

### General Description

The XR31233, XR31234 and XR31235 are controller area network (CAN) transceivers that conform to the ISO 11898 standard. Each provides transmit and receive signaling rates up to 1Mbps between a differential CAN bus and a CAN controller.

These devices are designed with cross-wire protection, overvoltage protection up to ±36V, loss of ground protection, thermal shutdown protection and common-mode transient protection of ±100V making them ideal for harsh environments used in industrial, automotive, transportation and building automation applications.

The low power consumption of the 3.3V supply makes these CAN transceivers desirable and are fully interoperable with 5V supplied transceivers on the same bus. They also offer high speed, slope control and low-power standby modes of operation.

### FEATURES

- Single 3.3V operation
- ±36V fault tolerance on analog bus pins
- Extended -25V to +25V common mode operation
- Robust ESD protection:
  - ±16kV HBM (bus pins)
  - ±8kV contact discharge (bus pins)
  - ±3kV HBM (non-bus pins)
- Up to 1Mbps data rates
- 11898-2 ISO compatible
- GIFT/ICT compliant
- 5V tolerant LVTTTL I/O's
- 200µA low current standby mode
- XR31233: Loopback mode
- XR31234: Ultra low current sleep mode
  - 50nA typical
- XR31235: Autobaud loopback mode

### APPLICATIONS

- Industrial control systems
- Motor and robotic control
- Building and climate control (HVAC)
- Automotive and transportation

### Typical Application

Ordering Information - [Back Page](#)

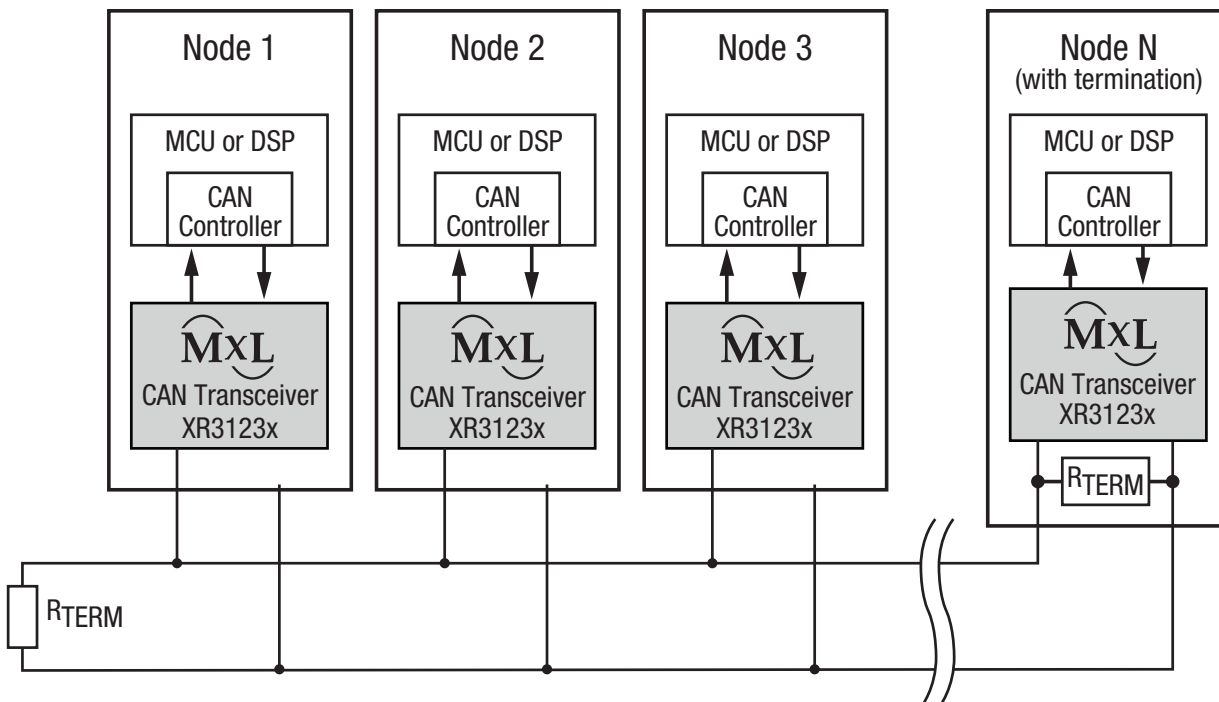


Figure 1: Typical CAN Bus

**Absolute Maximum Ratings**

Stresses beyond the limits listed below may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition may affect device reliability and lifetime.

