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INSTRUCTION MANUAL

MP-160

I-V Curve Tracer
With Switching Units:
MI-510/MI-510S
MI-520
MI-530
MI-540
MP-303



EKO

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2. Important User Information

Thank you for using EKO Products

Make sure to read this instruction manual thoroughly and to understand the contents before starting to operate the instrument. Keep this manual at safe and handy place for whenever it is needed.
For any questions, please contact us at one of the EKO offices given below:

2-1. Contact Information

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2-2. Warranty and Liability

For warranty terms and conditions, contact EKO or your distributor for further details.
EKO guarantees that the product delivered to customer has been verified, checked and tested to ensure that the product meets the appropriate specifications. The product warranty is valid only if the product has been installed and used according to the directives provided in this instruction manual.

In case of any manufacturing defect, the product will be repaired or replaced under warranty. However, the warranty does not apply if:

- Any modification or repair was done by any person or organization other than EKO service personnel.
- The damage or defect is caused by not respecting the instructions of use as given on the product brochure or the instruction manual.

2-3. About Instruction Manual

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This manual was issued: 2016/09/26

Version Number: 8

2-4. Environment

1. WEEE Directive 2002/96/EC (Waste Electrical and Electronic Equipment)

This product is not subjected to WEEE Directive 2002/96/EC however it should not be mixed with general household waste. For proper treatment, recovery and recycling, please take this product(s) to designated collection points.

Disposing of this product correctly will help save valuable resources and prevent any potential negative effects on human health and the environment, which could otherwise arise from inappropriate waste handling.

2. RoHS Directive 2002/95/EC

EKO Instruments has completed a comprehensive evaluation of its product range to ensure compliance with RoHS Directive 2002/95/EC regarding maximum concentration values for substances. As a result all products are manufactured using raw materials that do not contain any of the restricted substances referred to in the RoHS Directive 2002/95/EC at concentration levels in excess of those permitted under the RoHS Directive 2002/95/EC, or up to levels allowed in excess of these concentrations by the Annex to the RoHS Directive 2002/95/EC.

DECLARATION OF CONFORMITY

We: EKO INSTRUMENTS CO., LTD
1-21-8 Hatagaya Shibuya-ku,
Tokyo 151-0072 JAPAN

Declare under our sole responsibility that the product:

Product Name: I-V Curve Tracer, PV Selector, TC Selector
Model No.: MP-160, MI-510/MI-520/MI-530/MI-540

To which this declaration relates is in conformity with the following harmonized standards of other normative documents:

Harmonized standards:

EN 55022:1998+A1+A2 Class A (Emission)
EN 55024:1998+A1+A2 (Immunity)
EN 61000-4-2 EN 61000-4-3
EN 61000-4-4 EN 61000-4-5
EN 61000-4-6 EN 61000-4-8
EN 61000-4-11

Following the provisions of the directive:
EMC-directive : 89/336/EC
Amendment to the above directive : 93/68/EEC

Date: Apr. 24, 2009

Position of Authorized Signatory: Deputy General Manager of Quality Assurance Dept.

Name of Authorized Signatory: Shuji Yoshida

Signature of Authorized Signatory: Shuji Yoshida

3. Safety Information

EKO Products are designed and manufactured with consideration for safety; however, please make sure to read and understand this instruction manual thoroughly to be able to operate the instrument safely in the correct manner.



WARNING CAUTION

Attention to user; pay attention to the instructions given on the instruction manual with this sign.



HIGH VOLTAGE WARNING

High voltage is used; pay special attention to instructions given on this instruction manual with this sign to prevent electric leakage and/or electric shocks.



3-1. WARNING/CAUTION

1. Installation

Do not use in a place where the device will be exposed to vibration or mechanical impact, high humidity or dust, extreme temperature changes, and/or near existence of strong electromagnetic field. These will lead to instrument defects.

2. Handling

- Do not use these instruments for any other purpose than the intended use.
- Do not disassemble, modify or touch inside of these instruments unless instructed in the manual.
- If smoke or odor from these instruments is noticed, immediately turn OFF the power switch.



3-2. HIGH VOLTAGE WARNING

- When connecting and disconnecting these instruments to and from PV device, always check the connector areas before operating for any risks of electric shocks by using voltage tester and so on.
- Ground the PV devices and all the other devices around by grounding cable. If it is not appropriately grounded, it may cause electric shocks and/or electric leakage accidents.
- Do not touch the terminal blocks and the outlet of power sources with wet hands. It may cause an electric shock or short circuit.
- When using MP-160, turn OFF and disconnect powers of the PV device and all the other devices including inverter, then take measurement in a condition which is not connected to anything other than MP-160.
- Always use the connecting terminals and cables which meet the rating capacity of the PV device, and make sure to connect securely so that they will not come off from the connector.
- Before switching on the instrument check the rated voltage and type of the power supply (AC/DC).

4. Introduction

The MP-160 I-V tracer is the best solution for testing single or multiple solar cell- or module characteristics in combination with a solar simulator or natural sun light. It can be found in factory quality control applications or outdoors long term performance assessment studies of modules exposed to natural conditions. The cell or module performance characteristics are determined by changing the electrical load during the I-V sweep. The radiant energy on the module energy can be measured simultaneously with the voltage and current measurements necessary to calculate to STC or equivalent standards.
By combining with each of the switching units (MI-510/MI-510S/MI-520/MI-530/MI-540/MP-303), any type of measurement system can be configured using multiple modules, pyranometers, and thermopiles.

Why performing long term testing?

Solar cells and modules usually show a gradual performance decline when deployed outdoors and exposed to environmental conditions. EKO evaluation systems are designed to measure the performance characteristics and maximum output power of solar cells and modules. Those are measurement quantities that physically correlate to the incident irradiance and electric load, the spectral efficiency which is strongly depending on the solar spectrum and other electrical properties e.g. the diode characteristics and internal resistance affecting the cell efficiency. To get a proper understanding of the individual performance parameters or characteristics relative to the influencing measurement conditions, special measurement equipment is required. For this purpose EKO offers an adequate measurement solution for most relevant quantities.

To test the long term stability of PV modules, most obvious with EKO's MP-160 based outdoors test system the I-V characteristics of PV cells and modules can be measured simultaneously with various meteorological components like irradiance, wind, humidity and pressure. The PV measurement system is based on a single or multi channel I-V curve tracer with module switching units and data logger.

With EKO's indoor test system cells can be tested in a controlled environment according to the several test standard defined to measure module performance and stability.

The outdoor Photovoltaic (PV) module(s) evaluation system based on the MP-160 is designed to measure I-V curve and module back-side temperature to evaluate the variance of the performance of each module under natural sun light and environmental conditions. The main instrument is I-V curve tracer MP-160 with additional PV modules selector, thermocouples selector and pyranometer selector can be connected to MP-160 according to the required quantity of PV modules. The measurement software “MP160o.exe” controls MP-160 and selectors. I-V curve, temperature and solar irradiance of each module are measured one by one sequentially. By setting the start, finish time of the day and time interval, the system measures all modules uninterrupted over a long period of time.

4-1. Main Features

I-V Curve Tracer MP-160 is applicable to all types of modules.

The main features of the hardware and software for each, outdoor and indoor measurement systems are listed on the table below:

Table 4-1. Hardware Features

Hardware Features	Outdoor Measurement	Indoor Measurement
Connecting with Pyranometer	✔	✔
Connecting with Reference Cell	✔	✔
Connecting with Thermocouples, 2channels	✔	✔
Multi-channel measurement by combining with module switching unit (MI-510/520)	✔	-
Multi-channel measurement by combining with thermocouple switching unit MI-540	✔	-
Multi-channel measurement by combining with pyranometer switching unit MI-530 (pyranometer up to 5 units can be connected)	✔	-
Interlocking with solar simulator shutter	-	✔*

*Requires modification with additional parts and software with shutter control function

Figure 4-2. Software Features

Software Features	Outdoor Measurement	Indoor Measurement
Manual Measurement	✔	✔
Continuous Measurement	✔	-
Assigning the number of measurement up to 10 times		✔
Superimposing I-V curve graphs	-	✔
Rs calculation using JIS8913 Standard	-	✔
Manual Range Measurement	✔	✔
Automatic Range Measurement by connecting with Pyranometer	✔	-
Selection between T-type Thermocouple and K-type Thermocouple	✔	-
Module back side temperature measurements in 2 locations per one module	✔	-
Sweep in Voc → Isc direction	✔	✔
Sweep in Isc → Voc direction	✔	-
Averaging I-V curve	-	✔
Processing moving average for I-V curve	✔	✔
STC Conversion	✔	✔

Figure 4-2. Software Features – Continued

Software Features	Outdoor Measurement	Indoor Measurement
Interlocking with solar simulator shutter	-	✔**
Automatic CSV conversion during measurement	✔	-
Convert multiple data into CSV in offline condition	✔	-
Show data in specific time period	✔	-
Select data from specific time period	✔	-
Filtering function for data by irradiance	✔	-

**Requires software with shutter control function

4-2. Package Contents

Check the package contents first; if any missing item or damage is noticed, please contact EKO immediately.

Table 4-3 Package Contents for MP-160

Standard Items	Qty.	Remarks
MP-160	1	
Power Cable	1	Cable length: 2.5m
Communication Cable	1	RS-232 Cross Cable, Length: 1.5m
Inspection Report	1	
Software and Instruction Manual	1	CD-ROM (mp160o.exe Outdoor application)

If any of the switching units are purchased together with MP-160, following items are included in the packaging for each switching unit. Note that each type switching unit has different contents.

Table 4-4 Package Contents for MI-510/510S /MI-520, and MP-303

Standard Items	Qty.	Remarks
MI-510/510S /MI-520 or MP-303	1	
Power Cable	1	Cable Length: 2.5m
Switching Control Cable	1	Cable Length: Approx. 60cm
PV Junction Cable	1	Cable Length: Approx. 60cm
Inspection Report	1	

Table 4-5 Package Contents for MI-530

Standard Items	Qty.	Remarks
MI 530	1	
Power Cable	1	Cable Length: 2.5m
Switching Control Cable	1	Cable Length: Approx. 60cm
Inspection Report	1	

Table 4-6 Package Contents for MI-540

Standard Items	Qty.	Remarks
MI 540	1	
Power Cable	1	Cable Length: 2.5m
Switching Control Cable	1	Cable Length: Approx. 60cm
T-type Thermocouple Junction Cable	1	Cable Length: Approx. 60cm
Signal Junction Cable	1	Cable Length: Approx. 60cm
Inspection Report	1	

5. Getting Started

5-1. MP-160 Parts Name and Descriptions

Each part name and its main functions are described below.

1. Front Panel



Figure 5-1. Front Panel

STAND BY LED:	Blinks when the measurement is ready to start measurement.
RUN LED:	Blinks during the measurement.
POWER Switch:	Power switch.

2. Rear Panel

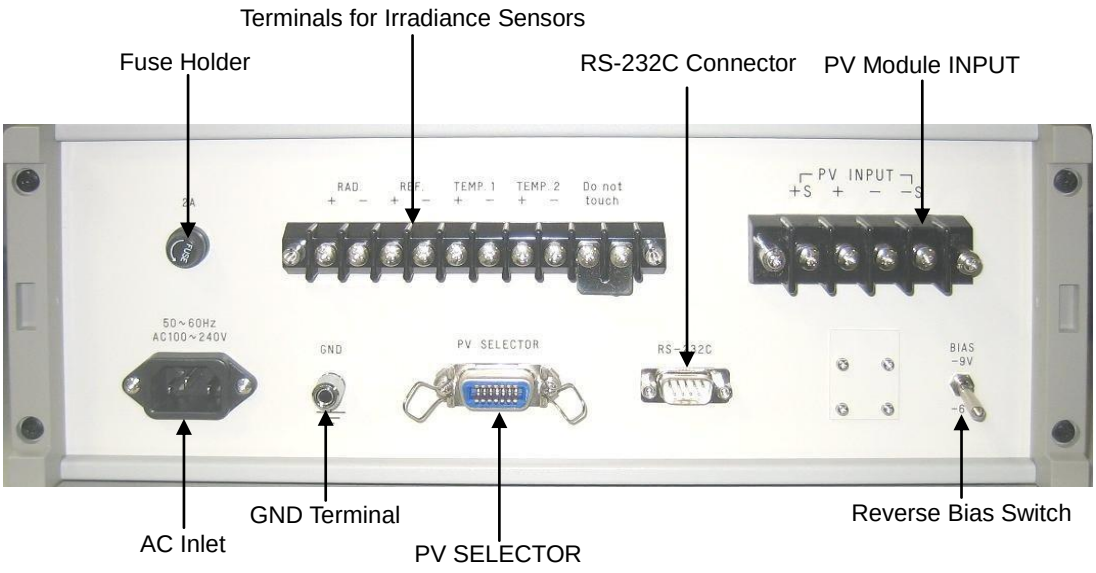


Figure 5-2. Rear Panel

3. Terminals for Irradiance Sensors

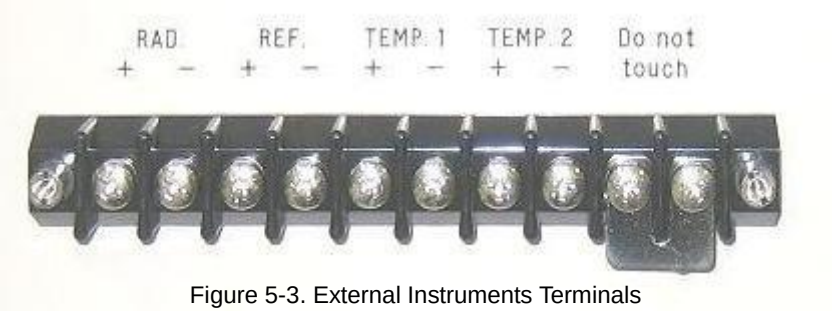


Figure 5-3. External Instruments Terminals

RAD Terminal:	Pyranometer input channel
REF Terminal:	Reference cell input channel (external shunt resistance) or photo-detector
TEMP1 and TEMP2 terminals:	2ch. Thermocouple terminals T-type or K-type thermocouple can be selected from software.
Do not touch:	Terminal for terminal block reference temperature measurement (Do NOT touch this terminal!)

4. PV INPUT Terminal (4Wire)



Connecting the PV cell or Module to the MP-160 make sure to switch OFF the mains power and disconnect from all ancillary electronic equipment (e.g. inverter). Wear electric insulated gloves to protect from electric shocks while connecting the PV cell or module to the MP-160.

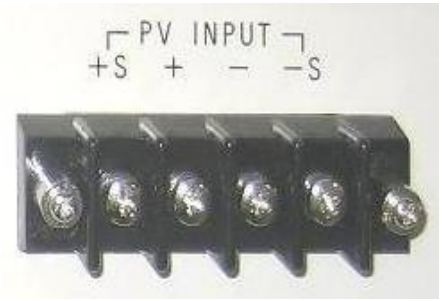


Figure 5-4. PV INPUT Terminal

+S, +: (+) PV cell or module input terminal

-S, -: (-) PV cell or module input terminal

5. Reverse Bias Switch

Reverse bias switch for -9V or -6V bias Voltages to compensate for voltage drop in cables to Isc point on I-V curve.



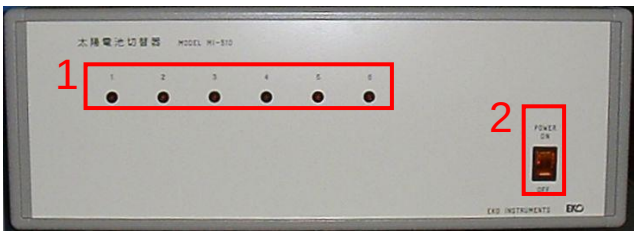
When measuring a low capacity single cells (such as DSG), switch to -6V otherwise the cell could be damaged when a reverse-bias is applied.



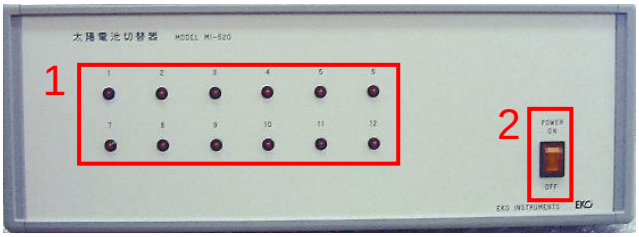
Figure 5-5.
Reverse Bias Switch

5-2. Switching Units: Parts Name and Descriptions

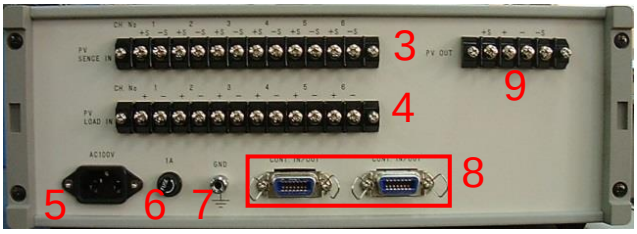
1. MI-510 /MI-510S (6ch.) & MI-520 (12ch.) PV Module Switching Unit



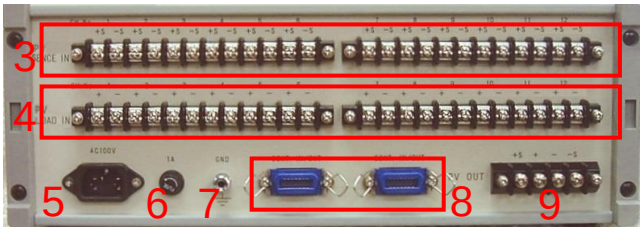
MI-510/510S Front Panel



MI-520 Front Panel



MI-510/510S Rear Panel



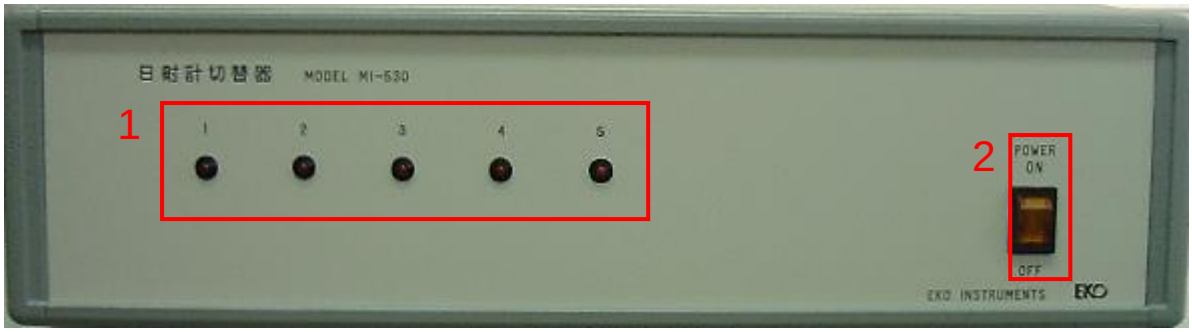
MI-520 Rear Panel

Figure 5-6 MI-510/510S & MI-520 Front and Rear Panel

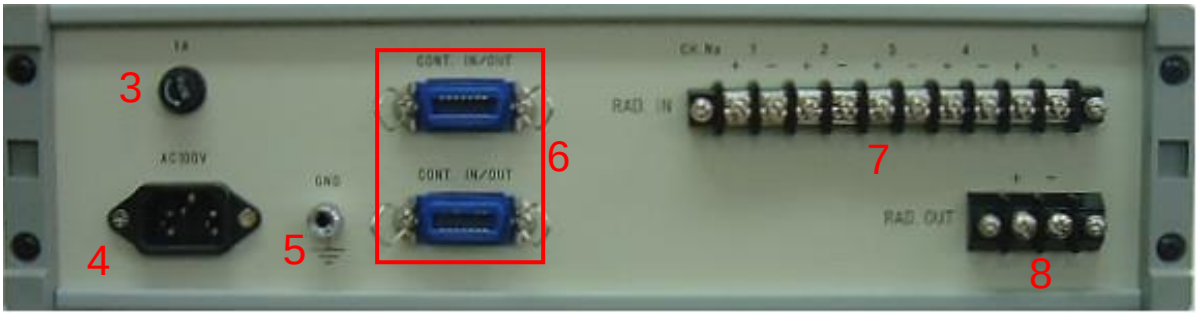
Table 5-1 MI-510/MI-520 Name and Function

	Names	Function & Details
1	Power switch	ON→ Power ON and lamp will be lit OFF→ Power OFF
2	Channel Lamp (1~6)	MI-510/510S: CH1~CH6 MI-520: CH1~CH12 LED of selected channel will turn on.
3	PV LOAD IN	MI-510/510S: CH 1 to 6, + and - MI-520: CH 1 to 12, + and - Connect the current output cables of PV modules
4	PV SENCE IN	MI-510/510S: CH1 to 6, + and - MI-520: CH1 to 12, + and - Connect the voltage output cables of PV modules
5	AC Inlet	Apply AC100 - 240V, 50/60Hz
6	Fuse holder	1A fuse
7	GND Terminal	Grounding terminal
8	CONT. IN/OUT Connector	2 CONT. IN/OUT connectors available. One is for connecting with MP-160 “PV SELECTOR” connector, and another is for additional switching device (MI-510, MI-520, MI-530 or MI-540). MI-510 and MI-520 can connect maximum of 4 units each.
9	PV OUT Terminal	Connect 4-wire PV cable to PV INPUT of MP-160 Voltage Terminal: +S and –S Terminals Current Terminal: + and – Terminals

2. MI-530 5-Channel Pyranometer Switching Unit



MI-530 Front Panel



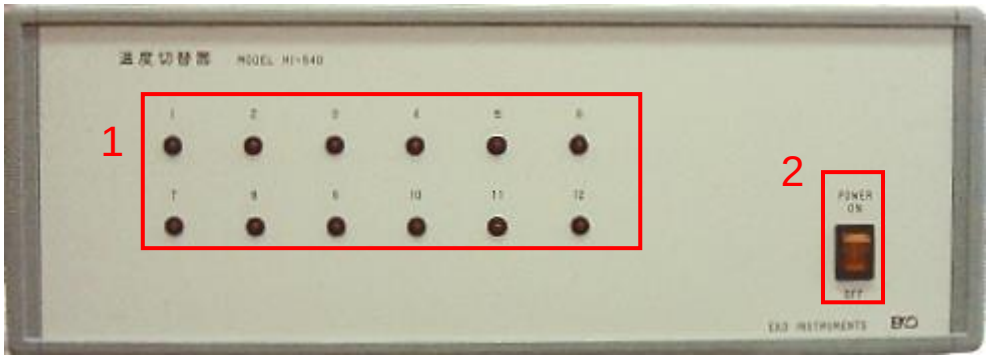
MI-530 Rear Panel

Figure 5-7. MI-530 Front & Rear Panel

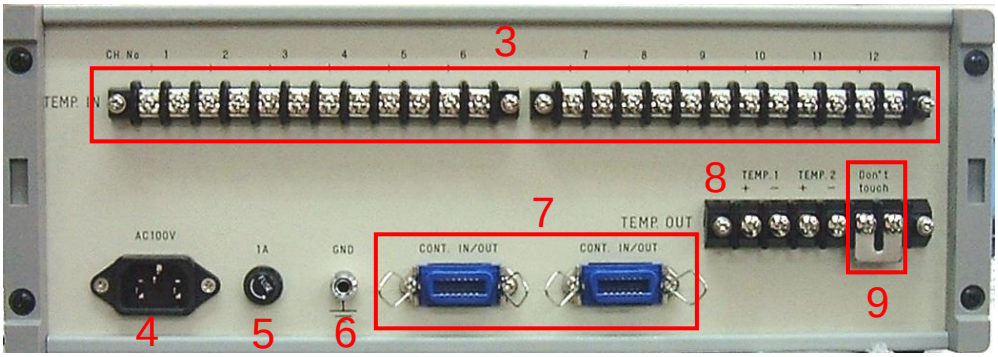
Table 5-3 MI-530 Name and Function

	Names	Function & Details
1	Power switch	ON→ Power ON and lamp will be lit OFF→ Power OFF
2	Channel Lamp (1~5)	LED of selected channel will be lit
3	Fuse holder	1A fuse
4	AC Inlet	Apply AC100 - 240V, 50/60Hz
5	GND Terminal	Grounding terminal
6	CONT. IN/OUT Connector	2 CONT. IN/OUT connectors available One is for connecting with “CONT.IN/OUT” connector on MI-520 or MI-540, and another is for additional switching device. (MI-510, MI-520, MI-530 or MI-540)
7	RAD. IN Terminal (1~5ch.)	Connect the pyranometers CH 1 to 5 (+/-)
8	RAD. OUT Terminal	Selected pyranometer output terminal to MP-160 “RAD +, –“ terminal.

3. MI-540 12-Channel Thermocouple Switching Unit



MI-540 Front Panel



MI-540 Rear Panel

Figure 5-8. MI-540 Front & Rear Panel

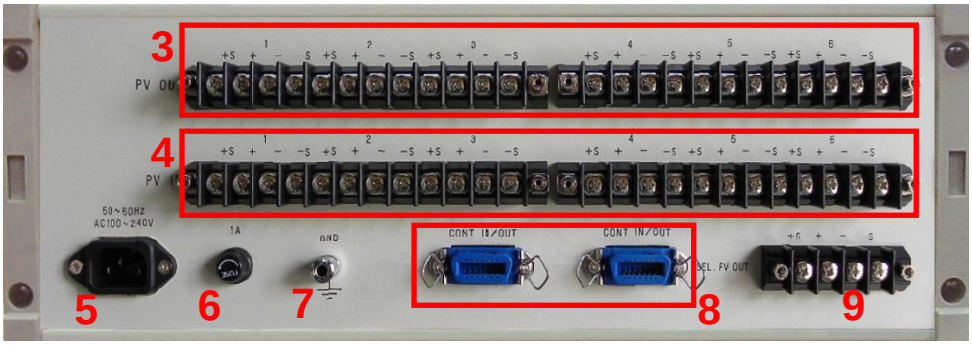
Table 5-4 MI-540 Name and Function

	Names	Function & Details
1	Power switch	ON→ Power ON and lamp will be lit OFF→ Power OFF
2	Channel Lamp (1~12)	LED of selected channel will turn on.
3	TEMP. IN Terminal	Connect the T-type thermo couple of PV modules CH 1 to 12, + and -
4	AC Inlet	Apply AC100 - 240V, 50/60Hz
5	Fuse holder	Use 1A fuse
6	GND Terminal	Grounding terminal
7	CONT. IN/OUT Connector	2 CONT. IN/OUT connectors available. One is for connecting with “CONT.IN/OUT” connector on MI-530, and another is for additional switching device. (MI-510, 520, 530 or 540)
8	TEMP. OUT Terminal	TEMP.1 (+, -): Connect with junction cable for T1 to TEMP1 (+. -) terminal of MP-160. TEMP.2 (+. -): Connect with junction cable for T2 to TEMP2 (+. -) terminal of MP-160.
9	Do not touch	Reference point of the instrument temperature. Please do not touch this point.

4. MP-303 System Switching Unit



MP-303 Front Panel



MP-303 Rear Panel

Figure 5-9. MP-303 Front Panel & Rear Panel

Table 5-4. MP-303 Name and Function

	Names	Function & Details	
1	Power Switch	ON→ Power ON and lamp will be turn on OFF→ Power OFF	
2	Channel Lamps	CH1 ~ CH6	LED of selected channel will turn on.
3	PV OUT Terminal	CH 1~ CH6 Voltage Terminal: ＋S & －S Terminals Current Terminal: ＋& － Terminals	Can be connected to PV module loaded side terminal, MPPT, and other loads.
4	PV IN Terminal	CH 1~ CH6 Voltage Terminal: ＋S & －S Terminals Current Terminal: ＋& － Terminals	Connect to PV module
5	AC Inlet	Apply AC100 - 240V, 50/60Hz	
6	Fuse holder	1A fuse	
7	GND Terminal	Grounding terminal	
8	CONT. IN/OUT Connector	2 CONT. IN/OUT connectors available. One is for connecting with MP-160 “PV SELECTOR” connector, and another is for additional switching device (MP-303, MI-510, MI-520, MI-530 or MI-540). MP-303 can connect maximum of 4 units.	
9	SEL. PV OUT Terminal	Connect to “PV INPUT” terminal on MP-160 Voltage Terminal: +S and –S Terminals Current Terminal: + and – Terminals	

6. Outdoor Measurement System Setup

6-1. Measurement System Configurations

With MP-160 I-V curve tracer, there are mainly two ways to setup for outdoor cell or module performance measurements.

1. Basic System Configuration

Single PV module Measurement

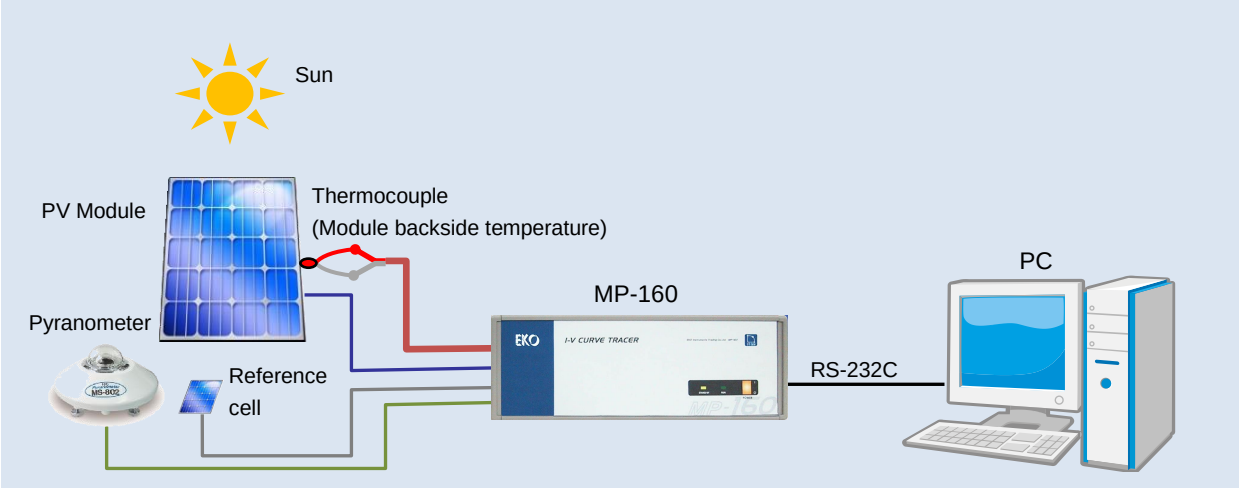


Figure 6-1. Connecting Only the Main Unit

1) Connect PV module to PV INPUT terminal on the rear panel of MP-160 with 2 of each + and – cables.
NOTE: By connecting the 2-wire with jumper will cause unstable measurement.

2) Attach the thermocouple to the back side of PV module and connect the other end to TEMP1 on the terminals for meteorological instruments.
See [Appendix A-2. Measuring PV Module Back Temperature] for how to attach the thermocouple to the back side of PV module.

Use TEMP2 terminal for measuring ambient temperature for single module measurement.
When using switching unit with outdoor version software, only TEMP1 is available. TEMP2 is not available as it will be used with thermocouple switching unit and for transferring terminal temperature of switching unit.

Table 6-1. Functions of TEMP1 & TEMP2 Terminals

Measurement Condition			TEMP1	TEMP2
Only MP-160	Indoor Software	Temperature 1ch Measurement	Module Backside Temperature	Temperature, etc.
	Outdoor Software	Temperature 1ch Measurement	Module Backside Temperature	Temperature, etc.
MP-160＋ MI-510/520	Outdoor Software	Temperature 1ch Measurement	Module Backside Temperature	Reference Point Temperature
MP-160＋ MI-510/520＋ MI-540	Outdoor Software	Temperature 1ch Measurement	Module Backside Temperature	Reference Point Temperature
	Outdoor Software	Temperature 2ch Measurement	Module Backside Temperature 1	Module Backside Temperature 2 NOTE1

NOTE1: For thermocouple measurement, it requires reference point. When taking measurement only with MP-160, measure the “Do not touch” terminal temperature and this will be the reference point as it is corrected. When using the Thermocouple Switching Unit MI-540, the terminal temperature which is the closest to the terminal which is connected with thermocouple will be the reference point; thus use the “Do not touch” terminal on the MI-540. In order to send this temperature information to MP-160, these TEMP2 terminals on MI-540 and MP-160 need to be connected using compensating lead wire. When measuring temperature in 2 locations on 1 module, the reference point cannot be taken from MI-540, thus “Do not touch” terminal temperature on MP-160 will be the reference point; however, it is assumed that the temperatures between MP-160 and MI-540 are the same. Make sure to setup the MP-160 and MI-540 so that there will not be any temperature differences. If temperature differences occur, it will lead to measurement error.

Table 6-2 Reference Point Measurement Place & Remarks

Measurement Condition	Reference Point Temperature Measuring Place	Remarks
Measuring only with MP-160	“Do not touch” Terminal on MP-160	
Measuring with MI-540	”Do not touch” Terminal on MI-540	In order to send this temperature information to MP-160, these TEMP2 terminals on MI-540 and MP-160 need to be connected using compensating lead wire.
Measuring 1 PV module with 2ch.	MP-160 Terminal	It is assumed that the temperatures between MP-160 and MI-540 are the same. Make sure to setup the MP-160 and MI-540 so that there will not be any temperature differences. If temperature differences occur, it will lead to measurement error.

3) Connect pyranometer to the RAD terminal which is located on the MP-160 rear panel, terminals for Meteorological Instruments.
Pyranometer sensitivity is required to be entered from software.
In such case measuring multiple PV modules in different directions and angles then converting with STC, maximum of 5 units of pyranometers can be used with Pyranometer Switching Unit MI-530, corresponding to each module in different directions/angles.
See [6-2. 3. MI-530 Pyranometer Switching Unit] for details.

4) When using reference cell, it is connected to REF terminal on MP-160 rear panel; however, its maximum voltage input is 300mV, thus in order to connect current-output reference cell, it is required to convert the current to voltage by connecting the optional shunt resistant box to REF terminal in parallel. Depending on the input current, it requires to select the shunt resistant value so that the output terminal will be within 300mV.
Shunt resistant value and reference cell sensitivity need to be entered from software.

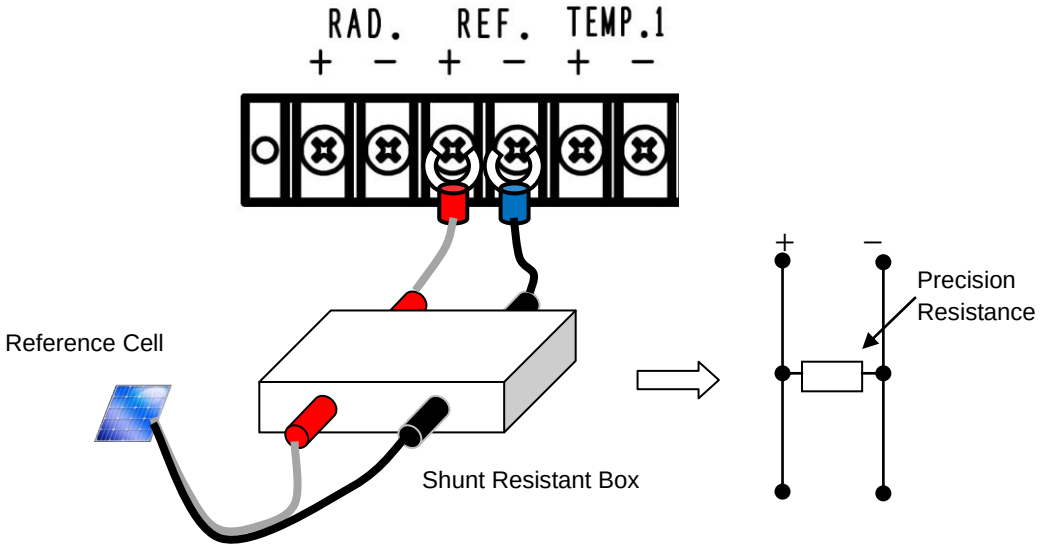


Figure 6-2. Connecting Shunt Resistant Box to REF Terminal

5) Connect PC and MP-160 with RS-232C cross cable.

2. System Configuration Using Switching Unit

Setup 1~48 PV Modules Outdoor. The illustrations show the basic connections and setup.

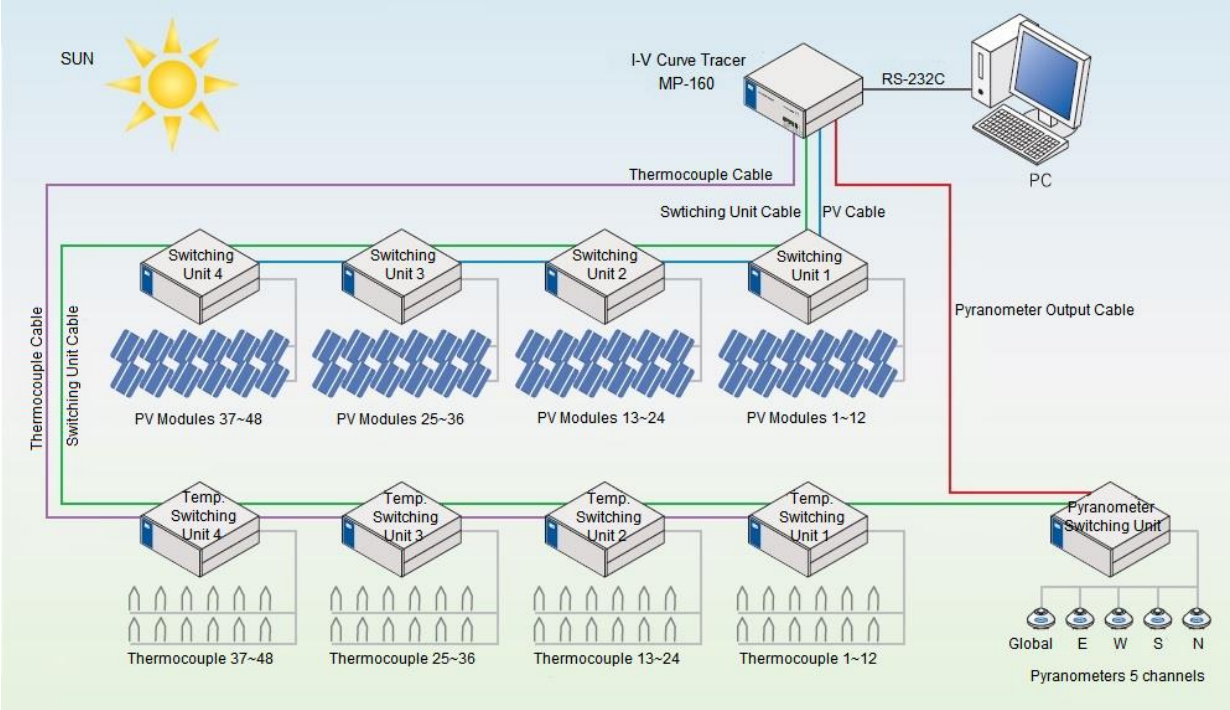


Figure 6-3. 1~48ch. System Using Switching Units

In the case that the 1 channel is used for 1 PV module, the terminal temperature on the thermocouple switching unit is measured using the temperature of T-type thermocouple inside the thermocouple switching unit.MI-540 T1 terminal is connected to MP-160 T1 terminal using junction cable for T1.

