IEC 60749-34-1

Edition 1.0 2025-06

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Semiconductor devices - Mechanical and climatic test methods - Part 34-1: Power cycling test for power semiconductor module

Dispositifs à semiconducteurs - Méthodes d'essais mécaniques et climatiques - Partie 34-1: Essai de cycles en puissance pour modules de puissance à semiconducteurs

ICS 31.080.01

ISBN 978-2-8327-0496-7

IEC 60749-34-1:2025-06(en-fr)

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Semiconductor devices - Mechanical and climatic test methods - Part 34-1: Power cycling test for power semiconductor module

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IEC 60749-34-1 has been prepared by subcommittee IEC technical committee TC 47: Semiconductor devices. It is an International Standard.

The text of this International Standard is based on the following documents:

Draft	Report on voting
47/2902/FDIS	47/2924/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, and the ISO/IEC Directives available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 60749 series, published under the general title *Semiconductor devices – Mechanical and climatic test methods*, can be found on the IEC website.

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

- reconfirmed,
- withdrawn, or
- revised.

INTRODUCTION

A power semiconductor module is affected by thermal and mechanical stress due to the power dissipation of the internal semiconductor dies and connectors. This occurs when low-voltage operating bias for forward conduction is periodically applied and removed, causing rapid changes in temperature. The power cycling test is intended to simulate the temperature swing in typical power electronics applications, which is different from the stable temperatures reached under the high temperature operating life (HTOL) test as shown in IEC 60749-23. Exposure to the power cycling test would not induce the same failure mechanisms as exposure to the thermal cycling test, or thermal shock test. The power cycling test is a destructive test that will cause wear-out failure of the device under test (DUT) if it is driven above the specification of the device.

The power cycling test is applied to general power semiconductor modules such as for example those used for motor control, robots, and renewable energy generation. The power cycling test has two modes: a short-time test (based on a short cycle time) that simulates rapid acceleration and deceleration of the equipment, and a long-time test (based on a long cycle time) that simulates repeated operation and stop of the equipment. The short-time test mainly verifies the effect of the temperature change of virtual junction temperature (T_{vj}) and causes the deterioration of the joint between the semiconductor die and the wire, and that of the die attach under the semiconductor die. The long-time test verifies the effect of the temperature change of case temperature (T_c) and causes the deterioration of the joining layer between the metallic base plate and the insulating substrate, and the deterioration of the die attach under the semiconductor die.

The power cycling test is performed in two cases: as a certification test for the products whose power cycling lifetime model has already been confirmed, and as a lifetime model validation test for the products whose lifetime model has not been confirmed. The purpose of the certification test is to verify that the product has a longer life than the specified number of cycles.

Moreover, the purpose of the lifetime model validation test is to statistically estimate the power cycling lifetime model from the test results and obtain the expected lifetime model of power modules. This is essential when customers design the lifetime of their products.

1 Scope

This part of IEC 60749 describes a test method that is used to determine the capability of power semiconductor modules to withstand thermal and mechanical stress resulting from cycling the power dissipation of the internal semiconductors and the internal connectors. It is based on IEC 60749-34, but is developed specifically for power semiconductor module products, including insulated-gate bipolar transistor (IGBT), metal-oxide-semiconductor field-effect transistor (MOSFET), diode and thyristor.

If there is a customer request for an individual use or an application specific guideline (for example ECPE Guideline AQG 324), details of the test method can be based on these requirements if they deviate from the content of this document.

This test causes wear-out and is considered destructive.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60191-4, *Mechanical standardization of semiconductor devices – Part 4: Coding system and classification into forms of package outlines for semiconductor device packages*

IEC 60747-2:2016, *Semiconductor devices – Part 2: Discrete devices – Rectifier diodes*

IEC 60747-6:2016, *Semiconductor devices – Part 6: Discrete devices – Thyristors*

IEC 60747-8:2010, *Semiconductor devices - Discrete devices – Part 8: Field-effect transistors*
IEC 60747-8:2010/AMD1:2021

IEC 60747-9:2019, *Semiconductor devices – Part 9: Discrete devices – Insulated-gate bipolar transistors (IGBTs)*

IEC 60749-34, *Semiconductor devices – Mechanical and climatic test methods – Part 34: Power cycling*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

- IEC Electropedia: available at https://www.electropedia.org/
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NOTE Further terms and definitions pertaining to semiconductor devices can be found in the IEC 60747 series and IEC 60749 series.