INTERNATIONAL STANDARD

**ISO/IEC 14165-246**

First edition
2019-12

Corrected version
2020-01

# Information technology — Fibre channel —

## Part 246: Backbone — 6 (FC-BB-6)

Reference number
ISO/IEC 14165-246:2019(E)

© ISO/IEC 2019



**COPYRIGHT PROTECTED DOCUMENT**

© ISO/IEC 2019

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

# Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents) or the IEC list of patent declarations received (see http://patents.iec.ch).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by INCITS (as INCITS 509-2014) and drafted in accordance with its editorial rules. It was assigned to Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 25, *Interconnection of information technology equipment*, and adopted under the "fast-track procedure".

This corrected version of ISO/IEC 14165-246:2019 incorporates the following corrections: throughout the document, formatting errors affecting the links have been corrected. This has also resulted in a different pagination of the document.

A list of all parts in the ISO/IEC 14165 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

© ISO/IEC 2019 – All rights reserved

**Contents** **Page**

Foreword . . . . . xiv

Introduction . . . . . xviii

1 Scope . . . . . 1

2 Normative References . . . . . 5
2.1 Overview . . . . . 5
2.2 Approved references . . . . . 5
2.3 References under development . . . . . 6
2.4 ITU-T references . . . . . 6
2.5 IETF references . . . . . 6
2.6 IEEE references . . . . . 7

3 Definitions and conventions . . . . . 8
3.1 Common definitions . . . . . 8
3.2 FC-BB_IP definitions . . . . . 10
3.3 FC-BB_GFPT definitions . . . . . 12
3.4 FC-BB_PW definitions . . . . . 13
3.5 FC-BB_E definitions . . . . . 13
3.6 Editorial conventions . . . . . 16
3.7 List of commonly used acronyms and abbreviations . . . . . 17
3.7.1 General . . . . . 17
3.7.2 FC-BB_IP . . . . . 18
3.7.3 FC-BB_GFPT . . . . . 18
3.7.4 FC-BB_PW . . . . . 18
3.7.5 FC-BB_E . . . . . 18
3.8 Symbols . . . . . 19
3.9 Keywords . . . . . 19

4 FC-BB-6 Structure and Concepts . . . . . 20
4.1 FC-BB-6 backbone mappings . . . . . 20
4.2 FC-BB-6 reference models . . . . . 20
4.2.1 FC-BB-6 reference models overview . . . . . 20
4.2.2 FC-BB_IP reference model . . . . . 21
4.2.3 FC-BB_GFPT reference model . . . . . 23
4.2.4 FC-BB_PW reference model . . . . . 24
4.2.5 FC-BB_E reference models . . . . . 25
4.2.5.1 FC-BB_E VN_Port to VF_Port reference model . . . . . 25
4.2.5.2 FC-BB_E VE_Port to VE_Port reference model . . . . . 25
4.2.5.3 FC-BB_E VN_Port to VN_Port reference model . . . . . 26
4.2.5.4 FC-BB_E VA_Port to VA_Port reference model . . . . . 27
4.3 FC-BB-6 models overview . . . . . 27
4.3.1 FC-BB_IP . . . . . 27
4.3.2 FC-BB_GFPT . . . . . 28
4.3.3 FC-BB_PW . . . . . 28
4.3.4 FC-BB_E . . . . . 29
4.4 FC-BB-6 requirements . . . . . 29
4.4.1 Fibre Channel Class support . . . . . 29
4.4.2 Payload transparency . . . . . 29
4.4.2.1 FC-BB_IP . . . . . 29
4.4.2.2 Transparent FC-BB (FC-BB_GFPT and FC-BB_PW) . . . . . 30

© ISO/IEC 2019 – All rights reserved 

4.4.2.3 FC-BB_E . . . 30
4.4.3 Latency delay and timeout value . . . 30
4.4.4 QoS and bandwidth . . . 31
4.4.5 In-order delivery . . . 31
4.4.6 Flow control . . . 31
4.5 FC-BB-6 SW_ILS codes . . . 32

5 FC-BB_IP Structure and Concepts . . . 33
5.1 Applicability . . . 33
5.2 FC-BB_IP overview . . . 33
5.3 VE_Port functional model . . . 34
5.3.1 FC-BB_IP interface protocol layers . . . 34
5.3.2 E_Port/F_Port FC interface . . . 36
5.3.3 FC Switching Element (SE) with FC routing . . . 36
5.3.4 FC-BB_IP protocol interface . . . 36
5.3.4.1 Major components . . . 36
5.3.4.2 FC and FCIP Entities . . . 36
5.3.4.3 VE_Port Virtual ISL exchanges . . . 39
5.3.4.4 Control and Service Module (CSM) . . . 39
5.3.4.5 Platform Management Module (PMM) . . . 39
5.3.5 IP network interface . . . 42
5.4 B_Access functional model . . . 42
5.4.1 FC-BB_IP interface protocol layers . . . 42
5.4.2 B_Port FC interface . . . 42
5.4.3 FC-BB_IP protocol interface . . . 42
5.4.3.1 Major components . . . 42
5.4.3.2 FC and FCIP Entities . . . 43
5.4.3.3 B_Access Virtual ISL exchanges . . . 45
5.4.3.4 B_Port Control and Service Module (CSM) . . . 49
5.4.3.5 B_Port Platform Management Module (PMM) . . . 49
5.4.4 IP Network Interface . . . 49
5.5 FC-BB_IP network topologies . . . 49
5.6 Mapping and message encapsulation using TCP/IP . . . 51
5.6.1 Encapsulated frame structures . . . 51
5.6.1.1 FC frame encapsulation structure . . . 51
5.6.1.2 Encapsulated FCIP Special Frame (FSF) structure . . . 52
5.6.2 TCP/IP encapsulation . . . 53
5.7 FC-BB_IP protocol procedures . . . 54
5.7.1 Overview . . . 54
5.7.2 Procedures for platform management . . . 54
5.7.2.1 Function . . . 54
5.7.2.2 Procedures for discovery . . . 54
5.7.2.3 Procedures for extending FC-SP-2 security . . . 54
5.7.3 Procedures for connection management . . . 56
5.7.3.1 Function . . . 56
5.7.3.2 Procedures for link setup . . . 57
5.7.3.3 Procedures for data transfer . . . 57
5.7.3.4 Procedures for FCIP Link disconnection . . . 58
5.7.3.5 Procedures for multiple connection management . . . 58
5.7.4 Procedures for error detection recovery . . . 58
5.7.4.1 Procedures for handling invalid FC frames . . . 58
5.7.4.2 Procedures for error recovery . . . 59
5.7.5 FC-BB_IP system parameters . . . 59
5.7.5.1 FC timers . . . 59

