



CAN TRANSCEIVER

FEATURES

- Drop-In Improved Replacement for the PCA82C250 and PCA82C251
- Bus-Fault Protection of ± 36 V
- Meets or Exceeds ISO 11898
- Signaling Rates⁽¹⁾ up to 1 Mbps
- High Input Impedance Allows up to 120 SN65HVD251 Nodes on a Bus
- Bus Pin ESD Protection Exceeds 14 kV HBM
- Unpowered Node Does Not Disturb the Bus
- Low Current Standby Mode . . . 200 μ A Typical
- Thermal Shutdown Protection

- Glitch-Free Power-Up and Power-Down Bus Protection For Hot-Plugging
- DeviceNet Vendor ID # 806

APPLICATIONS

- CAN Data Buses
- Industrial Automation
 - DeviceNet™ Data Buses
 - Smart Distributed Systems (SDS™)
- SAE J1939 Standard Data Bus Interface
- NMEA 2000 Standard Data Bus Interface
- ISO 11783 Standard Data Bus Interface

DESCRIPTION

The SN65HVD251 is intended for use in applications employing the Controller Area Network (CAN) serial communication physical layer in accordance with the ISO 11898 Standard. The SN65HVD251 provides differential transmit capability to the bus and differential receive capability to a CAN controller at speeds up to 1 megabits per second (Mbps).

Designed for operation in harsh environments, the device features cross-wire, over-voltage and loss of ground protection to ± 36 V. Also featured are over-temperature protection as well as -7 V to 12 V common-mode range, and tolerance to transients of ± 200 V. The transceiver interfaces the single-ended CAN controller with the differential CAN bus found in industrial, building automation, and automotive applications.

Rs, pin 8, provides for three different modes of operation: high-speed, slope control, or low-power mode. The high-speed mode of operation is selected by connecting pin 8 to ground, allowing the transmitter output transistors to switch as fast as possible with no limitation on the rise and fall slope. The rise and fall slope can be adjusted by connecting a resistor to ground at pin 8; the slope is proportional to the pin's output current. Slope control with an external resistor value of 10 k Ω gives ~ 15 V/us slew rate; 100 k Ω gives ~ 2 V/us slew rate.

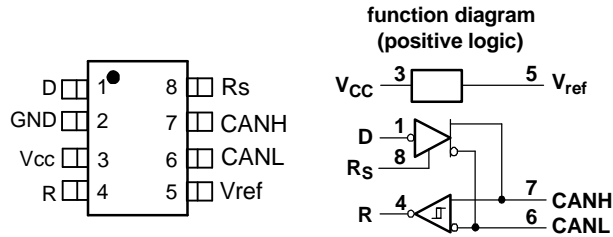
If a high logic level is applied to the Rs pin 8, the device enters a low-current standby mode during which the driver is switched off and the receiver remains active. The local protocol controller reverses this low-current standby mode when it needs to transmit to the bus.

The SN65HVD251 may be used in CAN, DeviceNet™ or SDS™ applications with the Texas Instruments' TMS320F241 and TMS320F243 DSPs with CAN 2.0B controllers.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

DeviceNet is a trademark of Allen-Bradley.
SDS is a trademark of Honeywell.

**(1) ORDERING INFORMATION**

PART NUMBER	PACKAGE	MARKED AS
SN65HVD251D	8-pin SOIC (Tube)	VP251
SN65HVD251DR	8-pin SOIC (Tape & Reel)	VP251
SN65HVD251P	8-pin DIP	65HVD251

(1) ⁽¹⁾The signaling rate of a line is the number of voltage transitions that are made per second expressed in the units bps (bits per second).

ABSOLUTE MAXIMUM RATINGS^{(1), (2)}

			SN65HVD251
Supply voltage range, V_{CC}			-0.3 V to 7V
Voltage range at any bus terminal (CANH or CANL)			-36 V to 36 V
Transient voltage per ISO 7637, pulse 1, 2, 3a, 3b			CANH, CANL ± 200 V
Input voltage range, V_I (D, Rs, or R)			-0.3 V to $V_{CC} + 0.5$
Electrostatic discharge	Human Body Model ⁽³⁾	CANH, CANL and GND	14 kV
		All pins	6 kV
	Charged-Device Model ⁽⁴⁾	All pins	1 kV
Continuous total power dissipation			(see Dissipation Rating Table)
Storage temperature range, T_{stg}			-65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds			260°C

- (1) 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.
- (2) All voltage values, except differential I/O bus voltages, are with respect to network ground terminal.
- (3) Tested in accordance with JEDEC Standard 22, Test Method A114-A.
- (4) Tested in accordance with JEDEC Standard 22, Test Method C101.

ABSOLUTE MAXIMUM POWER DISSIPATION RATINGS

PACKAGE	CIRCUIT BOARD MODEL	$T_A = 25^\circ\text{C}$ POWER RATING	DERATING FACTOR ⁽¹⁾ ABOVE $T_A = 25^\circ\text{C}$	$T_A = 85^\circ\text{C}$ POWER RATING	$T_A = 125^\circ\text{C}$ POWER RATING
SOIC (D)	Low-K ⁽²⁾	600 mW	4.4 mW/°C	312 mW	120 mW
	High-K ⁽³⁾	963 mW	7.7 mW/°C	501 mW	193 mW
PDIP (P)	Low-K ⁽²⁾	984 mW	7.8 mW/°C	512 mW	197 mW
	High-K ⁽³⁾	1344 mW	10.8 mW/°C	699 mW	269 mW

- (1) This is the inverse of the junction-to-ambient thermal resistance when board-mounted and with no air flow.
- (2) In accordance with the Low-K thermal metric definitions of EIA/JESD51-3.
- (3) In accordance with the High-K thermal metric definitions of EIA/JESD51-7.

THERMAL CHARACTERISTICS

PARAMETER	TEST CONDITIONS	VALUE			UNITS
		MIN	TYP	MAX	
Θ_{JB} Junction-to-board thermal resistance	D		78.7		°C/W
	P		56.5		

THERMAL CHARACTERISTICS (continued)

PARAMETER	TEST CONDITIONS	VALUE			UNITS
		MIN	TYP	MAX	
Θ_{JC} Junction-to-board thermal resistance	D		44.6		°C/W
	P		54.5		
P_D Device power dissipation	$V_{CC} = 5\text{ V}$, $T_j = 27\text{ °C}$, $R_L = 60\Omega$, R_S at 0 V, Input to D a 500-kHz 50% duty cycle square wave			97.7	mW
	$V_{CC} = 5.5\text{ V}$, $T_j = 130\text{ °C}$, $R_L = 60\Omega$, R_S at 0 V, Input to D a 500-kHz 50% duty cycle square wave			142	mW
T_{SD} Thermal shutdown junction temperature			165		°C

RECOMMENDED OPERATING CONDITIONS

over recommended operating conditions (unless otherwise noted).

