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Space engineering - Multipaction design and test

Space engineering - Multipaction design and test

Raumfahrttechnik - Multiplication Konzeption und Test

Systemes sol et opérations - Conception et test prenant en compte l'effet Multipactor

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Space engineering - Multipaction design and test

Systèmes sol et opérations - Conception et test prenant en compte l'effet Multipactor

Raumfahrttechnik (Engeneering) - Multipaction Konzenption und Test

This European Standard was approved by CEN on 29 April 2004.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

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Foreword

This document (EN 14777:2004) has been prepared by CEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2005, and conflicting national standards shall be withdrawn at the latest by January 2005.

It is based on a previous version[1)] originally prepared by the ECSS E-20-01 Working Group, reviewed by the ECSS Engineering Panel and approved by the ECSS Steering Board. The European Cooperation for Space Standardization (ECSS) is a cooperative effort of the European Space Agency, National Space Agencies and European industry associations for the purpose of developing and maintaining common standards.

This European Standard is one of the series of space standards intended to be applied together for the management, engineering and product assurance in space projects and applications.

Requirements in this European Standard are defined in terms of what shall be accomplished, rather than in terms of how to organize and perform the necessary work. This allows existing organizational structures and methods to be applied where they are effective, and for the structures and methods to evolve as necessary without rewriting the standards.

The formulation of this European Standard takes into account the existing EN ISO 9000 family of documents.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

1) ECSS-E-20-01

Introduction

Single carrier multipaction has well-established theoretical and testing procedures, and the heritage from proven components enables to define testing margin values as requirements for European space missions. Applying the single carrier margin to peak in-phase multi-carrier signals is recognized as excessively onerous in many cases, but the present understanding of multipaction for multicarrier signals is not well enough established for a reduced limit to be specified. For this reason, the margins for the multi-carrier case are stated as recommendations, with a view to their evolving to requirements in the longer term.

1 Scope

This document specifies the requirements and recommendations for the design and test of RF components and equipment to achieve acceptable performance with respect to multipaction-free operation in service in space. The document includes:

— verification planning requirements;

— definition of a route to conform to the requirements;

— design and test margin requirements;

— design and test requirements; and

— informative annexes that provide guidelines on the design and test processes.

This document is intended to result in the effective design and verification of the multipaction performance of the equipment and consequently in a high confidence in achieving successful product operation.

This document covers multipaction events occurring in all classes of RF satellite components and equipment at all frequency bands of interest. Operation in single carrier CW and pulse modulated mode are included, as well as multi-carrier operations. This document does not include breakdown processes caused by collisional processes, such as plasma formation.

This document is applicable to all space missions.

When viewed in a specific project context, the requirements defined in this document should be tailored to match the genuine requirements of a particular profile and circumstances of a project.

NOTE Tailoring is a process by which individual requirements of specifications, standards and related documents are evaluated and made applicable to a specific project, by selection and in some exceptional cases, modification of existing or addition of new requirements.

2 Normative references

The following referenced documents are indispensable for the application 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.

EN 13701:2001, *Space systems — Glossary of terms.*

EN 14725, *Space engineering — Verification.*

EN ISO 14644–1, *Cleanrooms and associated controlled environments — Part 1: Classification of air cleanliness (ISO 14644-1:1999).*

ESCC Basic Specification No. 24900*, Issue 1, October 2002, Minimum requirements for controlling environmental contamination of components.*

ESCC Basic Specification No. 20600*, Issue 1, February 2003, Preservation, packaging and despatch of ESCC electronic components.*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 13701:2001 and the following apply.

3.1.1
acceptance margin
margin to use for acceptance testing

3.1.2
acceptance stage
verification stage with the objective of demonstrating that the product is free of workmanship defects and integration errors and ready for its intended use

3.1.3
analysis uncertainty
numerical value of the uncertainty associated with an analysis

NOTE In performing analysis, a conservative approach based on pessimistic assumptions is used when assessing threshold powers for the onset of multipaction.

