

Information technology — Intelligent Peripheral Interface —

Part 3: Device generic command set for magnetic and optical disk drives

The European Standard EN 29318-3:1993 has the status of a
British Standard

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National foreword

This British Standard reproduces verbatim ISO/IEC 9318-3:1990 and implements it as the UK national standard.

In 1993 the European Committee for Standardization (CEN) accepted ISO/IEC 9318-3:1990 as European Standard EN 29318-3:1993. As a consequence of implementing the European Standard this British Standard is renumbered as BS EN 29318-3 and any reference to BS ISO/IEC 9318-3 should be read as a reference to BS EN 29318-3.

This British Standard is published under the direction of the Information Systems Technology Standards Policy Committee whose Technical Committee IST/6 has the responsibility to:

- aid enquirers to understand the text;
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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, page 2, the ISO/IEC title page, pages ii to xxx, pages 1 to 200, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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English version

Information technology — Intelligent Peripheral
Interface —
Part 3: Device generic command set for magnetic and
optical disk drives

(ISO/IEC 9318-3:1990)

Technologies de l'information — Interface pour
les périphériques intelligents — Partie 3: Jeu
de commandes génériques appareils pour les
disques magnétiques et optiques
(ISO/IEC 9318-3:1990)

Informationstechnik — Intelligente
Peripherie-Schnittstelle — Teil 3: Allgemeiner
Befehlssatz für magnetische und optische
Plattenlaufwerke
(ISO/IEC 9318-3:1990)

This European Standard was approved by CEN on 1993-10-20. CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CEN

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

Central Secretariat: rue de Stassart 36, B-1050 Brussels

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Foreword

On the proposal of the CEN Central Secretariat, the Technical Board decided to submit the International Standard: *Information technology — Intelligent Peripheral Interface — Part 3: Device generic command set for magnetic and optical disk drives* (ISO/IEC 9318-3:1990) to the formal vote.

The result of the formal vote was positive.

For the time being, this document exists only in English.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 1994, and conflicting national standards shall be withdrawn at the latest by April 1994.

In accordance with the CEN/CENELEC Internal Regulations, the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

**Information technology — Intelligent Peripheral
Interface**

Part 3:

Device generic command set for magnetic and optical
disk drives

Technologies de l'information — Interface pour les périphériques intelligents —

*Partie 3: Jeu de commandes génériques appareil pour les disques magnétiques et
optiques*



Reference number
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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.

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

International Standard ISO/IEC 9318-3 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*.

ISO/IEC 9318 consists of the following parts, under the general title *Information technology — Intelligent Peripheral Interface*:

- *Part 1: Physical level;*
- *Part 2: Device specific command set for magnetic disk drives;*
- *Part 3: Device generic command set for magnetic and optical disk drives;*
- *Part 4: Device generic command set for magnetic tape drives.*

Annex A forms an integral part of this part of ISO/IEC 9318. Annex B and Annex C are for information only.

Introduction

This part of ISO/IEC 9318 does not replace any existing standard, but it does complement other Intelligent Peripheral Interface (IPI) standards (see clause 2).

This part of ISO/IEC 9318 provides a definition of the device-generic portion of a series of standards called the Intelligent Peripheral Interface (IPI), a high performance, general-purpose parallel peripheral interface. This part of ISO/IEC 9318 responds to an industry market need (expressed both by users and manufacturers) to limit the increasing costs in hosts associated with changes in peripherals.

The first five clauses of this part of ISO/IEC 9318 contain material that is useful across all classes of devices that the device-generic command sets can support. Clauses 6 to 12 are oriented to particular device classes and in this document are intended for use with Magnetic and Optical disks.

Clause 1 describes the scope.

Clause 2 lists the normative reference.

Clause 3 provides descriptions and conventions.

Clause 4 describes the environment-of-use and projected application areas.

Clause 5 describes the Message Packet structure used for commands and responses.

Clause 6 describes Control commands.

Clause 7 describes Position commands.

Clause 8 describes the most generic Transfer commands.

Clause 9 describes the Combination Transfer commands, which require a minimum of two sets of extents.

Clause 10 describes the other Transfer commands, which are more device specific than those in clause 8.

Clause 11 describes the Diagnostic commands.

Clause 12 summarizes the commands defined in the document.

1 Scope

This part of ISO/IEC 9318 describes the Logical Level 3 (generic level) Interface for magnetic and optical disk drives. See clause 6 of ISO/IEC 9318-1 for an explanation of the levels.

The physical, electrical, and configuration characteristics and the transmission protocol of this interface are in accordance with ISO/IEC 9318-1. The interface is capable of handling data rates from 0 to at least 10 Mbytes/s, depending on driver and receiver classes.

The purpose of this part of ISO/IEC 9318 is to facilitate the development and utilization of an intelligent interface which permits the interconnection of multiple peripheral types such as disk, tape, communications, to a controller.

This part of ISO/IEC 9318 does not replace any existing standard, but it does complement other Intelligent Peripheral Interface (IPI) standards (see clause 2).

This part of ISO/IEC 9318 provides a definition of the device-generic portion of a family of standards called the Intelligent peripheral Interface (IPI), a high performance, general-purpose parallel peripheral interface.

