AM26LV32 Low-Voltage, High-Speed Quadruple Differential Line Receiver

1 Features

- Switching Rates Up to 32 MHz
- Operates From Single 3.3-V Supply
- Ultra-Low Power Dissipation: 27 mW Typical
- Open-Circuit, Short-Circuit, and Terminated Fail-Safe
- −0.3-V to 5.5-V Common-Mode Range With ±200-mV Sensitivity
- Accepts 5-V Logic Inputs With 3.3-V V_{CC}
- Input Hysteresis: 50 mV Typical
- 235 mW With Four Receivers at 32 MHz
- Pin-to-Pin Compatible With AM26C32 and AM26LS32

2 Applications

- High-Reliability Automotive Applications
- Factory Automation
- ATM and Cash Counters
- Smart Grid
- AC and Servo Motor Drives

3 Description

The AM26LV32 device is a BiCMOS, quadruple differential line receiver with 3-state outputs, which is designed to be similar to the TIA/EIA-422-B and ITU Recommendation V.11 receivers with reduced common-mode voltage range due to reduced supply voltage.

The device is optimized for balanced bus transmission at switching rates up to 32 MHz. The enable function is common to all four receivers and offers a choice of active-high or active-low inputs. The 3-state outputs permit connection directly to a bus-organized system. Each device features high input impedance, input hysteresis for increased noise immunity, and input sensitivity of ±200 mV over a common-mode input voltage range from −0.3 V to 5.5 V. When the inputs are open-circuit, the outputs are in the high logic state.

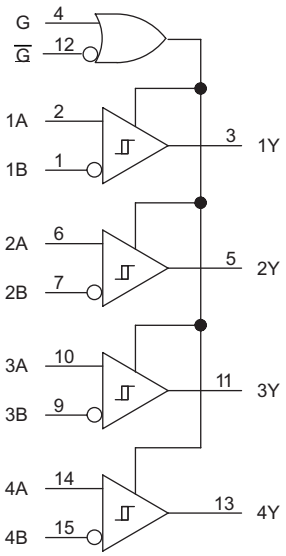
The AM26LV32C is characterized for operation from 0°C to 70°C. The AM26LV32I is characterized for operation from −45°C to 85°C.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
AM26LV32D	SOIC (16)	9.90 mm × 3.90 mm
AM26LV32NS	SO (16)	10.20 mm × 5.30 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Logic Diagram (Positive Logic)



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4 Revision History

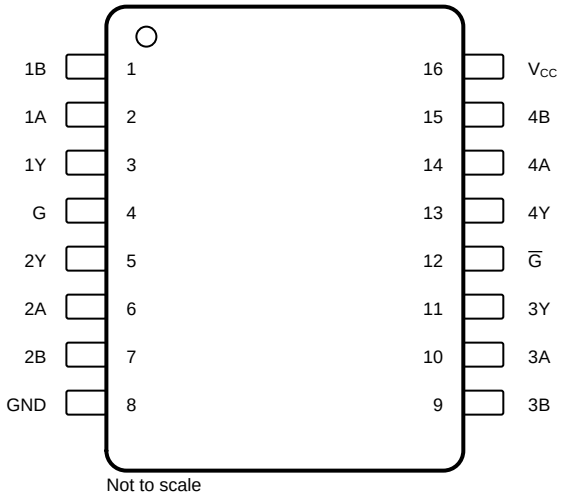
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision E (June 2005) to Revision F **Page**

- Added *ESD Ratings* table, *Thermal Information* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section ... 1
- Deleted MB570 from *Features* list ... 1
- Deleted *Ordering Information* table; see *Mechanical, Packaging, and Orderable Information* at the end of the data sheet. 1
- Deleted Lead temperature (260°C maximum) from *Absolute Maximum Ratings* table ... 4
- Changed Package thermal impedance, $R_{\theta JA}$, values in *Thermal Information* table From: 73°C To: 72.9°C (D) and From: 64°C To: 74°C (NS) ... 4

5 Pin Configuration and Functions

D and NS Package
16-Pin SOIC and SO
Top View



Not to scale

Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
1A	2	I	RS422, RS485 differential input (noninverting)
1B	1	I	RS422, RS485 differential input (inverting)
1Y	3	O	Logic level output
2A	6	I	RS422, RS485 differential input (noninverting)
2B	7	I	RS422, RS485 differential input (inverting)
2Y	5	O	Logic level output
3A	10	I	RS422, RS485 differential input (noninverting)
3B	9	I	RS422, RS485 differential input (inverting)
3Y	11	O	Logic level output
4A	14	I	RS422, RS485 differential input (noninverting)
4B	15	I	RS422, RS485 differential input (inverting)
4Y	13	O	Logic level output
$\overline{G}$	12	I	Active-low select
G	4	I	Active-high select
GND	8	—	Ground
V_{CC}	16	—	Power supply

6 Specifications

6.1 Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted)(1)

	MIN	MAX	UNIT
Supply voltage, V_{CC}(2)	–0.3	6	V
Input voltage, V_I	–4	8	V
Differential input voltage, V_{ID}(3)		±12	V
Enable input voltage	–0.3	6	V
Output voltage, V_O	–0.3	6	V
Maximum output current, I_O		±25	mA
Storage temperature, T_{stg}	–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) All voltage values are with respect to the GND terminal.
(3) Differential input voltage is measured at the noninverting input with respect to the corresponding inverting input.

6.2 ESD Ratings

		VALUE	UNIT
$V_{(ESD)}$ Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	500	V
	Charged-device model (CDM), per JEDEC specification JESD22-C101(2)	500	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
Supply voltage, V_{CC}		3	3.3	3.6	V
High-level input voltage, $V_{IH(EN)}$		2			V
Low-level input voltage, $V_{IL(EN)}$				0.8	V
Common-mode input voltage, V_{IC}		–0.3		5.5	V
Differential input voltage, V_{ID}				±5.8	V
High-level output current, I_{OH}				–5	mA
Low-level output current, I_{OL}				5	mA
Operating free-air temperature, T_A	AM26LV32C	0		70	°C
	AM26LV32I	–40		85	

6.4 Thermal Information

THERMAL METRIC(1)(2)		AM26LV32		UNIT
		D (SOIC)	NS (SO)	
		16 PINS	16 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	72.9	74	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	32.4	31.1	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	30.4	34.8	°C/W
ψ_{JT}	Junction-to-top characterization parameter	5.4	5.1	°C/W
ψ_{JB}	Junction-to-board characterization parameter	30.1	34.5	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report.
(2) The package thermal impedance is calculated in accordance with JESD 51.

