ADCMT®

4601
I-V Meter

Best for Solar Cell and Module Production Lines by High-Speed I-V Measurement

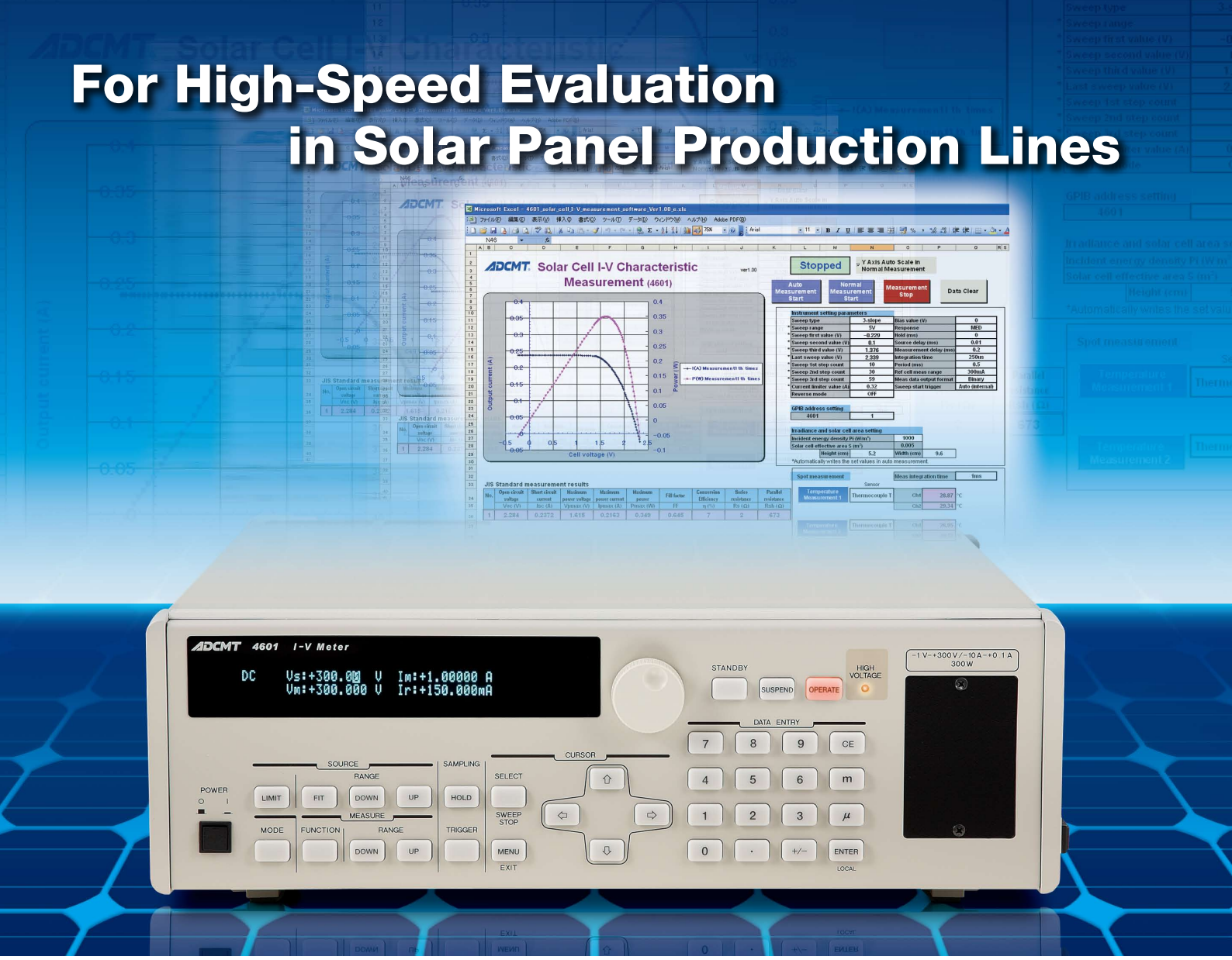
- High-speed measurement at 100 points in 5ms.
- 50µs to 6s/point that supports various kinds of solar cells
- Sampling for short-pulsed, middle-pulsed and long-pulsed light
- 3-slope linear sweep function to measure finely around Isc, Pmax and Voc
- Output range of 300V/1A and 30V/10A
- Parallel measurement of device voltage, current and reference cell current

