07 - 10 September 2009

PROCEEDINGS

54. IWK

Internationales Wissenschaftliches Kolloquium
International Scientific Colloquium

Information Technology and Electrical Engineering - Devices and Systems, Materials and Technologies for the Future

Faculty of Electrical Engineering and Information Technology

Startseite / Index:
http://www.db-thueringen.de/servlets/DocumentServlet?id=14089

TECHNISCHE UNIVERSITÄT
ILMENAU

Impressum

Herausgeber: Der Rektor der Technischen Universität Ilmenau
Univ.-Prof. Dr. rer. nat. habil. Dr. h. c. Prof. h. c.
Peter Scharff

Redaktion: Referat Marketing
Andrea Schneider

Fakultät für Elektrotechnik und Informationstechnik
Univ.-Prof. Dr.-Ing. Frank Berger

Redaktionsschluss: 17. August 2009

Technische Realisierung (USB-Flash-Ausgabe):
Institut für Medientechnik an der TU Ilmenau
Dipl.-Ing. Christian Weigel
Dipl.-Ing. Helge Drumm

Technische Realisierung (Online-Ausgabe):
Universitätsbibliothek Ilmenau
ilmedia
Postfach 10 05 65
98684 Ilmenau

Verlag:
Verlag ISLE, Betriebsstätte des ISLE e.V.
Werner-von-Siemens-Str. 16
98693 Ilmenau

ISBN (USB-Flash-Ausgabe): 978-3-938843-45-1
ISBN (Druckausgabe der Kurzfassungen): 978-3-938843-44-4

Startseite / Index:
http://www.db-thueringen.de/servlets/DocumentServlet?id=14089

SAFETY REQUIREMENTS ON PHOTOVOLTAIC-MODULES

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ABSTRACT

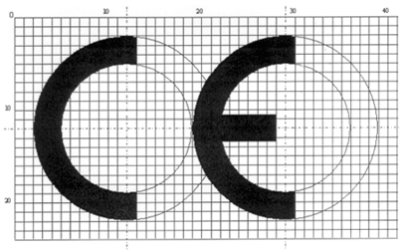
The consideration of requirements from all relevant directives given by the European Community is a necessary condition for the selling or operating of electrical equipment in the European Single Market. The producer or marketer documents the compliance with the normative specifications by placing the CE-mark. The present paper describes especially the electrical safety requirements on photovoltaic modules and comments the evaluation of these properties by means of laboratory measurements on base of valid standards.

Index Terms – Photovoltaic-Modules, CE-Marking, Safety requirements, Laboratory measurement

1. INTRODUCTION

Photovoltaic (PV) modules and photovoltaic installations represent electrical equipment and the fulfillment of test specifications, the conformity assessment and the CE-marking are obligatory for such components and equipments. The selection and application of the appropriate directives and standards are an important challenge to each manufacturer of PV products. The following subtasks are to deal for the process of the CE-Marking:

1. Selection of all relevant EU Directives for the given product
2. Choice of the product standards according the Official Journal of the European Communities
3. Evaluation of the conformity of product properties to the requirements of the directives
4. Issue a declaration of conformity
5. Placement of the CE-Mark



The Low-Voltage (LV) Directive (2006/95/EG) is mandatory for PV-Modules with voltages above 75V DC. But the scope of the European directive relating the Electromagnetic Compatibility (EMC) will be not applicable in her present version for the modules as electromagnetic passive components. This directive shall not apply to equipment the inherent nature of the physical characteristics of which is such that:

(a) it is incapable of generating or contributing to electromagnetic emissions which exceed a level allowing radio and telecommunication equipment and other equipment to operate as intended; and

(b) it will operate without unacceptable degradation in the presence of the electromagnetic disturbance normally consequent upon its intended use. (EMC-directive, article 1, clause 3)

However complete PV-Installations (modules, power converter etc) are to regard, the consideration of both directives is necessary. If movable parts are additional present, the application of the EC-Machinery Directive is to prove.

