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Passive RF and microwave devices, intermodulation level measurement – Part 5: Measurement of passive intermodulation in filters

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CONTENTS

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PASSIVE RF AND MICROWAVE DEVICES, INTERMODULATION LEVEL MEASUREMENT –

Part 5: Measurement of passive intermodulation in filters

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 62037-5:2013. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC 62037-5 has been prepared by IEC technical committee 46: Cables, wires, waveguides, RF connectors, RF and microwave passive components and accessories. It is an International Standard.

This second edition cancels and replaces the first edition published in 2013. This edition constitutes a technical revision.

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

a) dynamic testing requirements updated to define impact energy and locations to apply impacts to devices under test.

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

Draft	Report on voting
46/837/FDIS	46/858/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. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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 document will remain unchanged until the stability date indicated on the IEC website under 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- withdrawn,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.

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PASSIVE RF AND MICROWAVE DEVICES, INTERMODULATION LEVEL MEASUREMENT –

Part 5: Measurement of passive intermodulation in filters

1 Scope

This part of IEC 62037 defines test fixtures and procedures recommended for measuring levels of passive intermodulation generated by filters, typically used in wireless communication systems. The purpose is to define qualification and acceptance test methods for filters for use in low intermodulation (low IM) applications.

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 60068-2-75:2014, *Environmental testing – Part 2-75: Tests – Test Eh: Hammer tests*

IEC 62037-1~~:2012~~, *Passive RF and microwave devices, intermodulation level measurement – Part 1: General requirements and measuring methods*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.2 Abbreviated terms

DUT Device under test

IM Intermodulation

PIM Passive intermodulation

VSWR Voltage standing wave ratio

4 General comments on PIM testing of filter assemblies

4.1 Sources of error: back-to-back filters

Testing filter assemblies for PIM ~~may~~ can be error prone if certain precautionary guidelines are not followed. Since PIM can be a frequency-dependent phenomenon, mathematically related to the harmonics of the input signals and combinations thereof, consideration should be given not only to the behaviour of the test set-up under fundamental stimulation, but also its harmonic performance. In particular, consider a receive-band PIM test set-up as shown in Figure 1. As shown, this set-up could be used to measure the PIM in a two-port device under test (DUT); however, the accuracy of the measurement could be in question due to the back-to-back filters (diplexers) used.

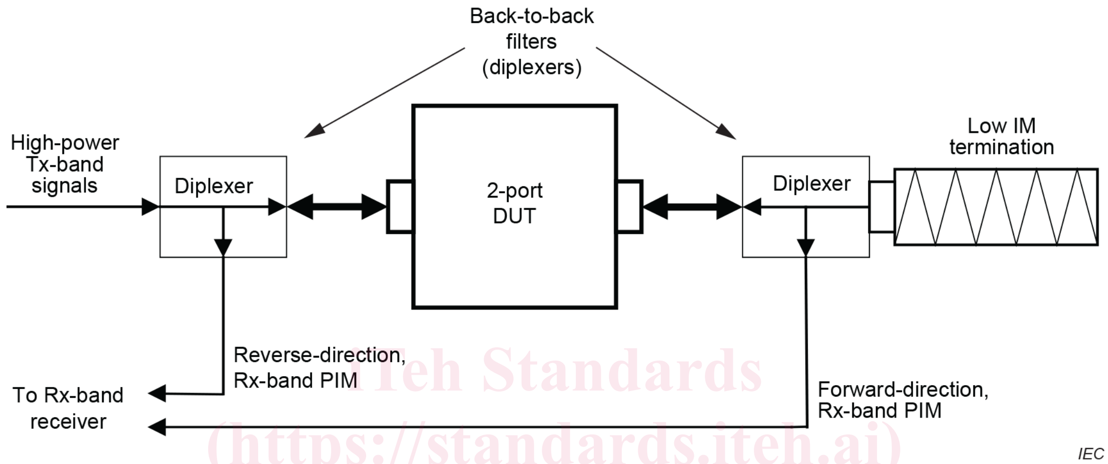


Figure 1 – Typical receive band PIM test set-up

While the diplexers certainly appear as a matched load around the fundamental frequencies and receive-band IM products, they ~~may~~ can be very poorly matched at the harmonics of the fundamentals. A poor match will set up a standing wave at the harmonic frequencies which ~~may~~ can re-illuminate any PIM sources within the DUT with higher-than-typical current densities. Furthermore, the measured IM response will become highly dependent upon the electrical length of the DUT because the locations of the peaks and valleys of any standing waves will move with respect to the PIM sources as the electrical length of the DUT changes.