New

GPIB USB

http://www.adcmt-e.com

For High-Speed Evaluation in Solar Panel Production Lines



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

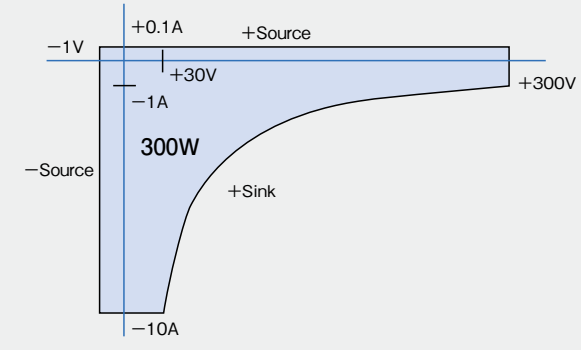
It supports short, middle and long light pulses and achieves I-V measurement at maximum 100 points in only 5ms. The 4601 measures voltage, current and reference cell current in parallel in the minimum 50µs to the maximum 6s per step.

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

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

In addition, the 2-channel temperature measurement function selectable from thermocouple (type T), platinum resistance bulb (Pt100) and IC sensor (AD590), and the voltage measurement function usable for thermopile measurement are embedded.

Output range



Voltage source/measurement:
-1V to +300V
Range 5V/50V/300V
Minimum resolution 100µV (source)/10µV (measurement)

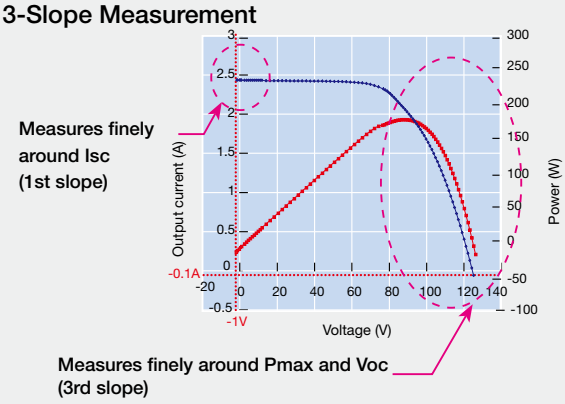
Current measurement:
-10.2A to +0.1A
Range 300µA/3mA/30mA/300mA/3A/10A
Minimum resolution 1nA

