4601

I-V Meter

Operation Manual

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Safety Summary

To ensure thorough understanding of all functions and to ensure efficient use of this instrument, please read the manual carefully before using. Note that ADC Corporation (hereafter referred to as ADC) bears absolutely no responsibility for the result of operations caused due to incorrect or inappropriate use of this instrument.

If the equipment is used in a manner not specified by ADC, the protection provided by the equipment may be impaired.

- **Warning Labels**

  Warning labels are applied to ADC products in locations where specific dangers exist. Pay careful attention to these labels during handling. Do not remove or tear these labels. If you have any questions regarding warning labels, please ask your nearest ADC dealer. Our address and phone number are listed at the end of this manual.

  Symbols of those warning labels are shown below together with their meaning.

  DANGER: Indicates an imminently hazardous situation which will result in death or serious personal injury.

  WARNING: Indicates a potentially hazardous situation which will result in death or serious personal injury.

  CAUTION: Indicates a potentially hazardous situation which will result in personal injury or a damage to property including the product.

- **Basic Precautions**

  Please observe the following precautions to prevent fire, burn, electric shock, and personal injury.

  - Use a power cable rated for the voltage in question. Be sure however to use a power cable conforming to safety standards of your nation when using a product overseas.
  - When inserting the plug into the electrical outlet, first turn the power switch OFF and then insert the plug as far as it will go.
  - When removing the plug from the electrical outlet, first turn the power switch OFF and then pull it out by gripping the plug. Do not pull on the power cable itself. Make sure your hands are dry at this time.
  - Before turning on the power, be sure to check that the supply voltage matches the voltage requirements of the instrument.
  - Connect the power cable to a power outlet that is connected to a protected ground terminal. Grounding will be defeated if you use an extension cord which does not include a protective conductor terminal.
  - Be sure to use fuses rated for the voltage in question.
  - Do not use this instrument with the case open.
  - Do not place anything on the product and do not apply excessive pressure to the product. Also, do not place flower pots or other containers containing liquid such as chemicals near this

product.

- When the product has ventilation outlets, do not stick or drop metal or easily flammable objects into the ventilation outlets.
- When using the product on a cart, fix it with belts to avoid its drop.
- When connecting the product to peripheral equipment, turn the power off.

- **Caution Symbols Used Within this Manual**

  Symbols indicating items requiring caution which are used in this manual are shown below together with their meaning.

  DANGER: Indicates an item where there is a danger of serious personal injury (death or serious injury).

  WARNING: Indicates an item relating to personal safety or health.

  CAUTION: Indicates an item relating to possible damage to the product or instrument or relating to a restriction on operation.

- **Safety Marks on the Product**

  The following safety marks can be found on ADC products.

   : ATTENTION - Refer to manual.

   : Protective ground (earth) terminal.

   : DANGER - High voltage.

   : CAUTION - Risk of electric shock.

- **Replacing Parts with Limited Life**

  The following parts used in the instrument are main parts with limited life.
  Replace the parts listed below before their expected lifespan has expired to maintain the performance and function of the instrument.
  Note that the estimated lifespan for the parts listed below may be shortened by factors such as the environment where the instrument is stored or used, and how often the instrument is used.
  The parts inside are not user-replaceable. For a part replacement, please contact the ADC sales office for servicing.

  Each product may use parts with limited life.
  For more information, refer to the section in this document where the parts with limited life are described.

Main Parts with Limited Life

Part name	Life
Unit power supply	5 years
Fan motor	5 years
Electrolytic capacitor	5 years
LCD display	6 years
LCD backlight	2.5 years
Floppy disk drive	5 years
Memory backup battery	5 years

- **Hard Disk Mounted Products**

  The operational warnings are listed below.

  - Do not move, shock and vibrate the product while the power is turned on.
    Reading or writing data in the hard disk unit is performed with the memory disk turning at a high speed. It is a very delicate process.

  - Store and operate the products under the following environmental conditions.
    An area with no sudden temperature changes.
    An area away from shock or vibrations.
    An area free from moisture, dirt, or dust.
    An area away from magnets or an instrument which generates a magnetic field.

  - Make back-ups of important data.
    The data stored in the disk may become damaged if the product is mishandled. The hard disc has a limited life span which depends on the operational conditions. Note that there is no guarantee for any loss of data.

- **Precautions when Disposing of this Instrument**

  When disposing of harmful substances, be sure dispose of them properly with abiding by the state-provided law.

  Harmful substances: (1) PCB (polycarbon biphenyl)
  (2) Mercury
  (3) Ni-Cd (nickel cadmium)
  (4) Other
  Items possessing cyan, organic phosphorous and hexadic chromium and items which may leak cadmium or arsenic (excluding lead in solder).

  Example: fluorescent tubes, batteries

Environmental Conditions

This instrument should be only be used in an area which satisfies the following conditions:

- An area free from corrosive gas
- An area away from direct sunlight
- A dust-free area
- An area free from vibrations
- Altitude of up to 2000 m

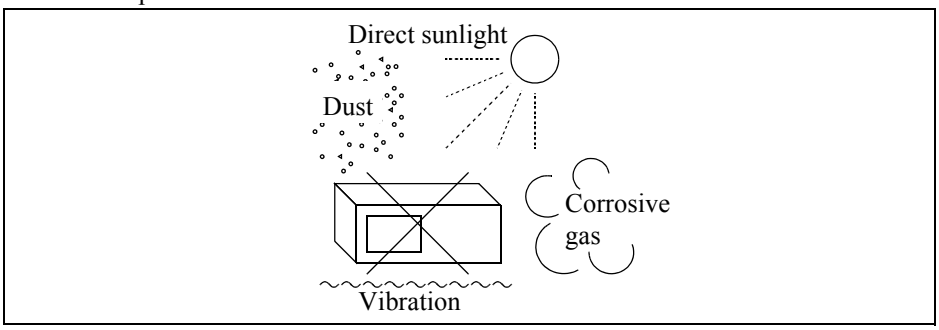
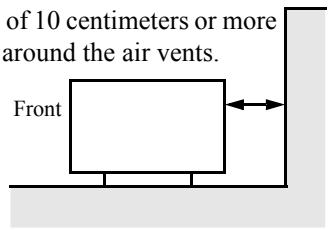


Figure-1 Environmental Conditions

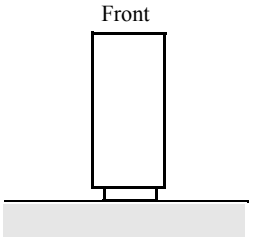
- Operating position



The instrument must be used in a horizontal position.
To prevent the internal temperature from rising, cooling fans are installed in some instruments.
The air vents on the case must be unblocked.

Figure-2 Operating Position

- Storage position



This instrument should be stored in a horizontal position.
When placed in a vertical (upright) position for storage or transportation, ensure the instrument is stable and secure.

-Ensure the instrument is stable.
-Pay special attention not to fall.

Figure-3 Storage Position

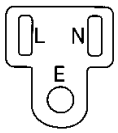
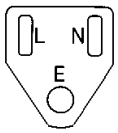
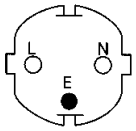
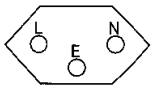
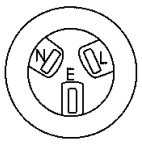
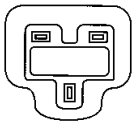
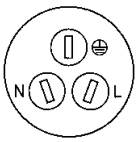
- The classification of the transient over-voltage, which exists typically in the main power supply, and the pollution degree is defined by IEC61010-1 and described below.

  Impulse withstand voltage (over-voltage) category II defined by IEC60364-4-443

  Pollution Degree 2

Types of Power Cable

Replace any references to the power cable type, according to the following table, with the appropriate power cable type for your country.

Plug configuration	Standards	Rating, color and length	Model number (Option number)
	PSE: Japan Electrical Appliance and Material Safety Law	125 V at 7 A Black 2 m (6 ft)	Straight: A01402 Angled: A01412
	UL: United States of America CSA: Canada	125 V at 7 A Black 2 m (6 ft)	Straight: A01403 (Option 95) Angled: A01413
	CEE: Europe DEMKO: Denmark NEMKO: Norway VDE: Germany KEMA: The Netherlands CEBEC: Belgium OVE: Austria FIMKO: Finland SEMKO: Sweden	250 V at 6 A Gray 2 m (6 ft)	Straight: A01404 (Option 96) Angled: A01414
	SEV: Switzerland	250 V at 6 A Gray 2 m (6 ft)	Straight: A01405 (Option 97) Angled: A01415
	SAA: Australia, New Zealand	250 V at 6 A Gray 2 m (6 ft)	Straight: A01406 (Option 98) Angled: ---------
	BS: United Kingdom	250 V at 6 A Black 2 m (6 ft)	Straight: A01407 (Option 99) Angled: A01417
	CCC:China	250 V at 10 A Black 2 m (6 ft)	Straight: A114009 (Option 94) Angled: A114109

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1. PREFACE

This chapter describes the accessories, operating environment, precautions, and operating check for personnel who operate the 4601. Carefully read through this manual before using the 4601.

1.1 Product Overview

The 4601 I-V Meter is designed for solar panel inspection used with a solar simulator, which is developed with ADC's DC Voltage/Current Source technologies.

It supports short, middle and long light pulses and achieves I-V measurement at maximum 100 points in only 5 ms. The 4601 measures voltage, current and reference cell current in parallel in the minimum 50 μs to the maximum 6 s per step.

The optimal measurement timing for various kinds of solar cells can be set with measurement delay time of the minimum 20 μs and integration time of the minimum 5 μs.

The 4601 has not only the simple linear sweep function but also the 2-slope linear sweep function and 3-slope linear sweep function to measure finely required points. Also, there are three types of sampling to synchronize with solar simulators.

In addition, there are two terminals for temperature measurement using thermocouples (type T), another two terminals for temperature measurement using platinum resistance bulbs (Pt100) or IC sensors (AD590), and one terminal for voltage measurement using thermopiles.

The 4601 requires an output unit that is separately sold.

The output unit incorporates output terminals and a relay that turns ON or OFF the output.

This relay has a limited life cycle, and the 4601 measures the relay ON/OFF operations. When the life cycle is reached, an alarm is generated. In this case, the output unit needs to be replaced.

■ Voltage source/voltage measurement/current measurement terminal

- Voltage source/measurement range: -1.00 V to +300.00 V
- Voltage range: 5 V, 50 V, 300 V
- Voltage source resolution: 100 μV, 1 mV, 10 mV
- Voltage measurement resolution: 10 μV, 100 μV, 1 mV
- Current measurement range: -10.2999 A to +0.1 A
- Current range: 300 μA, 3 mA, 30 mA, 300 mA, 3 A, 10 A
- Current measurement resolution: 1 nA, 10 nA, 100 nA, 1 μA, 10 μA, 100 μA
- Maximum source power: 30 W (without a booster, source: +300 V/+0.1 A)
- Maximum load power: 300 W (sink: +30 V/-10 A to +300 V/-1 A)

■ Reference cell measurement terminal

- Current measurement range: -32.000 mA to +319.999 mA
- Current range: 3mA, 30 mA, 300 mA
- Current measurement resolution: 10 nA, 100 nA, 1 μA

■ Voltage measurement terminal

- Voltage measurement range: ±3.19999 V
- Voltage range: 30 mV, 300 mV, 3 V
- Voltage measurement resolution: 0.1 μV, 1 μV, 10 μV

■ Temperature measurement T-type thermocouple measurement terminal

- Measurement range: -50.00 °C to +400.00 °C
- Measurement resolution: 0.01 °C

■ Temperature measurement Pt measurement terminal

- Measurement range: Pt100 -200.00 °C to +850.00 °C
  JPt100 -200.00 °C to +649.00 °C
- Measurement resolution: 0.01 °C

■ Temperature measurement AD590 measurement terminal

- Measurement range: -50.00 °C to +150.00° C
- Measurement resolution: 0.01 °C

AD converter	Measurement terminal	Sweep source mode	DC source mode
ADC1	Voltage measurement (Vm)	✓	✓
ADC2	Current measurement (Im)	✓	✓
ADC3	Reference cell measurement terminal (Ir)	✓(fixed)	Select
	Voltage measurement terminal (Em)	-	Select
	T-type thermocouple measurement terminal (Tc1) Ch1	-	Select
	T-type thermocouple measurement terminal (Tc2) Ch2	-	Select
	Pt measurement terminal (Pt1) Ch1	-	Select
	Pt measurement terminal (Pt2) Ch2	-	Select
	IC sensor measurement terminal (Ad1) Ch1	-	Select
	IC sensor measurement terminal (Ad2) Ch2	-	Select

Configuration

The following figure shows the configuration of the 4601.

■ Voltage source/voltage measurement/current measurement terminal Vs/Vm/Im

The voltage source unit (Vs) that applies voltage to solar cells (PV), the volt meter (Vm) that measures the output voltage and the ammeter (Im) that measures the output current are connected to the replaceable output unit.

The output unit is an optional accessory. It employs a 4-terminal structure and is selectable from the safety socket type and the terminal block type.

Vm and Ir have dedicated AD converters (ADC) respectively.

For Im, the source direction is represented by +.

■ Reference cell measurement terminal CELL Ir

This terminal is an ammeter (Ir) to measure the reference cell current.

It employs a 4-terminal structure so that the terminal voltage becomes 0 V, and is connected by a cannon plug.

The AD converter (ADC3) selects voltage measurement (Em) or temperature measurement (Tc, Pt, AD) in the DC source mode, or works exclusively for Ir in the sweep source mode, and executes measurement in synchronous with ADC1 and ADC2.

For Ir, the sink direction is represented by +.

■ Voltage measurement terminal Em

This terminal is a volt meter (Em) to measure voltage output sensors such as a thermopile.

■ Temperature measurement T-type thermocouple measurement terminal Tc1, Tc2

This terminal is for T-type thermocouple sensors.

■ Temperature measurement Pt and IC sensor measurement terminal Pt1, Ad1, Pt2, Ad2

Pt and Ad for both the Ch1 and Ch2 use the same terminals. Either Pt1 or Ad1, Pt2 or Ad2 are selected respectively.

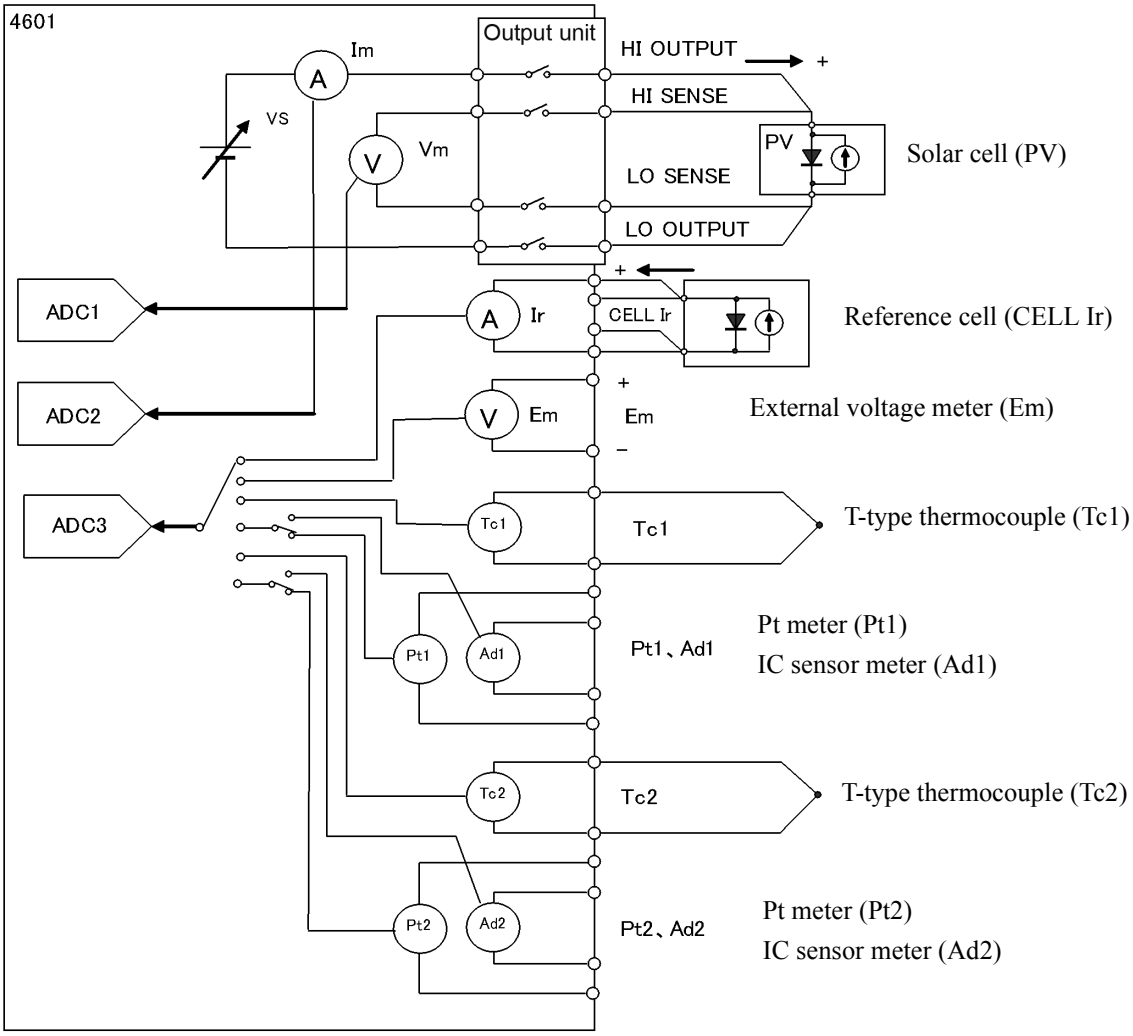

Figure 1-1 4601 Configuration

For information on the connection of each terminal, refer to Section 5.1, "Connection of Sample."

Output Range

The following figure shows the output range of the 4601.

The current source of the 4601 is +0.1 A in the range from -1 V to +300 V.

The current sink is -10.2 A in the range from -1 V to + 30 V and -1 A at +300 V.

At +30 V to +300V the 4601 is capable of 300 W sink operation.

The maximum load power is 300 W and the maximum current is calculated by "I = -300/Vo."

Example: When the output voltage is +60 V, the sink current is I = -300/60 = -5 A.

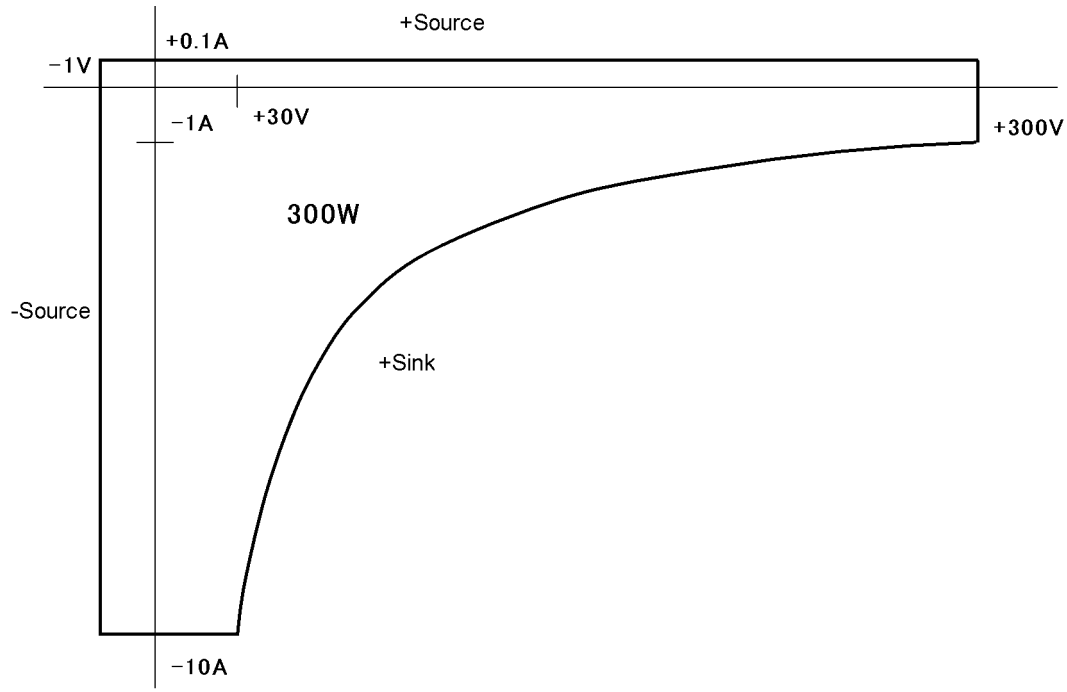

Figure 1-2 Output Range

Limitation by Ambient Temperature

The maximum load (sink) power is 300 W continuous at 0 to 40 °C, 240 W continuous at 40 to 50 °C, and 300 W continuous within five seconds at 40 to 50 °C.

The maximum output (source) power is 30 W continuous at 0 to 40 °C, 24 W continuous at 40 to 50 °C, and 30 W continuous within five seconds at 40 to 50 °C.

Thus, loading of 300 W is possible up to 50 °C when the source time is within five seconds in sweep source.

1. Maximum power limitation at the time of continuous loading

   When the 4601 is used continuously as load, there is a maximum load power limitation by the ambient temperature as shown in Figure 1-3.

   The maximum load power is 300 W at the ambient temperature of 40 °C or below and 240 W at 50 °C.

   Also, as for continuous output, the maximum power is 30 W at the ambient temperature of 40 °C or below and 24 W at 50 °C.

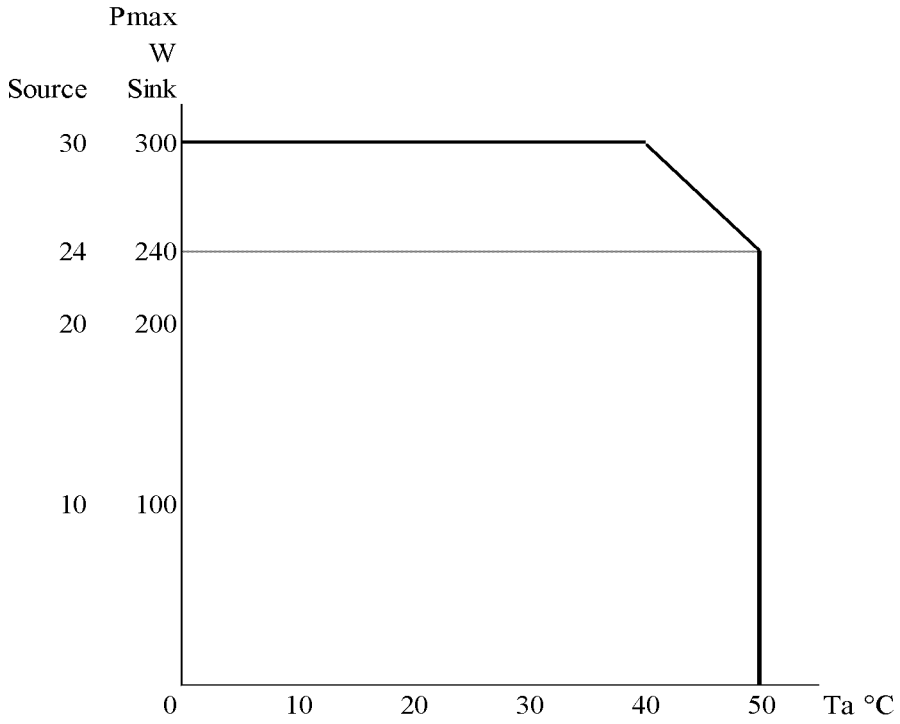

Figure 1-3 Maximum Power Limitation at Time of Continuous Loading

2. Duty ratio limitation at the time of 300 W(sink)/30 W (source) loading

When the 4601 is used with the maximum load power of 300 W (sink)/30 W (source) , there is a duty ratio limitation by the ambient temperature as shown in Figure 1-4.

The maximum power loading is available continuously at the ambient temperature of 40 °C or below; however the duty ratio is 70% and the loading time is within 5 seconds at 50 °C.

That is, pausing for 2.1 seconds is required after continuous loading for 5 seconds.

Pausing for 0.42 second or longer is required after continuous loading for 1 second.

Pausing time tr is obtained by the following formula:

$$tr = \left[\frac{1}{-0.03 * Ta + 2.2} - 1 \right] * to\ (s)$$

to: Maximum load of 300 W (sink)/30 W (source) application time (5 seconds or less)

Ta: Ambient temperature of 40 °C to 50 °C

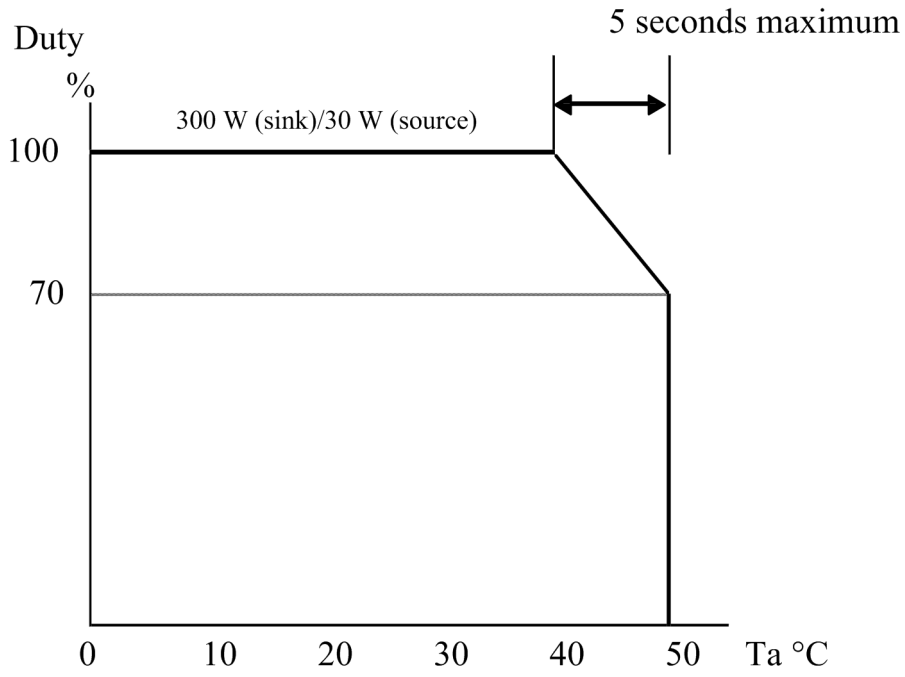

Figure 1-4 Duty Ratio Limitation at Time of 300 W (Sink)/30 W (Source) Loading

1.2 Supplied Accessories

The 4601 standard accessories are listed below. If any accessory is missing or damaged, contact an ADC CORPORATION sales representative. Specify the part number when ordering.

Table 1-1 Standard Accessory List

Name	Part number	Quantity	Remarks
Power cable *1	A01402	1	
Power fuse *2	DFT-AA2R5A	1	100 V/120 V slow blow
	DFT-AA1R6A		220 V/240 V slow blow
Thermocouple connector	JCE-DA0002PX02	2	Plug
Pt, AD590 connector	JCS-RB0005JX03	2	Plug
	YEE-1000734	2	Cover
EMC-compliant clamp filter	DEE-100115	4	Ferrite core with case
Cable tie	ESM-000257	4	Clamp filter fixing tie
Operation Manual	E4601	1	This manual

*1 : The power cable can be changed by specifying the option at the time of order.
For more information, refer to “Safety Summary.”
*2 : Either of fuses is included depending on the power supply option.

1.3 Output Unit

As the voltage source/voltage measurement/current measurement terminal employs a unit system, it requires the output unit that is sold separately.
The output unit contains the operate/standby relay. When the number of relay operations counted by the 4601 reaches the relay life cycle, the 4601 generates an alarm.
There are the following two types of output units with different terminal structures, either of which can be mounted on the front or rear panel.

Table 1-2 Output Unit List

Output unit	Description
CC046010	Safety socket terminal output unit
CC046011	Terminal block output unit

NOTE: When the output units are mounted on both the front and rear panels, operations will not be guaranteed.

1.3.1 Removing Panel

Remove the panel from the front or rear output unit mounting section.
The removed screws will be reused to mount the output unit.

1.3.2 Mounting Output Unit

Unscrew the screws from the front or rear mounting section to remove the panel.
Unpack the output unit, and mount it on the front or rear mounting section.
Check that the connector is fit completely.
Then, fix the output unit with the removed screws.

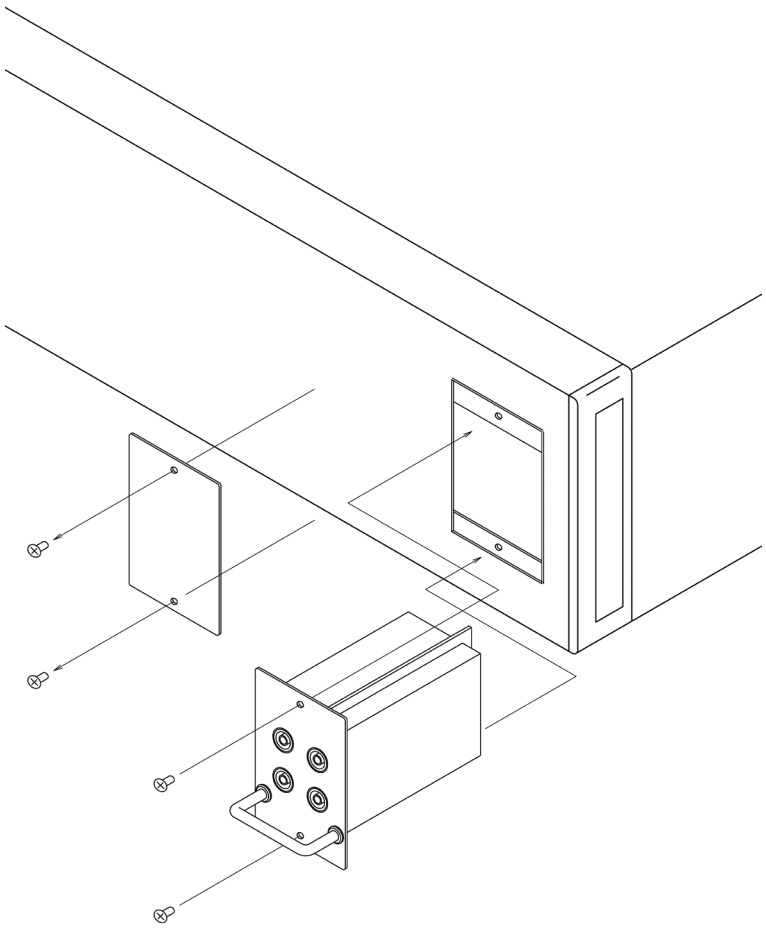

Figure 1-5 Mounting Output Unit

NOTE: Turn OFF the Power switch on the front panel of the 4601 before installing the output unit.

1.4 Optional Accessories

The 4601 optional accessories are listed below. Specify the part number when ordering.

Table 1-3 Optional Accessory List

Name	Part number	Description
Output unit	CC046010	Safety socket terminal output unit
	CC046011	Terminal block output unit
Connection cable	A01044	Input and output cable (safety plug)
Rack mount set	CC022003	Rack mount set 3U JIS
	CC024003	Rack mount set 3U EIA
	CC028003	Front handle set 3U
	A02615	Slide rail set

NOTE: ***Use the slide rail set or angle bars to mount the 4601 on the rack mount set. The rack mount set is not rigid enough to support the instrument by itself. Using the slide rail set A02615 is recommended. Contact an ADC CORPORATION sales representative for rack setup and other technical support.***

1.5 Options

For power supply options, refer to Section 1.6.2 “Power Specification.”

1.6 Operating Environment

This section describes the required environmental and power supply conditions.

1.6.1 Environmental Conditions

The 4601 must be installed in an environment meeting the following conditions:

- Operating environment: Ambient temperature 0 °C to +50 °C
  Relative humidity 85% or lower without condensation
- Storage environment Ambient temperature -25 °C to +70 °C
  Relative humidity 85% or lower without condensation
- Location not subject to corrosive gasses
- Away from direct sunlight
- Dust free
- Vibration free
- Noise free
  The 4601 is designed with full consideration given to the noise contained in the AC power line. Nevertheless, it is recommended that the 4601 be used in an environment with as little line noise as possible.
  If line noise is unavoidable, use a noise filter.
- Positioning of the 4601
  A cooling fan is located on the rear panel and vents are located on the side panels. Blocking the fan or vents cause the internal temperature to rise, possibly causing faulty operation.
  Leave at least 10 cm of free space between the rear panel and the wall. Also, do not position the 4601 with the rear panel facing down.
- Mounting in a rack
  Ensure that exhaust air from other devices is not directed at the vents on the side of the 4601.
  To prevent the temperature in the rack from rising, install a heat sink fan.

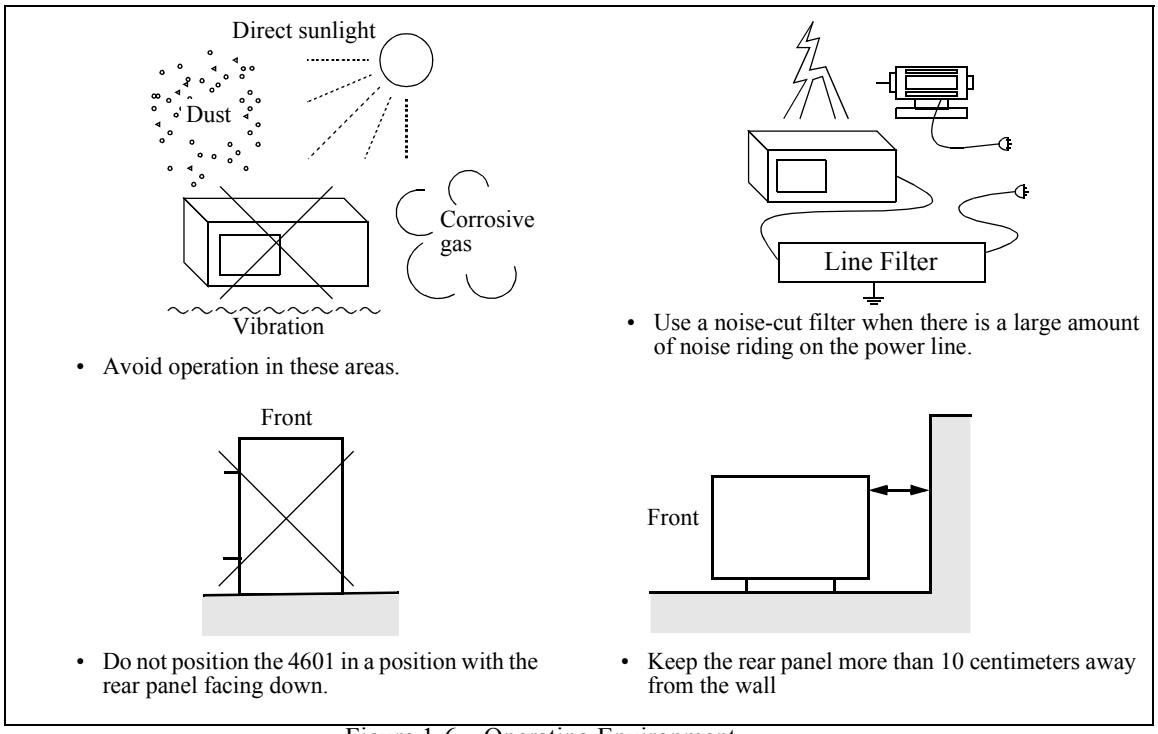

Figure 1-6 Operating Environment

NOTE: ***Warm-up Time***
Allow the 4601 to warm up for at least 60 minutes after turning on the power to ensure the specified accuracy of the 4601.
After warm-up, execute zero measurement to secure precise measurement results.
For more information, refer to Section 5.3.6, "Zero Measurement."

1.6.2 Power Specification

Table 1-4 below shows the 4601 power supply specifications.

CAUTION: ***To prevent damage to the 4601, do not apply a voltage or frequency that exceeds the specified range.***

Table 1-4 Power Supply Specification

	Standard	Optional		
		32	42	44
	100 VAC	120 VAC	220 VAC	240 VAC
Input voltage range	90 V to 110 V	108 V to 132 V	198 V to 242 V	207 V to 250 V
Frequency range	48 Hz to 66 Hz			
Power consumption	230 VA or less			
Fuse	T2.5 A/250 V		T1.6 A/250 V	

Ensure that the power voltage setting on the rear panel matches the voltage of the commercial power supply.

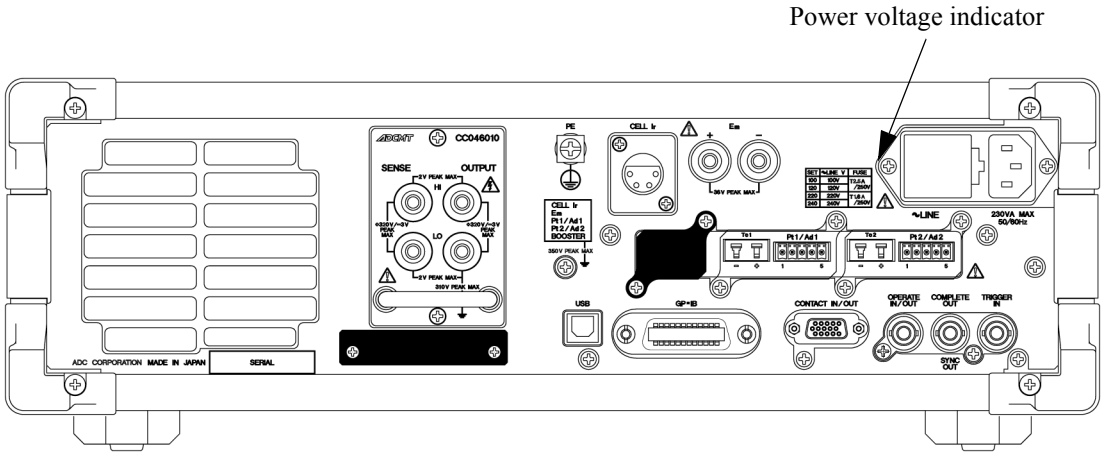

Figure 1-7 Set Power Voltage Indicator

1.6.3 Changing Power Voltage, and Checking and Replacing Power Fuse

The 4601 power voltage can be changed manually.
This section describes the procedure for changing the power voltage, and checking and replacing the power fuse.

CAUTION:

1. ***If the power fuse opens, a problem may have occurred in this instrument. Contact an ADC CORPORATION sales representative.***
2. ***Always use the same fuse type and rating to prevent fire.***

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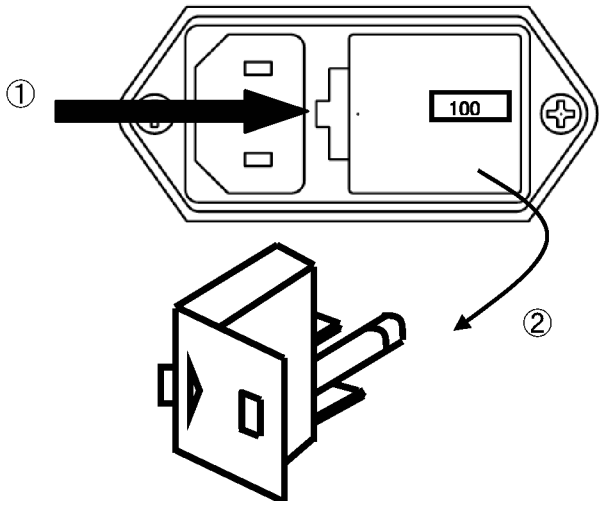
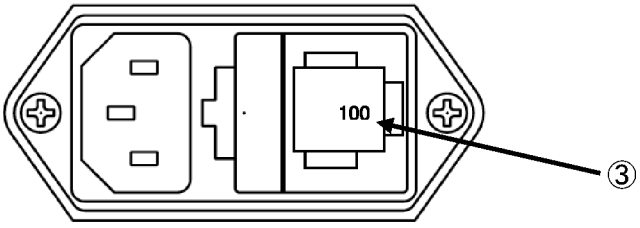
1. Remove the power cable from the 4601.
2. Push the tab (①) in the direction of the arrow with a flathead screwdriver (①) and pull out the fuse holder (②).

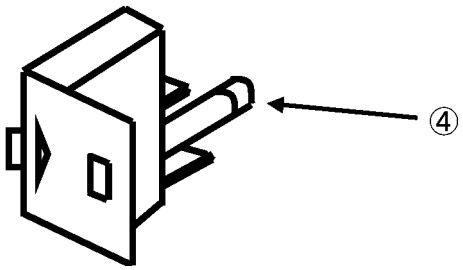


3. Pull out the voltage selector (③). (Power voltages: 100 V, 120 V, 220 V and 240 V are printed on each side respectively.)



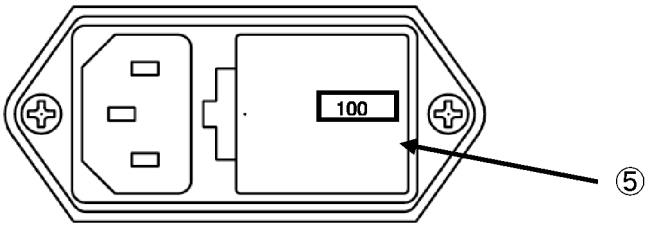
4. Reseat the voltage selector (③) so that the desired voltage is faced outward.

5. Insert a rated fuse (See Table 1-4) to the fuse holder (④).



6. Return the fuse holder into the tab.

7. Check that the correct power voltage (⑤) appears.



1.6.4 Power Cable

The 4601 is provided with the 3-pin power cable including a ground pin. Always use this power cable to ground the 4601 to a 3-pin power outlet for prevention of electrical shock.

1. Check for any damage to the power cable.

WARNING: ***Never use the damaged cable. It may result in electric shock.***

2. Connect the AC power connector on the rear panel to a 3-pin power outlet including a ground terminal by using the power cable. (See Figure 1-8, “Connecting Power Cable.”)

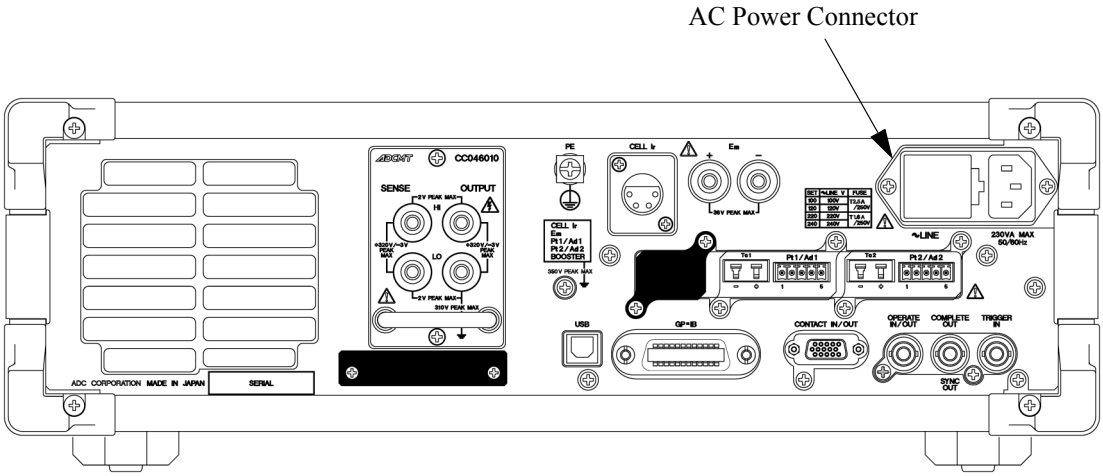


Figure 1-8 Connecting Power Cable

CAUTION:

1. ***Be sure to turn OFF the POWER switch on the front panel before connecting the power cable.***
2. ***Select a power cable depending on the power outlet voltage and type. The power cable should conform to the safety standards of your country.***
   For more information, refer to, “Safety Summary.”
3. ***To prevent electric shock, connect the power cable to a 3-pin power outlet with a ground terminal. If an extension cable without a ground terminal is used, the protective ground feature will be rendered ineffective.***

1.7 Operating Check

This section describes the simple self-test which must be performed when operating the 4601 for the first time. Follow the procedure below to ensure the 4601 operates correctly.

1. Ensure that the **POWER** switch on the front panel is set to OFF.
2. Plug the power cable into the AC Power Connector on the rear panel.

CAUTION: ***To prevent damage to the 4601, do not apply a voltage or frequency that exceeds the specified range.***

3. Plug the power cable into an AC wall outlet. (See Figure 1-8, “Connecting Power Cable.”)
4. Turn ON the **POWER** switch on the front panel.

   After all the indicators light up for seconds, a self-test is performed. (Duration: approx. 5 sec. See Figure 1-9.)

   The screen display changes as follows:

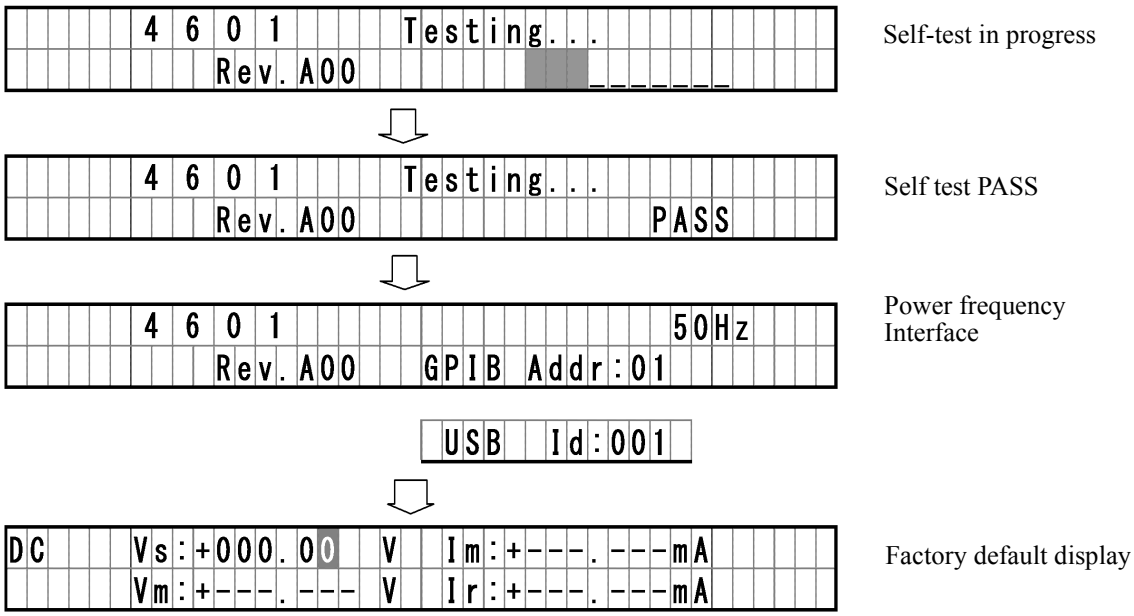


Figure 1-9 Display at Power ON

5. Pressing OPERATE (the backlight goes ON) outputs the displayed source value and starts measurement.

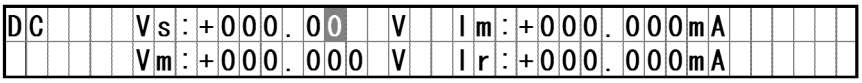


Figure 1-10 Display during OPERATE

6. Pressing OPERATE again (the backlight goes OFF) turns off the output and stops measurement.

NOTE:

1. ***The 4601 starts up with the initial values that are preset before shipment when it is turned on for the first time.***
   When the setting parameter condition at Power ON is changed, the screen display may be different from Figure 1-8.
   For more information, refer to Section 3.6.3, "Auto Parameter Loading at Power ON."
   When turning on the output for the first time, pay attention to source value setting and load connection.
2. ***If a problem occurs during the self-test, an error message will appear on the screen.***
   Refer to Section A.2, "Error Message List."

1.8 Cleaning, Storage, and Transport Methods

1.8.1 Cleaning

Clean the 4601 by wiping or brushing its surface with a soft cloth or cloth which has been dampened in water containing a mild detergent.

CAUTION:

1. ***Ensure that water does not penetrate the 4601 (wring out the cloth so it is damp and not saturated).***
2. ***Avoid using organic solvents such as benzene, toluene, xylene, acetone, etc. They will cause deformation of the plastic parts.***

1.8.2 Storage

Store the 4601 in a location where the temperature is within the range of -25 °C to +70 °C. If storing for an extended period (90 days or longer), place the 4601 in a moisture-proof bag together with a desiccant. Avoid storing the 4601 in a location where there is a lot of dust or where it will be subjected to direct sunlight.

1.8.3 Transport

To transport the 4601, use the original box that it came in. If the box is not available any longer, pack the 4601 in accordance with the following guidelines.

Packing procedure

1. Prepare a corrugated cardboard box with dimensions that are larger than the external dimensions of the 4601 by 15 cm or more to allow for shock absorbent material.
2. Wrap the 4601 with a protective sheet.
3. Line the box with shock absorbing material so that the 4601 is protected on all sides.
4. Close the box with industrial staples or use packing tape.

When sending the 4601 to an ADC CORPORATION sales representative for service or repairs, attach a label stating the following items.

- Company name and address
- Name of the person in charge
- Serial number (shown on the rear panel)
- Type of service required

1.9 Warm-up Time

Allow the 4601 to warm up for at least 60 minutes after turning on the power to ensure the specified accuracy of the 4601. After warm-up, execute zero measurement.

1.10 Calibration

Calibrate the 4601 in accordance with the procedure described in Chapter 8. “CALIBRATION.”
When asking ADC for calibration service, contact an ADC CORPORATION sales representative.

Recommended calibration interval	1 year

1.11 Life Limited Parts

Follow the guidelines below to replace parts that are life limited.

