

DIN EN 61784-2

ICS 35.160

Ersatz für
DIN EN 61784-2:2008-10
Siehe Anwendungsbeginn

**Industrielle Kommunikationsnetze –
Profile –
Teil 2: Zusätzliche Feldbusprofile für Echtzeitnetzwerke basierend
auf ISO/IEC 8802-3
(IEC 61784-2:2010);
Englische Fassung EN 61784-2:2010, nur auf CD-ROM**

Industrial communication networks –
Profiles –
Part 2: Additional fieldbus profiles for real-time networks based on ISO/IEC 8802-3
(IEC 61784-2:2010);
English version EN 61784-2:2010, only on CD-ROM

Réseaux de communication industriels –
Profils –
Partie 2: Profils supplémentaires des bus de terrain pour les réseaux temps réel
basés sur l'ISO/CEI 8802-3
(CEI 61784-2:2010);
Version anglaise EN 61784-2:2010, seulement en CD-ROM

Gesamtumfang 241 Seiten

DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE

Anwendungsbeginn

Anwendungsbeginn für die von CENELEC am 2010-09-01 angenommene Europäische Norm als DIN-Norm ist 2011-04-01.

Daneben darf DIN EN 61784-2:2008-10 noch bis 2013-09-01 angewendet werden.

Nationales Vorwort

Vorausgegangener Norm-Entwurf: E DIN IEC 61784-2:2009-06.

Für diese Norm ist das nationale Arbeitsgremium K 956 „Feldbus“ der DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE (www.dke.de) zuständig.

Die enthaltene IEC-Publikation wurde vom SC 65C „Industrial networks“ erarbeitet.

Das IEC-Komitee hat entschieden, dass der Inhalt dieser Publikation bis zu dem Datum (stability date) unverändert bleiben soll, das auf der IEC-Website unter „<http://webstore.iec.ch>“ zu dieser Publikation angegeben ist. Zu diesem Zeitpunkt wird entsprechend der Entscheidung des Komitees die Publikation

- bestätigt,
- zurückgezogen,
- durch eine Folgeausgabe ersetzt oder
- geändert.

Für den Fall einer undatierten Verweisung im normativen Text (Verweisung auf eine Norm ohne Angabe des Ausgabedatums und ohne Hinweis auf eine Abschnittsnummer, eine Tabelle, ein Bild usw.) bezieht sich die Verweisung auf die jeweils neueste gültige Ausgabe der in Bezug genommenen Norm.

Für den Fall einer datierten Verweisung im normativen Text bezieht sich die Verweisung immer auf die in Bezug genommene Ausgabe der Norm.

Der Zusammenhang der zitierten Normen mit den entsprechenden Deutschen Normen ergibt sich, soweit ein Zusammenhang besteht, grundsätzlich über die Nummer der entsprechenden IEC-Publikation. Beispiel: IEC 60068 ist als EN 60068 als Europäische Norm durch CENELEC übernommen und als DIN EN 60068 ins Deutsche Normenwerk aufgenommen.

Das Präsidium des DIN hat mit Präsidialbeschluss 1/2004 festgelegt, dass DIN-Normen, deren Inhalt sich auf internationale Arbeitsergebnisse der Informationsverarbeitung gründet, unter bestimmten Bedingungen allein in englischer Sprache veröffentlicht werden dürfen. Diese Bedingungen sind für die vorliegende Norm erfüllt.

Da sich die Benutzer des vorliegenden Norm-Entwurfs der englischen Sprache als Fachsprache bedienen, wird die englische Fassung der EN 61784-2 veröffentlicht. Für die meisten der verwendeten Begriffe existieren keine gebräuchlichen deutschen Benennungen, da sich die deutschen Anwender in der Regel ebenfalls der englischen Benennungen bedienen. Diese Norm steht nicht in unmittelbarem Zusammenhang mit Rechtsvorschriften und ist nicht als Sicherheitsnorm anzusehen.

Erklärung zu Schutzrechten

Die Verwendung einiger Protokolltypen, auf die die vorliegende Norm verweist, wird von den Inhabern, die Rechte geistigen Eigentums an ihnen haben, beschränkt. Auf jeden Fall erlaubt die Verpflichtung zur begrenzten Freigabe der Rechte geistigen Eigentums, der sich ihre Inhaber unterworfen haben, die Verwendung eines bestimmten Data-Link-Layer-Protokolls eines Typs zusammen mit Physical-Layer- und Application-Layer-Protokollen in Typ-Kombination, wie sie in der Normenreihe IEC 61784 festgelegt sind. Die Verwendung von Protokolltypen in anderen Kombinationen kann eine Erlaubnis ihrer Inhaber der Rechte geistigen Eigentums erfordern.

Änderungen

Gegenüber DIN EN 61784-2:2008-10 wurden folgende Änderungen vorgenommen:

- a) Verweisung auf die gültige Ausgabe der IEC 61588 (IEC 61588:2008);
- b) Verweisung auf IEC 61784-5-11 hinzugefügt;
- c) weitere Verweisungen auf den neuesten Stand gebracht;
- d) textliche Verbesserungen in 7.1 und 7.3.1;
- e) DLL-Protokoll-Auswahltabellen in 7.3.2.2 auf den neuesten Stand gebracht;
- f) AL-Dienste-Auswahltabellen in 7.3.3.1 auf den neuesten Stand gebracht;
- g) in 8.1.2 empfohlene Parameterwerte für die IP-Konfiguration hinzugefügt;
- h) Auswahltabellen für CPF 3 auf den neuesten Stand gebracht, sodass sie mit dem Entwurf zur Neuauflage der IEC 61158-5-10 übereinstimmen;
- i) 12.1 erweitert;
- j) die DLL-Protokoll-Auswahl für CP 11/1 in 12.2.2.2 auf den neuesten Stand gebracht, sodass sie mit dem Entwurf für die Neuauflage der IEC 61158-4-11 übereinstimmt;
- k) in 12.3 das neue Profil CP 11/2 hinzugefügt;
- l) 15.1 in Hinblick auf CP 14/3 erweitert;
- m) Festlegung von CP 14/3 in 15.4 hinzugefügt;
- n) neuer Unterabschnitt 3.3.12 für CPF 17-Symbole hinzugefügt;
- o) neuen Abschnitt 18 für CPF 17 (RAPIEnet) mit einem Profil hinzugefügt.

Frühere Ausgaben

DIN EN 61784-2: 2008-10

– Leerseite –

**Industrial communication networks -
Profiles -
Part 2: Additional fieldbus profiles for real-time networks based
on ISO/IEC 8802-3
(IEC 61784-2:2010)**

Réseaux de communication industriels -
Profils -
Partie 2: Profils supplémentaires des bus
de terrain pour les réseaux temps réel
basés sur l'ISO/CEI 8802-3
(CEI 61784-2:2010)

Industrielle Kommunikationsnetze -
Profile -
Teil 2: Zusätzliche Feldbusprofile für
Echtzeitnetzwerke basierend
auf ISO/IEC 8802-3
(IEC 61784-2:2010)

This European Standard was approved by CENELEC on 2010-09-01. 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 Central Secretariat 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 Central Secretariat 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, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

CENELEC

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

Management Centre: Avenue Marnix 17, B - 1000 Brussels

Foreword

The text of document 65C/601/FDIS, future edition 2 of IEC 61784-2, 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 was approved by CENELEC as EN 61784-2 on 2010-09-01.

This European Standard supersedes EN 61784-2:2008.

The main changes with respect to EN 61784-2:2008 are listed below:

- a) update of the dated references to the EN 61158 series, to EN 61784-1, to the EN 61784-3 series, to the EN 61784-5 series and to EN 61918 throughout the document;
- b) update of selection tables for CPF 2, CPF 3, CPF 11 and CPF 14;
- c) addition of a new profile CP 11/2 in 12.3;
- d) addition of a new profile CP 14/3 in subclause 15.5;
- e) addition of a new Communication Profile Family - CPF 17;
 - new subclause 3.3.12 (CPF 17 symbols);
 - new Clause 18 for CPF 17 with one profile;
- f) addition of a new Communication Profile Family - CPF 18;
 - new subclause 3.3.13 (CPF 18 symbols);
 - new Clause 19 for CPF 18 with one profile;
 - specification changes for CPF3;
- g) update of the requirements for all conformance classes;
- h) added precise timing requirements for IP;
- i) updated timing requirements for IO devices;
- j) added precise timing requirements for PTCP;
- k) increasing the amount of synchronized devices in line;
- l) integrating the fast startup as additional feature.

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

The following dates were fixed:

- | | | |
|--|-------|------------|
| – latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2011-06-01 |
| – latest date by which the national standards conflicting with the EN have to be withdrawn | (dow) | 2013-09-01 |

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61784-2:2010 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/TR 61158-1:2010	NOTE Harmonized as CLC/TR 61158-1:2010 (not modified).
IEC 61158-3-8:2007	NOTE Harmonized as EN 61158-3-8:2008 (not modified).
IEC 61158-4-8:2007	NOTE Harmonized as EN 61158-4-8:2008 (not modified).
IEC 61158-5-8:2007	NOTE Harmonized as EN 61158-5-8:2008 (not modified).
IEC 61158-6-8:2007	NOTE Harmonized as EN 61158-6-8:2008 (not modified).
ISO/IEC 9646 series	NOTE Harmonized in EN ISO/IEC 9646 series (not modified).

CONTENTS

	Page
INTRODUCTION.....	15
1 Scope.....	16
2 Normative references	16
3 Terms, definitions, abbreviated terms, acronyms, and conventions.....	21
3.1 Terms and definitions	21
3.2 Abbreviated terms and acronyms	24
3.3 Symbols	27
3.3.1 CPF 2 symbols	27
3.3.2 CPF 3 symbols	28
3.3.3 CPF 4 symbols	29
3.3.4 CPF 6 symbols	29
3.3.5 CPF 10 symbols	30
3.3.6 CPF 11 symbols	30
3.3.7 CPF 12 symbols	31
3.3.8 CPF 13 symbols	32
3.3.9 CPF 14 symbols	32
3.3.10 CPF 15 symbols	33
3.3.11 CPF 16 symbols	33
3.3.12 CPF 17 symbols	34
3.3.13 CPF 18 symbols	35
3.4 Conventions	35
3.4.1 Conventions common to all layers	35
3.4.2 Physical layer	36
3.4.3 Data-link layer	37
3.4.4 Application layer.....	37
4 Conformance to communication profiles	37
5 RTE performance indicators	38
5.1 Basic principles of performance indicators.....	38
5.2 Application requirements	39
5.3 Performance indicators.....	39
5.3.1 Delivery time	39
5.3.2 Number of RTE end-stations.....	40
5.3.3 Basic network topology	40
5.3.4 Number of switches between RTE end-stations	40
5.3.5 Throughput RTE	40
5.3.6 Non-RTE bandwidth	40
5.3.7 Time synchronization accuracy.....	40
5.3.8 Non-time-based synchronization accuracy	41
5.3.9 Redundancy recovery time	41
6 Conformance tests	41
6.1 Concept	41
6.2 Methodology.....	42
6.3 Test conditions and test cases	42
6.4 Test procedure and measuring	42