High-Efficiency Production by High-Speed 3-Slople Measurement

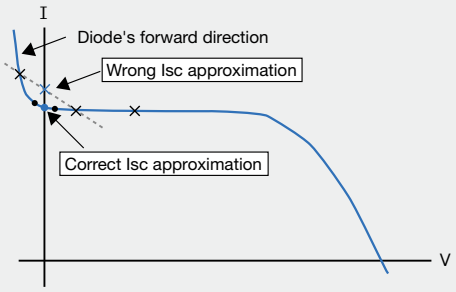
3-Slope Measurement

Solar cell evaluation obtains Isc, Voc and Pmax from measured values by I-V measurement.
Correct Isc is approximated as a straight line between the value that is closest to and less than 0V and the value that is closest to and greater than or equal to 0V.
Thus, the measurement needs to sweep voltages across 0V from negative to positive.
However, when a solar panel on which Voc is 300V approximately is measured at 100 points, one step is 3V in normal linear sweep. This results in measured data far from "V=0V."
Moreover, the larger the point count is, the slower the total measurement speed becomes.
Using 2-slope or 3-slope linear sweep will allow you to measure around "V=0V" finely without increasing the step count.
In the same way, to obtain correct Voc, around I=0A and Pmax need to be measured finely. In this case, 3-slope linear sweep is effective.
As for a solar panel having bypass diodes, current flows through the bypass diodes in the forward direction at a voltage less than -0.6V. As the current value becomes high in the forward area, measuring the solar panel with a step of 0.5V or higher will bring incorrect Isc approximation.
To prevent this, straight-line approximation is performed by measuring the solar panel with fine steps at a voltage from -0.5V.

3-Slope Measurement



I-V characteristic of PV panel with bypass diodes

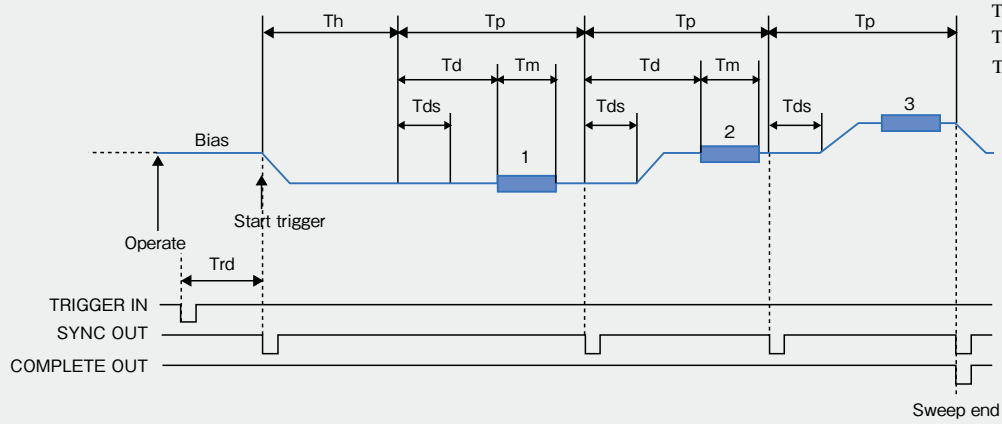


Basic Sweep Timing

Setting times, sweep operations and timings with external control signals are shown below:

- 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 changes with the period time.
- When the sampling is HOLD, the sweep step operates by every trigger input.
- When the sampling is HOLD, the step count per trigger can be set.

Sampling: AUTO



Th: Hold time 0 to 6s
Tp: Period time 50µs to 6s
Td: Measurement delay time 20µs to 6s
Tds: Source delay time 10µs to 6s
Tcn: Operate processing time
Trd: Trigger delay time 0 to 6s
Tm : Measurement time
[Integration time
+Measurement data processing time]

Good Connection with Solar Simulator

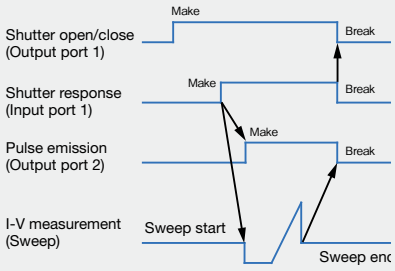
Synchronization with Solar Simulator

To evaluate a solar panel using pulsed light, the shutter open/close and pulse emission of a solar simulator and the sweep timings of the I-V meter need to be synchronized.