Contact an ADC CORPORATION sales representative for replacement.

Part name	Expected life cycle	Remarks
Mechanical relay used in the output unit	1,000,000 operations	The output unit is a consumable accessory and does not carry a warranty. The 4601 internally calculates the number of relay contact operations. If the number of operations exceeds the expected life cycle, "+571 Operate Relay Lifetime" occurs at power ON, key operation or remote self-test execution, or when the output status is set to Standby. Normal operation is possible when this error message appears. Replace the relay in reference to the expected life span noted at left.
Cooling fan	40,000 hours	When the cooling fan stops, the message "+401 Fan Stopped" is displayed and the operation stops.
Vacuum fluorescent display	20,000 hours	
Panel key	1,000,000 operations	
USB connector	1,500 times	
Rotary knob	1,000,000 operations	

CAUTION:
- ***Switch the 4601 output status between Operate or Suspend and Standby when the illumination of the solar simulator is turned OFF.***
  Relay ON/OFF operations when the illumination is turned ON may shorten the relay life cycle.
- ***The above life cycles are reference information and are NOT guaranteed.***
- ***When the internal used mechanical relay exceeds the expected life span and the error occurs, contact an ADC CORPORATION sales representative immediately.***

1.12 Product Disposal and Recycling

Correctly dispose of the 4601 in accordance with local and national regulations.

Before disposal, remove the following parts from the product to prevent dispersal of substances that may adversely affect the environment, human health, or the ecosystem.

NOTE: ***For assistance with locating a waste disposal company, contact an ADC CORPORATION sales representative.***

Name of substance or removed part	Used?	Location	Unit	Part
Capacitor containing polychlorinated biphenyls (PCBs)	No	-		
Part containing mercury	No	-		
Battery	No	-		
Printed circuit boards	Yes	Unit	Main AMP ANALOG TERMINAL OUTPUT PANEL	Printed circuit boards
Toner cartridge	No	-		
Plastic containing brominated flame retardants	Yes	Unit	BLQ-009005 BLP-009006 BLH-009007 BLB-009008 BLB-009011 BLN-009001	Connectors, diodes, Zener diodes, FET, analog ICs, logic ICs, FLASH memory, transistors, infrared ray LEDs
Parts containing asbestos	No	-		
Cathode-ray tubes	No	-		
Chloroflourocarbon (CFC), hydrochlorofluorocarbon (HCFC), hydrofluorocarbon (HFC), or hydrocarbon (HC)	No	-		
Electric-discharge indicator	No	-		
LCD display of 100 cm^2 or larger	No	-		
Connecting cable	Yes	Between units		Power cable
Parts containing flame-resistant ceramic fibers	Yes	-		Output terminal section
Parts containing radioactive material	No	-		

Name of substance or removed part	Used?	Location	Unit	Part
Electrolytic capacitors containing substance of concern (With height > 25 mm, dia. > 25 mm, or equivalent volume)	No	-		
Arsenic or its compounds	Yes	Unit	Electronic components	Logic ICs, Photocouplers
Nickel or its compounds	Yes	Unit		Electronic components, mechanical components
Lead or its compounds	Yes	Unit	BLQ-009005 BLP-009006 BLH-009007 BLB-009008 BLB-009011 BLN-009001	Lead solder used for assembling electronic components on printed circuit boards
PVC	Yes	Unit		PVC components
Antimony or its compounds	Yes	Unit		Electronic components

2. PANEL DESCRIPTIONS

This chapter describes the part names and functions on the front and rear panels, and the annotations displayed on the screen.

The basic operations are described in Chapter 3, “BASIC OPERATIONS.”

The applied functional operations are described in Chapter 4, “FUNCTIONAL REFERENCE.” and Chapter 5, “OPERATIONAL DESCRIPTIONS.”

2.1 Front Panel

This section describes the panel keys or connectors in each section on the front panel.

The following figure shows the 4601 with the safety socket terminal output unit mounted on the front.

For more information on the panel keys, refer also to Section 4.2, "Panel Key Descriptions."

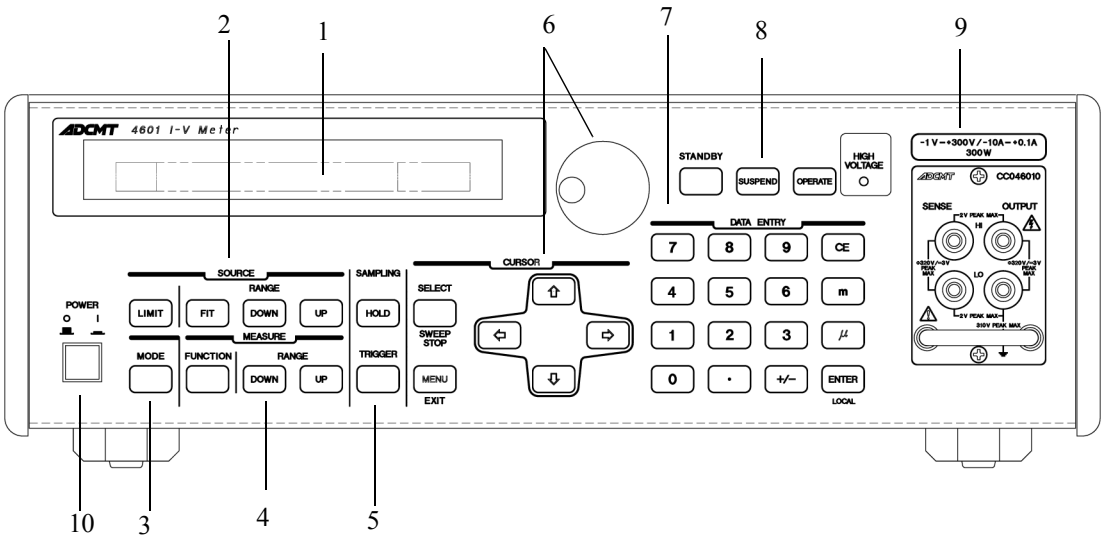


Figure 2-1 Front Panel

The front panel is divided into the following ten sections.

1. Display Section
2. SOURCE LIMIT Section
3. MODE Section
4. MEASURE Section
5. SAMPLING Section
6. CURSOR Section
7. DATA ENTRY Section
8. OPERATE Section
9. Front Output Unit Section
10. POWER Switch

2.1.1 Display Section

The screen employs a dot matrix vacuum fluorescent display.

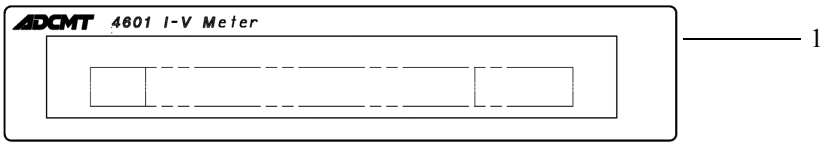


Figure 2-2 Display Section

1. Display — Displays the source value, the voltage measured value, the current measured value, the reference current measured value and the unit operational status.
Also, functions as a setting screen for setting parameters.
Brightness adjustment and screen ON/OFF setting are available, helping to extend the screen lifetime and to reduce standby power consumption.
For how to set the display, refer to J) SYSTEM in Section 4.2.10, "MENU Key (Parameter Setting)."

2.1.2 SOURCE LIMIT Section

The SOURCE LIMIT section consists of keys to switch the voltage source range and the current limit range.

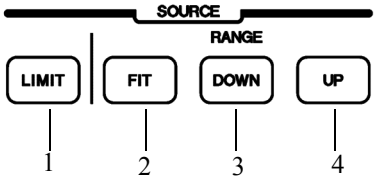


Figure 2-3 SOURCE LIMIT Section

1. **LIMIT** key — Sets the current limit value and displays the setting value.
2. **FIT** key — Sets the optimal voltage source range or current limit range for the setting value.
3. **DOWN** key — Lowers the voltage source range or current limit range.
4. **UP** key — Raises the voltage source range or the current limit range.

2.1.3 MODE Section

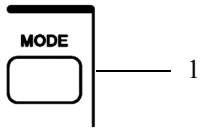


Figure 2-4 MODE Section

1. **MODE** key — Switches between the DC source mode and the sweep source mode.

2.1.4 MEASURE Section

This section is used to switch the measurement function and the range displayed in the lower right on the screen in the DC source mode.

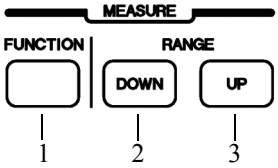


Figure 2-5 MEASURE Section

1. **FUNCTION** key — Selects from the following eight functions for ADC3 measurement in the DC source mode (Refer to Section 4.2.7).
   Ir : Reference cell current measurement
   Em : External voltage measurement
   Tc1 : Ch1 T-type thermocouple measurement
   Pt1 : Ch1 resistance bulb (Pt) temperature measurement
   Ad1 : Ch1 IC sensor AD590 temperature measurement
   Tc2 : Ch2 T-type thermocouple measurement
   Pt2 : Ch2 resistance bulb (Pt) temperature measurement
   Ad2 : Ch2 IC sensor AD590 temperature measurement
2. **DOWN** key — Lowers the reference cell current measurement range or external voltage measurement range.
   Ir : 3 mA, 30 mA, 300 mA
   Em : 30 mV, 300 mV, 3 V
3. **UP** key — Raises the reference cell current measurement range or external voltage measurement range.

2.1.5 SAMPLING Section

This section is used to set the sampling in the DC source mode or sweep source mode.

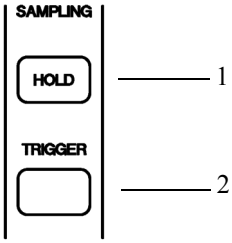


Figure 2-6 SAMPLING Section

1. **HOLD** key — Switches the sampling between AUTO and HOLD.
2. **TRIGGER** key — Functions as measurement trigger in the DC source mode and as sweep start or sweep step trigger in the sweep source mode.

2.1.6 CURSOR Section

This section is used to select the digit or change the value when changing the voltage source value, current limit value or setting value in the menu.

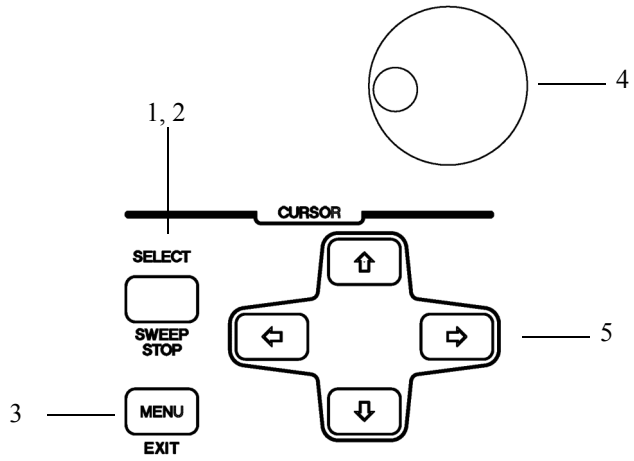


Figure 2-7 CURSOR Section

1.	**SELECT** key	Selects either item when there are two numeric items to be set such as current limit.
2.	**SWEEP STOP** key	Stops sweep.
3.	**MENU/EXIT** key	Moves or return to the menu select screen.
4.	Rotary knob	Selects digits, raises or lowers values, or selects the menu levels.
5.	←↑→↓keys	Raises or lowers values, selects categories in the menu or selects parameters.

2.1.7 DATA ENTRY Section

The DATA ENTRY keys are used to change the voltage source value, the current limit value and the parameters to be input.

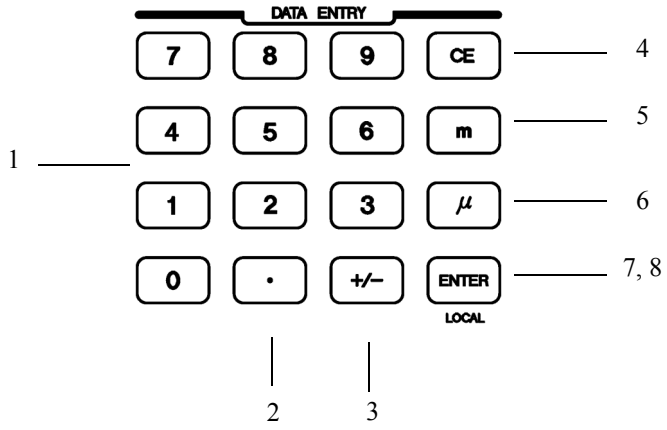


Figure 2-8 DATA ENTRY Section

1. **0 to 9** keys — Enters numeric data from 0 to 9.
2. • key — Enters a decimal point.
3. +/- key — Sets the polarity to positive or negative.
4. **CE** key — Cancels input data for data setting.
5. **m** key — Sets unit “m” for numeric data.
6. μ key — Sets unit “μ” for numeric data.
7. **ENTER** key — Finishes data entry and stores the parameter.
8. **LOCAL** key — Switches from remote operation to local operation.

NOTE: ***Local operation is prohibited if the LLO (Local Lock Out) command is set through the GPIB or USB interface.***

2.1.8 OPERATE Section

Sets the output ON or OFF.

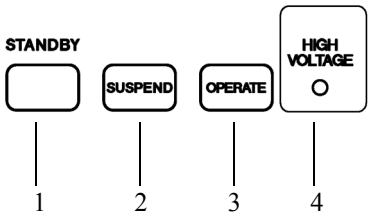


Figure 2-9 OPERATE Section

1. **STANDBY** key — Sets the output status to Standby (output unit relay OFF).

2. **SUSPEND** key — Sets the output status to Suspend (output unit relay ON, voltage source: 0V and high-impedance).
   Pressing the **SUSPEND** key again in the Suspend status sets the output status to Standby.

3. **OPERATE** key — Sets the output status to Operate (output unit relay ON and voltage source: setting voltage).
   Pressing the **OPERATE** key again in the Operate status sets the output status to Standby.

4. **HIGH VOLTAGE** indicator
   Goes ON informing hazardous voltage when the voltage source value is set to +55 V or higher.

2.1.9 Front Output Unit Section

The following is an example when the safety socket terminal output unit is installed on the front.

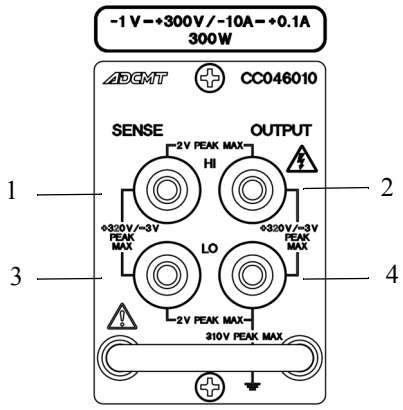


Figure 2-10 Front Output Unit Section (for Safety Socket)

1. **HI SENSE** terminal — HI-side sense terminal for output voltage
2. **HI OUTPUT** terminal — HI-side current output terminal
3. **LO SENSE** terminal — LO-side sense terminal for output voltage
4. **LO OUTPUT** terminal — LO-side current output terminal

Maximum input voltage

HI-LO	+320 V/-3 V peak max
SENSE-OUTPUT	2 V peak max

CAUTION:

1. ***The optional output unit can be mounted on either front or rear of the output terminal unit.***
   When the output units are mounted on both the sides, operations will not be guaranteed.
2. ***Turn OFF the 4601 when removing or mounting the output unit.***

2.1.10 POWER Switch

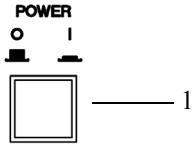


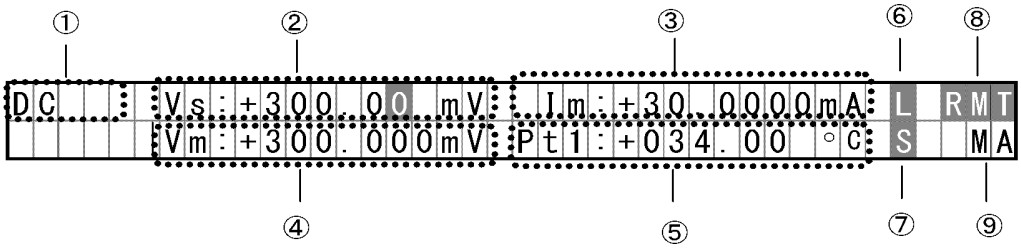
Figure 2-11 POWER Switch

1. **POWER** switch: Turns the power ON or OFF.

2.2 Screen Display (Annotations)

This section describes the screen display (annotations).

Display in the DC mode



Display in the sweep mode

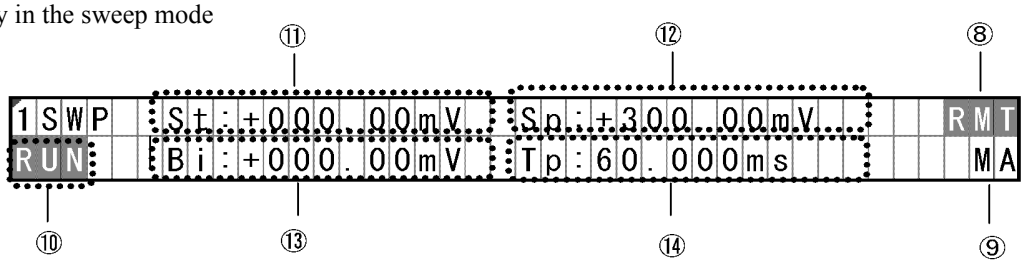


Figure 2-12 Screen Display (Annotations)

① Source mode

DC	DC source mode
1SWP	1-slope linear sweep
2SWP	2-slope linear sweep
3SWP	3-slope linear sweep
mSWP	Memory sweep
fSWP	Fixed level sweep

② Vs: Voltage source value

③ Im: Current measured value (ADC2 measurement)

④ Vm: Voltage measured value (ADC1 measurement)

⑤ ADC3 measurement

Ir	Reference cell current measurement
Em	External voltage measurement
Tc1	Ch1 T-type thermocouple measurement
Pt1	Ch1 resistance bulb (Pt) temperature measurement
Ad1	Ch1 IC sensor AD590 temperature measurement
Tc2	Ch2 T-type thermocouple measurement
Pt2	Ch2 resistance bulb (Pt) temperature measurement
Ad2	Ch2 IC sensor AD590 temperature measurement

⑥	L	LIMIT	Appears when the current limit is detected at voltage current measurement. Displayed with the measured value.
⑦	S	OSC	Appears when oscillation is detected at voltage current measurement. Displayed with the measured value.
⑧	RMT		Appears in remote control.
⑨	MA		Appears when the 4601 is addressed as Lister or Talker in remote control.
⑩	RUN	RUN	Indicates sweep in progress.
⑪	St		Sweep start value
⑫	Sp		Sweep stop value
⑬	Bi		Sweep bias value
⑭	Tp		Period time (cycle)

2.3 Rear Panel

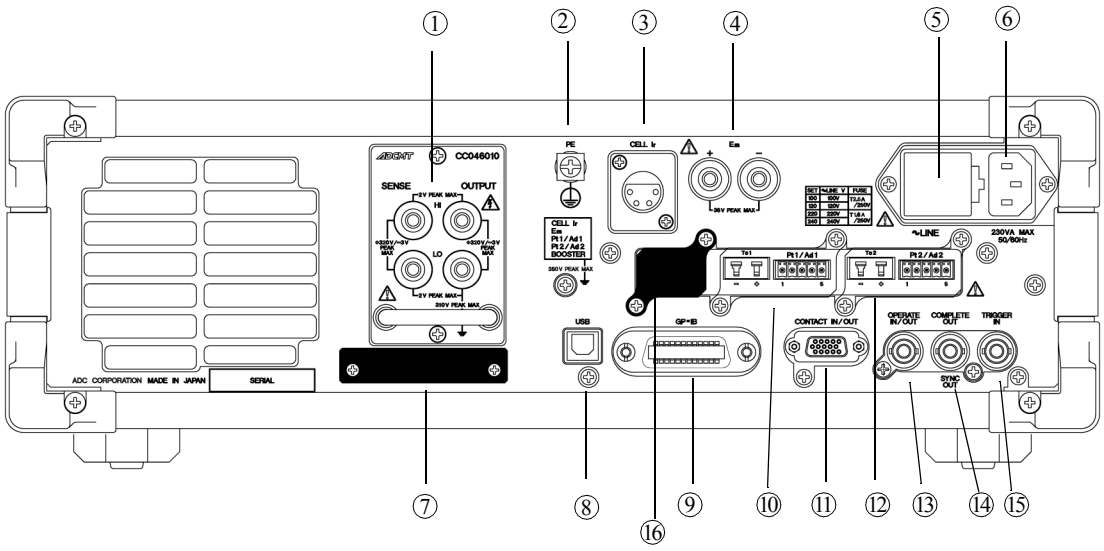


Figure 2-13 Rear Panel

① Rear output terminal — Shows that output unit (safety socket output terminal unit) is mounted on the rear.

② Ground terminal PE — Protective ground terminal

③ Reference cell connection terminal CELL Ir — Receptacle for the 4-pin cannon plug to connect the reference cell (Refer to Section 5.1.2, "Reference Cell Measurement Terminal")
Maximum allowable input 5 V peak

④ Voltage measurement terminal Em — Terminal to measure voltages such as thermopile voltage (Refer to Section 5.1.3, "External Voltage Measurement Terminal")
Maximum allowable input 36 V peak

⑤ Voltage selector and fuse holder — Voltage can be switched manually to match the AC power supply.
A fuse is contained inside.

CAUTION: Use an appropriate fuse.

⑥ AC power connector — Used to connect the 4601 to the AC power supply by using the supplied power cable.

⑦ Booster connector — Used to connect the optional current booster. For how to connect it, refer to the operation manual of the booster unit.

⑧ USB connector — Used to remotely control the 4601 by USB.

⑨ GPIB connector — Used to remotely control the 4601 by GPIB.

⑩ Temperature measurement connector Tc1, Pt1, Ad1

5-pin connector for Ch1 to connect the miniature thermocouple socket that connects the T-type thermocouple, the PT sensor and IC sensor (AD590) (Refer to 5.1.4, "Temperature Measurement Terminal")

For more information on the IC sensor (AD590), refer to the data sheet of Analog Devices, Inc.

⑪ Contact signal input and output CONTACT IN/OUT

15-pin Dsub connector for contact signals that are used to control shutter opening and closing of a solar simulator (Output: 4 bits and input: 2 bits) (Refer to Section 5.5.1, "Contact Signal Input and Output")

⑫ Temperature measurement connector Tc1, Pt2, Ad2

5-pin connector for Ch2 to connect the miniature thermocouple socket that connects the T-type thermocouple, the PT sensor and IC sensor (AD590) (Refer to 5.1.4, "Temperature Measurement Terminal")

For more information on the IC sensor (AD590), refer to the data sheet of Analog Devices, Inc.

⑬ OPERATE IN/OUT — BNC connector for input and output signals to synchronize the output ON or OFF of multiple devices (Refer to Section 5.5.2, "External Control Signals)

⑭ COMPLETE OUT SYNC OUT

BNC connector to output measurement end, sweep end and step synchronous signals (Refer to Section 5.5.2, "External Control Signals)

⑮ TRIGGER IN — BNC connector to input measurement start and sweep start signals (Refer to Section 5.5.2, "External Control Signals)

⑯ No display — Input and output connector for maintenance

3. BASIC OPERATIONS

This chapter describes how to operate the 4601 using examples.

NOTE: ***The operation procedures listed permit the settings to be made in the shortest time. If the display differs from the one shown, repeat the procedure from the beginning.***

Set the 4601 source and measurement functions in reference to Figure 3-1, "Settings and Operations from Source to Measurement."

For other settings, refer to Section 4.2.10, "MENU Key (Parameter Setting)."

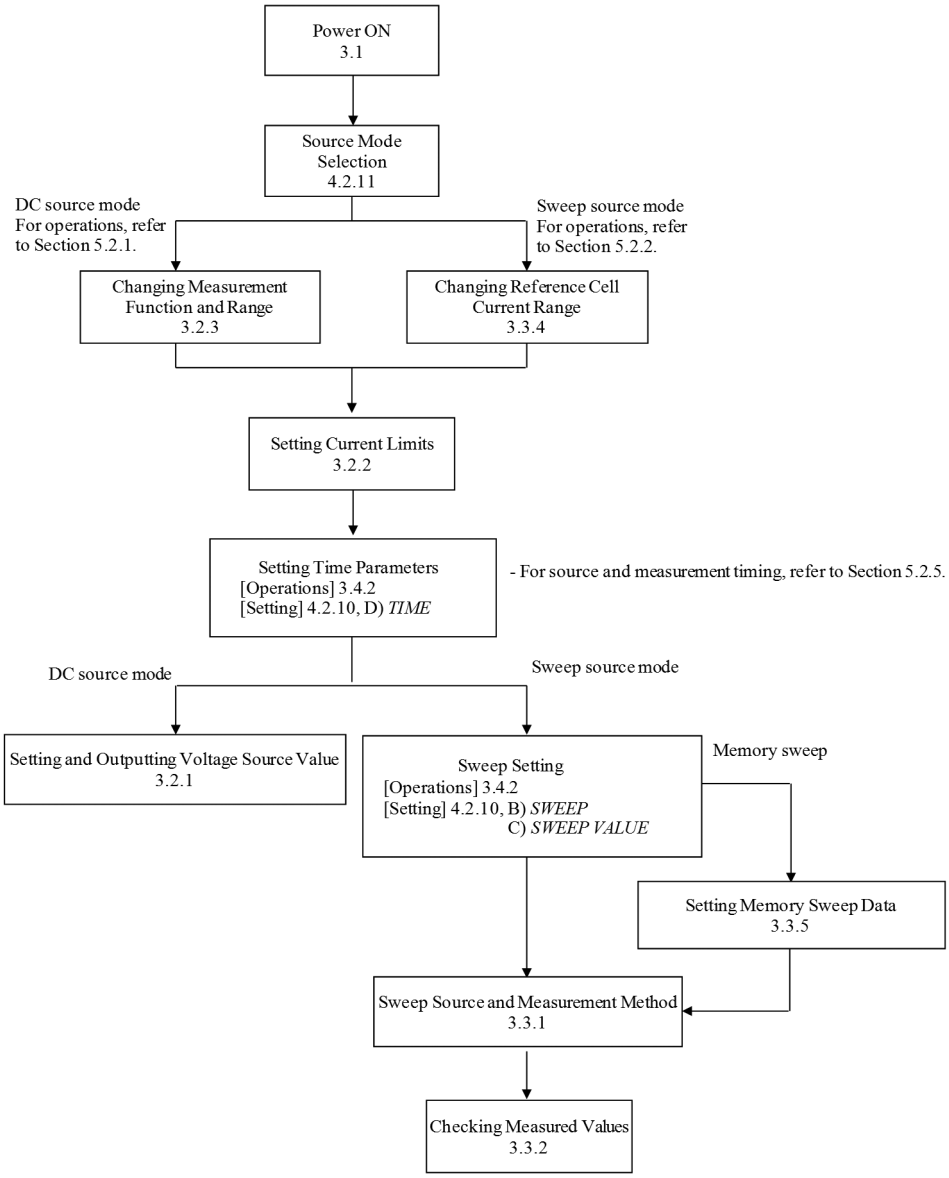


Figure 3-1 Settings and Operations from Source to Measurement

3.1 Power ON

Turn On the 4601 according to the following procedure:

① Ensure that the voltage of the used power supply matches the power voltage display on the rear panel. Then, connect the supplied power cable

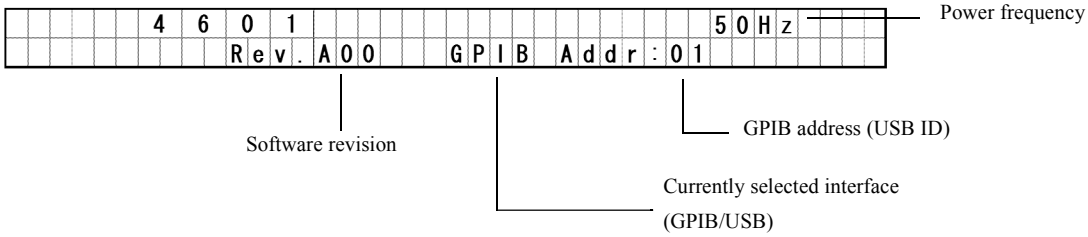
CAUTION: To prevent damage to the 4601, do not apply a voltage or frequency that exceeds the specified range.

② Press the **POWER** switch to turn on the power.

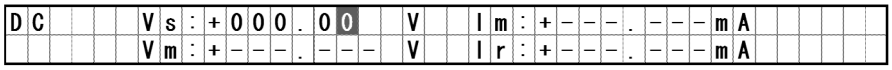
③ After the panel and all the indicators go ON, the self-test is automatically executed.

④ When a problem occurs during the self-test, an error message is displayed.
For more information on the error contents, refer to Section A.2, "Error Message List."

⑤ When the self-test terminates correctly, the screen is displayed as follows for about three seconds.



⑥ The start up process is complete, and the DC source mode screen appears.



CAUTION:

1. ***The 4601 starts up with the initial values that are preset before shipment when it is turned on for the first time. When the setting parameter condition at Power ON is changed, the screen display may be different from the above figure.***
   For more information, refer to Section 3.6.3, "Auto Parameter Loading at Power ON."
   When turning on the output for the first time, pay attention to the source value setting and the load connection.
2. ***If a problem occurs during the self-test, an error message will appear on the screen.***
   Refer to Section A.2, "Error Message List." to solve the problem.

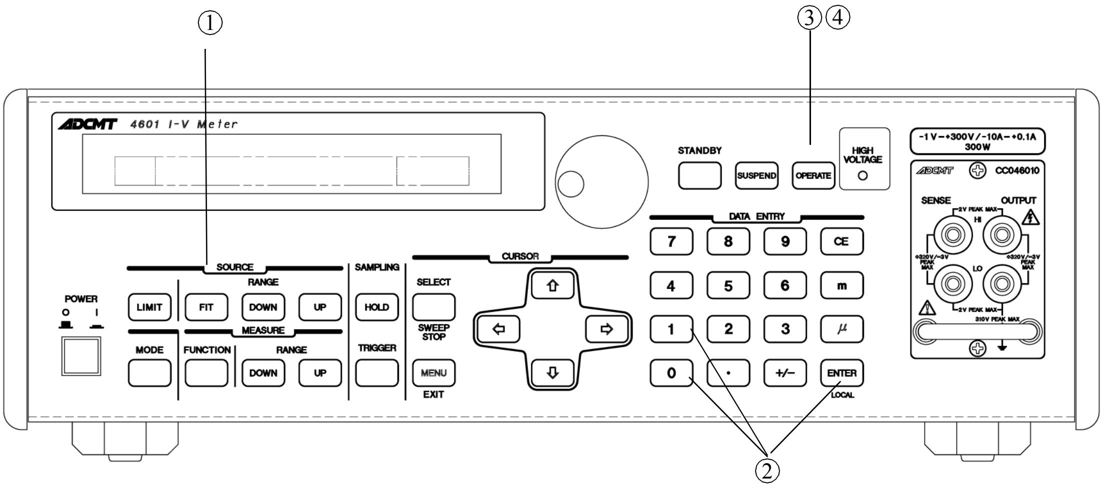
3.2 DC Source Mode

3.2.1 Setting and Outputting Voltage Source Value

1. Setting the voltage source value using the numeric keypad

   This section describes the procedure of setting the source value using the numeric keypad and outputting it.

   Each procedure should be started with the initial state (factory default settings). If the 4601 is not in the initial state, initialize the 4601 referring to Section 3.5.2, "Restoring to Factory Default Settings" previousely.
   Output voltage of +10.000 V according to the following procedure:



Operating procedure

① Press [FIT] to select the optimal range setting.
The **FIT** key goes ON, which indicates the optimal range setting status.

② Press [1] [0] [ENTER] to set the source value to 10 V.

Example display

```
DC    Vs:+10.000  V  Im:+---.---mA
      Vm:+---.---  V  Ir:+---.---mA
```

③ Press [OPERATE] to output the source value (Operate). While the source value is output, the **OPERATE** key lights up.
When the Operate status is set, current measurement (Im), voltage measurement (Vm) and reference cell current measurement (Ir) start.
The current measurement (Im) range is the same as the current limit range.
The voltage measurement (Vm) range is the same as the voltage source range.
The reference cell current measurement range is the setting range.

Example display

```
DC    Vs:+10.000  V  Im:+000.000mA
      Vm:+10.0000 V  Ir:+000.000mA
```

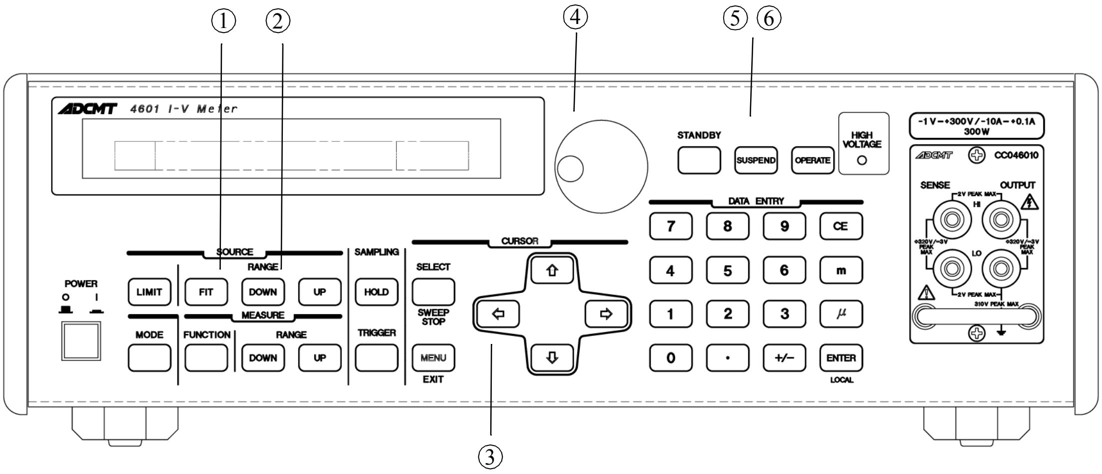
④ Press OPERATE again to stop the output (Standby). The **OPERATE** key goes OFF.

2. Setting the voltage source value using the rotary knob (for fixed range)

   This section describes the procedure of setting the source value using the rotary knob and outputting it.

   Each procedure should be started with the initial state (factory default settings). If the 4601 is not in the initial state, initialize the 4601 referring to Section 3.5, "Initializing Setting Conditions." previously.

   Output voltage of +10.000 V according to the following procedure:



Operating procedure

① Check that the **FIT** key is OFF and the fixed range is selected.

Example display

```
DC    Vs:+000.00  V  Im:+---.---mA
      Vm:+---.--- V  Ir:+---.---mA
```

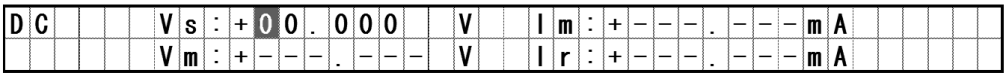
② Press DOWN to switch to the 50 V range.

Example display

```
DC    Vs:+00.000  V  Im:+---.---mA
      Vm:+---.--- V  Ir:+---.---mA
```

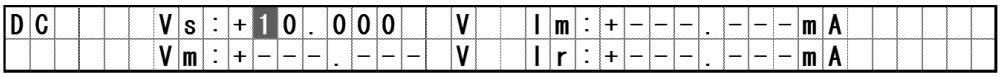
③ Press ⇦ three times to move the cursor onto the tenth digit.

Example display



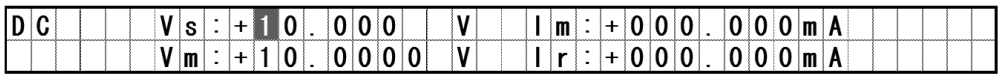
④ Set to 10 V by rotating the rotary knob.

Example display



⑤ Press OPERATE to output the source value (Operate). While the source value is output, the **OPERATE** key lights up.

Example display



⑥ Press OPERATE again to stop the output (Standby). The **OPERATE** key goes OFF.

3. Setting voltage ranges

The following table shows the setting voltage ranges

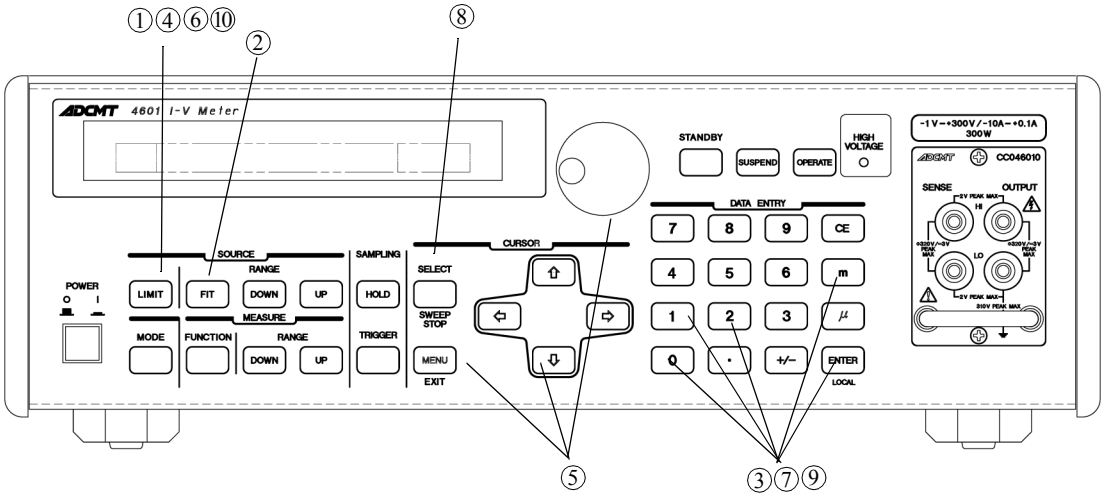
Range	Setting ranges	Resolution
5 V	-1.0000 V to +5.0000 V	100 μV
50 V	-1.000 V to +50.000 V	1 mV
300 V	-1.00 V to +300.00 V	10 mV

3.2.2 Setting Current Limits

Both positive and negative current limits can be set on the 4601 to prevent the 4601 and the devices from overcurrent.

1. Setting the current limits

   Set the current limit values to ±1 A, and +0.1 A and -2 A according to the following procedure:

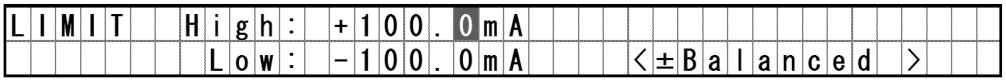


Operating procedure

① Press [LIMIT] to switch to the limit setting screen. The **LIMIT** key goes ON.

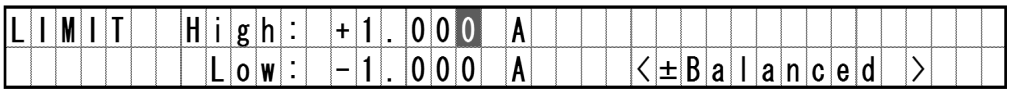
② The **FIT** key goes ON, which indicates the optimal range setting status.

Example display



③ Press [1] [0] [0] [0] [ENTER] to set the limit values to ±1 A.

Example display



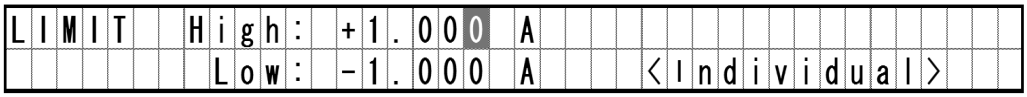
④ Press [LIMIT] to return to the DC source mode screen.

When setting the positive limit and the negative limit to difference values, operate as follows:

⑤ Press MENU . Select **3) Limit Input** from **A) SOURCE** with ⇦ , ⇨ , and ⇩ and change from **±Balanced** to **Individual** with the rotary knob.
Then, press MENU to exit the menu screen.

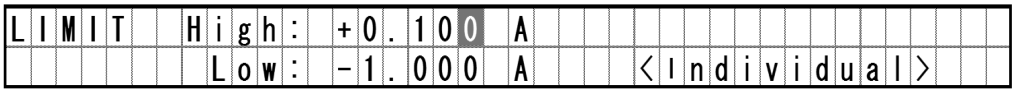
⑥ Press LIMIT to switch to the limit setting screen.

Example display



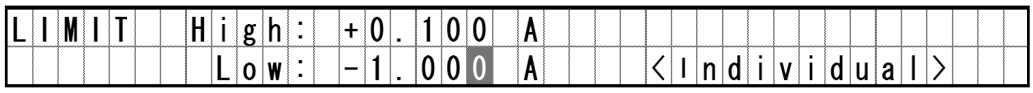
⑦ Press 1 0 0 m ENTER to change the limit values to +0.1A and -1A.

Example display



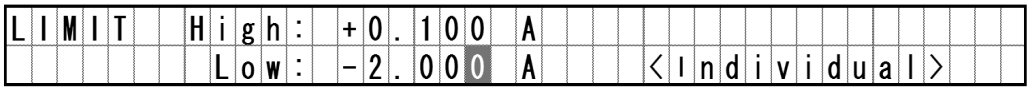
⑧ Press the **SELECT** key.

Example display



⑨ Press 2 ENTER to change the limit values to +0.1A and -2A.

Example display

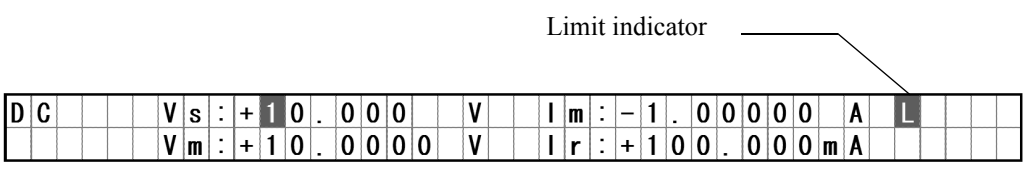


⑩ Press LIMIT to return to the DC source mode screen.

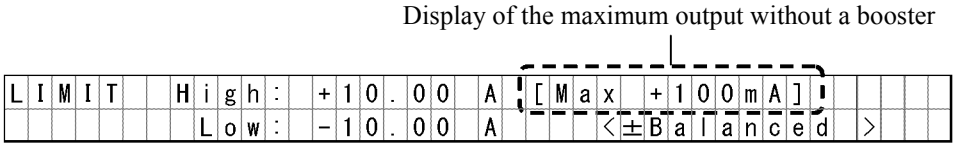
2. Current limit detection

When the limit is detected during measurement, the limit indicator appears together with the measured data.

Example display



3. Setting ranges of current limits(for optimal range)
   The following table shows the setting ranges of current limits.
   Current of +0.1 A or higher can be set but cannot be output without a booster.
   The maximum output value is displayed on the limit setting screen as shown blow.



Range	Limit setting range	Limit setting resolution
300 µA	3 µA to 320 µA	100 nA
3 mA	320.1 µA to 3.2 mA	1 µA
30 mA	3.201 mA to 32 mA	10 µA
300 mA	32.01 mA to 320 mA	100 µA
3 A	320.1 mA to 3.2 A	1 mA
10 A	3.201 A to 10.2 A	10 mA

NOTE: ***The polarities of current limits and current measurement are represented as "+" for source and as "-" for sink."***
The above ranges are applied to the current limit setting ranges and the current measurement ranges; however the output range is limited to +0.1 A and -10.2 A.

4. Relation between current limit setting and settling time
   The current limit setting have an influence on the settling time.
   The larger both the positive and negative current limit setting values are, the shorter the settling time is.
   Thus, setting the current limites using the optimal range is recommnedned.
   For more information on the settling time, refer to Section 5.2.6, "Settling Time."
5. Setting ranges of current limits (for fixed range)

Range	Limit setting range	Limit setting resolution
300 µA	3 µA to 320 µA	100 nA
3 mA	30 µA to 3.2 mA	1 µA
30 mA	0.3 mA to 32 mA	10 µA
300 mA	3 mA to 320 mA	100 µA
3 A	30 mA to 3.2 A	1 mA
10 A	0.1 A to 10.2 A	10 mA

NOTE: ***The polarities of current limits and current measurement are represented as "+" for source and as "-" for sink."***
The above ranges are applied to the current limit setting ranges and the current measurement ranges; however the output range is limited to +0.1 A and -10.2 A.

3.2.3 Changing Measurement Function and Range

As the 4601 includes three AD converters (ADC1 to ADC3), it can measure three points simultaneously. The three measurement points are shown below, and among which ADC3 has eight measurement functions.
The ADC3 function is selectable from the eight functions in the DC source mode; however it is fixed to reference cell current measurement Ir in the sweep source mode.

(1) ADC1: Output voltage measurement Vm

(2) ADC2: Output current measurement Im

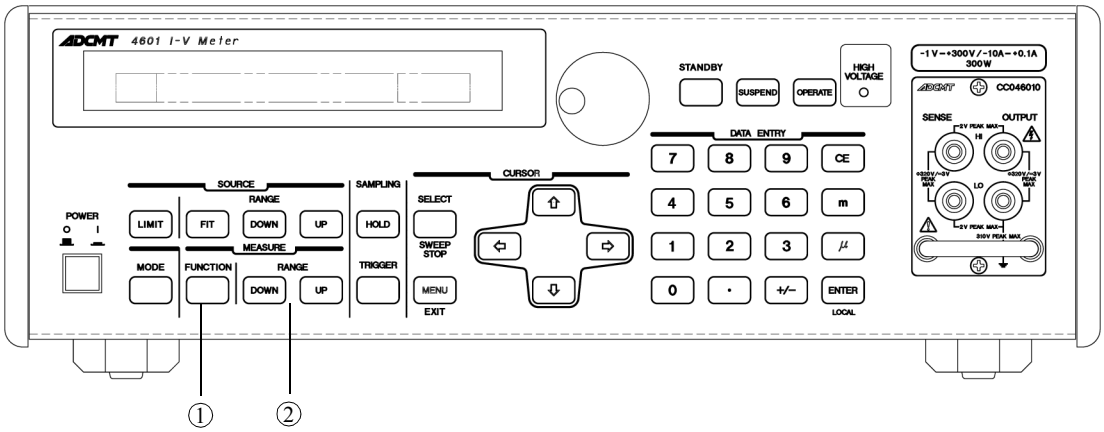
(3) ADC3: Reference cell/external voltage/temperature measurement

- Ir : Reference cell current measurement
- Em : External voltage measurement
- Tc1 : Ch1 T-type thermocouple measurement
- Pt1 : Ch1 resistance bulb (Pt) temperature measurement
- Ad1 : Ch1 IC sensor AD590 temperature measurement
- Tc2 : Ch2 T-type thermocouple measurement
- Pt2 : Ch2 resistance bulb (Pt) temperature measurement
- Ad2 : Ch2 IC sensor AD590 temperature measurement

This section describes how to set the above eight measurement functions and ranges.

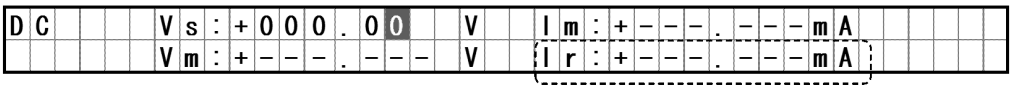
3.2.3 Changing Measurement Function and Range

1. Changing the measurement function



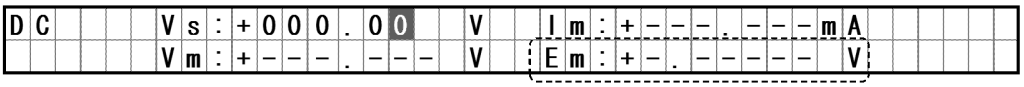
Operating procedure

Example display



① Pressing the **FUNCTION** key changes the measurement function display on the lower right.

Example display



Every pressing the **FUNCTION** key switches the function as shown on the right.

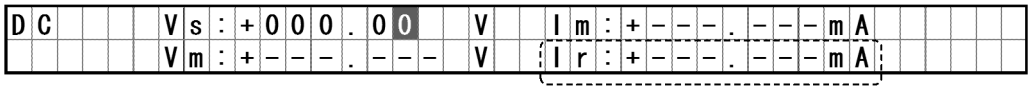
```
Tc1:+-----.--  °C
Pt1:+-----.--  °C }*
Ad1:+-----.--  °C }
Tc2:+-----.--  °C
Pt2:+-----.--  °C }*
Ad2:+-----.--  °C }
 Ir:+----.---  mA
```

*Either Pt1 or Ad1, Pt2 or Ad2 are displayed depending on the "Pt/Ad Select" setting in the menu.

2. Changing the measurement range

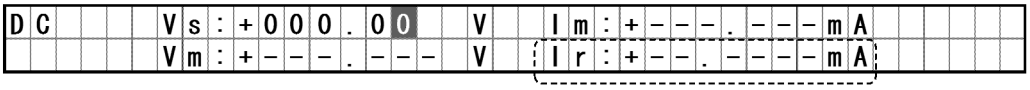
Operating procedure

Example display



② When the reference cell current measurement or external voltage measurement function is selected, pressing DOWN on the MEASURE section lowers the range by one and pressing UP raises it by one.