MI-540 T2 terminal is connected to MP-160 T2 terminal using either junction cable (thermocouple cable) for T2 or T-type thermocouple.

Even if the software is setup to use K-type thermocouple, the terminal temperature of MI-540 T2 is measured using T-type thermocouple, thus the measurement is compensated with T-type thermocouple formula.

To measure multiple PV modules I-V curves using MP-160, a module switching unit (MI-510/MI-520/MI-510S) is used. There are 6 channel module switching unit (MI-510/MI-510S) and 12 channel module switching unit (MI-520). To measure more than just 6 or 12 PV modules, multiple switching units can be used by connecting each module switching unit in daisy chain connection with cables. Using one module witching unit as “1 unit”, maximum of 4 units of module switching unit, in other words, maximum of 48 channels of PV modules can measured. Each module switching unit is identified by given unit number with internal dip switch.

Moreover, not only to also measure temperature for each PV module by using thermocouple switching units, all sorts of combination setups will be available by different conditions.

For pyranometer switching unit MI-530, only one unit can be connected per measurement system; assuming to measure 5 directions of zenith, east, west, south, and north, according to the direction of the PV module setup, 5 units of pyranometers can be connected. Therefore, when PV modules are setup in different directions in one system, irradiance measurements required for STC can be acquired.

3. Connection of System Using Switching Unit

1) Below diagram shows the connection of one temperature measurement on one PV module.

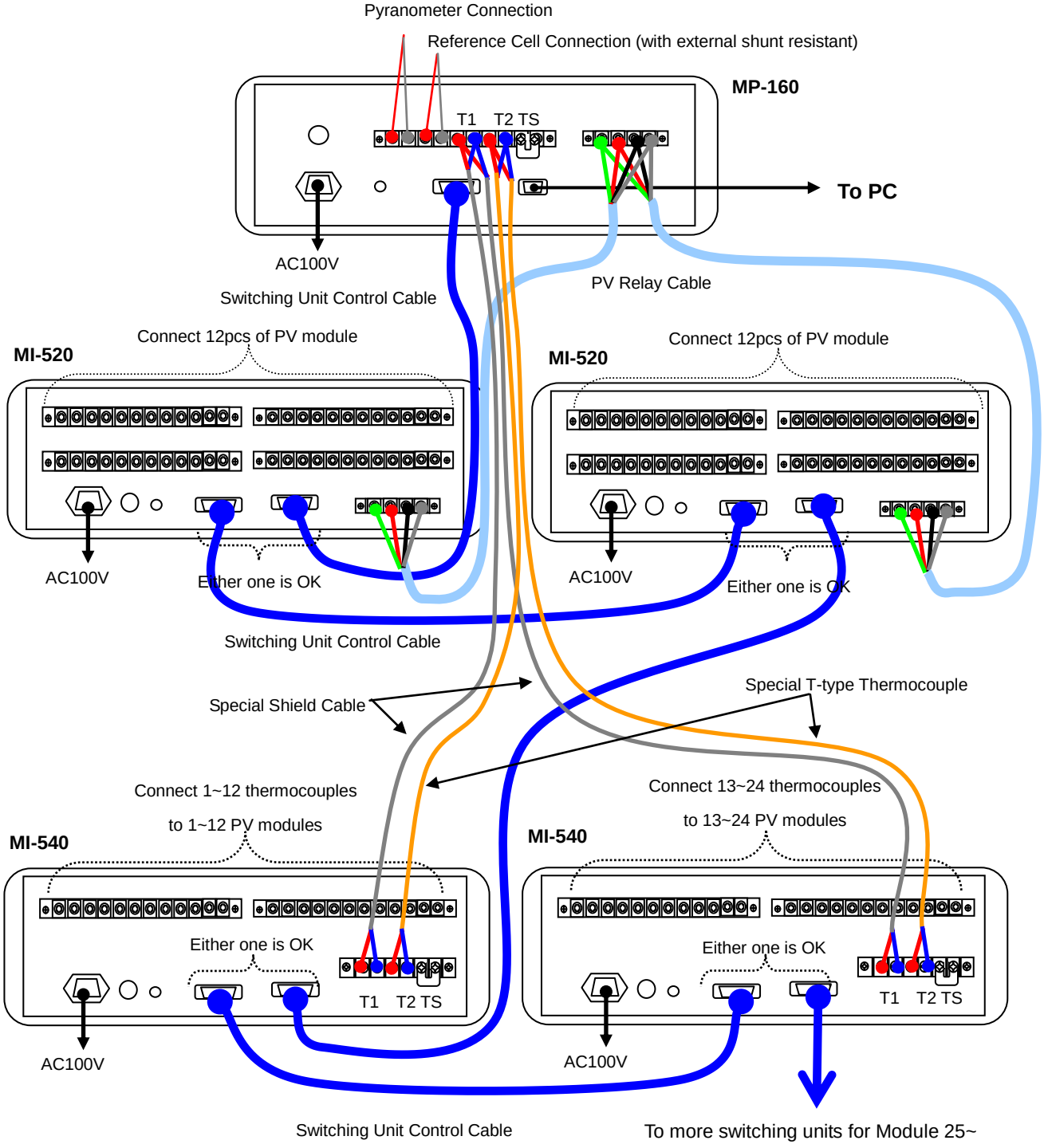


Figure 6-4. Connection Diagram
(for one temperature measurement against one PV module)

2) Measuring Multiple PV Modules with 2 temperature sensors

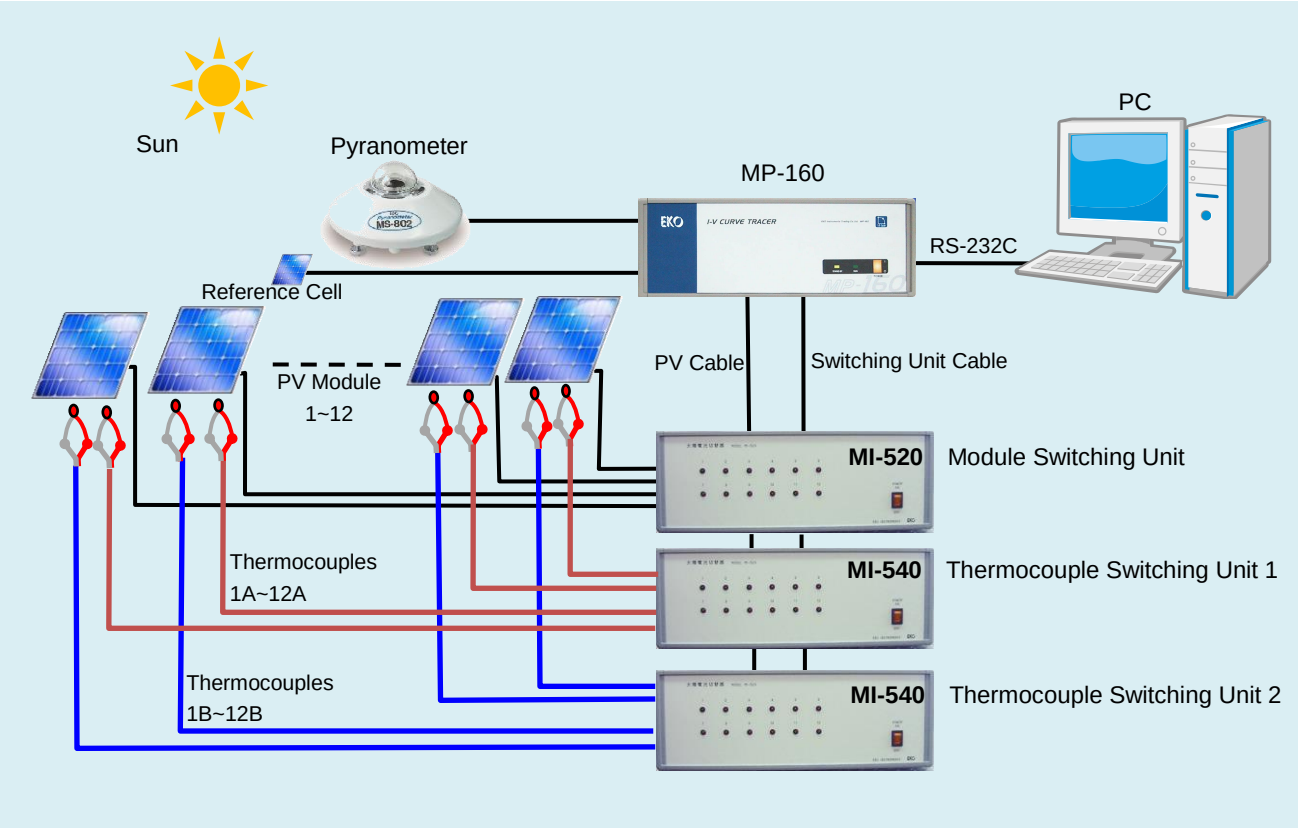


Figure 6-5. 1~12ch System with Switching Unit
(Measuring temperature in 2 places for each 1 module)

When taking temperature measurements from 2places on one PV module, the TEMP2 terminal of thermocouple switching unit MI-540 will not be connected to MP-160, and the terminal temperature on MP-160 is used as reference point.

Therefore, install the MI-540 and MP-160 next to each other or stacking up. By installing separate location will cause difference in terminal temperature and leads to error in measured temperature.

TEMP2 terminal on MP-160 is connected to TEMP1 on another unit of thermocouple switching unit MI-540; thus reference point temperature for the thermocouple is taken from the terminal temperature of MP-160.

Thermocouple type (K-type or T-type) can be entered from the software. Use each T-type and K-type compensation formula to calculate the temperature.

3) The connection configuration is shown below for measuring the PV Module temperature at 2 positions.

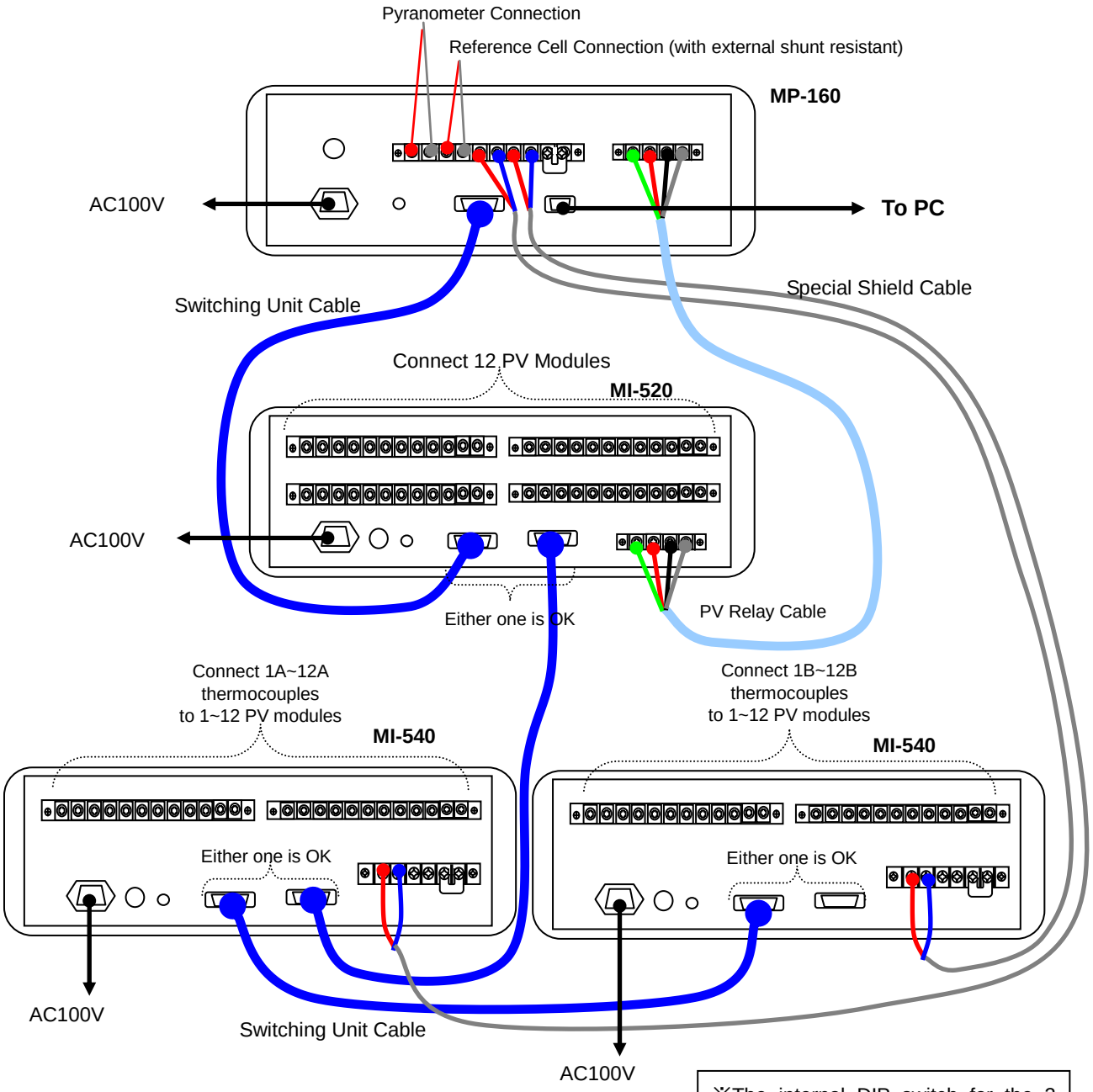


Figure 6-6. Connection Diagram

(Measuring temperature in 2 places on 1 PV Module)

4. System Configuration Using System Switching Unit

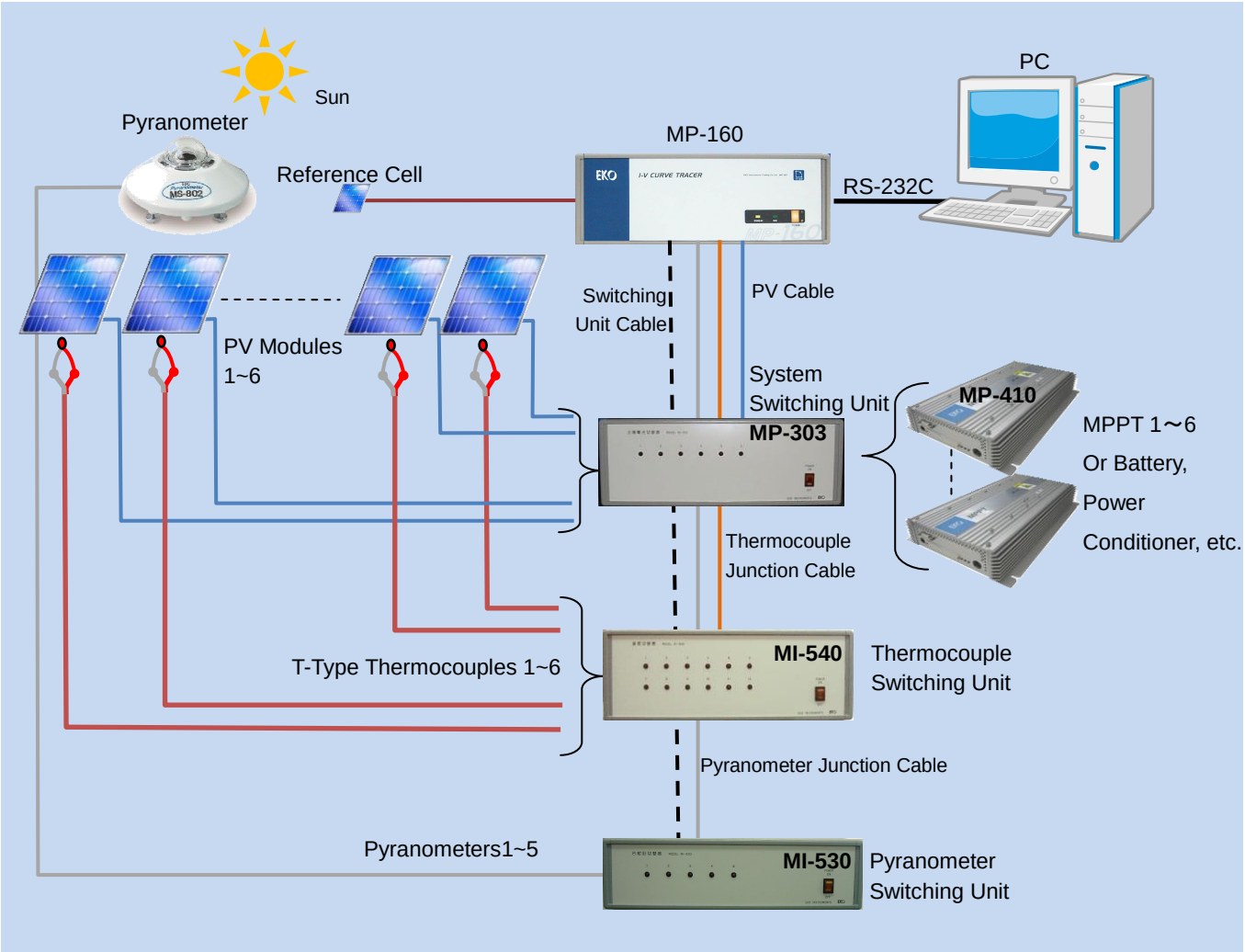


Figure 6-7. 1~6ch System using System Switching Unit

System switching unit MP-303 has 6 channel switching function in one unit. Maximum of 4 units can be connected and allow up to 24 channel switching. PV output is connected to MPPT (MP-410), charge controller, and power conditioner for battery when it is not used for I-V measurement; minimizing the no-load condition of PV module and using the generated power, allowing configuring an effective system for long-term exposure test and durability test as it generates power.

6-2. Connections and Setup

1. Common Procedure for All Switching Unit Types

1) Upper Plate

For the switching units, MI-510/510S/520/530/540, and MP-303 requires to open the upper lid for the unit number and channel number setup. Below explains how to remove the upper plate.

To Remove the Upper Plate

(1) Place the switching unit rear panel facing toward you.
(2) Unscrew the 4 screws at the rear panel.
(3) Remove the side edges.
(4) Pull the upper plate out and remove it.
(5) The dip switch on the PCB will appear.

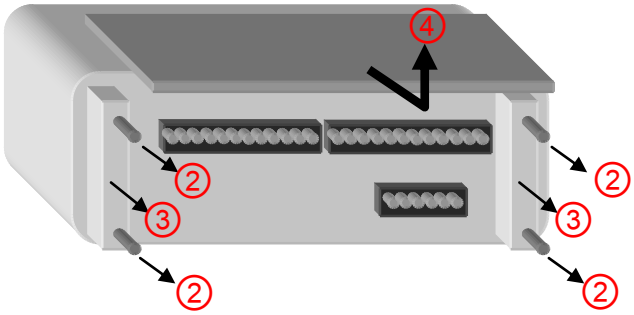


Figure 6-8 Removing Upper Plate

2) Connecting CONT. IN/OUT and PV SELECTOR

There are 2 CONT. IN/OUT connectors on each switching unit. One of the connector is connected to MP-160 PV SELECTOR connector by attached control cable, and other connector can be connected to other switching unit.

MI-510, MS-510S, MI-520, and MP-303 can connect up to 4 units.

MI-510S and MP-303 can be setup 2 units as 1set unit, thus maximum of 8 units can be connected.

MI-530 can connect only 1 unit.

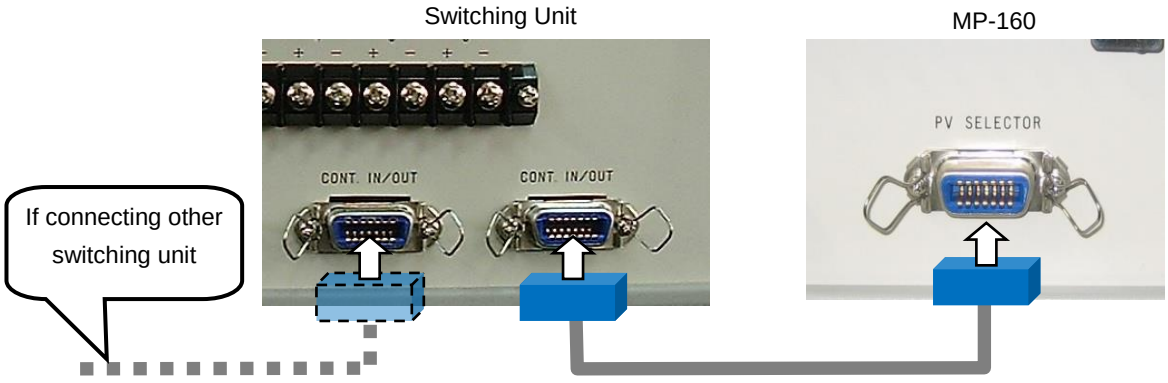


Figure 6-9. PV SELECTOR Connector Connection

2. MI-510/510S/520 Module Switching Unit

1) Connecting to I-V Curve Tracer MP-160: How to Connect PV OUT and PV INPUT

Connect straight to the PV INPUT terminal on the MP-160 rear panel with PV junction cable.

NOTE: Make sure that the power switch is turned OFF when cables are connected.

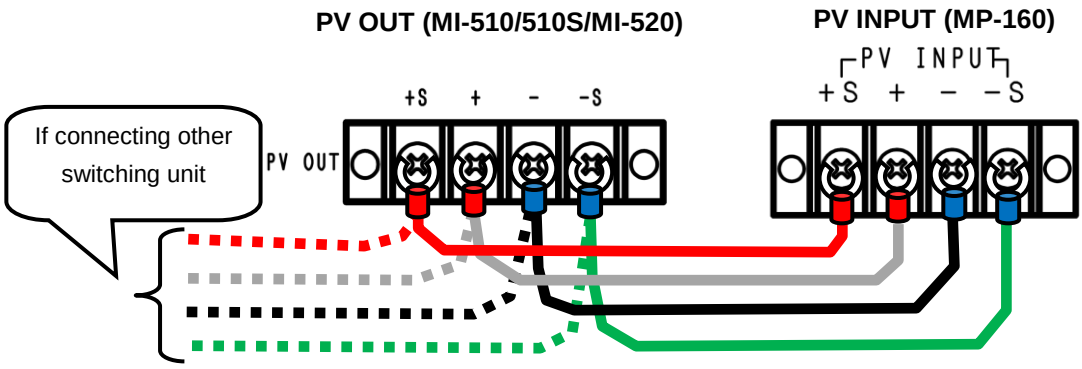


Figure 6-10. MI-510/510S/520 PV OUT & PV INPUT Connection

2) Connecting to PV Module

Connect the PV module current terminal to the + and − of each channels for PV LOAD IN terminal, and connect the voltage terminal to the +S and −S for PV SENCE IN terminal.

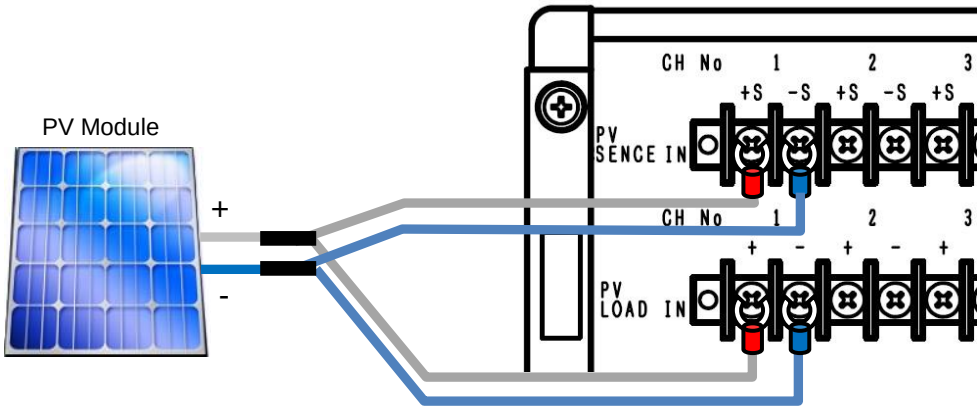


Figure 6-11. MI-510/510S/520 Connecting to PV Module

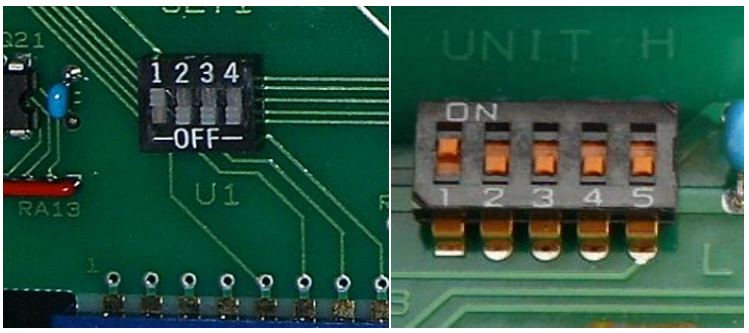
3) Internal Dip Switch Setting

The internal dip switch is located on the upper circuit board inside the switching unit; thus in order to setup, the upper lid must be removed.

When using multiple units of module switching units, the unit numbers are assigned for identification by setting up the internal dip switches. One unit of module switching unit is assigned as 1 unit.

The dip switch 1~4 represent the UNIT number. When using multiple module switching units, make sure the dip switches are not overlapped. Corresponding to the units 1~4, setup one of the dip switch to ON.

NOTE: Multiple bits cannot be turned ON, as well as it will not function if all the bits are turned OFF.



MI-510/520 MI-510S

Figure 6-12. Internal Dip Switch

MI-510 has 1~5 dip switches. The switches 1~4 have same functions as the dip switches in MI-510/520, and 5th one is the switch for a function to manage 2 units of MI-510S with 1 unit of MI-540 (thermocouple switching unit). When the No. 5 dip switch is set to “L (OFF)” side, the PV terminals correspond to 1ch ~6ch; when the No.5 dip switch is set to “H (ON)” side, the PV terminals correspond to 7ch ~ 12ch. This allows to have 12ch module switching unit just like the MI-520 by using 2 units of MS-510S. This function will be necessary when thermocouple switching unit MI-540 is used at the same time, corresponding to 12ch with one unit.

Table 6-3. Dip-Switch Setting (MI-510/510S/520)

Dip SW	MI-510/510S/520				Only MI-510s	
Connecting Units Qty	SW1	SW2	SW3	SW4	SW5	Corresponding Channels
UNIT 1	ON	OFF	OFF	OFF	OFF	1~6
					ON	7~12
UNIT 2	OFF	ON	OFF	OFF	OFF	1~6
					ON	7~12
UNIT 3	OFF	OFF	ON	OFF	OFF	1~6
					ON	7~12
UNIT 4	OFF	OFF	OFF	ON	OFF	1~6
					ON	7~12

3. MI-530 Pyranometer Switching Unit

1) Connecting to I-V Curve Tracer MP-160: How to connect to RAD.OUT Terminal

Connect the attached designated cable to RAD.OUT terminal on the MP-160 rear panel. (See below figure)

Connect the cable end with shield cable to the RAD +, - terminals on MP-160. (Make sure to connect the + and − correctly). Connect the shield cable to GND terminal on MP-160.

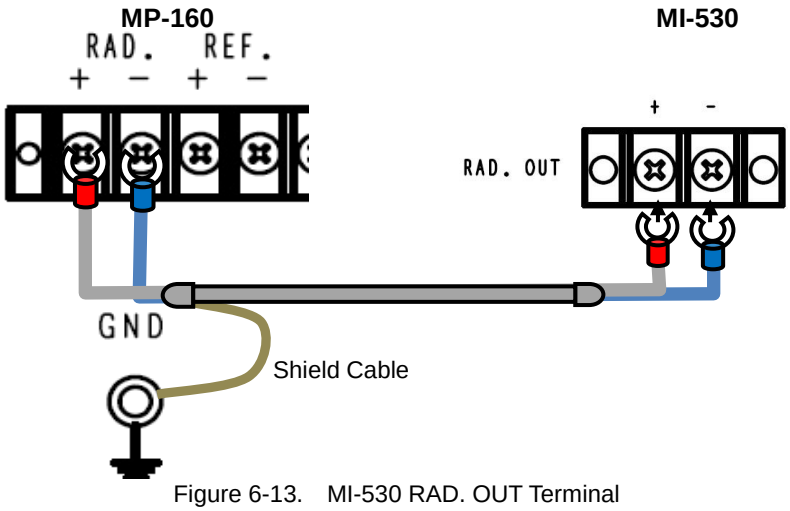


Figure 6-13. MI-530 RAD. OUT Terminal

2) Connecting Pyranometer Output Cable

Connect the pyranometer output cables+ and - to + and − terminals for each channel on MI-530 RAD.IN terminal.

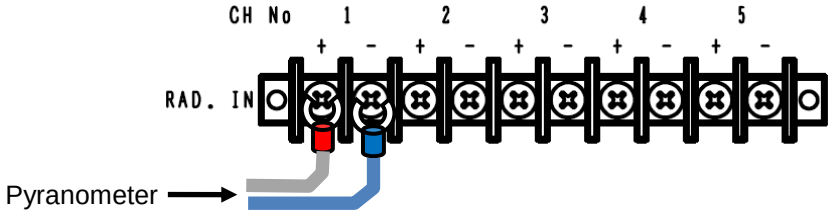


Figure 6-14 MI-530 Terminal

3) Internal Dip Switch Setting

Internal Dip Switch is located on the top circuit board as the upper lid is opened.

How to Setup Dip Switch and Rotary Switch

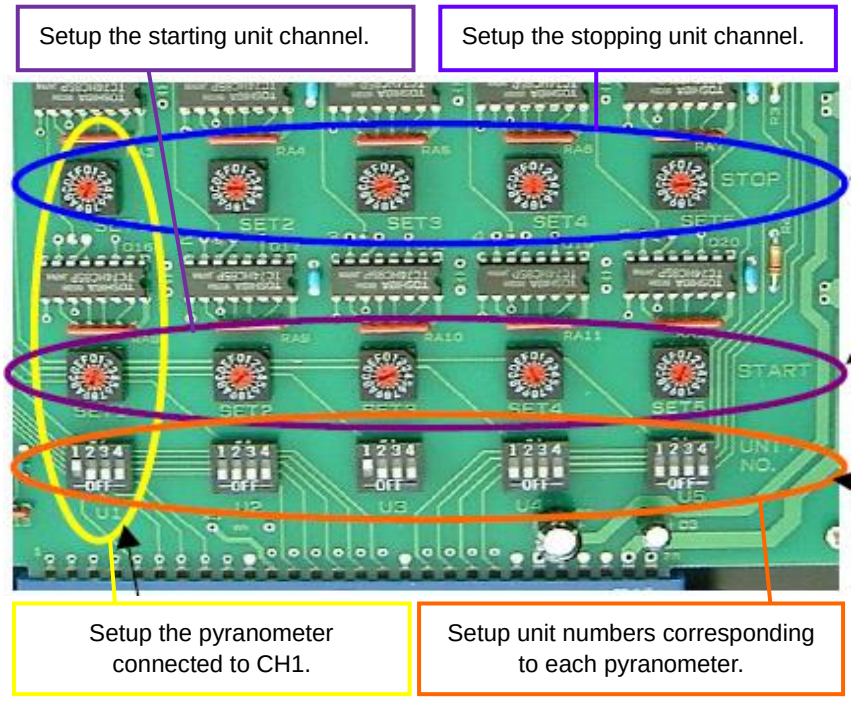


Figure 6-15. MI-530 Dip Switch and Rotary Switch Setup

Table 6-4. MI-530 Dip Switch & Rotary Switch

Switch Types	Detail
Dip switches (UNIT NO., U1 to U5)	Unit numbers are determined by the settings of internal Dip Switch for PV Module Switching Unit MI-520 connected to MP-160. 1~4 bits for Dip Switch are corresponding to the unit number 1~4 units.
Rotary switches (START, SET1 to SET5)	START rotary switch sets the first PV module number which is setup on MI-510/520 switching unit.
Rotary switches (STOP, SET1 to SET5)	STOP rotary switch sets the last PV module number which is setup on MI-510/520 switching unit.

Numerical encode of the rotary switches use hexadecimal as follows.

PV Module Number	1	2	3	4	5	6	7	8	9	10	11	12
Rotary Switch	1	2	3	4	5	6	7	8	9	A	B	C

(0, D, E and F are not used)

NOTE:

※ Setup all dip switches that are not used for pyranometer channels to OFF

※ One pyranometer cannot be setup with multiple units.

※ Dip switch U1~U5 cannot be set to ON with multiple bits, also it does not function with all bits set to OFF

Example 1)

Pyranometer #1 is assigned to PV module #1 ~ #6

Pyranometer #2 is assigned to PV module #7 ~ #12

PV modules:	12
PV Selector MI-520:	1
Pyranometer Selector MI-530:	1
Pyranometers:	2

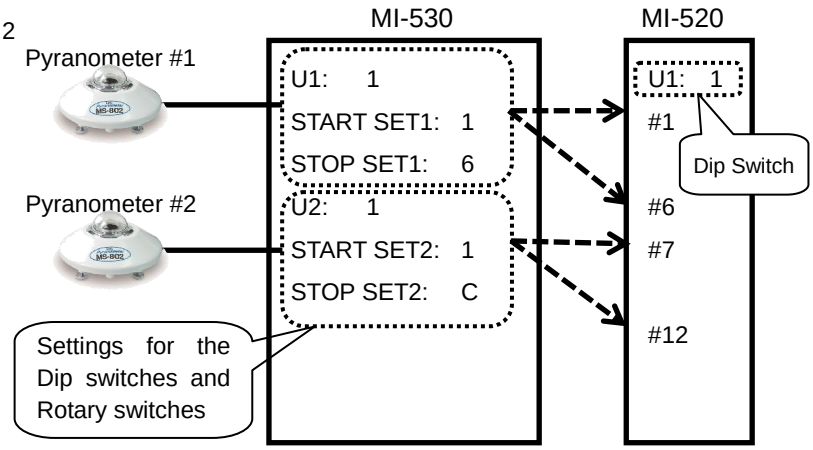


Figure 6-16 MI-530 Connection Example 1

Example 2)

Pyranometer #1 is assigned to PV module #1 ~ #4 (MI-520 #1)

Pyranometer #2 is assigned to PV module #5 ~ #8 (MI-520 #1)

Pyranometer #3 is assigned to PV module #9 ~ #12 (MI-520 #1)

Pyranometer #4 is assigned to PV module #13 ~ #16 (MI-520 #2)

Pyranometer #5 is assigned to PV module #17 ~ #20 (MI-520 #2)

PV modules:	20
PV Selector MI-520:	2
Pyranometer Selector MI-530:	1
Pyranometers:	5

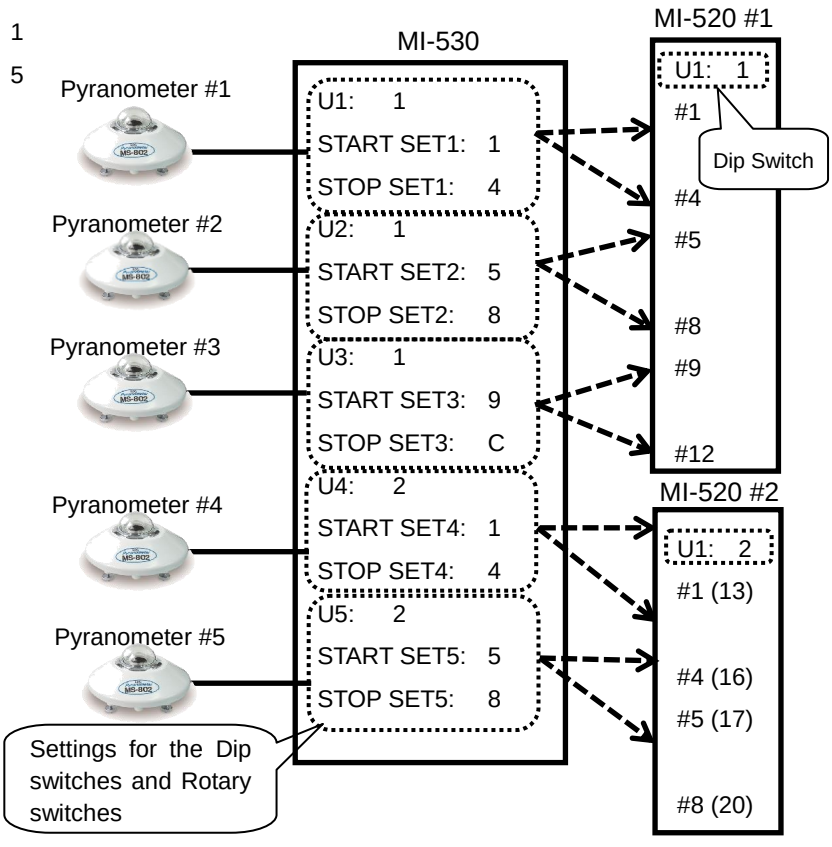


Figure 6-17 MI-530 Connection Example 2

1. MI-540 Thermocouple Switching Unit

1) Connecting to I-V Curve Tracer MP-160

a. Connecting TEMP.1 and TEMP.2

Connect the attached designated cable to the MP-160 rear panel “TEMP1” and “TEMP2” (see below figure). Connect the cable ends with shield cable to MP-160 TEMP1 + and – terminals. TEMP2 + and – terminals are connected with T-type thermocouple with shield cable. (Make sure to connect the + and – properly). Connect the shield cable to MP-160 GND terminal.

TEMP.1 (+, -): 2-wire cable with shield cable

TEMP.2 (+, -): T-type thermocouple (with shield)

+: Copper

-: Constantan

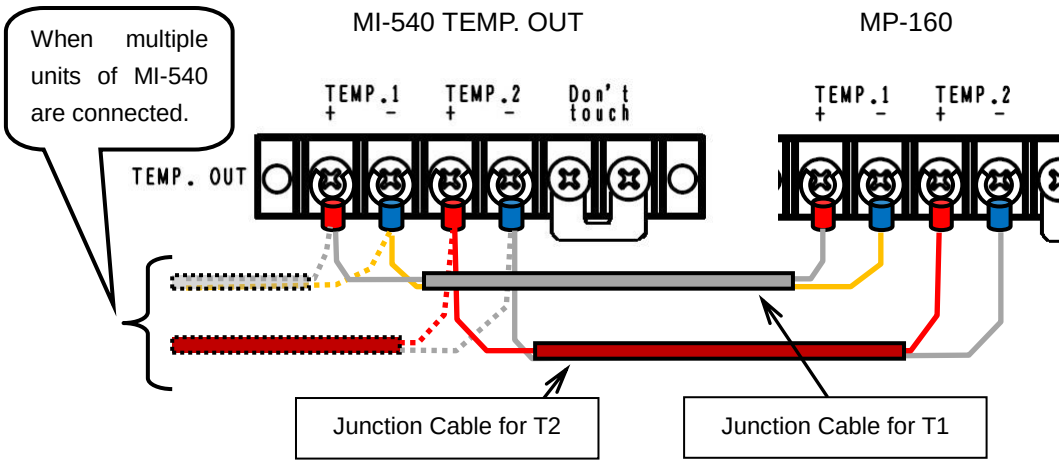


Figure 6-18 MI-540 TEMP.1 and TEMP.2 Terminals

NOTE: The “Don’t touch” terminal on the MI-540 measures the reference temperature using T-type thermocouple. The MI-540 T2 terminal should be connected to T2 terminal on MP-160 using junction cable (thermocouple) for 2T or T-type compensating lead wire. Even if the temperature is measured with K-type thermocouple, the MI-540 terminal temperature is measured with T-type thermocouple, T-type should be used for the junction cable for T2.