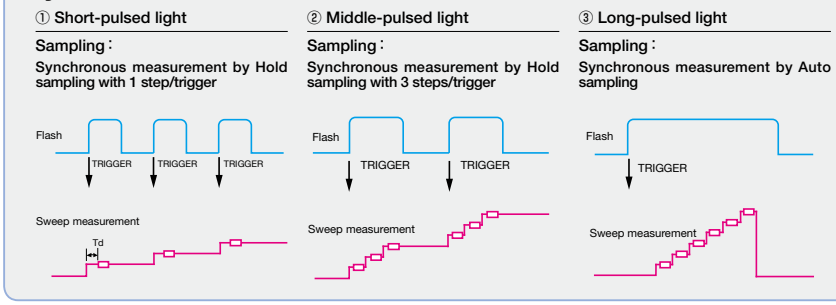
The 4601 is equipped with four output ports and two input ports for semiconductor relay contact signals that can used for shutter open/close control and light emission control, making it possible to synchronize with the solar simulator. In addition, in sweep measurement using external trigger input signals, the step count per pulsed light can be controlled by setting the sampling and the step count per trigger.

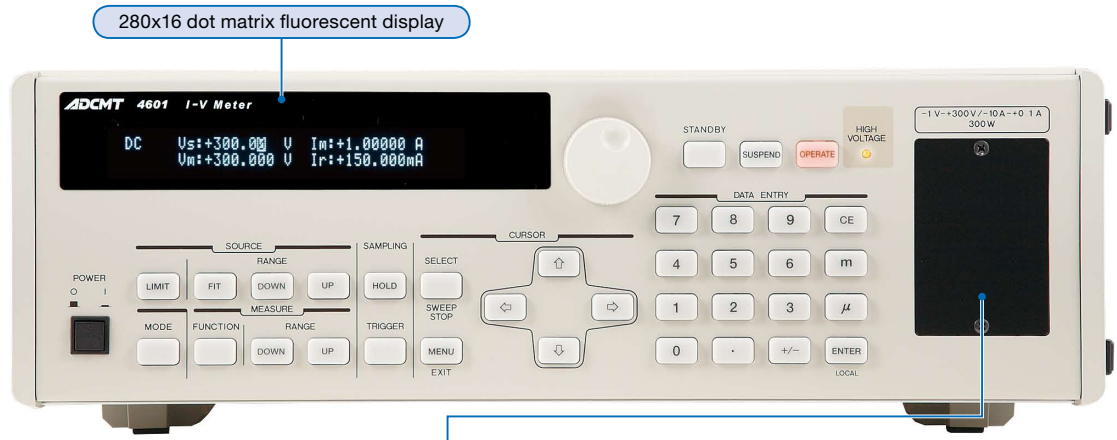
As the reference cell current is measured at the same time as the output voltage and current of a solar cell, you can compensate for optical power fluctuations generated at the time of pulse emission in I-V characteristics.

Solar Simulator Example



Synchronization with Solar Simulator





Specifications

Overall accuracy : At temperature of 23°C ± 5°C, for one year, and with integration time of 1 PLC or more.
Includes calibration accuracy, 1-day stability, temperature coefficient, and linearity.

Voltage source/voltage measurement/current measurement terminal OUTPUT/SENSE terminal

Voltage source/measurement range:

Range	Source range	Setting resolution	Measurement range	Measurement resolution
5V	–1.0000V to +5.0000V	100µV	–1.00999V to +5.00999V	10µV
50V	–1.000V to +50.000V	1mV	–1.0999V to +50.0999V	100µV
300V	–1.00V to +300.00V	10mV	–1.999V to +300.999V	1mV

Current limit/current measurement range:

Range	Limit setting range*1	Limit setting resolution	Measurement range*1	Measurement resolution
300µA	3µA to 320µA	100nA	0 to ±320.999µA	1nA
3mA	320.1µA to 3.2mA	1µA	0 to ±3.20999mA	10nA
30mA	3.201mA to 32mA	10µA	0 to ±32.0999mA	100nA
300mA	32.01mA to 320mA	100µA	0 to ±320.999mA	1µA
3A	320.1mA to 3.2A	1mA	0 to ±3.20999A	10µA
10A	3.201A to 10.2A	10mA	0 to ±10.2999A	100µA

*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 -10.2A + and 0.1A.