The intent of the IPI is to isolate the host (CPU), both hardware and software, from changes in peripherals by providing a "function-generic" command set to allow the connection of multiple types of peripherals (disks, printers, tapes, communications). To smooth the transition from the current methods to the generic approach, the IPI supports device-specific command sets to aid in bridging the gap between the two approaches.

To accomplish this set of goals, the design of the IPI includes device-specific and device-generic command sets, both utilizing a common physical bus. The device-specific command set provides:

- device-oriented control;
- physical data addressing;
- timing critical operations;
- lower device cost.

The device-generic command set provides a higher level of functionality and portability. It includes:

- host/device independence;
- logical data addressing;
- timing independence;
- command queuing capability.

A system is not restricted to the use of one level of command set or the other. It is possible that both levels of command sets will be utilized with a given system's architecture to balance such parameters as system performance, cost, and peripheral availability. It is also possible for the host to provide for migration from device-specific to device-generic levels while still retaining the same physical interface.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitutes provisions of this part of ISO/IEC 9318. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this part of ISO/IEC 9318 are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO/IEC 9318-1:—, *Information technology — Intelligent Peripheral Interface — Part 1: Physical Level*¹⁾.

3 Definitions and conventions

3.1 Definitions

For the purpose of this part of ISO/IEC 9318, the following definitions apply:

3.1.1

actual address

the address of the facility, which is unique and is used by the slave to accomplish selection (the interface by which facilities are attached to the slave may or may not be an IPI)

3.1.2

addressee

the slave, the facility, or the combination of the two that are identified by the combination of Slave Address and Facility Address

3.1.3

alias

the name of a partition within a facility

3.1.4

attributes

each slave (or facility) has a level of functionality that can be described by a table that contains entries for characteristics that require definition to the master. The entries are self-defining and are termed attributes

3.1.5

burst

the maximum number of octets to be transferred in any one Information Transfer. The transfer of a number of bursts may be implicit within a single command request

3.1.6

command

a sequence issued by the master to initiate some specific operation

3.1.7

check sum disk operation

a high availability solution for a disk cluster in which a check sum is used to allow a failure in one device to be transparent to the host (i.e., the data in the failed device is reconstructed from the remaining devices)

NOTE If a device fails, although processing may continue, it is without protection.

¹⁾ To be published.

3.1.8**command address**

the two octets of Slave Address and Facility Address in the basic Command packet which uniquely identify the addressee (or optionally partition) to which the command is issued

3.1.9**data**

any Information Transfer over the interface not associated with either a command or a response

3.1.10**DataBlock**

a term which is uniquely defined in this part of ISO/IEC 9318 to mean the logical representation of data on the media. A DataBlock may or may not have a relationship to PhysicalBlocks (i.e., it may be equal to, less than, or greater than PhysicalBlocks in size). If commands are issued with DataBlock addresses to a slave that supports logical addressing, the slave is responsible to locate the physical representation of data by logical address correctly, and present it to the master in DataBlocks

3.1.11**extent**

a range of contiguous blocks, defined as the count of a number of blocks beginning at a data address (PhysicalBlock or DataBlock) within (and limited to) a partition

3.1.12**facility address**

the octet value in the Command Address that may be an Actual Address, Selection Address, Synonym, or Alias. It is used to identify the facility (or partition) to which the command is addressed. Valid values are from 0 to 255

3.1.13**housekeeping**

a procedure which is required at initial usage of a slave (or facility) because the master must obtain the attributes in order to adapt to, or configure, its functionality

3.1.14**individual**

this term refers to the execution of commands that must be completed before the next command can be issued

3.1.15**information transfer**

the transferring of octets on the Physical Interface of commands, responses, and data that are framed by a Bus Exchange

3.1.16**interrupts**

the ability at the Physical Interface for the slave to advise the master of which types of Response are available in the slave. The slave uses interrupts to initiate assertion of the ATTENTION IN signal

3.1.17**L-available (logically available)**

See 4.7.1.7.

3.1.18**L-busy (logically busy)**

See 4.7.1.9.

3.1.19**level 2 (device-specific)**

this term refers to commands that may be timing critical and that are used to define the execution of device-dependent operations. (See ISO/IEC 9318-2 for a further explanation and description of these commands)

3.1.20

level 3 (device-generic)

this term refers to commands that are not timing critical and that are in an intelligent environment in which the slave has functional control (which may or may not be overridden by the master) over the attached facility or facilities

3.1.21

logical address

the address of a cluster configuration by which the master would address the cluster

3.1.22

logical interface

this term refers collectively to all protocols higher than the Physical Interface

3.1.23

mandatory

to conform to the standard, all functions described as mandatory shall be implemented as defined in this part of ISO/IEC 9318

3.1.24

multiplex

the ability of a master to intersperse the execution of commands between addressees; or of a slave to intersperse the execution of commands between different facilities; or of a slave to intersperse transfer information in bursts that are less than the requested transfer size

3.1.25

operational

See 4.7.1.3.

