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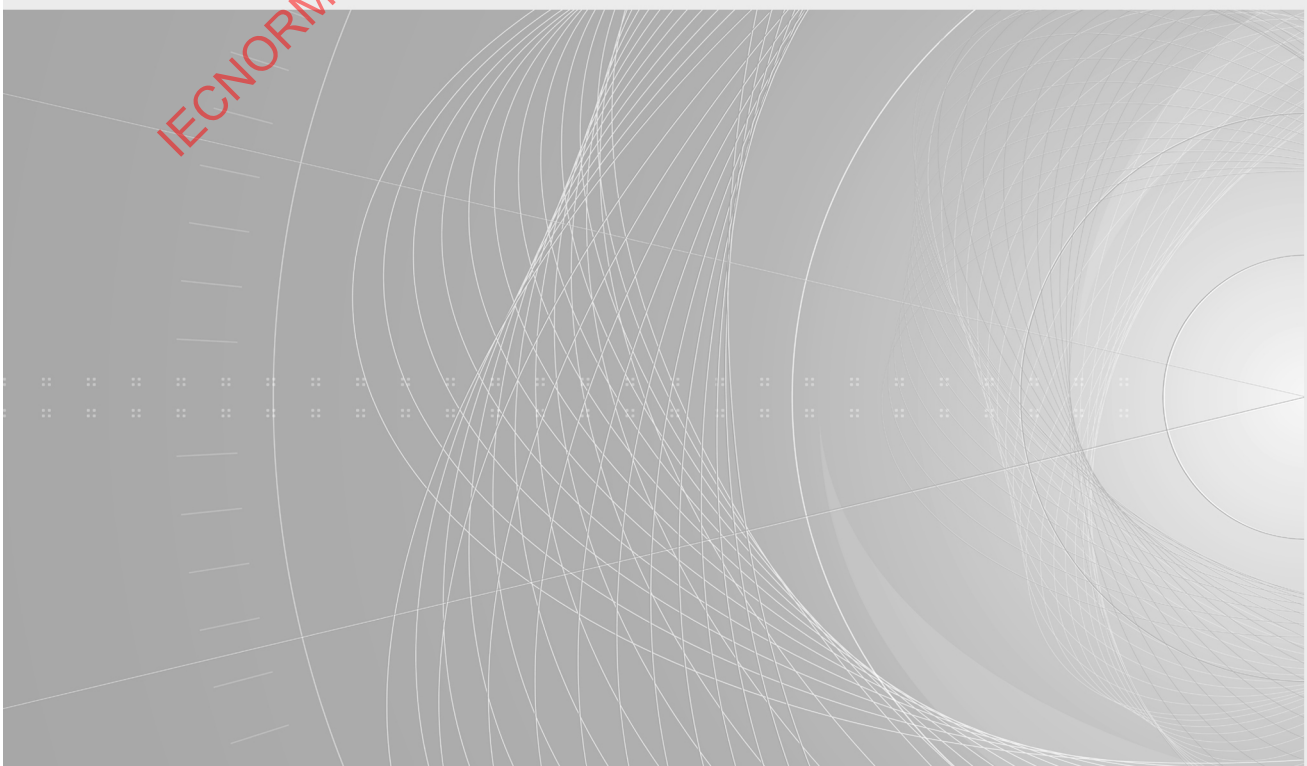
Edition 1.0 2019-11

TECHNICAL REPORT

Incompatibility of connectors for DC-application in photovoltaic systems



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IEC TR 63225, which is a Technical Report, has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

The text of this Technical Report is based on the following documents:

Draft TR	Report on voting
82/1499/DTR	82/1552A/RVDTR

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

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

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

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- withdrawn,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

A bilingual version of this publication may be issued at a later date.

INCOMPATIBILITY OF CONNECTORS FOR DC-APPLICATION IN PHOTOVOLTAIC SYSTEMS

1 Scope

This document highlights the problem of incompatibility of connectors for DC-application in photovoltaic systems (DC connectors) produced by different manufacturers. It addresses four particular issues in that context:

- background information on incompatibility of DC connectors from different manufacturers;
- observations and challenges concerning the handling of DC connectors from different manufacturers;
- stakeholders concerned by the incompatibility of DC connectors;
- recommendations for long-term standardization and interim measures to address incompatibility of DC connectors.

2 Normative references

IEC 62852, *Connectors for DC-application in photovoltaic systems – Safety requirements and tests*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62852 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
DC connector
connector designed for use in DC circuits of photovoltaic systems, as defined in IEC 62852.

