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Passive RF and microwave devices, intermodulation level measurement –
Part 6: Measurement of passive intermodulation in antennas

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

PASSIVE RF AND MICROWAVE DEVICES, INTERMODULATION LEVEL MEASUREMENT –

Part 6: Measurement of passive intermodulation in antennas

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.
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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 62037-6:2013. 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 62037-6 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
46/838/FDIS	46/859/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 6: Measurement of passive intermodulation in antennas

1 Scope

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

2 Normative references

~~The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.~~

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

~~IEC 62037-3, *Passive r.f. and microwave devices, intermodulation level measurement – Part 3: Measurement of passive intermodulation in coaxial connectors*~~

There are no normative references in this document.

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

AIM Active intermodulation
AUT Antenna under test
ESD Electrostatic discharge
HPA High power amplifier
IM Intermodulation
LNA Low noise amplifier
PIM Passive intermodulation
RF Radio frequency

4 Definitions of antenna as it pertains to PIM

4.1 Antenna

An antenna is that part of a radio transmitting or receiving system which is designed to provide the required coupling between a transmitter or a receiver and the medium in which the radio wave propagates.

The antenna consists of a number of parts or components. These components include, but are not limited to, one or many radiating elements, one or many RF interfaces, a distribution or combining feed network, internal support structures, devices which control or adjust the amplitude/phase response and distribution to the radiating element(s), filters, diplexers, orthomode transducers, polarizers, waveguides, coaxial cables or printed circuits. In addition, peripheral components could also influence the PIM performance of the antenna. These components ~~may~~ can include, but are not limited to, mounting brackets, mounting hardware, radome, radome fasteners, thermal insulation and grounding hardware.

4.2 Antenna under test

The antenna hardware can have an effect on the overall antenna PIM performance. Therefore, it is necessary to specify the hardware which is to be part of the antenna under test (AUT).

4.3 Active antenna

An active antenna incorporates active devices such as low noise amplifiers (LNAs), high power amplifiers (HPAs), phase shifters, etc. An active antenna has the additional concern of active intermodulation (AIM) which is typically at a much higher level than PIM. The measurement of PIM in the presence of AIM is not within the scope of this document. If required, the PIM measurement of an active antenna shall be performed on the passive portion of the antenna only.

4.4 Antenna PIM

The antenna PIM is defined as the PIM that is generated by the antenna assembly itself at a reference plane or RF interface. The PIM can be measured in a radiated or conducted (transmissive or reflective) mode.

5 Antenna design and field installation considerations

5.1 Environmental effects on PIM performance

Any hardware located in the nearby environment can significantly influence the PIM performance of an antenna or antenna system. The effect of ferromagnetic materials, dissimilar metallic junctions which are part of neighbouring hardware, such as other antennas, tower structures, aircraft fuselage components, spacecraft thermal control hardware, DC and ESD grounding hardware, non-high pressure mechanical connections, etc., can potentially have a detrimental effect on the PIM performance of the communication system.

5.2 Antenna interface connection

Any interface that is exposed to RF is a potential PIM source and shall be designed to be low PIM. Care shall be taken to ensure that all the mating surfaces are clean. The connections, whether coaxial or waveguide, should be inspected for dirt, metallic filings, sharp protruding material, and other potential contaminates. Any coaxial connections shall be torqued to the manufacturer's specifications to ~~assure~~ ensure proper metal-to-metal contact pressure is achieved. If waveguide is used, then the flange bolts shall be torqued to the recommended manufacturer's specifications. Careful attention shall be paid to the alignment of the mating coaxial connectors or waveguide flanges.

The materials and combination of materials used in the connectors, including plating, are important for the PIM performance. The use of a soft plating material (e.g. gold, silver, etc.) of sufficient thickness (several skin depths) over a hard-base material (brass, BeCu, etc.) is usually preferable. The number of interfaces (coaxial connectors and adapters) should be minimized. This will reduce the number of metal-to-metal junctions and, thus, the possibility of PIM generation. More information about coaxial connectors can be found in IEC 62037-3.

5.3 Mounting considerations to avoid PIM generation

The antenna shall be properly secured to its mounting bracket. All bolts and holding harnesses used to secure the antenna to its support structure shall be tightened and torqued according to the manufacturer's specifications. The coaxial or waveguide transmission line(s) leading to the antenna input port(s) shall also be well-secured and prohibited from rubbing or moving.

Care should be taken in the antenna placement by pointing it towards a clear sky view and to isolate it from all possible neighbouring sources of interference such as tower structures, near-by antennas, buildings, walls, aircraft fuselage, spacecraft platform, etc.

5.4 Neighbouring sources of interference

Knowledge of the RF environment in which the antenna is to be installed is important. Care should be taken in the antenna placement to isolate it from all possible neighbouring sources of interference. For instance, structures having low contact pressure or corroding parts should be avoided. Additionally, other antennas radiating in a similar band or in bands whose harmonics could fall within the receive frequency band of the antenna being installed also require consideration. Other electric or electronic devices ~~may~~ can emit interfering RF signals that fall into the receive frequency band of the antenna.

5.5 Standard practices and guidelines for material selection

IEC 62037-1:~~2012~~2021, Clause 6 serves as a guide for the design, selection of materials, and handling of components that ~~may~~ can be susceptible to PIM generation. It is very important to consider the application of the antenna, as there are large differences in acceptable PIM levels between space applications and terrestrial applications.

6 PIM measurement considerations

6.1 Quality assurance process and handling procedures

The purpose of Clause 6 is to provide guidance in the areas of quality control as it pertains to the performance of PIM testing of antenna products. Procedures are included to enhance the accuracy and ensure safety when performing PIM measurements on antenna products. The following guidelines will help minimize errors induced within the test system.

6.2 Measurement accuracy

The accuracy of PIM tests performed on antenna products ~~may~~ can be severely affected by a multitude of sources that ~~may~~ can be either external or internal to the test system. Some of the sources which can affect the results of PIM tests performed on antenna products include, but are not limited to, the following:

a) objects comprising parts made of electrically conductive materials that are exposed to the electromagnetic fields radiated by the AUT;
b) loose, damaged or corroded mounting hardware attached to the AUT;
c) loose or corroded hardware exposed to the radiated RF fields from the AUT;
d) radio frequency signals generated by external sources;
e) faulty or poorly performing coaxial interface cables;
f) dirty/contaminated/worn interface connections;

g) improperly mated interface connections;

h) poorly shielded RF interface connections;

i) inadequately filtered AIM from the test set-up;

j) consideration ~~should be given to~~ of input transmission line losses;

k) contaminated absorbers.

6.3 Test environment

When applicable, PIM measurements ~~may~~ can be accomplished outdoors. In performing such a test, it is important to ensure that government regulations pertaining to the maximum authorized RF radiation levels are met. Also, the RF energy radiated from the AUT ~~may~~ can generate PIM in surrounding structures that may couple back into the antenna resulting in invalid PIM test results. Additionally, external sources of RF radiation ~~may~~ can interfere with the test measurements. A survey of the frequencies locally in use is recommended prior to testing. Many of the external sources of PIM ~~may~~ can be minimized or eliminated by performing the PIM testing of antennas within an anechoic test chamber providing a low PIM test environment. More information on the construction of anechoic test chambers suitable for PIM testing is provided in 6.8.

6.4 Safety

Performing PIM tests on antenna products can be dangerous. Potentially high voltages and high levels of RF energy ~~may~~ can be present both within the AUT and within the test environment. The AUT should be positioned such that personnel will not be exposed to electromagnetic fields exceeding the acceptable levels specified by government agencies.

6.5 Test set-up

6.5.1 Coaxial test cable assemblies

A problem with PIM test set-ups using coaxial cable interfaces is the need to repeatedly connect/disconnect coaxial connectors. The following are some recommendations on test set-up procedures.

a) Sealing O-rings at connector interfaces should be thoroughly cleaned or should preferably be avoided if possible. These O-rings accumulate metal filings, which can become a source of PIM.

b) Inspect connectors, dielectric and interface mating surfaces or flanges for contamination, especially metallic debris, just prior to mating the interface. Also inspect connector mating surfaces for burrs, scratches, dents, and loss of plating. Proper installation and torquing of the hardware will minimize the generation of PIM within interface connections.

c) Clean compressed air should be used to blow potential metal particles from the connector interfaces after each connect-disconnect cycle.

d) Great care shall be taken to ensure that the cables have not been stressed or fatigued to the point of cracking. The inner and outer conductors can crack under the insulating cable jacket and not be detectable by visual inspection. This will cause intermittent PIM signals to be generated. One way to test for this is to flex or tap on the cable while performing a baseline test. If there are fluctuations in the PIM signal, the cable ~~may~~ can be damaged and should be replaced.

