

DIN EN 16603-20-01

ICS 49.140

Einsprüche bis 2014-10-22
Vorgesehen als Ersatz für
DIN EN 14777:2005-10

Entwurf

**Raumfahrttechnik –
Multipaction, Konzeption und Test;
Englische Fassung FprEN 16603-20-01:2014**

Space engineering –
Multipaction, design and test;
English version FprEN 16603-20-01:2014

Systèmes sol et opérations –
Conception et test prenant en compte l'effet Multipactor;
Version anglaise FprEN 16603-20-01:2014

Anwendungswarnvermerk

Dieser Norm-Entwurf mit Erscheinungsdatum 2014-08-22 wird der Öffentlichkeit zur Prüfung und Stellungnahme vorgelegt.

Weil die beabsichtigte Norm von der vorliegenden Fassung abweichen kann, ist die Anwendung dieses Entwurfes besonders zu vereinbaren.

Stellungnahmen werden erbeten

- vorzugsweise online im Norm-Entwurfs-Portal des DIN unter www.entwuerfe.din.de bzw. für Norm-Entwürfe der DKE auch im Norm-Entwurfs-Portal der DKE unter www.entwuerfe.normenbibliothek.de, sofern dort wiedergegeben;
- oder als Datei per E-Mail an nl@din.de möglichst in Form einer Tabelle. Die Vorlage dieser Tabelle kann im Internet unter www.din.de/stellungnahme oder für Stellungnahmen zu Norm-Entwürfen der DKE unter www.dke.de/stellungnahme abgerufen werden;
- oder in Papierform an den DIN-Normenausschuss Luft- und Raumfahrt (NL), 10772 Berlin (Hausanschrift: Burggrafenstr. 6, 10787 Berlin).

Die Empfänger dieses Norm-Entwurfs werden gebeten, mit ihren Kommentaren jegliche relevanten Patentrechte, die sie kennen, mitzuteilen und unterstützende Dokumentationen zur Verfügung zu stellen.

Gesamtumfang 98 Seiten

DIN-Normenausschuss Luft- und Raumfahrt (NL)

Nationales Vorwort

Dieses Dokument (FprEN 16603-20-01:2014) wurde vom Technischen Komitee CEN/CLC/TC 5 „Raumfahrt“ erarbeitet, dessen Sekretariat vom DIN (Deutschland) gehalten wird.

Dieses Dokument ist derzeit zum einstufigen Annahmeverfahren vorgelegt.

Dieses Dokument wird DIN EN 14777:2005-10 ersetzen.

Dieses Dokument wurde speziell zur Behandlung von Raumfahrtsystemen erarbeitet und hat daher Vorrang vor jeglicher Europäischer Norm, da es denselben Anwendungsbereich hat, jedoch über einen größeren Geltungsbereich (z. B. Luft- und Raumfahrt) verfügt.

Das zuständige deutsche Normungsgremium ist der Arbeitsausschuss NA 131-10-01 AA „Interoperabilität von Informations-, Kommunikations- und Navigationssystemen“ im DIN-Normenausschuss Luft- und Raumfahrt (NL).

Änderungen

Gegenüber DIN EN 14777:2005-10 wurden folgende Änderungen vorgenommen:

- a) Norm-Nummer geändert.
- b) keinerlei Änderungen des Textes.

Nationaler Anhang NA (informativ)

3 Begriffe und Abkürzungen

3.1 Begriffe aus anderen Normen

Für die Anwendung dieses Dokuments gelten die Begriffe nach ECSS-S-ST-00-01 und insbesondere die folgenden Begriffe:

Ausheizen

Inspektion

3.2 Begriffe zur vorliegenden Norm

3.2.1

Fehlerspielraum bei der Abnahme

Spanne, die bei der Abnahmeprüfung genutzt werden kann

3.2.2

Abnahmestufe

Verifikationsstufe mit dem Ziel nachzuweisen, dass das Produkt frei von Fertigungs- und Integrationsfehlern und bereit für seine vorgesehene Nutzung ist

3.2.3

Unbestimmtheit der Analyse

numerischer Wert für die Unbestimmtheit im Zusammenhang mit der Analyse

ANMERKUNG Bei der Durchführung der Analyse wird für die Bewertung der Schwellenenergie, die den Multipactor-Effekt auslöst, ein konservativer Ansatz auf Grundlage einer pessimistischen Annahme verwendet.

3.2.4

Montage

Zusammenbau (Prozess)

Vorgang des mechanischen Zusammenfügens der Hardware, um nach dem Herstellungsverfahren eine Konfiguration auf niedriger Stufe zu erhalten

ANMERKUNG Diese Definition unterscheidet sich von der Definition „Montage <Handlung>“ in ECSS-S-ST-00-01.