Note 1 to entry: This document generally refers to connectors of type MC4 or similar, and particularly products that are often referred to as “MC4-compatible”.

3.2
compatible DC connectors
interoperable DC connectors
intermateable DC connectors
<connector pair> components which terminate conductors for the purpose of providing connection to and disconnection from a suitable mating component under supervision of one quality management system

4 Background

In the early years of terrestrial photovoltaics, a range of different DC connectors were available on the market. They were of distinctly different designs and could not be connected between

each other. In the early 2000s the connector type MC4[1] became more and more popular. Manufacturers started to adapt their connectors to the MC4 type. However, no international or consortia-based interface technical specifications for this connector type are available. IEC 62852, often referred to in this context, is a product safety standard and is not intended to test intermateability.

Several countries report that problems with DC connectors are a major cause for failure such as fire hazards in PV systems. Reports from different testing laboratories have shown that DC connectors from different manufacturers may not be safe to interconnect. Even if they meet basic quality requirements in the short term, they may derate when connected to products from different manufacturers.

Disregarding these circumstances, DC connectors are often declared by manufacturers as being compatible with each other. This claim of compatibility is potentially misleading as it suggests a safe interoperability of DC connectors from different manufacturers.

The reasons for the incompatibility of DC connectors from different manufacturers over the intended lifetime of the connectors are as follows.

- Different metal alloys are used. This results in a high risk of increased resistance between the DC connectors, for example because of contact corrosion and/or thermal expansion differences.
- Different contact designs are used. This results in a high risk of increased resistance.
- Mechanical tolerances are not specified. This can lead to both material stress and loose contacts risking an increased resistance between the DC connectors. This increased resistance can also result from products under the same quality management system over the intended lifetime of the connectors if the tolerances are not sufficiently defined by the manufacturer.
- The material used for the polymeric parts of the DC connector is not specified. This creates a risk of chemical incompatibility and different thermal expansion behaviour resulting in accelerated ageing of the components and increased resistance, and exacerbating the points previously mentioned during long-term implementation on a PV installation. In addition, degradation and corrosion of the polymeric parts from external factors is a risk that could lead to ingress of dust and water.
- Even if a pair of connectors from different manufacturers have been declared compatible at one point in time, the quality management system or materials used by one brand might change in the interim, meaning that later batches of the same connector are in fact no longer compatible.

IEC 61730-1 tackles the safe electrical operation of PV modules, but does not tackle the topic of connecting DC connectors from different manufacturers. However, IEC 62548 and IEC 60364-7-712:2017 are installation standards and they explicitly do not allow the connection of DC connectors from different manufacturers. IEC 62852 is not intended to be used for DC connectors produced by different manufacturers and does not guarantee long-term reliability of components from different quality management systems.

Despite the explicit prohibitions in these International Standards, even installers aware of the dangers of using connectors from different manufacturers continue to do so since there are often insufficient available alternatives.

[1] Manufactured by Multi-Contact AG (since 1 January 2017 named Stäubli Electrical Connectors AG). This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of this product.

5 Observations

Despite the knowledge of incompatibility of DC connectors from different manufacturers, many installers combine DC connectors from different manufacturers. The reasons include the following.

- The manufacturer of the DC connector attached to the PV module is not known;
- The manufacturer of the DC connector attached to the PV module is known but the installer has no access to the supply chain of this manufacturer.
- The installer would lose the module warranty if he or she cuts the DC connector to attach two connectors from the same manufacturer.
- The installer rejects field crimping of DC connectors because he or she sees poor field crimping quality as a bigger safety risk than the connection of DC connectors from different manufacturers.
- Adapter cables (with two connector types) meeting interoperability requirements are sometimes available, but they are expensive, difficult to find and introduce additional points of potential failure by increasing the quantity of crimps and connectors in the system.

These reasons often give the installer or system owner few choices but to assume the risks of mating connectors from different manufacturers and as a result several fire hazards caused by non-compatible DC connectors have been reported. Although a burnt connector leaves little evidence to ascertain the initiating root cause, connectors from different manufacturers are found to be a common factor.

These observations are not new and multiple agencies have reported the problem. For several years, test laboratories have been reporting insufficient connection quality and reliability if DC connectors from different manufacturers are connected, and it can be assumed that the continuing connection between incompatible connectors will lead to an increasing number of fire hazards in future. Nevertheless, no satisfactory solution has been found yet to the problem of needing to use connectors from the same manufacturer, but not having easy supply of all connectors currently available on the market for use in the field.

