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Slew Rate Control of LVDS Circuits

Application Report

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Slew Rate Control of LVDS Circuits

ABSTRACT

This application report provides guidelines for controlling slew rate, EMI, and crosstalk when using LVDS devices.

1 Introduction

Low voltage differential signaling (LVDS) techniques can be used in a wide range of applications according to the EIA/TIA-644 standard. With LVDS components, 400 Mb/s connections over 10 meters (33 ft) are possible. For data rates over longer distances up to 100 meters (330 ft), see paragraph 2. Because of the high slew rate of the devices, EMI and crosstalk must be reduced. In applications with data rates up to about 200 Mb/s, the slew rate of the transmitter can be limited using external capacitors to reduce EMI and crosstalk. This document provides guidelines on how to control the slew rate. This document uses the SN65LVDS31 and SN65LVDS32 transmitter-receiver pair, but the guidelines are applicable to other LVDS devices as well.

2 Design Considerations

This paragraph describes design requirements and gives recommended solutions and techniques for overcoming problems.

2.1 Background

The SN65LVDS31 LVDS transmitter consists of switched current sources that produce a differential voltage across a 90- to 130-Ω load resistor. The load resistor must be matched to the characteristic impedance of the twisted pair cable. Category 5 twisted pair data transmission cables have a characteristic impedance of 100 Ω ±15%.

The SN65LVDS31 supplies a minimum output current of 2.47 mA at 25°C. A typical value is 3.4 mA. The current sources have a slight positive temperature coefficient of about 10% over the ambient temperature range of –40 to 85°C.

Figure 1 shows how the external capacitance is connected to reduce the slew rate.

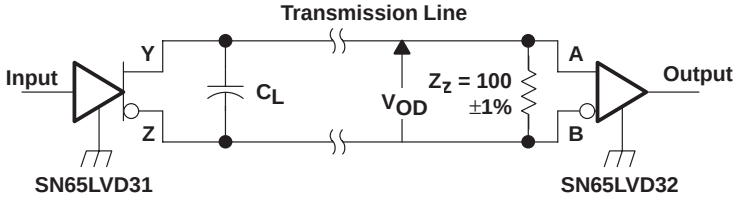

Figure 1. LVDS Basic Setup

Equation (1) shows the theoretical rise time for a given load capacitor. Rise and fall time and slew rate are calculated using 20% and 80% of the V_{OD} (see Figure 2).

$$t_r = \frac{V_{OD(20–89\%)}}{I} \cdot C_L \quad (1)$$

Where:

t_r = rise and fall time [s]
V_{OD} = output differential voltage [V]
I = diver output current [A]
C_L = load capacitor [F]

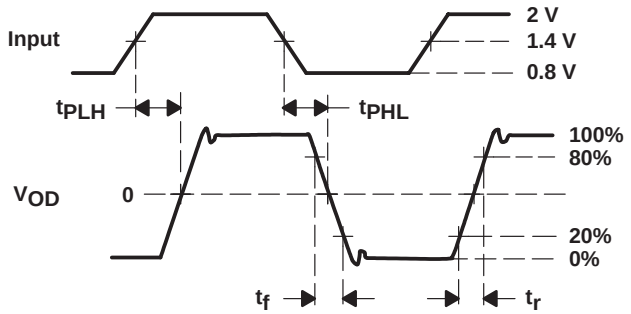

Figure 2. Output Differential Voltage vs Input Voltage

Equation (1) is valid for ideal infinite fast switching circuits. In reality, Equation (1) needs a small correction. The data sheet shows that the circuit has a typical rise time of 0.5 ns when soldered on a printed circuit board:

$$t_r = \frac{V_{OD(20–89\%)}}{I} \cdot C_L + 0.5 \text{ ns} \quad (2)$$

In Figure 3, the calculated slew rate (SR) for devices with a minimum, typical, and maximum output current are displayed using Equation (2).

