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ABSTRACT

This technical report describes the methods by which users may measure the performance characteristics of a parallel SCSI domain. This report does not provide definitions or specifications of components utilized in configuring the domain. Physical attributes of the domain are defined in the SCSI family of standards. These standards should be consulted before implementing the recommendations outlined in this technical report. The information in this technical report does not supersede any requirements in the referenced standards.

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1 Scope

This technical report provides guidance to users of parallel SCSI beyond that contained in the formal standards.

This technical report describes the methods of characterizing a parallel SCSI domain by varying analog driver parameters and monitoring the results. The architecture for varying receiver parameters may be consistent with that used when varying analog driver parameters. The architecture for varying receiver parameters is not addressed in this technical report.

This technical report addresses measuring the performance of driver-receiver connections. SCSI Parallel Interface-4 specifies minimum requirements of those connections.

2 References

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

Copies of the following standards may be obtained from ANSI: approved ANSI standards, approved and draft international and regional standards (ISO, IEC, CEN/CENELEC, ITUT), and approved and draft foreign standards (including BSI, JIS, and DIN). For further information, contact ANSI Customer Service Department at 212-642-4900 (phone), 212-302-1286 (fax) or via the World Wide Web at http://www.ansi.org.

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2.1 Approved references

Currently, there are no approved normative references.

2.2 References under development

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

T10/1365-D, SCSI Parallel Interface-4

T10/1157-D, SCSI Architecture Model-2

T10/1416-D, SCSI Primary Commands-3

NCITS TR-23:1998, SCSI Enhanced Parallel Interface

3 Definitions, abbreviations, and keywords

3.1 Definitions

3.1.1 application client: An object that is the source of SCSI commands. Further definition of an application client is found in the SCSI Architecture Model-2 standard.

3.1.2 asynchronous transfer: An information transfer that uses the asynchronous REQ/ACK handshake with a REQ/ACK offset of zero.

3.1.3 byte: Indicates an 8-bit construct.

3.1.4 domain: The configuration of components within a service delivery subsystem that includes SCSI expanders, terminators, and cable plants that logically connect all attached SCSI initiators and SCSI targets.

3.1.5 double transition (DT): The latching of data on both the assertion edge and the negation edge of the REQ or ACK signals.

3.1.6 driver: The circuitry used to control the state of the SCSI bus segment.

3.1.7 driver-receiver connection: An assembly of driver, receiver, terminators, and the cable plant that produce the electrical coupling between the driver and receiver involved in the measurement.

3.1.8 expander: A device that connects SCSI bus segments together to form a single domain.

3.1.9 fast-5: Negotiated to receive synchronous data at a transfer period that translates into a transfer rate less than or equal to 5 megatransfers per second.

3.1.10 fast-10: Negotiated to receive synchronous data at a transfer period that translates into a transfer rate greater than 5 megatransfers per second and less than or equal to a transfer rate of 10 megatransfers per second.

3.1.11 fast-20: Negotiated to receive synchronous data at a transfer period that translates into a transfer rate greater than 10 megatransfers per second and less than or equal to a transfer rate of 20 megatransfers per second.

3.1.12 fast-40: Negotiated to receive synchronous data at a transfer period that translates into a transfer rate greater than 20 megatransfers per second and less than or equal to a transfer rate of 40 megatransfers per second.

3.1.13 fast-80: Negotiated to receive synchronous data at a transfer period that translates into a transfer rate greater than 40 megatransfers per second and less than or equal to a transfer rate of 80 megatransfers per second.

3.1.14 fast-160: Negotiated to receive synchronous data at a transfer period that translates into a transfer rate of 160 megatransfers per second.

3.1.15 initiator: Synonymous with SCSI initiator port (see 3.1.26).

3.1.16 logical unit: An externally addressable entity within a SCSI target device. See the SCSI Architecture Model-2 standard for a detailed definition of a logical unit.

3.1.17 logical unit number (LUN): An identifier for a logical unit.

3.1.18 margining: The process of measuring the response of driver-receiver connections to controllable changes in the driver properties.

3.1.19 megatransfers per second: The repetitive rate that data are transferred across the bus. This is equivalent to 2^20 bytes per second on an 8-bit wide bus.

3.1.20 path: The cable, printed circuit board or other means for providing the conductors and insulators that connect two or more points.

3.1.21 receiver: The circuitry used to detect the state of the SCSI bus segment.

3.1.22 SCSI address: The decimal representation of the unique address assigned to a SCSI device.

3.1.23 SCSI bus segment: A SCSI bus segment consists of all the conductors and connectors required to attain signal line continuity between every driver, receiver, and two terminators for each signal. It is not necessary that a SCSI bus segment contain any specific combination of devices but a segment has at least two devices attached. Devices include: targets, initiators, and expanders in this context. The end-points of SCSI bus segments are defined by the position of the terminators.

3.1.24 SCSI device: A device containing at least one SCSI port and the means to connect its drivers and receivers to the bus segment.

3.1.25 SCSI ID: The bit-significant representation of the SCSI address where ID0 is the least significant bit.

3.1.26 SCSI initiator port: A SCSI initiator device object acts as the connection between application clients and the service delivery subsystem through which requests and responses are routed. See the SCSI Architecture Model-2 standard for a detailed definition of a SCSI initiator port.

3.1.27 SCSI target port: A SCSI target device object that contains a task router and acts as the connection between device servers and task managers and the service delivery subsystem through which requests and responses are routed. See the SCSI Architecture Model-2 standard for a detailed definition of a SCSI target port.