PARAMETER		MIN	NOM	MAX	UNIT
Supply voltage, V_{CC}		4.5		5.5	V
Voltage at any bus terminal (separately or common mode) V_I or V_{IC}		-7 ⁽¹⁾		12	V
High-level input voltage, V_{IH}	D input	0.7 V_{CC}			V
Low-level input voltage, V_{IL}	D input			0.3 V_{CC}	V
Differential input voltage, V_{ID}		-6		6	V
Input voltage to R_S , $V_{I(R_S)}$		0		V_{CC}	V
Input voltage at R_S for standby, $V_{I(R_S)}$		0.75 V_{CC}		V_{CC}	V
R_S wave-shaping resistance		0		100	k Ω
High-level output current, I_{OH}	Driver	-50			mA
	Receiver	-4			
Low-level output current, I_{OL}	Driver			50	mA
	Receiver			4	
Operating free-air temperature, T_A		-40		125	°C
Junction temperature, T_j	PDIP Package			145	°C
	SOIC Package			150	

(1) The algebraic convention, in which the least positive (most negative) limit is designated as minimum is used in this data sheet.

DRIVER ELECTRICAL CHARACTERISTICS

over recommended operating conditions (unless otherwise noted).

PARAMETER	TEST CONDITIONS	MIN	TYP ⁽¹⁾	MAX	UNIT	
$V_{O(D)}$ Bus output voltage (Dominant)	CANH	Figure 1 & Figure 2 , D at 0 V R_S at 0 V	2.75	3.5	4.5	V
	CANL		0.5		2	
$V_{O(R)}$ Bus output voltage (Recessive)	CANH	Figure 1 & Figure 2 , D at 0.7 V_{CC} , R_S at 0 V	2	2.5	3	V
	CANL		2	2.5	3	
$V_{OD(D)}$ Differential output voltage (Dominant)	Figure 1 , D at 0 V, R_S at 0 V	1.5	2	3	V	
$V_{OD(D)}$ Differential output voltage (Dominant)	Figure 2 & Figure 3 , D at 0 V, R_S at 0 V	1.2	2	3.1	V	
$V_{OD(R)}$ Differential output voltage (Recessive)	Figure 1 & Figure 2 , D at 0.7 V_{CC}	-120		12	mV	
$V_{OD(R)}$ Differential output voltage (Recessive)	D at 0.7 V_{CC} , no load	-0.5		0.05	V	
$V_{OC(pp)}$ Peak-to-peak common-mode output voltage	Figure 9, R_S at 0 V		600		mV	
I_{IH} High-level input current, D Input	D at 0.7 V_{CC}	-40		0	μ A	
I_{IL} Low-level input current, D Input	D at 0.3 V_{CC}	-60		0	μ A	

(1) All typical values are at 25°C and with a 5-V supply.

DRIVER ELECTRICAL CHARACTERISTICS (continued)

over recommended operating conditions (unless otherwise noted).

PARAMETER		TEST CONDITIONS	MIN	TYP ⁽¹⁾	MAX	UNIT	
$I_{OS(SS)}$	Short-circuit steady-state output current	Figure 11, V_{CANH} at -7 V, CANL Open	-200			mA	
		Figure 11, V_{CANH} at 12 V, CANL Open			2.5		
		Figure 11, V_{CANL} at -7 V, CANH Open	-2				
		Figure 11, V_{CANL} at 12 V, CANH Open			200		
C_O	Output capacitance	See receiver input capacitance					
I_{OZ}	High-impedance output current	See receiver input current					
$I_{IRs(s)}$	R_s input current for standby	R_s at $0.75 V_{CC}$	-10			μA	
$I_{IRs(f)}$	R_s input current for full speed operation	R_s at 0 V	-550		0	μA	
I_{CC}	Supply current	Standby			275	μA	
		Dominant	D at 0 V, 60Ω load, R_s at 0 V			65	mA
		Recessive	D at V_{CC} , no load, R_s at 0 V			14	

DRIVER SWITCHING CHARACTERISTICS

over recommended operating conditions (unless otherwise noted).

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{pLH}	Propagation delay time, low-to-high-level output	Figure 4, R_s at 0 V		40	70	ns
		Figure 4, R_s with 10 k Ω to ground		90	125	
		Figure 4, R_s with 100 k Ω to ground		500	800	
t_{pHL}	Propagation delay time, high-to-low-level output	Figure 4, R_s at 0 V		85	125	
		Figure 4, R_s with 10 k Ω to ground		200	260	
		Figure 4, R_s with 100 k Ω to ground		1150	1450	
$t_{sk(p)}$	Pulse skew ($ t_{pHL} - t_{pLH} $)	Figure 4, R_s at 0 V		45	85	
		Figure 4, R_s with 10 k Ω to ground		110	180	
		Figure 4, R_s with 100 k Ω to ground		650	900	
t_r	Differential output signal rise time	Figure 4, R_s at 0 V	35		100	
t_f	Differential output signal fall time		35		100	
t_r	Differential output signal rise time	Figure 4, R_s with 10 k Ω to ground	100		250	
t_f	Differential output signal fall time		100		250	
t_r	Differential output signal rise time	Figure 4, R_s with 100 k Ω to ground	600		1550	
t_f	Differential output signal fall time		600		1550	
t_{en}	Enable time from standby to dominant	Figure 8			0.5	μs

RECEIVER ELECTRICAL CHARACTERISTICS

over recommended operating conditions (unless otherwise noted).

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{IT+}	Positive-going input threshold voltage	R_s at 0 V, (See Table 1)		750	900	mV
V_{IT-}	Negative-going input threshold voltage		500	650		
V_{hys}	Hysteresis voltage ($V_{IT+} - V_{IT-}$)		100			
V_{OH}	High-level output voltage	Figure 6, $I_O = -4mA$	0.8 V_{CC}			V
V_{OL}	Low-level output voltage	Figure 6, $I_O = 4mA$		0.2 V_{CC}		V

RECEIVER ELECTRICAL CHARACTERISTICS (continued)

over recommended operating conditions (unless otherwise noted).

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_I	Bus input current	CANH or CANL at 12 V			600	μA
		CANH or CANL at 12 V, V_{CC} at 0 V	Other bus pin at 0 V, R_s at 0 V, D at $0.7 V_{CC}$		715	
		CANH or CANL at -7 V		-460		
		CANH or CANL at -7 V, V_{CC} at 0 V		-340		
C_I	Input capacitance, (CANH or CANL)	Pin-to-ground, $V_I = 0.4 \sin(4E6\pi t) + 0.5 \text{ V}$, D at $0.7 V_{CC}$			20	pF
C_{ID}	Differential input capacitance	Pin-to-pin, $V_I = 0.4 \sin(4E6\pi t) + 0.5 \text{ V}$, D at $0.7 V_{CC}$		10	pF	
R_{ID}	Differential input resistance	D at $0.7 V_{CC}$, R_s at 0 V	40		100	$\text{k}\Omega$
R_{IN}	Input resistance, (CANH or CANL)	D at $0.7 V_{CC}$, R_s at 0 V	20		50	$\text{k}\Omega$
I_{CC}	Supply current	Standby	R_s at V_{CC} , D at V_{CC}		275	μA
		Dominant	D at 0 V, 60Ω Load, R_s at 0 V		65	mA
		Recessive	D at V_{CC} , No Load, R_s at 0 V		14	

RECEIVER SWITCHING CHARACTERISTICS

over recommended operating conditions (unless otherwise noted).