6.5 Electrical Characteristics

over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
V_{IT+}	Differential input high-threshold voltage				0.2	V
V_{IT-}	Differential input low-threshold voltage		–0.2			V
V_{IK}	Enable input clamp voltage	I_I = − 18 mA		–0.8	–1.5	V
V_{OH}	High-level output voltage	V_{ID} = 200 mV, I_{OH} = −5 mA	2.4	3.2		V
V_{OL}	Low-level output voltage	V_{ID} = 200 mV, I_{OH} = 5 mA		0.17	0.5	V
I_{OZ}	High-impedance-state output current	V_O = 0 to V_{CC}			±50	µA
$I_{IH(E)}$	High-level enable input current	V_{CC} = 0 or 3 V, V_I = 5.5 V			10	µA
$I_{IL(E)}$	Low-level enable input current	V_{CC} = 3.6 V, V_I = 0 V			–10	µA
r_I	Input resistance		7	12		kΩ
I_I	Input current	V_I = 5.5 V or − 0.3 V, all other inputs GND			±700	µA
I_{CC}	Supply current	$V_{I(E)}$ = V_{CC} or GND, no load, line inputs open		8	17	mA
C_{pd}	Power dissipation capacitance(2)	One channel		150		pF

(1) All typical values are at V_{CC} = 3.3 V and T_A = 25°C.
(2) C_{pd} determines the no-load dynamic current: $I_S = C_{pd} \times V_{CC} \times f + I_{CC}$.

6.6 Switching Characteristics

over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{PLH}	Propagation delay time, low- to high-level output	See Figure 4	8	16	20	ns
t_{PHL}	Propagation delay time, high- to low-level output	See Figure 4	8	16	20	ns
t_t	Transition time (t_r or t_f)	See Figure 4		5		ns
t_{PZH}	Output-enable time to high level	See Figure 5		17	40	ns
t_{PZL}	Output-enable time to low level	See Figure 6		10	40	ns
t_{PHZ}	Output-disable time from high level	See Figure 5		20	40	ns
t_{PLZ}	Output-disable time from low level	See Figure 6		16	40	ns
$t_{sk(p)}$(1)	Pulse skew			4	6	ns
$t_{sk(o)}$(2)	Pulse skew			4	6	ns
$t_{sk(pp)}$(3)	Pulse skew (device to device)			6	9	ns

(1) $t_{sk(p)}$ is $|t_{PLH} - t_{PHL}|$ of each channel of the same device.
(2) $t_{sk(o)}$ is the maximum difference in propagation delay times between any two channels of the same device switching in the same direction.
(3) $t_{sk(pp)}$ is the maximum difference in propagation delay times between any two channels of any two devices switching in the same direction.

6.7 Typical Characteristics

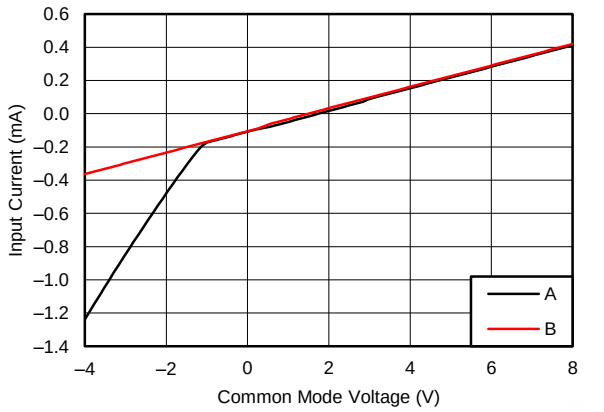


Figure 1. RS422 Port Current vs Common-Mode Voltage

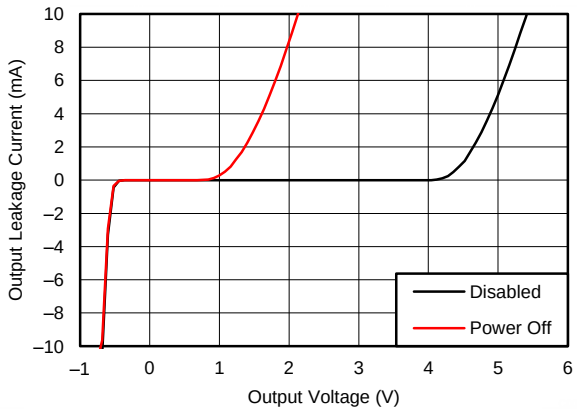


Figure 2. Output Y Leakage Current vs Output Y Voltage

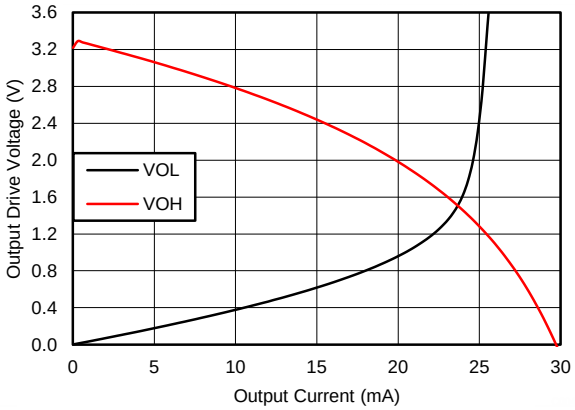
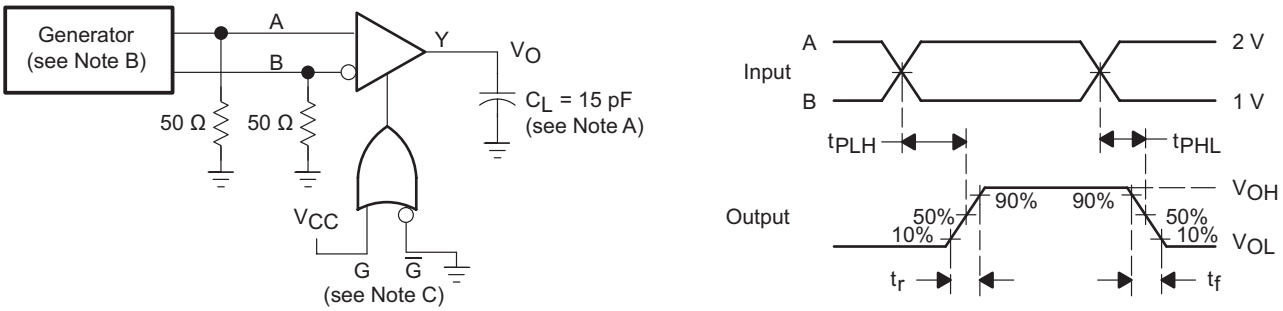


