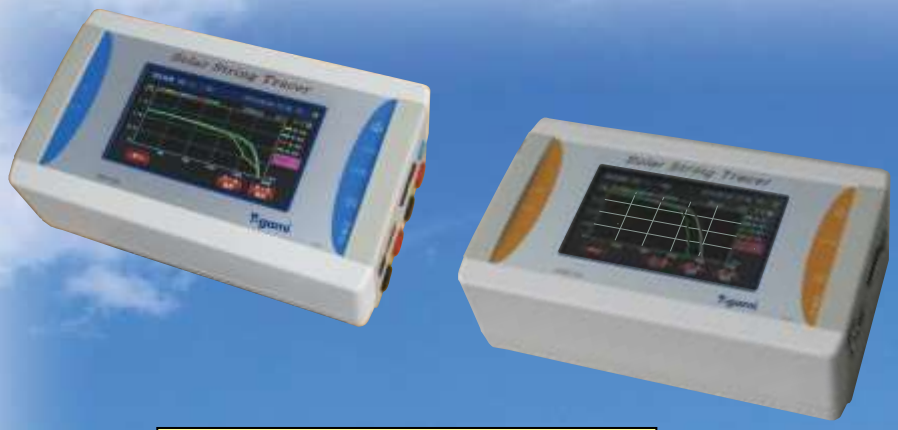
PV Doctor

Togami

For the inspection and fault location of the photovoltaic modules

Photovoltaic Module Fault Detectors



String Tracer (I-V curve tracer)

Cell Line Checker (Fault module detector)

Feb. 2016
Catalog No. C0234c

Togami Electric Mfg.Co.,Ltd.

PV Doctor

T·gami has solutions!

Do you have any of the following issues in your PV system?

- I don't know how to invest the cause of declining the power output.
- I don't know which tool is suitable for the detailed module inspection.
- There is no tool to check the photovoltaic module condition.
- I'm looking for a tool which is cheap and easy to use.

If you have these issues and leave them unsolved, you may have the unexpected troubles, such as...

- ◆ Unexpected decline of power output which may lead to the compensation issue of electricity sales to the grid.
- ◆ Accidents, such as fire, caused by photovoltaic module, etc.

Japan Photovoltaic Energy Association <Guideline for maintenance and inspection of small-scale photovoltaic generation system>

Periodic Inspection

- Visual check (breakage, etc.)
- Power output check (Inverter monitoring)
- Measurement of open-circuit voltage (Voc)
- Measurement of short-circuit current (Isc)
- Measurement of insulation resistance

Guideline recommends the I-V curve measurement by the curve tracer other than Voc measurement.

Daily Inspection

- Visual check (breakage, etc.)
- Power output check (Inverter monitoring)

PV Doctor Series solve your problem!

Preventive inspection for “safety assurance” and causal investigation for “electricity output declines”

User

Decline in electricity output
(Decline in revenue from selling electricity to the grid)

Complaints (inquiries)

First Step

- **Measurement of open-circuit voltage** — PV Doctor String Tracer
- **Visual check (breakage)**
- **Measurement of insulated resistance**

Second Step (Detailed Inspection)

- **String output check (I-V curve measurement)** — PV Doctor String Tracer
- **Detection of photovoltaic module fault point** — PV Doctor Cell Line Checker

Causal investigation will bring the following benefits to each party!

PV home builders, etc.

Even if any failure, such as decline in electricity output, occurs **within the warranty period**, only the defective module(s) should be changed. Therefore, warranty expense can be minimized.

PV contractors, Electrical contractors, etc.

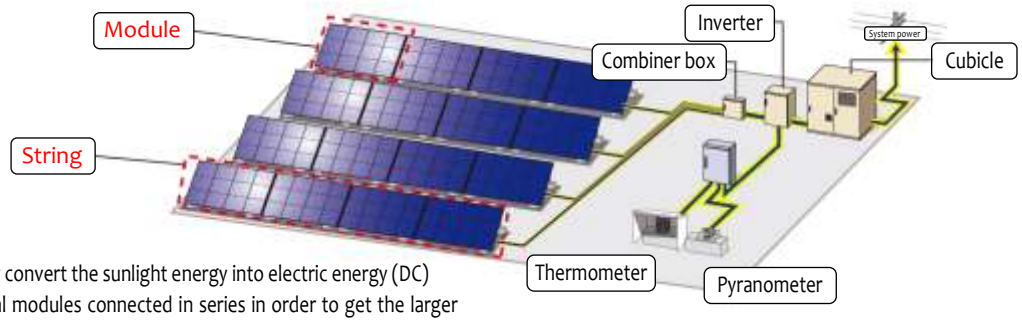
- Fault point identification will lead to the advantageous negotiation with both user and manufacturer.
- New business expansion in the maintenance and inspection may differentiate from the competitors.

User

Even if any failure, such as decline in electricity output, occurs **after the warranty period**, you may only exchange the defective module(s), which enables to minimize the maintenance expense.

“Enhance safety” and “maintain relevant power output” as power generation system.

Photovoltaic power generation system



Module : Panel to directly convert the sunlight energy into electric energy (DC)

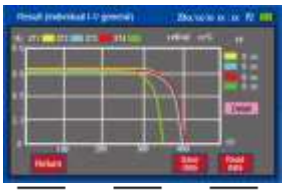
String : A unit of several modules connected in series in order to get the larger power output

Features of PV Doctor from T·gami and comparison with other equipment

Fault String Detection

Others	String Tracer (both individual and simultaneous measurement)
Inspection of PV system at construction and completion & Periodic and daily inspections	
System check prior to the measurement	Confirm the number of modules per string is same.
Set pyranometer and thermometer to PV system or measuring equipment.	Speedy & Easy! → Not necessary for relative comparison of strings
Measure I-V curve of one or two strings.	Measure I-V curves up to four strings.
Tens of second/string	Speedy! → Approx. 1 sec/string
Input the panel data into the measuring equipment (Some makers may not indicate in the module.) STC conversion by the equipment or PC software	Speedy & Easy! → No need of STC conversion because of the relative comparison of four strings in String Tracer
String condition check	

