



BSI Standards Publication

Industrial communication networks — Wireless communication networks

Part 2: Coexistence management

National foreword

This British Standard is the UK implementation of EN 62657-2:2017+A1:2019. It is identical to IEC 62657-2:2017, incorporating amendment 1:2019. It supersedes BS EN 62657-2:2017, which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by **A1** **A1**.

The UK participation in its preparation was entrusted to Technical Committee GEL/65, Measurement and control.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2019
Published by BSI Standards Limited 2019

ISBN 978 0 580 51005 2

ICS 33.040; 33.040.40; 25.040.40; 35.100; 35.100.01; 25.040.01

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 August 2017.

Amendments/corrigenda issued since publication

Date	Text affected
31 December 2019	Implementation of IEC amendment 1:2019 with CENELEC endorsement A1:2019

English Version

**Industrial communication networks - Wireless communication
networks - Part 2: Coexistence management
(IEC 62657-2:2017)**

Réseaux de communication industriels - Réseaux de
communication sans fil - Partie 2: Gestion de coexistence
(IEC 62657-2:2017)

Industrielle Kommunikationsnetze - Funk-
Kommunikationsnetze - Teil 2: Koexistenz-Management
(IEC 62657-2:2017)

This European Standard was approved by CENELEC on 2017-06-15. 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 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 CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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



European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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

EN 62657-2:2017+A1:2019 (E)

European foreword

The text of document 65C/861/FDIS, future edition 2 of IEC 62657-2, prepared by SC 65C "Industrial networks" of IEC/TC 65 "Industrial-process measurement, control and automation" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 62657-2:2017.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2018-03-15
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2020-06-15

This document supersedes EN 62657-2:2015.

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

Endorsement notice

The text of the International Standard IEC 62657-2:2017 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 61158 Series	NOTE	Harmonized as EN 61158 Series.
IEC 61360 Series	NOTE	Harmonized as EN 61360 Series.
IEC 61784-1	NOTE	Harmonized as EN 61784-1.
IEC 61784-2	NOTE	Harmonized as EN 61784-2.
IEC 61918	NOTE	Harmonized as EN 61918.
IEC 62591	NOTE	Harmonized as EN 62591.
IEC 62601	NOTE	Harmonized as EN 62601.
IEC 62734	NOTE	Harmonized as EN 62734.
IEC 62890	NOTE	Harmonized as EN 62890.

Foreword to amendment A1

The text of document 65C/968/FDIS, future IEC 62657-2/A1, prepared by SC 65C "Industrial networks" of IEC/TC 65 "Industrial-process measurement, control and automation" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 62657-2:2017/A1:2019.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2020-07-18
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2022-10-18

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

Endorsement notice

The text of the International Standard IEC 62657-2:2017/A1:2019 was approved by CENELEC as a European Standard without any modification.

Annex ZA

(normative)

Normative references to international publications with their corresponding European publications

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

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 62657-1	2017	Industrial communication networks - Wireless communication networks - Part 1: Wireless communication requirements and spectrum considerations	EN 62657-1	201X ¹
IEC 62443	Series	Industrial communication networks - Network and system security	EN 62443	Series ¹

¹ At draft stage.

This page deliberately left blank

CONTENTS

FOREWORD	6
INTRODUCTION	8
INTRODUCTION to Amendment 1	9
1 Scope	10
2 Normative references	10
3 Terms, definitions, abbreviated terms and conventions	10
3.1 Terms and definitions	10
3.2 Abbreviated terms	23
3.3 Conventions	24
4 Coexistence concept in industrial automation	24
4.1 Overview	24
4.2 Objective	25
4.3 Necessity to implement a coexistence management	28
4.4 Interference potential	30
4.5 Ancillary conditions	31
4.6 Requirements to wireless devices for support of coexistence management	32
4.7 Concepts	32
4.7.1 Manual coexistence management	32
4.7.2 Automated non-collaborative metrics-based coexistence management	33
4.7.3 Automated collaborative metrics-based coexistence management	33
4.8 Best practices to achieve coexistence	34
4.9 Coexistence conceptual model	36
4.10 Coexistence management and selection of a wireless solution	38
4.11 Coexistence management system	40
5 Coexistence management parameters	40
5.1 General	40
5.1.1 Definition and usage of parameters	40
5.1.2 Physical link	40
5.2 Adjacent channel selectivity	41
5.3 Antenna gain	41
5.4 Antenna radiation pattern	41
5.5 Antenna type	41
5.6 Availability	41
5.7 Bandwidth	42
5.8 Bit rate of physical link	42
5.9 Centre frequency	42
5.10 Characteristic of the area of operation	42
5.11 Communication load	42
5.12 Cut-off frequency	44
5.13 Data throughput	45
5.14 Device type information	45
5.15 Distance between wireless devices	45
5.16 Duty cycle	46
5.17 Dwell time	48
5.18 Equivalent isotropic radiated power	49
5.19 Equivalent radiated power	50