6.5	Test report	43
7	Communication Profile Family 2 (CIP™) - RTE communication profiles	43
7.1	General overview	43
7.2	Profile 2/2	44
7.2.1	Physical layer	44
7.2.2	Data-link layer	44
7.2.3	Application layer	44
7.2.4	Performance indicator selection	44
7.3	Profile 2/2.1	48
7.3.1	Physical layer	48
7.3.2	Data-link layer	48
7.3.3	Application layer	49
7.3.4	Performance indicator selection	51
8	Communication Profile Family 3 (PROFIBUS & PROFINET) – RTE communication profiles	53
8.1	General overview	53
8.1.1	CPF 3 overview	53
8.1.2	Administrative numbers	53
8.1.3	Node Classes	53
8.1.4	Application classes	56
8.1.5	Communication classes	56
8.1.6	Redundancy classes	57
8.1.7	Media classes	57
8.1.8	Records	58
8.1.9	Communication feature list	63
8.1.10	Conformance class behaviors	64
8.2	Profile 3/4	67
8.2.1	Physical layer	67
8.2.2	Data-link layer	67
8.2.3	Application layer	68
8.2.4	Performance indicator selection	73
8.3	Profile 3/5	80
8.3.1	Physical layer	80
8.3.2	Data-link layer	80
8.3.3	Application layer	81
8.3.4	Performance indicator selection	86
8.4	Profile 3/6	87
8.4.1	Physical layer	87
8.4.2	Data-link layer	87
8.4.3	Application layer	88
8.4.4	Performance indicator selection	92
9	Communication Profile Family 4 (P-NET) - RTE communication profiles	94
9.1	General overview	94
9.2	Profile 4/3, P-NET on IP	95
9.2.1	Physical layer	95
9.2.2	Data-link layer	95
9.2.3	Application layer	96
9.2.4	Performance indicator selection	97

10	Communication Profile Family 6 (INTERBUS®) - RTE communication profiles.....	100
10.1	General overview	100
10.2	Profile 6/4	101
10.2.1	Mapping	101
10.2.2	Type 10 service and protocol selection	103
10.2.3	Type 8 service and protocol selection	103
10.2.4	Performance indicator selection.....	103
10.3	Profile 6/5	104
10.3.1	Mapping	104
10.3.2	Type 10 service and protocol selection	105
10.3.3	Type 8 service and protocol selection	105
10.3.4	Performance indicator selection.....	105
10.4	Profile 6/6	106
10.4.1	Mapping	106
10.4.2	Type 10 service and protocol selection	106
10.4.3	Type 8 service and protocol selection	106
10.4.4	Performance indicator selection.....	106
11	Communication Profile Family 10 (Vnet/IP) - RTE communication profiles	107
11.1	General overview	107
11.2	Profile 10/1.....	108
11.2.1	Physical layer	108
11.2.2	Data link layer	108
11.2.3	Application layer.....	110
11.2.4	Performance indicator selection.....	111
12	Communication Profile Family 11 (TCnet) - RTE communication profiles	116
12.1	General overview	116
12.2	Profile 11/1.....	117
12.2.1	Physical layer	117
12.2.2	Data-link layer	117
12.2.3	Application layer.....	119
12.2.4	Performance indicator selection.....	120
12.3	Profile 11/2.....	125
12.3.1	Physical layer	125
12.3.2	Data-link layer	125
12.3.3	Application layer.....	127
12.3.4	Performance indicator selection.....	127
13	Communication Profile Family 12 (EtherCAT) - RTE communication profiles	133
13.1	General overview	133
13.2	Profile CP 12/1	133
13.2.1	Physical layer	133
13.2.2	Data-link layer	134
13.2.3	Application layer.....	137
13.2.4	Performance indicator selection.....	138
13.3	Profile CP 12/2	141
13.3.1	Physical layer	141
13.3.2	Data-link layer	141
13.3.3	Application layer.....	144
13.3.4	Performance indicator selection.....	146

14	Communication Profile Family 13 (ETHERNET Powerlink) - RTE communication profiles	148
14.1	General overview	148
14.2	Profile 13/1.....	148
14.2.1	Physical layer	148
14.2.2	Data-link layer	149
14.2.3	Application layer	149
14.2.4	Performance indicator selection	149
15	Communication Profile Family 14 (EPA)- RTE communication profiles.....	154
15.1	General overview	154
15.2	CPF 14 (EPA) communication concept	154
15.2.1	General	154
15.2.2	Network Topology.....	155
15.2.3	EPA devices	156
15.3	Profile 14/1.....	156
15.3.1	Physical layer	156
15.3.2	Data-link layer	156
15.3.3	Network Layer	156
15.3.4	Transport Layer	157
15.3.5	Application layer	157
15.3.6	Performance indicator selection	158
15.4	Profile 14/2.....	161
15.4.1	Physical layer	161
15.4.2	Data-link layer	161
15.4.3	Network Layer	162
15.4.4	Transport Layer	162
15.4.5	Application layer	162
15.4.6	Performance indicator selection	163
15.5	Profile 14/3.....	166
15.5.1	Physical layer	166
15.5.2	Data-link layer	166
15.5.3	Network Layer	167
15.5.4	Transport Layer	167
15.5.5	Application layer	167
15.5.6	Performance indicator selection	168
16	Communication Profile Family 15 (MODBUS-RTPS)- RTE communication profiles	173
16.1	General overview	173
16.2	Profile 15/1.....	173
16.2.1	Physical layer	173
16.2.2	Data-link layer	173
16.2.3	Application layer	173
16.2.4	Performance indicator selection	174
16.3	Profile 15/2.....	178
16.3.1	Physical layer	178
16.3.2	Data-link layer	178
16.3.3	Application layer	178
16.3.4	Performance indicator selection	179
17	Communication Profile Family 16 (SERCOS)- RTE communication profiles	183
17.1	General overview	183

17.2	Profile 16/3 (SERCOS III).....	184
17.2.1	Physical layer	184
17.2.2	Data-link layer	184
17.2.3	Application layer.....	184
17.2.4	Performance indicator selection.....	185
18	Communication Profile Family 17(RAPIEnet) - RTE communication profiles	191
18.1	General overview	191
18.2	Profile 17/1.....	192
18.2.1	Physical layer	192
18.2.2	Datalink layer	192
18.2.3	Application layer.....	192
18.2.4	Performance indicator selection.....	193
19	Communication Profile Family 18 (SafetyNET p) – RTE communication profiles	198
19.1	General overview	198
19.2	Profile 18/1.....	198
19.2.1	Physical layer	198
19.2.2	Data link layer	198
19.2.3	Application layer.....	201
19.2.4	Performance indicator selection.....	202
19.3	Profile 18/2.....	204
19.3.1	Physical layer	204
19.3.2	Data link layer	204
19.3.3	Application layer.....	207
19.3.4	Performance indicator selection.....	208
	Annex A (informative) Performance Indicator calculation	211
A.1	CPF 2 (CIP) - Performance indicator calculation.....	211
A.1.1	Profile 2/2 EtherNet/IP	211
A.1.2	Profile 2/2.1 EtherNet/IP with Time Synchronization	212
A.2	CPF 3 - Performance indicator calculation	213
A.2.1	Application Scenario.....	213
A.2.2	Structural examples used for calculation	213
A.2.3	Principles used for calculation	219
A.3	CPF 4/3 P-NET on IP - Performance indicator calculation.....	222
A.3.1	Application scenario	222
A.3.2	Delivery time calculation.....	222
A.3.3	Non-RTE throughput calculation	223
A.3.4	Non time-base synchronization accuracy.....	225
A.3.5	RTE throughput calculation	225
A.3.6	CPF 4/3, Derivation of delivery time formula.....	226
A.3.7	CPF 4/3, Ethernet characteristics	228
	Bibliography.....	229
	Annex ZA (normative) Normative references to international publications with their corresponding European publications	231
	Figure 1 – Example of graphical representation of consistent indicators.....	39
	Figure 2 – Conformance test overview	41
	Figure 3 – Example of network topology using CP 3/4, CP 3/5, and CP 3/6 components	67

Figure 4 – Example of network topology with wireless segment	70
Figure 5 – Calculation basis for delivery time and throughput RTE.....	76
Figure 6 – Linking-device communication profiles RTE-network context.....	101
Figure 7 – Linking-device mapping principle	102
Figure 8 – Data Mapping.....	102
Figure 9 – Throughput RTE and non-RTE bandwidth	123
Figure 10 – CP 11/2: Throughput RTE and non-RTE bandwidth.....	130
Figure 11 – EPA system network topology example	155
Figure A.1 – CP 3/4: Example of line structure.....	213
Figure A.2 – CP 3/4: Example of ring structure	213
Figure A.3 – CP 3/4: Example of a wireless segment	214
Figure A.4 – CP 3/4: Example of an integrated wireless client.....	214
Figure A.5 – CP 3/5: Example of line structure.....	215
Figure A.6 – CP 3/5: Example of ring structure	215
Figure A.7 – CP 3/6: Example of line structure.....	216
Figure A.8 – CP 3/6: Example of ring structure	217
Figure A.9 – CP 3/6: Example of tree structure	218
Figure A.10 — CP 3/6: Example of comb structure	219
Figure A.11 – Definition of bridge delay	220
Figure A.12 – Example of a switch structure	221
Figure A.13 – Application configuration.....	222
Figure A.14 – Non-RTE throughput calculation	224
Figure A.15 – Non time-base synchronization accuracy	225
Table 1 – Layout of profile (sub)clause selection tables	35
Table 2 – Contents of (sub)clause selection tables	35
Table 3 – Layout of service selection tables.....	36
Table 4 – Contents of service selection tables	36
Table 5 – Layout of parameter selection tables	36
Table 6 – Contents of parameter selection tables	36
Table 7 – Layout of class attribute selection tables	37
Table 8 – Contents of class attribute selection tables.....	37
Table 9 – Basic network topology types	40
Table 10 – CP 2/2: performance indicator overview	44
Table 11 – CP 2/2: Performance indicator dependency matrix	45
Table 12 – CP 2/2: consistent set of performance indicators for factory automation	48
Table 13 – CP 2/2.1: DLL protocol selection	48
Table 14 – CP 2/2.1: DLL protocol selection of management objects	49
Table 15 – CP 2/2.1: AL service selection.....	49
Table 16 – CP 2/2.1: AL protocol selection	50
Table 17 – CP 2/2.1: performance indicator overview	51
Table 18 – CP 2/2.1: performance indicator dependency matrix.....	52
Table 19 – CP 2/2.1: Consistent set of performance indicators for motion control	52

Table 20 – Administrative numbers assignment	53
Table 21 – IP layer parameters for IO controller	54
Table 22 – IP layer parameters for IO device	54
Table 23 – Timeout values for name resolution	55
Table 24 – Reaction time for an IO device	55
Table 25 – Timeout values for PTCP	56
Table 26 – Maximum time values for PTCP	56
Table 27 – Communication classes applicable in conformance classes	57
Table 28 – Redundancy class applicable in conformance classes	57
Table 29 – Index (user specific)	58
Table 30 – Index (subslot specific)	58
Table 31 – Index (slot specific)	60
Table 32 – Index (AR specific)	61
Table 33 – Index (API specific)	62
Table 34 – Index (device specific)	63
Table 35 – Communication feature list	63
Table 36 – Conformance class behaviors	64
Table 37 – Conformance class behaviors for network components	66
Table 38 – CP 3/4: AL service selection for an IO device	68
Table 39 – CP 3/4: AL protocol selection for an IO device and Network component	71
Table 40 – CP 3/4: AL protocol selection for an IO controller	72
Table 41 – CP 3/4, CP 3/5 and CP 3/6: performance indicator overview	74
Table 42 – CP 3/4, CP 3/5 and CP 3/6: performance indicator dependency matrix	74
Table 43 – Manager parameters	77
Table 44 – Client parameters	78
Table 45 – CP 3/4: Consistent set of PI for MinDeviceInterval = 128 ms	79
Table 46 – CP 3/4: Assumed values for consistent set of PI calculation	80
Table 47 – CP 3/5: AL service selection for an IO device	81
Table 48 – CP 3/5: AL protocol selection for an IO device and Network component	83
Table 49 – CP 3/5: AL protocol selection for an IO controller	84
Table 50 – CP 3/5: Consistent set of PI for MinDeviceInterval = 128 ms	86
Table 51 – CP 3/5: Assumed values for consistent set of PI calculation	87
Table 52 – CP 3/6: AL service selection for an IO device	88
Table 53 – Buffering capacity	89
Table 54 – CP 3/6: AL protocol selection for an IO device and network component	90
Table 55 – CP 3/6: AL protocol selection for an IO controller	91
Table 56 – CP 3/6: Consistent set of PI for MinDeviceInterval=1ms with 64 end-stations	93
Table 57 – CP 3/6: Assumed values for consistent set of PI calculation	94
Table 58 – CP 4/3: DLL service selection	95
Table 59 – CP 4/3: DLL protocol selection	96
Table 60 – CP 4/3: AL service selection	96
Table 61 – CP 4/3: AL protocol selection	96
Table 62 – CP 4/3: Performance indicator overview	97

