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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Passive rf and microwave devices, intermodulation level measurement – Part 7: Field measurements of passive intermodulation

Dispositifs rf et à micro-ondes passifs, mesure du niveau d'intermodulation – Partie 7: Mesures de l'intermodulation passive sur le terrain

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PASSIVE RF AND MICROWAVE DEVICES, INTERMODULATION LEVEL MEASUREMENT –

Part 7: Field measurements of passive intermodulation

FOREWORD

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

Draft	Report on voting
46/903/FDIS	46/912/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 parts of the IEC 62037 series, 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- withdrawn,
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- amended.

PASSIVE RF AND MICROWAVE DEVICES, INTERMODULATION LEVEL MEASUREMENT –

Part 7: Field measurements of passive intermodulation

1 Scope

This part of IEC 62037 defines test methods for reverse measurement of passive intermodulation (PIM) in systems of RF components deployed in the field. Field PIM measurements can be conducted on RF systems terminated into low PIM loads or on antenna feed systems that broadcast the test signals into the environment.

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 62037-1:2021, *Passive RF and microwave devices, intermodulation level measurement – Part 1: General requirements and measuring methods*

IEC 62037-2:2021, *Passive RF and microwave devices, intermodulation level measurement – Part 2: Measurement of passive intermodulation in coaxial cable assemblies*

IEC 62037-3:2021, *Passive RF and microwave devices, intermodulation level measurement – Part 3: Measurement of passive intermodulation in coaxial connectors*

IEC 62037-5:2021, *Passive RF and microwave devices, intermodulation level measurement – Part 5: Measurement of passive intermodulation in filters*

IEC 62037-6:2021, *Passive RF and microwave devices, intermodulation level measurement – Part 6: Measurement of passive intermodulation in antennas*

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 https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.2 Abbreviated terms

DTP Distance to PIM

DUT Device under test

IM Intermodulation

PIM Passive intermodulation

TMA Tower mounted amplifier

VSWR Voltage standing wave ratio

4 General considerations

4.1 Test environment

When a field PIM measurement is conducted on an antenna feed system that allows the test signals to broadcast into the environment, it is important to ensure that government regulations pertaining to the maximum authorized RF radiation levels are met. This applies to all fixed frequency PIM tests, swept PIM tests and distance-to-PIM (DTP) tests described in this document. See Annex A for information on distance-to-PIM measurements.

Field PIM measurements conducted on antenna feed systems measure the linearity of the entire RF path including the site RF infrastructure (coaxial cables, filters, antennas, etc.) and the environment where the antenna is installed (mounting hardware, cable support brackets, metal objects in front of or in the vicinity of the antenna). Technicians performing field PIM tests through an antenna shall avoid placing objects with non-linear PIM behaviour such as keys, cell phones, ladders and tools in locations in front of or in the vicinity of the antenna that might impact results.

4.2 Test frequencies

The f_1, f_2 and IM product frequency selected for the test shall fall within the operating bandwidth of the system under test. The f_1 and f_2 test frequencies shall be able to pass through the entire system and the IM product frequency being measured shall be able to return to the PIM analyzer for measurement. If devices are present in the RF path that block the f_1 and/or f_2 test frequency or prevent the desired IM product frequency from returning to the PIM analyzer, bypass these devices with short, low PIM jumper cables while testing.

The f_1 and f_2 test signals shall be spaced far enough apart in frequency to place the IM product being measured in the receive band of the PIM analyzer. To meet this requirement, one or both test signals will likely be outside of the spectrum owned by the operator commissioning the test. While it is unlikely that PIM test signals will cause harmful interference to other operators, it is good practice to select f_1 and f_2 test frequencies that fall in the guard bands between operators.

When PIM testing through an antenna, interfering signals can be received from user equipment operating at the IM product frequency. A survey of frequencies locally in use should be conducted prior to testing. If interfering signals are detected, change the f_1 and/or f_2 test frequency to move the IM product frequency to unused spectrum, such as a guard band frequency between active channels.