Combiner box



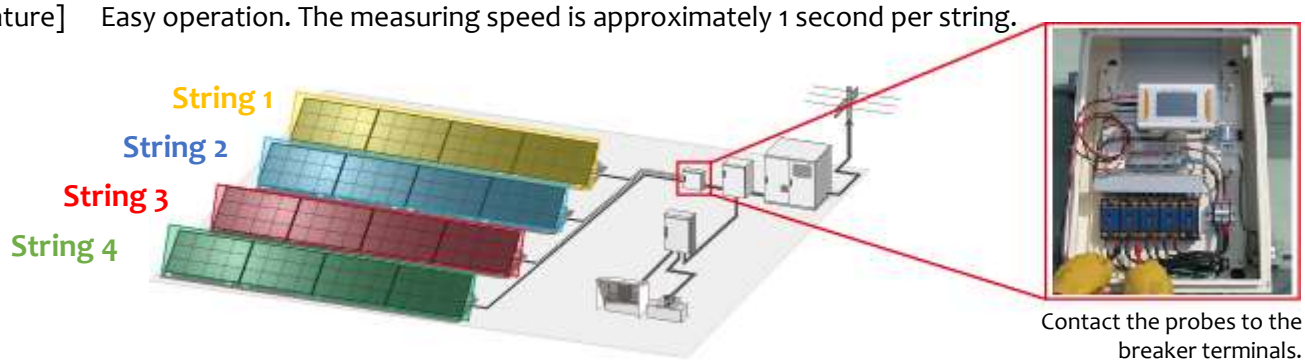
Fault Module Detection

Others	Cell Line Checker
Fault string investigation	
Connect the equipment to the breaker of fault string.	Connect the transmitter to the breaker of fault string.
Detection & Location You may not be able to conduct the correct detection if... (1) the modules are connected in parallel. (2) there are several open circuit point. (3) the amount of solar radiation is not enough. (4) there is any shade on the modules.	Accurate! → Fault point location with receiver (1) can be used in either connection (series or parallel). (2) can locate the open-circuit or loose connection points. (3) can be used if the amount of solar radiation is at least 200W/m². (4) can locate the fault accurately even though there is shade.
Fault module, loose connection point detection, etc.	

Combiner box

String Tracer (I-V curve tracer)

[Function] Fault module can be detected by the relative comparison of up to 4 strings in a screen.
[Feature] Easy operation. The measuring speed is approximately 1 second per string.



Contact the probes to the breaker terminals.

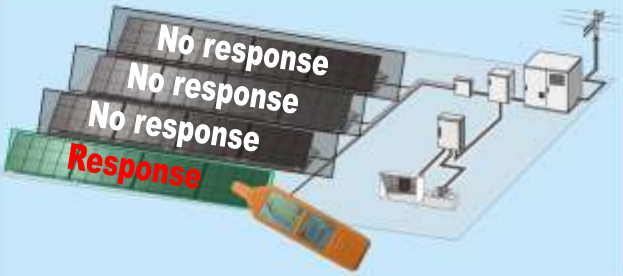
[Screen]

String 1 String 2 String 3 String 4

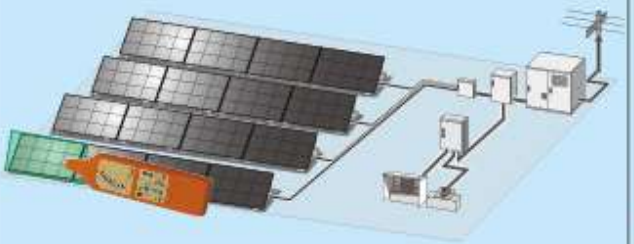
Cell Line Checker (Fault module detector)

[Function] (1) Module configuration per string
(2) Fault point location
[Feature] Fault module can be identified.

(1) Checking the module configuration per string

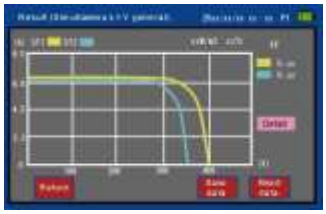
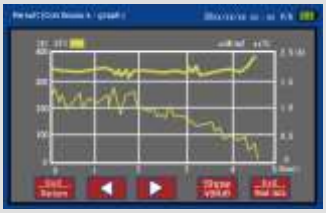
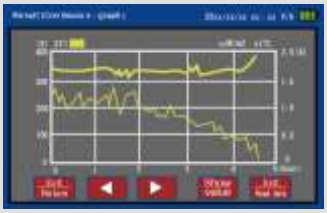
Connect the transmitter to the breaker terminal of the string.	On the surface of modules connected to the signal input string, receiver detects the signal and shows response by light and sound.	Confirm the module configuration of the string.
		

(2) Locating the fault point

Connect the transmitter to the breaker terminal of the fault string.	Conduct the fault location on the fault string.	Confirm the fault module.
		 On the surface of normal module, receiver detects and shows the signal input from transmitter by light and sound. However, on the fault point, no signal can be detected. * For bypass diode open-circuit check, you need a special procedure.

PV Doctor

String Tracer (I-V curve tracer)

Type		SPST-A1-Y1	SPST-A2-Y1
Voltage measuring Range		[General (c-Si, CIS, etc.)] 20.0Vdc to 700.0Vdc [Hybrid (Si-HJT)] 20.0Vdc to 600.0Vdc	[General (c-Si, CIS, etc.)] [Hybrid (Si-HJT)] 20.0Vdc to 1000.0Vdc
Current measuring Range		[General (c-Si, CIS, etc.)] 0.5Adc to 10.0Adc [Hybrid (Si-HJT)] 0.5Adc to 7.0Adc	[General (c-Si, CIS, etc.)] [Hybrid (Si-HJT)] 0.5Adc to 10.0Adc
Power measuring Range		[General (c-Si, CIS, etc.)] 10W to 4900W [Hybrid (Si-HJT)] 10W to 2900W	[General (c-Si, CIS, etc.)] [Hybrid (Si-HJT)] 10W to 8000W
Rated power voltage		[AC adopter] 100V to 240Vac, 50/60Hz [Size AA battery×4] 6.0Vdc (Range: 4.8 to 7.2Vdc)	
Accuracy		Voltage:±1%rdg ±5dgt Current:±1%rdg ±5dgt Power:±2%rdg ±5dgt	
Dimensions		195×115×70mm	
Weight		690g (excl. batteries)	600g (excl. batteries)
Measuring speed		Approx. 100ms (per string)	
Functions	Individual I-V curve measurement	 Measure and display up to 4 strings	
	Simultaneous I-V curve measurement	 Measure and display up to 4 strings	 Measure and display up to 2 strings
	String voltage/current Measurement * Clamp CT is necessary for the measurement.	 Measure up to 4 strings	 Measure up to 2 strings
	Voltage test		(Voc measurement)
	STC conversion *1	N/A (Accompanied PC software can conduct STC conversion.)	String Trace main unit can conduct STC conversion.
Detailed specification page		7 to 10	

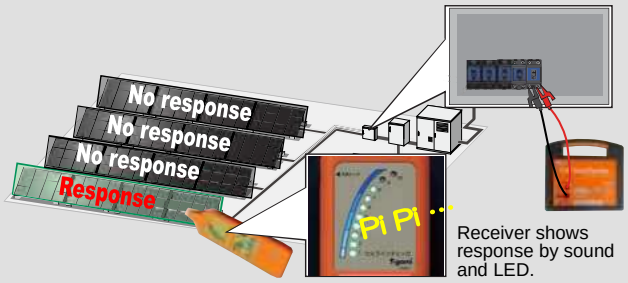
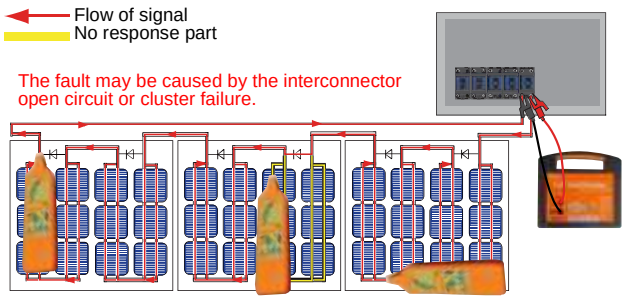
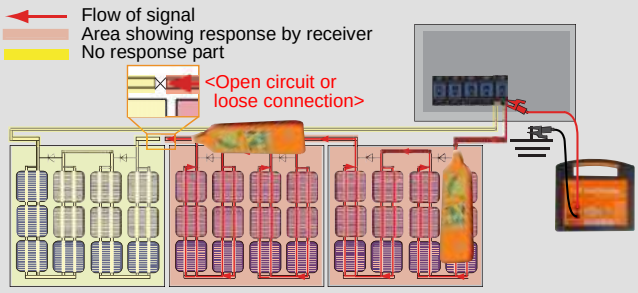
*1 Pyranometer and thermometer (optional) is necessary for STC conversion.