Table 63 – CP 4/3: Performance indicator dependency matrix	97
Table 64 – CP 4/3: Consistent set of performance indicators	100
Table 65 – Parameters for calculation of consistent set of performance indicators	100
Table 66 – CPF 6: device CP identifier assignment.....	101
Table 67 – Linking-device Type 10 network performance indicator overview	104
Table 68 – OSI layers and CPF 10 layers	107
Table 69 – Overview of CPF 10 profile.....	108
Table 70 – CP 10/1: DLL service selection.....	109
Table 71 – CP 10/1: DLL protocol selection	109
Table 72 – Transport Layer Parameter selection.....	110
Table 73 – CP 10/1: AL service selection.....	111
Table 74 – CP 10/1: AL protocol selection	111
Table 75 – CP 10/1: Performance indicator overview	111
Table 76 – CP 10/1: Performance indicator dependency matrix.....	112
Table 77 – CP 10/1: Consistent set of performance indicators for the communication between two end-stations belonging to the same domain	115
Table 78 – CP 10/1: Consistent set of performance indicators for the communication between two end-stations belonging to different domains.....	115
Table 79 – CP 10/1: Consistent set of performance indicators for the communication between two end-stations belonging to the same domain with one lost flame.....	116
Table 80 – CP 10/1: Consistent set of performance indicators for the communication between two end-stations belonging to different domains with one lost flame.....	116
Table 81 – CPF 11: Overview of profile sets	117
Table 82 – CP 11/1: DLL service selection.....	117
Table 83 – CP 11/1: DLL protocol selection	118
Table 84 – CP 11/1: DLL protocol selection of Clause 5.....	118
Table 85 – CP 11/1: DLL protocol selection of Clause 6.....	119
Table 86 – CP 11/1: AL service selection.....	120
Table 87 – CP 11/1: AL protocol selection	120
Table 88 – CP 11/1: Performance indicator overview	120
Table 89 – CP 11/1: Performance indicator dependency matrix.....	121
Table 90 – CP 11/1: TCC data service selection	121
Table 91 – CP 11/1: Consistent set of PIs preferential for RTE communications	125
Table 92 – CP 11/1: Consistent set of PIs both for RTE and non-RTE communications.....	125
Table 93 – CP 11/2: DLL protocol selection	126
Table 94 – CP 11/2: DLL protocol selection of Clause 5.....	126
Table 95 – CP 11/2: DLL protocol selection of Clause 6.....	127
Table 96 – CP 11/2: Performance indicator overview	128
Table 97 – CP 11/2: Performance indicator dependency matrix.....	128
Table 98 – CP 11/2: TCC data service selection	129
Table 99 – CP 11/2: Consistent set of PIs preferential for RTE communications	132
Table 100 – CP 11/2: Consistent set of PIs both for RTE and non-RTE communications.....	132
Table 101 – CP 12/1: PhL selection of preferred physical layer.....	133
Table 102 – CP 12/1: PhL selection of an optimized physical layer	134

Table 103 – CP 12/1: DLL service selection	134
Table 104 – CP 12/1: DLL protocol selection	135
Table 105 – CP 12/1: DLL service selection	136
Table 106 – CP 12/1: DLL protocol selection	136
Table 107 – CP 12/1: AL service selection	137
Table 108 – CP 12/1: AL protocol selection	137
Table 109 – CP 12/1: AL service selection	138
Table 110 – CP 12/1: AL protocol selection	138
Table 111 – CP 12/1: Performance indicator overview	139
Table 112 – CP 12/1: Performance indicator dependency matrix.....	139
Table 113 – CP 12/1: Performance indicator ranges	140
Table 114 – CP 12/1: Consistent set of performance indicators for mid size automation systems	141
Table 115 – CP 12/2: DLL service selection	142
Table 116 – CP 12/2: DLL protocol selection	142
Table 117 – CP 12/2: DLL service selection	143
Table 118 – CP 12/2: DLL protocol selection	143
Table 119 – CP 12/2: AL service selection	144
Table 120 – CP 12/2: AL protocol selection	145
Table 121 – CP 12/2: AL service selection	145
Table 122 – CP 12/2: AL protocol selection	146
Table 123 – CP 12/2: Performance indicator overview	146
Table 124 – CP 12/2: Performance indicator dependency matrix.....	147
Table 125 – CP 12/2: Consistent set of performance indicators	148
Table 126 – CPF 13: Overview of profile sets	148
Table 127 – CP 13/1: DLL service selection	149
Table 128 – CP 13/1: DLL protocol selection	149
Table 129 – CP 13/1: AL service selection	149
Table 130 – CP 13/1: AL protocol selection	149
Table 131 – CP 13/1: Performance indicator overview	150
Table 132 – CP 13/1: Performance indicator dependency matrix.....	150
Table 133 – CP 13/1: Consistent set of PIs small size automation system	153
Table 134 – CP 13/1: Consistent set of PIs medium size automation system	153
Table 135 – CP 13/1: Consistent set of PIs large size automation system.....	154
Table 136 – CP 14/1: AL service selection	157
Table 137 – CP 14/1: AL protocol selection	157
Table 138 – CP 14/1: Performance indicator overview	158
Table 139 – CP 14/1: Performance indicator dependency matrix.....	159
Table 140 – CP 14/1: Consistent set of performance indicators	161
Table 141 – CP 14/2: DLL service selection.....	161
Table 142 – CP 14/2: DLL protocol selection	162
Table 143 – CP 14/2: AL service selection	162
Table 144 – CP 14/2: AL protocol selection	163

Table 145 – CP 14/2: Performance indicator overview	163
Table 146 – CP 14/2: Performance indicator dependency matrix.....	164
Table 147 – CP 14/2: Consistent set of performance indicators	166
Table 148 – CP 14/3: DLL service selection.....	166
Table 149 – CP 14/3: DLL protocol selection	167
Table 150 – CP 14/3: AL service selection.....	167
Table 151 – CP 14/3: AL protocol selection	168
Table 152 – CP 14/3: Performance indicator overview	168
Table 153 – CP 14/3: Performance indicator dependency matrix.....	169
Table 154 – CP 14/3: Consistent set of performance indicators	171
Table 155 – CP 14/3: Consistent set of performance indicators	172
Table 156 – CP 14/3: Consistent set of performance indicators	172
Table 157 – CP 15/1: AL service selection.....	174
Table 158 – CP 15/1: AL protocol selection	174
Table 159 – CP 15/1: Performance indicator overview	174
Table 160 – CP 15/1: Performance indicator dependency matrix.....	175
Table 161 – CP 15/2: AL service selection.....	179
Table 162 – CP 15/2: AL protocol selection	179
Table 163 – CP 15/2: Performance indicator overview	179
Table 164 – CP 15/2: Performance indicator dependency matrix.....	180
Table 165 – CP 16/3: DLL service selection.....	184
Table 166 – CP 16/3: DLL protocol selection	184
Table 167 – CP 16/3: AL service selection.....	184
Table 168 – CP 16/3: AL protocol selection	185
Table 169 – CP 16/3: Performance indicator overview	185
Table 170 – CP 16/3: Performance indicator dependency matrix.....	186
Table 171 – CP 16/3: scenario with a minimum cycle time of 31,25 µs.....	189
Table 172 – CP 16/3: scenario with a cycle time of 500 µs (real-time only)	190
Table 173 – CP 16/3: Scenario with a cycle time of 500 µs (real-time and non-real-time)....	190
Table 174 – CP 16/3: scenario with non symmetrical data throughput and a cycle time of 500 µs (real-time and non-real-time).....	191
Table 175 – CPF 17: Overview of profile sets	191
Table 176 – CP 17/1: DLL service selection.....	192
Table 177 – CP 17/1: DLL protocol selection	192
Table 178 – CP 17/1: AL service selection.....	193
Table 179 – CP 17/1: AL protocol selection	193
Table 180 – CP 17/1: Performance indicator overview	193
Table 181 – CP 17/1: Performance indicator dependency matrix.....	194
Table 182 – Consistent set of PIs small size automation system.....	197
Table 183 – Parameters for Calculation of Consistent set of performance indicators.....	197
Table 184 – CP 18/1: DLL service selection.....	199
Table 185 – CP 18/1: DLL protocol selection	200
Table 186 – CP 18/1: AL service selection.....	201

Table 187 – CP 18/1: AL protocol selection 201

Table 188 – CP 18/1: Performance indicator overview 202

Table 189 – CP 18/1: Performance indicator dependency matrix..... 202

Table 190 – CP 18/2: DLL service selection..... 205

Table 191 – CP 18/2: DLL protocol selection 206

Table 192 – CP 18/2: AL service selection..... 207

Table 193 – CP 18/2: AL protocol selection 208

Table 194 – CP 18/2: Performance indicator overview 208

Table 195 – CP 18/2: Performance indicator dependency matrix..... 209

INTRODUCTION

This part of IEC 61784 provides additional Communication Profiles (CP) to the existing Communication Profile Families (CPF) of IEC 61784-1 and additional CPFs with one or more CPs. These profiles meet the industrial automation market objective of identifying Real-Time Ethernet (RTE) communication networks coexisting with ISO/IEC 8802-3 – commonly known as Ethernet. These RTE communication networks use provision from ISO/IEC 8802-3 for the lower communication stack layers and additionally provide more predictable and reliable real-time data transfer and means for support of precise synchronization of automation equipment.

More specifically, these profiles help to correctly state the compliance of RTE communication networks with ISO/IEC 8802-3, and to avoid the spreading of divergent implementations.

Adoption of Ethernet technology for industrial communication between controllers and even for communication with field devices promotes use of Internet technologies in the field area. This availability would be unacceptable if it causes the loss of features required in the field area for industrial communication automation networks, such as:

- real-time,
- synchronized actions between field devices like drives,
- efficient, frequent exchange of very small data records.

These new RTE profiles may take advantage of the improvements of Ethernet networks in terms of transmission bandwidth and network span.

Another implicit but essential requirement is that the typical Ethernet communication capabilities, as used in the office world, are fully retained, so that the software involved remains applicable.

The market is in need of several network solutions, each with different performance characteristics and functional capabilities, matching the diverse application requirements. RTE performance indicators (see Clause 5), which values will be provided with RTE devices based on communication profiles specified in this part of IEC 61784, enable the user to match network devices with application dependant performance requirements of an RTE network.

Subclause 5.1 specifies basic principles of performance indicators required to express RTE performance of a CP. Subclause 5.2 describes the view of application requirements. An application-dependant class could be used to find out a suitable CP. Clause 4 specifies how conformance of a device to the CPF or CP should be stated.

INDUSTRIAL COMMUNICATION NETWORKS – PROFILES –

Part 2: Additional fieldbus profiles for real-time networks based on ISO/IEC 8802-3

1 Scope

This part of IEC 61784 specifies

- performance indicators supporting classification schemes for Real-Time Ethernet (RTE) requirements;
- profiles and related network components based on ISO/IEC 8802-3, IEC 61158 series, and IEC 61784-1;
- RTE solutions that are able to run in parallel with ISO/IEC 8802-3-based applications.

These communication profiles are called Real-Time Ethernet communication profiles.

NOTE The RTE communication profiles use ISO/IEC 8802-3 communication networks and its related network components or IEC 61588 and may in some cases amend those standards to obtain RTE features.

