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**Power conditioner for small photovoltaic
power generating system**

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Foreword

This Japanese Industrial Standard has been revised by the Minister of Economy, Trade and Industry, through deliberations at the Japanese Industrial Standards Committee in accordance with the Industrial Standardization Act. This edition replaces the previous edition (**JIS C 8980** : 2009), which has been technically revised, and **JIS C 8962** : 2008, which has been withdrawn.

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Power conditioner for small photovoltaic power generating system

1 Scope

This Japanese Industrial Standard specifies the performance evaluation and test methods for stand-alone power conditioners of constant AC output voltage and constant output frequency, stand-alone power conditioners of constant DC output voltage, and the utility-connected power conditioners among the power conditioners for photovoltaic power generating system (hereafter referred to as PCS) complying with **a)** and **b)** below. However, AC module is excluded.

- a) Rated output : ≥ 10 W, < 100 W
 - 1) DC input and output voltage : ≥ 30 V, ≤ 750 V
 - 2) AC output voltage : ≥ 30 V, ≤ 600 V
- b) Rated output : ≥ 100 W, < 50 kW
 - 1) DC input and output voltage : ≤ 750 V
 - 2) AC output voltage : ≤ 600 V

In this Standard, a PCS to which an accumulator device is connected refers only to those which is connected to the accumulator device on the input side. Among the components of utility-connected PCS, the utility interaction protective function and utility interaction protective device such as an islanding operation detection device are excluded. A utility-connected PCS includes those having isolated operation function.

For the component equipment combined with PCSs such as an accumulator device and various interfaces, refer to the respective individual standards.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. For standards with the year indication, only the editions of the indicated year shall be applied and the revisions (including amendments) made thereafter shall not be applied. For those without the indication of the year, the most recent editions (including amendments) shall be applied.

JIS C 1302 *Insulation resistance testers*

JIS C 6950-1 *Information technology equipment — Safety — Part 1 : General requirements*

JIS C 8303 *Plugs and receptacles for domestic and similar general use*

JIS C 8905 *General rules for stand-alone photovoltaic power generating system*

JIS C 8960 *Glossary of terms for photovoltaic power generation*

JIS C 8961 *Measuring procedure of power conditioner efficiency for photovoltaic systems*

JIS C 60068-1 *Environmental testing — Part 1 : General and guidance*

JIS C 60068-2-38 *Environmental testing — Part 2-38 : Tests — Test Z/AD : Composite temperature/humidity cyclic test*

JIS Z 8732 *Acoustics — Determination of sound power levels of noise sources using sound pressure — Precision methods for anechoic and hemi-anechoic rooms*

IEC 60990 : 2016 *Methods of measurement of touch current and protective conductor current*

3 Terms and definitions

For the purpose of this Standard, the terms and definitions given in **JIS C 8905** and **JIS C 8960**, and the following apply.

3.1

equivalent solar irradiance

assumed solar irradiance for determination of output power capacity of a photovoltaic array simulator

3.2

multi-input type PCS

PCS having plural input circuits

3.3

rated capacity

apparent power at a PCS output end when a PCS is operated at rated capacity, rated voltage and rated power factor (unit : kVA)

3.4

rated output current

current at a PCS output end when a PCS is operated at rated capacity, rated voltage and rated power factor (unit : A)

NOTE Rated output current = Rated capacity/Rated voltage

3.5

rated power factor

power factor when a PCS performs the utility-connected steady-state operation (unit : absolute number)

NOTE The relation among rated capacity, rated output current and rated power factor is shown in Annex A.