2) Connecting T-type Thermocouple

Connect to + and – terminals per each channels on “TEMP.IN” terminal with + and – cable ends of T-type thermocouples.

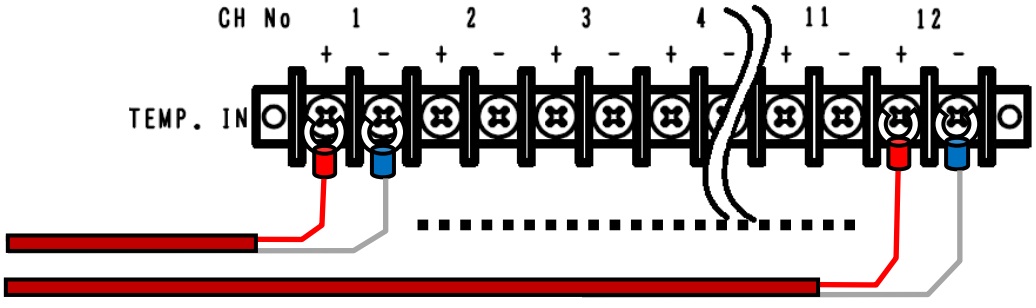


Figure 6-19. MI-540 TEMP. IN Terminal

+: Copper

-: Constantan

3) Internal Dip Switch Setting

Internal Dip Switch is located on the top circuit board as the upper lid is opened.

How to Setup Dip Switch

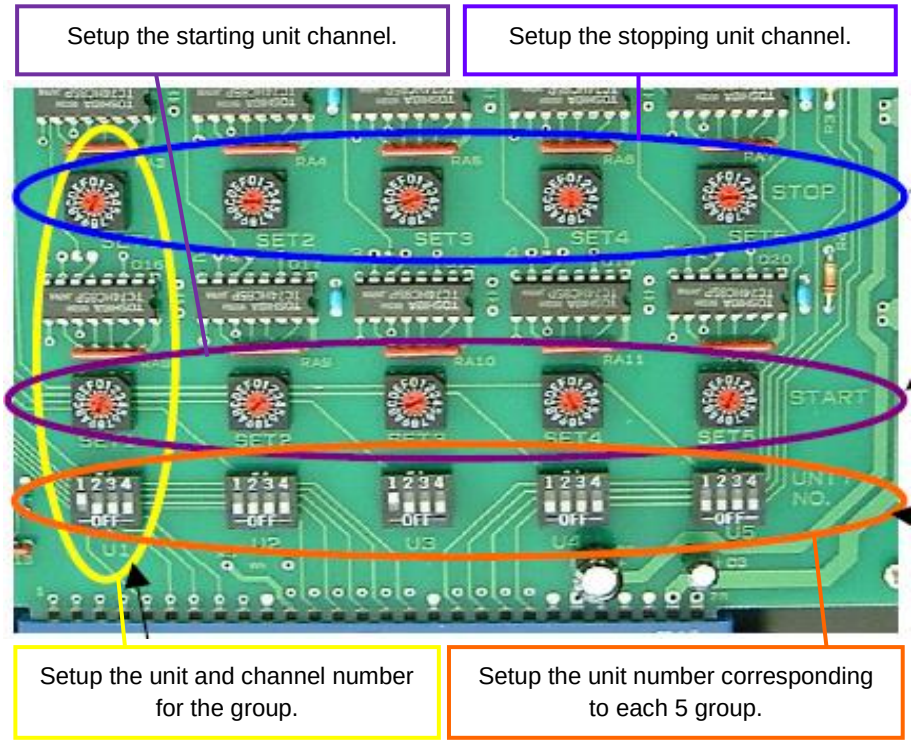


Figure 6-20. MI-540 Dip Switch and Rotary Switch

Figure 6-5. MI-540 Dip Switch & Rotary Switch

Switch Types	Detail
Dip switches (UNIT NO., U1 to U5)	Unit numbers are determined by the settings of internal Dip Switch for PV Module Switching Unit MI-520 connected to MP-160. 1~4 bits for Dip Switch are corresponding to the unit number 1~4 units.
Rotary switches (START, SET1 to SET5)	START rotary switch sets the first PV module number which is setup on MI-510/520 switching unit.
Rotary switches (STOP, SET1 to SET5)	STOP rotary switch sets the last PV module number which is setup on MI-510/520 switching unit.

Numerical encode of the rotary switches use hexadecimal as follows.

PV Module Number	1	2	3	4	5	6	7	8	9	10	11	12
Rotary Switch	1	2	3	4	5	6	7	8	9	A	B	C

(0, D, E and F are not used)

NOTE:

※ Setup all dip switches that are not used for pyranometer channels to OFF

※ Duplicate channel number cannot be setup on one unit.

※ When measuring multiple channels, always setup the rotary switch as START < STOP.

※ If unit is changed, duplicated channel number is possible.

Example 1)

PV modules: 12

PV Selector MI-520: 1

TC Selector MI-540: 1

Setup Module 1~12 on MI-520 and MI-540 in one-on-one condition.

PV Module output cable

Thermocouple cable

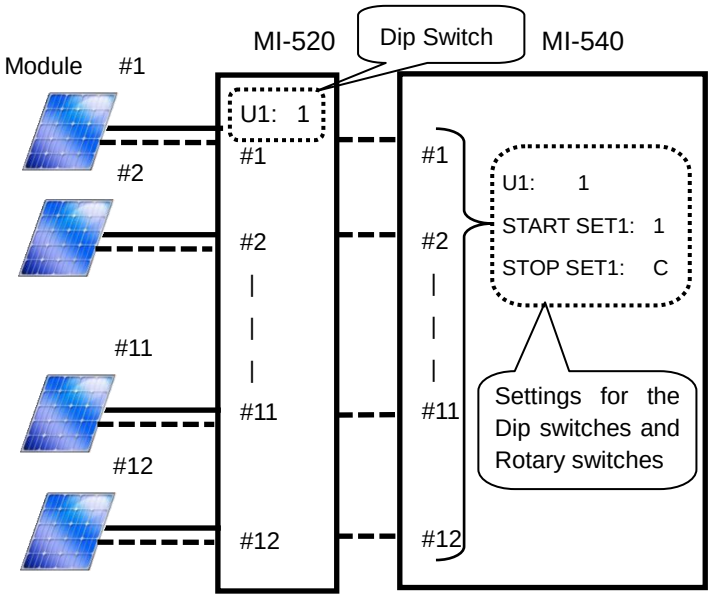


Figure 6-21 MI-540 Connection Example 1

Example 2)

PV modules: 24

PV Selector MI-520: 2

TC Selector MI-540: 1

Temperature of Module 1 is assigned to both modules1 and 13

PV Module output cable

Thermocouple Connection Image (UNIT1)

Thermocouple Connection Image (UNIT2)

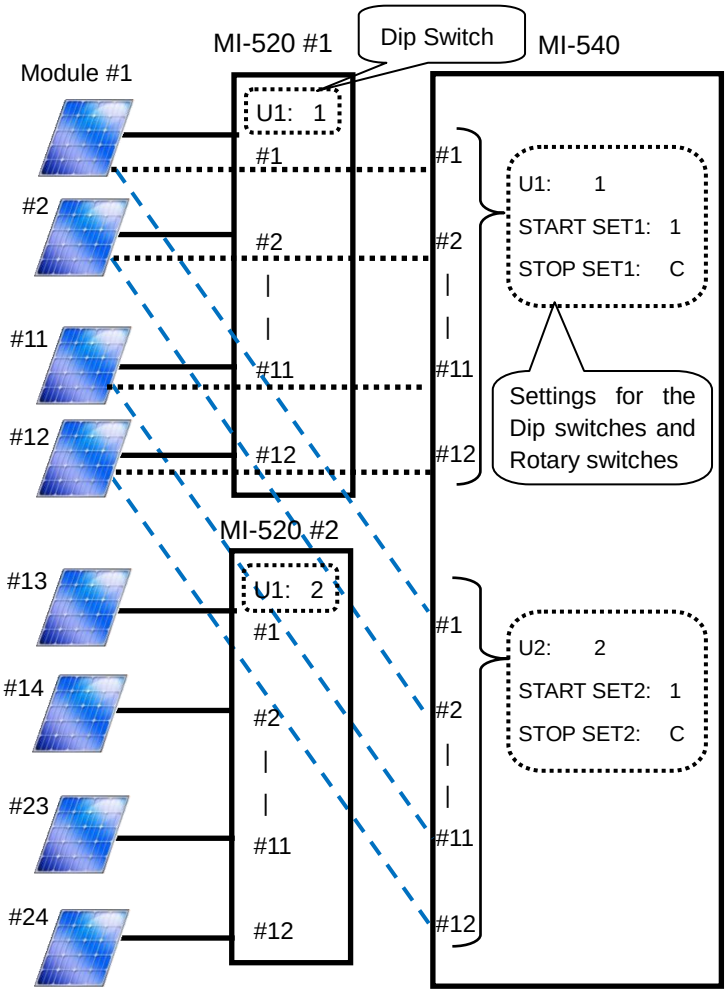


Figure 6-22 MI-540 Connection Example 2

Example 3)

PV Modules: 12

PV Selector MI-520: 2

TC Selector MI-540: 1

Channel of MI-540 is assigned as:

Unit 1 (Module No.1 to 6) and

Unit 2 (Module No.7 to 12).

PV Module cable

Thermocouple cable

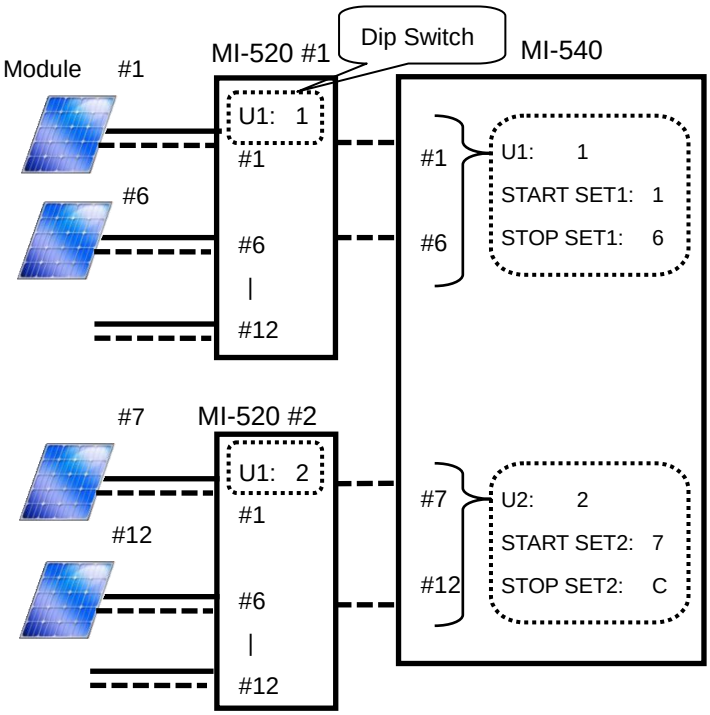


Figure 6-23. MI-540 Connection Example 3

Example 4)

PV modules: 12

PV Selector MI-520: 2

TC Selector MI-540: 1

Assign 2 units of module selector MI-510 per 1unit of MI-540.

The #7~#12 on UNIT1 and #7~#12 on UNIT2 are setup as “not in use” on the software.

PV Module cable

Thermocouple cable

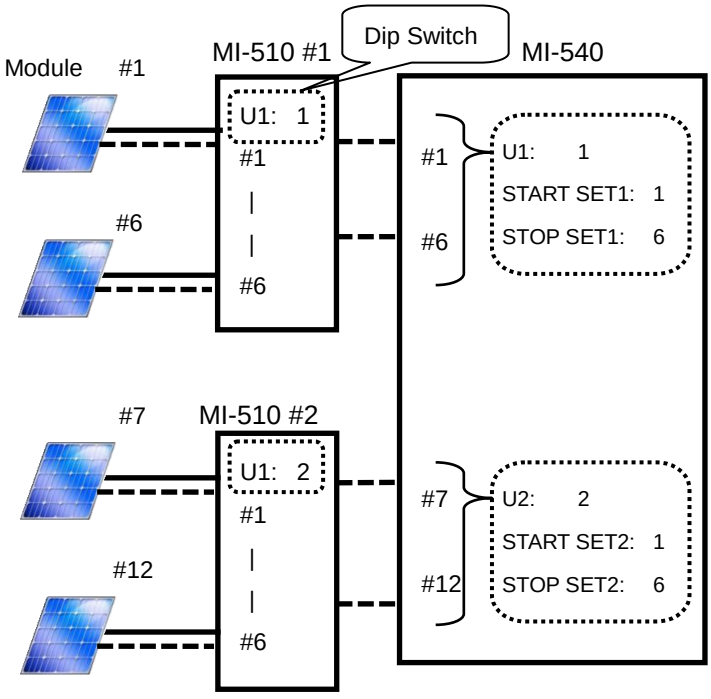


Figure 6-24 MI-540 Connection Example 4

The switching unit is operated only by ON/OFF switch; it is controlled all by the switching unit control signal from the MP-160.

2. MP-303 System Switching Unit

1) Connecting to I-V Curve Tracer MP-160

How to connect SEL. PV OUT and PV INPUT

Connect with straight connection using attached PV junction cable to MP-160 rear panel "PV INPUT" terminal.

NOTE: When connecting the cable, make sure the power switched is turned OFF.

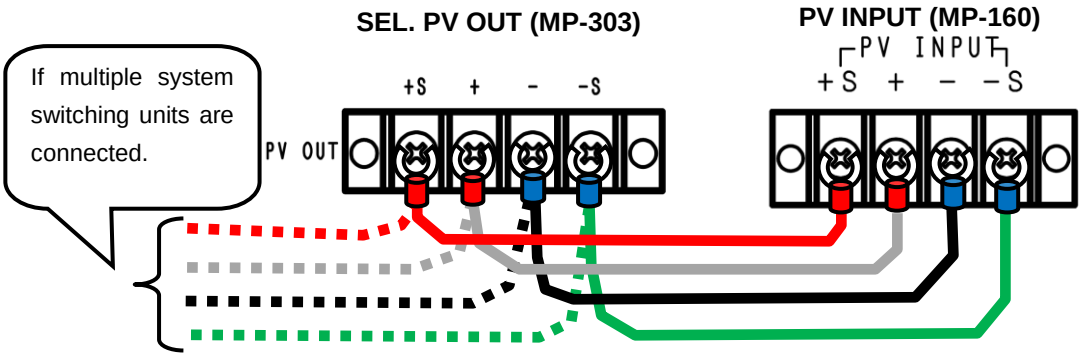


Figure 6-25. SEL. PV OUT & PV INPUT Connection

2) PV IN、PV OUT Terminal Connection

a. PV IN Terminal

Sprit the PV cable into two at close to connector for plus and minus electrodes for PV module, and making the cable into 4 terminal by converting into terminal for current and voltage. Connect the plus side cable to +S and + terminals, minus side cable to − and −S terminals on the PV IN terminal for each channel.

NOTE: Use 4-pin shield cable more than 2sq, and connect the shield cable to MP-303 body ground terminal.

b. PV OUT Terminal

Electric load device, such as power conditioner, battery charge controller or MPPT, can be connected. As long as the connecting device is within the loading capacity, any type of device can be connected since the cannel is completely switched to MP-160 side only when the MP-160 is measuring; after the measurement is finished, the load is connected as MP-160 is completely disconnected.

4 terminals (+S, +, -, -S) for PV IN 1~6 are corresponding to the 4 terminals of PV OUT 1~6 by one-to-one.

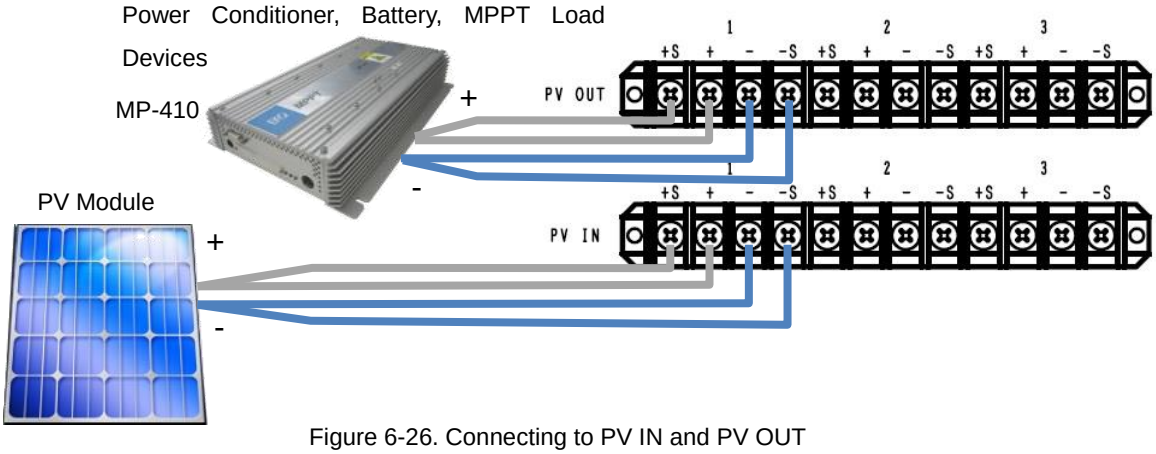


Figure 6-26. Connecting to PV IN and PV OUT

3) Internal Dip Switch Setting

Internal Dip Switch is located on the top circuit board as the upper lid is opened.

How to Setup Dip Switch:

The system overall unit number is determined by the internal dip switch setting inside MP-303.

One unit of MP-303 will be the Unit 1.

The dip switches 1~4 represent the unit numbers. When connecting multiple switching units, make sure these dip switches do not duplicate.

Corresponding to the unit 1~4, turn ON one of the 1~4 dip switches in U1.

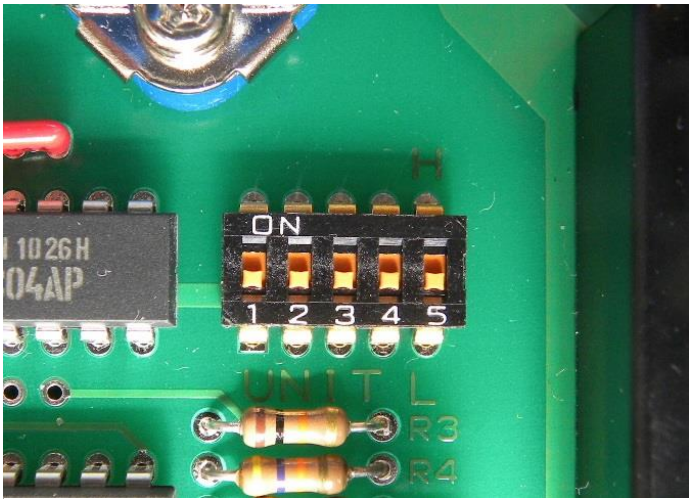


Figure 6-27. Internal Dip Switch

NOTE: The multiple bits of dip switch 1~4 cannot be turned ON; however, the dip switch will not function if all of them are turned OFF.

When the dip switch 5 is turned to L side (OFF), the PV terminal corresponds to 1ch~6ch; when the switch is turned to H side (ON), PV terminal corresponds to 7ch~12ch. When using 2 units of MP-303 as UNIT1, it can operate as a system switching unit with 1ch~12ch by setting one of the units dip switch 5 to L side (OFF) and another unit dip switch 5 to H side (ON), considering 2 units of MP-303 as UNIT1 on the MP-160. Thermocouple switching unit MI-540 has 12ch as 1 unit; therefore, when connecting with MI-540 will require this setting.

Table 6-6. Dip-Switch Setting (MP-303)

Dip Switch / Connecting Unit Qty.	SW1	SW2	SW3	SW4	SW5	Corres. Channel
UNIT 1	ON	OFF	OFF	OFF	OFF	1~6
					ON	7~12
UNIT 2	OFF	ON	OFF	OFF	OFF	1~6
					ON	7~12
UNIT 3	OFF	OFF	ON	OFF	OFF	1~6
					ON	7~12
UNIT 4	OFF	OFF	OFF	ON	OFF	1~6
					ON	7~12

7. Indoor Measurement System Setup

1. System Configuration Using Solar Simulator

PV cell measurement under solar simulator

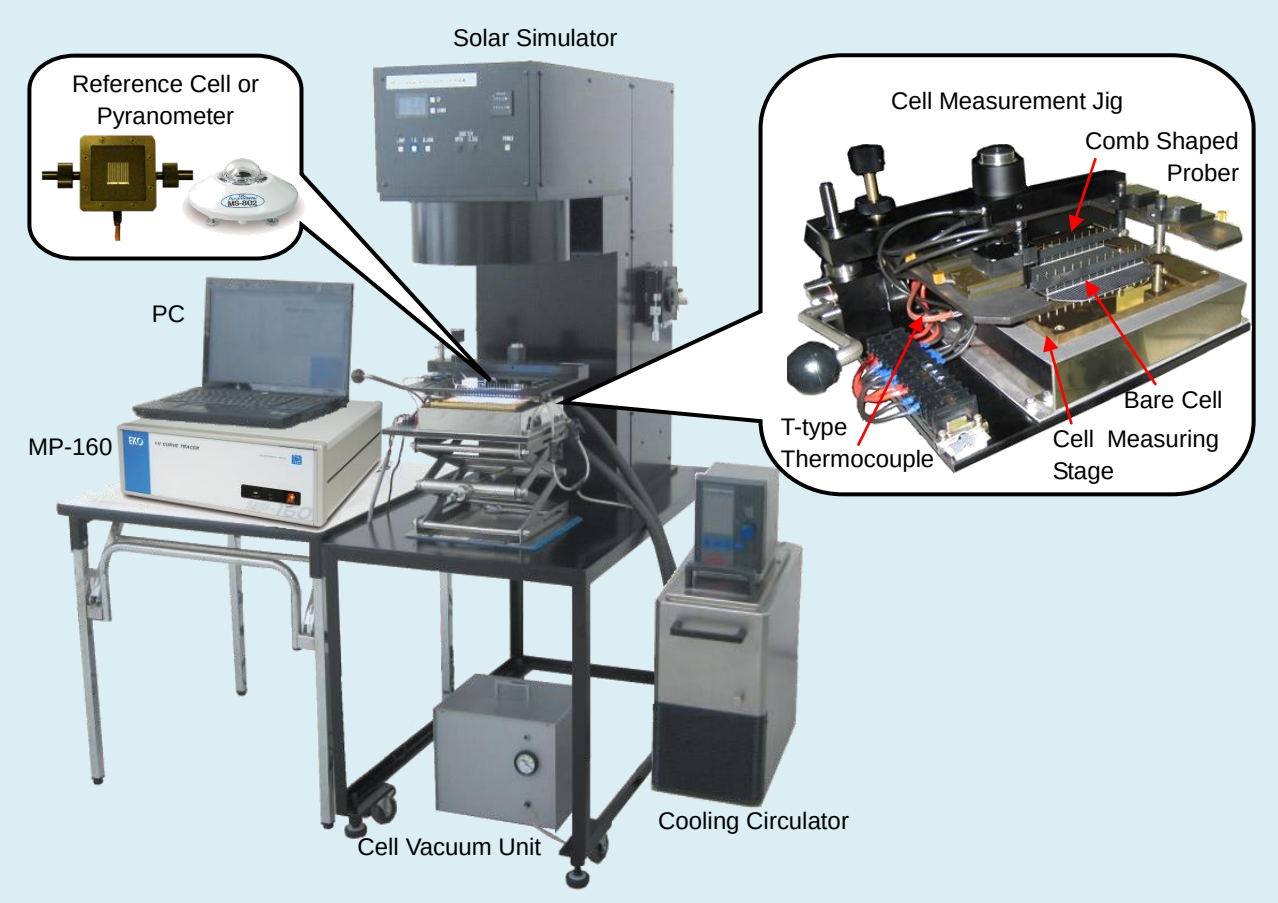


Figure 7-1. PV Cell Measurement System Diagram

For PV cell evaluation under solar simulator, above system configuration can be built.

3) Light Source: Solar Simulator

Irradiates 1SUN spectrum simulating the sun light. Accuracy is standardized by spectral irradiance, temporal instability of irradiance, and irradiance non-uniformity.

4) I-V Curve Tracer : MP-160

5) Cell Measurement Jig

By the combination of the cell measurement stage and comb-shaped prober, measurement terminals are taken out for easier measurement by 4-terminal method. Depending on the cell type and shape, the customizing may be required; please contact EKO for details.

6) Cooling circulator

The characteristics changes by the temperature of PV cell, thus I-V curve is measured on the bare cell by maintaining the cell measuring stage at 25 ℃ by running water through the cell measuring stage.

7) Cell Vacuuming Unit

Overall surface of the cell measuring stage is made of positive electrode (+) and cell contact is too week only by placing the bare cell on the measuring stage. There are multiple holes on the measuring stage for air suction, and bare cell is vacuumed on to the measuring stage to create good contact

8) Reference Cell (or Pyranometer)

Reference cell is required for adjusting the solar simulator light amount to 1SUN (1000W/m2). Connect either reference cell or pyranometer to MP-160 to measure the irradiance of the light source. If this irradiance is already known without measurement, this value can be entered in the software as fixed value for light source irradiance.

9) Temperature Sensor: T-type Thermocouple

Measures the temperature of cell measuring stage and if the temperature shifts from 25℃, the temperature is taken as the PV cell back surface temperature and used for STC calculation on I-V Curve Tracer MP-160.

2. Connection

The connection for measurement under solar simulator is same as the PV module measurement.

1) Connect PV cell to + and - PV INPUT terminals that are located on the MP-160 rear panel.

Cell measuring jig is used for bare cell measurement; however, 4-terminal connection is required from the cell base for laminated cell and DSC cell for high accuracy measurements.

As the current flow increases, the voltage decreases by the Ohm's Law, and it will lead to measurement error, thus minimize the contact resistance on the contact point with cell electrode terminal as much as possible. To minimize the wiring resistance, connect with thicker and shorter cable as possible.

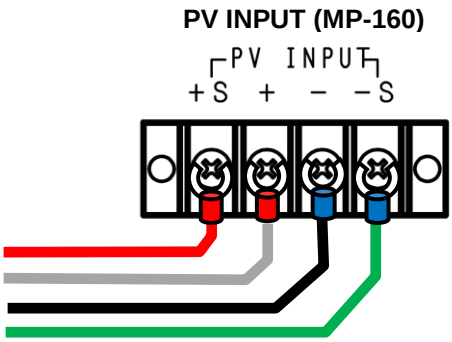


Figure 7-2. PV INPUT Connection

NOTE: Connecting with 2 cables and using jumper at the terminal will cause the measurement to be unstable.

2) Attach the thermocouple on the back surface of the PV cell and connect to TEMP1 on the meteorological instrument terminal.

When cell measuring stage is used, and if there is a hole to insert the sheath type thermocouple, insert the sheath in this hole.

When measuring laminated cell, select sheet type thermocouple and attach it with insulating tape.

Use TEMP2 terminal for measuring ambient temperature when taking measurement using only the MP-160 unit

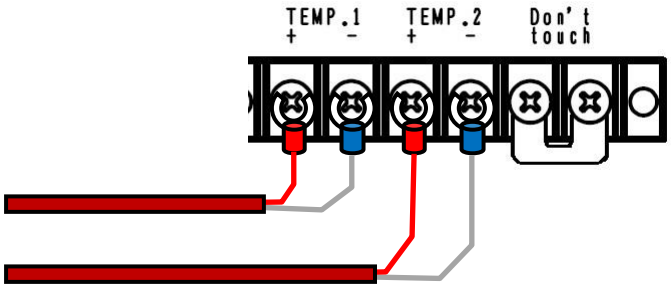


Figure 7-3. TEMP.1 & TEMP.2 Terminal Connection

3) Connect pyranometer to the RAD terminal on the meteorological instrument terminal.
Pyranometer sensitivity is required to enter from software.

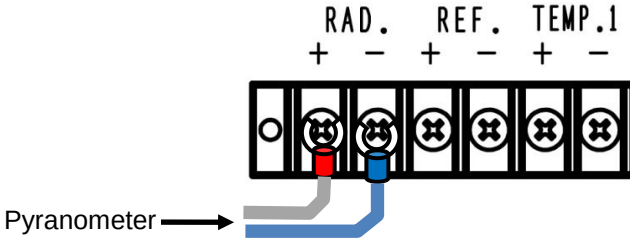


Figure 7-4. Pyranometer Connection

4) When reference cell is used, it is connected to REF terminal; however, the maximum voltage input for this terminal is 300mV. Therefore to connect current output type reference cell, optional shunt resistance box needs to be connected to REF terminal in parallel to convert the current into voltage. Depending on the current to be input, the shunt resistance value needs to be selected so that the output terminal side will be within 300mV.
The shunt resistance value and sensitivity of reference cell need to be entered from the software.

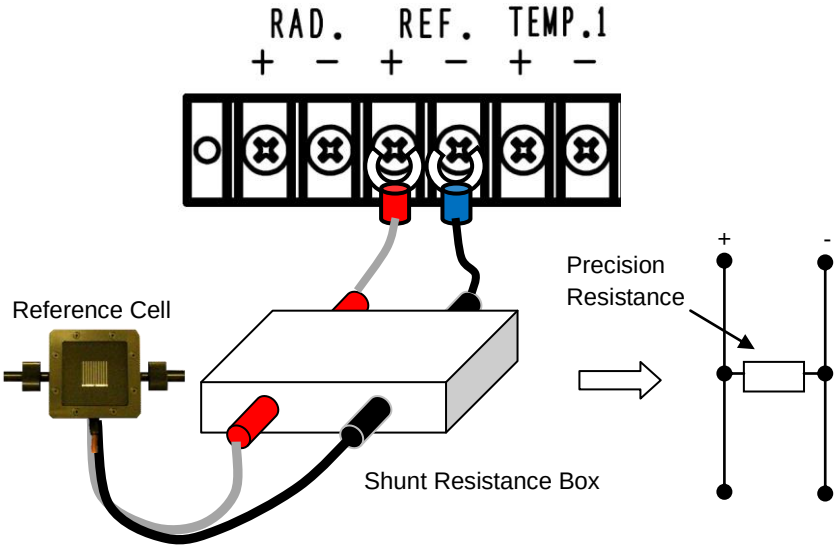


Figure 7-5. Shunt Resistance Box to REF Terminal Connection

5) Connect the PC and MP-160 with RS-232C cross cable.
If the PC does not have RS-232C port, connect by using RS-232C → USB converter and the RS-232C cross cable.
NOTE: RS-232C → USB converter may not be compatible depending on the manufacturer.

8. Software

MP-160 Outdoor software has dedicated functions for outdoor PV module I-V measurements such as STC conversion based on simultaneous measurements of irradiance and PV module back side temperature.
In this chapter all software functions are described.

8-1. Installation and Uninstallation

If your PC runs on operating system (OS) Windows Vista or Windows 7 or 8, read [Appendix-1. Installing Software on Windows Vista / Windows 7 or 8].
Both outdoor and indoor measurement software are installed in the same manner; the images shown in this section are the example of outdoor measurement software installation.

1. Software Installation

1) Turn ON the PC power and inset the software installation CD into the CD disk drive as the desk top of the window is indicated on screen.
2) Access the installation disk from [MP160o_Software_Ver_2.3.0.x_Installer] or [MP160i_Software_Ver_2.1.0.x_Installer] → [English], and click the “Setup.exe” inside this file to start the installer.
3) Wizard window for the installation will appear; click [Next >] button to go to the next step.

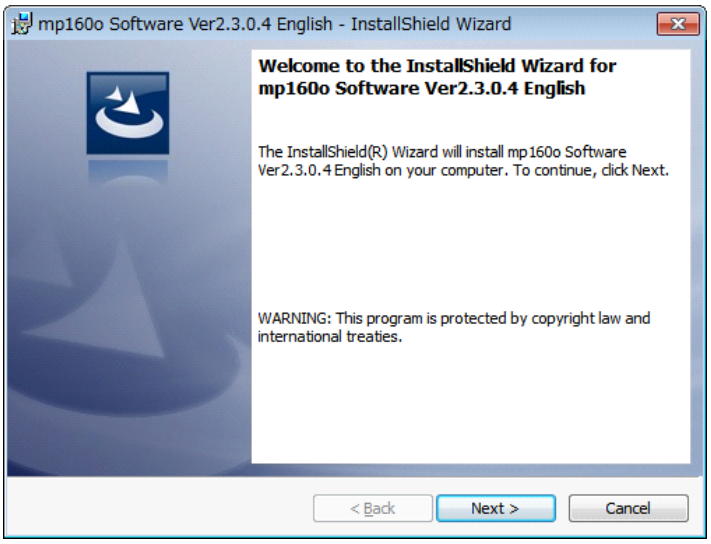


Figure 8-1. Installation Wizard Start Window

4) Below “Software License Agreement” window will appear. Select “I accept the terms in the license agreement” and click [Next >] button

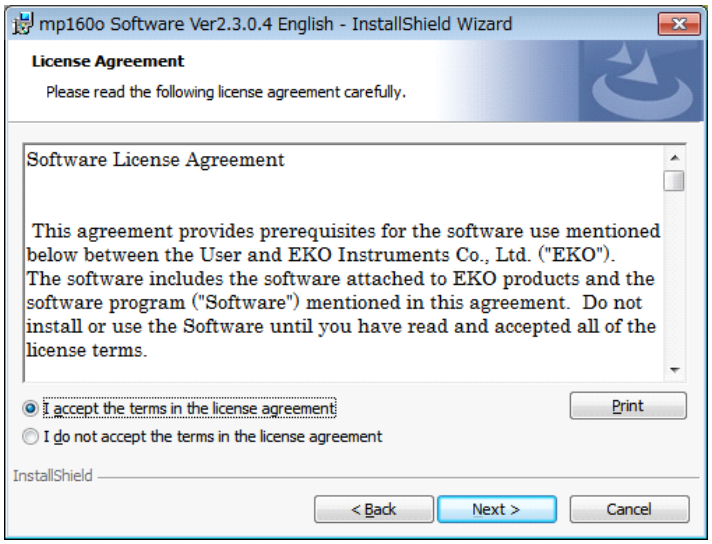


Figure 8-2. License Agreement Window

5) “Destination Folder” window appears. If the software is installed in “C:¥EKO” folder, click [Next >] button to go forward. If installing in different folder, click [Change…] button to select a desired folder.

NOTE: When changing the installation folder and using a PC with Windows Vista/7/8 for Operation System, UAC (User Account Control) function will be activated. Trying to access and install and/or save data in a folder which OS is controlling the folder access, it may cause problems. “C:¥Program Files”, “C:¥ProgramData”, “C:¥Windows”, and system drive route folder “C:¥” are examples of the controlled folders. When changing the installation folder, make sure to select a folder other than mentioned above.

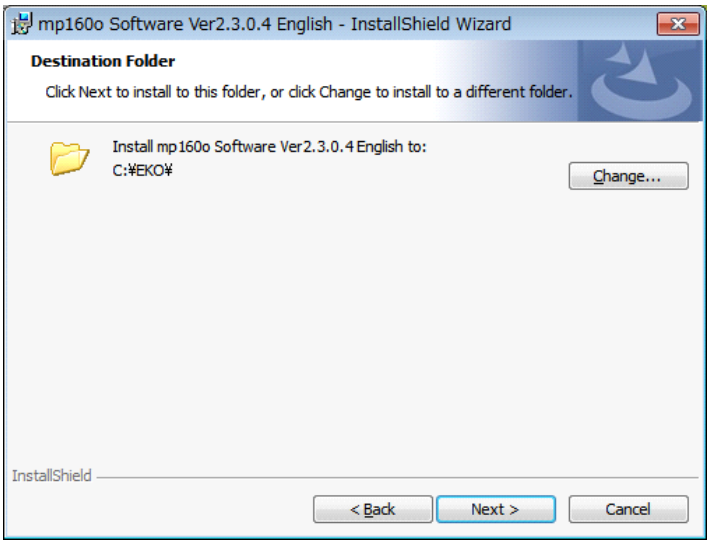


Figure 8-3. Destination Folder Setting

6) Installation confirmation window appears. Confirm the destination folder and click [Install] button to go forward.

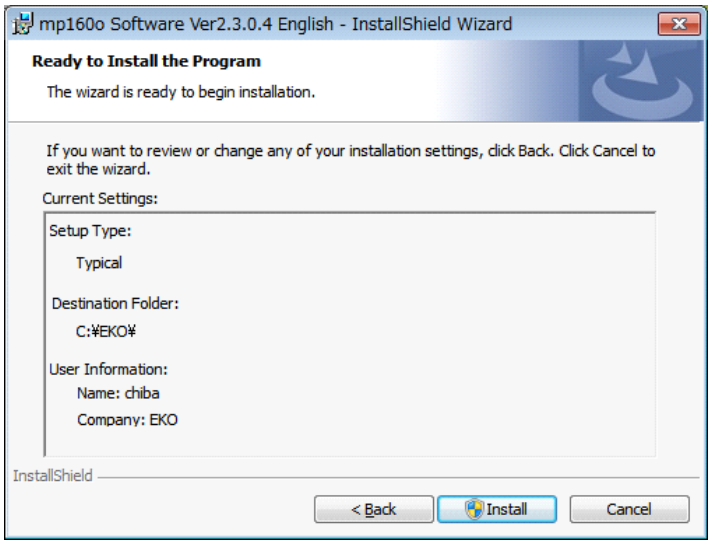


Figure 8-4. Installation Confirmation Window

7) After awhile, the screen get dark and “User Account Control” window appears. Clicking [Yes] button will start installation.

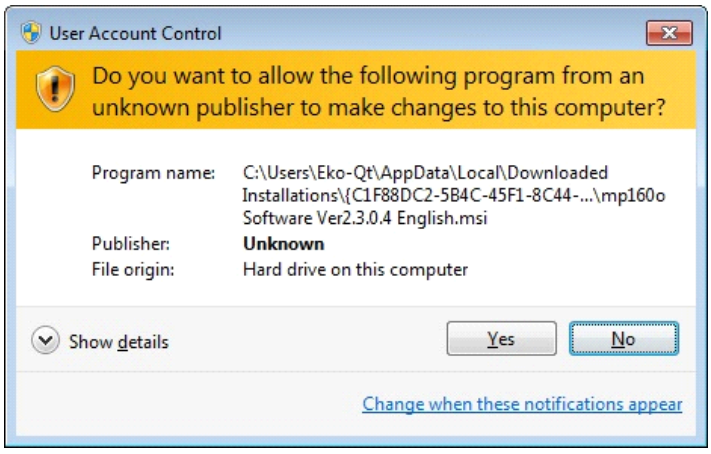


Figure 8-5. User Account Control Window

8) Once the installation is completed, below window appears. Click [Finish] button to close the installation wizard window.

