MEMORANDUM -- 10 Jan 1992

TO: John Lohmeyer, Chairman, X3T9.2

FROM: Bill Spence

SUBJECT: Single-ended Cable Impedance Revisited

The X3T9.2/91-179 proposals re the specification of SCSI cable impedance were cursorily reviewed and approved in general content at the 12/10 SPI meeting. The specific recommendation about single-ended cable impedance was modified, however, to be 95 +/- 15 ohms. Specifically, the intent was to set a target figure, even though realities of the technology might require allowing a considerable tolerance.

On sober second thought, I think I find a respectable basis for arguing that both of these figures can be improved. Not to beat about the bus, I propose the following figures:

87 +/- 5 ohms

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At the 12/10 SPI meeting, Robert Allgood brought in X3T9.2/91-213, in which he had calculated both assertion and negation noise margins for a variety of combinations of cable and terminator impedances (linear terminators only). As I understood him, he included the effects of neither attenuation nor the observed degradation caused to the assertion signal by the presence of numerous devices on the SCSI bus. He found the optimum point for the two noise margins to be when the cable and terminator impedances are pretty nearly equal. If I understood him right, this result applies directly to a zero length bus with minimum (i.e., 2 device) loading (zero-length meaning short enough that no attenuation occurs).

Kurt Chan had brought in a somewhat similar study earlier--X3T9.2/91-002R1--but Kurt's study was for various lengths of cables with cable attenuation present (still no representation of the effects of the devices present on the bus). His results somewhat support but extend Robert's results, as illustrated by the following two examples. In both cases, 110-ohm Boulay termination is assumed, and the cable impedance presented produces balanced noise margins.

Cable Length	Cable Impedance
25 m	79 ohms
6 m	85 ohms

F[illegible] didn't study the zero length case, and it may not have come out real close t[illegible] 110 ohms, but he did find that the shorter the bus, the higher the cable impedance would be to produce balanced noise margin--and of course, the greater the noise margins.

In my two attempts to address this matter--X3T9.2/90-170R1 and X3T9.2/90-185R1, I had started from somewhat the opposite end. At that time, many people active in SCSI cable issues were system integrators and their supporters who were needing greater reliability and greater lengths than then were being achieved. The zero-length case was not of interest, and the 6 m case was of interest onl if it was not possible to develop good system performance at longer lengths.

My studies were on 22 m systems with 8 devices on the bus. My host was at a at a bus end, my stubs were the shortest possible, and I used 110-ohm Boulay termination and high-quality polyolefin external cables with the clock lines in the core and the data and parity lines around the outside. These were experimental studies, so that the effect of the devices on the bus were fully represented (and found to be significant). I seemed to find the optimum impedance for that extreme case to be 82.5 ohms--AND I ACHIEVED GOOD WAVEFORMS AND FULLY RELIABLE PERFORMANCE in such systems!

Floring Oprescu recently pointed out the damage which significant lumped capacitance does to bus waveforms, and that the lower the bus impedance, the better the resistance to the effects of the lumped capacitance.

People who have large well designed and controlled systems need bus impedance in the low 80's to permit long buses. Short buses then are not optimized, but they still have greater margins than the long buses and work fine. The latest inputs to the committee, however, are coming from people interested in making "mongrel" systems work, and they would be happy just to get to 6 m. They want all the noise margin they can get, so they want balanced margin at the shorter lengths. In such cases, impedances in the high 80's and low 90's may be justified.

Although more sophisticated terminators and active negation drivers are appearing, making cable impedance much less critical, the system we should be designing for seems to me clearly to be a 110-ohm Boulay terminated system with passive-negation drivers. In such case, there is a long history in this committee that the good performance is achieved with shielded cables with impedances which in almost all cases do not exceed 90 ohms.

I propose that the committee has no valid experimental results on which to base a target impedance as high as 95 ohms.

What everyone agrees is vitally needed is better respect for the cable impedance specification. Reducing the tolerance to +/- 5 ohms sends a powerful message in that direction.

IS IT PRACTICAL?

Absolutely.

Cable		Type	Dielectric	AWG	S/E Impedance
Montrose CBL7259		Round	FP	28	89
Madison 4242		Round	FP	28	85
3M 3801	.050 pitch	Flat	PVC	26	89
3M 3749	.025 pitch	Flat	TPE	30	85