3.1.26

optional

features that are not required by the standard. However, if any feature defined by the standard is implemented, it shall be done in the same way as defined by the standard

3.1.27

parity disk operation

a high availability solution for a disk cluster in which a parity device contains redundancy for the remaining devices such that a single device failure is transparent to the host (i.e., the data on the failed device is reconstructed from the remaining devices)

NOTE The use of parity usually implies that the devices are also-in parallel.

3.1.28

P-available (physically available)

See 4.7.1.1.

3.1.29

P-busy (physically busy)

See 4.7.1.5.

3.1.30

partition

a recording area that may be logically addressed. A partition may be slave defined (e.g., data area, CE area, IML area) or may be master defined (e.g., an addressable set of contiguous blocks within the data area). See also alias

3.1.31

PhysicalBlock

this term is uniquely defined in this part of ISO/IEC 9318 as meaning the physical representation of data on the media (e.g., sectors or records on disk and blocks or records on tape). It is used to prevent confusion between industry usage of terms

3.1.32**physical interface**

this term refers to the mechanical, electrical, and bus protocol characteristics specified in ISO/IEC 9318-1

3.1.33**queued**

the ability of a slave to accept multiple commands per Facility Address from the master and execute them in a sequence according to slave-defined or master-defined algorithms

3.1.34**ready**

this term is used to indicate that a slave or facility can execute its intended functions

3.1.35**response**

a sequence issued by a slave to advise the master of the results of a command, or of conditions within the slave

3.1.36**selection address**

the address used by the master at the Physical Interface to select a slave, a facility, or both (This may not be the same as the Actual Address if Synonyms are used).

3.1.37**shadow disk operation**

a high availability solution for a disk cluster in which duplicate copies of a disk exist. This allows continued operation even though one device fails

NOTE If one device fails, processing may continue, but it is without protection

3.1.38**synonym**

the ability to redefine the Facility Address of a Facility. There may be more than one synonym to address the same facility

3.1.39**vendor unique**

those features that can be defined by a vendor in a specific implementation. Caution should be exercised in defining and using such features since they may or may not be standard between vendors

3.2 Conventions

In this part of ISO/IEC 9318, certain terms that are proper names of signals are printed in uppercase to avoid possible confusion with other uses of the same words (e.g., ATTENTION IN). Any lowercase uses of these words have the normal English meaning.

A number of conditions, sequence parameters, events, English text, states or similar terms are printed with the first letter of each word in uppercase and the rest lowercase (e.g., In, Out, Selective Reset, Bi-directional, Bus Control, Operation Response). Any lowercase uses of these words have the normal English meaning.

4 Logical interface characteristics**4.1 Operations**

The Logical Interface uses a packet structure to transfer Commands from the master to the slave and Responses from the slave to the master. A Bus Exchange at the Physical Interface requires a Bus Control sequence and its associated Ending Status sequence to frame the Information Transfer of Commands, Responses, and data.

The Commands and Responses vary in length and only a single packet of data is transferred for each Information Transfer.

4.1.1 Commands

Commands are issued by the master to instruct the slave, facility, or both to perform an operation. The slave returns a Response when the command has been completed (unless inhibited by the “Inhibit Operation Response on Success” attribute set by the master).

4.1.1.1 Command types

The command types include:

- Control. The Control commands provide for control of the slave and facility or facilities.
- Position. The Position commands cause the positioning of the facility or facilities.
- Transfer. The Transfer commands may cause multiple blocks of data to be transferred between the master and the facility. Before data is actually transferred, the slave activates the Class 2 Interrupt to inform the master that it is ready to transfer data. The complete data transfer may be broken up into several Information Transfers. A slave with Command Queuing shall generate a Transfer Notification to inform the master of the identity of the command for which the transfer is pending.
- Combination. The Combination commands provide for operations between two facilities attached to the same slave, or between two facilities attached to different slaves if Slave-to-Slave Information Transfers are supported at the Physical Interface. In an operation between two different slaves, the master shall designate a dominant slave and a subservient slave. The dominant slave assumes the role of the master for the purpose of initiating Information Transfers to carry out slave-to-slave operations.
- Diagnostic. The Diagnostic commands provide for maintenance and diagnostic operations between a master and a slave or facility. These commands may be product specific, vendor specific, or both.

4.1.1.2 Command stacking

A slave that can accept more than one command is capable of command stacking. The number of commands that may be stacked is defined by the slave’s attributes. When a master attempts to send more commands to a slave than can be accepted, rejection occurs at the Physical Interface. Commands that are stacked may be Individual or Queued.

4.1.1.2.1 Individual

The slave can accept only one operation for every facility under its control (i.e., a queue of one).

4.1.1.2.2 Queued

The master can have more than one operation for every facility concurrently active under control of the slave, and the slave is responsible to execute them. This permits the slave the freedom to optimize the sequence of command execution to enhance performance (e.g., seek ordering algorithms). The master has the ability to override slave optimization via Attributes.

