel	Check that the power cord is not broken and that the connection at the power cord connector is secure.
	Yes	Malfunction	Remove the power cord plug from the outlet. Immediately stop the use of the instrument and request repairs.

■ The display is dark.

Check Item		Possible Cause	Remedy
Location and Status of the Object	Check Result		
Is rated voltage applied for the input power supply (AC)?	No	Low supply voltage	Use the KFM2030 in the input supply voltage range.
	Yes	Bad contrast adjustment	Adjust the contrast. Reference: Page 2-1 "Rotary knob"

■ Keys do not work.

Check Item		Possible Cause	Remedy
Location and Status of the Object	Check Result		
Is the RMT LED lit?	Yes	The KFM2030 is being remotely controlled via the external interface.	Press the RMT/LOCAL key.
	No	Malfunction	Immediately stop the use of the instrument and request repairs.

■ Input current is unstable or oscillates.

Check Item		Possible Cause	Remedy
Location and Status of the Object	Check Result		
Is rated voltage applied for the input power supply (AC)?	No	Low supply voltage	Use the KFM2030 in the input supply voltage range.
	Yes	Malfunction	Immediately stop the use of the instrument and request repairs.
Is the alarm LED lit or ALM: displayed on the LCD?	Yes	An internal or external error occurred on the KFM2030.	Check the alarm type and carry out the appropriate remedy. Reference: section 3.4, "Protection Function"
Is there a large loop in the load wire?	Yes	Effect of magnetic flux	Twist the wires. Reference: section 3.2, "Connecting to the Fuel Cell"

■ An alarm occurs.

Check Item		Possible Cause	Remedy
Location and Status of the Object	Check Result		
Is the fan stopped?	Yes	Overheat protection tripped.	Immediately stop the use of the instrument and request repairs.
Are the bent holes obstructed?	Yes	Overheat protection tripped.	Allow at least 20 cm between the vent holes and the wall. In addition, do not place objects within 20 cm.
Is the overcurrent protection (OCP) tripping while using external control?	Yes	External input voltage greater than or equal to 10 V was applied, or full scale adjustment have not been made.	Set the external input voltage to 10 V or less. Adjust the full scale.
Is OCP tripped?	Yes	Malfunction	Immediately stop the use of the instrument and request repairs.

■ The load cannot be turned on.

Check Item		Possible Cause	Remedy
Location and Status of the Object	Check Result		
Is ALM: displayed on the LCD?	Yes	An alarm was activated.	Press the OFF key once and then the ON key.
Is the load being turned on using external control?	Yes	The load is turned OFF from the panel.	Turn the load on from the panel. Reference: section 3.3.3, "Turning the Load On/Off"

■ The impedance measurement is unstable.

Check Item		Possible Cause	Remedy
Location and Status of the Object	Check Result		
Is there a large loop in the sensing wire?	Yes	Effect of magnetic flux	Shorten the wires.
Is the voltage measurement stable?	No	The fuel cell output is not stable.	Stabilize the fuel cell output.

■ Voltage display is unstable, or incorrect.

Check Item		Possible cause	Remedy
Location and status of the object	Check result		
Is the measuring AC current set to "OFF"?	Yes	Effect of the common mode noise.	Use the GUARD terminal. Reference: section A.3, "Concerning the GUARD Terminal"
Is the ground wire of the power cord grounded?	No	Effect of the common mode noise.	Ground the ground wire. Reference: section 1.4, "Connecting the Power Cord"

This chapter describes the electrical and mechanical specifications of the KFM2030.

6.1 Electrical Performance

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

- The warm-up time is 30 minutes (with current flowing).