 © ISO/IEC 2019 – All rights reserved

5.7.5.2 TCP timers . . . 59
5.7.5.3 Maximum number of attempts to complete an encapsulated FC frame transmission . . . 59
5.7.5.4 Maximum number of outstanding encapsulated FC frames . . . 60
5.8 FC-BB_IP service considerations . . . 60
5.8.1 Latency delay . . . 60
5.8.2 Throughput . . . 60
5.8.2.1 How timeouts affect throughput . . . 60
5.8.2.2 How loss affects throughput . . . 60
5.8.2.3 Other factors that affect throughput . . . 60
5.8.3 Reliability . . . 61
5.8.3.1 Loss of connectivity . . . 61
5.8.3.2 Loss of synchronization . . . 61
5.8.3.3 Loss or corruption of TCP segments . . . 61
5.8.3.4 Loss or corruption of FC frames . . . 61
5.8.3.5 FCIP error reporting . . . 61
5.8.4 Quality of Service (QoS) . . . 62
5.8.5 Delivery order . . . 62
5.8.6 IP multicast and broadcast . . . 62
5.8.7 Security and authentication . . . 62

6 Transparent FC-BB (FC-BB_GFPT and FC-BB_PW) Structure and Concepts . . . 64
6.1 Applicability . . . 64
6.2 FC-BB_GFPT overview . . . 64
6.3 FC-BB_PW overview . . . 65
6.4 Transparent FC-BB functional model . . . 66
6.4.1 Transparent FC-BB initialization . . . 66
6.4.2 Transparent FC-BB initialization state machine . . . 66
6.4.2.1 Initialization state machine keywords . . . 66
6.4.2.2 Initialization state machine . . . 66
6.4.3 Login Exchange Monitors . . . 71
6.4.4 Port initialization parameter observation and modification . . . 75
6.4.5 Handling of BB_SCs, BB_SCr, and R_RDY Primitive Signals and BB_Credit initialization . . . 76
6.4.6 Transparent FC-BB Primitive Signals . . . 77
6.4.7 Transparent FC-BB flow control . . . 78
6.4.7.1 Overview . . . 78
6.4.7.2 FC-BB_GFPT Alternate Simple Flow Control (ASFC) . . . 78
6.4.7.3 FC-BB_PW Alternate Simple Flow Control (ASFC) . . . 78
6.4.7.4 PING and PING_ACK signals . . . 79
6.4.8 Adaptation of FC information for Transparent FC-BB . . . 81
6.4.8.1 Adaptation of FC information for GFPT transport in FC-BB_GFPT . . . 81
6.4.8.2 Adaptation of FC information for PW transport in FC-BB_PW . . . 83
6.4.9 WAN Holdoff Timeout Value (WAN_HOLDOFF_TOV) . . . 85
6.4.10 Transparent FC-BB frame compression encoding . . . 85
6.4.10.1 FC-BB_GFPT FC frame compression . . . 85
6.4.10.2 FC-BB_PW FC frame compression . . . 86
6.4.10.3 LZS compression algorithm . . . 86

7 FC-BB_E Structure and Concepts . . . 87
7.1 Applicability . . . 87
7.2 FC-BB_E overview . . . 87
7.3 ENode functional model . . . 93
7.4 VN2VN ENode functional model . . . 94

© ISO/IEC 2019 – All rights reserved

7.5 FCF functional model . . . 96
7.6 Controlling FCF functional model . . . 99
7.7 FDF functional model . . . 101
7.8 FCoE Virtual Links . . . 103
7.9 VN_Port MAC addresses . . . 108
7.10 FCoE frame format . . . 108
7.11 FC-BB_E device initialization . . . 109
7.11.1 FCoE Initialization Protocol (FIP) overview . . . 109
7.11.2 FIP VLAN discovery protocol . . . 110
7.11.2.1 Overview . . . 110
7.11.2.2 ENode/FCF VLAN discovery . . . 110
7.11.2.3 FCF/FCF VLAN discovery . . . 112
7.11.2.4 VN2VN ENode VLAN discovery . . . 112
7.11.2.5 ENode/FDF VLAN discovery . . . 115
7.11.2.6 FDF/Controlling FCF VLAN discovery . . . 115
7.11.3 FIP discovery protocol . . . 115
7.11.3.1 Overview . . . 115
7.11.3.2 ENode/FCF discovery . . . 115
7.11.3.3 FCF/FCF discovery . . . 118
7.11.3.4 FDF/Controlling FCF discovery . . . 120
7.11.4 FCoE Virtual Link instantiation protocol . . . 121
7.11.4.1 VN_Port to VF_Port Virtual Links . . . 121
7.11.4.2 VE_Port to VE_Port Virtual Links . . . 121
7.11.4.3 VN_Port to VN_Port Virtual Links . . . 122
7.11.4.4 VA_Port to VA_Port Virtual Links . . . 122
7.11.5 FCoE Virtual Link maintenance protocol . . . 123
7.11.5.1 Virtual Link maintenance protocol overview . . . 123
7.11.5.2 VN_Port to VF_Port Virtual Link maintenance protocol . . . 123
7.11.5.3 VE_Port to VE_Port Virtual Link maintenance protocol . . . 126
7.11.5.4 VN_Port to VN_Port Virtual Link and VN2VN Neighbor Set maintenance protocol . . . 126
7.11.5.5 VA_Port to VA_Port Virtual Link maintenance protocol . . . 127
7.11.6 Locally Unique N_Port_IDs . . . 127
7.11.6.1 Overview . . . 127
7.11.6.2 Multi-node operation . . . 128
7.11.6.3 Point-to-point operation . . . 130
7.11.6.4 Persistence of Locally Unique N_Port_IDs . . . 131
7.11.7 FIP frames . . . 132
7.11.7.1 FIP frame format . . . 132
7.11.7.2 Encapsulated FIP operation . . . 132
7.11.7.3 FIP descriptors . . . 136
7.11.8 FIP operations . . . 146
7.11.8.1 FIP operations overview . . . 146
7.11.8.2 FIP Discovery Solicitation . . . 150
7.11.8.3 FIP Discovery Advertisements . . . 152
7.11.8.4 FIP Virtual Link Instantiation requests and replies . . . 152
7.11.8.5 FIP Keep Alive . . . 156
7.11.8.6 FIP Clear Virtual Links . . . 156
7.11.8.7 FIP VLAN Request . . . 157
7.11.8.8 FIP VLAN Notification . . . 158
7.11.8.9 FIP VN2VN VLAN Notification . . . 158
7.11.8.10 FIP Vendor Specific frames . . . 158
7.11.8.11 N_Port_ID Probe Request . . . 158
7.11.8.12 N_Port_ID Probe Reply . . . 159