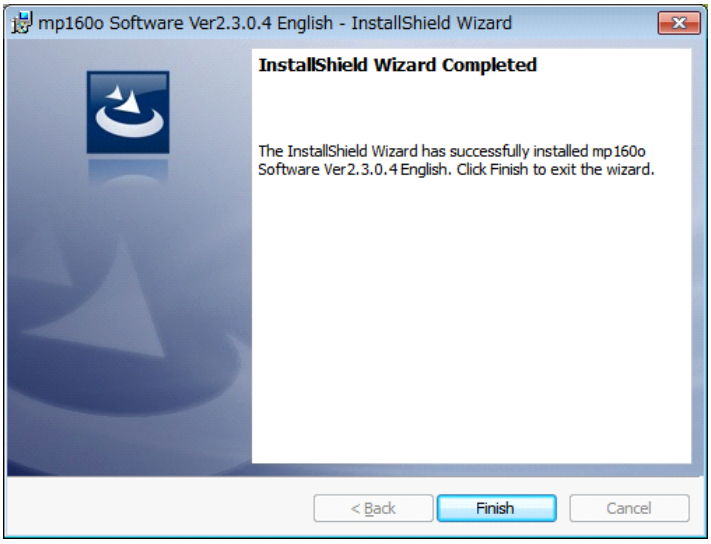


Figure 8-6. Wizard Complete Window

9) When the installation is complete, shortcut icon is created on the desk top. If clicked on “create shortcut in start menu”, below shortcut icon is created.

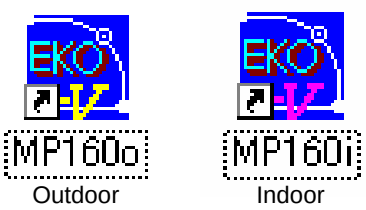


Figure 8-7. Shortcut Icon

Do not copy both outdoor and indoor or old- and new-version software in the same folder. When the outdoor and indoor software executables are installed in a same folder, the parameters and data files can be overwritten. Make sure to assign separate folders for each outdoor and indoor or for old- and new-version software.

2. Software Uninstallation

There are 2 ways for uninstalling the software from PC.

1) Uninstalling from [Program and Features]

Access in the order of: [Control Panel] → [Program] → [Program and Features] by clicking. Select the program to be deleted. Popup menu will appear by right-clicking on the deleting item; select “Uninstall (U)”.

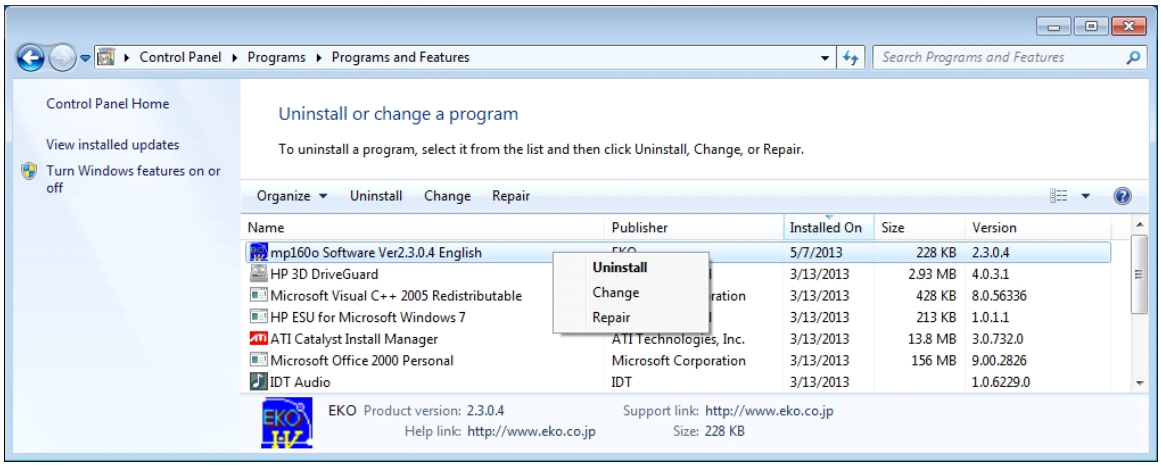


Figure 8-8. Uninstalling from “Program and Features”

Below confirmation message window will appear. To uninstall, click [Yes] button. Soon the item will disappear from the Program and Features window and the software is uninstalled.

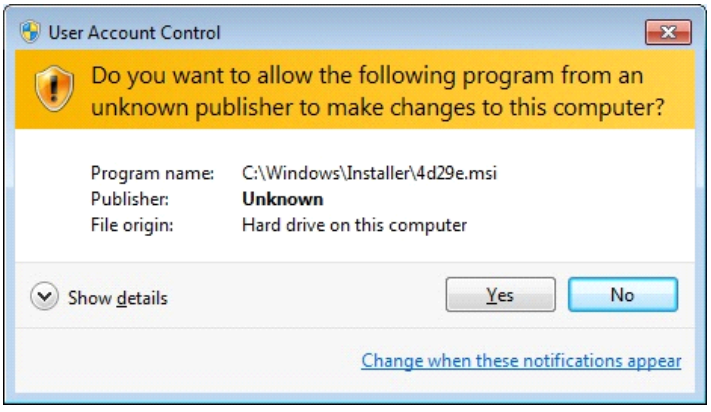


Figure 8-9. User Account Control Window

2) Uninstalling from Install Disk

Just like when the software was installed, access from CD-ROM to start-up the Setup.exe for the software to be uninstalled.

Follow the messages indicated on this window and if the software is already installed, “Modify”, “Repair”, and “Remove” are shown on the window as options.

Select “Remove” on this window and click [Next >] button.

Follow the guide messages and the installed software is uninstalled.



Figure 8-10. Program Maintenance Window

8-2. Setup and Measurement: Outdoor Measurement

When the “MP160o_V_2.3.x.x._installer” is started, the main screen window is displayed. In this window, there are three tab menus, “Measure”, “Graph”, and “Save”. By clicking the tabs, the menu contents change. When the software is started, the Measure tab is displayed as default.

1. “Measurement” Tab Menu

The main window is displayed as shown below when the software is started.

By clicking on each tab, each tab menu is displayed.

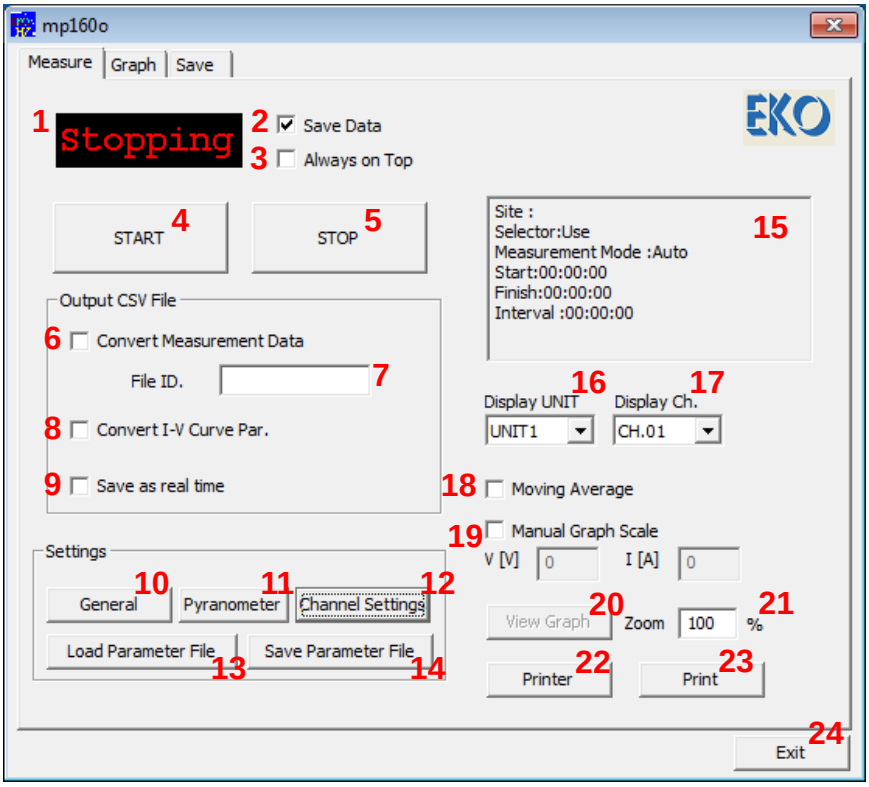


Figure 8-11. Measure Tab Window (Start-Up)

Each button functions are described as below:

Table 8-1 Measure Tab Functions

	Names	Function & Details
1	Measurement Status Display	Displays the measurement status (Stopping, Measuring, Waiting)
2	[Save Data] Checkbox	Check to save the measured data
3	[Always on Top] Checkbox	Check to display this window on top of the desktop
4	[START] Button	Click to start measurement
5	[STOP] Button	Click to terminate measurement
6	[Convert Measurement Data] Checkbox	Check for automatic CSV conversion of individual measurement data files.
7	[File ID.] Textbox	The characters entered in this textbox will appear at the beginning of the file created. (Max. 5 characters)
8	[Convert I-V Curve Par.] Checkbox	Checking here will automatically create a file with specific value which is same as the CSV conversion file created on the Save tab menu, and the specific value data are overwritten at each measurement.

Table 8-1 Measure Tab Functions - Continued

	Names	Function & Details
9	[Save as Real Time] Checkbox	There is no internal clock inside the MP-160, thus measurement data time is provided from the PC time. However, when taking multi-channel measurement using module switching units, it cannot take measurement of all channels at the same time, and measurement is taken sequentially from the younger channel number. When the measurement time comes, the PC sends an order to MP-160 only once to start the measurement. MP-160 receives this order and takes measurements by switching through each channel; once all the measurements are taken from each channel, all data are sent to PC all at once. Uncheck: Each data is saved with the measurement time which is the time when initial measurement start order was given on the PC side for all channels. Therefore, the difference in measurement times for the first and last channel will be larger as the number of channels increase. It is recommended to uncheck this checkbox if measurement time for each channel should be uniformed for data processing. Check: The estimated measurement time, which is calculated from channel quantity and interval time between the channels, is given to each channel data. It is recommended to check this checkbox if data should be treated strictly with real measurement time. **NOTE: In case of saving the data with real time, make sure there is no unused channel in the middle of channel sequence. If a channel is missing, the time for the rest of the channel will be shifted by the missing channel(s).**
10	[General] Button	Setup COM port, measurement mode, data saving folder, etc.
11	[Pyranometer] Button	Setup pyranometer calibration constant value
12	[Channel Setting] Button	Setup PV measurement input channels
13	[Load Parameter File] Button	Upload parameter file
14	[Save Parameter File] Button	Save the setup parameters
15	Measurement Information Window	Displays the measurement information
16	Display UNIT Box	Select switcher unit to be displayed on graph.
17	Display Ch. Box	Select channel to be displayed on graph.
18	[Moving Average] Checkbox	Check here when setting movement averaging procedure When it is unavoidable for noise to appear on the graph and Voc, Isc, and Pm cannot be calculated, this function is used, processing the total of 10 points data before and after the I-V curve sampling point to minimize the noise appearing on the graph. (See [9) Moving Average Function] in this section)
19	[Display Graph Range] Checkbox & V [V], I [A] Boxes	Setup the graph scale manually. Enter numbers here to setup voltage and current range on graph (units shown in [V], [A])

Table 8-1 Measure Tab Functions - Continued

	Names	Function & Details
20	[View Graph] Button	Display graph again after changing the unit, graph scale, correction process requirements.
21	Zoom ☐%	Enter the scaling factor for the graph display window.
22	[Printer] Button	Setup printer.
23	[Print] Button	Print the I-V curve graph
24	[Exit] Button	Exit the program

1) General Setting

First, click “General” button on the Measure Tab to setup the COM port, automatic measurement time, and the folder for measurement data to be saved. (If parameter is already saved, click [Load Parameter File] button to upload the parameters.)

Enter the information on following items and click [OK] button.

*Underlined parameters are required to enter.

a. Site

Enter the name of the measurement site or facility.

b. Communication Port

Setup the communication COM port for MP-160.

Search for available COM port and the COM ports that are not connected show in gray. Select a COM port which is available.

c. Baud Rate

Select communication speed for MP-160 (usually 38.4kbps).

d. Channel Switching Interval

Waiting time between channels when module selector is used (usually zero “0” seconds, maximum time is 1.5 seconds).

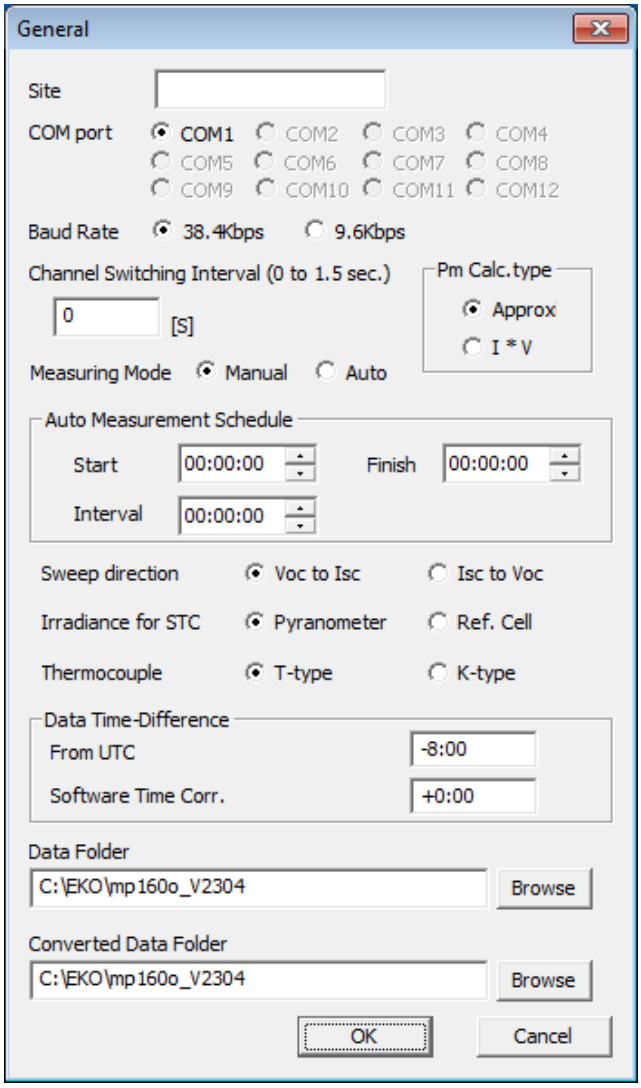


Figure 8-12. General Setting Dialog Window

e. Pm Calculation Type

Pm calculation method can be selected. Select either approximation (approximate with third order polynomial) or I x V (actual measurement value).

"I x V" calculation method provides result which is relatively accurate; however, "approximate" calculation may better in some cases depending on the condition.

For example, when measuring a PV module which has high FF value and steep curve near the Pm, there are some cases that the Pm value is calculated significantly off from the P-V curve with the third-order polynomial approximation calculation. In such case, select I x V calculation with real measurement value for the result closer to the real value, simply because the approximation will have larger error than I x V calculation.

If the Pm value is calculated significantly off from the P-V curve using either the calculation method, the measurement can be recalculated by changing this setting and view it on the graph and/or save as CSV fie.

f. Measurement Mode

Select Manual or Automatic measurement.

g. Automatic Measurement Mode Setting

Measurement start time, end time, and intervals are setup; by clicking the [START] button on the measure tab, long-term measurement is started automatically for the assigned time frame.

h. Sweep Direction

Select and setup sweeping directions, Isc←Voc or Isc→Voc.

i. Irradiance from Reference Data Measurement

Solar irradiance value used for STC conversion can be selected from either entering pyranometer or reference cell

j. Thermocouple Type

Select either T-type or K-type thermocouple.

k. Time Adjustments:

- Time difference setup with UTC

  Setup the Coordinate Universal Time, UTC (synonymous with Greenwich Mean Time, GMT). This is acquired automatically from PC setup time as the software is started for the very first time; the time difference between the UTC and local time is calculated, and this value is displayed as the initial value. The setup is registered in AutoSave.prm file when exiting the software.

  This function displays the data measured in different time zone (overseas) with the local time. If measurements are taken within Japan, this setup is not necessary.

  Example: When the time zone setting is setup as "(UTC +09;00) Osaka, Sapporo, Tokyo", there should be +9:00 is displayed.

- Local Time Adjustment:

  This function is used to display the data, which was taken with old version software and in different time zone shown in the local time. If the data is taken with new version software, this process is not necessary. To upload the data which was acquired with the old version software, it cannot be automatically determine in which time zone the data was acquired, thus use must key enter the calculated time difference.

l. Data Folder

Setup the save location for the measured data. (Directory will show when [Browse] button is clicked)

m. Converted Data Folder

Setup the save location for the converted data. (Directory will show when [Browse] button is clicked)

2) Pyranometer Setting

Setup the pyranometer information from [Pyranometer] button on the Measure Tab. By clicking the [Pyranometer] button, below dialog box will appear.

Enter the information on all following items and click [OK] button.

*Underlined parameters are required to enter.

a. Threshold Irradiance

A minimum irradiance value (Threshold) can be set to exclude low irradiance data caused by instable atmospheric conditions.

b. Pyranometer Calibration Constant

Set the calibration constant of the pyranometer which is connected to MP-160.

c. Pyranometer

When using Pyranometer selector, setup the “name” and “calibration constant” of pyranometers up to 5 units.

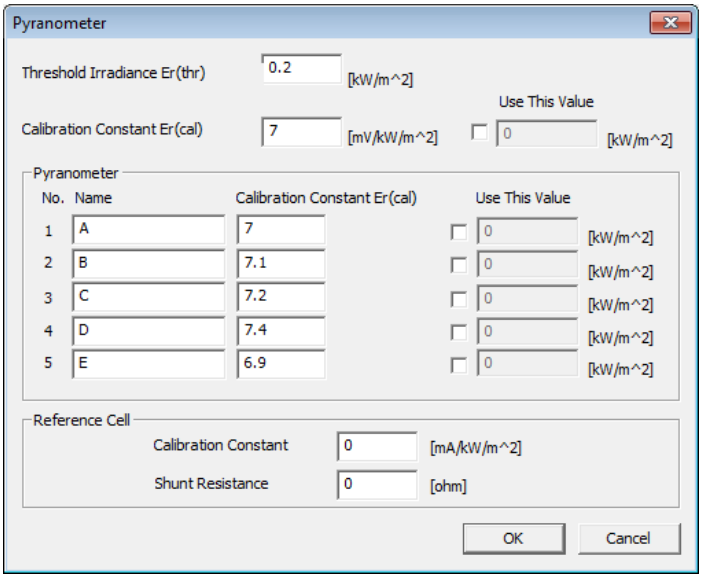


Figure 8-13. Pyranometer Setting Dialog Window

NOTE: When using module selector and there is only one unit of pyranometer on the main unit, enter the pyranometer name and calibration constant in No. 1 box.

If “Use This Value” checkbox is checked, fixed irradiance value can be entered, and the output characteristics will be graphed with this value. (This is used when using solar simulator and the irradiance intensity is already known.)

3) Channel Setting

Channels and selectors are setup from the [Channel Setup] button. When this button is clicked, below dialog box appears. Enter the information on following items and click [OK] button.

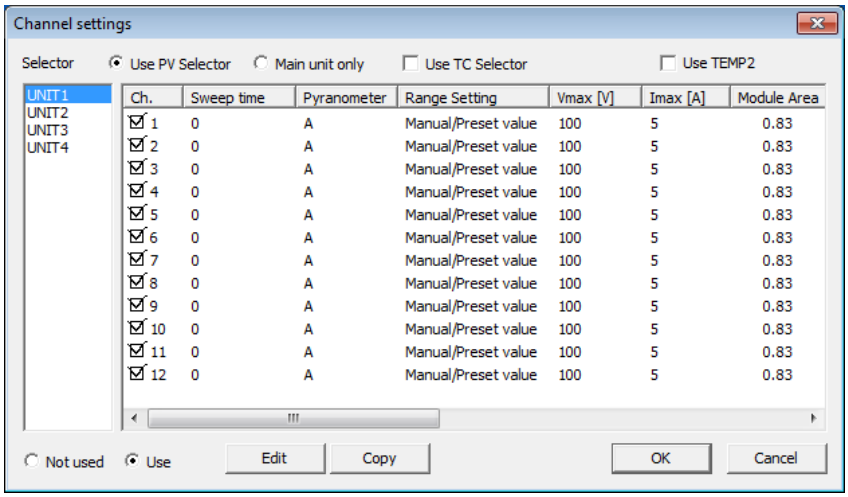


Figure 8-14. Channel Setting Dialog Window

a. Selector Setting

Select when using the PV module switching unit (MI-510 / 520 / 303) or just the MP-160 only (Main unit only).

If the PV module switching unit is used, click the “Use PV Selector” radio button; also if thermocouple switching unit (MI-540) (temperature switching unit) is used, place a check in the “Use TC selector” checkbox.

b. To Measure 2 Thermocouples against 1 PV Module

When measuring the PV backside temperature with two thermocouples, check “Use TEMP 2”. The selector connection will be different from the usual method.

If only MP-160 is used (without any selectors), check “Main Unit Only” checkbox which is located at the top of the Channel Setting dialog window.

Also, two channels of temperature can be measured by checking “Use TEMP 2” checkbox (Top right on the window shown on Figure 6-14) in this step.

c. Setup measurement Channels: When using the Main Unit Only

Select channel 1 (“☐1” on the Ch. Column and click). When selected, the channel line is highlighted as “☐1 “.

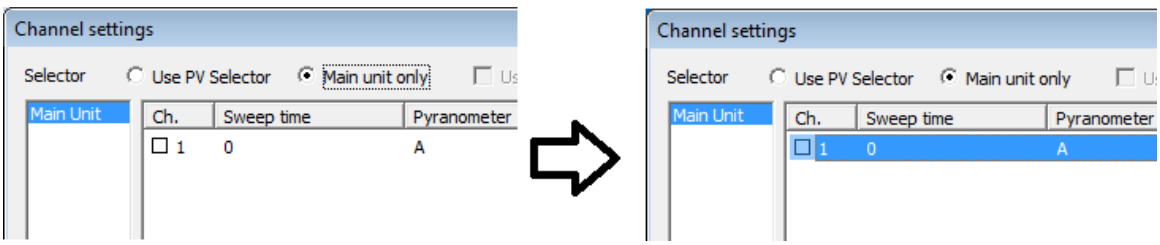


Figure 8-15. Channel Setting – Using Only MP-160 - No.1

Selected channels can be set to either "Use" or “Not used” by clicking the radio buttons at the bottom of the dialog box; also each channel can be setup to use or not use by checking or un-checking the highlighted as “☐1 “ with double click. For the channels selected to use, the square box changes to ☑.

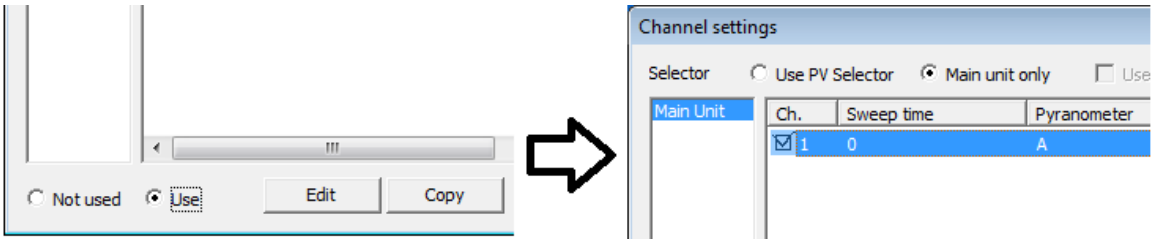


Figure 8-16. Channel Setting – Using Only MP-160 – No.2

d. When using Switching Unit

Select switching unit UNIT1~4 and set the using channels.

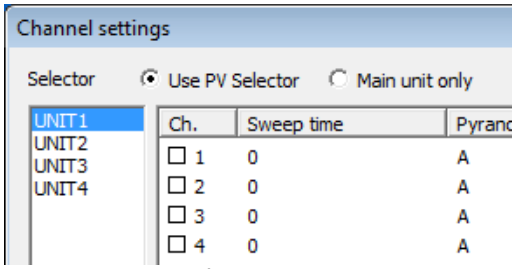


Figure 8-17.
Channel Setting – Using Switching Units

4) Edit Channel Settings

After selecting the channel(s) to be used from ☐1 to ☐12 and click Edit button, the Edit Channel Settings dialog box appears as the figure below.

Enter the parameters and click [OK] to accept.

Underlined parameters are required to enter.

a. Sweep Time

Define the Sweep time for 256 points measured with the I-V curve. 0~330 seconds (Usually it takes approximately 1.4 seconds unconditionally when sweeping time is setup between 0~1 sec.; when the setup value is more than 2 sec., it reflects the actual sweep time.

b. Pyranometer

This parameter is set when the selector is used. Set even when only module selector is used.

c. Range Setting

Set to Manual or Auto-range when used with a Pyranometer or reference cell.

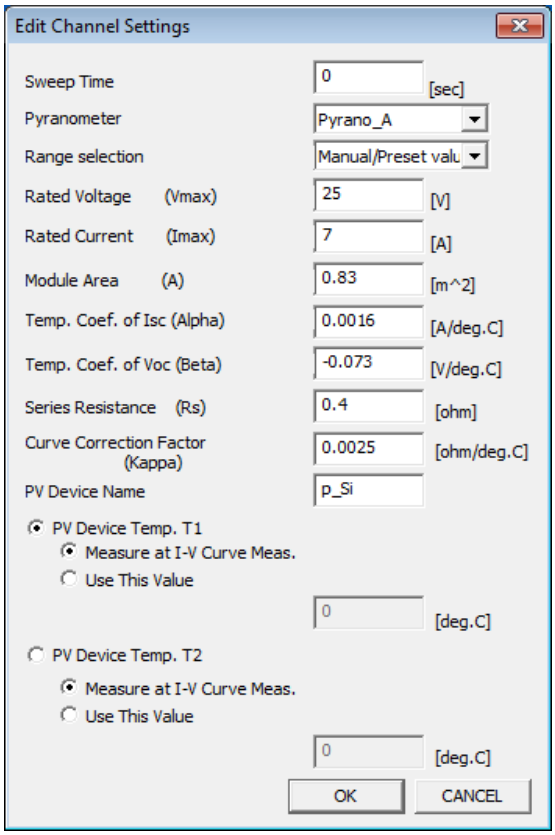


Figure 8-18.
Edit Channel Settings Dialog Window

Note: In case the MP-160 is used without any solar sensor, make sure to select an appropriate current and voltage range manually. Prevent potential over range situations as it might damage the MP-160.

d. Rated Voltage (Vmax)

Set the rated output voltage of the PV module. Usually the nominal open circuit voltage (Voc) is set.

e. Rated Current (Imax)

Set the rated output current of the PV module. Usually setup the nominal short circuit current (Isc).

f. Module Area A

Set the effective area (m^2) of the PV module.

g. Temperature Coefficient Alpha (Isc α)

Set the current depended temperature coefficient.

h. Temperature Coefficient Beta (Voc β)

Set the temperature coefficient for Voc

i. Series Resistance Rs

Set series resistance in Ohm.

j. Curve Correction Factor κ

Set curve-correction factor (Ohm /℃).

k. PV Cell/Module/Array Name

Set PV device name

l. PV Device Temperature T1 and T2

Select a thermocouple type, T1 or T2, for PV module temperature. When not selected, T1 is used automatically. Select either “Measure during I-V measurement” or “Use this value”. When “Use this value” is selected, enter a fixed temperature value.

5) Copying Channel Information

When using multiple numbers of PV modules, which are identical, select all channels from 1 to 12 and click [Copy] on the Channel Settings dialog box; the same setting values will be copied to the other channel(s).

Select a selector unit and the channel number which will be copied from and click [Copy] button on the Channel Settings dialog box, the Copy Channel Settings dialog box appears.

Select the channel (s) is (are) copied, and click [Copy] button. To exit this dialog, click [Close] button.

Once all the settings are completed, click [OK] on the Channel Setup dialog then measurement can be started.

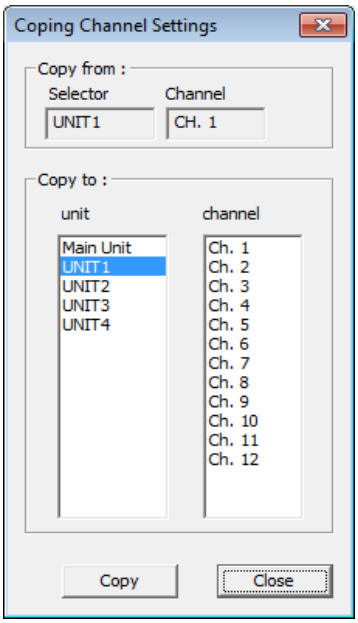


Figure 8-19.
Copying Channel Settings Dialog

6) Saving Parameters

When the parameter settings are completed, make sure to save the parameters.

Also, if the parameters will be uploaded later, assign the location to be saved and load the "*.prm" file.

NOTE: When the program was finished without saving parameters, the setup information will be saved in AutoSave.prm file automatically.

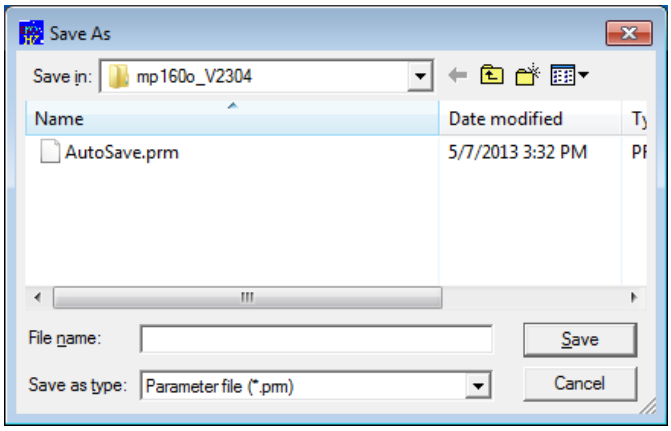


Figure 8-20. Save Parameter

7) Start Measurement

Click [START] on the Measure Tab window to start a single (Manual) or sequential (Auto) measurement. When it is in the automatic measurement mode, it is indicated as "Waiting" while waiting for the measurement.

To terminate the automatic measurement, click the [STOP] button.

NOTE: When the data needs to be saved, check the checkbox for "Save Data" prior to taking measurements. (If this checkbox is not checked, the data will not be saved and the data cannot be reviewed afterwards.)

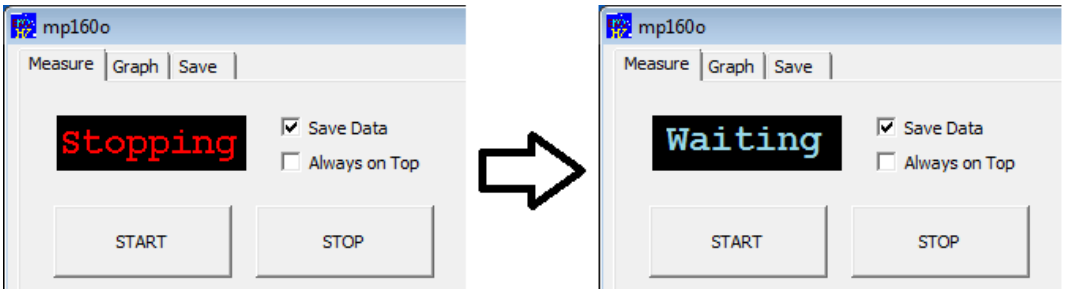


Figure 8-21. Measurement Mode Display

8) Displaying Measurement Results

When the measurement is finished, the I-V curve graph will be displayed as shown below.

If the graph scale is not shown correctly, check the checkbox for “Manual Graph Scale”, enter the Vmax and Imax values then click the [Graph] button again.

Also when using selector, select “Display Unit” and “Display Ch.” to display the specific channel data.

When right clicking the mouse anywhere on the graph, a bitmap image will be saved in a specified folder.

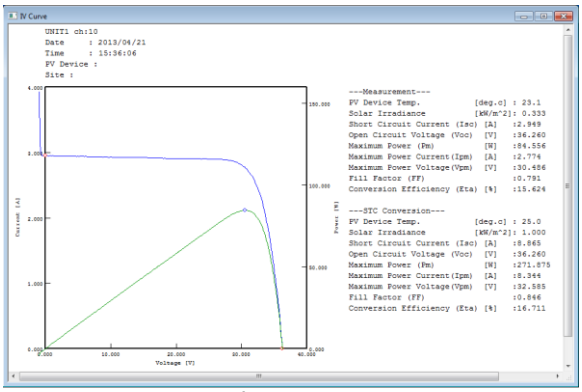


Figure 8-22.
Measurement Result Graph (I-V Curve)

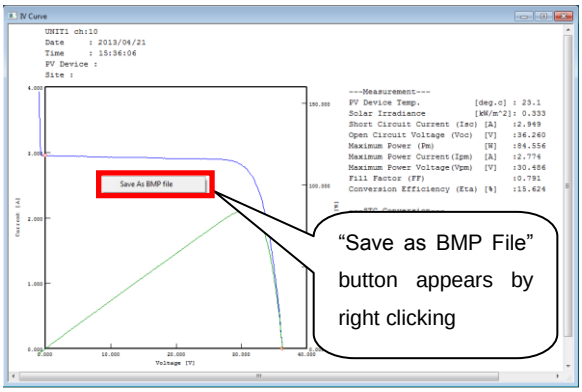
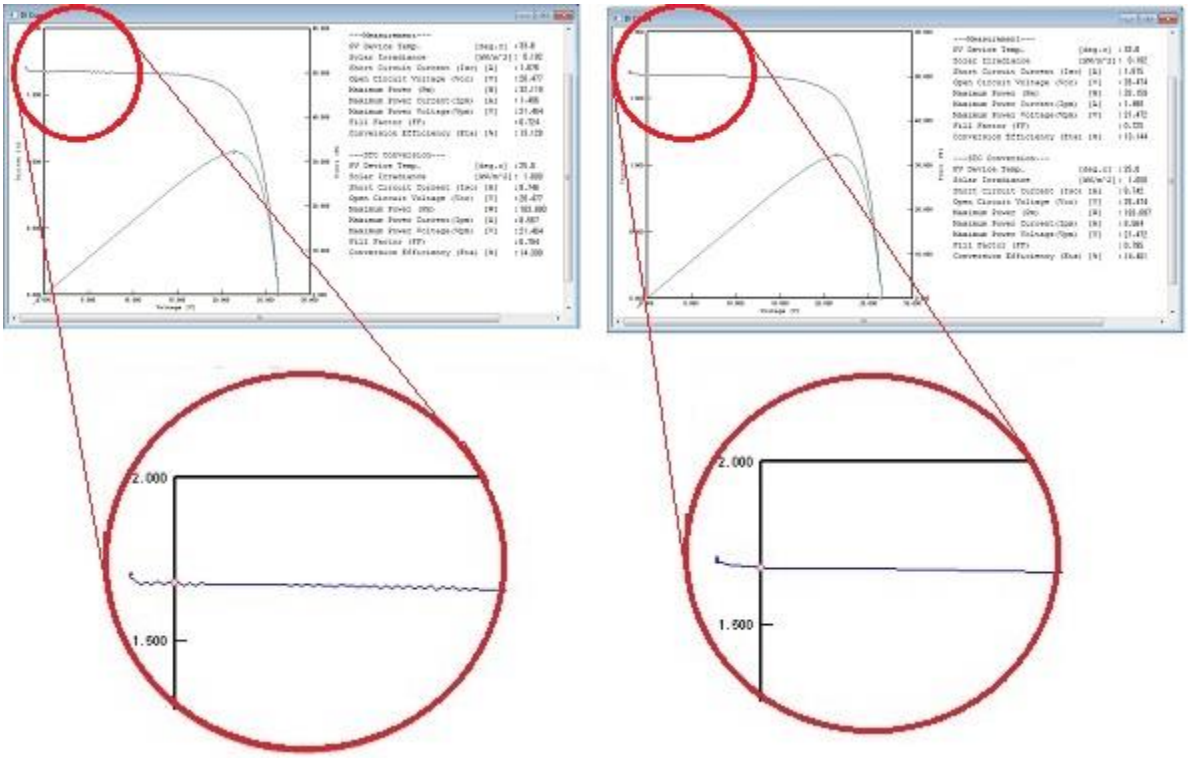


Figure 8-23. Save as BMP File Button

9) Moving Average Function

An example of the Moving Average Function is shown in below figure. When putting a check on this function, the average value of 10 points data is calculated consequently.



Without Moving Averaging Procedure With Moving Averaging Procedure

Figure 8-24. Moving Average Function

When the Main Window is hidden under the Graph Window and it is inconvenient to operate, check the checkbox for “Always on Top” prior to start measuring; the Main Window will always be on top on the PC desk top.

10) Setting Automatic Continuous Measurement Mode after Restarting PC

In case the computer shutdown during the auto measurement mode, the measurements will resume right after the computer is restarted.

To setup the automatic continuous measurement mode, follow the below procedure:

(1) Create a shortcut icon for mp160o.exe

The shortcut created by the software installer cannot be used for this setting; newly create the shortcut icon by right clicking the executing file, from “New” → “Desktop (Create Shortcut)".

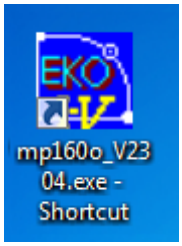


Figure 8-25.
mp160_V230x Shortcut Icon

(2) Right click the shortcut icon “mp160o_V230x.exe” and select Property from the menu.

Add the automatic starting option “-a” + absolute path for parameter file name after the shortcut “Link” address.

Example:

C:¥Eko¥mp160o_V230x¥mp160o_V230x.exe

↓

C:¥Eko¥mp160o_V230x¥mp160o_V230x.exe **-a** C:¥Eko¥mp160o_V230x¥AutoSave.prm

(3) Setup the shortcut file for mp160o_V230x.exe with added auto-start option and parameter file name in the startup folder.

(4) Select all programs from the Start Menu.

(5) Right click the Start up and select “Open”.

(6) Start up folder opens; copy (or drag) the shortcut file for mp160o_V230x.exe with added auto-start option and parameter file name.

(7) By clicking the shortcut, the software automatically starts up with the measurement start condition.