3.2.5

Chargen-Abnahmeprüfung

Prüfung, die an einer Probe jeder Charge raumfahrtbezogener Einheiten durchgeführt wird, um die Übereinstimmung dieser Einheiten mit den Abnahmeanforderungen zu verifizieren

ANMERKUNG Zu den Anforderungen bezüglich der Probengröße siehe 8.3.1 a.

3.2.6

Entwurfstoleranz

theoretisch berechnete Spanne zwischen der festgelegten Belastbarkeit des Bauteils und dem Ergebnis der Analyse, nachdem die Unbestimmtheit der Analyse abgezogen wurde

ANMERKUNG Bei der Unbestimmtheit der Analyse wird der ungünstigste Fall verwendet.

3.2.7**Entwicklungsprüfung**

Prüfungen, die während der Entwurfs- und Entwicklungsphase durchgeführt werden und die theoretischen Entwurfstätigkeiten unterstützen können

3.2.8**Abstandsspannung**

Spannung innerhalb des kritischen Abstands

ANMERKUNG Der kritische Abstand entspricht der kritischsten Stelle im raumfahrtbezogenen Hochfrequenz-Bauteil, an der der Multipactor-Effekt auftreten kann.

3.2.9**herstellungsbegleitende Prüfung**

Prüfungen, die während der Herstellung an raumfahrtbezogenen Standardgeräten durchgeführt werden können

ANMERKUNG Die Prüfung wird an einem Gerät in nicht gebrauchstauglichem Zustand oder an einem Bestandteil oder einer Unterbaugruppe, der/die nach seiner/ihrer späteren Integration in das Gerät nicht vollständig geprüft werden kann, durchgeführt. Die Prüfung ist Bestandteil der Verifikation.

3.2.10**Integration**

Prozess der physikalischen und funktionalen Kombination von Produkten unterer Herstellungsstufen, um eine besonders funktionale Konfiguration zu erhalten

ANMERKUNG Der Begriff „Produkt“ kann Hardware, Software oder beides umfassen.

3.2.11**Messunsicherheit**

Unsicherheit, mit der der festgelegte Leistungspegel auf das Prüfstück angewendet wird

3.2.12**Modellphilosophie**

Festlegung der bestmöglichen Anzahl und Eigenschaften physikalischer Modelle, um unter Nutzung der kürzestmöglichen Planung und einer angemessenen Abwägung von Kosten und Risiken ein hohes Vertrauen in die Produktverifikation zu erreichen

3.2.13**mittlere Leistung**

bei einem Mehrfach-Trägerbetrieb mit n Trägersignalen ist die mittlere Leistung die Summe der Leistungen jedes einzelnen Trägersignals (P_i):

$$P_{\text{mean}} = \sum_{i=1}^N P_i$$

Die mittlere Leistung wird auch als durchschnittliche Leistung bezeichnet.

3.2.14**Spitzenleistung**

bei einem Betrieb mit Einzel-Trägersignalen ist die Spitzenleistung die Höchstleistung im Pulsbetrieb; im Falle eines Arbeitszyklus von 100 % entspricht die Spitzenleistung der mittleren Leistung

3.2.15**Hüllkurvenspitzenleistung**

PEP

bei einem Mehrfach-Trägerbetrieb mit n Trägersignalen ist die Hüllkurvenspitzenleistung der höchstmögliche Leistungspegel, wenn sämtliche Trägersignale phasengleich sind

3.2.16

P20

bei einem Mehrfach-Trägerbetrieb mit n Trägersignalen ist die P20-Leistung der Mindestleistungspegel eines Mehrfach-Trägersignals einer maximalen Leistung während eines Zeitraums, der 20 Durchgangszeiten entspricht

3.2.17

Qualifizierungsspanne

Spanne zwischen dem festgelegten Leistungspegel und dem Leistungspegel, bei dem eine Qualifizierungsprüfung unter Berücksichtigung der Messunsicherheit durchgeführt wird

3.2.18

Qualifizierungsstufe

Verifizierungsstufe mit dem Ziel nachzuweisen, dass der Entwurf den zutreffenden Anforderungen einschließlich der Qualifizierungsspannen entspricht

3.2.19

Qualifizierungsprüfung

an einer einzelnen raumfahrtbezogenen Standardeinheit durchgeführte Prüfung zum Beweis dafür, dass eine geeignete Spanne in Entwurf und Ausführungsnorm vorhanden ist

ANMERKUNG Solch eine geeignete Spanne ist die Qualifizierungsspanne.