6.5.2 Defining a good low PIM reference load

A good low PIM load can be made using a long section of high quality coaxial cable terminated with a high quality (low PIM) connector. This connector should be soldered to the coaxial cable on both the inner and outer conductors. The length of cable should be held in a fixture so that no fatigue is placed on the connector or cable. When soldering coaxial cables, it should be done very carefully to avoid melting or deforming the insulation, which can cause impedance changes.

6.5.3 Test set-up and test site baseline PIM verification

Prior to the testing of the antenna, perform a baseline PIM test set-up noise floor verification. To verify the test set-up itself, a low PIM termination may be used. Check the cables and connections for sensitivity to flexure, mechanical stress and configuration during the baseline test.

The test site should also be evaluated to ensure that it does not generate unacceptable levels of PIM or to identify any potential extraneous interfering RF sources. The test site could be an anechoic test enclosure or a chosen outdoor site. If an anechoic chamber is used, special design considerations are needed as outlined in 6.8. During the site verification, if possible, use a low PIM reference antenna having a radiation pattern and gain comparable to that of the AUT in order to ensure that the test environment is exposed to representative flux densities as for the AUT test.

The actual antenna PIM test should be performed using the same set-up as for the baseline test: minimize movements of components, do not add components, minimize changes in the environment, etc. After the antenna PIM test is completed or as required during the test, compare the baseline test results with previous set-up verification results for any sign of degradation in the test system.

6.6 PIM test configurations

A typical test set-up for antenna reverse (reflected) PIM testing is shown in Figure 1 and ~~one~~ another for antenna forward (transmitted) PIM is shown in Figure 2. It should be noted that the dynamic range between the two test configurations should be examined to assess the appropriate choices to use. In both cases, the test should take place in either a well-designed low PIM anechoic chamber or outdoors, which would allow the full range of antenna movement. For the antenna forward (transmitted) PIM test, a low PIM antenna on the receiver side of the test set-up is required. Also, for this test, the environment ~~may~~ can be first verified by using two low PIM antennas.

Whenever possible, the diplexer (Figure 1) and the filter (Figure 2), both of which should be low PIM, shall be placed as close as possible to the AUT input port to minimize PIM generated by the test set-up. The overall cable or waveguide lengths should be minimized to deliver maximum power to the AUT. Also, coaxial and waveguide adapters should be avoided as much as possible.

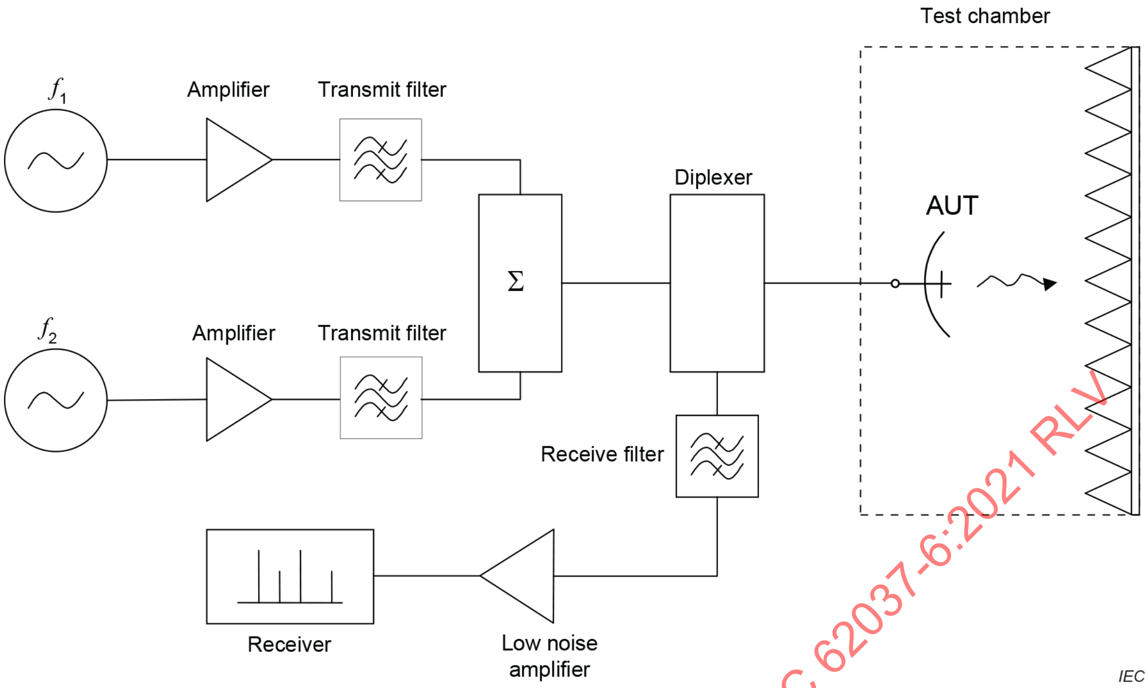

Figure 1 – Antenna reverse PIM test set-up

Each set-up has two synthesized sources, amplified separately to avoid AIM (active intermodulation). The two-tone-test results in discrete intermodulation products, whose levels are to be measured. These PIM products are typically first amplified by one or two stages of LNAs before detection by the spectrum analyzer or digital receiver. This is in order to increase the sensitivity of the set-up.

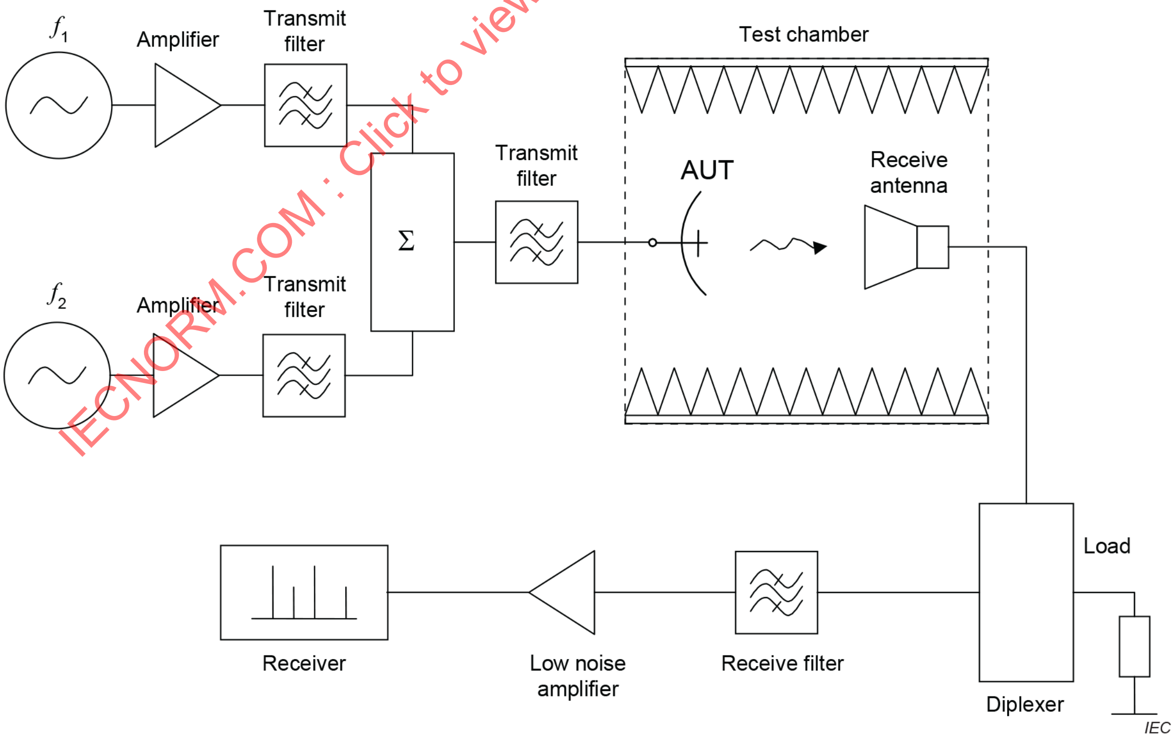

Figure 2 – Antenna forward PIM test set-up

6.7 Combined environmental and PIM testing

6.7.1 General

Whenever possible and practical, each AUT should be measured for PIM while being exposed to representative environmental operating conditions. If it is not possible, the AUT may be measured for PIM before and after exposure to representative environmental conditions.