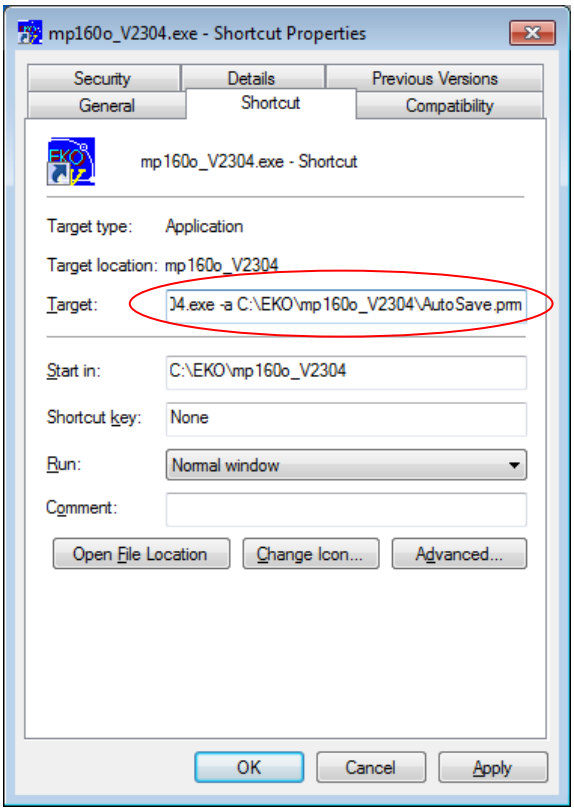


Figure 8-26. mp160o_V230x.exe Property

Now the automatic continuous measurement mode is setup.

Make sure to restart the PC to see if the software will start the measurement automatically.

2. “Graph” Tab Menu

When the “Graph” tab is clicked, the display will change as shown below.

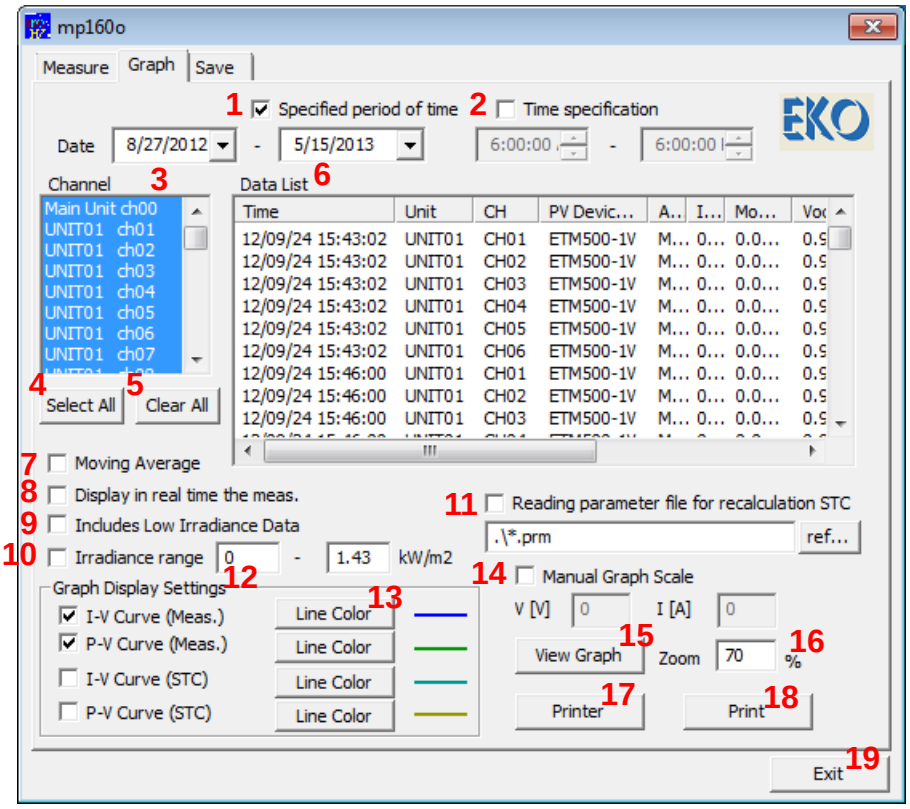


Figure 8-27. Graph Tab Menu

Table 8-2. Graph Tab Functions

	Names	Function & Details
1	[Specified Period of Time] Checkbox Date 2012/09/27▼ ~2012/09/27▼	To display the saved data, specify the particular measurement dates.
2	[Time Specification] Checkbox 06:00:00 ÷ ~ 18:00:00÷	Enter the start and finish time of measurement to extract data from the specified time and appear on the Data List Box.
3	CHANNEL Box	Shows list of selector units and channels for selecting the unit and channel numbers.
4	[Clear All] Button	Clear all channels which are selected in the Data List Box.
5	[Select All] Button	Select all channels which are listed in the Data List Box.
6	Data List Box	Shows list of measurement data which are applicable to the specified date (Chronologic order). Select subjected data and click [View Graph] button to display the graph.
7	[Moving Average] Checkbox	Check here when setting movement averaging procedure When it is unavoidable for noise to appear on the graph and Voc, Isc, and Pm cannot be calculated, this function is used, processing the total of 10 points data before and after the I-V curve sampling point to minimize the noise appearing on the graph. (See [9) Moving Average Function] in this section)

Table 8-2. Graph Tab Functions - Continued

	Names	Function & Details
8	[Display in Real Time Measurement] Checkbox	There is no internal clock inside the MP-160, thus measurement data time is provided from the PC time. However, when taking multi-channel measurement using module switching units, it cannot take measurement of all channels at the same time, and measurement is taken sequentially from the younger channel number. When the measurement time comes, the PC sends an order to MP-160 only once to start the measurement. MP-160 receives this order and takes measurements by switching through each channel; once all the measurements are taken from each channel, all data are sent to PC all at once. Uncheck: Each data is saved with the measurement time which is the time when initial measurement start order was given on the PC side for all channels. Therefore, the difference in measurement times for the first and last channel will be larger as the number of channels increase. It is recommended to uncheck this checkbox if measurement time for each channel should be uniformed for data processing. Check: The estimated measurement time, which is calculated from channel quantity and interval time between the channels, is given to each channel data. It is recommended to check this checkbox if data should be treated strictly with real measurement time. **NOTE: In case of saving the data with real time, make sure there is no unused channel in the middle of channel sequence. If a channel is missing, the time for the rest of the channel will be shifted by the missing channel(s).**
9	[Include Low Irradiance Data] Checkbox	Show irradiance data below the threshold which is set on the Pyranometer setting dialog window on the Data List Box.
10	[Irradiance Range] Checkbox ☐ ~ ☐kW/m^2	Set irradiance range to extract the data within this range; the data will be shown in the Data List Box.
11	[Reading Parameter for recalculation STC] ☐ [ref…]	Recalculate the STC with different PV module parameter than the original measurement. Check here and select a modified parameter file to recalculate the STC.
12	Graph Display Settings Checkboxes	Show/not show the I-V curve, P-V curve, and/or Standard Condition I-V and P-V curve.
13	[Line Color] Button	Select color of each curve; selected color is shown on the right.
14	[Manual Graph Scale] Checkbox V [V] ☐ I [A] ☐.	Specify the voltage axis and current axis full scales on the graph. After the values are entered, click [View Graph] button to redisplay the graph.
15	[View Graph] Button	Display the I-V curve graph. This button is used after units, graph scale, and conditions of correction process are changed.

Table 8-2. Graph Tab Functions - Continued

	Names	Function & Details
16	Zoom ☐%	Enter the scaling factor for the graph display window.
17	[Printer] Button	Printer setting dialog window.
18	[Print] Button	Print the I-V curve graph
19	[Exit] Button	Exit program

1) Calendar Function

From the Graph tab menu, select a measurement date.

By clicking the left/right arrow buttons on the calendar, the calendar will appear.

To change the year and month, click the arrow buttons and bring the calendar of desired month.

By clicking the date, the data measured on this day will be listed in the Data List Box in order of measurement time.

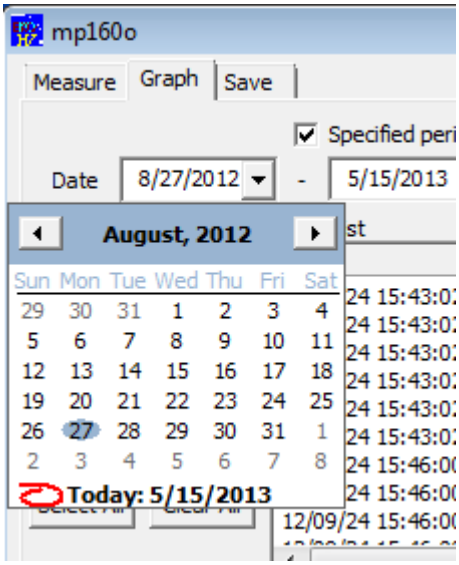


Figure 8-28. Calendar Function

2) CHANNEL Selection

In the CHANNEL field, all the channels are initially selected; click [Clear All] button to unselect all the channels then select the unit(s) and channel(s) which to be displayed.

By clicking the data with the desired time to be displayed from this list of data; the selected data will be highlighted in the list.

Click [View Graph] button to display the graph.

3) Graph Display Range Setting

If the graph scale is not appropriate, check "Graph Scale" and enter the values for Vmax and Imax then click [View Graph] button again.

4) Show/Not Show I-V, P-V Curve, Standard Condition I-V and P-V Curves

To show or not show the "raw data I-V curve", "raw data P-V curve", "standard condition data I-V curve", and/or "standard condition data P-V curve", either check or uncheck these checkboxes then click [View Graph] button.

NOTE: When displaying a graph, setup the same parameter file as the measurement condition. If the parameter file is changed, especially the PV cell parameter and selection of pyranometer/standard cell, the graph will be shown with the STC calculation under the changed parameter file condition. The selection of thermocouple T1/T2 and thermocouple type T/K will affect on the STC conversion.

5) Graph Color Setting

To change the color of the I-V curve and/or P-V curve, click [Line Color] button. Color selecting pallet dialog window will appear as shown.

Select the desired color and click [OK] button.

6) Print Function

To print the I-V curve graph, first open the Printer Setting Dialog Window by clicking [Printer] button.

Set the “printer” to be used and “paper size”, “print direction” then click [OK] button. Display the graph which to be printed, click the [Print] button. Print Dialog Window appears for setting the printing quantity and so on then click [OK].

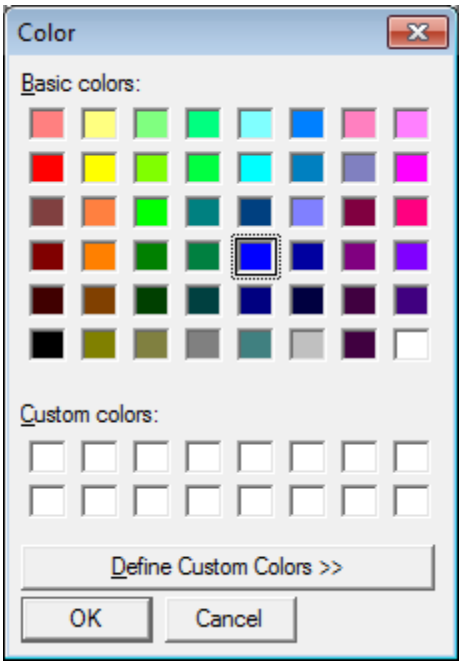


Figure 8-29. Color Setting Dialog Window

3. “Save” Tab Menu

When “Save” tab is clicked, the display will change as shown below.

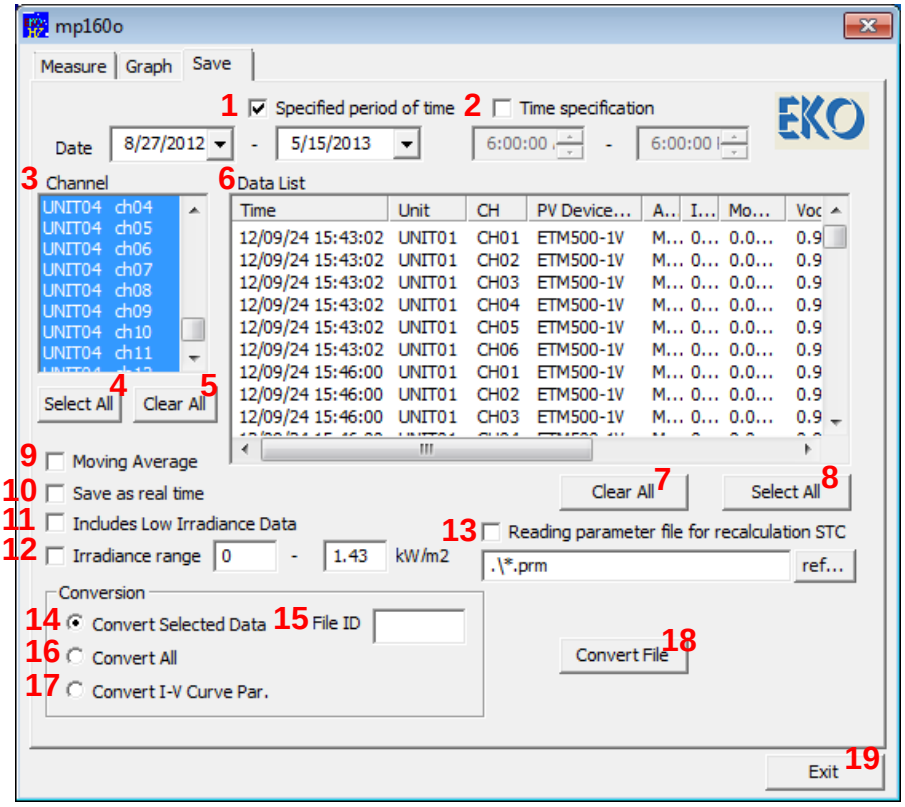


Figure 8-30. Save Tab Window

Table 8-3 Graph Tab Functions

	Names	Function & Details
1	[Specified Period of Time] Checkbox Date 2012/09/27 ~2012/09/27	To display the saved data, specify the measurement dates of the data. Specify the time period of data to be displayed, and the data extracted from the specified time period will appear on the Data List Box. By clicking the down arrow button, a calendar will appear; a specific date can be displayed by selecting the date.
2	[Time Specification] Checkbox 06:00:00 ~ 18:00:00	Enter the start and finish time of measurement to extract data from the specified time and appear on the Data List Box.
3	CHANNEL Box	Shows list of selector units and channels for selecting the unit and channel numbers.
4	[Clear All] Button	Clear all channels which are selected in the Data List Box.
5	[Select All] Button	Select all channels which are listed in the Data List Box.
6	Data List Box	Shows list of data which are applicable to the specified date in the order of time. Select subjected data and click [View Graph] button to display the graph.
7	[Clear All] Button	Clear all data which are selected in the Data List Box.
8	[Select All] Button	Select all data which are listed in the Data List Box.
9	[Moving Average] Checkbox	Display I-V curve graph by processing the moving average with 10 point before and after the I-V curve sampling point.

Table 8-3 Graph Tab Functions - Continued

	Names	Function & Details
10	[Display in Real Time Measurement] Checkbox	There is no internal clock inside the MP-160, thus measurement data time is provided from the PC time. However, when taking multi-channel measurement using module switching units, it cannot take measurement of all channels at the same time, and measurement is taken sequentially from the younger channel number. When the measurement time comes, the PC sends an order to MP-160 only once to start the measurement. MP-160 receives this order and takes measurements by switching through each channel; once all the measurements are taken from each channel, all data are sent to PC all at once. Uncheck: Each data is saved with the measurement time which is the time when initial measurement start order was given on the PC side for all channels. Therefore, the difference in measurement times for the first and last channel will be larger as the number of channels increase. It is recommended to uncheck this checkbox if measurement time for each channel should be uniformed for data processing. Check: The estimated measurement time, which is calculated from channel quantity and interval time between the channels, is given to each channel data. It is recommended to check this checkbox if data should be treated strictly with real measurement time. **NOTE: In case of saving the data with real time, make sure there is no unused channel in the middle of channel sequence. If a channel is missing, the time for the rest of the channel will be shifted by the missing channel(s).**
11	[Include Low Irradiance Data] Checkbox	Show the irradiance data below the threshold value which is set on the Pyranometer setting dialog window on the Data List Box.
12	[Irradiance Range] ☐ ~ ☐ kW/m^2	Define irradiance range to extract the data within this range; the data will be shown in the Data List Box.
13	Reading parameter file for recalculation STC] Checkbox ☐ [ref…]	Recalculate the STC with different PV module parameter than the original measurement. Check here and select a modified parameter file to recalculate the STC.
14	[Convert Selected Data] Radio button	Click here to create each CSV file for multiple data which are selected from the Data List Box. Click [Convert File] button after selecting the data from the Data List Box.
15	File ID ☐ Box	Enter a maximum of five characters in this box when individual conversion is selected; the entered characters will show at the head of created file.
16	[Convert All] Radio Button	Convert all data selected from the Data List Box into one CSV file per day and channel all at once. Click [Convert file] button after selecting the data from the Data List Box.

Table 8-3 Graph Tab Functions - Continued

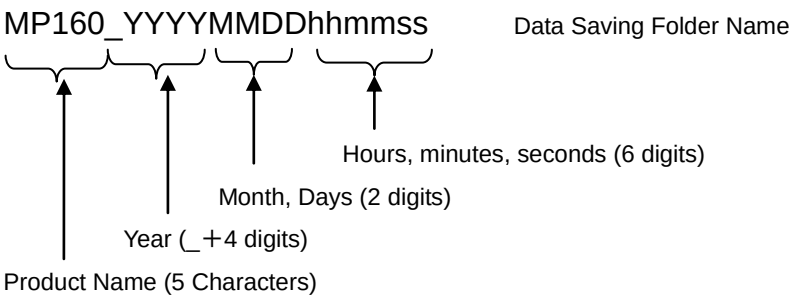
	Names	Function & Details
17	[Convert I-V Curve Par.] Radio Button	Convert by extracting the specific value of data selected from the Data List Box into one file.
18	[Convert File] Button	Click here to create a CSV file for the data selected from the Data List Box converted into either an individual file or characteristics value.
19	[Exit] Button	Exit program

1) To Save Data

In order to save the measured data in text format, follow below procedure.

a. Select the same parameter file (*.prm) which is same parameter as the measurement.
b. Set the measurement date which to be converted and saved.
c. When “UNIT**ch**” is selected from the CHANNEL Box, the data for this channel will be shown on the Data List Box.
d. Select the data to be converted from the items listed in the order of measurement time.
e. Select from “Convert All”, “Convert Selected Data” or “Convert I-V Curve Par.” Then click Convert File] button.
A folder with the date of when [Convert File] button is clicked is created in the folder setup in the General Setting Dialog Window “Converted Data Folder”; inside this folder the converted data in CSV format is saved.
The folder will be created each time the [Convert File] button is clicked.

The data folder name saved in the “Save” tab menu is as follow:



Converted data is saved into text format as described in next section.

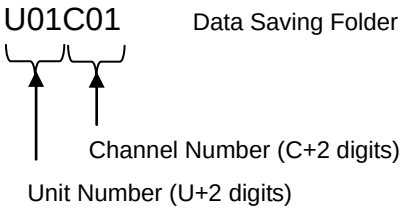
NOTE: When converting into text file format, setup the same parameter file as the measurement condition. If the parameter file is changed, especially the PV cell parameter and selection of pyranometer/standard cell, the graph will be shown with the STC calculation under the changed parameter file condition. The selection of thermocouple T1/T2 and thermocouple type T/K will affect on the STC conversion.

f. Data Saving Method when Selected Automatically Creating CSV File

When “Convert Measurement Data” is checked on Measure tab menu, a folder is created with folder names with unit number and channel number which are divided from the data as shown below then individual CSV data are saved automatically at the time of measurement.

Also the number of folders for the quantity of unit and channels are created, thus even if the date changes, the data are saved in the same folder for the same unit and channel numbers.

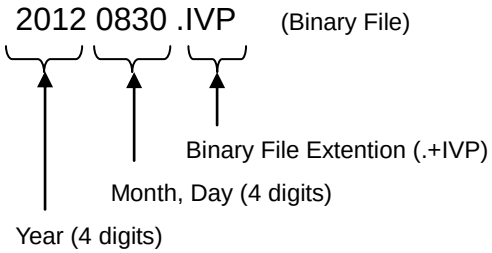
Data folder name created when selecting the function automatically creating CSV file:



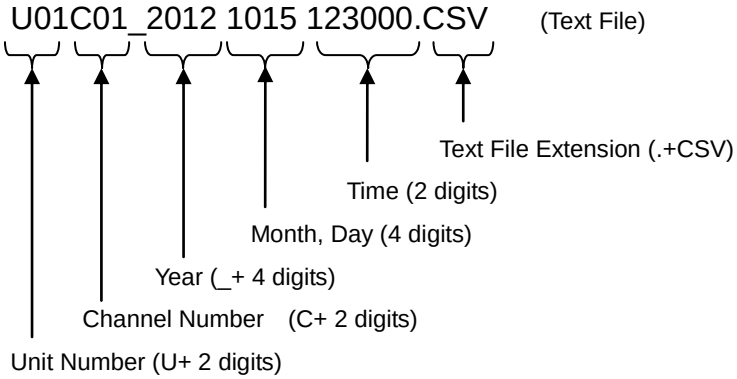
2) Data Format

Measurement results are saved daily in the specified folder in the disk as binary file.

a. Binary file is named as following:



b. Individual file is named as following (when automatically creating CSV):

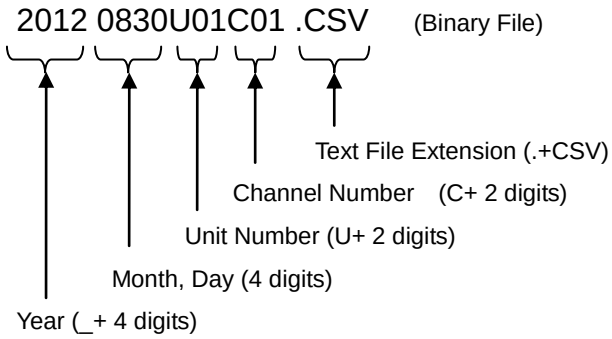


NOTE: Maximum of 5 characters can be added at the head of above file name for identification.

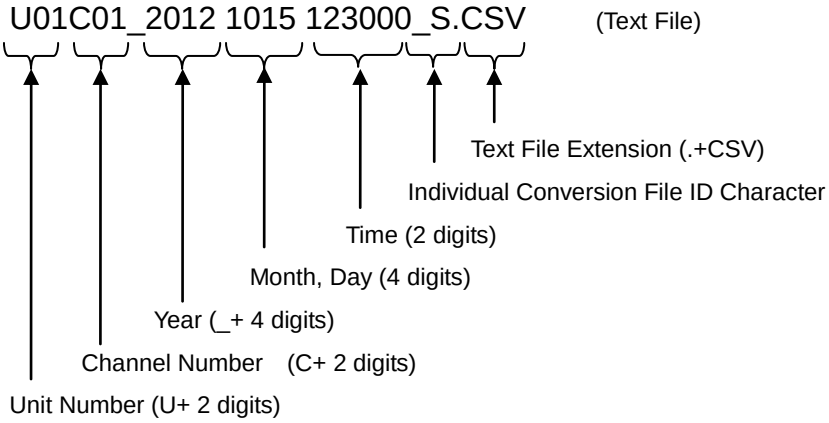
Example) Entering 5 characters of “ABCDE”

ABCDE_U01C01_2012101512300.CSV

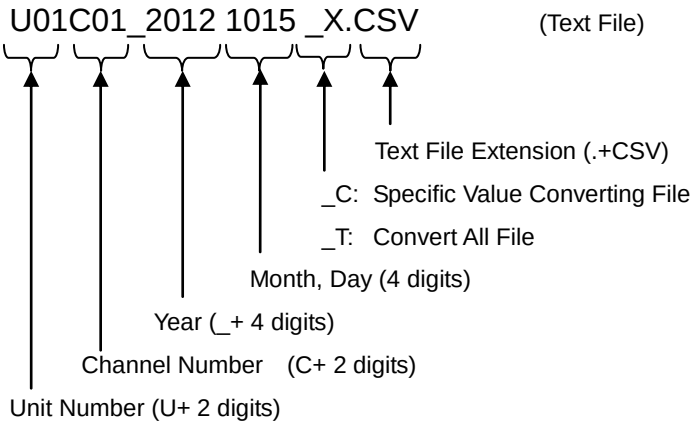
c. File with Characteristics Value is named as following(when automatically creating CSV):



d. Individual Converting File in the Save tab menu is named as following:



e. Conversion File in the Save tab menu is named as following:



3) I-V Curve Data File (CSV Conversion Method)

Below shows the text data format created by “convert all” and “individual conversion”.

```
Type of tracer = MP-160
Software Version = 2.2.10
File name = F:\MP160o\20101216_S0001.CSV
Installation Site =
Date = 2010/12/16
Time = 00:00:00-00:00:00
Measurement Mode = MANUAL
Series Resistance(Rs) = 0.00000[ohm]
Temp. Coef. of Isc (Alpha) = 0.00000[A/deg.C]
Temp. Coef. of Voc (Beta) = 0.00000[V/deg.C]
Curve Correction Factor (Kappa) = 0.00000[ohm/deg.C]
Rated Voltage(Vmax) = 0.800000[V]
Rated Current(Imax) = 0.060000[A]
PV Device Name =
Calibration Constant of Pyranometer = 0.000[mV/kW/m^2]
Calibration Constant= 0.000[mV/kW/m^2]
Shunt Resistance = 0.000[ohm]
Time 17:41:55
Ref. Temp. [deg.C] 20.4
Temp.T1 [deg.C] 45.6
Temp. T2 [deg.C] = -
PV Device Area [m^2] = 0.0004
Solar Irradiance [kW/m^2] 0.000000
Reference Cell[kW/m^2] = 0.000000
PV device temp. = T1(T)
use er = Pyranometer
Sweep = Voc to Isc
```

Indicates the information of channel and thermocouple used on STC conversion
Ex.) Used K-type thermocouple on T1: (K)
Used T-type thermocouple on T2: (T)

Indicates the sensor used on STC conversion

Voc [V]	Isc [A]	Jsc [mA/cm^2]	Pm [W]	Vpm [V]	Ipm [A]	Eta [%]	FF	Voc(stc) [V]	Isc(stc) [A]	Jsc(stc) [mA/cm^2]
0.783664	0.049586	12.396436	0.026439	0.5687	0.04649	0	0.680387	0.146941	0	0

Voltage V [\	Current I [A]	Light Intensity P [mV]	STC Voltage Vstc [V]	STC Current Istc [A]
-0.0962	0.04903	-0.01	-0.0962	-0.000556
-0.0934	0.04916	0.06	-0.0934	-0.000426
-0.0883	0.04898	-0.01	-0.0883	-0.000606
-0.0929	0.04909	0.06	-0.0929	-0.000496
-0.0915	0.04917	0	-0.0915	-0.000416
-0.0991	0.04912	0.06	-0.0991	-0.000466
-0.0854	0.04926	0	-0.0854	-0.000326
-0.1034	0.04888	0.05	-0.1034	-0.000706

Total 256 Points
When converting all, items other than the measurement time is repeated

Table 8-4 Measurement Items and Units.

Measurement Items		STC	Units
Open Circuit Voltage	Voc	Voc (stc)	[V]
Short Circuit Current	Isc	Isc (stc)	[A]
Short Circuit Current Density	Jsc	Jsc (stc)	[mA/cm^2]
Maximum Power Output	Pm	Pm (stc)	[W]
Maximum Power Voltage	Vpm	Vpm (stc)	[V]
Maximum Power Current	Ipm	Ipm (stc)	[A]
Conversion Efficiency	η	η (stc)	[%]
Fill Factor	F.F.	---	

4) Convert by Specific Value Data File (CSV Conversion Method)

By selecting “Convert by Specific Value”, data format will be created as shown below

Type of tracer = MP-160
Software Version = 2.2.10
File name = F:\MP160o\20101216U1C04_C0001.CSV
Installation Site =
Date = 2010/12/16
Time = 00:00:00-00:00:00
Measurement Mode = MANUAL
Series Resistance(Rs) = 0.00000[ohm]
Temp. Coef. of Isc (Alpha) = 0.00000[A/deg.C]
Temp. Coef. of Voc (Beta) = 0.00000[V/deg.C]
Curve Correction Factor (Kappa) = 0.00000[ohm/deg.C]
Rated Voltage(Vmax) = 0.800000[V]
Rated Current(Imax) = 0.060000[A]
PV Device Name =
Calibration Constant of Pyranometer = 0.000[mV/kW/m^2]
Calibration Constant= 0.000[mV/kW/m^2]
Shunt Resistance = 0.000[ohm]

Indicates the sensor used on STC conversion

Time	PV Device Area	PV Device Name	Sweep	Std.Cell	Er	Use Er	T1	T2	Use Temp.	Voc	Isc	Jsc	Pm	Vpm	Ipm	Eta	FF	Voc(stc)	Isc(stc)	Jsc(stc)	Pm(stc)	Vpm(stc)	Ipm(stc)
	[m^2]			[kW/m^2]	[kW/m^2]		[deg.C]	[deg.C]		[V]	[A]	[mA/cm^2]	[W]	[V]	[A]	[%]		[V]	[A]	[mA/cm^2]	[W]	[V]	[A]
17:29:13	0.0004		Voc to Isc	0	0	Pyranometer	45.025124	-	T1(T)	0.79	0.05	12.8475	0.04	0.59	0.06	0.00	0.89	0.0000	0.00000	0.000000	0.00722	0.516	0.0140
17:38:06	0.0004		Voc to Isc	0	0	Pyranometer	45.427017	-	T1(T)	0.78	0.05	12.3699	0.03	0.58	0.04	0.00	0.67	0.0000	0.00000	0.000000	0.00021	0.368	0.0006
17:41:55	0.0004		Voc to Isc	0	0	Pyranometer	45.564064	-	T1(T)	0.78	0.05	12.3964	0.03	0.57	0.05	0.00	0.68	0.1469	0.00000	0.000000	0.00013	0.401	0.0003
17:46:23	0.0004		Voc to Isc	1	0	Pyranometer	44.916325	-	T1(T)	0.79	0.05	12.3476	0.03	0.58	0.05	6.56	0.68	0.7862	0.04939	12.347596	0.02625	0.581	0.0452
17:53:50	0.0004		Voc to Isc	1	0	Pyranometer	44.670261	-	T1(T)	0.78	0.05	12.3135	0.03	0.55	0.05	6.32	0.66	0.7828	0.04925	12.313512	0.02529	0.554	0.0457
18:10:00	0.0004		Voc to Isc	1	0	Pyranometer	44.824066	-	T1(T)	0.78	0.05	12.4012	0.03	0.54	0.05	6.55	0.67	0.7838	0.04961	12.401195	0.02619	0.545	0.0481
18:28:40	0.0004		Voc to Isc	1	0	Pyranometer	48.636112	-	T1(T)	0.77	0.05	12.4980	0.03	0.57	0.05	6.51	0.67	0.7747	0.04999	12.497978	0.02603	0.569	0.0457
18:37:00	0.0004		Voc to Isc	1	0	Pyranometer	49.401413	-	T1(T)	0.78	0.05	12.4685	0.03	0.57	0.05	6.53	0.67	0.7767	0.04987	12.468526	0.02614	0.575	0.0455

Indicates the information of channel and thermocouple used on STC conversion
Ex.) Used K-type thermocouple on T1: (K)
Used T-type thermocouple on T2: (T)

Table 8-5 Measurement Items and Units

Measurement Items		STC	Units
Effective PV Cell Area	Apr	---	[cm^2]
Solar Irradiance	Er	---	[mW/cm^2]
TEMP 1 Measurement Temperature	T1	---	[℃]
Open Circuit Voltage	Voc	Voc (stc)	[mV]
Short Circuit Current	Isc	Isc (stc)	[mA]
Short Circuit Current Density	Jsc	Jsc (stc)	[mA/cm^2]
Maximum Power Output	Pm	Pm (stc)	[mW]
Maximum Power Voltage	Vpm	Vpm (stc)	[mV]
Maximum Power Current	Ipm	Ipm (stc)	[mA]
Conversion Efficiency	η	η (stc)	[%]
Fill Factor	F.F.	---	

8-3. Setup and Measurement: Indoor Measurement

1. “Measure” Tab Menu

The main window is displayed as shown below when the software is started.

By clicking on each tab, each tab menu is displayed.

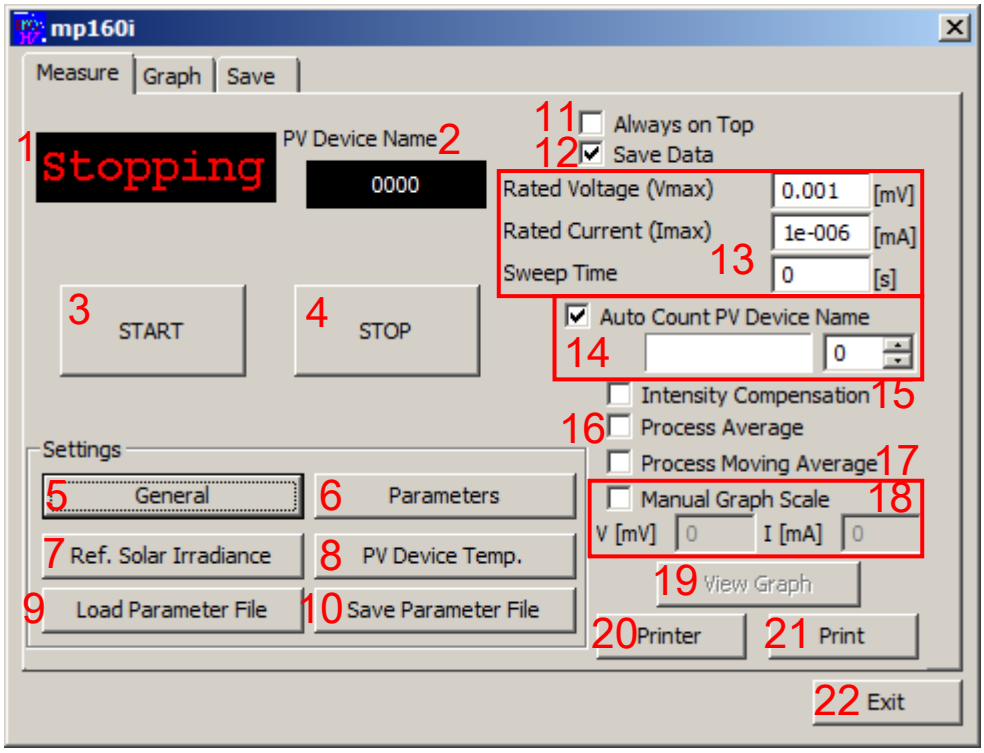


Figure 8-31 Measure Tab Window

Table 8-6 Measure Tab Functions

	Names	Function & Details
1	Measurement Status Display	Displays the measurement status (Stopping, Measuring、Standby)
2	PV Device Name Display	PV device name entered in the Comments textbox provided in the Parameter Setting Dialog Window. Also checking [Auto Count PV Device Name] Checkbox will display 4 digits of sequential number after the PV device name, indicating the number of measurement frequency
3	[START] Button	Click here to start measurement
4	[STOP] Button	Click here to terminate measurement
5	[General] Button	Setup COM port, measurement mode, data saving folder, etc.
6	[Parameters] Button	Click here to set PV cell or module parameters
7	[Ref. Solar Irradiance] Button	Click here to set reference cell or pyranometer parameters
8	[PV Device Temp.]	Set temperature measurements parameters
9	[Load Parameter File]	Upload parameter file (ini. file)
10	[Save Parameter File]	Save the setup parameters (ini. file)
11	[Always on Top] Checkbox	Check here to display this window on top on the desktop
12	[Save Data] Checkbox	Check here to save measured data

Table 8-6 Measure Tab Functions - Continued

	Names	Function & Details
13	Rated Voltage (Vmax) Rated Current (Imax) Sweep Time	Enter range values (Voltage, Current and Sweep time)
14	[Auto Count PV Device Name] Checkbox	Check here for displaying 4 digits of sequential number after the PV device name, indicating the number of measurement frequency
15	[Intensity Compensation] Checkbox	Check here to correct the light intensity fluctuation
16	[Process Average] Checkbox	Check here to process average I-V curves
17	[Process Moving Average] Checkbox	Check here to process moving averaging function When it is unavoidable for noise to appear on the graph and Voc, Isc, and Pm cannot be calculated, this function is used, processing the total of 10 points data before and after the I-V curve sampling point to minimize the noise appearing on the graph.
18	[Manual Graph Scale] Checkbox & V [V], I [A] Boxes	Setup the graph scale manually. Enter numbers here to setup voltage and current range on graph (units shown in [V], [A])
19	[View Graph] Button	Display graph
20	[Printer] Button	Setup printer.
21	[Print] Button	Print the I-V curve graph
22	[Exit] Button	Exit the program

1) General Settings

When the [General] button is clicked, the General Settings dialog box is displayed.

*Underlined parameters are required to enter.

n. Communication Port

Setup the communication COM port for MP-160. Search for available COM port and the COM ports that are not connected show in gray. Select a COM port which is available.

o. Baud Rate

Select communication speed for MP-160 (usually 38.4kbps).

p. Measurement Mode

Select Manual or Automatic measurement.

- Manual Measurement:
  Set Sweep Time (0~330sec.).
- Continuous Measurement:
  Enter continuous measurement frequency and interval and the sweep time (0~330sec.) per measurement frequency.

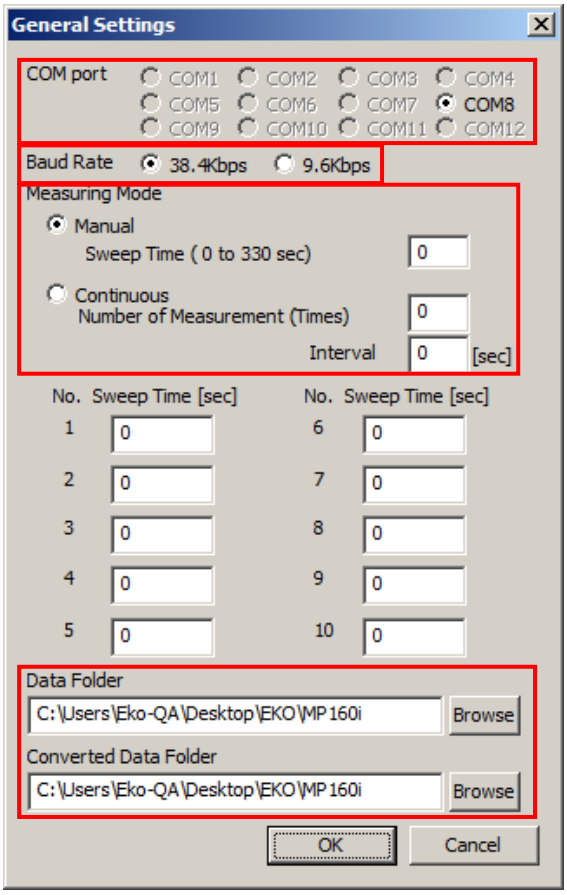


Figure 8-32. General Settings Window

q. Data Folder

Setup the save location for the measured data. (Directory will show when [Browse] button is clicked)

r. Converted Data Folder

Setup the save location for the converted data. (Directory will show when [Browse] button is clicked)

2) Parameter Setting

When the [Parameters] button is clicked, Parameters dialog window is displayed.

