

# ISO/IEC 14776-224:2019-10 (E)

## Information technology - Small computer system interface (SCSI) - Part 224: Fibre Channel Protocol for SCSI, fourth version (FCP-4)

---

### Contents

- FOREWORD. . . . . 8**
- INTRODUCTION. . . . . 10**
  
- 1 Scope . . . . . 11**
  
- 2 Normative references . . . . . 11**
  
- 3 Terms, definitions, abbreviations and conventions . . . . . 12**
  - 3.1 Terms and definitions . . . . . 12
  - 3.2 Abbreviations . . . . . 18
  - 3.3 Keywords . . . . . 20
  - 3.4 Editorial conventions. . . . . 21
  
- 4 General. . . . . 23**
  - 4.1 Structure and concepts. . . . . 23
  - 4.2 FCP I/O operations . . . . . 24
  - 4.3 Bidirectional and unidirectional commands and FCP\_RSP IU format . . . . . 26
  - 4.4 Precise delivery of commands . . . . . 26
  - 4.5 Confirmed completion of FCP I/O operations. . . . . 27
  - 4.6 Retransmission of unsuccessfully transmitted IUs . . . . . 28
  - 4.7 Task retry identification. . . . . 28
  - 4.8 Discovery of FCP capabilities. . . . . 29
  - 4.9 Task management functions. . . . . 29
    - 4.9.1 Task management functions overview . . . . . 29
    - 4.9.2 ABORT TASK task management function. . . . . 31
    - 4.9.3 QUERY TASK task management function . . . . . 31
  - 4.10 Clearing effects of task management, FCP, FC-FS-3, FC-LS-2, and FC-AL-2 actions . . . . . 32
  - 4.11 I\_T nexus loss notification events. . . . . 34
  - 4.12 Transport Reset notification events . . . . . 34
  - 4.13 Port Login/Logout . . . . . 34
  - 4.14 Process Login and Process Logout . . . . . 35
  - 4.15 Link management . . . . . 35
  - 4.16 FCP addressing and Exchange identification. . . . . 35
  - 4.17 Use of Worldwide\_Names . . . . . 35
  
- 5 FC-FS-3 frame header. . . . . 37**
  - 5.1 FC-FS-3 frame header overview . . . . . 37
  - 5.2 FC-FS-3 frame header fields . . . . . 37
    - 5.2.1 R\_CTL field . . . . . 37
    - 5.2.2 D\_ID field . . . . . 37
    - 5.2.3 CS\_CTL field . . . . . 37
    - 5.2.4 S\_ID field . . . . . 37
    - 5.2.5 TYPE field . . . . . 37
    - 5.2.6 F\_CTL field . . . . . 37
    - 5.2.7 SEQ\_ID field . . . . . 38
    - 5.2.8 DF\_CTL field . . . . . 38
    - 5.2.9 SEQ\_CNT field . . . . . 38
    - 5.2.10 OX\_ID field . . . . . 38
    - 5.2.11 RX\_ID field . . . . . 38
    - 5.2.12 PARAMETER field . . . . . 38