2 Normative references

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

IEC 61158-2:2010, *Industrial communication networks – Fieldbus specifications – Part 2: Physical layer specification and service definition*

IEC 61158-3-2:2007, *Industrial communication networks – Fieldbus specifications – Part 3-2: Data-link layer service definition – Type 2 elements*

IEC 61158-3-4:2007, *Industrial communication networks – Fieldbus specifications – Part 3-4: Data-link layer service definition – Type 4 elements*

IEC 61158-3-7:2007, *Industrial communication networks – Fieldbus specifications – Part 3-7: Data-link layer service definition – Type 7 elements*

IEC 61158-3-11:2007, *Industrial communication networks – Fieldbus specifications – Part 3-11: Data-link layer service definition – Type 11 elements*

IEC 61158-3-12:2010, *Industrial communication networks – Fieldbus specifications – Part 3-12: Data-link layer service definition – Type 12 elements*

IEC 61158-3-13:2007, *Industrial communication networks – Fieldbus specifications – Part 3-13: Data-link layer service definition – Type 13 elements*

IEC 61158-3-14:2010, *Industrial communication networks – Fieldbus specifications – Part 3-14: Data-link layer service definition – Type 14 elements*

IEC 61158-3-15:2007, *Industrial communication networks – Fieldbus specifications – Part 3-15: Data-link layer service definition – Type 15 elements*

- IEC 61158-3-17:2007, *Industrial communication networks – Fieldbus specifications – Part 3-17: Data-link layer service definition – Type 17 elements*
- IEC 61158-3-19:2010, *Industrial communication networks – Fieldbus specifications – Part 3-19: Data-link layer service definition – Type 19 elements*
- IEC 61158-3-21:2010, *Industrial communication networks – Fieldbus specifications – Part 3-21: Data-link layer service definition – Type 21 elements*
- IEC 61158-3-22:2010, *Industrial communication networks – Fieldbus specifications – Part 3-22: Data-link layer service definition – Type 22 elements*
- IEC 61158-4-2:2010, *Industrial communication networks – Fieldbus specifications – Part 4-2: Data-link layer protocol specification – Type 2 elements*
- IEC 61158-4-4:2007, *Industrial communication networks – Fieldbus specifications – Part 4-4: Data-link layer protocol specification – Type 4 elements*
- IEC 61158-4-11:2010, *Industrial communication networks – Fieldbus specifications – Part 4-11: Data-link layer protocol specification – Type 11 elements*
- IEC 61158-4-12:2010, *Industrial communication networks – Fieldbus specifications – Part 4-12: Data-link layer protocol specification – Type 12 elements*
- IEC 61158-4-13:2007, *Industrial communication networks – Fieldbus specifications – Part 4-13: Data-link layer protocol specification – Type 13 elements*
- IEC 61158-4-14:2010, *Industrial communication networks – Fieldbus specifications – Part 4-14: Data-link layer protocol specification – Type 14 elements*
- IEC 61158-4-17:2007, *Industrial communication networks – Fieldbus specifications – Part 4-17: Data-link layer protocol specification – Type 17 elements*
- IEC 61158-4-19:2010, *Industrial communication networks – Fieldbus specifications – Part 4-19: Data-link layer protocol specification – Type 19 elements*
- IEC 61158-4-21:2010, *Industrial communication networks – Fieldbus specifications – Part 4-21: Data-link layer protocol specification – Type 21 elements*
- IEC 61158-4-22:2010, *Industrial communication networks – Fieldbus specifications – Part 4-22: Data-link layer protocol specification – Type 22 elements*
- IEC 61158-5-2:2010, *Industrial communication networks – Fieldbus specifications – Part 5-2: Application layer service definition – Type 2 elements*
- IEC 61158-5-4:2007, *Industrial communication networks – Fieldbus specifications – Part 5-4: Application layer service definition – Type 4 elements*
- IEC 61158-5-9:2007, *Industrial communication networks – Fieldbus specifications – Part 5-9: Application layer service definition – Type 9 elements*
- IEC 61158-5-10:2010, *Industrial communication networks – Fieldbus specifications – Part 5-10: Application layer service definition – Type 10 elements*
- IEC 61158-5-11:2007, *Industrial communication networks – Fieldbus specifications – Part 5-11: Application layer service definition – Type 11 elements*

IEC 61158-5-12:2010, *Industrial communication networks – Fieldbus specifications – Part 5-12: Application layer service definition – Type 12 elements*

IEC 61158-5-13:2007, *Industrial communication networks – Fieldbus specifications – Part 5-13: Application layer service definition – Type 13 elements*

IEC 61158-5-14:2010, *Industrial communication networks – Fieldbus specifications – Part 5-14: Application layer service definition – Type 14 elements*

IEC 61158-5-15:2010, *Industrial communication networks – Fieldbus specifications – Part 5-15: Application layer service definition – Type 15 elements*

IEC 61158-5-17:2007, *Industrial communication networks – Fieldbus specifications – Part 5-17: Application layer service definition – Type 17 elements*

IEC 61158-5-19:2010, *Industrial communication networks – Fieldbus specifications – Part 5-19: Application layer service definition – Type 19 elements*

IEC 61158-5-21:2010, *Industrial communication networks – Fieldbus specifications – Part 5-21: Application layer service definition – Type 21 elements*

IEC 61158-5-22:2010, *Industrial communication networks – Fieldbus specifications – Part 5-22: Application layer service definition – Type 22 elements*

IEC 61158-6-2:2010, *Industrial communication networks – Fieldbus specifications – Part 6-2: Application layer protocol specification – Type 2 elements*

IEC 61158-6-4:2007, *Industrial communication networks – Fieldbus specifications – Part 6-4: Application layer protocol specification – Type 4 elements*

IEC 61158-6-10:2010, *Industrial communication networks – Fieldbus specifications – Part 6-10: Application layer protocol specification – Type 10 elements*

IEC 61158-6-11:2007, *Industrial communication networks – Fieldbus specifications – Part 6-11: Application layer protocol specification – Type 11 elements*

IEC 61158-6-12:2010, *Industrial communication networks – Fieldbus specifications – Part 6-12: Application layer protocol specification – Type 12 elements*

IEC 61158-6-13:2007, *Industrial communication networks – Fieldbus specifications – Part 6-13: Application layer protocol specification – Type 13 elements*

IEC 61158-6-14:2010, *Industrial communication networks – Fieldbus specifications – Part 6-14: Application layer protocol specification – Type 14 elements*

IEC 61158-6-15:2010, *Industrial communication networks – Fieldbus specifications – Part 6-15: Application layer protocol specification – Type 15 elements*

IEC 61158-6-17:2007, *Industrial communication networks – Fieldbus specifications – Part 6-17: Application layer protocol specification – Type 17 elements*

IEC 61158-6-19:2010, *Industrial communication networks – Fieldbus specifications – Part 6-19: Application layer protocol specification – Type 19 elements*

IEC 61158-6-21:2010, *Industrial communication networks – Fieldbus specifications – Part 6-21: Application layer protocol specification – Type 21 elements*

- IEC 61158-6-22:2010, *Industrial communication networks – Fieldbus specifications – Part 6-22: Application layer protocol specification – Type 22 elements*
- IEC 61588:2009, *Precision clock synchronization protocol for networked measurement and control systems*
- IEC 61784-1:2010, *Industrial communication networks – Profiles – Part 1: Fieldbus profiles*
- IEC 61784-5-2:2010, *Industrial communication networks – Profiles – Part 5-2: Installation of fieldbuses – Installation profiles for CPF 2*
- IEC 61784-5-3:2010, *Industrial communication networks – Profiles – Part 5-3: Installation of fieldbuses – Installation profiles for CPF 3*
- IEC 61784-5-6:2010, *Industrial communication networks – Profiles – Part 5-6: Installation of fieldbuses – Installation profiles for CPF 6*
- IEC 61784-5-11:2010, *Industrial communication networks – Profiles – Part 5-11: Installation of fieldbuses – Installation profiles for CPF 11*
- IEC 61918:2010, *Industrial communication networks – Installation of communication networks in industrial premises*
- ISO/IEC 8802-2, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 2: Logical link control*
- ISO/IEC 8802-2/Cor. 1
- ISO/IEC 8802-3:2000, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*
- ISO/IEC 8802-11, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications*
- ISO 15745-3, *Industrial automation systems and integration – Open systems application integration framework – Part 3: Reference description for IEC 61158-based control systems*
- ISO 15745-4:2003, *Industrial automation systems and integration – Open systems application integration framework – Part 4: Reference description for Ethernet-based control systems*
- Amendment 1 (2006): PROFINET profiles*
- IEEE 802.1AB, *IEEE Standard for Local and metropolitan area networks Station and Media Access Control Connectivity Discovery*
- IEEE 802.1D, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – IEEE standard for local and metropolitan area networks – Common specifications – Media access control (MAC) Bridges*
- IEEE 802.1Q *IEEE Standard for Information technology – Telecommunications and information exchange between systems – IEEE standard for Local and metropolitan area networks – Virtual bridged local area networks*

IEEE 802.3-2002: *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications*

NOTE 1 Compliance with future editions of this standard will need checking.

NOTE 2 IEEE 802.3-2002 includes extensions to ISO/IEC 8802-3:2000. When a next edition of ISO/IEC 8802-3 is available the references to IEEE 802.3-2002 will be replaced if appropriate.

IEEE Std 802.3ab, *Information technology – telecommunications and information exchange between systems – local and metropolitan area networks – Specific requirements. Supplement to Carrier Sense Multiple Access with Collision Detection (CSMA/CD) access method and physical layer specifications – Physical layer parameters and specifications for 1000 Mb/s operation over 4-pair of category 5 balanced copper cabling, type 1000BASE-T*

IEEE Std 802.11g, *IEEE Standard for Information technology— Telecommunications and information exchange between systems— Local and metropolitan area networks— Specific requirements — Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications – Amendment 4: Further higher data rate extension in the 2,4 GHz band*

IEEE Std 802.11h, *IEEE Standard for Information technology — Telecommunications and information exchange between systems — Local and metropolitan area networks — Specific requirements — Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications – Amendment 5: Spectrum and transmit power management extensions in the 5 GHz band in Europe*

IEEE Std 802.11e, *IEEE Standard for Information technology — Telecommunications and information exchange between systems — Local and metropolitan area networks — Specific requirements — Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications – Amendment 8: Medium Access Control (MAC) quality of service enhancements*

IEEE Std 802.11i, *IEEE Standard for Information technology — Telecommunications and information exchange between systems — Local and metropolitan area networks— Specific requirements — Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications – Amendment 6: Medium Access Control (MAC) security enhancements*

IEEE Std 802.15.1, *IEEE Standard for Information technology— Telecommunications and information exchange between systems — Local and metropolitan area networks — Specific requirements — Part 15: Wireless medium access control (MAC) and physical layer (PHY) specifications for wireless personal area networks (WPANs)*

IETF RFC 768, *User Datagram Protocol*, available at <<http://www.ietf.org>>

IETF RFC 791, *Internet Protocol*, available at <<http://www.ietf.org>>

IETF RFC 792, *Internet Control Message Protocol*, available at <<http://www.ietf.org>>

IETF RFC 793, *Transmission Control Protocol*, available at <<http://www.ietf.org>>

IETF RFC 826, *Ethernet Address Resolution Protocol*, available at <<http://www.ietf.org>>

IETF RFC 894, *A standard for the Transmission of IP Datagrams over Ethernet Networks*, available at <<http://www.ietf.org>>

IETF RFC 1112, *Host Extensions for IP Multicasting*, available at <<http://www.ietf.org>>

IETF RFC 1122, *Requirements for Internet Hosts – Communication Layers*, available at <<http://www.ietf.org>>

IETF RFC 1123, *Requirements for Internet Hosts – Application and Support*, available at <<http://www.ietf.org>>

IETF RFC 1127, *A Perspective on the Host Requirements RFCs*, available at <<http://www.ietf.org>>

IETF RFC 1213, *Management Information Base for Network Management of TCP/IP-based internets: MIB-II*, available at <<http://www.ietf.org>>

IETF RFC 1305, *Network Time Protocol (Version 3)*, available at <<http://www.ietf.org>>

IETF RFC 2131, *Dynamic Host Configuration Protocol*, available at <<http://www.ietf.org>>

IETF RFC 2236, *Internet Group Management Protocol, Version 2*, available at <<http://www.ietf.org>>

IETF RFC 2544, *Benchmarking Methodology for Network Interconnect Devices*, available at <<http://www.ietf.org>>

IETF RFC 2988, *Computing TCP's Retransmission Timer*, available at <<http://www.ietf.org>>

Open Software Foundation (OSF): C706, *CAE Specification DCE1.1: Remote Procedure Call*, available at <<http://www.opengroup.org/onlinepubs/9629399/toc.htm>>

3 Terms, definitions, abbreviated terms, acronyms, and conventions

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 8802-3 and IEEE 802.1D, as well as the following, apply.