3.1.28 SCSI Terminator: The terminator is at each end of a SCSI bus segment. The terminator provides impedance match and biasing, holding the bus in a negated state when it is not driven.

3.1.29 service delivery subsystem: That part of a SCSI I/O system that transmits service requests to a logical unit or target and returns logical unit or target responses to an initiator.

3.1.30 single transition (ST): The latching of data only on the assertion edge of the REQ or ACK signals.

3.1.31 synchronous transfer: An information transfer that uses an REQ/ACK offset other than zero.

3.1.32 target: Synonymous with SCSI target port (see 3.1.27).

3.2 Abbreviations

Async	Asynchronous data transfer
CRC	Cyclic redundancy check
DT	Double transition
ECP	Expander communication protocol (see SCSI Parallel Interface-4)
LUN	Logical unit number
SCSI	Small computer system interface
ST	Single transition
T	Terminator

3.3 Keywords

3.3.1 **may**: A keyword that indicates flexibility of choice with no implied preference.

3.3.2 **may not**: Keywords that indicates flexibility of choice with no implied preference.

3.3.3 **should**: A keyword indicating flexibility of choice with a preferred alternative; equivalent to the phrase “it is recommended.”

4 Examples of parallel SCSI domain configurations

4.1 SCSI bus segment and driver-receiver connections

A SCSI bus segment consists of all the conductors and connectors required to attain signal line continuity between every driver, receiver, and two terminators for each signal. Examples of SCSI bus segments are shown in Figure 2, Figure 3, Figure 4, Figure 5, and Figure 6. The end-points of SCSI bus segments are defined by the position of the terminators.

The driver-receiver connection is an assembly of driver, receiver, terminators, and the cable plant that produce the electrical coupling between the driver and receiver involved in the measurement.

Figure 1 details a complementary set of driver-receiver connections. This technical report considers single driver-receiver connections only. A complete characterization of a SCSI bus segment requires every driver-receiver connection in the SCSI bus segment to be examined. Since SCSI is a bi-directional architecture, a minimum of two driver-receiver connections exist in every SCSI bus segment. Complete characterization of a domain requires characterization of all SCSI bus segments in the domain.

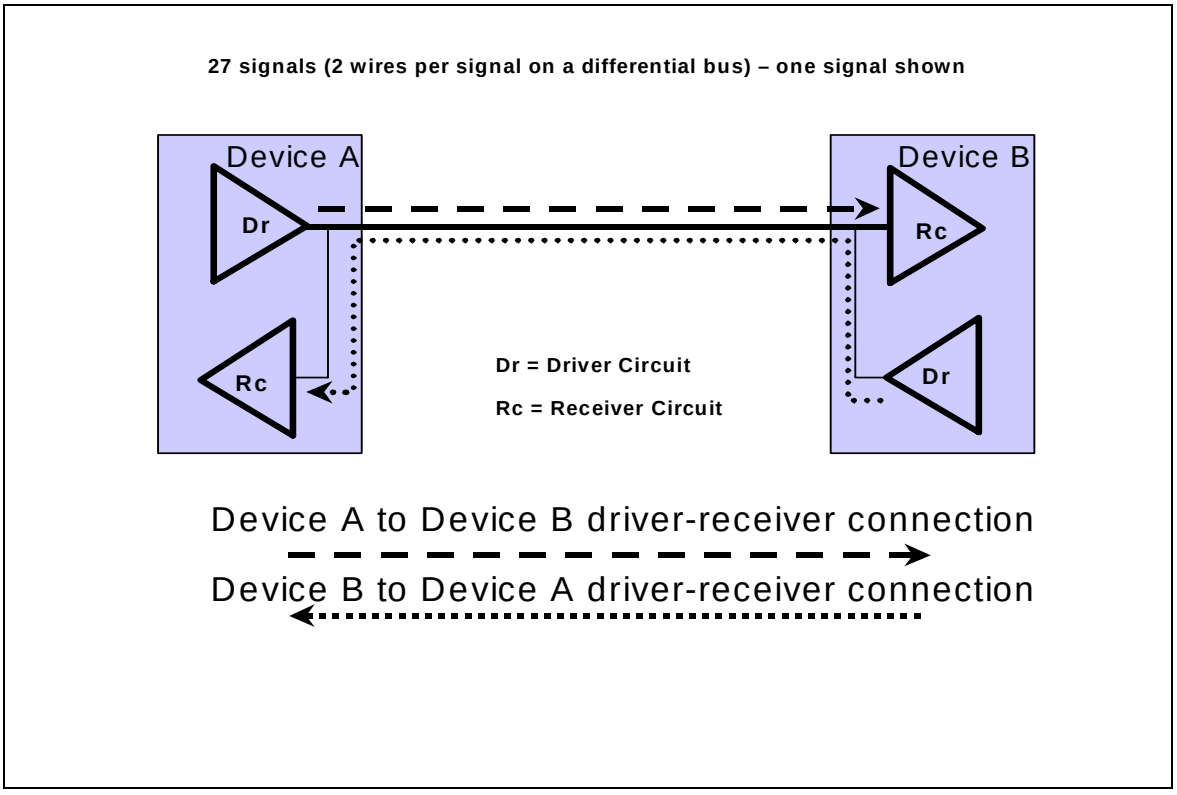

Figure 1 – Driver-receiver connection

4.2 Typical configurations

Domains are configurations, examples of which are shown in Figure 2, Figure 3, Figure 4, Figure 5, and Figure 6.

There are several components that constitute a SCSI system. Figure 2 shows a simplified SCSI system consisting of an initiator, targets, cable and terminators.

