queue tagged commands are executed in the strict order received, regardless of initiator. In a stream of tagged commands, an untagged command serves as a synchronizing command.

Only one command with a given tag can be active against an LU from an initiator at a time. The number of queue tag bits assures that an unused tag can easily be found.

If the command queue is nearly full, an indication must be given to an initiator that no more commands can be enqueued until or more of the already queued commands is complete. The command queue full indication is given as a message response to any of the queue tag messages. The command queue full indication must be given while there is still space in the queue for operations from all initiators that have not received a queue full indication.

The command queue tagging protocol is chosen to be compatible with SCSI X3.13I-1986, as well as functional with the SCSI-2 standard. The command queue tagging protocol is further chosen to allow disconnection any time after the IDENTIFY message and the QUEUE TAG message have been transmitted.

Both deferred errors and normal errors are handled in the normal manner. Normal errors are indicated by CHECK CONDITION status. REQUEST SENSE commands are executed against the same queue tag to obtain the information stored for the failing operation. Deferred errors are normally related to a command that has long since completed. As such, there is no attempt to point back to the queue tag assigned to the original failing command. Since command queuing with disconnection performs such the same function as the Immediate bit, it is expected that few fully tagged commands will choose to use the Immediate bit. This limits the set of errors that can become deferred errors.

This proposal is added to the end of section 6 of the SCSI-2 document. Since a previous proposal adds section 6.5, it is proposed that this section be added as section 6.6. The section will include both a description of simple command queuing and full command queuing. In addition to the inclusion of section 6, section 5 will pick up a new message in table 5-2 and in section 5.5.2. The details of the modifications are explained below.

Table 5-2 on page 5-14 of the 1/9/87 document will be modified in the following manner. The line describing codes 00h - 7Fh shall be replaced with five lines as follows:

| 00h | 0 0 | QUEUE FULL |
| 00h - 0Fh | Reserved Codes | |
| 10h | 0 0 | NON-SYNC QUEUE TAG |
| 11h | 0 0 | SYNCHRONIZING QUEUE TAG |
| 12h - 7Fh | Reserved Codes | |

Section 5.5.2 will have new text added between the text.
SYNCHRONIZING QUEUE TAG 11h. If the optional full queueing function described in section 6.6.2 is supported and if a synchronizing tagged command is required, the SYNC QUEUE TAG extended message is transmitted immediately after the IDENTIFY message to provide a logical identifier for that particular command or link of commands as it is being executed by the initiator and the Logical Unit. The SYNC QUEUE TAG message is a two-byte message with the following structure:

```
Byte 0    SYNC QUEUE TAG
Byte 1    QUEUE TAG logical identifier
```

The use of the SYNCHRONIZING QUEUE TAG implies that the command or link of commands must be queued by the target SCSI device and executed against the LU in an arbitrary order. The transmission of a command without any tagging message implies that the untagged command or link of commands must be executed in the order transmitted relative to other commands to that LU from that initiator. The transmission of a command with the SYNC QUEUE TAG message implies that tagged synchronizing commands or links of commands must be executed in the strict order received to that LU regardless of the initiator.

The SYNCHRONIZING QUEUE TAG message out phase is requested by the initiator immediately after the IDENTIFY message by leaving ATN active after the time that ACK drops in response to the REQ for the IDENTIFY message. The device supporting full queueing will not disconnect until after both the IDENTIFY and the SYNC QUEUE TAG messages have been received.

Section 6.6 will describe the queueing capability of the SCSI with the following text:

4.6 Command Queuing

Command queueing allows more than one command to be in process under control of an LU at the same time. Simple command queueing allows an LU to simultaneously accept commands from more than one initiator at a time. Full command queueing allows an LU to simultaneously accept multiple commands from each initiator to each LU. By using command queueing, a target avoids the overhead of presenting BUSY status to a command when it is actually busy processing
describing BUS DEVICE RESET and the text describing IDENTIFY. The text will be as follows:

 QUEUE FULL 00h. If the optional full queuing function is implemented, the QUEUE FULL message is presented to the selecting initiator when a NON-SYNCHRONIZING QUEUE TAG or a SYNCHRONIZING QUEUE TAG message is generated and when the command queue is full so that no other commands can be accepted from that initiator for that LUN. Aside from this extra message phase, the command is executed normally. The Initiator is obligated to send no new commands to that LUN until one or more of the previously queued commands has been complete.