Impedance Measurement Section

Measurement frequency		10 mHz to 10 kHz
Frequency resolution		1.00, 1.26, 1.58, 2.00, 2.51, 3.00, 3.16, 4.00, 5.00, 6.00, 6.30, 7.00, 8.00, 9.00 sequence with a resolution of 14 points/decade
Impedance measurement range ^{*1}	165 mA range	30 mΩ, 100 mΩ, 300 mΩ, or AUTO
	500 mA range	10 mΩ, 30 mΩ, 100 mΩ, or AUTO
Measuring AC current	165 mA range	60 mArms±10 % ^{*2}
	500 mA range	180 mArms±10 % ^{*2}
	OFF	Mechanically opens the AC current source
Measurement resolution	10 mΩ range	1 μΩ
	30 mΩ and 100 mΩ ranges	10 μΩ
	300 mΩ range	100 μΩ
Measured value display		Select and display 4 items among R, X, Z , θ, voltage, and current.
Measurement accuracy ^{*2,*3}	R and X from 10 mHz to 900 Hz	±2 % of range ^{*4}
	R and X from 1 kHz to 4 kHz	±3 % of range ^{*4}
	R and X from 5 kHz to 10 kHz	±4 % of range ^{*4}

*1. Can measure up to approximately 4 times the range. However, over range may occur at a value lower than the range if the fuel cell drift or ripple is large or high level of noise exists in the environment. Maximum capable measurement value is approximately 1.2 Ω.

*2. At 15 °C to 35 °C

*3. After 32 counts of the moving average count

*4. range: Measurement range

DC Voltage and Current Measurement Section

Voltage range		Auto switching between 2 V and 20 V
Voltage measurement resolution	2 V range	100 μ V
	20 V range	1 mV
Voltage measurement accuracy ^{*1}	2 V range	$\pm(0.2 \% \text{ of rdg}^{*2} + 6 \text{ digit})$
	20 V range	$\pm(0.7 \% \text{ of rdg}^{*2} + 8 \text{ digit})$
Current measurement resolution		1 mA
Current measurement accuracy		$\pm 2 \%$ with respect to 30 A
Monitor output	Voltage monitor	Outputs 10 V with respect to a sensing input voltage of 20 V
	Voltage monitor accuracy ^{*1}	$\pm 0.05 \text{ V}$
	Current monitor	Outputs 10 V with respect to a load current of 30 A
	Current monitor accuracy ^{*1}	$\pm 0.2 \text{ V}$

*1. At 15 °C to 35 °C

*2. rdg: Input voltage reading

Electronic Load Section

Operation mode		Constant current
Range		5 A and 30 A
Maximum load current		30 A
Input voltage range		0 V to 20 V
Maximum input power		60 W
Current setting resolution	5 A range	0.1 mA
	0.5 A range	0.01 mA
Current setting accuracy ^{*1}		$\pm(0.5 \% \text{ of set}^{*2} + 10 \text{ mA})$
External control ^{*3}	5 A range	0 A to 5 A with respect to 0 V to 10 V
	30 A range	0 A to 30 A with respect to 0 V to 10 V

*1. At 15 °C to 35 °C

*2. set: Input current setting

*3. The full scale of the setting can be fine tuned

Protection Function

Overvoltage protection (OVP)		Cuts off the load when a voltage greater than or equal to 21 V is applied to the sensing terminal
Undervoltage protection (UVP)	Cuts off the load if the sensing terminal falls below the preset voltage	
	Setting range	-2 V to 20 V, Mask Time: 0 s to 10 s (in 1 second)
Overheat protection (OHP)		Cuts off the load when the load device reaches an abnormal temperature. OHP LED lights.
Overload protection (OPP)		CP (constant power) trips and OVER LOAD LED lights with a power greater than or equal to 63 W
Overcurrent protection (OCP)		Cuts off the load when a load current greater than or equal to 31.5 A flows.
Disconnection detection (OPEN)		Cuts off the load when the load cable is not wired or is loose.

