IEC 60749-37

Edition 2.0 2022-10

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

**Semiconductor devices – Mechanical and climatic test methods –
Part 37: Board level drop test method using an accelerometer**

**Dispositifs à semiconducteurs – Méthodes d'essais mécaniques et climatiques –
Partie 37: Méthode d'essai de chute au niveau de la carte avec utilisation d'un accéléromètre**

IEC 60749-37:2022-10(en-fr)

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

Tel.: +41 22 919 02 11
info@iec.ch
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
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 It also gives information on projects, replaced and withdrawn publications.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 60749-37

Edition 2.0 2022-10

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Semiconductor devices – Mechanical and climatic test methods – Part 37: Board level drop test method using an accelerometer

Dispositifs à semiconducteurs – Méthodes d’essais mécaniques et climatiques – Partie 37: Méthode d'essai de chute au niveau de la carte avec utilisation d'un accéléromètre

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 31.080.01

ISBN 978-2-8322-5837-8

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.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

SEMICONDUCTOR DEVICES –
MECHANICAL AND CLIMATIC TEST METHODS –

Part 37: Board level drop test method using an accelerometer

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 60749-37 has been prepared by IEC technical committee 47: Semiconductor devices. It is an International Standard.

This second edition, based on JEDEC document JESD22-B111A, cancels and replaces the first edition published in 2008. It is used with permission of the copyright holder, JEDEC Solid State Technology Association. This edition constitutes a technical revision.

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

a) correction of a previous technical error concerning test conditions;
b) updates to reflect improvements in technology.

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

Draft	Report on voting
47/2651/CDV	47/2719/RVC

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 of the IEC 60749 series, under the general title *Semiconductor devices – Mechanical and climatic test methods*, can be found in 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.

INTRODUCTION

Handheld electronic products fit into the consumer and portable market segments. Included in handheld electronic products are cameras, calculators, cell phones, cordless phones, pagers, palm size PCs, personal computer memory card international association (PCMCIA) cards, smart cards, personal digital assistants (PDAs) and other electronic products that can be conveniently stored in a pocket and used while held in user's hand.

These handheld electronic products are more prone to being dropped during their useful service life because of their size and weight. This dropping event can not only cause mechanical failures in the housing of the device but also create electrical failures in the printed circuit board (PCB) assemblies mounted inside the housing due to transfer of energy through PCB supports. The electrical failures sometimes result from various failure modes such as cracking of the circuit board, track cracking on the board, cracking of solder interconnections between the components and the board, and component cracks. The primary driver of these failures is excessive flexing of the circuit board due to input acceleration to the board created from dropping the handheld electronic product. This flexing of the board causes relative motion between the board and the components mounted on it, resulting in component, interconnect or board failures. The failure is a function of the combination of the board design, construction, material, thickness and surface finish; interconnect material and standoff height and component size.

Correlation between test and field conditions is not yet fully established. Consequently, the test procedure is presently more appropriate for relative component performance than for use as a pass/fail criterion. Rather, results can be used to augment existing data or establish a baseline for potential investigative efforts in package/board technologies.

The comparability between different test sites, data acquisition methods, and board manufacturers has not been fully demonstrated by existing data. As a result, if the data are to be used for direct comparison of component performance, matching studies will first be performed to prove that the data are in fact comparable across different test sites and test conditions.

This method is not intended to substitute for full characterization testing, which could incorporate substantially larger sample sizes and increased number of drops. Due to limited sample size and number of drops specified here, it is possible that enough failure data are not generated in every case to perform full statistical analysis.

SEMICONDUCTOR DEVICES – MECHANICAL AND CLIMATIC TEST METHODS –

Part 37: Board level drop test method using an accelerometer

1 Scope

This part of IEC 60749 provides a test method that is intended to evaluate and compare drop performance of surface mount electronic components for handheld electronic product applications in an accelerated test environment, where excessive flexure of a circuit board causes product failure. The purpose is to standardize the test board and test methodology to provide a reproducible assessment of the drop test performance of surface-mounted components while producing the same failure modes normally observed during product level test.

This document aims at prescribing a standardized test method and reporting procedure. This is not a component qualification test and is not meant to replace any system level drop test that is sometimes used to qualify a specific handheld electronic product. The standard is not meant to cover the drop test required to simulate shipping and handling-related shock of electronic components or PCB assemblies. These requirements are already addressed in test methods such as IEC 60749-10. The method is applicable to both area array and perimeter-leaded surface mounted packages.