5.20	Frequency band	50
5.21	Frequency channel	50
5.22	Frequency hopping procedure.....	50
5.23	Future expansion plan	50
5.24	Geographical dimension of the plant	51
5.25	Infrastructure device	51
5.26	Initiation of data transmission	51
5.27	ISM application	51
5.28	Length of user data per transfer interval.....	51
5.29	Limitation from neighbours of the plant	52
5.30	Maximum number of retransmissions	52
5.31	Mechanism for adaptivity	52
5.32	Medium access control mechanism.....	52
5.33	Modulation	53
5.34	Natural environmental condition	53
5.35	Network topology	53
5.36	Packet loss rate	53
5.37	Position of wireless devices	54
5.38	Power spectral density.....	54
5.39	Purpose of the automation application	55
5.40	Receiver blocking	55
5.41	Receiver input level	55
5.42	Receiver sensitivity	55
5.43	Regional radio regulations	55
5.44	Relative movement	56
5.45	Response time.....	56
5.46	Security level	56
5.47	Spatial coverage of the wireless communication network	56
5.48	Spurious response	57
5.49	Total radiated power	57
5.50	Transfer interval.....	57
5.51	Transmission gap.....	58
5.52	Transmission time.....	59
5.53	Transmitter output power	62
5.54	Transmitter sequence	62
5.55	Transmitter spectral mask.....	63
5.56	Update time	64
5.57	Wireless device density	65
5.58	Wireless communication network density	65
5.59	Wireless technology or standard	66
6	Coexistence management information structures	66
6.1	General.....	66
6.2	General plant characteristic	67
6.3	Application communication requirements	68
6.3.1	Overview	68
6.3.2	Requirements influencing the characteristic of wireless solutions	69
6.3.3	Performance requirements.....	70
6.4	Characteristic of wireless system type and wireless device type	70
6.4.1	Overview	70

6.4.2	Characteristic of wireless system type	71
6.4.3	Characteristic of wireless device type	71
6.5	Characteristic of wireless solution	74
6.5.1	Overview	74
6.5.2	Characteristic of a wireless network solution.....	74
6.5.3	Characteristic of a wireless device solution.....	75
7	Coexistence management process	76
7.1	General.....	76
7.1.1	Overview	76
7.1.2	Documentation	77
7.1.3	Suitable documentation method.....	79
7.1.4	Application of tools	80
7.2	Establishment of a coexistence management system	80
7.2.1	Nomination of a coexistence manager	80
7.2.2	Responsibility of a coexistence manager	81
7.2.3	Support by radio experts.....	81
7.2.4	Training	81
7.3	Maintaining coexistence management system.....	82
7.4	Phases of a coexistence management process	82
7.4.1	Investigation phase.....	82
7.4.2	Planning phase.....	85
7.4.3	Implementation phase.....	87
7.4.4	Operation phase	88
8	Coexistence parameter templates.....	90
	Bibliography.....	95
	Figure 1 – Issues of consideration	27
	Figure 2 – Applications using frequency spectrum	28
	Figure 3 – Progression of expense to achieve coexistence corresponding to the application classes	32
	Figure 4 – Separation of wireless systems according to frequency and time	35
	Figure 5 – Coexistence conceptual model.....	37
	Figure 6 – Flow chart of the coexistence conceptual model.....	38
	Figure 7 – Selection of a wireless system in the coexistence management process	39
	Figure 8 – Communication load in case of two wireless devices	43
	Figure 9 – Communication load in the case of several wireless devices	44
	Figure 10 – Cut-off frequencies derived from maximum power level	45
	Figure 11 – Distance of the wireless devices	46
	Figure 12 – Duty cycle	47
	Figure 13 – Maximum dwell time	49
	Figure 14 – Power spectral density of an IEEE 802.15.4 system	54
	Figure 15 – Communication cycle, application event interval and machine cycle	58
	Figure 16 – Minimum transmission gap	59
	Figure 17 – Example of the density functions of transmission time	60
	Figure 18 – Example of the distribution functions of transmission time	61
	Figure 19 – Transmitter sequence.....	66

Figure 20 – Transmitter spectral mask of an IEEE 802.15.4 system	64
Figure 21 – Example of distribution functions of the update time	65
Figure 22 – Principle for use of coexistence parameters	66
Figure 23 – Parameters to describe the general plant characteristic	67
Figure 24 – Parameters to describe application communication requirements	69
Figure 25 – Parameters to describe wireless network type and device type	70
Figure 26 – Power spectral density and transmitter spectral mask of a DECT system	72
Figure 27 – Medium utilization in time and frequency of a DECT system	73
Figure 28 – Parameters to describe a wireless solution	74
Figure 29 – Relations of the documents in a coexistence management system specification	79
Figure 30 – Planning of a wireless system in the coexistence management process	86
Figure 31 – Implementation and operation of a wireless system in the coexistence management process	89
Table 1 – Example of a classification of application communication requirements	26
Table 2 – Application profile dependent observation time values	47
Table 3 – Parameter options for frequency channel	50
Table 4 – List of parameters used to describe the general plant characteristic	68
Table 5 – List of parameters used to describe the requirements influencing the characteristic of wireless solutions	69
Table 6 – List of parameters used to describe performance requirements	70
Table 7 – List of parameters used to describe the wireless system type	71
Table 8 – List of parameters used to describe the transmitter of a wireless device type	73
Table 9 – List of parameters used to describe the receiver of a wireless device type	74
Table 10 – List of parameters used to describe a wireless network solution	75
Table 11 – List of parameters used to describe the transmitter of a wireless device solution	75
Table 12 – List of parameters used to describe the receiver of a wireless device solution	76
Table 13 – Template used to describe the general plant characteristic	90
Table 14 – Template used to describe the application communication requirements	91
Table 15 – Template used to describe the wireless system type	91
Table 16 – Template used to describe a wireless device type	92
Table 17 – Template used to describe the wireless network solution	92
Table 18 – Template used to describe a wireless device solution	93
Table 19 – Template used to describe an ISM application	94

INTERNATIONAL ELECTROTECHNICAL COMMISSION

INDUSTRIAL COMMUNICATION NETWORKS – WIRELESS COMMUNICATION NETWORKS –

Part 2: Coexistence management

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 62657-2 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

This second edition cancels and replaces the first edition published in 2013. This edition constitutes a technical revision.

