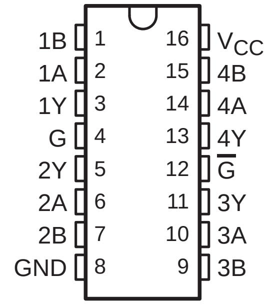
- **Switching Rates up to 32 MHz**
- **Operates from a Single 3.3-V Supply**
- **Ultra-Low Power Dissipation . . . 27 mW Typ**
- **Open-Circuit, Short-Circuit, and Terminated Fail-Safe**
- **–0.3-V to 5.5-V Common-Mode Range With ±200 mV Sensitivity**
- **Accepts 5-V Logic Inputs With a 3.3-V V_{CC}**
- **Input Hysteresis . . . 50 mV Typ**
- **235 mW With Four Receivers at 32 MHz**
- **Pin-to-Pin Compatible With AM26C32, AM26LS32, and MB570**

D OR NS† PACKAGE
(TOP VIEW)



† The NS package is only available left-ended taped and reeled.

description

The AM26LV32, BiCMOS, quadruple, differential line receiver with 3-state outputs is designed to be similar to 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 receiver high input impedance and 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 circuited, the outputs are in the high logic state. This device is designed using the Texas Instruments (TI™) proprietary LinIMPACT-C60™ technology, facilitating ultra-low power consumption without sacrificing speed.

This device offers optimum performance when used with the AM26LV31 quadruple line drivers.

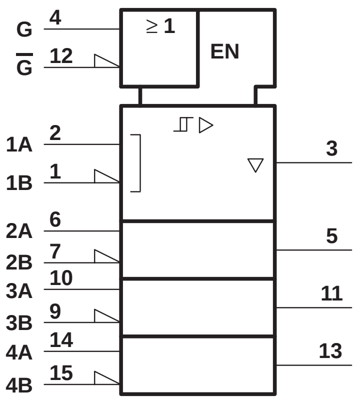
The AM26LV32C is characterized for operation from 0°C to 70°C.

FUNCTION TABLE
(each receiver)

DIFFERENTIAL INPUT	ENABLES G	ENABLES $\overline{G}$	OUTPUT
$V_{ID} \geq 0.2$ 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‡	H	X	H
	X	L	H
X	L	H	Z

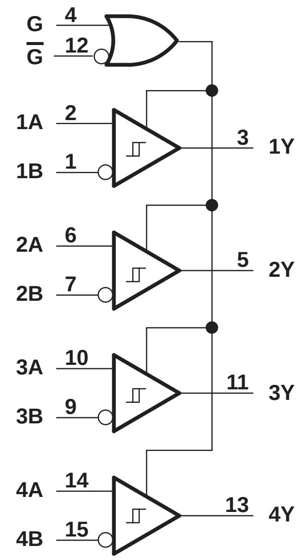
H = high level, L = low level, X = irrelevant,
Z = high impedance (off), ? = indeterminate
‡ See application information attached.

