

LVDS in Harsh Environments with the Next Generation Receivers from Texas Instruments

TI has developed the next generation of TIA/EIA-644 low voltage differential signaling (LVDS) receivers for operation in noisy and harsh environments. Because of the reduced common-mode voltage range dictated by the 644 standard, LVDS was unsuitable in some applications as a replacement for the long established standards like RS485 and RS422. TI has addressed this concern by releasing a series of receivers with improved ground noise tolerance, making TI's next generation receivers suitable for these more rugged applications. This document describes the following:

- How common-mode noise is generated and how it affects the transmission system.
- Which noise margins exist in the transmission systems available today.
- What the test results prove.
- The benefits of the next generation LVDS receivers SN65LVDS32A, SN65LVDS3486A and SN65LVDS9637A, which are also available as SN65LVDT with an integrated 110 W termination.

INTRODUCTION

A data stream is subject to external influences such as power cables, other transmission cables, and ESD when it leaves the board environment and goes to a twisted-pair shielded cable. All these influences are sources of ground noise, which affects the common-mode voltage between the transmitter and the receiver. The longer the distance and the more dense the cable trays, the more likely it is that noise problems will appear. This document describes how the next generation LVDS receivers from TI exceed the EIA/TIA-644 standard requirements.

GROUND NOISE

Whenever there is physical distance between a transmitter and receiver, ground shifts and noise occur. These signals are represented in Figure 1 as U noise. The following figure depicts the source of noise voltage.

Figure 2 illustrates some potential external influences on a data connection. Both capacitive (E-field) and magnetic (H-field) couplings are possible. Magnetic couplings can only induce a voltage across the shield impedance when there is a complete loop with sufficient area. If the dashed impedances are virtually 8, the only influence on the data connection is through

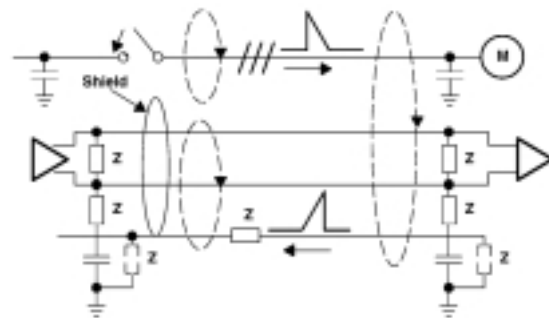


Figure 2. Capacitive and Magnetic Couplings (see Note 1).

capacitive coupling. Disturbances from power switches in the example can easily have frequency components over 100 MHz.

NOTE 1: Not all possible connections, impedances, and influences are shown. Magnetic couplings are indicated with dashed lines. Capacitive couplings are through indicated capacities.

NOISE MARGIN COMPARISON

Induced voltages between grounds of transmitters and receivers can both raise and lower the common-mode operating voltage, V_{ic} . (See Figure 3 for definitions of

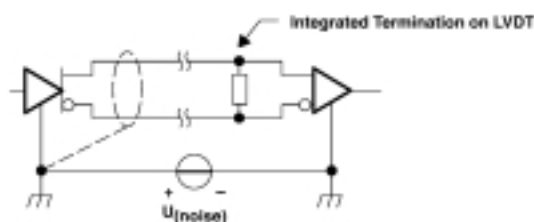


Figure 1. Noise Voltage Source.

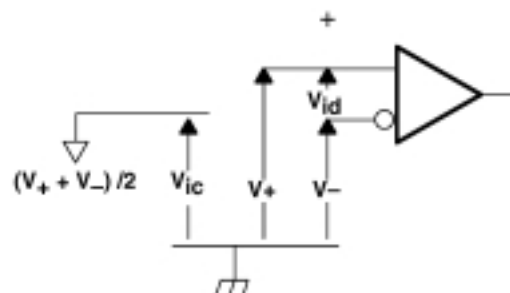


Figure 3. Definitions of Voltages.

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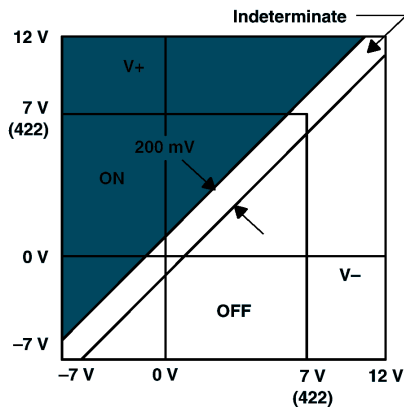


Figure 4. RS-422/485

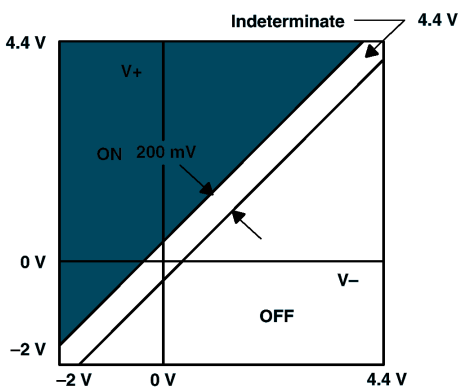


Figure 5. TIA/EIA-644 A

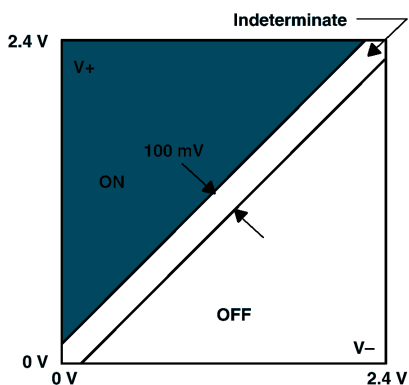


Figure 6. Standard TIA/EIA-644.

