



ISO/IEC 14776-323

Edition 1.0 2017-01

# INTERNATIONAL STANDARD



---

**Information technology – Small computer system interface (SCSI) –  
Part 323: SCSI Block Commands – 3 (SBC-3)**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

---

ICS 35.200

ISBN 978-2-8322-3721-2

**Warning! Make sure that you obtained this publication from an authorized distributor.**

FOREWORD .....	5
INTRODUCTION .....	7
General .....	7
SCSI standards family .....	7
1 Scope .....	8
2 Normative references .....	8
3 Terms, definitions, symbols, abbreviations, keywords, and conventions .....	9
3.1 Terms and definitions .....	9
3.2 Symbols .....	19
3.3 Abbreviations .....	19
3.4 Keywords .....	20
3.5 Editorial conventions .....	21
3.6 Numeric and character conventions .....	22
3.6.1 Numeric conventions .....	22
3.6.2 Units of measure .....	22
3.7 State machine conventions .....	24
4 Direct access block device type model .....	25
4.1 Direct access block device type model introduction .....	25
4.2 Direct access block device type model .....	26
4.2.1 Direct access block device type model overview .....	26
4.2.2 Logical block access command types .....	26
4.2.3 Logical block access operation types .....	26
4.3 Media examples .....	26
4.3.1 Media examples overview .....	26
4.3.2 Rotating media .....	27
4.3.3 Memory media .....	27
4.4 Removable media .....	27
4.5 Logical Blocks .....	28
4.6 Physical blocks .....	29
4.7 Logical block provisioning .....	33
4.7.1 Logical block provisioning overview .....	33
4.7.2 Fully provisioned logical unit .....	34
4.7.3 Logical block provisioning management .....	34
4.7.3.1 Logical block provisioning management overview .....	34
4.7.3.2 Resource provisioned logical unit .....	34
4.7.3.3 Thin provisioned logical unit .....	35
4.7.3.4 Unmapping LBAs .....	35
4.7.3.4.1 Processing unmap requests .....	35
4.7.3.4.2 Unmap operations .....	35
4.7.3.4.3 WRITE SAME command and unmap operations .....	36
4.7.3.5 Autonomous LBA transitions .....	37
4.7.3.6 Thin provisioned logical unit resource exhaustion considerations .....	37
4.7.3.7 Logical block provisioning thresholds .....	37
4.7.3.7.1 Logical block provisioning thresholds overview .....	37
4.7.3.7.2 Logical block provisioning armed decreasing thresholds .....	38
4.7.3.7.3 Logical block provisioning armed increasing thresholds .....	39
4.7.3.7.4 Logical block provisioning threshold notification .....	40
4.7.4 LBP (logical block provisioning) state machine .....	40
4.7.4.1 LBP state machine overview .....	40
4.7.4.2 LBP state machine for thin provisioned logical units supporting anchored LBAs .....	41
4.7.4.3 LBP state machine for thin provisioned logical units not supporting anchored LBAs .....	41
4.7.4.4 LBP state machine for resource provisioned logical units .....	42
4.7.4.5 Performing read operations with respect to logical block provisioning .....	42
4.7.4.6 LBP1:Mapped state .....	44

4.7.4.6.1 LBP1:Mapped state description.....	44
4.7.4.6.2 Transition LBP1:Mapped to LBP2:Deallocated .....	44
4.7.4.6.3 Transition LBP1:Mapped to LBP3:Anchored .....	44
4.7.4.7 LBP2:Deallocated state.....	44
4.7.4.7.1 LBP2:Deallocated state description.....	44
4.7.4.7.2 Transition LBP2:Deallocated to LBP1:Mapped .....	44
4.7.4.7.3 Transition LBP2:Deallocated to LBP3:Anchored .....	45
4.7.4.8 LBP3:Anchored state .....	45
4.7.4.8.1 LBP3:Anchored state description .....	45
4.7.4.8.2 Transition LBP3:Anchored to LBP1:Mapped .....	45
4.7.4.8.3 Transition LBP3:Anchored to LBP2:Deallocated .....	45
4.8 Data de-duplication.....	45
4.9 Ready state .....	45
4.10 Initialization.....	46
4.11 Sanitize operations .....	46
4.11.1 Sanitize operations overview .....	46
4.11.2 Performing a sanitize operation .....	47
4.11.3 Completing a sanitize operation.....	48
4.12 Write protection .....	49
4.13 Medium defects .....	49
4.13.1 Medium defects overview .....	49
4.13.2 Generation of defect lists .....	52
4.14 Write and unmap failures.....	53
4.15 Caches .....	53
4.15.1 Caches overview.....	53
4.15.2 Read caching .....	53
4.15.3 Write caching .....	53
4.15.4 Command interactions with caches .....	54
4.15.5 Write operation and write medium operation interactions with caches .....	54
4.15.6 Read operation and read medium operation interactions with caches .....	54
4.15.7 Verify medium operation interactions with caches.....	55
4.15.8 Unmap operation interactions with caches .....	55
4.15.9 Power loss effects on caches .....	55
4.16 Implicit head of queue command processing .....	56
4.17 Reservations.....	56
4.18 Error reporting .....	58
4.18.1 Error reporting overview.....	58
4.18.2 Processing pseudo unrecovered errors .....	60
4.18.3 Block commands sense data descriptor .....	61
4.18.4 User data segment referral sense data descriptor.....	62
4.18.5 Direct-access block device sense data descriptor .....	64
4.19 Model for XOR commands .....	65
4.19.1 Model for XOR commands overview .....	65
4.19.2 SCSI storage array device supervised XOR operations .....	66
4.19.2.1 SCSI storage array device supervised XOR operations overview .....	66
4.19.2.2 Update write operation .....	66
4.19.2.3 Regenerate operation.....	66
4.19.2.4 Rebuild operation .....	67
4.19.3 Array subsystem considerations .....	67
4.19.3.1 Array subsystem considerations overview .....	67
4.19.3.2 Access to an inconsistent stripe .....	67
4.20 Rebuild assist mode .....	67
4.20.1 Rebuild assist mode overview .....	67
4.20.2 Enabling rebuild assist mode .....	68
4.20.3 Using the rebuild assist mode .....	68
4.20.3.1 Using rebuild assist mode overview .....	68
4.20.3.2 Unpredicted unrecovered read error .....	68
4.20.3.3 Predicted unrecovered read error .....	69