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{pLH}	Propagation delay time, low-to-high-level output	Figure 6		35	50	ns
t_{pHL}	Propagation delay time, high-to-low-level output			35	50	
$t_{sk(p)}$	Pulse skew ($t_{pHL} - t_{pLH}$)				20	
t_r	Output signal rise time			2	4	
t_f	Output signal fall time			2	4	
$t_{p(sb)}$	Propagation delay time in standby	Figure 12, R_s at V_{CC}			500	

VREF-PIN CHARACTERISTICS

over recommended operating conditions (unless otherwise noted).

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_O	Reference output voltage	$-5 \mu\text{A} < I_O < 5 \mu\text{A}$	$0.45 V_{CC}$		$0.55 V_{CC}$	V
		$-50 \mu\text{A} < I_O < 50 \mu\text{A}$	$0.4 V_{CC}$		$0.6 V_{CC}$	

DEVICE SWITCHING CHARACTERISTICS

over recommended operating conditions (unless otherwise noted).

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{loop1}	Figure 10, R_s at 0 V		60	100	ns
	Figure 10, R_s with 10 k Ω to ground		100	150	
	Figure 10, R_s with 100 k Ω to ground		440	800	
t_{loop2}	Figure 10, R_s at 0 V		115	150	ns
	Figure 10, R_s with 10 k Ω to ground		235	290	
	Figure 10, R_s with 100 k Ω to ground		1070	1450	
t_{loop2}	Figure 10, R_s at 0 V, V_{CC} from 4.5 V to 5.1 V,		105	145	ns

PARAMETER MEASUREMENT INFORMATION

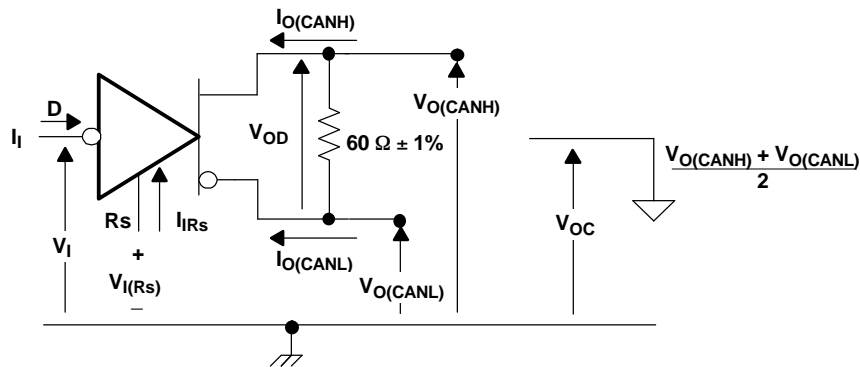


Figure 1. Driver Voltage, Current, and Test Definition

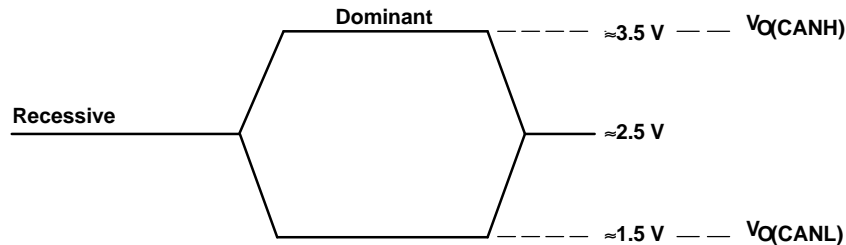


Figure 2. Bus Logic State Voltage Definitions

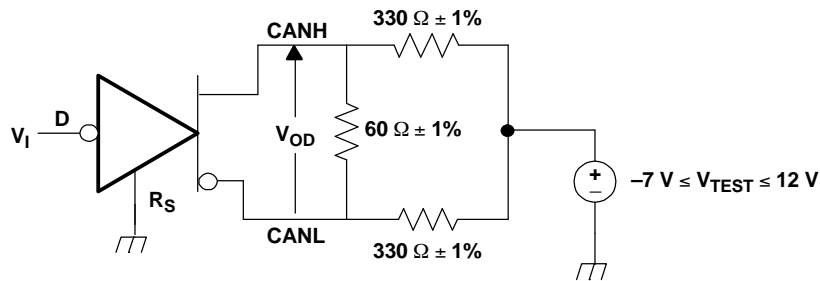


Figure 3. Driver V_{OD}

PARAMETER MEASUREMENT INFORMATION (continued)

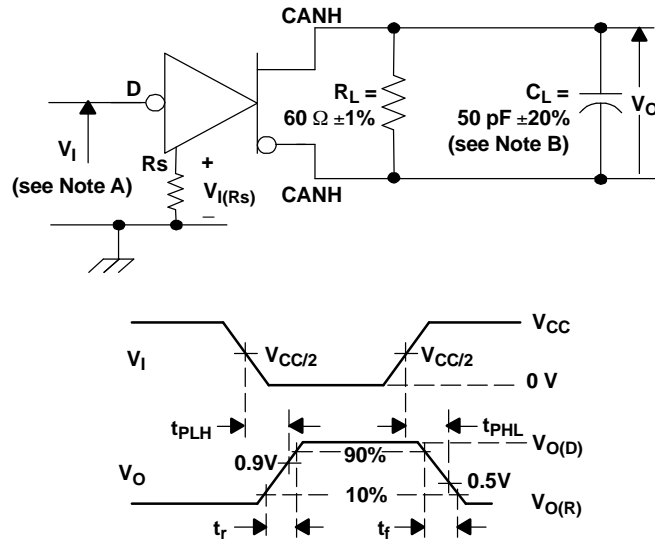


Figure 4. Driver Test Circuit and Voltage Waveforms

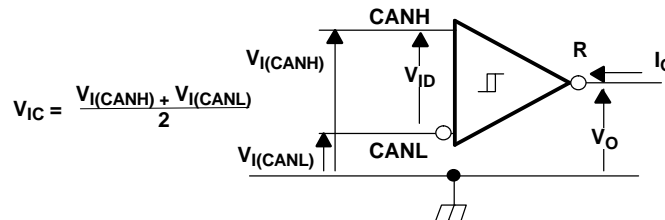
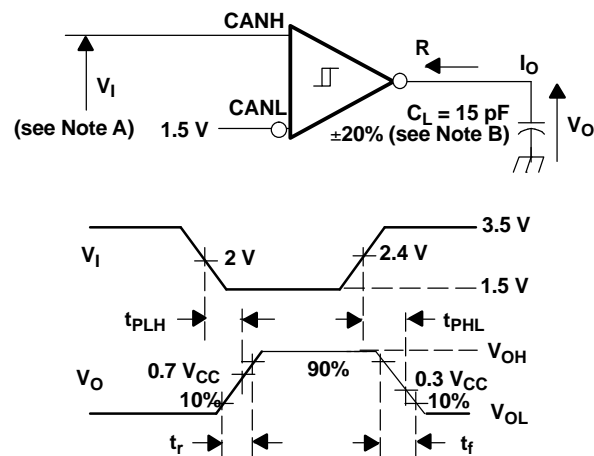