This test method uses an accelerometer to measure the mechanical shock duration and magnitude applied which is proportional to the stress on a given component mounted on a standard board. The test method described in IEC 60749-40 uses strain gauge to measure the strain and strain rate of a board in the vicinity of a component. The customer specification states which test method is to be used.

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 60749-10:2022, *Semiconductor devices – Mechanical and climatic test methods – Part 10: Mechanical shock – Device and subassembly*

IEC 60749-20, *Semiconductor devices – Mechanical and climatic test methods – Part 20: Resistance of plastic-encapsulated SMDs to the combined effect of moisture and soldering heat*

IEC 60749-20-1, *Semiconductor devices – Mechanical and climatic test methods – Part 20-1: Handling, packing, labelling and shipping of surface-mount devices sensitive to the combined effect of moisture and soldering heat*

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/

ISO Online browsing platform: available at https://www.iso.org/obp

3.1
component
packaged semiconductor device

3.2
single-sided assembly
printed circuit board assembly with components mounted on only one side of the board

3.3
double-sided assembly
printed circuit board assembly with components mounted on top and bottom sides of the board

3.4
handheld electronic product
product that can conveniently be stored in a pocket (of sufficient size) and used when held in user's hand

Note 1 to entry: Handheld electronic products include cameras, calculators, cell phones, pagers, palm-size PCs (formerly called 'pocket organizers'), personal computer memory card international association (PCMCIA) cards, smart cards, mobile phones, personal digital assistants (PDAs) and other communication devices.

3.5
peak acceleration
maximum acceleration during the dynamic motion of the test apparatus

3.6
pulse duration
acceleration interval
time interval between the instant when the acceleration first reaches 10 % of its specified peak level and the instant when the acceleration first returns to 10 % of the specified peak level after having reached that peak level

3.7
table drop height
free-fall drop height of the drop table needed to attain the prescribed peak acceleration and pulse duration

3.8
event
electrical discontinuity of resistance greater than 1 000 Ω lasting for 1 µs or longer

3.9
event detector
continuity test instrument capable of detecting electrical discontinuity of resistance greater than 1 000 Ω lasting for 1 µs or longer

4 Test apparatus and components

4.1 Test apparatus

The shock-testing apparatus shall be capable of providing shock pulses up to a peak acceleration of 2 900 $m \cdot s^{-2}$ with a pulse duration between 0,3 ms and 8,0 ms to the body of the device and a velocity change of 1 250 $mm \cdot s^{-1}$ to 5 430 $mm \cdot s^{-1}$. For free-state testing, a velocity change of 1 250 $mm \cdot s^{-1}$ to 5 430 $mm \cdot s^{-1}$ and a pulse duration between 0,3 ms and 2,0 ms is sufficient. Conversely, for mounted-state testing, apparatus capable of a velocity change of

1 000 mm·s^{-1} to 5 430 mm·s^{-1} and a pulse duration between 5,0 ms and 8,0 ms to the body of the component is sufficient.

The acceleration pulse shall be a half-sine waveform with an allowable deviation from specified peak acceleration not greater than ±10 %. The test velocity change shall be ±10 %of the specified level. The pulse duration shall be measured between the points at 10 % of the peak acceleration during rise time and 10 % of the peak acceleration during decay time. Absolute tolerances of the pulse duration shall be ±15 % of the specified duration. The test equipment transducer shall have a natural frequency greater than 5 times the frequency of the shock pulse being established, and measured through a low-pass filter having a bandwidth greater than 5 times the frequency of the shock pulse being established. Filtering shall not be used in lieu of good measurement setup and procedure practices.

Appropriate equipment calibration shall be carried out prior to any testing.

4.2 Test components

This document covers all area arrays and perimeter-leaded surface-mountable packaged semiconductor devices such as ball grid arrays (BGA), land grid arrays (LGA), chip scale packages (CSP), thin small outline packages (TSOP) and quad flat no-lead packages (QFN) typically used in handheld electronic product. The maximum size of the component body covered in this document is 15 mm x 15 mm in general. A larger body size may be used for a special board layout as described in detail in 4.3. All components used for this testing shall be daisy-chained. The daisy chain is made at the die level or by providing daisy chain links at the lead-frame or substrate level. In case of non-daisy chain die, a mechanical dummy die shall be used inside the package to simulate the actual structure of the package. The die size and thickness shall be similar to the functional die size to be used in application. The component materials, dimensions and assembly processes shall be representative of typical production device.

