

DIN EN 16603-20-07

ICS 49.140

Ersatz für
DIN EN 16603-20-07:2014-09**Raumfahrttechnik –
Elektromagnetische Kompatibilität;
Englische Fassung EN 16603-20-07:2022**Space engineering –
Electromagnetic compatibility;
English version EN 16603-20-07:2022Ingénierie spatiale –
Compatibilité électromagnétique;
Version anglaise EN 16603-20-07:2022

Gesamtumfang 111 Seiten

DIN-Normenausschuss Luft- und Raumfahrt (NL)

Nationales Vorwort

Dieses Dokument (EN 16603-20-07:2022) wurde vom Technischen Komitee CEN/CLC/JTC 5 „Raumfahrt“ erarbeitet, dessen Sekretariat von DIN (Deutschland) gehalten wird.

Das zuständige deutsche Normungsgremium ist der Arbeitsausschuss NA 131-06-02 AA „Interoperabilität von Informations-, Kommunikations- und Navigationssystemen“ im DIN-Normenausschuss Luft- und Raumfahrt (NL).

Dieses Dokument enthält unter Berücksichtigung des Präsidialbeschlusses 1/2004 nur die englische Originalfassung von EN 16603-20-07:2022.

Dieses Dokument wurde speziell für die Behandlung von Raumfahrtsystemen erarbeitet und hat daher Vorrang vor jeder anderen Europäischen Norm, die denselben Anwendungsbereich hat, jedoch über einen größeren Geltungsbereich (z. B. Luft- und Raumfahrt) verfügt.

Aktuelle Informationen zu diesem Dokument können über die Internetseiten von DIN (www.din.de) durch eine Suche nach der Dokumentennummer aufgerufen werden.

Änderungen

Gegenüber DIN EN 16603-20-07:2014-09 wurden folgende Änderungen vorgenommen:

- a) Implementierung von Änderungswünschen;
- b) redaktionelle Überarbeitung der Norm.

Frühere Ausgaben

DIN EN 16603-20-07:2014-09

Nationaler Anhang NA (informativ)

Begriffe und Abkürzungen

Reihenfolge und Inhalt der folgenden Begriffe sind identisch mit denen in Abschnitt Begriffe der englischen Fassung.

3 Begriffe und Abkürzungen

3.1 Begriffe aus anderen Normen

- a) Für die Anwendung dieser Norm gelten die Begriffe nach ECSS-S-ST-00-01, insbesondere die folgenden Begriffe:
- 1) kritische Einheit
 - 2) Kunde
 - 3) Gerät
 - 4) Trägerrakete, Trägerfahrzeug
 - 5) Mission
 - 6) Anforderung
 - 7) sicherheitskritische Funktion
 - 8) Lieferant
 - 9) Raumfahrzeug
 - 10) Untersystem
 - 11) System
 - 12) Prüfung
 - 13) Verifizierung
- b) Für die Anwendung dieser Norm haben die folgenden Begriffe eine spezifische Definition nach ECSS-E-ST-20:
- 1) leitungsgeführte Störaussendung
 - 2) elektromagnetische Verträglichkeit
 - 3) Überwachung der elektromagnetischen Verträglichkeit
 - 4) elektromagnetische Störung
 - 5) Sicherheitsfaktor für elektromagnetische Störung

- 6) Störaussendung
 - 7) Hochspannung
 - 8) indirekte Blitzauswirkungen
 - 9) gestrahlte Störaussendung
 - 10) Hochfrequenz
 - 11) Empfindlichkeit
 - 12) Empfindlichkeitsschwelle
- c) Für die Anwendung dieses Dokuments haben die folgenden Begriffe eine spezifische Definition nach ECSS-E-ST-20-06:
- 1) elektrostatische Entladung (ESD)
 - 2) Sekundärbogen
- d) Für die Anwendung dieses Dokuments hat der folgende Begriff eine spezifische Definition nach ECSS-E-ST-33-11:
- 1) elektrische Anzünd- und Zündmittel (EED)

3.2 Für diese Norm spezifische Begriffe

3.2.1

Umgebungspegel

gestrahlter und leitungsgeführter Signal- und Rauschpegel, der am festgelegten Prüfort zur festgelegten Prüfzeit vorliegt, wenn das zu prüfende Gerät nicht in Betrieb ist

ANMERKUNG Der „Umgebungspegel“ setzt sich beispielsweise aus atmosphärischen Störungen, von anderen Quellen ausgehenden Störungen und Leitungsrauschen oder anderen, innerhalb des Messgeräts erzeugten Störungen zusammen.

3.2.2

Antennenfaktor

Faktor, der bei richtiger Anwendung auf die Spannung an den Eingangsschlüssen des Messgeräts die elektrische oder magnetische Feldstärke ergibt

ANMERKUNG 1 Dieser Faktor beinhaltet die Auswirkungen von effektiver Länge der Antenne, Fehllanschlüssen und Übertragungsverlusten.

ANMERKUNG 2 Die elektrische Feldstärke wird gewöhnlich in V/m angegeben und die magnetische Feldstärke in A/m oder T.

3.2.3

asymmetrische Spannung

Spannungsdifferenz zwischen Quelle und festgelegtem Bezugspunkt des Empfängers

3.2.4

Verfahren der Kontaktentladung

Prüfverfahren, bei dem der Kontakt der Elektrode des Hochspannungs-Prüfgenerators mit dem Entladungskreis beibehalten und die Entladung durch einen Entladungsschalter ausgelöst wird

3.2.5**elektromagnetische Umgebungseinflüsse**

Einfluss der elektromagnetischen Umgebung auf Geräte, Systeme und Plattformen

ANMERKUNG Dies umfasst alle elektromagnetischen Teilbereiche, einschließlich elektromagnetischer Verträglichkeit, elektromagnetischer Störung, elektromagnetischer Anfälligkeit, Gefährdungen von Personal durch elektromagnetische Strahlung, elektrisch initiiertes Anzünd- und Zündmittel, flüchtiger Stoffe sowie Auswirkungen von natürlichen Phänomenen.