PV Doctor

Cell Line Checker (Fault module detector)

Transmitter

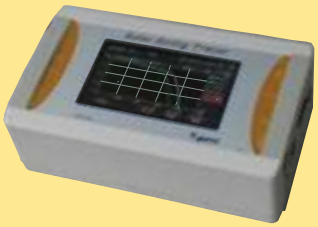

Receiver

Type			SPLC-B-Y	
Transmitter	Rated power voltage		9.0Vdc(Range: 6.5 to 9.0Vdc)	
	Applicable voltage range	Magnetic field mode	15.0Vdc to 1000.0Vdc	
		Electric field mode	0V to 1000.0Vdc (0V for open-circuit fault detection)	
	Detecting method		Current consumption (Magnetic field mode)	
			Signal input (Electric field mode)	
	Signal frequency		5kHz	
	Dimensions		205 x 222 x 80mm	
	Weight		Approx. 1000g (with battery)	
Receiver	Rated power voltage		9.0Vdc (Range: 6.5 to 9.0Vdc)	
	Receiver sensitivity level		Select from 5 levels. Each level has 5 level adjust from -20% to +20%.	
	Receiver display		Receiving level display: Flashing 10 green LEDs Alarm sound synchronized with LED flash	
	Dimensions		235 x 60 x 30mm	
	Weight		Approx. 160g (with battery)	
Functions	Phenomenon	Function	Procedure	
			CB	Transmitter / Response of receiver
	No system map and no information on configuration per string	[Magnetic field mode] Configuration check of the string	Off	Combiner box. Connect to breaker for string configuration check.  Receiver shows response by sound and LED.
	Output drop e.g.) cluster failure e.g.)interconnector open-circuit	[Magnetic field mode] Fault point location		Combiner box. Connect to breaker of fault string. 
	Voc=0 by I-V curve tracer or tester	[Electric field mode] Open-circuit between modules and loose connection, etc.		Combiner box. Connect plus terminal to breaker and minus terminal to earth. 
Detailed specification page			11 to 14	

PV Doctor String Tracer

(I-V curve tracer)

SPST-A1-Y1



SPST-A2-Y1

☆Displaying 4-string I-V curves in a screen

☆Easy determination of faulty module by the relative comparison of strings

☆Usable at the installation inspection

■ Purpose

Electrical failure of module at string level can be detected in the residential, industrial, and utility-scale PV power generation systems.
Installation inspection and maintenance check can be conducted effectively.

■ Features

- **Four measuring modes: Individual I-V measurement, simultaneous I-V measurement, string voltage/current measurement, and voltage test**
- **Relative comparison of I-V curves of each string makes the performance check quick and easy.**
- **Measured data can be saved on SD card and used on PC.**

***The data management software is Windows 7 compatible.**

- **For relative comparison among strings, pyranometer and thermometer are not necessary.**
- **For STC conversion, pyranometer and thermometer (options) are necessary.**

■ Functions

Function	Detail of function
Individual I-V curve measurement CB in the combiner box shall be “OFF”.	String I-V curve can be measured by 1 channel at a time. Measured results, up to 4 strings, can be displayed in a graph, and each string condition can be compared relatively. Needle type probes for 1 channel shall be contacted with the terminals of a string at a time; therefore, there is no need to clamp the leads to the terminals.
Simultaneous I-V curve measurement & String condition check CB in the combiner box shall be “OFF”.	String I-V curves up to 4 strings for SPST-A1-Y1 and 2 strings for SPST-A2-Y1 can be measured at a time, and measured data can be saved. All measured results (max. 4 strings for SPST-A1-Y1 and 2 strings for SPST-A2-Y1) can be displayed in a graph, and strings can be compared relatively to check the conditions. V_{OC} is measured to judge whether the relative comparison of I-V curves is effective by checking the string circuit failure, number of string modules, etc.
String voltage/current measurement CB in the combiner box shall be “ON”, and inverter shall be under operation.	In a certain intervals, voltage and current of the strings (max. 4 strings for SPST-A1-Y1 and 2 strings for SPST-A2-Y1) can be measured at a time, and the data can be saved. ・ Measuring item (voltage/current) and strings can be selected. ・ Continuous measurement up to 7 days is possible. Results can be displayed in either “numerical data” or “graphs” in the screen. * When continuous measurement mode is selected, make sure to use the accompanied AC adapter.
Voltage test (V_{OC} measurement)	Open circuit voltage of a string can be measured.

■ Specifications

Voltage measuring range	SPST-A1-Y1	[General (c-Si, CIS, etc.)] *1 20.0V to 700.0Vdc [Hybrid (Si-HJT)] *1 20.0V to 600.0Vdc
	SPST-A2-Y1	20.0V to 1000.0Vdc
Current measuring range	SPST-A1-Y1	[General (c-Si, CIS, etc.)] *1 0.5A to 10.0Adc [Hybrid (Si-HJT)] *1 0.5A to 7.0Adc
	SPST-A2-Y1	0.5A to 10.0Adc
Power measuring range	SPST-A1-Y1	[General (c-Si, CIS, etc.)] *1 10W to 4900W [Hybrid (Si-HJT)] *1 10W to 2900W
	SPST-A2-Y1	10W to 8000W
Rated power voltage	[AC adopter] 100V to 240Vac, 50/60Hz [Size AA battery×4] 6.0Vdc (Range: 4.8 to 7.2Vdc) *2, *3	

Accuracy	Voltage: ±1%rdg ±5dgt Current: ±1%rdg ±5dgt Power: ±2%rdg ±5dgt	
Measuring points	100 points (per string)	
Measuring time	Approx. 100ms (per string) *4	
Max. continuous use (LCD brightness set: +10) *5	- LCD display on: Approx. 9 hours - Touch screen operation: Approx. 6 hours - I-V measurement: Approx. 4 hours	
Savable data	500 files/day x 100 days = Max. 50,000 files Manage the data with the software in case the number of files exceeds the above. Delete the data in the SD card.	
Other functions	Automatic power off (5 minutes)	
Dimensions	195×115×70mm	
Weight	SPST-A1-Y1	690g (excl. batteries)
	SPST-A2-Y1	600g (excl. batteries)
Accessories	Clamp probe, Needle probe: 1set, I-V test lead, SD card *6, AC adapter, Instruction manual, Shoulder belt, Size AA battery: 4, and Carrying case	

*1 Measuring ranges are different depending on the module types.
*2 If battery level is decreased, measurement will stop because the inrush current causes the instant voltage drop.
*3 Battery can be NiMH rechargeable battery or alkaline battery.
*4 I-V curve measurement (individual mode) takes 3.1 sec to measure a string: 1sec for probe contact check + 100ms for I-V measurement + 2 sec for the interval until the next measurement
I-V curve measurement (simultaneous mode) needs 5 sec interval between measurements. Within 5 sec after a string measurement, start selection button will not be shown on the screen.
*5 Hours are based on the continuous use of full charged four(4) 1900mAh NiMH batteries.
*6 SD card contains the data management software and software installation manual.