There are eight PV cell / module parameters to be setup.

NOTE:

- ✧ Active PV Device Area (Ain) means simply the PV device area which generates power. This is reflected to short-circuit density (Jsc) besides the true PV device conversion efficiency (ηin).
- ✧ Total PV Device Area (Apr) means the PV device area which includes frame and margin. This is reflected to the effective PV device conversion efficiency (ηpr).

The "Comments" section with 6 items does not relate directly to the measurement; however it is recommended to enter information as much as possible for data identification and organizing. These information are also saved in the contents of data files.

When completed entering all the necessary parameters, click [OK]. Entered contents will be cancelled by clicking [Cancel] button.

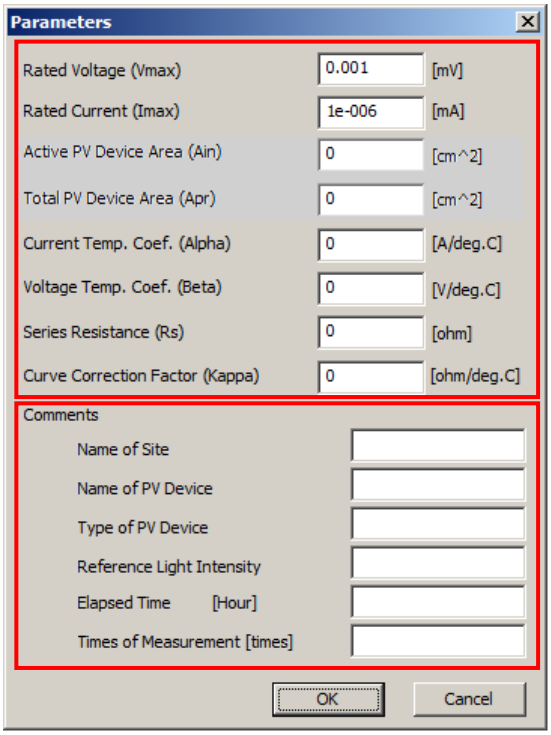


Figure 8-33. Parameters

3) Setting Reference Solar Irradiance

When the [Ref. Solar Irradiance] button is clicked, the dialog box is displayed (Figure 8-34).

Select either "Measure at I-V Curve measurement" or "Use This Value for All Measurement"

There are two ways to measure the solar irradiance, by using pyranometer or by using standard cell. Enter the calibration constant value of pyranometer or standard cell and shunt resistance value of standard cell.

The measured value will be indicated on the "Solar Irradiance Er =" box by clicking each [Measure] button.

NOTE: PV cell must be connected to PV INPUT terminal, otherwise error will occur and measurement cannot be taken. Make sure the PV cell is connected.

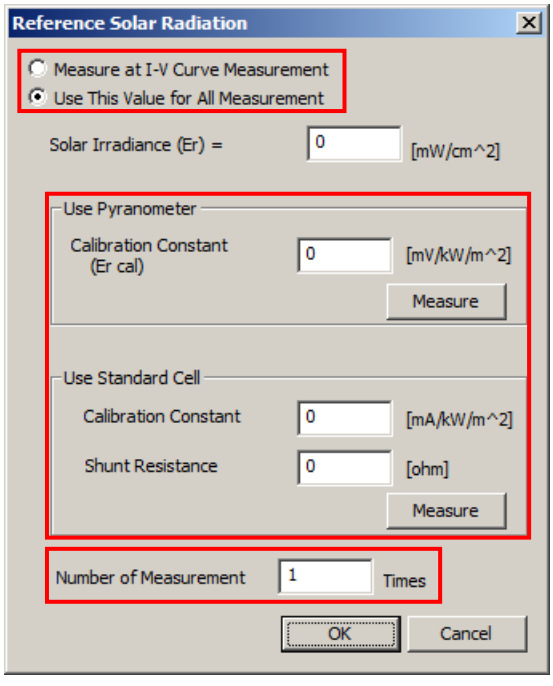


Figure 8-34. Reference Solar Radiation

When connecting a silicon photodiode sensor instead of a reference cell (such as the EKO Instruments ML-01) to the REF terminal, enter the calibration constant value of the silicon photodiode sensor in the calibration constant box for standard cell. Also, enter 1 [ohm] in the standard cell shunt resistance box. (This is to match the unit of the calibration constant value.)

Once completed entering values, click [OK] button. Entered contents will be cancelled with [Cancel] button.

4) Setting PV Device Temperature

A dialog box shown on the left will be displayed when the [PV Device Temp.] button is clicked.

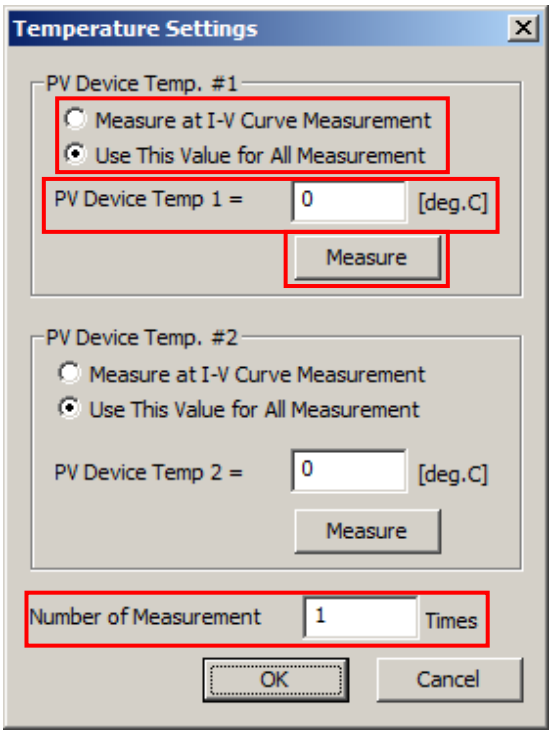


Figure 8-35. Temperature Settings Window

Select measurement method for the back surface temperature of the PV device:

- Measure at the same time as measuring I-V
- Keep the value indicated

"PV Device Temp. #1" will use the conversion in standard test condition.

Use the "PV Device Temp. #2" as necessary.

If "Measure at I-V Curve Measurement" is selected, the PV device temperature is measured, and by clicking each [Measure] button, the measured value is displayed in the box

Temperature measurement will be repeated for the number of times entered on the "Number of Measurement" box, and the average value is displayed.

Once completed entering values, click [OK]. Entered contents are cancelled with [Cancel] button.

5) Saving and Up Loading Parameter File

a. Saving Parameter File

After completing the parameter setting, click [Save Parameter File] on the Measure Tab Window; it is recommended to assign an appropriate file name.

After entering the file name, click [Save] button.

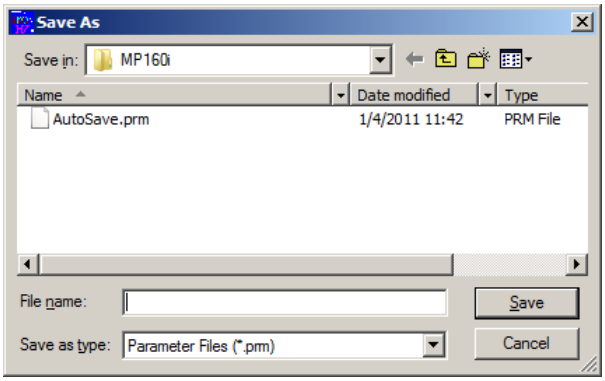


Figure 8-36. Save As

b. Up Loading Parameter File

The setup parameters saved here can be retrieved when the software is started the next time by clicking on [Load Parameter File] button and selecting a file. Select a file name and, click the [Open] button.

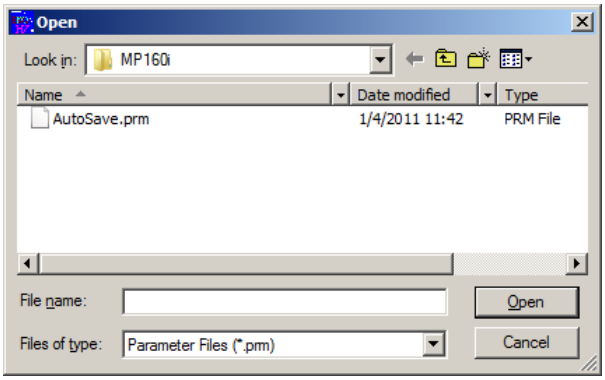


Figure 8-37. Open

After completing all the above settings, it is ready to start measurement.

6) Measurement

By clicking the [START] button, the measurement is started; the measurement indication box should be indicated as “Measuring”.

Measurement can be terminated during sequential measurement by clicking the [STOP] button.

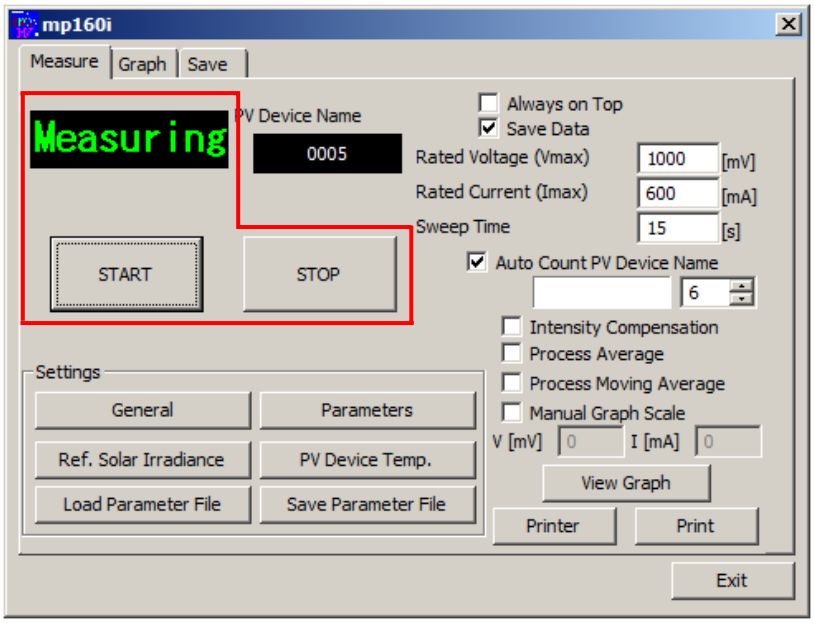


Figure 8-38. Measure Window

NOTE: Measured results will NOT be saved unless the “Save Data” checkbox is checked.

7) Graph Display

When the measurement is completed, the I-V curve graph is displayed.

The figure shown below is an example of manual measurement graph display.

If [Print] button is clicked with this screen displayed, graph is printed. Make sure to setup printer from [Printer] button and it is in a printable condition prior to taking measurement.

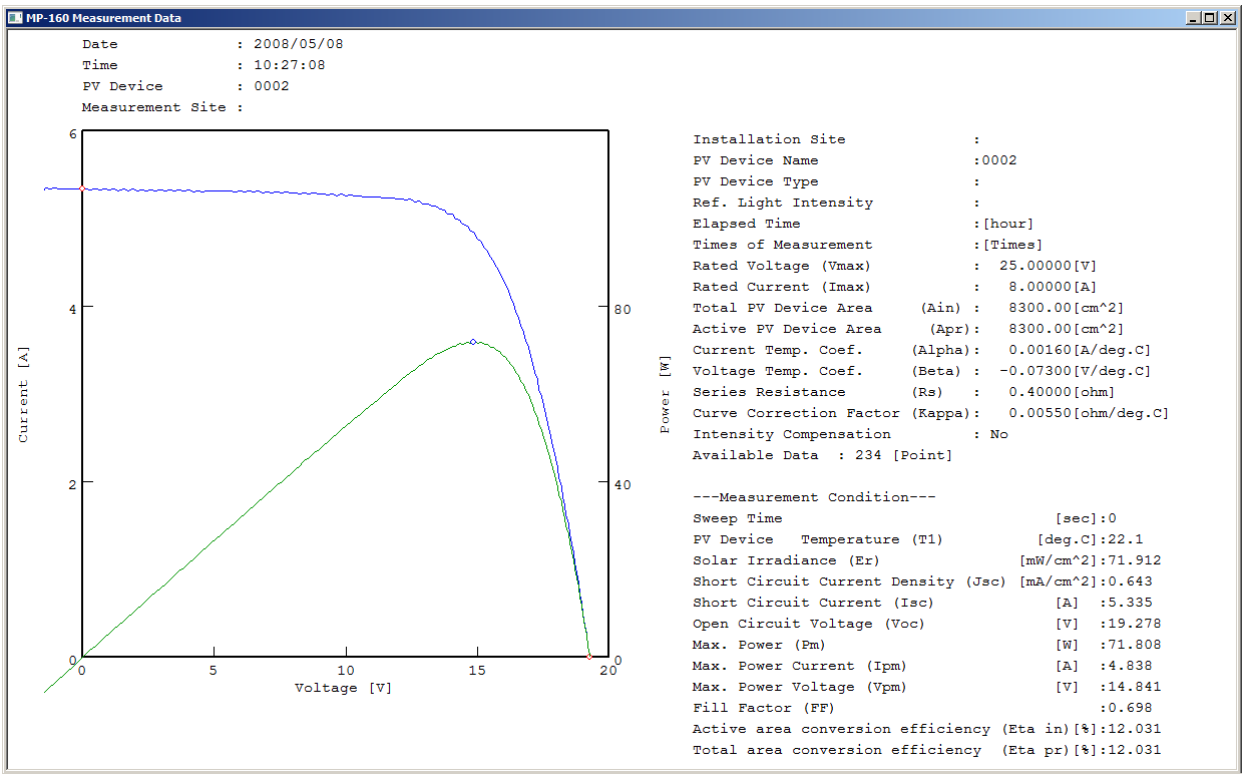


Figure 8-39. Graph Display Window

[Save as BMP] button will show when right clicking the mouse on this graph window; it can be saved as BMP by clicking this button. Select a folder for saving as BMP.

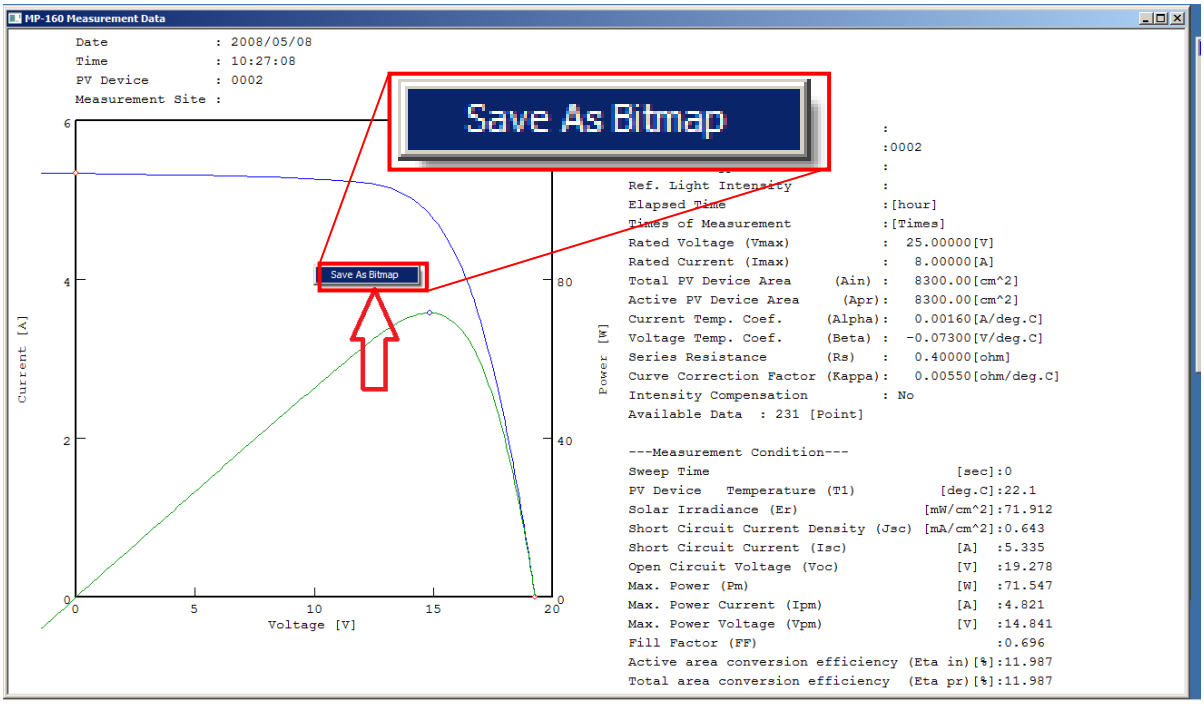
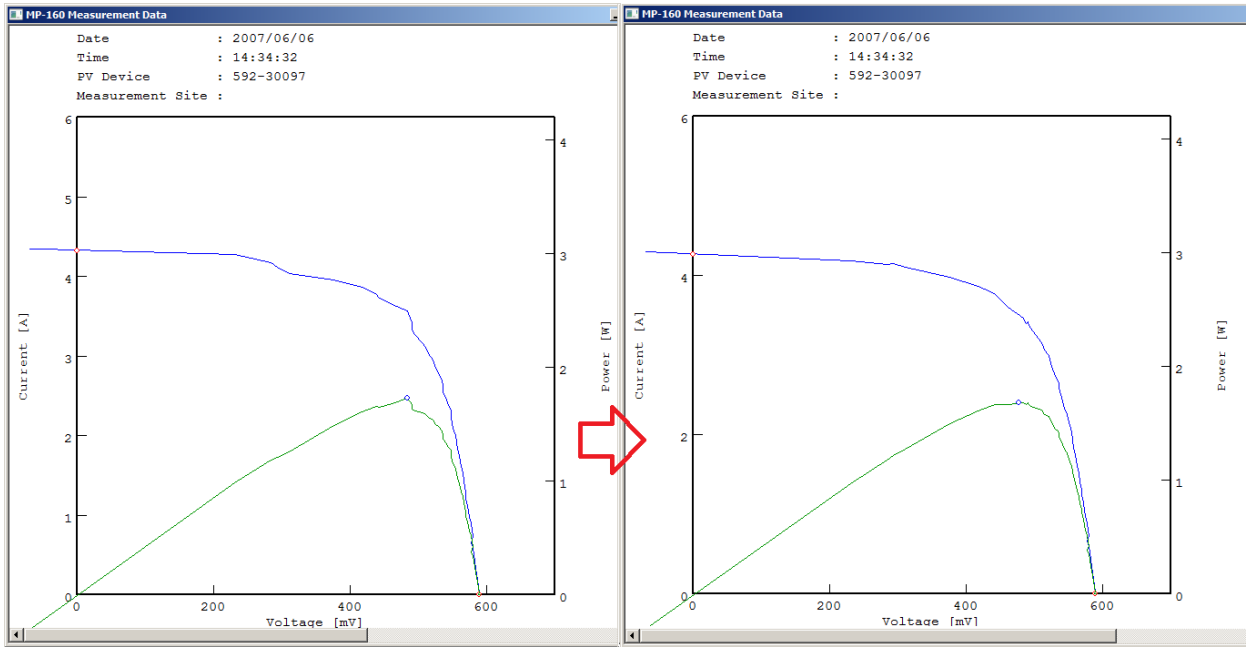


Figure 8-40. Save as BMP

8) Light Intensity Compensation Function

Below graphs show comparison of measurement result with and without the Light Intensity Compensation function. Check the “Intensity Compensation” checkbox when there are some fluctuations on the light source and the light intensity is monitored.



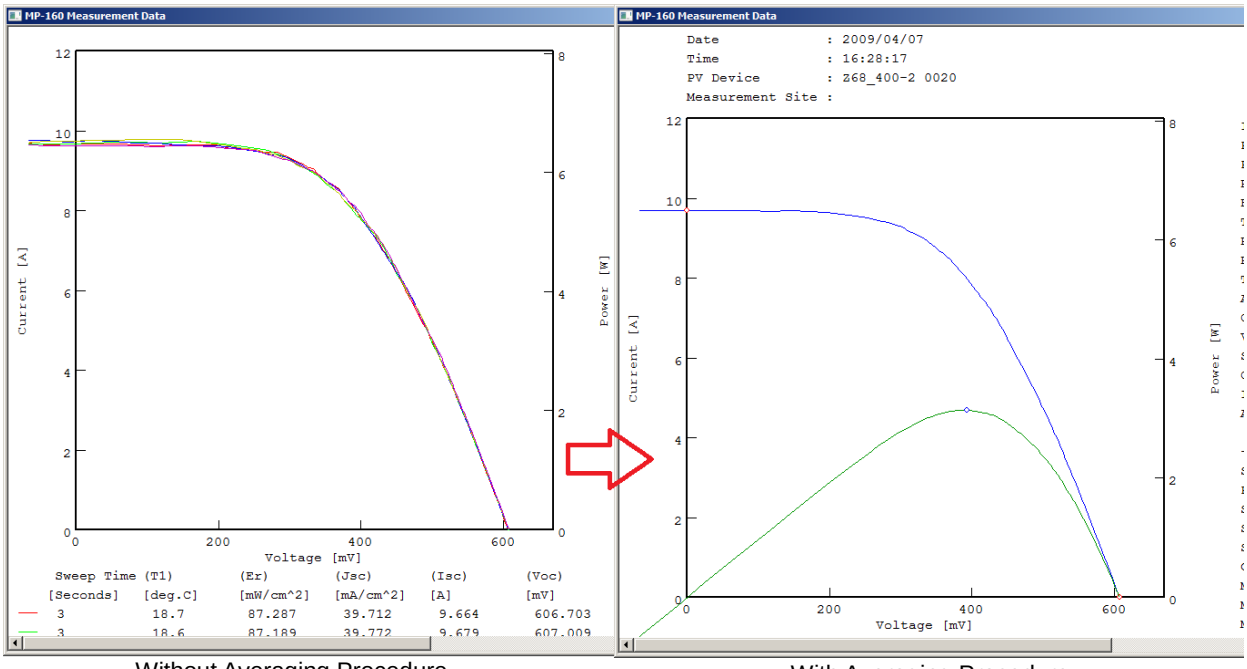
Without Light Intensity Compensation

With Light Intensity Compensation

Figure 8-41. Light Intensity Compensation

9) Averaging Procedure

Below diagram shows an example of Averaging Procedure. When the “Process Average” checkbox is checked, the average of output characteristics for continuous measurement is calculated.



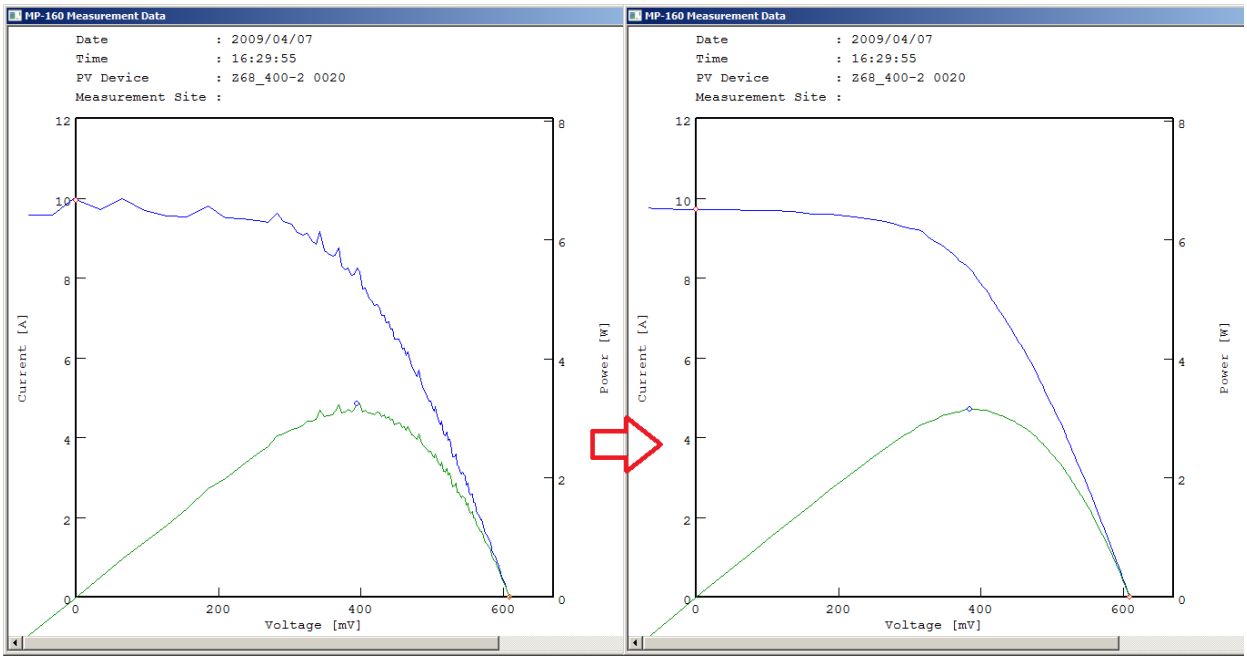
Without Averaging Procedure

With Averaging Procedure

Figure 8-42. Averaging Procedure

10) Movement Averaging Procedure

Below diagram shows an example of Movement Averaging Procedure. When the “Process Moving Average” checkbox is checked, the average value of 10 points data are calculated sequentially and analyses the variation trends of the overall data.



Without Movement Averaging Function With Movement Averaging Function

Figure 8-43. Movement Averaging Procedure

2. “Graph” Tab Menu

When the “Graph” tab is clicked, the display will change as shown below.

Each buttons and the screen functions are described:

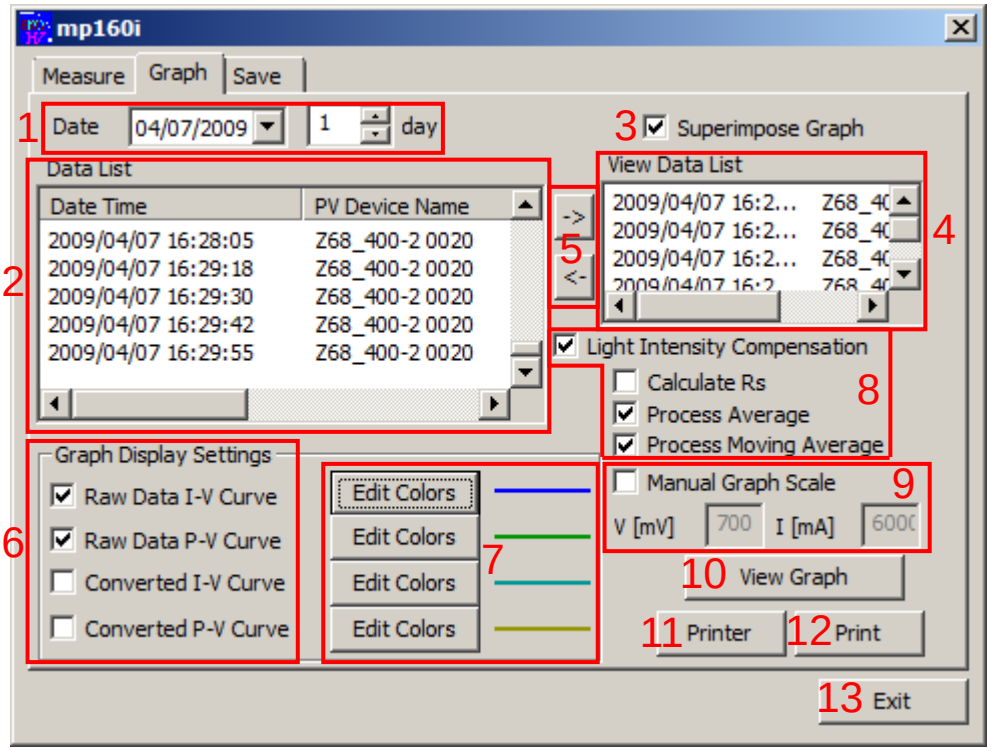


Figure 8-44. Graph Window

Table 8-7 Graph Tab Functions

	Names	Function & Details
1	Date	Shows Measured Date Click the down arrow to show calendar and select date from calendar
2	Data List Box	Shows list of data which are applicable to the selected date
3	[Superimpose] Checkbox	Check here to change the graph mode to superimposing
4	View Data List Box	Shows list of selected data for superimposing graph
5	[→] & [←] Buttons	When the graph indication is on superimpose mode, click these buttons to select or deselect data and transfer to and from View data list
6	[Graph Display Settings] Checkboxes	Check to show each graph
7	[Edit Colors] Button	Click here to select color of each curve; selected color is shown on the right.
8	[Light Intensity Compensation] Checkbox	Check here when correcting the light intensity fluctuation
	[Calculate Rs] Checkbox	Check here to calculate series resistance R_s from 2 types of outputs
	[Process Average] Checkbox	Check here when calculating average of multiple characteristics
	[Process Moving Average] Checkbox	Check here when setting movement averaging procedure When it is unavoidable for noise to appear on the graph and Voc, Isc, and Pm cannot be calculated, this function is used, processing the total of 10 points data before and after the I-V curve sampling point to minimize the noise appearing on the graph.

Table 8-7 Graph Tab Functions - Continued

	Names	Function & Details
9	[Manual Graph Scale] Checkbox & V [mV], I [mA] Boxes	Check here to setup the graph scale manually Enter numbers here to setup voltage and current range on graph (units shown in [V], [A])
10	[View Graph] Button	Re-display graph after light intensity correction or display ranges are changed
11	[Printer] Button	Setup printer
12	[Print] Button	Print the graph
13	[Exit] Button	Exit the program

1) Calendar Function

First on the Graph tab menu, select a measurement date.

When the down arrow button on the right side of date box is clicked, calendar is displayed.

To change the year and month, click the left/right arrow buttons on the calendar. Once the date is selected, the data measured on this particular day will be listed by every hour. Clicking a specific data listed on the Data List will highlight the selected row.

Clicking [View Graph] button will display the graph of this data.

If the scale indicated is not correct, check the “Manual Graph Scale”, enter the Vmax and Imax values in each box then click the [View Graph] button again.

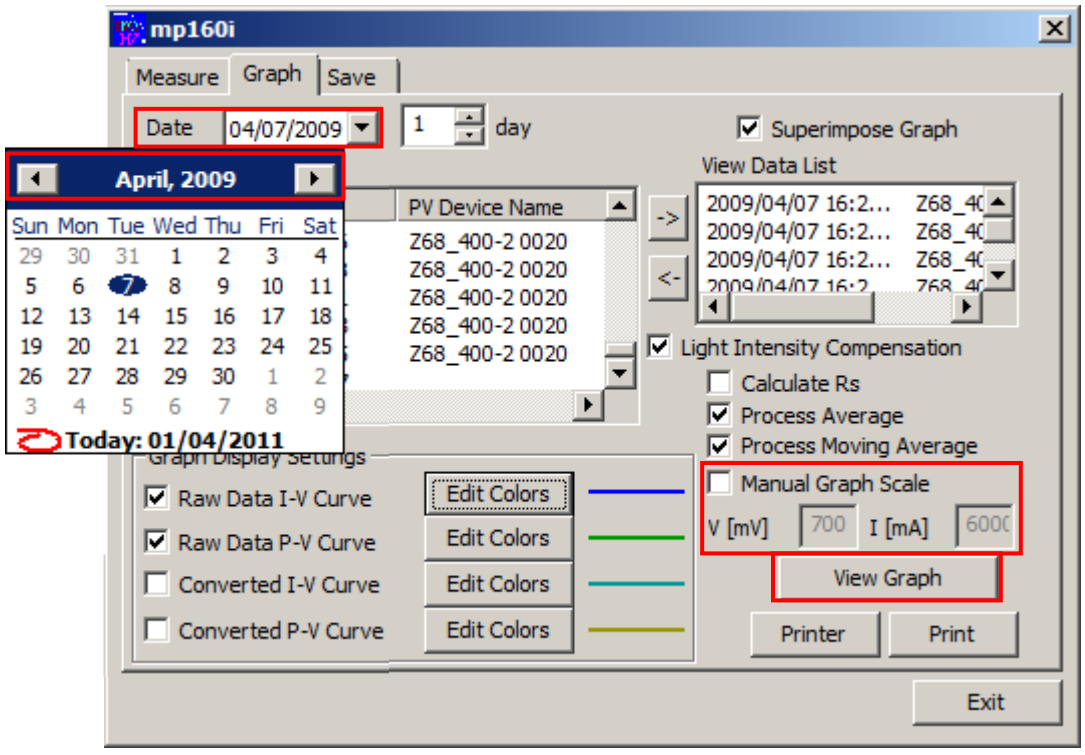


Figure 8-45. Calendar

2) Superimpose Mode

When “Superimpose Graph” checkbox is checked, multiple data can be displayed on one graph.

Check the “Superimpose Graph” checkbox.

Select data with desired time from the data list, and click [→] button to transfer to the View Data List window.

The selected data on View Data List window can be transfer back to the Data List by clicking [←] button.

The data transferred to View Data List can be displayed on graph up to 10 data; graph is shown when [View Graph] button is clicked.

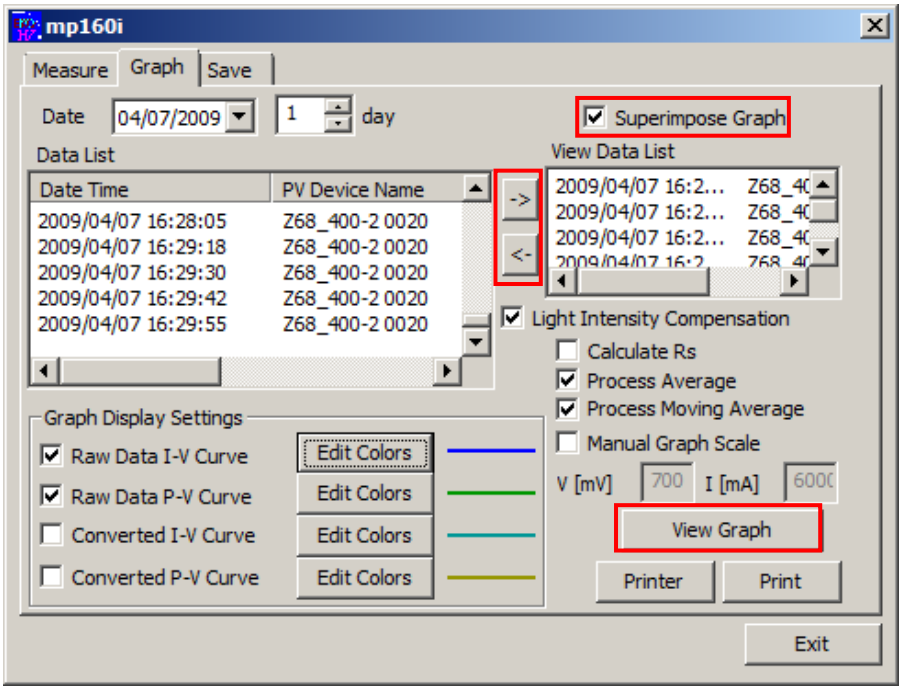


Figure 8-46. Superimpose Mode

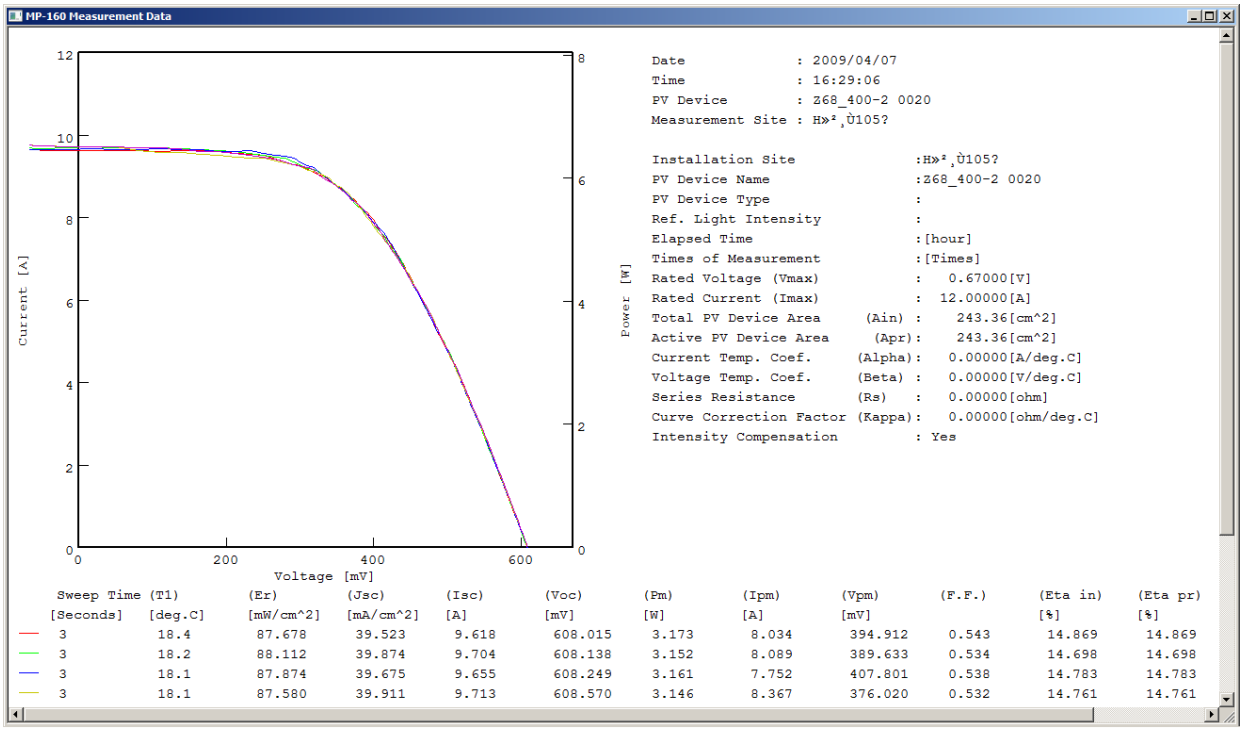


Figure 8-47. Superimposed Graph

The above graph shows an example of continuously measured I-V curves displayed in superimposed mode. After taking continuous measurement with variable setting on the sweeping time per each measurement times, it is possible to superimpose the data with changed sweeping time on the same graph. This is applicable for evaluating such as dye-sensitized PV cell.

3) R_s Calculation Function

Check the “Superimpose Graph” and “Calculate R_s” checkboxes.

Select three points of data which differ more than 5% among the solar irradiation intensity of each.

Click the [View Graph] button, then a graph and characteristics values of the three points are displayed; as indicated below, series resistance R_s can be calculated from the three I-V characteristics based on JIS standard. Check the “R_s Calculation” and click the [View Graph] button, the R_s calculation result is indicated.