Figure 3. Output Y Drive Voltage vs Output Y Current

7 Parameter Measurement Information

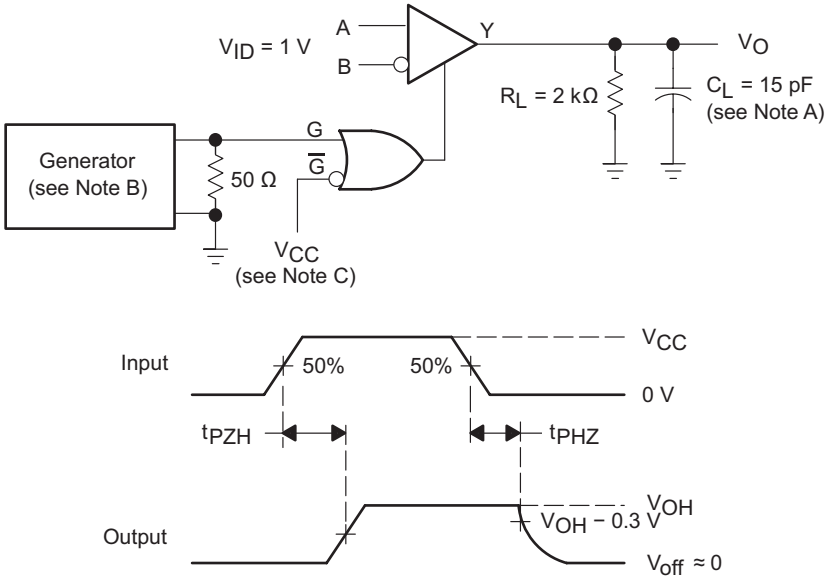


A. C_L includes probe and jig capacitance.

B. The input pulse is supplied by a generator having the following characteristics: Z_O = 50 Ω, PRR = 10 MHz, t_r and t_f (10% to 90%) ≤ 2 ns, 50% duty cycle.

C. To test the active-low enable $\overline{G}$, ground G and apply an inverted waveform $\overline{G}$.

Figure 4. t_{PLH} and t_{PHL} Test Circuit and Voltage Waveforms



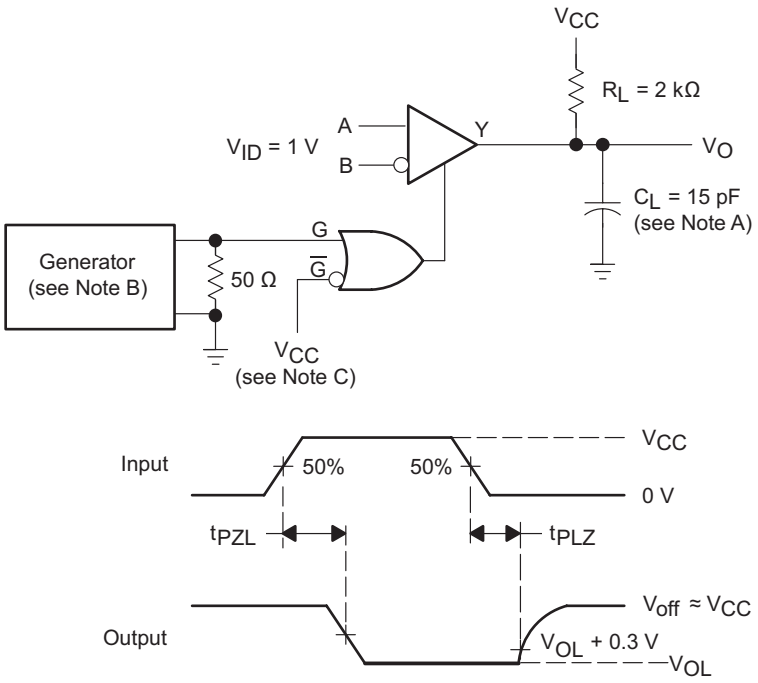
A. C_L includes probe and jig capacitance.

B. The input pulse is supplied by a generator having the following characteristics: Z_O = 50 Ω, PRR = 10 MHz, t_r and t_f (10% to 90%) ≤ 2 ns, 50% duty cycle.

C. To test the active-low enable $\overline{G}$, ground G and apply an inverted waveform $\overline{G}$.

Figure 5. t_{PZH} and t_{PHZ} Test Circuit and Voltage Waveforms

Parameter Measurement Information (continued)



A. C_L includes probe and jig capacitance.

B. The input pulse is supplied by a generator having the following characteristics: Z_O = 50 Ω, PRR = 10 MHz, t_r and t_f (10% to 90%) ≤ 2 ns, 50% duty cycle.

C. To test the active-low enable $\overline{G}$, ground G and apply an inverted waveform $\overline{G}$.

Figure 6. t_{PZL} and t_{PLZ} Test Circuit and Voltage Waveforms

8 Detailed Description

8.1 Overview

The AM26LV32 device is a quadruple differential line receiver that meets the necessary requirements for NSI TIA/EIA-422-B, TIA/EIA-423-B, and ITU Recommendation V.10 and V.11. This device allows a low-power or low-voltage MCU to interface with heavy machinery, subsystems, and other devices through long wires of up to 1000 m, giving any design a reliable and easy-to-use connection. As with any RS422 interface, the AM26LV32 works in a differential voltage range, which enables very good signal integrity.

8.2 Functional Block Diagram

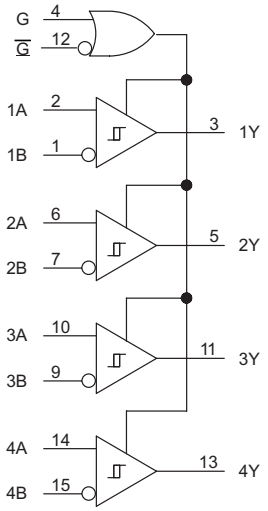


Figure 7. Logic Diagram (Positive Logic)

8.3 Feature Description

The device can be configured using the G and $\overline{G}$ logic inputs to select receiver output. The high voltage or logic 1 on the G pin allows the device to operate on an active-high, and having a low voltage or logic 0 on the $\overline{G}$ enables active-low operation. These are simple ways to configure the logic to match that of the receiving or transmitting controller or microprocessor.

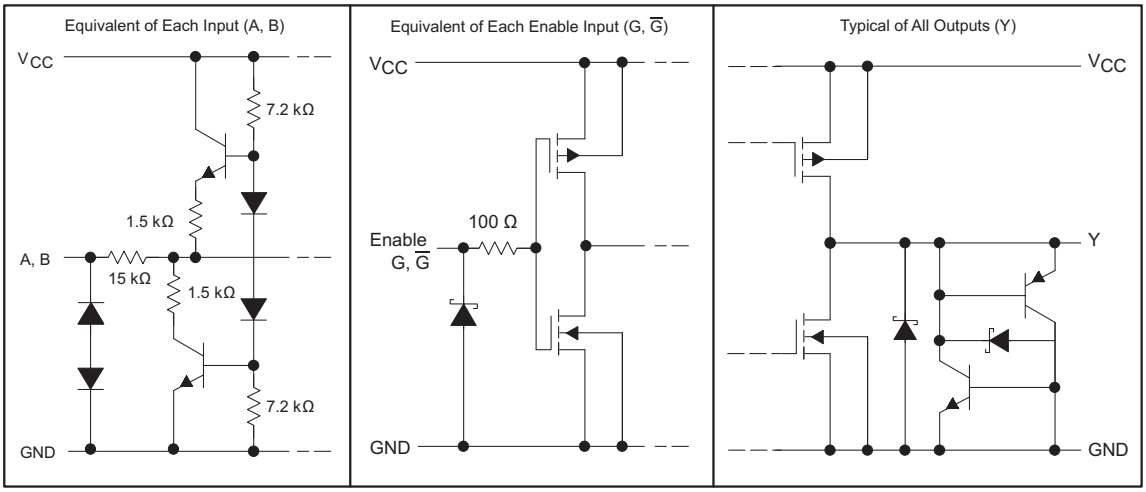


Figure 8. Schematics of Equivalent Inputs and Outputs

8.4 Device Functional Modes

The receivers implemented in these RS422 devices can be configured using the G and $\overline{G}$ logic pins to be enabled or disabled. This allows the option to ignore or filter out transmissions as desired. Table 1 lists the function of each receiver.