■ Accessories

Clamp probes
(SPST-A1-Y1: 4 sets)
(SPST-A2-Y1: 2 sets)

Needle probes

I-V test leads
(SPST-A1-Y1: 4 sets)
(SPST-A2-Y1: 2 sets)

AA alkaline batteries

AC adapter

SD card

Carrying case

■ Options

Clamp sensor

Type	SPST-A-F1
Measuring range (accuracy)	0 to 10.0A (±1%rdg ±5dgt)
Length of cable	1.5 meters
Weight	80g/unit

Pyranometer & thermometer

Type	SPST-A-F2
Measuring range (accuracy)	0 to 1200W/m^2(±5%rdg ±5dgt) -20 to 100°C(±1%rdg ±2dgt)
Length of cable	10 meters
Dimensions	Pyranometer: 40x100x80(mm) Thermometer: 50x70x6(mm)
Weight	Pyranometer: 700g Thermometer & cable: 720g

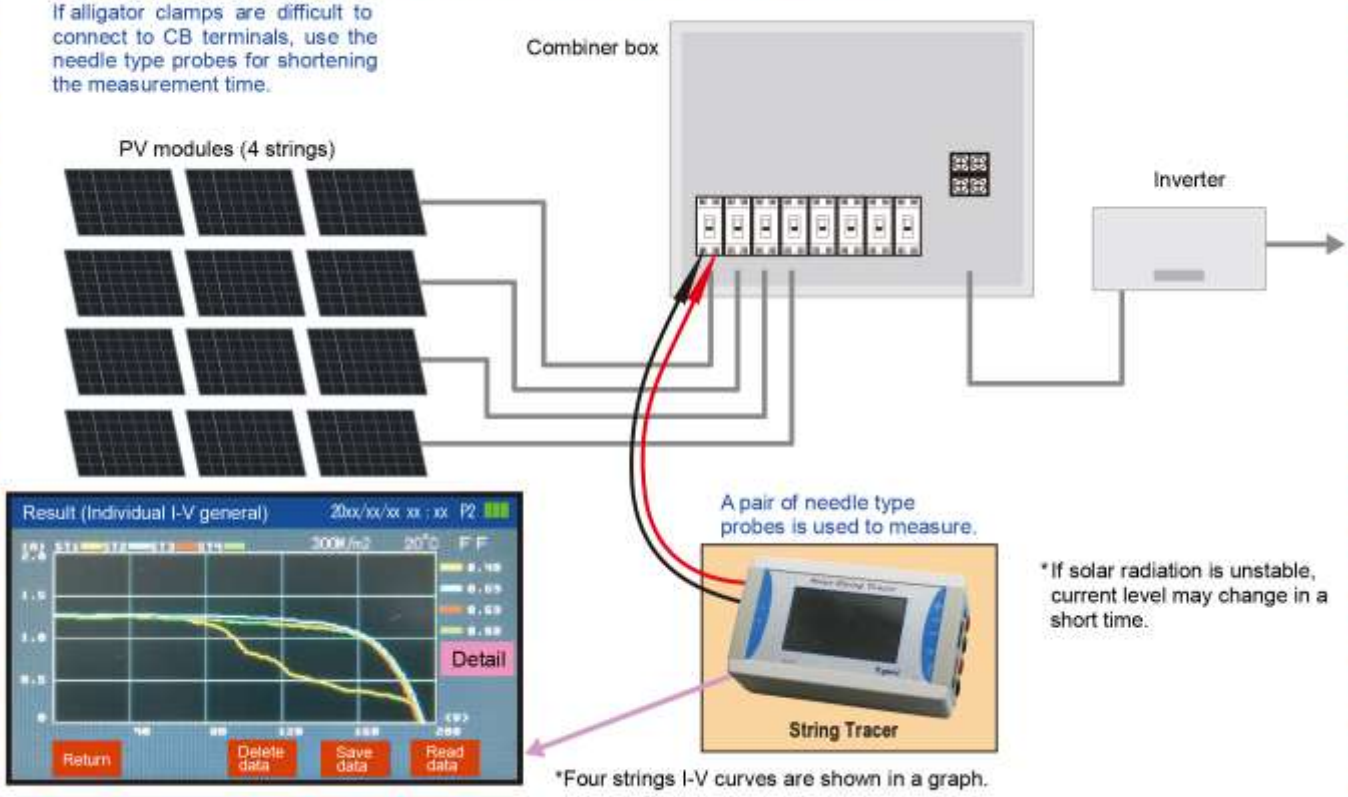
Magnetic test probe

Type	SPST-A-F4
Length of cable	1.5 meters
Withstand voltage	1000V CATIII

■ I-V curve measurement modes

(1)Individual mode (CB in combiner box: OFF)

If alligator clamps are difficult to connect to CB terminals, use the needle type probes for shortening the measurement time.