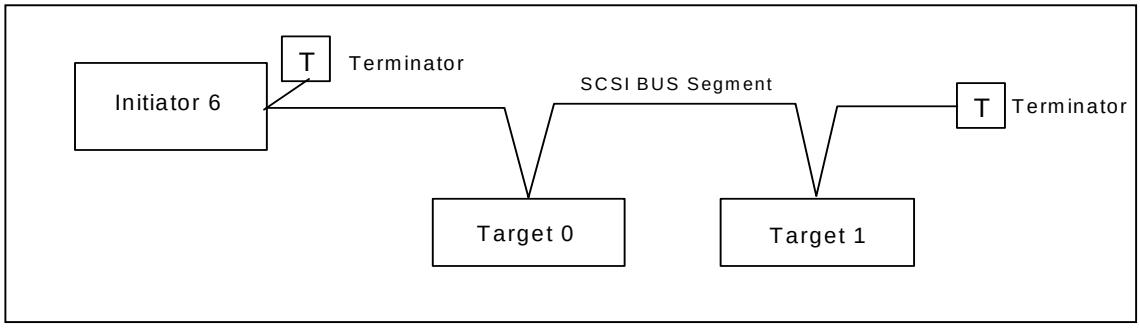

Figure 2 – Simplified domain A

Each initiator and each target of the SCSI system is assigned one of 16 pre-defined and unique SCSI address set by the user. These addresses are hard wired and remain constant, as long as the hardware value is not physically changed. Expanders do not have SCSI addresses, but a secondary address that is not predefined in hardware.

Figure 3 shows a domain with the initiator positioned between two targets.

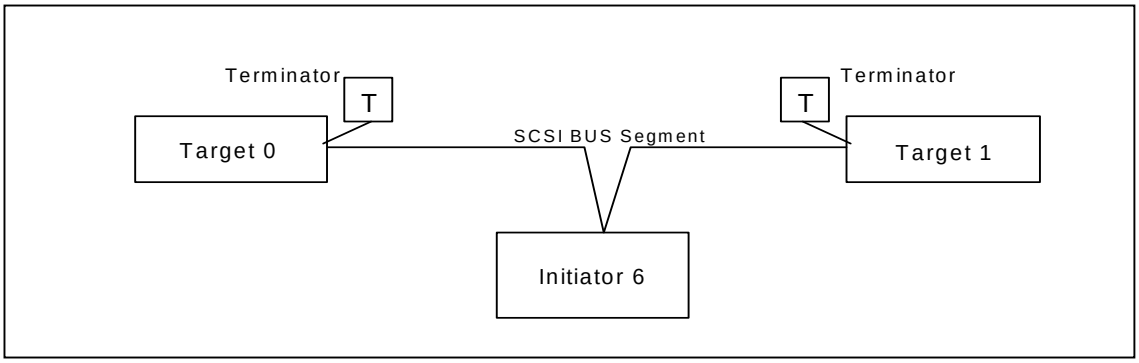

Figure 3 – Simplified domain B

Figure 4 shows a domain with an expander in series between a target and initiator.

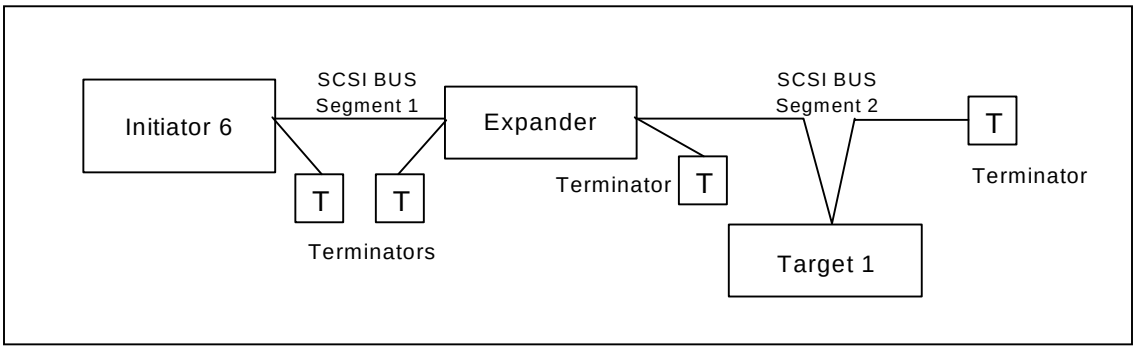

Figure 4 – Example domain with expander

Figure 5 shows a domain that incorporates two initiators within the subsystem.

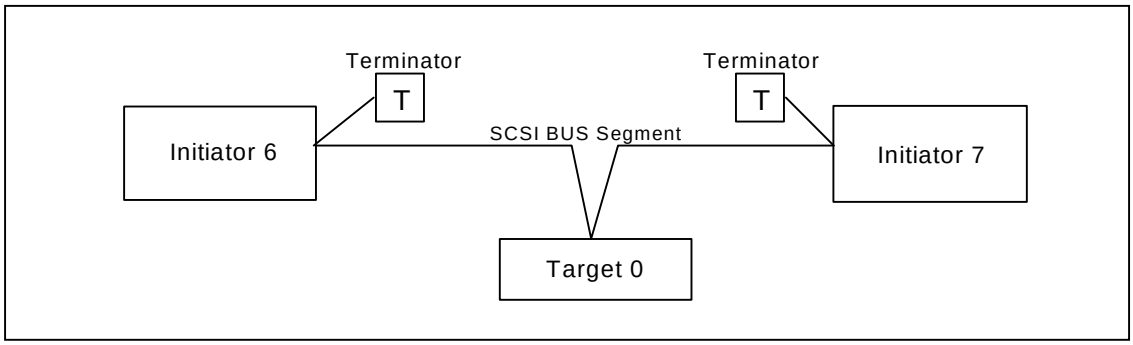

Figure 5 – Example dual initiator domain

The detailed rules for configuring domains with expanders are contained in SCSI Enhanced Parallel Interface and SCSI Parallel Interface-4. These rules define requirements for constructing valid domains and for dynamically reconfiguring domains. Considerations for extending the length of individual SCSI bus segments are presented in SCSI Enhanced Parallel Interface.