Example display



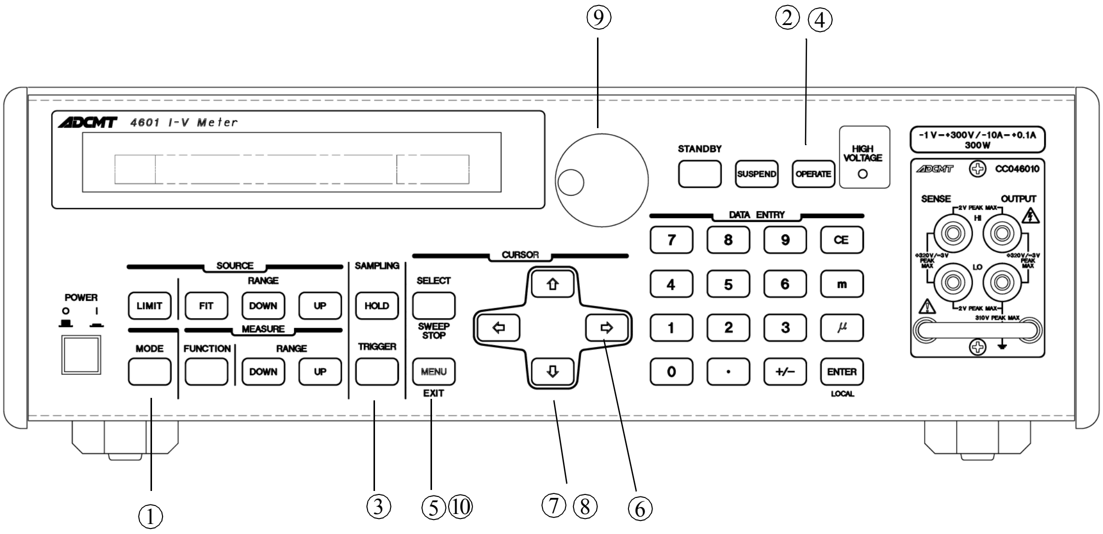
3.3 Sweep Source Mode

Solar cell I-V characteristic measurement sweeps the source voltage in the sweep source mode, measures voltage and current at each step, and displays the data graphically.
The data is converted into a graph on an external computer via the GPIB or USB interface.
This section describes the sweep source mode operation.

3.3.1 Sweep Source and Measurement Method

This section describes measurement by using the sweep source mode.

Each procedure should be started with the initial state (factory default settings). If the 4601 is not in the initial state, initialize the 4601 referring to Section 3.5.2, “Restoring to Factory Default Settings” previously.



① Press the **MODE** key.

Example display

```
1SWP  St:-0.0010 V  Sp:+0.0020 V
      Bi:+0.0000 V  Tp:50.000ms
```

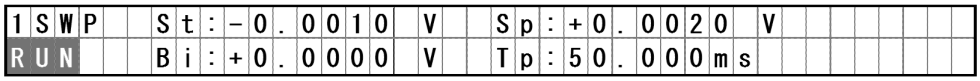
The example display indicates the following setting values:

St: Start value Sp: Last value Bi: Bias value Tp: Period

② Press OPERATE. The **OPERATE** key goes ON.

③ Press the **TRIGGER** key
Sweep starts. **RUN** appears, indicating sweep in progress.

Example display



When sweep ends, **RUN** disappears and the screen returns to the display before start. The measured data is stored in the measurement memory. For more information, refer to Section 5.3.7, "Measurement Data Memory."

④ Press OPERATE. The **OPERATE** key goes OFF.

3.3.2 Checking Measured Values

⑤ Press MENU. The **MENU** key goes ON.

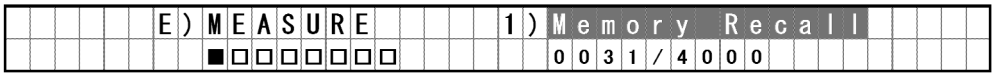
Example display

⑥ Press ⇨ four times to show the following display.

Example display

⑦ Press ⇩.

Example display



⑧ Press ⇩.

Example display

⑨ Rotate the rotary knob to check the measured value at each step.

Example display

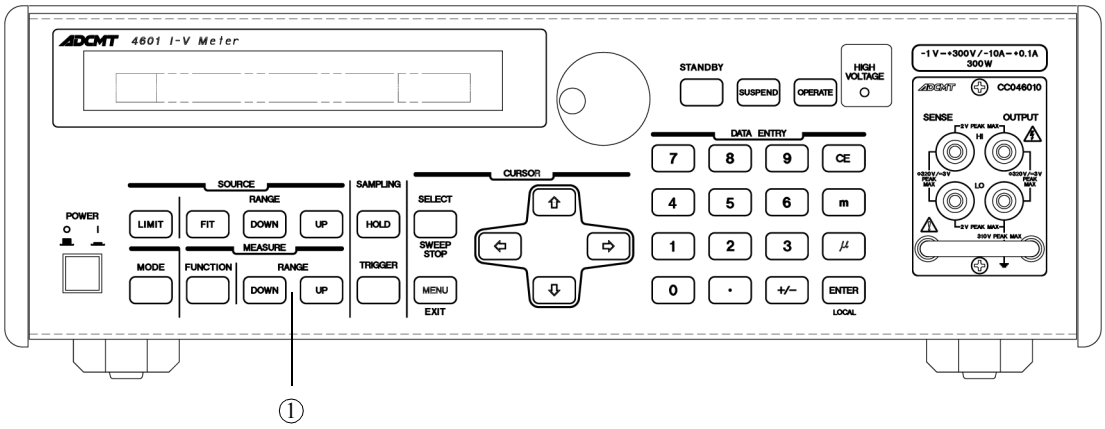
⑩ Press MENU.

The **MENU** key goes OFF, and the screen returns to the sweep source mode screen.

3.3.3 Setting Current Limits

The procedure of setting the current limits is the same as the procedure described in Section 3.2.2, “Setting Current Limits.”

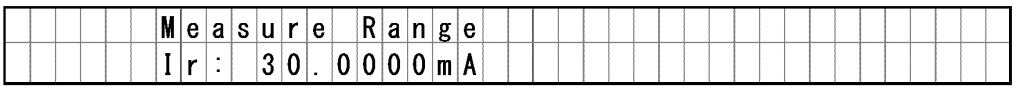
3.3.4 Changing Reference Cell Current Range



In the sweep source mode, the ADC3 measurement function is fixed to the reference cell current measurement function Ir.

① The reference cell current measurement range is changed with DOWN or UP on the **MEASURE** section. Pressing DOWN lowers the range by one and pressing UP raises it by one, and then displays the changed range for about two seconds.

Example display

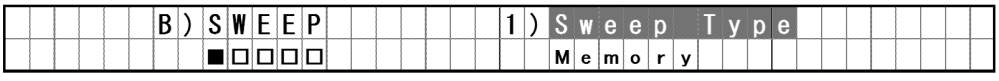


3.3.5 Setting Memory Sweep Data

This section describes the procedure of setting memory sweep source data.

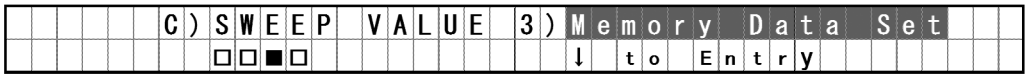
① Press MENU . Check that **1) Sweep Type** is set to **Memory** in category **B) SWEEP**.

Example display



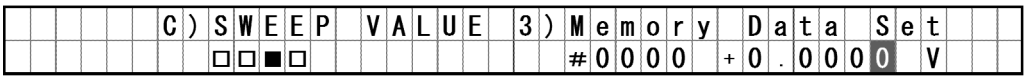
② Select **3) Memory Data Set** from **C) SWEEP VALUE** with ⇧ , ⇦ , ⇨ , and ⇩ .

Example display



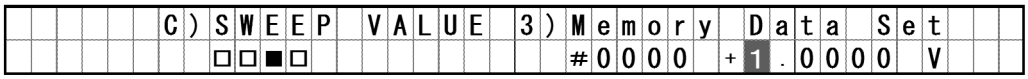
③ Press ⇩ to move to the lower level.

Example display



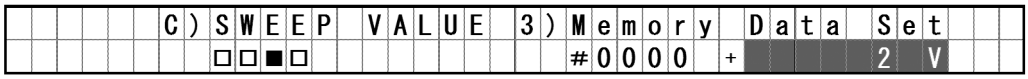
④ Set the source value with ⇧ , ⇦ , ⇨ , and ⇩ or by using the rotary knob.

Example display



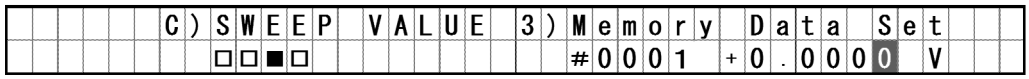
⑤ When using the numeric keypad, press 2 .

Example display



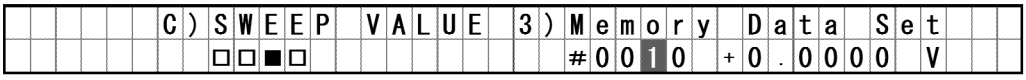
⑥ Pressing ENTER sets the next address automatically.

Example display



⑦ To change the address, press the **SELECT** key and set it by using the rotary knob or numeric keypad.

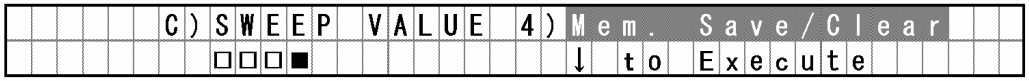
Example display



⑧ Press the **SELECT** key, and repeat Step ④ to ⑦ to set necessary source data.

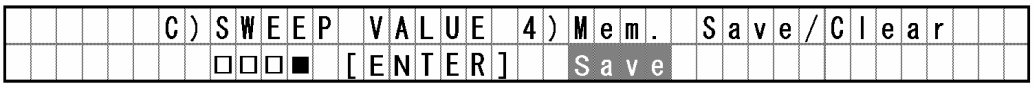
⑨ Select **4) Mem. Save/Clear** with ⇧ , ⇦ , ⇨ , and ⇩ .

Example display



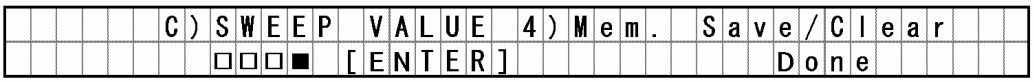
⑩ Press ⇩ .

Example display



⑪ Press ENTER to save the setting values to the non-volatile memory.

Example display



⑫ When the settings are complete, press MENU to exit the data setting status.

3.4 Menu Operation

The 4601 functions and parameters are set on a hierarchical menu.

This section describes the menu structure and the procedures of operating the menu.

3.4.1 Menu Structure

The menu is a 3-level hierarchical structure.

Level 1	Category level	Selects categories.
Level 2	Select level	Selects parameters to set within the categories.
Level 3	Input/Run level	Changes parameter settings and executes functions.

The following figure shows the items and their descriptions in each category.

3.4.1 Menu Structure

Category level *1	*2	Select level (15 characters max.) *3, *4	Input/Run level *5	
A) SOURCE		1) Suspend Z	Suspend output impedance	
		2) Response	Response	
		3) Limit Input	Limit value input mode	
B) SWEEP		1) Sweep Type	Sweep source mode	
		2) Sweep Range	Sweep source range	
		3) Reverse	Sweep reverse mode	
		4) Return to Bias	Bias output	
		5) Step / Trigger	Sweep step count per trigger	
C) SWEEP VALUE		1) Bias Value	Bias output value	For Linear setting
		2) First Value	Linear sweep first value	
		3) Last Value	Linear sweep last value	
		4) Step Count	Linear sweep step count	
: Overlapping (same) parameter		1) Bias Value	Bias output value	For Linear2 setting
		2) First Value	2-slope linear sweep first value	
		3) Second Value	2-slope linear sweep second value	
		4) Last Value	2-slope linear sweep last value	
		5) Cnt. @ 1st-2nd	2-slope linear sweep first step count	
		6) Cnt. @ 2nd-Last	2-slope linear sweep second step count	
		1) Bias Value	Bias output value	For Linear3 setting
		2) First Value	3-slope linear sweep first value	
		3) Second Value	3-slope linear sweep second value	
		4) Third Value	3-slope linear sweep third value	
		5) Last Value	3-slope linear sweep last value	
		6) Cnt. @ 1st-2nd	3-slope linear sweep first step count	
		7) Cnt. @ 2nd-3rd	3-slope linear sweep second step count	
		8) Cnt. @ 3rd-Last	3-slope linear sweep third step count	
		1) Bias Value	Bias output value	For Fix setting
		2) Level Value	Fixed sweep level value	
		3) Sample Count	Fixed sweep sample count	
		1) Bias Value	Bias output value	For Memory setting
		2) Sweep Address	Memory sweep start/stop address	
		3) Memory Data Set	Source memory setting	
		4) Mem. Save/Clear	Source memory save/clear	
D) TIME		1) Integ. Time	Integration time	
		2) Source Delay	Source delay time	
		3) Measure Delay	Measurement delay time	
		4) Period	Period time	
		5) Hold Time	Hold time	
		6) Trigger Delay	Trigger delay time	
E) MEASURE		1) Memory Recall	Measurement data memory recall	
		2) Memory Store	Measurement data memory	
		3) Memory Clear	Measurement data memory clear	
		4) Measure Zero	Zero measurement	
		5) Measure Switch	Measurement ON/OFF	
		6) Pt/Ad Select	Selection between Pt1 or Ad1, Pt2 or Ad2	
		7) RTD	Resistance bulb	
		8) Temp. Unit	Temperature unit	
F) EXT.SIGNAL		1) Operate Control	OPR/STBY in/out setting	
		2) Comp./Sync. Sel	Complete Out/Sync. Out select	
		3) Signal Width	Complete Out/Sync. Out signal pulse width	
G) PARAMETER		1) Load	Parameter load (0 to 3)/default value	
		2) Save	Parameter save (0 to 3)/saved value initialization	
		3) Load @ PWR On	Parameter load at power ON	
H) INTERFACE		1) Interface Bus	Interface select	For GPIB setting
		2) GPIB Address	GPIB address	
		3) Header	Header ON/OFF	
		4) Output Format	Measurement data output format	
		5) Output Vm Data	Output target measurement data	
		6) Output Im Data	Output target measurement data	
		7) Output ADC3 Dt	Output target measurement data	
		1) Interface Bus	Interface select	For USB setting
		2) USB Id	USB ID	
		3) Header	Header ON/OFF	
		4) Output Format	Measurement data output format	
		5) Output Vm Data	Output target measurement data	
		6) Output Im Data	Output target measurement data	
		7) Output ADC3 Dt	Output target measurement data	
I) MAINTENANCE		1) Self Test	Self test execution	
		2) Disp/Key Test	Display/key test execution	
		3) Calib. Mode	Calibration mode	
		4) Counter Select	Relay counter select	
		5) Relay Counter	Output relay switching count display	
		6) Reset Counter	Output relay switching count initialization	
		7) Serial Number	Serial number	
J) SYSTEM		1) Display On/Off	Display ON/OFF	
		2) Brightness	Display brightness	
		3) Buzzer	Notice buzzer	
		4) Error Queue	Error log readout	

* 1: Use ⇦ , ⇨ or the rotary knob to select the categories.

* 2: Use ⇩ to move from the Category level to the Select level.

* 3: Use ⇦ , ⇨ or the rotary knob to select the parameters at the Select level.

* 4: Use ⇩ to move from the Select level to the Input/Run level.

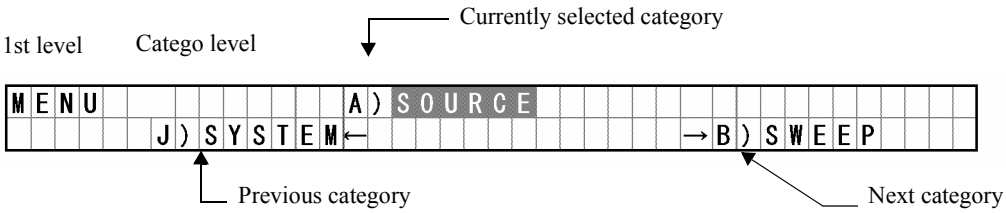
* 5: Use ⇦ , ⇨ or the rotary knob to change the parameters at the Input/Run level.

3.4.2 How to Operate Menu

Change the parameters in the menu in according to the following procedure:

① Press MENU . The **MENU** key goes ON.

Example display

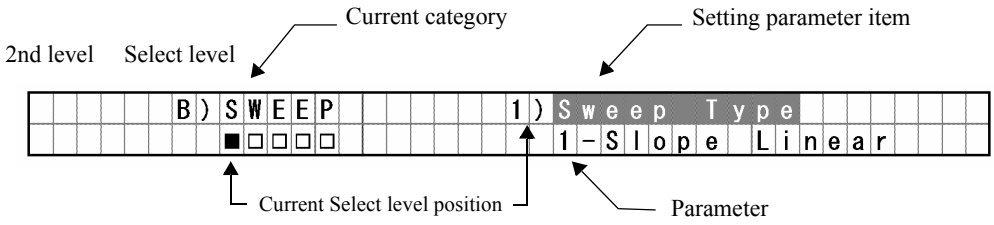


② Select the categories with ⇦ or ⇨ or by using the rotary knob.

Example display

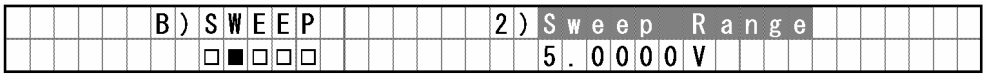
③ Move from the Category level to the Select level with ⇩ .

Example display



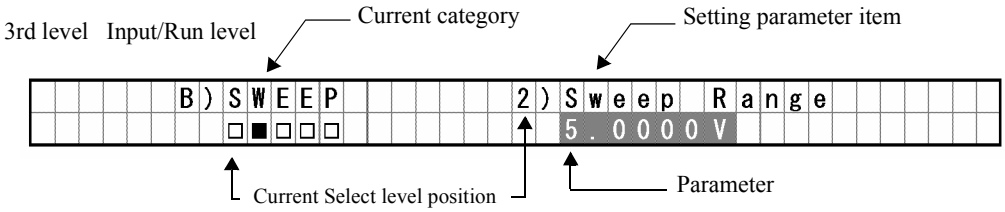
④ Select the parameter items at Select level with ⇦ or ⇨ or by using the rotary knob.

Example display



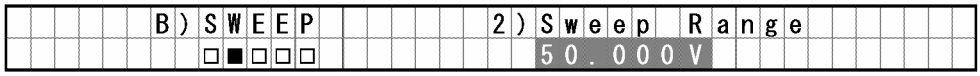
⑤ Move from the Select level to the Input/Run level with ⇩ .

Example display



⑥ Change the parameters at Input/Run level with ⇦ or ⇨ or by using the rotary knob.

Example display



⑦ After changing the parameters, press MENU to exit the menu. The **MENU** key goes OFF.

3.5 Initializing Setting Conditions

This section describes the procedure of initializing the setting conditions (parameters) of the 4601.

There are the following two types of initialization by key operations:

- Initializing the parameters from the menu
- Restoring to the factory default settings

For information on the initial values and the factory default settings, refer to Section 6.6.3, "Remote Command List."

3.5.1 Initializing Parameters from Menu

① Press MENU . The **MENU** key goes ON.

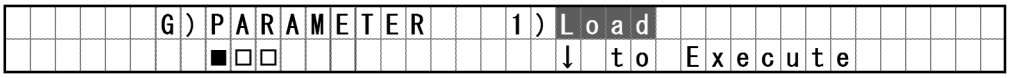
Example display

② Press ⇦ or ⇨ to select **G) PARAMETER** from the categories.

Example display

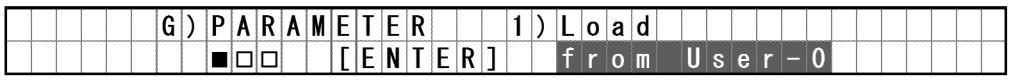
③ Press ⇩ to move to the lower level.

Example display



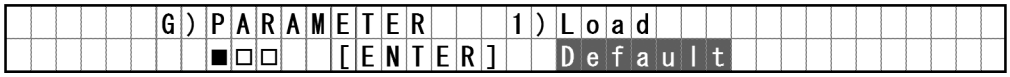
④ Press ⇩ to move to the lower level.

Example display



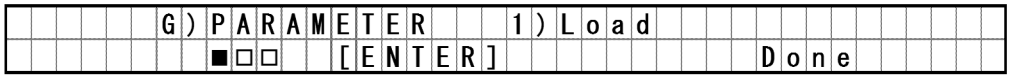
⑤ Press ⇦ or ⇨ or rotate the rotary knob to select **Default**.

Example display



⑥ Press ENTER to load the default values.

Example display



⑦ Press MENU to exit the menu.

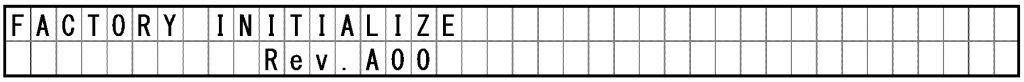
3.5.2 Restoring to Factory Default Settings

Operating procedure

① Turn OFF the power.

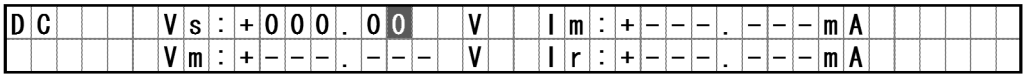
② Turn ON the power while pressing ⇧ and CE at the same time.

Example display Indicates that the 4601 is booting up.



③ The 4601 starts up with all the parameters restored to the factory default settings.

Example display



3.6 Saving and Loading Parameters

The 4601 can save setting parameters to and load them from the non-volatile memory, areas User-0 to User-3. The 4601 has a program memory data area, separated from the parameter save area.

This section describes the procedures of saving and loading the parameters.

3.6.1 Loading Parameters

The setting parameters saved separately in the non-volatile memory, areas User-0 to User-3 can be loaded.

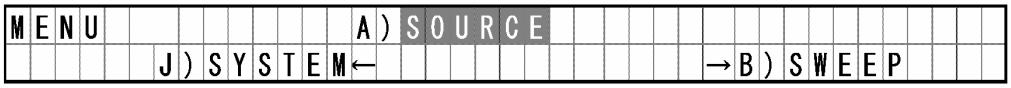
For information on how to save the parameters, refer to Section 3.6.2, “Saving Parameters.”

The following is an example to load the parameters from User-1.

Operating procedure

① Press MENU . The **MENU** key goes ON.

Example display

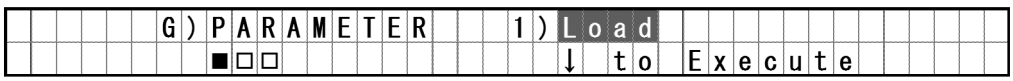


② Press ⇦ or ⇨ or rotate the rotary knob to select **G) PARAMETER** from the categories.

Example display

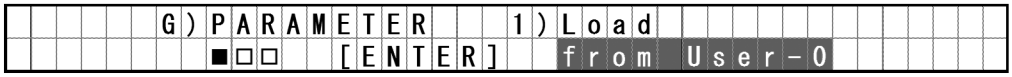
③ Press ⇩ to move to the lower level.

Example display



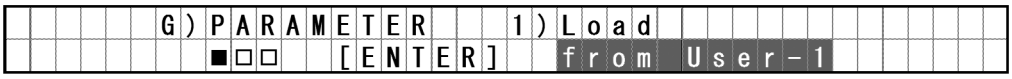
④ Press ⇩ to move to the lower level.

Example display



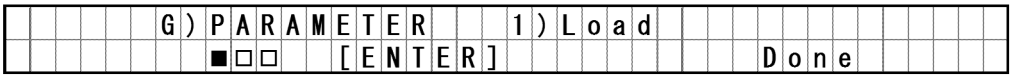
⑤ Press ⇦ or ⇨ or rotate the rotary knob to select **User-1**.

Example display



⑥ Press ENTER to load the parameters from User-1.

Example display



The descriptions of these parameters are as follows:

User-0	Loads the parameters from User-0.
User-1	Loads the parameters from User-1.
User-2	Loads the parameters from User-2.
User-3	Loads the parameters from User-3.
Default	Loads the initial values.

⑦ Press MENU to exit the menu.

3.6.2 Saving Parameters

The setting parameters can be saved to the non-volatile memory, areas User-0 to User-3 separately.
The 4601 can start up with the parameters saved in User-0 at power ON.
For information on how to load the parameters, refer to Section 3.6.1, “Loading Parameters.”
For information on how to start the 4601 with the parameters saved in User-0, refer to Section 3.6.3, “Auto Parameter Loading at Power ON.”
The following is an example to save the parameters to User-3.

Operating procedure

① Press MENU . The **MENU** key goes ON.

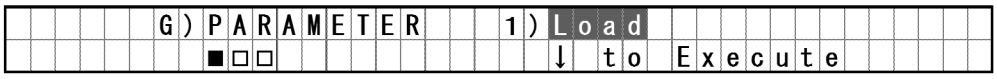
Example display

② Press ⇦ or ⇨ or rotate the rotary knob to select **G) PARAMETER** from the categories.

Example display

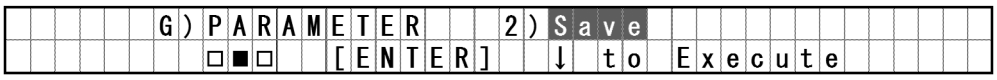
③ Press ⇩ to move to the lower level.

Example display



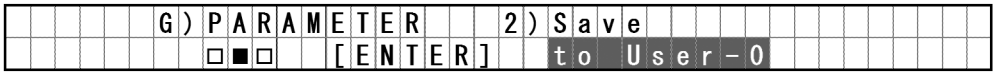
④ Press ⇦ or ⇨ or rotate the rotary knob to select **Save**.

Example display



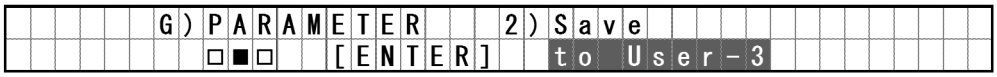
⑤ Press ⇩ to move to the lower level.

Example display



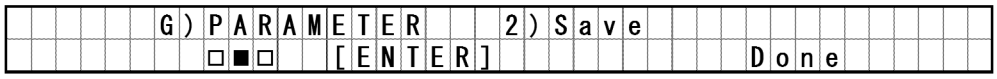
⑥ Press ⇦ or ⇨ or rotate the rotary knob to select **User-3**.

Example display



⑦ Press ENTER to save the parameters to User-3

Example display



The descriptions of these parameters are as follows:

User-0	Saves the parameters to User-0.
User-1	Saves the parameters to User-1.
User-2	Saves the parameters to User-2.
User-3	Saves the parameters to User-3.
Default to All	Initializes User-0 to User-3.

⑧ Press MENU to exit the menu screen.

3.6.3 Auto Parameter Loading at Power ON

The 4601 memorizes the settings at power OFF and starts up with the same settings at next power ON.

To start up using predefined parameters, parameters saved in User-0 can be loaded at startup.

The following shows the procedure of changing the setting to start the 4601 with the parameters saved in User-0.

For information on how to save the parameters to User-0, refer to Section 3.6.2, “Saving Parameters.”

Operating procedure

① Press [MENU] . The **MENU** key goes ON.

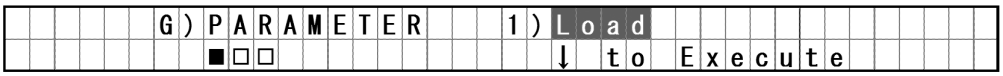
Example display

② Press [⇦] or [⇨] or rotate the rotary knob to select **G) PARAMETER** from the categories

Example display

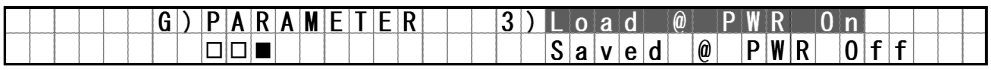
③ Press [⇩] to move to the lower level.

Example display



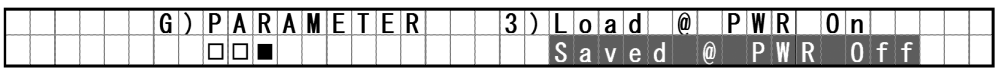
④ Press [⇦] or [⇨] or rotate to select **Load @ PWR On**.

Example display



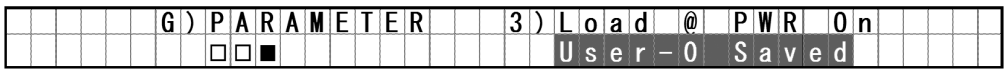
⑤ Press [⇩] to move to the lower level.

Example display



⑥ Press ⇦ or ⇨ or rotate to select **User-0 Saved**.

Example display



⑦ Press MENU to exit the menu.

4. FUNCTIONAL REFERENCE

This chapter describes panel keys, parameter groups (categories), parameter items and parameter functions in the following sections:

- 4.1 Menu Index: Use this section as an index for the parameters in the menu.
- 4.2 Panel Key Descriptions: Describes panel keys, parameter groups (categories), parameter items and parameter functions.

4.1 Menu Index

Use the Menu Index as the index for the set items in the menu.

4.2 Panel Key Descriptions

This section describes the function of the panel keys and the parameters in the menu in alphabetical order.

4.2.1 CURSOR Key (Cursor Moving)

←, → keys	Moves the cursor (highlight) that indicates a digit of the source value to the right or left. Selects items on the menu screen.
↑, ↓ keys	Increases or decreases a figure at the digit indicated by the cursor. Moves up and down the hierarchy on the menu screen.

4.2.2 DATA ENTRY Keys (Source Value Setting)

The DATA ENTRY keys are used to change the voltage source value, the current source values, the limit values and the parameters to be input.

0 to 9 keys	Enters numeric data from 0 to 9.
• key	Enters a decimal point.
+/- key	Sets the polarity to positive or negative.
CE key	Cancels input data for data setting.
m key	Sets unit "m" for numeric data.
μ key	Sets unit "μ" for numeric data.
ENTER key	Finishes data entry and stores the parameter.
LOCAL key	Switches from remote operation to local operation.

4.2.3 DOWN Key (Voltage Source or Current Limit Range Down)

Decreases the voltage source range or current limit range by one.

However, it is impossible to decrease to the range that cannot output the currently set source value.

4.2.4 DOWN Key (Measurement Range Down)

Decreases the external voltage measurement range or referenced cell current range by one.

4.2.5 EXIT Key (Menu Setting Cancellation)

Exits the menu screen to return to the source value screen. (The **MENU** key goes OFF.)

4.2.6 FIT Key (Optimal Voltage Source or Current Limit Range)

Selects the optimal range for voltage source or current limit automatically.
When the optimal range is selected, the **FIT** key lights up.

4.2.7 FUNCTION Key (ADC3 Measurement Function Selection)

Selects from the eight functions for ADC3 measurement.

Ir:	Reference cell current measurement	
Em:	External voltage measurement	
Tc1:	Ch1 T-type thermocouple measurement	
Pt1:	Ch1 resistance bulb (Pt) temperature measurement	
Ad1:	Ch1 IC sensor AD590 temperature measurement	} *
Tc2:	Ch2 T-type thermocouple measurement	
Pt2:	Ch2 resistance bulb (Pt) temperature measurement	} *
Ad2:	Ch2 IC sensor AD590 temperature measurement	

*Either Pt1 or Ad1, Pt2 or Ad2 are selected depending on the "Pt/Ad Select" setting in the menu.

4.2.8 HOLD Key (Sampling Selection)

Switches the sampling between AUTO and HOLD.
The **HOLD** key goes ON when the sampling is set to HOLD.

4.2.9 LIMIT Key (Current Limit Setting)

Switches between the voltage source value screen and the current limit value screen.
Sets the current limit values on the current limit value screen.

4.2.10 MENU Key (Parameter Setting)

Switches to the menu screen to set the parameter groups (categories).

Goes ON during menu screen display.

For information on how to set the parameters using the menu, refer to Section 3.4, "Menu Operation."

A) ***SOURCE*** Sets the source-related parameters.

1) ***Suspend Z*** Sets the output impedance in the Suspend status.

High Impedance	Sets the output impedance in the Suspend status to high impedance. (Sets the output voltage to 0 V and the current limit to the minimum value = ±30 digits in the setting current limit range.)
Low Impedance	Sets the output impedance in the Suspend status to low impedance. (Sets the output voltage to 0 V and the current limit to the setting current limit value.)

2) ***Response*** Sets the voltage source response.

Extra Fast	Sets the voltage source response to extra fast speed.
Fast	Sets the voltage source response to high speed.
Medium	Sets the voltage source response to medium speed.
Slow	Sets the voltage source response to low speed.

3) ***Limit Input*** Changes the current limit setting mode.

±Balanced	Sets the high and low current limits to the same values with different polarities.
Individual	Sets the high and low current limits separately.

B) ***SWEEP*** Sets the sweep type and the sweep-related parameters.

1) ***Sweep Type*** Sets the sweep type.

1-Slope Linear	Selects 1-slope linear sweep.
2-Slope Linear	Selects 2-slope linear sweep.
3-Slope Linear	Selects 3-slope linear sweep.
Fixed Level	Selects fixed level sweep.
Memory	Selects memory sweep.

2) ***Sweep Range*** Sets the voltage source range for sweep operation.

5.0000 V	Selects the 5 V range.
50.000 V	Selects the 50 V range.
300.00 V	Selects the 300 V range.

3) ***Reverse*** Switches reverse sweep ON or OFF.

Off: One-way sweep

On: Round sweep

4) ***Return to Bias*** Selects whether sweep stops at the bias value or stop value.

Off: Stop value

On: Bias value

5) ***Step /Trigger*** Sets the step count per trigger to between 1 and to 2000 when the sampling is set to HOLD.

C) ***SWEEP VALUE*** Sets the sweep source value.
The setting parameters vary depending on the sweep type as follows:

1-slope linear sweep:

1) ***Bias Value*** Sets the bias value.

2) ***First Value*** Sets the start value.

3) ***Last Value*** Sets the stop value.

4) ***Step Count*** Sets the step count.

2-slope linear sweep:

1) ***Bias Value*** Sets the bias value.

2) ***First Value*** Sets the start value.

3) ***Second Value*** Sets the start value for the second slope.

4) ***Last value*** Sets the stop value.

5) ***Cnt. @ 1st-2nd*** Sets the step count for the first slope.

6) ***Cnt. @ 2nd-Last*** Sets the step count for the second slope.

3-slope linear sweep:

1) ***Bias Value*** Sets the bias value.

2) ***First Value*** Sets the start value.

3) ***Second Value*** Sets the start value for the second slope.

4) ***Third Value*** Sets the start value for the third slope.

5) ***Last Value*** Sets the stop value.

6) ***Cnt. @ 1st-2nd*** Sets the step count for the first slope.

7) ***Cnt. @ 2nd-3rd*** Sets the step count for the second slope.

8) ***Cnt. @ 3rd-Last*** Sets the step count for the third slope.

Fixed level sweep:

1) ***Bias Value*** Sets the bias value.

2) ***Level Value*** Sets the level value.

3) ***Sample Count*** Sets the sampling count.

Memory sweep:

1) ***Bias Value*** Sets the bias value.

2) ***Sweep Address*** Sets the start address and the stop address.

3) ***Memory Data Set*** Sets the source value at each memory address.

4) ***Mem. Save/Clear*** Saves or clears the memory data.

D) ***TIME*** Sets the time parameters.

1) ***Integ. Time*** Sets the integration time IT.

2) ***Source Delay*** Sets the source delay time Tds.

3) ***Measure Delay*** Sets the measurement delay time Td.

4) ***Period*** Sets the sampling interval in the DC source mode or the step time Tp in the sweep source mode.

5) ***Hold Time*** Sets the hold time Th in the sweep source mode.

6) ***Trigger Delay*** Sets the delay time Tdr between the external trigger (TRIGGER IN signal) and the sweep start or between the external trigger and the next step value output.

E) ***MEASURE*** Sets the measurement-related parameters.

1) ***Memory Recall*** Recalls and displays data from the measurement data memory.

2) ***Memory Store*** Selects whether measured data is stored to the measurement data memory or not (ON or OFF) in the DC source mode.
Memory store is always set to ON in the sweep source mode.

3) ***Memory Clear*** Clears data in the measurement data memory.

4) ***Measure Zero*** Measures necessary internal zero points to cancel zero point errors in measured values. Zero measurement should be executed after warm up.

5) ***Measure Switch*** Switches measurement ON or OFF.

6) ***Pt/Ad Select*** Selects the sensor to be connected to the temperature measurement connector.

7) ***RTD*** Sets the resistance bulb standard.

Pt100	Pt100 (compliant with JIS C1604-1997/IEC 60751)
JPt100	JPt100 (compliant with JIS C1604-1981)

8) ***Temp. Unit*** Sets the temperature unit.
°C, ° F or K

F) ***EXT.SIGNAL*** Sets the external signal-related parameters.

1) ***Operate Control*** Selects the signal for the BNC connector **OPERATE IN/OUT** on the rear panel.

Standby In	Sets Standby when the signal level changes from LO to HI.
OPR/STBY In	Sets Standby when the signal level changes from LO to HI. Sets Operate when the signal level changes from HI to LO.
OPR/SUS In	Sets Suspend when the signal level changes from LO to HI. Sets Operate when the signal level changes from HI to LO.
Operate Out	Outputs LO in the Operate status. Outputs HI in the Standby or Suspend status.

2) ***Comp./Sync. Sel*** Selects the signal for the BNC connector **COMPLETE OUT/SYNC OUT** on the rear panel.

Sync. Out	Outputs the Sync. Out signal.
Complete Out	Outputs the Complete Out signal.

3) ***Signal Width*** Selects the signal width of Complete Out/Sync Out between 10 μs and 100 μs.

G) ***PARAMETER*** Loads or saves the setting parameters.

1) ***Load*** Loads the setting parameters saved in the non-volatile memory.

from User-0	Loads the parameters from the non-volatile memory, User-0.
from User-1	Loads the parameters from the non-volatile memory, User-1.
from User-2	Loads the parameters from the non-volatile memory, User-2.
from User-3	Loads the parameters from the non-volatile memory, User-3.
Default	Loads the factory default values as setting parameters.

2) ***Save*** Saves the setting parameters to the non-volatile memory.

to User-0	Saves the current parameters to the non-volatile memory, User-0.
to User-1	Saves the current parameters to the non-volatile memory, User-1.
to User-2	Saves the current parameters to the non-volatile memory, User-2.
to User-3	Saves the current parameters to the non-volatile memory, User-3.
Default to All	Saves the factory default values to the non-volatile memory, User-0 to User-3.

3) ***Load @ PWR On*** Selects the setting parameter condition at power ON.

Saved @ PWR Off Start up using the parameters saved when the power was last turned off.

User-0 Saved Start up using the parameters saved in the non-volatile memory, User-0.

H) ***INTERFACE*** Selects and sets the interface.

1) ***Interface Bus*** Selects either the GPIB interface or the USB interface.

GPIB interface:

2) ***GPIB Address*** Sets the GPIB address from 0 to 30.

GPIB interface:

2) ***USB Id*** Sets the USB ID from 1 to 127.

3) ***Header*** Sets the header of the talker format to ON or OFF.

4) ***Output Format*** Selects the output format between ASCII and BINARY.

5) ***Output Vm Data*** Sets whether the Vm data (ADC1 measured value) is output or not.

On: Output

Off: No output

6) ***Output Im Data*** Sets whether the Im data (ADC2 measured value) is output or not.

On: Output

Off: No output

7) ***Output ADC3 Dt*** Sets whether the ADC3 measured value is output or not.

On: Output

Off: No output

I) ***MAINTENANCE*** Sets the maintenance and inspection-related parameters.

1) ***Self Test*** Executes the self test.
For more information, refer to Section 5.7, "Self Test."

2) ***Disp/Key Test*** Executes a test for the display and the panel keys.

For more information, refer to Section 5.7, "Self Test."

3) ***Calib. Mode*** Selects the calibration mode.

On: Sets the status in which source values and measured values are calibrated.
For more information, refer to Chapter 8., "CALIBRATION."

Off: Sets the normal measurement status.

4) ***Counter Select*** Selects the relay counter.

5) ***Relay Counter*** Displays the relay ON/OFF count stored in the selected relay counter.

6) ***Reset Counter*** Clears the selected relay counter.

7) ***Serial Number*** Displays the serial number.

J) ***SYSTEM*** Sets the system-related parameters.

1) ***Display On/Off*** Turns ON or OFF the screen.

On:	Turns ON the screen.
OFF in Remote:	Turns OFF the screen only in remote control.
Off:	Turns OFF the screen. The **MODE** key blinks during screen OFF state. Pressing the **MODE** key in this state cancels the screen OFF setting.

2) ***Brightness*** Adjusts the screen brightness in three levels.

Level-3	3/3 brightness, highest level
Level-2	2/3 brightness, medium level
Level-1	1/3 brightness, lowest level

3) ***Buzzer*** Buzzes when each operation is complete.

On:	Turns ON the buzzer.
Off:	Turns OFF the buzzer.

4) ***Error Queue*** Reads out the data stored in the error logs.
For more information, refer to Section 5.8, "Error Log."

4.2.11 MODE Key (Source Mode Selection)

Switches between the DC source mode and the sweep source mode.

4.2.12 OPERATE Key (Output ON/OFF)

Sets the source value output to ON (Operate) or OFF (Standby).

The **OPERATE** key lights up during output ON (Operate) status.

4.2.13 SELECT Key (Numeric Item Selection)

Selects either item when there are two numeric items to be set such as current limit.

4.2.14 STANDBY Key (Output OFF)

Sets the voltage output status to Standby (output unit relay OFF).

4.2.15 SUSPEND Key (Output OFF)

Sets the voltage output status to Suspend.

Suspend status:

While the output unit relay is set to ON, the voltage source value is 0 V and the current limit is set to the setting value or minimum value in the setting range.

4.2.16 SWEEP STOP Key (Sweep Stop)

Stops the sweep operation in the sweep source mode.

4.2.17 TRIGGER Key (Measurement Trigger and Sweep Start)

DC source mode:

When the sampling is set to AUTO, this key is ignored.

When the sampling is set to HOLD (the **HOLD** key goes ON), this key functions as measurement trigger key.

Sweep source mode:

When the sampling is set to AUTO, this key functions as sweep start key.

When the sampling is set to HOLD (the **HOLD** key goes ON), this key functions as sweep step trigger key.

4.2.18 UP Key (Voltage Source Range Up or Current Limit Range Up)

Raises the voltage source range or the current limit range by one.

4.2.19 UP Key (Measurement Range Up)

Raises the external voltage measurement range or the reference cell current range by one.

5. OPERATIONAL DESCRIPTIONS

5.1 Connection of Sample

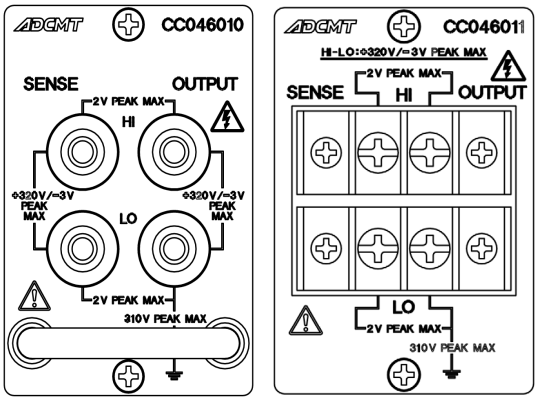
For the connections to solar cells to be tested and sensors, see Figure 1-1.

5.1.1 Connection with Output Unit

The output terminal unit can be mounted on either the front or rear panel.

The following figure shows the safety socket terminal output unit CC046010 and the terminal block output unit CC046011.

The output unit employs a four-terminal configuration. Connect the sample to the output unit so that SENSE and OUTPUT are connected on the sample terminals.



CC046010 applicable plug:

Product equivalent to Multi-Contact safety plug ϕ 4

CC046011 applicable connector:

Product equivalent to JST Mfg. spade tongue terminal V2-S3A

Figure 5-1 Output Unit

When the cable wiring is long (1 m or longer), connect the sample using twisted pair cables to reduce cable inductance that may cause response delay as shown in Figure 5-2 (A).

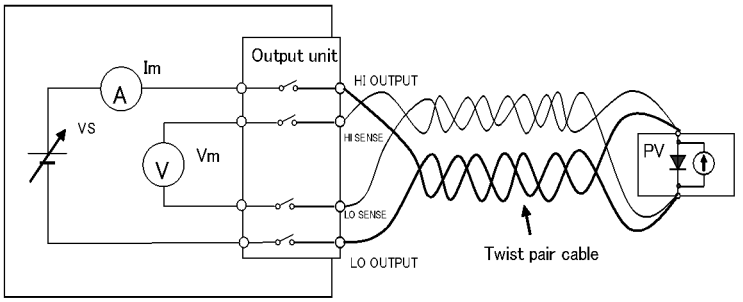
In addition, for micro current (1 μA or less) measurement, use shielded twisted pair cables as shown in Figure 5-2 (B).

CAUTION:

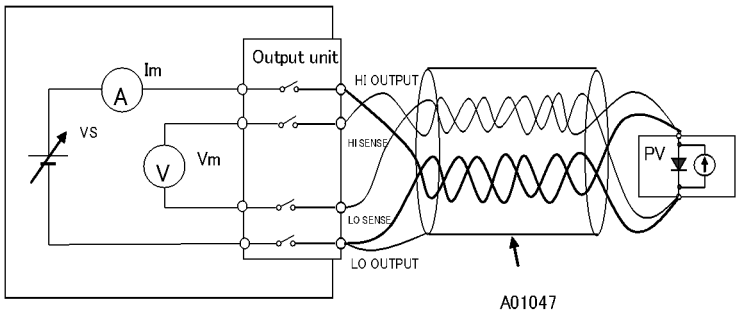
1. ***When the output units are mounted on both the front and rear panels, operations will not be guaranteed.***
2. ***The output unit is equipped with surge arrestors for electrostatic protection. Consequently, the dielectric strength between each output terminal and the protective earth depends on its surge arrester. Repeated discharge causes the surge arresters to deteriorate.***

WARNING: ***Do not connect an external power supply or other devices to the output unit when the 4601 is in the Operate status. It may result in electric shock. Otherwise, the life of the relay in the output unit may be shortened significantly.***

Twist pair cables are connected to HI OUTPUT and LO OUTPUT and to HI SENSE and LO SENSE in pairs respectively. The wire size is determined depending on the current value used on the OUTPUT side. Table 5-1 below shows the allowable current value and its corresponding wire size.



(A) Wiring Using Twisted Pair Cables



(B) Wiring Using Shielded Twisted Pair Cables

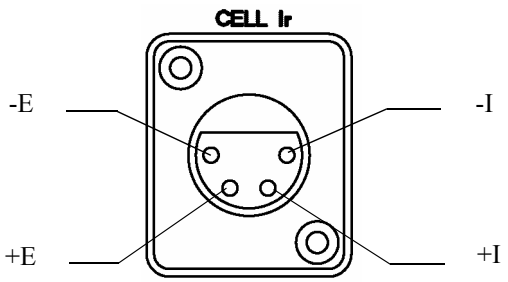
Table 5-1 Allowable Current Value and Wire Size

Current value	Wire (AWG)
Up to 500 mA	24
Up to 2 A	22
Up to 3.2 A	18
Up to 5 A	16
Up to 10 A	14

Figure 5-2 Connection with Output Unit

5.1.2 Reference Cell Measurement Terminal

The following figure shows the terminal to measure the reference cell current.



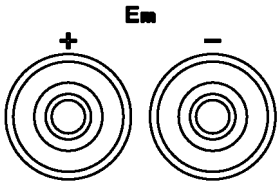
Applicable plug:

Product equivalent to HIROSE ELECTRIC HA316P-4S (71)

Figure 5-3 Reference Cell Measurement Terminal

5.1.3 External Voltage Measurement Terminal

The following figure shows the terminal to measure voltage.



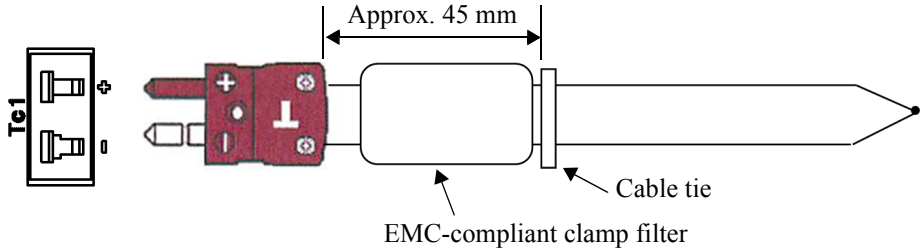
Applicable plug:
Product equivalent to Multi-Contact safety plug ϕ 4

Applicable cable:
Cable A01044
Alligator clip adapter A08532

Figure 5-4 External Voltage Measurement Terminal

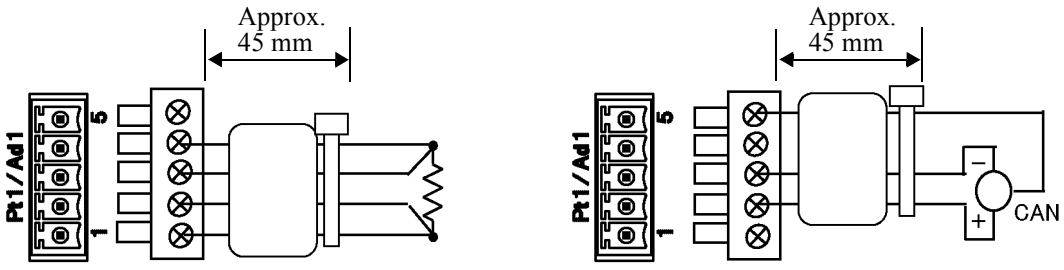
5.1.4 Temperature Measurement Terminal

Figure 5-5 shows the thermocouple connector and Figure 5-6 shows the connector for the platinum resistance bulb and the IC sensor AD590.
Supplied plugs: JCE-DA0002PX02 and JCS-RB0005JX03 (cover: YEE-1000734) are used.
When connecting a cable to the thermocouple connector Tc1 or Tc2, the platinum resistance bulb connector Pt1 or Pt2, or the IC sensor connector Ad1 or Ad2, attach the EMC-compliant clamp filter as shown in Figure 5-5 or Figure 5-6.