4.2 Environmental and dynamic PIM testing

Environmental and dynamic PIM testing, which ~~may~~ can include placing vibrational or thermal stresses upon filter assemblies while concurrently measuring the PIM produced, may not give accurate or repeatable results. There are several significant factors affecting the results of these types of PIM tests.

a) DUT/test system isolation – it is highly desirable that any environmental and dynamic stresses placed upon a DUT be isolated from the test system such that there are no measurable residual effects. This not only addresses the practical issues of test system reliability and maintenance, but it directly affects the issue of measurement repeatability. That is, should a particular piece of the test system require replacement after a set number of trials, then the results of subsequent measurements may be skewed by the performance of the replaced part.

b) Measurement repeatability – it should be possible to repeat the results obtained from a particular measurement within a specific precision. However, the inherent sensitivity of the PIM response ~~may~~ can prevent a desired precision from being achieved.

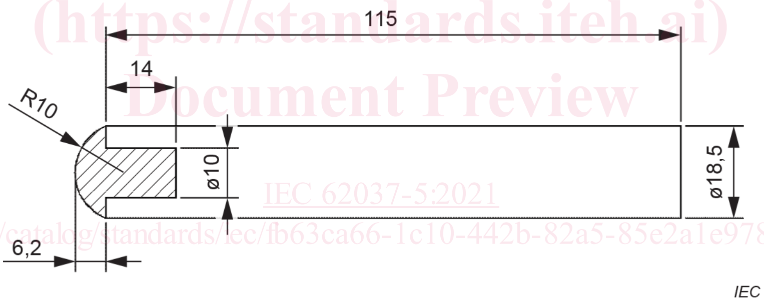
c) Stress repeatability – the particular stress placed upon the DUT shall be repeatable both between tests upon the same DUT and tests between different DUTs. However, in the experience of many, it is likely that the repeatability of the particular stress will be far worse than that of the particular PIM test results so that the standard specifying the stress may not be unnecessarily rigorous.

Based upon these factors, measuring PIM from a filter assembly whilst it undergoes thermal or vibrational stresses is not currently recommended.

A less vigorous form of dynamic testing ~~may~~ should be performed on a filter assembly in order to demonstrate that stability of the PIM level is maintained after certain ~~vibrational~~ stresses have been applied. This style of dynamic test ~~can take~~ typically takes the form of ~~tapping~~ striking the assembly with an instrument that will not damage the surface of the assembly~~, such as a length of nylon rod or hard rubber hammer~~. The impact of this tapping shall be at least that described in IEC 60068-2-75:2014, Clause 7 for the 0,14 J drop, with conditions given in IEC 60068-2-75:2014, Table 1 and Table 2, that is, a 0,25 kg striking element of polyamide (Rockwell hardness: 85 < HRR < 100) dropped from a height of 56 mm.

The impact shall be applied as close as possible to each of the connectors of the filter, while still impacting the filter body. The impact near each connector shall be repeated three times. Also, for any side of the filter that has no connectors, three impacts shall be applied along one edge of that side. The shape of the striking element shall be the same as described in IEC 60068-2-75, for ≤ 1 J. An example, taken from IEC 60068-2-75:2014, Annex A, is shown Figure 2.

Dimensions in millimetres



SOURCE: IEC 60068-2-75:2014, Figure A.1.

Figure 2 – Example of a striking element for ≤ 1 J

The results of the PIM tests shall be documented in a report. That report shall state

1) the test severity level, i.e. the weight and drop height for the impact test,
2) the frequency range(s) of the PIM test(s), the greatest PIM value after the application of the impacts.

If something other than the vertical hammer test method is applied, then there shall be documentation showing that the alternative test method produces an impact at least as great as the vertical hammer test.

4.3 General test procedure

An appropriate test set-up ~~can~~ shall be selected from the example schematics described in Clause 4, according to the specific test requirements called for. The procedure is as follows:

a) calibrate the test set-up for correct carrier signal level and IM receiver level as described in ~~Clause 7 of~~ IEC 62037-1~~:2012~~;
b) connect the filter DUT in the test set-up;

c) measure the IM performance of the DUT on the receiver.

The results obtained ~~should~~ shall be expressed in one of the forms indicated in ~~Clause 8 of~~ IEC 62037-1~~:2012~~.

5 Example of test equipment schematics for filter testing

5.1 General

Several examples of schematics are presented. Each figure corresponds to a particular test scenario as indicated in the matrix in Table 1. It will be noted that some of the example schematics are modifications of the test configurations shown in ~~Figure 1 and Figure 2 of~~ IEC 62037-1~~:2012~~. These modifications allow the operator to satisfactorily perform a range of tests which are more specific to the requirement of filter assemblies.

It is imperative that the residual PIM level of the test system be verified prior to measurement of the filter assembly. It is strongly recommended that this level be at least 10 dB below the PIM level requirement of the filter assembly, in order to minimize errors due to the system itself. This measurement can be carried out in the following example set-ups by ~~precluding~~ excluding the DUT from the measurement system and monitoring the resultant PIM level under the normal test conditions. The only systems which deviate slightly from this are Figure 6 and Figure 9 and notes are provided for these two set-ups, indicating the test point at which the system residual intermodulation distortion can be measured with the DUT removed.