 NON-SYNCHRONIZING QUEUE TAG 10h. If the optional full queuing function described in section 6.6.2 is supported and if a non-synchronizing tagged command is required, the NON-SYNC QUEUE TAG extended message is transmitted immediately after the IDENTIFY message to provide a logical identifier for that particular command or link of commands as it is being executed by the initiator and the Logical Unit. The NON-SYNC QUEUE TAG message is a two-byte message with the following structure:

| Byte 0 | NON-SYNC QUEUE TAG | 10h |
| Byte 1 | QUEUE TAG logical identifier |

The use of the NON-SYNCHRONIZING QUEUE TAG implies that the command or link of commands may be queued by the target SCSI device and executed against the LU in an arbitrary order. The transmission of a command without any tagging message implies that the untagged command or link of commands must be executed in the order transmitted relative to other commands to that LUN from that initiator. The transmission of a command with the SYNC QUEUE TAG message implies that tagged synchronizing command or link of commands must be executed in the strict order received to that LUN regardless of the initiator.

The NON-SYNC QUEUE TAG message out phase is requested by the initiator immediately after the IDENTIFY message to confirm the transmission using the ACK command. Target devices supporting full queuing will not disconnect until after both the IDENTIFY and the NON-SYNC QUEUE TAG messages have been received.

The NON-SYNC QUEUE TAG message in is provided immediately after the reselection IDENTIFY message in has been presented to complete the identification process of the operation being continued. If no type of tagging message in is provided, it is assumed that the reconnection is being made on behalf of an active untagged command.

SYNCHRONIZING QUEUE TAG 11h. If the optional full queuing function described in section 6.6.2 is supported and if a synchronizing tagged command is required, the SYNC QUEUE TAG extended message is transmitted immediately after the IDENTIFY message to provide a logical identifier for that particular command or link of commands as it is being executed by the initiator and the Logical Unit. The SYNC QUEUE TAG message is a two-byte message with the following structure:

| Byte 0 | SYNC QUEUE TAG | 11h |
| Byte 1 | QUEUE TAG logical identifier |

The use of the SYNCHRONIZING QUEUE TAG implies that the command or link of commands must be queued by the target SCSI device and executed against the LU in the strict order received. All previous NON-SYNC QUEUE TAG labeled commands must be executed before the command labeled by the SYNC QUEUE TAG. All subsequent NON-SYNC QUEUE TAG labeled commands are executed after the command labeled by the SYNC QUEUE TAG, regardless of initiator. The transmission of a command without any tagging message implies that the untagged command or link of commands must be executed in the order transmitted relative to other commands to that LUN from that initiator.

The SYNC QUEUE TAG message out phase is requested by the initiator immediately after the IDENTIFY message by leaving ATN active after the time that ACK drops in response to the REQ for the IDENTIFY message. Target devices supporting full queuing will not disconnect until after both the IDENTIFY and the SYNC QUEUE TAG messages have been received.

The SYNC QUEUE TAG message in is provided immediately after the reselection IDENTIFY message in has been presented to complete the identification process of the operation being continued. If no type of tagging message in is provided, it is assumed that the reconnection is being made on behalf of an active untagged command.

Section 6.6 will describe the queuing capability of the SCSI with the following text:

6.6 Command Queuing

Command queuing allows more than one command to be in process under control of an LU at the same time. Simple command queuing allows an LU to simultaneously accept commands from more than one initiator at a time. Full command queuing allows an LU to simultaneously accept multiple commands from each initiator to each LU. By using command queuing, a target avoids the overhead of presenting BUS status to a command when it is actually busy processing
other commands. In addition, command transmission overheads are decreased because command transmission can be overlapped with mechanical delays in the target LU.

6.6.1 Simple Command Queueing

Simple command queueing allows an LU to accept a new command from an initiator while the LU is actually processing commands for another initiator. Only one command may be active for each LU from each initiator at any time.

A new command may be accepted for the LU at any time that the SCSI bus is free whether or not another command from a different initiator is active. The target may force the command to disconnect before or after the Command Descriptor Block has been received. It is preferable for the target to accept the Command Descriptor Block so that processing may begin immediately upon termination of the active command and other previously scheduled queued commands.