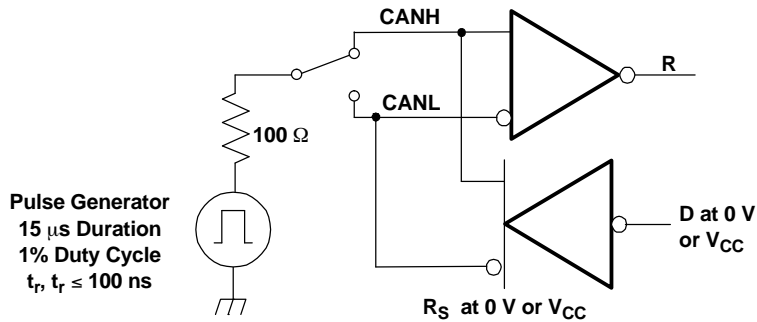
Figure 5. Receiver Voltage and Current Definitions



- A. The input pulse is supplied by a generator having the following characteristics: PRR ≤ 125 kHz, 50% duty cycle, $t_r \leq 6\text{ns}$, $t_f \leq 6\text{ns}$, $Z_0 = 50\Omega$.
- B. C_L includes instrumentation and fixture capacitance within $\pm 20\%$.

Figure 6. Receiver Test Circuit and Voltage Waveforms

PARAMETER MEASUREMENT INFORMATION (continued)



A. This test is conducted to test survivability only. Data stability at the R output is not specified.

Figure 7. Test Circuit, Transient Over-Voltage Test

Table 1. Receiver Characteristics Over Common Mode Voltage

INPUT		MEASURED	OUTPUT	
V_{CANH}	V_{CANL}	$ V_{ID} $	R	
12 V	11.1 V	900 mV	L	V_{OL}
-6.1 V	-7 V	900 mV	L	
-1 V	-7 V	6 V	L	
12 V	6 V	6 V	L	
-6.5 V	-7 V	500 mV	H	V_{OH}
12 V	11.5 V	500 mV	H	
-7 V	-1 V	6 V	H	
6 V	12 V	6 V	H	
open	open	X	H	

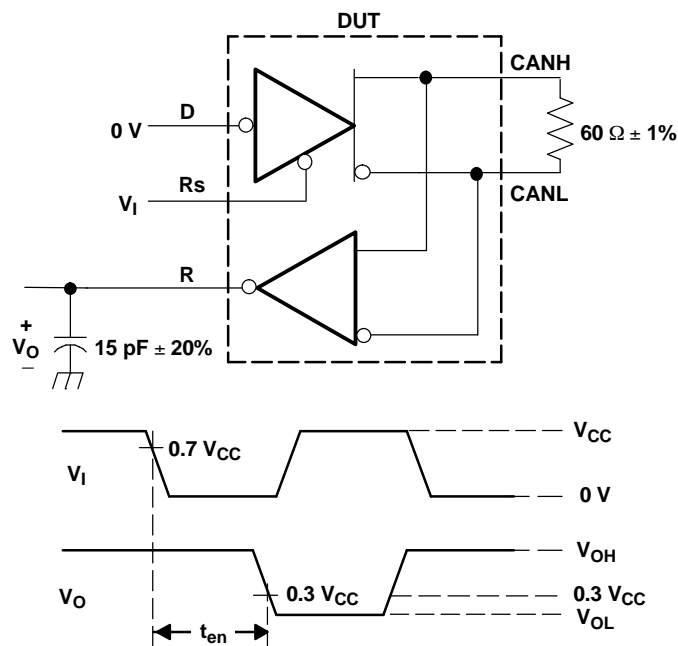
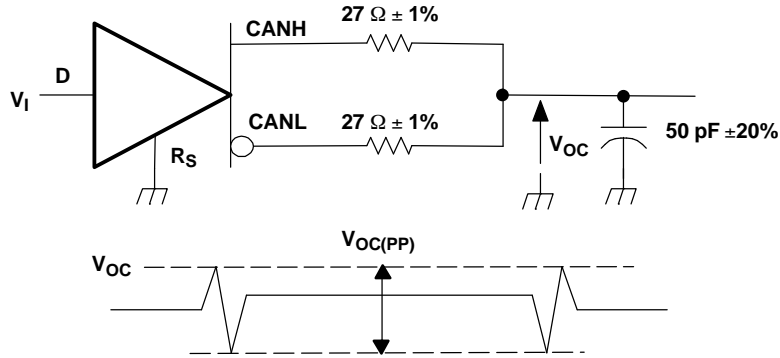


Figure 8. t_{en} Test Circuit and Voltage Waveforms



- A. The input pulse is supplied by a generator having the following characteristics: PRR \leq 125 kHz, 50% duty cycle, $t_r \leq$ 6ns, $t_f \leq$ 6ns, $Z_O = 50\Omega$.