This second edition includes the following significant technical changes with respect to the previous edition:

- a) update of the normative references, terms, definitions, symbols and abbreviations;
- b) addition of terms;

- c) checking of the life-cycle terms of this document versus the terms used in IEC 62890:—¹ and addition of explanations;
- d) addition and modification of text to make the text more readable;
- e) alignment of some definitions and specifications of coexistence parameters in order to facilitate their future inclusion in the IEC Common Data Dictionary (IEC CDD) maintained by the IEC.

The text of this standard is based on the following documents:

FDIS	Report on voting
65C/861/FDIS	65C/873/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all the parts of the IEC 62657 series, under the general title *Industrial communication networks – Wireless communication networks*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

¹ Under preparation. Stage at the time of publication: IEC/AFDIS 62890:2017.

INTRODUCTION

The overall market for wireless network solutions spans a range of diverse applications, with differing performance and functional requirements. Within this overall market, the industrial automation domain could include:

- process automation, covering for example the following industry branches:
 - oil and gas, refining,
 - chemical,
 - pharmaceutical,
 - mining,
 - pulp & paper,
 - water & wastewater,
 - steel
- electric power such as:
 - power generation (for example wind turbine),
 - power transmission and distribution (grid),
- factory automation, covering for example the following industry branches:
 - food and beverage,
 - automotive,
 - machinery,
 - semiconductor.

Industrial automation requirements for wireless networks are different from those of, for example, the telecommunications, commercial and consumer markets. These industrial automation requirements are identified and provided in IEC 62657-1.

Industrial premises may contain a variety of wireless network technologies and other sources of radio frequency emissions.

This document is intended for designers and persons responsible for production and process plants, system integrators and mechanical engineers having to integrate and start up wireless systems in machines and plants, and producers of industrial wireless solutions. In particular, it is intended to motivate exchange of information between automation and radio engineers.

Many wireless industrial automation applications are also located in physical environments over which the operator/owner can exert control. That is, within a physical facility where the presence and operation of all radio frequency emitting devices are under the control of a single entity. This allows wireless management strategies to be employed which are not feasible for equipment installed in public or other unmanaged areas.

In industrial automation, many different wireless networks may operate in the same premises. Examples of these networks are IEC 62591 [8]² (WirelessHART^{®3}), IEC 62601 [9] (WIA-PA) and IEC 62734 [10] (ISA100.11a); all these networks use IEEE 802.15.4 [19] for the process automation applications. Other examples of wireless networks are specified in IEC 61784-1 [4] and IEC 61784-2 [5] CPs that use IEEE 802.11 [17] and IEEE 802.15.1 [18] for factory automation applications. Different to wired fieldbuses, the wireless communication devices can interfere with others on the same premises or environment, disturbing each other. Other sources of radio frequency energy in these bands, often at high energy levels, include radio-frequency process heating, plastic welding, plasma lamps, and microwave irradiation devices.

Clearly, without a means to manage the coexistence of these varied emitters, it would be problematic to ensure that wireless networks meet the time-criticality and other performance requirements of industrial automation.

The IEC 62657 series has two parts:

- Part 1: Wireless communication requirements and spectrum considerations
- Part 2: Coexistence management

IEC 62657-1 provides general requirements for industrial automation and spectrum considerations that are the basis for industrial communication solutions. This document specifies the coexistence management of wireless devices to ensure predictable performance. It is intended to facilitate harmonization of future adjustments to international, national, and local regulations.

This document provides the coexistence management concept and process. Based on the coexistence management process, a predictable assuredness of coexistence can be achieved for a given spectrum with certain application requirements. This document describes mechanisms to manage the potential mutual interference that might occur due to the operation of multiple wireless devices in a plant.

This document provides guidance to the users of wireless networks on selection and proper use of wireless networks. To provide suitable wireless devices to the market, it also serves vendors in describing the behaviours of wireless devices to build wireless networks matching the application requirements.

This document is based on analyses of a number of International Standards, which focus on specific technologies. The intention of this standard is not to invent new parameters but to use already defined ones and to be technology independent.

INTRODUCTION to Amendment 1

This Amendment 1 to the second edition includes the following significant technical changes:

- a) alignment of some definitions and specifications of coexistence parameters in order to facilitate their future inclusion in the IEC Common Data Dictionary (IEC CDD) maintained by the IEC.

² Numbers in square brackets refer to the bibliography.

³ WirelessHART is the registered trade name of the FieldComm Group, see www.fieldcommgroup.org. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

INDUSTRIAL COMMUNICATION NETWORKS – WIRELESS COMMUNICATION NETWORKS –

Part 2: Coexistence management

1 Scope

This document:

- specifies the fundamental assumptions, concepts, parameters, and procedures for wireless communication coexistence;
- specifies coexistence parameters and how they are used in an application requiring wireless coexistence;
- provides guidelines, requirements, and best practices for wireless communication's availability and performance in an industrial automation plant; it covers the life-cycle of wireless communication coexistence;
- helps the work of all persons involved with the relevant responsibilities to cope with the critical aspects at each phase of life-cycle of the wireless communication coexistence management in an industrial automation plant. Life-cycle aspects include: planning, design, installation, implementation, operation, maintenance, administration and training;
- provides a common point of reference for wireless communication coexistence for industrial automation sites as a homogeneous guideline to help the users assess and gauge their plant efforts;
- deals with the operational aspects of wireless communication coexistence regarding both the static human/tool-organization and the dynamic network self-organization.