<b>6 FCP link service definitions</b> .....	<b>39</b>
6.1 Overview of link service requirements .....	39
6.2 Overview of Process Login and Process Logout .....	39
6.3 PRLI ELS .....	40
6.3.1 Use of PRLI ELS by the Fibre Channel Protocol .....	40
6.3.2 New or repeated Process Login .....	40
6.3.3 PRLI ELS request FCP Service Parameter page format .....	41
6.3.4 PRLI ELS accept FCP Service Parameter page format .....	44
6.4 PRLO ELS .....	45
6.5 Read Exchange Concise (REC) ELS .....	45
<b>7 FC-4 specific Name Server registration and objects</b> .....	<b>47</b>
7.1 Overview of FC-4 specific objects for the Fibre Channel Protocol .....	47
7.2 FC-4 TYPEs object .....	47
7.3 FC-4 Features object .....	47
<b>8 FCP FC-4 Link Service (FCP_LS) definitions</b> .....	<b>49</b>
8.1 FCP_LS overview .....	49
8.2 Sequence Retransmission Request (SRR) FCP_LS request .....	49
8.3 FCP_LS Accept (FCP_ACC) .....	50
8.4 FCP_LS Reject (FCP_RJT) .....	51
<b>9 FCP Information Unit (IU) usage and formats</b> .....	<b>53</b>
9.1 FCP Information Unit (IU) usage .....	53
9.2 FCP_CMND IU .....	54
9.2.1 Overview and format of FCP_CMND IU .....	54
9.2.2 FCP_CMND IU field descriptions .....	55
9.2.2.1 FCP_LUN field .....	55
9.2.2.2 COMMAND REFERENCE NUMBER field .....	55
9.2.2.3 COMMAND PRIORITY field .....	56
9.2.2.4 TASK ATTRIBUTE field .....	56
9.2.2.5 TASK MANAGEMENT FLAGS FIELD .....	56
9.2.2.6 ADDITIONAL FCP_CDB LENGTH field .....	58
9.2.2.7 RDDATA bit and WRDATA bit .....	58
9.2.2.8 FCP_CDB field .....	59
9.2.2.9 ADDITIONAL_FCP_CDB field .....	59
9.2.2.10 FCP_DL field .....	59
9.2.2.11 FCP_BIDIRECTIONAL_READ_DL field .....	59
9.3 FCP_XFER_RDY IU .....	59
9.3.1 Overview and format of FCP_XFER_RDY IU .....	59
9.3.2 FCP_DATA_RO field .....	60
9.3.3 FCP_BURST_LEN field .....	60
9.4 FCP_DATA IU .....	60
9.4.1 FCP_DATA IU overview .....	60
9.4.2 FCP_DATA IUs for read and write operations .....	61
9.4.3 FCP_DATA IUs for bidirectional commands .....	62
9.4.4 FCP_DATA IU use of fill bytes .....	62
9.5 FCP_RSP IU .....	63
9.5.1 Overview and format of FCP_RSP IU .....	63
9.5.2 STATUS QUALIFIER field .....	64
9.5.3 FCP_BIDI_RSP bit .....	64
9.5.4 FCP_BIDI_READ_RESID_UNDER bit .....	64
9.5.5 FCP_BIDI_READ_RESID_OVER bit .....	65
9.5.6 FCP_CONF_REQ bit .....	65
9.5.7 FCP_RESID_UNDER bit .....	65
9.5.8 FCP_RESID_OVER bit .....	65
9.5.9 FCP_SNS_LEN_VALID bit .....	65
9.5.10 FCP_RSP_LEN_VALID bit .....	65