Communication Interface

RS232C	Connector	9-pin D-sub terminal on the rear panel
	Bit rate	2400 bps/ 4800 bps/ 9600 bps/ 19200 bps
	Data bits	7 bit or 8 bit
	Stop bits	Fixed to 2 bit
	Parity	Fixed to none
	Acknowledge	ON or OFF
GPIB		Complies with IEEE Std.488-1978
	Subset	SH1, AH1, T6, L4, SR1, RL1, PP0, DC1, DT1, C0, and E1
	Device address	Set in the range of 1 to 30 (3 by factory default)
USB		USB specification 2.0 Self-powered
	Device class	USB Test and Measurement Class (USMTMC Specification 1.0 and USMTMC-USB488 Specification 1.0)
	Data rate	12 Mbps maximum (full speed)
Common Specifications	Messaging protocol	IEEE488.2 std 1992
	Command language	SCPI Specification 1999.0

Miscellaneous

Display	240 × 64 dot LCD, with CCFL backlight, contrast adjustable
Installation altitude	2000 m or less
Storage temperature and relative humidity range	Temperature: -10 °C to 60 °C (14 °F to 140 °F) Humidity: 90 % or less (no condensation)
Operating temperature and relative humidity range	Temperature: 0 °C to 40 °C (32 °F to 104 °F) Humidity: 20 % to 85 % or less (no condensation)
Line voltage range	90 VAC to 132 VAC, 180 VAC to 250 VAC
Line frequency range	45 Hz to 65 Hz
Maximum power consumption	600 VA
Safety ^{*1}	Complies with the requirements of the following directives and standards. Low Voltage Directive 2006/95/EC EN 61010-1 Class I Pollution degree 2
Electromagnetic Compatibility (EMC) ^{*1, *2}	Complies with the requirements of the following directives and standards. EMC Directive 2004/108/EC EN 61326-1, EN 61000-3-2, EN 61000-3-3 Applicable condition All of the wires and wires connected to the KFM2030 are less than 3 m in length. Using the accessory sensing wire and load cables.
Dimensions	See outline drawing.
Weight	9.5 kg (20.94 lb)
Battery life	Approx. 3 years
Battery backup	Backs up setup information

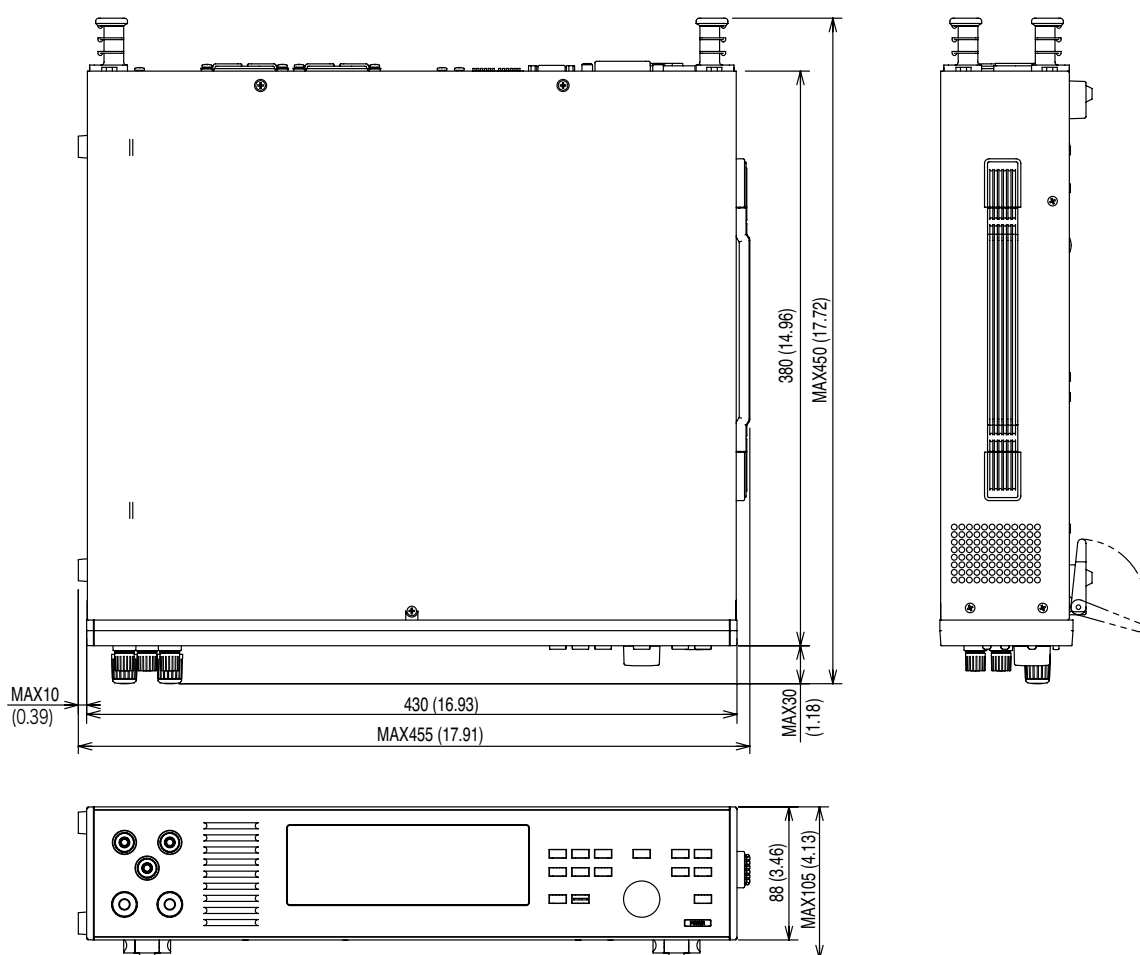
Accessories	Power cord	1
	Spare fuse ^{*3} (250 VAC, 6.3 A)	1
	Sensing wire (AWG24, 2-core shielded wire 1.8 m)	1
	Load cable (8 mm ² , 1.5 m, insulation cap: red)	1
	Load cable (8 mm ² , 1.5 m, insulation cap: white)	1
	CD-ROM	1
	User's manual	1