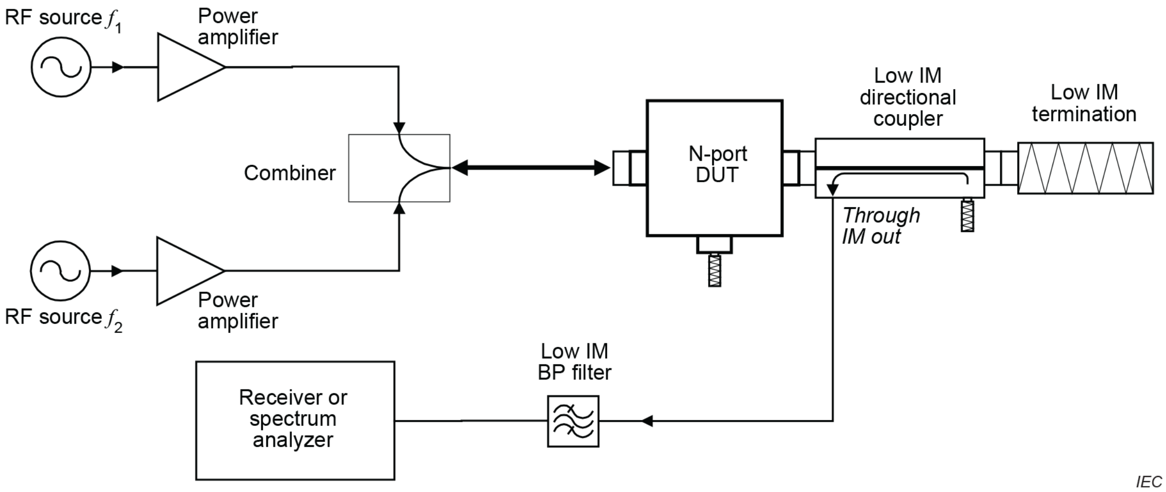
Table 1 – Summary table referencing examples of test equipment schematics for measuring PIM on filter-type devices

	Tx band	Rx band	
Measurement type	**Two high-power carriers**	**Two high-power carriers**	**One high-power carrier + injected interferer**
N-port, forward IM	Figure 5	Figure 4	Figure 7
N-port, reverse IM		Figure 5	Figure 8
N-port, receive port IM		Figure 6	Figure 9

Figure 6 and Figure 9 outline equipment set-ups which measure the PIM present at a receive port of the filter assembly. These set-ups are distinct from those measuring PIM in the reverse direction (Figure 5 and Figure 8) and can give quite different results. It is therefore important that consideration is given to using the appropriate measurement system, in order to measure the required PIM performance.

5.2 Transmit band testing

Passive IM testing within the transmit band is typically performed on isolators and other relatively high PIM components. For this test, two carriers are combined into a single transmission line and then passed through the DUT. Once these are through the DUT, it is advisable to sufficiently attenuate the two carriers to prevent the generation of active IM products and possible damage within the receiver. A low noise amplifier is typically not required due to the high PIM signal levels present from the DUT in these tests. This is described in Figure 3.



The combiner port-to-port isolation plus band stop/low pass filters should be optimized to set the test bench system residual to an acceptable level.

Consideration should be given to the possible generation of IM products within the receiver/spectrum analyzer and whether a sufficient dynamic range can be obtained. An optional IM band pass filter may be used to allow these conditions to be met.

Unused DUT ports shall be terminated in a matched load.

The low IM directional coupler could alternatively be replaced by an appropriate diplexer.