Plug: JCE-DA0002PX02 (Product equivalent to LABFACILITY IM-T-M)

Figure 5-5 Thermocouple Connector



(a) Pt Connection (b) AD590 Connection

Plug: JCS-RB0005JX03, YEE-1000734
(Product equivalent to PHOENIX CONTACT MC1, 5/5-ST-3, 81 or KGG-MC1, 5/5)

Figure 5-6 Platinum Resistance Bulb and IC Sensor Connector

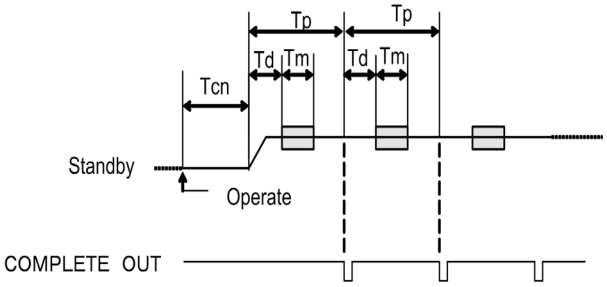
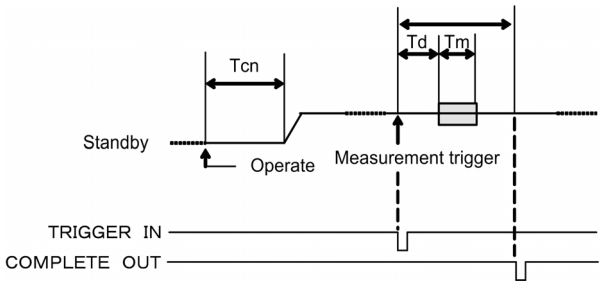
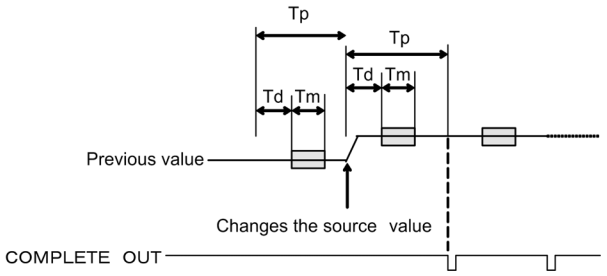
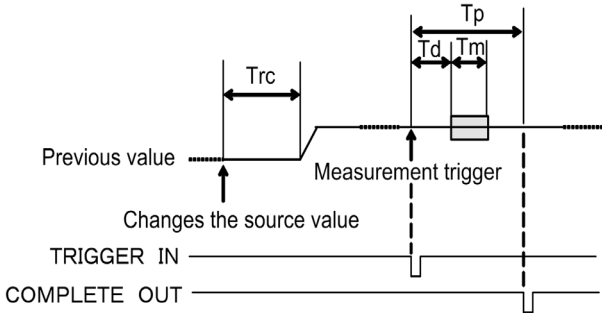
5.2 Source Mode

This section describes the basic operations and timing of the DC source mode and the sweep source mode.
The 4601 has two source modes: the sweep source mode that allows easy acquisition of PV I-V characteristic curves, and the DC source mode that allows checking of system connections or device operations.
For more information on the source function (Operate, Standby and Suspend) and the measurement function (measurement function and measurement data memory), refer to Section 5.3, "Source Measurement Function."

5.2.1 DC Source Mode

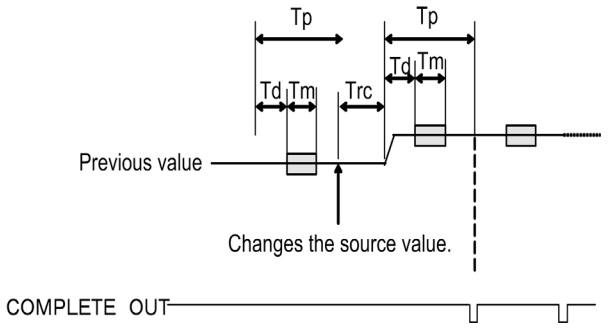
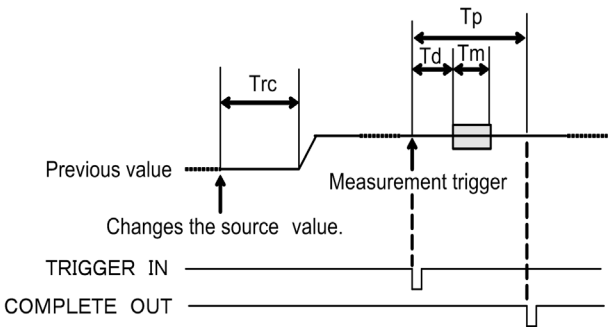
The following table shows the operational descriptions of the DC source mode.

Table 5-2 Operations in DC Source Mode (1 of 2)

<table>
<tr><th>Operational condition</th><th>Sampling</th><th>Description</th><th>Operation</th><th>Remarks</th></tr>
<tr><td rowspan="2">Operate ON</td><td>AUTO</td><td>Executes continuous measurement with the setting period time Tp.</td><td> 
</td><td rowspan="2">Tp: Period time
Td: Measurement delay time
Tds: Source delay time
Tm: Measurement time (Integration time + Measurement data processing time)
Tcn: Operate processing time
Trc: Range change processing time</td></tr>
<tr><td>HOLD</td><td>Executes measurement by trigger input.</td><td> 
</td></tr>
<tr><td rowspan="2">Changing the source value</td><td>AUTO</td><td rowspan="2">Source value changing does not induce range changing.</td><td> 
</td></tr>
<tr><td>HOLD</td><td> 
</td></tr>
</table>

5.2.1 DC Source Mode

Table 5-2 Operations in DC Source Mode (2 of 2)

Operational condition	Sampling	Description	Operation	Remarks
Changing the source value	AUTO	Source value changing induces range changing.		Tp: Period time Td: Measurement delay time Tds: Source delay time Tm: Measurement time (Integration time + Measurement data processing time) Tcn: Operate processing time Trc: Range change processing time
	HOLD			

a. When the sampling is set to AUTO:
- Measurement repeats itself with the specified period time.
- The period time is extended if measurement does not finish within the period time.

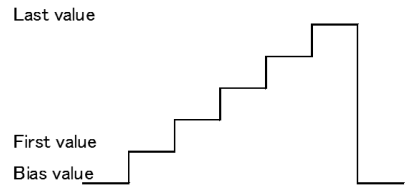
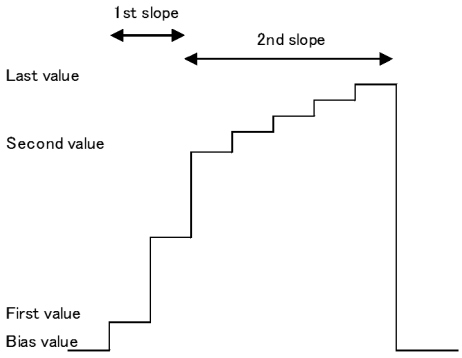
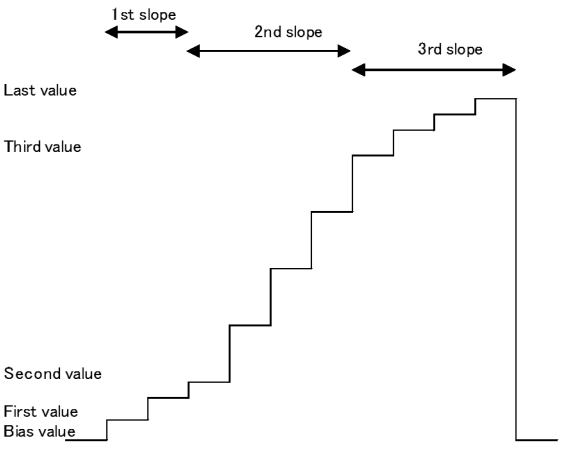
b. When the sampling is set to HOLD:
- Measurement starts when the measurement delay time has passed after trigger input.
- Trigger input during measurement is ignored.

c. When the output status is Standby or Suspend:
- Measurement is not executed during Standby or Suspend.

5.2.2 Sweep Source Mode

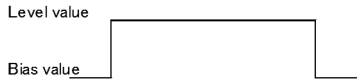
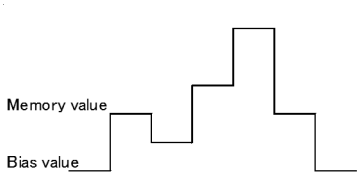
There are the following types of the sweep source mode: linear sweep for simple source measurement, 2-slope linear sweep and 3-slope linear sweep that allow fine-step source measurement at necessary points, fixed level sweep that sweeps a constant value the specified number of sample count, and memory sweep that sweeps arbitrary values stored in the memory from the start address to the stop address.
In addition, the 4601 has the reverse function that can switch between one-way sweep and round sweep.
The following table shows the operational descriptions of the sweep source mode with reverse OFF (one-way sweep).

Table 5-3 Operational Descriptions of Sweep Source Mode (1 of 2)

Sweep type	Operational description	Waveform
Linear sweep 1SWP	Sweeps by staircase waveforms of the step count between the first value and the last value.	
2-slope linear sweep 2SWP	Sweeps by staircase waveforms of the 1st step count between the first value and the second value, and sweeps by staircase waveforms of the 2nd step count between the second value and the last value.	
3-slope linear sweep 3SWP	Sweeps by staircase waveforms of the 1st step count between the first value and the second value, sweeps by staircase waveforms of the 2nd step count between the second value and the third value, and sweeps by staircase waveforms of the 3rd step count between the third value and the last value.	

5.2.2 Sweep Source Mode

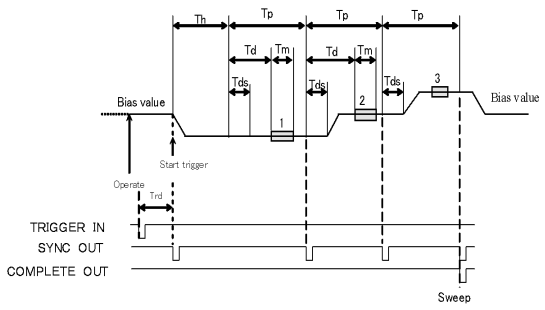
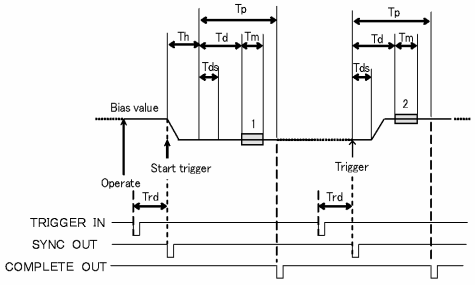
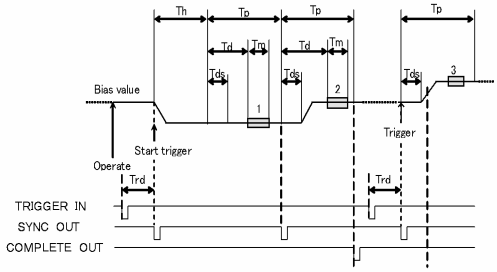
Table 5-3 Operational Descriptions of Sweep Source Mode (2 of 2)

Sweep type	Operational description	Waveform
Fixed level sweep fSWP	Sweeps the specified constant value the specified number of sample count.	
Memory sweep mSWP	Sweeps the source values stored in the memory from the start address to the stop address.	

1. Sweep type setting
   - Select SWP with the **MODE** key.
   - Select B) SWEEP with the **MENU** key.
     From the parameters in 1) Sweep Type, select *1-Slope Linear, 2-Slope Linear, 3-Slope Linear, Fixed Level or Memory* for each sweep type.

The following table shows the source and measurement timings in the sweep source mode with reverse OFF (one-way sweep).

Table 5-4 Source Measurement Operations in Sweep Source Mode

Operational condition	Sampling	Description	Operation	Remarks
Operate ON	AUTO	Executes continuous measurement with the setting period time Tp.		Th: Hold time Tp: Period time Td: Measurement delay time Tds: Source delay time Tm: Measurement time (Integration time + Measurement data processing time) Tcn: Operate processing time Trd: Trigger delay time
	HOLD	Executes measurement by trigger input. The step count per trigger is 1.		
		Executes measurement by trigger input. The step count per trigger is other than 1.		

- The bias value is output before sweep start.
- The start value is output when the start trigger is input.
- Sweep starts when the hold time has passed after start trigger input.
- As for external trigger input, the trigger is enabled when the trigger delay time has passed.
- When the sampling is AUTO, the sweep step changed with the period time.
- When the sampling is HOLD, the sweep step operates by every trigger input.

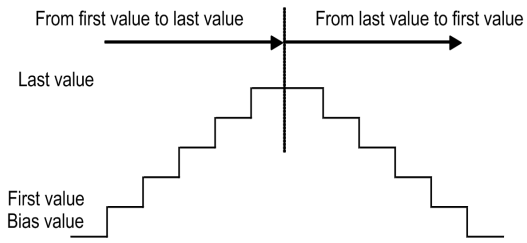
5.2.3 Reverse Function

Turning ON or OFF the reverse function switches the sweep operation between one-way sweep and round sweep.

Reverse OFF: One-way sweep

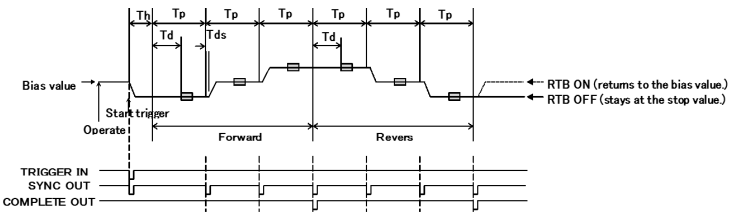
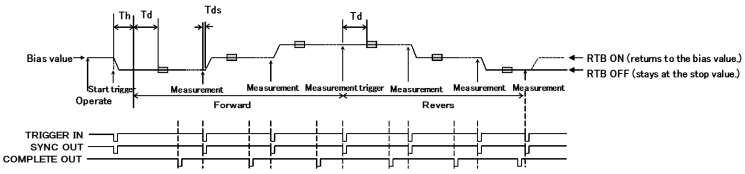
Reverse ON: Round sweep

The sweep operation of the linear sweep is described below.

Sweep type	Operational description	Waveform
Linear sweep ***1SWP***	Sweeps by staircase waveforms of the step count between the first value and the last value. When reaching the last value, sweeps in the same way from the last value to the start value.	

Other sweep types also sweep from the last value to the first value when reaching the last value in the same way with reverse ON.
The following table shows the source and measurement timings in the sweep source mode with reverse ON (round sweep).

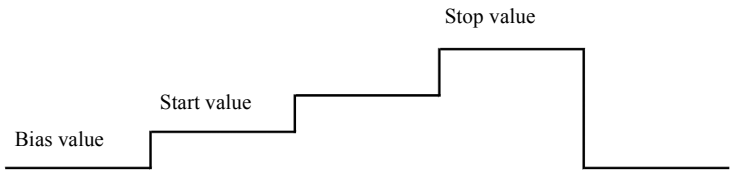
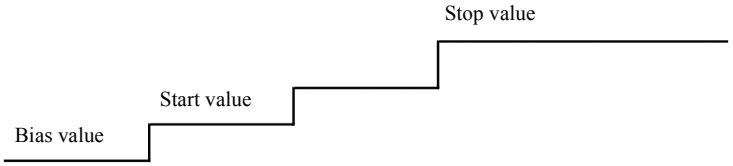
Table 5-5 Reverse Operations in Sweep Source Mode

Operational condition	Sampling mode	Operation	Remarks
Sweep source	AUTO		Th: Hold time Tp: Period time Td: Measurement delay time Tds: Source delay time Tm: Measurement time (Integration time + Measurement data processing time) Tcn: Operate processing time
	HOLD		

5.2.4 Output at Sweep End

The output value at the sweep end can be switched by setting RTB.

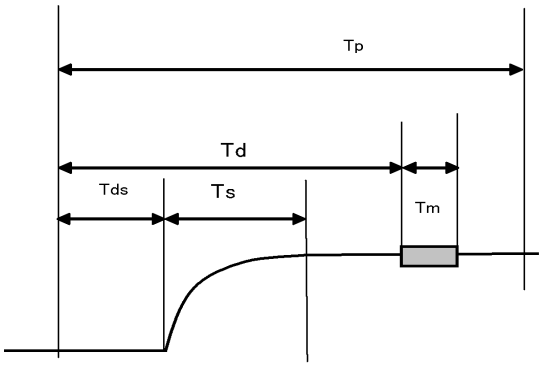
Return to Bias

RTB	Waveform	Description
ON		Returns to the bias value at the sweep end.
OFF		Holds the stop value at the sweep end.

5.2.5 Source and Measurement Timings

5.2.5.1 Basic Source and Measurement Timings

The following figure shows the basic timings of voltage source and voltage and current measurements.



Tp:	Measurement cycle in the DC source mode Step cycle in the sweep source mode
Tds:	Source delay time
Ts:	Settling time
Td:	Measurement delay time
Tm:	Measurement time Tm=Tit+Tk
Tit:	Integration time
Tk:	Measurement data processing time

Figure 5-7 Basic Source and Measurement Timings

- Set the measurement delay time Td longer than the settling time Ts to obtain stable measured values.
  Ts < Td

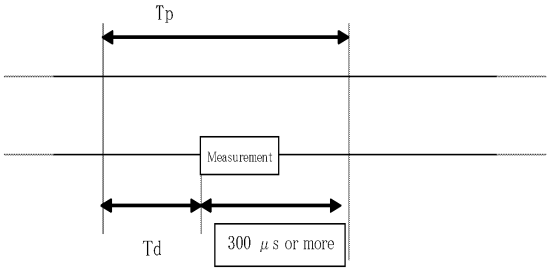
5.2.5.2 Restrictions on Time Parameters

The time parameters impose setting restrictions on each other. If any restriction is ignored in setting, an error message appears in the Operate or Suspend status.

1. Setting restrictions

- (Measurement delay time (Td) + 300 μs) < Period time (Tp)

  Condition) Source mode: DC mode



- Period time (Tp) ≥ 10 ms

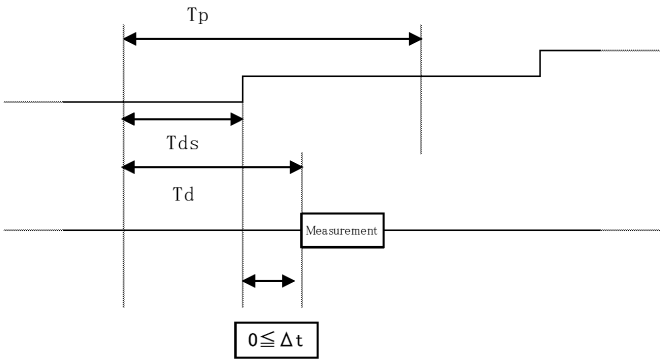
  Condition) Source mode: DC mode

NOTE:

- ***If the period time is less than 10 ms when the source mode is switched from the sweep mode to the DC mode, the period time is changed to 10 ms.***
- ***When the source mode is restored from the DC mode to the sweep mode, the original period time is set. However, if the period time is set in the DC mode, the setting value does not change when the source mode is switched to the sweep mode.***

- Source delay time (Tds) ≤ Measurement delay time (Td)

  Condition) Source mode: Sweep mode

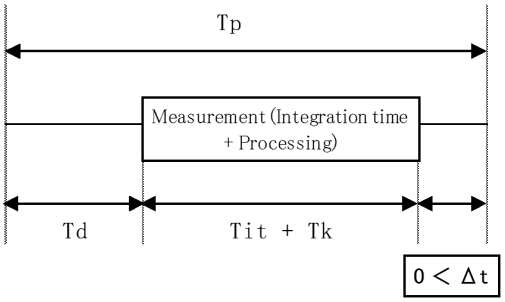


- Period time (Tp) ≥ 200 μs

  Condition) Source mode: Sweep mode
  Sampling: HOLD

- Measurement delay time (Td) + Integration time (Tit) + AD processing time (Tk) < Period time (Tp)

  Condition) Source mode: DC sweep mode



Integration time	Tit Time [ms]		Tk time [ms]	Tit+Tk [ms]	
	50 Hz	60 Hz		50 Hz	60 Hz
5 μs	0.005		0.013	0.018	
10 μs	0.01		0.017	0.027	
25 μs	0.025		0.027	0.052	
50 μs	0.05		0.045	0.095	
100 μs	0.1		0.08	0.18	
250 μs	0.25		0.04	0.29	
500 μs	0.5		0.04	0.54	
1 ms	1		0.04	1.04	
2.5 ms	2.5		0.04	2.54	
5 ms	5		0.04	5.04	
10 ms	10		0.04	10.04	
1 PLC	20	16.666	0.04	20.04	16.706
2 PLC	40	33.333	0.04	40.04	33.373
100 ms	100		0.04	100.04	
200 ms	200		0.04	200.04	

2. Relation between setting restrictions and source modes

   The following table shows the setting restrictions to be checked according to the source mode.

Setting restriction	Source mode/Sampling		
	DC	SWP/AUTO	SWP/HOLD
[(Td+300 μs) < Tp]	✓	-	-
[10 ms ≤ Tp]	✓	-	-
[200 μs ≤ Tp]	-	-	✓
[Tds ≤ Td]	-	✓	✓
[(Td+Tit+Tk) < Tp]	-	✓	✓

3. Source delay time and measurement delay time

   The setting resolutions of the source delay time and the measurement delay time are determined by the period time resolution. The source delay time and the measurement delay time operate with the rounded off values.

   (The setting values are displayed on the screen.)

Period time setting range	Resolution
0.050 ms to 60.000 ms	1 μs
60.01 ms to 600.00 ms	10 μs
600.1 ms to 6000.0 ms	100 μs

The following table shows the minimum setting value for each resolution.

Time parameter	Period time resolution		
	1 μs	10 μs	100 μs
Source delay time (Tds)	10 μs	20 μs	200 μs
Measurement delay time (Td)	20 μs	20 μs	200 μs

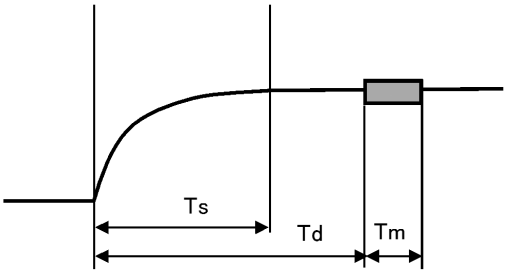
5.2.6 Settling Time

The settling time for voltage source varies depending on the response switching.

The stability of output voltage or current varies depending on the cable inductance or device capacitance. Also, the slower the response is, the more the output voltage or current is stabilized.

However, slow response makes the total throughput slow, too.

Thus, the response needs to be set in consideration of the actual cable wiring, the device characteristics and the required measurement speed.



Ts: Settling time
Td: Measurement delay time
Tm: Measurement time

Figure 5-8 Settling Time and Measurement Delay Time

This section describes how to calculate the 4601 settling time with a pure resistance load (CL < 10 pF).

The settling time Ts is calculated using the time constant τp that is determined by the voltage source range and the response time, the slew rate Sr and the source voltage change ΔVs as follows:

$Ts = \Delta Vs/Sr + \alpha \times \tau p$ [μs]

ΔVs: Source voltage change [V]

Sr: Slew rate [μs]

α: Coefficient determined by the error (%) from the final value

10% : 2.3

1% : 4.6

0.1% : 6.9

τp: Time constant [μs]

5.2.6 Settling Time

Condition:

When the response is fast or Ext.fast, Sr and τp used in the settling time formula vary depending on the source voltage change ΔVs and its maximum value ΔVs max as follows.

ΔVs ≤ ΔVs max: Use values in column ① for Sr and τp.

ΔVs > ΔVs max: Use values in column ② for Sr and τp.

When the response is slow or medium, Sr and τp do not depend on ΔVs and ΔVs max.

ΔVs max [V] (IL: 3mA to 10A range)

Current limit count value D	Response			
	slow	medium	fast	Ext.fast
1000 to 3200	-	-	50	36
600 to 1000	-	-	0.075×(D-600)+20	0.054×(D-600)+14
30 to 600	-	-	0.033×D	0.024×D

Sr [μs]

Range	Response					
	slow	medium	fast		Ext.fast	
			①	②	①	②
5 V	0.1	0.1	0.35	0.1	1.1	0.1
50 V	0.1	0.35	1.1	0.35	1.1	0.35
300 V	0.1	0.35	1.1	0.35	1.1	0.35

τp [μs]

Range	Response					
	slow	medium	fast		Ext.fast	
			①	②	①	②
5 V	51	23	5.5	23	5.5	23
50 V	60	34	17	34	10.1	34
300 V	65	34	20	34	9.1	34

Example 1) Voltage source range: 5 V, current limit range: 3 A, current limit value: 100 mA, response: Ext.fast
As the current limit count value D is 100, ΔVs max=0.024 × 100=2.4[V].
Settling time until the source voltage enters within an error of 10% when changing by 1 V:

Ts = 1/1.1 + 2.3 × 5.5 = 13.6 [μs]

Example 2) Voltage source range: 300 V, current limit range: 300 mA, current limit value: 100 mA, response: slow
As the response is slow, there is no condition on ΔVs max.
Settling time until the source voltage enters within an error of 0.1% when changing by 5 V:

Ts = 5/0.1 + 6.9 × 65 = 499 [μs]

NOTE:

- ***To shorten the settling time, set the current limit to 1000 counts or more and the minimum source voltage change ΔVs.***
- ***Set the response to medium or slow in the current limit 300 μA range.***
- ***Set the measurement delay time Td longer than the above settling time Ts.***
  Td ≥ Ts
  Set the period time Tp from the measurement delay time Td, the integration time Tit and the AD processing time Tk as follows: (Refer to Section 5.2.5, "Source and Measurement Timings.")
  Tp ≥ Td + Tit + Tk

5.3 Source Measurement Function

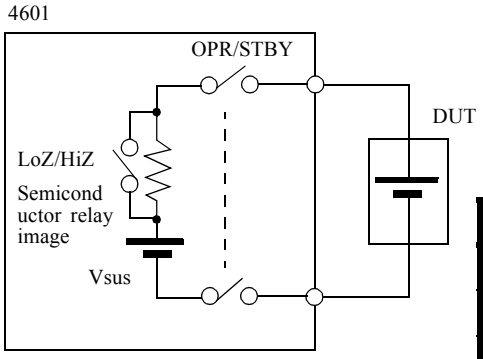
5.3.1 Source Range

When the optimal range for voltage source is selected (the **FIT** key goes ON) in the DC source mode, the range is determined according to the following list:

Source function	Setting value	Range
Voltage source	0 V≤ | Vs | ≤ 5.0000 V 5.0000 V < | Vs | ≤ 50.000 V 50.000 V < | Vs | ≤ 300.00 V	5 V 50 V 300 V

5.3.2 Suspend Function

The 4601 can select from three output statuses; Standby (output relay OFF), Suspend HiZ (output relay ON and high resistance), and Suspend LoZ (output relay ON and low resistance).
The suspend function is available in both the DC source mode and the sweep source mode.
Using this function can reduce unnecessary relay ON/OFF action of the output unit, which reduces deterioration of the throughput due to relay operation time and improve the life of the relay.
Therefore, setting in the Suspend status is recommended whenever turning OFF the output to change the measurement condition.
The following figure shows a conceptual diagram of output status.



Vsus: Output voltage in Suspend (0 V)
LoZ/HiZ: Output resistance switching in Suspend status
OPR/STBY: Operate/Standby switching relay

Range	Suspend (LoZ, HiZ) source accuracy
5 V	±1 mV
50 V	±10 mV
300 V	±100 mV

Output OFF status	Output relay	Output status	Setting current limit value
LoZ	ON	Vsus, low resistance	Setting current limit (IL)
HiZ	ON	Vsus, high resistance	Minimum value in the setting current limit range (30 digits)
STBY	OFF	Open	-

Figure 5-9 Conceptual Diagram of Output Status

1. Operation
   1. Standby status

      Pressing **STANDBY** sets the output status to Standby.
      The 4601 is securely isolated from the DUT.
   2. HiZ Suspended status

      Pressing **SUSPEND** sets the output status to Suspend. The **SUSPEND** key goes ON.

      This is the status for the LoZ/HiZ switch OFF with the OPR/STBY relay ON.

      Vsus voltage (0 V) is output in the Suspend status.

      As the output status is high resistance, it rarely affects the DUT.
   3. LoZ Suspended status

      LoZ Suspend status is the same as HiZ Suspend status except that the output status is low resistance.

      This status is effective in setting the DUT to low impedance status when the output is OFF.

      The output response speed is faster because the limit value does not change in the Operate status.
   4. Current limit in Suspend

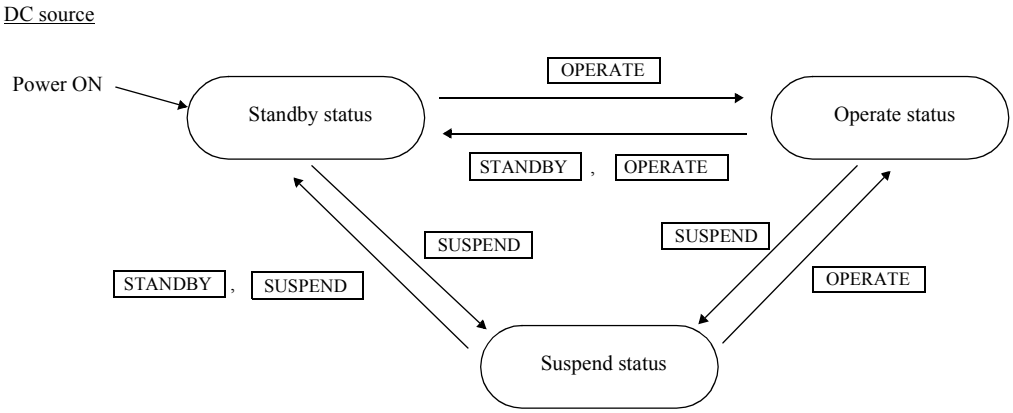
      The output in the Suspend status is always 0 V. The current limit is set to the values shown in Figure 5-9, "Conceptual Diagram of Output Status."
2. Setting Suspend conditions

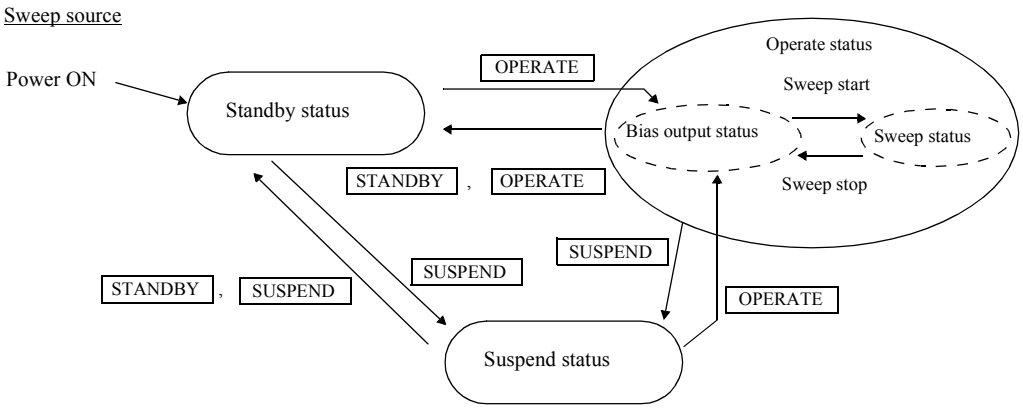
   Setting the output resistance in the Suspend status

   Select **A) SOURCE → 3) Suspend Z** on the menu screen.

   High Impedance: High resistance output status
   The current limit values are set to 30 digits in the setting range.

   Low Impedance: Low resistance output status
   The setting current limit values are applied.
3. Shifting between Operate, Standby, and Suspend





NOTE: ***The source data during sweeping is generated with the following timing.***
1. Standby → Operate
2. Standby → Suspend
3. When Operate is set after changing the sweep parameters in the Suspend status

4. Switching between Suspend and Operate

The sweep data of the 4601 is created basically when the output status is switched from Standby to Operate or Suspend.
It takes time to create the sweep data because values at each step are calculated and the source values are saved in the memory.
It takes longer to switch between Standby and Operate because relay ON/OFF operations are required.
To reduce time and delete these unnecessary relay ON/OFF operation, the output status is switched between Suspend and Operate.
The source values are not calculated when the output status is switched from Suspend to Operate unless the sweep parameters are changed. However, the source values are recalculated when any of the following items is changed:

① Sweep type

② Sweep range

③ First value/second value/third value/last value

④ Sweep step value

⑤ Start address/stop address

⑥ Level value

⑦ Sample count

5. Effective operations in each status are described below.

Status		Effective operation
Operate		Measurement
Suspend	HiZ	Device replacement
	LoZ	Measurement stop. The output status is as follows: Sweep mode: 0 V in the bias range DC mode: 0 V in the setting voltage range
Standby		Disconnecting electrically the he device from the 4601

5.3.3 High Voltage Indicator Lightning Condition

When the 4601 generates 55 V or higher or its source condition is set, the High Voltage indicator goes ON.

<table>
<tr><td colspan="3">DC mode</td><td colspan="3">Sweep mode</td></tr>
<tr><td>Standby</td><td>Suspend</td><td>Operate</td><td>Standby</td><td>Suspend</td><td>Operate</td></tr>
<tr><td colspan="3" rowspan="2">55 V ≤ Source value</td><td colspan="3">55 V ≤ Bias value</td></tr>
<tr><td colspan="2"></td><td>55 V ≤ Sweep value</td></tr>
</table>

5.3.4 Measurement Function and Range

As the 4601 includes three AD converters (ADC1 to ADC3), it can measure three points simultaneously. The three measurement points are shown below, and among which ADC3 has eight measurement functions.
The ADC3 function is selectable from the eight functions in the DC source mode; however it is fixed to reference cell current measurement Ir in the sweep source mode.

1. ADC1: Output voltage measurement Vm
2. ADC2: Output current measurement Im
3. ADC3: Reference cell/external voltage/temperature measurement
   - Ir : Reference cell current measurement
   - Em : External voltage measurement
   - Tc1 : Ch1 T-type thermocouple measurement
   - Pt1 : Ch1 resistance bulb (Pt) temperature measurement
   - Ad1 : Ch1 IC sensor AD590 temperature measurement
   - Tc2 : Ch2 T-type thermocouple measurement
   - Pt2 : Ch2 resistance bulb (Pt) temperature measurement
   - Ad2 : Ch2 IC sensor AD590 temperature measurement

Ir Reference cell current measurement range

Range	Measurement range *	Measurement resolution
3 mA	0 to ±3.19999 mA	10 nA
30 mA	0 to ±31.9999 mA	100 nA
300 mA	-32.000 mA to ±319.999 mA	1 μA

*: The polarities of measured values are represented as "+" for sink and as "-" for source.

Em External voltage measurement range

Range	Measurement range	Measurement resolution
30 mV	±31.9999 mV	0.1 μV
300 mV	±319.999 mV	1 μV
3 V	±3.19999 V	10 μV

5.3.5 Spot Measurement

The spot measurement operates only in remote control (GPIB/USB) and not by using the keys.
This function returns measured data when recognizing specified commands regardless of the source mode and Operate/Suspend/Standby.
The integration time for measurement can be set separately from the integration time for sweep.

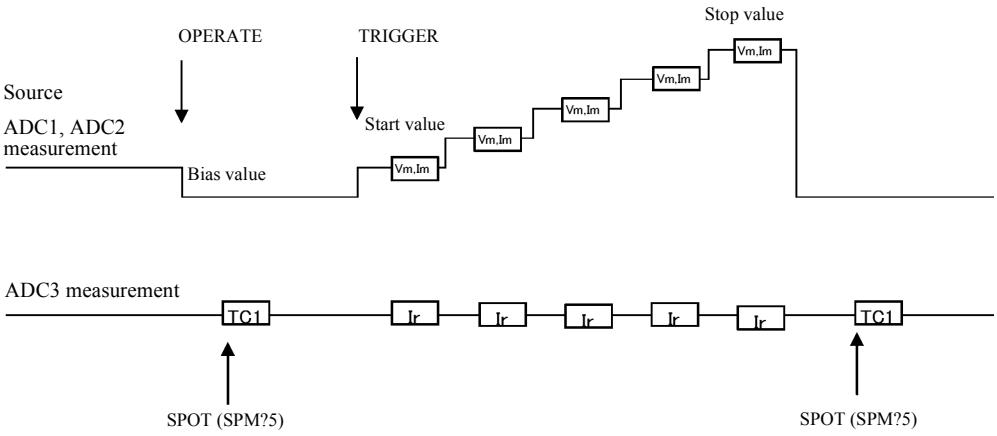
AD converter	Measurement function	Command
ADC1	Output voltage measurement Vm	SPM?1
ADC2	Output current measurement Im	SPM?2
ADC3	Reference cell/external voltage/temperature measurement	
	Ir: Reference cell current measurement	SPM?3
	Em: External voltage measurement	SPM?4
	Tc1: Ch1 T-type thermocouple measurement	SPM?5
	Pt1: Ch1 resistance bulb (Pt) temperature measurement	SPM?6
	Ad1: Ch1 IC sensor AD590 temperature measurement	
	Tc2: Ch2 T-type thermocouple measurement	SPM?8
	Pt2: Ch2 resistance bulb (Pt) temperature measurement	SPM?9
	Ad2: Ch2 IC sensor AD590 temperature measurement	

NOTE: ***ADC3 spot measurement returns to the previous measurement status after the specified function is measured.***
(It returns to the Ir function in the sweep mode.)

Example of use (in the sweep mode)

As for I-V characteristic measurement of solar cells, temperature measurement is performed before and after I-V measurement with the output status kept in Operate.

In ADC3 measurement, temperature measurement Tc1 is performed before and after sweep and reference cell current measurement Ir is performed during sweep.



5.3.6 Zero Measurement

Zero measurement is a function that measures analog common voltage and cancels the offset errors of the AD converters automatically.
Execute zero measurement once after warm-up.

1. Types of zero measurement
   Types of AZ data (excluding the integration time)

No.	ADC	Function		Range	Zero code
1	① ADC1	Vm	Voltage measurement	5 V-300 V	AZ10
2	② ADC2	Im	Current measurement	300 μA-10 A	AZ20
3	③ ADC3	Ir	Current measurement	3 mA-300 mA	AZ30
4		Em	Voltage measurement	30 mV	AZ31
5				300 mV	AZ32
6				3 V	AZ33
7		Tc1,Tc2	Temperature measurement	54 mV	AZ34

   AZ data to be used (excluding the integration time)

No.	ADC	Function		Range	Zero code
1	① ADC1	Vm	Voltage measurement	5 V-300 V	AZ10
2	② ADC2	Im	Current measurement	300 μA-10 A	AZ20
3	③ ADC3	Ir	Current measurement	3 mA-300 mA	AZ30
4		Em	Voltage measurement	30 mV	AZ31
5				300 mV	AZ32
6				3 V	AZ33
7		Tc1	Temperature measurement	55 mV	AZ34
8		Tc2	Temperature measurement	55 mV	AZ34
9		Ad1	Temperature measurement	3 V	AZ33
10		Ad2	Temperature measurement	3 V	AZ33

2. Timing of zero measurement

   ① Zero measurement is performed when being specified by the ZM command or menu operation (Refer to E) MEASURE in Section 4.2.10).

   ② Zero measurement is performed internally when the integration time or measurement function range is changed or spot measurement is performed.

5.3.7 Measurement Data Memory

The measurement data memory can store up to 4000 data for each measurement types: ADC1, ADC2 and ADC3 (in the DC mode, or in the sweep mode with reverse ON). When the memory runs out, memory storing stops and the MFL bit of the status register is set to ON.

In the DC mode, the memory store function turns ON by selecting **E) MEASURE** from the categories in the menu and setting **2) Memory Store** to **ON**.

The measurement memory contents are automatically cleared when **2) Memory Store** is switched from **OFF** to **ON**.

In the sweep mode, the memory store function automatically turns ON and cannot be turned OFF.

In the sweep mode, the measurement memory contents are cleared by trigger input. Also, no measured values are stored in the memory if sweep is paused or stopped.

To clear the memory, execute **3) Memory Clear**.

The following shows the procedure of reading the memory.

① Press [MENU] . The **MENU** key goes ON.

Example display

```
MENU                    A) SOURCE
        J) SYSTEM←                  →B) SWEEP
```

② Press [⇨] four times to show the following display.

Example display

```
MENU                    E) MEASURE
        D) TIME←                    →F) EXT. SIGNAL
```

③ Press [⇩] .

Example display

```
        E) MEASURE          1) Memory Recall
        ■□□□□□□□□           0031/4000
```

④ Press [⇩] .

Example display

```
RCL     No. 0030                    Im: +000.001mA
        Vm: +0.00200 V              Ir: +000.001mA
```

⑤ Specify the memory address to call the measured value at each step by using the rotary knob or numeric keypad.

Example display

⑥ Press MENU .

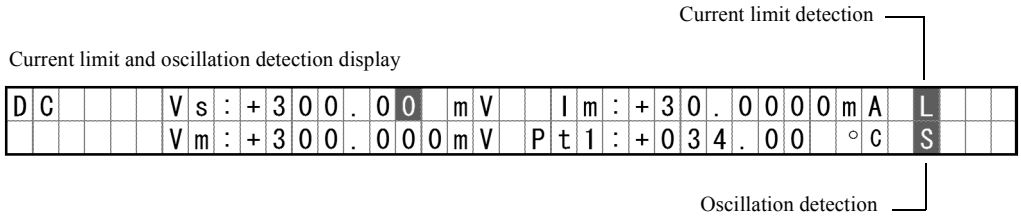
The **MENU** key goes OFF and the memory read status is complete.

5.4 Alarm Detection

5.4.1 Current Limit Detection

When the output current reaches the setting current limit value, the current limit is detected.

The current limit alarm is detected at the same time of measurement and displayed with the measured values.



5.4.2 Oscillation Detection

The output may oscillate under the influence of the device capacitance or cable inductance.

The 4601 detects such an oscillation by its output terminals and internal circuits and displays an alarm with measured values.

If the oscillation is detected, slow the response so that the output does not oscillate. Then, change the measurement delay timing or other timings and perform measurement.

The oscillation is detected in the range between 1 KHz and 1 MHz approximately.

The following list shows the sensitivity of oscillation detection.

Table 5-6 Oscillation Detection Sensitivity

Frequency	100 Hz	1 kHz	10 kHz	100 kHz	1 MHz	10 MHz
Detection sensitivity [mVp-p]	-	70	50	50	400	-

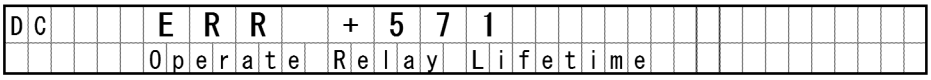
5.4.3 Relay Life Cycle Detection

The 4601 stores the relay ON/OFF operations of the output unit, and generates an alarm when the relay life cycle is reached.

Every time the output relay in the output unit is switched, the relay counter value increments. If the value has reached 1,000,000 times or more when the self test is executed or the output status is set to Standby, an error is displayed.

The 4601 operates normally even if this alarm is displayed, however measurements are not guaranteed. Thus, when the alarm is displayed, replace the output unit.

For information on how to replace the output unit, refer to Section 1.3, "Output Unit."



The 4601 is equipped with ten relay counters to control multiple output units.

When using more than one output unit, change the counter select number at the time of output unit replacement.

The counter specified by the counter select number counts up, and its counter value is checked.

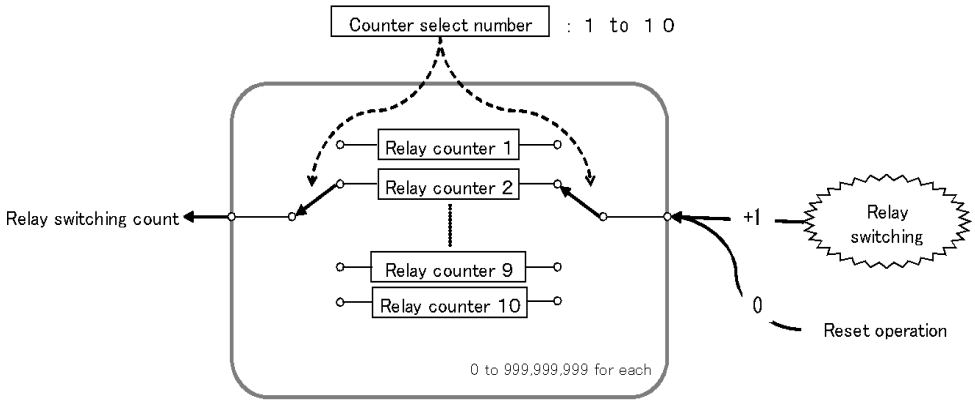


Figure 5-10 Relay Counter Structure

Each counter counts up to 999,999,999 maximum.

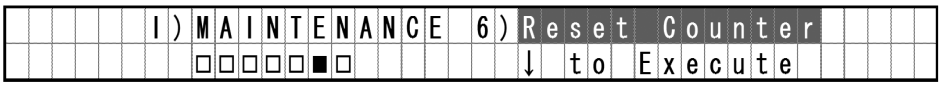
Each counter can be read out and reset from the menu or by using the remote control commands.

The relay counter is cleared according to the following procedure:

Operating procedure

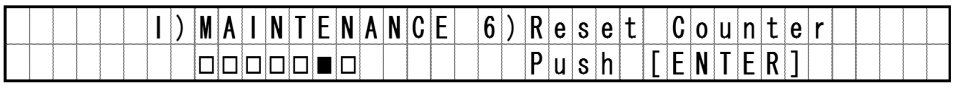
① Press MENU to select **1) MAINTENANCE** from the categories and **6) Reset Counter** from the parameter items.

Example display



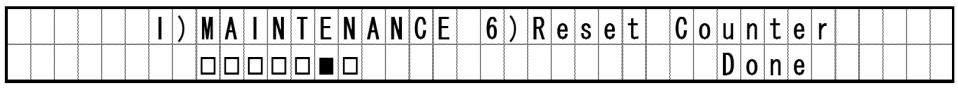
② Press ⇩ to move to the lower level.

Example display



③ Press ENTER to reset the relay counter.

Example display



④ Press MENU to exit the menu.

5.4.4 Other Alarm Detection

Other alarms are detected in the event of occurrence of abnormalities such as overvoltage or fan stop.
When any of these alarms is detected, the output turns OFF and is set to the Standby status.
In this case, turn the power OFF, disconnect the output cable, and turn the power ON again.
If the alarm is still generated, request a repair service.

Error code	Message	Detection timing	Description
+401	Fan Stopped	At any time	The rear panel fan stops.
+402	Over Heat	At any time	The temperature of the internal amplifier rises unusually.
+403	Booster Unit Error	At any time	A booster error occurs.
+404	Over Load	At any time	Overvoltage or overcurrent is applied from the outside, or an internal error occurs.
+405	Over Voltage	At any time	Overvoltage of +310 V or higher or -3 V or less is applied from the outside.

5.5 Rear Input and Output Signal

5.5.1 Contact Signal Input and Output

Optical semiconductor relay contact signals can be output arbitrarily to the contact input and output terminal (CONTACT IN/OUT), and the contact signal input ports can be read out.

<table>
<tr><th>Command</th><th>Description</th></tr>
<tr><td>DSOn,v</td><td>Contact signal output port setting
Select the output port by n (0 to 3) and the output status by v (0: Break, 1: Make).
<table>
<tr><th>n</th><th>Target</th><th>Output signal</th><th>Pin number</th></tr>
<tr><td>0</td><td>Output port 1</td><td>Relay contact</td><td>1-2</td></tr>
<tr><td>1</td><td>Output port 2</td><td>Relay contact</td><td>3-4</td></tr>
<tr><td>2</td><td>Output port 3</td><td>Relay contact</td><td>6-7</td></tr>
<tr><td>3</td><td>Output port 4</td><td>Relay contact</td><td>8-9</td></tr>
</table></td></tr>
<tr><td>DSO?n</td><td>Query of output setting
Response: DSO<n>,<v>
n: 0 to 3, v: 0 or 1</td></tr>
<tr><td>DSI?n</td><td>Contact signal input port reading
Select the input port by n (0 or 1).
<table>
<tr><th>n</th><th>Target</th><th>Output signal</th><th>Pin number</th></tr>
<tr><td>0</td><td>Input port 1</td><td>Contact input</td><td>11-12</td></tr>
<tr><td>1</td><td>Input port 2</td><td>Contact input</td><td>13-14</td></tr>
</table>
Response: 0 (Break) or 1 (Make)</td></tr>
</table>

Contact signal Input and Output Pins

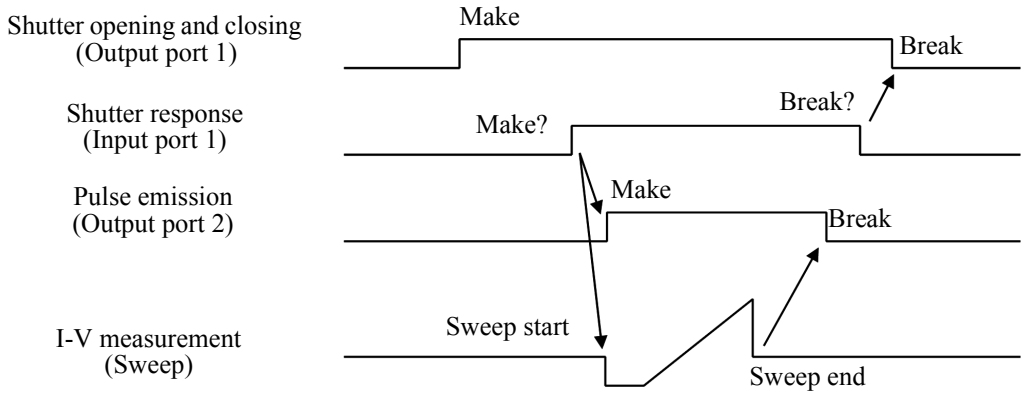
Pin No.	Signal name	Input/output	Target	Remarks
1	DGOUT1+	Output	Output port 1	Optical semiconductor relay contact output
2	DGOUT1-			
3	DGOUT2+	Output	Output port 2	Optical semiconductor relay contact output
4	DGOUT2-			
5	Not in use			
6	DGOUT3+	Output	Output port 3	Optical semiconductor relay contact output
7	DGOUT3-			
8	DGOUT4+	Output	Output port 4	Optical semiconductor relay contact output
9	DGOUT4-			
10	Not in use			
11	DGIN1+	Input	Input port 1	Contact input Pulled up to +5 V by 10 kΩ
12	DGIN1-			GND
13	DGIN2+	Input	Input port 2	Contact input Pulled up to +5 V by 10 kΩ
14	DGIN2-			GND
15	Not in use			

Optical semiconductor relay contact:

Allowable contact voltage (at Break)	30 V DC
Allowable contact current	120 mA DC
Voltage between contact and GND	30 V
Contact operation time	1 ms or less

4601-side connector:	D02-M15SAG-20L9	Receptacle with a socket contact (Japan Aviation Electronics Industry, Ltd.)
Destination connector:	D02-M15PG-N-F0	Housing, optional pin contact (Japan Aviation Electronics Industry, Ltd.)
	D02-22-22P-PKG100	Pin contact, #24 to #22 AWG (Japan Aviation Electronics Industry, Ltd.)
	D02-22-26P-PKG100	Pin contact, #28 to #26 AWG (Japan Aviation Electronics Industry, Ltd.)
	DE-C8-J9-F2-1R	Junction shell (Japan Aviation Electronics Industry, Ltd.)