*1. Not applicable to custom order models.

*2. Applies only to models that have CE marking on the panel.

*3. Contained in the AC LINE connector.

6.2 Outline Drawing



Unit: mm (inch)

Appendix

A.1 Overview of the Fuel Cell

A fuel cell is a generating device that produces power by a chemical reaction between the fuel (hydrogen or methanol) and oxygen.

There are various types of fuel cells such as phosphoric acid fuel cell (PAFC), molten carbonate fuel cell (MCFC), solid oxide fuel cell (SOFC), and polymer electrolyte fuel cell*¹ (PEFC). The principle structure of a PEFC is shown in Fig. A-1.

A membrane electrode assembly (MEA), which comprises a proton-exchange membrane and electrodes sandwiching the membrane, is placed between separators. Hydrogen and oxygen are supplied to the separator to generate power.

This one block corresponds to a cell. A cell generates an electromotive force of slightly less than 1 V. If high electromotive force is required, multiple cells are stacked together as shown in Fig. A-1. This is called a stack.

The current is drawn from the collecting electrode plates. In addition to the fuel cell unit, a system that supplies fuel smoothly through the stack is required for the fuel cell to actually work. Various instruments are needed to test the electric performance of fuel cells such as a load device for absorbing the generated power, ammeter, voltmeter, and impedance meter.