6.7.2 Mechanical considerations

A loose mechanical joint is likely to cause PIM. Materials expand and contract due to temperature changes. Different materials expand and contract at different rates. This difference can cause varying amounts of stress to be induced in any mechanical joint of the antenna components. The differences in expansion and contraction can even cause the parts to move so much as to loosen a mechanical joint. A bolted joint that was torqued to its specified value can loosen to the point where the required clamping force is no longer being produced. Evaluation of mechanical connections may be accomplished by performing PIM testing during thermal cycling.

Vibrations can produce detrimental effects similar to those from thermal environments.

For terrestrial applications, extreme temperature cycling occurs only in specific geographical areas and is more applicable to aeronautical and space applications. Wind-induced vibrations occur in most terrestrial and aeronautical applications but never for space applications. However, vibrations are induced on space-borne antennas during platform manoeuvres. For space and aeronautical applications, it is recommended that PIM testing be performed during thermal cycling before and after vibration testing.

6.7.3 Test system cables and connectors

The test cables connected to the antenna under test are exposed to the same test environments as the antenna itself. Therefore, great care shall be taken in selecting cables suitable for PIM testing in the specific test environment. The entire test set-up, including the cables, shall be verified under the same test conditions as for the AUT testing.

6.8 PIM test chamber design

6.8.1 General

The purpose of 6.8 is to provide guidance for the construction of test chambers suitable for the performance of PIM testing on antennas.

Evaluation of antenna products for PIM presents additional challenges not found with other non-radiating components. The antenna will be connected to an RF source and will radiate RF energy during the PIM test. This energy shall not be allowed to excite potential PIM sources in the test environment. It is also sometimes not practical to perform these tests in an outdoor environment since the radiated RF energy should preferably be contained. To successfully perform PIM testing on antennas, it ~~may~~ can be desirable to construct an RF anechoic chamber specially designed for PIM testing.

The main components of an RF anechoic test chamber are:

a) RF absorber materials;
b) supporting structures and walls;
c) RF shielding.

Each of these components will be discussed in 6.8.2 to 6.8.4.

6.8.2 RF absorber materials

RF absorber materials are commonly manufactured from a carbon impregnated foam. This material offers attenuation to radio frequency signals as they pass through it. This attenuation of the signal (absorption of energy) serves in essence as a "load" to the antenna.

RF absorber materials are available in many styles and sizes. The selection of style and size is dependent on the frequency of operation and the placement within the test chamber. Proper selection of the RF absorbers ~~may~~ can be the most critical factor in the construction of a PIM test chamber. Recommendations that ~~may~~ can help in the selection process are as follows:

a) Select an absorber with an incident RF attenuation greater than 30 dB.
b) For good results, place pyramidal absorber panels in the field of the antenna radiation pattern, preferably with normal incidence to the beam peak. However, best results can be achieved when the interior of the test chamber is completely covered with RF absorber material.
c) As a minimum, ensure there are enough panels to avoid back reflections.

For safety purposes, select an absorber that contains fire retardant materials and is rated for the anticipated maximum power dissipation required.

6.8.3 Supporting structures and walls

The supporting structure and walls for the PIM test chamber shall provide a suitable inner surface for attachment of the RF absorber material. In some applications, the supporting structure and walls ~~may~~ can also be required to assist in the control of the temperature, the pressure, the humidity level, or other environmental conditions for the test.

The materials and methods of construction will vary greatly depending on the specific application. For many applications, simple lumber and plywood provide very good results. Cement block construction also provides excellent support but at a much greater expense. Some general considerations in designing the support structure and walls are as follows:

a) The use of metal shielding in the outer structure improves the isolation of the anechoic chamber and is recommended when RF shielding needs to be high (see 6.8.4). However, it is critical to ensure that the design does not include metal-to-metal junctions that themselves have poor PIM performance. Examples of this would include overlapping metal plates or the use of metal hardware going through sheet metal parts that are exposed.
b) Wood supports can be successfully joined using screws. Screws are stronger than nails and it is easier to control their final location. Do not allow metal fasteners to contact each other, even within the framework.
c) Make sure that the actual dimensions of absorber panels are known before completing the design of the structure as they do not usually have the exact size advertised.
d) The size of the test chamber should be large enough to allow the test antenna to be sufficiently far from any RF absorber to avoid mutual coupling between the radiating antenna and the absorber material.
e) Hinges, fasteners, light fixtures, fire sprinklers, mounting hardware, etc., should all be evaluated for potential PIM generation.

6.8.4 RF shielding

RF shielding may or may not be required, depending on the particular application. The purpose of RF shielding ~~may~~ can be for security, to maintain a low RF noise floor in the test facility or ~~may~~ can be required to ensure personnel safety. A method of identifying the need for RF shielding is based on the calculated power densities. From such calculations, it ~~may~~ can be found that RF levels behind the RF absorber are extremely low and therefore safe. It is always recommended that an RF survey of the area surrounding the chamber be performed prior to the approval of the final test plan or procedure.

Methods of RF shielding also vary depending on the application. One method providing good results for most applications is to apply thin aluminium sheets or panels to the exterior surface of the test chamber structure. The sheets can be securely attached using adhesive products. Placing a plastic insulating material on the edge of each panel will prevent any direct contact between panels. A small gap between the panels will not pass RF energy except at extremely small wavelengths compared to the gap size. Although RF power levels ~~may~~ can be extremely low at the RF shield, it would still be advisable to avoid materials which ~~may~~ can generate PIM such as wire mesh fabrics.

7 Dynamic PIM measurement considerations

7.1 General

In real operating conditions, an antenna is submitted to varying amounts of stress, like temperature changes and vibrations. Since PIM sources are often caused by loose metal-to-metal contacts, whenever possible and practical, each antenna should be measured for PIM while being exposed to representative operating conditions.

It is not possible to define a single test representing all the possible operating conditions for any antenna but defining some guidelines to apply some stresses during PIM test can be done. This is the goal of the "dynamic testing methodology" proposed in Clause 7, "dynamic" meaning here with mechanical stresses.

7.2 Dynamic testing methodology

There are several methods to apply stress on an antenna. Nevertheless, the PIM dynamic test shall be done in an acceptable time frame, in a practical and pragmatic manner, shall not cause irreversible damages on the AUT and shall take into account that antennas can have different various forms. The stress applied during the PIM dynamic tests should be able to detect potential instabilities within the antenna.

Methodologies permitting to apply a shock sequence are compatible with these inputs and goals.

The report should document the type, description and conditions of the test and the PIM values prior to each dynamic test, during dynamic test, and after dynamic test. If the PIM cannot be measured during the stress, the results shall be compared before and after the test sequence.

7.3 Shocks test

A shocking sequence is applied along the antenna, every 30 cm at least, preferably on its rear face. Shock should not be applied on potential AUT accessories or other fragile parts.

At each location, two consecutive impacts are applied.

The impact energy value shall be 1 J. The impact force can be applied by using a spring hammer or automated impact hammer. A description of related tools and methodology can be found in IEC 60068-2-75.

It is preferable that an impactor is made from polyamide (hardness range between 85 HRR and 100 HRR Rockwell hardness according to ISO 2039-2) in order to ensure the energy transfer and to prevent PIM generation by the impactor due to metal-to-metal contact with the AUT (see Figure 3 for the hammer description). The surface impact should be sufficiently wide not to damage the AUT.

It is preferable that impact locations are a structural part of the product, solid enough to withstand a mechanical shock without damage.