This document provides a major contribution to national and regional regulations. It does not exempt devices from conforming to all requirements of national and regional regulations.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 62657-1:—⁴, *Industrial communication networks – Wireless communication networks – Wireless communication requirements and spectrum considerations*

IEC 62443 (all parts), *Industrial communication networks – Network and system security*

3 Terms, definitions, abbreviated terms and conventions

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

⁴ Under preparation. Stage at the time of publication: IEC/RFDIS 62657-1:2017.

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

A1 3.1.1

adjacent channel interference

interference that occurs from wireless devices using adjacent frequency channels

3.1.2

adjacent channel selectivity

ability of a radio receiver to respond to the desired signal and to reject signals in adjacent frequency channels

3.1.3

antenna gain

ratio of the power required at the input of a reference antenna to the power supplied to the input of the given antenna to produce, in a given direction, the same field strength at the same distance

[SOURCE: Federal Standard 1037C:1996, modified – Deletion of “loss-free” before “reference antenna”, deletion of the two notes and synonyms] [21]

3.1.4

antenna radiation pattern

variation of the field intensity of an antenna as an angular function with respect to the axis

3.1.5

antenna type

structure or device used to collect or radiate electromagnetic waves

3.1.6

application communication requirements

quantitative requirements specifying the required conditions and the required characteristics of wireless communication solutions at the communication interface that is met in order to achieve the purpose of the automation application

3.1.7

automation application

industrial automation application

application of measurement and automatic control in the industrial automation domain

3.1.8

automation application data length

user data length

number of octets that are exchanged at the reference interface

3.1.9

availability,

<performance>

ability of an item to be in a state to perform as required function under given conditions at a given instant of time or over a given time interval, assuming that the required external resources are provided

Note 1 to entry: This ability depends on the combined aspects of the reliability performance, the maintainability performance, and the maintenance support performance.

Note 2 to entry: Required external resources, other than maintenance resources, do not affect the availability performance of the item.

[SOURCE: IEC 60050-191:1990, 191-02-05, modified – Deletion of third note to entry]

3.1.10

bandwidth

frequency bandwidth

difference between upper cut-off frequency and lower cut-off frequency

3.1.11

bit rate of the physical link

measure of the number of binary digits transferred per second

3.1.12

cellular topology

cellular network topology

network topology where the geographical area is divided in cells

Note 1 to entry: A device can move from one cell to another cell. Devices that are in a cell communicate through a central hub. Hubs in different cells are interconnected.

3.1.13

center frequency

geometric mean of lower cut-off frequency and upper cut-off frequency of a frequency channel

3.1.14

channel number

unsigned integer number identifying a wireless communication channel in accordance to an authoritative document or rule

3.1.15

channel occupation

time in which the medium is busy

Note 1 to entry: Beyond the pure transfer of user data, this time includes all time slices necessary to process the transmission protocol, for example to transfer an acknowledgement.

3.1.16

characteristic of the area of operation

distinguishing properties of the area where the wireless communication network is operated

3.1.17

characteristic of wireless communication solution

parameters of wireless communication solutions which are implementations of wireless communication systems and devices

3.1.18

characteristic of wireless device solution

parameters related to individual nodes within a network implementing a wireless communication solution

3.1.19

characteristic of wireless device type

specification of transmitter and receiver parameters

3.1.20

characteristic of wireless network solution

parameters related to a network as a whole used implementing a wireless communication solution

3.1.21

characteristic of wireless system type

parameters describing the kind of wireless communication system

3.1.22

characteristic of wireless system type and wireless device type

parameters that characterize the model of a wireless system or a wireless device by providing the parameters to specify a wireless system type and a wireless device type

3.1.23

coexistence

wireless communication coexistence

state in which all wireless communication solutions of a plant using shared medium fulfil all their application communication requirements

Note 1 to entry: In IEEE 802.15.2-2003 [19] the coexistence is defined as a characteristic of a device.

3.1.24

coexistence assessment

undertaking of an investigation in order to arrive at a judgment, based on evidence of the suitability of a set of products and their installation to achieve coexistence

3.1.25

coexistence management

process to establish and to maintain coexistence that includes technical and organizational measures

3.1.26

coexistence management information

parameters for the wireless coexistence management process

3.1.27

coexistence manager

role of a nominated person to manage coexistence

3.1.28

coexistence planning

process that describes the allocation of wireless communication resources (time, frequencies, coding, space) to each wireless communication system in order to achieve coexistence

3.1.29

communication load

amount of user data to be transmitted from the automation application within a certain period of time

3.1.30

cut-off frequency

frequency limit, nearest to the frequency where the spectral power density drops below a certain level, defining the frequency bandwidth

3.1.31

data throughput

ratio of the number of user data per time period, transferred within a consumer at the reference interface to the application

3.1.32

device type information

manufacturer name, manufacturer contact, the type and version of hardware and software