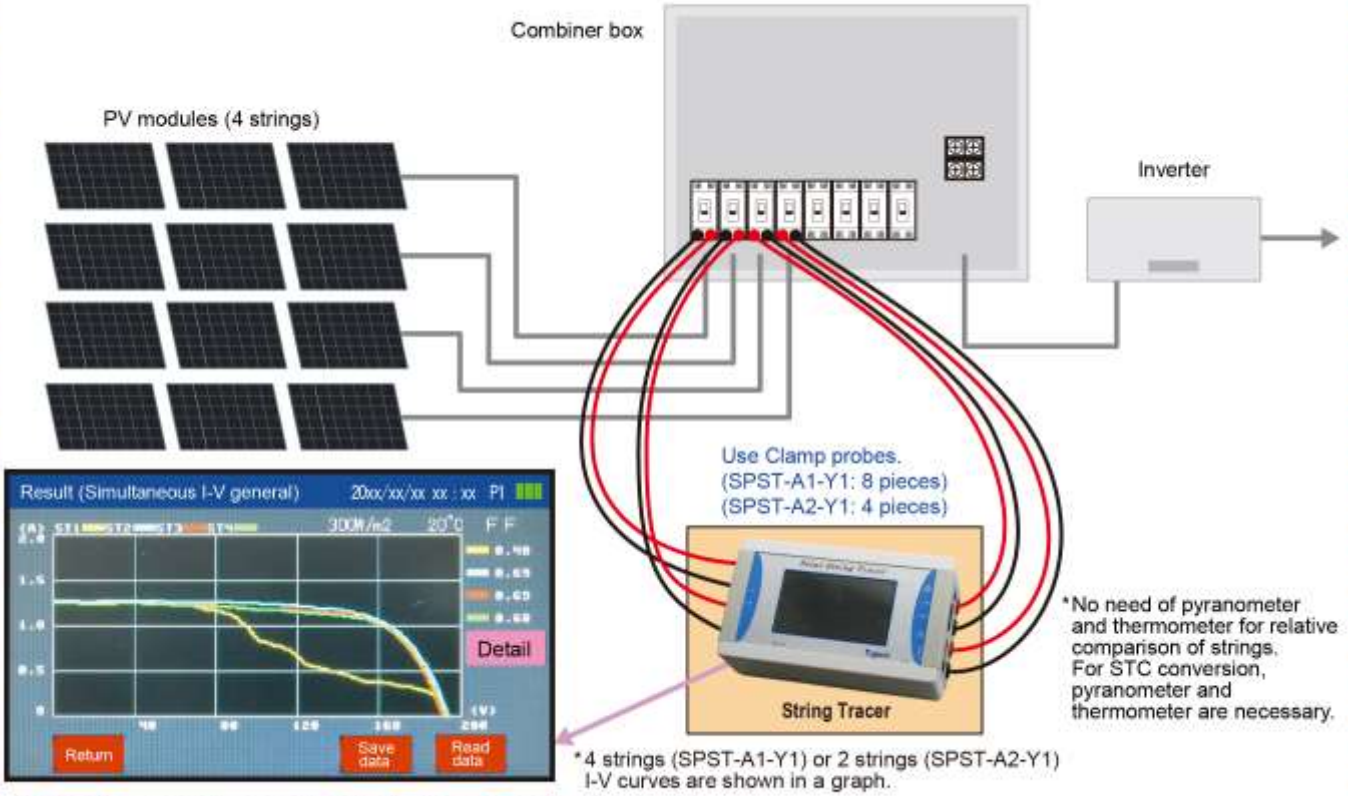


*If solar radiation is unstable, current level may change in a short time.

*Four strings I-V curves are shown in a graph.

If **Detail** is selected, measured results: V_{oc} (V) open-circuit voltage, I_{sc} (A) short-circuit current, P_{max} (W) Maximum power, and FF value are shown.

(2) Simultaneous mode (CB in combiner box: OFF)



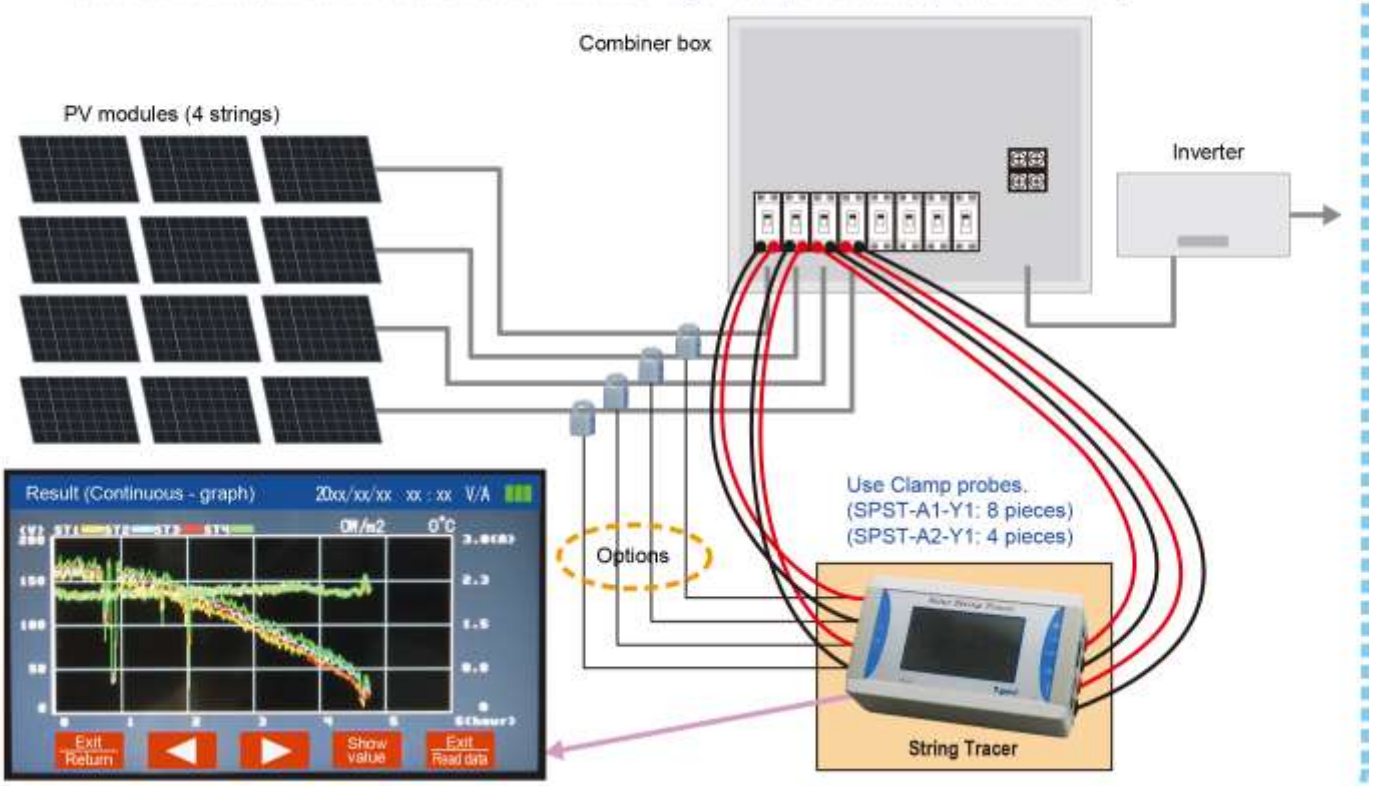
*No need of pyranometer and thermometer for relative comparison of strings. For STC conversion, pyranometer and thermometer are necessary.

*4 strings (SPST-A1-Y1) or 2 strings (SPST-A2-Y1) I-V curves are shown in a graph.