3.2.6**Feldstärke**

Resultierende aus Strahlung, Induktion und quasistatischen Komponenten des elektrischen oder magnetischen Feldes

ANMERKUNG Die Verwendung des Begriffs „elektrische Feldstärke“ oder „magnetische Feldstärke“ ist abhängig davon, ob das resultierende elektrische bzw. magnetische Feld gemessen wird.

3.2.7**Grundebene**

Metallblech oder -platte, verwendet als gemeinsamer Bezugspunkt für Rückleitungen sowie elektrische oder magnetische Signalpotenziale

3.2.8**fehlerhafte Antwort**

entweder unbeabsichtigte oder unzulässige Antwort eines Untersystems oder Geräts

3.2.9**unbeabsichtigte Antwort**

funktionell ordnungsgemäße Antwort eines Untersystems (innerhalb des normalen Grenzbereichs), die durch elektromagnetische Störung ausgelöst wird, aber bei einem anderen als dem normalen Betriebszyklus auftritt, was wiederum zu einer fehlerhaften Antwort des gesamten Raumfahrtssystems führt

3.2.10**Netznachbildung****Netzimpedanz-Stabilisierungsnetzwerk**

in die Stromversorgungsleitungen eines zu prüfenden Geräts eingefügtes Netzwerk, welches in einem gegebenen Frequenzbereich eine festgelegte Quellenimpedanz für die Messung von Störströmen und -spannungen bereitstellt und durch welches das Gerät in diesem Frequenzbereich als vom Stromversorgungsnetz getrennt betrachtet werden kann

3.2.11**außer Betrieb**

Zustand, in welchem das Gerät nicht mit Energie gespeist wird

3.2.12**umgebende Abschirmung**

Abschirmung, die ein gebündeltes oder geschirmtes Kabel umgibt

3.2.13**passives Intermodulationsprodukt**

Erzeugung eines Signals bei Frequenz $f = n \times f_1 + m \times f_2$ aus zwei Signalen bei den Frequenzen f_1 und f_2 , wobei n und m positive oder negative ganzzahlige Werte sind, mittels einer passiven Einrichtung, gewöhnlich mit einem elektrischen Kontakt

3.2.14

Anschluss

Stelle für den Zugriff auf ein Gerät oder Netz, an der Energie eingespeist oder entnommen werden kann oder die Geräte- oder Netzvariablen beobachtet oder gemessen werden können

3.2.15

Anforderungen an die Qualität der Versorgungsspannung

Anforderungen, welche das/die leitungsgeführte Spannungsaussehen oder Impedanz definieren, die der Spannungsnutzer erwarten kann

ANMERKUNG Rauschen aufgrund von beispielsweise Lastregulierung, Spitzen und Einbrüchen.

3.2.16

weichmagnetisches Material

ferromagnetisches Material mit einer Koerzitivität $< 100 \text{ A/m}$

3.2.17

Nebenwellen-Aussendung

elektromagnetische Störaussendung vom vorgesehenen Ausgangsanschluss eines elektronischen Geräts, jedoch außerhalb der vorgesehenen Aussendungsbandbreite

3.2.18

Prüfantenne

Antenne mit festgelegten Eigenschaften, die für die Verwendung unter festgelegten Bedingungen bei der Durchführung von Prüfungen vorgesehen ist

3.2.19

Einheit

Gerät, das als Einheit für Zwecke der Analyse, Herstellung, Instandhaltung oder das Führen von Aufzeichnungen angesehen wird

ANMERKUNG Beispielsweise hydraulische Stellantriebe, Armaturen, Batterien und einzelne Elektronikboxen, wie z. B. fahrzeuginterne Computer, Trägheitsmesseinheiten, Reaktionsrad, Sternensensor, Leistungsregler, Sender, Empfänger oder Multiplexer.

3.3 Abkürzungen

Für die Anwendung dieser Norm gelten die Abkürzungen nach ECSS-S-ST-00-01 und die folgenden Abkürzungen:

Abkürzung	Bedeutung
AC	Wechselstrom (en: alternating current)
ACS	Lageregelungssystem (en: attitude control system)
AM	Amplitudenmodulation (en: amplitude modulation)
AWG	amerikanische Norm für Drahtquerschnitte (en: American wire gauge)
BCI	Stromeinspeisung in den Kabelbaum (en: bulk cable injection)
CE	leitungsgeführte Störaussendung (en: conducted emission)
CS	leitungsgeführte Empfindlichkeit (en: conducted susceptibility)
CW	Dauerstrich (en: continuous wave)

DC	Gleichstrom (en: direct current)
EED	elektrische Anzünd- und Zündmittel (en: electro-explosive device)
EGSE	elektrisches Bodendienstgerät (en: electrical ground support equipment)
EHF	extrem hohe Frequenz (en: extremely high frequency) (30 GHz bis 300 GHz)
EMV	elektromagnetische Verträglichkeit (EMC, en: electromagnetic compatibility)
EMCAB	beratender Ausschuss für elektromagnetische Verträglichkeit (en: electromagnetic compatibility advisory board)
EMCCP	Überwachungsplan für elektromagnetische Verträglichkeit (en: electromagnetic compatibility control plan)
EMEVP	Prüfplan für elektromagnetische Auswirkungen (en: electromagnetic effects verification plan)
EMEVR	Prüfbericht für elektromagnetische Auswirkungen (en: electromagnetic effects verification report)
EMI	elektromagnetische Störung (en: electromagnetic interference)
EMISM	Sicherheitsfaktor für elektromagnetische Störungen (en: electromagnetic interference safety margin)
ESD	elektrostatische Entladung (en: electrostatic discharge)
EUT	zu prüfendes Gerät (en: equipment under test)
HV	Hochspannung (en: high voltage)
ICD	Schnittstellenkontrolldokument (en: interface control document)
LEO	erdnahe Umlaufbahn (en: low Earth orbit)
LF	Niederfrequenz (en: low frequency)
LISN	Netznachbildung (en: line impedance stabilization network)
MGSE	mechanisches Bodendienstgerät (en: mechanical ground support equipment)
PAM	Pulsamplitudenmodulation (en: pulse amplitude modulation)
PCM	Puls-Code-Modulation (en: pulse coded modulation)
RE	gestrahlte Störaussendung (en: radiated emission)
RF	Hochfrequenz (en: radio frequency)
r.m.s.	Effektivwert (en: root-mean-square)
RS	Empfindlichkeit gegenüber gestrahlter Störaussendung (en: radiated susceptibility)
SHF	Ultrahochfrequenz (en: super-high frequency) (3 GHz bis 30 GHz)