4.20.3.4 Unpredicted unrecovered write error.....	69
4.20.3.5 Predicted unrecovered write error .....	69
4.20.4 Disabling the rebuild assist mode .....	70
4.20.5 Testing rebuild assist mode .....	70
4.21 START STOP UNIT and power conditions.....	70
4.21.1 START STOP UNIT and power conditions overview.....	70
4.21.2 Processing of concurrent START STOP UNIT commands.....	70
4.21.3 Managing logical block access commands during a change to the active power condition .....	71
4.21.4 Stopped power condition .....	71
4.21.5 START STOP UNIT and power condition state machine .....	71
4.21.5.1 START STOP UNIT and power condition state machine overview.....	71
4.21.5.2 SSU_PC0:Powered_On state .....	73
4.21.5.2.1 SSU_PC0:Powered_On state description .....	73
4.21.5.2.2 Transition SSU_PC0:Powered_On to SSU_PC4:Active_Wait .....	74
4.21.5.2.3 Transition SSU_PC0:Powered_On to SSU_PC8:Stopped.....	74
4.21.5.3 SSU_PC1:Active state .....	74
4.21.5.3.1 SSU_PC1:Active state description .....	74
4.21.5.3.2 Transition SSU_PC1:Active to SSU_PC5:Wait_Idle .....	74
4.21.5.3.3 Transition SSU_PC1:Active to SSU_PC6:Wait_Standby .....	74
4.21.5.3.4 Transition SSU_PC1:Active to SSU_PC10:Wait_Stopped.....	75
4.21.5.4 SSU_PC2:Idle state .....	75
4.21.5.4.1 SSU_PC2:Idle state description .....	75
4.21.5.4.2 Transition SSU_PC2:Idle to SSU_PC4:Active_Wait .....	75
4.21.5.4.3 Transition SSU_PC2:Idle to SSU_PC5:Wait_Idle .....	75
4.21.5.4.4 Transition SSU_PC2:Idle to SSU_PC6:Wait_Standby .....	76
4.21.5.4.5 Transition SSU_PC2:Idle to SSU_PC7:Idle_Wait .....	76
4.21.5.4.6 Transition SSU_PC2:Idle to SSU_PC10:Wait_Stopped .....	76
4.21.5.5 SSU_PC3:Standby state .....	76
4.21.5.5.1 SSU_PC3:Standby state description .....	76
4.21.5.5.2 Transition SSU_PC3:Standby to SSU_PC4:Active_Wait .....	76
4.21.5.5.3 Transition SSU_PC3:Standby to SSU_PC6:Wait_Standby .....	77
4.21.5.5.4 Transition SSU_PC3:Standby to SSU_PC7:Idle_Wait .....	77
4.21.5.5.5 Transition SSU_PC3:Standby to SSU_PC9:Standby_Wait.....	77
4.21.5.5.6 Transition SSU_PC3:Standby to SSU_PC10:Wait_Stopped .....	78
4.21.5.6 SSU_PC4:Active_Wait state .....	78
4.21.5.6.1 SSU_PC4:Active_Wait state description .....	78
4.21.5.6.2 Transition SSU_PC4:Active_Wait to SSU_PC1:Active .....	79
4.21.5.7 SSU_PC5:Wait_Idle state .....	79
4.21.5.7.1 SSU_PC5:Wait_Idle state description .....	79
4.21.5.7.2 Transition SSU_PC5:Wait_Idle to SSU_PC2:Idle .....	79
4.21.5.8 SSU_PC6:Wait_Standby state.....	79
4.21.5.8.1 SSU_PC6:Wait_Standby state description .....	79
4.21.5.8.2 Transition SSU_PC6:Wait_Standby to SSU_PC3:Standby.....	79
4.21.5.9 SSU_PC7:Idle_Wait state .....	79
4.21.5.9.1 SSU_PC7:Idle_Wait state description .....	79
4.21.5.9.2 Transition SSU_PC7:Idle_Wait to SSU_PC2:Idle .....	80
4.21.5.10 SSU_PC8:Stopped state.....	80
4.21.5.10.1 SSU_PC8:Stopped state description .....	80
4.21.5.10.2 Transition SSU_PC8:Stopped to SSU_PC4:Active_Wait .....	80
4.21.5.10.3 Transition SSU_PC8:Stopped to SSU_PC7:Idle_Wait .....	81
4.21.5.10.4 Transition SSU_PC8:Stopped to SSU_PC9:Standby_Wait .....	81
4.21.5.11 SSU_PC9:Standby_Wait state .....	81
4.21.5.11.1 SSU_PC9:Standby_Wait state description .....	81
4.21.5.11.2 Transition SSU_PC9:Standby_Wait to SSU_PC3:Standby .....	81
4.21.5.12 SSU_PC10:Wait_Stopped state .....	82
4.21.5.12.1 SSU_PC10:Wait_Stopped state description .....	82
4.21.5.12.2 Transition SSU_PC10:Wait_Stopped to SSU_PC8:Stopped .....	82
4.22 Protection information model.....	82

