Accredited Standards Committee*
X3, Information Technology

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Reply to: John Lohmeyer

To: Membership of X3T10

From: John Lohmeyer, Chair X3T10

Subject: Minutes of X3T10 SPI-2 LVDS Study Group Meeting
Denver, CO -- October 13, 1995

Agenda

1. Opening Remarks

2. Approval of Agenda

3. Attendance and Membership

4. LVDS Terminator Specifications [Aloisi / Ham]
   4.1 DIFFSENS Operation [Ham]

5. LVDS Driver/Receiver Specifications
   5.1 Review of Power Budget Documentation

6. LVDS Cable Specifications
   6.1 Crosstalk testing [Spitler]
   6.2 The Case for 50 Ohm Cables (95-308r0) [McCall]

7. LVDS Testing Results [Ham]

8. Other Topics
   8.1 Hybrid Signaling? [McGrath]
   8.2 Should RST Signal Remain Single-Ended? [Gardner]
   8.3 Document review (95-315) [Ham]

9. Meeting Schedule

10. Adjournment

Results of Meeting

1. Opening Remarks

John Lohmeyer, the X3T10 Chair, called the meeting to order at 9:00 a.m., Friday October 13, 1995. He thanked Symbios Logic for hosting the meeting.

As is customary, the people attending introduced themselves and a copy of the attendance list was circulated.

2. Approval of Agenda

The draft agenda was approved with the addition of the following items:

4.1 DIFFSENS Operation Review [Ham]
8.3 Document Review (95-315) [Ham]

3. Attendance and Membership

Attendance at working group meetings does not count toward minimum attendance requirements for X3T10 membership. Working group meetings are open to any person or organization directly and materially affected by X3T10's scope of work. The following people attended the meeting:

Name	S	Organization	Electronic Mail Address
Mr. Norm Harris	P	Adaptec, Inc.	nharris@eng.adaptec.com
Mr. Dennis R. Haynes	P	Burr-Brown Corp.	haynes_dennis@bbrown.com
Mr. Louis Grantham	P	Dallas Semiconductor	grantham@dalsemi.com
Dr. William Ham	A#	Digital Equipment Corp.	ham@subsys.enet.dec.com
Mr. Andy Chen	A#	Fujitsu Computer Prods Amer	achen@fcpa.fujitsu.com
Mr. Richard Greenberg	V	IBM Corp.	
Mr. Dean Wallace	P	Linfinity Micro	75671.3443@compuserve.com
Mr. Edward A. Gardner	V	Ophidian Designs	gardner@acm.org
Mr. Ting Li Chan	A	QLogic Corp.	
Mr. Clinton Wong	V	Quantum Corp.	cwong@asic.qntm.com
Mr. Richard Uber	V	Quantum Corp.	duber@tdh.qntm.com
Mr. Henry Wong	V	Quantum Corp.	hwong@asic.qntm.com
Mr. Brian N. Davis	A#	Seagate Technology	brian_davis@notes.seagate.com
Mr. Erich Oetting	P	Storage Technology Corp.	Erich_Oetting@Stortek.com
Mr. John Lohmeyer	P	Symbios Logic Inc.	john.lohmeyer@symbios.com
Mr. Tracy Spitler	V	Symbios Logic Inc.	tracy.spitler@symbios.com
Mr. Kevin Bruno	V	Symbios Logic Inc.	kevin.bruno@symbios.com
Mr. Richard Mourn	V	Symbios Logic Inc.	richard.mourn@symbios.com
Mr. Kevin Gingerick	V	Texas Instruments	4307725@mcimail.com
Mr. Paul D. Aloisi	P	Unitrode Integrated Circuits	Aloisi@uicc.com
Mr. Tak Asami	A	Western Digital Corporation	asami@dt.wdc.com

21 People Present

Status Key:
- P - Principal
- A,A# - Alternate
- O - Observer
- L - Liaison
- V - Visitor

4. LVDS Terminator Specifications [Aloisi / Ham]

Paul presented the terminator circuit from 95-269r5. He pointed out that the circuit shown is ideal and actual implementations would be slightly different. He said that he sees no problems in implementing the terminator and

expects to have samples in Spring 1996. Paul's terminator circuit included the ability to switch between single-ended, LVDS, and off (high impedance).

There was some discussion about whether a simpler three-resistor circuit might be adequate for many applications. Dennis Haynes presented a three-resistor terminator circuit that used 1.14k ohm bias resistors from +3 volt and ground to a 120 ohm shunt resistor. Several refinements were suggested, including the need to regulate the 3 volt input.

Paul noted that a three-resistor circuit would use more steady-state power and would be difficult to make in a switchable variety. There was another concern about the constant bias current fighting the drivers. Kevin Gingerick pointed out that the constant bias current does not factor into the initial transition; it only affects steady-state signal levels.

Eventually, the two terminator approaches were labeled the non-linear and linear alternatives. It was agreed that both alternatives should be permitted. Dennis Haynes presented several foils describing a general circuit model of a terminator that accommodated both alternatives. John Lohmeyer suggested that the draft standard should document a set of V-I curves that would contain all legal terminators. The discussion was interrupted to re-visit the signal and noise budget after it was noticed that there had been an error in our previous calculations (see item 5.1).