— Leerseite —

English version

Space engineering - Electromagnetic compatibility

Ingénierie spatiale - Compatibilité électromagnétique

Raumfahrttechnik - Elektromagnetische Kompatibilität

This European Standard was approved by CEN on 29 May 2022.

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. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN and CENELEC member.

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 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, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and United Kingdom.



CEN-CENELEC Management Centre:
Rue de la Science 23, B-1040 Brussels

Table of contents

European Foreword	7
Introduction	9
1 Scope	10
2 Normative references	11
3 Terms, definitions and abbreviated terms	12
3.1 Terms from other standards.....	12
3.2 Terms specific to the present standard	13
3.3 Abbreviated terms.....	15
4 Requirements	17
4.1 General system requirements	17
4.2 Detailed system requirements	17
4.2.1 Overview	17
4.2.2 EMC with the launch system	17
4.2.3 Lightning environment.....	18
4.2.4 Spacecraft charging and effects	18
4.2.5 Spacecraft DC magnetic emission	19
4.2.6 Radiofrequency compatibility	19
4.2.7 Hazards of electromagnetic radiation	20
4.2.8 Intrasystem EMC	20
4.2.9 EMC with ground equipment.....	20
4.2.10 Grounding	21
4.2.11 Electrical bonding requirements	21
4.2.12 Shielding (except wires and cables)	23
4.2.13 Wiring (including wires and cables shielding)	23
5 Verification	25
5.1 Overview	25
5.1.1 Introduction	25
5.1.2 Electromagnetic effects verification plan	25
5.1.3 Electromagnetic effects verification report.....	25

5.2	Test conditions	25
5.2.1	Measurement tolerances.....	25
5.2.2	Test site	26
5.2.3	Ground plane	28
5.2.4	Power source impedance.....	28
5.2.5	General test precautions	30
5.2.6	EUT test configurations.....	30
5.2.7	Operation of EUT	33
5.2.8	Use of measurement equipment	34
5.2.9	Emission testing.....	36
5.2.10	Susceptibility testing.....	37
5.2.11	Calibration of measuring equipment.....	39
5.2.12	Power bus voltage.....	40
5.2.13	Photographic data	40
5.3	System level	40
5.3.1	General	40
5.3.2	Safety margin demonstration for critical or EED circuits	40
5.3.3	EMC with the launch system	41
5.3.4	Lightning	41
5.3.5	Spacecraft and static charging	41
5.3.6	Spacecraft DC magnetic field emission	42
5.3.7	Intra-system electromagnetic compatibility	42
5.3.8	Radiofrequency compatibility	42
5.3.9	Grounding	42
5.3.10	Electrical bonding.....	42
5.3.11	Wiring and shielding.....	42
5.4	Equipment and subsystem level test procedures	43
5.4.1	Overview	43
5.4.2	CE, power leads, differential mode, 30 Hz to 100 kHz.....	43
5.4.3	CE, power and signal leads, 50 kHz to 100 MHz.....	45
5.4.4	CE, power leads, inrush current	48
5.4.5	DC Magnetic field emission, magnetic moment.....	51
5.4.6	RE, electric field, 30 MHz to 18 GHz	54
5.4.7	CS, power leads, 30 Hz to 100 kHz.....	58
5.4.8	CS, bulk cable injection, 50 kHz to 100 MHz.....	61
5.4.9	CS, power leads, transients	65
5.4.10	RS, magnetic field, 30 Hz to 100 kHz.....	69

5.4.11	RS, electric field, 30 MHz to 18 GHz	72
5.4.12	Susceptibility to wire-coupled electrostatic discharges (legacy method).....	79
5.4.13	Susceptibility to wire-coupled electrostatic discharges (current injection probe method).....	84
5.4.14	Susceptibility to electrostatic discharges into the chassis	87
5.4.15	CE, power leads, time domain	90
Annex A (informative) Subsystem and equipment limits.....		92
A.1	Overview	92
A.2	CE on power leads, differential mode, 30 Hz to 100 MHz	92
A.3	CE on power leads, in-rush currents.....	94
A.4	CE on power and signal leads, common mode, 50 kHz to 100 MHz	94
A.5	<<deleted>>	95
A.6	DC magnetic field emission	95
A.6.1	General	95
A.6.2	Characterization.....	95
A.6.3	Limit	96
A.7	RE, low-frequency magnetic field.....	96
A.8	RE, low-frequency electric field.....	96
A.9	RE, electric field, 30 MHz to 18 GHz.....	97
A.10	CS, power leads, differential mode, 30 Hz to 100 kHz	97
A.11	CS, power and signal leads, common mode, 50 kHz to 100 MHz	98
A.12	CS, power leads, short spike transients	99
A.13	RS, magnetic field, 30 Hz to 100 kHz.....	100
A.14	RS, electric field, 30 MHz to 18 GHz.....	101
A.15	Susceptibility to wire-coupled electrostatic discharges (legacy method).....	102