3.1.4
assembly (process)
process of mechanical mating of hardware to obtain a low level configuration after the manufacturing process

(see also EN 13701)

3.1.5
batch acceptance test
test performed on a sample from each batch of flight units to verify that the units conform to the acceptance requirements

NOTE For requirements on the sample size, see 8.3.1.a.

3.1.6
design margin
theoretically computed margin between the specified power handling of the component and the result of an analysis after the analysis uncertainty has been subtracted

NOTE As for the analysis uncertainty, the worst case is used.

3.1.7
development test
testing performed during the design and development phase which can supplement the theoretical design activities

3.1.8
gap voltage
voltage in the critical gap

NOTE The critical gap corresponds to the most critical location in the space RF component where the multipaction can occur.

3.1.9
in-process test
testing performed during the manufacture of flight standard equipment

NOTE It is carried out with the equipment in an unfinished state or on a part or sub-assembly that cannot be tested fully when later integrated into the equipment. The tests form part of verification.

3.1.10
integration
process of physically and functionally combining lower level products to obtain a particular functional configuration

NOTE The term product can include hardware, software or both.

3.1.11
measurement uncertainty
uncertainty with which the specified power level is applied to the test item

3.1.12
model philosophy
definition of the optimum number and characteristics of physical models to achieve a high confidence in the product verification with the shortest planning and a suitable weighing of costs and risks

3.1.13
qualification margin
margin between the specified power level and the power level at which a qualification test is performed, taking into account the measurement uncertainty

3.1.14
qualification stage
verification stage with the objective to demonstrate that the design conforms to the applicable requirements including proper margins

3.1.15
qualification test
testing performed on a single flight standard unit to establish that a suitable margin exists in the design and build standard

NOTE Such suitable margin is the qualification margin.

3.1.16
review-of-design
verification method using validation of previous records or evidence of validated design documents, when approved design reports, technical descriptions and engineering drawings unambiguously show that the requirement is conformed to

3.1.17
test margin
margin demonstrated by test

3.1.18
unit acceptance test
testing carried out on each flight standard unit to verify that the unit conforms to the acceptance requirements

3.1.19
verification level
product architectural level at which the relevant verification is performed

3.2 Abbreviated terms

The following abbreviated terms are defined and used within this document:

Abbreviation	Meaning
AC/DC	alternating current/direct current
BAT	batch acceptance test
BSE	back-scattered electron
CFRP	carbon-fibre-reinforced plastic
CW	continuous wave
DUT	device under test
ECSS	European Cooperation for Space Standardization
EMC	electromagnetic compatibility
ERS	European remote sensing satellite
ESCC	European Space Components Coordination
FM	flight model
HPA	high power amplifier
IF	intermediate frequency
LNA	low noise amplifier
OMUX	output multiplexer
PIC	particle in cell
PID	process identification document
PIMP	passive intermodulation product
RF	radio frequency
SEE	secondary electron emission
TEM	transverse electromagnetic mode
TWTA	travelling wave tube amplifier
UAT	unit acceptance test
UV	ultraviolet
VSWR	voltage standing wave ratio
WG	wave guide

4 Verification

4.1 Verification process

a) The process of verification of the component with respect to multipaction performance shall demonstrate conformance to the margin requirements defined in 4.6.

b) Verification of the component with respect to multipaction shall be performed as part of the overall component verification process specified in EN 14725.

NOTE 1 The requirements contained in this document are in line with those of EN 14725, with tailoring specific to multipaction performance verification.

c) Such verification shall be adequately planned for each component

NOTE 2 It can involve a combination of design analyses, inspections, development testing, in-process testing, qualification testing, batch acceptance testing and unit acceptance testing.

4.2 Verification levels

a) Multipaction performance should be verified at the component level.

b) If this is not feasible or practicable, then verification may be performed at the subassembly level.

4.3 Verification plan

4.3.1 Introduction

The verification plan is a key document in establishing and documenting the route to achieve acceptable performance with respect to multipaction. The plan can be a separate document or incorporated into other planning documents.

4.3.2 Generation and updating

a) A verification plan shall be produced in the early part of the design phase.

b) Such a verification plan shall be updated in the light of any unexpected results from analyses or tests.