4.22.1 Protection information overview.....	82
4.22.2 Protection types .....	82
4.22.2.1 Protection types overview .....	82
4.22.2.2 Type 0 protection.....	83
4.22.2.3 Type 1 protection.....	84
4.22.2.4 Type 2 protection.....	84
4.22.2.5 Type 3 protection.....	85
4.22.3 Protection information format.....	85
4.22.4 Logical block guard .....	89
4.22.4.1 Logical block guard overview .....	89
4.22.4.2 CRC generation.....	89
4.22.4.3 CRC checking .....	90
4.22.4.4 CRC test cases .....	90
4.22.5 Application of protection information.....	90
4.22.6 Protection information and commands .....	91
4.23 Grouping function .....	91
4.24 Background scan operations .....	91
4.24.1 Background scan overview .....	91
4.24.2 Background pre-scan operations .....	92
4.24.2.1 Enabling background pre-scan operations .....	92
4.24.2.2 Suspending and resuming background pre-scan operations .....	92
4.24.2.3 Halting background pre-scan operations.....	93
4.24.3 Background medium scan .....	93
4.24.3.1 Enabling background medium scan operations .....	93
4.24.3.2 Suspending and resuming background medium scan operations .....	94
4.24.3.3 Halting background medium scan operations .....	94
4.24.4 Interpreting the logged background scan results .....	95
4.25 Association between commands and CbCS permission bits .....	95
4.26 Deferred microcode activation.....	97
4.27 Model for uninterrupted sequences on LBA ranges .....	97
4.28 Referrals .....	97
4.28.1 Referrals overview .....	97
4.28.2 Discovering referrals .....	98
4.28.3 Referrals in sense data .....	99
4.29 ORWRITE commands .....	100
4.29.1 ORWRITE commands overview .....	100
4.29.2 ORWgeneration code .....	100
4.29.2.1 ORWgeneration code overview .....	100
4.29.2.2 ORWgeneration code processing .....	101
4.29.3 Change generation and clear operation.....	101
4.29.4 Set operation.....	103
4.30 Block device ROD token operations.....	104
4.30.1 Block device ROD token operations overview .....	104
4.30.2 POPULATE TOKEN command and WRITE USING TOKEN command completion .....	105
4.30.3 Block device specific ROD tokens .....	105
4.30.4 Block device zero ROD token .....	106
4.30.5 ROD token device type specific data .....	106
5 Commands for direct access block devices .....	108
5.1 Commands for direct access block devices overview .....	108
5.2 COMPARE AND WRITE command .....	111
5.3 FORMAT UNIT command .....	113
5.3.1 FORMAT UNIT command overview .....	113
5.3.2 FORMAT UNIT parameter list.....	117
5.3.2.1 FORMAT UNIT parameter list overview .....	117
5.3.2.2 Parameter list header .....	117
5.3.2.3 Initialization pattern descriptor.....	122
5.4 GET LBA STATUS command .....	123

5.4.1 GET LBA STATUS command overview.....	123
5.4.2 GET LBA STATUS parameter data .....	125
5.4.2.1 GET LBA STATUS parameter data overview .....	125
5.4.2.2 LBA status descriptor .....	126
5.4.2.3 LBA status descriptor relationships .....	126
5.5 ORWRITE (16) command .....	127
5.6 ORWRITE (32) command .....	133
5.7 POPULATE TOKEN command .....	135
5.7.1 POPULATE TOKEN command overview .....	135
5.7.2 POPULATE TOKEN parameter list.....	136
5.7.3 Block device range descriptor.....	138
5.8 PRE-FETCH (10) command.....	139
5.9 PRE-FETCH (16) command.....	140
5.10 PREVENT ALLOW MEDIUM REMOVAL command.....	141
5.11 READ (10) command .....	142
5.12 READ (12) command .....	146
5.13 READ (16) command .....	148
5.14 READ (32) command .....	149
5.15 READ CAPACITY (10) command .....	150
5.15.1 READ CAPACITY (10) overview .....	150
5.15.2 READ CAPACITY (10) parameter data .....	151
5.16 READ CAPACITY (16) command .....	151
5.16.1 READ CAPACITY (16) command overview.....	151
5.16.2 READ CAPACITY (16) parameter data .....	152
5.17 READ DEFECT DATA (10) command .....	154
5.17.1 READ DEFECT DATA (10) command overview.....	154
5.17.2 READ DEFECT DATA (10) parameter data .....	156
5.18 READ DEFECT DATA (12) command .....	156
5.18.1 READ DEFECT DATA (12) command overview.....	156
5.18.2 READ DEFECT DATA (12) parameter data .....	158
5.19 READ LONG (10) command .....	159
5.20 READ LONG (16) command .....	161
5.21 REASSIGN BLOCKS command.....	161
5.21.1 REASSIGN BLOCKS command overview.....	161
5.21.2 REASSIGN BLOCKS parameter list.....	163
5.22 RECEIVE ROD TOKEN INFORMATION .....	165
5.22.1 RECEIVE ROD TOKEN INFORMATION overview .....	165
5.22.2 RECEIVE ROD TOKEN INFORMATION parameter data for POPULATE TOKEN command .....	165
5.22.3 The RECEIVE ROD TOKEN INFORMATION parameter data for the WRITE USING TOKEN command.....	168
5.23 REPORT REFERRALS command .....	169
5.23.1 REPORT REFERRALS command overview .....	169
5.23.2 REPORT REFERRALS parameter data .....	170
5.24 SANITIZE command.....	171
5.24.1 SANITIZE command overview.....	171
5.24.2 SANITIZE command service actions .....	172
5.24.2.1 SANITIZE command service actions overview .....	172
5.24.2.2 OVERWRITE service action.....	172
5.24.2.3 BLOCK ERASE service action .....	173
5.24.2.4 CRYPTOGRAPHIC ERASE service action .....	174
5.24.2.5 EXIT FAILURE MODE service action .....	174
5.25 START STOP UNIT command.....	174
5.26 SYNCHRONIZE CACHE (10) command.....	178
5.27 SYNCHRONIZE CACHE (16) command.....	179
5.28 UNMAP command.....	180
5.28.1 UNMAP command overview .....	180
5.28.2 UNMAP parameter list .....	181
5.29 VERIFY (10) command .....	182