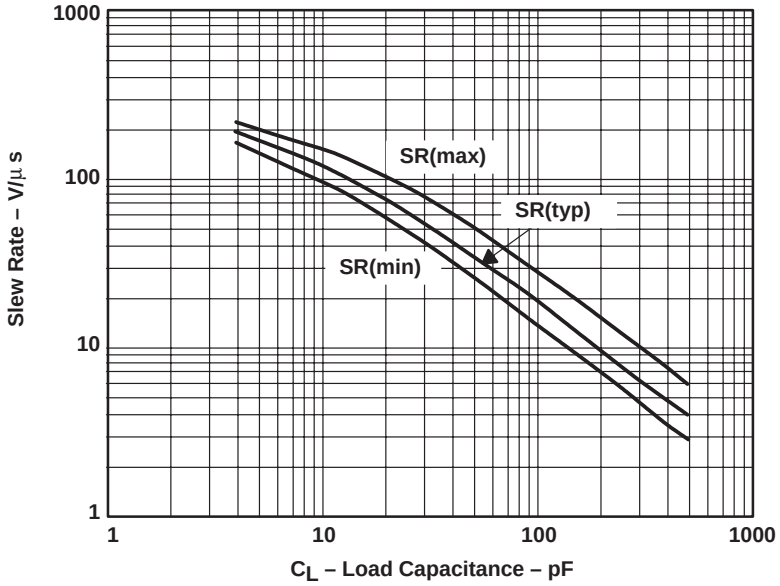

Figure 3. Calculated Minimum, Typical, and Maximum Slew Rates

2.2 Practical Measurements

To compare measured and calculated values, the circuit from Figure 1 is connected with a 15 cm (.5 ft) category 5 cable using the folloiwing equipment:

- HP8110A 150 MHz pulse generator
- Tektronix CSA404 communication signal analyzer using a P6247 differential probe.

Figure 4 shows the results of the measurements.

The dc circuit current of the SN65LVDS31 under test is 3.1 mA. Differential voltage amplitude and rise times were measured with SMD capacitors with tolerances of 5% (see Figure 5).

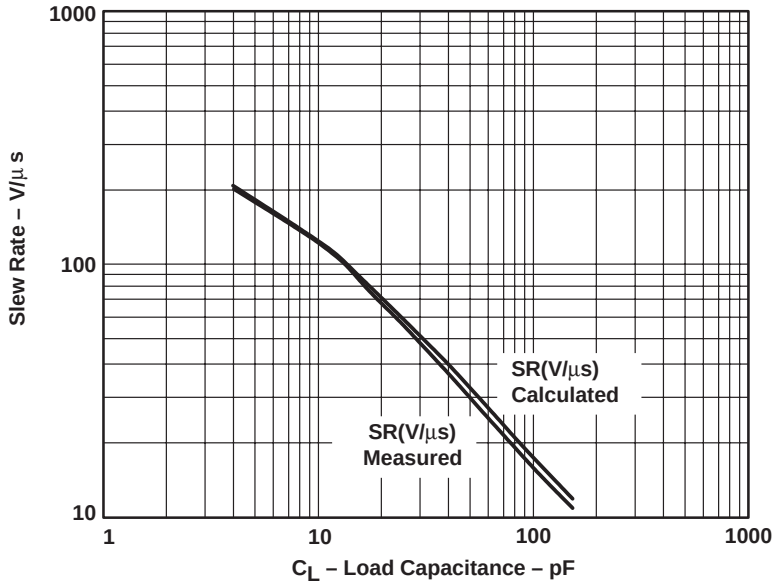

Figure 4. Calculated vs Measured Slew Rate

2.3 Recommendations

Figure 5 shows that loading the LVDS transmission line with external capacitors decreases the differential output voltage at the receiver input. This is due to the current mode characteristics of LVDS. The driver current is constant, so the capacitor current subtracts from the total current available at the termination. As the data rate increases, the current in the capacitor increases, which results in V_{OD} (the voltage across the receiver inputs) being reduced. Capacitor selection should be based upon the desired slew rate for the maximum data rate, while keeping a minimum V_{OD} of 150 mV. This is in keeping with general design guidelines where outside factors such as power supply noise, input data jitter, and channel-to-channel crosstalk through the cable and receiver reduce the minimum V_{OD} even further. In applications where the interconnection cable and LVDS receiver contain only a single LVDS data channel, a minimum V_{OD} of 100 mV is usually sufficient. Figure 5 also shows clearly that a 12-pF capacitor can be used at high data rates with a minimal impact on V_{OD}, while Figure 4 shows that a 12-pF capacitor will keep the slew rate in the 100-V/μs range.