3.1.33

distance between wireless devices

geographical distance between devices within a three-dimensional space

3.1.34

duty cycle

ratio of the transmitter sequence referenced to a given observation time for the used frequency channel

3.1.35

dwelt time

period spent at a particular frequency during any single hop of a frequency hopping system

3.1.36

equivalent isotropic radiated power

product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna (absolute or isotropic gain)

[SOURCE: Radio Regulations (2012) – Art.1 §1.161, modified — term modified from isotropically to isotropic and definition reformatted according to the ISO/IEC Directives Part 2]

3.1.37

effective radiated power

product of the power supplied to the antenna and its gain relative to a half-wave dipole in a given direction

[SOURCE: Radio Regulations (2012) – Art.1 §1.162, modified — Deleted “(in a given direction)” and definition reformatted according to the ISO/IEC Directives Part 2]

3.1.38

electromagnetic interference

EMI

degradation of the performance of an equipment, transmission channel or system caused by an electromagnetic disturbance

Note 1 to entry: In French, the terms “perturbation électromagnétique” and “brouillage électromagnétique” designate respectively the cause and the effect, and should not be used indiscriminately.

Note 2 to entry: In English, the terms “electromagnetic disturbance” and “electromagnetic interference” designate respectively the cause and the effect, and should not be used indiscriminately.

[SOURCE: IEC 60050-161:1990/AMD1:1997, 161-01-06, modified – Corrected mistakes in the Notes to entry]

3.1.39

frequency band

range in the frequency spectrum that is assigned by regulatory organizations for use for specific applications or a group of applications

Note 1 to entry: The ITU as international regulatory organization assigns only radio communication services to a specific range in the frequency spectrum.

3.1.40

frequency channel

span of the frequency spectrum which is characterized by lower cut-off frequency and upper cut-off frequency or by center frequency and bandwidth

3.1.41

frequency hopping procedure

sequence of frequency channels used for transmission (hopping sequence) and dwell time

3.1.42

future expansion plan

possible installation of new wireless communication solutions and buildings that can affect coexistence

3.1.43

general plant characteristics

parameters that characterizes the plant in general with respect to all wireless communication applications

3.1.44

geographical dimension of the plant

length, width and height of the intended space of the wireless system

3.1.45

industrial automation application

control or management systems used in industrial production, including supervisory control and data acquisition systems, distributed control systems, and other control system configurations often found in the industrial sectors and critical infrastructures

3.1.46

industrial communication network

data communications sub-systems for industrial-process measurement and control as well as on instrumentation systems used for research, development or testing purposes

3.1.47

immunity

ability of an item to continue operating properly in the event of an interference, up to a certain level of interference, and to be resilient above this level

Note 1 to entry: Immunity of an item is achieved by adding to the robustness of the item the ability to be resilient to interference.

3.1.48

infrastructure device

device that is essential for building up a wireless communication system according to a technology or standard, but not having an interface to an automation application

EXAMPLE Router or base stations without interfaces to the wired industrial network or without automation application functions.

3.1.49

initiation of data transmission

method that specifies how the application initiates the data transfer

3.1.50

intermodulation sensitivity

levels of out-of-band interfering signals that, when mixed in the receiver front-end, produce an in-band third order non-linearity product

3.1.51

interference

radio frequency interference

effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radio communication system, manifested by any performance degradation, misinterpretation, or loss of information which could be extracted in the absence of such unwanted energy

[SOURCE: Database ITU Terms and Definitions]

3.1.52

industrial, scientific and medical application

operation of equipment or appliances designed to generate and use locally radio frequency energy for industrial, scientific, medical, domestic or similar purposes, excluding applications in the field of telecommunications

[SOURCE: Radio Regulations (2012) – Art.1 §1.15]

3.1.53

jitter

time variation of an expected occurrence

Note 1 to entry: Examples are variation of transmission time and update time.

3.1.54

length of user data per transfer interval

number of the octets sent out during a transfer interval, where the octets that are added because of the requirements of the wireless communication protocol are subtracted

Note 1 to entry: The application data length affects the communication load and might account for the temporal separation of the wireless communication systems.

3.1.55

life-cycle

length of time from the start of the development phase of a product type to the product abandonment

[SOURCE: IEC 62890:—⁵, 3.1.19]

3.1.56

limitation from neighbours of the plant

description of the neighbors of the plant that are likely to cause limitations for wireless communication

EXAMPLE High power radio source(s).

3.1.57

linear topology

linear network topology

topology where the nodes are connected in series, with two nodes connected to only one other node and all others each connected to two other nodes (that is, connected in the shape of a line)

Note 1 to entry: This topology corresponds to that of an open ring.

[SOURCE: IEC 61918:2013, 3.1.44, modified – Added an admitted term]

3.1.58

lower cut-off frequency

frequency furthest below the frequency of maximum power where the power spectral density drops below a certain level

3.1.59

mechanisms for adaptivity

measures to modify one or more of the systems operational parameters in order to improve the systems robustness against interferences and to minimize the medium utilization

⁵ Under preparation. Stage at the time of publication: IEC 62890/FDIS:2019.

3.1.60

maximum number of retransmissions

upper limit of how many times user data are allowed being retransmitted automatically by the communication stack because of transmission errors

3.1.61

mechanism for adaptivity

technique or procedure to increase coexistence capability

3.1.62

medium access control mechanism

transmission technique how to access the medium

Note 1 to entry: Examples are CSMA, TDMA, or combination of both.

