

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE



**Passive RF and microwave devices, intermodulation level measurement –  
Part 1: General requirements and measuring methods**

**Dispositifs RF et à micro-ondes passifs, mesure du niveau d'intermodulation –  
Partie 1: Exigences générales et méthodes de mesure**

ITeC STANDARD PREVIEW  
(standards.iteh.ai)

IEC 62037-1:2012

<https://standards.iteh.ai/catalog/standards/sist/0cd55cef-b202-4d32-bb4f-f59f9f87e632/iec-62037-1-2012>

f59f9f87e632/iec-62037-1-2012



## THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2012 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 Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
Fax: +41 22 919 03 00  
[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 corrigenda or an amendment might have been published.

#### IEC Catalogue - [webstore.iec.ch/catalogue](http://webstore.iec.ch/catalogue)

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

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

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in 14 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

#### IEC publications search - [www.iec.ch/searchpub](http://www.iec.ch/searchpub)

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 Glossary - [std.iec.ch/glossary](http://std.iec.ch/glossary)

More than 55 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

#### 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 also 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: [csc@iec.ch](mailto:csc@iec.ch).

### 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.

#### Catalogue IEC - [webstore.iec.ch/catalogue](http://webstore.iec.ch/catalogue)

Application autonome pour consulter tous les renseignements bibliographiques sur les Normes internationales, Spécifications techniques, Rapports techniques et autres documents de l'IEC. Disponible pour PC, Mac OS, tablettes Android et iPad.

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

Le premier dictionnaire en ligne de termes électroniques et électriques. Il contient plus de 30 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans 14 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

#### Recherche de publications IEC - [www.iec.ch/searchpub](http://www.iec.ch/searchpub)

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.

#### Glossaire IEC - [std.iec.ch/glossary](http://std.iec.ch/glossary)

Plus de 55 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

#### IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

#### Service Clients - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: [csc@iec.ch](mailto:csc@iec.ch).

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE



**Passive RF and microwave devices, intermodulation level measurement –  
Part 1: General requirements and measuring methods**

**Dispositifs RF et à micro-ondes passifs, mesure du niveau d'intermodulation –  
Partie 1: Exigences générales et méthodes de mesure**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

COMMISSION  
ELECTROTECHNIQUE  
INTERNATIONALE

PRICE CODE  
CODE PRIX



ICS 33.040.20

ISBN 978-2-8322-1350-6

**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

FOREWORD.....	3
1 Scope.....	5
2 Normative references.....	5
3 Abbreviations.....	5
4 Characteristics of intermodulation products.....	5
5 Principle of test procedure.....	6
6 Test set-up.....	6
6.1 General.....	6
6.2 Test equipment.....	6
6.2.1 General.....	6
6.2.2 Set-up 1.....	7
6.2.3 Set-up 2.....	8
7 Preparation of DUT and test equipment.....	8
7.1 General.....	8
7.2 Guidelines for minimizing generation of passive intermodulation.....	8
8 Test procedure.....	10
9 Reporting.....	10
9.1 Results.....	10
9.2 Example of results.....	10
10 Measurement error.....	11
Annex A (informative) Configuration of low-PIM termination.....	15
Annex B (informative) Test procedure considerations.....	17
Figure 1 – Set-up 1; reverse IM-test set-up.....	12
Figure 2 – Set-up 2; forward IM-test set-up.....	13
Figure 3 – Passive intermodulation (PIM) measurement error caused by residual system error.....	14
Figure A.1 – Long cable termination.....	15
Figure A.2 – Lumped termination with a linear attenuator.....	16
Table 1 – Guide for the design, selection of materials and handling of components that may be susceptible to PIM generation.....	9
Table 2 – Test set-up conditions.....	10

ITeH STANDARD PREVIEW

(standards.iteh.ai)

IEC 62037-1:2012

<https://standards.iteh.ai/catalog/standards/sist/0cd53eef-b202-4d32-bb4f-159187c0321cc-62037-1-2012>

159187c0321cc-62037-1-2012

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**PASSIVE RF AND MICROWAVE DEVICES,  
INTERMODULATION LEVEL MEASUREMENT –**

**Part 1: General requirements and measuring methods**

**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.  
<https://standards.iteh.ai/catalog/standards/sist/0cd53eef-b202-4d32-bb4f-519876c928c9/iec-62037-1-2012>
- 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.