Complex domains may be implemented where there are one or more expanders, multiple initiators, and multiple targets. Up to 16 SCSI addresses may be assigned.

Implementations may require physical cable lengths longer than those specified in the standards. If this is the case, expanders may be used to extend the physical length of the subsystem. Multiple expanders may be used.

An example of a complex domain is shown in Figure 6.

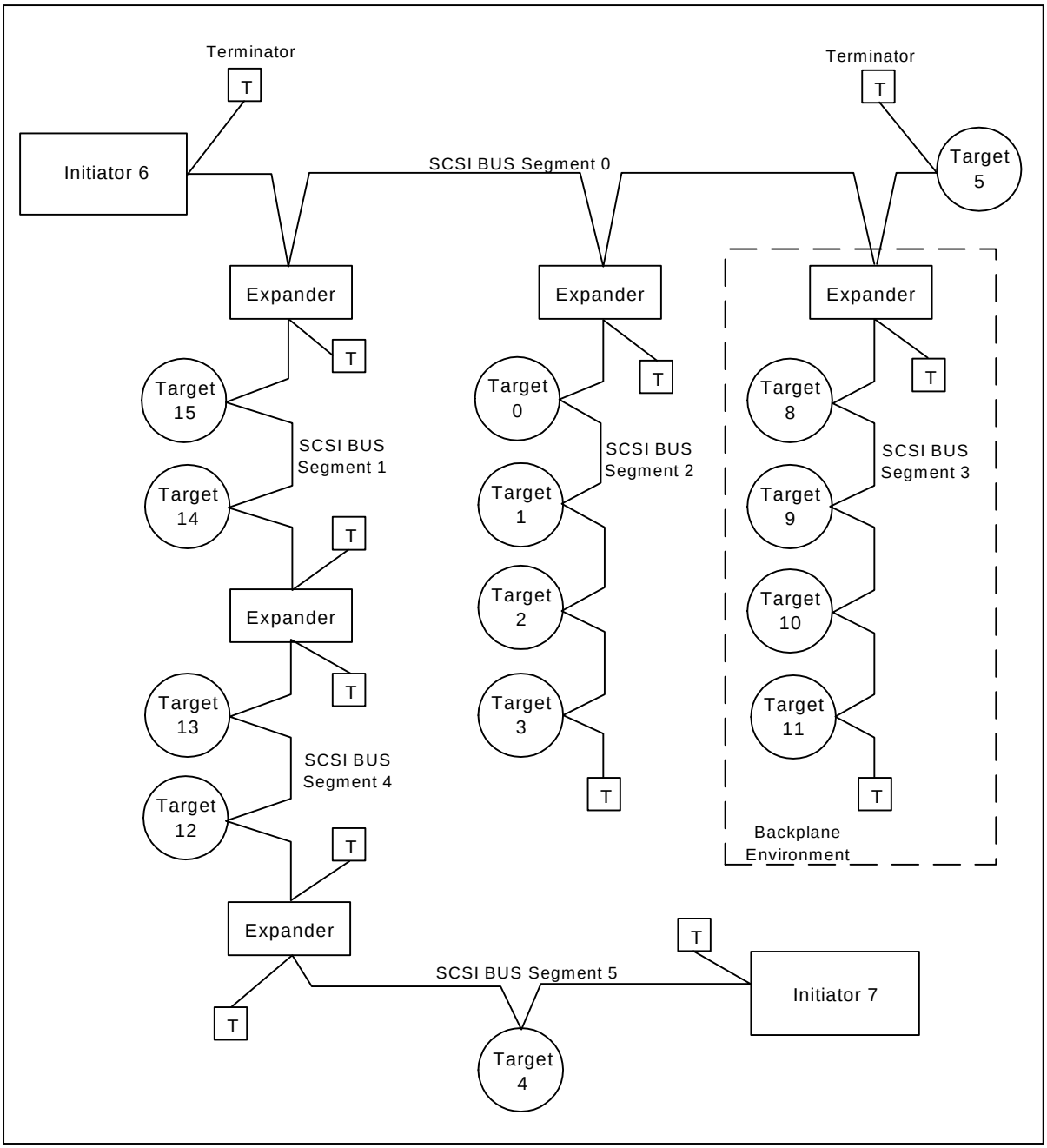

Figure 6 – Example of complex domain

5 Domain examination

5.1 General

Examination of the domain includes determining the topology of the domain, the performance of the SCSI bus segments within the domain, and the relative operating analog margins. This examination is accomplished by communicating with the SCSI devices and expanders that comprise the domain and analyzing the results. This information may be reported to the user for further processing. This examination is performed when the domain changes, either by the removal or insertion of components or whenever system initialization occurs. It may also be performed when requested by an application.

5.2 Topology discovery

Determining the topology of the domain involves identifying the valid SCSI addresses and their relationship to each other and to expanders within a domain. This assumes that the basic physical connections are intact and the rules outlined in SCSI Parallel Interface-4 are followed.