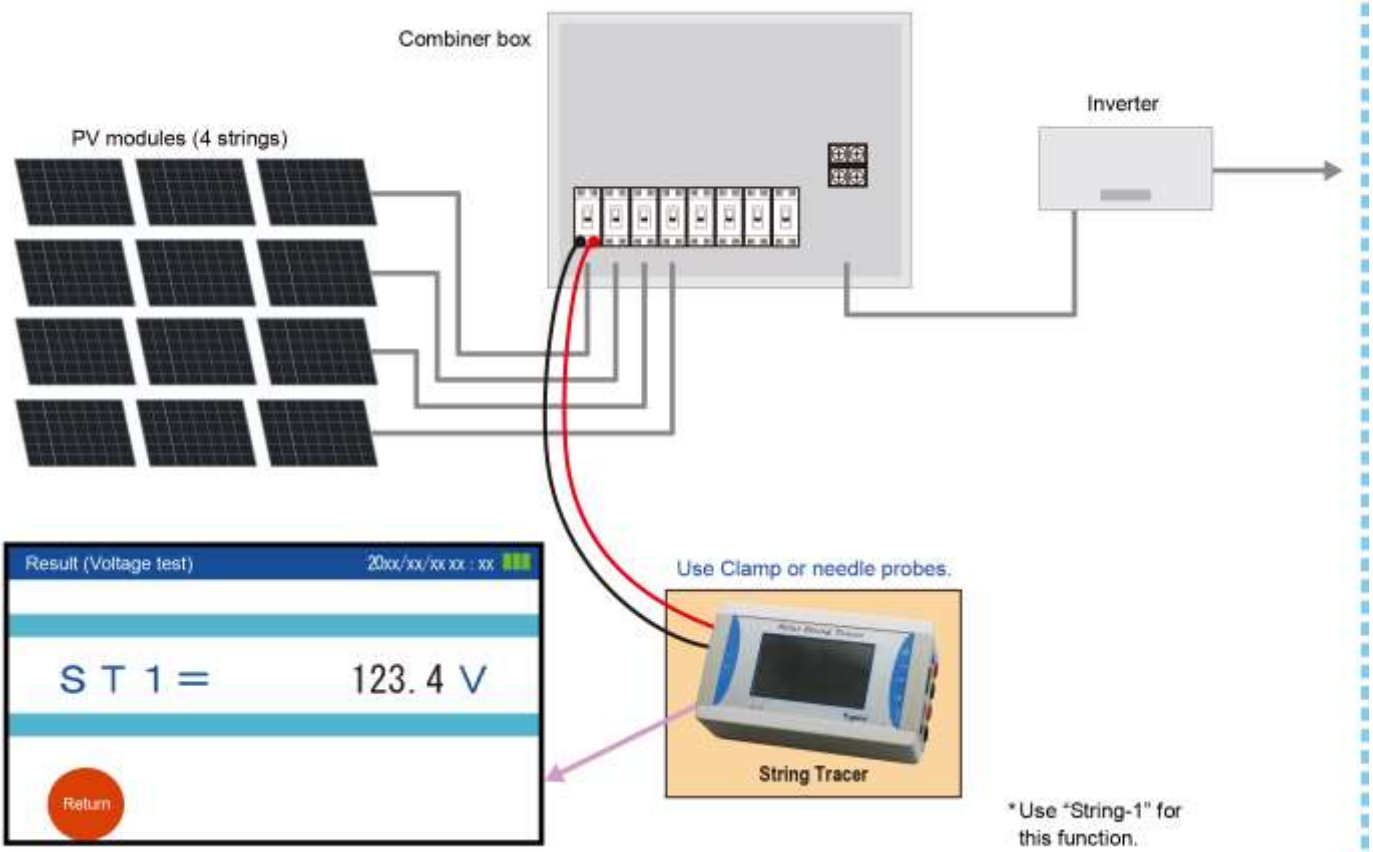
If **Detail** is selected, measured results: V_{oc} (V) open-circuit voltage, I_{sc} (A) short-circuit current, P_{max} (W) Maximum power, and FF value are shown.

(3) String voltage/current measurement
(CB in combiner box: ON & Inverter: operation)

In a certain intervals, voltage and current of the strings (max. 4 strings for SPST-A1-Y1 and 2 strings for SPST-A2-Y1) can be measured at a time, and the data can be saved for maximum 7 days. * Clamp CT sensors (option) are necessary.



(4) Voltage test (Open-circuit voltage measurement)



PV Doctor

Cell Line Checker

(Fault module detector)

SPLC-B-Y

☆String configuration can be identified.
☆Fault point (wiring failure) can be detected.
☆Shadow on the module will not affect the results.
☆Installation inspection is effectively conducted.
☆Detection can be conducted on the rear surface of modules.

■ Purpose

Detect the string configuration and fault module and cell at the time of PV systems maintenance.

■ Features

- **Cluster failure and bypass diode open circuit can be easily detected.** **[Magnetic field mode]**
- **Open circuit or loose connector between modules can be detected.** **[Electric field mode]**
- **Detection can be conducted under the cloudy weather.**
- **Cell interconnector failure can be detected; therefore, module power output reduction is possibly predicted.** **[Magnetic field mode]**

[Magnetic field mode]
- Identification of a string configuration
- Detection of fault modules, clusters, and cells
- Detection of the fault bypass diode in a module

[Electric field mode]
- Detection of the broken/disconnected wire between modules
- Detection of the connecter between modules having fault continuity

Quality of installation of PV system can be enhanced because Cell Line Checker can detect the wiring and connector failures between modules.

■ Detailed functions depending on module fault causes

Phenomenon	Details of failure phenomenon	Causes	Applicable functions
Decline of power output	**No output from the string** *Series circuit in a string is disconnected.	(1) Broken/loose connector or disconnected wire between modules (2) Damaged bypass diode and disconnected busbar, disconnected interconnector, or damaged cell	[Magnetic field mode] ・Detection of fault module ・Detection of wiring failure between modules [Electric field mode] ・Detection of connector having defective continuity or wiring disconnection
	Declined output from the string *Series circuit in module is disconnected.	(1) Fault busbar (2) Complete interconnector disconnection (3) Cell damage (severe)	[Magnetic field mode] ・Detection of fault module ・Detection of fault cluster in the fault module ・Detection of fault cell in the fault module ・Detection of fault bypass diode
	Declined output from the string *Part of series circuit in module is damaged.	(1) Disconnection of one of interconnectors (2) Cell damage (light)	

■ Specifications

【Transmitter】

Rated power voltage	9.0Vdc (Range: 6.5 to 9.0Vdc) *1	
Applicable voltage range	Magnetic field mode	15.0Vdc to 1000.0Vdc
	Electric field mode	0V to 1000.0Vdc (0V for connection fault detection)
Detecting method	Current consumption (Magnetic field mode) Signal input (Electric field mode)	
Signal frequency	5kHz	
Display	Green or Blue LED by flashing or ON	
Dimensions	205 x 120 x 50mm	
Weight	Approx. 1000g (with battery)	
Other functions	Auto-power off *2	

【Receiver】

Rated power voltage	9.0Vdc (Range: 6.5 to 9.0Vdc) *1
Receiver sensitivity level	Select from 5 levels. Each level has 5 level adjust from -20% to +20%.
Receiver display	Receiving level display: Flashing 10 green LEDs Alarm sound synchronized with LED flash
Built-in sensor	Coil sensor: 1 Electrode sensor: 1
Dimensions	235 x 60 x 30mm
Weight	Approx. 160g (with battery)
Other functions	Auto-power off and Silent mode *3

*1 One 9V battery is used. (Manganese or alkaline battery)
*2 [Magnetic field mode] The power is automatically turned off when input voltage gets less than 10V and non-operated duration exceeds 10min.
[Electric field mode] The power is automatically turned off when non-operated duration exceeds 2hr.
*3 The power is automatically turned off when no signal input and non-operated duration continues 10min.