5.30 VERIFY (12) command .....	195
5.31 VERIFY (16) command .....	196
5.32 VERIFY (32) command .....	197
5.33 WRITE (10) command.....	198
5.34 WRITE (12) command.....	201
5.35 WRITE (16) command.....	202
5.36 WRITE (32) command.....	203
5.37 WRITE AND VERIFY (10) command .....	204
5.38 WRITE AND VERIFY (12) command .....	205
5.39 WRITE AND VERIFY (16) command .....	206
5.40 WRITE AND VERIFY (32) command .....	207
5.41 WRITE LONG (10) command.....	208
5.42 WRITE LONG (16) command.....	211
5.43 WRITE SAME (10) command.....	212
5.44 WRITE SAME (16) command.....	214
5.45 WRITE SAME (32) command.....	215
5.46 WRITE USING TOKEN command .....	217
5.46.1 WRITE USING TOKEN command overview.....	217
5.46.2 WRITE USING TOKEN parameter list.....	218
5.47 XDWRITEREAD (10) command.....	220
5.48 XDWRITEREAD (32) command.....	222
5.49 XPWRITE (10) command.....	222
5.50 XPWRITE (32) command .....	224
 6 Parameters for direct access block devices .....	225
6.1 Parameters for direct access block devices introduction.....	225
6.2 Address descriptors.....	225
6.2.1 Address descriptor overview.....	225
6.2.2 Short block format address descriptor .....	226
6.2.3 Extended bytes from index address descriptor.....	226
6.2.4 Extended physical sector format address descriptor .....	228
6.2.5 Long block format address descriptor.....	229
6.2.6 Bytes from index format address descriptor .....	229
6.2.7 Physical sector format address descriptor .....	230
6.3 Diagnostic parameters.....	231
6.3.1 Diagnostic parameters overview.....	231
6.3.2 Rebuild Assist Input diagnostic page .....	232
6.3.3 Rebuild Assist Output diagnostic page .....	233
6.3.4 Translate Address Input diagnostic page.....	234
6.3.5 Translate Address Output diagnostic page.....	236
6.4 Log parameters .....	237
6.4.1 Log parameters overview.....	237
6.4.1.1 Summary of log pages .....	237
6.4.1.2 Setting and resetting log parameters .....	237
6.4.2 Background Scan log page.....	238
6.4.2.1 Background Scan log page overview .....	238
6.4.2.2 Background Scan Status log parameter.....	240
6.4.2.3 Background Scan Results log parameter .....	242
6.4.3 Format Status log page.....	245
6.4.3.1 Format Status log page overview .....	245
6.4.3.2 Format Data Out log parameter .....	246
6.4.3.3 Grown Defects During Certification log parameter.....	247
6.4.3.4 Total Blocks Reassigned During Format log parameter.....	248
6.4.3.5 Total New Blocks Reassigned log parameter .....	249
6.4.3.6 Power On Minutes Since Format log parameter .....	250
6.4.4 Logical Block Provisioning log page .....	251
6.4.4.1 Logical Block Provisioning log page overview.....	251
6.4.4.2 Available LBA Mapping Resource Count log parameter .....	253

6.4.4.2.1 Available LBA Mapping Resource Count log parameter overview .....	253
6.4.4.2.2 RESOURCE COUNT field.....	254
6.4.4.3 Used LBA Mapping Resource Count log parameter .....	254
6.4.4.4 De-duplicated LBA Resource Count log parameter .....	255
6.4.4.5 Compressed LBA Resource Count log parameter .....	256
6.4.4.6 Total Efficiency LBA Resource Count log parameter .....	257
6.4.5 Non-volatile Cache log page.....	258
6.4.5.1 Non-volatile Cache log page overview .....	258
6.4.5.2 Remaining Nonvolatile Time log parameter .....	259
6.4.5.3 Maximum Nonvolatile Time log parameter.....	260
6.4.6 Solid State Media log page .....	260
6.4.6.1 Solid State Media log page overview .....	260
6.4.6.2 Percentage Used Endurance Indicator log parameter .....	262
6.5 Mode parameters .....	263
6.5.1 Mode parameters overview.....	263
6.5.2 Mode parameter block descriptors.....	264
6.5.2.1 Mode parameter block descriptors overview.....	264
6.5.2.2 Short LBA mode parameter block descriptor .....	264
6.5.2.3 Long LBA mode parameter block descriptor .....	266
6.5.3 Application Tag mode page .....	267
6.5.3.1 Introduction.....	267
6.5.3.2 Application tag descriptor .....	269
6.5.4 Background Control mode page .....	270
6.5.5 Caching mode page .....	272
6.5.6 Informational Exceptions Control mode page .....	276
6.5.7 Logical Block Provisioning mode page .....	281
6.5.7.1 Logical Block Provisioning mode page overview .....	281
6.5.7.2 Threshold descriptor format .....	282
6.5.8 Read-Write Error Recovery mode page.....	283
6.5.9 Verify Error Recovery mode page.....	289
6.6 Vital product data (VPD) parameters.....	290
6.6.1 VPD parameters overview .....	290
6.6.2 Block Device Characteristics VPD page .....	291
6.6.3 Block Limits VPD page .....	294
6.6.4 Logical Block Provisioning VPD page .....	297
6.6.5 Referrals VPD page .....	299
6.6.6 Third-Party Copy VPD page .....	300
6.6.6.1 Third-Party Copy VPD page overview .....	300
6.6.6.2 Block device third-party copy descriptor type codes .....	300
6.6.6.3 Block Device ROD Token Limits descriptor .....	301
6.7 Copy manager parameters.....	302
Annex A (informative) Numeric order codes .....	303
A.1 Variable length CDBs .....	303
A.2 Service action CDBs .....	304
Annex B (informative) XOR command examples.....	305
B.1 XOR command examples overview .....	305
B.2 Update write operation .....	305
B.3 Regenerate operation .....	306
B.4 Rebuild operation .....	307
Annex C (informative) CRC example in C.....	309
Annex D (informative) Sense information for locked or encrypted logical units .....	311
Annex E (informative) Optimizing block access characteristics .....	312
E.1 Optimizing block access overview .....	312