3.2.20

Designreview

Verifizierungsverfahren unter Verwendung der Validierung früherer Berichte oder von Belegen validierter Entwurfsdokumente, wenn genehmigte Designberichte, technische Beschreibungen und technische Zeichnungen eindeutig zeigen, dass die Anforderung erfüllt wurde

3.2.21

Prüfspanne

Spanne, die durch eine Prüfung nachgewiesen wird

3.2.22

Abnahmeprüfung der Einheit

Prüfung, die an jeder raumfahrtbezogenen Standardeinheit durchgeführt wird, um zu verifizieren, dass die Einheit den Abnahmeanforderungen entspricht

3.2.23

Verifizierungsstufe

Stufe der Produktarchitektur, auf der die relevante Verifizierung durchgeführt wird

3.3 Abkürzungen

Die folgenden Abkürzungen wurden im Rahmen dieser Norm festgelegt und verwendet:

AC/DC	Wechselstrom/Gleichstrom (en: alternating current/direct current)
BAT	Chargen-Abnahmeprüfung (en: batch acceptance test)
BSE	Rückstreu-Elektronenemission (en: back-scattered electron emission)
CFRP	karbonfaserverstärkter Kunststoff (en: carbon-fibre-reinforced plastic)
CW	kontinuierliche Welle (en: continuous wave)
DUT	Gerät in der Prüfung (en: device under test)

ECSS	Europäische Kooperation für Raumfahrtnormung (en: European Cooperation for Space Standardization)
EMC	elektromagnetische Verträglichkeit (en: electromagnetic compatibility)
ERS	Europäischer Fernmeldesatellit (en: European remote sensing satellite)
ESCC	Europäische Koordinierung zur Standardisierung in der Raumfahrt (en: European Space Components Coordination)
FM	Flugmodell (en: flight model)
HPA	Hochleistungsverstärker (en: high power amplifier)
IF	Zwischenfrequenz (en: intermediate frequency)
LNA	Verstärker mit niedrigem Eigenrauschen (en: low noise amplifier)
OMUX	Ausgabemultiplexer (en: output multiplexer)
PIC	Particle-in-cell-Verfahren (en: particle in cell)
PID	Prozessidentifizierungsdokument (en: process identification document)
PIMP	passives Intermodulationsprodukt (en: passive intermodulation product)
RF	Hochfrequenz, Funkfrequenz (en: radio frequency)
SEE	sekundäre Elektronenemission (en: secondary electron emission)
REG	geregelter Elektronenstrahl-Erzeuger (en: regulated electron gun)
RS	radioaktive Quelle (en: radioactive source)
TEM	TM-Modus, TM-Welle (en: transverse electromagnetic mode)
TWTA	Wanderfeldröhrenverstärker (en: travelling wave tube amplifier)
UAT	Abnahmeprüfung der Einheit (en: unit acceptance test)
UV	ultraviolett (en: ultraviolet)
VSWR	Stehwellenverhältnis (en: voltage standing wave ratio)
WG	Wellenleiter (en: wave guide)

May 2014

ICS 49.140

Will supersede EN 14777:2004

English version

Space engineering - Multipaction, design and test

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

Raumfahrttechnik - Multipaction-Konzeption und -Test

This draft European Standard is submitted to CEN members for unique acceptance procedure. It has been drawn up by the Technical Committee CEN/CLC/TC 5.

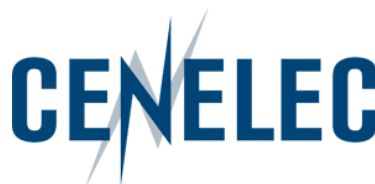
If this draft becomes a European Standard, CEN and CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

This draft European Standard was established by CEN and CENELEC in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN and CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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

Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Warning : This document is not a European Standard. It is distributed for review and comments. It is subject to change without notice and shall not be referred to as a European Standard.



CEN-CENELEC Management Centre:
Avenue Marnix 17, B-1000 Brussels

Table of contents

Foreword	7
Introduction.....	8
1 Scope.....	9
2 Normative references	10
3 Terms, definitions and abbreviated terms.....	11
3.1 Terms and definitions from other standards	11
3.2 Terms and definitions specific to the present standard	11
3.3 Abbreviated terms.....	14
4 Verification	15
4.1 Verification process	15
4.2 Verification levels.....	15
4.3 Verification plan	15
4.3.1 Introduction	15
4.3.2 Generation and updating.....	16
4.3.3 Description	16
4.4 Verification routes	17
4.5 Classification of component type	17
4.6 Single carrier	18
4.6.1 General	18
4.6.2 Margins	18
4.6.3 Route to demonstrate compliance.....	18
4.7 Multi-carrier.....	21
4.7.1 General	21
4.7.2 Threshold above peak envelope power.....	21
4.7.3 Threshold below peak envelope power	22
4.7.4 Route to demonstrate conformance	22
5 Design analysis	25
5.1 Overview	25
5.2 General requirements	25