- V<sub>CC</sub> ..... -0.3V to 7V
- Voltage at any bus terminal (CANH or CANL).. -36V to 36V
- Voltage input, transient pulse, CANH and CANL, through 100Ω (Figure 9) ..... -100V to 100V
- Input voltage (D, RS, EN, LBK, AB) ..... -0.5V to 7V
- Output voltage ..... -0.5V to 7V
- Receiver output current ..... -10mA to 10mA
- Continuous total power dissipation..... 540mW
- Operating junction temperature ..... 150°C
- Storage temperature..... -65°C to 150°C
- Lead temperature (soldering 10 seconds)..... 300°C

**Operating Conditions**

- V<sub>CC</sub> supply range .....3.0V to 3.6V
- Operating temperature range ..... -40°C to 125°C
- Package power dissipation, 8-pin NSOIC  $\Theta_{JA}$ .....128.4°C/W

**ESD Ratings**

- Human Body Model (HBM), bus pins ..... ±16kV
- Human Body Model (HBM), non-bus pins ..... ±3kV
- IEC61000-4-2 (Contact Discharge), bus pins ..... ±8kV

## Electrical Characteristics

Unless otherwise noted:  $V_{CC} = 3.0V$  to  $3.6V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ . Typical values are at  $V_{CC} = 3.3V$ ,  $T_A = 25^\circ C$

Symbol	Parameter	Conditions	Min	Typ	Max	Units	
<b>Driver DC Characteristics</b>							
$V_{O(D)}$	Bus output voltage (Dominant)	CANH	D at 0V, RS at 0V, see <a href="#">Figure 3</a> and <a href="#">Figure 4</a>	2.3		$V_{CC}$	V
		CANL		0.5		1.25	
$V_O$	Bus output voltage (Recessive)	CANH	D at 3V, RS at 0V, see <a href="#">Figure 3</a> and <a href="#">Figure 4</a>		2.3		V
		CANL			2.3		
$V_{OD(D)}$	Differential output voltage (Dominant)		D at 0V, RS at 0V, see <a href="#">Figure 3</a> and <a href="#">Figure 4</a>	1.5	2	3	V
			D at 0V, RS at 0V, see <a href="#">Figure 4</a> and <a href="#">Figure 5</a>	1.2	2	3	
$V_{OD}$	Differential output voltage (Recessive)		D at 3V, RS at 0V, see <a href="#">Figure 3</a> and <a href="#">Figure 4</a>	-120		12	mV
			D at 3V, RS at 0V, No Load	-0.5		0.05	V
$V_{OC(PP)}$	Peak-to-peak common-mode output voltage		See <a href="#">Figure 12</a>		1		V
$I_{IH}$	High-level input current	D, EN, LBK, AB	D = 2V or EN = 2V or LBK = 2V or AB = 2V	-30		30	$\mu A$
$I_{IL}$	Low-level input current	D, EN, LBK, AB	D = 0.8V or EN = 0.8V or LBK = 0.8V or AB = 0.8V	-30		30	$\mu A$
$I_{OS}$	Short-circuit output current		VCANH = -25V, CANL Open, see <a href="#">Figure 17</a>	-250			mA
			VCANH = 25V, CANL Open, see <a href="#">Figure 17</a>			3	
			VCANH = -25V, CANH Open, see <a href="#">Figure 17</a>	-3			
			VCANH = 25V, CANH Open, see <a href="#">Figure 17</a>			250	
$C_O$	Output capacitance		See receiver input capacitance				
$I_{RS(S)}$	RS input current for standby		RS at 0.75 Vcc	-10			$\mu A$
$I_{CC}$	Supply current	Sleep	EN at 0V, D at $V_{CC}$ , RS at 0V or VCC		0.05	2	$\mu A$
		Standby	RS at $V_{CC}$ , D at $V_{CC}$ , AB at 0V, LBK at 0V, EN at $V_{CC}$		200	600	
		Dominant	D at 0V, No Load, AB at 0V, LBK at 0V			6	mA
		Recessive	D at $V_{CC}$ , No Load, AB at 0V, LBK at 0V, RS at 0V, EN at $V_{CC}$			6	

## Electrical Characteristics, (Continued)

Unless otherwise noted:  $V_{CC} = 3.0V$  to  $3.6V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ . Typical values are at  $V_{CC} = 3.3V$ ,  $T_A = 25^\circ C$ .