4.3 Safety

Performing field PIM tests through antennas can be dangerous. Potentially high voltages and high levels of RF energy can be present near the antenna. Technicians performing field PIM tests shall remain at a safe distance from the antenna and minimize exposure to electromagnetic fields in order to not exceed the acceptable levels specified by government agencies.

PIM tests require technicians to disconnect the coaxial cables at the radio output ports. Make sure that all radios feeding the line under test are locked-off and non-transmitting to prevent RF burns.

5 Field PIM test equipment

PIM test equipment used for field measurements shall be capable of performing a reverse (reflected) PIM test in accordance with IEC 62037-1:2021, 6.2.2. Field PIM test equipment will experience shock and vibration during transportation to a site and during use. In addition, field test equipment will often be used in outdoor, uncontrolled thermal environments. For these reasons, field PIM test equipment shall be ruggedized to perform reliably under typical test conditions.

6 Test procedure

6.1 General

Unless otherwise specified, test tones from the PIM analyzer will be injected into the system under test through the same connector that transmit signals enter the system from the radio.

6.2 Equipment verification

6.2.1 General

Because field PIM test equipment can be exposed to mechanical and thermal stress between tests, it is important to verify before testing that the equipment is in good operating condition. In addition to good operating condition verification, the following verification steps can be performed as needed while testing to rule out equipment issues when unexpected results are encountered.

6.2.2 Clean and inspect RF connections

Clean and inspect all RF connectors in the test set-up using isopropyl alcohol and a lent-free wipe prior to beginning verification tests. Mating surfaces inside the RF connectors should be clean and free of oils, dirt or objects that will increase contact resistance. In addition, all metal flakes shall be removed from inside the RF connector. Replace any worn or damaged components found during visual inspection.

6.2.3 Residual PIM test

Measure the residual PIM of the test set-up including the PIM analyzer and any coaxial cables and RF adapters used to connect the PIM analyzer to the system under test. Connect one end of the coaxial cable test lead to the PIM analyzer and the other end to a low PIM termination. Flex the test cable while measuring the test set-up. The test set-up peak self-intermodulation (including contribution of the load) should be at least 10 dB below the level to be measured on the system under test as specified in IEC 62037-1.

6.2.4 PIM standard test

A PIM standard is a device that consistently produces a known 3rd order IM product level when tested at a specified power level using specified f_1 and f_2 test signals. Some PIM standards include an integrated RF termination while others are "in-line" standards that require a low PIM termination to be connected to the output port of the standard. Connect the PIM standard plus termination directly to the output port of the PIM analyzer and measure the 3rd order IM level. The value measured should be within 3 dB of the expected value for that standard.

6.3 VSWR verification

Measure the VSWR of the system including the test lead and any RF adapters used to connect the PIM analyzer to the system at the f_1, f_2 and IM product frequencies. Unless otherwise specified, the VSWR should be <1,92:1 (10 dB return loss). If higher reflected energy is detected, investigate and repair the fault prior to performing a field PIM test.

6.4 Interference verification

Perform an external noise level measurement at the desired IM product frequency prior to performing a field PIM test. The magnitude of external received signals at the IM product frequency should be 10 dB lower than the IM level to be measured on the system under test. This test can be performed using a spectrum analyzer attached to the system under test or by using the PIM test equipment itself with the receiver active and the test signs turned off.

6.5 Static PIM test

"Static" means "without movement or stress". Perform an initial static PIM test to determine the IM product level generated by the system. If the static IM product level is below the specified pass/fail threshold, proceed to “dynamic” PIM testing. If the IM product level is above the specified pass/fail threshold, find and repair the PIM faults before proceeding.

