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LVDS Signal Quality: Jitter Measurements Using Eye Patterns Test Report #1



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LVDS SIGNAL QUALITY

This report provides data rate versus cable length recommendations for LVDS drivers and receivers in a typical application for a particular twisted pair cable. The questions of: How Far? and How Fast? seem simple to answer at first, but after detailed study their answers become quite complex. This is not a simple device parameter specification. But rather, a system level question, and to be answered correctly a number of other parameters besides the switching characteristics of the drivers and receivers must be known. This includes the measurement criteria for signal quality that has been selected, and also the pulse coding that will be used (NRZ for example). Additionally, other system level components should be known too. This includes details about the cable, connector, and information about the printed circuit board (PCB). Since the purpose is to measuring signal quality, it should be done in a test fixture that matches the end environment as close as possible, or even better in the actual application if possible. Eye pattern measurements may be used to measure the amount of jitter versus the unit interval to establish the data rate versus cable length curves and therefore are a very accurate way to measure the expected signal quality in the end application. This test report assumes: maximum jitter allotment of 20%, measurements taken at 0V (differential zero) for minimum jitter, measurements taken at ± 100 mV for maximum jitter, and then provides the corresponding data rate versus cable length recommendations.

WHY EYE PATTERNS?

The eye pattern is used to measure the effects of inter symbol interference on random data being transmitted through a particular media. The transition time of the signal is effected by the prior data bits, this is especially true for NRZ data which does not guarantee transitions on the line. For example in NRZ coding, a transition high after a long series of lows has a slower rise time than the rise time of a periodic (010101) waveform. This is due to the low pass filter effects that the cable causes. *Figure 1* illustrates the superposition of six different data patterns. Overlaid they form the eye pattern that is the input to the cable. The right hand side of *Figure 1*, illustrates the same pattern at the end of the cable. Note the rounding of the formerly sharp transitions. The width of the crossing point is now wider, and the opening of the eye is also now smaller (see AN-808 for an extensive discussion on eye patterns).

When line drivers (generators) are supplying symmetrical signals to clock leads, the period of the clock, rather than the unit interval of the clock waveform, should be used to determine the maximum cable lengths (e.g., though the clock rate is twice the data rate, the same maximum cable length limits apply). This is due to the fact that a periodic waveform is not prone to distortion from inter symbol distortion as is a data line.

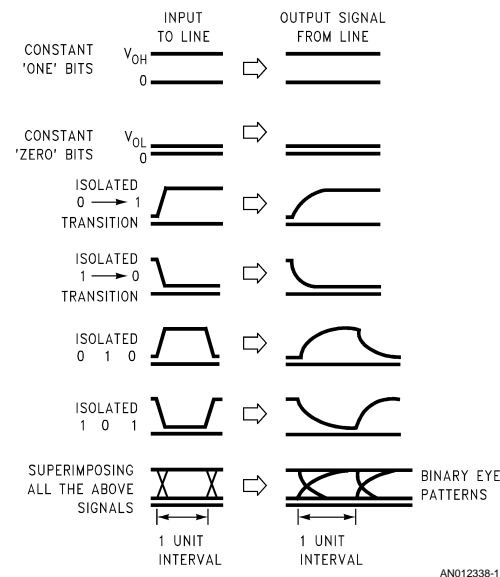


FIGURE 1. Formation of an Eye Pattern by Superposition

Figure 2 describes the measurement locations for minimum jitter. Peak-to-Peak Jitter is the width of the signal crossing the optimal receiver thresholds. For a differential receiver, that would correspond to 0V (differential). However, the receiver is specified to switch between -100 mV and $+100$ mV. Therefore for a worse case jitter measurement, a box should be drawn between ± 100 mV and jitter measured between

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the first and last crossing at ± 100 mV. If the vertical axis units in Figure 2 was 100 mV/division, the worst case jitter ± 100 mV levels.

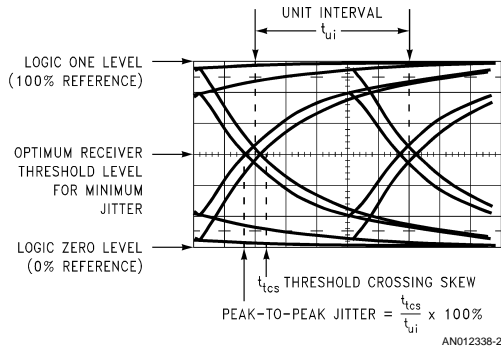


FIGURE 2. NRZ Data Eye Pattern

EYE PATTERN TEST CIRCUIT

LVDS drivers and receivers are intended to be primarily used in an uncomplicated point-to-point configuration as is shown in Figure 3. This figure details the test circuit that was used to acquire the Eye pattern measurements. It includes the following components:

PCB#1: DS90C031 LVDS Quad Driver soldered to the PCB with matched PCB traces between the device (located near the edge of the PCB) to the connector. The connector is an AMP amplate 50 series connector.

Cable: Cable used for this testing was Berk-Tek part number 271211. This is a 105Ω (Differential Mode) 28 AWG stranded twisted pair cable (25 Pair with overall shield) commonly used on SCSI applications. This cable represents a common data interface cable. For this test report the following cable lengths were tested: 1, 2, 3, 5, and 10 meter(s). Cables longer than 10 meters were not tested, but may be employed at lower data rates.

PCB#2: DS90C032 LVDS Quad Receiver soldered to the PCB with matched PCB traces between the device (located near the edge of the PCB) to the connector. The connector is an AMP amplate 50 series connector. A 100Ω surface mount resistor was used to terminate the cable at the receiver input pins.