E.2 Starting logical block offset .....	312
E.3 Optimal granularity sizes .....	312
E.4 Optimizing transfers .....	312
E.5 Examples .....	313
Annex F (informative) Logical block provisioning reporting examples .....	314
F.1 Logical block provisioning reporting examples overview.....	314
F.2 Interpreting log parameter counts .....	314
F.3 Dedicated resource, threshold set tracked example .....	315
F.3.1 Dedicated resource, threshold set tracked example overview .....	315
F.3.2 Dedicated resource, threshold set tracked example configuration .....	315
F.3.3 Dedicated resource, threshold set tracked example sequence .....	316
F.3.4 Dedicated resource, threshold set tracked example initial conditions .....	317
F.3.5 Operations that occur .....	317
F.3.6 Dedicated resource, threshold set tracked example final log page values.....	318
F.4 Shared resource, logical block tracked example .....	318
F.4.1 Shared resource, logical block tracked example overview .....	318
F.4.2 Shared resource, logical block tracked example configuration.....	319
F.4.3 Shared resource, logical block tracked example time line .....	319
F.4.4 Shared resource, logical block tracked example initial conditions .....	320
F.4.5 Operations that occur .....	320
F.4.6 Shared resource, logical block tracked example final log page values .....	321
F.5 Shared available, dedicated used, logical block tracked example .....	322
F.5.1 Shared available, dedicated used, logical block tracked example overview .....	322
F.5.2 Shared available, dedicated used, logical block tracked example configuration .....	322
F.5.3 Shared available, dedicated used, logical block tracked example time line .....	322
F.5.4 Shared available, dedicated used, logical block tracked example initial conditions .....	323
F.5.5 Operations that occur .....	323
F.5.6 Shared available, dedicated used, example final log page values .....	324
Annex G (informative) Discovering referrals examples.....	325
G.1 Referrals example with no user data segment multiplier .....	325
G.2 Referrals example with non-zero user data segment multiplier.....	327
Bibliography .....	329

Figure 0 – SCSI document relationships .....	7
Figure 1 – Example state machine figure .....	24
Figure 2 – One or more physical blocks per logical block examples .....	30
Figure 3 – One or more logical blocks per physical block examples .....	31
Figure 4 – Two logical blocks per physical block alignment examples .....	31
Figure 5 – Four logical blocks per physical block alignment examples .....	32
Figure 6 – Examples of the relationship between mapped and unmapped LBAs and physical blocks .....	33
Figure 7 – Armed decreasing threshold operation .....	39
Figure 8 – Armed increasing threshold operation .....	39
Figure 9 – LBP state machine (anchored LBAs supported and deallocated LBAs supported) .....	41
Figure 10 – LBP state machine (anchored LBAs not supported) .....	42
Figure 11 – LBP state machine (deallocated LBAs not supported) .....	42
Figure 12 – SSU_PC state machine .....	73
Figure 13 – Referrals .....	98
Figure B.1 – Update write operation (SCSI storage array device supervised) .....	306
Figure B.2 – Regenerate operation (SCSI storage array device supervised) .....	307
Figure B.3 – Rebuild operation (SCSI storage array device supervised) .....	308
Figure G.1 – Referrals example with no user data segment multiplier ....	325
Figure G.2 – Referrals example with non-zero user data segment multiplier .....	327

Table 1 – Numbering convention examples .....	22
Table 2 – Comparison of decimal prefixes and binary prefixes .....	23
Table 3 – Direct access block device type model topics .....	25
Table 4 – Logical block provisioning states supported by logical block provisioning type .....	33
Table 5 – WRITE SAME command and unmap operations .....	36
Table 6 – Threshold resource value, threshold type value, and threshold arming value for logical block provisioning thresholds .....	38
Table 7 – Logical block data returned by a read operation from a mapped LBA .....	43
Table 8 – Logical block data returned by a read operation from an unmapped LBA .....	43
Table 9 – Defect lists (i.e., PLIST and GLIST) .....	50
Table 10 – Address descriptor formats .....	52
Table 11 – SBC-3 commands that are allowed in the presence of various reservations .....	57
Table 12 – Example error conditions .....	59
Table 13 – Sense data field usage for direct access block devices .....	60
Table 14 – Block commands sense data descriptor format .....	62
Table 15 – User data segment referral sense data descriptor format .....	62
Table 16 – User data segment referral descriptor format .....	63
Table 17 – Target port group descriptor .....	64
Table 18 – Direct-access block device sense data descriptor format .....	65
Table 19 – Summary of states in the SSU_PC state machine .....	72
Table 20 – Logical block data format with a single protection information interval .....	85
Table 21 – An example of the logical block data for a logical block with more than one protection information interval .....	86
Table 22 – Content of the first LOGICAL BLOCK REFERENCE TAG field for the first logical block in the Data-In Buffer and/or Data-Out Buffer .....	87
Table 23 – Content of subsequent LOGICAL BLOCK REFERENCE TAG fields for a logical block in the Data-In Buffer and/or Data-Out Buffer .....	88
Table 24 – CRC polynomials .....	89
Table 25 – CRC test cases .....	90
Table 26 – Associations between commands and CbCS permissions .....	96
Table 27 – Commands that require uninterrupted sequences .....	97
Table 28 – Performing an ORWRITE set operation .....	103
Table 29 – ROD token type values .....	106
Table 30 – Block device zero ROD token format .....	106
Table 31 – Commands for direct access block devices .....	108
Table 32 – COMPARE AND WRITE command .....	112
Table 33 – FORMAT UNIT command .....	114
Table 34 – FORMAT UNIT command address descriptor support requirements .....	116
Table 35 – FORMAT UNIT parameter list .....	117
Table 36 – Short parameter list header .....	117
Table 37 – Long parameter list header .....	118
Table 38 – FMTINFO field and PROTECTION FIELD USAGE field .....	119
Table 39 – Initialization pattern descriptor .....	122
Table 40 – INITIALIZATION PATTERN TYPE field .....	123
Table 41 – GET LBA STATUS command .....	124
Table 42 – GET LBA STATUS parameter data .....	125
Table 43 – LBA status descriptor format .....	126
Table 44 – PROVISIONING STATUS field .....	126
Table 45 – ORWRITE (16) command .....	127
Table 46 – ORPROTECT field - checking protection information from the read operations .....	128
Table 47 – ORPROTECT field - checking protection information from the Data-Out Buffer .....	131
Table 48 – ORWRITE (32) command .....	133
Table 49 – BMOP field .....	134
Table 50 – POPULATE TOKEN command .....	135
Table 51 – POPULATE TOKEN parameter list .....	136
Table 52 – Block device range descriptor .....	138
Table 53 – PRE-FETCH (10) command .....	139
Table 54 – PRE-FETCH (16) command .....	140