9.5.11 SCSI STATUS CODE field . . . . .	65
9.5.12 FCP_RESID field . . . . .	65
9.5.13 FCP_BIDIRECTIONAL_READ_RESID field . . . . .	66
9.5.14 FCP_SNS_LEN field . . . . .	67
9.5.15 FCP_RSP_LEN field . . . . .	67
9.5.16 FCP_RSP_INFO field . . . . .	67
9.5.17 FCP_SNS_INFO field . . . . .	68
9.6 FCP_CONF IU . . . . .	68
<b>10 SCSI mode parameters for the Fibre Channel Protocol . . . . .</b>	<b>69</b>
10.1 Overview of mode pages for the Fibre Channel Protocol . . . . .	69
10.2 Disconnect-Reconnect mode page . . . . .	69
10.2.1 Overview and format of Disconnect-Reconnect mode page for FCP . . . . .	69
10.2.2 BUFFER FULL RATIO field . . . . .	70
10.2.3 BUFFER EMPTY RATIO field . . . . .	70
10.2.4 BUS INACTIVITY LIMIT field . . . . .	70
10.2.5 DISCONNECT TIME LIMIT field . . . . .	71
10.2.6 CONNECT TIME LIMIT field . . . . .	71
10.2.7 MAXIMUM BURST SIZE field . . . . .	71
10.2.8 EMDP bit . . . . .	71
10.2.9 FAA BIT, FAB BIT, AND FAC bit . . . . .	72
10.2.10 FIRST BURST SIZE field . . . . .	72
10.3 Fibre Channel Logical Unit Control mode page . . . . .	73
10.4 Fibre Channel Port Control mode page . . . . .	73
10.4.1 Overview and format of Fibre Channel Port Control mode page . . . . .	73
10.4.2 DISABLE TARGET ORIGINATED LOOP INITIALIZATION (DTOLI) bit . . . . .	74
10.4.3 DISABLE TARGET INITIATED PORT ENABLE (DTIPE) bit . . . . .	74
10.4.4 ALLOW LOGIN WITHOUT LOOP INITIALIZATION (ALWLI) bit . . . . .	74
10.4.5 REQUIRE HARD ADDRESS (RHA) bit . . . . .	74
10.4.6 DISABLE LOOP MASTER (DLM) bit . . . . .	75
10.4.7 DISABLE DISCOVERY (DDIS) bit . . . . .	75
10.4.8 PREVENT LOOP PORT BYPASS (PLPB) bit . . . . .	75
10.4.9 DISABLE TARGET FABRIC DISCOVERY (DTFD) bit . . . . .	75
10.4.10 RR_TOV UNITS field . . . . .	75
10.4.11 SEQUENCE INITIATIVE RESOURCE RECOVERY TIMEOUT VALUE (RR_TOVSEQ_INIT) field	76
<b>11 Timers for FCP operation and recovery . . . . .</b>	<b>77</b>
11.1 Summary of timers for the Fibre Channel Protocol . . . . .	77
11.2 Error_Detect Timeout (E_D_TOV) . . . . .	78
11.3 Resource Allocation Timeout (R_A_TOV) . . . . .	78
11.4 Resource Recovery Timeout (RR_TOV) . . . . .	78
11.5 Read Exchange Concise Timeout Value (REC_TOV) . . . . .	78
11.6 Upper Level Protocol Timeout (ULP_TOV) . . . . .	79
<b>12 Link error detection and error recovery procedures . . . . .</b>	<b>80</b>
12.1 Error detection and error recovery overview . . . . .	80
12.1.1 Exchange level . . . . .	80
12.1.2 Sequence level . . . . .	80
12.2 FCP error detection . . . . .	80
12.2.1 Overview of FCP-4 error detection . . . . .	80
12.2.2 FCP-4 error detection using protocol errors for all classes of service . . . . .	80
12.2.3 Error detection mechanisms for acknowledged classes of service . . . . .	81
12.3 Exchange level recovery using ABTS-LS . . . . .	81
12.3.1 ABTS-LS overview . . . . .	81
12.3.2 Initiator FCP_Port Exchange termination . . . . .	82
12.3.3 Target FCP_Port response to Exchange termination . . . . .	82
12.3.4 Additional error recovery by initiator FCP_Port . . . . .	83
12.3.5 Additional error recovery by target FCP_Port . . . . .	83