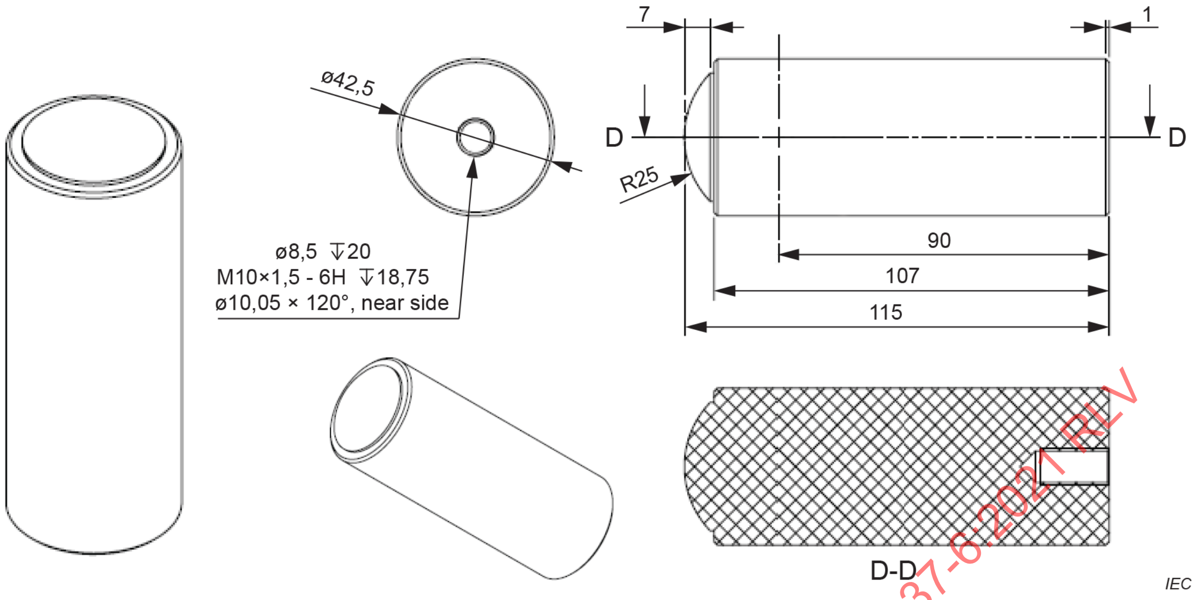

Figure 3 – Hammer description

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ISO 2039-2, *Plastics – Determination of hardness – Part 2: Rockwell hardness*

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Passive RF and microwave devices, intermodulation level measurement –
Part 6: Measurement of passive intermodulation in antennas

Dispositifs RF et à micro-ondes passifs, mesure du niveau d'intermodulation –
Partie 6: Mesure de l'intermodulation passive dans les antennes

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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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.

PASSIVE RF AND MICROWAVE DEVICES, INTERMODULATION LEVEL MEASUREMENT –

Part 6: Measurement of passive intermodulation in antennas

1 Scope

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

2 Normative references

There are no normative references in this document.

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

AIM Active intermodulation

AUT Antenna under test

ESD Electrostatic discharge

HPA High power amplifier

IM Intermodulation

LNA Low noise amplifier

PIM Passive intermodulation

RF Radio frequency

4 Definitions of antenna as it pertains to PIM

4.1 Antenna

An antenna is that part of a radio transmitting or receiving system which is designed to provide the required coupling between a transmitter or a receiver and the medium in which the radio wave propagates.

The antenna consists of a number of parts or components. These components include, but are not limited to, one or many radiating elements, one or many RF interfaces, a distribution or combining feed network, internal support structures, devices which control or adjust the amplitude/phase response and distribution to the radiating element(s), filters, diplexers, orthomode transducers, polarizers, waveguides, coaxial cables or printed circuits. In addition, peripheral components could also influence the PIM performance of the antenna. These components can include, but are not limited to, mounting brackets, mounting hardware, radome, radome fasteners, thermal insulation and grounding hardware.

4.2 Antenna under test

The antenna hardware can have an effect on the overall antenna PIM performance. Therefore, it is necessary to specify the hardware which is to be part of the antenna under test (AUT).

4.3 Active antenna

An active antenna incorporates active devices such as low noise amplifiers (LNAs), high power amplifiers (HPAs), phase shifters, etc. An active antenna has the additional concern of active intermodulation (AIM) which is typically at a much higher level than PIM. The measurement of PIM in the presence of AIM is not within the scope of this document. If required, the PIM measurement of an active antenna shall be performed on the passive portion of the antenna only.

4.4 Antenna PIM

The antenna PIM is defined as the PIM that is generated by the antenna assembly itself at a reference plane or RF interface. The PIM can be measured in a radiated or conducted (transmissive or reflective) mode.

5 Antenna design and field installation considerations

5.1 Environmental effects on PIM performance

Any hardware located in the nearby environment can significantly influence the PIM performance of an antenna or antenna system. The effect of ferromagnetic materials, dissimilar metallic junctions which are part of neighbouring hardware, such as other antennas, tower structures, aircraft fuselage components, spacecraft thermal control hardware, DC and ESD grounding hardware, non-high pressure mechanical connections, etc., can potentially have a detrimental effect on the PIM performance of the communication system.

5.2 Antenna interface connection

Any interface that is exposed to RF is a potential PIM source and shall be designed to be low PIM. Care shall be taken to ensure that all the mating surfaces are clean. The connections, whether coaxial or waveguide, should be inspected for dirt, metallic filings, sharp protruding material, and other potential contaminates. Any coaxial connections shall be torqued to the manufacturer's specifications to ensure proper metal-to-metal contact pressure is achieved. If waveguide is used, then the flange bolts shall be torqued to the recommended manufacturer's specifications. Careful attention shall be paid to the alignment of the mating coaxial connectors or waveguide flanges.

The materials and combination of materials used in the connectors, including plating, are important for the PIM performance. The use of a soft plating material (e.g. gold, silver, etc.) of sufficient thickness (several skin depths) over a hard-base material (brass, BeCu, etc.) is usually preferable. The number of interfaces (coaxial connectors and adapters) should be minimized. This will reduce the number of metal-to-metal junctions and, thus, the possibility of PIM generation. More information about coaxial connectors can be found in IEC 62037-3.

5.3 Mounting considerations to avoid PIM generation

The antenna shall be properly secured to its mounting bracket. All bolts and holding harnesses used to secure the antenna to its support structure shall be tightened and torqued according to the manufacturer's specifications. The coaxial or waveguide transmission line(s) leading to the antenna input port(s) shall also be well-secured and prohibited from rubbing or moving.

Care should be taken in the antenna placement by pointing it towards a clear sky view and to isolate it from all possible neighbouring sources of interference such as tower structures, near-by antennas, buildings, walls, aircraft fuselage, spacecraft platform, etc.

5.4 Neighbouring sources of interference

Knowledge of the RF environment in which the antenna is to be installed is important. Care should be taken in the antenna placement to isolate it from all possible neighbouring sources of interference. For instance, structures having low contact pressure or corroding parts should be avoided. Additionally, other antennas radiating in a similar band or in bands whose harmonics could fall within the receive frequency band of the antenna being installed also require consideration. Other electric or electronic devices can emit interfering RF signals that fall into the receive frequency band of the antenna.

5.5 Standard practices and guidelines for material selection

IEC 62037-1:2021, Clause 6 serves as a guide for the design, selection of materials, and handling of components that can be susceptible to PIM generation. It is very important to consider the application of the antenna, as there are large differences in acceptable PIM levels between space applications and terrestrial applications.

6 PIM measurement considerations

6.1 Quality assurance process and handling procedures

The purpose of Clause 6 is to provide guidance in the areas of quality control as it pertains to the performance of PIM testing of antenna products. Procedures are included to enhance the accuracy and ensure safety when performing PIM measurements on antenna products. The following guidelines will help minimize errors induced within the test system.

6.2 Measurement accuracy

The accuracy of PIM tests performed on antenna products can be severely affected by a multitude of sources that can be either external or internal to the test system. Some of the sources which can affect the results of PIM tests performed on antenna products include, but are not limited to, the following:

a) objects comprising parts made of electrically conductive materials that are exposed to the electromagnetic fields radiated by the AUT;
b) loose, damaged or corroded mounting hardware attached to the AUT;
c) loose or corroded hardware exposed to the radiated RF fields from the AUT;
d) radio frequency signals generated by external sources;
e) faulty or poorly performing coaxial interface cables;
f) dirty/contaminated/worn interface connections;
g) improperly mated interface connections;
h) poorly shielded RF interface connections;
i) inadequately filtered AIM from the test set-up;
j) consideration of input transmission line losses;
k) contaminated absorbers.