 © ISO/IEC 2019 – All rights reserved

7.11.8.13 N_Port_ID Claim Notification . . . 159
7.11.8.14 N_Port_ID Claim Response . . . 159
7.11.8.15 N_Port_ID Beacon . . . 160
7.12 Timers and constants . . . 160
7.13 FC-BB_E Link Error Status Block (LESB) definition . . . 162
7.14 Link incidents definition . . . 163
7.15 Distributed FCF operations . . . 164

Annex A: FC-BB_GFPT Interoperability Guidelines (Informative) . . . 165
A.1 GFPT-specific interoperability guidelines . . . 165

Annex B: FCoE and FIP Frame Examples (Informative) . . . 166
B.1 Overview . . . 166

Annex C: Increasing FC-BB_E Robustness Using Access Control Lists (Informative) . . . 167
C.1 Overview . . . 167
C.2 Access Control Lists . . . 168
C.2.1 ACL overview . . . 168
C.2.2 ACL nomenclature . . . 169
C.3 Perimeter ACL construction . . . 169
C.3.1 Perimeter ACL construction overview . . . 169
C.3.2 FIP frame transmission . . . 170
C.3.3 Prevention of the transmission of frames using an FCF-MAC address for the source address . . . 170
C.3.4 Prevention of frames using FCoE Type or FCoE source addresses prior to successful completion of FIP FLOGI . . . 170
C.3.5 Enabling traffic after successful completion of FIP FLOGI or FIP NPIV FDISC 170
C.3.6 Prevention of duplicate VN_Port MAC addresses . . . 170
C.3.7 ACL summary . . . 171
C.4 Security in depth . . . 171
C.4.1 Overview . . . 171
C.4.2 Bridge-to-bridge link receiving ENode frames destined to FCF(s) . . . 172
C.4.3 Bridge-to-bridge link receiving FCF frames destined to ENode(s) . . . 172
C.4.4 Bridge-to-bridge link receiving both FCF and ENode frames . . . 173
C.4.5 Additional FCF protection . . . 173
C.5 Prevention of FCoE related traffic . . . 173
C.6 Automatic configuration of ACLs . . . 174
C.7 Ethernet bridge learning considerations . . . 174
C.8 VLAN considerations . . . 175
C.9 Access Control Lists in a Locally Unique N_Port_ID configuration . . . 175
C.9.1 Overview . . . 175
C.9.2 Prevention of FCoE traffic . . . 175
C.9.3 FCoE perimeter ACL . . . 175
C.9.4 Graceful handling of network joins . . . 176

Annex D: FCoE Security Recommendations (Informative) . . . 178
D.1 Overview . . . 178
D.2 Considerations . . . 178
D.3 General deployment recommendations . . . 178
D.4 Bridge recommendations . . . 178
D.5 ENode and FCF recommendations . . . 180
D.6 Additional threat isolation using FPMAs . . . 182

Annex E: FCoE MIB Definition (Normative) . . . 184
E.1 FCoE MIB definition . . . 184

© ISO/IEC 2019 – All rights reserved

Annex F: Locally Unique N_Port_ID (Informative) . . . . . 205

Annex G: Options for Handling FCoE and FIP Traffic (Informative) . . . . . 211

 © ISO/IEC 2019 – All rights reserved

**Tables** **Page**

Table 1 – FC-BB-6 organization . . . 1
Table 2 – Reference models and resident FC_Port types . . . 21
Table 3 – FC-BB-6 SW_ILS codes . . . 32
Table 4 – FC-BB-6 ELS codes . . . 32
Table 5 – EBP request payload . . . 46
Table 6 – EBP accept payload . . . 46
Table 7 – EBP reject reason code explanation . . . 47
Table 8 – TCP/IP Segment structure carrying encapsulated FC frame . . . 51
Table 9 – Encapsulated FC frame structure . . . 51
Table 10 – TCP/IP Segment structure carrying encapsulated FSF . . . 52
Table 11 – Encapsulated FSF structure . . . 52
Table 12 – ASF request payload . . . 56
Table 13 – ASF accept response payload . . . 56
Table 14 – Transparent FC-BB initialization state machine keywords . . . 66
Table 15 – Login Exchange Monitor (LEM) state machine . . . 74
Table 16 – Values of FC-BB_GFPT ASFC_PAUSE and ASFC_RESUME Primitive Signals . . . 78
Table 17 – FC-BB_PW ASFC_PAUSE and ASFC_RESUME control frame payload values . . . 79
Table 18 – FC-BB_GFPT PING and PING_ACK Primitive Signal values . . . 80
Table 19 – FC-BB_GFPT PING and PING_ACK CCC bit field values . . . 80
Table 20 – FC-BB_PW PING and PING_ACK control frame payload values . . . 81
Table 21 – FC-BB_PW error indication control frame payload values . . . 85
Table 22 – FCoE PDU format . . . 108
Table 23 – FCoE SOF field . . . 109
Table 24 – FCoE EOF field . . . 109
Table 25 – FIP PDU format . . . 132
Table 26 – Encapsulated FIP operation format . . . 132
Table 27 – FIP Protocol Code and FIP Subcode field values . . . 133
Table 28 – Fabric Provided bit and Server Provided bit setting . . . 134
Table 29 – FIP descriptor type value ranges . . . 136
Table 30 – FIP descriptor types . . . 137
Table 31 – FIP Priority descriptor format . . . 138
Table 32 – FIP MAC address descriptor format . . . 138
Table 33 – FIP FC-MAP descriptor format . . . 138
Table 34 – FIP Name_Identifier descriptor format . . . 139
Table 35 – FIP Fabric descriptor format . . . 139
Table 36 – FIP Max FCoE Size descriptor format . . . 139
Table 37 – FIP FLOGI descriptor format . . . 140
Table 38 – FIP NPIV FDISC descriptor format . . . 140
Table 39 – FIP LOGO descriptor format . . . 141
Table 40 – FIP ELP descriptor format . . . 141
Table 41 – FIP Vx_Port Identification descriptor format . . . 141
Table 42 – FIP FKA_ADV_Period descriptor format . . . 142
Table 43 – FIP Vendor_ID descriptor format . . . 143
Table 44 – FIP VLAN descriptor format . . . 143
Table 45 – FIP Vendor Specific descriptor format . . . 143
Table 46 – FIP VN2VN Attributes descriptor format . . . 144
Table 47 – FIP Clear Virtual Links Reason Code descriptor format . . . 144
Table 48 – FIP Clear Virtual Links Reason Codes . . . 145
Table 49 – FIP Clear Virtual Links Reason Code Explanations . . . 145
Table 50 – FIP Clear Virtual Links Reason Code descriptor examples . . . 146
Table 51 – FIP operation descriptors and order . . . 147
Table 52 – FIP Fabric login rejections . . . 154