3.6

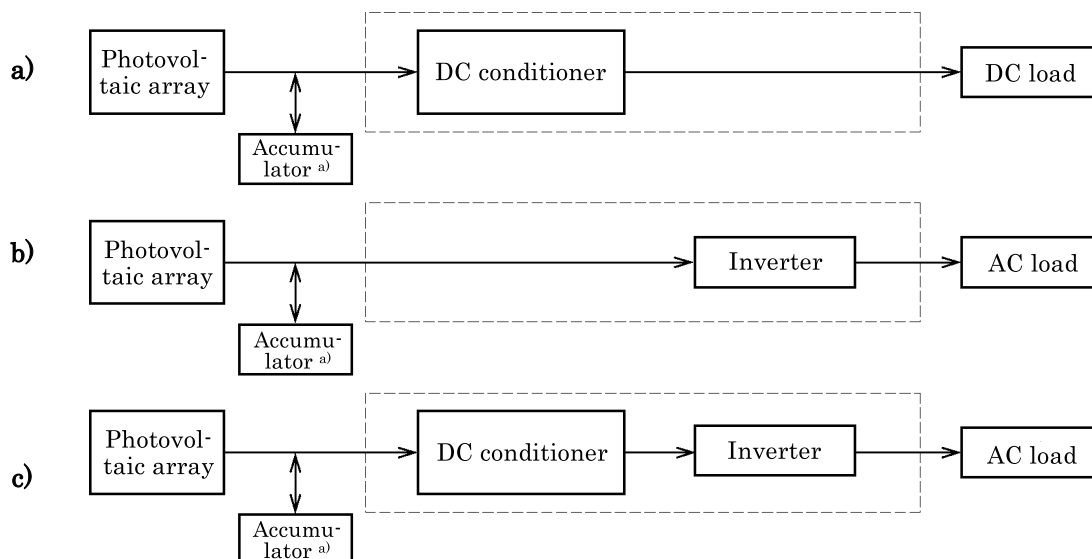
rated output

active power at a PCS output end when a PCS is operated at rated capacity, rated voltage and rated power factor (unit : kW)

4 Components

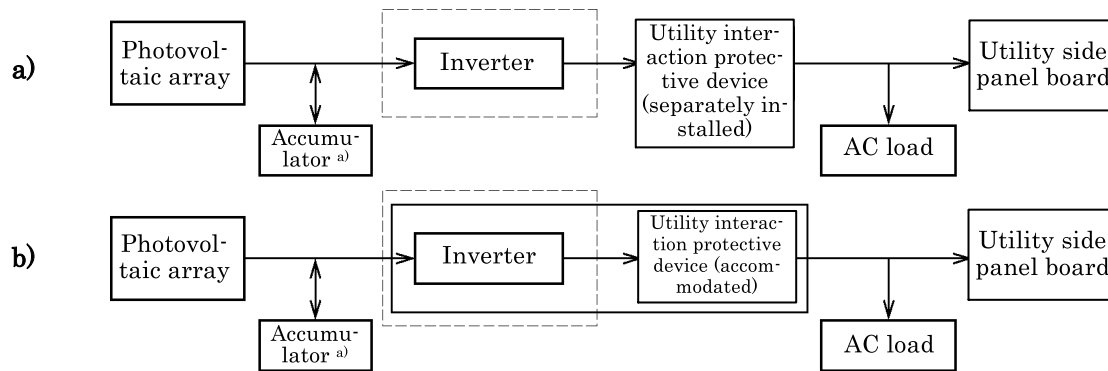
The basic constitution of a stand-alone PCS and that of a utility-connected PCS are shown in Figure 1 and Figure 2, respectively. This Standard covers items inside the broken lines in the figures.

Among the systems connected with an accumulator device, those of the constitution shown in the figures are covered.



Note ^{a)} In the case of the accumulator such as a lithium ion secondary battery which cannot be directly connected in parallel to a photovoltaic array, it contains a battery management unit (BMU) and DC-DC converter.

Figure 1 Block diagram of basic constitution of stand-alone PCS



Note ^{a)} In the case of the accumulator such as a lithium ion secondary battery which cannot be directly connected in parallel to a photovoltaic array, it contains a battery management unit (BMU) and DC-DC converter.

Figure 2 Block diagram of basic constitution of utility-connected PCS

5 Service conditions

5.1 Standard service conditions

The standard service conditions shall be as follows. Unless otherwise specified, PCSs shall be used under these service conditions.

- For PCSs installed indoors, the ambient temperature shall be within the range between 0 °C and 40 °C.
- For PCSs installed outdoors, the ambient temperature shall be within the range between –10 °C and 40 °C.
- For PCSs installed indoors, the humidity shall be within the range between 30 % and 90 %.
- PCSs shall be used in a place where altitude is not exceeding 1 000 m.

