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NORME INTERNATIONALE

Battery charge controllers for photovoltaic systems – Performance and functioning

Contrôleurs de charge de batteries pour systèmes photovoltaïques – Performance et fonctionnement

IEC 62509:2010

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

BATTERY CHARGE CONTROLLERS FOR PHOTOVOLTAIC SYSTEMS – PERFORMANCE AND FUNCTIONING

FOREWORD

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International Standard IEC 62509 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

This standard is to be read in conjunction with IEC 62093.

The text of this standard is based on the following documents:

FDIS	Report on voting
82/614/FDIS	82/623/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

BATTERY CHARGE CONTROLLERS FOR PHOTOVOLTAIC SYSTEMS – PERFORMANCE AND FUNCTIONING

1 Scope

This International Standard establishes minimum requirements for the functioning and performance of battery charge controllers (BCC) used with lead acid batteries in terrestrial photovoltaic (PV) systems. The main aims are to ensure BCC reliability and to maximise the life of the battery. This standard shall be used in conjunction with IEC 62093, which describes test and requirements for intended installation application. In addition to the battery charge control functions, this Standard addresses the following battery charge control features:

- photovoltaic generator charging of a battery,
- load control,
- protection functions,
- interface functions.

This standard does not cover MPPT performance, but it is applicable to BCC units that have this feature.

This standard defines functional and performance requirements for battery charge controllers and provides tests to determine the functioning and performance characteristics of charge controllers. It is considered that IEC 62093 is used to determine the construction requirements for the intended installation which includes but is not limited to aspects such as the enclosure, physical connection sturdiness and safety.

This standard was written for lead acid battery applications. It is not limited in terms of the BCC capacity to which it may be applied, however, the requirements for test equipment when applied to BCC with high voltage or current, for example, greater than 120 V or 100 A, may be difficult to achieve. These approaches may be applicable to other power sources and other battery technologies like Ni-Cd batteries by using the corresponding values of cell voltages.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61836, *Solar photovoltaic energy systems – Terms, definitions and symbols*

IEC 62093, *Balance-of-system components for photovoltaic systems – Design qualification natural environments*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61836 apply as well as the following.

3.1
battery charge controller (BCC)
an electronic device/s that controls the charging and discharging of the battery in a photovoltaic energy system. The charge control function may be included as a subsystem within another product.

3.2
bulk charge
initial charging stage aimed at restoring the battery charge as fast as possible, in which all the available charging current from the PV generator, or the maximum current rating of the BCC, is delivered to the battery.

NOTE Sometimes referred to as boost charge.

3.3
bulk voltage
threshold voltage used by the BCC as a control parameter to change charging mode from bulk charge to the next charging stage

NOTE Sometimes referred to as boost voltage.

3.4
bulk charge delay time
the amount of time for which the bulk voltage is to be maintained before the change from the bulk charge stage to the next charging stage is made

3.5
equalise current
a constant current applied to the battery during equalise charge; normally determined by battery manufacturer recommendations

3.6
equalise charge
a relatively high voltage charging stage that is maintained for a defined time. Charge control can be achieved by constant voltage or constant current regulation or a combination of both. Equalise charge is intended to bring all cells to the same state of charge and remove electrolyte stratification in flooded cells by causing them to produce gas and stir the electrolyte.

3.7
equalise voltage
the voltage that the battery is allowed to reach during equalisation. This voltage is set above the gassing point for flooded batteries and below the maximum allowable voltage that the battery can withstand without damage.

3.8
equalise time
time that the equalise voltage is maintained from the moment that the battery has reached the equalise voltage, to the moment when the equalise charge is terminated to enter the next charging stage

3.9
float charge
a constant voltage charging stage in which the battery is maintained at a voltage below the gassing point to complete the charging cycle and compensate for battery self discharge

3.10
float voltage
the minimum constant voltage necessary to offset the internal losses of the battery

3.11
load disconnect point
condition (usually battery voltage) at which the load terminals of the charge controller are switched off to prevent the battery from over discharging, or at which a control signal or alarm

is triggered to signal a low battery state of charge. When the condition is a battery voltage, the abbreviation LVD (Low Voltage Disconnect) is usually used.