3.1.1

active network

network in which data transmission between non-immediately-connected devices is dependent on active elements within those intervening devices that form the connection path [IEC 61918:2010]

3.1.2

communication cycle

<CPF 16>

fixed time period between two master synchronization telegrams

3.1.3

cyclic

repetitive in a regular manner

3.1.4

domain

<CPF 10>

part of the network consisting of one or two subnetwork(s)

NOTE Two subnetworks are required to compose a dual-redundant network, and each end-station in the domain is connected to both of the subnetworks.

3.1.5

end-station

a system attached to a network that is an initial source or a final destination of MAC frames transmitted across that network

NOTE A network layer router is, from the perspective of the network, an end-station. A switch, in its role of forwarding MAC frames from one link to another, is not an end-station.

3.1.6

field area

place in a manufacturing or process site where field devices are located

3.1.7

frame

a unit of data transmission on an ISO/IEC 8802-3 MAC (Media Access Control) that conveys a protocol data unit (PDU) between MAC service users
[IEEE Std. 802.1Q]

3.1.8

identification number (IDN)

<CPF 16>

designation of operating data under which a data block is preserved with its attribute, name, unit, minimum and maximum input values, and the data

3.1.9

IP channel

<CPF 16>

defined time slot within the communication cycle, which passes ISO/IEC 8802-3 Ethernet protocol frames (non-real-time communication)

3.1.10

jitter

temporal change in clock signal or temporal change in otherwise regular event

3.1.11

linear topology

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

[IEC 61918:2010]

3.1.12

link

transmission path between two adjacent nodes

[derived from ISO/IEC 11801]

3.1.13

logical double line

<CPF 18>

sequence of root device and all ordinary devices processing the DLPDU in forward and backward direction

3.1.14

master

<CPF 16>

node which assigns the other nodes the right to transmit

3.1.15

message

ordered series of octets intended to convey information

[derived from ISO 2382-16.02.01]

NOTE Normally used to convey information between peers at the application layer.

3.1.16

MDT0 telegram

<CPF 16>

telegram, in which the master transmits its synchronization data, as well as parts or all of its real-time data, to the slaves

3.1.17

node

network entity connected to one or more links

NOTE A node may be either a switch, an end-station or an RTE end-station.

3.1.18

packet

logical grouping of information used to describe a unit of data at any layer to convey the upper layer user data to its peer layer

NOTE A packet is identical to the PDU at each layer in terms of the OSI reference model. A data-link layer packet is a frame.

3.1.19

real-time

the ability of a system to provide a required result in a bounded time

3.1.20

real-time communication

transfer of data in real time

3.1.21

Real-Time Ethernet (RTE)

ISO/IEC 8802-3-based network that includes real-time communication

NOTE 1 Other communication can be supported, providing the real-time communication is not compromised.

NOTE 2 This definition is dedicated but not limited to ISO/IEC 8802-3. It could be applicable to other IEEE 802 specifications, for example IEEE 802.11.

3.1.22

real time frame line (RTFL)

<CPF 18>

communication model with devices communicating in a logical double line

3.1.23

real time frame network (RTFN)

<CPF 18>

communication model with devices communicating in a switched network

3.1.24

ring

active network where each node is connected in series to two other nodes
[IEC 61918:2010]

NOTE Ring may also be referred to as loop.

3.1.25

router

<CPF 10>

intermediate equipment that connects two or more subnetworks using a network layer relay function

3.1.26

RTE end device

device with at least one RTE end-station

3.1.27

RTE end-station

end-station with RTE capability

3.1.28

schedule

temporal arrangement of a number of related operations

3.1.29

star

network of three or more devices where all devices are connected to a central point
[derived from IEC 61918:2010]

3.1.30

subnetwork

<CPF 10>

part of a network that does not contain any routers

NOTE 1 A subnetwork consists of end-stations, bridges and segments.

NOTE 2 Every end-station included in a subnetwork has the same IP network address.

3.1.31

switch

MAC bridge as defined in IEEE 802.1D

3.1.32

telegram

<CPF 16>

frame

3.2 Abbreviated terms and acronyms

AL	Application Layer
APDU	Application Protocol Data Unit
API	Application Process Identifier
AR	Application Relationship
ARP	Address Resolution Protocol
ASE	Application Service Elements
CP	Communication Profile [according to IEC 61784-1:2010]
CPF	Communication Profile Family [according to IEC 61784-1:2010]
CRC	Cyclic Redundancy Check

CSMA-CD	Carrier Sense Multiple Access with Collision Detection
DA	Destination MAC Address
DHCP	Dynamic Host Configuration Protocol (see RFC 2131)
DL	Data-Link layer (as a prefix)
DLL	DL-Layer
DNS	Domain Name Service
DUT	Device under test
ECSME	EPA Communication Scheduling Management Entity
FA	Factory Automation
FCS	Frame check sequence
FrameID	Frame Identifier (see IEC 61158-6-10:2010)
GSD	General station description
HW	Hardware
IANA	Internet Assigned Numbers Authority
ICMP	Internet Control Message Protocol (see RFC 792)
ID	Identifier
IDN	IDentification Number
IETF	Internet Engineering Task Force
IO	Input Output
IP	Internet Protocol (see RFC 791)
IPv4	Internet Protocol version 4 (see RFC 791)
IRT	Isochronous RT
LAN	Local Area Network
LLC	Logical Link Control
LLDP	Link Layer Discovery Protocol (see IEEE 802.1-AB)
MAC	Media Access Control
MAC	Media Access Control (see ISO/IEC 8802.3)
Mbit/s	Million bits per second
Moctets/s	Million octets per second
MCR	Multicast communication relation
MIB	Management Information base
MRP	Medium redundancy protocol
MRPD	Media redundancy for planned duplication
ms	milli seconds
n.a.	Not applicable
NoS	Number of Switches

NRT	Non-real-time
PDU	Protocol Data Unit
PhL	Physical Layer
Phy	PHY Physical layer entity sublayer (see ISO/IEC 8802.3)
PI	Performance indicator
pps	Packets per second
PTCP	Precision Transparent Clock Protocol
PTP	Precision Time Protocol [IEC 61588]
RPC	Remote Procedure Call
RSTP	Rapid Spanning Tree Algorithm and protocol (see IEEE 802.1D)
RT	Real-time
RTA	Real-time protocol acyclic
RTE	Real-time Ethernet
RT-Ethernet	Real-time Ethernet
RTFL	Real time frame line
RTFN	Real time frame network
RTO	Retransmission Time Out [according to RFC 2988 - Computing TCP's Retransmission Timer]
RTPS	Real-Time Publish-Subscribe
SERCOS	SErial Real time COmmunication System
SNMP	Simple Network Management Protocol (see RFC 1213)
TCC	Time-Critical Cyclic
TCP	Transmission Control Protocol (see RFC 793)
TOS	Type of Service
UDP	User Datagram Protocol (see RFC 768)
VLAN	Virtual LAN

3.3 Symbols

3.3.1 CPF 2 symbols

Symbol	Definition	Unit
APDUsize	Size of the application protocol data unit per CP 2/2 connection	octets
CD	Cable segment delay	μs
CL	Cable segment length	m
DT	Delivery time	μs
EN_NRTE_PR	End-station non-RTE packet rate per CP 2/2 connection	pps
EN_RTE_PR	End-station RTE packet rate per CP 2/2 connection	pps
EN_PR	End-station packet rate	pps
EN_PR_MAX	End-station maximum packet rate	pps
EN_TNRTE_PR	End-station total non-RTE packet rate in pps	pps
EN_TRTE_PR	End-station total RTE packet rate	pps
k	Number of CP 2/2 connections supported by the end-station	—
m	Number of CR 2/2 non-RTE connections	—
n	Number of switches between sending and receiving end-stations	—
p	Number of CR 2/2 RTE connections	—
NRTE_BW	Non-RTE bandwidth	%
PD	Cable propagation delay	n/m
SD _r	Receiver stack delay	μs
SD _s	Sender stack delay	μs
SL	Switch latency	μs
SPD	Switch processing delay	μs
T _{x_packet}	Packet transmit time	μs

3.3.2 CPF 3 symbols

Symbol	Definition	Unit
cd	Cable delay (see attribute cable_delay in IEC 61158-5-10)	s
clt	Total cable length	m
cta_R	Application cycle time of the Receiver	s
cta_S	Application cycle time of the Sender	s
ctc	Communication cycle time	s
ctc	Communication cycle time	s
data	Complete Ethernet frame	octets
data_request	Requested RTE throughput	octets/s
data_RTE	Actual RTE throughput	octets/s
DT	Delivery time	s
endStations	Number of end-stations	—
EthernetDataRate	Ethernet data rate of the network	Mbit/s
MAC_delay	Delay on MAC layer	s
NonRTE	Percentage of non-RTE bandwidth	%
NoS	Number of switches	—
od	Other delays, e. g. signal forwarding in a ring	s
pd	Propagation delay	s
Phy_R_delay	Phy delay on receiver side	s
Phy_S_delay	Phy delay on sender side	s
protocolRTE	Percentage of protocol time	s
Queue_delay	Queue delay in a switch	s
RM	Time needed for management functions to support redundancy	s
RR	Attribute Reduction Ratio (see IEC 61158-5-10)	—
SCF	Attribute Send Clock Factor (see IEC 61158-5-10)	—
STTr	Receiver stack traversal time including Phy and MAC	s
STTs	Sender stack traversal time including Phy and MAC	s
Throughput_RTE	Throughput RTE	octets/s
Time_synchron_accuracy	Time synchronization accuracy	s
tt	Transfer time	s

3.3.3 CPF 4 symbols

Symbol	Definition	Unit
cd	Cable delay (Maximum on 100m)	μs
DT	Delivery time	μs
DTb	Delivery time, calculated by best-case values	μs
DTw	Delivery time, calculated by worst-case values	μs
FS	Number of frames allowed to be sent per second for one RTE end-station	—
NoAS	Number of accesses allowed per device per second	—
NoCEN	Number of RTE end-stations which can produce frames on the critical switch-to-switch link	—
NoNs[x]	Number of RTE end-stations connected to switch number x	—
NoNt	Number of RTE end-stations, in total	—
NoS	Number of switches in path from sender to receiver	—
pd	Propagation delay within a switch. Required minimum value	μs
QTES	Ethernet enforced quiet time on end-station to switch link	μs
QTSS	Ethernet enforced quiet time on switch-to-switch link	μs
STTr	Receiver stack transversal time including Phy and MAC	μs
STTs	Sender stack transversal time including Phy and MAC	μs
ttES	P-NET transfer time RTE end-station to switch (at maximum APDU size)	μs
ttESmin	P-NET transfer time RTE end-station to switch (at min APDU size)	μs
ttSS	P-NET transfer time switch-to-switch (at maximum APDU size)	μs

3.3.4 CPF 6 symbols

Symbol	Definition	Unit
DTLD	Total delivery time between a Type 8 slave and a Type 10 entity	μs
DT10	Delivery time of the Type 10 network	μs
Cta_M	Application cycle time of the mapping application in the linking-device	—
M	Type 8 Master implementation factor	—
n	Number of data octets (user data; payload)	octets
sl8	Number of Type 8 slaves connected to the linking-device	—
T _{bit}	Nominal bit duration (see 27.2 in IEC 61158-2:2010)	μs
t _s	Software processing time of the Type 8 master (application specific)	μs