Static PIM tests on antenna feed systems are typically conducted using fixed f_1, f_2 and IM product frequencies to avoid external interference at the IM product frequency and to minimize the probability of harmful interference by the test signals on other operators. Fixed frequency testing can occasionally report a passing PIM test result at the specified IM product frequency when there are multiple PIM sources present in the system under test. If multiple PIM sources are physically separated in such a way that the signals arrive at the PIM test equipment receiver 180º out of phase, the PIM signals will cancel, indicating low PIM in the system under test.

Static PIM tests can also be conducted using swept PIM measurements where one test frequency is fixed while sweeping the second test frequency across a range of spectrum. Changing the test frequencies changes the phase relationship between multiple IM product signals on the line. Sweeping across multiple test frequency combinations provides a range of IM product data points to help ensure that poor system PIM performance is not reported as good performance due to an unfortunate selection of test frequencies.

Swept PIM measurements on antenna feed systems can broadcast one or both test signals outside the licensed spectrum owned by the operator commissioning the test. The test signals are short duration and are typically transmitted in the downlink range of licensed spectrum holders. As a result, this test is unlikely to cause harmful interference to other users.

6.6 Dynamic PIM test

6.6.1 General

"Dynamic" means "with movement and/or with stress". Unless otherwise specified, perform a PIM test on the system while applying the specified dynamic stimulus to all components and connections in the system. The peak IM product level measured during the dynamic PIM test shall not exceed the specified pass/fail level for the system.

The purpose for applying a dynamic stimulus while PIM testing is to verify that all connections are tight and to identify any components with unstable PIM performance. The stimulus does not have to simulate environmental conditions to identify loose connections and unstable components. In addition, the stimulus does not have to exactly replicate the stimulus specified for factory PIM testing. The field dynamic stimulus shall not, however, be more severe than the stimulus defined in the relevant IEC 62037 specification for the component under test.

Fixed frequency PIM tests shall be used for maximum responsiveness while performing dynamic PIM tests. Multiple dynamic stimuli are required at each component and connection as described below to increase the probability of detection of PIM events.

6.6.2 Coaxial cable assemblies

Hold the cable at a distance of 4× the specified repeated bending radius of the cable and rotate the cable in either a clockwise or counterclockwise direction for 3 cycles. The radius of rotation should be equal to the cable diameter plus approximately 10 mm as specified in IEC 62037-2:2021, 4.2.

6.6.3 Coaxial connectors

Strike the connector with an instrument that will not damage the surface of the connector such as the plastic end of a screwdriver or the rubberized end of an adjustable wrench. Be careful not to strike the coaxial cable. Apply 5 impacts per connector with an impact energy less than or equal to the level specified in IEC 62037-3:2021, Table 1 for the connector type under test.

6.6.4 Splitters, combiners, filters and receive low noise amplifiers

Strike the device body with an instrument that will not damage the surface of the device such as the plastic end of a screwdriver or the rubberized end of an adjustable wrench. Two impacts shall be applied as close as possible to each connector on the device while still impacting the device body. For any side of the device that has no connectors, apply 3 impacts along each side. Impact energy shall be less than or equal 0,14 J per impact as specified in IEC 62037-5:2021, 4.2.

6.6.5 Antennas

Strike the rear surface of the antenna with an instrument that will not damage the surface of the antenna such as the plastic end of a screwdriver or the rubberized end of an adjustable wrench. Strikes should not be applied to AUT accessories or other fragile parts of the antenna. Two impacts shall be applied as close as possible to each connector on the device while still impacting the antenna rear surface. Additional impacts will be applied every 30 cm along the height of the antenna. Impact energy shall be less than or equal 1 J per impact as specified in IEC 62037-6:2021, 7.3.

7 Test specification

Test specifications shall specify:

a) test power level;

b) IM product order to be measured;

c) frequency band(s) or specific test frequencies within the band(s) to be measured.

8 Report

The report shall document the following:

a) residual PIM of the measurement system;

b) peak PIM of each antenna feed line while applying dynamic loading.