Table 1. Function Table (Each Receiver)

DIFFERENTIAL INPUT	ENABLES		OUTPUT(1)
	G	$\overline{G}$	
$V_{ID} \geq 0.2$ V	H	X	H
	X	L	H
–0.2 V < V_{ID} < 0.2 V	H	X	?
	X	L	?
$V_{ID} \leq$ –0.2 V	H	X	L
	X	L	L
Open, shorted, or terminated(2)	H	X	H
	X	L	H
X	L	H	Z

(1) H = high level, L = low level, X = irrelevant, Z = high impedance (off), ? = indeterminate
(2) See *Application and Implementation* section

8.4.1 Fail-Safe Conditions

The AM26LV32 is a quadruple differential line receiver that is designed to function properly when appropriately connected to active drivers. Applications do not always have ideal situations where all bits are being used, the receiver inputs are never left floating, and fault conditions do not exist. In actuality, most applications have the capability to either place the drivers in a high-impedance mode or power down the drivers altogether, and cables may be purposely (or inadvertently) disconnected, both of which lead to floating receiver inputs. Furthermore, even though measures are taken to avoid fault conditions like a short between the differential signals, this does occur. The AM26LV32 device has an internal fail-safe circuitry which prevents the device from putting an unknown voltage signal at the receiver outputs. In the following three cases, a high-state is produced at the respective output:

1. Open fail-safe: Unused input pins are left open. Do not tie unused pins to ground or any other voltage. Internal circuitry places the output in the high state.
2. 100-Ω terminated fail-safe: Disconnected cables, drivers in high-impedance state, or powered-down drivers does not cause the AM26LV32 to malfunction. The outputs remain in a high state under these conditions. When the drivers are either turned-off or placed into the high-impedance state, the receiver input may still be able to pick up noise due to the cable acting as an antenna. To avoid having a large differential voltage being generated, the use of twisted-pair cable induces the noise as a common-mode signal and is rejected.
3. Shorted fail-safe: Fault conditions that short the differential input pairs together does not cause incorrect data at the outputs. A differential voltage (V_{ID}) of 0 V forces a high state at the outputs. Shorted fail-safe, however, is not supported across the recommended common-mode input voltage (V_{IC}) range. An unwanted state can be induced to all outputs when an input is shorted and is biased with a voltage between −0.3 V and +5.5 V. The shorted fail-safe circuitry functions properly when an input is shorted, but with no external common-mode voltage applied.

8.4.2 Fail-Safe Precautions

The internal fail-safe circuitry was designed such that the input common-mode (V_{IC}) and differential (V_{ID}) voltages must be observed. To ensure the outputs of unused or inactive receivers remain in a high state when the inputs are open-circuited, shorted, or terminated, extra precaution must be taken on the active signal. In applications where the drivers are placed in a high-impedance mode or are powered-down, TI recommends that for 1, 2, or 3 active receiver inputs, the low-level input voltage (V_{IL}) must be greater than 0.4 V. As in all data transmission applications, it is necessary to provide a return ground path between the two remote grounds (driver and receiver ground references) to avoid ground differences. Table 2 and Figure 9 through Figure 11 are examples of active input voltages with their respective waveforms and the effect each have on unused or inactive outputs. Note that the active receivers behave as expected, regardless of the input levels.

Table 2. Active Receiver Inputs vs Outputs

1, 2, OR 3 ACTIVE INPUTS			SEE FIGURE	1, 2, OR 3 ACTIVE OUTPUTS	3, 2, OR 1 UNUSED OR INACTIVE OUTPUTS
V_{IL}	V_{ID}	V_{IC}			
900 mV	200 mV	1 V	Figure 9	Known state	High state
–100 mV	200 mV	0 V	Figure 10	Known state	?
600 mV	800 mV	1 V	Figure 11	Known state	High state
0 mV	800 mV	400 mV	Figure 12	Known state	?