logic symbol†

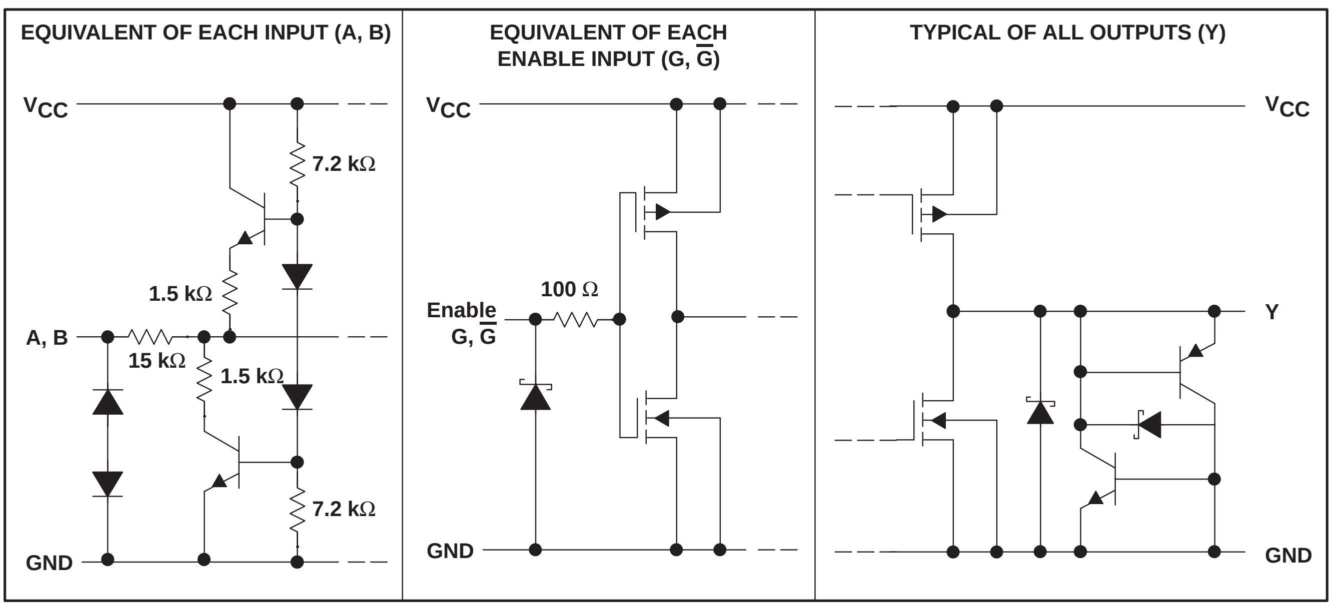


† This symbol is in accordance with ANSI/IEEE Std 91-1984 and IEC Publication 617-12.

logic diagram (positive logic)



schematics of equivalent inputs and outputs



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage range, V_{CC} (see Note 1) . . . . –0.3 V to 6 V
Input voltage range, V_I (A or B inputs) . . . . –4 V to 8 V
Differential input voltage, V_{ID} (see Note 2) . . . . ±12 V
Enable input voltage range . . . . –0.3 V to 6 V
Output voltage range, V_O . . . . –0.3 V to 6 V
Maximum output current, I_O . . . . ±25 mA
Package thermal impedance, θ_{JA} (see Note 3): D package . . . . 73°C/W
NS package . . . . 64°C/W
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds . . . . 260°C
Storage temperature range, T_{stg} . . . . –65°C to 150°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTES: 1. All voltage values are with respect to the GND terminal.
2. Differential input voltage is measured at the noninverting input with respect to the corresponding inverting input.
3. The package thermal impedance is calculated in accordance with JESD 51.

recommended operating conditions

		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	
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

electrical characteristics over recommended supply-voltage and operating free-air temperature ranges (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP†	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_{OL} = 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‡	One channel			150		pF

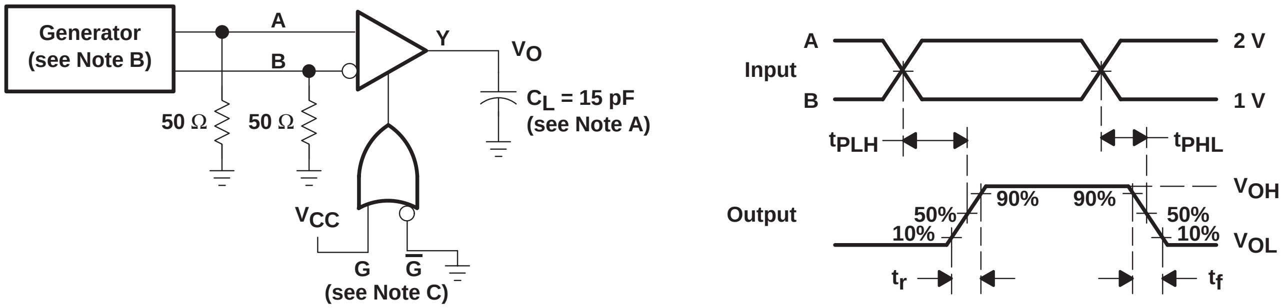
† All typical values are at V_{CC} = 3.3 V and T_A = 25°C.
‡ C_{pd} determines the no-load dynamic current: $I_S = C_{pd} \times V_{CC} \times f + I_{CC}$.