Symbol	Parameter	Conditions	Min	Typ	Max	Units	
Receiver DC Characteristics							
$V_{IT+}$	Positive-going input threshold voltage	AB at 0V, LBK at 0V, EN at $V_{CC}$ , see Table 1		750	900	mV	
$V_{IT-}$	Negative-going input threshold voltage		500	650			
$V_{HYS}$	Hysteresis voltage ( $V_{IT+}$ to $V_{IT-}$ )			100			
$V_{OH}$	High-level output voltage	$V_{CC} < 3.3V$ , $I_O = -4mA$ , see <a href="#">Figure 8</a>	2.0			V	
		$V_{CC} \geq 3.0V$ , $I_O = -4mA$ , see <a href="#">Figure 8</a>	2.4				
$V_{OL}$	Low-level output voltage	$I_O = 4mA$ , see <a href="#">Figure 8</a>			0.4		
$I_I$	Bus input current	CANH or CANL at 25V	Other bus pin at 0V, D at 3V, AB at 0V, LBK at 0V, RS at 0V, EN at $V_{CC}$	400		1250	$\mu A$
		CANH or CANL at -25V		-1400		-500	
$C_I$	Input capacitance (CANH or CANL)	Pin-to-ground, $V_I = 0.4 \sin(4E6\pi t) + 0.5V$ , D at 3V, AB at 0V, LBK at 0V, EN at $V_{CC}$		40		pF	
$C_{ID}$	Differential input capacitance	Pin-to-pin, $V_I = 0.4 \sin(4E6\pi t) + 0.5V$ , D at 3V, AB at 0V, LBK at 0V, EN at $V_{CC}$		20		pF	
$R_{ID}$	Differential input resistance	D at 3V, AB at 0V, LBK at 0V, EN at $V_{CC}$	40		100	k $\Omega$	
$R_{IN}$	Input resistance (CANH or CANL) to ground		20		50	k $\Omega$	

**Electrical Characteristics (Continued)**

Unless otherwise noted:  $V_{CC} = 3.0V$  to  $3.6V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ . Typical values are at  $V_{CC} = 3.3V$ ,  $T_A = 25^{\circ}C$ .

Symbol	Parameter	Conditions	Min	Typ	Max	Units
<b>Driver AC Characteristics</b>						
$t_{PLH}$	Propagation delay time, low-to-high-level output	RS at 0V, see <a href="#">Figure 6</a>		35	85	ns
		RS with 10k $\Omega$ to ground, see <a href="#">Figure 6</a>		70	125	
		RS with 100k $\Omega$ to ground, see <a href="#">Figure 6</a>		500	870	
$t_{PHL}$	Propagation delay time, high-to-low-level output	RS at 0V, see <a href="#">Figure 6</a>		70	120	ns
		RS with 10k $\Omega$ to ground, see <a href="#">Figure 6</a>		130	180	
		RS with 100k $\Omega$ to ground, see <a href="#">Figure 6</a>		870	1200	
$t_{sk(p)}$	Pulse skew ( $ t_{PHL} - t_{PLH} $ )	RS at 0V, see <a href="#">Figure 6</a>		35		ns
		RS with 10k $\Omega$ to ground, see <a href="#">Figure 6</a>		60		
		RS with 100k $\Omega$ to ground, see <a href="#">Figure 6</a>		370		
$t_r$	Differential output signal rise time	RS at 0V, see <a href="#">Figure 6</a>	5		70	ns
$t_f$	Differential output signal fall time		5		70	ns
$t_r$	Differential output signal rise time	RS with 10k $\Omega$ to ground, see <a href="#">Figure 6</a>	30		135	ns
$t_f$	Differential output signal fall time		30		135	ns
$t_r$	Differential output signal rise time	RS with 100k $\Omega$ to ground, see <a href="#">Figure 6</a>	350		1400	ns
$t_f$	Differential output signal fall time		350		1400	ns
$t_{en(s)}$	Enable time from standby to dominant	See <a href="#">Figure 10</a>		0.6	1.5	$\mu s$
$t_{en(z)}$	Enable time from sleep to dominant	XR31234 See <a href="#">Figure 11</a>		1	5	$\mu s$
<b>Receiver AC Characteristics</b>						
$t_{PLH}$	Propagation delay time, low-to-high-level output	See <a href="#">Figure 8</a>		35	60	ns
$t_{PHL}$	Propagation delay time, high-to-low-level output			35	60	ns
$t_{sk(p)}$	Pulse skew ( $ t_{PHL} - t_{PLH} $ )			7		ns
$t_r$	Output signal rise time <sup>(1)</sup>				5	ns
$t_f$	Output signal fall time <sup>(1)</sup>				5	ns