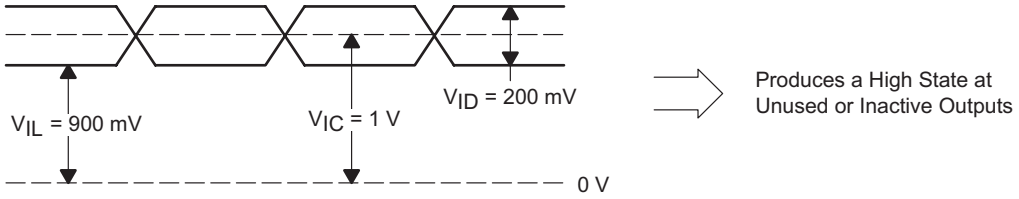


Figure 9. Waveform 1

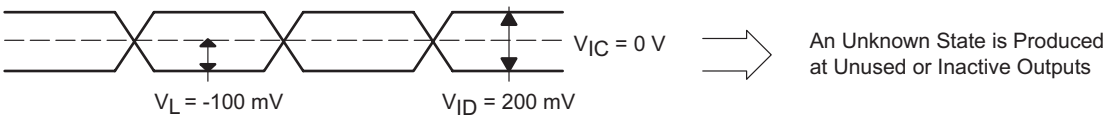


Figure 10. Waveform 2

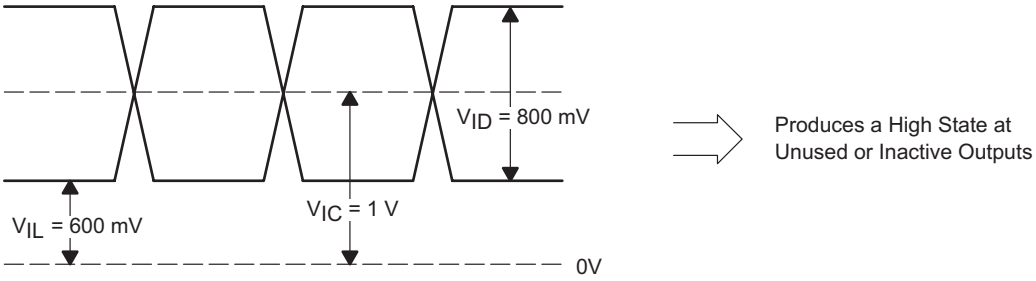


Figure 11. Waveform 3

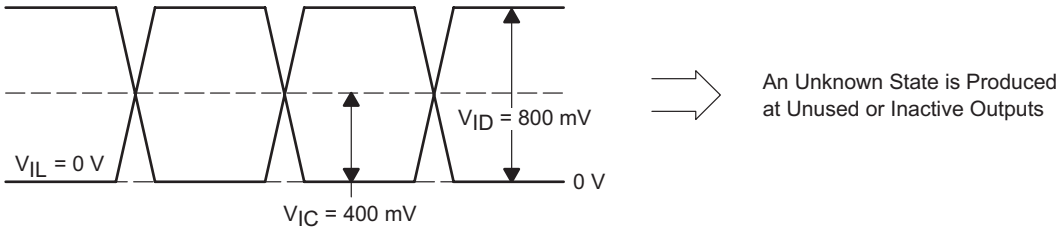


Figure 12. Waveform 4

In most applications, having a common-mode input close to ground and a differential voltage larger than 2 V is not customary. Because the common-mode input voltage is typically around 1.5 V, a 2-V V_{ID} would result in a V_{IL} of 0.5 V, thus satisfying the recommended V_{IL} level of greater than 0.4 V.

Figure 13 plots seven different input threshold curves from a variety of production lots and shows how the fail-safe circuitry behaves with the input common-mode voltage levels. These input threshold curves are representative samples of production devices. The curves specifically illustrate a typical range of input threshold variation. The AM26LV32 is specified with ±200 mV of input sensitivity to account for the variance in input threshold. Each data point represents the input's ability to produce a known state at the output for a given V_{IC} and V_{ID}. Applying a differential voltage at or above a certain point on a curve would produce a known state at the

output. Applying a differential voltage less than a certain point on a curve would activate the fail-safe circuit and the output would be in a high state. For example, inspecting the top input threshold curve reveals that for a V_{IC} that is approximately 1.6 V, V_{ID} yields around 87 mV. Applying 90 mV of differential voltage to this particular production lot generates a known receiver output voltage. Applying a V_{ID} of 80 mV activates the input fail-safe circuitry and the receiver output is placed in the high state. Texas Instruments specifies the input threshold at ±200 mV, because normal process variations affect this parameter. Note that at common-mode input voltages around 0.2 V, the input differential voltages are low compared to their respective data points. This phenomenon points to the fact that the inputs are very sensitive to small differential voltages around 0.2 V V_{IC}. TI recommends that V_{IC} levels be kept greater than 0.5 V to avoid this increased sensitivity at $V_{IC} \approx 0.2$ V. In most applications, because V_{IC} typically is 1.5 V, the fail-safe circuitry functions properly to provide a high state at the receiver output.

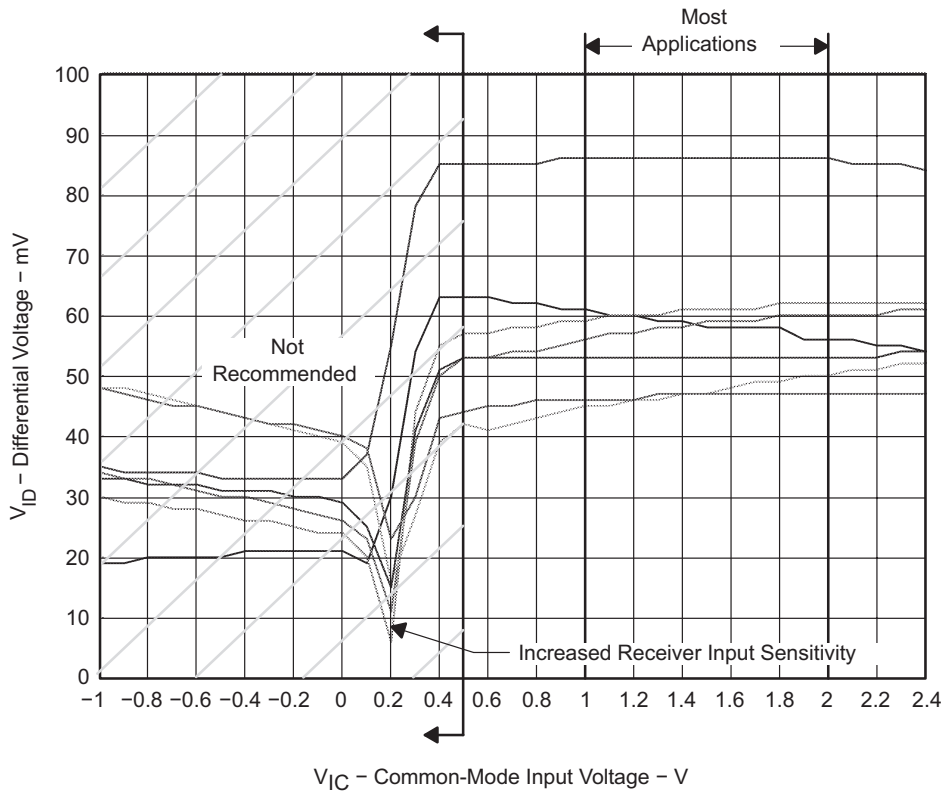


Figure 13. V_{IC} vs V_{ID} Receiver Sensitivity Levels

Figure 14 represents a typical application where two receivers are not used. In this case, there is no need to worry about the output voltages of the unused receivers because these are not connected in the system architecture.

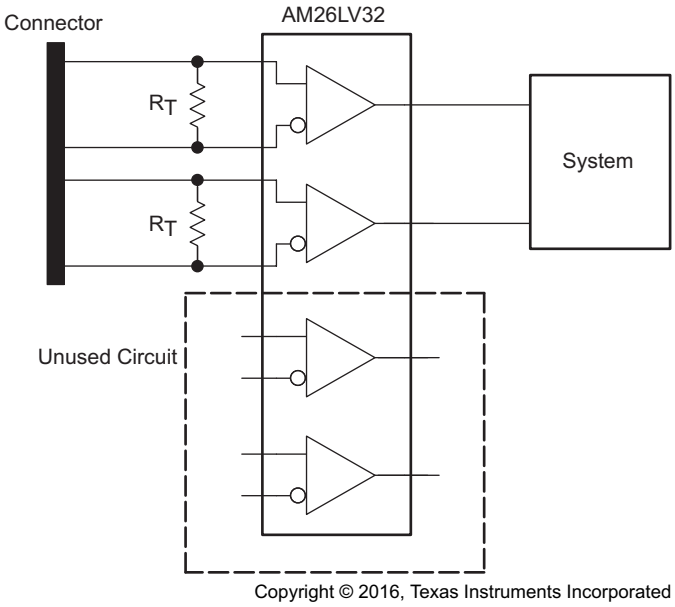


Figure 14. Typical Application With Unused Receivers

Figure 15 shows a common application where one or more drivers are either disabled or powered down. To ensure the inactive receiver outputs are in a high state, the active receiver inputs must have V_{IL} > 0.4 V and V_{IC} > 0.5 V.