switching characteristics, V_{CC} = 3.3 V, T_A = 25°C

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

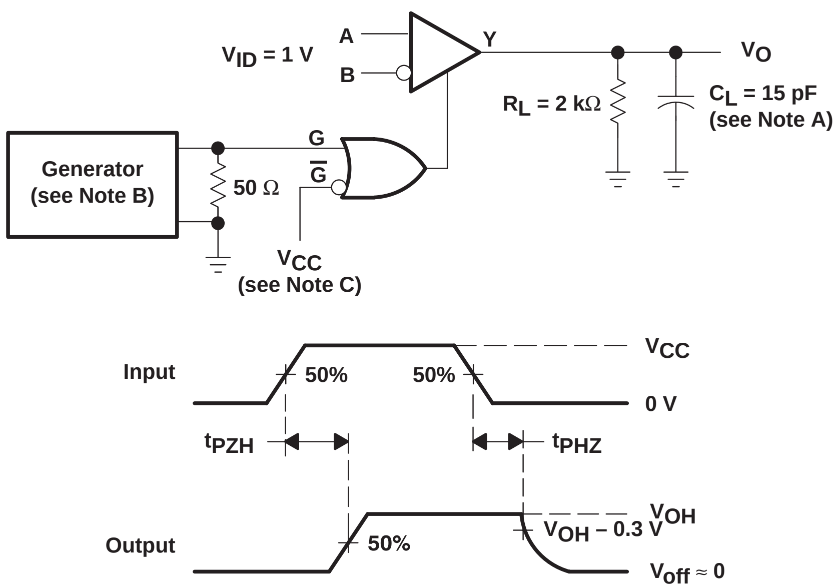
§ $t_{sk(p)}$ is $|t_{PLH} - t_{PHL}|$ of each channel of the same device.
¶ $t_{sk(o)}$ is the maximum difference in propagation delay times between any two channels of the same device switching in the same direction.
# $t_{sk(pp)}$ is the maximum difference in propagation delay times between any two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

PARAMETER MEASUREMENT INFORMATION



NOTES: 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 $\overline{G}$.

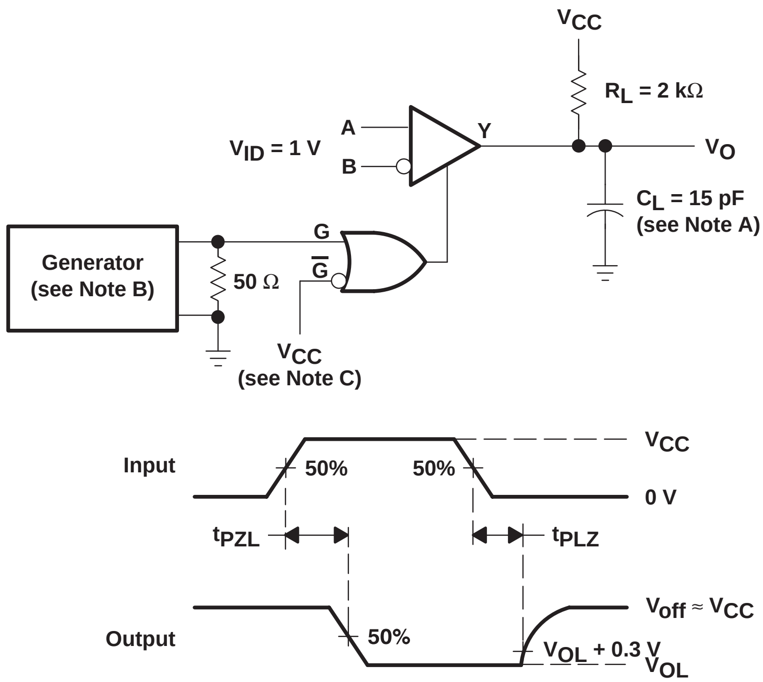
Figure 1. t_{PLH} and t_{PHL} Test Circuit and Voltage Waveforms



NOTES: 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 2. t_{PZH} and t_{PHZ} Test Circuit and Voltage Waveforms

PARAMETER MEASUREMENT INFORMATION



NOTES: 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 3. t_{PZL} and t_{PLZ} Test Circuit and Voltage Waveforms

APPLICATION INFORMATION

fail-safe conditions

The AM26LV32 quadruple differential line receiver 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 don't 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 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-ohm terminated fail-safe – Disconnected cables, drivers in high-impedance state, or powered-down drivers will not cause the AM26LV32 to malfunction. The outputs will 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 will induce the noise as a common-mode signal and will be rejected.
3. Shorted fail-safe – Fault conditions that short the differential input pairs together will not cause incorrect data at the outputs. A differential voltage (V_{ID}) of 0 V will force 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 will function properly when an input is shorted, but with no external common-mode voltage applied.

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. In order 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, it is recommended that for 1, 2, or 3 active receiver inputs, the low-level input voltage (V_{IL}) should 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 1 and Figures 4 through 7 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.