■ Accessories

Clamps and test leads

Rubber sheet

Carrying case

■ Options

Rod sensor

Type	SPLC-B-F1Y
Built-in sensor	2 coil sensors (horizontal & vertical)
Rod length when detecting	Max. 2meters (0.92meter when storing)
Dimensions when storing	920(H)×70(W)×60(D) (mm)
Weight	Approx. 850g (without receiver)
Other function	Angle adjustable sensor head
Accessories	Storage bag and shoulder belt

Needle probe

Type	SPST-A-F3
Withstand voltage	1000V CATIII

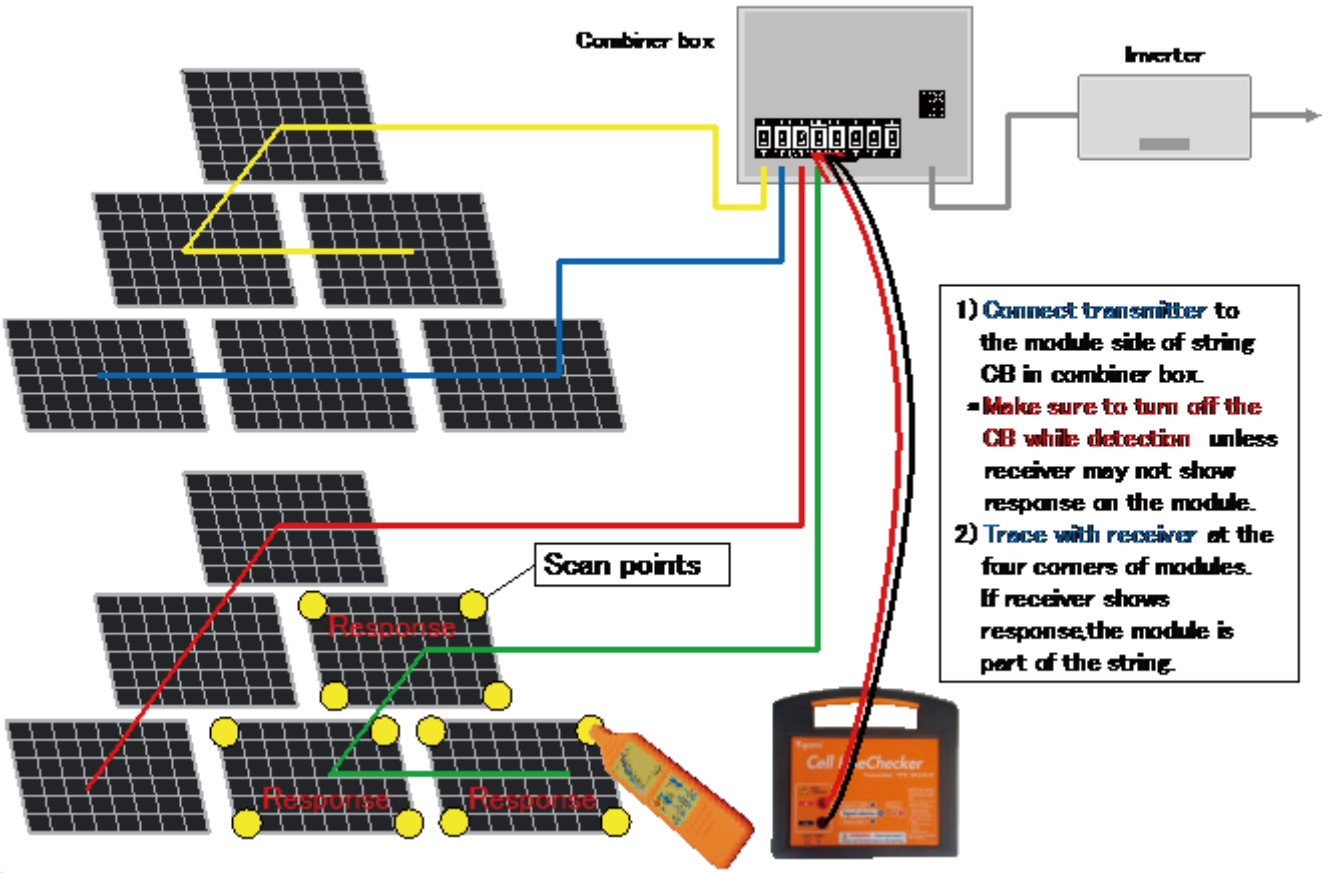
Magnetic test probe

Type	SPST-A-F4
Length of cable	1.5 meters
Withstand voltage	1000V CATIII

■ Example of detection

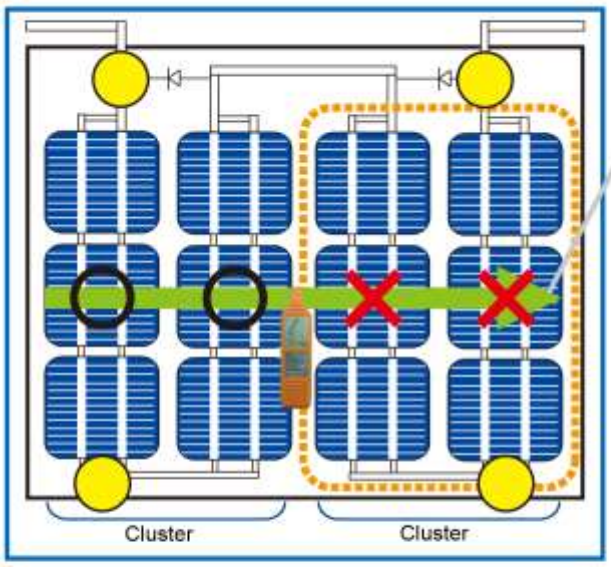
<String configuration check>

[Magnetic field mode]



<Detection of fault (non-generating) module>

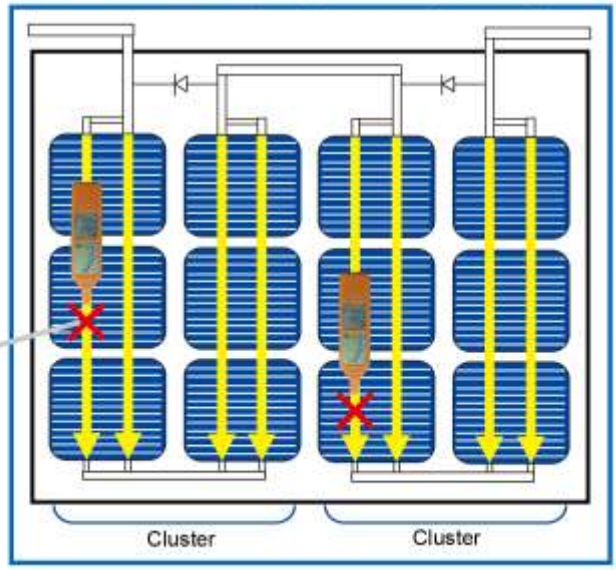
[Magnetic field mode]



1) Trace with receiver across the clusters in a module. If there is any module which does not show any response with receiver, the module/cluster has failure.

* If the module has 2 clusters, trace the module at the four corners. If there is any corner which does not show response, the module/cluster has failure.