4.1.1.3 Command execution order

The order in which commands are executed is controlled by the command modifier bits that are common to all commands. Commands that are identified as Chained, Sequential, or Ordered cannot be intermixed for a given addressee. The last command of a Chain, Sequence, or Order has no encoding of its identity in order to identify it as being the last one — the slave shall be capable of recognizing it as being the last one, rather than treating it as an Individual or Queued command. The execution scenarios possible are:

- a) Individual/Queued Commands. Commands other than those labeled by modifier bits as Chained, Sequential, Ordered, or Priority are executed in a slave-dependent order or a facility-dependent order or both.
- b) Chained Commands. Commands are executed in the order received by the slave [first in, first out (FIFO) order] [i.e., a sequence of commands (not necessarily stacked) to a single addressee]. The addressee is implicitly reserved as long as any command of the Chain is being executed. If a command in the Chain is unsuccessful, the Chain shall be terminated and the remaining commands are not executed. The Chained modifier encoding is not set for the last command in a Chain. The slave may multiplex operations for other addressees during execution of the Chain.

c) Sequential Commands. Commands are executed in the order received by the slave (FIFO order). There may be more than one addressee in a Sequence and the slave may multiplex other operations during execution of the Sequence. If a command in the Sequence is unsuccessful, the Sequence shall be terminated and the remaining commands are not executed. The Sequential modifier encoding is not set for the last command in a Sequence. There is no implicit Reserve of the addressee beyond the command being executed.

d) Ordered Commands. Commands are executed in the order received by the slave (FIFO order). There may be more than one addressee in an Order, but the slave shall not multiplex other operations during execution of the Order. If a command in the Order is unsuccessful, the Order shall be terminated and the remaining commands are not executed. The Ordered modifier encoding is not set for the last command in an Order. There is no implicit Reserve of the addressee beyond the command being executed.

e) Priority Commands. Priority commands and Priority Chains/Sequences/Orders are indicated by the command modifier bits. Only the first command in a Chain/Sequence/Order shall be designated as Priority, but the Priority shall apply to the entire Chain/Sequence/Order. A Priority command causes the slave to change the order of execution of stacked commands and also causes changes in interpreting the Command packet transmission for each addressee.

When a Priority Command packet is received for an addressee, any Chain/Sequence/Order that was in the process of being received shall be ended (i.e., the last packet received is interpreted as the last of the Chain/Sequence/Order regardless of the command modifier settings in that packet. This ending applies regardless of whether the slave is operating in a queued or non-queued environment.

NOTE This applies only to commands received over the same port.

Priority commands, whether Individual or part of a Chain/Sequence/Order, are executed before non-Priority commands. Priority commands are executed in Last In First Out (LIFO) order. With the exception of individual ABORT commands, the receipt of a Priority command does not affect the operation of any Individual command or commands in a Chain/Sequence/Order, except for the possible ending noted previously. When a Priority, Individual ABORT command is received, the slave shall suspend the command executing (if possible), and process the ABORT.

4.1.2 Operation responses

Each Command has an associated Response packet. Command Completion Response packets contain status that notifies the master whether or not the command was successful, and if not successful, why not. The response is not generated or transferred if the "Inhibit Operation Response on Success" attribute is set by the master.

Response packets are also generated to notify the master of commands that are ready for data transfer, or for asynchronous events that have occurred in the slave or facilities.

4.1.2.1 Interrupts

Physical Interface interrupts are used by the slave to request service from the master.

The master may poll any or all of the interrupt classes by setting the appropriate bits in the Request Interrupts octet of the Physical Interface. It is the responsibility of the master to prioritize the interrupts in the event that more than one slave is interrupting.

Optionally, the master may poll the interrupts from the facilities attached to a slave by the Request Facilities Interrupts octet of the Physical Interface if this feature is supported by the slave.

The Physical Interface ATTENTION IN signal is a logical OR of the interrupts from all but the addressee selected on the Physical interface. The interrupts may be enabled and disabled from generating Attention.

The interrupt classes for slaves and facilities are defined in descending order of priority. Slaves shall present interrupts in order of their priority, except when the response stack is full of lower order interrupt responses (i.e., if a Class 2 could be presented because data is available in a buffer, but the stack is full of Class 1 responses because the master has not requested them, the slave shall not respond to a poll for Class 2 interrupts).

An interrupt is cleared when the condition that caused it to be presented is no longer present.

The three classes of interrupts are as follows:

- a) Class 3 (Critical Status Pending). This interrupt shall be used to alert the master to events or conditions existing in a slave or facility that require immediate attention from the master and that are not associated with command completion. An Asynchronous response shall be used to alert the master, and the conditions initiating same are defined by the Major Status, associated Substatus, and Extended Substatus (if any).
- b) Class 2 (Transfer Status Pending). This interrupt shall be used by slaves to inform the master that data is ready to be transferred. A Transfer Notification to identify the command involved shall be generated by the slave unless the master is selecting facilities and executing Individual commands; or a Paused transfer implies the Transfer Notification.
- c) Class 1 (Status Pending). This interrupt shall be used to identify command completion responses, successful or otherwise, of commands issued by the master, and to inform the master of Asynchronous responses that are not critical. The Major Status and associated Substatus, if any, identify either the conditions under which the command terminated or the cause of the Asynchronous response.

An optional use of this interrupt is to report that the slave, which was previously reported Busy during a selection sequence, is no longer Busy. When the interrupt is used in this manner, the master is responsible for recognizing that there is not necessarily a Command Completion or Asynchronous Response packet already in the slave. If there is no Response packet pending in the slave, the interrupt shall be cleared by a successful selection sequence.