3.3.5 CPF 10 symbols

Symbol	Definition	Unit
Cdly	Cable delay	μs
Clen	Cable length	m
Dlen	Length of the complete Ethernet frame	bit
DT	Delivery time	μs
DTlost1	maximum delivery time with one lost frame for communication between two end-stations belonging to the same domain	μs
DTlost2	maximum delivery time with one lost frame for communication between two end-stations belonging to different domains	μs
DTmax1	maximum delivery time for communication between two end-stations belonging to the same domain	μs
DTmax2	maximum delivery time for communication between two end-stations belonging to different domains	μs
NoS	Number of switches in path from sender to receiver	—
Spd	Switch delay under not congested condition	μs
STTr	Receiver stack transversal time including PhL, DLL and AP	μs
STTs	Sender stack transversal time including PhL, DLL and AP	μs
Trate	Transfer bit rate	Mbit/s

3.3.6 CPF 11 symbols

Symbol	Definition	Unit
BW _{CNT}	Bandwidth used both for the communication scheduling and the protocol overhead	%
BW _{NRT}	Bandwidth used for the non-RTE communications	%
BW _{RTE}	Bandwidth used for the RTE communications	%
cd	Cable delay	μs
cdl	Cable length total	km
ct	Cycle time	ms
data	Complete Ethernet frame	—
DT _H	Delivery time of the high-speed cyclic data, which includes both the sender stack traversal time (STTs) and the receiver stack traversal time (STTr) including Phy and MAC	ms
DT _L	Delivery time of the low-speed cyclic data, which includes both the sender stack traversal time (STTs) and the receiver stack traversal time (STTr) including Phy and MAC	ms
DT _M	Delivery time of the medium-speed cyclic data, which includes both the sender stack traversal time (STTs) and the receiver stack traversal time (STTr) including Phy and MAC	ms
DV _{HS}	Total volume of the high-speed cyclic data	octets
DV _{LS}	Total volume of the low-speed cyclic data	octets
DV _{MS}	Total volume of the medium-speed cyclic data	octets
NoS	Number of switches	—
od	Other delays	μs
pd	Propagation delay	μs
STTs	Sender stack traversal time including Phy and MAC	μs
STTr	Receiver stack traversal time including Phy and MAC	μs
T _h	The high-speed transmission time period - the basic cycle_time (ct) of the TCC data service	ms

T_{HS}	Total sum of the frame transmit time, in which the TCC data frame conveys the high-speed cyclic data	μs
T_I	The Low-speed transmission time period	ms
T_{LS}	Total sum of the frame transmit time, in which the TCC data frame conveys the Low-speed Cyclic data	μs
T_m	The Medium-speed transmission time period	ms
T_{MAC}	Time for the maintenance and control, in which a new end-station is solicited to join and the periodic time operation is controlled	μs
T_{MS}	Total sum of the frame transmit time, in which the TCC data frame conveys the medium-speed cyclic data	μs
T_{NRT}	Total sum of the frame transmit time, in which the frame, with the non-RTE data as a payload, is sent out of the end-station within the time period of T_h and is used for the standard Ethernet application on sporadic basis	μs
TR_{HS}	Throughput RTE of the high-speed cyclic data	Moctets/s
TR_{LS}	Throughput RTE of the low-speed cyclic data	Moctets/s
TR_{MS}	Throughput RTE of the medium-speed cyclic data	Moctets/s
TR_{RTE}	Throughput RTE, and the sum of TR_{HS} , TR_{LS} and TR_{MS}	Moctets/s
T_{RTE}	Total sum of the frame transmit time, in which the frame, with the RTE data as a payload of a fixed length, is sent out of the end-station within the time period of T_h	μs
T_{SCH}	Total sum of the frame transmit time for the transmission scheduling	μs
tt	Transfer time	μs

3.3.7 CPF 12 symbols

Symbol	Definition	Unit
l_{tc}	Total cable length	m
NoS	Number of slaves	
Pd	Propagation delay	μs
t_{cd}	Cable delay	$\mu s/m$
t_{cpdl}	Data copy delay within a slave	μs
t_{cycle}	Cycle time	μs
t_D	Delivery time	μs
t_{data}	Time to transmit the longest real-time Ethernet frame	μs

3.3.8 CPF 13 symbols

Symbol	Definition	Unit
B_{NRTE}	Non-RTE bandwidth	%
M	Network MTU (maximum transmission unit)	octets
N	Number of RTE end-stations processed in one communication cycle	—
T_A	Time reserved for non-RTE data within one communication cycle	μs
T_C	Communication cycle time	μs
T_D	Delivery time	μs
$T_{FT,i}$	RTE frames transmission time for RTE end-station i	μs
T_P	Processing time in the receiving end-station	μs
$T_{RD,i}$	Response delay of the RTE end-station i	μs
T_S	Communication cycle start delay	μs
$T_{SD,i}$	Sum of all delays of infrastructure components (switches, hubs, cabling) for the RTE end-station i	μs

3.3.9 CPF 14 symbols

Symbol	Definition	Unit
DT	Delivery time	μs
D_size	Data size	octets
LCable	Cable length	m
Ndata	Length of complete Ethernet frame	octets
NRTE_BW	Non-RTE bandwidth	%
NSwitch	Number of switches between end-stations	
RateofEthernet	Ethernet data rate	Mbit/s
RMDData	Redundancy management data	octets
RTEDData	Real-time data	octets
TApp_R	Receiver stack processing time including Phy and MAC	μs
TCable	Cable delay	μs
TD_Sw	Time delay in switch	μs
TEthernet_S	Sender traversal time through MAC and Phy based on ISO/IEC 8802-3	μs
ThroughputRTE	RTE throughput	octets/s
TQueue_S	Sender queuing delay	μs
TSData	Time synchronization data	octets
TStack_S	Sender stack processing time	μs
TSwitch	Switch delay	μs
TTrf_S	Transfer time for one octet	μs
T_wire	Time per octet on a wire segment	μs
STT_s	Stack traversal time of the sender	μs
STT_r	Stack traversal time of the receiver	μs

3.3.10 CPF 15 symbols

Symbol	Definition	Unit
D_size	Data size	octets
DT	Delivery time	μs
DT_lf	Delivery time when a frame is lost	μs
DT_lfh	Delivery time when a frame is lost and the configuration is reliable with heartbeat	μs
DT_lfp	Delivery time when a frame is lost and the configuration is reliable periodic	μs
DT_n	Delivery time for the NACK message	μs
H	Period of the heartbeat, which is a configured parameter	μs
N_Sw	Number of switches between end-stations	—
RTO	TCP retransmission time out parameter	μs
STT_r	Stack traversal time of the receiver	μs
STT_r1	Part of the stack traversal time of the receiver that is independent of D-size	μs
STT_r2	Part of the stack traversal time of the receiver that depends linearly on D_size	μs
STT_s	Stack traversal time of the sender	μs
STT_s1	Part of the stack traversal time of the sender that is independent of D_size	μs
STT_s2	Part of the stack traversal time of the sender that depends linearly on D_size	μs
T	Period, which is a configured parameter	μs
T_wire	Time per octet on a wire segment	μs
TD_Sw	Time delay in switch	μs

3.3.11 CPF 16 symbols

Symbol	Definition	Unit
ac	Non-time based synchronization accuracy	ns
cd	Cable delay	μs/m
clt	Total cable length	m
ct	Cycle_time configured for the network segment	μs
data	Data to be transmitted in one cycle (including the complete Ethernet frame)	bit
DT	Delivery time	μs
fr	Frame runtime	μs
ma	Synchronization accuracy of the master device	μs
mct	Minimum cycle time	ms
N	Integer value	—
nf	Number of frames	—
nn	Number of nodes	—
pd	Propagation delay (signal delay) of a forwarding node	μs
sa	Synchronization accuracy of one slave device	μs
st	Separation time per frame	μs
tt	Transfer time	μs

3.3.12 CPF 17 symbols

Symbol	Definition	Unit
APDUsize	Size of the application protocol data unit in octets	octets
BW _{N RTE}	Non-RTE bandwidth, in %	%
LDR	Link data rate in bit per seconds	bps
LTC	Total cable length in meter	m
M	Number packets in the port transmit queue of node i in front on of this packet	—
N	Number of nodes between sending and receiving end-stations	—
NF _{E/S_MAX}	Maximum number of frames allowed to be sent per second for one end station	pps
NF _{RTE/S}	Number of frames allowed to be sent per second for one RTE end station	pps
Posize	Size of the protocol overhead in octets	octets
T _{CPD}	Cable propagation delay time in microseconds	μs
T _{CPD/M}	cable propagation delay in nanoseconds per meter (depending on the characteristics of the selected cable)	ns/m
T _{DELAY}	Delivery time in microseconds	μs
T _{DELAY_MAX}	Maximum delivery time in microseconds	μs
T _{DELAY_MIN}	Minimum delivery time in microseconds	μs
Throughput_RTE	Throughput RTE	octets/s
Throughput_RTE _{MAX}	Maximum throughput RTE	octets/s
T _{NLD}	Node latency delay time in microseconds	μs
T _{NLD_i}	Node latency delay time of node i in microseconds	μs
T _{NPD}	Node propagation delay time in microseconds	μs
T _{NPD_i}	Node propagation delay time of node i in microseconds	μs
T _{PKT}	Packet transmit time in microseconds	μs
T _{PKT_i}	Packet transmit time of node i in microseconds	μs
T _{RCV}	Receiver stack traversal time including Phy and MAC in microseconds	μs
T _{SND}	Sender stack traversal time including Phy and MAC in microseconds	μs
T _{TX_PKT_ij}	packet transmit time of packet j in microseconds in the port transmit queue of node i in front on of this packet (depending on APDU size of node i)	μs
T _{TX_PKT_j}	packet transmit time of packet j in microseconds in the port transmit queue in front on of this packet (depending on APDU size of node i)	μs

3.3.13 CPF 18 symbols

Symbol	Definition	Unit
l_B	Distance along the cable in backward direction	m
l_C	Cable length	m
l_F	Distance along the cable in forward direction	m
NoDoB	Number of devices in backward direction	—
NoDoF	Number of devices in forward direction	—
NoS	Number of switching devices	—
t_{CD}	Cable delay	ns/m
t_{cyc}	Cycle time of communication system/relation	μs
t_D	Delivery time	μs
t_{data}	Transmit time of DLPDUs	μs
t_{pd}	Propagation delay	μs
t_{STsink}	Sink stack traversal time	μs
t_{STsrc}	Source stack traversal time	μs
t_{sw}	Delay time of a switch	μs

3.4 Conventions

3.4.1 Conventions common to all layers

3.4.1.1 (Sub)clause selection tables

(Sub)clause selection for all layers is defined in tables, as shown in Table 1 and Table 2. The selected base specifications are indicated just before the selection table(s). Selection is done at the highest (sub)clause level possible to define the profile selection unambiguously.

Table 1 – Layout of profile (sub)clause selection tables

Clause	Header	Presence	Constraints

Table 2 – Contents of (sub)clause selection tables

Column	Text	Meaning
Clause	<#>	(Sub)clause number of the base specifications
Header	<text>	(Sub)clause title of the base specifications
Presence	NO	This (sub)clause is not included in the profile
	YES	This (sub)clause is fully (100 %) included in the profile in this case no further detail is given
	—	Presence is defined in the following subclauses
	Partial	Parts of this (sub)clause are included in the profile
	Optional	This (sub)clause may be additionally included in the profile
Constraints	See <#>	Constraints/remarks are defined in the given subclause, table or figure of this profile document
	—	No constraints other than given in the reference document (sub)clause, or not applicable
	<text>	The text defines the constraint directly; for longer text table footnotes or table notes may be used

If sequences of (sub)clauses do not match the profile, then the numbers are concatenated.