APPLICATION INFORMATION

Table 1. 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	4	Known state	High state
–100 mV	200 mV	0 V	5	Known state	?
600 mV	800 mV	1 V	6	Known state	High state
0	800 mV	400 mV	7	Known state	?

† Measured with respect to ground.

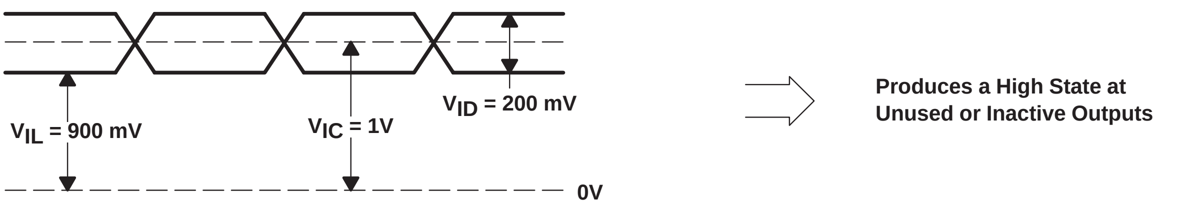


Figure 4. Waveform One

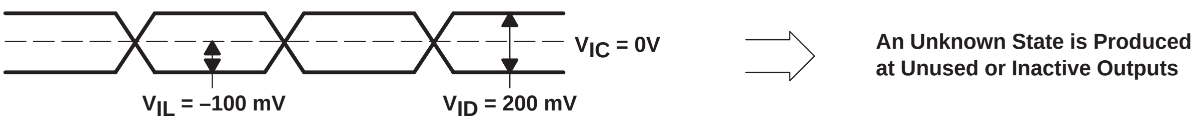


Figure 5. Waveform Two

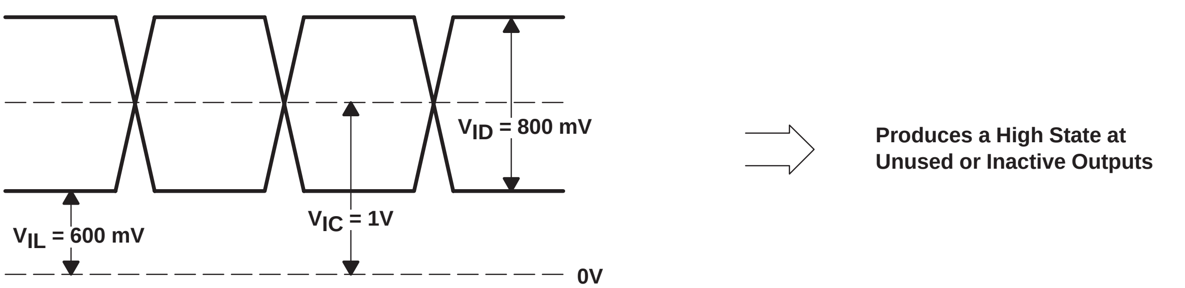


Figure 6. Waveform Three

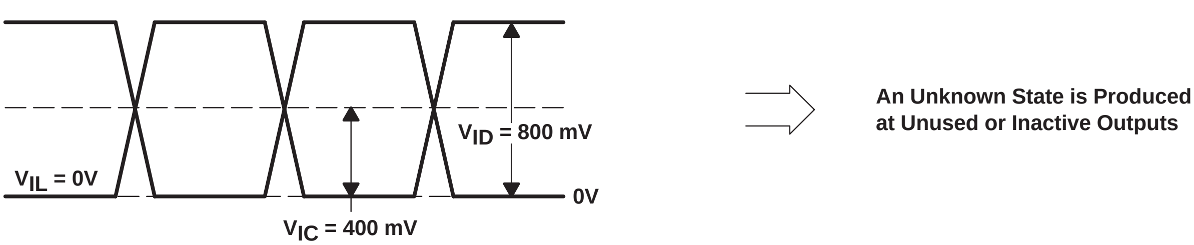


Figure 7. Waveform Four

APPLICATION INFORMATION

In most applications, it is not customary to have a common-mode input close to ground and to have a differential voltage larger than 2 V. Since 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 8 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} = 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, since 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}. It is recommended that V_{IC} levels be kept greater than 0.5 V to avoid this increased sensitivity at V_{IC} ≈ 0.2 V. In most applications, since V_{IC} typically is 1.5 V, the fail-safe circuitry functions properly to provide a high state at the receiver output.