Figure 9. Peak-to-Peak Common Mode Output Voltage

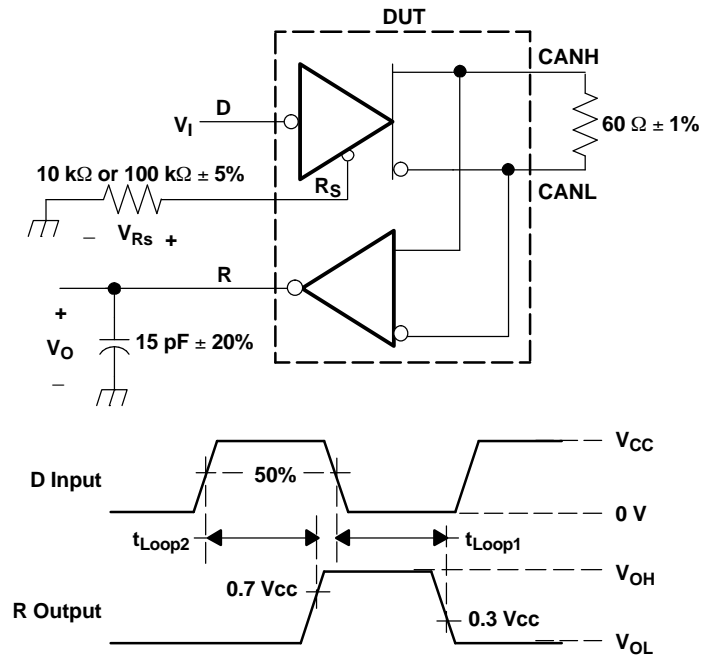


Figure 10. t_{LOOP} Test Circuit and Voltage Waveforms

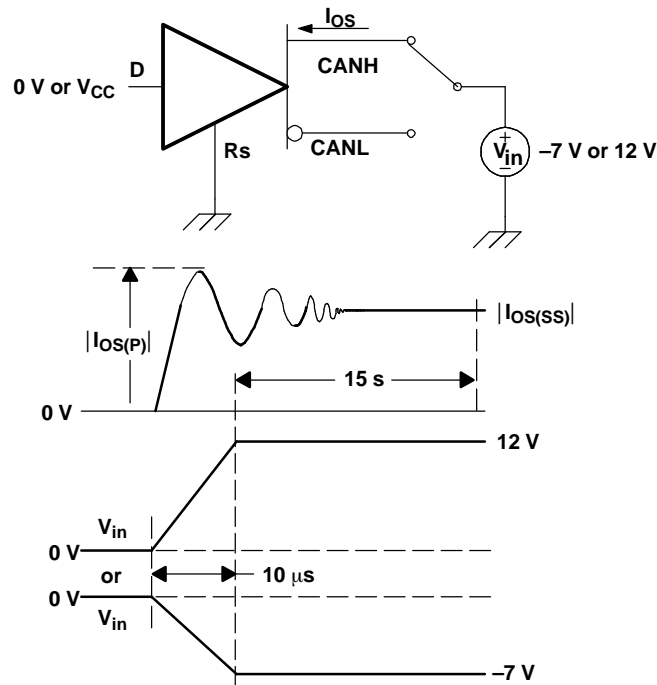
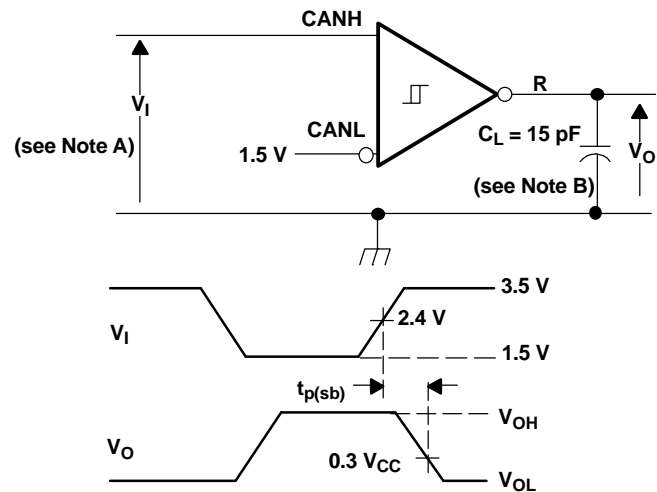


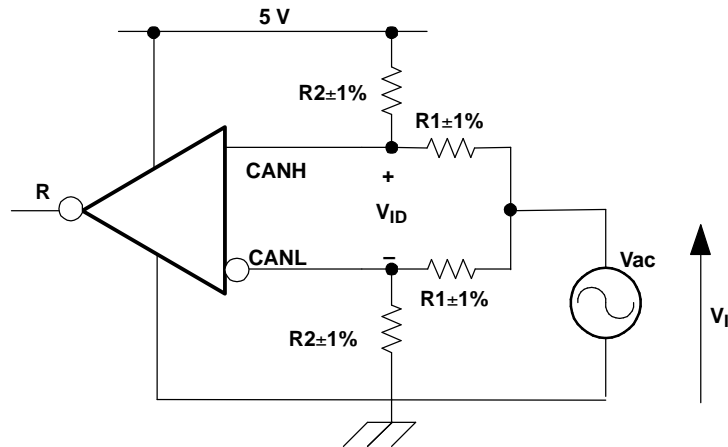
Figure 11. Driver Short-Circuit Test



- A. The input pulse is supplied by a generator having the following characteristics: PRR \leq 125 kHz, 50% duty cycle, $t_r \leq$ 6ns, $t_f \leq$ 6ns, $Z_o = 50\Omega$.
- B. C_L includes instrumentation and fixture capacitance within $\pm 20\%$.

Figure 12. Receiver Propagation Delay in Standby Test Circuit and Waveform

DEVICE INFORMATION



V_{ID}	R1	R2
500 mV	50 Ω	450 Ω
900 mV	50 Ω	227 Ω



A. All input pulses are supplied by a generator having the following characteristics: $f < 1.5$ MHz, $T_A = 25^\circ\text{C}$, $V_{CC} = 5.0$ V.

Figure 13. Common-Mode Input Voltage Rejection Test

FUNCTION TABLES

Table 2. DRIVER

INPUTS	Voltage at R_S , V_{RS}	OUTPUTS		BUS STATE
		CANH	CANL	
L	$V_{RS} < 1.2$ V	H	L	Dominant
H	$V_{RS} < 1.2$ V	Z	Z	Recessive
Open	X	Z	Z	Recessive
X	$V_{RS} > 0.75 V_{CC}$	Z	Z	Recessive

Table 3. RECEIVER

DIFFERENTIAL INPUTS [$V_{ID} = V(\text{CANH}) - V(\text{CANL})$]	OUTPUT R ⁽¹⁾
$V_{ID} \geq 0.9$ V	L
$0.5\text{V} < V_{ID} < 0.9$ V	?
$V_{ID} \leq 0.5$ V	H
Open	H

(1) H = high level; L = low level; X = irrelevant; ? = indeterminate; Z = high impedance