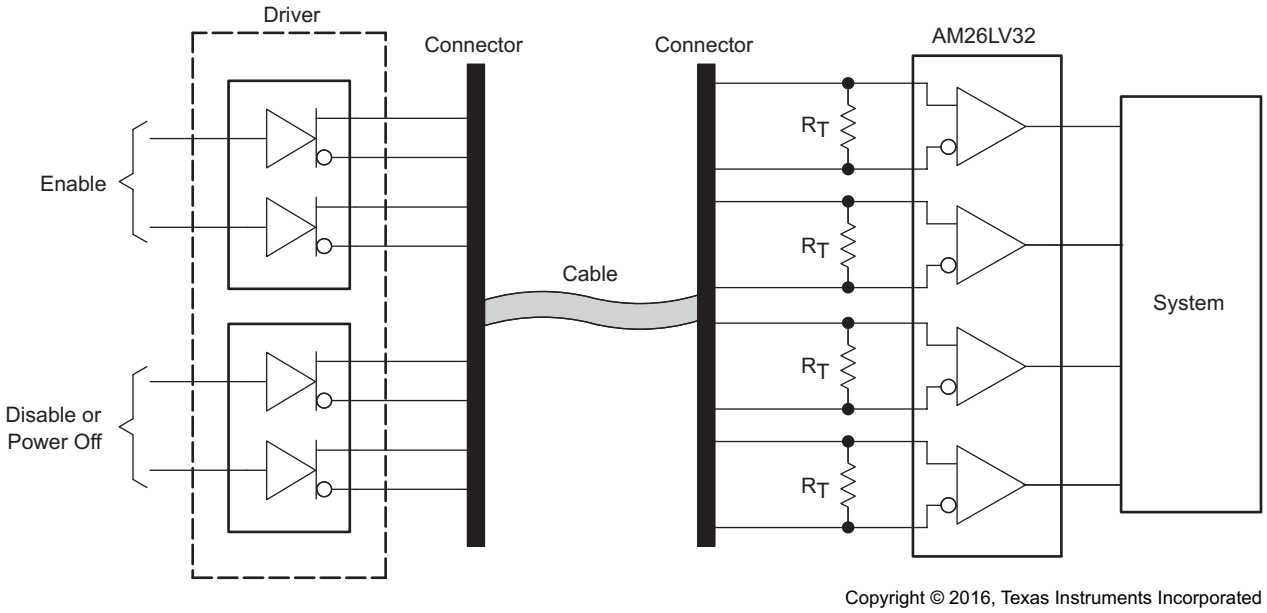


Figure 15. Typical Application Where Two or More Drivers Are Disabled

Figure 16 is an alternative application design to replace the application in Figure 15. This design uses two AM26LV32 devices instead of one. However, this design does not require the input levels be monitored to ensure the outputs are in the correct state, only that they comply to the RS-232 standard.

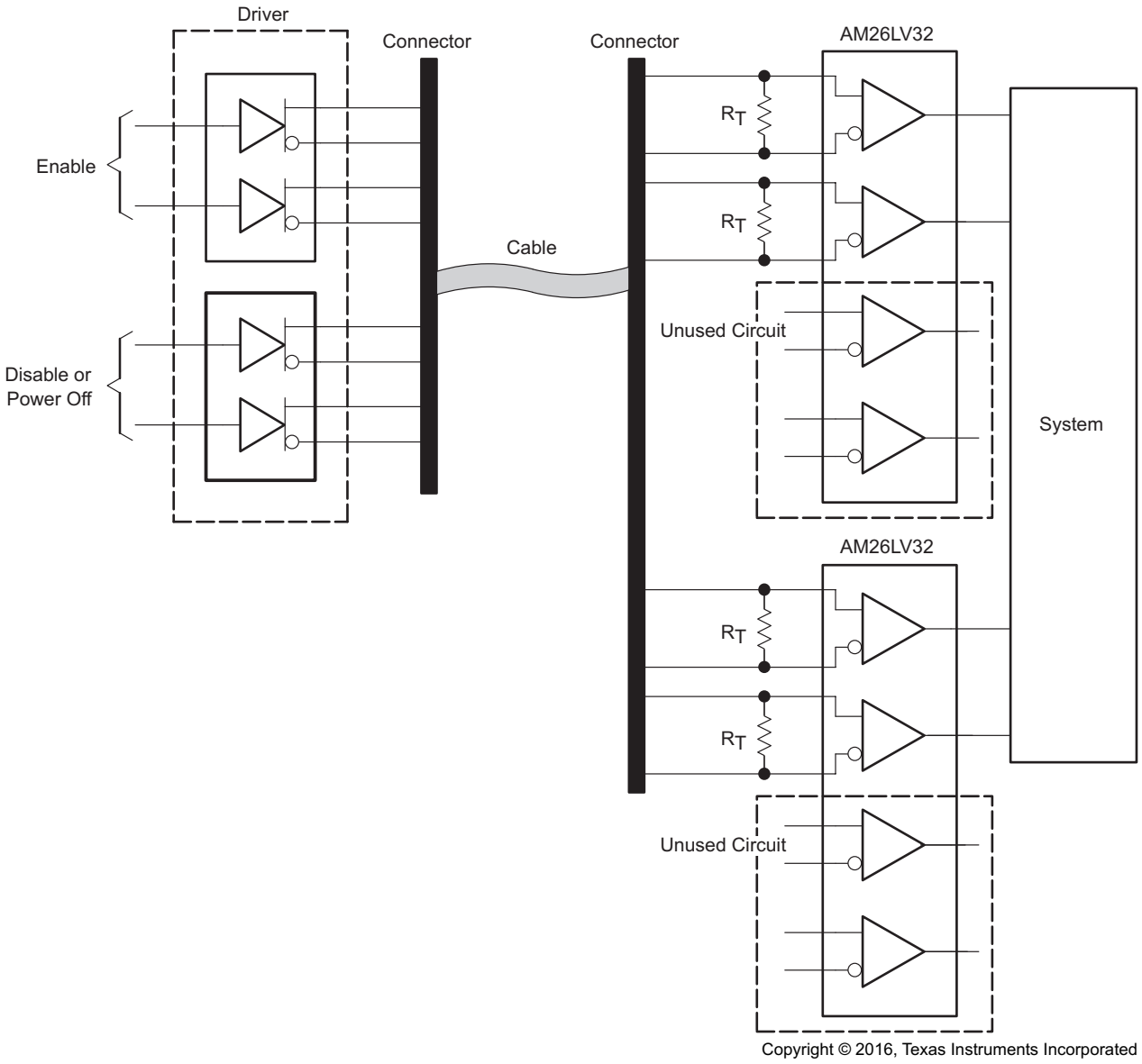


Figure 16. Alternative Solution for Figure 15

Figure 17 and Figure 18 show typical applications where a disconnected cable occurs. Figure 17 illustrates a typical application where a cable is disconnected. Similar to Figure 15, the active input levels must be monitored to make sure the inactive receiver outputs are in a high state. An alternative solution is shown in Figure 18.