3.12
load reconnect point
condition (usually battery voltage) at which the load terminals of the charge controller are switched back on to allow the battery to supply the load, or at which a control signal or alarm is switched off to signal a battery state of charge that warrants the supply of the load. When the condition is a battery voltage, the abbreviation LVR (Low Voltage Reconnect) is usually used.

3.13
self-adaptive
an algorithm that modifies the charge controller set-points based on state of charge calculations, battery state of charge history, etc., or a combination of these parameters

3.14
temperature compensation for end of charge voltage set-points
a temperature dependent coefficient applied to the end of charge voltage set-points when the temperature of the battery differs from the reference temperature (usually 25 °C). In addition to the temperature coefficient, temperature compensation normally has minimum and maximum limits that should be adhered to (i.e. voltage set-points should be constrained within a range).

4 Functionality and performance requirements of a PV BCC

4.1 General

This Clause describes the performance and functionality requirements for PV battery charge controllers (BCC). These requirements are divided in 5 main categories:

- Battery lifetime protection.
- Efficiency.
- User interface.
- Fail safe functions.
- Marking and documentation.

The provisions in this standard are not intended to preclude or rule out innovative control techniques aimed at providing effective battery charging. These however shall be verifiable by testing.

4.2 Applicability of requirements

Required provisions ensure reliable operation and essential protection functions, and are generally easily achievable on even inexpensive BCCs intended for small installations (e.g. single module installations at extra low voltage).

Recommended provisions ensure more effective battery charging, better efficiencies, longer battery lifetime and additional user interface functions. They are intended to provide and/or facilitate more advanced battery charging and load management.

4.3 Battery lifetime protection requirements

4.3.1 Prevent leakage current from battery to PV generator

The BCC shall limit leakage current flowing from the battery to the PV generator in order to prevent battery discharging at night. The allowable reverse current on the PV side shall be ≤ 0,1 % of the BCC rated input current when the battery voltage is equal to the rated voltage.

Compliance shall be verified by test according to 5.2.1.

4.3.2 Basic battery charging functions

4.3.2.1 General

The BCC shall provide appropriate charging set-points and load disconnect set-points for the specific battery technology or technologies it is intended to be used for.

4.3.2.2 Protect battery from over-charge

The BCC shall cut out or regulate the charging current to avoid over-charging of the battery according to battery manufacturer recommended end of charge set-point.

Compliance shall be determined by test according to 5.2.2.

4.3.2.3 Protect battery from over-discharge

The BCC shall have a provision to prevent the battery from over-discharging either by directly interrupting the current to the load, or by a trip signal to enable an external piece of equipment to stop the current to the load, or an alarm.

If battery over-discharge protection is achieved by means of audible or visible alarms that prompt the system user to disconnect all or non-essential load, this shall be clearly stated in the operation manual.

If over-discharge protection is reliant on the installation of an external device that provides over-discharge protection (such as an inverter), this fact shall be clearly stated in the installation manual.

Battery over-discharge protection can be triggered by a battery voltage measurement, a state of charge calculation, a combination of both or other algorithms. The protection set-points may be current compensated. Battery over-discharge protection set-point shall be verifiable by testing. The BCC documentation and/or interface shall clearly specify the algorithms and criteria used to establish the load disconnect and reconnect set-points.

Compliance shall be determined by test according to 5.2.3.

4.3.2.4 Set-point accuracy

The BCC measurement accuracy for voltage set-points for charge control shall be ±1 % or better. For load disconnect it shall be ±2 % or better.

Compliance shall be determined by test according to 5.2.2 and 5.2.3.

4.3.3 Charging regime

4.3.3.1 General

The BCC shall be matched to the specific battery technology for its intended use to ensure that correct charging set-points are implemented. The PV BCC can use a variety of methods

to ensure correct charging of batteries, the requirements in this clause include some of the possible solutions and do not limit other solutions.

4.3.3.2 Required charging stages

As a minimum, PV battery charge controllers shall have bulk and float charging stages.