5.3 Assumptions

Testing methods assumes the following:

a) Topology discovery, including the ability of specific devices to support Margin testing, is left to the application;
b) devices capable of any synchronous SCSI transfer rate are tested;
c) devices that do not have variable analog driver and receiver settings should reject or ignore the attempt to change the settings (i.e., do not hang the SCSI bus segment);
d) all devices were set (e.g., through firmware) to allow their maximum synchronous SCSI transfer rate; and
e) settings negotiated during Enhanced testing remain in effect during Margin testing.

5.4 Data patterns

Recommended data patterns for the Enhanced test are:

a) counting (0001h, 0203h, 0405h,…);
b) alternating ones and zeros (0000h, FFFFh, 0000h, FFFFh,…);
c) cross-talk (5555h, AAAAh, 5555h, AAAAh, …);
d) shifting bit (0000h, FFFEh, 0000h, FFFDh,…then FFFFh, 0001h, FFFFh, 0002h,…); and
e) user defined pattern (e.g., psuedo random pattern).

5.5 Test descriptions

5.5.1 Test order

The following test order is recommended for each target.

1) perform Basic tests (see 5.3.1); and
2) perform Enhanced tests (see 5.3.2).

The direction of P_CRCA during writes differs during ST data phases (initiator to target) and DT data phases (target to initiator), although it is the same for reads (target to initiator). To avoid bus contention, support for DT should be confirmed with the Basic test (which only uses reads) before running the Enhanced test with any transfer rate using DT data phases.

5.5.2 Test conditions

The entire domain is evaluated, on a target-by-target basis, from the perspective of each initiator in the domain. Each initiator-target connection is tested individually. Basic and Enhanced tests are performed on each target consecutively. Before running domain validation, a synchronous transfer timeout should be enabled in the port control mode page (see SCSI Parallel Interface-4).

If Basic or Enhanced tests fail, a fall-back setting is set and the tests are performed again. The recommended fall-back order is:

1) fast-160;
2) fast-80;
3) fast-40 (with DT clocking enabled);
4) fast-40 (with ST clocking enabled);
5) fast-20;
6) fast-10; and
7) asynchronous transfer.

5.5.3 Basic test

The Basic test determines if the initiator-target connection is capable of operating at the user-specified speed and width. The INQUIRY command (see SCSI Primary Commands-3) is used and its usage is controlled by the application.

The Basic test consists of issuing an INQUIRY command to a SCSI device three times; twice with the default transfer agreement and once with the transfer agreement set to the fastest supported values. The Basic test fails when the first 36 bytes of data returned at the negotiated synchronous speed does not match the data received at the asynchronous transfer speed. In addition, the Basic test fails if a CRC error (or parity error for non-DT clocking) or a timeout occurs. If data miscompare occurs the test should be repeated (e.g., this could be due to the target changing the INQUIRY data during SCSI device initialization). After a finite number of retries, if data miscompare recurs then fall-back should be attempted (see 5.5.2).

The Basic test detects most physical configuration problems including:

a) path width errors (i.e., narrow cable used between wide SCSI devices);
b) expander errors (e.g., expanders not capable of the negotiated transfer rate);
c) gross cable errors (e.g., broken wire);
d) incorrect termination (e.g., missing or bad terminator); or
e) damaged transceiver.

5.5.4 Enhanced test

The Enhanced test uses synchronous data transfer with complex data patterns to further test the initiator-target connection. The WRITE BUFFER and READ BUFFER commands (see SCSI Primary Commands-3) are used to perform this test. During this test, the application should prevent other processes from using the SCSI device. Some data patterns are more stressful on the domain. At a minimum, it is recommended that the application use the data patterns specified in 6.3.2.

The following test procedure is recommended:

1) Issue a READ BUFFER command with echo buffer descriptor mode to determine if an echo buffer is supported, obtain the size of the echo buffer, and determine whether multiple initiators are able to use the echo buffer without overwriting each others' data.
2) issue a WRITE BUFFER command with echo buffer mode using a selected data pattern;

3) issue a READ BUFFER command with echo buffer mode. If the command results in a CHECK CONDITION with a sense key of ABORTED COMMAND and an additional sense code of ECHO BUFFER OVERWRITTEN, repeat the write at step 2);
4) compare the read data with the selected data pattern; and
5) return to step 2) with another data pattern or finish the Enhanced test.

The Enhanced test fails if the data used in the WRITE BUFFER and READ BUFFER commands fails to compare, has a CRC error (or parity error for non-DT clocking), or encounters a timeout.

The Enhanced test may identify additional problems including:

a) incorrect impedance cables;
b) SCSI device spacing problems;
c) improper termination;
d) marginal transceivers;
e) excessive cross talk; or
f) excessive system noise.

5.5.5 Test output

If no errors are encountered, then no user interaction is required and Margin tests may proceed.

If any negotiated synchronous setting for any target is set to a synchronous fall-back setting it is recommended that Margin tests be performed at the fall-back settings for that target.

If issues are encountered, actions that may be taken are:

a) Recommend a course of debug activity based on the application's determination of the topology. This should be displayed to the user in a dialog box or saved for future access; or
b) Submit an error to the operating system event notification log.

5.6 Margin Test

5.6.1 Assumption

The application has ascertained the topology and performed the Basic and Enhanced tests.

