To: John Lohmeyer
Chairman, X3T9.2
NCR Corporation
3718 N. Rock Road
Wichita, Kansas 67226

From: Robert Snively
Sun Microsystems
2550 Garcia Ave
Mountain View, CA 94043
(415) 336-5332

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Subject: Summary of Sun Microsystems' analysis of SCSI cables

Two groups within Sun Microsystems have examined the characteristics of SCSI cabling configurations for the X3T9.2 SCSI Committee. Vit Novak in Sun's I/O Subsystems group has studied the characteristics of cabling configurations using low-density flat cables and a variety of common shielded round cables. Alex Pappas in Sun's Peripheral Engineering group has studied similar configurations using high-density flat cables and a similar set of shielded round cables. The results from both activities are contained in documents X3T9.2/89-38, R1 and X3T9.2/89-39, R1 and lead to similar conclusions and recommendations. Those conclusions and recommendations are summarized here.

1) The cable configurations used by early SCSI devices were primarily low density flat cables with insulation displacement connectors. These cables are still an excellent choice where the entire SCSI system is contained within a shielded frame.

2) Shielded round cables should be selected very carefully for proper operation with single-ended SCSI systems using long cables. The extra grounding inherent in single-ended systems significantly lowers the effective characteristic impedance. The effect of the low cable impedance is the generation of unfavorable reflections that may dramatically degrade the operation of devices located close to the active host. The cables selected must have characteristic impedances greater than about 90 ohms when operating in single-ended mode to avoid such problems. To achieve this, it is expected that cables with a specified characteristic impedance even greater than 110 ohms must be selected. Note that these cables may be bulkier than would be considered ideal, especially for

B–cable implementations. Mismatches of impedance caused by variations in cables or by the loading effects of clustered controllers also contribute to unfavorable reflections, but appear to be much less important than a significant length of low impedance cable.

3) Proper termination power is key to a successful SCSI implementation. The specified minimum value of 4.25 is probably lower than is desirable if voltage drops in the wires and connectors are also considered. It is highly recommended that terminator power be supplied at a minimum of 4.5 volts and that it be supplied by more than one device on the cable, preferably by a device at each end of the cable. This requires care in the design of the power supply circuit so that the protective diodes and current limiting devices defined by the specification do not force the term power voltage below the minimum value. If cable conductors smaller than 28 gauge must be used to meet the impedance requirements, conductors of at least 28 gauge should be reserved for the term power signal.

4) Receivers for SCSI signals must be carefully designed to prevent the detection of false indications under marginal power supply and noise conditions. It is highly recommended that a threshold voltage about halfway between 0.8 and 2.0 volts be selected to maximize noise immunity and insensitivity to signal reflections. This value of 1.4 volts will provide very robust operation when the required hysteresis of 200 millivolts is also applied.

5) The results of the experiments performed by Sun indicate that asynchronous SCSI data transfer is much less affected by cable reflections than synchronous data transfer. Our preliminary information indicates that the state sequencing hardware that manages asynchronous transfer deglitches most single signal transition cases, while synchronous data transfer allows a single transition of very short duration to be accepted as a valid signal. It is highly recommended that circuit designers install glitch detection circuitry that will prevent a very short noise or reflection generated signal from being detected as a normal signal. The result can either be the detection of a soft error or the suppression of the detection of the signal. The problem is especially critical on the trailing edge of Req or Ack.

A second cause of sensitivity to synchronous transfer is that the length of time a pulse is affected by reflections is a significant fraction of the total duration of a synchronous transfer Req or Ack pulse. In the worst case, it is likely that the synchronous pulse may not always be detected.

The results of Sun's cable studies are especially useful in that they quantify the marginal behavior of single–ended SCSI systems by using Term Power voltage margining and extended reliability tests. The correlation of the behavior of actual systems with the results of waveform analysis and time domain reflectometry measurements is very good and provides a helpful mechanism for verifying that a system is properly implemented.

The committee may choose to address the worst problems of the cabling structure by including any of the following changes in the SCSI specification. If these changes are not accepted, they are still very good guidelines.

Add:

To section 4.2, page 4–1, a fourth implementor's note:

4) Round cable specifications should be carefully examined for operation with single–ended SCSI systems. The extra ground lines carried in a single–ended SCSI cable typically reduce the characteristic impedance significantly below the manufacturer specified characteristic impedance.

Change:

Section 4.4.1.2, replacing the line "minimum input hysteresis" with the following text:

Transition Threshold:	1.4v +/– .1 volt dc
Minimum Hysteresis:	0.2 volt dc

Change:

Section 4.3, replacing the Vterm for Single–ended cable A and cable B with the following text:

Vterm = 4.5 to 5.25 volts dc

Sincerely,

Robert Snively