6.3 Test environment

When applicable, PIM measurements can be accomplished outdoors. In performing such a test, it is important to ensure that government regulations pertaining to the maximum authorized RF radiation levels are met. Also, the RF energy radiated from the AUT can generate PIM in surrounding structures that may couple back into the antenna resulting in invalid PIM test results. Additionally, external sources of RF radiation can interfere with the test measurements. A survey of the frequencies locally in use is recommended prior to testing. Many of the external sources of PIM can be minimized or eliminated by performing the PIM testing of antennas within an anechoic test chamber providing a low PIM test environment. More information on the construction of anechoic test chambers suitable for PIM testing is provided in 6.8.

6.4 Safety

Performing PIM tests on antenna products can be dangerous. Potentially high voltages and high levels of RF energy can be present both within the AUT and within the test environment. The AUT should be positioned such that personnel will not be exposed to electromagnetic fields exceeding the acceptable levels specified by government agencies.

6.5 Test set-up

6.5.1 Coaxial test cable assemblies

A problem with PIM test set-ups using coaxial cable interfaces is the need to repeatedly connect/disconnect coaxial connectors. The following are some recommendations on test set-up procedures.

a) Sealing O-rings at connector interfaces should be thoroughly cleaned or should preferably be avoided if possible. These O-rings accumulate metal filings, which can become a source of PIM.

b) Inspect connectors, dielectric and interface mating surfaces or flanges for contamination, especially metallic debris, just prior to mating the interface. Also inspect connector mating surfaces for burrs, scratches, dents, and loss of plating. Proper installation and torquing of the hardware will minimize the generation of PIM within interface connections.

c) Clean compressed air should be used to blow potential metal particles from the connector interfaces after each connect-disconnect cycle.

d) Great care shall be taken to ensure that the cables have not been stressed or fatigued to the point of cracking. The inner and outer conductors can crack under the insulating cable jacket and not be detectable by visual inspection. This will cause intermittent PIM signals to be generated. One way to test for this is to flex or tap on the cable while performing a baseline test. If there are fluctuations in the PIM signal, the cable can be damaged and should be replaced.

6.5.2 Defining a good low PIM reference load

A good low PIM load can be made using a long section of high quality coaxial cable terminated with a high quality (low PIM) connector. This connector should be soldered to the coaxial cable on both the inner and outer conductors. The length of cable should be held in a fixture so that no fatigue is placed on the connector or cable. When soldering coaxial cables, it should be done very carefully to avoid melting or deforming the insulation, which can cause impedance changes.

6.5.3 Test set-up and test site baseline PIM verification

Prior to the testing of the antenna, perform a baseline PIM test set-up noise floor verification. To verify the test set-up itself, a low PIM termination may be used. Check the cables and connections for sensitivity to flexure, mechanical stress and configuration during the baseline test.

The test site should also be evaluated to ensure that it does not generate unacceptable levels of PIM or to identify any potential extraneous interfering RF sources. The test site could be an anechoic test enclosure or a chosen outdoor site. If an anechoic chamber is used, special design considerations are needed as outlined in 6.8. During the site verification, if possible, use a low PIM reference antenna having a radiation pattern and gain comparable to that of the AUT in order to ensure that the test environment is exposed to representative flux densities as for the AUT test.

The actual antenna PIM test should be performed using the same set-up as for the baseline test: minimize movements of components, do not add components, minimize changes in the environment, etc. After the antenna PIM test is completed or as required during the test, compare the baseline test results with previous set-up verification results for any sign of degradation in the test system.

6.6 PIM test configurations

A typical test set-up for antenna reverse (reflected) PIM testing is shown in Figure 1 and another for antenna forward (transmitted) PIM is shown in Figure 2. It should be noted that the dynamic range between the two test configurations should be examined to assess the appropriate choices to use. In both cases, the test should take place in either a well-designed low PIM anechoic chamber or outdoors, which would allow the full range of antenna movement. For the antenna forward (transmitted) PIM test, a low PIM antenna on the receiver side of the test set-up is required. Also, for this test, the environment can be first verified by using two low PIM antennas.

Whenever possible, the diplexer (Figure 1) and the filter (Figure 2), both of which should be low PIM, shall be placed as close as possible to the AUT input port to minimize PIM generated by the test set-up. The overall cable or waveguide lengths should be minimized to deliver maximum power to the AUT. Also, coaxial and waveguide adapters should be avoided as much as possible.

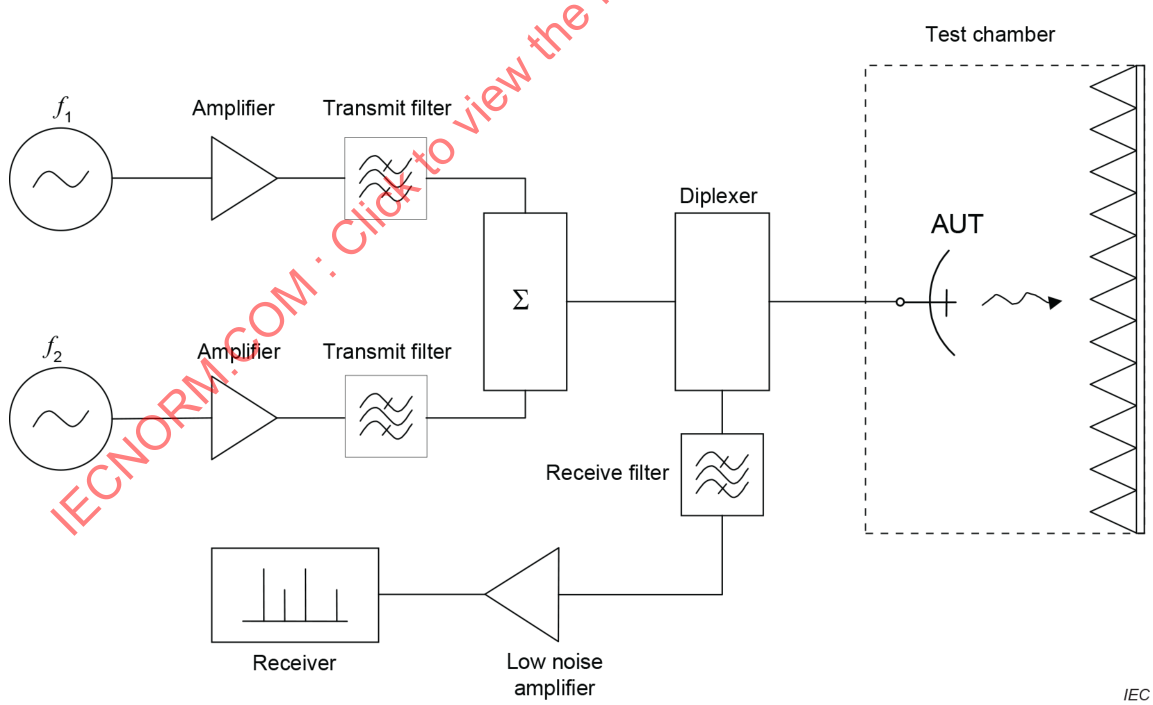

Figure 1 – Antenna reverse PIM test set-up

Each set-up has two synthesized sources, amplified separately to avoid AIM (active intermodulation). The two-tone-test results in discrete intermodulation products, whose levels are to be measured. These PIM products are typically first amplified by one or two stages of LNAs before detection by the spectrum analyzer or digital receiver. This is in order to increase the sensitivity of the set-up.