International Standard IEC 62037-1 has been prepared by technical committee 46: Cables, wires, waveguides, R.F. connectors, R.F. and microwave passive components and accessories.

This bilingual version (2014-01) corresponds to the monolingual English version, published in 2012-05.

This first edition of IEC 62037-1 replaces IEC 62037, published in 1999. It constitutes a technical revision.

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

FDIS	Report on voting
46/402/FDIS	46/416/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.

The French version of this standard has not been voted upon.

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

A list of all the parts in the IEC 62037 series, published under the general title *Passive RF and microwave devices intermodulation level measurement*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability 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.

**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 62037-1:2012](https://standards.iteh.ai/catalog/standards/sist/0cd53eef-b202-4d32-bb4f-f59f9f87e632/iec-62037-1-2012)

<https://standards.iteh.ai/catalog/standards/sist/0cd53eef-b202-4d32-bb4f-f59f9f87e632/iec-62037-1-2012>

# PASSIVE RF AND MICROWAVE DEVICES, INTERMODULATION LEVEL MEASUREMENT –

## Part 1: General requirements and measuring methods

### 1 Scope

This part of IEC 62037 deals with the general requirements and measuring methods for intermodulation (IM) level measurement of passive RF and microwave components, which can be caused by the presence of two or more transmitting signals.

The test procedures given in this standard give the general requirements and measurement methods required to characterize the level of unwanted IM signals using two transmitting signals.

The standards in this series address the measurement of PIM, but do not cover the long term reliability of a product with reference to its performance.

This standard is to be used in conjunction with other appropriate part(s) of IEC 62037.

**iTeh STANDARD PREVIEW**

### 2 Normative references **(standards.iteh.ai)**

None.

[IEC 62037-1:2012](https://standards.iteh.ai/catalog/standards/sist/0cd53eef-b202-4d32-bb4f-f59f9f87e632/iec-62037-1-2012)

<https://standards.iteh.ai/catalog/standards/sist/0cd53eef-b202-4d32-bb4f-f59f9f87e632/iec-62037-1-2012>

### 3 Abbreviations

CATV Community antenna television

DUT Device under test

IM Intermodulation

PIM Passive intermodulation

### 4 Characteristics of intermodulation products

PIM interference is caused by sources of non-linearity of mostly unknown nature, location and behaviour. A few examples are inter-metallic contacts, choice of materials, corrosion products, dirt, etc. Most of these effects are subject to changes over time due to mechanical stress, temperature changes, variations in material characteristics (cold flow, etc.) and climatic changes, etc.

The generation of intermodulation products originates from point-sources inside a DUT and propagate equally in all available directions.

The generation of passive intermodulation products (PIM) does not necessarily follow the law of the usual non-linear equation of quadratic form. Therefore, accurate calculation to other power levels causing the intermodulation is not possible and PIM comparisons should be made at the same power level.

Furthermore, PIM generation can be frequency-dependent. When PIM generation is frequency-dependant, the PIM performance shall be investigated over the specified frequency band.

## 5 Principle of test procedure

Test signals of frequencies  $f_1$  and  $f_2$  with equal specified test port power levels are combined and fed to the DUT. The test signals should contain at least 10 dB less harmonic or self-intermodulation signal level than the expected level generated in the DUT.

The PIM is measured over the specified frequency range. The intermodulation products of order  $(2f_1 \pm f_2)$ ,  $(2f_2 \pm f_1)$  etc. are measured.

In most cases, the third order intermodulation signals represent the worst case condition of unwanted signals generated; therefore, the measurement of these signals characterizes the DUT in a sufficient way. However, the test set-ups given in Clause 6 are suitable for measuring other intermodulation products.

In other systems (such as CATV), the 3<sup>rd</sup> order may not be as applicable in characterizing the DUT.

Intermodulation can be measured in reverse and forward direction. Reverse and forward is referred to the direction of propagation of the most powerful carrier.

## 6 Test set-up

### 6.1 General

Experience shows that the generation of intermodulation products originates from point-sources inside a device under test (DUT) and propagates equally in all available directions. Therefore, either the reverse (reflected) or the forward (transmitted) intermodulation signal can be measured.

<https://standards.iteh.ai/catalog/standards/sist/0cd53eef-b202-4d32-bb4f-59987e632/iec-62037-1-2012>

Two different test set-ups are described in Figure 1 and Figure 2 and are for reference only. Other topologies are possible.