Figures

Figure 4-1: Bonding requirements	22
Figure 5-1: RF absorber loading diagram	27
Figure 5-2: Line impedance stabilization network schematic	29
Figure 5-3: General test setup	31
Figure 5-4: Typical calibration fixture	35
Figure 5-5: Conducted emission, 30 Hz to 100 kHz, measurement system check	45
Figure 5-6: Conducted emission, 30 Hz to 100 kHz, measurement setup.....	45
Figure 5-7: Conducted emission, measurement system check	46
Figure 5-8: Conducted emission, measurement setup in differential mode	47

Figure 5-9: Conducted emission, measurement setup in common mode.....	47
Figure 5-10: Inrush current: measurement system check setup.....	49
Figure 5-11: Inrush current: measurement setup.....	49
Figure 5-12: Smooth deperm procedure.....	54
Figure 5-13: Electric field radiated emission. Basic test setup	56
Figure 5-14: Electric field radiated emission. Antenna positioning	56
Figure 5-15: Electric field radiated emission – Multiple antenna positions	57
Figure 5-16: CS, power leads, measurement system check set-up	59
Figure 5-17: CS, power leads, signal injection.....	60
Figure 5-18: Bulk cable injection, calibration set-up.....	64
Figure 5-19: Signal test waveform	64
Figure 5-20: CS, power and signal leads, bulk cable injection	65
Figure 5-21: CS, power leads, differential mode transients, calibration setup	66
Figure 5-22: CS, power leads, differential mode transients, injection setup	67
Figure 5-23: <<deleted>>	67
Figure 5-24: CS, power leads, common mode transients, calibration setup.....	67
Figure 5-25: CS, power leads, common mode transients, probe injection setup	68
Figure 5-26: Measurement system check configuration of the radiating system	70
Figure 5-27: Basic test setup	70
Figure 5-28: <<deleted>>	74
Figure 5-29: Example of electric field calibration test setup	75
Figure 5-30: RS Electric field – Multiple test antenna positions.....	76
Figure 5-31: <<deleted>>	76
Figure 5-32: Susceptibility to ESD: calibration configuration.....	81
Figure 5-33: Susceptibility to ESD: test equipment configuration.....	82
Figure 5-34: Example of compliant discharge current shape	83
Figure 5-35: Test setup for calibration of test waveform	85
Figure 5-36: Typical ESD pulse measured during calibration (3 A/div, 4 ns/div)	86
Figure 5-37: Wire-coupled ESD test setup (current injection probe method).....	86
Figure 5-38: Discharge current verification setup.....	89
Figure 5-39: Ideal contact discharge current waveform at 8 kV	89
Figure 5-40: Conducted emission, power leads, time domain: measurement setup.....	91
Figure A-1 : Power leads, differential mode conducted emission limit.....	93
Figure A-2 : Common mode conducted emission limit.....	95
Figure A-3 : Radiated electric field limit	97
Figure A-4 : Conducted susceptibility limit, frequency domain	98
Figure A-5 : Calibration level at the measurement port of the calibration fixture	99

Figure A-6 : CS, voltage spike in percentage of test bus voltage	100
Figure A-7 : Radiated susceptibility limit	101

Tables

Table 5-1: Absorption at normal incidence.....	27
Table 5-2: Bandwidth and measurement time	36
Table 5-3: Maximum step sizes for susceptibility tests.....	38
Table 5-4: Correspondence between test procedures and limits	43
Table A-1 : Equipment: susceptibility to conducted interference, test signal	99

European Foreword

This document (EN 16603-20-07:2022) has been prepared by Technical Committee CEN/CLC/JTC 5 "Space", the secretariat of which is held by DIN.

This standard (EN 16603-20-07:2022) originates from ECSS-E-ST-20-07C Rev.2.

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 April 2023, and conflicting national standards shall be withdrawn at the latest by April 2023.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 16603-20-07:2014.

The main changes with respect to EN 16603-20-07:2014 are listed below:

- Implementation of Change Requests.
- Specification of the maximum frequency step size for susceptibility tests, in clause 5.2.10.1.
- Addition of clause 5.2.12 "Power bus voltage".
- Addition of clause 5.2.13 "Photographic data".
- Specification of a method for conducted susceptibility to short transients coupled on EUT power leads in both differential and common mode, in clause 5.4.9.
- Specification of the radiated susceptibility tests to electric fields to follow a substitution method, in clause 5.4.11.
- Addition of clause 5.4.13 "Susceptibility to wire-coupled electrostatic discharges (current injection probe method)".
- Addition of clause 5.4.14 "Susceptibility to electrostatic discharges into the chassis".
- Addition of clause 5.4.15 "CE, power leads, time domain".

This document has been prepared under a standardization request given to CEN by the European Commission and the European Free Trade Association.

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

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: 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, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.

Introduction

Electromagnetic compatibility (EMC) of a space system or equipment is the ability to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment.

The space system is designed to be compatible with its external natural, induced, or man-made electromagnetic environment. Natural components are lightning for launchers, the terrestrial magnetic field for space vehicles. Spacecraft charging is defined as voltage building-up of a space vehicle or spacecraft units when immersed in plasma. Electrostatic discharges result from spacecraft charging with possible detrimental effects. External man-made interference, intentional or not, are caused by radar or telecommunication beams during ground operations and the launching sequence. Intersystem EMC also applies between the launcher and its payload or between space vehicles.

Intrasystem EMC is defined between all electrical, electronic, electromagnetic, and electromechanical equipment within the space vehicle and by the presence of its self-induced electromagnetic environment. It comprises the intentional radiated electromagnetic fields and parasitic emission from on-board equipment. Both conducted and radiated emissions are concerned. An electromagnetic interference safety margin is defined at system critical points by comparison of noise level and susceptibility at these points.

1

Scope

EMC policy and general system requirements are specified in ECSS-E-ST-20.