Overall accuracy

Voltage source/voltage measurement

Range	Voltage source	Voltage measurement
	±(% of setting+V)	±(% of reading+V)
5V	0.025+1mV	0.025+500µV
50V	0.025+10mV	0.025+2mV
300V	0.025+100mV	0.025+20mV

Current limit/current measurement

Range	Current limit*2	Current measurement
	±(% of setting+A)	±(% of reading+A+A×Vo/1V)
300µA	0.1+1µA	0.03+70nA +5nA
3mA	0.1+10µA	0.03+700nA+50nA
30mA	0.1+100µA	0.03+7µA +500nA
300mA	0.1+1mA	0.03+70µA +5µA
3A	0.1+10mA	0.05+700µA+50µA
10A	0.3+100mA	0.15+7mA +500µA

*2: In the 300mA, 3A and 10A ranges, the positive current limit is limited to +0.1A and its accuracy is +0.11A ± 8%.

Voltage output: -1V to + 300V
Maximum output power: 30W (without a booster, source: +300V/+0.1A)
Maximum load power: 300W (sink: +30V/-10A to +300V/-1A)
Maximum output current (without a booster):
-10.2A (sink), +0.1A (source) at -1V to + 30V
(-300/Vo) A (sink), 0.1A (source) at + 30V to + 300V
Output terminal: Front/rear
HI OUTPUT, HI SENSE, LO OUTPUT, LO SENSE
Safety socket/terminal block (Either type is selectable and mounted on the front or rear.)
Maximum remote sensing voltage: ±1V max
Remote sensing voltage = (Vo + 3V -0.1·Io)/2
Vo: output voltage, Io: sink current
As for sink operation with the output voltage of 0V to -1V, the remote sensing voltage becomes ±1V when the result of the above formula is ±1V or higher.
Maximum input voltage: +320V/-3V peak max (HI-LO)
2V peak max (OUTPUT-SENSE)
310V peak max (LO-chassis)

Voltage measurement terminal

Measurement range:

Range	Measurement range	Measurement resolution	Overall accuracy
			±(% of reading+V)
30mV	±31.9999mV	0.1µV	0.025+15µV
300mV	±319.999mV	1µV	0.025+15µV
3V	±3.19999V	10µV	0.025+30µV

Maximum allowable input voltage 36Vpeak
310V peak (terminal-chassis)

Reference cell measurement terminal

Measurement range:

Range	Measurement range*3	Measurement resolution	Overall accuracy
			±(% of reading+A)
3mA	0 to ±3.19999mA	10nA	0.03+350nA
30mA	0 to ±31.9999mA	100nA	0.03+3.5µA
300mA	-32.000mA to +319.999mA	1µA	0.03+35µA

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

Voltage drop between terminals: ±1mV or less at the end of 4-wire connection
Maximum allowable input voltage: 5V peak (terminal-terminal)
310V peak (terminal-chassis)

Temperature measurement type T thermocouple measurement terminal

	Measurement range	Measurement resolution	Overall accuracy
			±(% of reading+°C)
Type T thermocouple	-50.00°C to +400.00°C	0.01°C	0.1+0.8°C

Maximum allowable input voltage: 36V peak (terminal-terminal)
310V peak (terminal-chassis)
Thermocouple standard: JIS C1602-1995
Cold junction compensation: Internal

Temperature measurement Pt measurement terminal

Resistance bulb: Pt100 (compliant with JIS C1604-1997)
JPt100 (compliant with JIS C1604-1981)
Wire connection: 4-wire connection
Allowable lead resistance: 10Ω or less
Measurement unit: Selectable from °C, °F and K

	Measurement range	Resolution	Overall accuracy	Measurement current
			±(% of reading+°C)	
Pt100	–200.00°C to +850.00°C	0.01°C	0.025+0.15°C	1mA
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: 36V peak (terminal-terminal)
310V peak (terminal-chassis)

Temperature measurement AD590 measurement terminal

	Measurement range	Measurement resolution	Overall accuracy
			±(% of reading+°C)
AD590	–50.00°C to +150.00°C	0.01°C	0.025+0.1°C

The accuracy of the temperature sensor AD590 is not included. (Add the AD590 accuracy to above.)