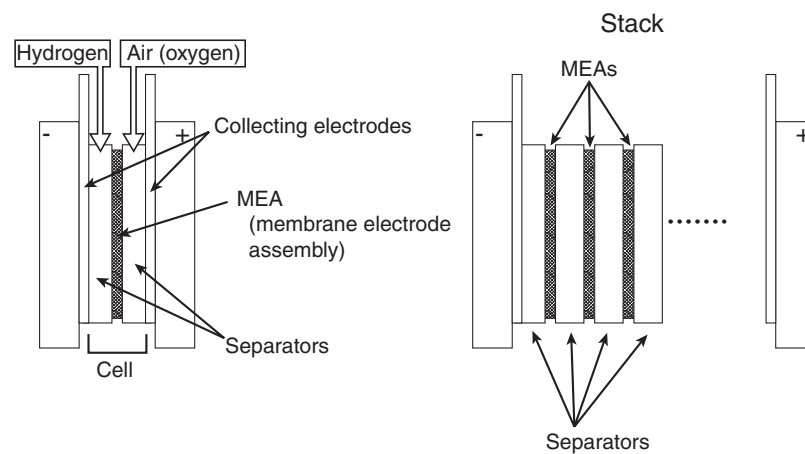


Fig.A-1 PEFC fuel cell structure

1. Or proton exchange membrane fuel cell (PEMFC)

A.2 Impedance Measurement Method of the KFM2030

Impedance refers to electrical resistance in an AC circuit. It is generally denoted as Z and defined by the following equation.

$$Z = \frac{(E \cdot \sin(\omega t + \theta))}{(I \cdot \sin(\omega t))}$$

E : Voltage amplitude

I : Current amplitude

θ : Phase angle (phase difference between the voltage and current)

ω : Angular frequency

t : Time

When the relation of the voltage, the current, and impedance are expressed by the vector on the complex plane, it becomes following Ohm's laws.

$$\dot{Z} = \frac{\dot{E}}{\dot{I}}$$

When the "R" is a component of real number, and "X" is a component of imaginary number of the impedance \dot{Z} , the relation of impedance magnitude of \dot{Z} " $|Z|$ " and the phase angle " θ " can be referred by the following formula.

$$|Z| = \sqrt{R^2 + X^2} \quad \theta = \tan^{-1}(X/R)$$

R : Resistance

X : Reactance

The KFM2030 measures the impedance using a configuration generally called galvanostat in the chemical field. The KFM2030 supplies a prescribed AC current I to the fuel cell and measures the AC voltage E that appears. From this result, the KFM 2030 determines R , X , $|Z|$, and θ of the fuel cell according to the relationships described above.

A.3 Concerning the GUARD Terminal

The GUARD terminal is connected to the chassis and it is the circuit common for the measuring related circuits. This terminal is not used for the input terminal of measurement application.

When the noise that is called a common mode has been generated from the equipment such as gas supply system other than the fuel cell, it may cause the effect for the measurement. In such cases, wire the equipment which generates the noise to connect to the GUARD terminal, the effect for the measurement will be reduced. If the chassis is not grounded, it will not effect for the noise reduction. Be sure to ground the ground wire of the power cord.

If the different potential of the chassis is connected to the KFM2030, note that the trouble may occur to the entire test system of the fuel cell.

Do not connect the output terminal of the fuel cell directly with the GUARD terminal. The KFM2030 may not operate normally.

The input terminal of the KFM2030 are configured as shown in Fig. A-2. When the terminal voltage of fuel cell is 20 V, it operates as applying 10 V for each HIGH and LOW of the GUARD terminal and the SENSING terminal. The KFM2030 will not work when greater than 10 V is applied to the GUARD terminal and the SENSING terminal.