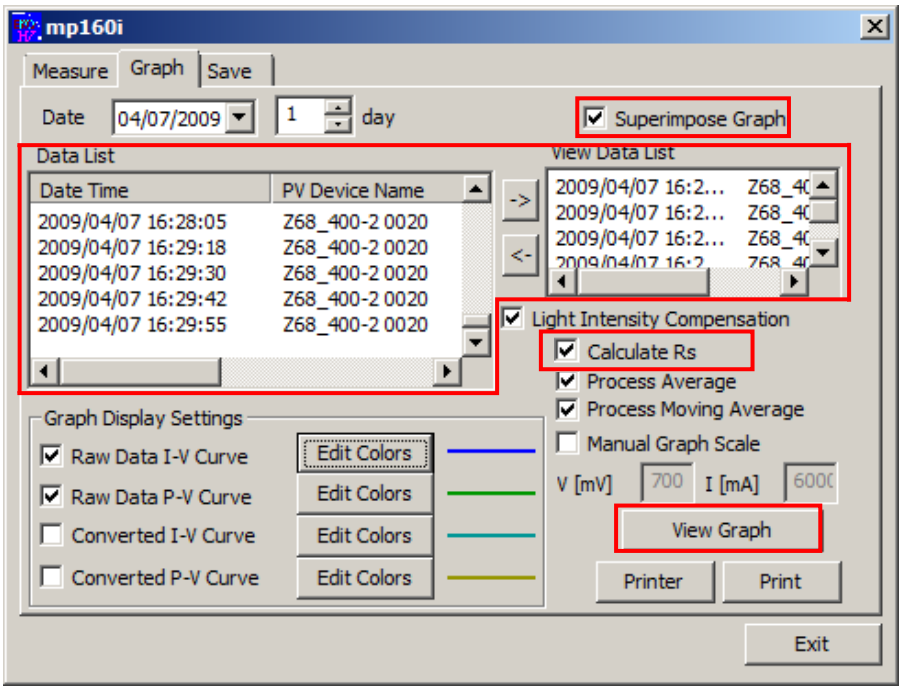


Figure 8-48. R_S Calculation Function

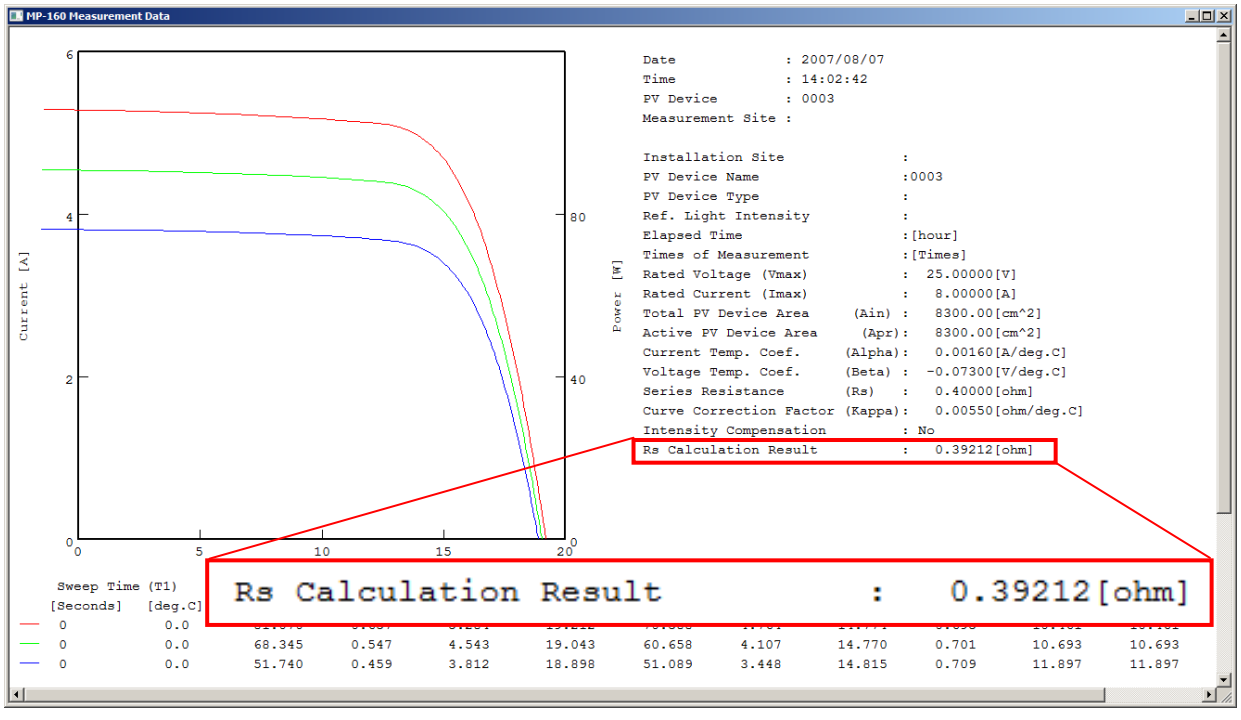


Figure 8-49. R_s Calculation Graph

NOTE: R_s values will not be shown if the differences of the solar irradiance intensity of the selected three data are not more than 5% or the selected less than 3 points.

NOTE: With this R_s calculation result can be saved as BMP file on this screen; however, there is no function available to save it as text file.

4) Graph Color Setting

Each curve on the graph can be assigned with specific color for easy identification.

To change the line color of the I-V curve or P-V curve, click [Edit Color] button; the “Color” dialog window will show. Select and click the desired color and click [OK] button.

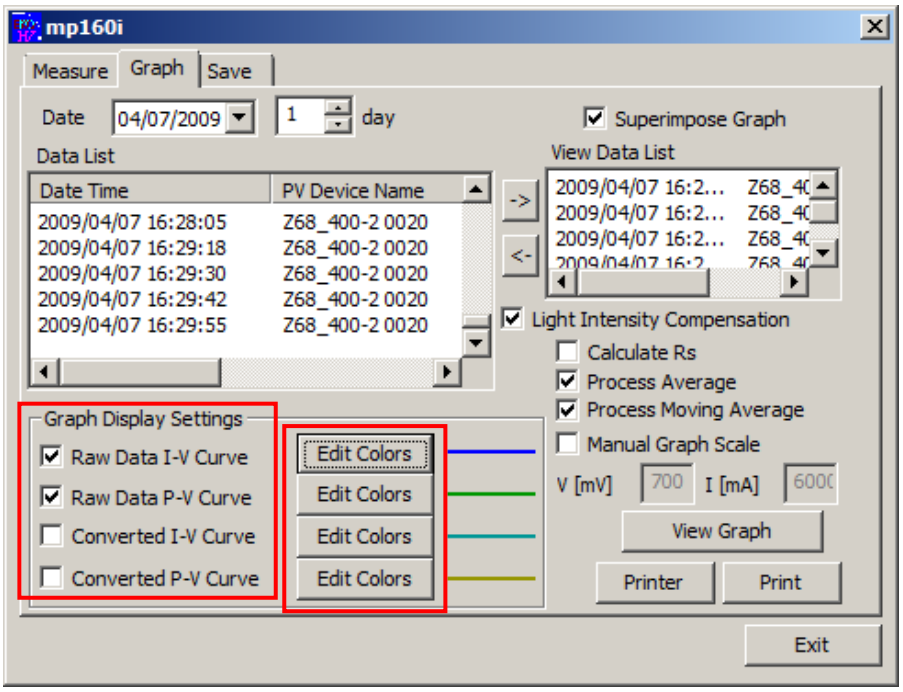


Figure 8-50. Graph Color Settings

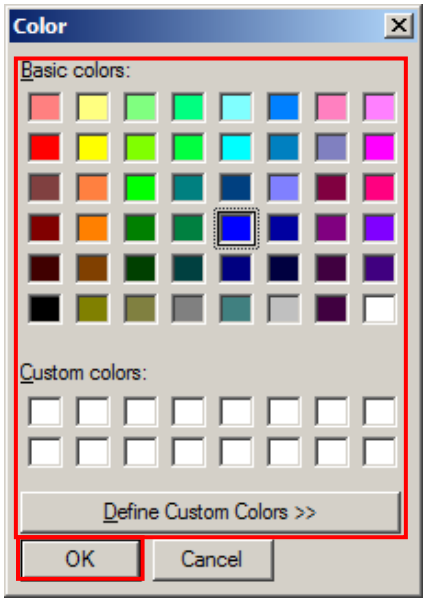


Figure 8-51. Graph Indication Colors

5) Printer Setting and Printing

In the case of printing I-V curve graph, first open the Printer Setting dialog window by clicking [Printer] button. Setup the “Printer”, “Paper” and “Page Direction” and click [OK] button. Display the graph to be printed then click [Print] button. “Print” dialog window appears; setup the printing quantity and so on then click [OK] button.

3. “Save” Tab Menu

When “Save” tab is clicked, the display will change as shown below.

Each buttons and the screen functions are described as below:

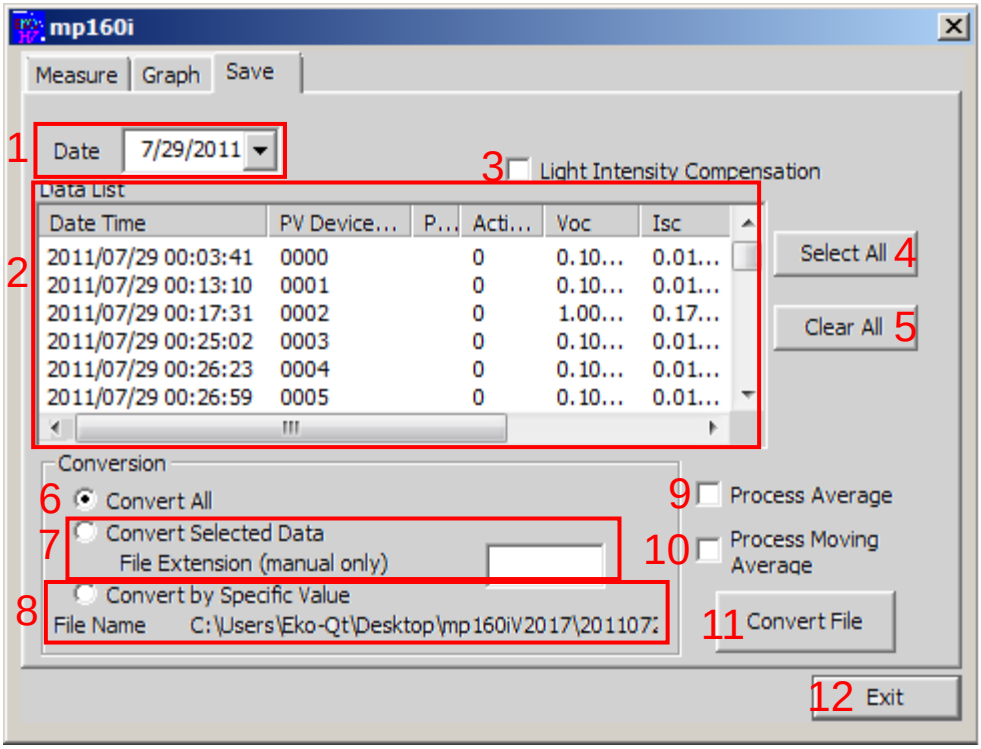


Figure 8-52. Save Window

Table 8-8 Save Tab Functions

	Names	Function & Details
1	Date Dropdown List Date 201/09/27▼	Shows Measured Date Calendar will show by clicking the down arrow and date can be selected from calendar
2	Data List Box	Shows the data measured on the dates selected from the “Date” dropdown list.
4	[Select All] Button	Click here to select all the data on the data list; all data will be highlighted
5	[Clear All] Button	Click here to clear all the selected data on the Data List
6	[Convert All] Radio Button	Click here to convert selected data into text format in one file all at once.
7	[Convert Selected Data] Radio Button & [File Extension (manual only)] Textbox.	Click here to convert a selected file into text format. Identification name can be entered up to 5 characters only for the individual conversions on manual measurement data
8	[Convert by Specific Value] Radio Button	Click here to convert the characteristics value of selected data on the Data List into one file, and the saving file name is shown.
9	[Process Average] Checkbox	Check here when calculating average of multiple characteristics
10	[Process Moving Average] Checkbox	Check here when setting movement averaging procedure When it is unavoidable for noise to appear on the graph and Voc, Isc, and Pm cannot be calculated, this function is used, processing the total of 10 points data before and after the I-V curve sampling point to minimize the noise appearing on the graph.
11	[Convert File] Button	Create a converted file to be saved
12	[Exit] Button	Exit this program

1) Saving Data

Measured results are saved in an assigned disk folder as binary file per each day.

a. Setup the measurement date to be saved.

b. Select data to be converted from the listed items in the order of measurement time

c. Select “Convert All”, “Convert Selected Data”, or “Convert by Specific Value” then click [Convert File] button.

The data to be saved is displayed as the “File Name”

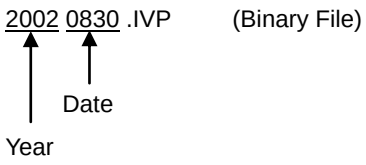
Converted data is saved in text file with following format.

NOTE: When converting the file in to text file format, make sure the same parameter file from the measurement is used. If the parameter is changed, reference value is calculated with the changed parameter and output to the text file. Especially selecting the PV cell parameter, pyranometer/reference cell, thermocouple T1/T2, and thermocouple type T/K-type will affect on the reference value calculation.

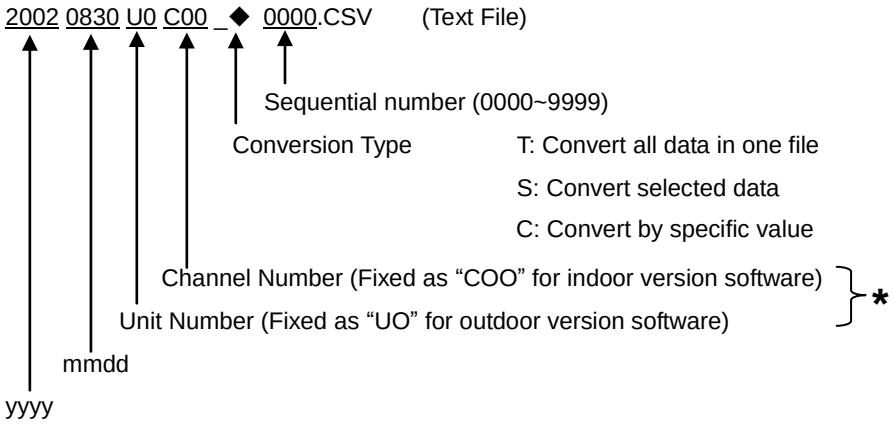
2) Data Format

Measurement results are saved by days in the folder assigned in the disk as binary file.

a. Naming format for the binary file are as follow:



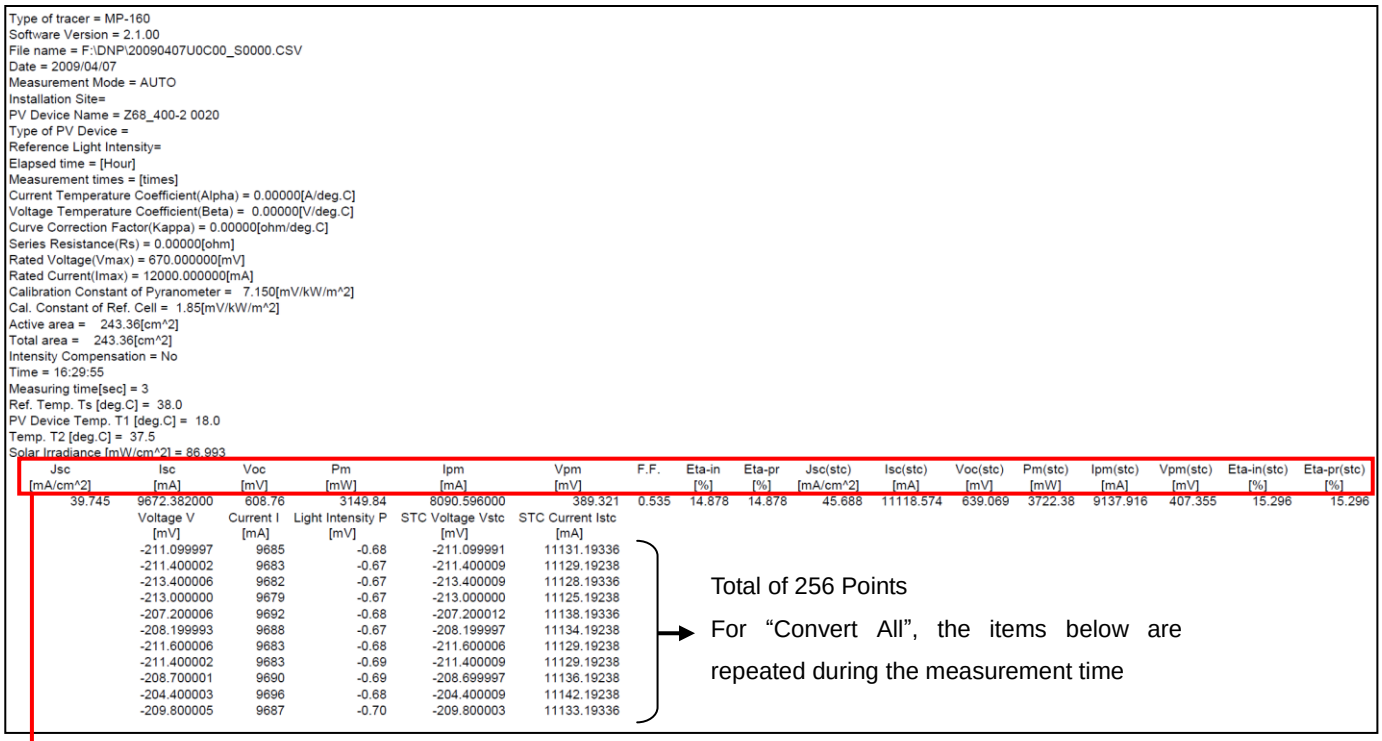
b. The naming format for the text file are as follow:



*If the data is measured manually and creating individual conversion file, file identification name with five maximum characters can be entered from key operation.

3) CSV Data Format (CSV Conversion Method)

By selecting “Convert All” or “Convert Selected Data”, data format will be created as shown below.



Type of tracer = MP-160
Software Version = 2.1.00
File name = F:\DNP\20090407U0C00_S0000.CSV
Date = 2009/04/07
Measurement Mode = AUTO
Installation Site=
PV Device Name = Z68_400-2 0020
Type of PV Device =
Reference Light Intensity=
Elapsed time = [Hour]
Measurement times = [times]
Current Temperature Coefficient(Alpha) = 0.00000[A/deg.C]
Voltage Temperature Coefficient(Beta) = 0.00000[V/deg.C]
Curve Correction Factor(Kappa) = 0.00000[ohm/deg.C]
Series Resistance(Rs) = 0.00000[ohm]
Rated Voltage(Vmax) = 670.000000[mV]
Rated Current(Imax) = 12000.000000[mA]
Calibration Constant of Pyranometer = 7.150[mV/kW/m^2]
Cal. Constant of Ref. Cell = 1.85[mV/kW/m^2]
Active area = 243.36[cm^2]
Total area = 243.36[cm^2]
Intensity Compensation = No
Time = 16:29:55
Measuring time[sec] = 3
Ref. Temp. Ts [deg.C] = 38.0
PV Device Temp. T1 [deg.C] = 18.0
Temp. T2 [deg.C] = 37.5
Solar Irradiance [mW/cm^2] = 86.993

Jsc [mA/cm^2]	Isc [mA]	Voc [mV]	Pm [mW]	Ipm [mA]	Vpm [mV]	F.F.	Eta-in [%]	Eta-pr [%]	Jsc(stc) [mA/cm^2]	Isc(stc) [mA]	Voc(stc) [mV]	Pm(stc) [mW]	Ipm(stc) [mA]	Vpm(stc) [mV]	Eta-in(stc) [%]	Eta-pr(stc) [%]
39.745	9672.382000	608.76	3149.84	8090.596000	389.321	0.535	14.878	14.878	45.688	11118.574	639.069	3722.38	9137.916	407.355	15.296	15.296

Voltage V [mV]	Current I [mA]	Light Intensity P [mV]	STC Voltage Vstc [mV]	STC Current Istc [mA]
-211.099997	9685	-0.68	-211.099991	11131.19336
-211.400002	9683	-0.67	-211.400009	11129.19238
-213.400006	9682	-0.67	-213.400009	11128.19336
-213.000000	9679	-0.67	-213.000000	11125.19238
-207.200006	9692	-0.68	-207.200012	11138.19336
-208.199993	9688	-0.67	-208.199997	11134.19238
-211.600006	9683	-0.68	-211.600006	11129.19238
-211.400002	9683	-0.69	-211.400009	11129.19238
-208.700001	9690	-0.69	-208.699997	11136.19238
-204.400003	9696	-0.68	-204.400009	11142.19238
-209.800005	9687	-0.70	-209.800003	11133.19336

Total of 256 Points

For “Convert All”, the items below are repeated during the measurement time

Table 8-9 Measurement Items and Units.

Measurement Items		STC	Units
Short Circuit Current Density	Jsc	Jsc (stc)	[mA/cm^2]
Short Circuit Current	Isc	Isc (stc)	[A]
Open Circuit Voltage	Voc	Voc (stc)	[V]
Maximum Power Current	Ipm	Ipm (stc)	[mA]
Maximum Power Voltage	Vpm	Vpm (stc)	[mV]
Maximum Power Output	Pm	Pm (stc)	[W]
Fill Factor	F.F.	---	
Active Area Conversion Efficiency	ηin	ηin (stc)	[%]
Conversion Efficiency	ηpr	ηpr (stc)	[%]

4) Convert by Specific Value Data File (CSV Conversion Method)

By selecting “Convert by Specific Value”, data format will be created as shown below

Type of tracer = MP-160
Software Version = 2.1.00
File name = F:\EKO\20090407U0C00_C0001.CSV
Date = 2009/04/07
Measurement Mode = AUTO
Installation Site=
PV Device Name = Z68_400-2 0020
Type of PV Device =
Reference Light Intensity=
Elapsed time = [Hour]
Measurement times = [times]
Current Temperature Coefficient(Alpha) = 0.00000[A/deg.C]
Voltage Temperature Coefficient(Beta) = 0.00000[V/deg.C]
Curve Correction Factor(Kappa) = 0.00000[ohm/deg.C]
Series Resistance(Rs) = 0.00000[ohm]
Rated Voltage(Vmax) = 670.000000[mV]
Rated Current(Imax) = 12000.000000[mA]
Calibration Constant of Pyranometer = 7.150[mV/kW/m^2]
Cal. Constant of Ref. Cell = 1.85[mV/kW/m^2]
Active area = 243.36[cm^2]
Total area = 243.36[cm^2]
Intensity Compensation = No

Time	Name of PV Device	Type of PV Device	Sweep time	Ain	Apr	Er	TS	T1	T2	Jsc	Isc	Voc	Pm	Ipm	Vpm	F.F.	Eta-in	Eta-pr	Jsc(stc)	Isc(stc)	Voc(stc)	Pm(stc)	Ipm(stc)	Vpm (stc)	Eta-in (stc)	Eta-pr (stc)
			[sec]	[cm^2]	[cm^2]	[mW/cm^2]	[deg.C]	[deg.C]	[deg.C]	[mA/cm^2]	[mA]	[mV]	[mW]	[mA]	[mV]		[%]	[%]	[mA/cm^2]	[mA]	[mV]	[mW]	[mA]	[mV]	[%]	[%]
16:28:05	Z68_400-2 0020		3	243.36	243.36	87.566	38	18.7	37.4	39.81	9688.227	606.516	3129.394	8093.696	386.646	0.533	14.685	14.685	45.463	11063.860	636.625	3670.066	9201.484	398.858	15.081	15.081
16:28:17	Z68_400-2 0020		3	243.36	243.36	87.287	38	18.7	37.5	39.77	9679.000	606.720	3132.795	8120.256	385.800	0.533	14.748	14.748	45.565	11088.744	636.559	3688.782	9200.159	400.948	15.158	15.158
16:28:29	Z68_400-2 0020		3	243.36	243.36	87.189	38	18.6	37.5	39.77	9678.521	607.005	3131.485	8074.853	387.807	0.533	14.758	14.758	45.614	11100.646	636.960	3693.763	9238.679	399.815	15.178	15.178
16:28:42	Z68_400-2 0020		3	243.36	243.36	87.846	38	18.5	37.5	39.76	9675.787	607.107	3136.453	8031.610	390.514	0.534	14.671	14.671	45.260	11014.468	635.360	3662.706	9256.536	395.689	15.051	15.051
16:28:54	Z68_400-2 0020		3	243.36	243.36	87.664	38	18.4	37.5	39.81	9689.111	607.803	3139.002	8032.253	390.800	0.533	14.714	14.714	45.416	11052.511	636.695	3676.589	9194.523	399.867	15.108	15.108
16:29:06	Z68_400-2 0020		3	243.36	243.36	87.678	38	18.4	37.5	39.77	9678.718	608.019	3141.016	7892.000	398.000	0.534	14.721	14.721	45.360	11038.895	636.799	3680.337	9175.442	401.107	15.123	15.123
16:29:18	Z68_400-2 0020		3	243.36	243.36	88.112	38	18.2	37.5	39.79	9682.698	608.115	3144.348	8080.167	389.144	0.534	14.664	14.664	45.156	10989.093	635.694	3658.862	9070.270	403.391	15.035	15.035

Table 8-10 Measurement Items and Units

Measurement Items		STC	Units
Active PV Device Area	Ain	---	[cm^2]
Total PV Device Area	Apr	---	[cm^2]
Solar Irradiance	Er	---	[mW/cm^2]
Terminal Temperature	TS	---	[℃]
TEMP 1 Measurement Temperature	T1	---	[℃]
TEMP 2 Measurement Temperature	T2	---	[℃]
Short Circuit Current Density	Jsc	Jsc (stc)	[mA/cm^2]
Short Circuit Current	Isc	Isc (stc)	[mA]
Open Circuit Voltage	Voc	Voc (stc)	[mV]
Maximum Power Output	Pm	Pm (stc)	[mW]
Maximum Power Current	Ipm	Ipm (stc)	[mA]
Maximum Power Voltage	Vpm	Vpm (stc)	[mV]
Fill Factor	F.F.	---	
Active Area Conversion Efficiency	ηin	ηin (stc)	[%]
Conversion Efficiency	ηpr	ηpr (stc)	[%]

9. Measurement Principle

9-1. Measurement Principle

I-V curve measurement method applied by the MP-160 is a combination of the so called bias power supply method and electric load method. Depending on the rated voltage and rated current, the bias power method is used for small capacity PV cells and electric load method is used for module measurement. Both methods perform a reverse bias voltage sweep through the short circuit current point.

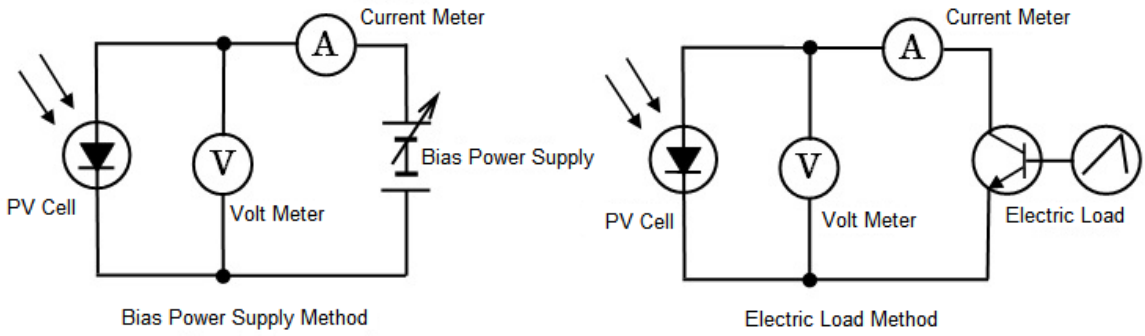


Figure 9-1. Bias Power Supply Method & Electric Load Method

1. Bias Power Supply Method

MP-160 is integrated with reverse bias power supply since there are cases that it takes measurement of minimal capacity less than 5W and cases that it draws graph line up to the 2nd quadrant of I-V curve graph. With this measurement range, MP-160 uses bias power supply method. Usually the I-V characteristics measurement method using such as bipolar power supply as the variable load of PV cell, and sweep the bias voltage against PV cell from less than 0V to more than Voc. For larger current capacity PV cell, the bias power would be larger and it generates more heat, this method is used for measurements of mainly the size of PV cell.

2. Electric Load Method

When measuring PV cell more than 5W with MP-160, it applies electric load method for the range of 0V ~ Voc. Usually the electric load method uses semiconductor device such as transistor for variable load and by controlling the voltage between the base and emitter for transistor it controls the current between collector and emitter. Up to the size of PV module or array can be measured by restricting the heat generation from the semiconductor element for electric load. MP-160 can be used for measurements of size of PV module.

3. I-V Measurement by 4-Terminal Method

The MP-160 uses 4-terminal wire connections to measure more precisely. In the case of a 2-terminal wire connection as shown on Figure 9-2, a voltage drop is caused due to the wire resistance which will affect the measurement accuracy. With 4 wire terminals, the voltage measurement circuit and current measurement circuit are separated.

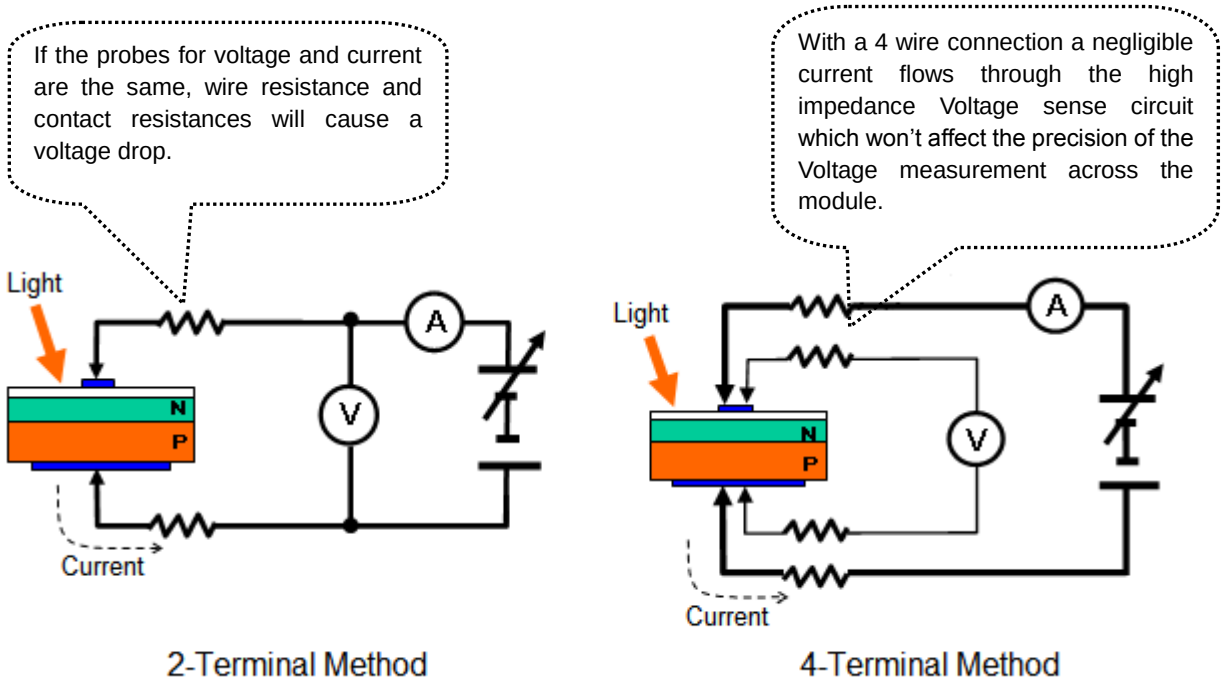


Figure 9-2. Differences of 2-terminal and 4-terminal Methods

9-2. Displayed Data and Essential Figures

The parameters measured by the MP-160 hardware are the current and voltage across the PV module or cell, solar irradiance intensity and PV module temperature (Thermocouple). All other parameters, such as short-circuit current Isc, open circuit voltage Voc, maximum power Pm, maximum power current Ipm, maximum power voltage Vpm, fill factor F.F., and conversion efficiency η are all calculated values from the actual measurement value of I-V curve and solar irradiance.

The displayed data on the MP-160 software is shown with one decimal point for temperature and three decimal points for all the other items. The calculation accuracy for current and voltage values of I-V curve is ±0.5% against full scale, thus the number of significant figures will be 3 digits. (Saved Files are not also saved with the number of significant figures.)

The Isc calculation method complies with IEC 60904-1 (JIS C8913); the Pm fits in the curve approximation formula near the peak of I-V curve. The peak value is set as Pm, and the current value of that point as Ipm and voltage value as Vpm. Open circuit voltage (Voc) and short circuit current (Isc) are obtained from calculating the intersection point of straight-line approximation which is determined from the points before and after the I-V curve intersects each X- and Y-axis. Fill factor (F.F.) is calculated with formula: Pm / (Isc x Voc), and the conversion efficiency (η) is calculated with formula: Pm/(PV device area x solar irradiance intensity). In order to display, the 4th decimal numbers are rounded up and made into three decimal point values. Therefore, the values will not exactly match all the way to the last digit with the displayed value, even by calculating the Pm value from formula Vpm x Ipm using displayed values on software.

10. Calibration & Troubleshooting

10-1. Calibration

It is recommended to recalibrate the instrument once every 1~2 years. For further information about the calibration and recalibration, please contact EKO.

10-2. Troubleshooting

Check the following items in case of trouble with the instrument. If any questions should remain, contact EKO for further technical support.

Table 10-1. Troubleshooting

Failure	Action
Good measurement cannot be taken with automatic range setting.	1) Automatic range may be setup without connecting a pyranometer. MP-160 selects an appropriate measurement range by using the pyranometer output as a reference. In case no pyranometer is used, set a manual measurement range. 2) In case of instable atmospheric conditions (sudden irradiance changes), the response time for thermopile type pyranometer output is slow, thus the output becomes over range and cannot be properly measured even if pyranometer is connected. In such case, it is recommended to use faster response time pyranometers, such as silicon type or reference cell.
I-V curve does not reach the short circuit current Isc.	1) Set the reverse bias switch to -9V. In case of long PV modules cables and high currents, a voltage drop will be caused due to cable internal resistance. The voltage range will be narrowed, and it refrains the I-V curve to reach the Isc point. By switching the reverse bias voltage from -6V to -9V, it creates 3V extra room to sweep through Isc. 2) In over range / current conditions, it exceeded the current limit and the sweep may have stopped. In the case of automatic range setting with pyranometer, I-V curve may not reach Isc with sudden change with weather. (See above, “Good measurement cannot be taken with automatic range setting.” for details)
Cannot measure the IV curve.	1) Check the connection of PV cable (for polarity, connection, disconnection). 2) Check to make sure the rating values are setup properly. Make sure to setup with +10% larger rating value against Voc and Isc.

Table 10-1. Troubleshooting - Continued

Failure	Action
MP-160 cannot be controlled from PC properly.	1) Make sure a proper communication cable with appropriate specifications is used. Use the attached RS-232C cross cable. Even the same RS-232C cross cable, there are RS-232C cable on market which sometimes the cross connection may be different by manufacturer and cannot operate, thus pay close attention to the specification to the communication cable connection. 2) When connecting multiple switching units, powers of the unused units cannot be turned OFF as they are still connected with switching unit control cable. Control cable is connected in parallel thus if any switching unit with power turned OFF, the overall system control signal will not function. If there are any switching units not in use, please disconnect.
Measurement software cannot be started on PC	If indoor and outdoor software are installed in a same folder, or older version software are installed in same folder, measurement software will not start. Install or move each software in different location then start the software.
The software operated properly with Windows XP, but it does not operate properly or does not operate after changing the PC operation system to Windows7.	1) Problem may be caused due to UAC. See APPENDIX 7-1. 2) When connecting to PC by using RS-232C USB, the USB driver may not be installed or it may not be applicable to Windows 7. Install the USB driver applicable for Windows 7 by downloading from the manufacturer's website. 3) When Starter is used with Windows 7 version, the software will not operate. Upgrade the operation system to Windows 7 Home Premium or Professional to solve this problem.
Most of the characters on the software window showed with "?" and corrupted.	MP-160 software is designed in bilingual of Japanese and English. When the operation system for PC is in Japanese, the software is displayed in Japanese, and for all the other language OS, the software is displayed in English. When language setting is changed, most of the characters will be shown with "?" symbols due to following reasons: 1) Using Japanese OS: When the setting was changed from Japanese to English (USA), accessing from "Control Panel" → "Region and Language" → "Administrative" → "Change system local..." English (United States) 2) Using English OS: By accessing from "Control Panel" → "Region and Language" → "Formats" → then changed the "Language" setting under "Format" to "Japanese (Japan)". To solve this problem change the settings back to the original language.
COM port cannot be setup.	This software is applicable to communication ports from COM1~Com12; however, when using RS232C-USB conversion cable to communicate with PC and USB, the COM port numbers are assigned to the COM port number which have never been used by other application software. However, if the COM port is assigned to numbers above COM12, it cannot be selected from this software. In such case, go to "Control Panel" → "System" → "Device Manager" → "Ports (COM & LPT)" and select the COM port number which is assigned. For the COM port number above COM12, open the property window and access "Properties" → "Port Settings" → "Advanced" → "COM Port Number" and change the setting to the COM port number below COM12 then restart the software.

