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NORME INTERNATIONALE

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 60749-37:2008

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FOREWORD

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

This standard cancels and replaces IEC/PAS 62050 published in 2004. This first edition constitutes a technical revision.

The text of this standard is based on the following documents:

FDIS	Report on voting
47/1937/FDIS	47/1948/RVD

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

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

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 publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn;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

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 may 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 should 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 must 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 might 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 may not be 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 and object

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.

The purpose of this standard is to prescribe 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 may be needed 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 the future IEC 60749-40[1] uses strain gauge to measure the strain and strain rate of a board in the vicinity of a component. The detailed specification states which test method is to be used.

2 Normative references

The following referenced documents are indispensable for the application 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 60749-10:2002, *Semiconductor devices – Mechanical and climatic test methods – Part 10: Mechanical shock*

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*[2]

3 Terms and definitions

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

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[1] Under consideration.

[2] In preparation.

3.1
component
packaged semiconductor device

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

3.3
double-sided PCB 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 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 $\mathrm{m \cdot s^{-2}}$ with a pulse duration between 0,3 ms and 8,0 ms to the body of the device and a velocity change of 710 $\mathrm{mm \cdot s^{-1}}$ to 5 430 $\mathrm{mm \cdot s^{-1}}$.

The acceleration pulse shall be a half-sine waveform with an allowable deviation from specified acceleration level not greater than ±20 % of the specified peak acceleration. This is determined by a transducer having a natural frequency 5 times the frequency of the shock pulse being established and measured through a low pass filter having a band width preferably at least 5 times the frequency of the shock pulse being established. It is very important that the transducer resonance does not approach the measured value. Filtering should not be used in lieu of good measurement set-up and procedure practices. 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 ±30 % of the specified duration. It is recommended that the test velocity change should be ±10 % of the specified level.

4.2 Test components

This standard 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. All components used for this testing must be daisy-chained. The daisy chain should either be 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 should 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 standard 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 should 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 should 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 the future 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 mirror-sided 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 up to 15 locations for component mounting and it is preferred that components be mounted on all 15 locations. Since the drop performance is a function of component location on the board, testing with components mounted on all 15 locations will provide useful information to the users of this data in proper layout of their product board. With the board supported at four corners, these locations cover the worst case board curvature (U8 location), the effect of proximity to support locations (U1, U5, U11, and U15 locations) and various locations in between. Because of various designs for tests, and designs for failure analysis practices used in the industry, it is recognized that populating boards with all 15 locations may not leave enough room between components for a large number of test points to properly identify the exact failure location. Therefore, options are provided for mounting just 1 or 5 components on the board using the following locations:

- 1-component configurations: location U8
- 5-component configurations: locations U2, U4, U8, U12, and U14

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

Number of components per board	Number of boards		Total number of components
	Side A assembly (via in pad)	Side B assembly (not via in pad)	
15	4	4	120
5	4	4	40
1	10	10	20

Since the number and size of the components mounted on the board may influence the dynamic response of the test board assembly during drop, it is required that additional data are provided whenever these 1-component or 5-component configurations are employed. The additional data shall directly compare the effect of optional component mounting (1- or 5-component) to the preferred 15-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- or 5-component per board configuration only.

Depending on the number of components mounted per board, Table 1 shall be used to determine the minimum quantity of assembled boards required for testing and the total number of components to be tested. Sample sizes greater than specified in Table 1 can be used to generate statistically sufficient data. In case of rectangular components, the longer side of the component should be parallel to the longer side of the board when mounted.

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.