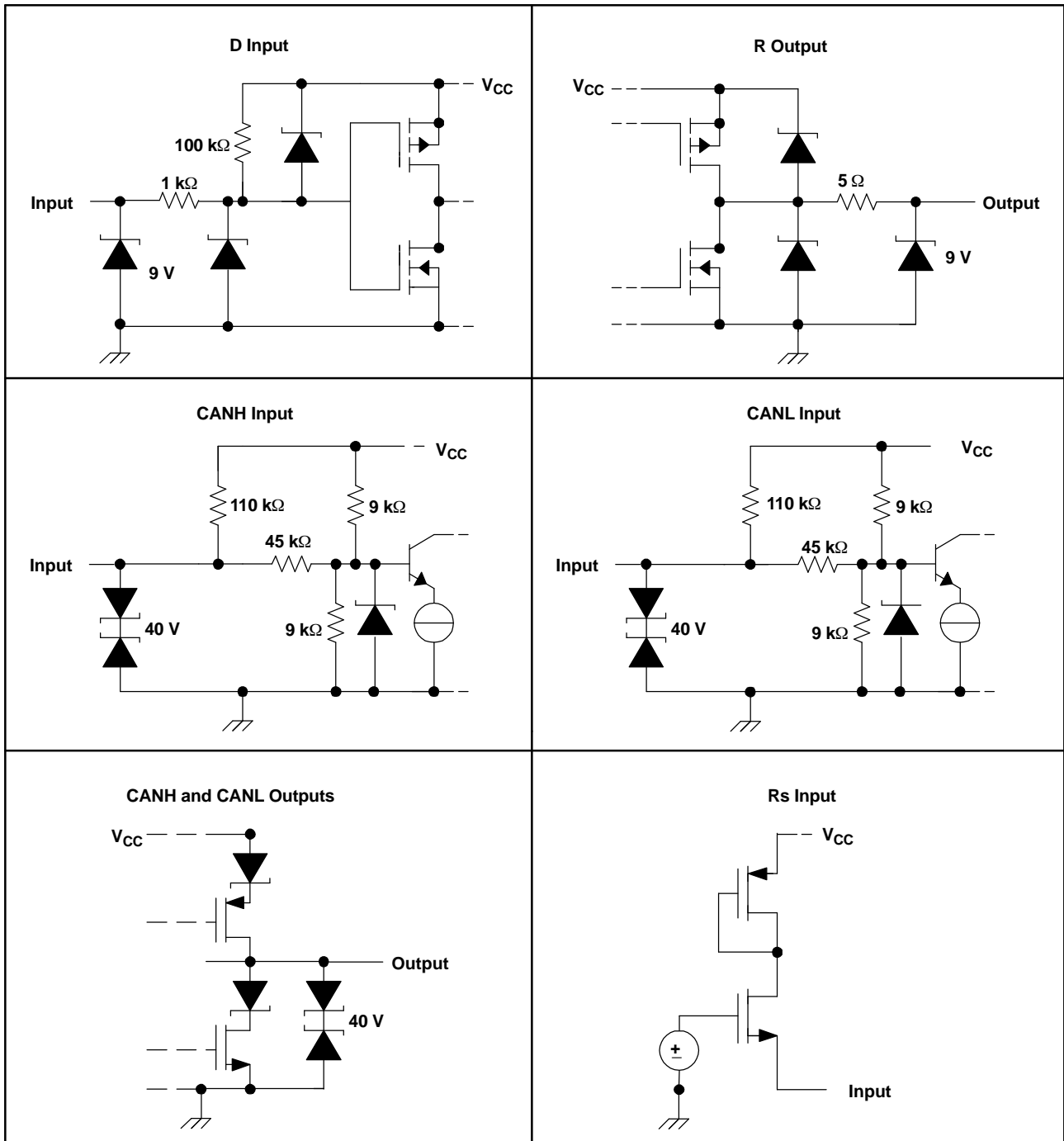


Figure 14. Equivalent Input and Output Schematic Diagrams

TYPICAL CHARACTERISTICS

**t_{LOOP1}-LOOP TIME
VS
FREE-AIR TEMPERATURE**

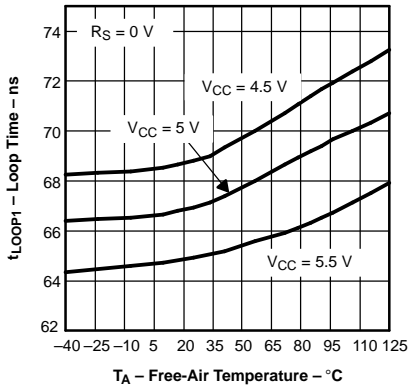


Figure 15.

**t_{LOOP2}-LOOP TIME
VS
FREE-AIR TEMPERATURE**

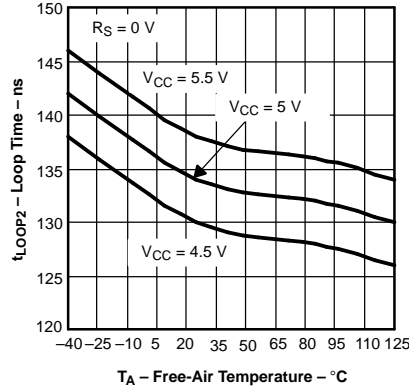


Figure 16.

**SUPPLY CURRENT (RMS)
VS
SIGNALING RATE**

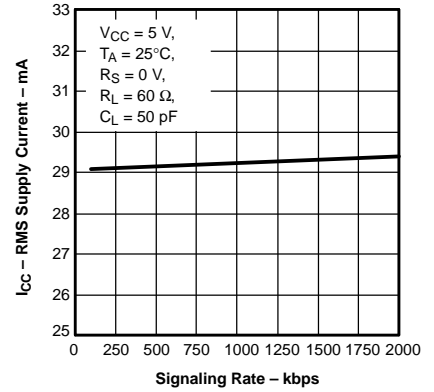


Figure 17.

**DRIVER LOW-LEVEL OUTPUT CURRENT
VS
LOW-LEVEL OUTPUT VOLTAGE**

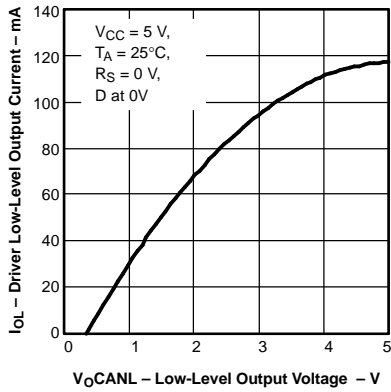


Figure 18.

**DRIVER HIGH-LEVEL OUTPUT CURRENT
VS
HIGH-LEVEL OUTPUT VOLTAGE**

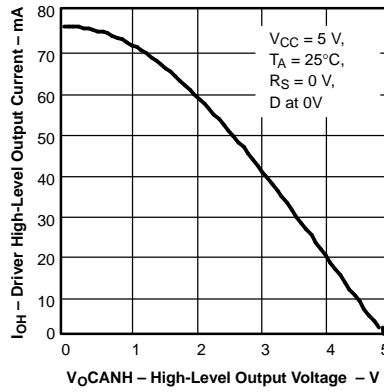


Figure 19.

**DOMINANT DIFFERENTIAL OUTPUT VOLTAGE
VS
FREE-AIR TEMPERATURE**

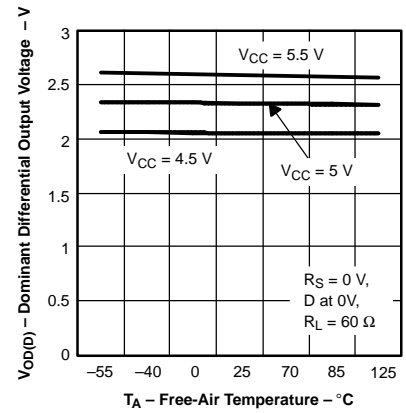


Figure 20.

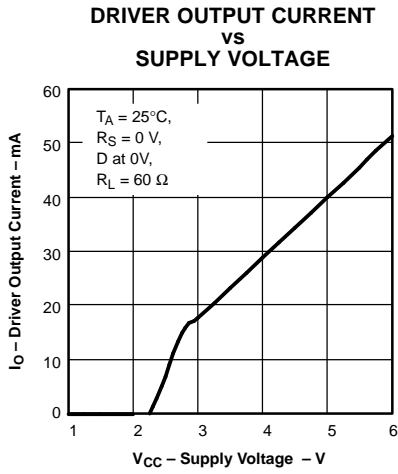


Figure 21.

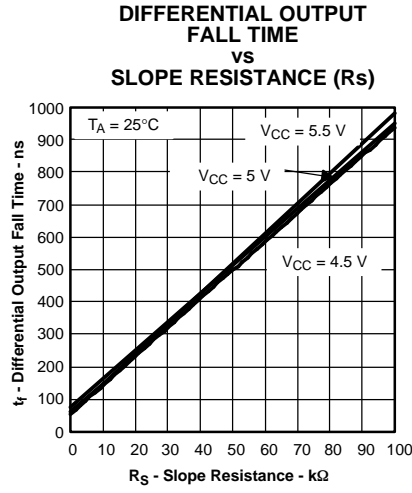


Figure 22.

