IEC 60749-28

Edition 2.0 2022-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Semiconductor devices – Mechanical and climatic test methods – Part 28: Electrostatic discharge (ESD) sensitivity testing – Charged device model (CDM) – device level

Dispositifs à semiconducteurs – Méthodes d'essais mécaniques et climatiques – Partie 28: Essai de sensibilité aux décharges électrostatiques (DES) – Modèle de dispositif chargé (CDM) – niveau du dispositif

IEC 60749-28 Ed.2.0 - Preview only Copy via ILNAS e-Shop

IEC 60749-28:2022-03(en-fr)

THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2022 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

IEC 60749-28 Ed.2.0 - Preview only Copy via ILNAS e-Shop

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, …). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch
Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 300 terminological entries in English and French, with equivalent terms in 19 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

A propos de l'IEC
La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC
Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC - webstore.iec.ch/advsearchform
La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études, …). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished
Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc
Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch
Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

Electropedia - www.electropedia.org
Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 300 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 19 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

IEC 60749-28

Edition 2.0 2022-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Semiconductor devices – Mechanical and climatic test methods – Part 28: Electrostatic discharge (ESD) sensitivity testing – Charged device model (CDM) – device level

Dispositifs à semiconducteurs – Méthodes d'essais mécaniques et climatiques – Partie 28: Essai de sensibilité aux décharges électrostatiques (DES) – Modèle de dispositif chargé (CDM) – niveau du dispositif

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 31.080.01

ISBN 978-2-8322-1082-9

Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

® Registered trademark of the International Electrotechnical Commission
Marque déposée de la Commission Electrotechnique Internationale

IEC 60749-28 Ed.2.0 - Preview only Copy via ILNAS e-Shop

CONTENTS

FOREWORD ... 6
INTRODUCTION ... 8
1 Scope ... 9
2 Normative references ... 9
3 Terms and definitions ... 9
4 Required equipment ... 10
4.1 CDM ESD tester ... 10
4.1.1 General ... 10
4.1.2 Current-sensing element ... 11
4.1.3 Ground plane ... 11
4.1.4 Field plate/field plate dielectric layer ... 11
4.1.5 Charging resistor ... 11
4.2 Waveform measurement equipment ... 12
4.2.1 General ... 12
4.2.2 Cable assemblies ... 12
4.2.3 Equipment for high-bandwidth waveform measurement ... 12
4.2.4 Equipment for 1,0 GHz waveform measurement ... 12
4.3 Verification modules (metal discs) ... 12
4.4 Capacitance meter ... 12
4.5 Ohmmeter ... 12
5 Periodic tester qualification, waveform records, and waveform verification requirements ... 13
5.1 Overview of required CDM tester evaluations ... 13
5.2 Waveform capture hardware ... 13
5.3 Waveform capture setup ... 13
5.4 Waveform capture procedure ... 13
5.5 CDM tester qualification/requalification procedure ... 14
5.5.1 CDM tester qualification/requalification procedure ... 14
5.5.2 Conditions requiring CDM tester qualification/requalification ... 14
5.5.3 1 GHz oscilloscope correlation with high bandwidth oscilloscope ... 14
5.6 CDM tester quarterly and routine waveform verification procedure ... 15
5.6.1 Quarterly waveform verification procedure ... 15
5.6.2 Routine waveform verification procedure ... 15
5.7 Waveform characteristics ... 15
5.8 Documentation ... 17
5.9 Procedure for evaluating full CDM tester charging of a device ... 17
6 CDM ESD testing requirements and procedures ... 18
6.1 Tester and device preparation ... 18
6.2 Test requirements ... 18
6.2.1 Test temperature and humidity ... 18
6.2.2 Device test ... 18
6.3 Test procedures ... 19
6.4 CDM test recording / reporting guidelines ... 19
6.4.1 CDM test recording ... 19
6.4.2 CDM Reporting Guidelines ... 19
6.5 Testing of Devices in Small Packages ... 19