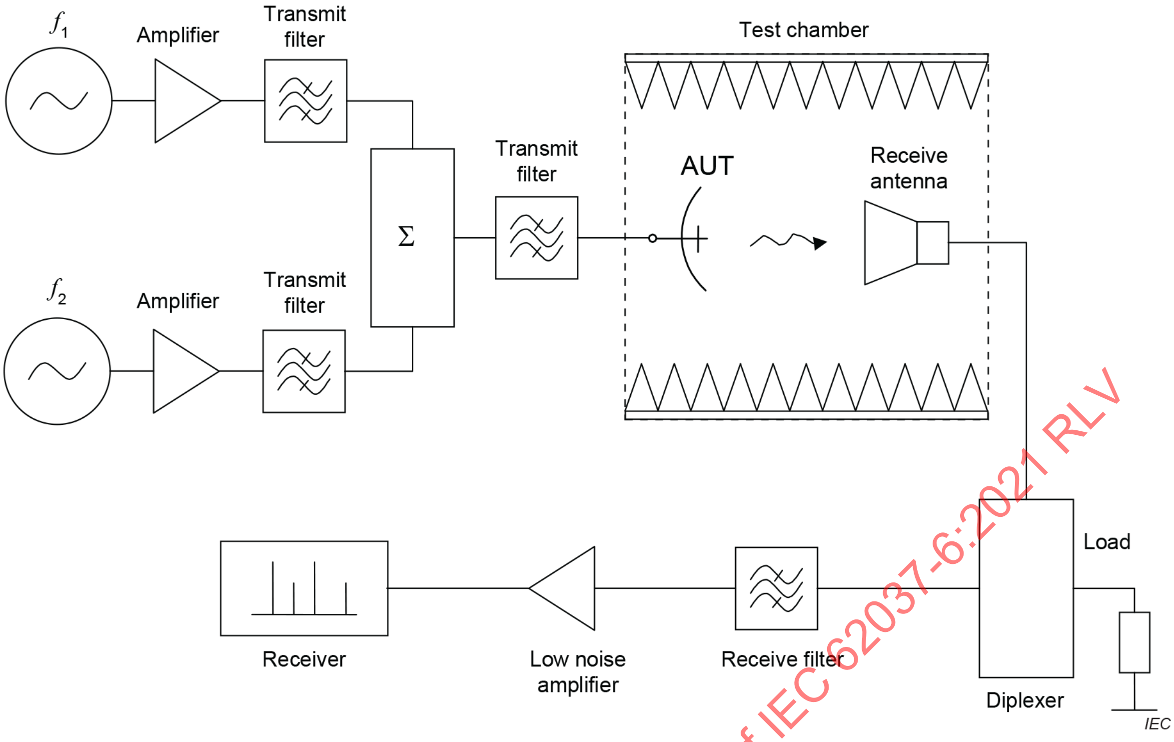

Figure 2 – Antenna forward PIM test set-up

6.7 Combined environmental and PIM testing

6.7.1 General

Whenever possible and practical, each AUT should be measured for PIM while being exposed to representative environmental operating conditions. If it is not possible, the AUT may be measured for PIM before and after exposure to representative environmental conditions.

6.7.2 Mechanical considerations

A loose mechanical joint is likely to cause PIM. Materials expand and contract due to temperature changes. Different materials expand and contract at different rates. This difference can cause varying amounts of stress to be induced in any mechanical joint of the antenna components. The differences in expansion and contraction can even cause the parts to move so much as to loosen a mechanical joint. A bolted joint that was torqued to its specified value can loosen to the point where the required clamping force is no longer being produced. Evaluation of mechanical connections may be accomplished by performing PIM testing during thermal cycling.

Vibrations can produce detrimental effects similar to those from thermal environments.

For terrestrial applications, extreme temperature cycling occurs only in specific geographical areas and is more applicable to aeronautical and space applications. Wind-induced vibrations occur in most terrestrial and aeronautical applications but never for space applications. However, vibrations are induced on space-borne antennas during platform manoeuvres. For space and aeronautical applications, it is recommended that PIM testing be performed during thermal cycling before and after vibration testing.

6.7.3 Test system cables and connectors

The test cables connected to the antenna under test are exposed to the same test environments as the antenna itself. Therefore, great care shall be taken in selecting cables suitable for PIM testing in the specific test environment. The entire test set-up, including the cables, shall be verified under the same test conditions as for the AUT testing.

6.8 PIM test chamber design

6.8.1 General

The purpose of 6.8 is to provide guidance for the construction of test chambers suitable for the performance of PIM testing on antennas.

Evaluation of antenna products for PIM presents additional challenges not found with other non-radiating components. The antenna will be connected to an RF source and will radiate RF energy during the PIM test. This energy shall not be allowed to excite potential PIM sources in the test environment. It is also sometimes not practical to perform these tests in an outdoor environment since the radiated RF energy should preferably be contained. To successfully perform PIM testing on antennas, it can be desirable to construct an RF anechoic chamber specially designed for PIM testing.

The main components of an RF anechoic test chamber are:

a) RF absorber materials;
b) supporting structures and walls;
c) RF shielding.

Each of these components will be discussed in 6.8.2 to 6.8.4.

6.8.2 RF absorber materials

RF absorber materials are commonly manufactured from a carbon impregnated foam. This material offers attenuation to radio frequency signals as they pass through it. This attenuation of the signal (absorption of energy) serves in essence as a "load" to the antenna.

RF absorber materials are available in many styles and sizes. The selection of style and size is dependent on the frequency of operation and the placement within the test chamber. Proper selection of the RF absorbers can be the most critical factor in the construction of a PIM test chamber. Recommendations that can help in the selection process are as follows:

a) Select an absorber with an incident RF attenuation greater than 30 dB.
b) For good results, place pyramidal absorber panels in the field of the antenna radiation pattern, preferably with normal incidence to the beam peak. However, best results can be achieved when the interior of the test chamber is completely covered with RF absorber material.
c) As a minimum, ensure there are enough panels to avoid back reflections.

For safety purposes, select an absorber that contains fire retardant materials and is rated for the anticipated maximum power dissipation required.

6.8.3 Supporting structures and walls

The supporting structure and walls for the PIM test chamber shall provide a suitable inner surface for attachment of the RF absorber material. In some applications, the supporting structure and walls can also be required to assist in the control of the temperature, the pressure, the humidity level, or other environmental conditions for the test.

The materials and methods of construction will vary greatly depending on the specific application. For many applications, simple lumber and plywood provide very good results. Cement block construction also provides excellent support but at a much greater expense. Some general considerations in designing the support structure and walls are as follows:

a) The use of metal shielding in the outer structure improves the isolation of the anechoic chamber and is recommended when RF shielding needs to be high (see 6.8.4). However, it is critical to ensure that the design does not include metal-to-metal junctions that themselves have poor PIM performance. Examples of this would include overlapping metal plates or the use of metal hardware going through sheet metal parts that are exposed.
b) Wood supports can be successfully joined using screws. Screws are stronger than nails and it is easier to control their final location. Do not allow metal fasteners to contact each other, even within the framework.
c) Make sure that the actual dimensions of absorber panels are known before completing the design of the structure as they do not usually have the exact size advertised.
d) The size of the test chamber should be large enough to allow the test antenna to be sufficiently far from any RF absorber to avoid mutual coupling between the radiating antenna and the absorber material.
e) Hinges, fasteners, light fixtures, fire sprinklers, mounting hardware, etc., should all be evaluated for potential PIM generation.

6.8.4 RF shielding

RF shielding may or may not be required, depending on the particular application. The purpose of RF shielding can be for security, to maintain a low RF noise floor in the test facility or can be required to ensure personnel safety. A method of identifying the need for RF shielding is based on the calculated power densities. From such calculations, it can be found that RF levels behind the RF absorber are extremely low and therefore safe. It is always recommended that an RF survey of the area surrounding the chamber be performed prior to the approval of the final test plan or procedure.

Methods of RF shielding also vary depending on the application. One method providing good results for most applications is to apply thin aluminium sheets or panels to the exterior surface of the test chamber structure. The sheets can be securely attached using adhesive products. Placing a plastic insulating material on the edge of each panel will prevent any direct contact between panels. A small gap between the panels will not pass RF energy except at extremely small wavelengths compared to the gap size. Although RF power levels can be extremely low at the RF shield, it would still be advisable to avoid materials which can generate PIM such as wire mesh fabrics.

7 Dynamic PIM measurement considerations

7.1 General

In real operating conditions, an antenna is submitted to varying amounts of stress, like temperature changes and vibrations. Since PIM sources are often caused by loose metal-to-metal contacts, whenever possible and practical, each antenna should be measured for PIM while being exposed to representative operating conditions.

It is not possible to define a single test representing all the possible operating conditions for any antenna but defining some guidelines to apply some stresses during PIM test can be done. This is the goal of the "dynamic testing methodology" proposed in Clause 7, "dynamic" meaning here with mechanical stresses.

7.2 Dynamic testing methodology

There are several methods to apply stress on an antenna. Nevertheless, the PIM dynamic test shall be done in an acceptable time frame, in a practical and pragmatic manner, shall not cause irreversible damages on the AUT and shall take into account that antennas can have different various forms. The stress applied during the PIM dynamic tests should be able to detect potential instabilities within the antenna.