The command is labeled implicitly by the known initiator and target addresses and the LUN. As long as only one command is active from each initiator, the LU can always reconnect to the correct initiator and pointer set with that information. It is the responsibility of the initiator to ensure that no more than one command is active at any time.

Section 6.5.1 describes the actions taken if more than one command is activated from an initiator to the same LUN.

Simple command queueing can be supported by SCSI-2 devices or by any SCSI X3.131-1986 device meeting conformance level 2.

It is assumed that the initiator will support the required number of active subchannel functions. Each subchannel is effectively a storage area for the pointers associated with each ongoing tagged queued command.

6.6.2 Full Command Queueing

Full command queueing allows a Logical Unit to continue accepting commands until its command queue is full, regardless of how many commands may already be active from each initiator.

Two messages, NON-SYNCHRONIZING QUEUE TAG and SYNCHRONIZING QUEUE TAG are defined to allow the initiator to uniquely label each command or set of linked commands with a distinctive QUEUE TAG logical identifier immediately after the IDENTIFY message is transferred. This allows the initiator to explicitly expand the implicit labeling of the commands so that a reconnection can always be properly identified by the combination of the initiator address, the target address, the LUN, and the QUEUE TAG logical identifier. Each initiator must ensure that all its outstanding QUEUE TAG

Logical identifiers are unique.

If only commands labeled by NON-SYNCHRONIZING QUEUE TAGS are being transmitted, the commands may be executed in an arbitrary order selected by the target device. Commands from other initiators are also executed in an arbitrary order. The command ordering is done by the target to meet the performance and functional goals desired for that target and Logical Unit.

For a particular Initiator, commands labeled by NON-SYNCHRONIZING QUEUE TAGS, commands labeled by SYNCHRONIZING QUEUE TAGS, and commands without logical identifiers may be executed to the same LU. Commands with SYNCHRONIZING QUEUE TAGS must be executed in the exact order received with respect to other SYNC QUEUE TAG labeled commands and with respect to commands without logical identifiers. In addition, all NON-SYNC QUEUE TAG labeled commands, regardless of initiator, received before a particular SYNC QUEUE TAG labeled command must be executed before that SYNC QUEUE TAG labeled command. All NON-SYNC QUEUE TAG labeled commands, regardless of initiator, received after a particular SYNC QUEUE TAG labeled command must be executed after that command.

Commands without logical identifiers must be managed according to the rules for simple queueing. Only one such command may be active at a time. Because of this restriction, such commands are always executed for each initiator in the order in which they are received from the initiator. No time relationship is determinable between activities on one initiator and activities on another except through the reservation process.

A target may elect to disallow the queueing of certain commands or execute the command without actually queueing it. In particular, the Reserve command and the Release command must not be queued unless the system provides external device or lock protection through software restrictions or a separate communication port. If the queueing of a particular command is not supported, the command may be rejected with an INVALID REQUEST sense code and an additional sense code of INVALID SEQUENCE (CODE TO BE DETERMINED). The TEST UNIT READY, INQUIRY, and REQUEST SENSE commands are typical of those that will normally be executed immediately without actually queueing the function.

Error information from errors that occur during execution of a command using any QUEUE TAG logical identifier is recovered by execution of a REQUEST SENSE command to the same LU using the same logical identifier value. The REQUEST SENSE command may be labeled by the Initiator as synchronizing or non-synchronizing, since the QUEUE TAG logical identifier will uniquely identify the necessary sense information.
Devices not supporting either QUEUE TAG message, either because they do not support command queuing or because they meet X3.131-1986, reject the QUEUE TAG message. The command is expected to continue from that time on in the normal manner without making use of the QUEUE TAG logical identifier. Command queuing may also be switched off by the device during certain initialization periods or to control internal resource utilization by responding immediately to either type of QUEUE TAG message out with a QUEUE FULL message in. The command will continue normally except that the initiator will be warned that no new command will be accepted for that LUN until at least one command has been completed back to that initiator from that LUN.

The above text should completely define the queuing function for SCSI-2 devices. Thank you for your acceptance of this proposal.

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