2. BASIC REQUIREMENTS

The product quality and the safety performance are particular important properties of PV-modules. Requirements to such PV-products can be classified in following fields:

1. Type requirements on PV-modules such as
   - EN 61215:2005 - Crystalline silicon terrestrial photovoltaic (PV) modules
   - EN 61646:2008 - Thin-film terrestrial photovoltaic (PV) modules

2. Safety requirements such as
   - EN 61730:2007 - Photovoltaic (PV) module safety qualification

3. Additional Requirements such as
   - EN 50380:2003 - Datasheet and nameplate information for photovoltaic modules

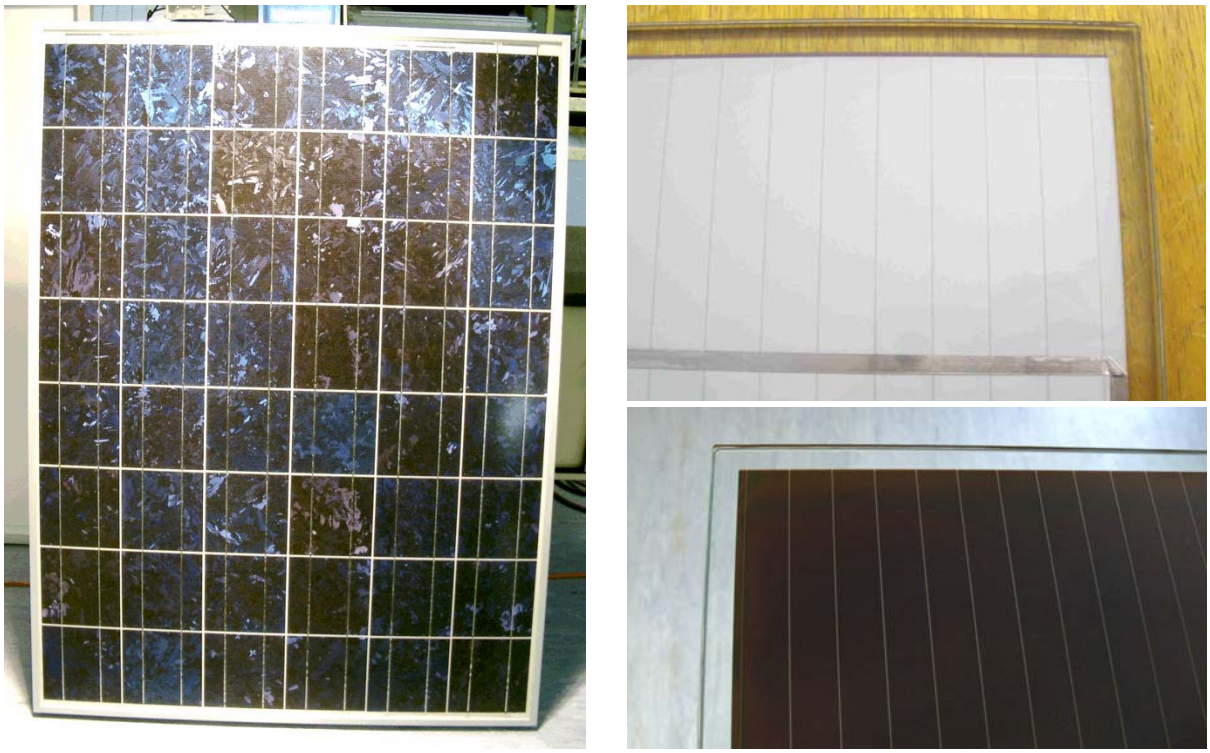


Figure 1 – Polycrystalline silicon photovoltaic module in frame construction and a frameless thin film module

The type requirements contain all influencing factors of electrical, mechanical and environmental stresses as well as the degradation. However the safety requirements describe test procedures for the evaluation relevant to security.

3. MARKING OF PV-MODULES

The assessment of the product quality should be facilitated by the marking with test symbols. The plurality of marks results to problems by the installer or user of PV-equipment in praxis.

The CE-Marking is basically not a symbol for the independent testing of a product. The manufacturer self documents with the placing solely the conformity with the requirements of the relevant directives. The European Union has given a guide for the application and realization of the directives [1]. The Low Voltage Directive 2006/95/EG [2] is valid for electrical equipment with rated voltages between 50 V and 1000 V AC respectively 75 V and 1500 V DC. This directive takes a centre stage for the CE-Marking of PV-Modules together with the listed product standards for the safety.

Especially the electric shock protection is a basic aspect for the safe operation of PV-modules and equipment. Compliance with safety class II demands becomes a great importance particularly for modules destined for high system voltages up to 1000 V. The clause 4 of this paper describes the scope, the claim and the realization of different safety tests according the EN 61730-2:2007 [3].

The compliance of safety class II requirements is documented by the corresponding symbol:

The International Electrotechnical Commission is the responsible organisation for the worldwide standardization. The “Global Approval Program for Photovoltaic’s” describes a certification procedure on base of reliable IECEE-rules (IECEE – IEC System for Conformity Testing and Certification of Electrical Equipment). In this way certified products are marked with the following symbol:

The TÜV Rheinland Group assigns the test symbol “TÜVdotCOM”. Precondition for the obtainment of this mark is among the type testing the periodic inspection of the fabrication.