5.2 Special service conditions

Special service conditions shall be either of the following conditions. When PCSs are used under these conditions, the service conditions shall be separately specified.

- PCSs are used in a place under other conditions than those specified in 5.1.
- PCSs are used in a place where it is significantly exposed to sea breeze.
- PCSs are used in a place where there is exceptional amount of ice and snow.
- PCSs are used in a place where it is significantly exposed to sand and dust.
- PCSs are used under other special conditions.

6 Classification

The PCSs are classified according to Table 1.

Table 1 Classification of PCSs

Number	Classification	Type
1	Utility connected or not	Utility-connected type ^{a)} Stand-alone type
2	Form of output	Direct current Alternating current Both direct and alternating current
3	Output waveform	Sine wave Non-sine wave
4	Nature of load	Common load Special load
5	Electrical system of output	Single-phase two-wire system Single-phase three-wire system Three-phase three-wire system Three-phase four-wire system DC two-wire system
6	Insulation system	High frequency insulating transformer Power frequency insulating transformer Without insulating transformer
7	DC side grounded or not	Grounded Non-grounded
8	With or without accumulator device	With accumulator device Without accumulator device
Note ^{a)} Including utility-connected PCSs with isolated operation function.		

7 Performance

7.1 Insulation resistance

When tested in accordance with **13.2**, the insulation resistance shall be not less than 1 MΩ.

7.2 Dielectric withstand voltage

When tested in accordance with **13.3**, the PCS shall withstand the specified voltage for 1 min.

7.3 Lightning impulse withstand voltage

When tested in accordance with **13.4**, an air gap flashover or dielectric breakdown penetrating insulation shall not occur.

7.4 Leakage current

When tested in accordance with **13.5**, the leakage current shall be not more than the limit value.

7.5 Equipment capabilities

The equipment capabilities shall be as follows.

- a) **Maximum input voltage** When tested in accordance with **13.6 a)**, the PCS shall be free from any abnormalities.
- b) **Overload capability** When tested in accordance with **13.6 b)**, the PCS shall withstand the specified overload operation.

The overload operation shall be performed under the overload factor stated in the specifications or catalogue, with respect to the rated output, for the duration stated in the specifications or catalogue. However, the accuracy of constant AC output voltage of overload operation does not need to be guaranteed.

- c) **Instantaneous overload capability (for stand-alone type)** When tested in accordance with **13.6 c)**, the PCS shall withstand the specified load.

The overload operation shall be performed under the instantaneous overload factor stated in the specifications or catalogue, with respect to the rated output, for the duration stated in the specifications or catalogue.

- d) **Maximum input rush current (when accumulator device is connected to input side)** When tested in accordance with **13.6 d)**, the PCS shall withstand the specified input rush current.

7.6 Operating range

The operating range shall be as follows.

- a) **Input voltage operating range** When tested in accordance with **13.7 a)**, the PCS shall be free from any abnormalities.
- b) **Output voltage adjustable range (for stand-alone type)** When tested in accordance with **13.7 b)**, the PCS shall be free from any abnormalities.
- c) **Load power factor allowable range (for stand-alone type)** When tested in accordance with **13.7 c)**, the PCS shall be free from any abnormalities.

7.7 Steady state characteristics

When the following characteristics are tested according to **13.8 a) to r)**, and if the relevant values are specified in the specifications or catalogue, the specified values shall be satisfied. When the PCS is used in the premises of the consumer, **k)** is not applicable and should be discussed separately with the installer.

The items **a)** to **i)** are applicable to stand-alone PCSs and items **a)** to **d)** and **j)** to **r)** are applicable to utility-connected PCSs.

- a) **Efficiency** The test in **13.8 a)** shall be performed.