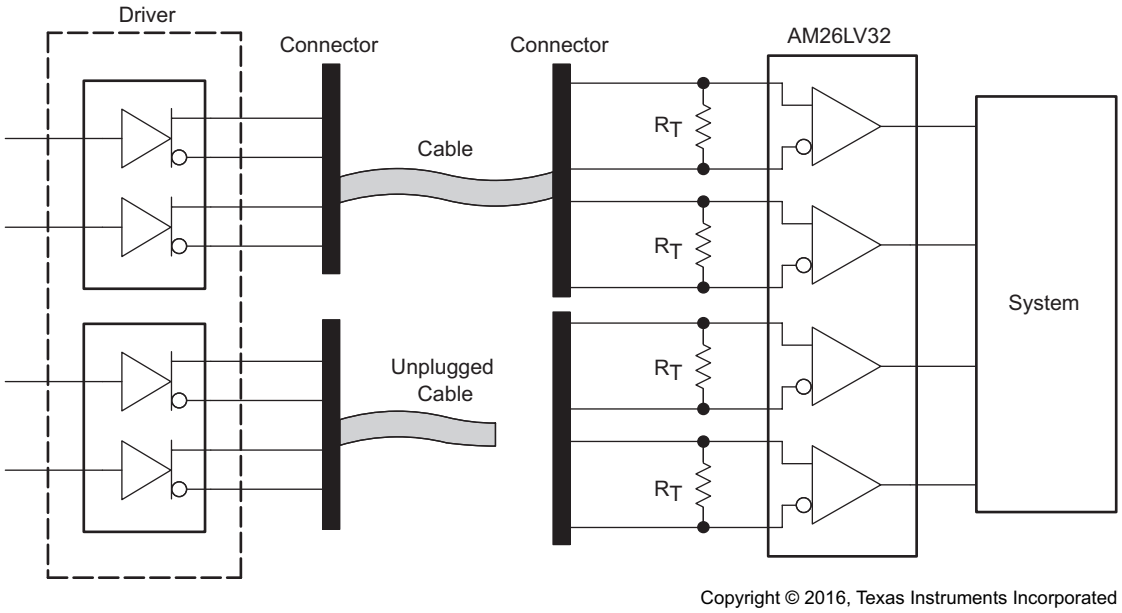


Figure 17. Typical Application Where Two or More Drivers Are Disconnected

Figure 18 is an alternative solution so the receiver inputs do not have to be monitored. This solution also requires the use of two AM26LV32 devices instead of one.

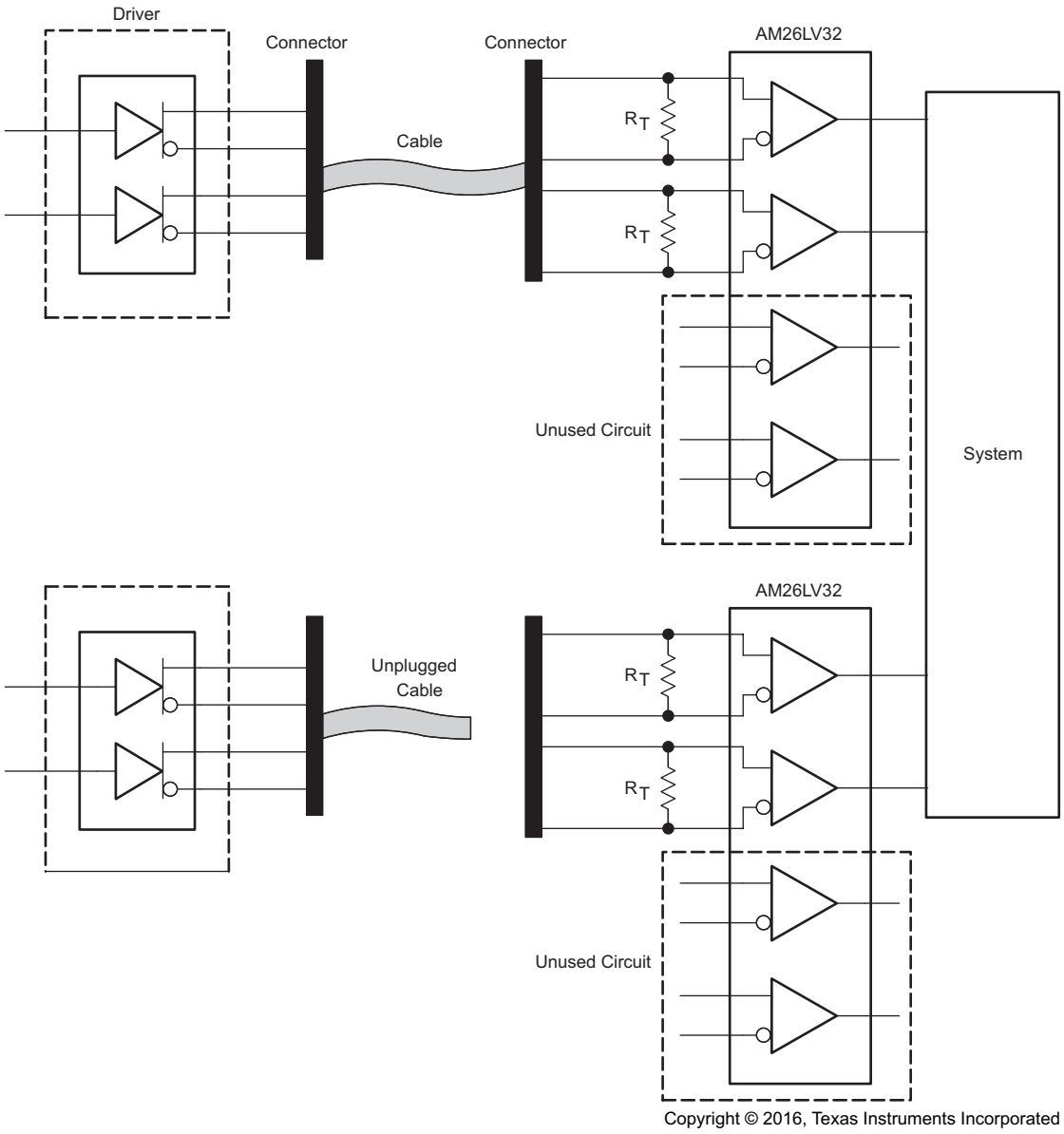


Figure 18. Alternative Solution to Figure 17

When designing a system using the AM26LV32, the device provides a robust solution where fail-safe and fault conditions are of concern. The RS422-like inputs accept common-mode input levels from −0.3 V to 5.5 V with a specified sensitivity of ±200mV. As previously shown, take care with active input levels because this can affect the outputs of unused or inactive bits. However, most applications meet or exceed the requirements to allow the device to perform properly.