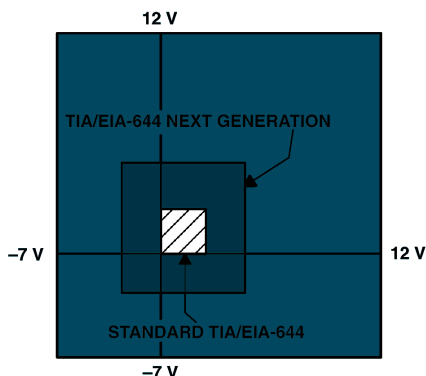


Figure 7. Allowable Pin Voltages.

voltages.) Receivers must be capable of detecting signaling voltage differences, V_{id} , across the termination resistor over a wide range of V_{ic} . See Figures 4 through 7 to compare different standards.

Figures 4 through 7 show V_- on the X axis and V_+ on the Y axis. Whenever V_+ is 100 mV or 200 mV (422/485) higher than V_- the output switches to ON and vice versa for the OFF condition. Each figure illustrates which U noise pp can be present without disturbing the data transmission.

These figures show that, depending on the standards, the following noise voltage margins apply:

- Approximately 9 V for RS422/485
- Over 3 V for TIA/EIA-644 next generation receivers
- 1 V for standard TIA/EIA-644

MORE SPEED, LESS CABLE

Table 1 shows a comparison between transmission standards. The distance for LVDS at 30 m/100 Mbps applies when using twisted-pair shielded CAT 5 cable. For longer distances at lower baud rates, two drivers can be tied together in parallel to overcome cable resistance.

PRACTICAL RESULTS

Figure 8 illustrates a test setup with capacitive noise coupling. Figure 9 illustrates the results of that test.

The signals in Figure 9 at a data rate of approximately 260 Mbit/s are as follows:

- Signal 1, LVDT32A input A (V_+)
- Signal 2, LVDT32A input B (V_-)
- Signal 3, LVDT32A output
- Signal 4, LVDS31 transmitter input

The capacitive common-mode noise coupling is generated in a 1.5 meter twisted-pair unshielded CAT 5 cable. The delay of 13.7 ns as indicated with a D consists of the following:

- 1.5 meters of cable
- internal delays of transmitter (typically 1.4/1.7 ns) and receiver (typically 4 ns). The Wavetek signal generator output voltage is 30 V and the bandwidth of the signal largely exceeds the bandwidth of the data signal.

SUMMARY OF THE ADVANTAGES

The advantages of the next generation of TI's LVDS receivers are summarized below. For more information, see the corresponding data sheets.

- Increased common-mode input voltage range
- Better than ± 15 kV Human Body Model (MIL Std 883) ESD protection, which simplifies conformity issues such as the European conformity procedure for appliances (CE) and minimizes the need for external components in an industrial environment.
- Integrated termination resistor on LVDT versions. This not only reduces the number of components and boardspace, it can also increase performance in some high-speed applications because of the near zero stub length.

Performance Measure	Data Transmission Standard			
	LVDS	PECL	RS-422/485	TTL
Speed	> 400 Mb/s	> 400 Mb/s	< 50 Mbps	< 100 Mbps
Power consumption	Low/100mW per channel at 400 Mbps	Medium	High	High for TTL Low for CMOS
Noise immunity	Improved with next generation LVDS-A	Medium	High	
EMI emissions	Similar to PECL ~10x better than RS-422/485 >> better than TTL	Medium	High	High
Voltage swing	~350 mV	~800 mV	~3.5 V	~3.7 V
Distance	30m/100 Mbps 100m/30 Mbps	Short	< 1200 m	< 1 m
Relative cost	Medium	High	Medium	Low

Table 1. Comparison Between Transmission Standards.

APPLICATION AREAS

The application areas for the next generation of LVDS receivers are as follows:

- Point-to-point base band data transmission
- Replacement or alternative to connections that use traditional RS422/485 circuits to improve EMI, reduce power consumption, or reduce the number of connections.

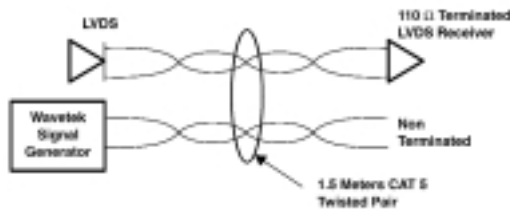


Figure 8. Setup of the test.

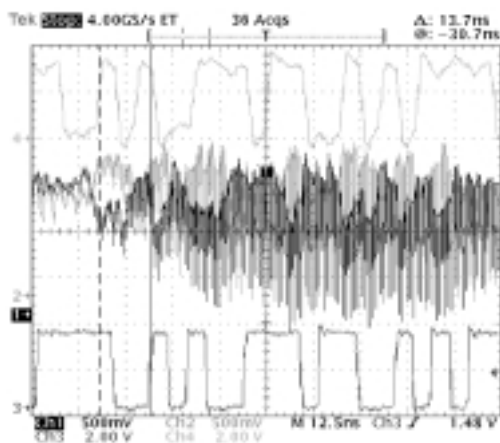


Figure 9. Results of the Setup as in Figure 8.

CONCLUSION

Practical results show that the next generation of LVDS receivers is capable of recovering a high-speed data stream successfully out of a high noise environment. For a given existing LVDS application two possible savings can be obtained:

- The application can run with the same data rate using cheaper cable.
- The application can run with the same cable using a higher data rate or with more parallel connections in the same cable.

For a given existing RS-422/485 application the next generation LVDS receivers do the following:

- Reduces the EMI and power consumption while maintaining the ruggedness required for industrial applications when upgrading to LVDS.
- Connects an LVDS/LVDT A receiver directly to an existing RS-422/485 transmitter as part of a testing or upgrade process ■

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