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Subject: **Differential SCSI Concerns**

I continue to have concerns about the differential noise immunity of the SCSI bus in future years as new faster differential transceivers are developed. We cannot depend on semiconductor houses to maintain the proper design and process controls which will prevent unacceptable noise in our application (i.e. SCSI bus transceivers) unless we specify what the output characteristics of these devices must be to prevent this noise. I will try to describe the potential problem here and I would like to know if you or anyone on the SCSI committee agrees (and/or cares) that there is a potential problem with differential SCSI. Please forgive me if I get too elementary here but I would like for everyone who reads this to understand it.

Differential transmission of digital signals is very good for common mode noise rejection but there is nothing inherent in the transmission mechanism which allows for good differential mode noise rejection. A typical source of common mode noise is a voltage/current transient which is coupled onto the transmission media from an external source through capacitive or (more commonly) inductive coupling. Since differential signal transmission media is typically twisted pair wiring or adjacent conductors of a ribbon cable, the voltage/current transient is induced onto both conductors in the same direction and with a similar magnitude. Voltage mode differential receivers will see this as a "voltage spike" on both differential inputs at the same time and since the input signal state is determined by the difference of the two input voltages, this input signal does not change state.

Differential mode noise, on the other hand, refers to voltage (or current) transients on the differential inputs which occur in the opposite directions. This can cause the input signal state to change. One very common source of this type of noise in high speed digital systems is a negative signal reflection. This occurs when a signal propagating down a transmission line (PC board trace or an I/O cable) reaches a point of impedance discontinuity where the impedance is lower than the characteristic impedance of the transmission line. Some of the energy in this signal waveform will be reflected back towards the source and will cause a distortion of the incident signal waveform which will look similar to Figure 2 of the attached drawing. The magnitude of this reflection is primarily a function of the incident waveform frequency and the magnitude of the impedance discontinuity. This type of signal noise has been experienced by many single ended SCSI users recently as the CMOS SCSI chips have been getting faster which caused excessive signal reflections, especially on SCSI busses with large impedance discontinuities such as flat cable to round cable or PC board SCSI busses. Since differential SCSI receivers have even less input hysteresis than single ended receivers, they are even more susceptible to this problem. The only reason that we have not seen a problem yet is that state of the art differential SCSI drivers are so slow, but there is no conscious effort on the transceiver vendor's part to maintain this slow output transition.

One important point here is to understand the difference between "data rate" frequency and "signal edge rate" frequency, it is the latter frequency that affects the magnitude of signal reflections. Figure 1 of the attached drawing shows three 10 Mhz "data rate" signals which could be one of the fast SCSI data handshake lines. However, waveform B would cause a considerably larger signal reflection than waveform A and Waveform C would cause a larger signal reflection than B even though they both have exactly the same rise and fall times. This is due to the high frequency "sharp corners" of waveform C. This can be easily documented if you describe each waveform in terms of its fourier series. Waveform A would be essentially 10 Mhz while waveform B might be composed of 10 Mhz + 20 Mhz ... + 200 Mhz components and C might be 10 Mhz + 20 Mhz ... + 300 Mhz and it is these higher frequency components which cause the larger signal reflections. As semiconductor vendors improve their silicon processes, the output edge frequency components will increase to the point that differential mode noise on a typical SCSI bus will propagate through the signal receivers and cause an invalid input signal state transition. Figure 2 shows a differential pair of signals which cause a differential receiver to switch states at time = t1, a negative signal reflection is detected at this receiver at time = t2 and is of sufficient magnitude (the SCSI standard only requires 35 mV of hysteresis) to cause a false input state transition at the TTL output of the receiver.