© ISO/IEC 2019 – All rights reserved

Table 53 – FC-BB_E timers and constants . . . . . 160
Table 54 – FC-BB_E Link Error Status Block format . . . . . 162
Table 55 – FC-BB_E Link Incidents . . . . . 164
Table B.1 – FCoE frame format example . . . . . 166
Table B.2 – FIP frame format example . . . . . 166
Table F.1 – FNV-1a Parameters . . . . . 208
Table G.1 – Options for handling FCoE and FIP traffic . . . . . 211

 © ISO/IEC 2019 – All rights reserved

**Figures** **Page**

Figure 1 – Scope and components of FC-BB_IP model. . . . . 2
Figure 2 – Scope and components of FC-BB_GFPT model . . . . . 3
Figure 3 – Scope and components of FC-BB_PW model . . . . . 4
Figure 4 – Scope and components of FC-BB_E model . . . . . 4
Figure 5 – FC-BB_IP reference model . . . . . 22
Figure 6 – FC-BB_GFPT reference model . . . . . 23
Figure 7 – FC-BB_PW reference model. . . . . 24
Figure 8 – FC-BB_E VN_Port to VF_Port reference model . . . . . 25
Figure 9 – FC-BB_E VE_Port to VE_Port reference model . . . . . 25
Figure 10 – FC-BB_E VN_Port to VN_Port reference model . . . . . 26
Figure 11 – FC-BB_E VA_Port to VA_Port reference model . . . . . 27
Figure 12 – FC-BB_IP network configuration . . . . . 33
Figure 13 – FC-BB_IP VE_Port functional model. . . . . 35
Figure 14 – FC-BB_IP Protocol Layers . . . . . 37
Figure 15 – Scope of VE_Port Virtual ISL . . . . . 39
Figure 16 – Security layers. . . . . 41
Figure 17 – FC-BB_IP B_Access functional model . . . . . 44
Figure 18 – Scope of B_Access Virtual ISL . . . . . 45
Figure 19 – B_Access initialization state machine . . . . . 48
Figure 20 – FC-BB_IP network topologies . . . . . 50
Figure 21 – TCP/IP encapsulation of an encapsulated FC frame . . . . . 53
Figure 22 – FC-BB_GFPT protocol levels and layers . . . . . 64
Figure 23 – FC-BB_PW protocol levels and layers . . . . . 65
Figure 24 – Transparent FC-BB initialization state machine . . . . . 67
Figure 25 – Example port initialization process . . . . . 77
Figure 26 – FC-BB_PW error indication control frame format . . . . . 79
Figure 27 – FC-BB_PW PING and PING_ACK control frame format. . . . . 81
Figure 28 – FC-BB_PW error indication control frame format . . . . . 85
Figure 29 – FC-BB_E mapping . . . . . 87
Figure 30 – FC-BB_E protocol levels and layers . . . . . 88
Figure 31 – FCoE VN_Port to VF_Port network configuration example. . . . . 89
Figure 32 – FCoE VE_Port to VE_Port network configuration example. . . . . 89
Figure 33 – FCoE multi-node VN_Port to VN_Port network configuration example . . . . . 90
Figure 34 – FCoE mixed network configuration example. . . . . 91
Figure 35 – FCoE point-to-point VN_Port to VN_Port network configuration example . . . . . 91
Figure 36 – FCoE VA_Port to VA_Port network configuration example. . . . . 92
Figure 37 – ENode functional model . . . . . 93
Figure 38 – VN2VN ENode functional model . . . . . 95
Figure 39 – FCF functional model . . . . . 97
Figure 40 – Controlling FCF functional model . . . . . 100
Figure 41 – FDF functional model . . . . . 102
Figure 42 – VE_Port to VE_Port Virtual Links example . . . . . 104
Figure 43 – VN_Port to VF_Port Virtual Links example . . . . . 104
Figure 44 – VN_Port to VN_Port Virtual Links multi-node example . . . . . 105
Figure 45 – VN_Port to VN_Port and VN_Port to VF_Port Virtual Links example . . . . . 106
Figure 46 – VN_Port to VN_Port Virtual Link point-to-point example. . . . . 107
Figure 47 – VA_Port to VA_Port Virtual Link example . . . . . 107
Figure 48 – VLAN discovery processing example in an ENode MAC (informative) . . . . . 111
Figure 49 – VLAN discovery processing in a VN2VN ENode MAC . . . . . 114
Figure C.1 – Bridge port to ACE cross reference. . . . . 168

© ISO/IEC 2019 – All rights reserved 

**Foreword** (This foreword is not part of American National Standard INCITS 509-2014.)

This standard defines the functions and mappings for transporting Fibre Channel over various network technologies.

This standard was developed by Task Group T11.3 of Accredited Standards Organization INCITS during 2009-2013. The standards approval process started in 2012. This document includes annexes that are informative and are not considered part of the standard.

This standard includes seven annexes. Annex E is normative and is considered part of the standard. All of the other annexes are informative and are not considered part of the standard.

Requests for interpretation, suggestions for improvements or addenda, or defect reports are welcome. They should be sent to the INCITS Secretariat, Information Technology Industry Council, 1101 K Street, NW Suite 610, Washington, DC 20005.

This standard was processed and approved for submittal to ANSI by the International Committee for Information Technology Standards (INCITS). Committee approval of the standard does not necessarily imply that all committee members voted for its approval. At the time it approved this standard, INCITS had the following members:

Philip Wennblom, Chair
Jennifer Garner, Secretary

| *Organization Represented* | *Name of Representative* |
|---|---|
| Adobe Systems Inc. | Scott Foshee |
| | Steve Zilles (Alt.) |
| AIM Global, Inc. | Steve Halliday |
| | Chuck Evanhoe (Alt.) |
| | Dan Kimball (Alt.) |
| Apple | Helene Workman |
| | Marc Braner (Alt.) |
| | David Singer (Alt.) |
| Distributed Management Task Force | John Crandall |
| | Jeff Hilland (Alt.) |
| | Lawrence Lamers (Alt.) |
| EMC Corporation | Gary Robinson |
| | Stephen Diamond (Alt.) |
| Farance, Inc. | Frank Farance |
| | Timothy Schoechle (Alt.) |
| Futurewei Technologies, Inc. | Yi Zhao |
| | Timothy Jeffries (Alt.) |
| | Wilbert Adams (Alt.) |
| GS1GO | Frank Sharkey |
| | Charles Biss (Alt.) |
| Hewlett-Packard Company | Karen Higginbottom |
| | Paul Jeran (Alt.) |
| IBM Corporation | Alexander Tarpinian |
| | Robert Weir (Alt.) |
| | Arnaud Le Hors (Alt.) |
| | Steve Holbrook (Alt.) |
| | Gerald Lane (Alt.) |
| IEEE | Jodi Haasz |
| | Terry deCourcelle (Alt.) |
| | Bob Labelle (Alt.) |
| | Tina Alston (Alt.) |
| Intel | Philip Wennblom |
| | Stephen Balogh (Alt.) |
| | Grace Wei (Alt.) |
| | Steven Balogh (Alt.) |


