Application Brief

ESD Protection for LIN Data Lines

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Introduction

Local Interconnect Network (LIN) is a communication protocol commonly used in automotive applications. As with other exposed connectors, the LIN interface can experience electrostatic discharge (ESD). Designing a LIN interface with a protection diode protects the LIN transceiver itself and the respective downstream bus components. To increase system-level robustness from ESD strikes, the characteristics of the LIN interface must be considered for correct ESD diode selection.

LIN Bus Overview

LIN is a single wire communications interface that is low-cost and space-efficient. Developed where speed is not critical, LIN data lines operate at a maximum of 20 Kbit/s. A LIN cluster is composed of a leader node and up to 15 follower nodes attached along the single LIN line, which is standardized by ISO 17897. The LIN bus is biased to the battery of the car, which is typically 12 V. Figure 1 shows a LIN transceiver node that is supplied by the car battery and connected to the single LIN line.

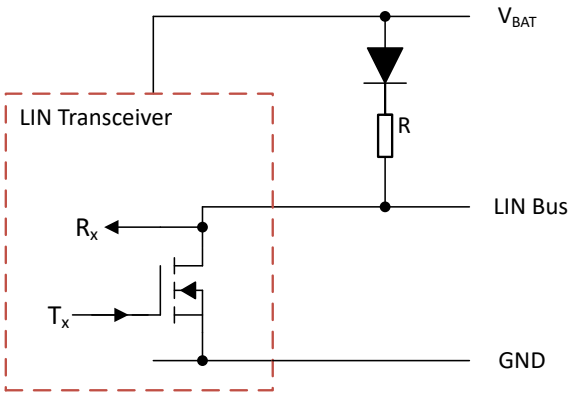

Figure 1. LIN Drive Schematic

Causes of ESD

ESD can be prevalent in any environment where exposed connectors are present, particularly the LIN bus. When the LIN bus is in contact with the outside world, the bus is at risk of a high voltage strike. This high voltage strike or transient can cause damage to the LIN transceiver and subsequent components downstream.

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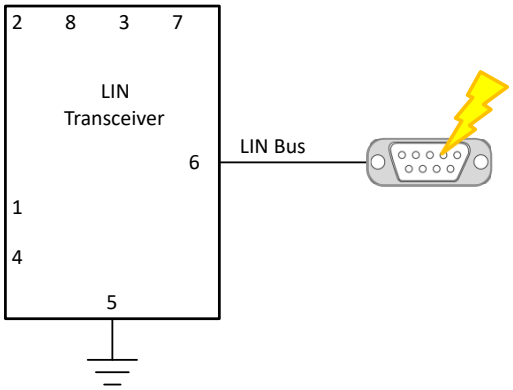

Figure 2. LIN Bus ESD Event

When a product moves through an assembly line in a factory, the cabling can build up excess charge. Once the cabling is connected to the LIN bus, the excess charge flows into the downstream circuitry which can cause permanent damage.

Maintenance on a car where cabling is disconnected and reconnected can also allow ESD to occur. Additionally, ESD strikes can take place due to the proximity of multiple electronic control units (ECUs) nearby. Overall, the LIN bus can encounter ESD in a variety of situations and must be considered.

ESD Protection Requirements

To protect the LIN system, use the list of key parameters.

- IEC 61000-4-2 Rating:
  - Real-world ESD strikes are defined by the IEC 61000-4-2 testing standard. This standard is more rigorous than the human body model (HBM). LIN transceivers have HBM ESD protection at minimum, which is protection on the component level for assembly and manufacturing environments. However, they do not account for system level ESD encountered in uncontrolled end-user environments. 15kV of IEC 61000-4-2 rating is suggested, while more rigorous options up to 30 kV are available.
  - For a detailed explanation, see Electrostatic Discharge: Human Body Mode versus IEC61000-4-2.
- Working Voltage:
  - The LIN bus must not exceed the ESD diodes reverse working voltage (V_{RWM}). The LIN bus operates in a range of 9 V to 18 V. To mitigate the risk of an improper battery jump-start, 24 V_{RWM} is required when two 12-V batteries are connected in series. In addition, larger vehicles such as 18-wheelers use 24 V.
- Capacitance:
  - For proper transmission and minimal noise, LIN follower node capacitance must not exceed 220 pF in most applications. For design flexibility, selecting a diode with the least amount of capacitance (50 pF is the recommended maximum) is recommended.
- Clamping Voltage:
  - The clamping voltage must be less than the absolute maximum rating of the LIN transceiver, typically ±45 V maximum. The clamping voltage is the voltage drop the protected IC experiences during an ESD strike, which is why the clamping voltage must be below the maximum transceiver rating.
- Polarity:
  - A bidirectional diode is required to avoid damage due to faulty battery wiring resulting in a negative DC voltage on the LIN bus.
- Current Leakage:
  - When the LIN transceiver is in a low-power mode (if applicable), power must be conserved. A low maximum leakage current rating is suggested to allow the diode to conserve power when working below the working voltage.