This ECSS-E-ST-20-07 Standard addresses detailed system requirements (Clause 4), general test conditions, verification requirements at system level, and test methods at subsystem and equipment level (Clause 5) as well as informative limits (Annex A).

Associated to this standard is ECSS-E-ST-20-06 “Spacecraft charging”, which addresses charging control and risks arising from environmental and vehicle-induced spacecraft charging when ECSS-E-ST-20-07 addresses electromagnetic effects of electrostatic discharges.

Annexes A to C of the ECSS-E-ST-20 standard document EMC activities related to ECSS-E-ST-20-07: the EMC Control Plan (Annex A) defines the approach, methods, procedures, resources, and organization, the Electromagnetic Effects Verification Plan (Annex B) defines and specifies the verification processes, analyses and tests, and the Electromagnetic Effects Verification Report (Annex C) document verification results. The EMEVP and the EMEVR are the vehicles for tailoring this standard.

This standard may be tailored for the specific characteristic and constraints of a space project in conformance with ECSS-S-ST-00-02.

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 revision 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 more 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 16601-00-010	ECSS-S-ST-00-01	ECSS system - Glossary of terms
EN 16603-20	ECSS-E-ST-20	Space engineering - Electrical and electronic
EN 16603-20-06	ECSS-E-ST-20-06	Space engineering - Spacecraft charging
EN 16603-33-11	ECSS-E-ST-33-11	Space engineering - Explosive subsystems and devices
EN 16603-50-14	ECSS-E-ST-50-14	Space engineering – Spacecraft discrete interfaces
	IEC 61000-4-2 (Edition 1.2)	Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test

Terms, definitions and abbreviated terms

3.1 Terms from other standards

- a. For the purpose of this Standard, the terms and definitions from ECSS-S-ST-00-01 apply, in particular for the following terms:
 1. critical item
 2. customer
 3. equipment
 4. launcher, launch vehicle
 5. mission
 6. requirement
 7. safety critical function
 8. supplier
 9. spacecraft, space vehicle
 10. subsystem
 11. system
 12. test
 13. verification
- b. For the purposes of this Standard, the following terms have a specific definition contained in ECSS-E-ST-20:
 1. conducted emission
 2. electromagnetic compatibility
 3. electromagnetic compatibility control
 4. electromagnetic interference
 5. electromagnetic interference safety margin
 6. emission
 7. high-voltage
 8. lightning indirect effects
 9. radiated emission
 10. radiofrequency
 11. susceptibility
 12. susceptibility threshold

- c. For the purposes of this document, the following terms have a specific definition contained in ECSS-E-ST-20-06:
 - 1. electrostatic discharge (ESD)
 - 2. secondary arc
- d. For the purposes of this document, the following term has a specific definition contained in ECSS-E-ST-33-11:
 - 1. electro-explosive device (EED)

3.2 Terms specific to the present standard

3.2.1 ambient level

level of radiated and conducted signal, and noise that exist at the specified test location and time when the equipment under test is not operating

NOTE E.g. atmospherics, interference from other sources, and circuit noise or other interference generated within the measuring set compose the “ambient level”.

3.2.2 antenna factor

factor that, when properly applied to the voltage at the input terminals of the measuring instrument, yields the electric or magnetic field strength

NOTE 1 This factor includes the effects of antenna effective length, mismatch, and transmission losses.

NOTE 2 The electric field strength is normally expressed in V/m and the magnetic field strength in A/m or T.

3.2.3 common mode voltage

voltage difference between source and receiver ground references

3.2.4 contact discharge method

method of testing in which the electrode of the high-voltage test generator is held in contact with the discharge circuit, and the discharge actuated by a discharge switch

3.2.5 electromagnetic environmental effects

impact of the electromagnetic environment upon equipment, systems, and platforms

NOTE It encompasses all electromagnetic disciplines, including electromagnetic compatibility, electromagnetic interference, electromagnetic vulnerability, hazards of electromagnetic radiation

to personnel, electro-explosive devices, volatile materials, and natural phenomena effects.

3.2.6 field strength

resultant of the radiation, induction and quasi-static components of the electric or magnetic field

NOTE The term “electric field strength” or “magnetic field strength” is used, according to whether the resultant, electric or magnetic field, respectively, is measured.

3.2.7 ground plane

metal sheet or plate used as a common reference point for circuit returns and electrical or signal potentials

3.2.8 improper response

subsystem or equipment response which can be either inadvertent or unacceptable

3.2.9 inadvertent response

proper subsystem functional response (within normal range of limits) actuated by electromagnetic interference, but occurring at other than the normal operational cycle, which in turn causes improper response to the total space system

3.2.10 line impedance stabilization network

network inserted in the supply leads of an apparatus to be tested which provides, in a given frequency range, a specified source impedance for the measurement of disturbance currents and voltages and which can isolate the apparatus from the supply mains in that frequency range

3.2.11 not operating

condition wherein no power is applied to the equipment

3.2.12 overshield

shield surrounding a bundle or a shielded cable

3.2.13 passive intermodulation product

generation of a signal at frequency $f = n \cdot f_1 + m \cdot f_2$ from two signals at frequencies f_1 and f_2 , where n and m are positive or negative integers, by a passive device, usually an electrical contact

3.2.14 port

place of access to a device or network where energy can be supplied or withdrawn, or where the device or network variables can be observed or measured

3.2.15 power quality requirements

requirements which define the conducted voltage noise or impedance the power user can expect

NOTE Noise e.g. from load regulation, spikes, and sags.

3.2.16 soft magnetic material

ferromagnetic material with a coercivity smaller than 100 A/m

3.2.17 spurious emission

electromagnetic emission from the intended output terminal of an electronic device, but outside of the designed emission bandwidth

3.2.18 test antenna

antenna of specified characteristics designated for use under specified conditions in conducting tests

3.2.19 unit

equipment that is viewed as an entity for purposes of analysis, manufacturing, maintenance, or record keeping

NOTE E.g. hydraulic actuators, valves, batteries, and individual electronic boxes such as on-board computer, inertial measurement unit, reaction wheel, star tracker, power conditioning unit, transmitters, receivers, or multiplexers.