Table 55 – PREVENT ALLOW MEDIUM REMOVAL command .....	141
Table 56 – PREVENT field .....	141
Table 57 – READ (10) command .....	142
Table 58 – RDPROTECT field .....	143
Table 59 – READ (12) command .....	147
Table 60 – READ (16) command .....	148
Table 61 – READ (32) command .....	149
Table 62 – READ CAPACITY (10) command .....	150
Table 63 – READ CAPACITY (10) parameter data .....	151
Table 64 – READ CAPACITY (16) command .....	152
Table 65 – READ CAPACITY (16) parameter data .....	152
Table 66 – P_TYPE field and PROT_EN bit .....	153
Table 67 – LOGICAL BLOCKS PER PHYSICAL BLOCK EXPONENT field .....	153
Table 68 – READ DEFECT DATA (10) command .....	154
Table 69 – REQ_PLIST bit and REQ_GLIST bit .....	155
Table 70 – READ DEFECT DATA (10) parameter data .....	156
Table 71 – READ DEFECT DATA (12) command .....	157
Table 72 – READ DEFECT DATA (12) parameter data .....	158
Table 73 – READ LONG (10) command .....	159
Table 74 – READ LONG (16) command .....	161
Table 75 – REASSIGN BLOCKS command .....	162
Table 76 – REASSIGN BLOCKS parameter list .....	163
Table 77 – REASSIGN BLOCKS short parameter list header .....	163
Table 78 – REASSIGN BLOCKS long parameter list header .....	163
Table 79 – Reassign LBA if the LONGLBA bit is set to zero .....	164
Table 80 – Reassign LBA if the LONGLBA bit is set to one .....	164
Table 81 – RECEIVE ROD TOKEN INFORMATION reference .....	165
Table 82 – RECEIVE ROD TOKEN INFORMATION parameter data for POPULATE TOKEN .....	166
Table 83 – RECEIVE ROD TOKEN INFORMATION parameter data for WRITE USING TOKEN .....	168
Table 84 – REPORT REFERRALS command .....	169
Table 85 – REPORT REFERRALS parameter data .....	170
Table 86 – SANITIZE command .....	171
Table 87 – SANITIZE service action codes .....	172
Table 88 – OVERWRITE service action parameter list .....	172
Table 89 – TEST field .....	173
Table 90 – START STOP UNIT command .....	175
Table 91 – POWER CONDITION and POWER CONDITION MODIFIER field .....	176
Table 92 – SYNCHRONIZE CACHE (10) command .....	178
Table 93 – SYNCHRONIZE CACHE (16) command .....	179
Table 94 – UNMAP command .....	180
Table 95 – UNMAP parameter list .....	181
Table 96 – UNMAP block descriptor .....	182
Table 97 – Data-Out Buffer contents for the VERIFY (10) command .....	183
Table 98 – VERIFY (10) command .....	183
Table 99 – VRPROTECT field with the BYTCHK field set to 00b – checking protection information from the verify operations .....	185
Table 100 – VRPROTECT field with the BYTCHK field set to 01b or 11b – checking protection information from the verify operations .....	188
Table 101 – VRPROTECT field with the BYTCHK field set to 01b or 11b – checking protection information from the Data-Out Buffer .....	190
Table 102 – VRPROTECT field with the BYTCHK field set to 01b or 11b – compare operation requirements ..	192
Table 103 – VERIFY (12) command .....	195
Table 104 – VERIFY (16) command .....	196
Table 105 – VERIFY (32) command .....	197
Table 106 – WRITE (10) command .....	198
Table 107 – WRPROTECT field .....	199
Table 108 – WRITE (12) command .....	201
Table 109 – WRITE (16) command .....	202

Table 110 – WRITE (32) command .....	203
Table 111 – WRITE AND VERIFY (10) command .....	204
Table 112 – WRITE AND VERIFY (12) command .....	205
Table 113 – WRITE AND VERIFY (16) command .....	206
Table 114 – WRITE AND VERIFY (32) command .....	207
Table 115 – WRITE LONG (10) command .....	208
Table 116 – COR_DIS bit, WR_UNCOR bit, and PBLOCK bit .....	209
Table 117 – WRITE LONG (16) command .....	211
Table 118 – WRITE SAME (10) command .....	213
Table 119 – UNMAP bit, ANCHOR bit, and ANC_SUP bit relationships .....	214
Table 120 – WRITE SAME (16) command .....	215
Table 121 – NDOB bit and UNMAP bit interactions .....	215
Table 122 – WRITE SAME (32) command .....	216
Table 123 – WRITE USING TOKEN command .....	217
Table 124 – WRITE USING TOKEN parameter list .....	218
Table 125 – XDWRITEREAD (10) command .....	221
Table 126 – XDWRITEREAD (32) command .....	222
Table 127 – XPWRITE (10) command .....	223
Table 128 – XPWRITE (32) command .....	224
Table 129 – Parameters for direct access block devices .....	225
Table 130 – Address descriptors .....	226
Table 131 – Short block format address descriptor (000b) .....	226
Table 132 – Extended bytes from index format address descriptor (001b) .....	227
Table 133 – Sorting order for extended bytes from index format address descriptors .....	227
Table 134 – Extended physical sector format address descriptor (010b) .....	228
Table 135 – Sorting order for extended physical sector format address descriptors .....	229
Table 136 – Long block format address descriptor (011b) .....	229
Table 137 – Bytes from index format address descriptor (100b) .....	229
Table 138 – Sorting order for bytes from index format address descriptors .....	230
Table 139 – Physical sector format address descriptor (101b) .....	230
Table 140 – Sorting order for physical sector format address descriptors .....	230
Table 141 – Diagnostic page codes for direct access block devices .....	231
Table 142 – Rebuild Assist Input diagnostic page .....	232
Table 143 – Rebuild Assist Output diagnostic page .....	233
Table 144 – Translate Address Input diagnostic page .....	234
Table 145 – Translate Address Output diagnostic page .....	236
Table 146 – Log page codes and subpage codes for direct access block devices .....	237
Table 147 – Keywords for resetting or changing log parameters .....	238
Table 148 – Background Scan log page parameter codes .....	238
Table 149 – Background Scan log page .....	239
Table 150 – Background Scan Status log parameter format .....	240
Table 151 – BACKGROUND SCAN STATUS field .....	241
Table 152 – Background Scan Results log parameter format .....	242
Table 153 – REASSIGN STATUS field .....	243
Table 154 – Format Status log page parameter codes .....	245
Table 155 – Format Status log page .....	245
Table 156 – Format Data Out log parameter format .....	246
Table 157 – Grown Defects During Certification log parameter format .....	247
Table 158 – Total Blocks Reassigned During Format log parameter format .....	248
Table 159 – Total New Blocks Reassigned log parameter format .....	249
Table 160 – Power On Minutes Since Format log parameter format .....	250
Table 161 – Logical Block Provisioning log parameters .....	251
Table 162 – Logical Block Provisioning log page .....	252
Table 163 – Available LBA Mapping Resource Count log parameter format .....	253
Table 164 – SCOPE field .....	253
Table 165 – Used LBA Mapping Resource Count log parameter format .....	254
Table 166 – De-duplicated LBA Resource Count log parameter format .....	255
Table 167 – Compressed LBA Resource Count log parameter format .....	256