5.2.1	Field analysis	25
5.2.2	Secondary emission yield data	25
5.3	Critical region identification	26
5.4	Multipaction sensitivity analysis	27
5.5	Venting	27
6	Test conditions	28
6.1	Cleanliness	28
6.2	Pressure	28
6.3	Temperature	29
6.4	Frequencies	29
6.5	Pulse duration	29
6.5.1	General	29
6.5.2	CW units	30
6.5.3	Pulse duration	30
6.6	Electron seeding	30
6.6.1	Multipactor test in CW operation	30
6.6.2	Multipactor test in pulsed operation	30
6.6.3	Multipactor test in multi-carrier operation	31
6.6.4	Seeding sources	31
7	Methods of detection	33
7.1	General	33
7.2	Detection methods	33
7.3	Detection method parameters	33
7.3.1	Sensitivity	33
7.3.2	Rise time	34
8	Test procedures	35
8.1	Test configuration	35
8.2	Test facility validation	35
8.3	Test execution	36
8.3.1	General	36
8.3.2	Test procedure	36
8.4	Acceptance criteria	37
8.4.1	General	37
8.4.2	Multi-carrier test	38
Annex A	(informative) Multipaction background	39
A.1	Physics of multipaction	39

A.2	Other physical processes	40
A.3	RF operating environment	40
A.3.1	General	40
A.3.2	CW approach	41
A.3.3	Pulsed approach	41
A.3.4	Multi-carrier approach	41
A.3.5	Multi-carrier multipaction thresholds	42
A.4	Parallel plate multipaction	48
A.4.1	Introduction	48
A.4.2	Woode and Petit results	50
A.5	Coaxial line multipaction	52
A.5.1	Introduction	52
A.5.2	Problem definition	53
A.5.3	Simulations	53
A.5.4	Results	53
Annex B	(normative) Cleaning, handling, storage and contamination	56
B.1	Generic process	56
B.1.1	Introduction	56
B.1.2	Cleaning and handling of critical components	56
B.2	Cleaning, handling and storage	56
B.2.1	Introduction	56
B.2.2	Cleaning and handling of critical components	57
B.2.3	Storage of components	58
B.3	Contaminants	59
B.3.1	The effect of contaminants on the multipaction threshold	59
B.3.2	Contamination measurement (wipe test)	59
B.3.3	Summary of test made and the results	59
B.3.4	Summary conclusions to the test	61
B.3.5	Surface verification	61
Annex C	(informative) Electron seeding	62
C.1	Introduction	62
C.2	CW test	62
C.3	Pulsed test	62
C.4	Multi-carrier test	62
C.4.1	General	62
C.4.2	Generic multi-carrier test	62
C.4.3	Multi-carrier test with transient detection	63

C.5	Types of seeding sources	64
C.5.1	Overview	64
C.5.2	Radioactive source	64
C.5.3	UV lamp	66
C.5.4	Regulated electron gun	67
C.6	Guidelines for the use of seeding sources	68
Annex D	(informative) Test methods	70
D.1	Introduction	70
D.2	General test methods	70
D.2.1	Close to carrier noise	70
D.2.2	Return loss	72
D.2.3	Harmonic noise	75
D.3	Transient tests methods	75
D.3.1	Introduction	75
D.3.2	Signal generation	77
D.4	Test facility validation	82
Annex E	(informative) Secondary electron emission	83
E.1	SEY Definition and properties	83
E.2	SEY and multipactor	84
E.3	Factors affecting SEY	86
E.4	SEY testing	87
Bibliography		91

Figures

Figure 4-1: Routes to conformance for single carrier	20
Figure 4-2: Routes to conformance for multi-carrier test	24
Figure 5-1: The susceptibility zone boundaries for examples of aluminium, copper, silver, gold and alodine 1200 used in Annex A	26
Figure A-1 : Total secondary electron emission as a function of the incident electron	48
Figure A-2 : Multipaction susceptibility zones for parallel plates of an example of aluminium	49
Figure A-3 : Multipaction threshold for all materials studied, plotted in a single graph as labelled	54
Figure D-1 : Generic close to carrier noise multipaction test site	71
Figure D-2 : Principal multipaction test set-up for nulling detection method	73
Figure D-3 : Test configuration (mode 1)	76
Figure D-4 : Test configuration (mode 2)	76

Figure D-5 : Detected envelope of a five carrier waveform	79
Figure D-6 : Charge probe.....	81
Figure E-1 : Typical dependence of SEY coefficients on primary electron energy.	84
Figure E-2 : Energy distribution of emitted electron from Au target surface submitted to 112 eV electron irradiation [23].....	84
Figure E-3 : Experimental arrangement for SEY test with emission collector.....	88
Figure E-4 : SEY experimental setup (without collector around the sample).....	89