3.1.63

mesh topology

mesh network topology

topology in which redundant physically-diverse routing paths are available between each pair of network nodes

Note 1 to entry: Wireless mesh topology is usable to extend coverage via multi-hop capability and/or to facilitate communication reliability by providing redundant paths between devices.

[SOURCE: IEC 62734:2014, 3.1.2.95, modified – Added an admitted term]

3.1.64

metrics

set of quantitative indicators corresponding to selected properties of a communication device, equipment, or wireless communication system

3.1.65

modulation

process of varying one or more properties of a periodic waveform with a modulating signal that contains information to be transmitted

3.1.66

natural environmental condition

condition that surrounds the wireless device and wireless system

Note 1 to entry: Examples are temperature, humidity, air pressure.

3.1.67

network

all of the media, connectors, repeaters, routers, gateways and associated node communication elements by which a given set of communicating devices are interconnected

[SOURCE: IEC 61158-2:2014, 3.1.30]

3.1.68

node

end-point of a branch in a network

[SOURCE: IEC 61918:2013, 3.1.50]

3.1.69

other frequency user

user which generates and uses radio frequency energy without having the objective of telecommunication

Note 1 to entry: Examples are welding machine, electrical drive and frequency converter

3.1.70

out-of-band emission

emission on a frequency or frequencies immediately outside the necessary bandwidth which results from the modulation process, but excluding spurious emissions

[SOURCE: Radio Regulations (2012) – Art.1 §1.144]

3.1.71

packet loss rate

ratio of number of packets, transferred from the application at the reference interface within the producer, and the number of packets, transferred at the reference interface to the application within the consumer

3.1.72

performance requirements

requirements describing the time and error behavior necessary to achieve the purpose of the automation application

3.1.73

physical link

relation between radio transceivers (physical end points) of two wireless devices

3.1.74

plant

managed facility, typically with a physically protected perimeter, hosting the physical process, operation, personnel, equipment

3.1.75

point-to-point topology

point-to-point network topology

topology where two nodes are directly connected to each other

3.1.76

position of wireless device

geographical position of the three dimensional space in absolute or relative coordinates where the device is located

3.1.77

power spectral density

distribution as a function of frequency of the power per unit bandwidth of the spectral components of a signal or a noise having a continuous spectrum and a finite mean power

[SOURCE: IEC 60050-713:1998, 713-09-12]

3.1.78

purpose of the automation application

summary of the automation application supported by the wireless network to the extent needed to provide a useful overview of the requirements imposed on the wireless network

3.1.79

radio channel

model considers the characteristic of the frequency channel, the environmental conditions, the distance between the wireless devices, the antenna characteristic

3.1.80

radio resource

means used by multiple wireless communication solutions for the purpose of radio signal transmission

3.1.81

radio robustness

attribute of wireless communication to fulfil the designated function despite the presence of other active wireless applications interfering in the sphere of influence

Note 1 to entry: This term has the same meaning as the definition of the term coexistence in IEEE 802.15.2:2003, 3.1.2 [19].

3.1.82

reference interface

exposed interface between an automation application and the wireless communication function

Note 1 to entry: There is no consistently defined interface for measurement and automation. The interface of the device might be a serial or a parallel hardware interface, a fieldbus interface, a software interface, or serial, parallel, discrete, and analog interface.

3.1.83

receiver blocking

effect of a strong interfering signal on the receiver's ability to detect a low-level wanted signal

3.1.84

receiver input level

received signals with levels above the receiver maximum input level

3.1.85

receiver maximum input level

maximum signal power that the system can tolerate without distortion of the signal

3.1.86

receiver sensitivity

minimal signal power to receive data with a defined bit error rate

3.1.87

regional radio regulation

regulation of important coexistence parameters such as frequency band and output power related to the region where the wireless application is intended to be used

3.1.88

relative movement

position of a wireless device over time

3.1.89

requirements influencing the characteristic of wireless solutions

application communication requirements that influence the performance of wireless solutions and thus the coexistence state

3.1.90

response time

time interval between the instant delivery of the first user data bit, or octet, of a packet to the reference interface of a transmitter, and the instant when the last bit, or octet, of the confirmation packet is delivered at the reference interface of the same transmitter, which can be assigned to the request

3.1.91

ring topology

ring network topology

active network where each node is connected in series to two other nodes

[SOURCE: IEC 61918:2013, 3.1.63, modified – ring" has been changed to "ring topology" and an admitted term has been added]

3.1.92

robustness

ability of an item to continue operating properly in the event of an interference, up to a certain level of the interference

Note 1 to entry: The robustness of an item may be increased with measures that modify one or more of its operational parameters.

3.1.93

security level

requirement category for cyber security

3.1.94

shared medium

resource of frequency band in particular area shared by several wireless applications

Note 1 to entry: In the industrial, scientific and medical (ISM)-bands many wireless applications are used. Due to this joint use, the term shared medium is used in this document. The frequency bands are used by diverse ISM applications and wireless communication applications.

3.1.95

spatial coverage of the wireless communication network

spatial coverage specified by length, width and height of a cuboid that encloses the wireless communication network

3.1.96

spurious emission

emission on a frequency or frequencies which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information, including harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions

[SOURCE: Radio Regulations (2012) – Art.1 §1.145]

3.1.97

spurious response

receiver output due to unwanted signals

Note 1 to entry: That means having frequencies other than those of the tuned frequency channel.