- b) **No load loss** The test in **13.8 b)** shall be performed.
- c) **Fixed voltage operation characteristic** The test in **13.8 c)** shall be performed.
- d) **DC input current ripple** The test in **13.8 d)** shall be performed.
- e) **AC output voltage distortion factor** The test in **13.8 e)** shall be performed.
- f) **Output constant voltage accuracy** The test in **13.8 f)** shall be performed.
- g) **Output frequency accuracy** The test in **13.8 g)** shall be performed.
- h) **Output voltage unbalance** The test in **13.8 h)** shall be performed.
- i) **DC output voltage ripple** The test in **13.8 i)** shall be performed.
- j) **AC output power factor** The test in **13.8 j)** shall be performed.
- k) **AC output current distortion factor** The test in **13.8 k)** shall be performed.
- l) **Voltage and frequency following range** The test in **13.8 l)** shall be performed.
- m) **Stand-by loss** The test in **13.8 m)** shall be performed.
- n) **Start and stop characteristics** The test in **13.8 n)** shall be performed.
- o) **Utility voltage distortion** The test in **13.8 o)** shall be performed.
- p) **Utility unbalance** The test in **13.8 p)** shall be performed.
- q) **Power factor range** The test in **13.8 q)** shall be performed.
- r) **Isolated operation function** The test in **13.8 r)** shall be performed.

7.8 Transient operation

When the following characteristics are tested according to **13.9 a)** to **j)**, and if the relevant values are specified in the specifications or catalogue, the specified values shall be satisfied.

The items **a)** to **d)** and **h)** are applicable to stand-alone PCSs and items **a)** and **e)** to **j)** are applicable to utility-connected PCSs.

- a) **Input power sudden change** The test shall be performed for the operating characteristics during sudden changes in input power due to sudden changes in solar irradiance according to **13.9 a)**.
- b) **Input voltage sudden change** The test shall be performed for the operating characteristics during sudden changes in input voltage according to **13.9 b)**.
- c) **Load make and break** The test shall be performed for the operating characteristics during load make and break according to **13.9 c)**.
- d) **Load sudden change** The test shall be performed for the operating characteristics during sudden changes in load power consumption according to **13.9 d)**.
- e) **Utility voltage sudden change** The test shall be performed for the operating characteristics during sudden changes in utility voltage within the specified range according to **13.9 e)**.

- f) **Utility phase sudden change** The test shall be performed for the operating characteristics during sudden changes in utility voltage phase within the specified range according to 13.9 f).
- g) **Load interruption** The test shall be performed for the operating characteristics at the time of load break according to 13.9 g).
- h) **Input side short circuit** The test shall be performed for the operating characteristics when short-circuit fault occurs in the input side circuit according to 13.9 h).
- i) **Output side short circuit** The test shall be performed for the operating characteristics when short-circuit fault occurs in the output side circuit according to 13.9 i).
- j) **Utility voltage instantaneous drop (residual voltage 20 % or more) (applicable to single-phase PCSs)** The test shall be performed for the operating characteristics when instantaneous drop of utility voltage occurs according to 13.9 j).
- k) **Utility voltage instantaneous drop (residual voltage less than 20 %) (applicable to single-phase PCSs)** The test shall be performed for the operating characteristics when instantaneous drop of utility voltage occurs (residual voltage less than 20 %) according to 13.9 k).
- l) **Utility voltage instantaneous drop associated with phase change (residual voltage 20 % or more) (applicable to single-phase PCSs)** The test shall be performed for the operating characteristics when instantaneous drop of utility voltage occurs according to 13.9 l).
- m) **Utility voltage instantaneous drop at the time of three-phase short circuit including Y connection and delta connection (residual voltage 20 % or more) (applicable to three-phase PCSs)** The test shall be performed for the operating characteristics when instantaneous drop of utility voltage occurs according to 13.9 m).
- n) **Utility voltage instantaneous drop associated with phase change in Y connection method (residual voltage 20 % or more) (applicable to three-phase PCSs)** The test shall be performed for the operating characteristics when instantaneous drop of utility voltage occurs according to 13.9 n).
- o) **Utility voltage instantaneous drop associated with phase change in delta connection method (residual voltage 20 % or more) (applicable to three-phase PCSs)** The test shall be performed for the operating characteristics when instantaneous drop of utility voltage occurs according to 13.9 o).
- p) **Utility voltage instantaneous drop at the time of three-phase short circuit including Y connection and delta connection (residual voltage less than 20 %) (applicable to three-phase PCSs)** The test shall be performed for the operating characteristics when instantaneous drop of utility voltage occurs (residual voltage less than 20 %) according to 13.9 p).
- q) **Frequency change** The test shall be performed for the operating characteristics when frequency change of utility voltage occurs according to 13.9 q).