Table 168 – Total Efficiency LBA Resource Count log parameter format .....	257
Table 169 – Nonvolatile Cache log parameters .....	258
Table 170 – Nonvolatile Cache log page .....	258
Table 171 – Remaining Nonvolatile Time parameter data .....	259
Table 172 – REMAINING NONVOLATILE TIME field .....	259
Table 173 – Maximum Nonvolatile Time parameter data .....	260
Table 174 – MAXIMUM NONVOLATILE TIME field .....	260
Table 175 – Solid State Media log parameters .....	261
Table 176 – Solid State Media log page .....	261
Table 177 – Percentage Used Endurance Indicator log parameter format .....	262
Table 178 – Mode page codes and subpage codes for direct access block devices .....	263
Table 179 – DEVICE-SPECIFIC PARAMETER field for direct access block devices .....	264
Table 180 – Short LBA mode parameter block descriptor .....	265
Table 181 – Long LBA mode parameter block descriptor .....	266
Table 182 – Application Tag mode page .....	268
Table 183 – Application tag descriptor format .....	269
Table 184 – Background Control mode page .....	270
Table 185 – Caching mode page .....	272
Table 186 – DEMAND READ RETENTION PRIORITY field .....	273
Table 187 – WRITE RETENTION PRIORITY field .....	274
Table 188 – SYNC_PROG field .....	275
Table 189 – Informational Exceptions Control mode page .....	276
Table 190 – Definitions for the combinations of values in EWASC, DEXCPT, and TEST .....	277
Table 191 – Method of reporting informational exceptions (MRIE) field .....	278
Table 192 – Use of the INTERVAL TIMER field and the REPORT COUNT field based on the MRIE field .....	280
Table 193 – Logical Block Provisioning mode page .....	281
Table 194 – Threshold descriptor format .....	282
Table 195 – THRESHOLD TYPE field .....	282
Table 196 – THRESHOLD ARMING field .....	282
Table 197 – Read-Write Error Recovery mode page .....	283
Table 198 – Error recovery bit combinations .....	285
Table 199 – Verify Error Recovery mode page .....	289
Table 200 – VPD page codes for direct access block devices .....	290
Table 201 – Block Device Characteristics VPD page .....	291
Table 202 – MEDIUM ROTATION RATE field .....	291
Table 203 – PRODUCT TYPE field .....	292
Table 204 – WABEREQ field .....	292
Table 205 – WACEREQ field .....	293
Table 206 – NOMINAL FORM FACTOR field .....	293
Table 207 – Block Limits VPD page .....	294
Table 208 – Transfer limits for commands .....	295
Table 209 – Logical Block Provisioning VPD page .....	297
Table 210 – PROVISIONING TYPE field .....	298
Table 211 – Referrals VPD page .....	299
Table 212 – Block device third-party copy descriptor type codes .....	300
Table 213 – Block Device ROD Token Limits descriptor .....	301
Table 214 – ROD token device type specific data .....	302
Table A.1 – Variable length command service action code assignments .....	303
Table A.2 – SERVICE ACTION IN (16) service actions .....	304
Table A.3 – SERVICE ACTION OUT (16) service actions .....	304
Table D.1 – Sense information for locked or encrypted logical units .....	311
Table F.1 – Dedicated resource, threshold set tracked example capacity information .....	315
Table F.2 – Dedicated resource, threshold set tracked example capacity information .....	316
Table F.3 – Dedicated resource, threshold set tracked example initial conditions .....	317
Table F.4 – Dedicated resource, threshold set tracked example final log page values .....	318
Table F.5 – Shared resource, logical block tracked example capacity information .....	319
Table F.6 – Shared resource, logical block tracked example initial conditions .....	320
Table F.7 – Shared resource, logical block tracked example final log page values .....	321

Table F.8 – Shared available, dedicated used example capacity information .....	322
Table F.9 – Shared resource, logical block tracked example initial conditions .....	323
Table F.10 – Shared available, dedicated used example final log page values .....	324
Table G.1 – Referrals application client information with no user data segment multiplier .....	326
Table G.2 – User data segment calculations with no user data segment multiplier .....	326
Table G.3 – Referrals application client information with non-zero user data segment multiplier .....	328
Table G.4 – User data segment calculations with non-zero user data segment multiplier .....	328