EXAMPLE concatenated subclauses

3.4 – 3.7	—	NO	—
-----------	---	----	---

3.4.1.2 Service selection tables

If the selection of services is defined in a table, the format of Table 3 is used. The table identifies the selected services and includes service constraints, as explained in Table 4.

Table 3 – Layout of service selection tables

Service ref.	Service name	Usage	Constraint

Table 4 – Contents of service selection tables

Column	Text	Meaning
Service ref.	<#>	(Sub)clause number of the base specifications where the service is defined
	—	Not applicable
Service name	<text>	The name of the service
Usage	M	Mandatory
	O	Optional
	—	Service is never used
Constraints	See <#>	Constraints/remarks are defined in the given subclause, table or figure of this profile document
	—	No constraints other than those given in the reference document (sub)clause, or not applicable
	<text>	The text defines the constraint directly; for longer text table footnotes or table notes may be used

If selection of service parameters is defined in a table the format of Table 5 is used. Each table identifies the selected parameters and includes parameter constraints, as explained in Table 6.

Table 5 – Layout of parameter selection tables

Parameter ref.	Parameter name	Usage	Constraint

Table 6 – Contents of parameter selection tables

Column	Text	Meaning
Parameter ref.	<#>	(sub)clause number of the base specifications where the service is defined
	—	Not applicable
Parameter name	<text>	The name of the service parameter
Usage	M	Mandatory
	O	Optional
	—	Attribute is never present
Constraints	See <#>	Constraints/remarks are defined in the given subclause, table or figure of this profile document
	—	No constraints other than those given in the reference document (sub)clause, or not applicable
	<text>	The text defines the constraint directly; for longer text table footnotes or table notes may be used

3.4.2 Physical layer

No additional conventions are defined.

3.4.3 Data-link layer

3.4.3.1 Service profile conventions

No additional conventions are defined.

3.4.3.2 Service and parameter selections

These are described using the common conventions, see 3.4.1.2.

3.4.4 Application layer

3.4.4.1 Service profile conventions

ASE and class selection is described using (sub)clause selection tables, see 3.4.1.1. If the use of selected ASE and classes is further constrained this is specified in the profile (e.g. an optional item of the base standard is mandatory in the profile).

If the selection of class attributes is defined in a table the format of Table 7 is used. The table identifies the selected class attributes and includes their constraints, as explained in Table 8.

Table 7 – Layout of class attribute selection tables

Attribute	Attribute Name	Usage	Constraint

Table 8 – Contents of class attribute selection tables

Column	Text	Meaning
Attribute	<#>	Attribute number of the base specification class
	—	Not applicable
Attribute Name	<text>	The name of the attribute
Usage	M	Mandatory
	O	Optional
	—	Attribute is never present
Constraints	See <#>	Constraints/remarks are defined in the given subclause, table or figure of this profile document
	—	No constraints other than those given in the reference document (sub)clause, or not applicable
	<text>	The text defines the constraint directly; for longer text table footnotes or table notes may be used

3.4.4.2 Service and parameter selections

These are described using the common conventions, see 3.4.1.2.

4 Conformance to communication profiles

A statement of compliance with an RTE Communication Profile Family (CPF) Profile of this part of IEC 61784 shall be stated¹ as either

- Compliance to IEC 61784-2:2010 CPF n <Type>, or
- Compliance to IEC 61784-2 (Ed.2.0) CPF n <Type>.

¹ In accordance with ISO/IEC Directives

and a statement of compliance with a communication profile (CP) of this part of IEC 61784 shall be stated as either

- Compliance to IEC 61784-2:2010 CP n/n <Type>, or
- Compliance to IEC 61784-2 (Ed.2.0) CP n/n <Type>.

where the Type within the angle brackets < > is optional and the angle brackets are not to be included. Type could be any character string.

A conformance statement should be supported with appropriate documentation as defined in Clause 6.

5 RTE performance indicators

5.1 Basic principles of performance indicators

A network that includes real-time communication and is based on the ISO/IEC 8802-3 standard is called a Real-time Ethernet (RTE) network. Users of RTE networks have different requirements for different applications. In order to satisfy these requirements in an optimal way RTE communication networks complying with CPs described in this standard will exhibit different performance.

Performance indicators (specified in 5.3) shall be used to specify capabilities of an RTE end device and an RTE communication network as well as to specify requirements of an application. Performance indicators will be used as a set of interaction means between the user of the RTE CP and the manufacturer of RTE CP compliant RTE end devices and network components. Subclause 5.2 specifies the application requirements view.

Performance indicators represent

- a) capabilities of an RTE end device,
- b) capabilities of an RTE communication network,
- c) as well as requirements of an application.

A consistent set of performance indicators (specified in 5.3) is used to represent the RTE capabilities. Some of the performance indicators are interdependent; in this case some indicator values depend on the value of others to provide a consistent set.

NOTE The interdependence is due to physical or logical constraints, which cannot be violated. For example the indicator "Throughput RTE (which would use 90 % of the total bandwidth)" and "Throughput non-RTE (90 %)" cannot happen at the same time because that would describe a transmission load of 180 %.

No general boundary values to specify RTE performance are specified for the indicators in this standard, but device suppliers need to specify boundary values for a CP-based product if they claim to be compliant to this standard.

Technology specific CPF subclauses specify

- a) selection of performance indicators out of possible performance indicators defined in 5.3 relevant to a given CP, optionally with their individual limits or ranges,
- b) interdependence between performance indicators,
- c) optionally, lists with consistent performance indicators values.
Each of the lists has one or more leading performance indicators. The leading performance indicators are preset to a fixed value (typically optimized to have the best overall performance). The other performance indicators in the list are shown with their related consistency limits,
- d) optionally, a more comprehensive representation of the relation between performance indicators (Figure 1 shows an example of a graphical representation).

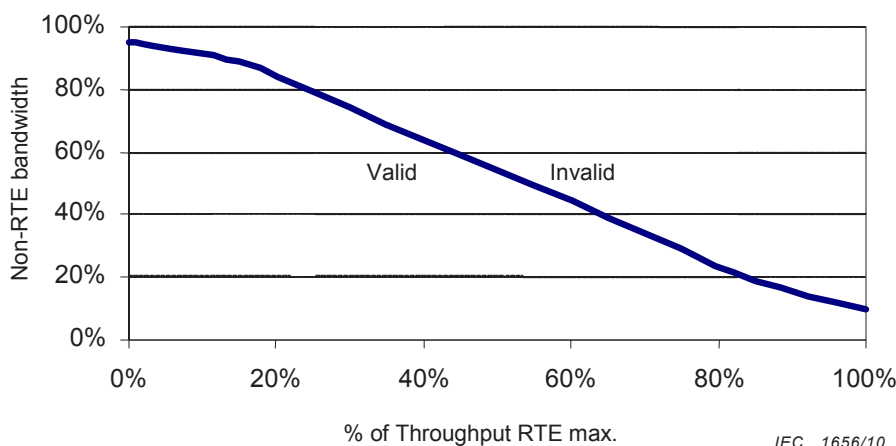


Figure 1 – Example of graphical representation of consistent indicators

The supplier of RTE end devices and RTE communication networks shall provide at least one consistent set of performance indicators. The boundary values given by the supplier should be based on conformance test principles specified in Clause 6.

NOTE 1 A set of lists with consistent performance indicators is only given when interdependence between performance indicators exists.

NOTE 2 Applications may have requirements where one particular indicator has higher importance than all the others. Such applications will find useful the opportunity to select the consistent indicator list with the relevant leading indicator. Other applications may have requirements where several indicators are of equally high importance. For such applications, a graphical or otherwise more comprehensive representation of the relation between consistent indicators is more appropriate. Figure 1 is an example of a graphical representation of consistent indicators given by a CP.

NOTE 3 RTE end devices are designed under the discretion of manufactures of such a device. Therefore no assumption could be made how many RTE end-stations (network interfaces) are build in one device. In order to achieve comparable performance indicators from the application perspective the performance indicators are build on RTE end-stations not on RTE devices.

5.2 Application requirements

The capabilities of an RTE communication network are specified in 5.3 as indicators. The indicators are used to match application requirements to the capabilities of components compliant to one or more CP(s) of this part of IEC 61784.

A profile is suitable if its indicator values at least meet the required indicator values.

NOTE 1 Sophisticated requirements are likely to find a smaller number of matching profiles.

NOTE 2 A principle for selecting the matching CP is described in ISO 15745-1.

NOTE 3 The application-dependent class should be a subset of a CP x/y to be suitable for this application.

5.3 Performance indicators

5.3.1 Delivery time

Delivery time shall indicate the time needed to convey an APDU containing data (message payload) that has to be delivered in real-time from one node (source) to another node (destination). The delivery time is measured at the interface between the application process and the (Fieldbus) application entity.

NOTE 1 A description of the Application Layer concept with a description of the Application Process and the Application Entity is given in the respective type-specific part of IEC 61158-5.

The maximum delivery time shall be stated for the following two cases:

- no transmission errors, and
- one lost frame with recovery.

NOTE 2 The permanent failure condition is described in 5.3.9.

Calculation of the maximum delivery time shall include the transmission time as well as any waiting time.

NOTE 3 Waiting time depends on the RTE network concept, the RTE network topology and the application load which is generated by the other nodes in the RTE network and the non-RTE traffic at that time.

5.3.2 Number of RTE end-stations

The number of RTE end-stations shall state the maximum number of RTE end-stations supported by a CP.

NOTE The network devices like a switch are not counted in the number of RTE end-stations.

5.3.3 Basic network topology

The basic network topology supported by a CP shall be stated out of the topologies listed in Table 9 or as a combination.

Table 9 – Basic network topology types

Basic network topology	CP
Hierarchical star	CP m/1
Ring (loop)	CP m/2
Linear topology	CP m/3
NOTE A real topology could be any combination of the three basic topologies.	

5.3.4 Number of switches between RTE end-stations

Number of switches between any two RTE end-stations that have an application relation.

5.3.5 Throughput RTE

Throughput RTE shall indicate the total amount of APDU data (by octet length) on one link per second.

5.3.6 Non-RTE bandwidth

The non-RTE bandwidth shall indicate the percentage of bandwidth, which can be used for non-RTE communication on one link. Additionally the total link bandwidth shall be specified.

NOTE The indicators throughput RTE and non-RTE bandwidth are related to each other.

5.3.7 Time synchronization accuracy

Time synchronization accuracy shall indicate the maximum deviation between any two node clocks.

5.3.8 Non-time-based synchronization accuracy

The non-time-based synchronization accuracy shall indicate the maximum jitter of the cyclic behavior of any two nodes, using triggering by periodical events over the network for establishing cyclic behavior.

NOTE 1 This factor accounts for coherency of data or actions triggered by the event, and it is a measure of the coherency spread.

NOTE 2 The event can be unicast, multicast or broadcast, or made of a set of simpler events.

5.3.9 Redundancy recovery time

Redundancy recovery time shall indicate the maximum time from failure to become fully operational again in case of a single permanent failure.

NOTE If a permanent failure occurs, the delivery time of a message is the redundancy recovery time.

6 Conformance tests

6.1 Concept

This part of IEC 61784 specifies the methodology of a conformance test for an RTE end device for one or more CPs. The concept of this conformance test is to verify the capabilities of a device under test (DUT) against a consistent set of indicators of a CP. The conformance test shall assure the interoperability of devices which claim compliance with the same CP. Figure 2 gives an overview of the conformance test related to this part of IEC 61784.

NOTE Conformance test implementation and conformance test execution are not defined in this standard.