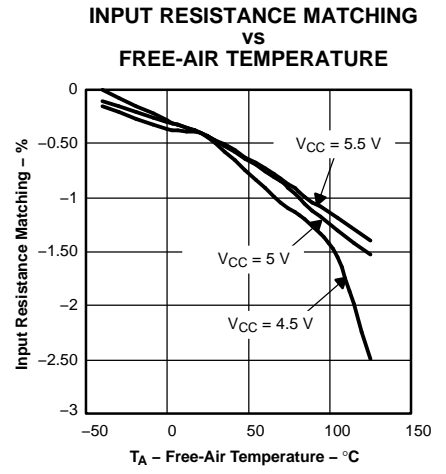


Figure 23.

APPLICATION INFORMATION

The basics of arbitration require that the receiver at the sending node designate the first bit as dominant or recessive after the initial wave of the first bit of a message travels to the most remote node on a network and back again. Typically, this *sample* is made at 75% of the bit width, and within this limitation, the maximum allowable signal distortion in a CAN network is determined by network electrical parameters.

Factors to be considered in network design include the ≈ 5 ns/m propagation delay of typical twisted-pair bus cable; signal amplitude loss due to the loss mechanisms of the cable; and the number, length, and spacing of drop-lines (stubs) on a network. Under strict analysis, variations among the different oscil-

lators in a system also need to be accounted for with adjustments in signaling rate and stub & bus length. Table 2 lists the maximum signaling rates achieved with the SN65HVD251 in high-speed mode with several bus lengths of category 5, shielded twisted pair (CAT 5 STP) cable.

Table 4. Maximum Signaling Rates for Various Cable Lengths

BUS LENGTH (m)	SIGNALING RATE (kbps)
30	1000
100	500
250	250
500	125
1000	62.5

The ISO 11898 Standard specifies a maximum bus length of 40 m and maximum stub length of 0.3 m with a maximum of 30 nodes. However, with careful design, users can have longer cables, longer stub lengths, and many more nodes on a bus. (Note: Non-standard application may come with a trade-off in signaling rate.) A large number of nodes requires a transceiver with high input impedance such as the HVD251.

The Standard specifies the interconnect to be a single twisted-pair cable (shielded or unshielded) with 120 Ω characteristic impedance (Z_0). Resistors equal to the characteristic impedance of the line terminate both ends of the cable to prevent signal reflections. Unterminated drop-lines connect nodes to the bus and should be kept as short as possible to minimize signal reflections.

Connectors, while not specified by the Standard should have as little effect as possible on standard operating parameters such as capacitive loading. Although unshielded cable is used in many applications, data transmission circuits employing CAN transceivers are usually used in applications requiring a rugged interconnection with a wide common-mode voltage range. Therefore, shielded cable is recommended in these electronically harsh environments, and when coupled with the Standard's -2 -V to 7-V common-mode range of tolerable ground noise, helps to ensure data integrity. The HVD251 enhances the Standard's insurance of data integrity with an extended -7 -V to 12-V range of common-mode operation.

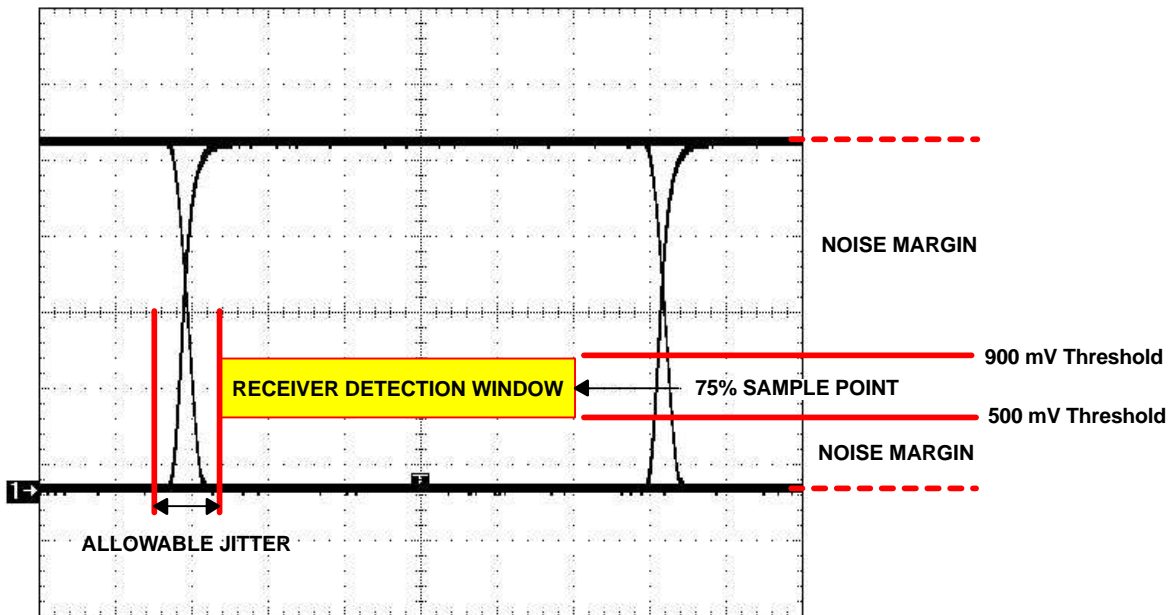


Figure 24. Typical CAN Differential Signal Eye-Pattern

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
SN65HVD251D	ACTIVE	SOIC	D	8	75	TBD	CU NIPDAU	Level-1-220C-UNLIM
SN65HVD251DR	ACTIVE	SOIC	D	8	2500	TBD	CU NIPDAU	Level-1-220C-UNLIM
SN65HVD251DRG4	PREVIEW	SOIC	D	8	2500	TBD	Call TI	Call TI
SN65HVD251P	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC

⁽¹⁾ The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

⁽²⁾ Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS) or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