**NOTE:**

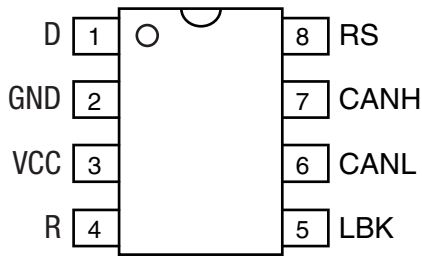
1. This spec is guaranteed by design and bench characterization.

**Electrical Characteristics, (Continued)**

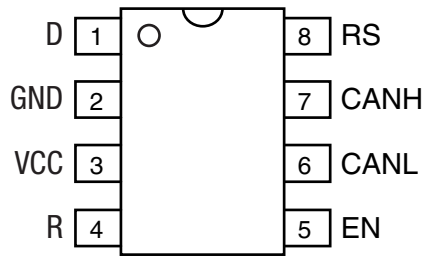
Unless otherwise noted:  $V_{CC} = 3.0V$  to  $3.6V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ . Typical values are at  $V_{CC} = 3.3V$ ,  $T_A = 25^{\circ}C$ .

Symbol	Parameter	Conditions	Min	Typ	Max	Units
<b>Device AC Characteristics</b>						
$t_{(LBK)}$	Loopback delay, driver input to receiver output	XR31233	See <a href="#">Figure 14</a>	7.5	12	ns
$t_{(AB1)}$	Loopback delay, driver input to receiver output	XR31235	See <a href="#">Figure 15</a>	10	20	ns
$t_{(AB2)}$	Loopback delay, bus input to receiver output		See <a href="#">Figure 16</a>	35	60	ns
$t_{(loop1)}$	Total loop delay, driver input to receiver output, recessive to dominant	RS at 0V, see <a href="#">Figure 13</a>		70	135	ns
		RS with 10k $\Omega$ to ground, see <a href="#">Figure 13</a>		105	190	
		RS with 100k $\Omega$ to ground, see <a href="#">Figure 13</a>		535	1000	
$t_{(loop2)}$	Total loop delay, driver input to receiver output, dominant to recessive	RS at 0V, See <a href="#">Figure 13</a>		70	135	ns
		RS with 10k $\Omega$ to ground, see <a href="#">Figure 13</a>		105	190	
		RS with 100k $\Omega$ to ground, see <a href="#">Figure 13</a>		535	1000	