TEST PROCEDURE

A pseudo-random (PRBS) generator was connected to the driver input, and the resulting eye pattern, measured differentially at TP' was observed on the oscilloscope. Different cable lengths (L) were tested, and the frequency of the input signal was increased until the measured jitter equaled 20% with respect to the unit interval for the particular cable length. The coding scheme used was NRZ. Jitter was measured twice at two different voltage points. First, jitter was measured at the 0V differential voltage (optimal receiver threshold point) for minimum jitter, and second at the maximum receiver threshold points (± 100 mV) to obtain the worst case or maximum jitter at the receiver thresholds. Occasionally jitter is measured at the crossing point alone, this will result in a much lower jitter point, but ignores the fact that the receivers may not switch at that very point. For this reason this signal quality test report measured jitter at both points.

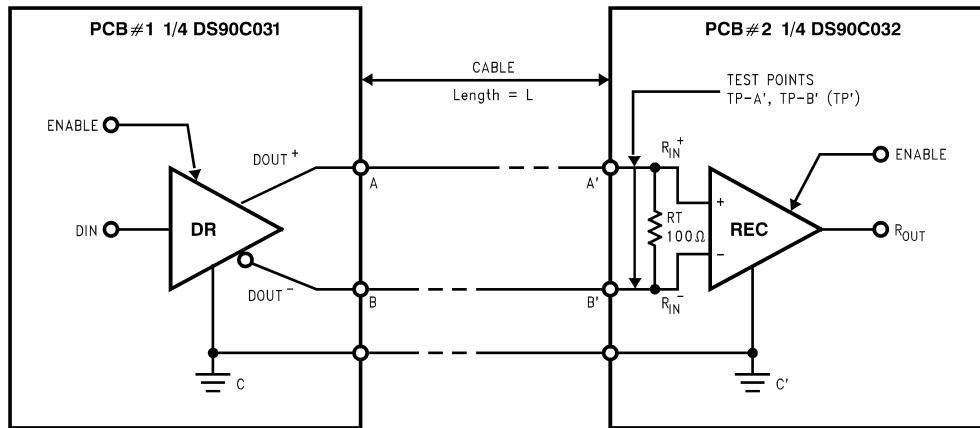


FIGURE 3. LVDS Signal Quality Test Circuit

RESULTS AND DATA POINTS

**20% Jitter Table @ 0V Differential
(Minimum Jitter)**

Cable Length (meter)	Data Rate (Mbps)	Unit Interval - tui (ns)	Jitter - tcs (ns)
1	400	2.500	0.490
2	391	2.555	0.520
3	370	2.703	0.524
5	295	3.390	0.680
10	180	5.550	1.160

As described above, Jitter was measured at the zero volt differential point. For the case with the 1 meter cable, 490 ps of jitter at 400 Mbps was measured, and 1.160 ns of jitter at 180 Mbps and with the 10 meter cable.

**20% Jitter Table @ ±100 mV
(Maximum Jitter)**

Cable Length (meter)	Data Rate (Mbps)	Unit Interval - tui (ns)	Jitter - tcs (ns)
1	200	5.000	1.000
2	190	5.263	1.053
3	170	5.882	1.176
5	155.5	6.431	1.286
10	100	10.000	2.000

The second case measured jitter between ±100 mV levels. For the 1 meter cable, 1 ns of jitter was measured at 200 Mbps, and for the 10 meter cable, 2 ns of jitter occurred at 100 Mbps.

Figure 4 is the graphical representation of the relationship between data rate and cable length for the application under test. Both curves assume a maximum allotment of 20% jitter with respect to the unit interval. Basically data rates between 200–400 Mbps are possible on the shorter lengths, and data rates of 100–200 Mbps are possible at 10 meters. It should be noted that employing a different coding scheme, a differ-

ent cable, a different wire gauge (AWG), etc., will create a different relationship between maximum data rate versus cable length.

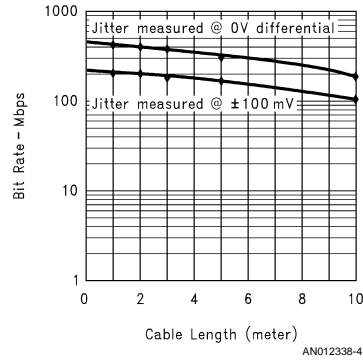


FIGURE 4. Data Rate versus Cable Length

CONCLUSIONS

Eye patterns provide a useful tool to analyze jitter and thus the resulting signal quality as it captures the effects of a random data pattern. They provide a method to determine the maximum cable length for a given data rate or vice versa. However, different systems can tolerate different amounts of jitter, commonly 5%, 10%, or 20% is selected, with 20% being the maximum allowed. Jitter in the system that is greater than 20% tends to close down the eye opening, and error free recovery of NRZ data is increasing more difficult. This report illustrates typical maximum cable lengths for a common data interface cable at 20% jitter, for data rates between 100 Mbps and 200 Mbps. Selecting a premium cable, a category 5 cable for example, will extend the curve significantly. While selecting a lower limit for jitter, 5% for example will decrease the maximum cable length.

REFERENCES

- To probe further the following National Semiconductor Application Notes are recommended which are all located in the INTERFACE: Data Transmission Databook:
 - AN-808 Long Transmission Lines and Data Signal Quality
 - AN-903 A Comparison of Differential Termination Techniques
 - AN-916 A Practical Guide to Cable Selection
- For additional information on cables contact: Berk-Tek @ 1-800-237-5835 (USA), 1-717-354-6200.

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