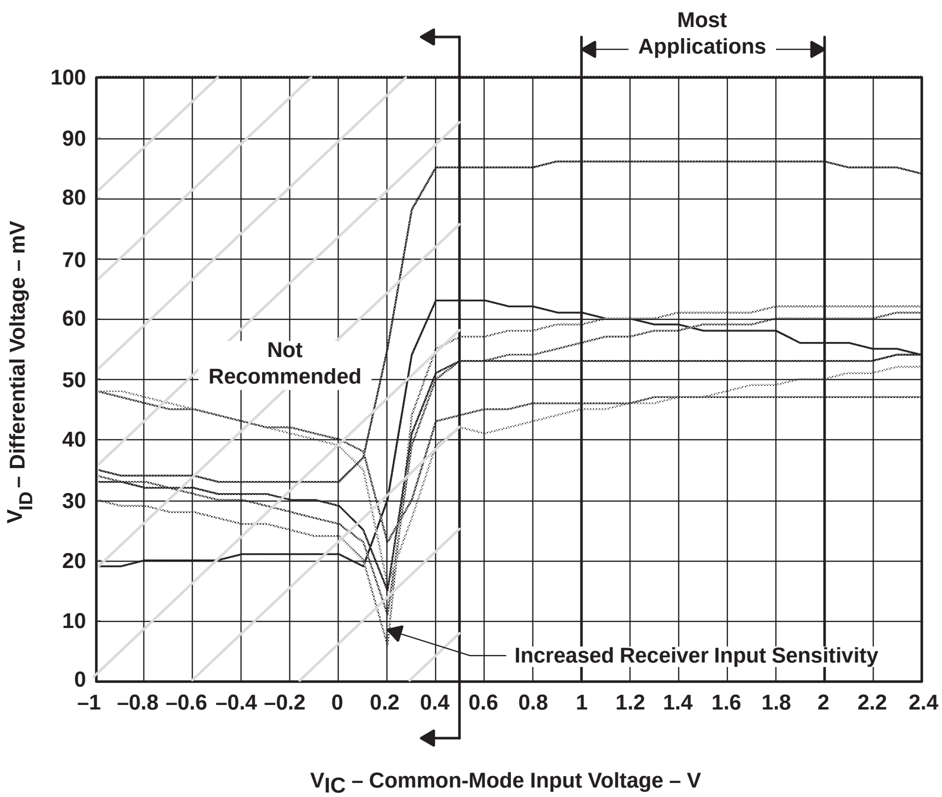


Figure 8. V_{IC} Versus V_{ID} Receiver Sensitivity Levels

APPLICATION INFORMATION

Figure 9 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 since they are not connected in the system architecture.

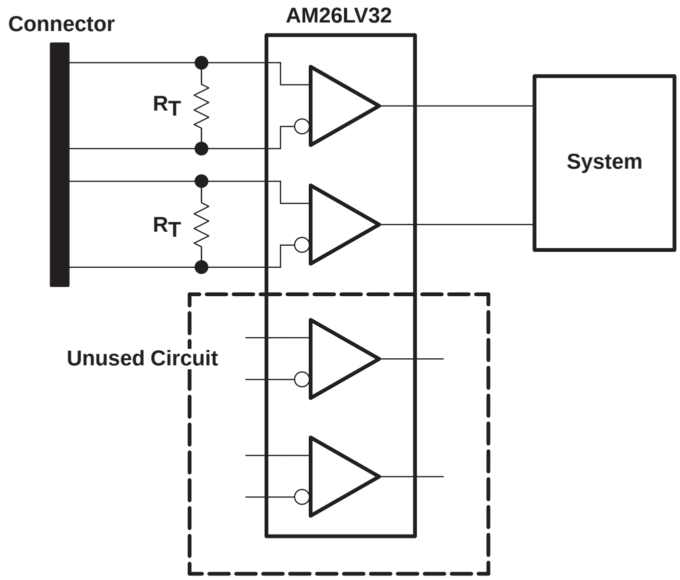


Figure 9. Typical Application with Unused Receivers

Figure 10 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.