5.6.2 Test order

The following test order identifies all driver-receiver connections involved with a specific initiator:

1) Margin the driver-receiver connections directly connected to the initiator;
2) Continue to expand the Margin tests to the driver-receiver connections at the far port (see SCSI Parallel Interface-4) of the first layer of expanders (i.e., those expanders directly connected to the initiator). See Figure 6 and the expanders connected to SCSI Bus Segment 0; and
3) Continue to expand the Margin tests to the driver-receiver connections at the far port of the second layer, and so on, of expanders (i.e., those expanders directly connected to the first layer of expanders). See Figure 6 and the expander connected between SCSI Bus Segment 1 and SCSI Bus Segment 4.

5.6.3 Test conditions

After each Margin test is completed, the application should set all margin parameter adjustments to the values shipped by the supplier.

A Margin test to a near port (see SCSI Parallel Interface-4) of an expander is not completed until one SCSI target on or beyond the far port of the expander has been tested.

In SCSI initiators, the MARGIN CONTROL expander function defined in ECP provides the fields that may be used to control margin parameters (see SCSI Parallel Interface-4). Other means, as defined by the supplier, may be used.

In SCSI targets, the margin control sub-page of the port control mode page contains the fields that control margin parameters (see SCSI Parallel Interface-4).

In expanders, the MARGIN CONTROL expander function provides the fields that control margin parameters (see SCSI Parallel Interface-4).

If a bus reset condition is used to recover from a hang conditions, all initiator, target, and expander margin parameter adjustments revert to the values shipped by the supplier.

To avoid unnecessary failures, applications are required to respond to CHECK CONDITION status, if issued after READ ECHO BUFFER command (see SCSI Primary Commands-3). Check sense data for an ASCQ of ECHO BUFFER OVERRIDDEN. This should indicate a corrupted echo buffer.

5.6.4 Margin test and parameters

The Margin test is the Enhanced test performed with altered margin parameters to determine if the driver-receiver connection operates under conditions other than those shipped by the supplier.

Margining has the following features:

a) driver signal variation;
b) methods for controlling SCSI expanders; and
c) faulty segment component (e.g., chip, connector, cable, etc.) detection.

SCSI Parallel Interface-4 references to default values is the same as those referenced herein as ‘shipped by the supplier’. These values are those available at power-on and saving changes are prohibited across power cycles. The Save Pages (SP) bit of the MODE SELECT command (see SCSI Primary Commands-3) is required to be set to zero when adjusting these values for purposes of domain validation.

Adjustment of driver parameters are required during a margining type verification sequence. Various parameters are adjusted to determine the performance of that driver-receiver connection. It is recommended that all margin parameter adjustments be set to the values shipped by the supplier when a bus free phase occurs.

For SCSI initiators, the MARGIN CONTROL expander function defined in ECP provides the fields that may be used to control margin parameters (see SCSI Parallel Interface-4). Other means, as defined by the supplier, may be used.

In SCSI targets, the margin control sub-page of the port control mode page contains the fields that control margin parameters (see SCSI Parallel Interface-4).

In expanders, the MARGIN CONTROL expander function defined in ECP provides the fields that control margin parameters (see SCSI Parallel Interface-4).

Examples of parameters that may be margined include:

a) driver asymmetry;
b) driver precompensation;
c) driver strength;
d) driver slew rate; and
e) vendor specific.

Values of the margin parameters are not defined by this technical report. Extreme field settings may not correspond to specification limits defined in SCSI Parallel Interface-4 or subsequent standards. The

margin parameter adjustments may be unique to each supplier. The application is required to understand the available settings and the resultant action of adjusting the margin parameter.

5.6.5 Test combinations

Perform Margin tests with each target while manipulating only one margin parameter at a time, on one driver-receiver connection at a time. Perform Margin tests at each adjustment of each margin parameter while holding all other margin parameter adjustments at the value shipped by the supplier.

For combination testing, the application may be responsible for too many combinations. A minimum number of combinations is recommended (e.g., an application may test only the minimum and the maximum of a set of margin parameter adjustments). Manipulation of four parameters results in sixteen tests. It is possible that maximum and minimum may be user defined to be something other than the full swing which the hardware is capable.

Perform Margin tests with each target while manipulating all margin parameter adjustments simultaneously on all driver-receiver connections along the path to each target.

5.6.6 Test direction

The test in 5.6.5 should be performed through an outbound data path to a particular target and inbound from a particular target. It is recommended that no simultaneous action of inbound and outbound margining exist.

5.6.7 Test criteria

A test performed with DT clocking is determined to have failed when a CRC error is detected, or data miscompares, or a transaction timeout occurs.

A test performed without DT clocking is determined to have failed when a parity error is detected, or data miscompares, or a transaction timeout occurs.

Margin tests are intended to be run on devices that support Fast-10 or higher operation.

It is recommended that ECHO READ/WRITE BUFFER command be used. If the Echo function is not available, the application may use normal READ/WRITE BUFFER commands (see SCSI Primary Commands-3).

5.6.8 Test output

Upon completion of Margin tests, set all margin parameter adjustments to the values shipped by the supplier.

A test report should be provided to the user.

If errors were encountered, several actions may be taken:

a) Suggest that the user reduce the peripheral’s maximum negotiated SCSI transfer rate. See 6.3.2 for recommended SCSI transfer rate reduction;
b) Recommend a course of debug activity based on the application’s determination of the topology. This should be displayed to the user in a dialog box or saved for future access; or
c) Submit an error to the operating system’s event notification log.

5.6.9 Flow chart

Figure 7 is a flow chart representative of the steps necessary to perform domain examination.