7.9 Noise

When noise is measured in accordance with **13.10** at the time of steady-state operation, the measured value shall be not more than the values in Table 2 and the tolerance of the indicated rated noise shall be +2 dB or less.

When exceeding these values, a warning message shall be displayed separately.

Table 2 Noise (A-weighted sound power level)

PCS rated output capacity (kW)	Indoor use (dB)	Outdoor use (dB)
Less than 2.5	65	70
2.5 or over to and excl. 4.0	70	75
4.0 or over	75	80

7.10 Temperature rise

When the test is performed in accordance with **13.11**, the temperature rise at each part of the PCS shall satisfy the value specified in the specifications or catalogue.

7.11 Composite temperature/humidity cycle (when installed outdoor)

When the composite temperature/humidity cyclic test is performed in accordance with **13.12**, the resultant insulation resistance and the dielectric withstand voltage shall satisfy **7.1** and **7.2**, respectively.

7.12 Protective functions

The PCSs, if having the following protective functions, shall be subjected to the tests in **13.13** and the results shall satisfy the stabilized value and recovery time specified in the specifications or catalogue.

a) Protective functions on DC power supply side (input side)

- **DC overvoltage protective function** The test shall be performed for the characteristics of protective functions for input overvoltage.
- **DC undervoltage protective function** The test shall be performed for the characteristics of protective functions for input undervoltage.
- **DC overcurrent protective function** The test shall be performed for the characteristics of protective functions for input overcurrent.
- **DC ground fault protective function** The test shall be performed for the characteristics of protective functions for the ground fault which occurred in the input side circuit.

b) Protective functions on output side

1) For AC

- **AC overvoltage protective function** The test shall be performed for the characteristics of protective functions for output overvoltage.

- **AC undervoltage protective function** The test shall be performed for the characteristics of protective functions for output undervoltage.
- **Frequency abnormality protective function** The test shall be performed for the characteristics of protective functions for output frequency rise and drop.
- **AC overcurrent protective function** The test shall be performed for the characteristics of protective functions for output overcurrent.
- **AC ground fault protective function** The test shall be performed for the characteristics of protective functions for the ground fault which occurred in the output side circuit.

2) **For DC**

- **DC overvoltage protective function** The test shall be performed for the characteristics of protective functions for output overvoltage.
 - **DC undervoltage protective function** The test shall be performed for the characteristics of protective functions for output undervoltage.
 - **DC overcurrent protective function** The test shall be performed for the characteristics of protective functions for output overcurrent.
 - **DC ground fault protective function** The test shall be performed for the characteristics of protective functions for the ground fault which occurred in the output side circuit.
- c) **Excess temperature rise protective function** The test shall be performed for the characteristics of protective functions for preventing abnormal temperature rise inside the PCS.
- d) **Output current limiting (power limiting) function** The test shall be performed for the characteristics of current limiting function and power limiting function for preventing overload operation.
- e) **DC outflow protective function** The test shall be performed for the characteristics of protective functions for preventing DC outflow to the load or grid.
- f) **Unbalance overvoltage protective function** The test shall be performed for the characteristics of protective functions for preventing the occurrence of overvoltage between the neutral line in the output side and each 200 V line of the PCS with the single-phase three-wire electric system.
- g) **Output voltage rise restrictive function** The test shall be performed on equipment with output voltage rise restrictive function.

8 Construction

The construction of PCSs shall comply with the following requirements.

- a) The live parts of electric circuit shall be so constructed that they are not easily accessible by hand.
- b) The enclosure, outer frame and accommodated equipment shall be made of materi-

als which have the mechanical strength to endure general shocks caused during transport and installation work, and the long-lasting weather resistance.