NOTE Some manufacturers give charging stages different names in their documentation than those defined in this standard. Care must be taken to identify the charging characteristics appropriately for each individual unit or manufacturer and cross-reference with the terminology used in this standard.

4.3.3.3 Recommended charging stages

In addition to the requirements of 4.3.3.2, battery charge controllers should provide equalise charge periodically to the battery. The periodicity of equalise charge should be more than 7 days.

4.3.3.4 Adjustable charging set-points

In order to ensure correct charging regime for the battery type, charging set-points should be adjustable or automatically selected either by means of individual set-point adjustment, or by battery type selection or self-detection of type of battery. This can be achieved by hardware means or software through user interface or by adjusting set-points as directed in manuals.

The specific charging regime used depends on the battery technology specified. A guide for the battery set-points for testing purposes where such information is unavailable from the manufacturer is given in Annex A.

Self-adaptive set-points based on advanced algorithms shall be able to be verified using information provided by the user interface and the BCC documentation. No specific test procedure has been developed for devices employing these advanced techniques.

NOTE Adjustable set-points may not be required for BCCs intended for low power applications (< 250 W) and for a particular type of battery.

4.3.3.5 Temperature compensated charging set-points

Bulk, float, and other high voltage or end of charge set-points should be temperature compensated. Temperature compensation if provided should be in accordance with battery manufacturer recommendations for the particular type of battery. Temperature compensated set-points shall be identifiable from the charge controller documentation.

NOTE Lead acid battery manufacturers typically specify a temperature compensation coefficient of –5 mV/°C/Cell.

4.3.3.6 Voltage drop compensation for set-point measurement

The BCC should provide a means to compensate for voltage drop in battery cables, or provide installation instructions to minimise voltage drop.

If the battery charge controller has the provision for battery sense cables, it shall be able to operate with or without these. This is to protect the unit against unintended disconnection of the battery sense cables. This requirement is tested according to 5.2.2 and 5.2.3 by performing the test with and without the sense wires connected at 25 °C test conditions.

4.3.4 Set-point security

Charging set-points shall be secured against change other than by a deliberate and qualified action.

Compliance shall be determined by inspection of the unit and accompanying operating instructions.

NOTE 1 This clause does not apply to battery charge controllers with fixed set-points.

NOTE 2 The use of a tool or password are acceptable means of protection.

4.3.5 Load disconnect capability

Where over-discharge protection is provided by means of load disconnect functionality the load disconnect and reconnect set-points shall be verified by testing according 5.2.3.

The load could be either a load directly switched or a load controlled by the BCC by other means. In the case of a BCC directly switching the load this should be provided by means of an integrated load breaking switching device.

If a BCC has multiple load disconnect set-points, these shall be verifiable by testing and able to be determined from the BCC user interface and/or clearly written in documentation.

NOTE Battery over discharge protection is a mandatory feature (see 4.3.2.3). BCC load disconnection capability is recommended only, but it must be achieved by other external means if not provided by the BCC, as it is essential for battery lifetime protection.

4.4 Energy performance requirements

4.4.1 Stand by self-consumption

With no PV input or load the self-consumption of a PV BCC shall be as detailed in Table 1, when the battery voltage is equivalent to 2,1 V/Cell ± 2 %, and the ambient temperature is 25 °C ± 2 °C.

Compliance shall be determined by test according to 5.3.1.

Table 1 – Requirements for self-consumption

Nominal charging current	Maximum self-consumption
< 5 A	5 mA
5 A ≤ I ≤ 50 A	0,1 % of nominal charging current
> 50 A	50 mA

NOTE The limits given in Table 1 are intended for the charge controller function in “night time” mode. Where there are other peripheral equipment such as load management devices, displays, data loggers and others that share the power supply of the BCC, these shall be disabled or disconnected from the BCC if possible.

4.4.2 BCC efficiency

Power efficiency of the BCC shall be evaluated from 10 % to 100 % of the rated charging current, at a battery voltage equivalent to 2,2 V/Cell ± 2 % and at ambient temperature of 25 °C ± 2 °C.