3.1.98

star topology

star network topology

network of three or more devices topology where all devices are connected to a central device

[SOURCE: IEC 61918:2013, 3.1.69, modified – "topology" has been added, "point (which may be active or passive)" has been replaced by "device", and an admitted term has been added]

3.1.99

telecommunication

any transmission, emission or reception of signs, signals, writings, images and sounds or intelligence of any nature by wire, radio, optical or other electromagnetic systems

[SOURCE: Radio Regulations (2012) – Art.1 §1.3]

3.1.100

topology of a network

network topology

pattern of the relative positions and interconnections of the individual elements of the network

[SOURCE: IEC 61918:2013, 3.1.73, modified – Deleted the “Note 1 to entry” and added an admitted term]

3.1.101

total radiated power

spatial power density integrated across the surface of the sphere

3.1.102

transfer interval

time difference between two consecutive transfers of user data from the automation application via the reference interface to the wireless communication function

3.1.103

transmission gap

gap between two successive channel usages by a transmitter

3.1.104

transmission time

interval from starting the delivery of the first application data octet of a packet to the reference communication interface of a producer until the delivery of the last application data octet of the same packet from the reference communication interface of a consumer

3.1.105

transmitter sequence

time that a transmitter uses a frequency channel without the possibility to be interrupted by a wireless device of the same network

3.1.106

transmission output power

total radiated power reduced by losses between the transmitter output and the antenna

3.1.107

transmitter spectral mask

envelope of maximum values of power spectral density over a frequency range

3.1.108

tree topology

tree network topology

network topology where all nodes are connected in a combination of a linear and a star topology

3.1.109

update time

interval from the delivery of the last user data byte of the packet of a producer, from the reference interface of a consumer to the automation application, until the delivery of the last user data byte of the following packet of the same producer

3.1.110

upper cut-off frequency

frequency furthest above the frequency of maximum power where the power spectral density drops below a certain level

3.1.111

wireless application

any use of electromagnetic waves with devices or equipment for the generation and use of radio frequency energy

Note 1 to entry: The definition includes radio determination equipment.

3.1.112

wireless communication

communication in which electromagnetic radiations are used to transfer information without the use of wires or optical fibers

3.1.113

wireless communication application

part of an industrial automation application that uses wireless communication

3.1.114

wireless communication network density

ratio of the number of wireless communication networks and the spatial coverage of the plant

3.1.115

wireless device

wireless automation device

equipment of wireless communication applications that uses radio waves for wireless communication with other equipment of wireless communication applications

3.1.116

wireless device density

number of wireless devices within the spatial coverage of the wireless communication network

3.1.117

wireless device receiver parameters

specification of wireless receiver characteristics

3.1.118

wireless device transmitter parameters

specification of wireless transmitter characteristics

3.1.119

wireless network

wireless communication network

network consisting of at least two wireless devices that established wireless communication

3.1.120

wireless solution

wireless communication solution

specific implementation or instance of a wireless communication system

Note 1 to entry: A wireless solution may be composed of products of one or more producers.

3.1.121

wireless system

wireless communication system

set of interrelated elements providing wireless communication

Note 1 to entry: A wireless system is a high level representation of a system, while a wireless solution is a practical instance of a system. A wireless system can comprise one or more wireless networks.

3.1.122

wireless technology or standard

naming the wireless technology or standard

EXAMPLE Examples of standards specifying a wireless communication network are IEC 62591, IEC 62601 and IEC 62734. 

3.2 Abbreviated terms

AFH	Adaptive frequency hopping
CEPT	European conference of postal and telecommunications administrations
CP	Communication profile according to IEC 61784-2 [5]
CSMA	Carrier sense multiple access
DAA	Detect and avoid
DAR	Detect and reduce
DAS	Detect and suppress
DECT	Digital enhanced cordless telecommunications
ECO	European communications office (the electronic communications committee of CEPT)
EIRP	Equivalent isotropic radiated power
EMC	Electromagnetic compatibility
EMI	Electromagnetic interference
ERP	Effective radiated power
GSM	Global system for mobile communications
IF	Intermediate frequency
IP	Internet protocol
ISM	Industrial, scientific and medical
IT	Information technology
ITU	International telecommunication union
LAN	Local area network
LOS	Line of sight
MAC	Medium access control
NLOS	Non line of sight
N/A	Not applicable
OLOS	Obstructed line of sight
PCB	Printed circuit board
PHY	Physical layer
PLR	Packet loss rate
PSD	Power spectral density
RFID	Radio frequency identification
SIR	Signal-to-interference ratio
TDMA	Time division multiple access
TRP	Total radiated power
UMTS	Universal mobile telecommunications system
WD	Wireless device
WIA-PA	Wireless network for industrial automation – process automation
WLAN	Wireless local area network

ZVEI Zentralverband Elektrotechnik- und Elektronikindustrie e.V.; the german electrical and electronic manufacturers' association

3.3 Conventions

NOTE The graphical representations of flow charts in figures are based on ISO 5807 [12].

The following conventions for the coexistence management parameter templates in Clause 8 apply:

- The column "Parameter" uses indentations to cluster certain parameters. The parameters that are more to the right belong to the parameter above that is more left.
- The column "Usage" specifies whether the parameter is mandatory, optional, or selection, if one out of several parameters is selected.
- The item "Value" can contain a range or a list of values if the parameters allow multiple options. If a parameter does not have a unit, then the item "Unit" shall be marked with not applicable (N/A).