Methodologies permitting to apply a shock sequence are compatible with these inputs and goals.

The report should document the type, description and conditions of the test and the PIM values prior to each dynamic test, during dynamic test, and after dynamic test. If the PIM cannot be measured during the stress, the results shall be compared before and after the test sequence.

7.3 Shocks test

A shocking sequence is applied along the antenna, every 30 cm at least, preferably on its rear face. Shock should not be applied on potential AUT accessories or other fragile parts.

At each location, two consecutive impacts are applied.

The impact energy value shall be 1 J. The impact force can be applied by using a spring hammer or automated impact hammer. A description of related tools and methodology can be found in IEC 60068-2-75.

It is preferable that an impactor is made from polyamide (hardness range between 85 HRR and 100 HRR Rockwell hardness according to ISO 2039-2) in order to ensure the energy transfer and to prevent PIM generation by the impactor due to metal-to-metal contact with the AUT (see Figure 3 for the hammer description). The surface impact should be sufficiently wide not to damage the AUT.

It is preferable that impact locations are a structural part of the product, solid enough to withstand a mechanical shock without damage.

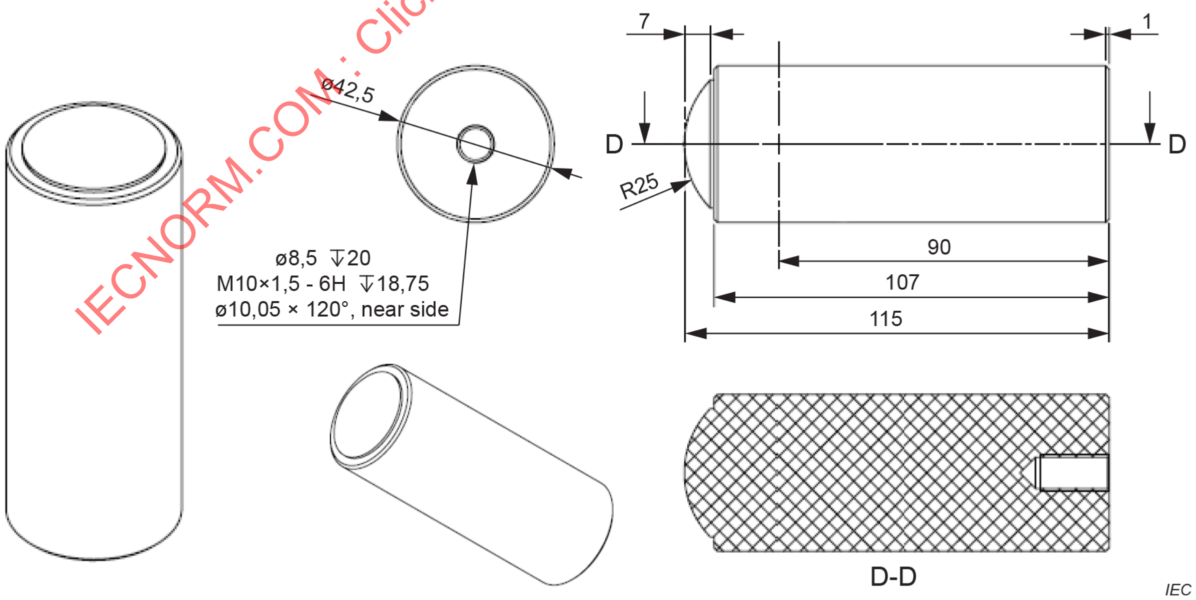

Figure 3 – Hammer description

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

IEC 62037-3, *Passive RF and microwave devices, intermodulation level measurement – Part 3: Measurement of passive intermodulation in coaxial connectors*

ISO 2039-2, *Plastics – Determination of hardness – Part 2: Rockwell hardness*

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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DISPOSITIFS RF ET À MICRO-ONDES PASSIFS, MESURE DU NIVEAU D'INTERMODULATION –

Partie 6: Mesure de l'intermodulation passive dans les antennes

AVANT-PROPOS

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L'IEC 62037-6 a été établie par le comité d'études 46: Câbles, fils, guides d'ondes, connecteurs, composants passifs pour micro-onde et accessoires. Il s'agit d'une Norme internationale.

Cette seconde édition annule et remplace la première édition parue en 2013. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) mise à jour des exigences relatives aux essais dynamiques afin de définir l'énergie des chocs et la position où ils sont appliqués sur les dispositifs soumis à essai.

Le texte de cette Norme internationale est issu des documents suivants:

Projet	Rapport de vote
46/838/FDIS	46/859/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à son approbation.

La langue employée pour l'élaboration de cette Norme internationale est l'anglais.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2, il a été développé selon les Directives ISO/IEC, Partie 1 et les Directives ISO/IEC, Supplément IEC, disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/standardsdev/publications/.

Une liste de toutes les parties de la série IEC 62037, publiées sous le titre général *Dispositifs RF et à micro-ondes passifs, mesure du niveau d'intermodulation*, se trouve sur le site web de l'IEC.

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- reconduit,
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- amendé.

DISPOSITIFS RF ET À MICRO-ONDES PASSIFS, MESURE DU NIVEAU D'INTERMODULATION –

Partie 6: Mesure de l'intermodulation passive dans les antennes

1 Domaine d'application

La présente partie de l'IEC 62037 définit les dispositifs et les procédures d'essai recommandés pour mesurer les niveaux d'intermodulation passive générés par des antennes, généralement utilisées dans des systèmes de communication sans fil. L'objectif est de définir des méthodes d'essai de qualification et d'acceptation pour des antennes destinées à être utilisées dans des applications de faible intermodulation (faible IM).

2 Références normatives

Le présent document ne contient aucune référence normative.

3 Termes, définitions et termes abrégés

3.1 Termes et définitions

Aucun terme n'est défini dans le présent document.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

3.2 Termes abrégés

AIM	Active InterModulation (intermodulation active)
AUT	Antenna Under Test (antenne soumise à essai)
DES	Décharge électrostatique
HPA	High Power Amplifier (amplificateur de puissance)
IM	Intermodulation
LNA	Low Noise Amplifier (amplificateur à faible bruit)
PIM	Passive InterModulation (intermodulation passive)
RF	Radio Frequency (fréquence radioélectrique)

4 Définitions d'une antenne dans le contexte de l'intermodulation passive

4.1 Antenne

Une antenne est la partie d'un système d'émission ou de réception d'ondes radioélectriques, destinée à assurer le couplage exigé entre un émetteur ou un récepteur et le milieu dans lequel se propagent les ondes radioélectriques.

L'antenne est constituée d'un certain nombre de pièces ou de composants. Ces composants comprennent, entre autres, un ou plusieurs éléments rayonnants, une ou plusieurs interfaces RF, un réseau de distribution ou un réseau combinant distribution et alimentation, des structures de support internes, des dispositifs qui contrôlent ou ajustent la réponse en amplitude/phase et la distribution vers l'élément ou les éléments rayonnants, des filtres, des diplexeurs, des coupleurs de polarisation, des polariseurs, des guides d'ondes, des câbles coaxiaux ou des circuits imprimés. En outre, les composants périphériques pourraient également influencer les performances de l'intermodulation passive de l'antenne. Ces composants peuvent comprendre, entre autres, des équerres de montage, du matériel de montage, un radôme, des dispositifs de fixation du radôme, une isolation thermique et du matériel de mise à la terre.

4.2 Antenne soumise à essai

Les matériels constituants de l'antenne peuvent avoir un effet sur l'ensemble des performances de l'intermodulation passive de l'antenne. Par conséquent, il est nécessaire de spécifier les matériels qui font partie de l'antenne soumise à essai (AUT).

4.3 Antenne active

Une antenne active comporte des dispositifs actifs tels que des amplificateurs à faible bruit (LNA), des amplificateurs de puissance (HPA), des déphaseurs, etc. Une antenne active présente également une intermodulation active (AIM), qui se situe généralement à un niveau bien plus élevé que l'intermodulation passive. La mesure de l'intermodulation passive en présence de l'intermodulation active ne relève pas du domaine d'application du présent document. Si cela est exigé, la mesure de l'intermodulation passive d'une antenne active doit être réalisée sur la partie passive de l'antenne uniquement.