Tables

Table 4-1: Classification of component type	18
Table 4-2: Margins applicable to Type 1, 2 and 3 components	18
Table 4-3: Multi-carrier margins applicable to Type 1 components when the single carrier multipaction threshold is above the peak envelope power	22
Table 4-4: Multi-carrier margins applicable to Type 1 components when the single carrier multipaction threshold is below the peak envelope power	22
Table A-1 : Worst case mode order for susceptible gaps for an example of gold.....	43
Table A-2 : Worst case mode order for susceptible gaps for an example of silver	44
Table A-3 : Worst case mode order for susceptible gaps for an example of aluminium	45
Table A-4 : Worst case mode order for susceptible gaps for an example of alodine	46
Table A-5 : Worst case mode order for susceptible gaps for an example of copper.....	47
Table A-6 : Constants for the tested materials.....	52
Table A-7 : Critical voltages for multipaction in 50 Ohms coaxial lines using an example of materials	54
Table C-1 : Rate and energy of injected electrons going through a particular aluminium wall.....	65

Foreword

This document (FprEN 16603-20-01:2014) has been prepared by Technical Committee CEN/CLC/TC 5 "Space", the secretariat of which is held by DIN (Germany).

This document (FprEN 16603-20-01:2014) originates from ECSS-E-20-01A Rev.1.

This document is currently submitted to the Unique Acceptance Procedure.

This document will supersede EN 14777:2004.

This document has been developed to cover specifically space systems and will therefore have precedence over any EN covering the same scope but with a wider domain of applicability (e.g. : aerospace).

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.

For the purpose of this document, the terms multipaction and multipactor are equivalent.

This document does not include major changes with respect to “issue A”. For full traceability with “issue A”, it has not been revisited for full compliance with the ECSS drafting rules for ECSS Standards. It is the ECSS policy that a document published as “Issue C” is in full compliance with these drafting rules. Therefore the ECSS Technical Authority decided to publish this update as “ECSS-E-20-01A Rev.1”.

1

Scope

This standard defines 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 standard 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 standard 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 standard 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 standard does not include breakdown processes caused by collisional processes, such as plasma formation.

This standard is applicable to all space missions.

NOTE Multipactor in multi-carrier operation is currently being investigated. Hence, please be aware that this document provides only recommendations to multi-carrier operation. These recommendations are provisional and will be reviewed in future versions.

This standard may be tailored for the specific characteristic and constraints of a space project in conformance with ECSS-S-ST-00.

2

Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references, subsequent amendments to, or revisions of any of these publications do not apply. However, parties to agreements based on this ECSS Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references the latest edition of the publication referred to applies.

EN reference	Reference in text	Title
EN 16601-00-01	ECSS-S-ST-00-01	ECSS - Glossary of terms
EN 16603-10-02	ECSS-E-ST-10-02	Space engineering - Verification
	ISO 14644-1:1999	Cleanrooms and associated controlled environments. Classification of air cleanliness
	ESCC 20600 Issue 1, February 2003	ESCC Basic Specification - Preservation, packaging and despatch of ESCC electronic components
	ESCC 24900 Issue 1, October 2002	ESCC Basic Specification - Minimum requirements for controlling environmental contamination of components

3

Terms, definitions and abbreviated terms

3.1 Terms and definitions from other standards

For the purpose of this standard, the terms and definitions from ECSS-S-ST-00-01 apply, in particular the following terms:

bake-out

inspection

3.2 Terms and definitions specific to the present standard

3.2.1 acceptance margin

margin to use for acceptance testing

3.2.2 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

3.2.3 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.

3.2.4 assembly (process)

process of mechanical mating of hardware to obtain a low level configuration after the manufacturing process

NOTE This definition differs from the definition of “assembly <act>” in ECSS-S-ST-00-01.

3.2.5 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 8.3.1a.

3.2.6 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.

3.2.7 development test

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

3.2.8 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.

3.2.9 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 as part or sub assembly that cannot be fully tested when later integrated into the equipment. The tests form part of verification.

3.2.10 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.

3.2.11 measurement uncertainty

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

3.2.12 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

3.2.13 mean power

in case of multi-carrier operation with n carriers, the mean power is the sum of the power of each carrier (P_i):

$$P_{mean} = \sum_{i=1}^N P_i$$

mean power is also called average power

3.2.14 peak power

in case of single-carrier operation, the peak power is the maximum power in pulse mode.

In case of duty cycle of 100%, the peak power corresponds to the mean power

3.2.15 peak envelope power (PEP)

in case of multi-carrier operation with n carriers, the peak envelope power is the maximum power level when all the carriers are in phase

3.2.16 P20

in case of multi-carrier operation with n carriers, the P20 power is the minimum power level of the multi-carrier signal of a maximized power during a time equal to the 20 gap crossing time

3.2.17 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

3.2.18 qualification stage

verification stage with the objective of demonstrating that the design conforms to the applicable requirements including qualification margins

3.2.19 qualification test

testing performed on a single flight standard unit for establishing that a suitable margin exists in the design and built standard

NOTE Such suitable margin is the qualification margin.