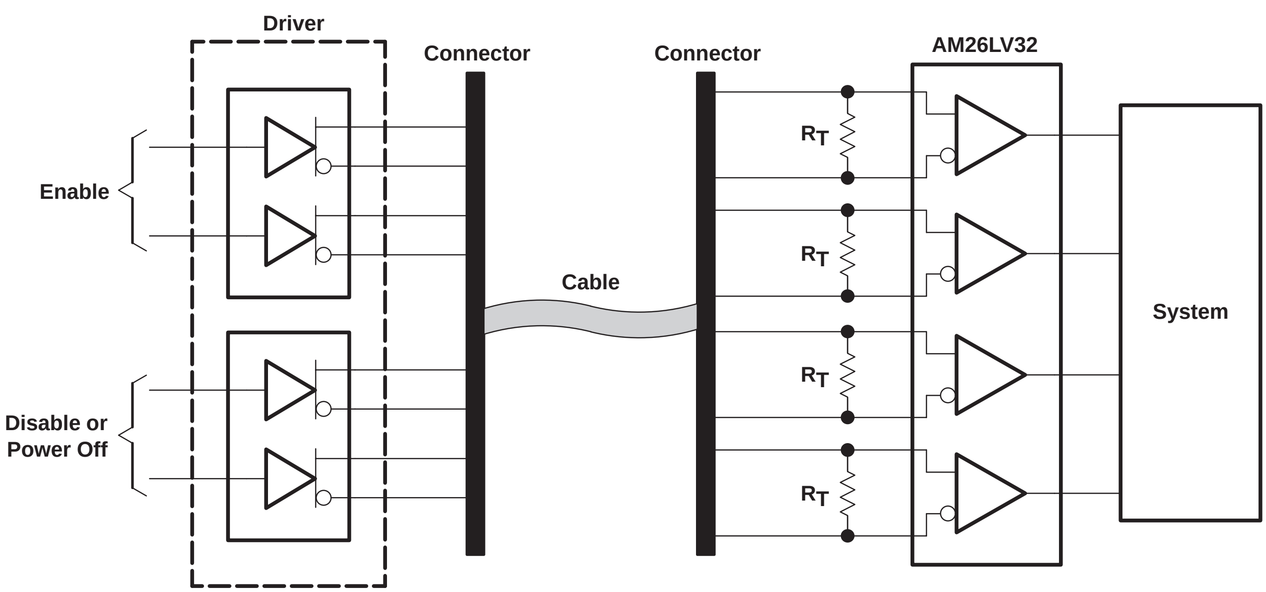


Figure 10. Typical Application Where Two or More Drivers are Disabled

APPLICATION INFORMATION

Figure 11 is an alternative application design to replace the application in Figure 10. 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.