Solar Simulator Operation Example



5.5.2 External Control Signals

These signals are I/O signals for synchronizing multiple units, scanner or DMM control, and other external controls.

The following table shows the signal names, levels and functions.

Table 5-7 External Control Signal Functions

Signal	Input/ Output	Level	Impedance	Function
TRIGGER IN	Input	TTL negative pulse (2 µs or more)	Approx. 10 kΩ	• Starts measurement in the DC source mode. • Starts the sweep source mode. • Steps up sweep.
COMPLETE OUT *1	Output	TTL negative pulse (10 µs or more) *3	Approx. 100 Ω open drain (Pulled up to +5 V by 10 kΩ)	• Measurement end and period end signal (DC source mode) • Sweep stop or end signal (sweep mode)
SYNC OUT *1	Output			• Step up signal in the sweep source mode
STBY IN *2	Input	TTL negative level	Approx. 10 kΩ	• Sets Standby when the signal level changes from LO to HI.
OPR/STBY IN *2				• Sets Standby when the signal level changes from LO to HI. • Sets Operate when the signal level changes from HI to LO.
OPR/SUS IN *2				• Sets Suspend when the signal level changes from LO to HI. • Sets Operate when the signal level changes from HI to LO.
OPERATE OUT *2	Output	TTL negative level	Approx. 100 Ω open drain (Pulled up to +5 V by 10 kΩ)	• Outputs LO in the Operate status. • Outputs HI in the Standby or Suspend status.

*1, *2: The same terminal is used by switching respectively.

*1: The SYNC OUT signal is not output in the DC source mode.

*3: The output signal pulse width can be changed to 100 µs.

5.5.3 Restrictions on Using External Trigger

This section describes restrictions on using the external trigger (TRIGGER IN signal).

The TRIGGER IN signal controls the source and measurement timings to synchronize with the external devices such as slave channel in the synchronized operation.

Confirm the following restrictions before inputting the external trigger to prevent any malfunctions.

If any of these restrictions is not satisfied, the TRIGGER IN signal may be ignored.

Restrictions:

1. Do not input the TRIGGER IN signal in the Standby status or when switching between Operate, Suspend, and Standby.
2. Restrictions on the period time Tp and the hold time Th

   When using the external trigger (TRIGGER IN signal), there are restrictions on setting the period time Tp and the hold time Th. (Refer to Table 5-8 and Table 5-9.)
3. Restriction on the time Thp (ext) between sweep start and the next trigger signal input

   In the sweep source mode, there is a restriction on setting the time Thp (ext) between trigger signal input for sweep start and another trigger signal input for the next step. (Refer to Table 5-8 and Table 5-9.)
4. Restriction on the required time Top between Operate setting and external trigger input.

   Secure the minimum required time Top between Operate setting by using the remote command or external signal (OPERATE IN signal input) and external trigger input. (Refer to Table 5-10).
5. Allow the 4601 at least 10 ms after completion of the previous sweep to input the TRIGGER IN signal for sweep start.

Table 5-8 Restrictions on Tp, Tp (ext), Th and Th (ext)

Source mode	Tp, Tp(ext)	Tp(ext) min	Th, Th(ext)	Thp(ext)
Sweep	0.2 ms ≤ Tp ≤ Tp (ext) - TA	0.5 ms	0 ms ≤ Th ≤ Th (ext) - 2 ms 2 ms ≤ Th (ext)	Thp (ext)= Th (ext) + Tp (ext)
DC	10 ms ≤ Tp ≤ Tp (ext) - TA	15 ms		

Table 5-9 TA Value

Source mode		Tp setting time
Sweep	DC	
250 µs	5 ms	0.050 ms to 60.000 ms
300 µs		60.01 ms to 600.00 ms
500 µs		600.1 ms to 6000.0 ms

Table 5-10 Restriction on Top

Status before Operate		Top
Standby		120 ms*1
Suspend	HIZ	60 ms
	LOZ	10 ms

Tp: Period time

Th: Hold time

Tp (ext): TRIGGER IN signal period

Th (ext): TRIGGER IN signal hold time (Time between sweep start trigger and start value generation)

Thp (ext): Time between sweep start trigger input and another trigger input for the next step value

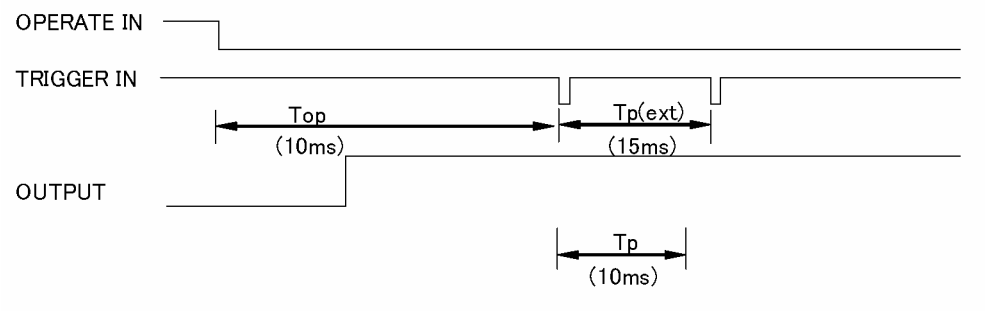
(*1) Approx. (step count x 0.5 ms) is added as for the sweep source mode.

Tp (ext)min: Operational minimum period of TRIGGER IN signal

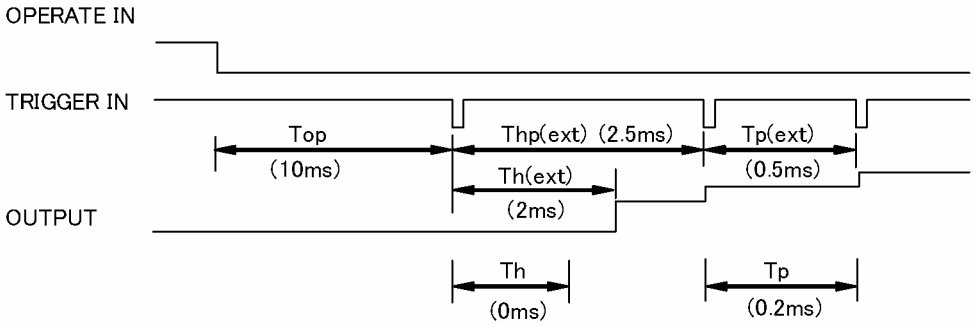
Condition:Sampling; HOLD, Integration time; 5 μs, Measurement delay; 20 μs,
Source delay; 10 μs, at high-speed burst operational status (*2)

(*2) High-speed-burst operational status
High-speed burst operational status starts when the TRIGGER IN signal is input with the sampling is set to HOLD in the sweep mode. And it is as follows:
Pressing the TRIGGER key and executing the *TRG command are ignored until the source measurement condition is changed or Suspend or Standby is specified.

- Example in the DC source mode



- Example in the sweep source mode



5.6 Operating Multiple 4601

This section describes synchronous operation, series connection, and parallel connection using more than one 4601.

5.6.1 Synchronous Operation

The synchronous operation of multiple 4601 units allows synchronization of measurement timing in the DC source mode, and both source and measurement timings in the sweep source mode.

The timing control for the synchronization is performed by the external control signals; TRIGGER IN, SYNC OUT and OPERATE IN/OUT, and by setting the time parameters such as measurement delay and source delay.

1. Three unit synchronous operation using SYNC OUT

   The Operate or Suspend status and the source and measurement timings are synchronized.

   The following shows the setting and connection for the synchronous operation.

Table 5-11 Setting for Three Unit Synchronous Operation Using SYNC OUT

Parameter	No.1	No.2	No.3
SYNC OUT control signal	SYNC OUT	-	-
OPERATE IN/OUT control signal	OPERATE OUT	OPR/SUS IN	OPR/SUS IN
Sampling	AUTO	HOLD	HOLD

The following connection requires BNC cables and BNC T junction connectors for junction between SYNC OUT and TRIGGER IN and between OPERATE IN and OPERATE OUT.

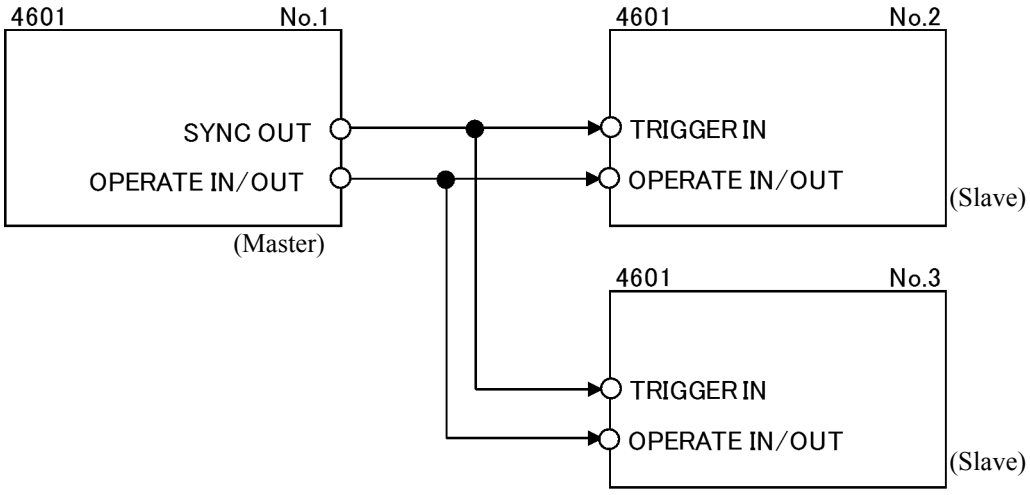
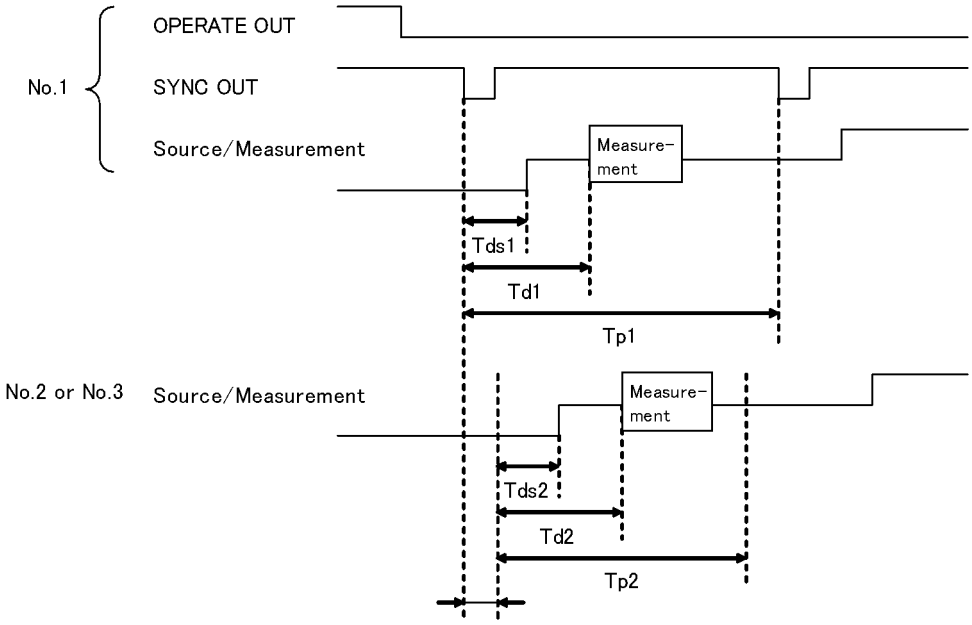
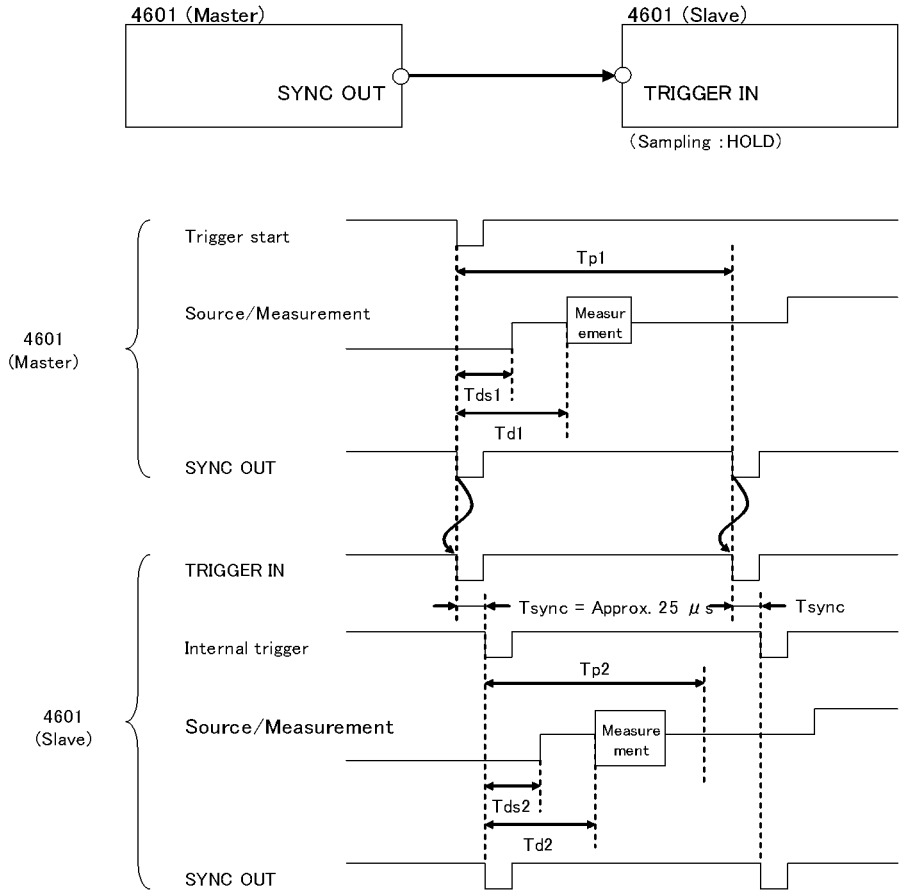


Figure 5-11 Connection for Three Unit Synchronous Operation Using SYNC OUT



Synchronous delay time Tsync = Approx. 25 μs

2. Restriction on Setting
   - The 4601 has a Tsync (approx. 25 μs) time delay from the external trigger input to the measurement start. Set this time delay according to the following formula 1. when using more than one 4601 in synchronous operation.
   - Slave Tp and Th have restrictions on using the external trigger.
   - The first synchronous sweep step has a gap within the Th accurate range.
   - Tp in synchronous operation has the following minimum value restrictions:
     Master Tp ≥ 500 μs Slave Tp ≥ 200 μs



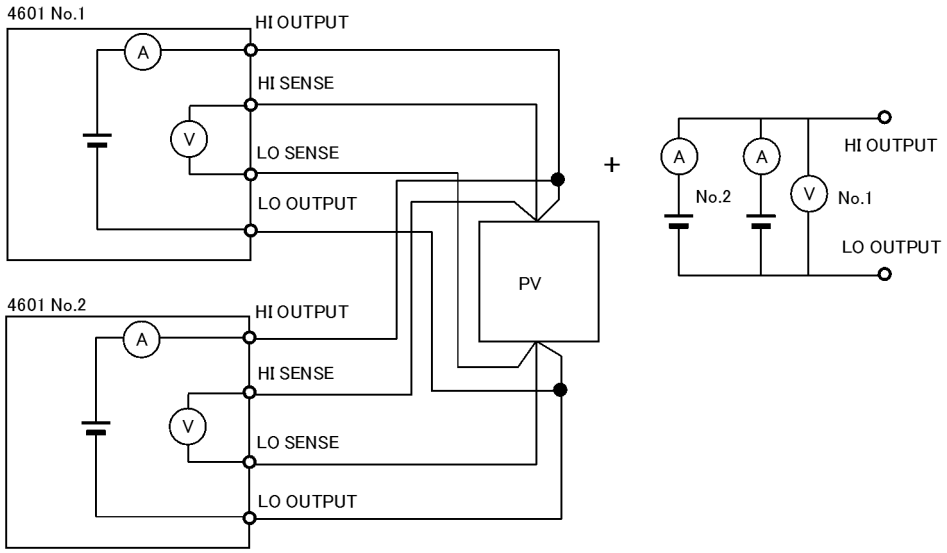
Therefore, consider Tsync time and set the relevant setting as follows:

1. Tds1 ≈ Tds2 + Tsync (25 μs)
2. Td1 ≈ Td2 - Tsync (25 μs)
3. Tp1 ≥ Tp2 + TA
   (Tp1 ≥ 500 μs, Tp2 ≥ 200 μs)

5.6.2 Parallel Connection

Two 4601 units connected in parallel are capable of sink operation up to +30 V/-20 A.

The following shows a connection diagram in which two units are connected in parallel using a 4-wire connection.



Output voltage = The smaller of the voltages set for No. 1 or No. 2

Figure 5-12 Parallel Connection

CAUTION:

1. ***If the load is opened, current flows from the higher to the lower of the set voltage. Depending on the settings, an overload may be generated.***
2. ***If the load is opened when three or more units are connected in parallel, the one to be used as source and the one to be used as sink are decided by the set voltage, and the voltage control is performed in accordance with this balance***

5.6.3 Series Connection

Two 4601 units connected in series are capable of sink operation up to +600 V/-1 A.
The output voltage is the total of No.1 output voltage (HI side) and No2. output voltage (LO side).
Set the current limit values under the following conditions:

No.1 current limit value < No.2 current limit value

When setting the limit values to 10 A, set as follows:

No.1 limit value = 10 A

No.2 limit value = 10.2 A

When the PV output voltage exceeds 300 V, set the output status to Operate or Suspend according to the following procedure.
If this procedure is not followed, an overvoltage alarm may occur.

<Operate procedure>

① No.2 setting voltage ≥ PV output voltage - 300 V

② No.1 setting voltage = 0 V

③ Set No.2 to Operate.

④ Set No.1 to Operate.

⑤ No.2 setting voltage = 0 V

⑥ Set the source voltage.

- When setting the output voltage to 300 V or less, set the No.2 output voltage.
- When setting the output voltage to higher than 300 V, set the No.2 output voltage to 300 V and set the No.1 output voltage as desired.

<Standby procedure>

① No.1 setting voltage = 0 V

② No.2 setting voltage ≥ PV output voltage - 300 V

③ Set No.1 to Standby.

④ Set No.2 to Standby.

As for series connection, select LoZ when using Suspend.
Use the No.1 measured value (HI side) as current measured value.
Figure 5-13 shows two units connected in series in 4-wire connection.

Example) Operate/Standby procedure when the PV output voltage is 500 V

<Operate procedure>

① No.2 setting voltage ≥ 500 V - 300 V (= 200 V)

② No.1 setting voltage = 0 V

③ Set No.2 to Operate.

④ Set No.1 to Operate.

⑤ No.2 setting voltage = 0 V

⑥ Set the source voltage.

- When setting the output voltage to 300 V or less, set the No.2 output voltage.
- When setting the output voltage to 500 V, set the No.2 output voltage to 300 V and set the No.1 output voltage to 200 V.

<Standby procedure>

① No.1 setting voltage = 0 V

② No.2 setting voltage ≥ 500 V - 300 V (= 200 V)

③ Set No.1 to Standby.

④ Set No.2 to Standby.

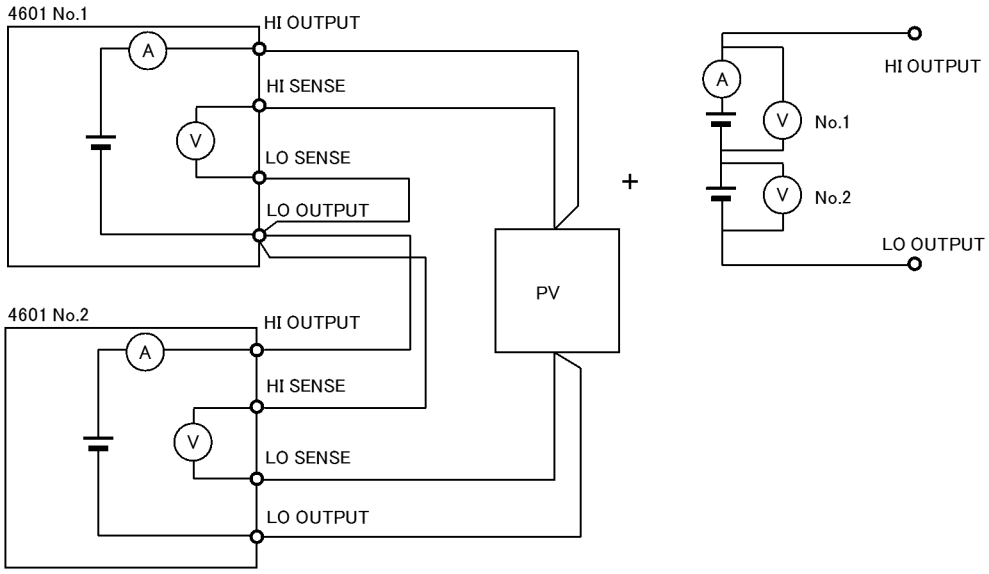


Figure 5-13 Series Connection

CAUTION:

1. ***If the load is short-circuited, reverse polarity voltage is applied to the 4601 themselves. Depending on the settings, an overload may be generated when the short-circuit occurs.***
2. ***Only two units can be connected in series. Do not connect three or more units in series. If the load is short-circuited, the maximum applicable voltage will be exceeded, causing damage to the 4601.***

WARNING: ***In series connection, use the reference cell terminal, the voltage measurement terminal and the temperature measurement connectors on the rear panel of the 4601 on the ground side. Do not these terminals or connectors of the other 4601 on the high-voltage side. Otherwise, it may cause the 4601 to be broken. Moreover, there is a risk of electrical shock. Attach the transparent terminal cover that was mounted on delivery.***

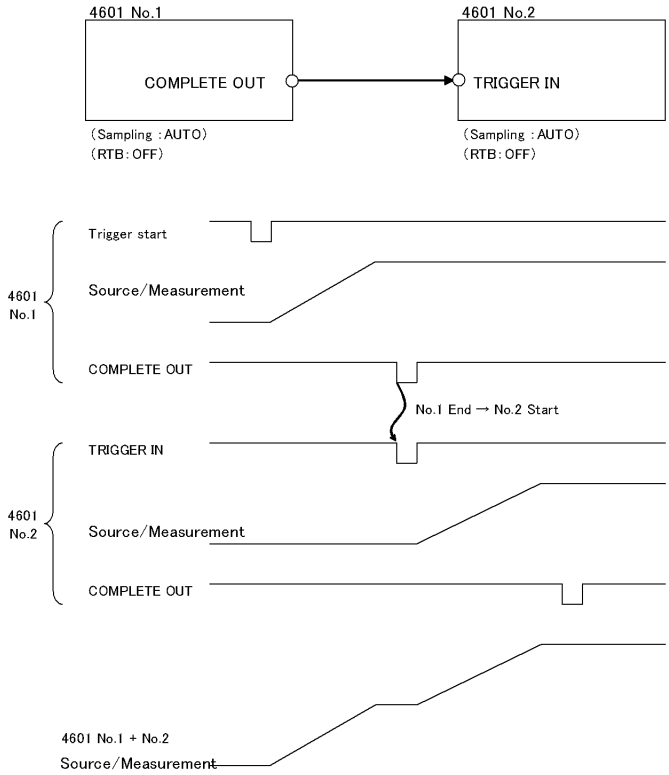
5.6.4 Serial Sweep

This section describes an example where one of two 4601 units connected in series finishes sweep and then the other starts sweep.
Two 4601 units in series connected are capable of sink operation up to +600 V /-1 A.
For the connection method, see Figure 5-14.

RTB (Return to Bias) of the first unit is set to OFF so that the output value does not return to the bias value and stays at the stop value at sweep end. The second unit starts sweep by the COMPLETE OUT signal from the first unit.

The measurement results are obtained by using the data of two units as follows:

Vm = Vm1	No.1 sweep period
Vm = (Vstop1 + Vm2)	No.2 sweep period
Im = Im1	No.1 sweep period
Im = Im2	No.2 sweep period
Ir = Ir1	No.1 sweep period
Ir = Ir2	No.2 sweep period
Vstop1:	No.1 sweep stop



The output voltage is the total of No.1 output voltage (HI side) and No2. output voltage (LO side).
Set the current limit values under the following conditions:

No.1 current limit value < No.2 current limit value

When setting the limit values to 10 A, set as follows:

No.1 limit value = 10 A

No.2 limit value = 10.2 A

When the PV output voltage exceeds 300 V, set the output status to Operate according to the following procedure.
If this procedure is not followed, an overvoltage alarm may occur.

<Operate procedure>

① No.2 bias value ≥ PV output voltage - 300 V

② No.1 bias value = 0 V

③ Set No.2 to Operate.

④ Set No.1 to Operate.

⑤ Start sweep.

As for series connection, select LoZ when using Suspend.
Figure 5-14 shows serial sweep connection.

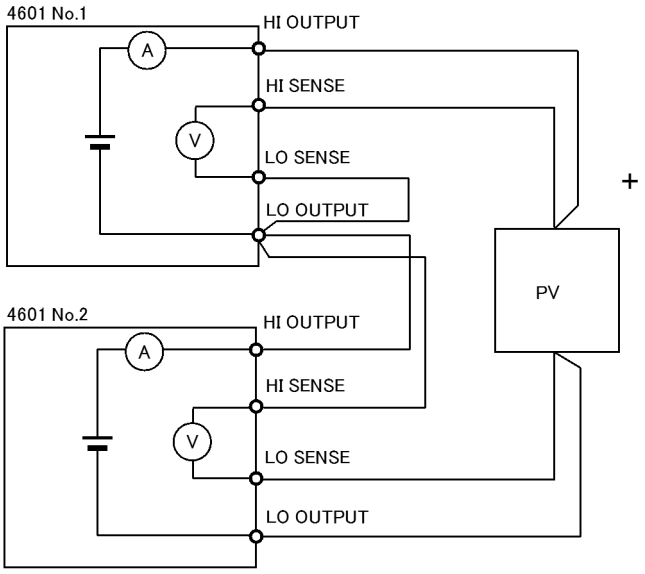


Figure 5-14 Serial Sweep Output Example and Connection Method

CAUTION:

1. ***If the load is short-circuited, reverse polarity voltage is applied to the 4601 themselves. Depending on the settings, an overload may be generated when the short-circuit occurs.***
2. ***Only two units can be connected in series. Do not connect three or more units in series. If the load is short-circuited, the maximum applicable voltage will be exceeded, causing damage to the 4601.***

WARNING: ***In series connection, use the reference cell terminal, the voltage measurement terminal and the temperature measurement connectors on the rear panel of the 4601 on the ground side. Do not these terminals or connectors of the other 4601 on the high-voltage side. Otherwise, it may cause the 4601 to be broken. Moreover, there is a risk of electrical shock. Attach the transparent terminal cover that was mounted on delivery.***

5.7 Self Test

The 4601 tests itself when the power is turned ON or the execution is requested by the command TST? or key operation.

The following table shows the self test descriptions, error codes and error messages.

Table 5-12 Self Test Items (1 of 3)

Error code	Description	Executing method			Message
		Power ON	*TST?	Key operation	
+001	ROM check SUM	✓			ROM check sum error
+002	Panel section RAM	✓			Panel memory error
+003	VFD module communication	✓			VFD module error
+004	RAM read/write	✓			RAM read/write failed
+005	Analog section communication	✓	✓	✓	Communication error (Analog)
+009	Sweep RAM read/write	✓			RAM-2 read/write failed
+012	CAL data SUM	✓	✓	✓	CAL data sum error
+013	Parameter SUM	✓	✓	✓	Parameter memory sum error
+101	Analog section RST signal	✓	✓	✓	ADRST Signal Check
+102	Analog section TRIG signal	✓	✓	✓	ADTRG Signal Check
+111	ADC1 operation IR1-IR2 ratio	✓	✓	✓	ADC1 Ratio 1 to 2
+112	ADC1 operation IR2-IR3 ratio	✓	✓	✓	ADC1 Ratio 2 to 3
+113	ADC1 operation IR3-IR4 ratio	✓	✓	✓	ADC1 Ratio 3 to 4
+114	ADC1 operation IR4-IR5 ratio	✓	✓	✓	ADC1 Ratio 4 to 5
+115	ADC1 operation IR5-IR6 ratio	✓	✓	✓	ADC1 Ratio 5 to 6
+121	ADC2 operation IR1-IR2 ratio	✓	✓	✓	ADC2 Ratio 1 to 2
+122	ADC2 operation IR2-IR3 ratio	✓	✓	✓	ADC2 Ratio 2 to 3
+123	ADC2 operation IR3-IR4 ratio	✓	✓	✓	ADC2 Ratio 3 to 4
+124	ADC2 operation IR4-IR5 ratio	✓	✓	✓	ADC2 Ratio 4 to 5
+125	ADC2 operation IR5-IR6 ratio	✓	✓	✓	ADC2 Ratio 5 to 6
+131	ADC3 operation IR1-IR2 ratio	✓	✓	✓	ADC3 Ratio 1 to 2
+132	ADC3 operation IR2-IR3 ratio	✓	✓	✓	ADC3 Ratio 2 to 3
+133	ADC3 operation IR3-IR4 ratio	✓	✓	✓	ADC3 Ratio 3 to 4
+134	ADC3 operation IR4-IR5 ratio	✓	✓	✓	ADC3 Ratio 4 to 5

Table 5-12 Self Test Items (2 of 3)

Error code	Description	Executing method			Message
		Power ON	*TST?	Key operation	
+135	ADC3 operation IR5-IR6 ratio	✓	✓	✓	ADC3 Ratio 5 to 6
+141	ADC1 operation ZERO measurement (AZ10)	✓	✓	✓	ADC1 Zero (AZ10)
+142	ADC2 operation ZERO measurement (AZ20)	✓	✓	✓	ADC2 Zero (AZ20)
+143	ADC3 operation ZERO measurement (AZ30)	✓	✓	✓	ADC3 Zero (AZ30)
+144	ADC3 operation ZERO measurement (AZ31)	✓	✓	✓	ADC3 Zero (AZ31)
+145	ADC3 operation ZERO measurement (AZ32)	✓	✓	✓	ADC3 Zero (AZ32)
+146	ADC3 operation ZERO measurement (AZ33)	✓	✓	✓	ADC3 Zero (AZ33)
+147	ADC3 operation ZERO measurement (AZ34)	✓	✓	✓	ADC3 Zero (AZ34)
+201	VSVM 5V ZERO	✓	✓	✓	VSVM 5V Zero
+202	VSVM 5V +FS	✓	✓	✓	VSVM 5V +Full Scale
+203	VSVM 5V -FS	✓	✓	✓	VSVM 5V -Full Scale
+204	VSVM 50V ZERO	✓	✓	✓	VSVM 50V Zero
+205	VSVM 50V +FS	✓	✓	✓	VSVM 50V +Full Scale
+206	VSVM 50V -FS	✓	✓	✓	VSVM 50V -Full Scale
+207	VSVM 300V ZERO	✓	✓	✓	VSVM 300V Zero
+208	VSVM 300V +FS	✓	✓	✓	VSVM 300V +Full Scale
+209	VSVM 300V -FS	✓	✓	✓	VSVM 300V -Full Scale
+211	IM 300 μA ZERO	✓	✓	✓	IM 300μA Zero
+212	IM 3mA ZERO	✓	✓	✓	IM 3mA Zero
+213	IM 30mA ZERO	✓	✓	✓	IM 30mA Zero
+214	IM 300mA ZERO	✓	✓	✓	IM 300mA Zero
+215	IM 3A ZERO	✓	✓	✓	IM 3A Zero
+216	IM 10A ZERO	✓	✓	✓	IM 10A Zero
+301	OVV detection check	✓	✓	✓	OVV Check
+302	OVL detection check	✓	✓	✓	OVL Check

Table 5-12 Self Test Items (3 of 3)

Error code	Description	Executing method			Message
		Power ON	*TST?	Key operation	
+015	No output unit mounted	✓	✓	✓	No Output unit
-313	Calibration data	✓	✓	✓	Calibration memory lost
+130	Sub CPU communication	✓	✓	✓	Sub CPU does not respond
+571	Operate relay lifetime	✓	✓	✓	Operate Relay Lifetime
-	All the panels light ON	✓		✓	Visual check of display
-	Buzzer			✓	Check by buzzer sound
-	Panel key			✓	Visual check of key display

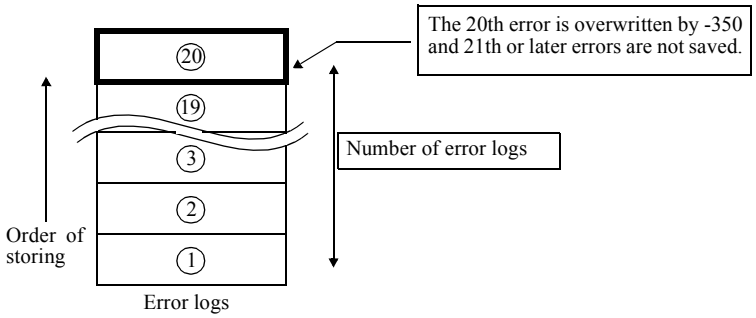
5.8 Error Log

The 4601 holds the error number in the error log memory when it detects an error.

1. Operation

   A maximum of twenty memory areas are available for the error log and they operate as follows:

   - A maximum 20 error numbers are stored in the order of detection.
   - If detection exceeds more than 20, the last saved error is replaced by -350, "Queue overflow" and the 21th or later errors are not written.



2. Clearing error logs

   The error logs are cleared by the following operations:

   - Power ON
   - When the error logs are read out. (The error logs are cleared when the menu screen finishes after the error log screen is displayed.)
   - When the ERR? or *CLS command is executed.

   Not cleared by *RST.

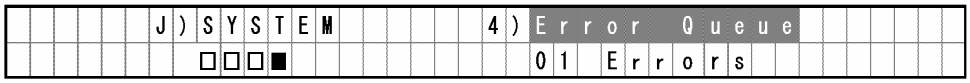
3. Reading out error logs

① Press MENU . The **MENU** key goes ON.

Example display

② Press ⇦ once and press ⇩ and ⇦ to show the following display.

Example display

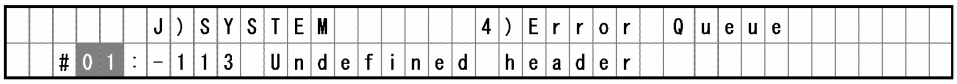


③ Press [⇩] .

④ Rotate the rotary knob or press [⇦] or [⇨] to change the error log number and read error descriptions.

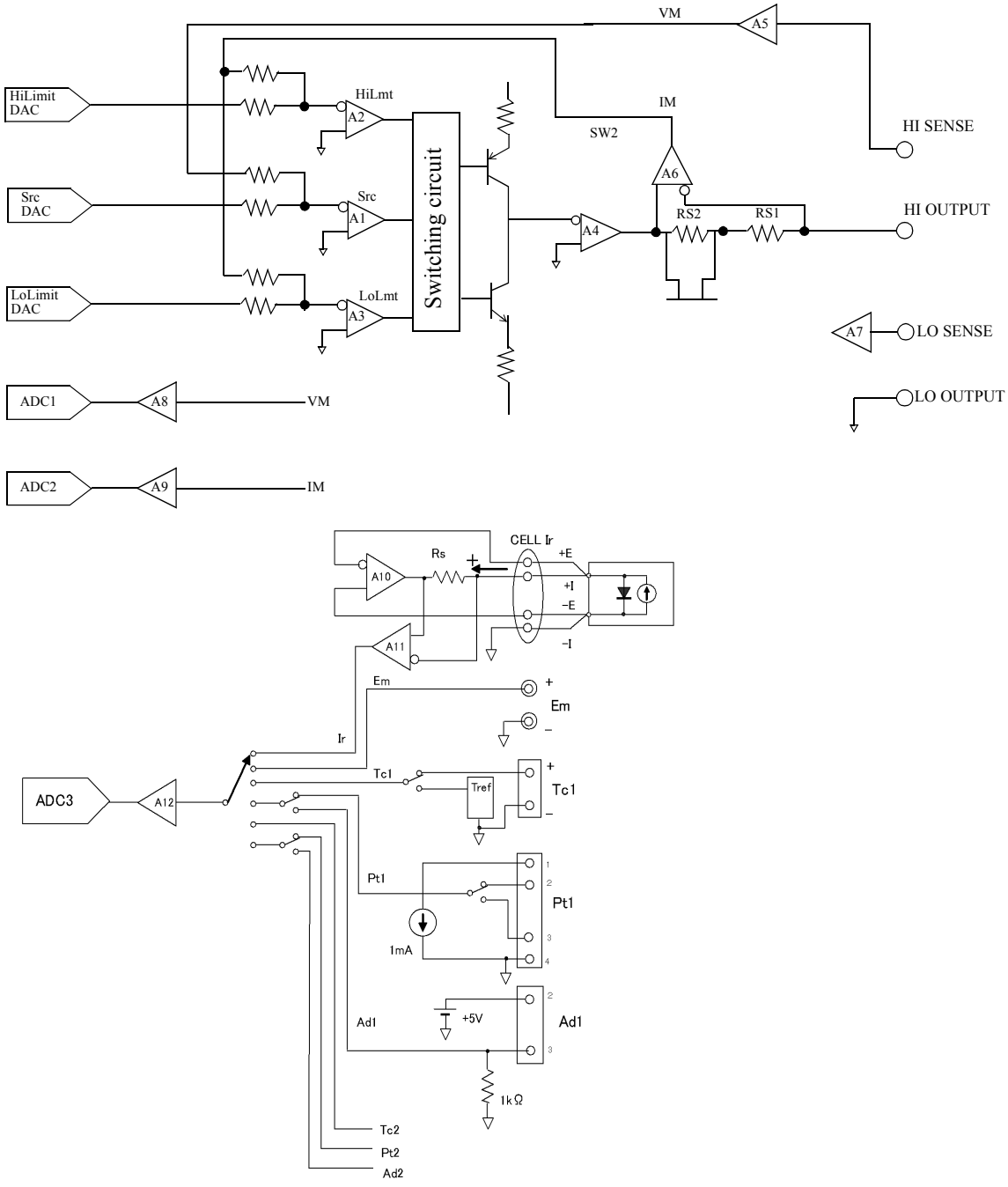
The following is an example of "Undefined header."

Example display



5.9 Operational Principles

5.9.1 Block Diagram



5.9.2 Operational Principles

5.9.2.1 Voltage Source/Voltage Measurement/Current Measurement Terminal Circuit

- The voltage source/voltage measurement/current measurement circuit of the 4601 contains a DA converter SrcDAC for setting the voltage source.

  This circuit also has two DA converters for setting the current limits: HiLimitDAC and LoLimitDAC.

  SrcDAC is 16-bit precision, and HiLimitDAC and LoLimitDAC are 13-bit precision.

  The output from the DA converters is input to three error amplifiers: Src (A1), HiLmt (A2), and LoLmt (A3) respectively.
- SrcDAC is a DA converter for voltage source and Src (A1) is an error amplifier for voltage source.

  Also, HiLimitDAC is a DA converter for current limiter on the HI side, and HiLmt (A2) is an error amplifier for current limiter on the HI side. Likewise, LoLimitDAC and LoLmt (A3) work as current limiters on the LO side.
- Source and limiter are switched by the switching circuit shown in the above figure, comparing the feedback amount for each, then switching to the larger one.
- Current range switching is done by switching the current detection resistor Rs. Consequently, the current measurement always takes place in the same range as that of current limiter.
- Voltage range switching is done by A_5, and the voltage measurement and voltage source always take place in the same range.
- The A_5 and A_6 amplifiers have high input impedance to minimize leakage.
- The A_7 amplifier also has a high input impedance to reduce errors in 4-wire connection.
- The AD converter employs an integral type AD, and the integration time can be set between 5 μs to 200 ms.

5.9.2.2 ADC3 Measurement Circuit

- The ADC3 measurement circuit can switch between eight functions: Ir, Em, Tc1, Pt1, Ad1, Tc2, Pt2 and Ad2 in the DC source mode or spot measurement.

  In the sweep source mode, only Ir is selected and measured simultaneously with Vm and Im.
- The reference cell current measurement circuit (Ir) is a 0 V source current measurement circuit.

  This circuit is 4-terminal output and operates to make both ends of the reference cell 0 V by the voltage sense terminals +E and -E.

  Current measurement is performed by measuring the voltage across the sense resistor Rs in the output circuit.

  The range is switched between 3 mA, 30 mA and 300 mA by switching this sense resistor.

  The output amplifier A10 can output up to approximately 340 mA at the positive side (sink), however it can output up to approximately -34 mA at the negative side (source).
- The external voltage measurement circuit (Em) switches the range between 30 mV, 300 mV and 3 V by switching the gain of the high input impedance amplifier A12 between x100, x10 and x1.
- The thermocouple measurement circuit (Tc1) measures the temperature of thermocouples by comparing the output voltage from the thermocouple sensor and the reference junction voltage.
- The Pt measurement circuit (Pt1) performs 4-terminal resistance measurement by applying current of 1 mA between pin 1 and pin 4 of the terminal from the constant current source and measures the voltages of pin 2 and pin 3 alternately.
- The Ad measurement circuit (Ad1) measures temperature by connecting the IC temperature sensor AD590 to pin 2 and pin 3 of the terminal. Power is supplied from +5 V, the output current from the sensor is applied to 1 kΩ , and current is measured, making it possible to measure temperature.
- Pt1 and Ad1 use the same measurement terminal. Either one is used by setting Pt/Ad Select.
- The circuits of Tc2, Pt2 and Ad2 are the same as those of Tc1, Pt1 and Ad1 respectively.

6. REMOTE PROGRAMMING

6.1 Using Interface

The 4601 offers GPIB and USB interfaces.
They cannot be used at the same time. Select which interface you wish to use.

6.1.1 Selecting Interface

The interface can only be selected from the front panel menu.

1. The selected interface is saved in the nonvolatile memory. The selected interface does not change when the unit is turned off or the interface is reset.
2. A unique unit address is set in the interface. If multiple instruments are connected to the USB interface, set individual identifying addresses (USB ID).

The following table shows the interface set items and default settings.

Set item	Default setting
Selected interface	GPIB
Header ON/OFF	ON
GPIB address/USB ID	1
GPIB Talker Functions	Addressable

To set the interface, select **H) INTERFACE→1) Interface Bus**.

To set the header ON/OFF, select **H) INTERFACE →3) Header**.

6.2 GPIB

6.2.1 Overview

GPIB (General Purpose Interface Bus) allows external control of the 4601 measurement function settings, measurement parameter settings, and reading measurement data, making it simple to configure an automated measurement system.
As GPIB signals from the 4601 are electrically isolated inside the unit from the measurement signal system, the connection of external devices does not affect the measured values. The remote commands are the same as with USB.

- General Specifications

  Standard: IEEE-488.2
  Code: ASCII code
  Logic level: Logical 0 (High) +2.4 V min.
  Logical 1 (Low) +0.4 V max.

Table 6-1 Interface Function

Code	Function
SH1	Source Handshake capability
AH1	Acceptor handshake capability
T6	Basic Talker, unaddressed if MLA, serial poll
L4	Basic Listener, unaddressed if MTA
SR1	Service Request capability
RL1	Remote/Local switching capability
PP0	No Parallel Poll capability
DC1	Device Clear capability (The SDC and DCL commands can be used.)
DT1	Device Trigger capability (The GET command can be used.)
C0	No Controller capability
E2	Using tri-state bus drivers

6.2.2 Precautions when Using GPIB

1. Do not use too long a connection cable or bus cable to connect any instrument or controller. Ensure that the total cable length does not exceed 20 m. ADC CORPORATION offers the following standard bus cables.

Table 6-2 Standard Bus Cable

Length	Name
0.5 m	408JE-1P5
1 m	408JE-101
2 m	408JE-102
4 m	408JE-104

2. Bus cables have piggyback connectors. A piggyback connector has both a male connector and a female connector by itself. The male and female connectors can be stacked on top of each other.
   When connecting bus cables, do not stack three or more connectors. Secure the connectors with the clamping screws.
3. Check the power requirements, grounding conditions, and setting conditions of each device before turning on the power of each device.
   Ensure that all devices on the bus are turned on. If any device on the bus is not turned on, the system may not operate correctly.
4. Connecting and disconnecting cables

   Turn off all devices on the bus before connecting or disconnecting GPIB cables. Check that the chassis of the devices on the bus are connected to each other and to the ground before connecting or disconnecting any GPIB cables.
5. ATN interrupt during message transmission

   If an ATN request interruption occurs during transfer of messages between devices, the ATN has priority and the previous status is cleared.
6. Up to 255 characters can be recognized in a single program command transmission.
   An error occurs if the program command exceeds 255 characters.
7. Retain the REN line at Low for 5 ms or longer following the transmission of program command.

6.2.3 Setting GPIB

This section describes the procedure of changing the GPIB address and the output format.

Changing the GPIB address from 01 to 12

Changing the output format from ASCII to binary

Operating procedure

① Press MENU . The **MENU** key goes ON.

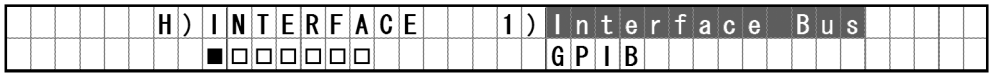
Example display

② Press ⇦ or ⇨ or rotate the rotary knob to select **H) INTERFACE** from the categories.

Example display

③ Press ⇩ to move to the lower level.

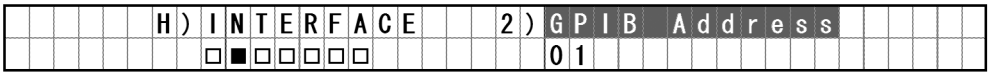
Example display



Check that the interface is set to GPIB.

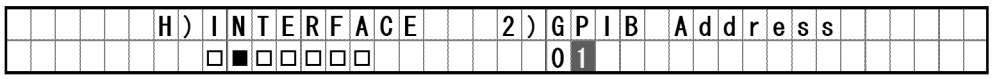
④ Press ⇦ or ⇨ or rotate the rotary knob to select **2) GPIB Address** from the parameters.

Example display



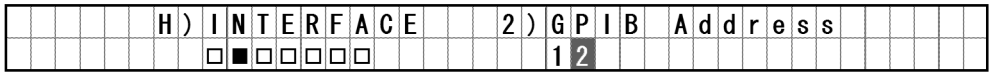
⑤ Press ⇩ to move to the lower level.

Example display



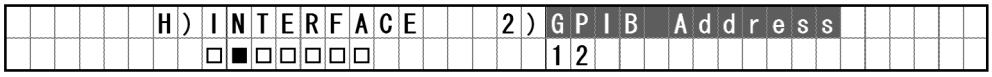
⑥ Press ⇦ or ⇨ to select the digit and rotate the rotary knob to change the value. Or directly input the address by using the numeric keypad.

Example display



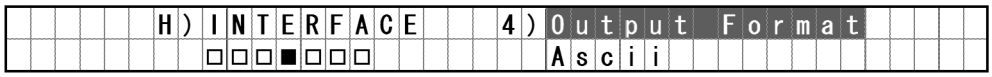
⑦ Press ⇧ to move to the upper level.

Example display



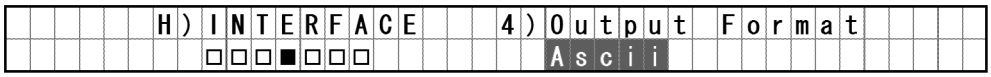
⑧ Press ⇦ or ⇨ or rotate the rotary knob to select **4) Output Format** from the parameters.