4.4 Intermodulation passive dans l'antenne

L'intermodulation passive dans l'antenne est définie comme l'intermodulation passive générée par l'antenne elle-même au niveau d'un plan de référence ou d'une interface RF. L'intermodulation passive peut être mesurée dans un mode rayonné ou conduit (transmis ou réfléchi).

5 Considérations relatives à la conception de l'antenne et à son installation sur le terrain

5.1 Effets de l'environnement sur les performances de l'intermodulation passive

Tout matériel situé dans l'environnement proche peut influencer de façon significative les performances de l'intermodulation passive d'une antenne ou d'un système d'antenne. L'effet des matériaux ferromagnétiques, des jonctions métalliques dissemblables faisant partie d'un matériel situé à proximité, par exemple d'autres antennes, des structures de tours, des composants de fuselage d'avions, des matériels de contrôle thermique des engins spatiaux, des matériels de mise à la terre du courant continu et des décharges électrostatiques (DES), des connexions mécaniques à pression non élevée, etc., peut éventuellement avoir un effet nuisible sur les performances de l'intermodulation passive du système de communication.

5.2 Connexion d'interface de l'antenne

Toute interface exposée aux fréquences radioélectriques est une source d'intermodulation passive potentielle et doit être conçue pour avoir une faible intermodulation passive. Des précautions doivent être prises pour assurer que toutes les surfaces de contact sont propres. Il convient de vérifier les connexions, qu'elles soient coaxiales ou à guides d'ondes, pour détecter la présence éventuelle de salissures, de débris (limaille) métalliques, de matériaux saillants et d'autres contaminants potentiels. Toutes les connexions coaxiales doivent être serrées à un couple conforme aux spécifications du fabricant pour assurer qu'une pression de contact adéquate entre métaux est obtenue. Si un guide d'ondes est utilisé, les boulons des brides doivent alors être serrés à un couple conforme aux spécifications recommandées par le fabricant. L'alignement des connecteurs coaxiaux d'accouplement ou des brides de guides d'ondes doit faire l'objet d'une attention particulière.

Les matériaux et les combinaisons de matériaux utilisés dans les connecteurs, y compris la métallisation, sont importants pour les performances de l'intermodulation passive. Il est généralement préférable d'utiliser un matériau de métallisation tendre (par exemple l'or, l'argent, etc.) d'épaisseur suffisante (plusieurs profondeurs de pénétration) sur un matériau à base dure (cuivre, BeCu, etc.). Il convient de réduire le plus possible le nombre d'interfaces (adaptateurs et connecteurs coaxiaux). Cela réduit le nombre de jonctions entre métaux et, par conséquent, la possibilité de génération d'intermodulation passive. Des informations supplémentaires sur les connecteurs coaxiaux peuvent être consultées dans l'IEC 62037-3.

5.3 Considérations relatives au montage pour éviter la génération d'intermodulation passive

L'antenne doit être fixée correctement sur son équerre de montage. Tous les boulons et les harnais de maintien utilisés pour fixer l'antenne sur sa structure de support doivent être serrés au couple conforme aux spécifications du fabricant. La ou les lignes de transmission coaxiales ou à guides d'ondes conduisant au(x) port(s) d'entrée de l'antenne doivent également être bien fixées et ne doivent pas subir de frottements ni être déplacées.

Il convient de placer l'antenne avec précaution en l'orientant par temps clair et en l'isolant de toute source possible de perturbations dans son voisinage, telle que des structures de tours, des antennes situées à proximité, des bâtiments, des parois, le fuselage des avions, des plates-formes d'engins spatiaux, etc.

5.4 Sources de perturbations dans le voisinage

Il est important de connaître l'environnement RF dans lequel l'antenne est censée être installée. Il convient de veiller au positionnement de l'antenne afin de l'isoler de toutes les éventuelles sources de perturbations adjacentes. Par exemple, il convient d'éviter les structures ayant une faible pression de contact ou des parties corrosives. En outre, d'autres antennes rayonnant dans une bande similaire ou dans des bandes dont les harmoniques pourraient se situer dans la bande de fréquences de réception de l'antenne installée, exigent également d'être prises en compte. D'autres dispositifs électriques ou électroniques peuvent émettre des signaux RF de perturbation qui se situent dans la bande de fréquences de réception de l'antenne.

5.5 Pratiques de référence et cadre directeur pour le choix des matériaux

L'Article 6 de l'IEC 62037-1:2021 sert de guide pour la conception, le choix des matériaux et la manipulation des composants pouvant être susceptibles de générer une intermodulation passive. Il est très important de prendre en compte l'application de l'antenne, dans la mesure où il existe d'importantes différences de niveaux d'intermodulation passive acceptables entre les applications spatiales et les applications terrestres.

6 Considérations relatives à la mesure de l'intermodulation passive

6.1 Processus d'assurance de la qualité et procédures de manipulation

L'objectif de l'Article 6 est de fournir des recommandations dans les domaines du contrôle de la qualité, en ce qui concerne les performances des essais d'intermodulation passive des constituants d'une antenne. Les procédures sont destinées à améliorer la précision et à assurer la sécurité lors des mesures d'intermodulation passive sur les constituants d'une antenne. Les lignes directrices suivantes contribuent à réduire le plus possible les erreurs induites dans le système d'essai.

6.2 Précision de mesure

La précision des essais d'intermodulation passive réalisés sur les constituants d'une antenne peut être fortement affectée par une multitude de sources pouvant être externes ou internes au système d'essai. Certaines des sources pouvant affecter les résultats des essais d'intermodulation passive réalisés sur les constituants d'antenne comprennent, entre autres, les éléments suivants:

a) des objets comprenant des pièces constituées de matériaux conducteurs, qui sont exposés aux champs électromagnétiques rayonnés par l'antenne soumise à essai;
b) des matériels de montage lâches, détériorés ou corrodés, fixés sur l'antenne soumise à essai;
c) des matériels lâches ou corrodés, exposés aux champs RF rayonnés en provenance de l'antenne soumise à essai;
d) des signaux aux fréquences radioélectriques générés par des sources externes;
e) des câbles d'interface coaxiaux défectueux ou fonctionnant mal;
f) des connexions d'interface sales/contaminées/usées;
g) des connexions d'interface mal accouplées;
h) des connexions d'interface RF mal écrantées;
i) une intermodulation active mal filtrée, provenant du montage d'essai;
j) la prise en compte des pertes sur la ligne de transmission d'entrée;
k) des absorbeurs contaminés.

6.3 Environnement d'essai

Lorsque cela est applicable, les mesures d'intermodulation passive peuvent être réalisées à l'extérieur. Lors de la réalisation d'un essai de ce type, il est important de s'assurer que les réglementations gouvernementales relatives aux niveaux de rayonnements RF maximaux autorisés sont satisfaites. De même, l'énergie RF rayonnée par l'antenne soumise à essai peut générer une intermodulation passive dans des structures environnantes qui peut se coupler en retour dans l'antenne, entraînant des résultats d'essais d'intermodulation passive non valides. En outre, les sources externes de rayonnement RF peuvent interférer avec les mesures d'essai. Il est recommandé de relever les fréquences utilisées localement avant de réaliser les essais. De nombreuses sources externes d'intermodulation passive peuvent être réduites le plus possible ou éliminées en réalisant les essais d'intermodulation passive des antennes au sein d'une chambre d'essai anéchoïque fournissant un environnement d'essai de faible intermodulation passive. Des informations supplémentaires sur la construction de chambres d'essai anéchoïques adaptées aux essais d'intermodulation passive sont données en 6.8.

6.4 Sécurité

Il peut être dangereux de réaliser des essais d'intermodulation passive sur les constituants d'une antenne. Des tensions potentiellement élevées et des niveaux potentiellement élevés d'énergie RF peuvent être présents à la fois dans l'antenne soumise à essai et dans l'environnement d'essai. Il convient de placer l'antenne en essai de sorte que le personnel ne soit pas exposé à des champs électromagnétiques dépassant les niveaux acceptables spécifiés par les organismes publics.

6.5 Montage d'essai

6.5.1 Cordons d'essai coaxiaux

Un problème avec les montages d'essai d'intermodulation passive utilisant des interfaces de câbles coaxiaux est la nécessité de connecter/déconnecter à plusieurs reprises les connecteurs coaxiaux. Les éléments suivants sont des recommandations à suivre concernant les procédures relatives aux montages d'essai.