9 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

9.1 Application Information

When designing a system that uses drivers, receivers, and transceivers that comply with RS422 or RS485, proper cable termination is essential for highly reliable applications with reduced reflections in the transmission line. Because RS422 allows only one driver on the bus, if termination is used, it is placed only at the end of the cable near the last receiver. In general, RS485 requires termination at both ends of the cable. Factors to consider when determining the type of termination usually are performance requirements of the application and the ever-present factor, cost. The different types of termination techniques include unterminated lines, parallel termination, ac termination, and multipoint termination.

9.2 Typical Application

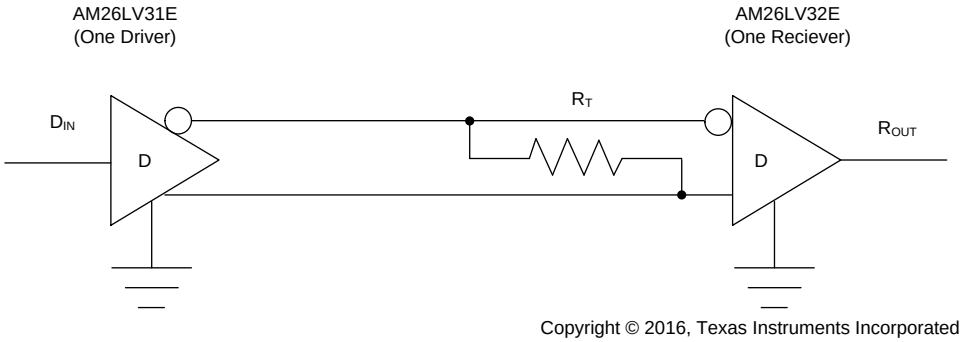


Figure 19. Differential Terminated Configuration

9.2.1 Design Requirements

Resistor and capacitor (if used) termination values vary from system to system. The termination resistor, R_T, must be within 20% of the characteristic impedance, R_{OUT}, of the cable and can vary from about 80 Ω to 120 Ω.

9.2.2 Detailed Design Procedure

Figure 19 shows a configuration with R_T as termination. Although reflections are present at the receiver inputs at a data signaling rate of 200 kbps with no termination, the RS422-compliant receiver reads only the input differential voltage and produces a clean signal at the output.

Typical Application (continued)

9.2.3 Application Curve

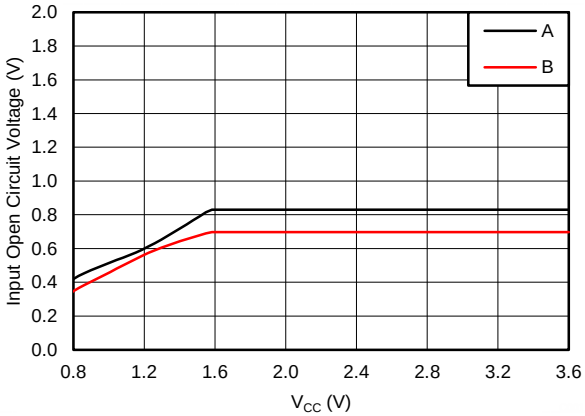


Figure 20. RS422 Port Open-Circuit Voltage vs V_{CC}

10 Power Supply Recommendations

Place 0.1-µF bypass capacitors close to the power-supply pins to reduce errors coupling in from noisy or high-impedance power supplies.

11 Layout

11.1 Layout Guidelines

For best operational performance of the device, use good PCB layout practices including:

- Noise can propagate into analog circuitry through the power pins of the circuit as a whole, as well as the operational amplifier. Bypass capacitors are used to reduce the coupled noise by providing low impedance power sources local to the analog circuitry.
- Connect low-ESR, 0.1-µF ceramic bypass capacitors between each supply pin and ground, placed as close to the device as possible. A single bypass capacitor from V+ to ground is applicable for single-supply applications.
- Separate grounding for analog and digital portions of circuitry is one of the simplest and most-effective methods of noise suppression. One or more layers on multilayer PCBs are usually devoted to ground planes. A ground plane helps distribute heat and reduces EMI noise pickup. Make sure to physically separate digital and analog grounds, and pay attention to the flow of the ground current.
- To reduce parasitic coupling, run the input traces as far away from the supply or output traces as possible. If it is not possible to keep them separate, it is much better to cross the sensitive trace perpendicular as opposed to in parallel with the noisy trace.
- Place the external components as close to the device as possible. Keeping RF and RG close to the inverting input minimizes parasitic capacitance.
- Keep the length of input traces as short as possible. Always remember that the input traces are the most sensitive part of the circuit.
- Consider a driven, low-impedance guard ring around the critical traces. A guard ring can significantly reduce leakage currents from nearby traces that are at different potentials.

11.2 Layout Example

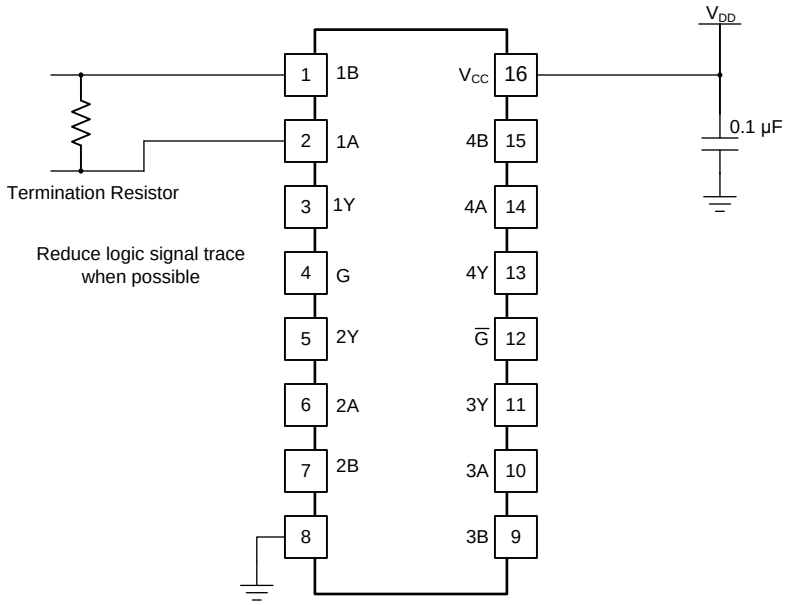


Figure 21. Layout With PCB Recommendations

12 Device and Documentation Support

12.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

12.2 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

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12.3 Trademarks

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12.4 Electrostatic Discharge Caution

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

12.5 Glossary

SLYZ022 — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

13 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

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