Example display



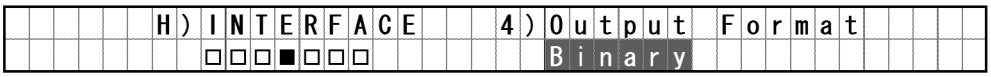
⑨ Press ⇩ to move to the lower level.

Example display



⑩ Press ⇦ or ⇨ or rotate the rotary knob to select the binary format.

Example display



⑪ Press MENU to exit the menu.

6.3 USB

6.3.1 Overview

The 4601 is USB (Universal Serial Bus) equipped conforming to USB 2.0 standard.
USB allows function settings and reading of measurement data with respect to multiple instruments connected to the bus using a PC, making it simple to configure an automated measurement system.

NOTE: Operations using a PC or hub cannot be always guaranteed

6.3.2 USB Specifications

- Standard: Complies with USB2.0 Full-Speed
- Connectors: USB B type (female)
- Identifier ID: USB ID, settable from 1 to 127
- Remote/Local: Available
- Input commands: Function setting and query with ASCII character string commands
- Output format: Measurement data and query response with ASCII character string commands
- Driver: ADC measuring instrument USB driver

6.3.3 Connecting with PC

Connect the USB connector (B type) on the rear of the 4601 to the PC USB connector with a cable. Fully insert all connectors.

Use a USB hub to connect multiple instruments to a single PC.

6.3.4 Precautions when Using USB

When running a query command, leave a 20 ms wait time right after the previous command.

6.3.5 Setting USB ID

This section describes the procedure of setting the USB ID address.

Changing the USB ID address from 01 to 12

Operating procedure

① Press MENU . The **MENU** key goes ON.

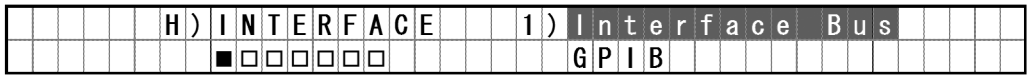
Example display

② Press ⇦ or ⇨ or rotate the rotary knob to select **H) INTERFACE** from the categories.

Example display

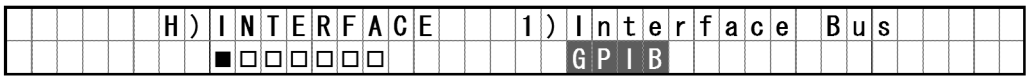
③ Press ⇩ to move to the lower level.

Example display



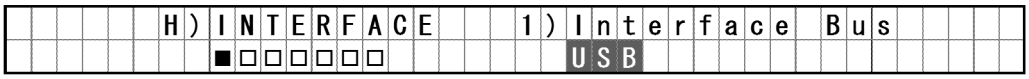
④ Press ⇩ to move to the lower level.

Example display



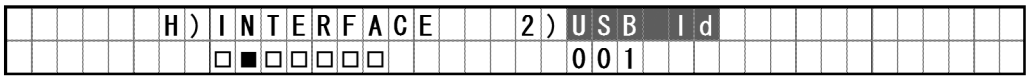
⑤ Press ⇦ or ⇨ or rotate the rotary knob to select **USB** from the parameters.

Example display



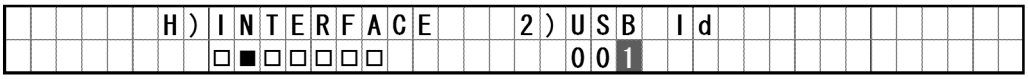
⑥ Press [⇧] to move to the upper level, and press [⇦] or [⇨] or rotate the rotary knob to select **2) USB Id**.

Example display



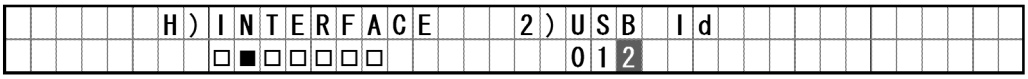
⑦ Press [⇩] to move to the lower level.

Example display



⑧ Press [⇦] or [⇨] to select the digit and rotate the rotary knob to change the value. Or directly input the USB ID by using the numeric keypad.

Example display

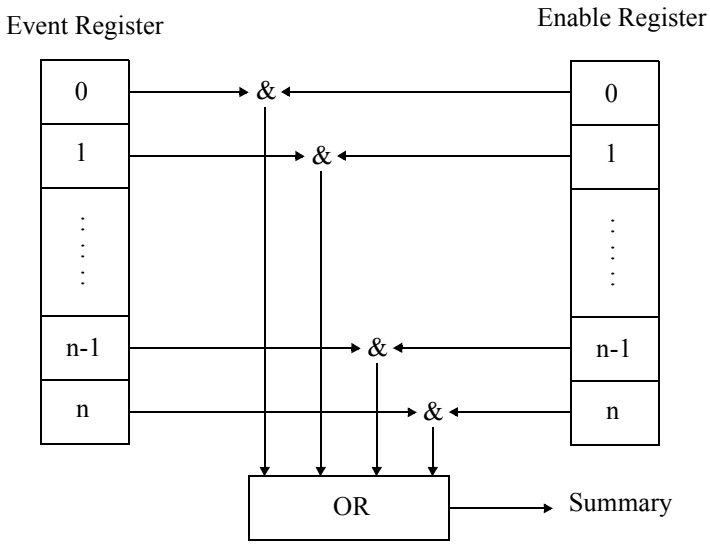


⑨ Press [MENU] to exit the menu.

6.4 Status Register Structure

The 4601 has a hierarchical status register structure that conforms to the IEEE standard 488.2-1987 and can send various statuses of the 4601 to the controller. This section describes the operation model of the status structure and the allocation of events.

The status register consists of the event register and the enable register.



- Event Register

  The event register latches and maintains the status for each event. (It may also hold changes.)
  Once the register is set, it remains set until it is read out by a query or cleared by *CLS.
  Data cannot be written into the event register.

- Enable Register

  The enable register specifies for which bits in the event register a valid status summary should be generated. The logical AND operation is executed between the enable register and the event register, and the OR result is generated as a summary. The summary is written into the status byte register.
  Data can be written into the enable register.

The 4601 has the following four types of status registers:

- Status Byte Register (STB)
- Standard Event Status Register (SESR)
- Questionable Event Register (QSR)
- Measurement Event Register (MER)

1. Statue Byte Register (STB)

Table 6-3 Status Byte Register

bit	Name	Description
0	MSB (Measurement Summary Bit)	ON: Set to 1 when any of Measurement Event Register events occurs and the bit is set to 1, if the corresponding bit of Measurement Event Enable Register is also 1. OFF: Set to 0 when Measurement Event Register is cleared by being read.
1	Not in use	Always set to 0
2	EAV (Error Available)	ON: Set to 1 when error information is stored in Error Queue. OFF: Set to 0 when Error Queue is read and becomes empty.
3	QSB (Questionable Summary Bit)	ON: Set to 1 when any of Questionable Event Register events occurs and the bit is set to 1, if the corresponding bit of Questionable Event Enable Register is also 1. OFF: Set to 0 when Questionable Event Register is cleared by being read.
4	MAV (Message Available)	ON: Set to 1 when the output data is entered in the output buffer. OFF: Set to 0 when the output buffer is read and becomes empty.
5	ESB (Standard Event Status)	ON: Set to 1 when any of SESR events occurs and the bit is set to 1, if the corresponding SESER bit is also 1. OFF: Set to 0 when SESR is cleared by being read (*ESR?).
6	MSS (Master Summary)	ON: Set to 1 when any of STB events occurs, if the corresponding SRER bit is 1.
	RQS (Request Service)	ON: Set to 1 when MSS is set to 1, and SRQ is generated. OFF: Set to 0 when STB is read by a serial poll.
7	Not in use	Always set to 0

- Common conditions in which the Status Byte Register is cleared
  All cleared when the power is turned ON.
  All cleared by *CLS except that MAV is not cleared if data exists in the output buffer.
  Not cleared even if read by *STB?.
- Conditions in which the Service Request Enable Register is cleared
  Cleared when the power is turned ON (the PSC flag is set to 1).
  Cleared when the *SRE0 command is executed.

The following figure shows the 4601 status register structure.

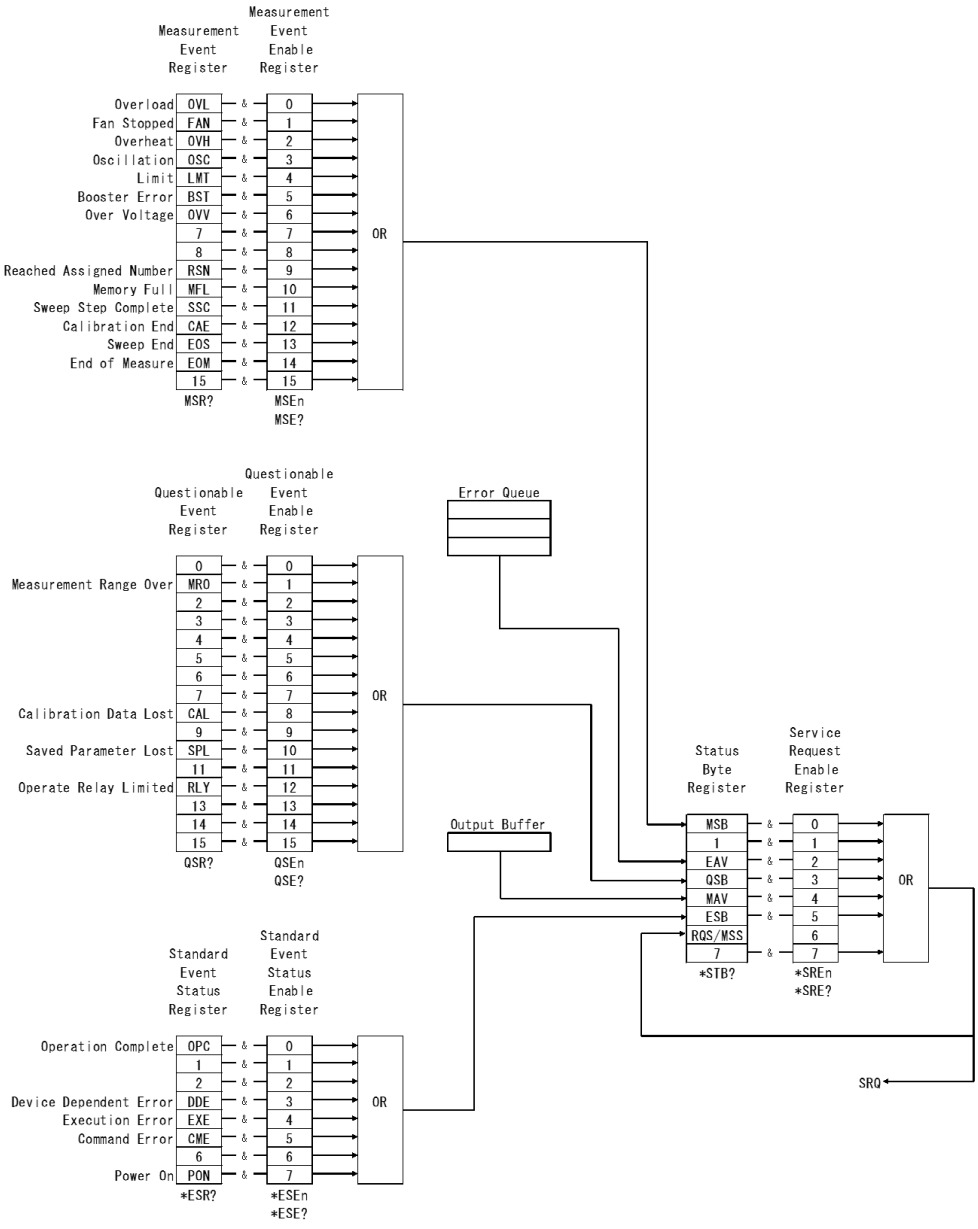


Figure 6-1 Status Register Structure

2. Standard Event Status Register (SESR)

Table 6-4 Standard Event Status Register

bit	Name	Description
0	OPC (Operation Complete)	ON: Set to 1 when all operations are complete after receiving the *OPC command.
1	Not in use	Always set to 0
2	Not in use	Always set to 0
3	DDE (Device Dependent Error)	ON: Set to 1 when a device-dependent error occurs.
4	EXE (Execution Error)	ON: Set to 1 when a received command is not currently executable. Set to 1 when incorrect data is entered in a command parameter.
5	CME (Command Error)	ON: Set to 1 when the received command is incorrectly spelled.
6	MSS (Master Summary)	Always set to 0
7	PON (Power On)	ON: Set to 1 when the power is turned ON.

- Common conditions in which the Standard Event Status Register is cleared
  All cleared when the power is turned ON.
  All cleared by *CLS.
  All cleared when read by *ESR?.
- Conditions in which the Standard Event Status Enable Register is cleared
  Cleared when the power is turned ON (the PSC flag is set to 1).
  Cleared when the *ESE0 command is executed.

3. Measurement Event Register (MER)

Table 6-5 Measurement Event Register

bit	Name	Description
0	OVL (Overload)	ON: Set to 1 when overload is detected
1	FAN (Fan Stopped)	ON: Set to 1 when fan stop is detected.
2	OVH (Overheat)	ON: Set to 1 when overheat is detected.
3	OSC (Oscillation)	ON: Set to 1 when oscillation is detected.
4	LMT (Limit)	ON: Set to 1 when the limit value is detected.
5	BST (Booster Error)	ON: Set to 1 when fan stop or overheat of the booster unit is detected.
6	OVV (Over Voltage)	ON: Set to 1 when overvoltage is detected.
7	Not in use	Always set to 0
8	Not in use	Always set to 0
9	RSN (Reached Assigned Number)	ON: Set to 1 when the specified memory store number is reached.
10	MFL (Memory Full)	ON: Set to 1 when the measurement buffer memory is full. OFF: Set to 0 when the measurement buffer memory is not full.
11	SSC (Sweep Step Complete)	ON: Set to 1 when sweep step is complete in the HOLD sampling (except external trigger). OFF: Set to 0 when sweep step starts. Set to 0 when sweep stops or starts.
12	CAE (Calibration End)	ON: Set to 1 when calibration is complete. OFF: Set to 0 when calibration starts.
13	SWE (Sweep End)	ON: Set to 1 when sweep is complete. OFF: Set to 0 when sweep starts.
14	EOM (End of Measure)	ON: Set to 1 when measurement is complete. OFF: Set to 0 when measurement starts. Set to 0 when measurement data is read out.
15	Not in use	Always set to 0

- Common conditions in which the Measurement Event Register is cleared
  All cleared when the power is turned ON.
  All cleared by *CLS.
  All cleared when read by MSR?.
- Conditions in which the Measurement Event Enable Register is cleared
  Cleared when the power is turned ON.
  Cleared when the MSE0 command is executed.

4. Questionable Event Register (QSR)

Table 6-6 Questionable Event Register

bit	Name	Description
0	Not in use	Always set to 0
1	MRO (Measurement Range Over)	ON: Set to 0 when a measurement over-range occurs.
2	Not in use	Always set to 0
3	Not in use	Always set to 0
4	Not in use	Always set to 0
5	Not in use	Always set to 0
6	Not in use	Always set to 0
7	Not in use	Always set to 0
8	CAL (Summary of Calibration)	ON: Set to 1 when the default calibration values or the calibration values acquired at previous power ON are used due to the calibration data SUM failure in the power ON check.
9	Not in use	Always set to 0
10	SPL (Saved Parameter Lost)	ON: Set to 1 when the default values or the setting values acquired at previous power ON are used due to the saved parameter SUM failure in the power ON check.
11	Not in use	Always set to 0
12	RLY (Operate Relay Limited)	ON: Set to 1 when the number of operate relay operations exceeds 1,000,000 times.
13	Not in use	Always set to 0
14	Not in use	Always set to 0
15	Not in use	Always set to 0

- Common conditions in which the Questionable Event Register is cleared
  All cleared when the power is turned ON.
  All cleared by *CLS.
  All cleared when read by QSR?.
- Conditions in which the Questionable Event Enable Register is cleared
  Cleared when the power is turned ON.
  Cleared when the QSE0 command is executed.

6.5 Data Output Format

6.5.1 Measured Value Output

The 4601 outputs data in the order of ① ADC1 measured value, ② ADC2 measured value and ③ ADC3 measured value.

When data of multiple measurement memories is output, this order is repeated. (① ② ③ ① ② ③ ...)

Whether each measured value is output or not can be set separately.

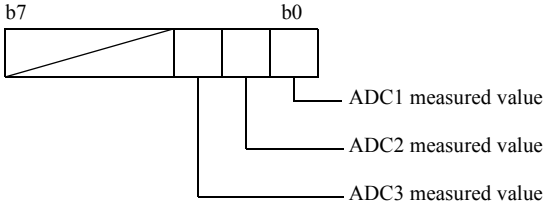
ADC1 measured value + ADC2 measured value + ADC3 measured value

6.5.2 Output Target Selection

The measured values to be output can be set by using the OTM command or from the MENU.

*This setting is not initialized by RST or RINI.

Internal data



OTM designated value	ADC3 measured value	ADC2 measured value	ADC1 measured value	
1	-	-	●	ADC1 measured value only
2	-	●	-	ADC2 measured value only
3	-	●	●	ADC1 and ADC2 measured values
4	●	-	-	ADC3 measured value only
5	●	-	●	ADC1 and ADC3measured values
6	●	●	-	ADC2 and ADC3measured values
7	●	●	●	All measured values (ADC1 to ADC3)

● :Output
-:No output

6.5.3 Output Format Selection

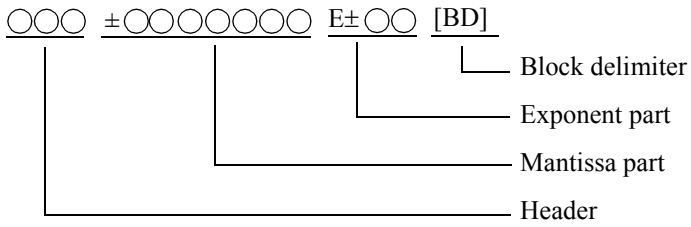
Either of the following two output formats of the measured values can be selected before measurement starts (DC mode) or before measurement memory data is output (sweep mode).

Format	Description
ASCII	• Outputs one value as a 12-byte (header OFF) or 15-byte (header ON) ASCII character string. • The internal processing time for data output is longer than in a binary format.
Binary	• Outputs one value as an 8-byte binary value (double-precision decimal value). • The internal processing time is shorter than in an ASCII format as the value does not need to be converted into an ASCII character string. • Consideration is required when data is loaded into a PC.

6.5.4 ASCII Output Format

Measured value format

When data is output in an ASCII format, each measured value is output as follows:



When multiple data sets are output, the data sets are separated by commas (“,”).

○○○± ○○○○○○○ E±○○, ○○○± ○○○○○○○ E±○○ , • • • • •[BD]

Header

Whether headers are output or not can be set by using the command or from the MENU.

Function		Target	Main header
(ADC1)	Vm	Vm	VM
(ADC2)	Im	Im	IM
(ADC3)	Ir	(Reference cell Isc)	IR
	Em	(EXT.DCV)	EM
	Tc1	Ch1 thermocouple T	TA
	Pt1	Ch1 PT100	PA
	Ad1	Ch1 AD590	AA
	Tc2	Ch2 thermocouple T	TB
	Pt2	Ch2 PT100	PB
	Ad2	Ch2 AD590	AB

High

Priority

Low

Factor		Sub header
High limit		U
Low limit		B
Over range		O
OSC		S
Temperature measurement	Celsius temperature	C
	Fahrenheit temperature	F
	Thermodynamic temperature	K
	Voltage value (Tc1/Tc2)	V
	Resistance value (Pt1/Pt2)	R
	Current value (Ad1/Ad2)	I
Non		␣

NOTE: ***When the binary output format is selected, the headers are not output regardless of the settings. Only in the calibration mode, voltage, current and resistance values are output on the sub headers of temperature measurement.***

Mantissa part and exponent part

ADC	Measurement function		Mantissa part	Exponent part
		Range/mode		
ADC1	Vm	5 V	±d.ddddd	E+00
		50 V	±dd.dddd	E+00
		300 V	±ddd.ddd	E+00
ADC2	Im	300 μA	±ddd.ddd	E-06
		3 mA	±d.ddddd	E-03
		30 mA	±dd.dddd	E-03
		300 mA	±ddd.ddd	E-03
		3 A	±d.ddddd	E+00
		10 A	±dd.dddd	E+00
ADC3	Ir	3 mA	±d.ddddd	E-03
		30 mA	±dd.dddd	E-03
		300 mA	±ddd.ddd	E-03
	Em	30 mV	±dd.dddd	E-03
		300 mV	±ddd.ddd	E-03
		3 V	±d.ddddd	E+00
	Tc1/Tc2	Temperature display	±dddd.dd	E+00
		Voltage display *	±dd.dddd	E-03
	Pt1/Pt2	Temperature display	±dddd.dd	E+00
		Resistance display *	±d.ddddd	E+03
	Ad1/Ad2	Temperature display	±dddd.dd	E+00
		Current display *	±ddd.ddd	E-03

±Range over	±9.99999	E+35
No measurement data	±8.88888	E+30

*: For the calibration mode

Block delimiter

The block delimiters can be specified by using the following commands:

Block delimiter	Setting command
CR LF+EOI	DL0
LF	DL1
EOI	DL2
LF+EOI	DL3

NOTE: ***When the binary output format is selected, "EOI" is specified regardless of the block delimiter settings.***

6.5.5 Binary Output Format

When the binary output format is selected, DC measurement data and measurement data in the measurement memories are output in IEEE 488.2 “Definite Length Block Response Data Format.”

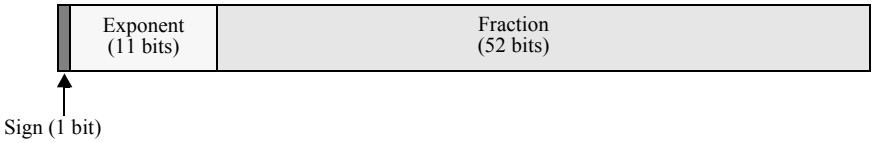
Internal latched data is output as it is as measurement data.

This data is latched as IEEE 754 double-precision floating-point data (8 bytes).

IEEE 754 floating-point arithmetic

- The base is 2. The base is not included in data.
- The mantissa is set to 1 or more and less than 2. (Normalization)
- “0” is represented by setting all the bits of the mantissa and the exponent to “0”.
- The mantissa and the exponent are represented in binary.
- The sign bit 0 is for positive and 1 is for negative.

● Double-precision floating-point format (64 bits)



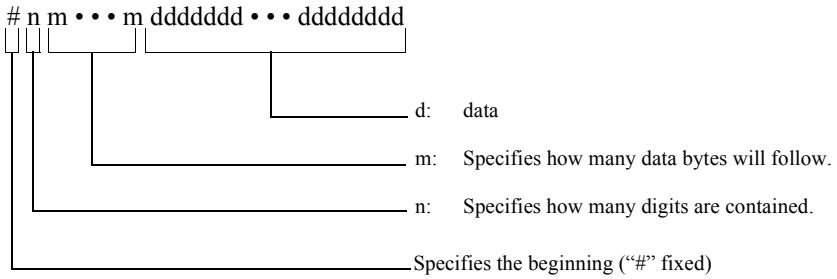
Exponent part: Add 1023 to the actual exponent.
Mantissa part: Omit 1 of the integer part.

When the binary output format is selected, the following rules are applied regardless of the settings.

- The headers are not output.
- The string delimiters are not output.
- EOI is output as a block delimiter.

The 4601 cannot output binary data through the USB interface for the convenience of CPU-CPU communication. If the USB interface is selected when the binary output is selected, the output format will be forcibly switched to ASCII output format.

◆ Definite Length Block Response Data Format



◆ Output example

#208<B><B><B><B><B><B><B><B>

<B>: 1-byte data

As the Windows systems use the little endian ordering, the endian of each data needs to be reversed. Otherwise, the received binary data is not returned to the original floating point.

Example of converting binary data to double-precision floating-point format

.NET)

```
Array.Reverse(byteArray, i, 8)'← Reverses the target data bytearray to an 8-byte unit.
                              'The double type consists of 8 bytes.
System.BitConverter.ToDouble(byteArray, i).ToString()
                                                    'Converts the byte array to double.
```

VBA)

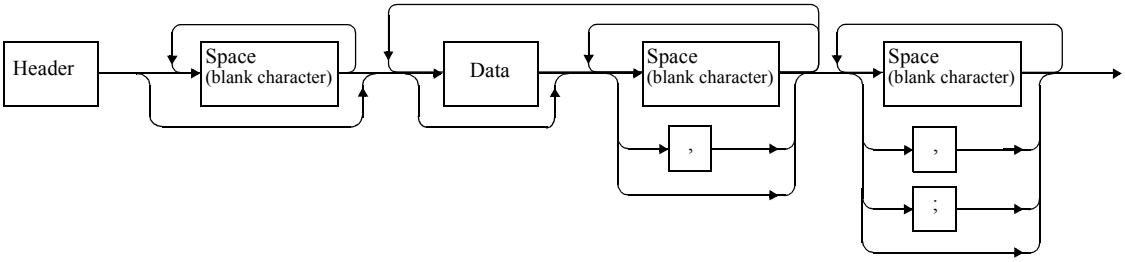
```
Declare Sub CopyMemory Lib "kernel32" Alias "RtlMoveMemory" (Destination As Any,
Source As Any, ByVal Length As Long)
Function ByteArrayToDouble(ByRef bytArray() As Byte) As Double
    Dim dblVal As Double
    Dim bytWork(0 To 7) As Byte
    Dim v As Variant
    Dim n As Integer

    n = 7
    For Each v In bytArray
        bytWork(n) = v
        n = n - 1
    Next
    Call CopyMemory(dblVal, bytWork(0), 8)
    ByteArrayToDouble = dblVal
End Function
```

6.6 Remote Commands

6.6.1 Command Syntax

The command syntax is defined by the following format.



1. Header

   There are two types of headers: common command headers and simple headers. The common command header has an asterisk mark (*) placed in front of the mnemonic.
   The simple header is a functionally independent command that has no hierarchical structure.
   Placing a question mark (?) right after the header forms a query command.

2. Space (blank character)

   One or more spaces can be used (Spaces may be omitted).

3. Data

   When a command requires multiple data sets, data sets are separated by comma (,). A space may be used directly before or after comma (,). For more information on the data types, refer to Section 6.6.2, “Data Format.”

4. Describing multiple commands

   The 4601 allows multiple commands to be described consecutively or separated by semicolon (;), comma (,), or space ( ) in one line.

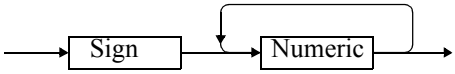
6.6.2 Data Format

The 4601 uses the following data types for data input and output.

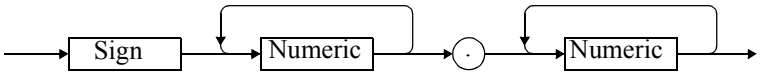
1. Numeric data

   There are three numeric data formats, any of which can be used for input.
   Some commands can add units to the data when the data is input.

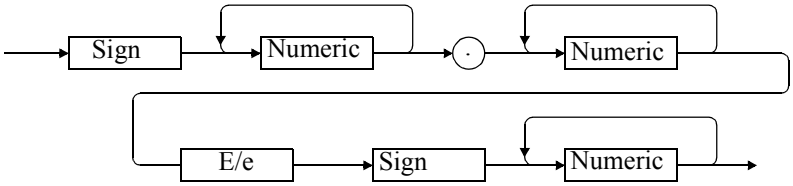
   - Integer type: NR1 format



   - Fixed-point type: NR2 format



   - Floating-point type: NR3 format



NOTE: ***When numeric data is expressed in exponent format in the 4601, the number conversion time becomes too long if the exponent is set to ±31 or higher (xx.xxxE±31). The exponent setting should not exceed ±30.***

6.6.3 Remote Command List

1. The Default column shows default settings at Power ON or at factory shipment.
   - The Power ON column shows the status when the power is turned ON.
   - The *RST or RINI command initializes the settings to factory default.
   - However, the RINI command cannot initialize *5 and the RINI or *RST command cannot initialize *6.
2. Note for description in the command list
   - Parameter enclosed in [ ] can be omitted.
   - Parameters enclosed in < > are single delimited data items.
   - The Operation column shows whether each command is acceptable or not in the Operate status (OPR) and the Suspend status (SUS) in the DC source mode or the sweep source mode.

     ○ : Acceptable in any of the Operate, Suspend and Standby status.

     △ : Acceptable in the HOLD status or Suspend status in the DC source mode.
     Acceptable in the sweep stop status or Suspend status in the sweep source mode.

     ▲ : Acceptable in the Suspend status.

     × : Not acceptable in both the Operate status and Suspend status.

     Every commands is always acceptable in the Standby status.

Item		Command	Description	Default		Operation		During calibration
				Power ON	Factory shipment	DC OPR/SUS	Sweep OPR/SUS	
Source	Source mode	MD0	DC mode		✓	▲	▲	×
		MD1	DC sweep mode					
		MD?	Response: MD0 to MD1			○	○	×
	Source range	SVRX	Optimal range			○	×	×
		SVR4	5 V range					
		SVR5	50 V range		✓			
		SVR6	300 V range					
		SVR?	Response: SVRX4 to SVRX6 (for the optimal range) SVR 4 to SVR 6 (for the fixed range)			○	○	×
	Source value	SOV ±data	Voltage source value setting		(0 V)	○	×	×
		SOV?	Response: SOV±d.ddddE±d *1 *2			○	○	×
	Limit range	LIRX	Optimal range			○	△	×
		LIR0	300 μA range					
		LIR1	3 mA range					
		LIR2	30 mA range					
		LIR3	300 mA range		✓			
		LIR4	3 A range					
		LIR5	10 A range					
		LIR?	Response: LIRX0 to LIRX5 (for the optimal range) LIR 0 to LIR 5 (for the fixed range)			○	○	×
	Limit value	LMI +data1, -data2	Current limit value setting data1:+ limit value data2:- limit value [NOTE] 1. data1, data2 ≥ 30digit		(±100 mA)	○	△	×
		LMI?	Response: LMI+<hl>,-<ll> *1 hl: <d.dddE±d> (+ limit value) ll: <d.dddE±d> (- limit value) *1			○	○	×
	Suspend Hi-Z/Lo-Z	SUZ0	Hi-Z: High resistance output status		✓	○	△	×
		SUZ1	Lo-Z: Low resistance output status					
		SUZ?	Response: SUZ0 or SUZ1			○	○	×
	Sampling	TRM0	AUTO		✓	○	△	×
		TRM1	HOLD					
		TRM?	Response: TRM0 or TRM1			○	○	×

*1: The response decimal point is different depending on the set value.
For the source value, limit value, and time parameter set up range, refer to Chapter 9, "SPECIFICATIONS.".

*2: Outputs the value that is currently generated or the value that is generated in the Operate status.

6.6.3 Remote Command List

Item		Command	Description	Default		Operation		During calibration
				Power ON	Factory shipment	DC OPR/SUS	Sweep OPR/SUS	
Source	Operate/ standby	SBY	Sets the output to OFF (Standby).		✓	○	○	○
		OPR	Sets the output to ON (Operate).			○	○	○
		SUS	Sets the output to Suspend (Suspend).			○	○	×
		SBY?, OPR?, SUS?	Returns the current output status. Response: Status: SBY?, OPR?, SUS? Operate: OPR Suspend: SUS Standby: SBY			○	○	○
	Source delay	TSD [time]	Tds: Source delay time setting Unit: ms Setting range: 0.01 to 5999.8 ms Resolution: 1/10/100 µs		(0.01 ms)	○	△	×
		TSD?	Response: TSDd.dddd			○	○	×
	Measurement delay	TMD [time]	Td: Measurement delay time setting Unit: ms Setting range: 0.02 to 5999.8 ms Resolution: 1/10/100 µs		(0.02 ms)	○	△	
		TMD?	Response: TMDd.dddd			○	○	×
	Period	TPD [time]	Tp: Period setting Unit: ms Setting range: 0.05 to 6000.0 ms Resolution: 1/10/100 µs		(50 ms)	○	△	×
		TPD?	Response: TPDd.dddd			○	○	×
	Hold time	THD [time]	Th: Hold time setting Unit: ms Setting range: 0 to 6000.0 ms Resolution: 100 µs fixed		(0 ms)	○	△	×
		THD?	Response: THDdddd.d			○	○	×
	Trigger delay	TRD [time]	Trigger delay setting Unit: ms Setting range: 0 to 6000.0 ms Resolution: 100 µs fixed		(0 ms)	○	△	×
		TRD?	Response: TRDdddd.d			○	○	×
	Response	FL0	SLOW		✓	×	×	×
		FL1	MED					
		FL2	FAST					
		FL3	Extra FAST					
		FL?	Response: FL0 to FL3			○	○	×
Sweep	Sweep range	SWR4	5 V range		✓	○	▲	×
		SWR5	50 V range					
		SWR6	300 V range					
		SWR?	Response: SWR4 to SWR6			○	○	×
	Linear sweep	SLN [±fd, ±ld, step]	fd: First value (-1 mV) ld: Last value (2 mV) step: Step count (1 to 1999) (30) If all the settings are omitted, set the sweep type only. However it is not allowed to omit each value separately.			○	▲	×
		SLN?	Response: SLN±<st>,±<sp>,<step> st,sp: <d.dddE±d> *1 step:<dddd>			○	○	×

*1: The response decimal point is different depending on the set value.
For the source value, limit value, and time parameter set up range, refer to Chapter 9, "SPECIFICATIONS.".

Item		Command	Description	Default		Operation		During calibration
				Power ON	Factory shipment	DC OPR/SUS	Sweep OPR/SUS	
Sweep	2-slope linear sweep	SLW [±fd, ±sd, ±ld, st1, st2]	fd: First value sd: Second value ld: Last value st1: Step 1 count (1 to 1999) st1+st2 ≤ 1999 st2: Step 2 count (1 to 1999) st1+st2 ≤ 1999 If all the settings are omitted, set the sweep type only. However it is not allowed to omit each value separately.		(-1 mV) (0 V) (2 mV) (10) (10)	○	▲	×
		SLW?	Response: SLW±<fd>, ±<md>, ±<ld>, <st1>, <st2> *1 fd,md,ld,: <d.ddddE±d> st1,st2: <dddd>			○	○	×
	3-slope linear sweep	SLR [±fd, ±sd, ±td, ±ld, st1, st2, st3]	fd: First value sd: Second value td: Third value ld: Last value st1: Step 1 count st1+st2+st3 ≤ 1999 st2: Step 2 count st1+st2+st3 ≤ 1999 st3: Step 3 count st1+st2+st3 ≤ 1999 If all the settings are omitted, set the sweep type only. However it is not allowed to omit each value separately.		(-1 mV) (0 V) (1 mV) (2 mV) (10) (10) (10)	○	▲	×
		SLR?	Response: SLR±<fd>, ±<sd>, ±<td>, ±<ld>, <st1>, <st2>,<St3>*1 fd, sd, td, ld: <d.ddddE±d> st1, st2, st3: <dddd>			○	○	×
	Fixed level sweep	SFX [±lvl, cnt]	lvl: Level source value cnt: Sampling count (1 to 2000) If all the settings are omitted, set the sweep type only. However it is not allowed to omit each value separately.		(0 V) (1)	○	▲	×
		SFX?	Response: SFX±<lvl>, <cnt> lvl: <d.ddddE±d> *1 cnt: <dddd>			○	○	×
	Memory sweep	SMD [st, sp]	st: Start address (0 to 1999) sp: Stop address (0 to 1999) If all the settings are omitted, set the sweep type only. However it is not allowed to omit each value separately.		(0) (0)	○	▲ *3	×
		SMD?	Response: SMD st, sp st,sp: <dddd>			○	○	×
	Sweep type	SX?	Returns the current sweep type. Response: Linear sweep: Same as the response of SLN? Fixed level sweep: Same as the response of SFX? Memory sweep: Same as the response of SRD? 2-slope linear sweep: Same as the response of SLW? 3-slope linear sweep: Same as the response of SLR?			○	○	×

*1: The response decimal point is different depending on the set value.
For the source value, limit value, and time parameter set up range, refer to Chapter 9, "SPECIFICATIONS.".

*3: When sweep stops in the Operate status, the values can be changed only between the start and stop address that was set while it is in the Standby or Suspend status.

6.6.3 Remote Command List

Item		Command	Description	Default		Operation		During calibration
				Power ON	Factory shipment	DC OPR/SUS	Sweep OPR/SUS	
sweep	Memory sweep source data	N [adr] P	Sweep memory data setting starts from N command and completes at P command. N<adr>, SOV<data1>, SOV<data2>, •••, P adr: Memory address (0 to 3999) data1: Voltage source value at adr data2: Voltage source value at adr+1 [NOTE] The range cannot be specified.		(0) (0) *6	○	×	×
		N? [adr]	Response: N<adr>, SOV±<data>, P adr: <dddd> data: <d.ddddE±d> *1			○	○	×
		NP?	Query of the source memory setting status Response: 0•••source memory setting complete 1•••source memory setting in progress			○	○	×
		RSAV	Saves the memory sweep data.			○	×	×
		RLOD	Loads the memory sweep data.			○	×	×
		RCLR	Initializes the memory sweep data. (Data saved in memory is not initialized.)			○	×	×
	Bias value	SB [data]	data: Bias value		(0)	○	▲	×
		SB?	Response: SB±<d.ddddE±d> *1			○	○	×
	RTB (Return To Bias)	RB0 RB1	OFF (Stays at the final value when sweep stops.) ON (Returns to the bias value when sweep stops.)		 ✓	○	△	×
		RB?	Response: RB0 or RB1			○	○	×
	Step count per trigger	SPN [cnt]	cnt: Step count per trigger (1 to 2000)		(1)	○	△	×
		SPN?	Response: SPN<cnt> cnt: <dddd>			○	○	×
	Reverse mode	SV0 SV1	OFF ON		✓	○	△	×
		SV?	Response: SV0 or SV1			○	○	×
	Sweep stop	SWSP	Stops the sweep.			○	○	×
	Trigger	*TRG	Sweep start trigger Measurement trigger			○	○	×
Mea-sure-ment	Function (ADC3 measurement)	F0 F3 F4 F5 F6 F8 F9	Measurement OFF DC current measurement Ir (Reference cell Isc)*7 External voltage measurement Em (EXT.DCV) Temperature measurement Tc1 Ch1 thermocouple T Temperature measurement Pt1or Ad1 Ch1 PT100 or Ch1 AD590 Temperature measurement Tc2 Ch2 thermocouple T Temperature measurement Pt2 or Ad2 Ch2 PT100 or Ch2 AD590		✓	○	△	×
		F?	Response: F0, F3 to F6, F8, F9			○	○	×
	Measurement range (ADC3 measurement)	R1 R2 R3	DCI (ISC) / DCV (EXT.DCV) 3 mA / 30 mV 30 mA / 300 mV 300 mA / 3 V		✓	○	△	×
		R?	Response: R1 to R3			○	○	×
	Pt/Ad selection	ATS0 ATS1	Pt1,Pt2 Ad1,Ad2		✓	○	△	×
		ATS?	Response: ATS0 or ATS1			○	○	×

*1: The response decimal point is different depending on the set value.
For the source value, limit value, and time parameter set up range, refer to Chapter 9, "SPECIFICATIONS.".
*6: Not initialized by the RINI or *RST command.
*7: Ir is set when switching to the sweep mode. It is not changed to another function in the sweep mode.

Item		Command	Description		Default		Operation		During calibration
					Power ON	Factory shipment	DC OPR/SUS	Sweep OPR/SUS	
Mea-sure-ment	Integration time	IT0	5 µs				○	△	×
		IT1	10 µs						
		IT2	25 µs						
		IT3	50 µs						
		IT4	100 µs						
		IT5	250 µs						
		IT6	500 µs						
		IT7	1 ms						
		IT8	2.5 ms						
		IT9	5 ms						
		IT10	10 ms						
		IT11	1 PLC			✓			
		IT12	2 PLC						
		IT13	100 ms						
		IT14	200 ms						
		IT?	Response:	IT0 to IT14			○	○	×
	Spot measure-ment integration time	SIT7	1 ms				○	△	×
		SIT8	2.5 ms						
		SIT9	5 ms						
		SIT10	10 ms						
		SIT11	1 PLC			✓			
		SIT12	2 PLC						
		SIT13	100 ms						
		SIT14	200 ms						
		SIT?	Response:	SIT7 to SIT14			○	○	×
	Spot measure-ment execution	SPM?1	Vm	Executes the specified function measurement and returns the measured value.			×	△	×
		SPM?2	Im	rng: 1 to 3 (can be omitted) For more information, refer to the R command of the measurement range setting					
		SPM?3 [,rng]	Ir	SPM?1: ADC1 Vm measurement					
		SPM?4 [,rng]	Em	SPM?2: ADC2 Im measurement					
		SPM?5	Tc1	SPM?3 to SPM?10: ADC3 specifying function measurement					
		SPM?6	Pt1 or Ad1						
		SPM?8	Tc2	The response is output in the format described in Section "6.5.4 ASCII Output Format."					
		SPM?9	Pt2 or Ad2	However, the header is always output in the ASCII format.					
			NOTE:	Not executable in the DC source mode.					
	Measurement buffer memory	ST0	Store	OFF *8		✓	○	×	×
		ST1		ON					
		ST?	Response:	ST0 or ST1			○	○	×
		RL	Initializes the stored data.				△	△	×
		RN n[,adr]	n:	0... Releases recall execution status.		*5	△	△	×
				1... Sets recall execution status.					
			adr:	Recall data number (0 to 3999)					
				(The data number is not changed if this setting is omitted.)					
				Reading out the recall data by using the talker function after the recall execution status is set performs the following operation.					
				• Increments the recall data number after the data output.					
				• If data does not exist in the specified number, the output becomes <EE +8.88888E+30>.					
				• Reading out does not erase the data in memory.					

*5: Not initialized by the RINI command.
*8: It is set to OFF when switching to the DC mode, and set to ON when switching to the sweep mode. It cannot be set to OFF in the sweep mode.

6.6.3 Remote Command List

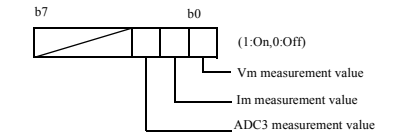
Item		Command	Description	Default		Operation		During calibration
				Power ON	Factory shipment	DC OPR/SUS	Sweep OPR/SUS	
Mea-sure-ment	Measurement buffer memory	RN?	Response: RNn,adr n : <d> adr: <dddd>			○	○	×
		SZ?	Reads out the number of stored data. Response: <dddd>	(0)	*6	○	○	×
		RNM adr	adr: Specifies the store data number (0 to 4000). When the store data number of the measurement buffer memory is reached, bit 4 (ASM) of the device event status register (DSR) is set. For adr=0, it is set to OFF.	0	*6	△	△	×
		RNM?	Response: RNMdddd			○	○	×
		RDN adr1,adr2	Specifies the memory range to be read by RDT?. *9 adr1: First recall data number (0 to 3999) adr2: Last recall data number (0 to 3999)	(0, 0)	*5	○	△	×
		RDN?	Response: RDN adr1,adr2 *9 adr1,adr2: <dddd>			○	○	×
		RDT?	Reads out the memory data in the specified range. *9 Response: The comma-separated data in the specified range is output in the format described in Section "6.5 Data Output Format." • If data does not exist in the specified number, the output becomes <EE +8.88888E+30>. • Executing this command releases the recall execution status.	(0)		○	△	×
	ZERO measurement	ZM	Executes ZERO measurement by using the currently set function, range and integration time.			○	△	×
	Temperature unit	TPU0	Temperature unit °C		✓	○	△	×
		TPU1	Temperature unit °F					
		TPU2	Temperature unit K					
		TPU?	Response: TPU0 to TPU2			○	○	×
	Resistance bulb	RTD0	Pt100		✓	○	△	×
		RTD1	JPt100					
		RTD?	Response: RTD0 to RTD1			○	○	×
System	User parameter	STP0	Saves setting parameters to the non-volatile memory, User-0.			○	△	×
		STP1	Saves setting parameters to the non-volatile memory, User-1.					
		STP2	Saves setting parameters to the non-volatile memory, User-2.					
		STP3	Saves setting parameters to the non-volatile memory, User-3.					
		SINI	Sets the factory default settings to USER0 through User-3.					
		RCLP0	Loads data from the non-volatile memory, User-0 as setting parameters.			×	×	×
		RCLP1	Loads data from the non-volatile memory, User-1 as setting parameters.					
		RCLP2	Loads data from the non-volatile memory, User-2 as setting parameters.					
		RCLP3	Loads data from the non-volatile memory, User-3 as setting parameters.					
		RINI	Loads the factory default settings as setting parameters.					
	Initialization	*RST	Initializes parameters. (Items except *6 are default values.)			○	○	○
		CDV	Device clear (Do not write with other commands in succession in one line.)			○	○	○

*5: Not initialized by the RINI command.
*6: Not initialized by the RINI or *RST command.
*9: Not specified by USB.

Item		Command	Description	Default		Operation		During calibration
				Power ON	Factory shipment	DC OPR/SUS	Sweep OPR/SUS	
System	Instrument information	*IDN?	Response: Instrument information query command ADC Corp.,4601,XXXXXXXXX,YYYYY ADC Corp. :Manufacturer (9 characters) 4601 :Device name (4 characters) xxxxxxxxx :Serial number (9 characters) yyyyy :ROM revision number (5 characters)			○	○	○
	Power frequency	Auto setting				○	○	○
		LF?	Response: LF0 ••• 50Hz LF1 ••• 60Hz					
	Notice buzzer	NZ0	OFF			○	△	×
		NZ1	ON		✓			
		NZ?	Response: NZ0 or NZ1			○	○	×
	Screen ON/OFF	DSW0	Screen OFF			○	△	×
		DSW1	Screen ON		✓			
		DSW2	Screen OFF only in remote control					
		DSW?	Response: DSW0 to DSW2			○	○	×
	Self test	*TST?	Executes the test and reads out the results. Response: 0•••Pass 1•••Fail			×	×	×
	Error log	ERR?	Reads out error descriptions. Response: ±ddd,"xxxxxxxxxx" Error string (up to 80 characters) Error code • Records up to 20 error logs by the FIFO method. • When 21th or later error occurs, the last saved error is replaced by -350 Queue overflow. • When there is no error, returns +000 "No error."			○	○	○
	Source control signal input and output	OP0	STBY In signal input (IN)		✓	×	×	×
		OP1	OPR/STBY IN signal input (IN)					
		OP2	OPR/SUS In signal input (IN)					
		OP3	Operate Out signal output (OUT)					
		OP?	Response: OP0 to OP3			○	○	×
	Synchronous control signal output setting	CP0	COMPLETE signal output			○	△	×
		CP1	Sync Out signal output		✓			
		CP?	Response: CP0 or CP1			○	○	×
		CW0	Specifies the synchronous control signal output width: 10 µs		✓	○	△	×
		CW1	Specifies the synchronous control signal output width: 100 µs					
		CW?	Response: CW0 or CW1			○	○	×
	Contact signal input and output	DSI?0	Reads out the contact signal input port 1.			○	○	×
		DSI?1	Reads out the contact signal input port 2.					×
			Response: 0 (Break) or 1 (make)					
		DSO n,v	Contact signal output port setting n: 0 Target: Contact signal output port 1 (break) *5 n: 1 Target: Contact signal output port 2 (break) *5 n: 2 Target: Contact signal output port 3 (break) *5 n: 3 Target: Contact signal output port 4 (break) *5 v = 0: Break 1: Make			○	○	×
		DSO? n	Response: DSO<n>,<v> n: 0 to 3 v: 0 or 1			○	○	×

*5: Not initialized by the RINI command.

6.6.3 Remote Command List

Item		Command	Description	Default		Operation		During calibration
				Power ON	Factory shipment	DC OPR/SUS	Sweep OPR/SUS	
System	Relay counter	RSL 1	Relay counter 1		✓	×	×	×
		RSL 2	Relay counter 2		*6			
		RSL 3	Relay counter 3					
		RSL 4	Relay counter 4					
		RSL 5	Relay counter 5					
		RSL 6	Relay counter 6					
		RSL 7	Relay counter 7					
		RSL 8	Relay counter 8					
		RSL 9	Relay counter 9					
		RSL 10	Relay counter 10					
		RSL?	Response: RSL1 to RSL10			○	○	×
		RCNT n	Writes the relay counter value. n: 0 to 999999999			×	×	○
		RCNT?	Reads out the relay counter value.		(0)	○	○	○
			Response: RCNTddddddddd		*6			
Remote	Block delimiter	DL0	CRLF<EOI>		✓ *5	○	△	×
		DL1	LF					
		DL2	<EOI> NOTE: EOI is always output regardless of the setting in the binary output mode.					
		DL3	LF<EOI>					
		DL?	Response: DL0 to DL3			○	○	×
	Measurement data output format	FMT0	ASCII format output		✓ *6	○	△	×
		FMT1	Binary format output *9			○	○	×
		FMT?	Response: FMT0 or FMT1			○	○	×
	Header output	OH0	OFF			○	△	×
		OH1	ON NOTE: The header is not output even if it is set to ON in the binary output mode.		✓ *6			
		OH?	Response: OH0 or OH1			○	○	×
	Output target data	OTM n	Specifies the output target data individually.  		✓ *6	○	△	○
			n: Setting contents 1: Outputs the Vm measurement value only. 2: Outputs the Im measurement value only. 3: Outputs the Vm and Im measurement values. 4: Outputs the ADC3 measurement value only. 5: Outputs the Vm and ADC3 measurement values. 6: Outputs the Im and ADC3 measurement values. 7: Outputs the Vm, Im and ADC3 measurement values.					
		OTM?	Response: OTM0 to OTM7			○	○	○

*5: Not initialized by the RINI command.
*6: Not initialized by the RINI or *RST command.
*9: Not specified by USB.