3.2.20 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

3.2.21 test margin

margin demonstrated by test

3.2.22 unit acceptance test

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

3.2.23 verification level

product architectural level at which the relevant verification is performed

3.3 Abbreviated terms

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

AC/DC	alternating current/direct current
BAT	batch acceptance test
BSE	back-scattered electron emission
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
REG	regulated electron gun
RS	radioactive source
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 clause 4.6.
- b. Verification of the component with respect to multipaction shall be performed as part of the overall component verification process specified in ECSS-E-ST-10-02.

NOTE The requirements contained in this standard are in line with those of ECSS-E-ST-10-02, with tailoring specific to multipaction performance verification.

- c. Such verification shall be adequately planned for each component.

NOTE 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 confidence 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. The verification plan specified in 4.3.2a shall be kept up-to-date and under configuration control.

NOTE The detailed verification plan adopted for any particular project can depend 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 standard, 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 standard,
 - 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. Clause 4.3.3e.5, 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

- a. Verification shall be accomplished by one of the following verification routes:
1. Analysis only
 2. Qualification tests only
 3. Acceptance (batch, or unit or both) tests only
 4. Previously qualified components

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

- b. The route analysis only, specified in 4.4a.1, shall not be followed unless the following conditions are met:
- (a) there is a proven heritage of similar qualified designs;
 - (b) the component has a geometry that allows accurate field calculations to be performed with high confidence;
 - (c) the multipaction-critical areas of the component have commonality with an existing design that has established the correlation between analysis and test.

4.5 Classification of component type

- a. The classification of component types given in Table 4-1 shall be used to determine the applicable multipaction margin in accordance with clause 4.6.

NOTE This 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 4-1: 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-dielectric 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 i.a.w. 5.5a.
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 i.a.w. 5.5a.
3	Any components not classified as Type 1 or Type 2.

4.6 Single carrier

4.6.1 General

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

4.6.2 Margins

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

Table 4-2: Margins applicable to Type 1, 2 and 3 components

#	Route	Margin (dB)		
		Type 1	Type 2	Type 3
1	Analysis	8	10	12
2	Qualification test	6	6	10
3	Batch acceptance test	4	4	6
4	Unit acceptance test	3	3	4

4.6.3 Route to demonstrate compliance

- a. The route to demonstrate conformance to CW and pulsed multipaction requirements illustrated in the flow diagram shown in Figure 4-1 shall be used.

- b. The unit shall not be accepted at each stage of the process unless
 - 1. the relevant margins are satisfied, and
 - 2. controls in the production process are such that adequate margins are carried through to the final components.

NOTE The stages in the process are analysis, qualification tests and acceptance tests, where the latter can be either batch or unit tests.

- c. If any stage of the process is omitted, then it shall be assumed that the margins are not satisfied and the 'no' route in the flow diagram (see Figure 4-1) shall be followed.