Table 1 lists devices that support these specifications.

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System Level Designs

TI offers several ESD diodes with robust specifications for a myriad of LIN use cases. Figure 3 shows the block diagram of TLIN1029A-Q1 paired with ESD1LIN24-Q1, demonstrating how the system provides system-level ESD immunity in an automotive environment.

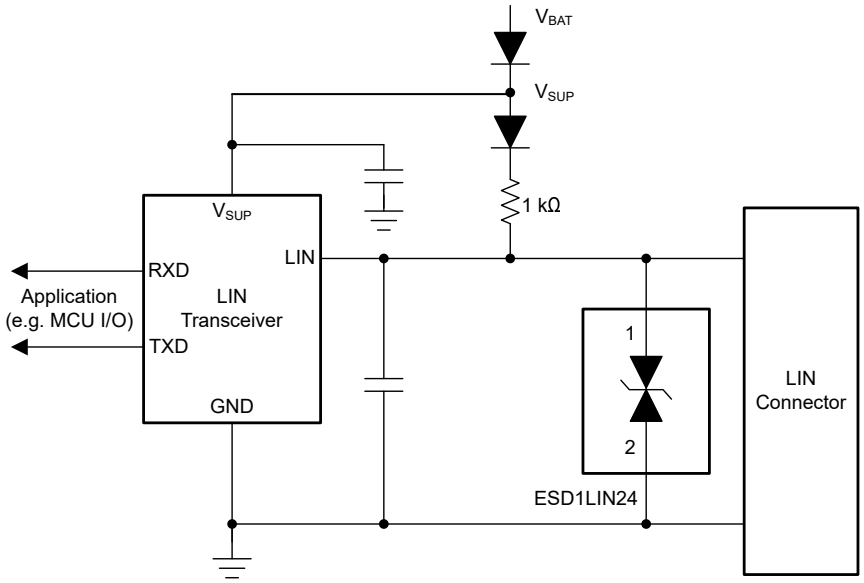

Figure 3. LIN Placement Diagram

In Figure 3, the diode is connected directly to the LIN data line of the LIN transceiver. To properly protect the circuit, place the diode as close to the ESD source or connector side as design rules allow. The clamping voltage of the ESD1LIN24-Q1 (valued at 37 V) is within the absolute maximum value of the TLIN1029A-Q1 (45 V). The IEC 61000-4-2 30-kV rating of the diode provides the maximum level of protection against unprecedented ESD strikes across the LIN bus.

For more information on ESD protection layouts, see the ESD Packaging and Layout Guide.

Summary

The LIN interface requires robust ESD protection to survive real-world ESD strikes. The selection of the correct diode is critical for proper system coverage in the event of high voltage transients, while allowing full function of the LIN transmission with low capacitance. The ESD7xx and ESD1LINxx device lines have low clamping voltages and high ESD ratings, providing ESD protection for the LIN bus interfaces. Table 1 lists these device suggestions.

Table 1. Device Suggestions

LIN Device	IEC 61000-4-2 (kV)	V_{RWM}(V)	Line Capacitance (pF)	Clamping Voltage (V)	Package Size (mm)
ESD1LIN24-Q1	30	24	3	37	SOT-323 (2.50 × 1.20)
ESD751-Q1	22	24	1.6	36.5	SOT-523 (1.60 × 0.80)
ESD761-Q1	15	24	1.1	36.3	DFN1006 (1.00 × 0.60)

References

- Texas Instruments, *LIN Protocol and Physical Layer Requirements*, application note.
- Texas Instruments, *System-Level ESD Protection Guide*, marketing selection guide.

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