4.1.2.2 Response types

The response types do not directly correspond to the three interrupt classes. An Asynchronous response may be Class 3 if critical (e.g., power failure warning), or Class 1 if not critical (e.g., transition from Ready to Not Ready).

4.1.2.2.1 Command completion response

This response shall be generated by the slave when a command has been completed, unless the response has been disabled by Attributes being set to "Inhibit Operation Response on Success."

The Class 1 interrupt is activated to inform the master that a Command Completion Response is available.

4.1.2.2.2 Transfer Notification Response (optional)

This response shall be generated by a slave capable of stacking Individual or Queued commands. It is used to identify the command with which the data transfer to follow is associated.

Transfer Notification Responses are not required under the following conditions:

- When commands are Individual, and the command was preceded by a facility selection
- For continuation of paused data transfers

The Class 2 Interrupt is activated to inform the master that a Transfer Notification Response is available.

4.1.2.2.3 Asynchronous response

This response shall be generated by the slave to advise the master of an unanticipated event not associated with command completion.

Either the Class 3 or Class 1 Interrupt is activated to inform the master that this response is available (depending upon whether or not it is considered critical by the slave).

4.1.2.2.4 Imbedded data response (optional)

This response shall be generated by the slave to send small amounts of data in a parameter field of the Response packet. No more than 254 octets can be transferred in this manner.

The objective of this response is to permit peripherals with very low transfer rates and small transfer needs to gather data in a manner that does not interfere with high-performance peripherals. This response shall not terminate the command, and many of them can be received in answer to a single command.

The Class 2 Interrupt is activated to inform the master that an Imbedded Data Response is available.

4.1.2.3 *Response handling*

When there is more than one Response packet to be transferred by the slave, it shall transfer Response packets to the master in the order of interrupt priority. Within an interrupt class, the responses shall be presented in order of command completion.

If facility selection precedes the request for a Response packet, the slave shall only transfer the highest priority response among those for the selected facility.

The master shall properly handle any Response packet that it receives, even if it is not necessarily the response type that it expected.

The master should not attempt to initiate the transfer of a Response packet before interrupts indicate the availability of a response ready to transfer. If the slave has no Response packet to transfer upon receiving a request for one, it shall terminate the attempted Information Transfer (without transferring any information) and not post the Successful bit in Slave Status.

When a slave that supports Control of Bus at the Physical Interface is given control, it may elect to transfer a Response packet or transfer data.

4.1.3 *Physical interface error recovery considerations*

Errors detected by the Physical Interface protocol require recovery action be taken via a Device-Generic protocol. Recovery procedures depend on the packet type (Command, Data, or Response), and on whether or not the error is detected prior to the Slave Status octet being presented.

4.1.3.1 *Recovery from unsuccessful Slave Status octet*

The Slave Status octet contains the Successful Information Transfer bit, which is set to 0 if any errors are detected by the slave prior to transmission of the octet. This includes not posting Successful if the slave recognized bad parity on the Master Status octet.

NOTE The slave does not change its Slave Status octet contents based on the contents of the Master Status octet.

Following a command transfer, if the Success bit in either the Master or the Slave Status octet is set to 0, the slave shall ignore the command. The master shall retransmit the command.

Following a data transfer, if the Success bit in either the Master or the Slave Status octet is set to 0, the slave shall terminate the command in progress. A response indicating the failure shall be generated.

Following a response transfer, if the Success bit in either the Master or the Slave Status octet is set to 0, the slave shall retain the response in its buffer and attempt re-transmittal under the master's control. The slave shall assert the appropriate interrupt upon deselection.

4.1.3.2 *Recovery from bad parity on the Slave Status octet*

If the master detects a parity error or any other invalid condition on the Slave Status octet, the slave has no way to determine what has happened (as this is presented in the last state before deselection may occur).

Whenever an invalid condition is detected in the Slave Status octet following a command, data, or Transfer Notification packet transfer, the master shall use an ABORT command or a selective reset (either Logical Interface Reset or Slave Reset) to force the slave to discontinue execution of the command.

If an invalid condition is detected in the Slave Status octet following a Response packet other than Transfer Notification (typically Command Completion), the master shall retry execution of the entire command because the slave is not aware of its failure, and has released the buffer containing the Response packet.

NOTE In the case of a slave that queues commands, the master may have to issue no more commands until it can match valid responses with all the issued commands in order to identify the one that was unsuccessful.

If an invalid condition is detected in the Slave Status octet following an Asynchronous Response packet, the master has no way of advising the slave that the Slave Status octet was not received correctly. Master-specific recovery procedures may choose whether or not to accept the contents of the Information Transfer. If it is a condition that keeps recurring, the slave shall generate another response.

NOTE Under this circumstance the error recovery action cannot be certain to obtain the same information as was originally presented.

4.2 *Operation sequences*

Operation sequences of the logical interface are controlled by the master, since it establishes the Bus Exchanges that transfer information between the master and slave. Optionally, the master may give control of the bus to a slave; actual control of the Information Transfer at the Physical Interface would then be performed by the slave.

The sequence of actions taken to execute operations between master and slave(s) is done as a series of Information Transfers across the Physical Interface. Slave selection and deselection is done as necessary to communicate with the desired addressee.