3.3 Abbreviated terms

For the purpose of this standard, the abbreviated terms of ECSS-S-ST-00-01 and the following apply:

Abbreviation	Meaning
AC	alternating current
ACS	attitude control system
AM	amplitude modulation
AWG	American wire gauge
BCI	bulk cable injection
CE	conducted emission
CS	conducted susceptibility
CW	continuous wave
DC	direct current
EED	electro-explosive device
EGSE	electrical ground support equipment
EHF	extremely high frequency (30 GHz-300 GHz)
EMC	electromagnetic compatibility

EMCAB	electromagnetic compatibility advisory board
EMCCP	electromagnetic compatibility control plan
EMEVP	electromagnetic effects verification plan
EMEVR	electromagnetic effects verification report
EMI	electromagnetic interference
EMISM	electromagnetic interference safety margin
ESD	electrostatic discharge
EUT	equipment under test
HV	high voltage
ICD	interface control document
LEO	low Earth orbit
LF	low frequency
LISN	line impedance stabilization network
MGSE	mechanical ground support equipment
PAM	pulse amplitude modulation
PCM	pulse coded modulation
RE	radiated emission
RF	radio frequency
r.m.s.	root-mean-square
RS	radiated susceptibility
SHF	super-high frequency (3 GHz-30 GHz)

4

Requirements

4.1 General system requirements

EMC policy and general system requirements, and the spacecraft charging protection programme are specified in ECSS-E-ST-20 Electromagnetic Compatibility clause and EMC Plan DRD.

4.2 Detailed system requirements

4.2.1 Overview

This clause 4.2 defines the requirements for design and realization at system level. They are the basis for definition of activities of the EMC programme to ensure space-system-level compatibility with minimum impact to programme, cost, schedule, and operational capabilities.

4.2.2 EMC with the launch system

4.2.2.1 Overview

General system requirements for “EMC with the launch system” are defined in ECSS-E-ST-20.

4.2.2.2 Detailed system requirements

- a. Overload capability of the spacecraft RF receivers during the pre-launch and launch phases with or without fairing, shall be demonstrated by the spacecraft supplier.

NOTE 1 It is expected the electromagnetic environment generated by companion payloads is assessed by the launching company and addressed in the User's Manual.

NOTE 2 A conductive fairing is likely to cause resonances and cavity effects.

- b. Spacecraft equipment shall not exhibit any malfunction, degradation of performance or deviation beyond the tolerance indicated in its individual specification after being exposed, even not operating, to the electromagnetic environment from the launcher and launch site.

NOTE Most of spacecraft equipment is not operating during launch. During the launching sequence spacecraft transmitters and receivers (platform and

payload) can be either in OFF- or ON-state depending on the launch vehicle.

- c. The electromagnetic interference safety margin (EMISM) of safety critical equipment shall be applied to equipment in ON-state during prelaunch and launch phase and to EEDs.

4.2.3 Lightning environment

4.2.3.1 Overview

Protection of the space system against both direct and indirect effects of lightning can be a combination of operational avoidance of the lightning environment and electrical overstress design techniques.

4.2.3.2 Requirements to the space system

- a. Assessment of risk, on the launch pad inside the protected area, for the space system and its equipment against direct and indirect effects of lightning before lift-off, shall be performed.
- b. The spacecraft supplier shall obtain from the launching company the electromagnetic environment imposed on the launcher payloads in case of lightning.

4.2.4 Spacecraft charging and effects

4.2.4.1 Overview

Mitigation of risks related to spacecraft charging results of a combination of rules and methods preventing voltage build-up and so minimizing the occurrence of ESD, and techniques for controlling EMI from residual ESD.

ECSS-E-ST-20 addresses management of spacecraft charging protection and system-level performance under effects of spacecraft charging and related ESD or secondary arcs.

ECSS-E-ST-20-06 addresses charging control and risks arising from spacecraft charging and other environmental effects on the spacecraft's electrical behaviour.

4.2.4.2 EMI control requirements to system and equipment in relation with ESD

- a. Analysis or tests at system level shall be performed for assessing the threat at subsystem or equipment level.

NOTE Analysis or tests can be defined in the time or frequency domain. They are expected to evaluate the coupling level from the ESD source to critical points.

- b. EMI control from residual ESD shall be performed by a combination of shielding and passive or active filtering techniques, implemented on the main structure, at subsystem level or inside equipment.

- c. EMI control efficiency shall be verified by test at subsystem or equipment level.

4.2.5 Spacecraft DC magnetic emission

4.2.5.1 Spacecraft with susceptible payload

- a. As part of the EMCCP, a magnetic cleanliness control plan shall document:
 - 1. magnetic control guidelines
 - 2. emission limits to magnetic sources
 - 3. a magnetic budget
 - 4. specific test methods applied to equipments for emission measurement and characterization

NOTE The test method described in 5.4.5 providing a dipole model can be inadequate and replaced by a multiple dipole model or a spherical harmonics model.

4.2.5.2 Attitude control system (ACS)

- a. As part of the EMCCP, a magnetic budget shall be maintained providing:
 - 1. Three-axes components of the space vehicle magnetic dipole (component decreasing with the inverse cube law with distance).
 - 2. If the solar array is rotating in the space vehicle axes, separate evaluation for the main body and the solar array.
 - 3. When the space vehicle is using a magnetic sensor as part of the ACS, evaluation of the magnetic field at its location.

NOTE 1 to item 1: Typical values lie in the range 1 Am² or less for small spacecraft to much more than 10 Am² for large spacecraft.

NOTE 2 to item 3: The angular deviation is the basic requirement; however, the requirement is generally expressed in terms of modification of the natural field strength at the sensor location. For LEO spacecraft if the error on each axis is less than 1 µT, the modification of the direction is kept less than 20 milliradians.