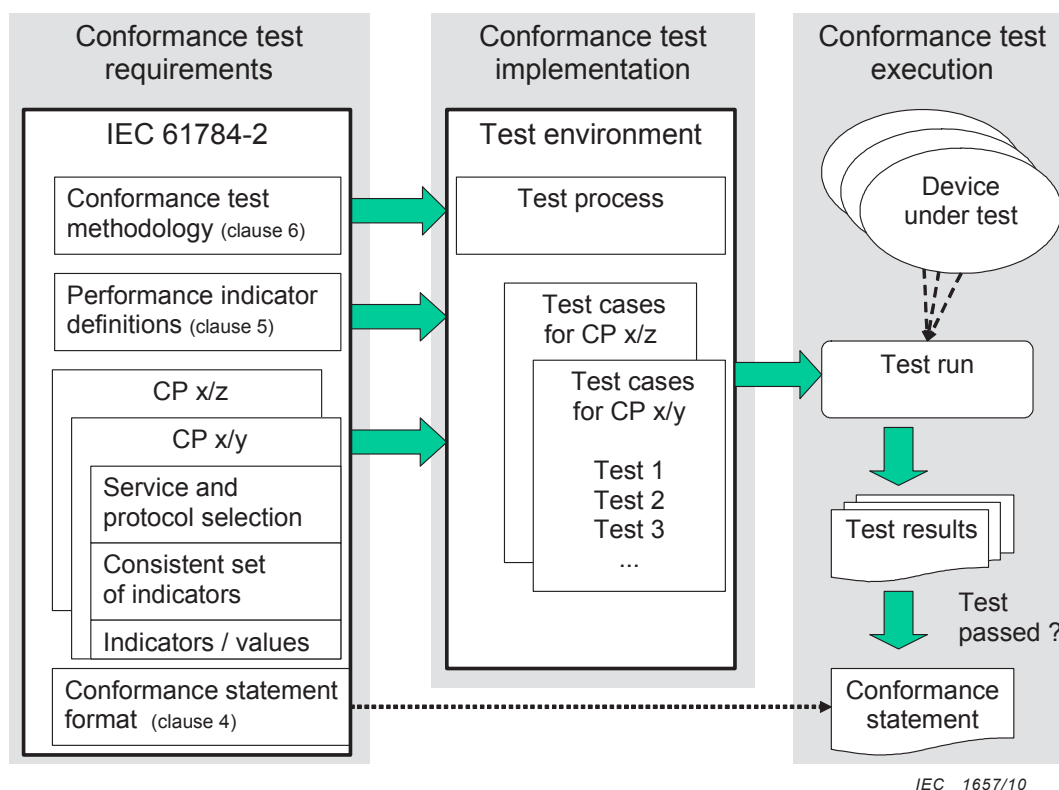


Figure 2 – Conformance test overview

6.2 Methodology

Test cases shall be developed in a way that tests are repeatable and the results can be verified. Test results shall be documented and shall be used as the basis for the conformance statement.

Conformance tests of a device shall include, as appropriate, the verification of

- the availability and correctness of the specified CP functionality,
- network related indicator values,
- device related indicator values.

The performance indicator values of the CP and of the device under test shall be used.

NOTE 1 It is assumed that the quality of the test cases guarantees the interoperability of a tested device. If any irregularities are reported the test cases will be adapted accordingly.

NOTE 2 A description of a conformance testing process is given in ISO/IEC 9646 series.

6.3 Test conditions and test cases

Test conditions and test cases shall be defined and documented based on a specific CP. This shall include the following indicators, when applicable:

- number of nodes;
- network topology;
- number of switches between nodes;
- RTE throughput,
- non-RTE bandwidth.

For each measured indicator (see 6.4), test condition and test case documents shall be prepared and shall describe:

- test purpose;
- test setup;
- test procedure;
- criteria for compliance.

Test set-up describes the equipment set-up necessary to perform the test including measurement equipment, device under test, auxiliary equipment, interconnection diagram, and test environmental conditions.

Parts of the test environment may be emulated or simulated. The effects of the emulation or simulation shall be documented.

The test procedure describes how the test should be performed, which also includes a description of specific set of indicators required to perform this test. The criteria for compliance define test results accepted as compliance with this test.

6.4 Test procedure and measuring

The measured indicators shall include, when applicable:

- delivery time;
- RTE throughput;
- non-RTE bandwidth;
- time synchronization accuracy;

- non-time based accuracy;
- redundancy recovery time.

The test procedure shall be based on the principles of 6.3.

The sequence of measuring actions to complete a test run shall be provided.

The number of independent runs of the test shall be provided.

The method to compute the result of the test from the independent runs shall be provided if applicable.

6.5 Test report

The test report shall contain sufficient information so that the test can be repeated and the results verified.

The test report shall contain at least

- the reference to the conformance test methodology according to 6.2,
- the reference to the performance indicator definitions according to Clause 5,
- the reference to the used CP according to this part of IEC 61784,
- a description of the conformance test environment including network emulators, measurement equipment and the person or organization responsible for the test execution, and the date of testing,
- the device under test, its manufacturer, and hardware and software revision,
- the number and type of devices connected to the network together with the topology,
- a reference to the test case specifications,
- the measured values,
- a statement according compliance with the CP.

7 Communication Profile Family 2 (CIP™²) - RTE communication profiles

7.1 General overview

Communication Profile Family 2 defines several communication profiles based on IEC 61158-2:2010 (protocol type 2), IEC 61158-3-2:2007, IEC 61158-4-2:2010, IEC 61158-5-2:2010, and IEC 61158-6-2:2010, and on other standards. These profiles all share for their upper layers the same communication system commonly known as the Common Industrial Protocol (CIP).

This part of IEC 61784 defines two RTE communication profiles.

– Profile 2/2 EtherNet/IP™³

This profile contains a selection of AL, DLL and PhL services and protocol definitions from IEC 61158-4-2:2010, IEC 61158-5-2:2010, and IEC 61158-6-2:2010, and the

² CIP™ is a trade name of ODVA, Inc. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by IEC of the trademark holder or any of its products. Compliance to this profile does not require use of the trade name CIP™. Use of the trade name CIP™ requires permission from ODVA, Inc.

³ EtherNet/IP™ is a trade name of ODVA, Inc. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by IEC of the trademark holder or any of its products. Compliance to this profile does not require use of the trade name EtherNet/IP™. Use of the trade name EtherNet/IP™ requires permission from ODVA, Inc.

TCP/UDP/IP/Ethernet protocol suite. This profile uses the CIP protocol and services in conjunction with the standard internet and Ethernet standards. This profile provides ISO/IEC 8802-3 and IEEE 802.3-2002 based real time communication, through the use of frame prioritization.

- Profile 2/2.1 EtherNet/IP™ with time synchronization

This profile is an extension of CP 2/2 that defines additional mechanisms to provide accurate time synchronization between nodes using EtherNet/IP. The addition of time synchronization services and protocols based on IEC 61588:2009 allows using it also for the most demanding applications.

NOTE 1 See IEC 61784-1:2010, A.2, for an overview of CIP and related networks communications concepts.

NOTE 2 Additional CPs are defined in the other parts of the IEC 61784 series.

7.2 Profile 2/2

7.2.1 Physical layer

See IEC 61784-1:2010, 6.3.1.

7.2.2 Data-link layer

See IEC 61784-1:2010, 6.3.2.

7.2.3 Application layer

See IEC 61784-1:2010, 6.3.3.

7.2.4 Performance indicator selection

7.2.4.1 Performance indicator overview

Table 10 provides an overview of CP 2/2 performance indicators.

Table 10 – CP 2/2: performance indicator overview

Performance indicator	Applicable	Constraints
Delivery time	Yes	None
Number of end-stations	Yes	None
Basic network topology	Yes	Only star topology is supported
Number of switches between end-stations	Yes	None
Throughput RTE	Yes	None
Non-RTE bandwidth	Yes	None
Time synchronization accuracy	No	—
Non-time-based synchronization accuracy	No	—
Redundancy recovery time	No	—

7.2.4.2 Performance indicator dependencies

7.2.4.2.1 Dependency matrix

Table 11 shows the dependencies between performance indicators for CP 2/2.

Table 11 – CP 2/2: Performance indicator dependency matrix

Dependent PI	Influencing PI					
	Delivery time	Number of end-stations	Basic network topology	Number of switches between end-stations	Throughput RTE	Non-RTE bandwidth
Delivery time		No	No	Yes	No	No
Number of end-stations	No		Yes	Yes	No	No
Basic network topology	No	No		No	No	No
Number of switches between end-stations	Yes	Yes	Yes		No	No
Throughput RTE	No	No	No	No		Yes
Non-RTE bandwidth	No	No	No	No	Yes	

7.2.4.2.2 Delivery time

Payload delivery time between any two end-stations depends on many factors as shown below. For one direction of a CP 2/2 network operating in full-duplex mode it can be calculated for each type of application message using Formulae (1), (2) and (3).

$$DT = SD_s + T_{x\_packet} + \sum_{i=1}^{n-1} CD_i + \sum_{k=1}^n SL_k + SD_r \quad (1)$$

$$CD_i = PD_i \times CL_i \quad (2)$$

$$SL_k = SPD_k + \sum_{j=1}^q T_{x\_packet\_j} + T_{x\_packet} \quad (3)$$

where

DT	is the delivery time in microseconds;
SD_s	is the sender stack delay in microseconds (depending on the selected hardware platform and the embedded software implementation);
T_{x_packet}	is the packet transmit time in microseconds;
N	is the number of switches between sending and receiving end-stations;
CD	is the cable segment delay in microseconds;
PD	is the cable propagation delay in nanoseconds per meter (depending on the characteristics of the selected cable);
CL	is the cable segment length in meters;
SL	is the switch latency in microseconds (measured based on RFC 2544, usually provided by the switch vendor);
SPD	is the switch processing delay in microseconds (provided by the switch vendor instead of

	SL);
Q	is the number packets in the port transmit queue in front on of this packet;
$T_{x\_packet\_j}$	is the transmit time of packet j ;
SD_r	is the receiver stack delay in microseconds (depending on the selected hardware platform the and embedded software implementation).

NOTE If a packet is lost, e.g. due to a transmission error, but the following one is received without errors then the delivery time will double. The CP 2/2 system performance will not be affected unless four consecutive packets are lost.

7.2.4.2.3 Number of end-stations

With regard to star topology, this standard considers network infrastructures containing only data-link layer (Ethernet) switches. This assumes that all end-stations are connected to the same subnet. Based on the CP 2/2 specification, a subnet can contain a maximum of 1 024 end-stations. The minimum number of end-stations is two, one producer and one consumer of the RTE data.

7.2.4.2.4 Basic network topology

The basic topology of the CP 2/2 network is a hierarchical star. Since basic network topology is given, it is not dependent on, or influenced by, any of the performance indicators.

7.2.4.2.5 Number of switches between end-stations

The number of switches between end-stations, which is the number of layers in a hierarchical star, is determined on the basis of:

- delivery time;
- number of end-stations, their physical location and the distance between them;
- network traffic profile (types of traffic, rates, traffic mix);
- performance of selected switches, in particular their throughput, their physical location, distance between them and number of ports per switch;
- network management requirements.

The minimum number is 1. The maximum number is 1 024 where each end-station has an individual switch, which is similar to the linear topology.

7.2.4.2.6 Throughput RTE

In switched Ethernet networks based on the star topology a link is a link between an end-station and a switch port. Based on the definition provided in 5.3.5, throughput RTE depends on the link data rate, link mode of operation (half or full-duplex) and protocol overhead. Throughput RTE for one direction of a CP 2/2 link operating in a full-duplex mode can be calculated on the basis of Formula (4).

$$\text{Throughput\_RTE} = \sum_{i=1}^k (APDUsize_i \times EN\_RTE\_PR_i) \leq EN\_PR\_MAX \quad (4)$$

where

$APDUsize$	is the size of the application protocol data unit per CP 2/2 connection in octets;
EN_RTE_PR	is the end-station RTE packet rate per CP 2/2 connection in packets per second (pps);
k	is the number of CP 2/2 connections supported by the end-station;
EN_PR_MAX	is the end-station maximum packet rate in pps.