## INFORMATION TECHNOLOGY – SMALL COMPUTER SYSTEM INTERFACE (SCSI) -

### Part 323: SCSI Block Commands – 3 (SBC-3)

#### FOREWORD

- 1) 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. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.
- 2) The formal decisions or agreements of IEC and ISO on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees and ISO member bodies.
- 3) IEC, ISO and ISO/IEC publications have the form of recommendations for international use and are accepted by IEC National Committees and ISO member bodies in that sense. While all reasonable efforts are made to ensure that the technical content of IEC, ISO and ISO/IEC publications is accurate, IEC or ISO cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees and ISO member bodies undertake to apply IEC, ISO and ISO/IEC publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any ISO, IEC or ISO/IEC publication and the corresponding national or regional publication should be clearly indicated in the latter.
- 5) ISO and IEC do not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. ISO or IEC are not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or ISO or its directors, employees, servants or agents including individual experts and members of their technical committees and IEC National Committees or ISO member bodies for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication of, use of, or reliance upon, this ISO/IEC publication or any other IEC, ISO or ISO/IEC publications.
- 8) Attention is drawn to the normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this ISO/IEC publication may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

International Standard ISO/IEC 14776-323 was prepared by subcommittee 25: Interconnection of information technology equipment, of ISO/IEC joint technical committee 1: Information technology.

The list of all currently available parts of the ISO/IEC 14776 series, under the general title *Information technology – Small computer system interface (SCSI)*, can be found on the IEC web site.

This International Standard has been approved by vote of the member bodies and the voting results may be obtained from the address given on the second title page.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2, except as described in 3.5 and 3.6.

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

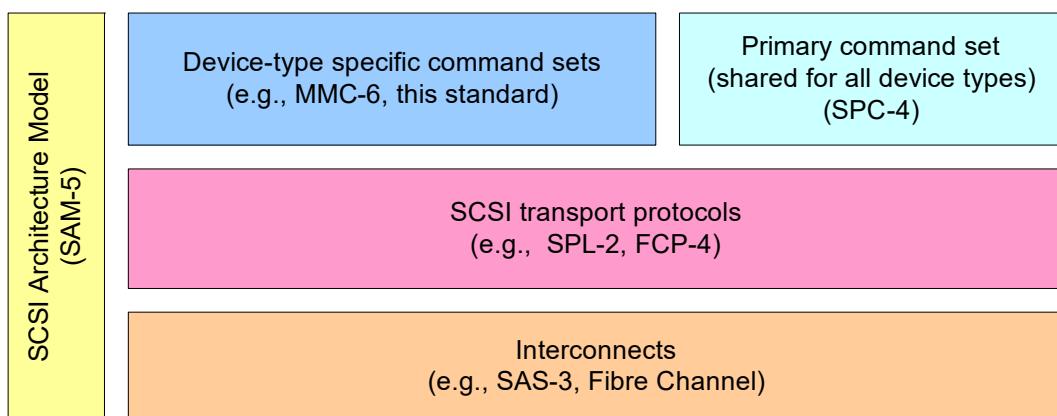
## INTRODUCTION

### General

The purpose of this standard is to define the model and command set extensions to be used in conjunction with the SCSI Primary Command Set standard - 4 (SPC-4) to facilitate operation of SCSI direct-access block devices (e.g., hard disk drives).

### SCSI standards family

Figure 0 shows the relationship of this standard to the other standards and related projects in the SCSI family of standards as of the publication of this standard.



**Figure 0 – SCSI document relationships**

Figure 0 gives the general relationship of the documents to one another and is not intended to imply a relationship such as a hierarchy, protocol stack, or system architecture.

The set of SCSI standards specifies the interfaces, functions, and operations necessary to ensure interoperability between conforming SCSI implementations. This standard is a functional description. Conforming implementations may employ any design technique that does not violate interoperability. See SAM-5 for more information about the relationships between the SCSI standards.

This standard makes obsolete the following concepts from SBC-2:

- a) linked commands;
- b) the partial medium indicator (PMI) bit and the LOGICAL BLOCK ADDRESS field in the READ CAPACITY (10) command and the READ CAPACITY (16) command;
- c) the READ (6) command and the WRITE (6) command;
- d) the XDREAD (10) command, the XDREAD (32) command, the XDWRITE (10) command, and the XDWRITE (32) command;
- e) the SYNC\_NV bit in the SYNCHRONIZE CACHE commands;
- f) the FUA\_NV bit in read commands;
- g) the FUA\_NV bit in write commands;
- h) the LBDATA bit and the PBDATA bit in the WRITE SAME commands;
- i) the initialization pattern modifier (IP MODIFIER) field in the initialization pattern descriptor in the FORMAT UNIT command; and
- j) the XOR Control mode page.

# INFORMATION TECHNOLOGY – SMALL COMPUTER SYSTEM INTERFACE (SCSI) –

## Part 323: SCSI Block Commands - 3 (SBC-3)

### 1 Scope

This part of ISO/IEC 14776 defines the command set extensions to facilitate operation of SCSI direct access block devices. The clauses in this standard, implemented in conjunction with the applicable clauses of SPC-4, specify the standard command set for SCSI direct access block devices.

The objectives of this standard are to:

- a) permit an application client to communicate over a SCSI service delivery subsystem (see SAM-5) with a logical unit that declares itself to be a direct access block device in the PERIPHERAL DEVICE TYPE field of the standard INQUIRY data (see SPC-4); and
- b) define commands and parameters unique to the direct access block device type.

### 2 Normative references

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

ISO/IEC 14776-262, *Information Technology - Small Computer System Interface (SCSI) - Part 262: SAS Protocol Layer - 2 (SPL-2)*

ISO/IEC 14776-342, *Information Technology - Small Computer System Interface (SCSI) - Part 342: Controller Commands - 2 (SCC-2)*

INCITS 513-2015, *Information Technology - SCSI Primary Commands - 4 (SPC-4)*

INCITS 515-2016, *Information Technology - SCSI Architecture Model - 5 (SAM-5)*

INCITS 517-2015, *Information Technology - SCSI / ATA Translation - 3 (SAT-3)*

INCITS 448-2008, *Information Technology - SCSI Enclosure Services - 2 (SES-2)*