Item		Command	Description	Default		Operation		During calibration
				Power ON	Factory shipment	DC OPR/SUS	Sweep OPR/SUS	
Remote	Status	*STB?	Query of the status byte register Response: ddd			○	○	○
		*SRE n	Service request enable register setting (n: 0 to 255)		*6	○	○	○
		*SRE?	Response: ddd			○	○	○
		*ESR?	Query of the standard event status register Response: ddd			○	○	○
		*ESE n	Standard event status enable register setting (n: 0 to 255)		*6	○	○	○
		*ESE?	Response: ddd			○	○	○
		MSR?	Query of the measurement event register Response: ddddd			○	○	○
		MSE n	Measurement event enable register setting (n: 0 to 65535)	(0)	*6	○	○	○
		MSE?	Response: ddddd			○	○	○
		QSR?	Query of the questionable event register Response: ddddd			○	○	○
		QSE n	Questionable event enable register setting (n: 0 to 65535)	(0)	*6	○	○	○
		QSE?	Response: ddddd			○	○	○
		*PSC n	When n is other than 0, SRER and SESER are cleared at power ON. When it is set to 0, SRER and SESER are not cleared at power ON.	(1)	*6	○	○	○
		*PSC?	Response: 0 or 1 (when n is set to other than 0)			○	○	
		*CLS	Status clear			○	○	○
	Operation complete	*OPC	Sets the LSB of the standard event status register after all operations are complete.			○	○	○
		*OPC?	Response: 1 (after all operations completed)			○	○	○
		*WAI	Waits until all operations are complete.(GPIB only) *9			○	○	○
Calibra-tion	Calibration data	XINI	Initializes the calibration data area for calibration execution. (The calibration data in the non-volatile memory is not affected.)			×	×	○
		XWR	Saves the calibration data to the non-volatile memory.			×	×	○
	Calibration execution	XVS	Voltage source function calibration			×	×	○
		XILH	Current limit (+) calibration					
		XILL	Current limit (-) calibration					
		XVM	Voltage measurement function calibration					
		XIM	Current measurement function calibration					
		XIR	Ir measurement function calibration					
		XEM	External voltage Em function calibration					
		XT1	Ch1 thermocouple T function calibration					
		XT2	Ch2 thermocouple T function calibration					
		XPT1	Ch1 PT function calibration					
		XPT2	Ch2 PT function calibration					
		XAD1	Ch1 AD590 sensor function calibration					
		XAD2	Ch2 AD590 sensor function calibration					
		XRJ1	Ch1 reference junction temperature calibration					
		XRJ2	Ch2 reference junction temperature calibration					

*6: Not initialized by the RINI or *RST command.
*9: Not specified by USB.

6.6.3 Remote Command List

<table>
<tr><th colspan="2" rowspan="2">Item</th><th rowspan="2">Command</th><th rowspan="2">Description</th><th colspan="2">Default</th><th colspan="2">Operation</th><th rowspan="2">During calibration</th></tr>
<tr><th>Power ON</th><th>Factory shipment</th><th>DC OPR/SUS</th><th>Sweep OPR/SUS</th></tr>
<tr><td rowspan="4">Calibra-tion</td><td>Calibration range</td><td>XR0
XR1
XR2
XR3
XR4
XR5
XR6</td><td>Calibration range setting
<table><tr><th></th><th>Voltage range</th><th>Current range</th></tr><tr><td>XR0</td><td>-</td><td>300 µA</td></tr><tr><td>XR1</td><td>-</td><td>3 mA</td></tr><tr><td>XR2</td><td>30 mV</td><td>30 mA</td></tr><tr><td>XR3</td><td>300 mV</td><td>300 mA</td></tr><tr><td>XR4</td><td>5 V 3 V</td><td>3 A</td></tr><tr><td>XR5</td><td>50 V</td><td>1 0A</td></tr><tr><td>XR6</td><td>300 V</td><td></td></tr></table></td><td></td><td></td><td>×</td><td>×</td><td>○</td></tr>
<tr><td rowspan="3">Calibration data</td><td>XDAT
XD data</td><td>Switches to the DMM data input mode.
data: DMM reading data</td><td></td><td></td><td>×</td><td>×</td><td>○</td></tr>
<tr><td>XADJ</td><td>Switches to the calibration data fine adjustment mode.</td><td></td><td></td><td>×</td><td>×</td><td>○</td></tr>
<tr><td>XNXT</td><td>Moves on to the next calibration.</td><td></td><td></td><td>×</td><td>×</td><td>○</td></tr>
</table>

6.7 Sample Program

This section describes program examples to remotely control the 4601 with the GPIB or USB interface.

The following sample programs are provided.
These programs can be downloaded from ADC's website.

http://www.adcmt.com/samplesoft/samplesoft_01.html

	Program contents
Example 1	The 4601 generates DC voltage in the DC source mode and measures Voc (open-circuit voltage) and Isc (short-circuit current).
Example 2-1	The 4601 executes 99-step linear sweep in the sweep source mode, receives a SRQ that indicates 100 data have been stored in the measurement memory, and reads out the data collectively from the measurement memory in the ASCII format. Temperature measurement for two channels using a T-type thermocouple is executed before and after sweep
Example 2-2	The 4601 executes 99-step linear sweep in the sweep source mode, polls the status register to find out that 100 data have been stored in the measurement memory, and reads out the data one by one from the measurement memory in the ASCII format collectively. Temperature measurement for two channels using a T-type thermocouple is executed before and after sweep
Example 3	The 4601 executes 99-step linear sweep in the sweep source mode, receives a SRQ that indicates 100 data have been stored in the measurement memory, and reads out the measurement memory in the binary format collectively. Temperature measurement for two channels using a T-type thermocouple is executed before and after sweep

- The sample programs have GPIB versions and UBS versions as follows:

GPIB: Example 1, Example 2-1, Example 3

USB: Example1, Example 2-2

The operating environment for the programs is as follows:

OS: Microsoft Windows XP Professional

Language: Microsoft Excel Visual Basic for Applications (VBA)

For GPIB interface

GPIB hardware: National Instruments NI GPIB-USB-HS

Module: Niglobal.bas, Vbib-21.bas
(Driver software attached with NI GPIB-USB-HS)

For USB interface

Module: ausb.bas
(ADC Instrument USB Driver)

Download the ADC Instrument USB Driver from ADC's website.

http://www.adcmt.com/driversoft/USB_driver.html

7. PERFORMANCE TEST

This chapter describes the methods for checking whether the 4601 operates in the specified accuracy.

7.1 Measuring Instruments Necessary for Performance Test

Use measuring instruments for the performance test which meet the specifications described in Section 8.1.1, "Measuring Instruments Necessary for Calibration."

7.2 Connections

The connections required for the performance test are the same as shown in Figure 8-4, "Connections for Calibration(4 of 4)."

7.3 Test Method

Execute the performance test under the following conditions in a location free of dust, vibration, noise or other adverse conditions:

Temperature:	23 °C±5 °C
Relative humidity:	60% or lower
Warm-up:	60 minutes or longer

7.3.1 Self-Test, Display, Key, and Buzzer

Press the **MENU** key. Select **1) MAINTENANCE** from the categories and **1) Self Test** from the parameters.

If an error occurs during the test, refer to Section 5.7, "Self Test" to verify the content of the error.
If any result of the following tests does not fall within the accuracy specifications, calibrate the 4601 as outlined in Chapter 8, "CALIBRATION" or contact an ADC CORPORATION sales representative for the calibration or servicing.

7.3.2 Voltage Source and Voltage Measurement Test

1. Connect the 4601 and DMM (Digital Multimeter) as shown in Figure 8-1 (a).
2. Set DMM to DCV, auto range and integration time of 10 PLC.
3. Set the 4601 to the DC source mode, AUTO sampling and integration time of 200 ms.
4. Set the output status to Operate.
5. With ZERO and ± Full Scale generated in the 5 V to 300 V range, verify that the difference between the source value and the DMM measured value and the difference between the source value and the voltage measured value of the 4601 are within the accuracies described in Chapter 9, "SPECIFICATIONS."

7.3.3 Current Measurement Test

1. Connect the 4601 and a current source standard as shown in Figure 8-1 (b).
2. Set the 4601 to the DC source mode, AUTO sampling and integration time of 200 ms.
3. Set the voltage source to 0 V and the current limit to ±320 μA.
4. Set the output status to Operate.
5. Generate 0 A, +300 μA and -300 μA from the standard, and verify that the difference between the source value and the measured current of the 4601 is within the accuracy described in Chapter 9, "SPECIFICATIONS."
6. Change the current limit value from ±3.2 mA to ±10.2 A, change the source value of the standard to ZERO and ±Full Scale, and check the accuracies in the same way as Step 4 and Step 5.
   In the 300 mA to 10 A range, check the positive current by +0.1 A and the negative current by - FS.
   The connection in the 3 A range and the 10 A range is shown in Figure 8-4 (c).

7.3.4 Current Limit Test

Perform this test after the current measurement test is complete.

1. Connect the 4601 and a current source standard as shown in Figure 8-2 (d).
2. Set the 4601 to the DC source mode, AUTO sampling and integration time of 200 ms.
3. Set the voltage source to +5 V and the current limit to ±300 μA.
4. Set the output status to Operate.
5. Generate +5 V and -5 V, and verify that the difference between the current limit and the measured current of the 4601 is within the accuracy described in Chapter 9, "SPECIFICATIONS."
6. Change the current limit from ±3.0 mA to ±10.0 A, and check the positive and negative current limit accuracies in the same way as Step 4 and Step 5.
   In the 300 mA to 10 A range, check the positive current limit by +0.1 A and the negative current limit by - FS.

7.3.5 Reference Cell Current Measurement Test

1. Connect the 4601 and a current source standard as shown in Figure 8-2 (e).
2. Set the 4601 to the DC source mode, AUTO sampling and integration time of 200 ms.
3. Set ADC3 measurement to the reference current function Ir and select the 3 mA range.
4. Set the output status to Operate.
5. Generate ZERO and ±FS from the standard, and verify that the difference between the measured current of the 4601 in the 3 mA to 300 mA range and the setting value of the standard is within the accuracy described in Chapter 9, "SPECIFICATIONS."
   -FS in the 300 mA range is checked by -30 mA.

7.3.6 Pt Temperature Measurement Test

1. Connect the 4601 and a resistance source standard as shown in Figure 8-2 (f).
2. Set the 4601 to the DC source mode, AUTO sampling and integration time of 200 ms.
3. Set ADC3 measurement to the Pt1 or Pt2 function.
4. Set the output status to Operate.
5. Set the resistance of the standard to 100 Ω, and verify that the measured value of the 4601 is within the accuracy described in Chapter 9, "SPECIFICATIONS."
   The temperature at the resistance is as follows:

Resistance value	100 Ω	Temperature	0 °C

7.3.7 AD590 Temperature Measurement Test

1. Connect the 4601 and a current source standard as shown in Figure 8-3 (g).
2. Set the 4601 to the DC source mode, AUTO sampling and integration time of 200 ms.
3. Set ADC3 measurement to the Ad1 or Ad2 function.
4. Set the output status to Operate.
5. Set the source current of the standard to 273.2 μA and 373.2 μA, and verify that the measured values of the 4601 are within the accuracies described in Chapter 9, "SPECIFICATIONS."
   The temperature at each current is as follows:

Current value	273.2 μA	Temperature	0 °C
Current value	373.2 μA	Temperature	100 °C

7.3.8 Type T Thermocouple Temperature Measurement Test

1. Connect the 4601 and a voltage source standard as shown in Figure 8-3 (h).
2. Set the 4601 to the DC source mode, AUTO sampling and integration time of 200 ms.
3. Set ADC3 measurement to the Tc1 or Tc2 function.
4. Set the output status to Operate.
5. Set the source voltage of the standard to 0 V and 10 mV, and verify that the measured values of the 4601 are within the accuracies described in Chapter 9, "SPECIFICATIONS."
   The temperature at each voltage is as follows:

Voltage value	0 V	Temperature *	Approx. 25 °C
Voltage value	10 mV	Temperature *	Approx. 200 °C

*When the ambient temperature of the 4601 is 25 °C

7.3.9 External Voltage Measurement Test

1. Connect the 4601 and a voltage source standard as shown in Figure 8-4 (j).
2. Set the 4601 to the DC source mode, AUTO sampling and integration time of 200 ms.
3. Set ADC3 measurement to the external voltage measurement Em and select the 30 mV range.
4. Set the output status to Operate.
5. Generate ZERO and ±FS from the standard, and verify that the difference between the voltage source of the 4601 in the 30 mV to 3 V range and the setting value of the standard is within the accuracy described in Chapter 9, "SPECIFICATIONS."

8. CALIBRATION

This chapter describes how to calibrate the 4601 to perform within the specified accuracy ranges.
In order to use the 4601 in the specified accuracies, periodic calibration at least once a year is recommended.
Contact an ADC CORPORATION sales representative for the calibration service.

NOTE: ***The 4601 is calibrated only by remote operation through the GPIB or USB interface, but not by manual operation.***

8.1 Preparation for Calibration

8.1.1 Measuring Instruments Necessary for Calibration

The following table shows the measuring instruments necessary for calibration in each range.

Table 8-1 Measuring Instruments Necessary for Calibration

Standard	Applicable range	Required accuracy	Recommended instrument *1
Digital voltmeter	1 μV to 1000 V	±20 ppm	6581*2
Current source	0 mA to 300 mA	±120 ppm	*2
	3 A	±250 ppm	
	10 A	±400 ppm	
Resistance	1 kΩ, 100 Ω	±30 ppm	
0 °C standard calibration bath Type T thermocouple class 1	0 °C	±0.1 °C	COPER ELECTRONICS ZC-114
			ADC 1101-100

*1: When the 6581 is used, the following conditions should be met:
Integration time: 20 PLC, Auto ZERO: ON, within 24 hours after INT CAL

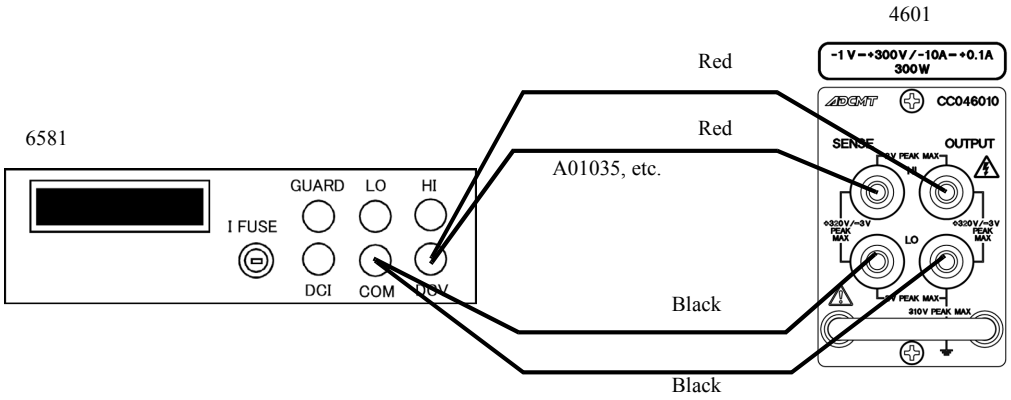
*2: When much externally induced noise exists, use shielded cables, such as A01035, A01047, etc.

8.1.2 Precautions

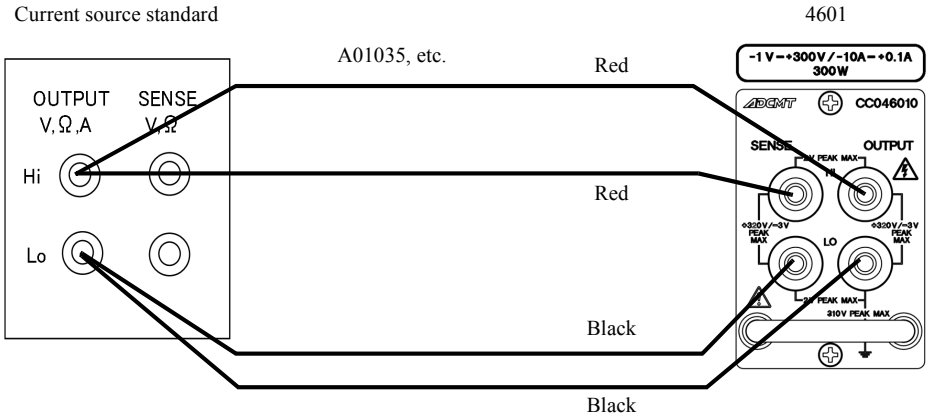
1. Use an AC power supply with the specified voltage.
2. Execute calibration under the following conditions in a location free of dust, vibration, noise or other adverse conditions:
   Temperature: 23 °C ±3 °C Relative humidity: 60% or lower
3. Allow the 4601 to warm-up for one hour or longer before calibration.
   Allow the measuring instrument to be used in calibration to warm-up for the period of time specified before the calibration.
   The warm-up time for the 6581 is four hours or longer.
4. After calibration, note the dates of the calibration and the next scheduled calibration on a card or sticker, etc. for convenience.

8.2 Connections

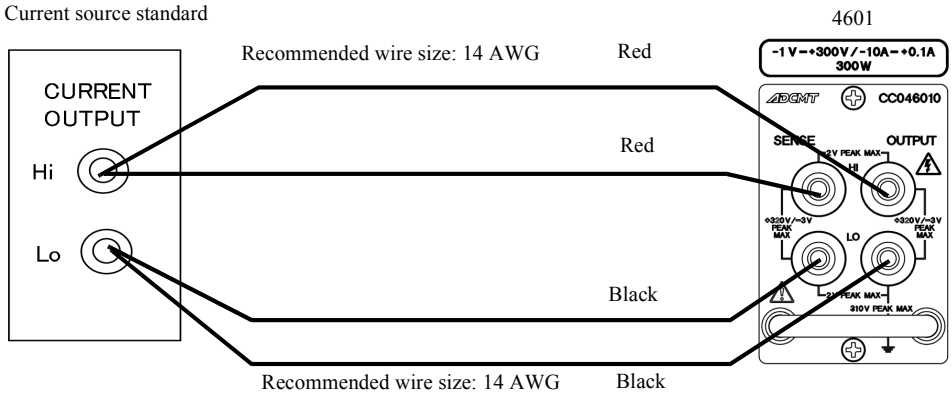
The following figure shows connections for calibrating the 4601 using the digital multimeter 6581, a current source standard, and a 0 °C standard calibration bath.



(a) Voltage source and voltage measurement calibration

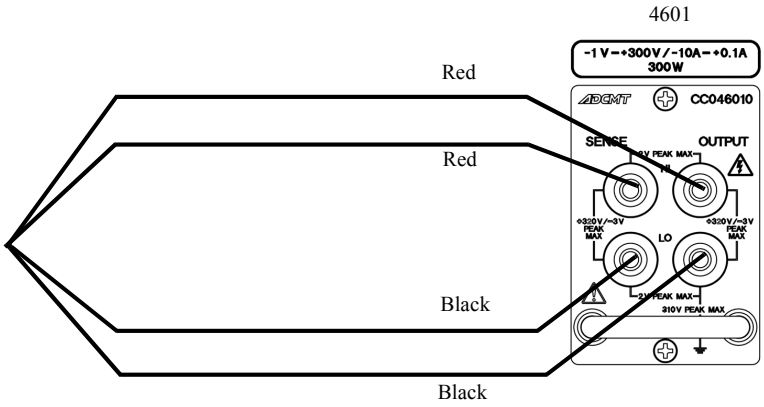


(b) Current Measurement Calibration (300 μA to 300 mA range)

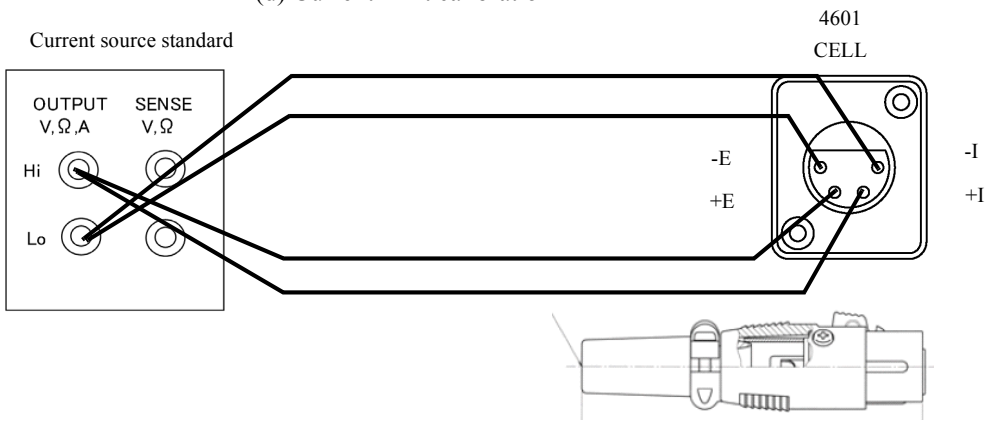


(c) Current Measurement Calibration (3 A to 10 A range)

Figure 8-1 Connections for Calibration (1 of 4)

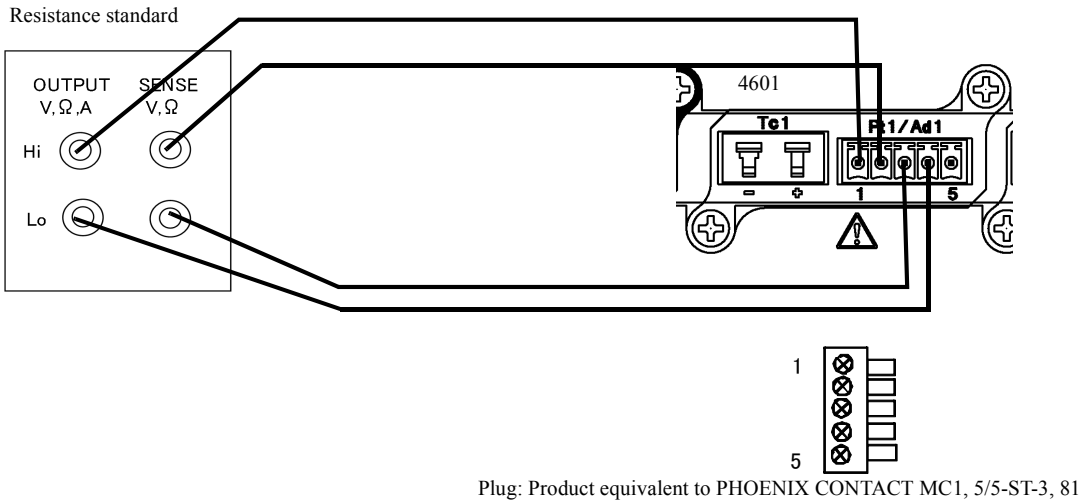


(d) Current limit calibration



Plug: Product equivalent to ITT CANNON cannon plug XLR-4-11C

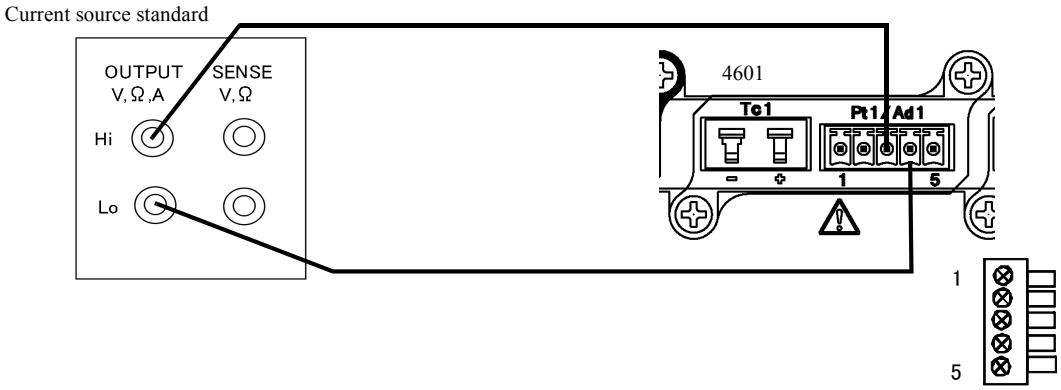
(e) Reference current measurement calibration



Plug: Product equivalent to PHOENIX CONTACT MC1, 5/5-ST-3, 81

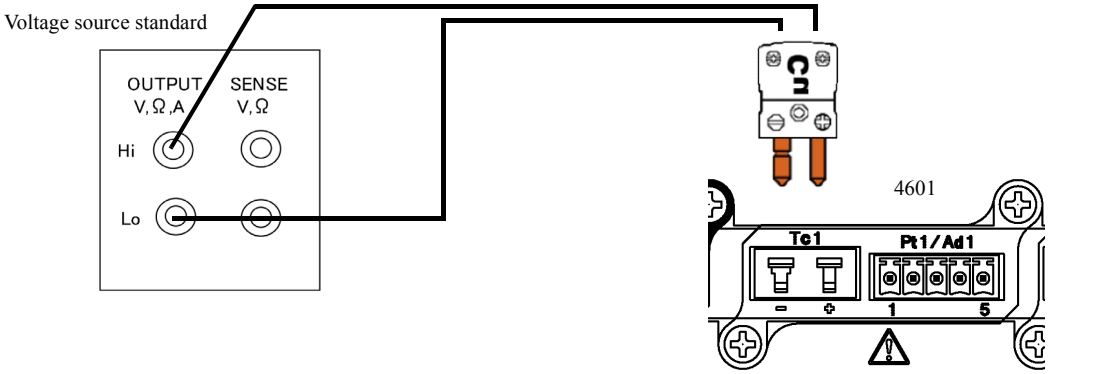
(f) Pt measurement calibration

Figure 8-2 Connections for Calibration (2 of 4)



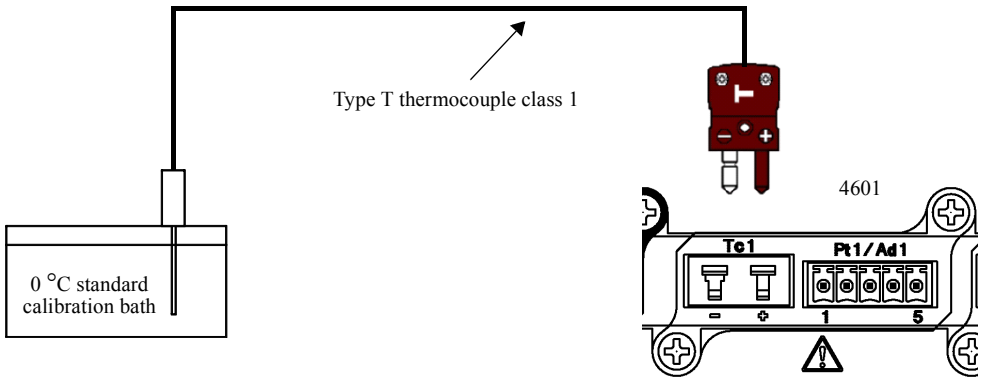
Plug: Product equivalent to
PHOENIX CONTACT MC1, 5/5-ST-3, 81

(g) AD590 measurement calibration



Plug: Product equivalent to LABFACILITY IM-T-M

(h) Thermocouple measurement calibration



Thermocouple: Type T thermocouple class 1

(i) Reference junction temperature calibration

Figure 8-3 Connections for Calibration (3 of 4)

(j) External voltage measurement calibration

Figure 8-4 Connections for Calibration(4 of 4)

8.3 Calibration Points and Tolerance Ranges

For calibration, use the measurement instruments satisfying the required accuracies described in Section 8.1.1, "Measuring Instruments Necessary for Calibration", meeting the tolerance ranges shown in the following table.

Table 8-2 Calibration Tolerance Ranges

1. Voltage source/voltage measurement/current measurement terminal

■ Source calibration

Voltage source calibration (VS)

Range	Calibration point	Tolerance specification [digit]
5 V	0.0000 V	±1d
	+5.0000 V	±1d
50 V	00.000 V	±1d
	+50.000 V	±1d
300 V	000.00 V	±1d
	+300.00 V	±1d

■ Voltage measurement calibration

Voltage measurement calibration (VS/VM)

Range	Calibration point	Tolerance specification [digit]
5 V	0.00000 V	±2d
	+5.00000 V	±2d
50 V	00.0000 V	±2d
	+50.0000 V	±2d
300 V	000.000 V	±2d
	+300.000 V	±2d

■ Current measurement calibration

Current measurement calibration (VM/IM)

Range	Calibration point	Tolerance specification [digit]
300 μA	000.000 μA -300.000 μA	±2d ±2d
3 mA	0.00000 mA -3.00000 mA	±2d ±2d
30 mA	00.0000 mA -30.0000 mA	±2d ±2d
300 mA	000.000 mA -300.000 mA	±5d ±5d
3 A	0.00000 A -3.00000 A	±5d ±5d
10 A	00.0000 A -10.0000 A	±5d ±5d

■ Current limit calibration

Current sink limit calibration (L limit)

Current limit range	Calibration point	Tolerance specification [digit]
300 μA	000.0 μA -300.0 μA	±0.5d ±0.5d
3 mA	0.000 mA -3.000 mA	±0.5d ±0.5d
30 mA	00.00 mA -30.00 mA	±0.5d ±0.5d
300 mA	000.0 mA -300.0 mA	±0.5d ±0.5d
3 A	0.000 A -3.000 A	±0.5d ±0.5d
10 A	00.00 A -10.00 A	±1d ±1d

Current source limit (H limit)

Current limit range	Calibration point	Tolerance specification [digit]
300 μA	000.0 μA +300.0 μA	±1.0d ±1.0d
3 mA	0.000 mA +3.000 mA	±1.0d ±1.0d
30 mA	00.00 mA +30.00 mA	±1.0d ±1.0d
300 mA	000.0 mA +100.0 mA	±1.0d ±1.2d
3 A	0.000 A +0.100 A	±1.0d ±1.2d
10 A	00.00 A +00.10 A	±1.0d ±1.2d

2. Voltage measurement terminal

External voltage measurement calibration (Em)

Range	Calibration point	Tolerance specification [digit]
30 mV	00.0000 mV +30.0000 mV	±5d ±5d
300 mV	000.000 mV +300.000 mV	±2d ±2d
3 V	0.00000 V +3.00000 V	±2d ±2d

3. Reference cell measurement terminal

Reference cell current measurement calibration (Ir)

Range	Calibration point	Tolerance specification [digit]
3 mA	0.00000 mA +3.00000 mA	±2d ±2d
30 mA	00.0000 mA +30.0000 mA	±2d ±2d
300 mA	000.000 mA +300.000 mA	±5d ±5d

4. Temperature measurement thermocouple measurement terminal

Thermocouple voltage measurement calibration (Tc1/Tc2)

Range	Calibration point	Tolerance specification [digit]
Tc1 50 mV	00.0000 mV +50.0000 mV	±20d ±20d
Tc2 50 mV	00.0000 mV +50.0000 mV	±20d ±20d

Thermocouple reference junction temperature calibration (Tc1/Tc2)

Range	Calibration point	Tolerance specification [digit]
Tc1	0 °C	±5d
Tc2	0 °C	±5d

5. Temperature measurement Pt measurement terminal

Pt resistance measurement calibration (Pt1/Pt2)

Range	Calibration point	Tolerance specification [digit]
Pt1 1 kΩ	0.00000 kΩ +1.00000 kΩ	±2d ±2d
Pt2 1 kΩ	0.00000 kΩ +1.00000 kΩ	±2d ±2d

6. Temperature measurement AD590 measurement terminal

AD590 current measurement calibration (Ad1/Ad2)

Range	Calibration point	Tolerance specification [digit]
Ad1 1 mA	0.00000 mA +0.30000 mA	±2d ±2d
Ad2 1 mA	0.00000 mA +0.30000 mA	±2d ±2d

8.4 Calibration Procedure

8.4.1 Calibration Operation

The 4601 is calibrated by using the remote commands through the GPIB or USB interface. Figure 8-5 to Figure 8-11 shows the flows of calibration processes.

Calibration procedure (1)

The following figure shows the overall flow of calibrations.

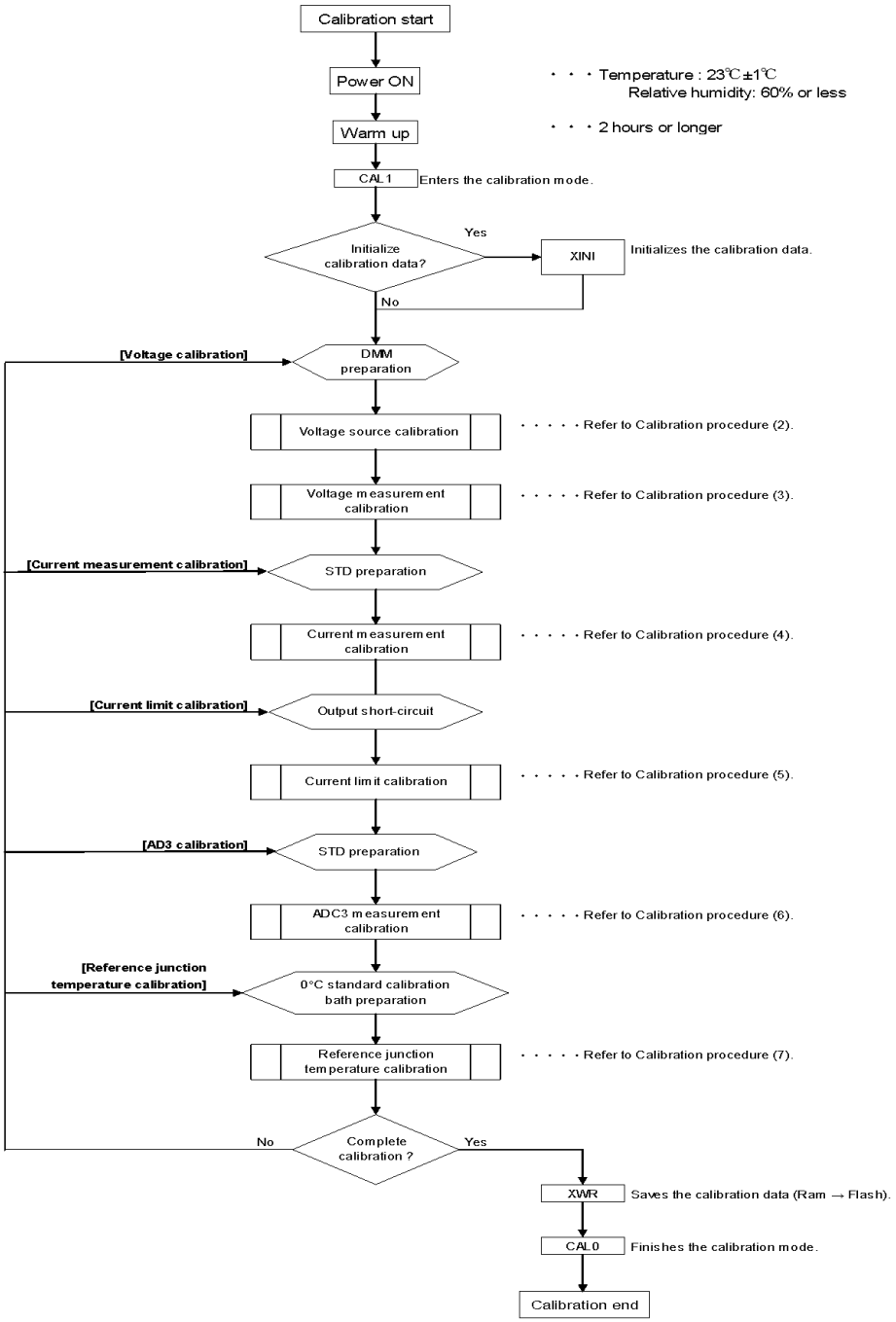


Figure 8-5 Calibration Procedure (1)

Calibration procedure (2)

The following figure shows the flow of voltage source calibration.
Connect the 4601 to the DMM as shown in Figure 8-1 (a).

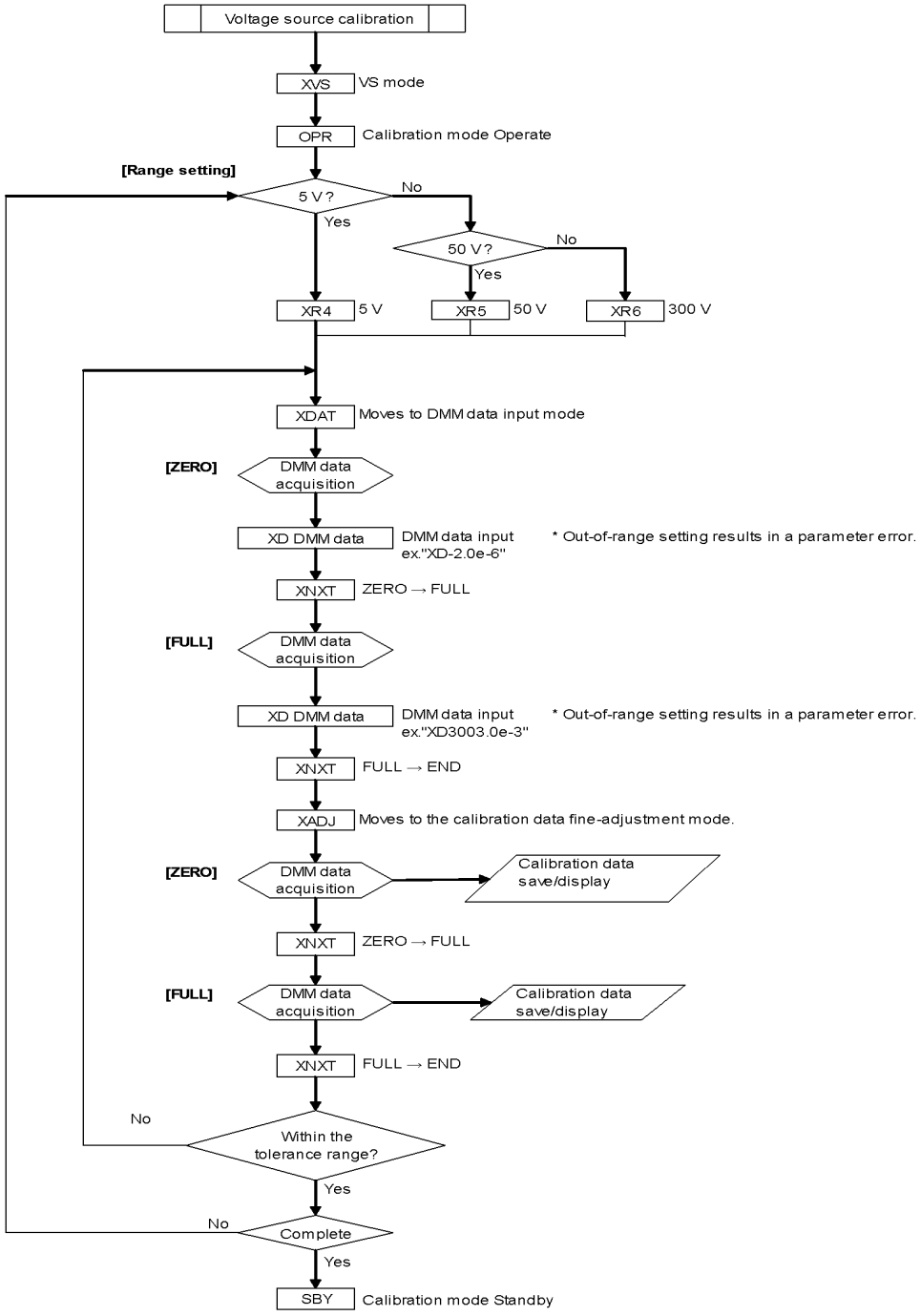


Figure 8-6 Calibration Procedure (2)

Calibration procedure (3)

The following figure shows the flow of voltage measurement calibration.
Connect the 4601 to the DMM as shown in Figure 8-1 (a).

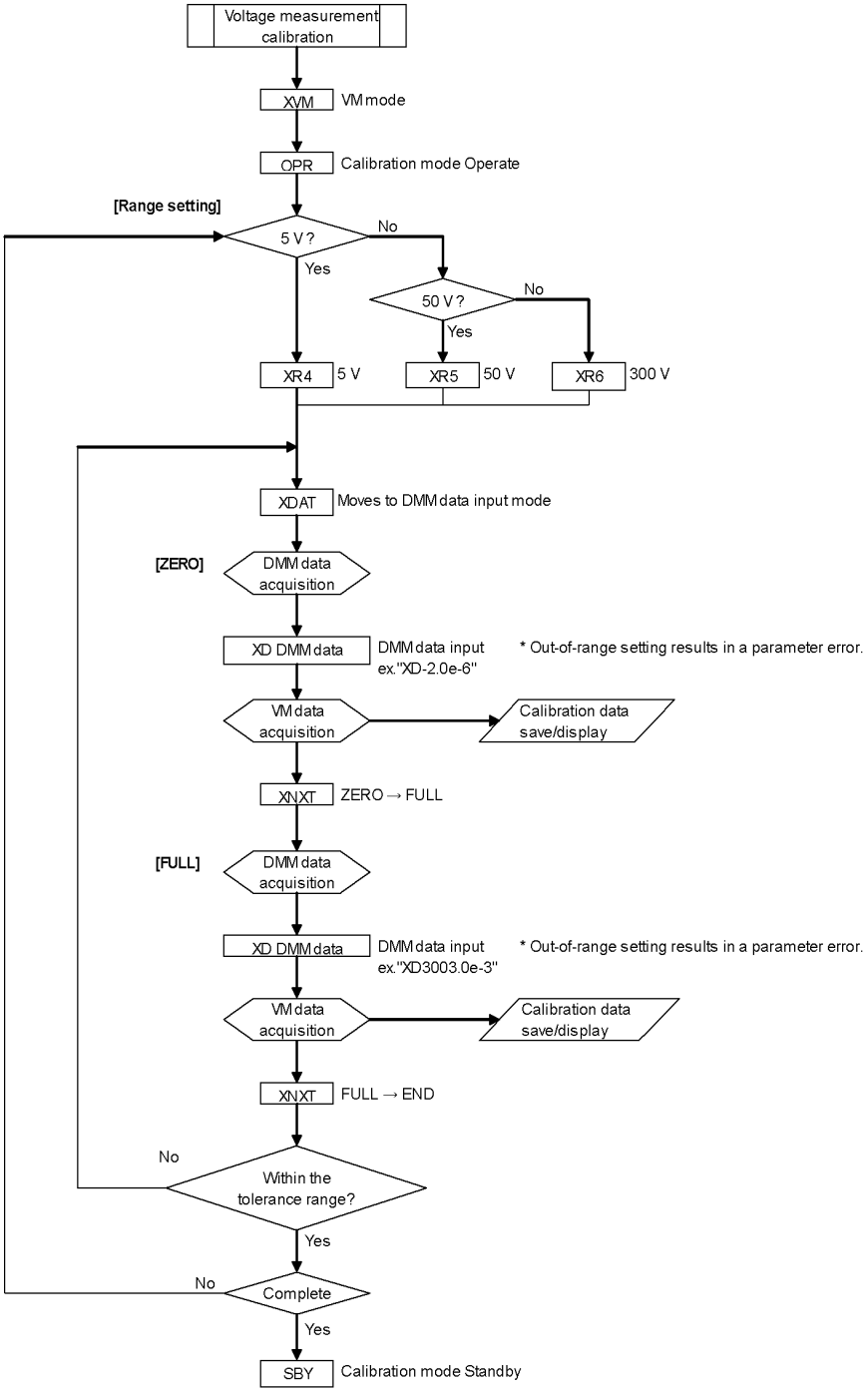


Figure 8-7 Calibration Procedure (3)

Calibration procedure (4)

The following figure shows the flow of current measurement calibration.
Connect the 4601 to the standard as shown in Figure 8-1 (b) in the 300µA to 300 mA range or Figure 8-1 (c) in the 3 A to 10 A range.

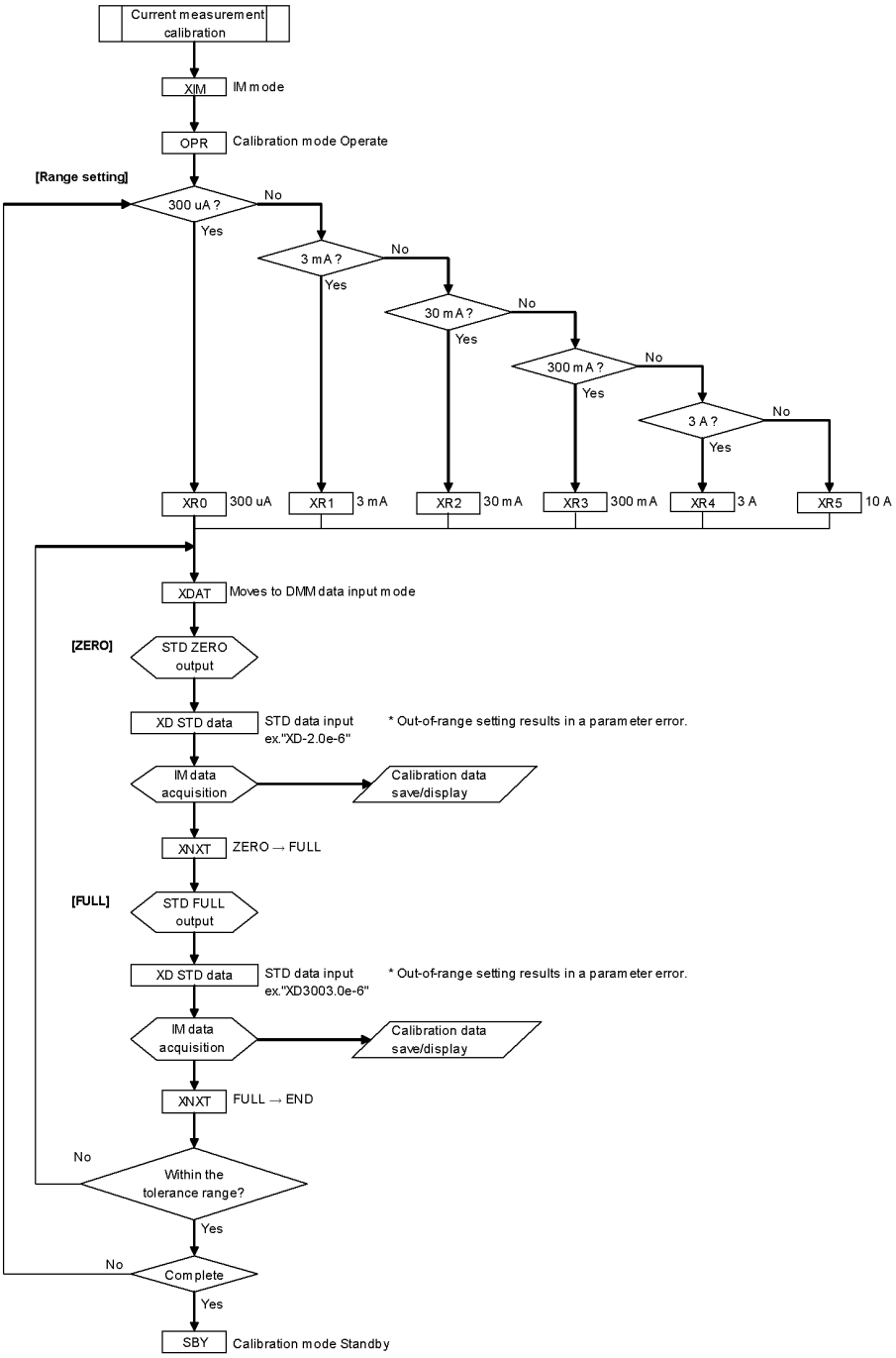


Figure 8-8 Calibration Procedure (4)

Calibration procedure (5)

The following figure shows the flow of current limit calibration.
Connect the 4601 as shown in Figure 8-2 (d).