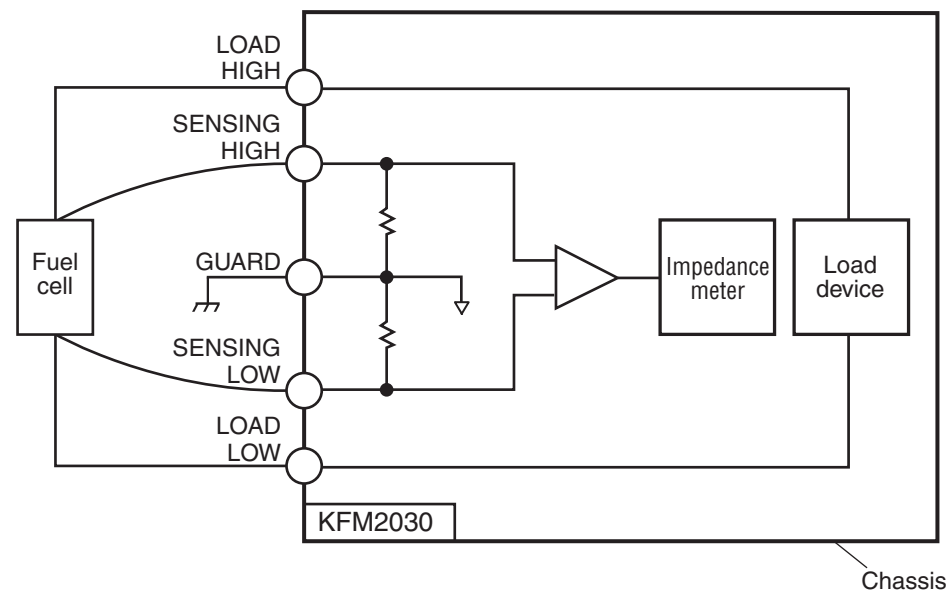


Fig. A-2 KFM2030 configuration

Index

A

ALARM	2-8
alarm, resetting of	3-12
ALM	2-3
AVERAGE	2-4
INTEGRATION	2-4
MOVING	2-4
average	3-6
Averaging	2-3

B

backup battery, replacement of	5-2
--------------------------------------	-----

C

calibration	5-1
cleaning	5-1
Coarse	2-1
contrast	2-1
CONTROL TERMINAL	2-7
ALARM	2-8
EXT V CC CONT	2-7
I MONITOR	2-8
LOAD ON/OFF	2-7
LOAD ON/OFF STATUS	2-8
RANGE	2-7
V MONITOR	2-7
CURR-AC	2-4
CURRENT	2-6
RANGE	2-6
SOURCE	2-6

D

default	3-13
---------------	------

E

EXT	2-6
Ext	3-4
EXT CONT	2-8
FSC	2-8
OFS	2-8
EXT V CC CONT	2-7
external control	3-4, 3-14

F

F1	2-4
F2	2-4
F3	2-4

F4	2-4
factory default	3-13
factory default settings	3-13
Fine	2-1
FSC	2-8
Fuel Cell Load & Impedance Measurement Software ..	4-5
fuse, replacement of	5-2

G

GPIOB	2-6, 4-3
GUARD terminal	A-3

H

HIGH	2-2
------------	-----

I

I MONITOR	2-8
icons	2-2
IMPD	2-4
CURR-AC	2-4
RANGE	2-4
Impedance	A-2
inspection	5-1
INT	2-6, 3-4
integral average	3-6
INTEGRATION	2-4

K

KI-VISA	4-6
---------------	-----

L

LCD	2-2
LOAD	2-1
LOAD ON	2-3
LOAD ON/OFF	2-7
LOAD ON/OFF STATUS	2-8
LOAD terminal	3-2

M

malfunctions and causes	5-3
Mask Time	2-6
measuring AC current	3-5
memory	3-12
MOVING	2-4
moving average	3-6

O

OCP	2-3, 3-12
OFS	2-8
OHP	2-3, 3-12
OPEN	2-3, 3-12
OPP	2-3
outline drawing	6-4
OVER LOAD	2-3, 3-12
OVER Range	2-3
OVP	2-3, 3-11

P

polymer electrolyte fuel cell (PEFC)	A-1
power cord	1-4
PROTECT	2-6
Mask Time	2-6
UVP	2-6
protection function	3-11
proton exchange membrane fuel cell (PEMFC)	A-1

R

R	P-1
RANGE	2-4, 2-6, 2-7
RECALL	2-5
RMT/LOCAL	2-6
RS232C	2-6, 4-2

S

SCPI commands	4-4
SENSING	2-2
SENSING terminal	3-2
separator	A-1
SOURCE	2-6
STORE	2-5
SYSTEM key	4-1

T

theta	P-1
-------------	-----

U

USB	2-6, 4-3
USBTMC driver	4-4
UVP	2-3, 2-6, 3-11

V

V MONITOR	2-7
VIEW	2-5
VISA driver	4-4, 4-6

X

X	P-1
---------	-----

Z

Z 	P-1
----------	-----