12.4	Sequence level error detection and recovery	83
12.4.1	Using information from REC ELS to perform Sequence retransmission	83
12.4.1.1	Polling Exchange state with REC ELS	83
12.4.1.2	Detection of errors while polling with REC ELS	83
12.4.1.3	FCP_CMND IU recovery	84
12.4.1.4	FCP_XFER_RDY IU recovery	84
12.4.1.5	FCP_RSP IU recovery	84
12.4.1.6	FCP_DATA IU recovery - write operations	85
12.4.1.7	FCP_DATA IU recovery - read operations	86
12.4.1.8	FCP_CONF IU recovery	86
12.4.2	Additional error recovery requirements	87
12.4.2.1	Error indicated in ACK	87
12.4.2.2	Missing ACK	87
12.4.2.3	Distinguishing Exchange to be aborted	87
12.5	Second-level error recovery	87
12.5.1	ABTS error recovery	87
12.5.2	REC ELS request error recovery	87
12.5.3	SRR FCP_LS request error recovery	88
12.6	Responses to FCP type frames before port login or process login	88
<b>Annex A (normative) SAM-5 mapping to FCP-4</b>		<b>89</b>
<b>Annex B (informative) FCP examples</b>		<b>91</b>
B.1	Examples of the use of FCP Information Units (IUs)	91
B.1.1	Overview of examples	91
B.1.2	Read command	91
B.1.3	Write command	92
B.1.4	Command with no data transfer or with check condition	92
B.1.5	Read command with multiple FCP_DATA IUs	93
B.1.6	Write command with FCP_XFER_RDY disabled	93
B.1.7	Bidirectional command with write before read	94
B.1.8	Bidirectional command with read before write	94
B.1.9	Bidirectional command with write first and write FCP_XFER_RDY disabled	95
B.1.10	Bidirectional command with intermixed writes and reads	96
B.1.11	Write command with confirmed completion	96
B.1.12	Task management function	97
B.1.13	Class 2 write command example, frame level	98
B.1.14	Class 2 read command example, frame level	100
<b>Annex C (informative) Error detection and recovery examples</b>		<b>102</b>
<b>Annex D (informative) FCP device discovery procedure</b>		<b>136</b>
D.1	FCP Device Discovery Procedure	136
D.1.1	Initiator discovery of Fabric-attached target FCP_Ports	136
D.1.2	Initiator discovery of loop-attached target FCP_Ports	136
D.2	Fabric and device verification	137
D.3	Logical unit verification	137
<b>Annex E (informative) FCP-4 examples of link service usage</b>		<b>138</b>
E.1	Formats for recovery link services	138
E.2	Abort Sequence (ABTS) request	138
E.2.1	Abort Sequence (ABTS) request fields	138
E.2.2	Basic Accept (BA_ACC) frame to ABTS	139
E.2.3	Basic Reject (BA_RJT) frame to ABTS	139
E.3	Reinstate Recovery Qualifier (RRQ) ELS	140

## Tables

Table 1 - Numbering conventions	21
Table 2 - SCSI and Fibre Channel Protocol functions	24
Table 3 - Discovery of FCP-4 capabilities	29
Table 4 - Task management functions, SAM-5 to FCP-4	30
Table 5 - SCSI Service Response mapping for FCP_CMND delivered task management functions	31
Table 6 - SCSI Service Response mapping for ABORT TASK	31
Table 7 - SCSI Service Response mapping for QUERY TASK	32
Table 8 - Clearing effects of link related actions	33
Table 9 - Clearing effects of initiator FCP_Port actions	34
Table 10 - FCP frame header	37
Table 11 - PRLI ELS request FCP Service Parameter page	41
Table 12 - PRLI ELS accept FCP Service Parameter page	44
Table 13 - FCP TYPE 08h definition of FC-4 Feature bits	47
Table 14 - Additional FCP Features TYPE 0Ah definition of FC-4 Feature bits	47
Table 15 - FCP_LS requests and responses	49
Table 16 - SRR FCP_LS request payload	50
Table 17 - FCP_ACC payload	51
Table 18 - FCP_RJT payload	51
Table 19 - FCP_RJT Reason Codes	52
Table 20 - FCP_RJT Reason Code Explanations	52
Table 21 - FCP Information Units (IUs) sent to target FCP_Ports	53
Table 22 - FCP Information Units (IUs) sent to initiator FCP_Ports	54
Table 23 - FCP_CMND IU payload	55
Table 24 - TASK ATTRIBUTE field	56
Table 25 - TASK MANAGEMENT FLAGS field	57
Table 26 - FCP_XFER_RDY IU payload	60
Table 27 - FCP_RSP IU payload	64
Table 28 - FCP_RSP_INFO field format	67
Table 29 - RSP_CODE field	68
Table 30 - Mode pages for FCP	69
Table 31 - Disconnect-Reconnect mode page (02h)	70
Table 32 - Fibre Channel Logical Unit Control mode page (18h)	73
Table 33 - Fibre Channel Port Control mode page (19h)	74
Table 34 - Values for RR_TOV UNITS	75
Table 35 - Timer summary	77
Table 36 - Initiator FCP_Port REC_TOV usage	79
Table 37 - Target FCP_Port REC_TOV usage	79
Table A.1 - Mapping of SAM-5 terms to FCP-4 objects and identifiers	89
Table A.2 - Procedure terms	89
Table B.1 - Read command example	91
Table B.2 - Write command example	92
Table B.3 - Command without data transfer example	92
Table B.4 - Read command with multiple FCP_DATA IUs example	93
Table B.5 - Write command with FCP_XFER_RDY disabled example	93
Table B.6 - Bidirectional command with write before read example	94
Table B.7 - Bidirectional command with read before write example	94
Table B.8 - Bidirectional command with write first and write FCP_XFER_RDY disabled example	95
Table B.9 - Bidirectional command with intermixed writes and reads example	96
Table B.10 - Write command with confirmed completion example	96
Table B.11 - Task management function example	97
Table E.1 - ABTS frame	138
Table E.2 - BA_ACC frame to ABTS	139
Table E.3 - BA_RJT frame to ABTS	139
Table E.4 - RRQ ELS request format	140