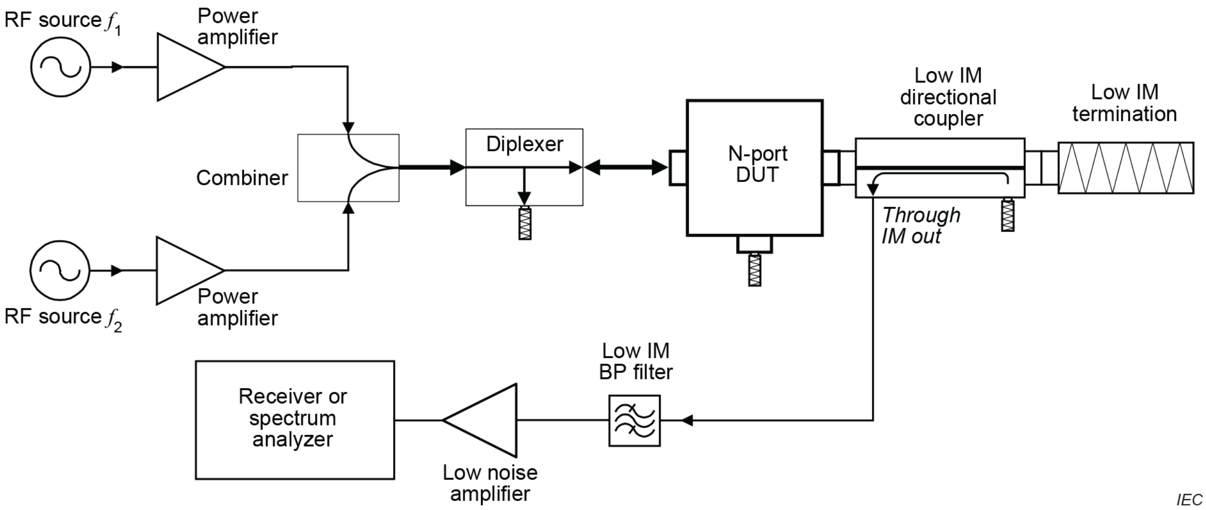
a) In this instance, it is strongly recommended that the replacement diplexer has a good VSWR in both the Tx and Rx bands.
b) Due to the potentially reflective nature of the replacement diplexer and DUT, it should also be recognized that there would be a mechanism that supports multipathing.

Figure 3 – Typical test equipment schematic for measuring transmit-band, forward, passive IM products on an N-port DUT using two high-power carriers

5.3 Receive band testing – Dual high-power carriers

When testing for PIM products in the receive band, a much greater measurement sensitivity is required than for transmit band testing. For this reason, a low-noise amplifier and bandpass filter are typically utilized before the measurement receiver (or spectrum analyzer).

Examples of schematics for both forward and reverse PIM testing on N-port devices are shown in Figure 4, Figure 5 and Figure 6.



The low IM directional coupler could alternatively be replaced by an appropriate diplexer.

a) In this instance, it is strongly recommended that the replacement diplexer has a good VSWR in both the Tx and Rx bands.

b) Due to the potentially reflective nature of the replacement diplexer and DUT, it should also be recognized that there would be a mechanism that supports multipathing.

The combiner and diplexer could alternatively be replaced by an appropriate triplexer.

1) In this instance, it is strongly recommended that the replacement triplexer has a good VSWR in both the Tx and Rx bands.

2) Due to the potentially reflective nature of the replacement triplexer and DUT, it should also be recognized that there would be a mechanism that supports multipathing.

Figure 4 – Typical test equipment schematic for measuring receive-band, forward, passive IM products on an N-port DUT, using two high-power carriers

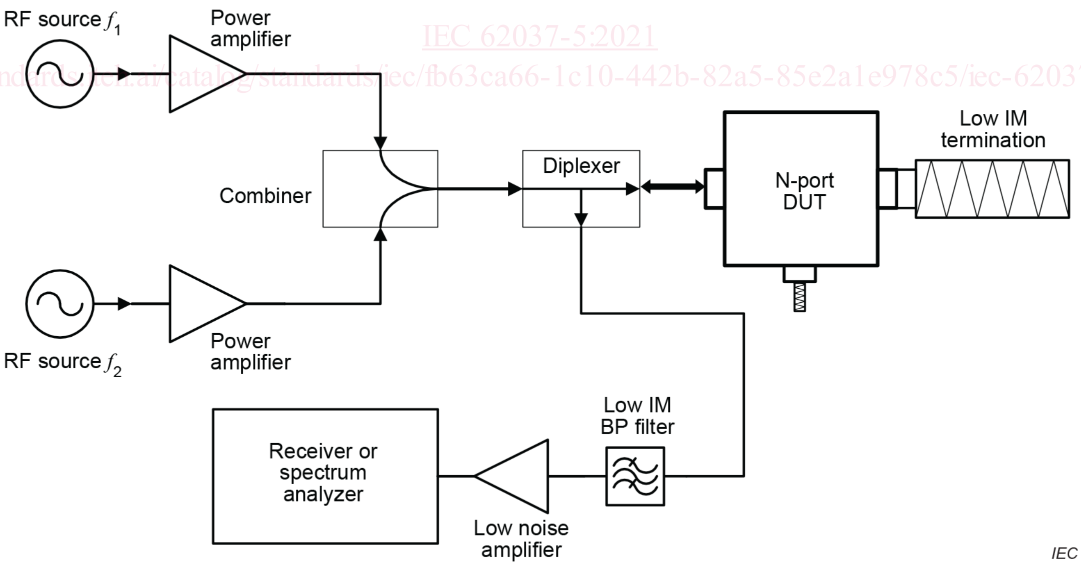


Figure 5 – Typical test equipment schematic for measuring receive-band, reverse, passive IM products on an N-port DUT, using two high-power carriers