4.2.1 Slave procedures

The following procedures are not necessarily supported by every slave. The slave's Attributes indicate those which are supported.

- a) Facility Selection and Facility Interrupts. When the slave supports facility selection and interrupts, the master may make use of them to exert control of the facility. The use of the facility interrupts allows the master to determine the facility requiring service and the facility selection allows the master to direct an operation to the desired facility.
- b) Slave Control. When the slave Control of Bus is supported (Bus Acknowledge octet), the master may give control of the subsequent Information Transfer to the slave to allow it to determine whether to transfer a Response packet or data. The slave shall not set the Operation Out bits in the Bus Acknowledge octet (i.e., attempt to cause a command to be transferred).
- c) Queued Facility. When the slave's Attributes indicate that a facility can operate in a queued environment, the master may issue more than one command for a facility.

4.2.2 Basic steps

The basic steps performed by the master in carrying out operations are

- a) transmit Command packet to slave;
- b) poll interrupts;
- c) receive response from slave;
- d) transfer data between master and slave.

These steps shall be as described in 4.2.2.1 through 4.2.2.4.

4.2.2.1 Transmit Command packet to slave

The master establishes a Bus Exchange to transfer a single Command packet to the selected slave. The number of commands that can be stacked at an addressee is defined in the Attributes.

Commands consist of variable length transfers, and some slaves may terminate the transfer based on the Packet Length defined in the first two octets. If slaves require master termination of transfers, the length of the transfer is decided by the master.

If the Master Status octet in the Ending Status sequence indicates an unsuccessful transfer, then the slave shall ignore the received command. No Response packet shall be generated.

If the Slave Status octet in the Ending Status sequence indicates a successful transfer, the master need not retain the entire Command packet.

4.2.2.2 Poll interrupts

The master polls interrupts to know when to perform data transfers or receive Responses. The polling of a specific interrupt from each of the slaves is performed by the Request Interrupt sequence of the Physical Interface. The presence of an interrupt in any of the slaves is typically provided by the ATTENTION IN signal at the Physical Interface. The master can choose to mask out interrupts by class from setting Attention (via the ATTENTION CONTROL command).

Even if a master has masked out all interrupts from setting Attention, it is still necessary to recognize that unsolicited Attentions could occur (e.g., if an attached slave executed a Power On reset, the mask information would be lost, and an Attention caused by powering on would be generated when its drivers were enabled).

If facility interrupts are supported by the slave, the master may poll facilities attached to a slave after receiving an interrupt from the slave.

NOTE The slave generates interrupts on behalf of the attached facility or facilities.

4.2.2.3 Receive Response packet from slave

Upon receiving an interrupt from a slave, the master establishes a Bus Exchange to transfer the slave's Response. There is one exception to this action by the master: when the interrupt is Class 2 and the master is executing in a non-queued environment with facility selection.

The master may give control of the bus to the slave (if this function is supported) so that the slave can decide whether to transfer a Response packet or to transfer data.

If the Master Status in the Ending Status sequence indicates a successful transfer, the slave releases the Response packet and deactivates the interrupt; otherwise, it retains the packet until successfully transferred.

The Response packet may indicate

- a) the successful or unsuccessful completion of a command;
- b) a notice that data is to be transferred for a particular command;
- c) the occurrence of an asynchronous event.

4.2.2.4 Transfer of data between master and slave

After receiving a Transfer Notification [or when there is a Class 2 interrupt in a non-queued environment with facility selection (see 4.2.2.3)], the master initiates a Bus Exchange to transfer data to or from the slave as required by the command identified in the response. (If the slave is given Control of Bus, it sets up the direction of transfer.)

The amount of data intended to be transferred shall be determined by the slave (because it generates SYNC IN at the Physical Interface). Whether or not the ending Master Status indicates a successful input transfer, the slave may release its input data buffer. If the Slave Status indicates a successful output transfer, the master may release its output data buffer.

If the master terminates a data transfer, the characteristics of the slave shall determine whether or not it is an unsuccessful transfer. To a fixed block class of device such as disk, the transfer would be considered unsuccessful unless the transfer was being Paused (optional feature) by the master. To a variable block class of device such as tape, master termination would normally be considered successful and a short PhysicalBlock would be written.

If not Paused by the master, the Command Completion response shall identify the termination to the master (whether or not the transfer was successful) as "Unexpected Master Status" in Machine Exception Substatus.

If the transfer requested by the command was completed successfully, unless overridden by Attributes, the slave shall generate a Class 1 interrupt and a Command Completion response. If the transfer is unsuccessful, the slave shall generate a Class 1 interrupt and report the appropriate status in the Command Completion Response.

4.2.3 Operation sequence examples

The four steps described in the preceding subclauses may be used in a number of ways, and can best be illustrated by a set of examples executing the same scenario in different implementations. In these examples, the data transfer for Facility 1 requires two transmissions because the slave paused (either unanticipated, or multiplexed) during transfer.

The examples attempt to define only major steps in the flow (e.g., deselection is implicit). To clarify direction of transfer, the terms "transmit" are used for transfers out to the slave, and "receive" is used for transfers in from the slave. The term "recognize" is used for polling because the master has a choice of alternatives when polling (between slaves, facilities and masking).