The efficiency shall be determined by test according to 5.3.2[N1].

4.5 Protection and fail safe requirements

4.5.1 Thermal performance

The BCC shall be capable of handling rated input current/power from the generator and, simultaneously, rated load current to load terminals (if provided) for at least 1 h at the manufacturer’s specified maximum rated ambient operating temperature ± 2 °C. Battery voltage shall be 2,2 V/Cell ± 2 %.

Compliance shall be determined by test according to 5.4.1.

NOTE Depending on the relative ratings of PV input and loads terminals, this test may result in battery charge or discharge conditions.

4.5.2 Overcurrent operation

4.5.2.1 PV side

The BCC shall not be damaged by excessive current from the PV generator up to 125 % of the full rated current. The BCC shall continue to operate normally after such an event and shall not require manual resetting.

NOTE The reset time for any automatic resetting trip mechanism, should be no longer than the time indicated in the manufacturer's instructions, if specified.

Compliance shall be determined by test according to 5.4.2.

4.5.2.2 Load side

If the BCC has a load terminal, this terminal shall be current protected to prevent over loads from causing damage to the operation of the essential PV BCC functions.

Compliance shall be determined by test according to 5.4.3.

The rating of the load terminals should match the requirement of the intended application/s.

4.5.3 PV generator and battery reverse polarity

The BCC shall be protected from reverse polarity connection of the PV generator or the battery by hardware or by documented procedure and markings.

NOTE The preferred method of protection against reverse polarity is by hardware means, but procedural documentation is allowed. This is a concern during installation and battery replacement.

Compliance shall be determined by test according to 5.4.4 and 5.4.5.

4.5.4 Open circuit on battery terminals (no battery connection)

BCC with load terminals shall be protected from damage to itself and protect the load from the open circuit voltage of the PV generator in the case of battery disconnection.

Compliance shall be determined by test according to 5.4.6.

4.6 User interface requirements

4.6.1 General

The user interface of a BCC should include any of the following types; LCD screen, LED indicators, audible alarms, relay contacts, other computer interface or other analogue or digital interface. The interface can provide the user with valuable information about the system operation if implemented properly.

The user interface may be integrated into another system component separate from the BCC such as an additional control/logging/interface unit that can be physically connected to the BCC or operate via wireless communication.

4.6.2 Operational information

4.6.2.1 General

The level of information provided to the user is determined by the intended application and its specific requirements.

The user interface of the charge controller should provide information such as detailed in 4.6.2.2.

4.6.2.2 Recommended operation information

- An indication of charging status (i.e. charging or not charging).
- An indication of load-disconnect state (or over discharge protection status).
- An indication of the state-of-charge of the connected battery.

Other additional operational information displayed by the unit may include but is not limited to:

- Charging set-points.
- Battery voltage.
- Charging current.
- Energy input/output.

4.6.3 User adjustable set-points and parameters

If user-adjustable set-points or parameters are provided, the user interface shall provide a facility to modify and display those adjustments as specified in 4.3.3.4.

NOTE This clause does not apply to battery charge controllers with fixed set-points.

Compliance shall be determined by inspection of the unit and accompanying user/installation manual.

4.6.4 Alarms

The following conditions should be signalled by the user interface:

- Low battery state of charge / Low battery voltage / Low availability.
- Load disconnect.
- BCC trip (e.g. by over temperature).

Visible and/or audible alarms, clearly identifiable by the system user, shall be triggered within the unit in case of any of the above conditions occurring. Audible alarms shall be time limited and revert to a visible alarm or be pulsed.

Compliance shall be determined by test according to 5.2.2 and 5.2.3.

5 Tests

5.1 General conditions for tests

5.1.1 Setup and preconditioning for tests

The BCC shall be mounted and installed according to the instructions supplied with the unit. Where the BCC is intended to be installed in a particular manner or configuration (e.g. wall-mounting), the installation shall mimic such conditions.

The BCC shall be installed in a temperature-controlled chamber for all tests. The test procedure shall not commence until the chamber and BCC temperatures have reached thermal stability.