

# INTERNATIONAL STANDARD

---

**Semiconductor devices - Measurement and evaluation methods of kinetic energy harvesting devices under practical vibration environment -  
Part 3: Human foot impact motion**



**THIS PUBLICATION IS COPYRIGHT PROTECTED**  
**Copyright © 2025 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.

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

Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

**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](http://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 It also gives information on projects, replaced and withdrawn publications.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](http://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](http://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](mailto:sales@iec.ch).

**IEC Products & Services Portal - [products.iec.ch](http://products.iec.ch)**

Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

**Electropedia - [www.electropedia.org](http://www.electropedia.org)**

The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

**Warning! Make sure that you obtained this publication from an authorized distributor.**

## CONTENTS

|   |    |
|---|----|
| FOREWORD .....  | 3  |
| 1 Scope .....   | 5  |
| 2 Normative references .....  | 5  |
| 3 Terms and definitions .....   | 5  |
| 4 Test bed of impact-driven energy harvesting devices .....   | 5  |
| 4.1 General .....   | 5  |
| 4.2 Vibrational exciter .....   | 6  |
| 4.3 Mounting fixture .....  | 6  |
| 4.4 Function generator .....  | 6  |
| 4.5 Power amplifier .....   | 6  |
| 4.6 Accelerometer .....   | 6  |
| 4.7 Data recorder .....   | 6  |
| 4.8 Load resistance .....   | 7  |
| 5 DUT .....   | 7  |
| 5.1 General .....   | 7  |
| 5.2 Confirmation of the DUT .....   | 7  |
| 6 Test conditions .....   | 7  |
| 6.1 Applied impact forces .....   | 7  |
| 6.2 Load resistances .....  | 7  |
| 6.3 Test environment .....  | 7  |
| 7 Measurement procedures .....  | 7  |
| 7.1 General .....   | 7  |
| 7.2 Input impulsive force .....   | 8  |
| 7.3 Output power .....  | 8  |
| 8 Test report .....   | 9  |
| Annex A (informative) Examples of experimental results using piezoelectric impact-driven energy harvesting device .....   | 12 |
| A.1 DUT .....   | 12 |
| A.2 Measurement procedure .....   | 14 |
| A.3 Output characteristics .....  | 14 |
| A.4 Examples of characteristics of actual wearable devices .....  | 19 |
| Bibliography .....  | 22 |
| Figure 1 – Test bed for impact-driven energy harvesting devices .....   | 6  |
| Figure 2 – A definition of sine half-wave acceleration pulses .....   | 8  |
| Figure A.1 – Cantilever-type piezoelectric impact-driven energy harvesting device used in the experiment .....  | 12 |
| Figure A.2 – Waveforms of input signal of function generator, acceleration, and output voltage (from top to bottom) of cantilever type piezoelectric energy harvester (acceleration $a_i = 90 \text{ m/s}^2$ ) .....  | 16 |
| Figure A.3 – Waveforms of input signal of function generator, acceleration, and output voltage (from top to bottom) of cantilever type piezoelectric energy harvester (acceleration $a_i = 180 \text{ m/s}^2$ ) ..... | 17 |
| Figure A.4 – Duration characteristics (parameter: vibrational excitation accelerations $a_i$ ) .....  | 18 |

|  |    |
|--|----|
| Figure A.5 – Waveforms of output voltage (upper) and power (lower) of $R_{TL}$ of a cantilever type piezoelectric energy harvester (acceleration $a_i = 90 \text{ m/s}^2$ , durations = 1 ms)..... | 19 |
| Figure A.6 – Examples of foot movements during walking and running [4] .....   | 20 |
| Figure A.7 – Configuration of measurement system of the impact acceleration and the output voltage of the DUT on a shoe.....   | 20 |
| Figure A.8 – Examples of measured waveforms of impact acceleration in a shoe sole .....  | 21 |
| Table 1 – Items and parameters required for the mandatory part of the test report.....   | 10 |
| Table 2 – Items and parameters of the optional part of the test report .....   | 11 |
| Table A.1 – Items and parameters of mandatory test report .....  | 12 |
| Table A.2 – Items and parameters of optional test report .....   | 13 |
| Table A.3 – Total load resistance dependency of output energy.....   | 19 |

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**Semiconductor devices -  
Measurement and evaluation methods of kinetic energy harvesting devices  
under practical vibration environment -  
Part 3: Human foot impact motion**

## 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) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 63150-3 has been prepared by IEC technical committee TC47: Semiconductor devices. It is an International Standard.

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

|              |                  |
|--------------|------------------|
| Draft        | Report on voting |
| 47/2948/FDIS | 47/2966/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](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/publications](http://www.iec.ch/publications).

A list of all parts in the IEC 63150 series, published under the general title *Semiconductor devices Measurement and evaluation methods of kinetic energy harvesting devices under practical vibration environment*, 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](http://webstore.iec.ch) in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

## **1 Scope**

This part of IEC 63150 specifies terms and definitions, and test methods of impact-driven energy harvesting devices of which electric energy is generated by impact force of human walking or running motion under practical human motion. This document is applicable to impact-driven energy harvesting devices embedded in wearables, especially, shoe-mounted energy harvesters, whose main element of the power generation is the impact energy. This measuring method is independent of power generation principles (such as piezoelectric, electrostatic, triboelectric, electromagnetic, etc.). According to typical human motion, power generation performance is measured in the condition of large-amplitude and low-frequency external mechanical excitation.

## **2 Normative references**

There are no normative references in this document.