After resolving the above budget issue, Dean Wallace sketched the V-I curves that bound the allowable terminator characteristics (a modified bowtie shape). He accepted an action item to create an electronic version of the V-I diagram. It was agreed that the terminator common mode voltage reference needs to be 1.25 volts +/- 0.05 volts through a 150 Ohm +/- 20% resistor.

4.1 DIFFSENS Operation [Ham]

Bill Ham reviewed the DIFFSENS circuit to clear up any misconceptions that may have existed from the recent reflector messages. Single-ended devices always ground the DIFFSENS line (and do not examine it). High-powered differential devices (RS-485) pull up the DIFFSENS line with 1k Ohm resistors and disable their drivers if the DIFFSENS line stays low (that is, one or more single-ended devices are connected).

LVDS terminators attempt to hold the DIFFSENS line at 1.3 volts. If the DIFFSENS line stays within the voltage range of 0.7 volts to 1.9 volts, then there are no single-ended or high-power differential devices on the bus; the LVDS devices and terminators are enabled to operate in LVDS mode. If the DIFFSENS line is above 1.9 volts, then all LVDS devices and terminators are disabled. If the DIFFSENS line is below 0.7 volts, then the LVDS devices and terminators either disable themselves or switch to single-ended mode, depending on their capabilities.

The above DIFFSENS rules are robust, avoiding physical damage and permitting devices to be implemented that autoswitch between single-ended and LVDS operation.

5. LVDS Driver/Receiver Specifications

5.1 Review of Power Budget Documentation

The previous signal budget calculations did not allow enough voltage for 100 mV receiver sensitivity. Bill Ham presented several possible new budgets:

Min Signal Current (half driver) (mA)	Driven Signal Level (mV)	Xtalk budget (mV)	Term Bias Level (mV)	Receiver Sensitivity (mV)	Net Margin (mV)
2	240	0	150	100	-10
2	240	0	150	50	+40
2	240	50	150	50	-10
3	360	50	150	50	+110
2.5	300	50	150	50	+50
2.5	300	50	150	70	+30
2	240	50	100	50	+40
0	none	50	100	50	0
2.2	264	50	120	50	+24
2	240	50	120	25 (h)	+25
2.2	264	35 (driven)	120	70	+39
3 (neighbor line)	360	n/a (undriven)	120	70	+50
2.2	264	35 (driven)	120	70 (h)	+15
3 (neighbor line)	360	n/a (undriven)	120	70 (h)	+75
2.2	264	35 (driven)	130	70	+29
		0 (undriven)	100	70	+30

(h) = 25 mV hysteresis receiver.
(driven) = line is driven
(undriven) = line is not driven, except by the terminator. (Such lines were also called ‘victims’ because they are vulnerable to crosstalk from neighboring lines.)

It was noted that the only victim line during normal SCSI protocol is RST (for flat ribbon cables). Since nearly all protocol chips have glitch filtering on RST, we may not need to worry too much about the noise margin on victim lines. The last two lines in the above table represent the eventual agreements reached during the meeting.

Signal budget agreements du jour:

Receiver sensitivity: 70 mV (no hysteresis)
Driver current: 4.4 mA minimum, 6 mA maximum
Terminator bias: 130 mV maximum, 100 mV minimum
Cable characteristic impedance: 120 Ohm minimum, 150 Ohm minimum
(We still need to create a cable crosstalk specification.)

6. LVDS Cable Specifications

6.1 Crosstalk testing [Spitler]

Tracy Spitler presented 95-336r0 which summarizes his crosstalk testing of mixed single-ended and LVDS signals on various cables. He also tested LVDS to LVDS crosstalk on both flat and twisted cables. The conclusion was that hybrid signals would result in unacceptable crosstalk from single-ended signals into adjacent LVDS lines, even with twisted-pair cables. LVDS to LVDS crosstalk on flat ribbon cables is moderately high. Flat ribbon cables should not be allowed in the SPI-2 standard for LVDS, but it may work in many configurations.

6.2 The Case for 50 Ohm Cables (95-308r0) [McCall]

It was noted that 50 Ohm cables would further aggravate the signal budget problems we addressed under item 5.1. Since David McCall was not present, this item was deferred until a subsequent meeting.

7. LVDS Testing Results [Ham]

Bill Ham briefly reviewed the testing results he had shown at the Bedford, NH meeting in September. Bill had some new data showing that he had achieved good margins at Fast-100 speeds using a point-to-point configuration of over 27 meters cable length.

8. Other Topics

8.1 Hybrid Signaling? [McGrath]

Based on the crosstalk testing results in 95-336r0 (see item 6.1), the study group recommends that hybrid signaling not be done.

8.2 Should RST Signal Remain Single-Ended? [Gardner]

Ed Gardner asked that this agenda item be removed from consideration.

8.3 Document review (95-315) [Ham]

Bill Ham reviewed 95-315r0 and plans to prepare a revision 1 for the Palm Springs meeting.

9. Meeting Schedule

The next meeting of SPI-2 Study Group will be Monday November 6, 1995, in Palm Springs, CA at the Hyatt Regency Suites Palm Springs (619-322-9000), hosted by Western Digital Corp. Another SPI-2 Study Group meeting is scheduled for December 15, 1995 in San Jose, CA hosted by Quantum.

10. Adjournment

The meeting was adjourned at 4:15 p.m. on Friday October 13, 1995.