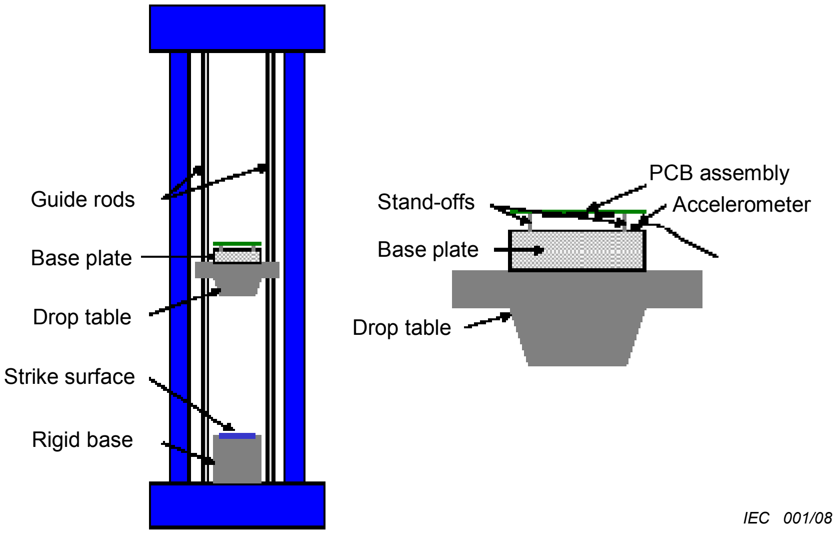


Figure 1 – Typical drop test apparatus and mounting scheme for PCB assembly

A base plate with suitable standoffs (e.g. 6 mm hexagonal outside diameter / M3 × 0,5 inside diameter, 10 mm long) 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 dependant upon the choice of screw. Since the length of shoulder is nominal, a number of washers should 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 standard 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 standard requires test condition B (1 500 m·s^{-2}, 0,5 ms duration, half-sine pulse), as listed in Table 1 of IEC 60749-10, 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. Other shock conditions, such as 2 900 m·s^{-2}, 0,3 ms duration, in addition to the required condition can also be used.

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 should be attached with beeswax (or equivalent adhesive) on top of the component located at position U8 to characterize the output acceleration response of the PCB assembly. It should be noted, however, that any additional mass will add significant dynamic weight to the board and may alter its dynamic response. Therefore, it is recommended that this characterization should only be carried out on a set-up board. In addition, a 45 ° rectangular rosette strain gauge shall be mounted on this set-up board underneath position U8 on the other side (non-component) side of the board to characterize strains in the X and Y directions as well as the principal strain and principal strain angle. 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 may also be mounted at different locations on the board to fully characterize the strain response of the assembly.

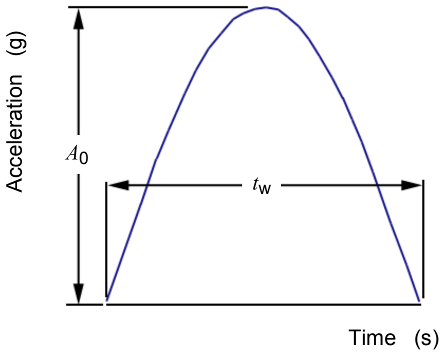
The board assembly shall then be mounted on the drop test fixture using four screws. The screws shall be tightened in diagonal pattern in the order of SW, NE, SE, and NW corners of the board. An additional accelerometer may also be mounted on the board assembly at or close to one of the support locations 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 and dropped on to the strike surface while measuring the G level, pulse duration, and pulse shape.

Multiple drops might be required whilst adjusting the drop height and strike surface to achieve the specified acceleration levels and pulse duration (1 500 m·s^{-2}, 0,5 ms half-sine pulse). It should be noted that the peak acceleration and the pulse duration is a function of not only the drop height but also the strike surface. Depending on the strike surface, the same drop height could result in different acceleration levels and pulse durations. Theoretically, the drop height needed to achieve the appropriate acceleration levels can be determined from Equations (1) and (2) and the associated Figure 2, where H is the drop height and C is the rebound coefficient (1,0 for no rebound, 2,0 for full rebound). However, this equation does not include the strike surface effect.

Experiments with different strike surface may be needed to achieve the desired peak value and duration.

$$A(t) = A_0 \sin\left(\frac{\pi t}{t_w}\right) \tag{1}$$

$$\sqrt{2gH} = A_0 \sin\left(\frac{2A_0 t_w}{C\pi}\right) \tag{2}$$



IEC 002/08

Figure 2 – Typical shock test half-sine pulse graphic and formulae