4. EXEMPLE OF TEST PROCEDURES

The normative base for the described tests and investigations is given by the standard EN 61730-2 – Photovoltaic (PV) module safety qualification. By now this standard is listed in the Official Journal of the European Communities regarding the Low Voltage Directive. Therefore the modules are to consider as electrical equipment according the established standards and rules of electrical engineering. Before the application of the standard at first the modules are to classify in one of three categories:

- Class A – General contact access is anticipated, dangerous system voltages greater than 50 V DC and/ or power class > 240 W, highest resulting safety requirements → safety class II
- Class B – Restricted to systems protected from public access, protection by basic insulation, important safety requirements → safety class 0
- Class C – Restricted to systems operating at less than 50 V DC and 240 W, modules are considered to meet the requirements for safety class III

According to a well-defined test schedule a series of single tests is to perform for the evaluation of the electrical safety. Below a few of these procedures are described.

4.1. Visual Inspection

Figure 2 – Visual inspection and test of the function

The intention of this first test is the detection of any visual defects in the module construction. For the performance of this test a sufficient illumination is necessary. A simple test of the module function will complete this investigation. Figure 2 shows a view of the test arrangement.

4.2. Dielectric Withstand Test

The purpose of this test is to determine whether or not the module is sufficiently well insulated between current carrying parts and the frame or the outside world (Figure 3). The value of the test voltage is in EN 61730-2 defined. For the application class A results:

$$U_{test} = 4 \bullet U_{sys} + 2000 \text{ V}.$$

For the performance the test on modules without frames or any electrical conductive parts the edges and / or the back side of the test specimens are to wrap with a conductive foil.

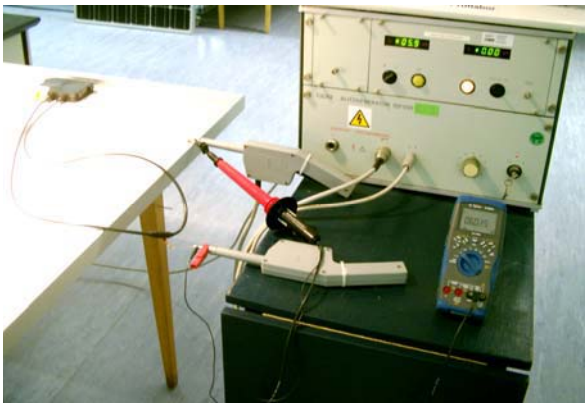


Figure 3 – Test of the dielectric withstand

The control of the clearance and creepage distances is not explicitly demanded in the applied standard. However, this aspect is to regard according the actual state of technology. This constructive safety requirement depends of course of the concrete module arrangement.

4.3. Ground Continuity Test

The purpose of the ground continuity test is to demonstrate that there is a conductive path between all exposed conductive surfaces of the module, so that the exposed conductive surfaces can be adequately grounded in a PV system.

The test is to perform with an injected current 2.5times of the maximum over-current protection rating for a time of 2 min. The measured voltage drop must have a low level so that the resistance between selected exposed conductive components is less than 0.1 Ω. This test is not to perform on frameless modules.

4.4. Accessibility Test

The accessibility test is to perform to determine if uninsulated electrical connections represent a shock hazard to personnel. For this a cylindrical test fixture according IEC 61032 and an ohmmeter or continuity tester is to use (Figure 4).

The test can be simplified if tested or certified components (junction boxes, connectors etc) were used for the construction of the module type.

Figure 4 – Accessibility Test

4.5. Wet Leakage Current Test

The purpose of this test is to evaluate the insulation of the module under wet operating conditions (Figure 5). The focus of the wet leakage current test is to verify that moisture from rain, fog, dew or melted snow does not enter the active parts of the module circuitry, where it might cause corrosion, a ground fault or safety hazard.

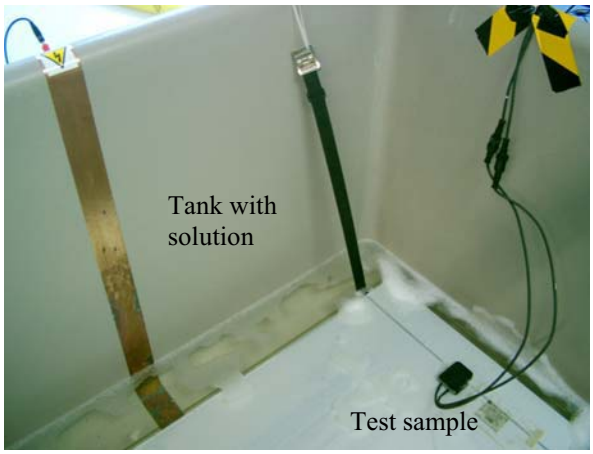


Figure 5 – Wet leakage current test

This investigation becomes more importance if the specimen was tested before with the damp heat test. This degradation procedure is to perform for 1000 h duration in a test cabinet with 85°C temperature and 85% humidity. The use of materials with hygroscopic unacceptable properties, any perforations on the module structure or open channels in the arrangement can result to hazardous leakage currents during the following test in conductive solution. Thereby, the leakage current during the application of the high test voltage can reach permissible values of some µA.