Set-up 1 is for measuring the reverse (reflected) intermodulation signal only, and set-up 2 is for measuring the forward (transmitted) intermodulation signal. The measurement method (reverse or forward) is dependent upon the DUT. The set-ups may be assembled from standard microwave or radio link hardware selected for this particular application. All components shall be checked for lowest self-intermodulation generation.

Experience shows that devices containing magnetic materials (circulators, isolators, etc.) can be prominent sources of intermodulation signal generation.

See Annex B for additional set-up considerations.

### 6.2 Test equipment

#### 6.2.1 General

Two signal sources or signal generators with power amplifiers are required to reach the specified test port power. The combining and diplexing device may comprise a circulator, hybrid junction, coupler or filter network.

The test set-up self-intermodulation generated (including contribution of the load) should be at least 10 dB below the level to be measured on the DUT. The associated error may be obtained from the graph in Figure 3.



The DUT shall be terminated by a load for the specified power if necessary. The receiving bandpass filter, tuned for the desired intermodulation signal, is followed by a low noise amplifier (if required) and a receiver.

See Annex B for additional set-up considerations.

### 6.2.2 Set-up 1

This set-up is to measure the reverse (reflected) IM-product and is therefore suitable for 1-port and multi-port DUTs. On multi-port DUTs, the unused ports shall be connected to a linear termination.

#### a) Generators

The generators shall provide continuous wave (CW) signals of the specified test port power. They shall have sufficient frequency stability to make sure that the IM-product can be detected properly by the receiver.

#### b) Transmit-filters

The filters are bandpass-filters tuned to the particular frequencies. They isolate the generators from each other and filter out the harmonics of  $f_1$  and  $f_2$ .

#### c) Combining and diplexing device

This device is used for combining the signals  $f_1$  and  $f_2$ , delivering them to the test port and provides a port for the extraction of the reverse (reflected) signal  $f_{IM}$ .

#### d) Receive-filter

This filter is used for isolating the input of the receiver from the signals  $f_1$  and  $f_2$  to the extent that IM-products are not generated within the receiver.

#### e) Test port

The DUT is connected to P4. The specified input power shall be at the DUT, with any set-up loss between the receiver and the DUT compensated for.

#### f) Termination

When a multi-port DUT is measured, the DUT shall be connected to a sufficiently linear termination (low intermodulation) of suitable power handling capability.

#### g) Receiver

The receiver shall be sensitive enough to detect a signal of the expected power level.

The receiver response time shall be sufficiently short to allow acquisition of rapid changes in amplitude. Sensitivity can be increased by a low noise preamplifier. Frequency stability shall be sufficient for the proper detection of the IM-signal.

When the PIM measurement result is close to the thermal noise floor of the receiver, the receiver sensitivity can be improved by reducing the resolution bandwidth (RBW). Furthermore, by using the averaging mode rather than the max-hold mode, a further improvement can be achieved, since the max-hold mode essentially measures the maximum thermal noise peak, while the averaging mode results in a measurement that is closer to the r.m.s. value.

### 6.2.3 Set-up 2

This set-up is to measure the forward (transmitted) IM-product and is therefore suitable only for two- or multi-port DUTs.

All components are the same as those of set-up 1, except for those as noted below:

a) Combining and diplexing device

The extraction-port P3 on this device shall be terminated to prevent reflection of the IM-signals.

b) Diplexing device

The signals  $f_1$ ,  $f_2$  and  $f_{IM}$  are split to P6 and P7. This device, together with an additional receive-filter, is used for the extraction of the intermodulation signals.

## 7 Preparation of DUT and test equipment

### 7.1 General

The DUT and test equipment shall be carefully checked for proper power handling range, frequency range, cleanliness and correct interconnection dimensions. All connector interfaces shall be tightened to the applicable IEC specification or, if none exists, to the manufacturer's recommended specification.

See Annex B for additional set-up considerations.

### 7.2 Guidelines for minimizing generation of passive intermodulation

The following guidelines and Table 1 should be considered and adhered to wherever possible.