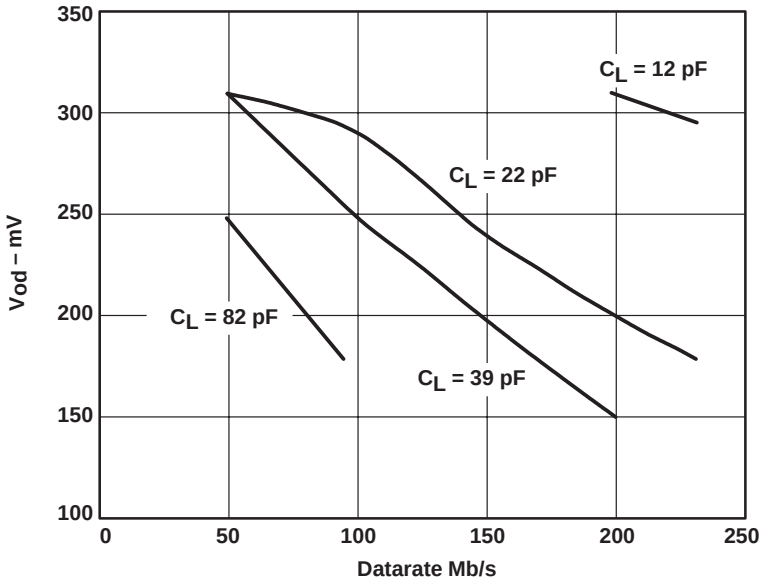

Figure 5. Differential Output Voltage vs. Load Capacitance

3 Summary

This application report shows the effects of capacitive loading on LVDS transmission lines. The data presented shows the interaction between capacitive loading and its results on slew rate, data rates, and LVDS output differential voltage (V_{OD}). The data can be used as selection guidelines for capacitor values to achieve the desired slew rate for a specific data rate and minimum V_{OD}. This will result in an LVDS interface optimized for data rate and V_{OD}, with minimum crosstalk and EMI.

4 References

- TI web pages **www.ti.com/sc**
- Data sheet SN65LVDS31 (literature number SLLS261A)
- Data sheet SN65LVDS32 (literature number SLLS262B)
- *Low Voltage Differential Signaling (VDS) – Design Notes* (literature number SLLA014)
- *Reducing Electronic Interference (EMI) With Low Voltage Differential Signaling (LVDS) Application Report* (literature number SLLA030)
- *Printed Circuit Board Layout for Improved Electromagnetic Compatibility – Application Report* (literature number SDZAE06)
- *What a Designer Should Know – Application Report* (literature number SDZAE03)
- *Data Transmission Design Seminar – Seminar Manual* (literature number SLLDE01C)
- *Digital Design Seminar – Seminar Manual* (literature number SDYDE01B)
- *Linear Design Seminar – Seminar Manual* (literature number SLYDE05)
- *Data Transmission Circuits, Line Circuits – Data Book* (literature number SLLD001)
- MSP Infonavigator CD ROM (literature number SLYC005A)
- *LVDS Standard* (TIA/EIA-644)
- *Commercial Building Telecommunications Cabling Standard* (ANSI/TIA/EIA-568-A)
- *DVB-TM Ad Hoc Group Physical Interfaces DVB-PI-232 Revised TM1449 Rev2*
- *Interfaces for CATV/SMATV Headends and Similar Professional Equipment*
- *IEEE 1596.3-1995 Draft Standard for Low-Voltage Differential Signals (LVDS) for Scalable coherent Interfaces (SCI) Draft 1.3*
- *High Speed LVDS Data Transmission on Various Cable Length – Application Report*

5 Abbreviations

ANSI	American National Standards Institute
EIA	Electronic Industries Association
EMI	Electromagnetic Interference
LVDS	Low Voltage Differential Signaling according to the EIA/TIA-644 standard
TIA	Telecommunications Industry Association