- c) The enclosure of PCS to be installed outdoors shall be so structured that no ingress of water detrimental to the functions occurs under the service conditions.
- d) The construction shall ensure that the temperatures of accommodated equipment will not exceed the respective maximum allowable temperatures.
- e) Necessary apparatus such as indicator lamps for operating conditions shall be attached on an easily visible position of each equipment.
- f) The enclosure shall be equipped with a grounding terminal.
- g) The construction shall ensure easy installation at site, connection of external conductors, operation of switches, checking of accommodated apparatus and equipment, etc.
- h) When an accumulator device is built in, the PCS shall be so constructed that maintenance and checking of accumulator device are possible.
- i) The portion in which an accumulator is accommodated shall be coated with an acid resistant or alkali resistant paint appropriate for the kind of accumulator device.
- j) The portion in which an accumulator is accommodated shall be constructed by taking the exhaust into consideration.

9 Conductor arrangement and colour indication

9.1 Conductor of main circuit

The conductor of the main circuit shall be arranged and given the colour at the end part or at other portion as specified in Table 3, and shall be in accordance with the following descriptions. The purchaser's specification shall be applied, if any.

- a) The circuit branched from a three-phase circuit or single-phase three-wire circuit shall be of the colour coding according to the circuit before branching.
- b) The first-phase of single-phase two-wire circuit may be coloured in black.
- c) The phase rotation in three-phase AC shall be in the order of first phase, second phase and third phase.
- d) The discrimination of right and left, and far and near of the conductor shall be based on the viewing from the operation side of the main switch of each part of the circuit or an equivalent side.
- e) When plug-in connectors are used in lieu of main circuit terminals, the kind, number of poles, pole arrangement and rating shall be as specified in **JIS C 8303**.

Table 3 Colour and arrangement of main circuit conductor

Voltage classification	Power system	Discrimination of right and left, top and bottom, and far and near	Red	White	Black	Blue
Low voltage	Three-phase three wires	Arranged left and right : from left Arranged top and bottom : from top Arranged far and near : from near	First phase	Grounded side Second phase	Isolated side Second phase	Third phase
	Three-phase four wires		First phase	Neutral phase	Second phase	Third phase
	Single-phase two wires		First phase	Grounded side Second phase	—	—
	Single-phase three wires		First phase	Neutral phase	Second phase	—
	DC two wires	Arranged left and right : from right Arranged top and bottom : from top Arranged far and near : from near	Positive pole	—	—	Negative pole

9.2 Board wiring

For the wire covering used for board wiring, Table 4 and the following apply.

For the main circuit, Table 3 may apply. The purchaser's specification shall be applied, if any.

- When applying a special wire for main circuit, the black colour may be applied.
- When applying a special wire for control circuit and so on, the colour may be changed to another colour.
- Earthing conductor means a wiring intended for earthing circuit or apparatus.
- When other colours than that specified in Table 4 are applied for the earthing wire by necessity, the green indication shall be applied at the end of wire.

Table 4 Colour of wire covering

Classification of circuit	Colour of covering
General	Yellow
Earthing conductor	Green or green/yellow

9.3 Grounded circuit

Clear indication by means of the symbol or letter specified below shall be provided on the wire end, in the vicinity of terminal, on the terminal block, etc. of the protective grounded circuit. The colour of wire covering shall be as given in Table 4.

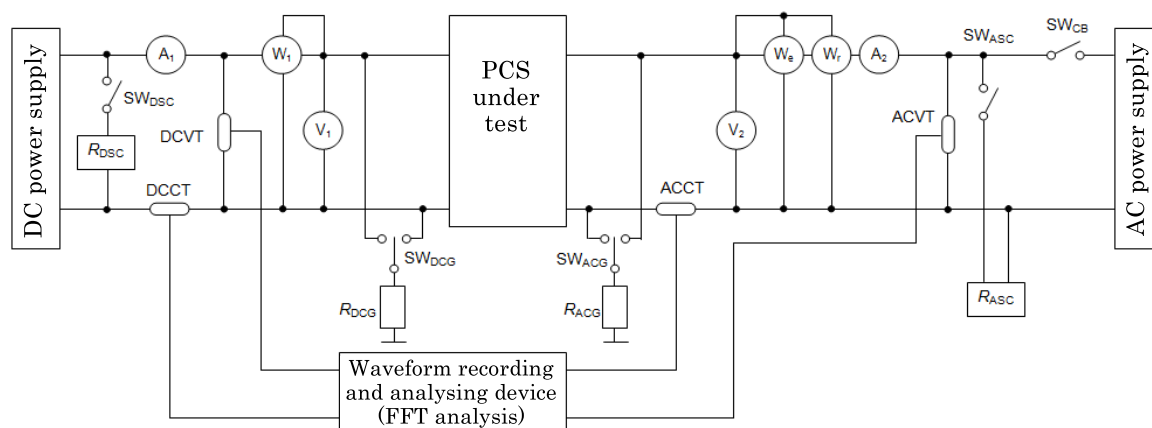
- a) Graphic symbol $\perp$ or $\oplus$
- b) Letter E, G or “ground”