- a) Non-linear materials should not be used in or near the current paths.
- b) Current densities should be minimized in the conduction paths (e.g. Tx channel), by using larger conductors.
- c) Minimize metallic junctions, avoid loose contacts and rotating joints.
- d) Minimize the exposure of loose contacts, rough surfaces and sharp edges to RF power.
- e) Keep thermal variations to a minimum, as the expansion and contraction of metals can create non-linear contacts.
- f) Use brazed, soldered or welded joints if possible – but ensure these joints are good and have no non-linear materials, cracks, contamination or corrosion.
- g) Avoid having tuning screws or moving parts in the high current paths – if necessary, then ensure all joints are tight and clean, and preferably, free from vibration.
- h) Cable lengths in general should be minimized and the use of high quality, low-IM cable is essential.
- i) Minimize the use of non-linear components such as high-PIM loads, circulators, isolators and semiconductor devices.
- j) Achieve good isolation between the high-power transmit signals and the low-power receive signals by filtering and physical separation.

**Table 1 – Guide for the design, selection of materials and handling of components that may be susceptible to PIM generation**

Part, material or procedure	Recommendations
Interfaces	Minimize the total number.
Connectors	Minimize the number of connectors used. Use high quality, low-PIM connectors mated with proper torque.
Inter-metallic connections	Each inter-metallic connection should be evaluated in terms of criticality for the total PIM level. Methods of controlling the performance are high contact pressure, insulation, soldering, brazing, etc.
Ferromagnetic materials	Not recommended (non-linear).
Non-magnetic stainless steel	Not recommended (contains iron).
Circulators, isolators and other ferrite devices	Not recommended.
Sharp edges	Avoid if it results in high current density.
Terminations or attenuators	Should be evaluated before use.
Hermetic seals / gaskets	Evaluate before use and avoid ferromagnetic materials.
Printed circuit boards (PCB)	Materials, processes and design should all be considered and evaluated. Use low-PIM materials; be careful with material impurities, contamination and etching residuals. The copper trace should be finished to prevent corrosion.
Dissimilar metals	Not recommended (risk of galvanic corrosion).
Dielectric material	Use clean, high quality material. Ensure it does not contain electrically conductive particles.
Machined dielectric materials	Use clean non-contaminated tools for machining.
Welded, soldered or brazed joint	Well executed and thoroughly cleaned, they provide satisfactory results. Shall be carefully inspected.
Carbon fibre epoxy composite (CFEC)	Generally acceptable for use in reflector and support structures, provided the fibres are not damaged. Should be evaluated if high flux density (e.g. >10 mW/cm <sup>2</sup> is expected).
Standard multilayer thermal blankets made of Vacuum Deposited Aluminium (VDA) on biaxially-oriented polyethylene terephthalate film or Polyimide film	Special design required.
Cleanliness	Maintain clean and dry surfaces.
Plating	The thickness of the plating should be at least three times greater than the skin depth of the wave resulting from the skin effect at the lowest relevant frequency.

## 8 Test procedure

Table 2 gives certain conditions for test set-up 1 and test set-up 2.

**Table 2 – Test set-up conditions**

Test set-up 1	Test set-up 2
The set-up shall be verified for correct signal levels applied to the DUT. For mobile communication systems, it is generally recommended to use $2 \times 20$ W (43 dBm) at the test port of the DUT, unless otherwise specified. Other systems may require different power levels.	
The minimum number of test frequencies and/or frequency spacing shall be specified.	
For lowest measurement uncertainty, the receiver shall be calibrated at the expected IM-level with a calibrated signal-source as indicated in Figure 1 and Figure 2.	
The termination shall be connected directly to the test port P4 and the self-intermodulation level of the set-up recorded.	P5 of diplexing device shall be connected directly to P4 of combining and summing device and the self-intermodulation level of the set-up recorded.
For low measurement uncertainties, the level of self-intermodulation should be at least 10 dB below the specified value for the DUT.	
Test the DUT as given in the specific set-up and procedure in the appropriate test set-up.	
An additional mechanical shock test may be carried out during the test sequence.	

**iTeh STANDARD PREVIEW**  
(standards.iteh.ai)

## 9 Reporting

### 9.1 Results

The input power at individual frequencies should be specified.

The values of  $f_1$  and  $f_2$  should be specified.

The PIM level and frequency should be specified.

### 9.2 Example of results

The result is expressed as an absolute magnitude in dBm or relative magnitude in dBc, referenced to the power of a single carrier.

The relationship between a measured IM<sub>3</sub>-value of –120 dBm can be converted to dBc as follows:

EXAMPLE:

$$f_1 = 936 \text{ MHz}, f_2 = 958 \text{ MHz}, f_{IM_3} = 914 \text{ MHz}$$

$$P(f_1) = P(f_2) = 20 \text{ W (+43 dBm)}$$

$$IM_3 = -163 \text{ dBc (-120 dBm)}$$