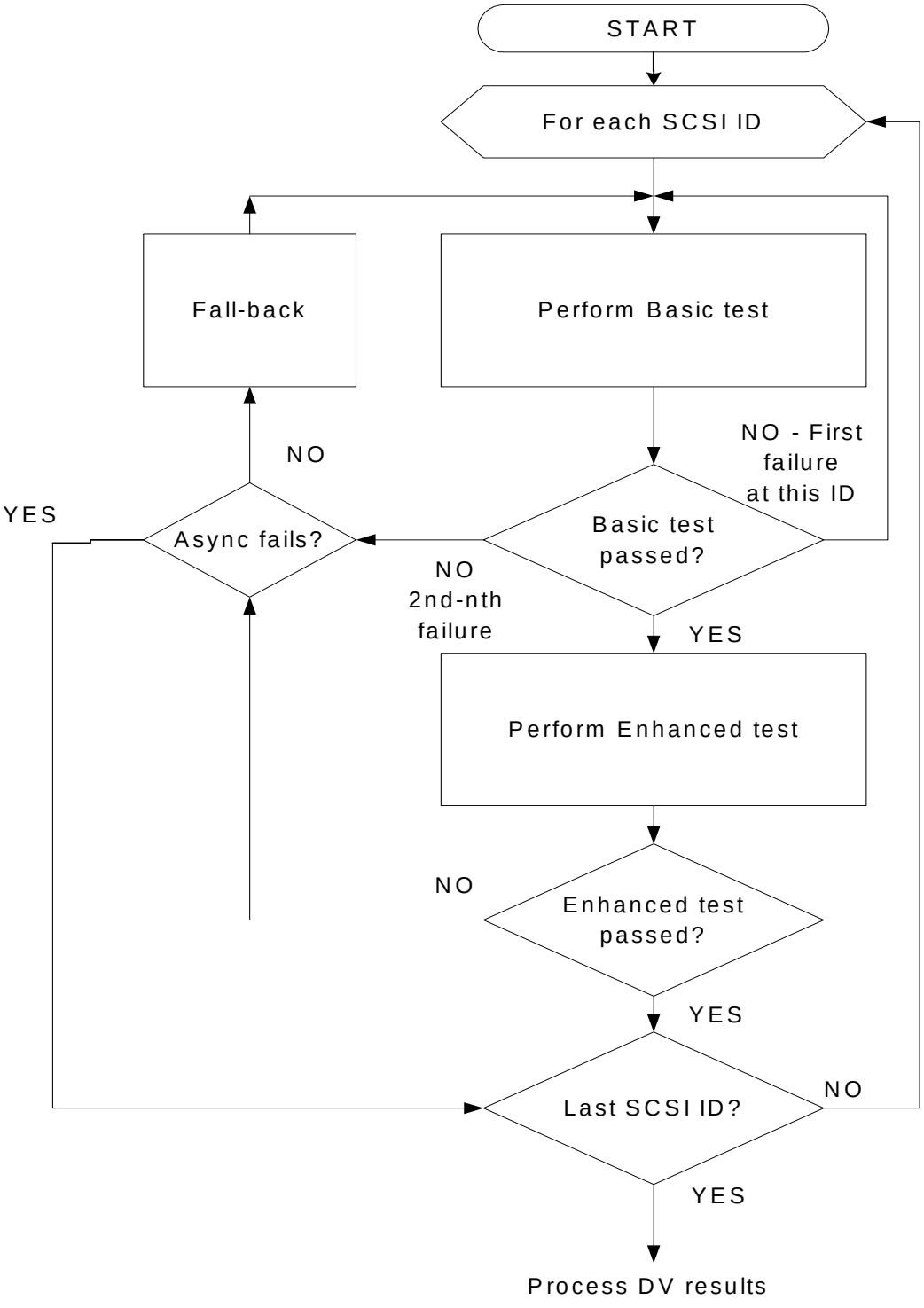

Figure 7 – Domain examination

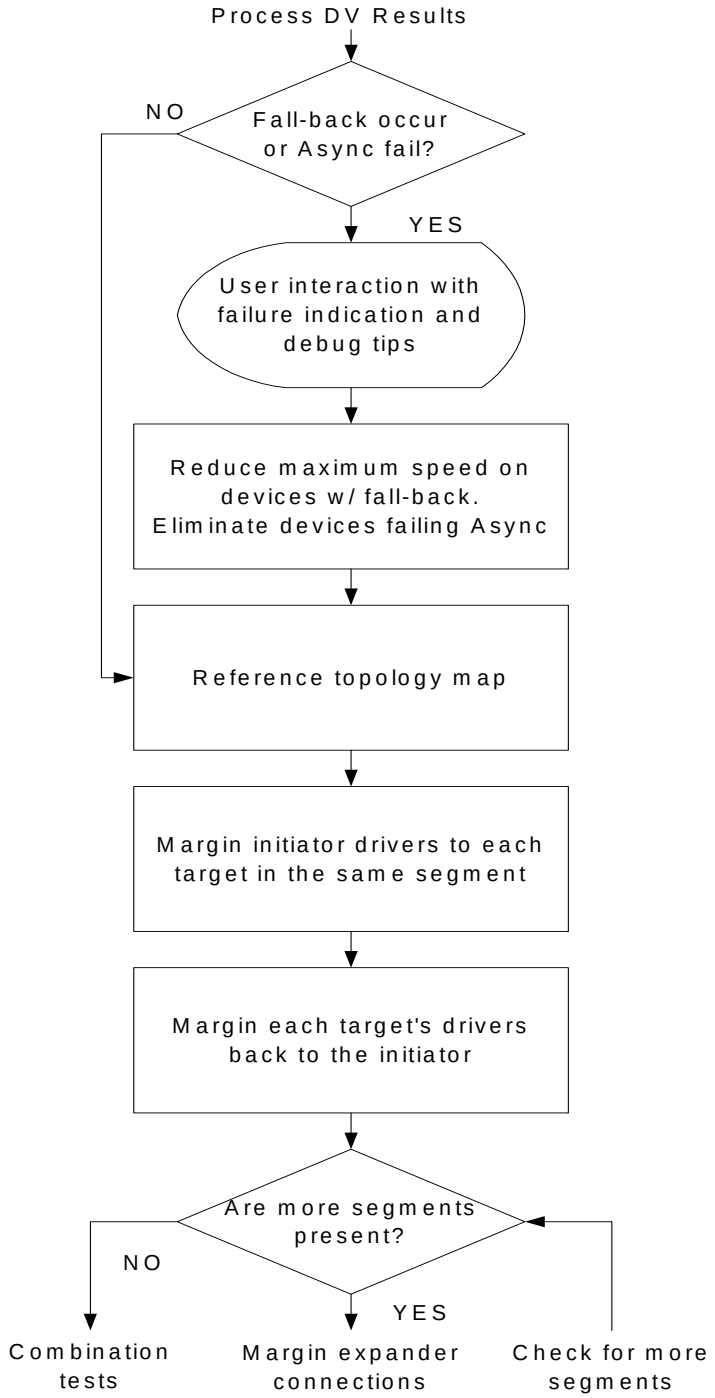