## Figures

Figure B.1 - Class 2 write command example . . . . .	98
Figure B.2 - Class 2 write data example . . . . .	99
Figure B.3 - Class 2 read command example . . . . .	100
Figure B.4 - Class 2 read data example . . . . .	101
Figure C.1 - Lengthy FCP_CMND or lost ACK . . . . .	103
Figure C.2 - FCP_CMND lost, unacknowledged classes . . . . .	104
Figure C.3 - FCP_CMND lost, acknowledged classes . . . . .	105
Figure C.4 - FCP_CMND ACK lost, acknowledged classes . . . . .	106
Figure C.5 - FCP_XFER_RDY lost, unacknowledged classes . . . . .	107
Figure C.6 - FCP_XFER_RDY lost, acknowledged classes . . . . .	108
Figure C.7 - FCP_XFER_RDY received, ACK lost, acknowledged classes . . . . .	109
Figure C.8 - FCP_RSP lost, FCP_CONF not requested, unacknowledged classes . . . . .	110
Figure C.9 - FCP_RSP lost, FCP_CONF not requested, acknowledged classes . . . . .	111
Figure C.10 - FCP_RSP lost read command, no FCP_CONF, acknowledged classes . . . . .	112
Figure C.11 - FCP_RSP received, ACK lost, acknowledged classes, example 1 . . . . .	113
Figure C.12 - FCP_RSP received, ACK lost, acknowledged classes, example 2 . . . . .	114
Figure C.13 - Lost write data, last frame of Sequence, unacknowledged classes. . . . .	115
Figure C.14 - Lost write data, last frame of Sequence, acknowledged classes. . . . .	116
Figure C.15 - Lost write data, not last frame of Sequence, unacknowledged classes. . . . .	117
Figure C.16 - Lost write data, not last frame of Sequence, acknowledged classes. . . . .	118
Figure C.17 - Lost read data, last frame of Sequence, unacknowledged classes. . . . .	119
Figure C.18 - Lost read data, last frame of Sequence, acknowledged classes. . . . .	120
Figure C.19 - Lost read data, not last frame of Sequence, unacknowledged classes. . . . .	121
Figure C.20 - Lost read data, not last frame of Sequence, acknowledged classes. . . . .	122
Figure C.21 - ACK lost on read, acknowledged classes . . . . .	123
Figure C.22 - ACK lost on write, acknowledged classes . . . . .	124
Figure C.23 - FCP_CONF lost, unacknowledged classes. . . . .	125
Figure C.24 - FCP_CONF lost, acknowledged classes. . . . .	126
Figure C.25 - ACK lost on FCP_CONF, acknowledged classes . . . . .	127
Figure C.26 - REC ELS request or REC ELS response lost, unacknowledged classes . . . . .	128
Figure C.27 - REC ELS lost, acknowledged classes. . . . .	129
Figure C.28 - REC ELS response lost, acknowledged classes . . . . .	130
Figure C.29 - Two REC ELSs lost, unacknowledged classes, abort the original Exchange . . . . .	131
Figure C.30 - SRR FCP_LS request lost, unacknowledged classes, abort original Exchange . . . . .	132
Figure C.31 - SRR FCP_LS response lost, unacknowledged classes . . . . .	133
Figure C.32 - SRR FCP_LS request lost, acknowledged classes . . . . .	134
Figure C.33 - SRR FCP_LS response lost, acknowledged classes . . . . .	135