© ISO/IEC 2019 – All rights reserved

| *Organization Represented* | *Name of Representative* |
|---|---|
| Microsoft Corporation | Jim Hughes |
| | Dick Brackney (Alt.) |
| | John Calhoon (Alt.) |
| National Institute of Standards & Technology | Michael Hogan |
| | Sal Francomacaro (Alt.) |
| | Dan Benigni (Alt.) |
| | Fernando Podio (Alt.) |
| | Teresa Schwartzhoff (Alt.) |
| | Wo Chang (Alt.) |
| | Elaine Newton (Alt.) |
| Oracle Corporation | Donald R. Deutsch |
| | Jim Melton (Alt.) |
| | Michael Kavanaugh (Alt.) |
| | Toshihiro Suzuki (Alt.) |
| | Jeff Mischkinsky (Alt.) |
| | Tony DiCenzo (Alt.) |
| | Patrick Curran (Alt.) |
| Purdue University | Stephen Elliott |
| | Kevin O'Connor (Alt.) |
| Telecommunications Industry Association (TIA) | Herb Congdon, II |
| | Cheryl Blum (Alt.) |
| | Florence Otieno (Alt.) |
| US Department of Defense | Jerry Smith |
| | Dennis Devera (Alt.) |
| | Dave Brown (Alt.) |
| | Leonard Levine (Alt.) |
| | Matthew Young (Alt.) |
| | Thomas D'Agostino (Alt.) |
| US Department of Homeland Security | Peter Shebell |
| | Gregg Piermarini (Alt.) |
| | Juan Gonzalez (Alt.) |

Technical Committee T11 on Fibre Channel Interfaces, which reviewed this standard, had the following members:

Steve Wilson, Chair
Claudio DeSanti, Vice-Chair
Richard Johnson, Secretary

| *Organization Represented* | *Name of Representative* |
|---|---|
| Agilent Technologies | Joachim Vobis |
| | Stephen Didde (Alt.) |
| | Steve Sekel (Alt.) |
| Amphenol Interconnect | Gregory McSorley |
| | Alex Persaud (Alt.) |
| | Michael Wingard (Alt.) |
| | Alex Persaud (Alt.) |
| Avago Technologies | Randy Clark |
| | David Cunningham (Alt.) |
| | Brian Misek (Alt.) |
| Broadcom Corporation | Pat Thaler |
| Brocade | Steven L. Wilson |
| | David Peterson (Alt.) |
| | Scott Kipp (Alt.) |
| | John Crandall (Alt.) |
| Cisco Systems | Claudio DeSanti |
| | Landon Noll (Alt.) |
| | Fabio Maino (Alt.) |
| | Joe Pelissier (Alt.) |
| CommScope | G. Mabud Choudhury |
| | Richard Case (Alt.) |
| | Paul Kolesar (Alt.) |
| | Joe Livingston (Alt.) |
| | Richard Baca (Alt.) |
| | Jack Jewell (Alt.) |

© ISO/IEC 2019 – All rights reserved

| *Organization Represented* | *Name of Representative* |
|---|---|
| Corning, Inc. | Doug Coleman |
| | Steven E. Swanson (Alt.) |
| Data Center Systems | Jack Edwards |
| | Kevin Ehringer (Alt.) |
| EMC Corporation | Gary S. Robinson |
| | David Black (Alt.) |
| | Erik Smith (Alt.) |
| | Louis Ricci (Alt.) |
| Emulex | Gautam Shiroor |
| | Hossein Hashemi (Alt.) |
| | David Baldwin (Alt.) |
| Finisar Corporation | Chris Yien |
| | Richard Johnson (Alt.) |
| Fujitsu America, Inc. | Sandy Wilson |
| | Eugene Owens (Alt.) |
| | Kun Katsumata (Alt.) |
| | Jim DeCaires (Alt.) |
| | Osamu Kimura (Alt.) |
| | Mark Malcolm (Alt.) |
| Hewlett Packard | Barry Maskas |
| | Krishna Babu Puttagunta (Alt.) |
| | Rupin Mohan (Alt.) |
| | Nadaraha Navaruparajah (Alt.) |
| | Siamack Ayandeh (Alt.) |
| IBM Corporation | Roger Hathorn |
| | Patty Driever (Alt.) |
| | Henry May (Alt.) |
| Intel Corporation | Mark Wunderlich |
| JDS Uniphase Corporation | Dave Lewis |
| | Jason Rusch (Alt.) |
| | Scott Baxter (Alt.) |
| | Paul Gentieu (Alt.) |
| LSI Corporation | Adam Healey |
| | John Lohmeyer (Alt.) |
| | Harvey Newman (Alt.) |
| Luxtera | Tom Palkert |
| Molex, Inc. | Jay Neer |
| | Mark Bugg (Alt.) |
| NetApp | Frederick Knight |
| | Denise Ridolfo (Alt.) |
| | Heather Lanigan (Alt.) |
| Oracle | Roger Dickerson |
| | Matt Gaffney (Alt.) |
| | Michael Roy (Alt.) |
| Panduit Corporation | Robert Elliott |
| | Jose Castro (Alt.) |
| | Steve Skiest (Alt.) |
| | Robert Reid (Alt.) |
| QLogic Corporation | Craig W.Carlson |
| | Skip Jones (Alt.) |
| | Alan Spalding (Alt.) |
| | Dean Wallace (Alt.) |
| | Ed McGlaughlin (Alt.) |
| TE Connectivity | Nathan Tracy |
| | Andrew Nowak (Alt.) |
| | Melissa Knox (Alt.) |


© ISO/IEC 2019 – All rights reserved

Task Group T11.3 on Interconnection Schemes, which developed and reviewed this standard, has the following members:

Craig W. Carlson, Chair
Lou Ricci, Vice-Chair
Landon Curt Noll, Secretary

| *Organization Represented* | *Name of Representative* |
|---|---|
| Broadcom | Pat Thaler |
| Brocade | David Peterson |
| | Steven L. Wilson (Alt.) |
| | John Crandall (Alt.) |
| Cisco Systems | Claudio DeSanti |
| | Landon Noll (Alt.) |
| | Fabio Maino (Alt.) |
| | Joe Pelissier (Alt.) |
| Dell | Joseph White |
| | Gaurav Chawla (Alt.) |
| | Manish Patil (Alt.) |
| | Jeff Young (Alt.) |
| EMC | Gary S. Robinson |
| | David Black (Alt.) |
| | Erik Smith (Alt.) |
| | Louis Ricci (Alt.) |
| Emulex | Gautam Shiroor |
| | David Baldwin (Alt.) |
| | Hossein Hashemi (Alt.) |
| Fujitsu | Sandy Wilson |
| | Eugene Owens (Alt.) |
| | Jim DeCaires (Alt.) |
| | Mark Malcolm (Alt.) |
| | Kun Katsumata (Alt.) |
| Hewlett Packard | Barry Maskas |
| | Krishna Babu Puttagunta (Alt.) |
| | Nadaraha Navaruparajah (Alt.) |
| | Rupin Mohan (Alt.) |
| | Siamack Ayandeh (Alt.) |
| IBM | Roger Hathorn |
| | Patty Driever (Alt.) |
| | Henry May (Alt.) |
| Intel | Mark Wunderlich |
| JDS Uniphase Corporation | Jason Rusch |
| | Scott Baxter (Alt.) |
| | Paul Gentieu (Alt.) |
| | George Bullis (Alt.) |
| LSI Corporation | John Lohmeyer |
| | Adam Healey (Alt.) |
| | Harvey Newman (Alt.) |
| NetApp | Frederick Knight |
| | Denise Ridolfo (Alt.) |
| Oracle | Roger Dickerson |
| | Matt Gaffney (Alt.) |
| | Ajoy Siddabathuni (Alt.) |
| | Hyon Kim (Alt.) |
| | Michael Roy (Alt.) |
| | Doug Meyers (Alt.) |
| QLogic | Craig W. Carlson |
| | Ed McGlaughlin (Alt.) |

© ISO/IEC 2019 – All rights reserved

## Introduction

FC-BB-6 defines mappings for transporting Fibre Channel over different network technologies. FC-BB-6 defines four distinct Fibre Channel mappings:

a) FC over TCP/IP;

b) FC over GFPT;

c) FC over MPLS; and

d) FC over Ethernet.

The FC over ATM and FC over SONET backbone mappings are not specified in FC-BB-6. As such, FC-BB-6 is not a complete replacement of FC-BB-3 (i.e., see FC-BB-3 for the specification of the FC over ATM and FC over SONET backbone mappings).


© ISO/IEC 2019 – All rights reserved

# Fibre Channel — Backbone - 6 (FC-BB-6)

## 1 Scope

This standard consists of distinct Fibre Channel mappings resulting in the following models:

- FC-BB_IP (FC over TCP/IP backbone network)
- Transparent FC-BB consisting of:
  - FC-BB_GFPT (FC over SONET/SDH/OTN/PDH backbone network using GFPT adaptation)
  - FC-BB_PW (FC over MPLS network using PW adaptation)
- FC-BB_E (FC over Ethernet)

Figure 1, figure 2, figure 3, and figure 4 illustrate the scope and the major components of the FC-BB-6 models and its relationship to the IETF, ITU-T, and IEEE standards. Table 1 shows the organization of this standard. FC-BB_IP, Transparent FC-BB, and FC-BB_E do not interoperate in any manner and are independent models.

**Table 1 – FC-BB-6 organization**

| Model Type | Applicable Clauses and Annexes |
|---|---|
| FC-BB_IP, FC-BB_GFPT, FC-BB_PW, FC-BB_E | 1, 2, 3, 4 |
| FC-BB_IP | 5 |
| Transparent FC-BB | |
| FC-BB_GFPT | 6, Annex A |
| FC-BB_PW | 6 |
| FC-BB_E | 7, Annex B, Annex C, Annex D, Annex E, Annex Annex F: , Annex G |



© ISO/IEC 2019 – All rights reserved

INCITS 509-2014

The scope and components of the FC-BB_IP model is shown in figure 1.

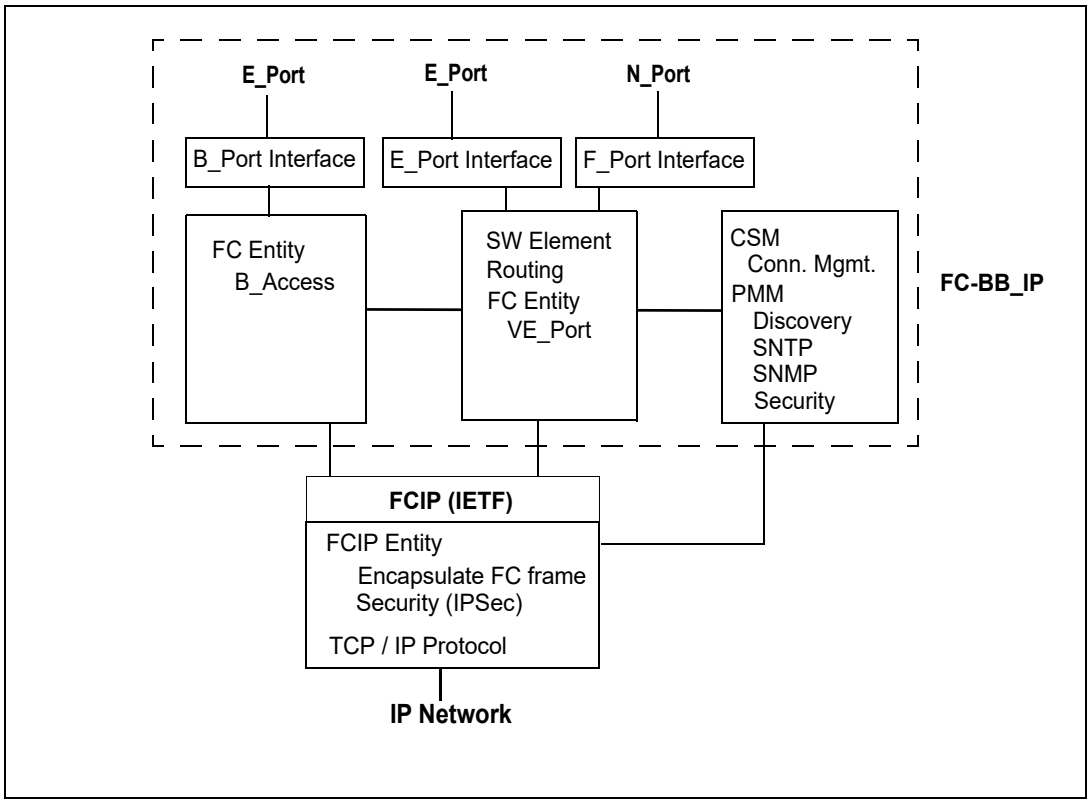



**Figure 1 – Scope and components of FC-BB_IP model**



© ISO/IEC 2019 – All rights reserved

The scope and components of the FC-BB_GFPT model is shown in figure 2.