Figure 7 continued – Domain validation

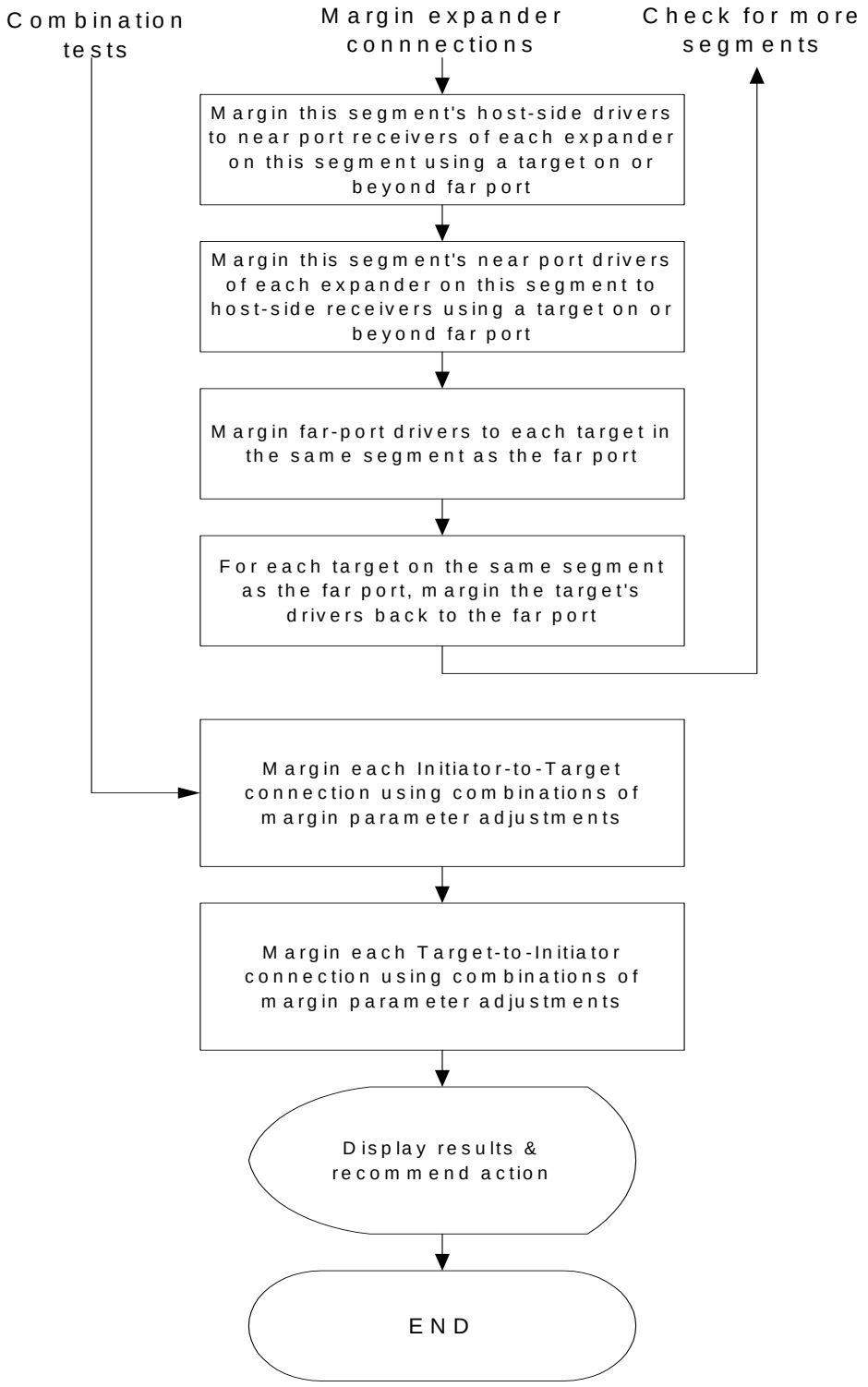

Figure 7 continued – Domain examination