NOTE The detailed verification plan adopted for any particular project depends on the qualification status of the equipment and on the model philosophy or production philosophy adopted.

4.3.3 Description

a) The verification plan shall present a coherent sequence of activities that are proposed in order to provide adequate evidence that the requirement specifications for the product are achieved for each delivered item.

b) The criteria for successful completion of each of the activities shall be stated and the verification plan shall show how the criteria have been selected, in accordance with this document, such that meeting of all criteria for each proposed activity results in acceptance of the delivered components with respect to multipaction.

c) The verification plan shall be a configured document and, once accepted by the customer, shall only be modified with the customer's approval.

d) The inputs to the verification plan shall include:

   1) this document;

   2) the component requirements specification;

   3) the proposed design; and

   4) the component qualification status with respect to multipaction performance.

e) The plan shall contain:

   1) a statement of the applicability of existing qualification status;

2) description of analyses to be performed (e.g. geometry, excitation, and analysis method), together with a statement of the requested accuracy from analyses, and the minimum design margin shown by the analysis and assumed in the remainder of the plan;

3) description of development tests to support the analyses or for other purposes, including, for each test, a description of the test item, the measurements to be made and a description of the intended use of the results;

4) inputs to the overall equipment test plan in terms of a list of tests to be performed on each model, including, for each test, the test configuration, type of signal (CW or pulsed), average and maximum power, diagnostic method, sensitivity, environmental conditions, qualification of personnel involved and acceptance criteria;

5) inputs to the overall inspection plan, giving details of inspections to be carried out on test items during manufacture, prior to test, after test, at equipment delivery and at the point of integration;

6) inputs to any process identification document (PID) that is being used to control similarity between different models or between models in a batch.

f) e) 5) above, referring to the verification plan, should be reviewed after any detailed analysis is completed and any multipaction-critical areas identified for inspection of dimensions, contamination pre-test and damage post-test.

4.4 Verification routes

Verification shall be accomplished by one of the following verification routes:

a) Analysis only, in which case the following requirements shall be met:

1) there is a proven heritage of similar qualified designs;

2) the component has a geometry that allows accurate field calculations to be performed with high confidence;

3) the multipaction-critical areas of the component have commonality with an existing design that has established the correlation between analysis and test.

b) Qualification tests only.

c) Acceptance (batch, or unit or both) tests only.

d) Previously qualified components.

NOTE The relevant margins for all routes are specified in 4.6.

4.5 Classification of component type

a) The classification of component types given in Table 1 shall be used to determine the applicable multipaction margin in accordance with 4.6.

NOTE This sub-clause defines a classification of component types according to the materials employed in the construction.

b) In case of doubt when determining the classification of any particular component, the type with a higher number shall be assumed.

Table 1 — Classification of component type

Type	Characteristics
1	The RF paths are entirely metallic (with known secondary electron emission properties) or are metallic with a non-organic surface treatment that increases the multipaction threshold. Note that this does not preclude the use of coated plastics or CFRP provided that only metal surfaces are subjected to the RF fields. The components are well vented.
2	The RF paths contain or can contain dielectrics or other materials for which the multipaction performance is well defined. The components are well vented.
3	Any components not classified as Type 1 or Type 2.

4.6 Single carrier

4.6.1 General

This sub-clause states the numerical values of the margins to be used for CW and pulsed systems.

4.6.2 Margins

The margins shown in Tables 2 to 4 for the three different component types shall be applied.

NOTE The margin is defined with respect to the peak operating power for the component.

Table 2 — Margins applicable to Type 1 components

Route	Analysis margin (dB)	Qualification test margin (dB)	Batch acceptance test margin (dB)	Unit acceptance test margin (dB)
1	8	-	-	-
2	-	6	-	-
3	-	-	4	-
4	-	-	-	3

Table 3 — Margins applicable to Type 2 components

Route	Analysis margin (dB)	Qualification test margin (dB)	Batch acceptance test margin (dB)	Unit acceptance test margin (dB)
1	10	-	-	-
2	-	6	-	-
3	-	-	4	-
4	-	-	-	3