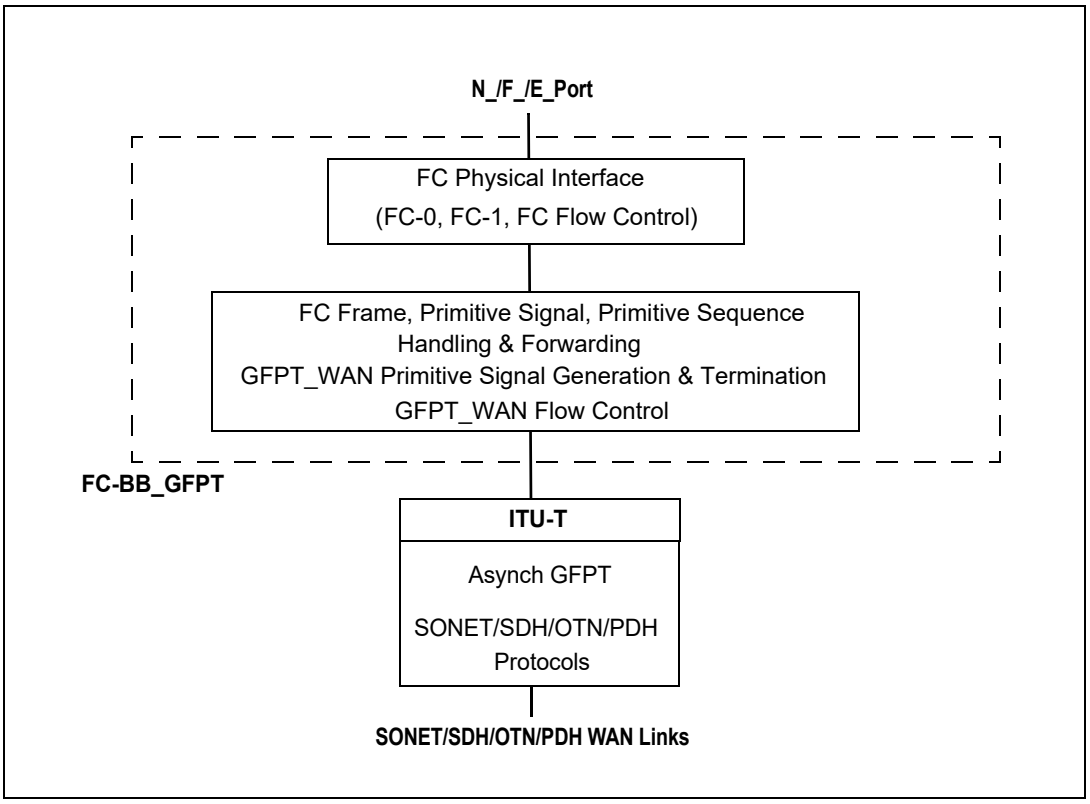



**Figure 2 – Scope and components of FC-BB_GFPT model**



© ISO/IEC 2019 – All rights reserved

INCITS 509-2014

The scope and components of the FC-BB_PW model is shown in figure 3.

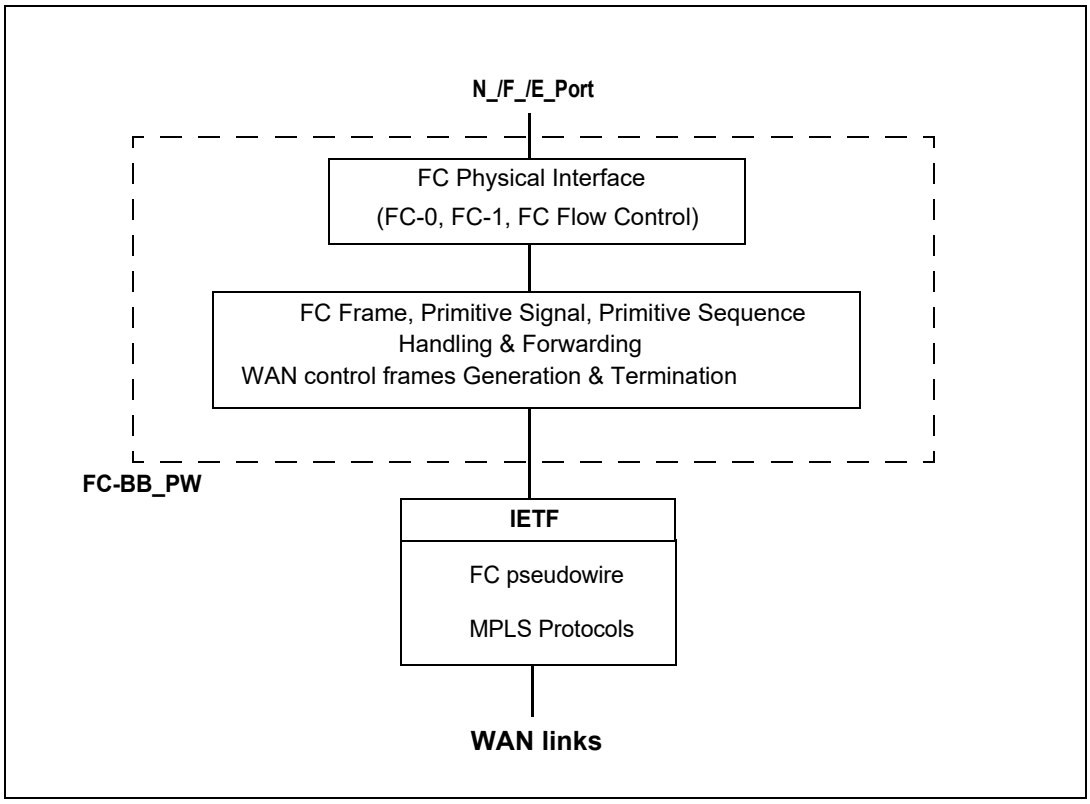



**Figure 3 – Scope and components of FC-BB_PW model**

The scope and components of the FC-BB_E model is shown in figure 4.