- b. The specified maximum magnetic field value shall comprise the remanent magnetization (magnets, electro-magnets in off-state, or residual perm-up due to hysteresis of soft materials), the induced magnetization of soft materials by the geomagnetic field, and the momentum of current loops.

4.2.6 Radiofrequency compatibility

- a. Spurious emissions requirements at antenna ports shall be specified for RF compatibility purpose by the spacecraft supplier.

- b. When specifying limits and frequency ranges, the following issues shall be included:
 - 1. sensitivity of possible victim receiver subsystems including out-of-band response,
 - 2. no limits apply to transmit frequencies and information carrying modulation bandwidths,
 - 3. highest and lowest intentional frequency used by space system receivers,
 - 4. antenna port attachments, gain/loss characteristics.

4.2.7 Hazards of electromagnetic radiation

Assessment of hazards to electromagnetic radiation is a part of the process specified in ECSS-Q-ST-40-02 "Hazard analysis", clause "Hazard analysis requirements".

4.2.8 Intrasystem EMC

- a. Intrasystem EMC shall be achieved by:
 - 1. allocation of equipment-level EMI requirements documented in the EMCCP, including:
 - (a) limits on conducted and radiated emission,
 - (b) susceptibility test levels.
 - 2. control of conducted and radiated propagation paths, as defined by clauses 4.2.10 to 4.2.13.

NOTE to item 1: Recommended data is defined in Annex A for equipment and subsystems.

- b. <<deleted, moved to 4.2.8a.2>>

4.2.9 EMC with ground equipment

- a. The EGSE and MGSE used for spacecraft integration and ground testing shall:
 - 1. not degrade the EMC performance of the spacecraft during AIT;
 - 2. be specified to have a known and controlled impact on grounding and isolation when used together with the spacecraft;
 - 3. not impair the ability to verify the EMC performance of the spacecraft during ground testing.

NOTE to item 2: This includes GSE interconnecting elements, such as harness or piping.

- b. The EGSE shall be immune to signals used for spacecraft susceptibility tests.

4.2.10 Grounding

4.2.10.1 Overview

As specified in ECSS-E-ST-20, a controlled ground reference concept is defined for the space system. Structural elements, antenna and RF reference grounds, power and signal returns, shields and cable shields, safety grounds, EGSE grounds are considered.

4.2.10.2 Requirements

- a. A system-level grounding diagram shall be established including the EGSE.
- b. A ground reference shall be identified for each power, signal, or RF source or receiver.
- c. An upper value of common mode voltage shall be specified considering:
 1. power quality requirements defined in ECSS-E-ST-20 for "Spacecraft bus",
 2. type of detectors and sensitivity,
 3. characteristics of analogue signal monitor receiver circuit, in accordance with ECSS-E-ST-50-14, Table 5-2 d,
 4. characteristics of bi-level signal monitor receiver circuit, in accordance with ECSS-E-ST-50-14, clause Table 6-2 e,
 5. hazards due to fault currents internal to the space vehicle or between the space vehicle and its EGSE.
- d. When power and signal share common paths (wire or structure), the magnitude of ground impedance shall be limited over the affected signal spectrum.

NOTE Non-exclusive techniques for reducing the impedance are decrease of common path length, decrease of wire and ground impedance, filters on common paths.

4.2.11 Electrical bonding requirements

4.2.11.1 Overview

Bonding requirements are a means for fulfilling grounding requirements.

Normative provisions are specified in clause 4.2.11.2 and illustrated in Figure 4-1.

NOTE Bonding requirements for charging control are specified in ECSS-E-ST-20-06 "Electrical continuity", including surfaces and structural and mechanical parts.

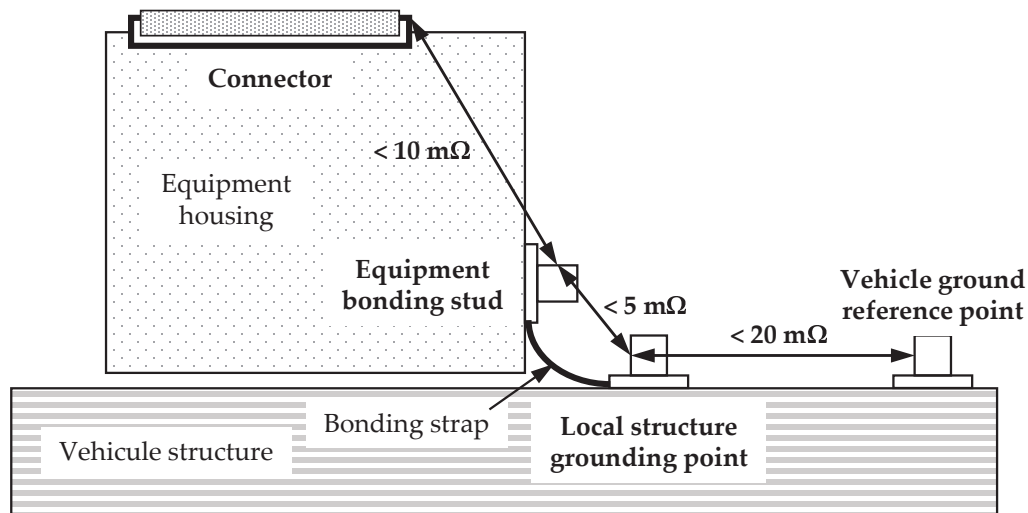


Figure 4-1: Bonding requirements

4.2.11.2 Normative provisions

- A vehicle ground reference point shall be defined on the vehicle structure, as a reference point for bonding verification.
- An equipment bonding stud connected to the unit housing shall be provided as a ground reference at equipment level.
- Each unit housing shall be bonded to the nearby local structure grounding point from the equipment bonding stud.
- The DC resistance between the equipment bonding stud and the local structure grounding point shall be less than $5\text{ m}\Omega$.
- The loop inductance between the equipment bonding stud and the nearby spacecraft structure shall be less than 30 nH .
- The DC resistance between each and every local structure grounding point and the vehicle ground reference point shall be less than $20\text{ m}\Omega$.
- The DC resistance between the equipment bonding stud and each connector housing shall be less than $10\text{ m}\Omega$.
- Bonds shall be capable to carry the fault currents determined by analysis at system level, without fusing, burning, or arcing.
- If the structure is used as the return current path, bonding provisions shall be such that DC and AC voltage drops along power paths comply with clause 4.2.10.2c.