4.2.3.1 Example of facility selection and individual commands

In this example, transfer commands are sent to facilities 0, 1 on slave 0.

- a) Select Slave 0/Facility 0 and transmit command packet
- b) Select Slave 0/Facility 1 and transmit Command packet
- c) Poll interrupts and recognize Class 2 Interrupt from Slave 0
- d) Poll Slave 0 and recognize Class 2 Interrupt from Facility 1
- e) Select Slave 0/Facility 1 and continue to perform data transfer until paused by Slave 0
- f) Poll interrupts and recognize Class 2 Interrupt from Slave 0
- g) Poll Slave 0 and recognize Class 2 Interrupt from Facility 0
- h) Select Slave 0/Facility 0 and perform data transfer until terminated by Slave 0
- i) Poll interrupts and recognize Class 1 Interrupt from Slave 0

- j) Poll Slave 0 and recognize Class 1 Interrupt from Facility 0
- k) Select Slave 0/Facility 0 and receive Command Completion Response with “Successful” Status
- l) Poll interrupts and recognize Class 2 Interrupt from Slave 0
- m) Poll Slave 0 and recognize Class 2 Interrupt from Facility 1
- n) Select Slave 0/Facility 1 and perform data transfer until terminated by Slave 0
- o) Poll interrupts and recognize Class 1 Interrupt from Slave 0
- p) Poll Slave 0 and recognize Class 1 Interrupt from Facility 1
- q) Select Slave 0/Facility 1 and receive Command Completion Response with “Successful” Status

4.2.3.2 *Example of facility selection and queued commands*

In this example, Transfer commands are sent to Facilities 0, 1 on Slave 0.

- a) Select Slave 0/Facility 0 and transmit Command packet
- b) Select Slave 0/Facility 1 and transmit Command packet
- c) Poll interrupts and recognize Class 2 Interrupt from Slave 0
- d) Poll Slave 0 and recognize Class 2 Interrupt from Facility 1
- e) Select Slave 0/Facility 1 and receive Transfer Notification identifying command
- f) Perform data transfer until paused by Slave 0
- g) Poll interrupts and recognize Class 2 Interrupt from Slave 0
- h) Poll Slave 0 and recognize Class 2 Interrupt from Facility 0
- i) Select Slave 0/Facility 0 and receive Transfer Notification identifying command
- j) Perform data transfer until terminated by Slave 0
- k) Poll interrupts and recognize Class 1 Interrupt from Slave 0
- l) Poll Slave 0 and recognize Class 1 Interrupt from Facility 0
- m) Select Slave 0/Facility 0 and receive Command Completion Response with “Successful” Status
- n) Poll interrupts and recognize Class 2 Interrupt from Slave 0
- o) Poll Slave 0 and recognize Class 2 Interrupt from Facility 1
- p) Select Slave 0/Facility 1 and receive Transfer Notification identifying command
- q) Perform data transfer until terminated by Slave 0
- r) Poll interrupts and recognize Class 1 Interrupt from Slave 0
- s) Poll Slave 0 and recognize Class 1 Interrupt from Facility 1
- t) Select Slave 0/Facility 1 and receive Command Completion Response with “Successful” Status

NOTE Applications that implement multiple commands per facility in a non-ordered sequence, although not included in this example, require the use of Transfer Notification Packets. This example represents the same scenario as the other examples in this clause.

4.2.3.3 *Example of slave selection*

In this example, Transfer commands are sent to Facilities 0, 1 on Slave 0.

- a) Select Slave 0 and transmit Command packet for Facility 0
- b) Remain selected and transmit Command packet for Facility 1
- c) Poll interrupts and recognize Class 2 Interrupt from Slave 0
- d) Select Slave 0 and receive Transfer Notification identifying command for Facility 1
- e) Perform data transfer until paused by Slave 0
- f) Poll interrupts and recognize Class 2 Interrupt from Slave 0
- g) Select Slave 0 and receive Transfer Notification identifying command for Facility 0
- h) Perform data transfer until terminated by Slave 0
- i) Poll interrupts and recognize Class 1 Interrupt from Slave 0
- j) Select Slave 0 and receive Command Completion Response for Facility 0 with “Successful” Status

- k) Poll interrupts and recognize Class 2 Interrupt from Slave 0
- l) Select Slave 0 and receive Transfer Notification identifying command for Facility 1
- m) Perform data transfer until terminated by Slave 0
- n) Poll interrupts and recognize Class 1 Interrupt from Slave 0
- o) Select Slave 0 and receive Command Completion Response for Facility 1 with “Successful” Status

4.2.3.4 Example of slave selection and slave control of Bus

In this example, Transfer commands are sent to Facilities 0 and 1 on Slaves 0 and 1, respectively. This introduces implicit Transfer Notification (i.e., only one data transfer is paused at a slave, so the Transfer Notification can be implied when the transfer is continued).