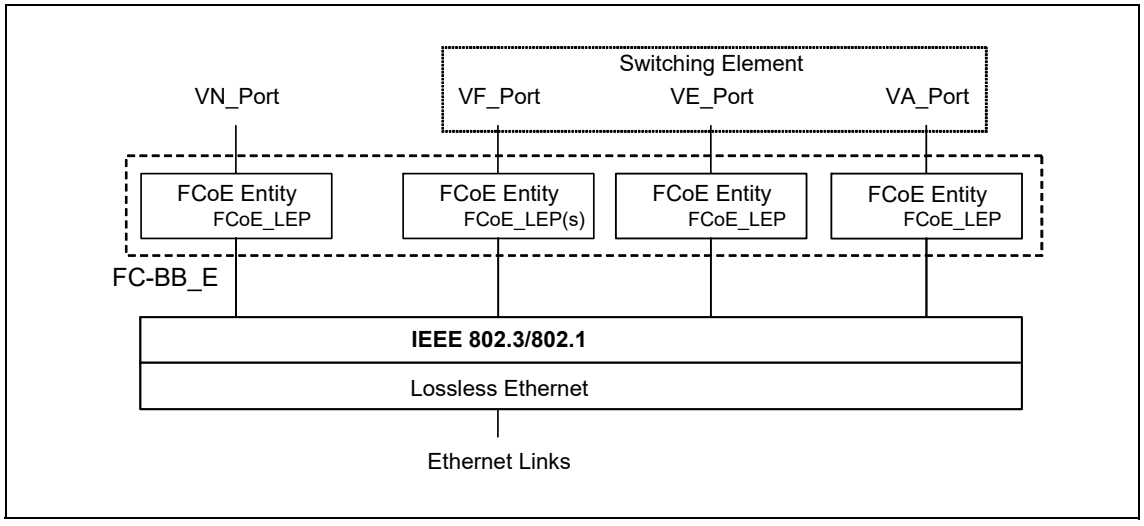



**Figure 4 – Scope and components of FC-BB_E model**



© ISO/IEC 2019 – All rights reserved

# 2 Normative References

## 2.1 Overview

The following standards contain provisions that, through reference in the text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below.

For electronic copies of ANSI and INCITS standards, visit ANSI's Electronic Standards Store (ESS) at http://www.ansi.org. For printed versions of most standards listed here, contact Global Engineering Documents, 15 Inverness Way East, Englewood, CO; 80112-5704, (800) 854-7179.

Orders for ISO Standards and ISO publications should normally be addressed to the ISO member in your country. If that is impractical, ISO Standards and ISO publications may be ordered from ISO Central Secretariat (ISO/CS):

Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
E-mail: customerservice@iso.org
Post: ISO, 8, chemin de Blandonnet,
CP 401 - 1214 Vernier, Geneva - Switzerland

In order to avoid delivery errors, it is important that you accurately quote the standard's reference number given in the ISO catalogue. For standards published in several parts, you should specify the number(s) of the required part(s). If not, all parts of the standard will be provided.

Copies of the following documents may be obtained from ANSI, an ISO member organization:

a) approved ANSI standards;
b) approved and draft international and regional standards (ISO and IEC); and
c) approved foreign standards (JIS and DIN).

For further information, contact the ANSI Customer Service Department:

Phone +1 212-642-4900
Fax: +1 212-302-1286
Web: http://www.ansi.org
E-mail: ansionline@ansi.org

or the InterNational Committee for Information Technology Standards (INCITS):

Phone 202-737-8888
Web: http://www.incits.org
E-mail: incits@itic.org

Additional availability contact information is provided below as needed.

## 2.2 Approved references

ANSI T1.105-2001, *Synchronous Optical Network (SONET) - Basic Description Including Multiplex Structures, Rates, and Formats*

ANSI INCITS 496-2012, *Fibre Channel - Security Protocols - 2 (FC-SP-2)*



© ISO/IEC 2019 – All rights reserved

INCITS 509-2014

ANSI INCITS 241-1994 (R1999), *Data Compression Method –Adaptive Coding with Sliding Window for Information Interchange*

### 2.3 References under development

At the time of publication, the following referenced standards were still under development. For information on the current status of the documents, or regarding availability, contact the relevant standards body or other organization as indicated.

For electronic copies of references under development by INCITS T11, see www.t11.org

T11/Project 2238-D, *Fibre Channel - Framing and Signaling - 4 (FC-FS-4)*

T11/Project 2220-D, *Fibre Channel - Switch Fabric - 6 (FC-SW-6)*

T11/Project 2237-D, *Fibre Channel - Link Services - 3 (FC-LS-3)*

### 2.4 ITU-T references

Copies of the following approved ITU-T standards may be obtained through the ITU-T Publications department at http://www.itu.int.

ITU-T Rec. G.707/Y.1322, (2007), *Network node interface for the synchronous digital hierarchy (SDH)*

ITU-T Rec. G.7041/Y.1303, (2005), *Generic Framing Procedure (GFP)*

ITU-T Rec. G.783, (2006), *Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks*

ITU-T Rec. G.806, (2006), *Characteristics of transport equipment - Description methodology and generic functionality*

ITU-T Rec. G.702, (1988), *Digital Hierarchy Bit Rates*

### 2.5 IETF references

Copies of the following approved IETF standards may be obtained through the Internet Engineering Task Force (IETF) at www.ietf.org.

RFC 5905, *Network Time Protocol Version 4: Protocol and Algorithms Specification,* June 2010

RFC 3246, *An Expedited Forwarding PHB (Per-Hop Behavior),* March 2002

RFC 3643, *Fibre Channel (FC) Frame Encapsulation,* December 2004

RFC 3821, *Fibre Channel Over TCP/IP (FCIP)*, July 2004

RFC 3822, *Finding Fibre Channel over TCP/IP (FCIP) Entities Using Service Location Protocol version 2 (SLPv2),* July 2004

RFC 3031, *Multiprotocol Label Switching (MPLS) Architecture,* January 2001

RFC 3985, *Pseudowire Emulation Edge-to-Edge (PWE3) Architecture,* March 2005



© ISO/IEC 2019 – All rights reserved

RFC 4385, *Multiprotocol Pseudowire Emulation Edge-to-Edge (PWE3) Control Word for Use over an MPLS PSN,* February 2006

RFC 4447, *Pseudowire Setup and Maintenance Using the Label Distribution Protocol (LDP),* April 2006

RFC 6307, *Encapsulation Methods for Transport of Fibre Channel frames Over MPLS Networks*, March 2012

### 2.6 IEEE references

Copies of the following approved IEEE standards may be obtained through the Institute of Electrical and Electronics Engineers (IEEE) at http://standards.ieee.org.

IEEE 802.3-2012: *IEEE Standard for Ethernet*

IEEE 802.1Q-2011: *Media Access Control (MAC) Bridges and Virtual Bridge Local Area Networks*

IEEE 802.1Qbb-2011: *Media Access Control (MAC) Bridges and Virtual Bridged Local Area Network - Amendment 17: Priority-based Flow Control*

IEEE 802.1Qaz-2011: *Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks - Amendment 18: Enhanced Transmission Selection for Bandwidth Sharing Between Traffic Classes*

IEEE 1588-2008: *Precision Clock Synchronization Protocol for Networked Measurement and Control Systems*

IEEE 802.1AS-2011: *Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks*



© ISO/IEC 2019 – All rights reserved