Maximum allowable input voltage: 4V peak (terminal-terminal)
310V peak (terminal-chassis)

Source/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: 5µs, 10µs, 25µs, 50µs, 100µs, 250µs, 500µs, 1ms, 2.5ms, 5ms, 10ms, 1PLC, 2PLC, 100ms, 200ms
(PLC: Power Line Cycle 50Hz: 20ms 60Hz: 16.66ms)
Sweep mode: Reverse ON (round)/OFF (one-way)
Maximum sweep step: 1999 steps
Maximum measurement points: 2000 points
Maximum sweep memory: 4000 data × 3

Measurement speed:	50µs/point to 6s/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)	

Setting time

Minimum step (repeat) time : Voltage/current/reference current measurement in fixed source/measurement ranges and with integration time of 5µs and minimum measurement/source delay time

Mode	Minimum step time
Sweep	50µs
DC	5ms

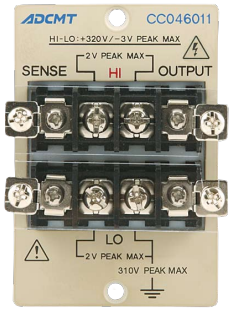
Setting time

Setting time	Setting range	Minimum resolution	Setting accuracy
Source delay time	0.010ms to 5999.8ms	1µs	±(0.1%+10µs)
Period (cycle)	0.050ms to 6000.0ms	1µs	±(0.1%+10µs)
Measurement delay time	0.020ms to 5999.8ms	1µs	±(0.1%+10µs)
Hold time	0ms to 6000.0ms	100µs	±(2%+2ms)
Trigger delay time	0ms to 6000.0ms	100µs	±(0.1%+100µs)

Output unit

One output unit is mounted on either the front or rear panel. It contains the relay circuit and the electrostatic discharge circuit. When the number of relay ON/OFF operations reaches the relay life cycle, the output unit can be replaced independently.

CC046010
Safety socket terminal output unit



CC046011
Terminal block output unit

General specifications

Operating environment:	Ambient temperature 0°C to +50°C, relative humidity 85% or below, with no condensation
Storage environment:	Ambient temperature -25°C to +70°C, relative humidity 85% or below, with 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	100V	120V	220V	240V

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:	50Hz/60Hz
Power consumption:	230VA or less
Dimensions:	Approx. 424(width) × 132 (height) × 500 (depth) mm
Mass:	15kg or less (including the output unit)
Safety:	Compliant with IEC61010-1 Ed.3
EMI:	Compliant with EN61326-1 classA

Supplied accessory

Part number	Name	Quantity
A01402	Power cable (JIS 2m)	1
JCE-DA0002PX02	Thermocouple connector	2
JCS-RB0005JX03	Pt, AD590 connector (plug)	2
YEE-1000734	Pt, AD590 connector (cover)	2
DEE-100115	EMC-compliant clamp filter	4
ESM-000257	Cable tie	4

Main body

Part number	Name
4601	I-V meter main body (not including the output unit)

Output unit (sold separately)

Part number	Name
CC046010	Safety socket terminal output unit
CC046011	Terminal block output unit

Optional accessories

Part number	Name
A01044	Input and output cable (safety plug)
A08531	Banana tip adapter (for A01044)
A08532	Alligator clip adapter (for A01044)
A01047-01/02/03/04	Input and output cable (high current 0.5m to 2m)
CC028003	Front handle set 3U
CC024003*	Rack mount set 3U EIA
CC022003*	Rack mount set 3U JIS (The front handle and the rack mount can be used in combination.)
A02615	Slide rail set

*Setting up a shelf or using the slide rail (A02615) is required.

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