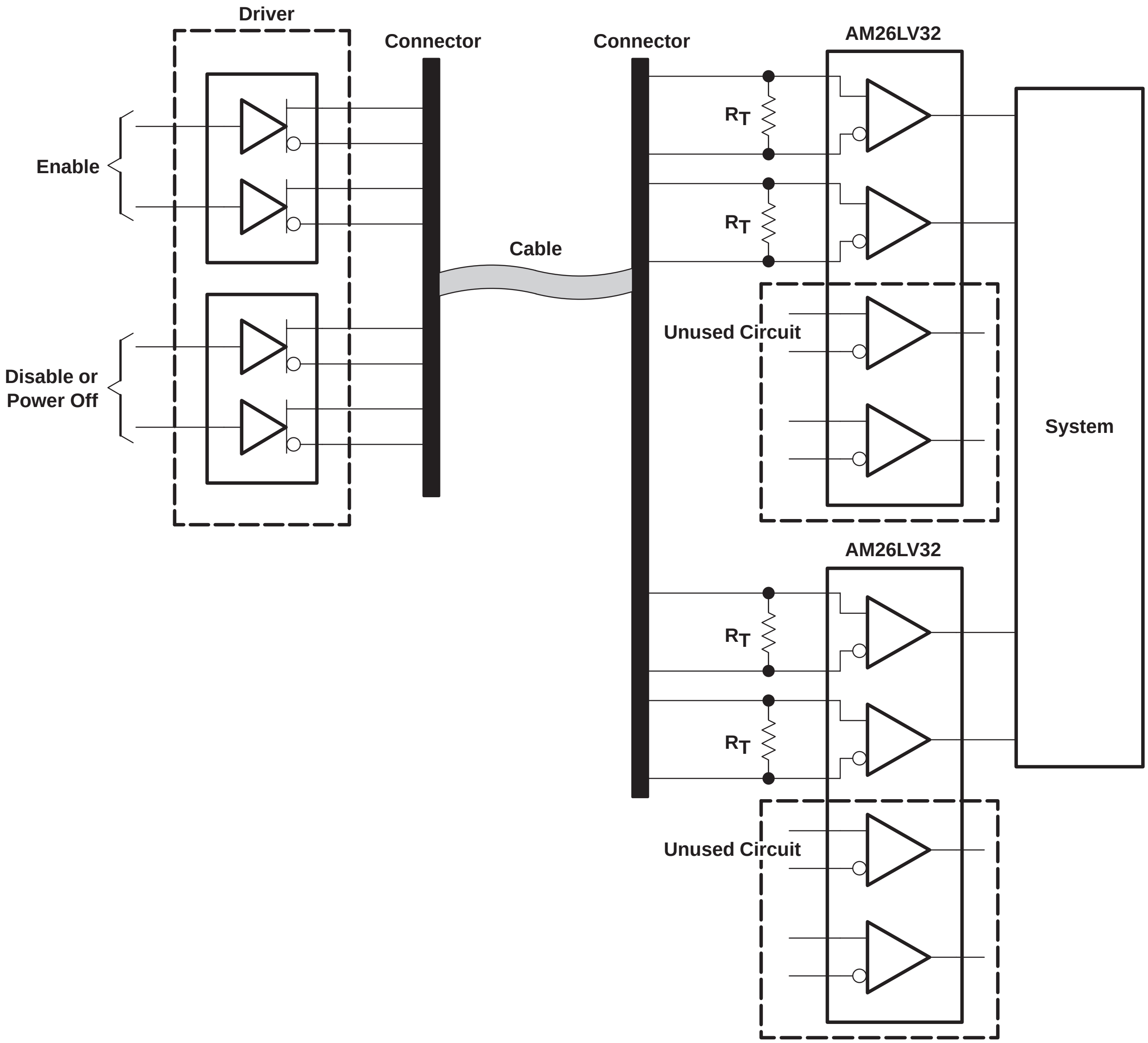


Figure 11. Alternative Solution for Figure 10

APPLICATION INFORMATION

Figures 12 and 13 show typical applications where a disconnected cable occurs. Figure 12 illustrates a typical application where a cable is disconnected. Similar to Figure 10, 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 13.

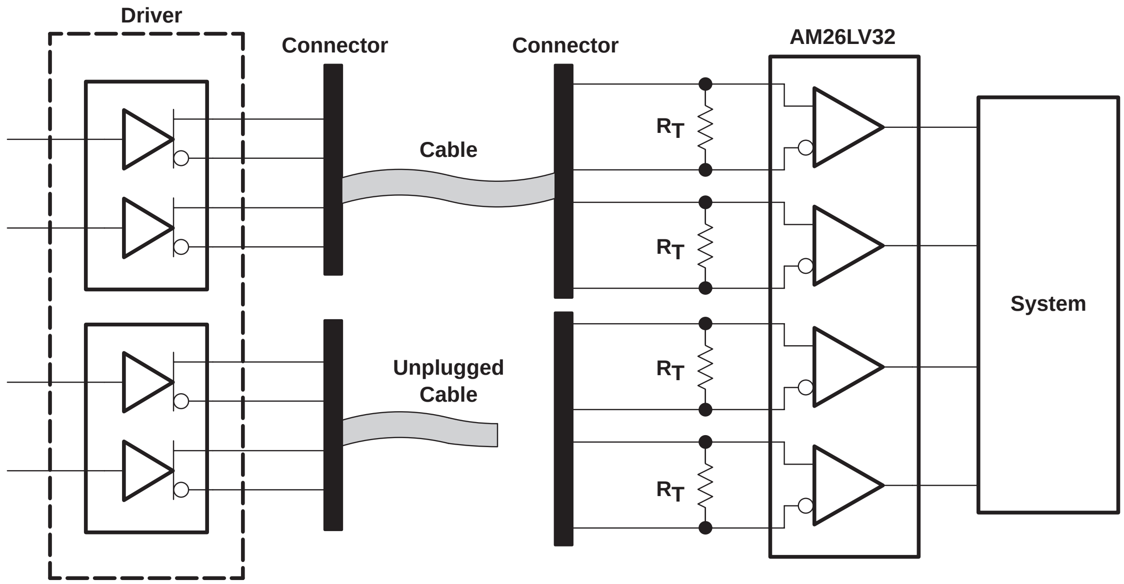


Figure 12. Typical Application Where Two or More Drivers are Disconnected

APPLICATION INFORMATION

Figure 13 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.