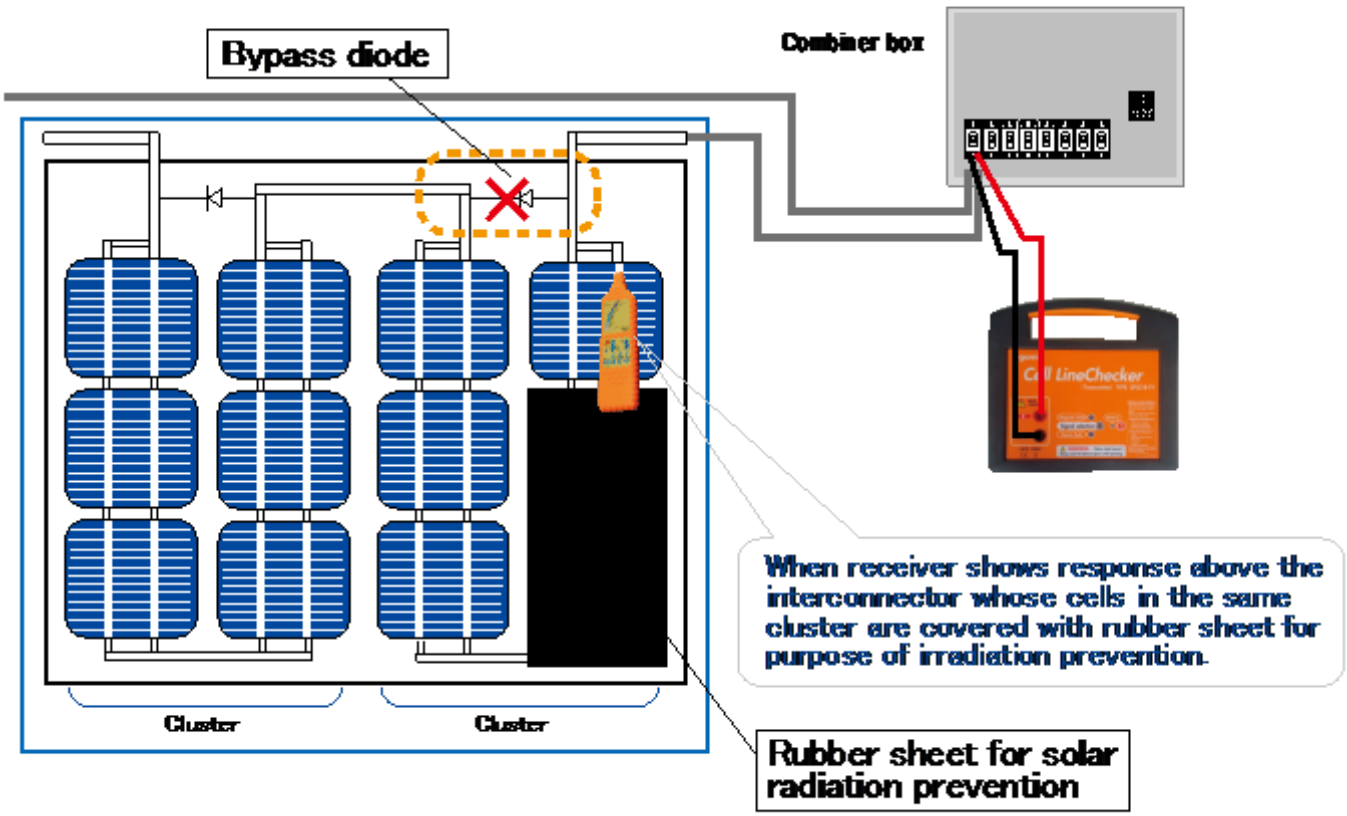
<Detection of fault (low-generating/heating) cell>



1) Trace along the interconnectors. If there is any interconnector which does not show any response, the interconnector has failure.

<Detection of fault module (bypass diode open circuit failure)>

[Magnetic field mode]

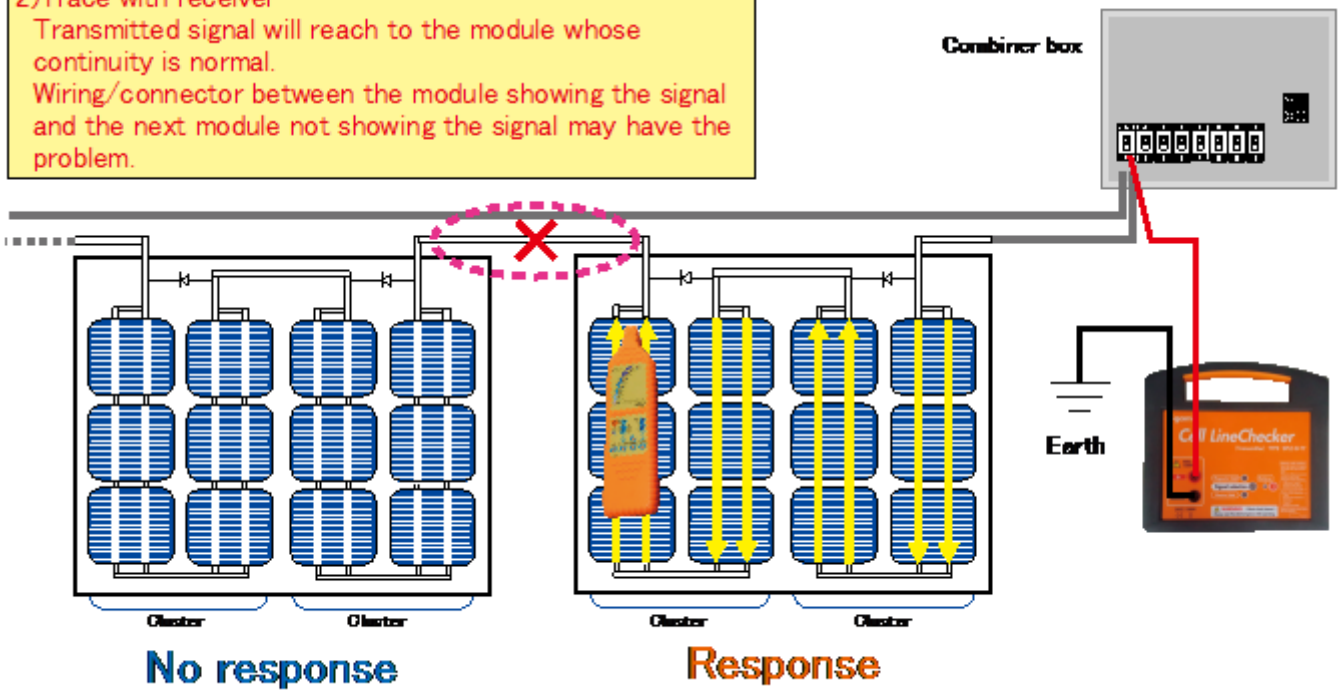


<Detection of wiring/connector failure between modules>

[Electric field mode]

1)Connect transmitter
Connect the plus terminal of transmitter to one of the string CB terminals and the minus terminal to the earth.

2)Trace with receiver
Transmitted signal will reach to the module whose continuity is normal.
Wiring/connector between the module showing the signal and the next module not showing the signal may have the problem.



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