- a) Select Slave 0 and transmit Command packet for Facility 0
- b) Select Slave 1 and transmit Command packet for Facility 1
- c) Poll interrupts and recognize Class 2 Interrupt from Slave 0
- d) Select Slave 0 and with Bus Control give Control of Bus to slave
- e) Receive Bus Acknowledge octet indicating Response (Operation In)
- f) Receive Transfer Notification identifying command for Facility 0
- g) Master sets Bus Control (Data Direction)
- h) Perform data transfer until paused by Slave 0
- i) Poll interrupts and recognize Class 2 Interrupt from Slave 1
- j) Select Slave 1 and with Bus Control give Control of Bus to slave
- k) Receive Bus Acknowledge octet indicating Response (Operation In)
- l) Receive Transfer Notification identifying command for Facility 1
- m) Master sets Bus Control (Data Direction)
- n) Perform data transfer until terminated by Slave 1
- o) Poll interrupts and recognize Class 2 Interrupt from Slave 0
- p) Select Slave 0 and with Bus Control give Control to slave
- q) Receive Bus Acknowledge octet with implicit Transfer Notification and Data Direction
- r) Perform data transfer until terminated by Slave 0
- s) Poll interrupts and recognize Class 1 Interrupt from Slave 0
- t) Select Slave 0 and with Bus Control give Control of Bus to slave
- u) Receive Bus Acknowledge octet indicating Response (Operation In)
- v) Receive Command Completion Response for Facility 0 with “Successful” Status
- w) Poll interrupts and recognize Class 1 Interrupt from Slave 1
- x) Select Slave 1 and with Bus Control give Control of Bus to slave
- y) Receive Bus Acknowledge octet indicating Response (Operation In)
- z) Receive Command Completion Response for Facility 1 with “Successful” Status

4.3 Multiplexed data transfers (optional)

Different computer system architectures will utilize the IPI, and a wide range of products may be intermixed on a single cable. There are occasions in which a transfer may be terminated for either an unanticipated reason or a deliberate event. The interface provides for both to occur via use of the Pause function at the Physical Interface. Command, and Response packet transfers cannot be paused — only data transfers may be paused and continued.

It is necessary that a master be able to control some of the ways in which different products from different vendors coexist. One important area is in ensuring equitable use of the bandwidth. A deliberate event to pause a transfer occurs when a master wishes to prevent a particular peripheral from dominating the use of the interface during Information Transfers.

In an application in which the master requests large data transfers, it is preferred that the master be able to predict the use of the interface. The master can accomplish this by multiplexing transfers between addressees on a predictable basis. The master may define (in Attributes) the maximum number of octets to be transferred in any one data transfer (a burst), even though any single command may itself define considerably more.

A command for a 20Koctets data transfer to a slave with a defined 8Koctets maximum burst size would require three data transfers in order to complete. The slave would pause after each 8Koctets burst and complete after the remainder of 4K was transferred.

4.3.1 Physical interface Pause and Continue (optional)

The Physical Interface provides the ability to Pause and Continue transfers from both the master and the slave. The master and the slave may use this function to interrupt a continuous data transfer. The slave shall transfer data in bursts no longer than those defined or set in Attributes.

The master cannot indicate any time dependency to the slave, only whether or not the transfer is paused. However, the slave can indicate to the master some idea of the expected time period that the transfer shall be paused. This is done through use of the Time-Dependent Operation bit in the Slave Status octet.

The meaning of the bits shall be as follows:

Pause		Time-Dependent Operation
0	0	No Delay
1	0	Short Delay
1	1	Long Delay
0	1	No More Data

If for some reason both the master and slave present the Pause bit in their respective ending status octets, the slave Pause shall override the master Pause.

In the following descriptions (4.3.2 to 4.3.9), the term P/TDO refers to the setting of the Pause and Time-Dependent Operation bits in the Slave Status octet.

4.3.2 Slave pause and master Continue

The master controls the slaves that receive service. The master shall use Attributes to establish the size of transfer, defined as a burst, to be multiplexed. During data transfers, when the burst defined by the master has been transmitted, the slave shall terminate. If information is immediately available to resume transfer with another burst, it shall so indicate by P/TDO=00. This condition can only occur on multiplexed burst boundaries.

If a slave Pauses with no information remaining in its buffer to be transferred, but it anticipates only a short delay before information shall be available, it shall set P/TDO=10. If, however, the delay is expected to exceed the value defined in Attributes, it shall set P/TDO=11.

If it is deselected, the slave shall generate a Class 2 interrupt when it has more information to transfer (immediately when P/TDO=00).

When a slave transferring information pauses at the end of a burst, the master may choose to deselect and poll the other slaves, or remain selected and continue the transfer.

To continue a paused data transfer, the master shall re-select (if necessary), and resumption of the data transfer may or may not be implicit, based on the mode of interface operation.

The slave shall always have a Transfer Notification packet prepared (if they are being used) so that if the master issues a Response request, the slave can respond with same.

4.3.2.1 Implicit continue

If the master is executing Individual commands with Facility Selection, it can reissue the same Bus Control octet as for the initial transfer.

If the master is executing Queued commands to a slave that can have more than one paused transfer, the master has to receive a Transfer Notification Response packet to know which one is being continued. To do so, the master may issue the Bus Control octet for a Response, or permit the slave Control of Bus and the slave shall set up the data transfer of a Response.