4 Coexistence concept in industrial automation

4.1 Overview

Wireless communication allows industrial processes to be implemented more cost-efficiently, flexibly and reliably, as well as allowing the use of new automation concepts. Industrial automation applications usually place stricter requirements on reliability and real-time capability of wireless communication than applications in the domestic and office domain. Industrial automation applications can also reside in industrial facilities with higher ambient electromagnetic interference (EMI) levels than those of in non-industrial domains.

Additional sources of radio frequency emissions will also need to be taken into account during coexistence management.

NOTE In some industrial environments other sources of radio frequency emissions can be present within the same bands as used by the wireless communications systems. These emitters can include devices with unintentional emissions, such as high power welding devices which generate wideband electromagnetic energy.

Because of those requirements, different wireless systems are used. It is quite likely that several wireless systems may operate simultaneously in one place. Since these wireless systems share a common medium, interferences can be assumed throughout their life-cycles. This impacts system performance including reliability and its ability to meet real-time response requirements. This document is intended to help identify potential risks and to recommend measures to control these risks, depending on the requirements of the industrial automation application. This document also illustrates that most often the coexistence of several wireless systems and simultaneously the efficient handling of the frequency spectrum as a limited resource is feasible if an appropriate approach is chosen, taking into account the respective requirements. In order to achieve this, a process is needed in which all aspects of the coexistence of wireless systems during design, commissioning, and operation, as well as maintenance, are considered. This process, called coexistence management of wireless solutions, is the subject of this document. Associated actions and decisions serve to comply with the claimed limit values for the application over the whole life-cycle of the plant.

This process can be more or less complex, depending on the relevance of the requirements related to the wireless communication for the plant. This complexity depends, among other aspects, on the characteristics of the wireless communication application served by each wireless solution (for example control with strict real time requirements), the number and location of the wireless solutions that can potentially interfere with each other, and the presence of any other radio frequency emitters in the same bands.

If no, or just modest, requirements are made on the wireless system, a lower effort for the coexistence of wireless solutions will be necessary than in the case of a wireless system that

is part of a control application with strict real-time requirements. However, it is strongly recommended to consider that additional wireless systems might be implemented later or that the requirements on the present wireless system might change in the future (for example due to additional applications). The plant design shall ensure that the applied coexistence measures match the requirements of the wireless system.

The state of coexistence is characterized by meeting the limit values of relevant parameters for all wireless communication applications in the considered area. This state of coexistence is accomplished with appropriate actions in planning and in operation. This clarifies that coexistence is not a static attribute of a wireless solution, but rather a state within the life-cycle of a plant. It is possible to leave this state temporarily or permanently due to certain events. The parameter limit values are determined by the automation application in which the wireless communication takes place. This also implies that the coexistence management shall be evaluated and established contextually and in full accordance with the automation application.

From a general point of view, coexistence of two or more wireless solutions may be achieved by making orthogonal the transmissions that come from different sources.

There are three possibilities to manage coexistence, where a) means a higher amount of labor hours to establish and maintain the coexistence management and b) and c) means an increasing level of automation:

- a) manual coexistence management (lowest level);
- b) automated non-collaborative metrics-based coexistence management;
- c) automated collaborative metrics-based coexistence management (highest level).

Automated and unattended techniques, and the algorithms on which they are based, are usually classified into two broad categories: collaborative and non-collaborative.

4.2 Objective

This document is focused on measures to provide coexistence of wireless systems for measurement and automation applications. These industrial automation applications can be classified in various ways. For example, in Table 1 they are classified according to the degree of the application criticality. Efforts for coexistence management can vary according to the classification described in Table 1.

Table 1 – Example of a classification of application communication requirements

Class	Application	Application communication requirements
Functional safety	Implementation of a safety-related system whose failure could have an impact on the safety of persons and/or the environment and/or the plant	The communication protocol should support functional safety communication and the coexistence management shall be established in order to fulfil all requirements of this document.
Control	Closed or open loop control	The communication protocol should support a higher availability, reliability, and time-criticality protocol than the one used for other application domains like consumer industry or telecommunication. The coexistence management shall be established in order to fulfil most of the requirements of this document.
Monitoring	Process visualization and alerting	No specific add-ons required for the communication protocol. Typically monitoring application can be satisfied by a relaxed set of requirements. The coexistence management shall be established in order to fulfil these minimum requirements.
NOTE The relative terms “most” and “minimum” are based on the graphical description in Figure 3.		

The classification of automation applications provided with Table 1 refers to the functional requirements of the process industry application to be satisfied. This classification can also be adapted in other application domains.

However, the determination of the criticality and the associated application communication requirements shall be determined on a case-by-case basis by the coexistence manager.

NOTE 1 Application communication requirements are described in IEC 62657-1.

Applications ranging from radio bar code readers to voice and video over IP applications can be classified likewise, and can be dealt with according to this document.

The applicability of this document is not confined to a specific band, for example the 2,4 GHz ISM band. Both concurrent communication systems and other approved wireless applications, such as microwave systems for drying or plastics welding, are considered as interferences. Moreover, further interferences might occur due to powerful low frequency electromagnetic fields (for example transformers, powerful motors or other EMI influences, see Figure 1). The interference sources to be considered are detailed in 4.4.

NOTE 2 The analysis of EMI is outside of scope of this document but has been considered.