4.3 Test board

Since the drop test performance is a function of the test board used for evaluation, this document describes a preferred test board construction, dimensions, and material that is representative of those used in handheld electronic products. If another board construction/material better represents a specific application, the test board construction, dimensions and material shall be documented. The test data generated using such a board shall be correlated at least once by generating the same data on the same component using the preferred board defined in this document (see Annex A for recommendations).

4.4 Test board assembly

Prior to board assembly, all devices shall be inspected for missing balls or bent leads. Board thickness, warpage and pad sizes shall also be measured using a sampling plan. A visual inspection shall be performed on all boards for solder mask registration, contamination and daisy chain connection. It is recommended that boards be inspected and accepted in accordance with a relevant national or international standard. One board shall also be used to measure the mechanical properties (modulus and glass transition temperature, T_{g}) of the board at the component location using dynamic mechanical analysis (DMA) and thermomechanical analysis (TMA) methods. It is highly recommended that the coefficient of thermal expansion (CTE) of the board be also measured in X, Y and Z direction. The mechanical property measurements are not required for every board lot, unless the fabrication process, material or vendor is changed from lot to lot.

The components shall be baked according to IEC 60749-20 and IEC 60749-20-1 prior to board assembly. The test boards shall be assembled using best known methods of printed circuit assembly process, representative of production methods. At least one board shall be used to adjust the board mounting process such as paste printing, placement and reflow profile. All assemblies shall be single-sided only, unless the component is anticipated for use in mirrorsided board assemblies. In that case, the components shall be mounted on each side of the board.

A 100 % X-ray inspection is recommended on assembled units to check for voids, short-circuits and other abnormalities. Electrical continuity test shall also be performed on all mounted units to detect any open-circuits or short-circuits.

4.5 Number of components and sample size

The board design recommended in Annex A allows 4 locations for component mounting and is recommended that all 4 components are mounted. Since the board is designed with full symmetry, all 4 components are expected to be subjected to the same drop performance and hereby the test results are treated as one single group. Statistical analysis on the data equivalence is suggested to ensure that variability in the component performance is insignificant before comprehensive data or full qualification is pursued. In order to get good statistically meaningful results, a total of 6 boards or 24 components are recommended as a minimum quantity per each design.

Since the number and size of the components mounted on the board can influence the dynamic response of the test board assembly during drop, it is required that additional data be provided whenever the 1-component configuration is employed. The additional data shall directly compare the effect of optional component mounting (1 component case) to the preferred 4-component mounting configuration. This comparison shall be provided for a component similar in size (within 20 % in both length and width) to the component, which has been tested using 1-component per board configuration only.

In the case of 1 component mount on the board, Table 1 shall be used to determine the minimum quantity of assembled board required for testing and total number of components to be tested. Sample sizes greater than specified below can also be used to generate statistically sufficient data.

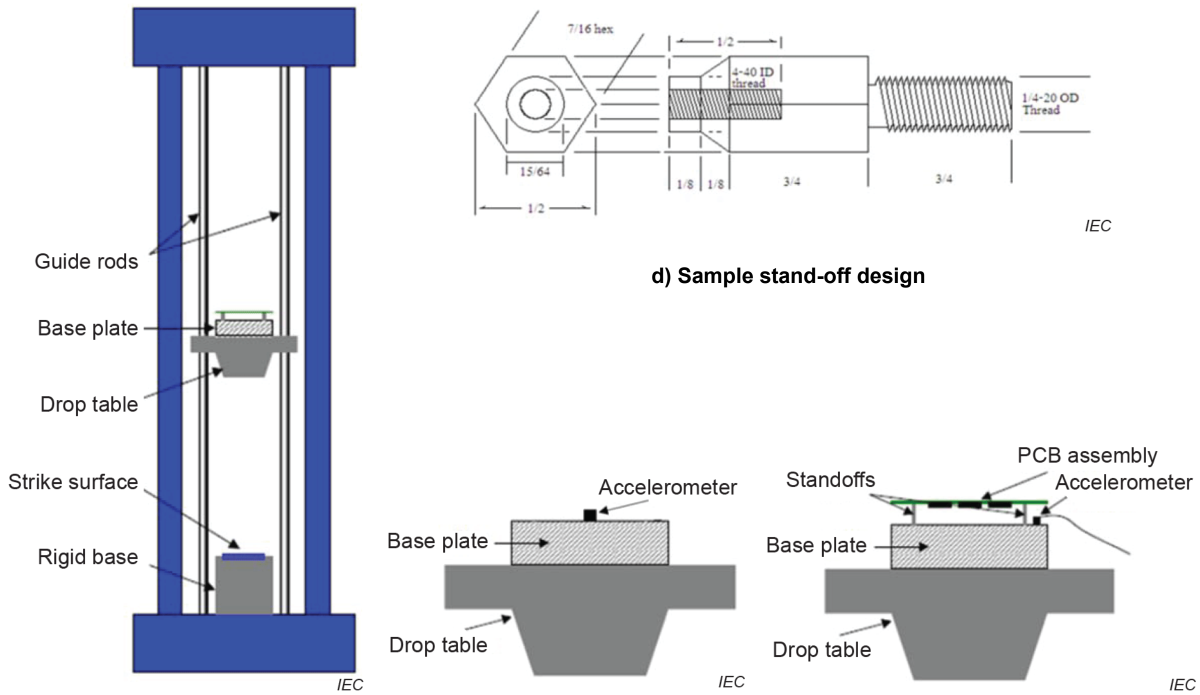
Table 1 – Quantity of test boards and components required for testing