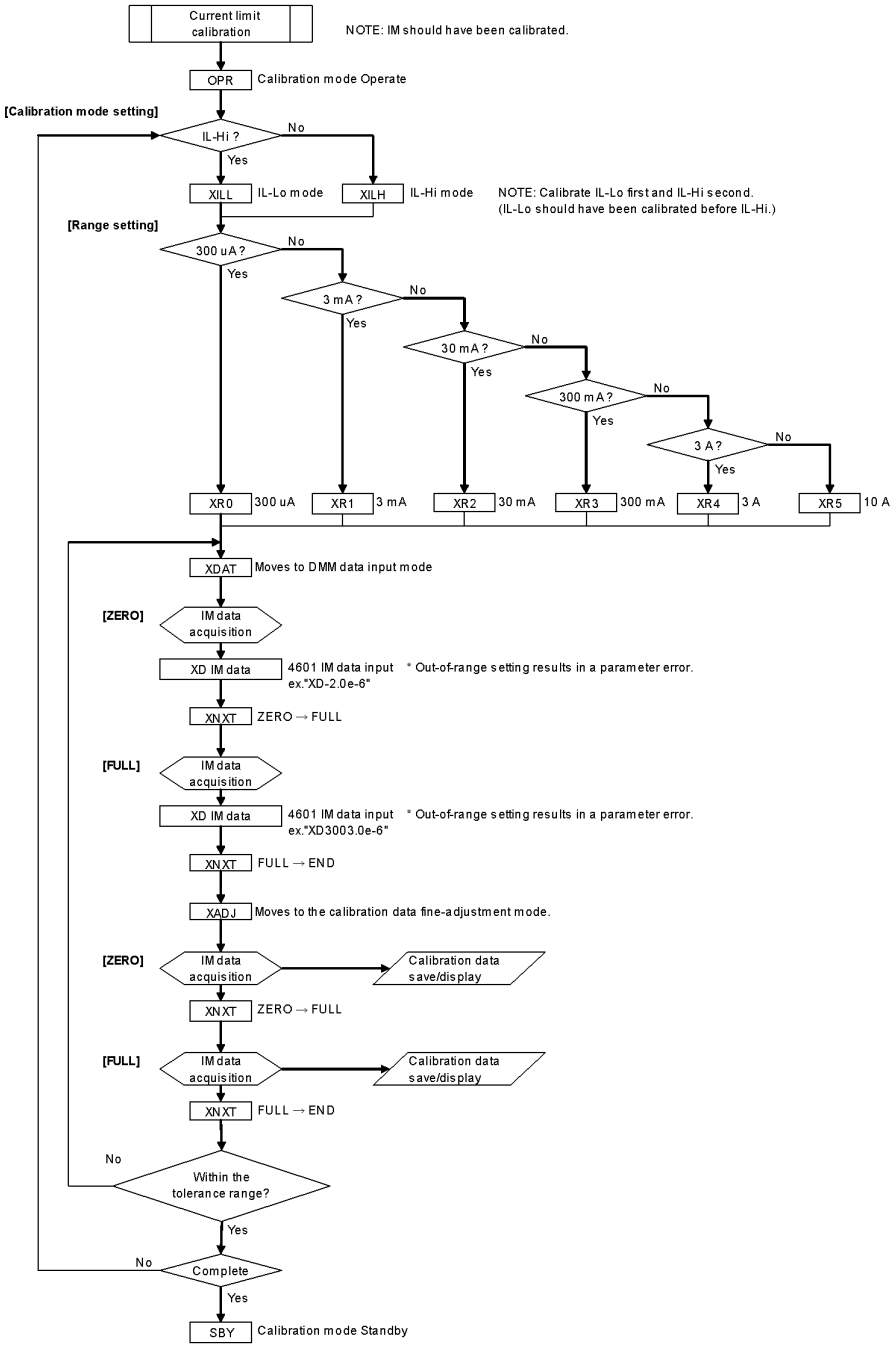
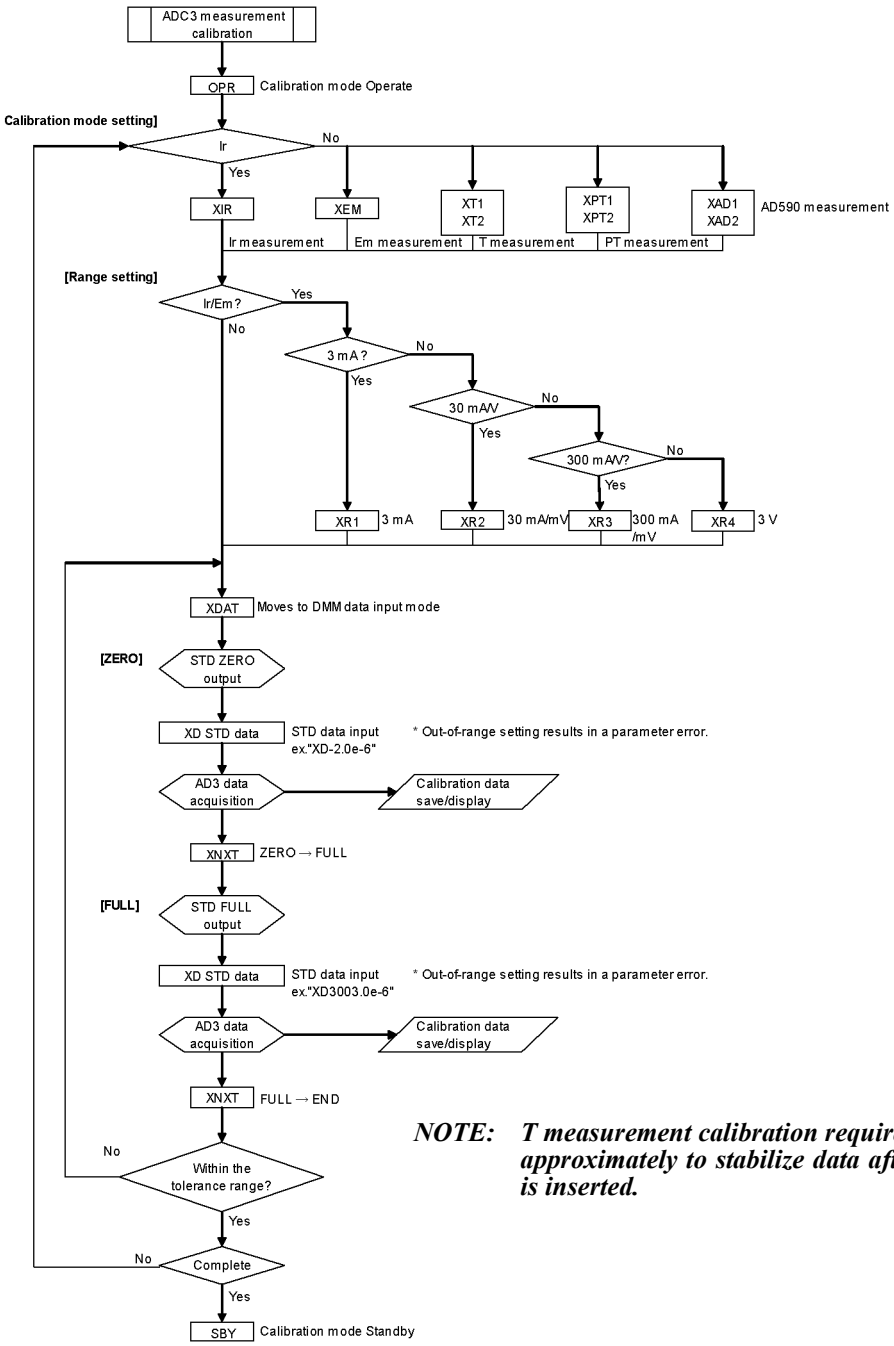


Figure 8-9 Calibration Procedure (5)

Calibration procedure (6)

The following figure shows the flow of ADC3 calibration.
Connect the 4601 as shown in Figure 8-2 (e) for Ir measurement calibration, Figure 8-4 (j) for Em measurement calibration, Figure 8-3 (h) for T measurement calibration, Figure 8-2 (f) for Pt measurement calibration or Figure 8-3 (g) for AD590 calibration.



NOTE: ***T measurement calibration requires five minutes approximately to stabilize data after the connector is inserted.***

Figure 8-10 Calibration Procedure (6)

Calibration procedure (7)

The following figure shows the flow of reference junction temperature calibration.
Connect the 4601 to the 0 °C standard calibration bath as shown in Figure 8-3 (i).

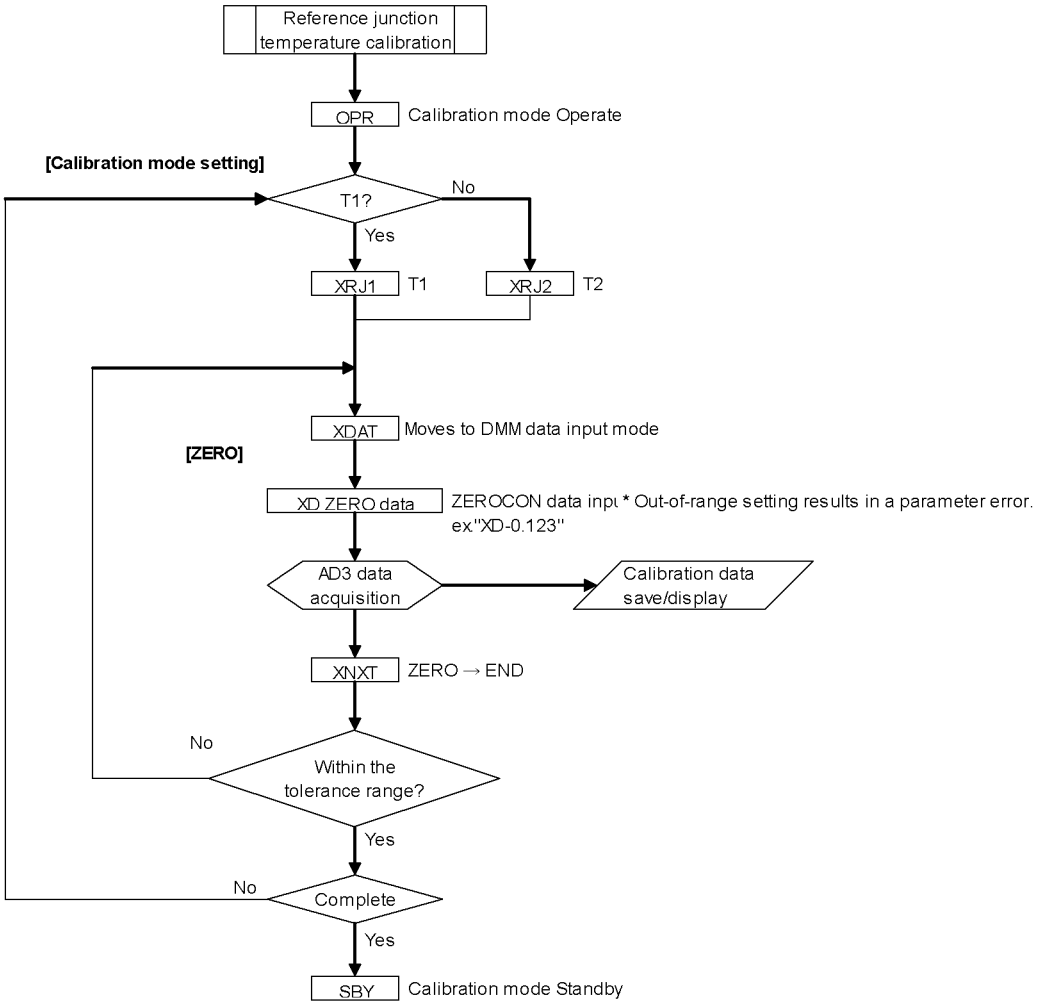


Figure 8-11 Calibration Procedure (7)

8.4.2 Calibration Procedure

8.4.2.1 Overall Calibration Procedure

The overall procedure of calibrations is described according to Figure 8-5 Calibration Procedure (1).

1. Enter the calibration mode by CAL1.
2. When executing all the calibrations, initialize calibration data only once by XINI at the start of the calibrations.
3. When executing voltage calibration, make connection for voltage calibration in reference to Section 8.2, "Connections."
4. Execute the calibrations according to Figure 8-6 Calibration Procedure (2) to Figure 8-11 Calibration Procedure (7).
5. Store the calibration data to the non-volatile memory by XWR.
6. Finish the calibration mode by CAL0.

8.4.2.2 Voltage Source Calibration

The procedure of voltage source calibration is described according to Figure 8-6 Calibration Procedure (2).

1. Select the voltage calibration mode.
   Voltage source: XVS
2. Set the calibration mode to Operate by OPR.
3. Select the range.
   5 V range: XR4
   50 V range: XR5
   300 V range: XR6
4. Enter the DMM data input mode by XDAT.
5. Set the DMM read value by XD data.
6. Move to the full-scale calibration mode by XNXT.
7. Set the DMM read value by XD data.
8. Finish the DMM data input mode by XNXT.
9. Move to the zero calibration data fine adjustment mode by XADJ.
10. Check the zero calibration value.
11. Move to the full-scale calibration data fine adjustment mode by XNXT.
12. Check the full-scale calibration value.
13. Move to the next step by XNXT.
14. Set calibration mode to Standby by SBY.

8.4.2.3 Voltage Measurement Calibration

The procedure of voltage measurement calibration is described according to Figure 8-7 Calibration Procedure (3).

1. Move to the voltage measurement calibration mode by XVM.
2. Set the calibration mode to Operate by OPR.
3. Select the range.
   5 V range: XR4
   50 V range: XR5
   300 V range: XR6
4. Enter the DMM data input mode by XDAT.
5. Set the DMM read value by XD data.
6. Read out and check the measurement data.
7. Move to the full-scale calibration mode by XNXT.
8. Set the DMM read value by XD data.
9. Read out and check the measurement data.
10. Move to the next step by XNXT.
11. Set calibration mode to Standby by SBY.

8.4.2.4 Current Measurement Calibration

The procedure of current measurement calibration is described according to Figure 8-8 Calibration Procedure (4).

1. Move to the current measurement calibration mode by XIM.
2. Set the calibration mode to Operate by OPR.
3. Select the range.
   300 μA range:: XR0
   3 mA range: XR1
   30 mA range: XR2
   300 mA range: XR3
   3 A range: XR4
   10 A range: XR5
4. Enter the DMM data input mode by XDAT.
5. Output the ZERO value from the standard.
6. Set the STD value by XD data.
7. Read out and check the measurement data.
8. Move to the full-scale calibration mode by XNXT.
9. Output the -FS value from the standard.
   The full scale is calibrated by the -FS value.

10. Set the STD value by XD data.
11. Read out and check the measurement data.
12. Move to the next step by XNXT.
13. Set calibration mode to Standby by SBY.

8.4.2.5 Current Limit Calibration

The procedure of current limit calibration is described according to Figure 8-9 Calibration Procedure (5).

Check that the current measurement calibration has been completed.

1. Set the calibration mode to Operate by OPR.
2. Select the current limit calibration mode.
   Current HI limt: XILH
   Current LO limit: XILL
   Calibrate the current LO limit first and the current HI limit second.
3. Select the range.
   300 μA range: XR0
   3 mA range: XR1
   30 mA range: XR2
   300 mA range: XR3
   3 A range: XR4
   10 A range: XR5
4. Enter the DMM data input mode by XDAT.
5. Set the IM read value of the 4601 by XD data.
6. Move to the full-scale calibration mode by XNXT.
7. Set the IM read value of the 4601 by XD data.
8. Finish the DMM data intpu mode by XNXT.
9. Move to the zero calibration data fine adjustment mode by XADJ.
10. Check the zero calibration value.
11. Move to the full-scale calibration data fine adjustment mode by XNXT.
12. Check the full-scale calibration value.
13. Move to the next step by XNXT.
14. Set calibration mode to Standby by SBY.

8.4.2.6 ADC3 Measurement Calibration

The procedure of ADC3 calibration is described according to Figure 8-10 Calibration Procedure (6).

1. Set the calibration mode to Operate by OPR.
2. Select the measurement function.

   Ir measurement: XIR

   Em measurement: XEM

   T thermocouple measurement:
   XT1
   XT2

   Pt measurement: XPT1
   XPT2

   AD590 measurement: XAD1
   XAD2

As for the Ir or Em measurement function, select the range.

3 mA range: XR1

30 mA/30 mV range: XR2

300 mA/300 mV range: XR3

3 V range: XR4

3. Enter the DMM data input mode by XDAT.
4. Output the ZERO value from the standard.
5. Set the STD value by XD data.
6. Read out and check the measurement data.
7. Move to the full-scale calibration mode by XNXT.
8. Output the FS value from the standard.
9. Set the STD value by XD data.
10. Read out and check the measurement data.
11. Move to the next step by XNXT.
12. Set calibration mode to Standby by SBY.

8.4.2.7 Reference Junction Temperature Calibration

The procedure of reference junction temperature calibration is described according to Figure 8-11 Calibration Procedure (7).

The ADC3 measurement function should be set to T thermocouple measurement.

1. Set the calibration mode to Operate.
2. Select the command depending on either Tc1 or Tc2 function.
   Tc1 function: XRJ1
   Tc2 function: XRJ2
3. Enter the DMM data input mode by XDAT.
4. Set the data (°C) of 0 °C standard calibration bath by XD data.
5. Read out and check the measurement data.
6. Move to the next step by XNXT.
7. Set calibration mode to Standby by SBY.

9. SPECIFICATIONS

Every overall accuracy is satisfied at a temperature of 23 ±5 °C and a relative humidity not exceeding 85%, and with the integration time of 1 PLC or longer, including the calibration accuracy, the 1-day stability, the temperature coefficient, and the linearity.
However, the stated temperature coefficients are reference values.

9.1 Voltage Source/Voltage Measurement/Current Measurement Terminal OUTPUT/SENSE Terminal

Voltage source/measurement range:

Range	Source range	Setting resolution	Measurement range	Measurement resolution
5 V	-1.0000 V to +5.0000 V	100 µV	-1.00999 V to +5.00999 V	10 µV
50 V	-1.000 V to +50.000 V	1 mV	-1.0999 V to +50.0999 V	100 µV
300 V	-1.00 V to +300.00 V	10 mV	-1.999 V to +300.999 V	1 mV

Current limit/current measurement range:

With the integration time of 1 PLC or longer

Range	Limit setting range *1	Limit setting resolution	Measurement range *1	Measurement resolution
300 µA	3 µA to 320 µA	100 nA	0 to ±320.999 µA	1 nA
3 mA	30 µA to 3.2 mA	1 µA	0 to ±3.20999 mA	10 nA
30 mA	0.3 mA to 32 mA	10 µA	0 to ±32.0999 mA	100 nA
300 mA	3 mA to 320 mA	100 µA	0 to ±320.999 mA	1 µA
3 A	30 mA to 3.2 A	1 mA	0 to ±3.20999 A	10 µA
10 A	0.1 A to 10.2 A	10 mA	0 to ±10.2999 A	100 µA

*1: The polarities of current limits and current measurement are represented as "+" for source and as "-" for sink.
The above ranges are applied to the current limit setting ranges and the current measurement ranges; however the output range is limited to +0.1 A and -10.2 A.

The measurement resolution with the integration time of 500 µs or less is as follows:

Integration time	5 µs	10 µs	25 µs	50 µs	100 µs	250 µs	500 µs
Measurement resolution (digits)	17	9	4	2	2	2	1

Overall accuracy

Voltage source/voltage measurement

Range	Voltage source	Voltage measurement
	±(% of setting + V)	±(% of reading + V)
5 V	0.025+1 mV	0.025+500 µV
50 V	0.025+10 mV	0.025+2 mV
300 V	0.025+100 mV	0.025+20 mV

Current limit/current measurement

Range	Current limit *2	Current measurement
	±(% of setting + A)	±(% of reading + A + A × Vo/1 V)
300 µA	0.1+1 µA	0.03+70 nA+5 nA
3 mA	0.1+10 µA	0.03+700 nA+50 nA
30 mA	0.1+100 µA	0.03+7 µA+500 nA
300 mA	0.1+1 mA	0.03+70 µA+5 µA
3 A	0.1+10 mA	0.05+700 µA+50 µA
10 A	0.3+100 mA	0.15+7 mA+500 µA

*2: In the 300 mA, 3 A and 10 A ranges, the positive current limit is limited to +0.1 A and its accuracy is +0.11 A ± 8%.

The following full-scale errors (digits) are added in voltage measurement and current measurement with the integration time of 10 ms or less.

	Measurement range	Integration time										
		5 µs	10 µs	25 µs	50 µs	100 µs	250 µs	500 µs	1 ms	2.5 ms	5 ms	10 ms
Voltage measurement	5 V	300	300	100	30	20	20	20	10	10	5	5
	50 V	300	300	100	30	20	20	20	10	10	5	5
	300 V	200	200	50	20	10	10	10	5	5	3	3
Current measurement	300 µA	400	250	200	150	150	100	100	100	100	100	100
	3 mA	400	250	100	50	30	30	25	25	20	20	10
	30 mA	400	250	100	50	30	30	20	20	20	15	10
	300 mA	400	250	100	50	30	30	20	20	20	15	10
	3 A	400	250	100	50	30	30	20	20	20	15	10
	10 A	400	250	100	50	30	30	20	20	20	15	10

Temperature coefficient

Voltage source/voltage measurement

Range	Voltage source	Voltage measurement
	±(ppm of setting + V)/°C	±(ppm of reading + V)/°C
5 V	25+100 µV	25+20 µV
50 V	25+1 mV	25+200 µV
300 V	25+10 mV	25+2 mV

Current limit/current measurement

Range	Current limit	Current measurement
	±(ppm of setting + A)/°C	±(ppm of reading + A + A × Vo/1 V)/°C
300 µA	100+60 nA	30+10 nA+0.25 nA
3 mA	100+600 nA	30+100 nA+2.5 nA
30 mA	100+6 µA	30+1 µA+25 nA
300 mA	100+600 µA	30+10 µA+250 nA
3 A	100+6 mA	50+100 µA+2.5 µA
10 A	300+60 mA	150+1 mA+25 µA

Voltage output:	-1 V to + 300 V	
Maximum source power:	30 W (without a booster, source: +300 V/+0.1 A)	
Maximum load power:	300 W (sink: +30 V/-10 A to +300 V/-1 A)	
Maximum output current: (without a booster)	-10.2 A (sink), +0.1 A (source) at -1 V to + 30 V	
	(-300/Vo) A (sink), 0.1 A (source) at + 30 V to + 300 V	
Output terminal:	Front/rear	HI OUTPUT, HI, SENSE, LO OUTPUT, LO SENSE Safety socket/terminal block (Either type of output units is selected and mounted on the front or rear.)
Maximum remote sensing voltage:		±1 Vmax Remote sensing voltage = (Vs + 3 V - 0.1Io)/2 Vs: output voltage, Io: sink current As for sink operation with the output voltage of 0 V to -1V, the remote sensing voltage becomes ±1 V when the result of the above formula is ±1 V or higher.
Maximum input voltage:		+320 V/-3 V peak max (HI-LO) 2 V peak max (OUTPUT-SENSE) 310 V peak max (LO-chassis)

9.2 Voltage Measurement Terminal Em Terminal

Range	Measurement range	Measurement resolution	Overall accuracy	Temperature coefficient
			±(% of reading + V)	±(ppm of reading + V)/°C
30 mV	±31.9999 mV	0.1 µV	0.025+15 µV	25+2 µV
300 mV	±319.999 mV	1 µV	0.025+15 µV	25+2.5 µV
3 V	±3.19999 V	10 µV	0.025+30 µV	25+5 µV

Maximum allowable input voltage 36 V peak(terminal-terminal)
310 V peak (terminal-chassis)

The measurement resolution with the integration time of 500 µs or less is as follows:

Integration time	5 µs	10 µs	25 µs	50 µs	100 µs	250 µs	500 µs
Measurement resolution (digits)	17	9	4	2	2	2	1

The following full-scale errors (digits) are added in voltage measurement and current measurement with the integration time of 10 ms or less.

Measurement range	Integration time										
	5 µs	10 µs	25 µs	50 µs	100 µs	250 µs	500 µs	1 ms	2. 5 ms	5 ms	10 ms
30 mV	2000	1500	1000	1000	500	300	300	200	200	100	50
300 mV	600	300	200	100	50	30	30	20	10	5	5
3 V	200	150	100	50	20	10	10	5	5	3	3

9.3 Reference Cell Measurement Terminal CELL Ir Terminal

Range	Measurement range *3	Measurement resolution	Overall accuracy	Temperature coefficient
			±(% of reading + A)	±(ppm of reading + A)/°C
3 mA	0 to ±3.19999 mA	10 nA	0.03+350 nA	30+35 nA
30 mA	0 to ±31.9999 mA	100 nA	0.03+3.5 µA	30+350 nA
300 mA	-32.000 mA to +319.999 mA	1 µA	0.03+35 µA	30+3.5 µA

*3: The polarities of measured values are represented as "+" for sink and as "-" for source."

Voltage drop between terminals: ±1 mV or less at the end of 4-wire connection

Maximum allowable input voltage: 5 V peak (terminal-terminal)
310 V peak (terminal-chassis)

The measurement resolution with the integration time of 500 µs or less is as follows:

Integration time	5 µs	10 µs	25 µs	50 µs	100 µs	250 µs	500 µs
Measurement resolution (digits)	17	9	4	2	2	2	1

The following full-scale errors (digits) are added in voltage measurement and current measurement with the integration time of 10 ms or less.

Measurement range	Integration time										
	5 µs	10 µs	25 µs	50 µs	100 µs	250 µs	500 µs	1 ms	2.5 ms	5 ms	10 ms
30 mV	400	200	100	50	30	15	10	10	10	5	5
300 mV	400	200	100	50	30	15	10	10	10	5	5
3 V	400	200	100	50	30	15	10	10	10	5	5

9.4 Temperature Measurement Thermocouple Measurement Terminal Tc1/Tc2 Terminal

	Measurement range	Measurement resolution	Overall accuracy	Temperature coefficient
			±(% of reading + °C)	±(ppm of reading + °C)/°C
Type T thermocouple	-50.00 °C to 400.00 °C	0.01 °C	0.1+0.8 °C	150+0.02 °C

Maximum allowable input voltage: 36 V peak (terminal-terminal)
310 V peak (terminal-chassis)

Thermocouple standard: JIS C1602-1995, IEC60584-1, 60584-2

Cold junction compensation: Internal

The measurement resolution with the integration time of 500 µs or less is as follows:

Integration time	5 µs	10 µs	25 µs	50 µs	100 µs	250 µs	500 µs
Measurement resolution (digits)	17	9	4	2	2	2	1

The following full-scale errors (digits) are added in measurement with the integration time of 10 ms or less.

	Integration time										
	5 µs	10 µs	25 µs	50 µs	100 µs	250 µs	500 µs	1 ms	2.5 ms	5 ms	10 ms
Type T thermocouple	150	100	50	50	40	40	40	30	20	20	20

9.5 Temperature Measurement Pt Measurement Terminal Pt1/Pt2 Terminal

Resistance bulb: Pt100 (compliant with JIS C1604-1997, IEC 60751)
JPt100 (compliant with JIS C1604-1981)

Wire connection: 4-wire connection

Cold junction compensation: Internal

Allowable lead resistance: 10 Ω or less

Measurement unit: Selectable from °C, ° F and K

	Measurement range	Measurement resolution	Overall accuracy	Temperature coefficient	Measured current
			±(% of reading + °C)	±(ppm of reading + °C)/°C	
Pt100	-200.00 °C to +850.00 °C	0.01 °C	0.025+ 0.15 °C	25+ 0.02 °C	1 mA
JPt100	-200.00 °C to +649.00 °C				

The measurement probe accuracy in 4-wire connection is not included. (Add the measurement probe accuracy to the above.)

Maximum allowable input voltage: 36 V peak (terminal-terminal)
310 V peak (terminal-chassis)

The measurement resolution with the integration time of 500 µs or less is as follows:

Integration time	5 µs	10 µs	25 µs	50 µs	100 µs	250 µs	500 µs
Measurement resolution (digits)	17	9	4	2	2	2	1

The following full-scale errors (digits) are added in measurement with the integration time of 10 ms or less.

	Integration time										
	5 µs	10 µs	25 µs	50 µs	100 µs	250 µs	500 µs	1 ms	2.5 ms	5 ms	10 ms
Pt100, JPt100	1000	500	250	100	100	50	30	30	15	10	10

9.6 Temperature Measurement AD590 Measurement Terminal Ad1/Ad2 Terminal

	Measurement range	Measurement resolution	Overall accuracy	Temperature coefficient
			±(% of reading + °C)	±(ppm of reading + °C)/°C
AD590	-50.00 °C to 150.00 °C	0.01 °C	0.025+0.1 °C	25+0.01 °C

The accuracy of the temperature sensor AD590 is not included. (Add the AD590 accuracy to the above.)

Maximum allowable input voltage: 4 V peak (terminal-terminal)
310 V peak (terminal-chassis)

The measurement resolution with the integration time of 500 µs or less is as follows:

Integration time	5 µs	10 µs	25 µs	50 µs	100 µs	250 µs	500 µs
Measurement resolution (digits)	17	9	4	2	2	2	1

The following full-scale errors (digits) are added in voltage measurement and current measurement with the integration time of 10 ms or less.

	Integration time										
	5 µs	10 µs	25 µs	50 µs	100 µs	250 µs	500 µs	1 ms	2.5 ms	5 ms	10 ms
AD590	300	150	60	30	20	10	10	10	5	3	3

9.7 Source and Measurement Functions

DC source/measurement:	DC voltage source, DC voltage/current measurement	
DC sweep source/measurement:	Source and measurement by linear, 2-slope linear, 3-slope linear, memory, fixed level	
Integration time:	5 μs,10 μs,25 μs,50 μs,100 μs,250 μs,500 μs,1 ms,2.5 ms, 5 ms,10 ms,1 PLC,2 PLC,100 ms,200 ms (PLC: Power Line Cycle 50 Hz: 20 ms 60 Hz: 16.66 ms)	
Sweep mode:	Reverse ON (round)/OFF (one-way)	
Maximum sweep step:	1999 steps	
Maximum measurement points:	2000 points	
Maximum sweep memory:	2000 data	
Measurement data memory:	4000 data × 3	
Measurement speed:	50 μs/point to 6 s/point (sweep source/measurement mode)	
Limit:	HI and LO limit values can be set separately. (These values cannot be set to the same polarity.)	
Trigger:	Auto trigger, external trigger	
GPIB interface:	Compliant with IEEE-488.2-1987	
	Interface function	SH1, AH1, T6, L4, SR1, RL1, PP0, DC1, DT1, C0, E2
	Connector	Amphenol 24 pin
USB interface:	USB 2.0 Full-speed	
	Connector	Type B
External control signal:	TRIGGER IN OPERATE IN/OUT COMPLETE OUT, SYNC OUT	
	Connector	BNC
Contact signal:	Output: 4 bits	Input: 2 bits
	Connector	Dsub 15 pin (High-density multicore type)

9.8 Setting Time

Minimum step (repeat) time: Voltage/current/reference current measurement in fixed source/ measurement ranges and with the integration time of 5 μs and with th minimum measurement/source delay time

Mode	Minimum step time
Sweep	50 μs
DC	5 ms

Setting time

Setting time	Setting range	Minimum resolution	Setting accuracy
Source delay time	0.010 ms to 5999.8 ms	1 μs	±(0.1% + 10 μs)
Period (cycle)	0.050 ms to 6000.0 ms	1 μs	±(0.1% + 10 μs)
Measurement delay time	0.020 ms to 5999.8 ms	1 μs	±(0.1% + 10 μs)
Hold time	0 ms to 6000.0 ms	100 μs	±(2% + 2 ms)
Trigger delay time	0 ms to 6000.0 ms	100 μs	±(0.1% + 100 μs)

9.9 General Specifications

Operating environment conditions: Ambient temperature 0 °C to +50 °C
Relative humidity 85% or below, no condensation

Storage environment conditions: Ambient temperature -25 °C to +70 °C
Relative humidity 85% or below, no condensation

Warming up time: 60 minutes or longer

Display: Dot matrix vacuum fluorescent display

Power supply: AC power 100V/120V/220V/240V (User selectable)

Option NO.	Standard	OPT.32	OPT.42	OPT.44
Power voltage	100 V	120 V	220 V	240 V

Specify the option when ordering.
When changing the power voltage, use only a power cable and rated fuse approved for the respective country.

Line frequency: 50 Hz/60 Hz

Power consumption: 230 VA or less

Dimensions: Approx. 424 (width) × 132 (height) × 500 (depth) mm

Mass: 15 kg or less (including the output unit)

Safety: Compliant with IEC61010-1 Ed.3

EMI: Compliant with EN61326-1 classA

APPENDIX

A.1 When Problems Occur (Before Requesting Repairs)

If any problem is encountered when using the 4601, inspect the unit referring to Table A-1. If the problem cannot be solved by the suggested remedial actions, contact an ADC CORPORATION sales representative.

Fees will be charged for repairs by ADC CORPORATION even if the problem is one of those listed in Table A-1. Therefore, carefully inspect the 4601 before requesting service

Table A-1 Items to be Inspected before Requesting Repair (1 of 2)

Q (Symptom)	A (Cause and Solution)
1. Turning on the **POWER** switch does not display the screen.	Cause: The power fuse is open. Solution: Replace it with the correct fuse.
2. Does not output the set source value.	Cause: It is in Standby or Suspended status. Solution: Set Operate and check that the **OPR** indicator on the front panel is ON.
	Cause: The source value is set to 0 V. Solution: Check the source value.
	Cause: Detection of an overload voltage (Over Load) has set it to Standby. Solution: Disconnect the cable.
	Cause: Overheat detection (Over Heat) or fan detection (Fan Stopped) has set it to Standby. Solution: Disconnect the cable and turn OFF the **POWER** switch. Turn ON the **POWER** switch again.
	Cause: The limiter is activated. Solution: Check the limiter settin
	Cause: • The **OUTPUT** terminal and the **SENSE** terminal are incorrectly connected. Solution: • The **SENSE** terminal is incorrectly connected in 4-wire connection. Check the cable connections again.
	Cause: Entered Standby due to the OPERATE IN/OUT signal. Solution: • Change the OPERATE IN/OUT signal setting to another setting. • Set the Operate Control signal to LO.

Table A-1 Items to be Inspected before Requesting Repair (2 of 2)

Q (Symptom)	A (Cause and Solution)
3. Does not output measured values.	Cause: It is in Standby or Suspended status. Solution: Set Operate and check that the **OPR** indicator on the front panel is ON.
	Cause: Measurement is not set to ON. Solution: Verify the measurement ON/OFF setting.
	Cause: A trigger signal is not input even when the trigger signal cable is connected to the external trigger. Solution: Verify TRIGGER IN connection cable and the signal.
4. A source value or measured value indication is unstable or is in error	Cause: Function or range settings have an error. Solution: Check the settings again.
	Cause: Incorrect cable connection Solution: Check cable connections again.
	Cause: Disconnected cable Solution: Verify the cables with a tester. If in error, replace it.
	Cause: A cable is connected to a wrong terminal. Solution: Check cable connections again.
	Cause: The induction noise scatters the measured values. Solution: Set the integration time to 1 PLC or longer.
5. The measured value is over range.	Cause: The current limit range or measurement range is low. Solution: Raise the current limit range or measurement range.
6. A relay life error occurred.	Cause: The internal relay operated more than 1,000,000 times. Solution: The output unit is a consumable accessory and does not carry a warranty. Replace to a new output unit.
7. An oscillation detection alarm occurs.	Cause: Oscillation due to device capacitance or inductance Solution: As checking the OSC indicator response, slow the voltage source response. (Refer to Section 4.2.10, A) Source, 2) Response.)

A.2 Error Message List

If an error occurs when using the 4601, an error code accompanied by an error message appears on the screen. The contents are explained in the following:

Error codes marked with ● are generated by the self test.

Table A-2 Error Message List (1 of 3)

Error code	Description	Message	
-102	Command syntax error	Syntax error	
-113	Unsupported command	Undefined header	
-200	Execution error (Command currently not executable)	Execution error	
-222	Out-of-range input value setting or insufficient parameter	Data out of range	
-313	Calibration data is lost.	Calibration memory lost	●
-314	Data saved by the *SAV command is lost.	Save/recall memory lost	
-315	Saved parameters are lost.	Configuration memory lost	
-330	Self test error	Self-test failed	●
-350	Error queue overflow	Queue overflow	
+001	ROM check SUM error	ROM check sum error	●
+002	Display section RAM test/communication error	Panel memory error	●
+003	VFD module communication error	VFD module error	●
+004	RAM read/write error	RAM read/write failed	●
+005	Analog section communication error	Communication error	●
+008	FLASH memory write error	FLASH memory error	
+009	Sweep RAM read/write	RAM-2 read/write failed	●
+012	Calibration data check SUM error	CAL data sum error	●
+013	Parameter check SUM error	Parameter sum error	●
+015	No output unit mounted	No Output unit	●
+130	Internal SCI communication start error	Sub CPU does not respond	●
+140	Internal SCI communication error (Receiving an improper code)	Sub CPU comm. error	
+141	Internal SCI communication error (Receiving another code during response)	Internal comm. error	
+150	USB communication error	Illegal packet received	
+101	Analog section RST signal test error	ADRST Signal Check	●
+102	Analog section TRIG signal test error	ADTRG Signal Check	●
+111	ADC1 operation IR1-IR2 ratio test error	ADC1 Ratio 1 to 2	●
+112	ADC1 operation IR2-IR3 ratio test error	ADC1 Ratio 2 to 3	●
+113	ADC1 operation IR3-IR4 ratio test error	ADC1 Ratio 3 to 4	●
+114	ADC1 operation IR4-IR5 ratio test error	ADC1 Ratio 4 to 5	●

Table A-2 Error Message List (2 of 3)

Error code	Description	Message	
+115	ADC1 operation IR5-IR6 ratio test error	ADC1 Ratio 5 to 6	●
+121	ADC2 operation IR1-IR2 ratio test error	ADC2 Ratio 1 to 2	●
+122	ADC2 operation IR2-IR3 ratio test error	ADC2 Ratio 2 to 3	●
+123	ADC2 operation IR3-IR4 ratio test error	ADC2 Ratio 3 to 4	●
+124	ADC2 operation IR4-IR5 ratio test error	ADC2 Ratio 4 to 5	●
+125	ADC2 operation IR5-IR6 ratio test error	ADC2 Ratio 5 to 6	●
+131	ADC3 operation IR1-IR2 ratio test error	ADC3 Ratio 1 to 2	●
+132	ADC3 operation IR2-IR3 ratio test error	ADC3 Ratio 2 to 3	●
+133	ADC3 operation IR3-IR4 ratio test error	ADC3 Ratio 3 to 4	●
+134	ADC3 operation IR4-IR5 ratio test error	ADC3 Ratio 4 to 5	●
+135	ADC3 operation IR5-IR6 ratio test error	ADC3 Ratio 5 to 6	●
+141	ADC1 operation zero measurement (AZ10) test error	ADC1 Zero (AZ10)	●
+142	ADC2 operation zero measurement (AZ20) test error	ADC2 Zero (AZ20)	●
+143	ADC3 operation zero measurement (AZ30) test error	ADC3 Zero (AZ30)	●
+144	ADC3 operation zero measurement (AZ31) test error	ADC3 Zero (AZ31)	●
+145	ADC3 operation zero measurement (AZ32) test error	ADC3 Zero (AZ32)	●
+146	ADC3 operation zero measurement (AZ33) test error	ADC3 Zero (AZ33)	●
+147	ADC3 operation zero measurement (AZ34) test error	ADC3 Zero (AZ34)	●
+201	VSVM 5V ZERO test error	VSVM 5 V Zero	●
+202	VSVM 5V +FS test error	VSVM 5 V +Full Scale	●
+203	VSVM 5V -FS test error	VSVM 5 V -Full Scale	●
+204	VSVM 50V ZERO test error	VSVM 50 V Zero	●
+205	VSVM 50V +FS test error	VSVM 50 V +Full Scale	●
+206	VSVM 50V -FS test error	VSVM 50 V -Full Scale	●
+207	VSVM 300V ZERO test error	VSVM 300 V Zero	●
+208	VSVM 300V +FS test error	VSVM 300 V +Full Scale	●
+209	VSVM 300V -FS test error	VSVM 300 V -Full Scale	●
+211	IM 300μA ZERO test error	IM 300 μA Zero	●
+212	IM 3mA ZERO test error	IM 3 mA Zero	●
+213	IM 30mA ZERO test error	IM 30 mA Zero	●
+214	IM 300mA ZERO test error	IM 300 mA Zero	●
+215	IM 3A ZERO test error	IM 3 A Zero	●

Table A-2 Error Message List (3 of 3)

Error code	Description	Message	
+216	IM 10A ZERO test error	IM 10 A Zero	●
+301	OVV detection check error	OVV Check	●
+302	OVL detection check error	OVL Check	●
+401	Fan stopped	Fan Stopped	
+402	Overheat	Over Heat	
+403	Booster unit error	Booster Unit Error	
+404	Overload	Over Load	
+405	Over voltage	Over Voltage	
+571	Operate relay lifetime	Operate Relay Lifetime	●
+801	1999 < Sweep step count	Over 1999 steps	
+802	Sweep data over range	Sweep Value Over Range	
+823	DC timer condition error (Not satisfy Tp>Td+300 μs)	Tp <= Td + 0.3 ms (DC)	
+824	SWEEP timer condition error (Not satisfy Tp>Td+Tit+Tad)	Tp <= Td + Tit + Tad	
+825	Timer condition error (Not satisfy Td ≥ Tds)	Td < Tds	
+828	DC timer condition error (Not satisfy Tp ≥ 10ms)	Tp < 10 ms (DC)	
+829	SWEEP HOLD timer condition error (Not satisfy Tp ≥ 200μs)	Tp < 0.2 ms (SWEEP HOLD)	
+855	Calibration data error	CAL data Over	

A.3 Execution Time

A.3.1 GPIB/USB Remote Execution Time (Typical Value)

Computer: DELL OPTIPLEX 755 (Core2 Duo processor) Windows XP SP.3
GPIB hardware: NATIONAL INSTRUMENTS PCI-GPIB
Language Visual Basic 2005

Item		Program code		Condition		GPIB Unit : ms	USB Unit : ms
Operate/ Suspend/ Standby	Operate	OPR	(In Standby)	Source mode: DC IT: 1 PLC (20 ms) Other: Default values		83	99
			(In Suspend HiZ)			9	24
			(In Suspend LoZ)			8	24
		OPR	(In Standby)	Source mode: Sweep Step count: 100 IT: 1 PLC (20 ms) Other: Default values		101	117
			(In Suspend HiZ)			9	25
			(In Suspend LoZ)			8	24
	Suspend	SUS	(OPR → SUS LoZ)	Source mode: DC IT: 1 PLC (20 ms) Other: Default values		8	23
			(OPR → SUS HiZ)			13	28
			(SBY → SUS LoZ)			82	98
			(SBY → SUS HiZ)			82	98
	Standby	SBY	(In Operate)	Source mode: DC IT: 1 PLC (20 ms) Other: Default values		93	99
			(In Suspend HiZ)			87	103
			(In Suspend LoZ)			87	103
Source range		SVR4 to SVR6				11 to 13	26 to 28
Voltage source*	Source value Bias value	SOV<data> SB<data>		Operate, Hold status	No range change	6 to 9	22 to 25
					With range change	11 to 14	27 to 30
Current limit value*		LMI<data>			No range change	6 to 9	22 to26
					With range change	7 to 70	24 to 87

Item		Program code	Condition	GPIB Unit : ms	USB Unit : ms
ZERO measurement		ZM	Source mode: DC Operate, Hold status	70	85
Measurement function		F3		27	43
		F4		27	43
		F5		105	121
		F6		6	22
		F7		27	42
		F8		105	121
		F9		6	21
		F10		28	44
Measurement range	Ir function	R1 to R3		6	21
	Em function	R1 to R3		28	43
Integration time		IT0		11	27
		IT1		11	27
		IT2		11	27
		IT3		11	27
		IT4		11	27
		IT5		12	27
		IT6		12	29
		IT7		14	30
		IT8		18	35
		IT9		26	41
		IT10		41	58
		IT11		71	88
		IT12		131	148
		IT13		311	328
		IT14		611	628
Time Parameter*	Trigger delay	TRD<data>		5 to 6	22 to 25
	Hold time	THD<data>		5 to 6	22 to 25
	Measurement delay	TMD<data>		5 to 6	22 to 25
	Period	TPD<data>		5 to 6	22 to 25
	Source delay	TSD<data>		5 to 6	22 to 25
Sweep Type*	Linear	SLN<data>	Standby status	6 to 9	24 to 33
	2-slope	SLW<data>		8 to 11	31 to 43
	3-slope	SLR<data>		10 to 14	34 to 48
	Fixed	SFX<data>		5 to 8	24 to 26
	Memory	SMD<data>		5 to 8	22 to 25
Source mode		MD0 (SWEEP → DC)		17	32
		MD1 (iDC → SWEEP)		38	54
Source memory setting*		N<adrs>,<data>,P		6 to 9	26 to 31

* The command with <data> is different in processing time according to the data length.

Measurement memory read time

Condition: Output data: Vm + Im + ADC3 measured value
Output: Standby

Read by the RDT? command (GPIB)

Output format	Data count	Header OFF	Header ON
ASCII	100	244 ms	264 ms
	1000	2.42 s	2.63 s
Binary	100	24 ms	
	1000	334 ms	

Measurement buffer memory read after the RN1 command

Interface	Data count	Header OFF	Header ON
GPIB	100	358 ms	382 ms
	1000	3.58 s	3.82 s
USB	100	22.5 s	25.15 s
	1000	22.51 s	25.16 s

Time between sweep start and data read

Indicates a time from executing 100 step sweep to completing the data output from the memory to GPIB by the RDT? command.

Condition: Sampling : internal trigger, Integration time: 5 μs

Output data: Vm + Im + ADC3 measured value

Reading starts after receiving SRQ that indicates the specified memory number is reached.

Output format	Header OFF	Header ON
ASCII	314 ms	335 ms
Binary	95 ms	

Time between spot measurement and data read

Condition: Spot measurement integration time: 1 PLC (20 ms)

Spot measurement	GPIB	USB
SPM?1 (Vm)	48 ms	66 ms
SPM?2 (Im)	48 ms	66 ms
SPM?3 (Ir)	58 ms	77 ms
SPM?4 (Em)	61 ms	84 ms
SPM?5 (Tc1)	177 ms	133 ms
SPM?6 (Pt1)	53 ms	69 ms
SPM?6 (Ad1)	61 ms	77 ms
SPM?8 (Tc2)	117 ms	133 ms
SPM?9 (Pt2)	53 ms	69 ms
SPM?9 (Ad2)	61 ms	77 ms

A.3.2 Internal Processing Time (Typical Value)

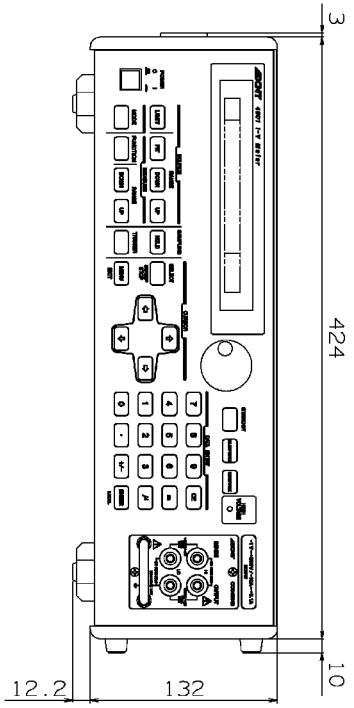
1. Source processing time

   Time between external trigger input and source value change

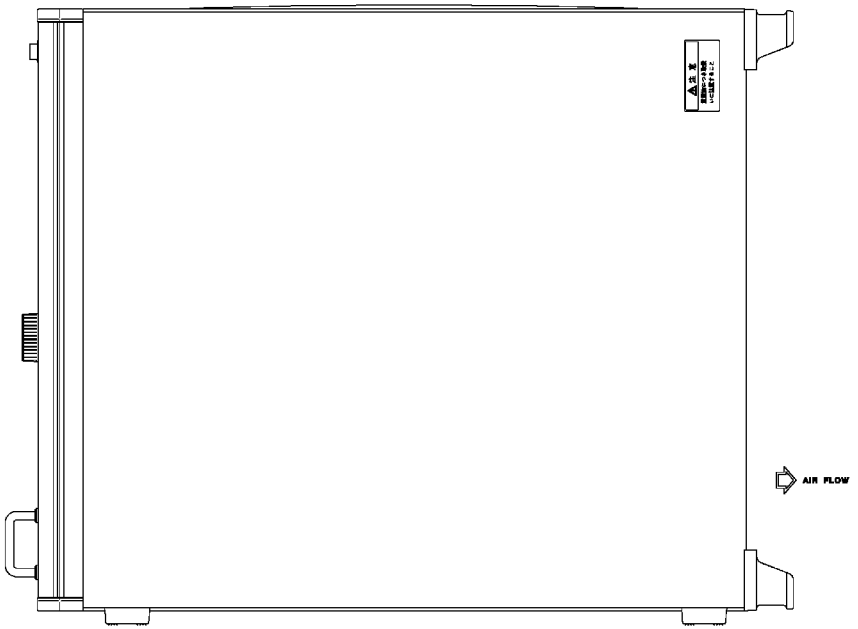
   For the time from when the source value changes to when the source value settles, refer to Section 5.2.6, “Settling Time.”

   Condition: Sampling : Hold or external trigger
   Source delay:10 μs
   Trigger delay:0 μs

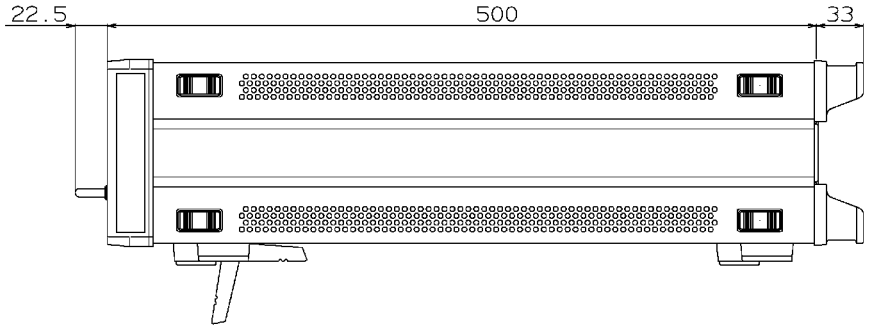
Source mode	Source value	Execution time
Sweep	Start value	650 μs
	Step value	36 μs



4601 FRONT VIEW



4601 TOP VIEW



4601 RIGHT SIDE VIEW

Unit : mm

NOTE

This drawing shows external dimensions of this instrument.

The difference in products and options used can cause a change in the appearance of the instrument.

DIMENSIONAL OUTLINE DRAWING

ALPHABETICAL INDEX

[Symbol]

[Numerics]

[A]

[B]

[C]

[D]

[E]

[F]

[G]

[R]

[S]

[T]

[U]

[V]

[W]

[Z]

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2. The warranty period for the Product (the "Warranty Period") will be a period of one year commencing on the delivery date of the Product.

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(2) The repair and calibration services may be declined if either of the following situations arise.

1) When required parts cannot be procured.

2) When the performance of the Product cannot be maintained after repair.

ADCMT® ADC CORPORATION

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