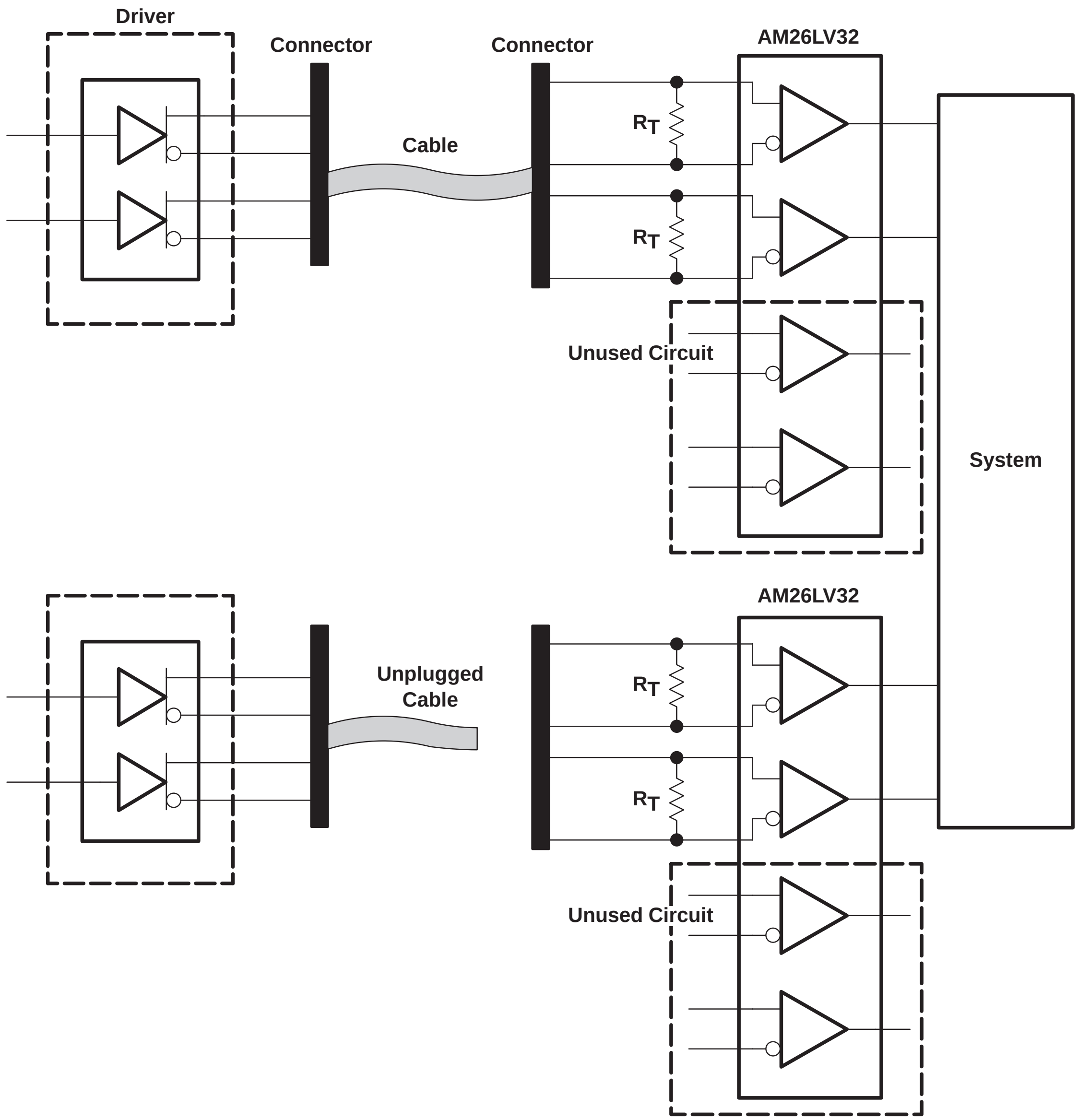


Figure 13. Alternative Solution to Figure 12

APPLICATION INFORMATION

When designing a system using the AM26LV32, the device provides a robust solution where fail-safe and fault conditions are of concern. The RS-422-like inputs accept common-mode input levels from –0.3 V to 5.5 V with a specified sensitivity of ±200mV. As previously shown, care must be taken with active input levels since they can affect the outputs of unused or inactive bits. However, most applications meet or exceed the requirements to allow the device to perform properly.