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

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IEC 62037-1:2012

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Part 1: General requirements and measuring methods

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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 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.

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

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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.

2 Normative references

None.

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 3rd 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.

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.