I recommend that the SCSI standard specify (or recommend) a yet to be determined measurement system and maximum frequency components for output waveforms for SCSI differential drivers. There also needs to be a specification for describing the homogeneity of the differential SCSI bus transmission media along with A.C. load specifications for SCSI devices and busses. I think that the frequency measurement and constant impedance cables can be specified but I don't know of any standard that has successfully specified an A.C. loading parameter. Please call me at your earliest convenience and let me know if you agree (or care) about what I have presented here and whether you would present this to the SCSI electrical special working group. You may distribute this to anyone that you want to see it.

cc:
T.Meade
D.Nickel
J.Peeples

Attachment: 2 page drawing

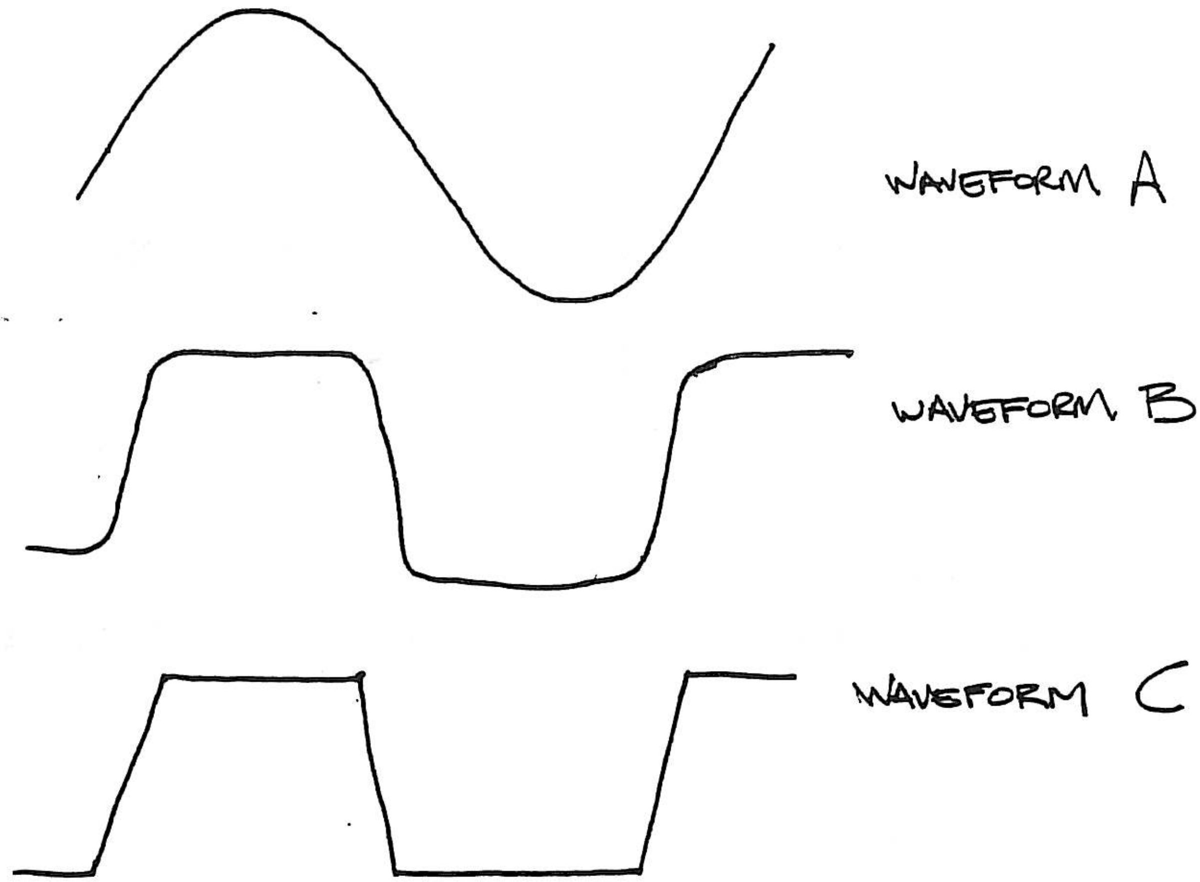

FIGURE 1

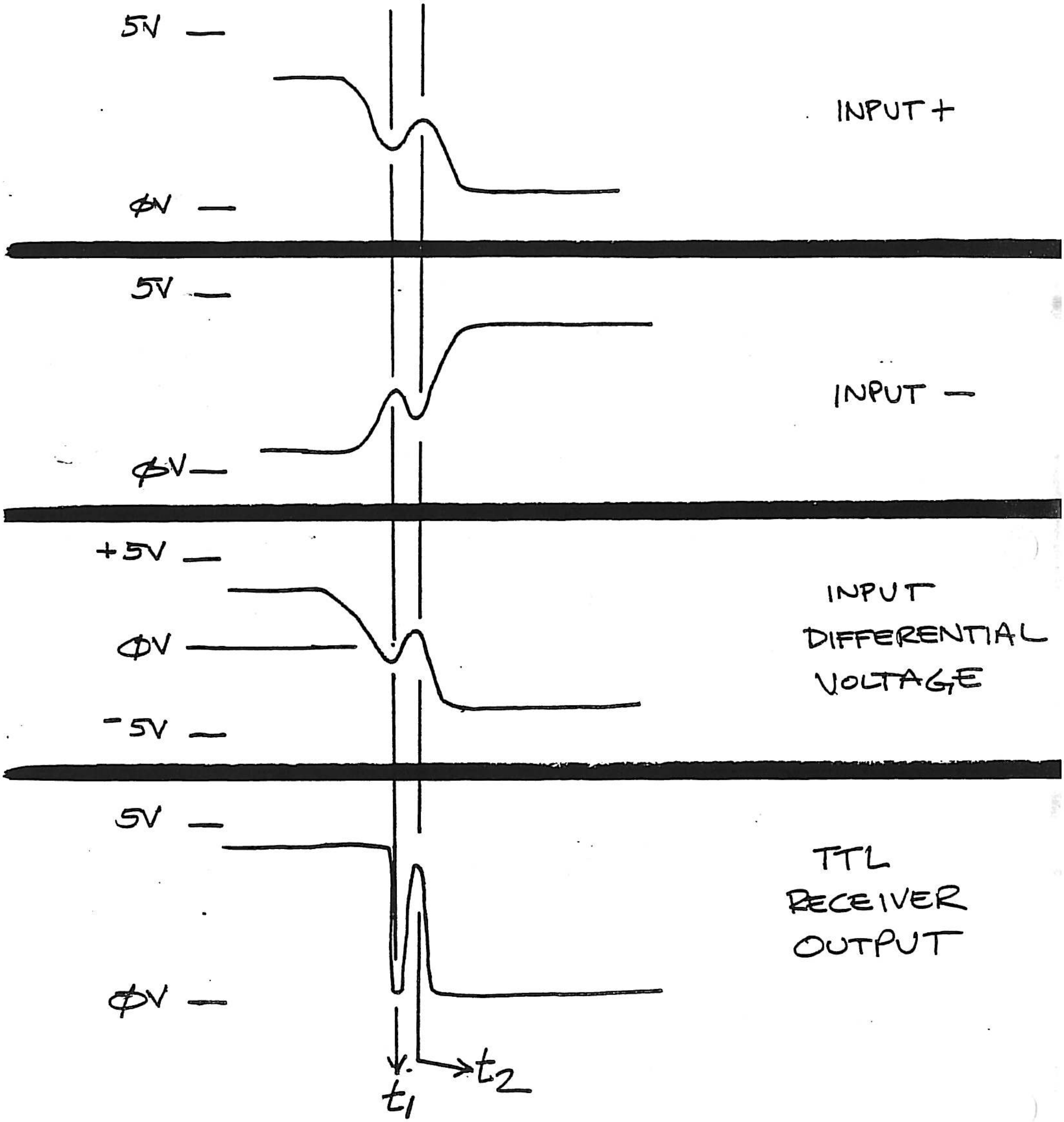
5V
ØV
INPUT +
5V
ØV
INPUT −
+5V
ØV
−5V
INPUT DIFFERENTIAL VOLTAGE
5V
ØV
TTL RECEIVER OUTPUT
t_1
t_2

FIGURE 2