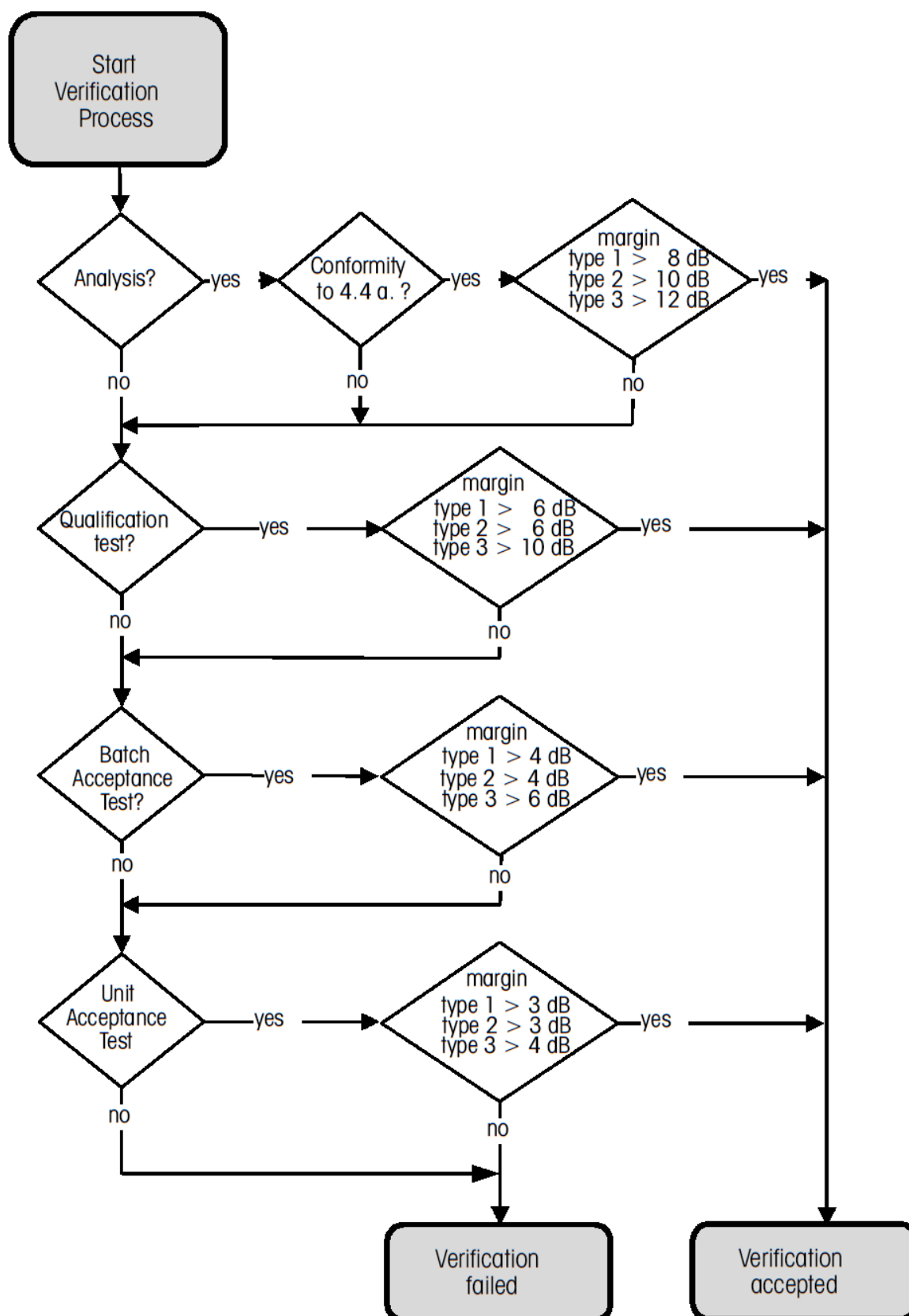


Figure 4-1: Routes to conformance for single carrier

4.7 Multi-carrier

4.7.1 General

This clause 4.7 presents recommendations for the verification of multipaction performance under multi-carrier conditions. The purpose of the multi-carrier margin recommendations is to give values which offer low probability for multipaction breakdown without over-designing the parts.

Up to the present time, there is not an applicable theory for multi-carrier operation. The only available criterion for establishing a multipactor discharge in multi-carrier operation is the 20-gap-crossing rule, presented in Annex A.

Multipactor in multi-carrier operation is currently under investigation (using test and numerical means like electron tracking simulators to verify the breakdown levels). Until the outcome of this activity yields a new approach, the 20-gap-crossing rule is provisionally adopted in this document, keeping in mind that all references to it (P_{20} and others) are intended to be reviewed in future versions.

Margins are only quoted for Type 1 components. Margins for component types 2 and 3 are currently under investigation. Verification for two cases is described in the two following clauses; the first treats the case of the multipaction threshold above the power of a single carrier CW signal whose power is equal to the peak envelope power of the multi-carrier signal, and the second treats the case of the multipaction threshold below the Peak envelope power. The second case becomes more likely as the number of carriers increases.

Multi-carrier verification follows the procedure used for the single carrier case. Margins are defined with respect to a single carrier signal at the lowest frequency in the multi-carrier signal and at peak envelope power, where the peak corresponds to the worst case in-phase signal power.

4.7.2 Threshold above peak envelope power

- a. When the single carrier multipaction threshold is above the peak envelope power, margins shown in Table 4-3 should be used.
- b. As for the single carrier case, analysis-only verification should not be done unless the appropriate analysis margin and the requirements listed in clause 4.6.3 are met.

Table 4-3: Multi-carrier margins applicable to Type 1 components when the single carrier multipaction threshold is above the peak envelope power

#	Route	Margin (dB) with respect to peak envelope power
1	Analysis	6
2	Qualification test	3
3	Batch acceptance test	0
4	Unit acceptance test	0

4.7.3 Threshold below peak envelope power

- a. When the single carrier multipaction threshold is below the peak envelope power, the margins shown in Table 4-4 should be used.

NOTE 1 In this case, the margins are defined with respect to a power level, P_{20} .

NOTE 2 Informative commentary on the derivation of electron crossing times and P_{20} for multi-carrier waveforms is given in Annex A.

- b. In case analysis fails, a test route should be taken.