4.6. Impulse Voltage Test

Impulse voltage tests are to perform to verify the capability of the solid insulation of the modules to withstand over-voltages of atmospheric origin. It also covers over-voltages due to switching of low voltage equipment. During the test of module types with a maximum system voltage of 1000 V (application class A) an impulse voltage of 8 kV with a wave-shape of 1.2/50 µs is to apply in each polarity.

For the performance of the test procedure the whole module is to cover with a well defined copper foil (Figure 6). In this arrangement the capacity of the test object reaches values of some 10 nF. Therefore the use of specified surge generators is necessary.

Figure 6 – Impulse voltage test

4.7. Partial Discharge Tests

Polymeric materials intend for use as a superstrate or substrate, without appropriate insulation pre-qualification must comply with the partial discharge test. Therefore the partial discharge test is to apply for such materials as Component Test.

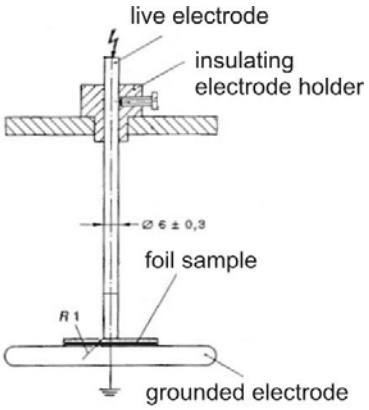


Figure 7 – Construction for the partial discharge measurement

This test refers to the IEC 60664-1. Figure 7 shows a principle construction for the performance of the test on a thin foil of back-sheet material. A view of a test arrangement inside of a shielded test room is given in Figure 8.

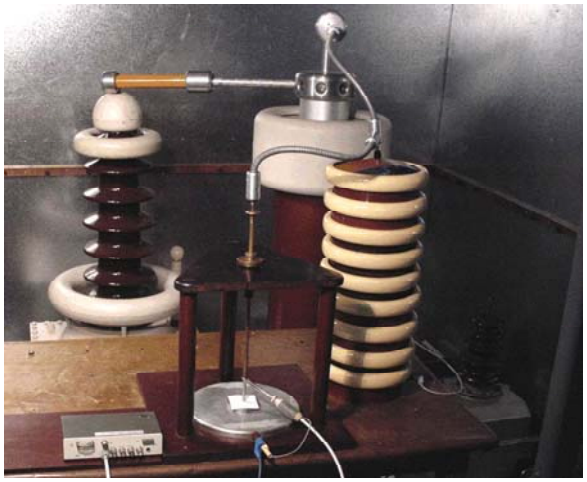


Figure 8 – Arrangement for the partial discharge test

5. SUMMARY

The safety requirements and especially the dielectric withstand of PV-modules by use in installations with high system voltages are fundamental properties of this components. Among the type tested product property the high quality of the serial production is to guarantee by the manufacturer. Blowholes, depositions, pollutions or moisture can influence the necessary electrical strength in a critical way.

Therefore test procedures to perform of dielectric withstand test or the wet leakage current test establish more and more during the running fabrication (in-line) by the manufacturer.

Furthermore it is to prove whether the partial discharge test of a whole module is a promising extension of the safety qualification.

In the future, the evaluation of complete PV-installations (Figure 9) obtains increasingly of importance. In that case also the EMC requirements become a greater weighting. Measures of lightning and overvoltage protection are additional necessary for the durable operation of the installations in a critical electromagnetic environment.

Figure 9 – Photovoltaic installation (ERSOL)

6. REFERENCES

[1] „Guide to the implementation of directives based on the New Approach and the Global Approach“, http://ec.europa.eu/enterprise/newapproach/legislation/guide/index.htm

[2] Directive 2006/95/EC of the European Parliament and of the Council of 12 December 2006 on the harmonisation of the laws of Member States relating to electrical equipment designed for use within certain voltage limits, Official Journal of the European Communities L 374/10 from 27.12.2006

[3] EN 61730-2: Photovoltaic (PV) module safety qualification - Part 2: Requirements for testing (IEC 61730-2:2004, modified)