6 Affected stakeholders

Several stakeholders are affected by the observations in Clause 5. The most affected are the following.

- Owners of PV systems and residents of buildings with PV systems can face reduced electricity production, financial losses and safety risks due to hazards occurring in the PV system.
- Module, inverter and cable manufacturers are restricted in the choice of DC connectors and are expected to include connectors in their product warranty, even though connector manufacturers are part of a value chain which does not fully manage to supply truly long-term compatible DC connectors.
- Different connector manufacturers need to be able to sell their product, and so they need to have a way of guaranteeing long-term compatibility with other manufacturers, which will avoid safety issues associated with the number of different manufacturers available.
- PV installers often end up taking responsibility for the quality issues caused by not having access to connectors from the same manufacturer.
- Insurance companies insure PV power plants which may have latent technical risks due to the long-term incompatibility of connectors, and therefore they face financial long-term risks which are not properly addressed today.

7 Proposed course of action

7.1 General

The following recommendations are aimed to mitigate the problems resulting from use of incompatible connectors. There is a preferred long-term aim, and short-term interim measures that can be adopted.

7.2 Long-term aim

1) The preferred long-term target is that manufacturers of DC connectors specify a common interface standard and coordinated quality management standards for DC connectors to ensure complete compatibility of materials, dimensions, tolerances and other properties needed to ensure safe and long-term reliability between all products of the same type.
2) Once the common interface standard has been developed, a new testing document or amendment in addition to IEC 62852 should be developed to test DC connectors complying to the new interface standard for long-term reliability. IEC 62548 should then be modified to allow the use of such new connectors.

IEC TC 82 is willing to offer a platform to support the development of any standards required for reaching this long-term aim.

If this long-term aim cannot be achieved, measures to avoid the intermating of DC connectors from different manufacturers should be intensified. Reintroducing distinctive DC-connector designs by each manufacturer could be an undesired but necessary measure.

7.3 Interim measures

Although the long-term aim described in 7.2 is the ideal objective, it may take time for multiple stakeholders to work on the solution(s). The following set of interim measures are therefore proposed in this document.

1) The awareness should be increased that intermating of DC connectors from different manufacturers increases the risk of fire hazards and is therefore dangerous.
2) The term "MC4 compatible" should no longer be used. Compatibility with DC connectors from other manufacturers should in general not be claimed unless a standard as described in 7.2 is developed and successfully used by the manufacturer. The term "MC4 compatibility" is misleading and promotes the dangerous intermating of DC connectors from different manufacturers.
3) Module manufacturers should facilitate the access to the DC connectors from the same manufacturer as they use for their product. These connectors should be used when building the string interconnection cables in the field. This can be possible in two ways.
   a) The module manufacturers distribute spare connectors and assembly instructions of the same model along with the PV modules (preferred).
   b) The module manufacturers declare the manufacturer and model of the DC connectors used in the module (minimum requirement).

   If manufacturers are unable to provide easy supply of the DC connectors they use in their products, then they should clearly indicate any implication on product warranty in the case a different manufacturer of DC connectors is directly connected, or in case the supplied DC connector is cut and a different connector is field-attached. The risks associated with connecting an incompatible DC connector from a different manufacturer should be highlighted and the practice discouraged, and the process of cutting and field-installing a DC connector should not invalidate the module product warranty. DC connector manufacturers should be motivated to form working groups in order to achieve the long-term aim in 7.2. This can be achieved by developing a completely new connector type or by standardizing an existing connector and aligning the quality management systems between the different DC connector manufacturers. PV module manufacturers, installers, and other stakeholders should also be encouraged to participate in the DC connector standardization process.

4) System owners should request that only truly compatible DC connectors be used in their installations. Installers should contact and put pressure on their suppliers, distributors, product manufacturers, and DC connector manufacturers to standardize their products and ensure long-term compatibility.

8 Conclusion

For as long as the application of photovoltaic technology for terrestrial grid connected purposes has been discussed, safety has always been a primary concern of the PV industry. The acceptance of PV is strongly linked to its reputation of being a clean, reliable and safe technology. The end customer expects and deserves a harmonized, safe and reliable connector regardless of the supply chain constraints and conflicts. It is therefore of paramount importance for the PV industry to find a solution to the problem of the incompatibility of DC connectors from different manufacturers described in this document.