IEC 60749-28 Ed.2.0 - Preview only Copy via ILNAS e-Shop

7 CDM classification criteria 20
Annex A (normative) Verification module (metal disc) specifications and cleaning guidelines for verification modules and testers 21
A.1 Tester verification modules and field plate dielectric 21
A.2 Care of verification modules 21
Annex B (normative) Capacitance measurement of verification modules (metal discs) sitting on a tester field plate dielectric 22
Annex C (normative) Testing of small package integrated circuits and discrete semiconductors (ICDS) 23
C.1 Testing rationale 23
C.2 Procedure for Determining C_{small} 23
C.3 ICDS Technology requirements 24
Annex D (informative) CDM test hardware and metrology improvements 25
Annex E (informative) CDM tester electrical schematic 27
Annex F (informative) Sample oscilloscope setup and waveform 28
F.1 General 28
F.2 Settings for the 1 GHz bandwidth oscilloscope 28
F.3 Settings for the high-bandwidth oscilloscope 28
F.4 Setup 28
F.5 Sample waveforms from a 1 GHz oscilloscope 28
F.6 Sample waveforms from an 8 GHz oscilloscope 29
Annex G (informative) Field-induced CDM tester discharge procedures 31
G.1 General 31
G.2 Single discharge procedure 31
G.3 Dual discharge procedure 31
Annex H (informative) Waveform verification procedures 33
H.1 Factor/offset adjustment method 33
H.2 Software voltage adjustment method 36
H.3 Example parameter recording tables 38
Annex I (informative) Determining the appropriate charge delay for full charging of a large module or device 40
I.1 General 40
I.2 Procedure for charge delay determination 40
Annex J (informative) Electrostatic discharge (ESD) sensitivity testing direct contact charged device model (DC-CDM) 42
J.1 General 42
J.2 Standard test module 42
J.3 Test equipment (CDM simulator) 42
J.3.1 Test equipment design 42
J.3.2 DUT (device under test) support 43
J.3.3 Metal bar/board 43
J.3.4 Equipment setup 43
J.4 Verification of test equipment 44
J.4.1 General description of verification test equipment 44
J.4.2 Instruments for measurement 45
J.4.3 Verification of test equipment, using a current probe 45
J.5 Test procedure 46
J.5.1 Initial measurement 46

IEC 60749-28 Ed.2.0 - Preview only Copy via ILNAS e-Shop

J.5.2 Tests ... 47
J.5.3 Intermediate and final measurement ... 47
J.6 Failure criteria ... 47
J.7 Classification criteria ... 47
J.8 Summary ... 47
Bibliography ... 49

Figure 1 – Simplified CDM tester hardware schematic ... 11
Figure 2 – CDM characteristic waveform and parameters ... 17
Figure E.1 – Simplified CDM tester electrical schematic ... 27
Figure F.1 – 1 GHz TC 500, small verification module ... 29
Figure F.2 – 1 GHz TC 500, large verification module ... 29
Figure F.3 – 8 GHz TC 500, small verification module (oscilloscope adjusts for attenuation) ... 30
Figure F.4 – GHz TC 500, large verification module (oscilloscope adjusts for attenuation) ... 30
Figure G.1 – Single discharge procedure (field charging, I_{CDM} Pulse, and slow discharge) ... 31
Figure G.2 – Dual discharge procedure (field charging, 1st I_{CDM} pulse, no field, 2nd I_{CDM} pulse) ... 32
Figure H.1 – An example of a waveform verification flow for qualification and quarterly checks using the factor/offset adjustment method ... 34
Figure H.2 – An example of a waveform verification flow for the routine checks using the factor/offset adjustment method ... 35
Figure H.3 – Example of average I_{peak} for the large verification module – high bandwidth oscilloscope ... 36
Figure H.4 – An example of a waveform verification flow for qualification and quarterly checks using the software voltage adjustment method ... 37
Figure H.5 – An example of a waveform verification flow for the routine checks using the software voltage adjustment method ... 38
Figure I.1 – An example characterization of charge delay vs. I_p ... 41
Figure J.1 – Examples of discharge circuit where the discharge is caused by closing the switch ... 43
Figure J.2 – Verification test equipment for measuring the discharge current flowing to the metal bar/board from the standard test module ... 44
Figure J.3 – Current waveform ... 44
Figure J.4 – Measurement circuit for verification method using a current probe ... 46