Number of components per board	Location	Number of boards		Total number of components
		Side A assembly (via in pad)	Side B assembly (not via in pad)	
4	U1, U2, U3 and U4	6	6	48
1	Centre of the board	16	16	32

5 Test procedure

5.1 Test equipment and parameters

The shock testing apparatus shall be mounted on a sturdy laboratory table or equivalent base and levelled before use. Means shall be provided in the apparatus (such as an automatic braking mechanism) to eliminate bounce and to prevent multiple shocks to the board. Figure 1 shows the typical drop test apparatus where the drop table travels down on guide rods and strikes the rigid fixture. The rigid fixture typically is covered with some form of material to achieve the desirable pulse and acceleration levels. The bottom of the drop table is usually rounded slightly to ensure a very small area of contact with the strike surface.



d) Sample stand-off design

a) Typical drop test apparatus **b) Pre-characterization set up without test board** **c) Assembly set up with board**

Figure 1 – Drop test apparatus detail

A base plate with suitable standoffs shall be rigidly mounted on the drop table. The thickness and mounting locations of the base plate shall be selected such that there is no relative movement between the drop table and any part of base plate during drop testing. This plate will serve as the mounting structure for the PCB assemblies. This is pictorially shown in Figure 1. The PCB assembly shall be mounted to the base plate standoffs using four screws, one at each corner of the board. The board shall be mounted using four suitable precision shoulder screws (e.g. M3 × 0,5). Test data suggests that the variations in response acceleration and strain are reduced significantly depending upon the choice of screw. Since the length of shoulder is nominal, a number of washers shall be placed between the screw head and the top surface of the board (nominal 1,0 mm thick) to avoid any gap between the top of the standoffs and the bottom surface of the board. Due to tolerance stack up, a small gap is still possible but this gap shall not exceed 50 µm. The use of shoulder screw eliminates the need to re-tighten screws between drops. The screws shall be tightened in a diagonal pattern in the order of SW, NE, SE, and NW corners of the board. The screw shall be tightened until the shoulder of the screw bottoms out against the standoff. The number of washers used shall be the same for all four screws. A custom board jig may be used instead of mounting the board directly to the plate.

Experience with different board orientations has suggested that the horizontal board orientation with components facing down results in maximum PCB flexure and, thus, the worst orientation for failures. Therefore, this document requires that the board shall be horizontal in orientation with components facing in downward direction during the test. Drop testing using other board orientations is not required but may be performed if deemed necessary. However, this is an additional test option and not a replacement for testing in the required orientation.

This document requires test condition B (15 000 m·s^{-2}, 0,5 ms duration, half-sine pulse), as listed in Table 1 of IEC 60749-10:2022, as the input shock pulse to the printed circuit assembly. This is the applied shock pulse to the base plate and shall be measured by accelerometer mounted at the centre of base plate or close to the support posts for the board. The velocity change of the drop pulse shall be also controlled and maintained at 4,67 m/s. The calculation of the velocity change is defined by the effective pulse where the acceleration must be equal to or above 1 500 m·s^{-2} as shown in Figure 2. No rebounces are allowed in this calculation.