4.2.11.3 External grounds

- The functionality of connecting grounding cables for charge equalization shall be provided on space systems.

NOTE Charge equalization is needed prior to implementing other procedures or the application of power across the interface.

4.2.12 Shielding (except wires and cables)

4.2.12.1 Overview

When shielding is used to control EMC with the environment, it can be provided by the basic space vehicle structure designed as a “Faraday cage”, by enclosures of electronics boxes, or by cable or bundle overshields.

4.2.12.2 Requirements

- a. Electronics units and cables external to the basic space vehicle structure shall have individual shields providing attenuation to EMI.

NOTE It is important to consider apertures used for pressure drop during ascent and for outgassing.

4.2.13 Wiring (including wires and cables shielding)

4.2.13.1 Classification of cables

- a. Categorisation of harness and separate routings for wires of different categories shall be defined as follows:
 - 1. applicable to critical lines as defined in ECSS-E-ST-20, Clause “Electromagnetic interference safety margin”.
 - 2. made on the basis of the characteristics of the signals on the wire (and hence the interference generated), and on the susceptibility of the circuit to EMI.
- b. Wires falling into one category shall be assembled into a same bundle.
- c. Bundles of different categories shall be separated either by a separation distance of 5 cm from the outer circumference or by a metallic screen when they are routed on parallel paths.

NOTE Overshields or spacecraft walls can be used to fulfil the requirement.

- d. Wires and cables shall be marked in such a manner that personnel can visually identify the EMC category for each wire or cable.

4.2.13.2 Cable shields

- a. Cable shields shall not be used as an intentional current carrying conductor, except coaxial cables in radiofrequency circuits and high-speed data links using coaxial cables.
- b. Cable shields, other than overshields, shall have an insulated sheath to prevent uncontrolled grounding.
- c. Connectors used to carry shielded wires shall have a conductive finish.
- d. The bonding of cable shields shall be done as follows:
 - 1. Bonding to chassis ground is performed at both ends:

- (a) through the equipment connector body,
- (b) using a backshell or a dedicated intermediate metal part,
- (c) with a DC resistance $\leq 5 \text{ m}\Omega$ between cable shield and connector housing.

NOTE 1 This is intended to prevent grounding of the shields inside the equipment through a connector ground pin, which could promote the propagation of interference.

NOTE 2 Examples of dedicated intermediate metal parts are combs, such as Halorings, or Tag rings.

- 2. <<deleted>>
- e. Overshields shall be bonded to chassis ground:
 - 1. at both ends,
 - 2. using a 360° connection,
 - 3. with a DC resistance $\leq 5 \text{ m}\Omega$ between overshield and connector housing.
- f. <<deleted>>

5

Verification

5.1 Overview

5.1.1 Introduction

This Clause specifies general conditions for EMC testing, requirements for verification at system level and detailed procedures for unit and subsystem level testing.

5.1.2 Electromagnetic effects verification plan

The electromagnetic effects verification plan (EMEVP) provides the instruction for conducting all activities needed to verify electromagnetic effects requirements. This document defines the approach, methods, procedures, and specific test conditions. The content is specified in the EMEVP DRD of ECSS-E-ST-20. The EMEVP is the vehicle for tailoring procedures and test conditions.

5.1.3 Electromagnetic effects verification report

The electromagnetic effects verification report (EMEVR) documents activities and report analysis or test results in relation with the verification of the electromagnetic effects. It is established based on the electromagnetic effects verification plan (EMEVP). The content of the EMEVR is defined in the EMEVR DRD of ECSS-E-ST-20 supplemented by specific requirements defined hereafter in 5.3 and 5.4.

5.2 Test conditions

5.2.1 Measurement tolerances

- a. The tolerance for EMC testing shall be as follows:
 - 1. Distance: ± 5 %
 - 2. Frequency: ± 2 %
 - 3. Amplitude, measurement receiver: ± 2 dB
 - 4. Amplitude, measurement system (includes measurement receivers, transducers, cables, connectors): ± 3 dB
 - 5. Time (waveforms): ± 5 %
 - 6. Resistors: ± 5 %

7. Capacitors: $\pm 20\%$

5.2.2 Test site

5.2.2.1 Overview

Shielded enclosures or unshielded sites are used for testing.

Shielded enclosures prevent external environment signals from contaminating emission measurements and susceptibility test signals from interfering with electrical and electronic items near the test facility.

In unshielded sites, the tests are performed during times and conditions when the electromagnetic ambient is at its lowest level.

5.2.2.2 Shielded enclosures

- a. The enclosures shall be large such that the EUT arrangement requirements of 5.2.6 and antenna positioning requirements described in the individual test procedures are satisfied.
- b. RF absorber material shall be used when performing electric field radiated emissions or radiated susceptibility testing to reduce reflections of electromagnetic energy and to improve accuracy and repeatability.

NOTE Example of RF absorber material are carbon impregnated foam pyramids, and ferrite tiles.

- c. The RF absorber shall be placed above, behind, and on both sides of the EUT, and behind the radiating or receiving antenna as shown in Figure 5-1.
- d. Minimum performance of the material shall be as specified in Table 5-1.

NOTE The manufacturer's specification of their RF absorber material (basic material only, not installed) can be used.