Table 1 – CDM waveform characteristics for a 1 GHz bandwidth oscilloscope ... 16
Table 2 – CDM waveform characteristics for a high-bandwidth (≥ 6 GHz) oscilloscope ... 16
Table 3 – CDM ESDS device classification levels ... 20
Table A.1 – Specification for CDM tester verification modules (metal discs) ... 21
Table H.1 – Example waveform parameter recording table for the factor/offset adjustment method ... 39
Table H.2 – Example waveform parameter recording table for the software voltage adjustment method ... 39
Table J.1 – Dimensions of the standard test modules ... 42

IEC 60749-28 Ed.2.0 - Preview only Copy via ILNAS e-Shop

Table J.2 – Specified current waveform 45
Table J.3 – Range of peak current I_{p1} for test equipment 45
Table J.4 – Specification of peak current I_{p1} for the current probe verification method 46

IEC 60749-28 Ed.2.0 - Preview only Copy via ILNAS e-Shop

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

SEMICONDUCTOR DEVICES –
MECHANICAL AND CLIMATIC TEST METHODS –

Part 28: Electrostatic discharge (ESD) sensitivity testing –
Charged device model (CDM) – device level

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 60749-28 has been prepared by IEC technical committee 47: Semiconductor devices, in collaboration with IEC technical committee 101: Electrostatics. It is an International Standard.

ANSI/ESDA/JEDEC JS-002-2018 has served as a basis for the elaboration of this standard. It is used with permission of the copyright holders, ESD Association and JEDEC Solid state Technology Association. ANSI/ESDA/JEDEC JS-002-2018 describes the field-induced (FI) method. An alternative, the direct contact (DC) method (not based on JS-002-2018), is described in Annex J.

This second edition cancels and replaces the first edition published in 2017. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

IEC 60749-28 Ed.2.0 - Preview only Copy via ILNAS e-Shop

a) a new subclause and annex relating to the problems associated with CDM testing of integrated circuits and discrete semiconductors in very small packages;

b) changes to clarify cleaning of devices and testers.

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

Draft	Report on voting
47/2746/FDIS	47/2754/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, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/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 "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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

IEC 60749-28 Ed.2.0 - Preview only Copy via ILNAS e-Shop

INTRODUCTION

The earliest electrostatic discharge (ESD) test models and standards simulate a charged object approaching a device and discharging through the device. The most common example is IEC 60749-26, the human body model (HBM). However, with the increasing use of automated device handling systems, another potentially destructive discharge mechanism, the charged device model (CDM), becomes increasingly important. In the CDM, a device itself becomes charged (e.g. by sliding on a surface (tribocharging) or by electric field induction) and is rapidly discharged (by an ESD event) as it closely approaches a conductive object. A critical feature of the CDM is the metal-metal discharge, which results in a very rapid transfer of charge through an air breakdown arc. The CDM test method also simulates metal-metal discharges arising from other similar scenarios, such as the discharging of charged metal objects to devices at different potential.

Accurately quantifying and reproducing this fast metal-metal discharge event is very difficult, if not impossible, due to the limitations of the measuring equipment and its influence on the discharge event. The CDM discharge is generally completed in a few nanoseconds, and peak currents of tens of amperes have been observed. The peak current into the device will vary considerably depending on a large number of factors, including package type and parasitics. The typical failure mechanism observed in MOS devices for the CDM model is dielectric damage, although other damage has been noted.

The CDM charge voltage sensitivity of a given device is package dependent. For example, the same integrated circuit (IC) in a small area package can be less susceptible to CDM damage at a given voltage compared to that same IC in a package of the same type with a larger area. It has been shown that CDM damage susceptibility correlates better to peak current levels than charge voltage.

IEC 60749-28 Ed.2.0 - Preview only Copy via ILNAS e-Shop