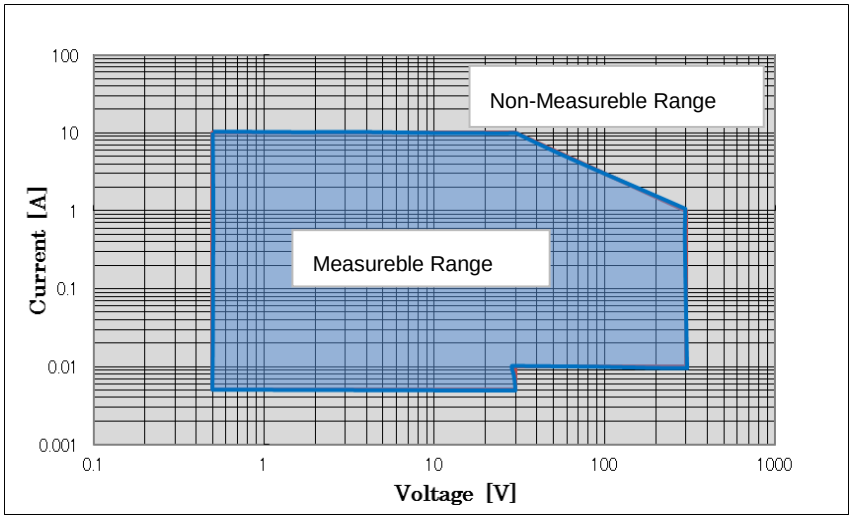
11. Specification

11-1. MP-160 Specification

Table 11-1. MP-160 Specification

<table>
<tr><th>Characteristics</th><th>Details</th></tr>
<tr><td>Input Voltage</td><td>300V (Max. 320V)</td></tr>
<tr><td>Input Current</td><td>10A (Max. 11A)</td></tr>
<tr><td>Input Power</td><td>300W (Max. 360W)</td></tr>
<tr><td>Sweep Direction</td><td>Voc → Isc sweeping, Isc → Voc sweeping can be selected on the software.
※However, do not sweep in the “Isc → Voc” direction for the PV device which may by destroyed due to the reverse bias, such as dye-sensitized solar cell. (It may damage the PV device side.)</td></tr>
<tr><td>Bias Function</td><td>In order to measure the open circuit voltage [Voc] and short circuit current [Isc] accurately, the vertical and horizontal axis of voltage/current graph need to cross; thus bias voltage is applied. There are 2 types of bias voltage, sequential bias and reverse bias.
Sequential Bias: +10~15% of voltage against Voc is applied. However, when the Voc is less than 0.6, only 1~1.2V is applied.
Reverse Bias: When the sweeping direction is in “Voc→Isc” and the samplings of voltage were in negative field 9 times continuously, reverse bias voltage will not be applied lower than this point. It depends on the current value of the PV cell, and the voltage will be around -.5V ~ -1V.
If the sweeping direction is “Isc → Voc”, the reverse bias is applied in the following condition:
<table>
<tr><th colspan="2">Setup Current Value I [A]</th><th>Reverse Bias Voltage [V]</th></tr>
<tr><td colspan="2">I < 2A</td><td>-1.3V</td></tr>
<tr><td colspan="2">2A≦ I <3A</td><td>-2.3V</td></tr>
<tr><td colspan="2">3A≦ I <4A</td><td>-3.5V</td></tr>
<tr><td colspan="2">4A≦ I <5A</td><td>-4.7V</td></tr>
<tr><td rowspan="2">5A≦ I</td><td>Switch -6V side</td><td>-6V</td></tr>
<tr><td>Switch -9V side</td><td>-9V</td></tr>
</table>
※However, the voltage value has ±10~15% errors.</td></tr>
<tr><td>Temperature Input</td><td>2 points (T-type thermocouple or K-type thermocouple can be selected on software.
*Only Ch.1 can be used on mp160o.exe Outdoor version software; Ch. 2 is used for temperature switch.</td></tr>
<tr><td>Irradiance Input</td><td>1 point (30mV)</td></tr>
<tr><td>Light Intensity Input</td><td>1 point (300mV input) External shunt resistance if required) *Indoor version</td></tr>
<tr><td>Accuracy</td><td>+/- 0.5%FS</td></tr>
</table>

Table 11-1. MP-160 Main Unit Specification - Continued

Characteristics	Details
Resolution	1/1000FS
Sweep Time	2~330 seconds
Minimum Range	0.5 V, 5 mA
Measureable Range	 *Since the measureable range may change due to the measurement condition, use this guide for your reference.
A/D Converter	16 bit (±15 bit)
Voltage Range	300V, 30V, 3V
Current Range	10A, 3A, 0.3A, 0.03A
I-V data points	256 sets (Voltage, Current, and Light amount, each 256 data)
Communication Speed	38400bps (Can be switched to 9600bps with the switch on circuit board.) Data length: 8bit, Stop Bit: 1bit, No Batteries, X on/off flow can be controlled. Delimiter CR+LF
Outer Dimension	370mm (W) x 133mm (H) x 350 (D)
Weight	9kg
Power	AC100-240V, 50/60Hz, Stand-by 20VA, Max.200VA
Fuse	2A, 250V (φ5x20mm)
Power Consumption	Max 180VA
Operating Conditions	Temperature: 0℃~40℃、Humidity: 20%RH ~ 90%RH (No condensation. Install in naturally ventilated environment)

11-2. Switching Units Specifications

Table 11-2. MI-510/MI-510S/520/530/540, MP-303 Specifications

Items	MI-510	MI-510S	MI-520	MI-530	MI-540	MP-303
Channel Qty.	6	6	12	5	12	6
Input Switching	PV Cell/Module	PV Cell/Module	PV Cell/Module	Pyranometer	T-type Thermocouple (Copper – Constantan)	PV Module
Number of devices to be connected to MP-160	1 ~ 4	1 ~ 8	1 ~ 4	1	1 ~ 4	1 ~ 8
Switching Capacity	DC100V, 7A	DC300V, 10A	DC100V, 7A	DC30V, 1A	---	DC300V, 10A (300W)
Control Input	TTL					
Power Supply	AC100 ~ 240V, 50/60Hz					
Fuse	1A, 250V (φ5 x 20mm)					
Power Consumption	30VA					
Operation Conditions	Temperature: 0 to 40℃, Humidity: 20%RH ~ 90%RH (No condensation. Install in naturally ventilated environment)					
Outer Dimensions	370 (w) x 133 (h) x 350 (d) mm	450 (w) x 155 (h) x 450 (d) mm	370 (w) x 133 (h) x 350 (d) mm	370 (w) x 99 (h) x 350 (d) mm	370 (w) x 133 (h) x 350 (d) mm	430(w) x 150(h) x 350(d) mm
Weights	5kg	12.3kg	5kg	4kg	5kg	10kg

11-3. Software

Table 11-3 Software Specifications

		Details
Outdoor Software Version		mp160o.exe 2.3.x.x
Indoor Software Version		mp160i.exe 2.1.x.x
Firmware Version		2.7
Applicable OS		Microsoft Windows /Me/2000/XP/Vista/7/8 (Japanese/English version)
Operation Environment		CPU: Pentium 200MHz equivalent or more Memory: More than 64MB HHD Capacity: More than 300MByte Display Resolution: More than 1024 x 768 dots Interface: More than one COM Ports should be available.
Other Requirements		➢ When taking continuous measurements for a long period of time with using USB-RS232C converter on the PC USB port, the measurements cannot be guaranteed. ➢ Do not use screen saver or power source controller functions. ➢ Start this software after virus check and TSR software have finished.
Program Name		mp160o.exe mp160i.exe
Outdoor Measurement Software	Software Functions	1. Displays I-V curve graphs 2. Setup measurement parameters 3. Takes manual measurement and automatic measurement by assigning interval and determining the start and end measurement time. 4. Multi-channel measurement using each switching unit 5. Saving measured data on PC as binary data/text. 6. Display and save the saved data as graph or numerical data offline. 7. Filtering function for acquired data (filtering by setting period of time, time range, and irradiance) 8. STC conversion function, recalculation function by changing parameters.
	Measurement Items	I-V curve (voltage, current and intensity) Short circuit current (Isc) Open circuit voltage (Voc) Maximum power (Pmax) Maximum power current (Ipmax) Maximum power voltage (Vpmax) Fill factor (FF) Conversion efficiency Solar irradiance (When connecting pyranometer) Light intensity (When connecting reference cell) PV cell/ module back side temperature (when connecting thermocouple)

Table 11-3 Software Specifications - Continued

		Details
Indoor Measurement Software	Software Functions	1. Displays I-V curve graphs 2. Setup measurement parameters 3. Takes manual measurement and continuous measurements up to 10 times by assigning the interval and sweep time per each measurement. 4. Saves measured data as binary data on PC and convert into text data as necessary. 5. Display saved data as graph or numerical data afterwards.
	Measurement Items	I-V curve (voltage, current and intensity) Solar irradiance Maximum power (Pmax) Short circuit current (Isc) Open circuit voltage (Voc) Maximum power current (Ipmax) Maximum power voltage (Vpmax) Fill factor (FF) Conversion efficiency PV device temperature(s) Ambient temperature (when a thermocouple is connected) Data storing - Raw measurement data (Binary) - Text conversion as CSV format I-V curve data and specific parameters

11-4. Cables

Table 11-4. MP-160 Cable Specification

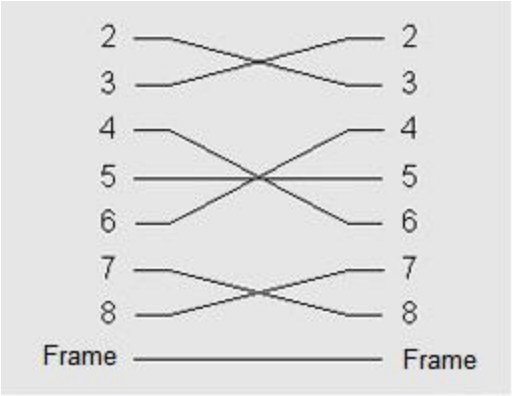
Cables	Details
AC Cable	Cable Length: 2.5m VCTF, 0.75sq x 3, Rating: 125V-7A
PV Cable	MVVS, 2sq x 4pins Shield Cable, Y-terminal (1.25Y-4)
Communication Cable	RS-232C Cross Cable 1.5m Dsub9pin Connector Female -- Female Wire connection: 

Table 11-5. MI-510/520 Cable Specification

Cables	Details
AC Cable	Cable Length: 2.5m VCTF, 0.75sq x 3, Rating: 125V-7A
PV Cable	MVVS, 2sq x 4pin Shield Cable, Y-terminal (1.25Y-4)
Junction Cable	Cable Length: Approx. 70cm MVVS, 2sq x 4pin Shield Cable, Y-terminal on both ends (1.25Y-4)
Switching Unit Control Cable	Flat Cable: 70cm Centronics Connector 14pin - 14pin

Table 11-6. MI-530/540 Cable Specification

Cables	Details	
AC Cable	Cable Length: 2.5m VCTF, 0.75sq x 3, Rating: 125V-7A	
PV Cable Junction Cable	MI-530:	SKVV, 0.5sq x 2pin Shield Cable, Y-terminal (1.25Y-4)
	MI-540:	T-type Thermocouple, Y-terminal (1.25Y-4)
Switching Unit Control Cable AC Cable	MI-530:	SKVV, 0.5sq x 2pin Shield Cable, Y-terminal (1.25Y-4)
	MI-540:	T1: SKVV, 0.5sq x 2pin Shield Cable, Y-terminal (1.25Y-4) T2: T-type Thermocouple or T-type Compensating Lead Wire, Y-terminal (1.25Y-4)
PV Cable	Flat Cable: 70cm Centronics Connector 14pin - 14pin	

11-5. Dimensions

1. MP-160 Dimension

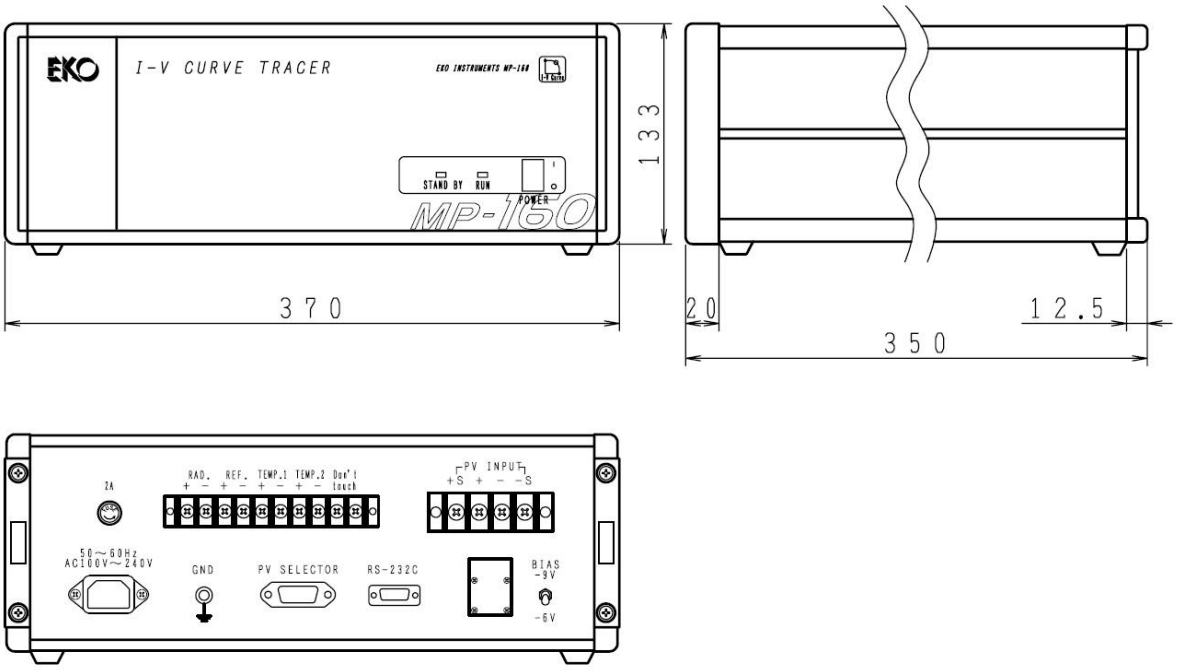


Figure 11-1. MP-160 Dimension

2. Switching Units Dimensions

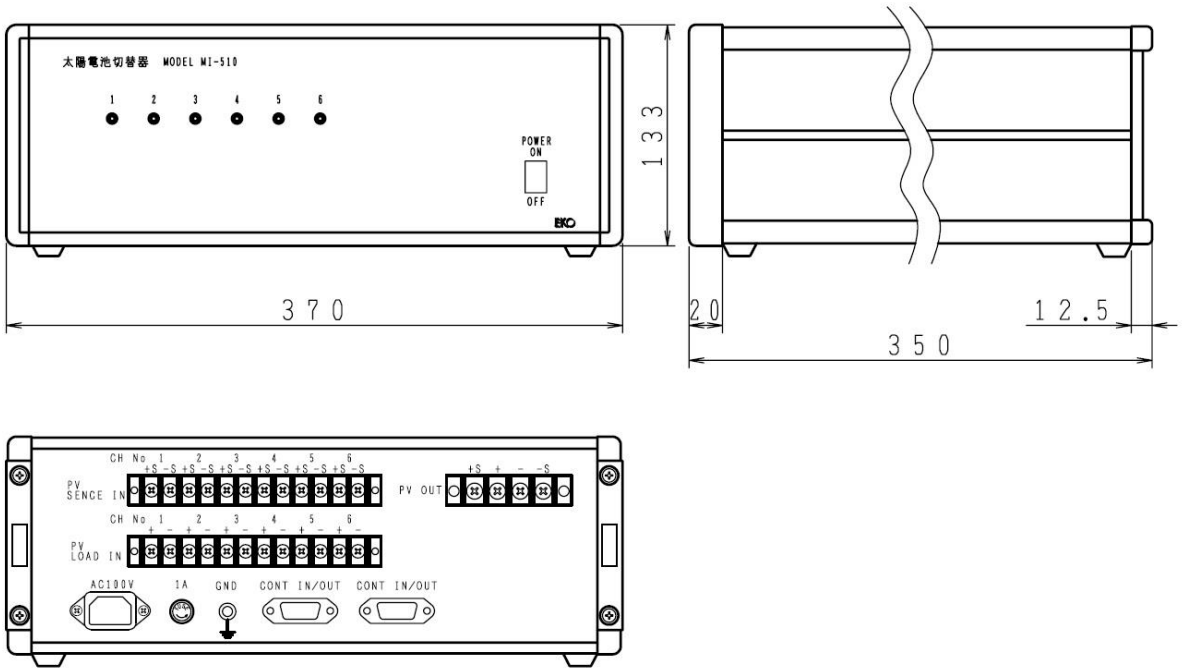


Figure 11-2. MI-510 Dimension

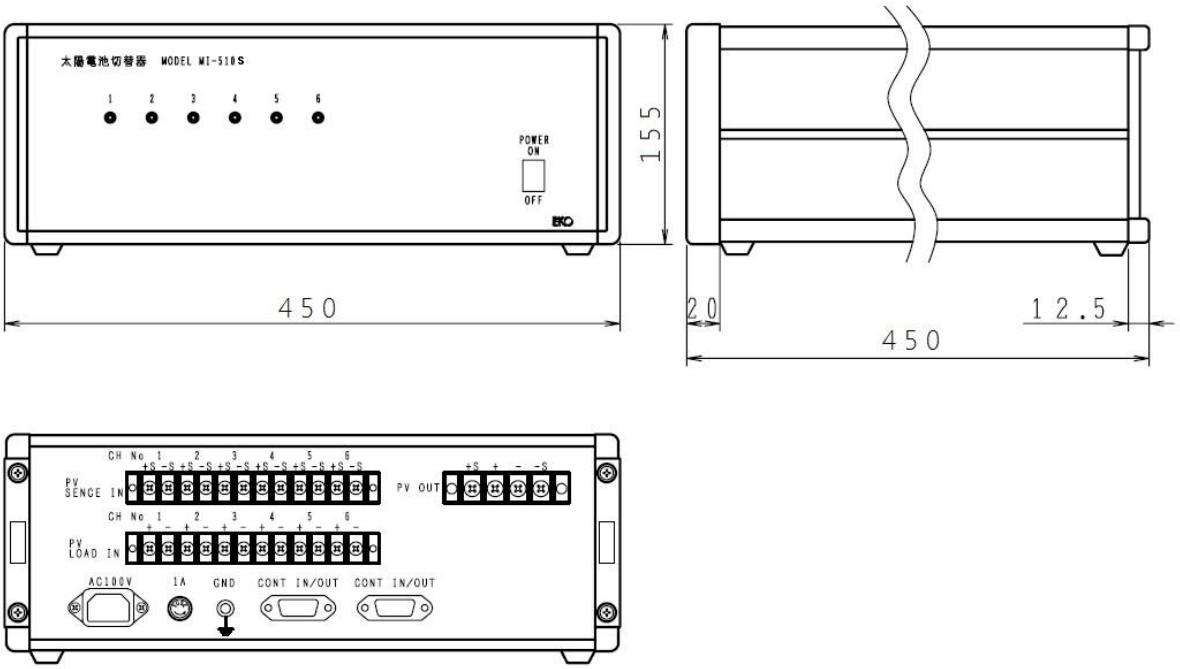


Figure 11-3. MI-510S Dimension

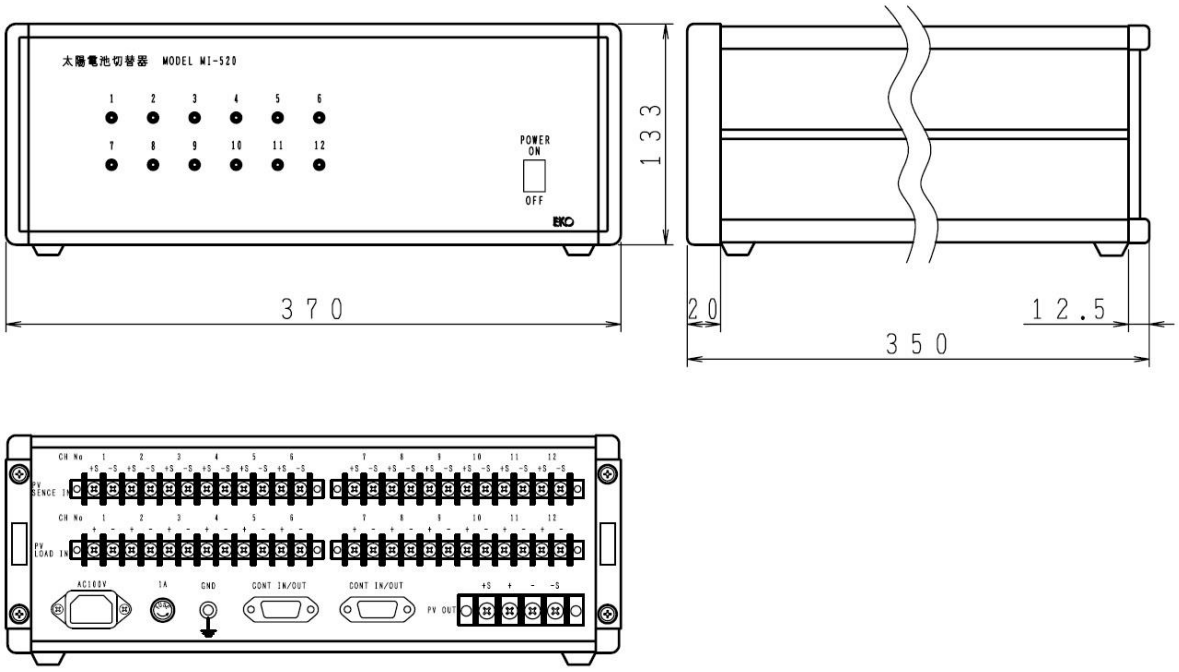


Figure 11-4. MI-520 Dimension

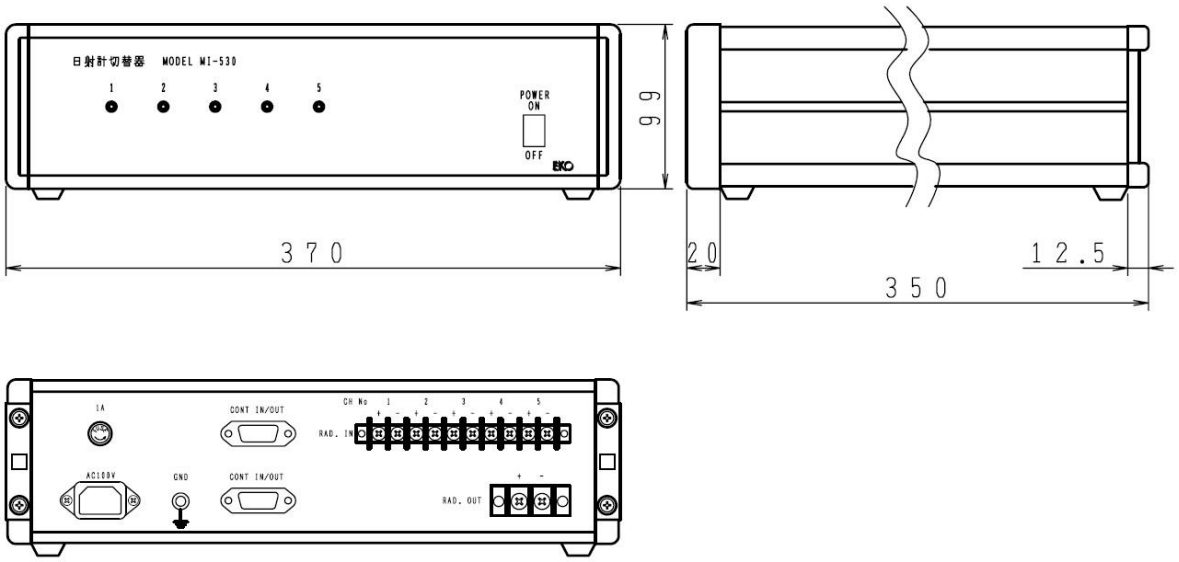


Figure 11-5. MI-530 Dimension

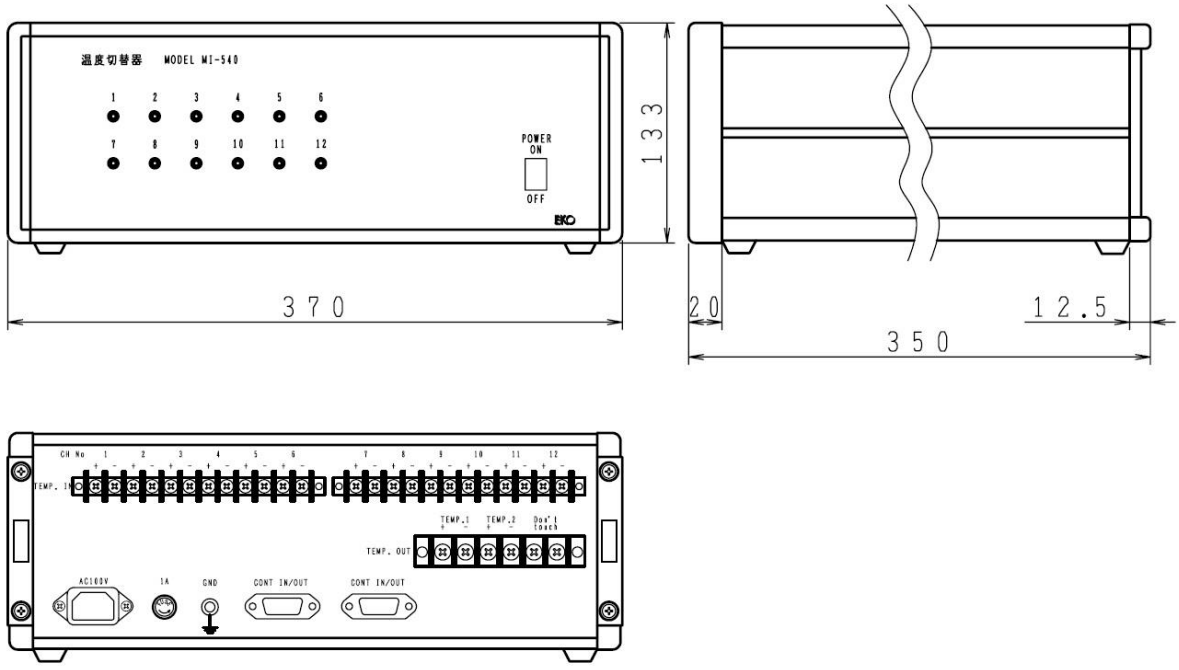


Figure 11-6. MI-540 Dimension

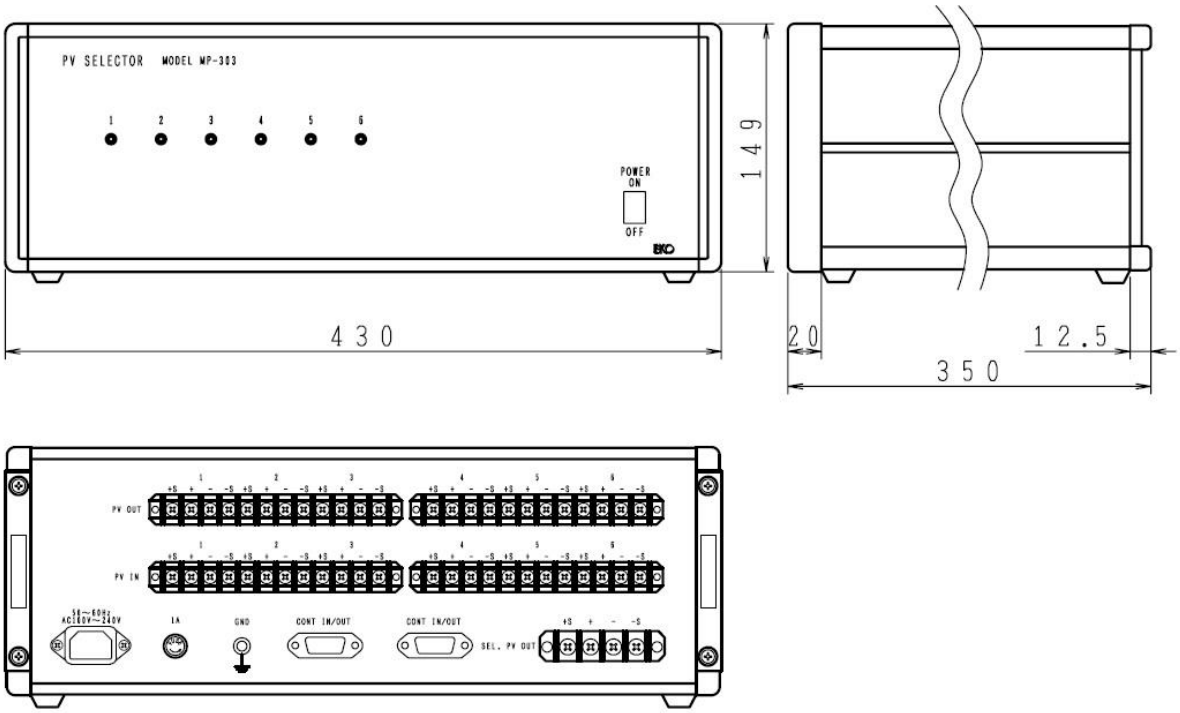


Figure 11-7. MP-303 Dimension

11-6. Accessories List

Table 11-7. Accessories List

Option Items	Remarks
PV Cable	Cable: MVVS, 2sq x 4 Shield Cable, Length can be specified by meter. Cable Ends: Y-terminal (1.25Y-4) /Gator clip (20A, 10A, 5A), as specified
Thermocouple Wire	T-type, Class 1, with/without shield cable as specified
Shunt Resistance Box	Resistance as specified (such as 0.01Ω, 0.1Ω, 1Ω)

APPENDIX

A-1. Installing Software on Windows Vista/Windows 7/8

If the MP-160 software is installed on a computer with OS type either “Windows Vista”, “Windows 7” or “Windows 8”, following error may occur due to the User Account Control (UAC) function. This section explains how to avoid these errors to occur.

Error 1: Measured data is not saved in the specified folder.

Error 2: The data converted into text file is not saved in the specified folder, or the file is not created

Error 3: The data was downloaded from MP-180 to PC, but the data was not downloaded in Specified folder.

Error 4: The setup parameter is not reflected on the measurements.

Cause:

The UAC is the basic technology of OS security integrated since Windows Visa version, and its function is to prevent the operating systems from being modified by virus, spyware, malicious software, and so on, but also it becomes effective when operating the unauthorized application with standard user authority; for a first time user may misunderstand this as application software defect.

In usual cases, when a file is created by operating the unauthorized application within secured area, and if the created file is assigned to be saved in the folder under “c:¥Program Files¥EKO” for example, the data file will be created in a totally different file by creating a virtual folder, such as:

“C:¥Users¥<user>¥AppData¥Local¥VirtualStore¥Program Files¥EKO”.

Therefore, when the user checks the folder “c:¥Program Files¥EKO”, the user cannot find the file in the specified folder.

In order to avoid such situation, there are several methods which are described below:

NOTE: When the software is installed with the installer included in the CD-ROM attached to MP-160, the software is installed by creating a folder called “C:¥EKO¥mp160o_V230x” by default setting, thus there should not be any problem.

However, if the install folder is installed purposely in separate location and/or copying the execution file in some place, you need to be careful with setups.

1. METHOD 1: Changing the Destination Folder

The easiest way to avoid the error is to install the application software in a location where it is not protected by the security.

Most of the installer for a usual application software are setup with “C:¥Program Files¥~” as the folder location for installation; therefore, install the software in a folder where it is not protected with security by OS, such as folder creating on desktop or folder created on the “C:¥” drive route.

2. METHOD 2: Operate the Application in Windows XP Mode

Right click the “Run Application File”, select “Compatibility” tab on the “Property”. In the compatibility mode, check the checkbox for “Run this program with compatible mode” and select “Windows XP (Service Pack 2 or 3)” from the dropdown box right below. Then click OK button.

After completing this setup, the data file will not be created in the virtual folder, but it will be created in the specified folder when running the application. However, when running the application, the dialog box as shown below is displayed for confirmation; click the “Authorize”.

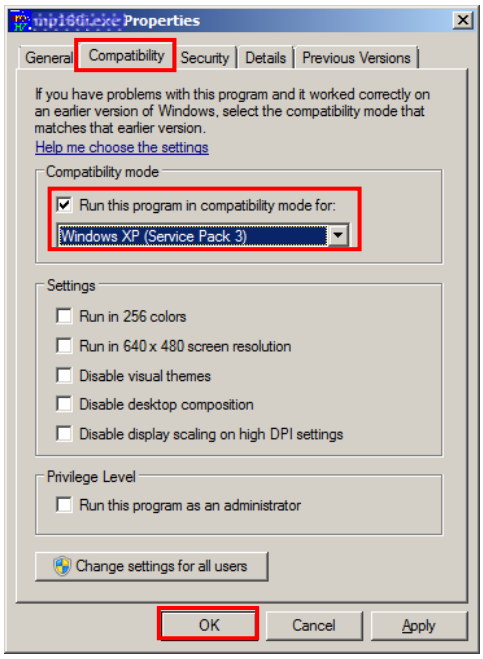


Figure A-1. XP Mode Setup
(Common for Windows Vista/7)

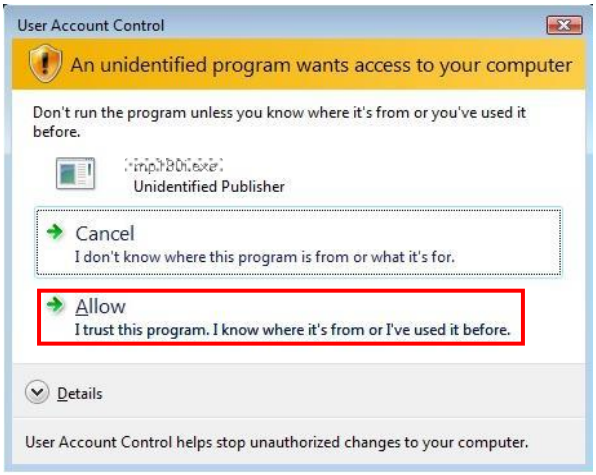


Figure A-2. Confirmation Dialog (Windows Vista)

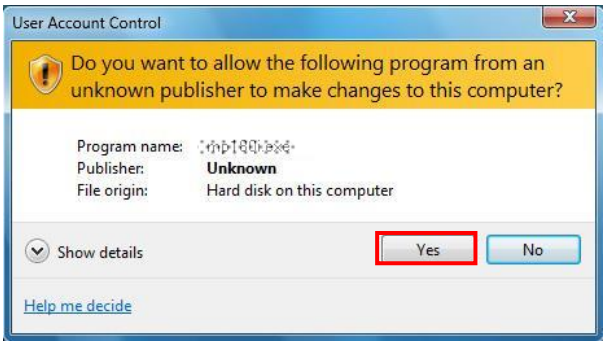


Figure A-3. Confirmation Dialog (Windows 7)

3. METHOD 3: Changing the Application Authorization

This method changes the application authority. Just like the Method 2, right click the “Run Application File”, select “Compatibility” tab on the “Property”. In the compatibility mode, check the checkbox for “Run this program with compatible mode” and click OK button. After setup, the application runs with administrator authority, and operates in the same way as the Method 2.

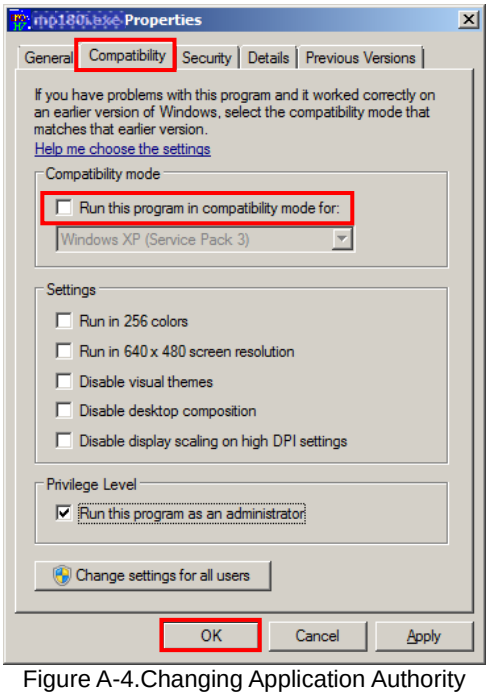


Figure A-4.Changing Application Authority
(Common for Windows Vista/7/8)

A-2. Measuring PV Module Backside Temperature

How to attach a Thermocouple:

When using thermocouple outdoors, the thermocouple must be waterproof. Continuously using a thermocouple in a wet condition will cause electrical spectaculars and may not be able to use the thermocouple in the end. To make a good thermal contact the thermocouple needs to be properly attached to the backside of the module.

We recommend the following:

1) Insulate the thermocouple cable end using an epoxy adhesive or heat shrink tube.
2) Place the thermocouple cable end in the center of the PV module and temporary attach the cable with tape.

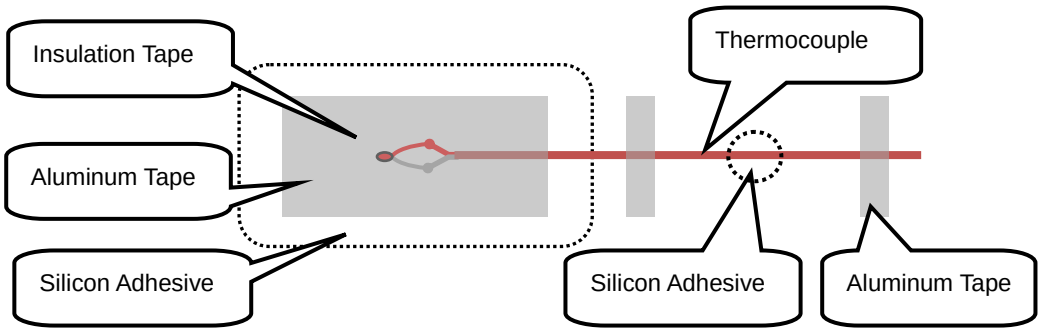


Figure A-5. Attaching Thermocouple

3) On top of the temporary attached thermocouple, put aluminum tape with good thermal conductivity properties, which is heat resistance and has long life bonding properties. Cover a wide area to improve the bonding strength.
4) On top of the aluminum tape, treat the surface with silicon adhesive for waterproof. However, make sure the silicon adhesive is applied with thin layer of 2~3mm so that it will not retain heat. (If butyl rubber type waterproof aluminum tape, waterproof treatment with silicon adhesive is not necessary.)
5) To avoid risks of cable breaking due to wind blowing, fasten rest of the thermocouple cable with silicon adhesive or aluminum tape in several places.

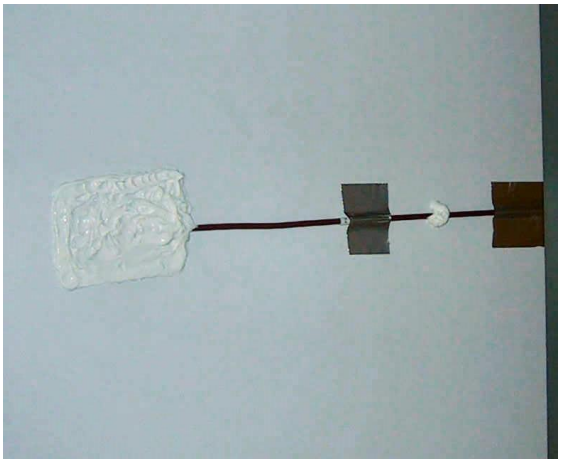


Figure A-6. Attached with Silicon Adhesive

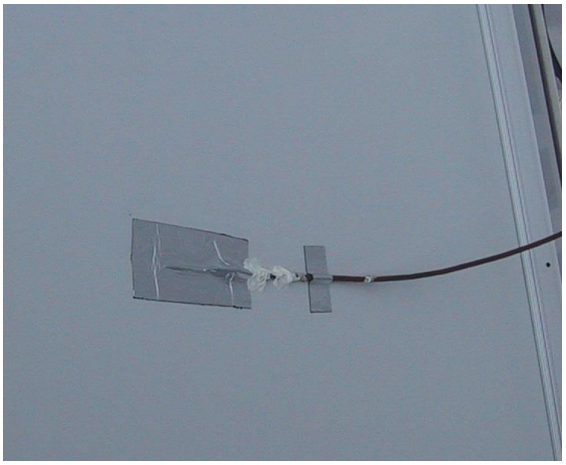


Figure A-7. Attached with Aluminum Tape (Butyl Rubber Type)

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