Table 4-4: Multi-carrier margins applicable to Type 1 components when the single carrier multipaction threshold is below the peak envelope power

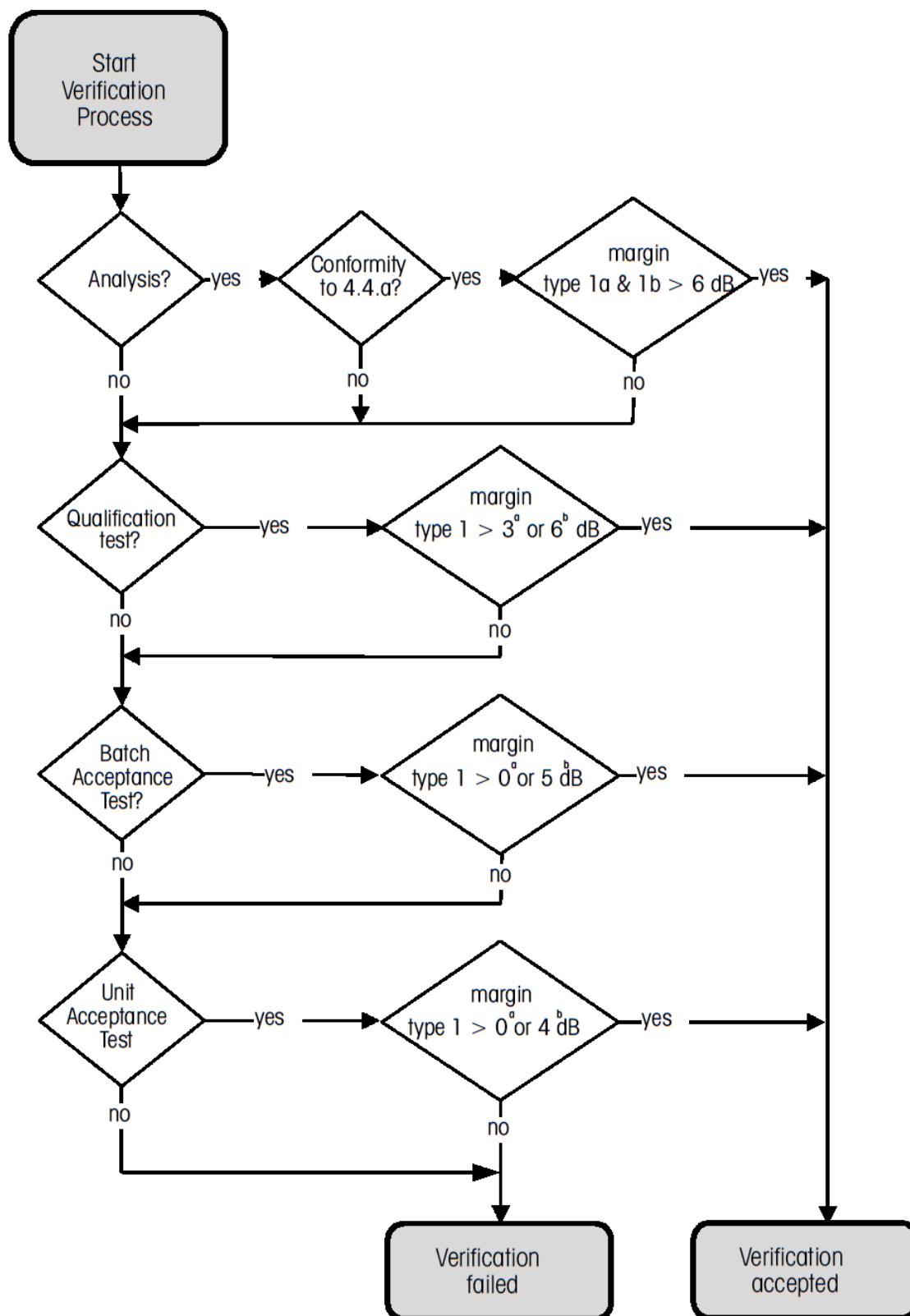
#	Route	Margin (dB) with respect to P_{20}
1	Analysis	6
2	Qualification test	6
3	Batch acceptance test	5
4	Unit acceptance test	4

4.7.4 Route to demonstrate conformance

- a. The route to demonstrating conformance under multi-carrier multipaction conditions illustrated in the flow diagram shown in Figure 4-2 should be used.
- b. The unit should not be accepted at each stage of the process unless:
- the relevant margins are satisfied, and
 - controls in the production process are such that adequate margins are carried through to the final components.

NOTE The stages in the process are analysis, qualification tests and acceptance tests, where the latter can be either batch or unit tests.

- c. If any stage of the process is omitted, then it is assumed that the margins are not satisfied and the 'no' route in the flow diagram shown in Figure 4-2 should be followed.



^a Margin applicable to Type 1 multi-carrier components for single carrier threshold above equivalent CW peak power

^b Margin applicable to Type 1 multi-carrier components for single carrier threshold below equivalent CW peak power

Figure 4-2: Routes to conformance for multi-carrier test