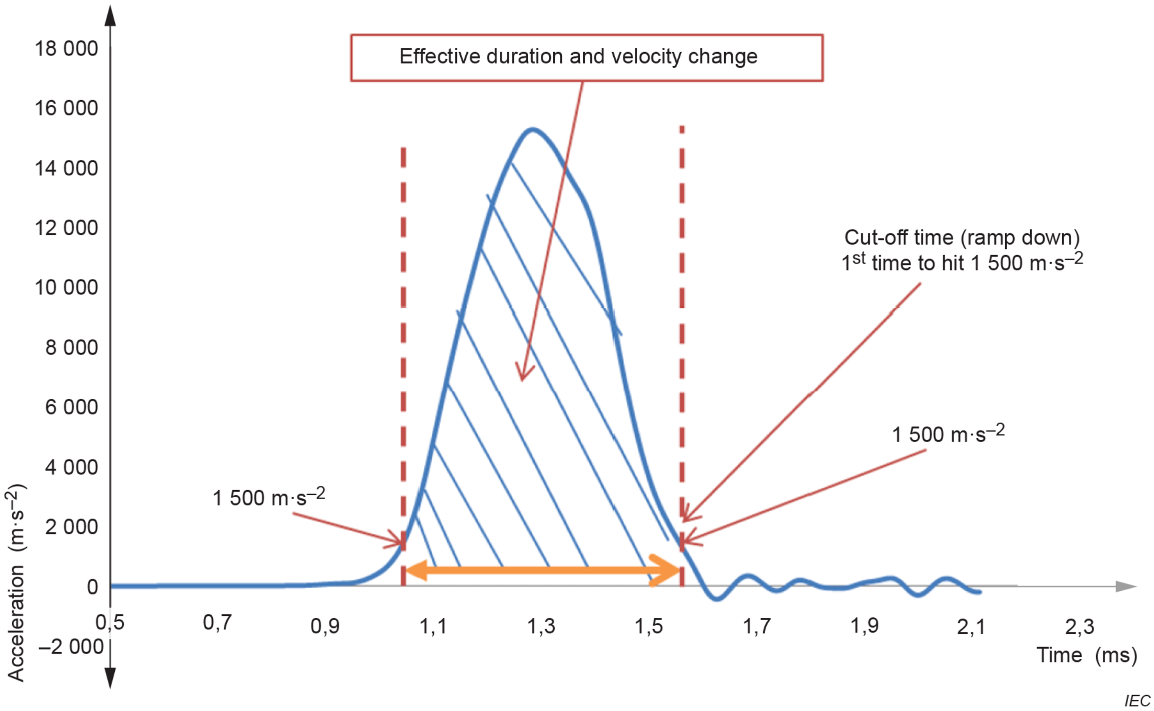


Figure 2 – Calculation of velocity change

5.2 Pre-test characterization

A set-up board with components mounted on it shall be used to adjust and characterize the drop test parameters and board response. A lightweight accelerometer is attached with (using suitable adhesive) in the centre of the mounting plate. Since the board weight is negligible as compared to mounting plate, setup characterization without a test board will not alter the results. Both the accelerometer and the strain gauge shall be connected to a data acquisition system capable of measuring at a scan frequency of 20 kHz and greater with a 16-bit signal width. Additional strain gauges can also be mounted at different locations on the board to fully characterize the strain response of the assembly.

The board assembly shall then be mounted on the drop test fixture using four screws. The screws shall be tightened in diagonal pattern in the order of SW, NE, SE, and NW corners of the board. An additional accelerometer may also be mounted on the board assembly at or close to one of the support locations to ensure that the input pulse to the base plate is transmitted to the PCB without any distortion. The drop table shall then be raised to the height required to meet test condition B of Table 1 of IEC 60749-10:2022 and dropped on to the strike surface while measuring the G level, pulse duration, and pulse shape.

The acceleration pulse shall follow a half-sine curve with a peak acceleration of 1 500 m·s^{-2} during each drop as shown in Figure 2. Multiple drops can be required while adjusting the drop height and impact surface to achieve the specified peak acceleration and change of velocity (1 500 m·s^{-2}, 4,67 m/s respectively). The variations of the peak acceleration and change of velocity needs to be controlled within 10 % on each individual measurement and 5% tolerance on average when 20 repeating measurements. The change of velocity is the total area enclosed by the acceleration pulse and the time axis. An effective change of velocity shall be counted in which only an acceleration equal to or higher than 1 500 m·s^{-2} is considered and any rebounces after the acceleration dropping to below 1 500 m·s^{-2} from the peak shall be ignored in the calculation. The time duration for defining the area of effective change of velocity is called effective pulse duration and shall also be maintained at 0,5 ms within 15 % tolerance which is in accordance with IEC 60749-10. The test equipment and transducer shall have a natural frequency greater than 5 times the frequency of the shock pulse being established, and measured through a low-pass filter having a bandwidth greater than 5 times the frequency of the shock pulse being established, see detail in IEC 60749-10. However, both unfiltered and