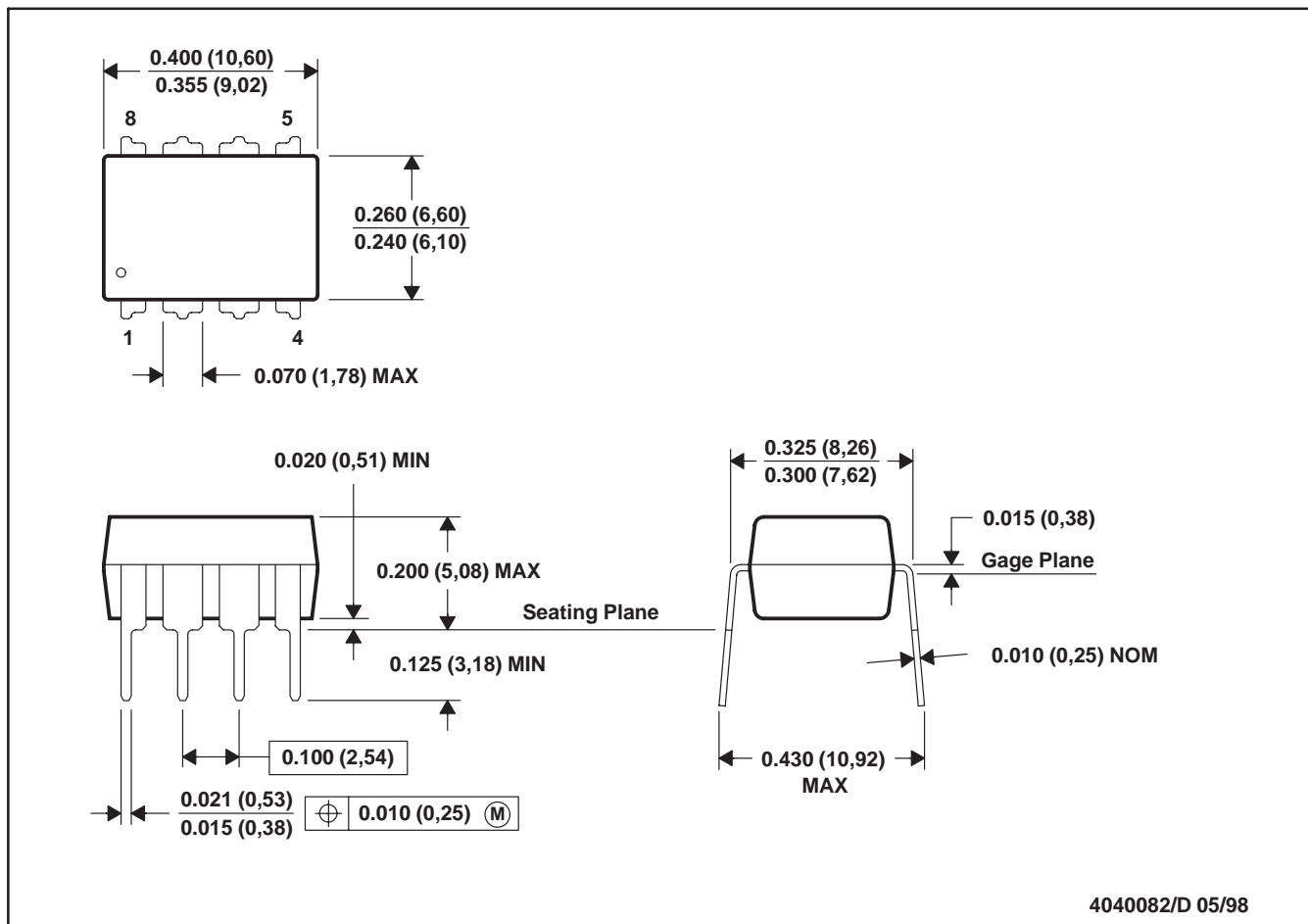
⁽³⁾ MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE



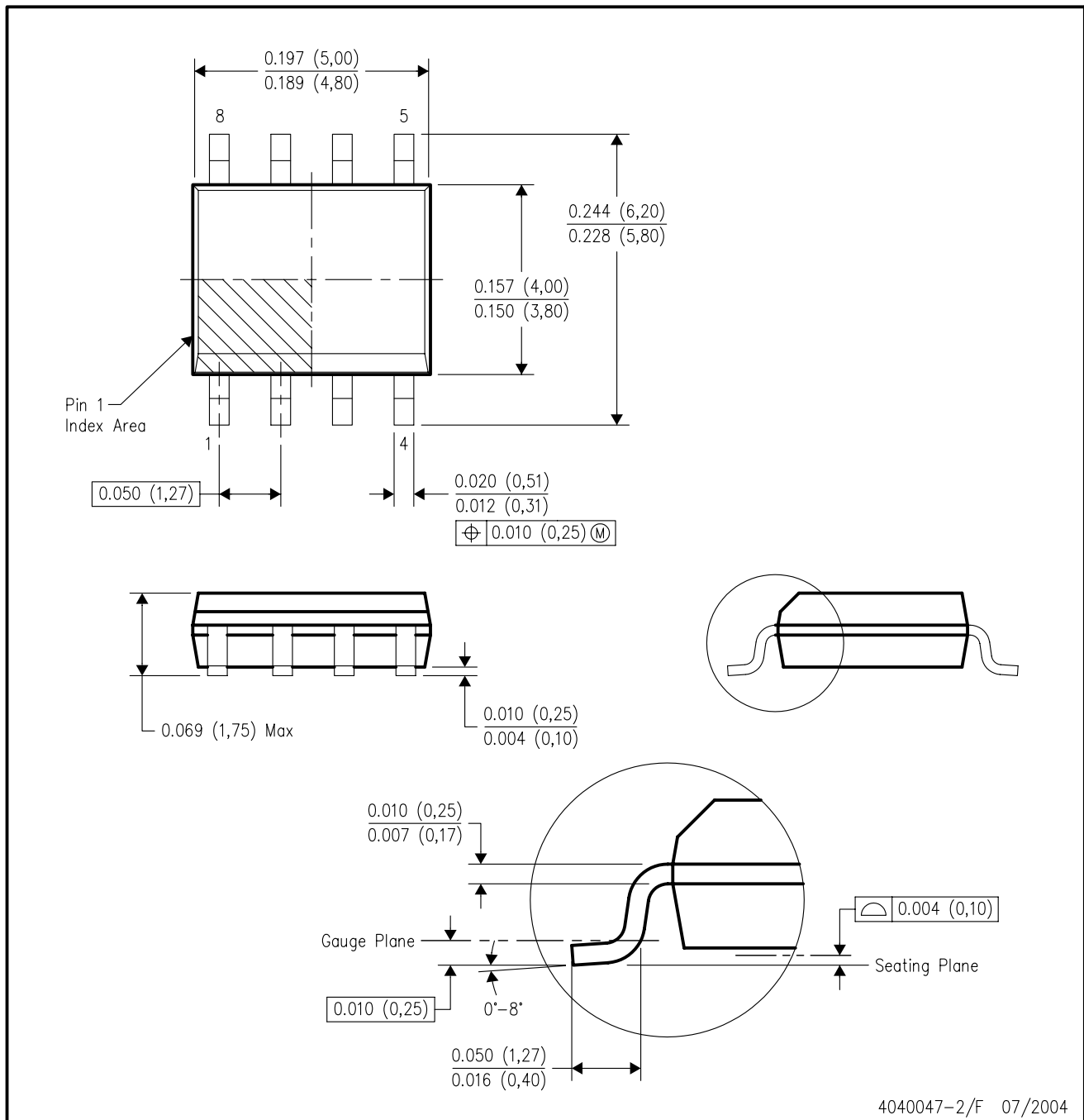
- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. Falls within JEDEC MS-001

For the latest package information, go to http://www.ti.com/sc/docs/package/pkg_info.htm



D (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
 - D. Falls within JEDEC MS-012 variation AA.

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Mailing Address: Texas Instruments
Post Office Box 655303 Dallas, Texas 75265