10 Test conditions

Unless otherwise specified, the test conditions shall fall within the range of standard atmospheric conditions used for measurement and testing specified in **JIS C 60068-1**.

11 Test circuits

The test circuit shall be as illustrated in Figure 3 or Figure 4. Figure 3 a) shall be used for stand-alone type with AC output, Figure 3 b) for stand-alone type with DC output, Figure 4 a) for utility-connected type of single input and Figure 4 b) for utility-connected type of multi-input. Figure 3 and Figure 4 illustrate standard test circuits for AC output of single-phase two-wire system. In the case of single-phase three-wire system or three-phase system, the circuit shall be similar as practical. Application of other test circuit shall be as agreed between the interested parties.



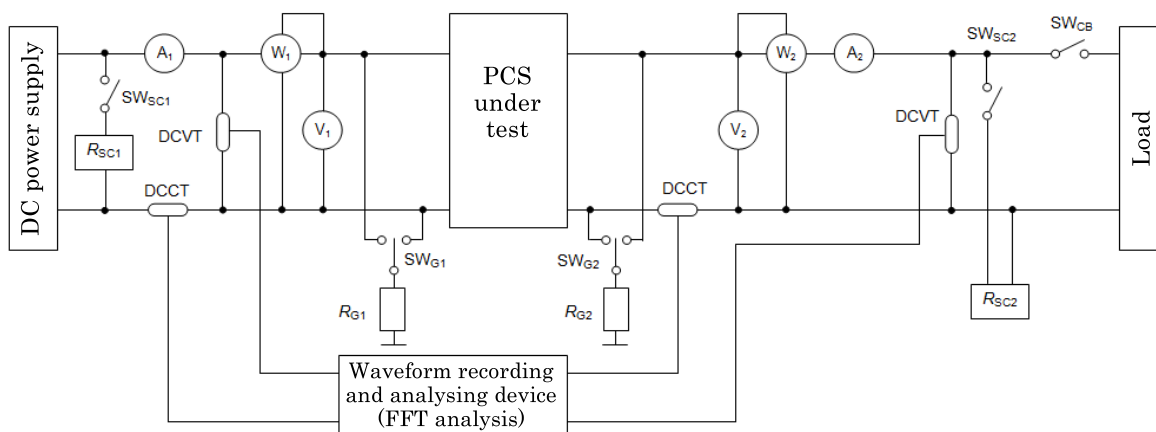
V_1 : DC voltmeter
 A_1 : DC ammeter
 W_1 : DC wattmeter

V_2 : AC voltmeter
 A_2 : AC ammeter
 W_e : AC wattmeter
 W_r : var meter

DCVT : DC potential divider
ACVT : AC potential transformer
 R_{DSC}, R_{ASC} : short-circuit resistor
 R_{DCG}, R_{ACG} : grounding resistor

DCCT : DC shunt
ACCT : AC current transformer

a) AC output



V_1 : DC voltmeter
 A_1 : DC ammeter
 W_1 : DC wattmeter
DCVT : DC potential divider
DCCT : DC shunt
 R_{SC1}, R_{SC2} : short-circuit resistor
 R_{G1}, R_{G2} : grounding resistor

V_2 : DC voltmeter
 A_2 : DC ammeter
 W_2 : DC wattmeter

b) DC output

Figure 3 Test circuit of stand-alone PCS