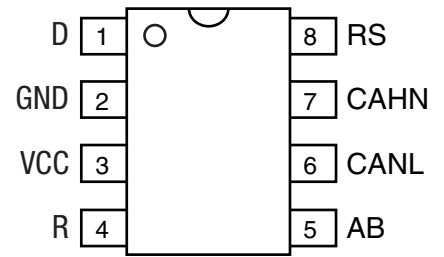
## Pin Configuration



Top View, XR31233



Top View, XR31234



Top View, XR31235

## Pin Functions

Pin Number	Pin Name	Type	Description			
1	D	Input	CAN transmit data input (LOW for dominant and HIGH for recessive bus states), also called TXD, driver input.			
2	GND	Power	Ground.			
3	VCC	Power	3.3V power supply input, bypass to ground with 0.1µF capacitor.			
4	R	Output	CAN receive data output (LOW for dominant and HIGH for recessive bus states), also called RXD, receiver output.			
5	LBK	Input	XR31233	Loopback mode input.	LBK = 1	Loopback mode. D input loops back to R output. D input does not drive or affect the activity of the CAN bus. Useful for checking connectivity and running diagnostics without disturbing the CAN bus.
					LBK = 0	Normal mode. D input drives CAN bus. If D = 0, the CAN bus is dominant. If D = 1 the CAN bus is recessive. See <a href="#">Figure 4.</a>
	EN	Input	XR31234	Enable input.	EN = 1	Normal mode. D input drives CAN bus. If D = 0, the CAN bus is dominant. If D = 1 the CAN bus is recessive. See <a href="#">Figure 4.</a>
					EN = 0	Sleep mode, low power.
	AB	Input	XR31235	Autobaud loopback mode input.	AB = 1	Autobaud loopback mode. Similar to loopback mode as the D input loops back to R output, except that the R output is a NOR function of the D input and the CAN bus activity. Useful for checking connectivity, running diagnostics and monitoring CAN bus activity, which allows local mode to detect and sync the baud rate up on the CAN bus.
					AB = 0	Normal mode. D input drives CAN bus. If D = 0, the CAN bus is dominant. If D = 1 the CAN bus is recessive. See <a href="#">Figure 4</a>
6	CANL	I/O	Low level CAN bus line.			
7	CANH	I/O	High level CAN bus line.			
8	RS	Input	Mode select pin: strong pulldown to GND = high speed mode, strong pullup to VCC = low power mode, 10kΩ to 100kΩ pulldown to GND = slope control mode.			

## Device Functional Modes

### Driver (XR31233 or XR31235)

Inputs			Outputs		
D	LBK/AB	RS	CANH	CANL	Bus State
X	X	$> 0.75 V_{CC}$	Z	Z	Recessive
L	L or open	$\leq 0.33 V_{CC}$	H	L	Dominant
H or open	X		Z	Z	Recessive
X	H	$\leq 0.33 V_{CC}$	Z	Z	Recessive

### Receiver (XR31233)

Inputs				Output
Bus State	$V_{ID} = V_{CANH} - V_{CANL}$	LBK	D	R
Dominant	$V_{ID} \geq 0.9V$	L or open	X	L
Recessive	$V_{ID} \leq 0.5V$ or open	L or open	H or open	H
?	$0.5V < V_{ID} < 0.9V$	L or open	H or open	?
X	X	H	L	L
X	X		H	H

### Receiver (XR31235)

Inputs				Output
Bus State	$V_{ID} = V_{CANH} - V_{CANL}$	AB	D	R
Dominant	$V_{ID} \geq 0.9V$	L or open	X	L
Recessive	$V_{ID} \leq 0.5V$ or open	L or open	H or open	H
?	$0.5V < V_{ID} < 0.9V$	L or open	H or open	?
Dominant	$V_{ID} \geq 0.9V$	H	X	L
Recessive	$V_{ID} \leq 0.5V$ or open	H	H	H
Recessive	$V_{ID} \leq 0.5V$ or open	H	L	L
?	$0.5V < V_{ID} < 0.9V$	H	L	L

### Driver (XR31234)

Inputs			Outputs		
D	EN	RS	CANH	CANL	Bus State
L	H	$\leq 0.33 V_{CC}$	H	L	Dominant
H	X	$\leq 0.33 V_{CC}$	Z	Z	Recessive
Open	X	X	Z	Z	Recessive
X	X	$> 0.75 V_{CC}$	Z	Z	Recessive
X	L or open	X	Z	Z	Recessive



## Device Functional Modes (Continued)

## Receiver (XR31234)

Inputs			Output
Bus State	$V_{ID} = V_{CANH} - V_{CANL}$	EN	R
Dominant	$V_{ID} \geq 0.9V$	H	L
Recessive	$V_{ID} \leq 0.5V$ or open	H	H
?	$0.5V < V_{ID} < 0.9V$	H	?
X	X	L or open	H

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

Applications Information

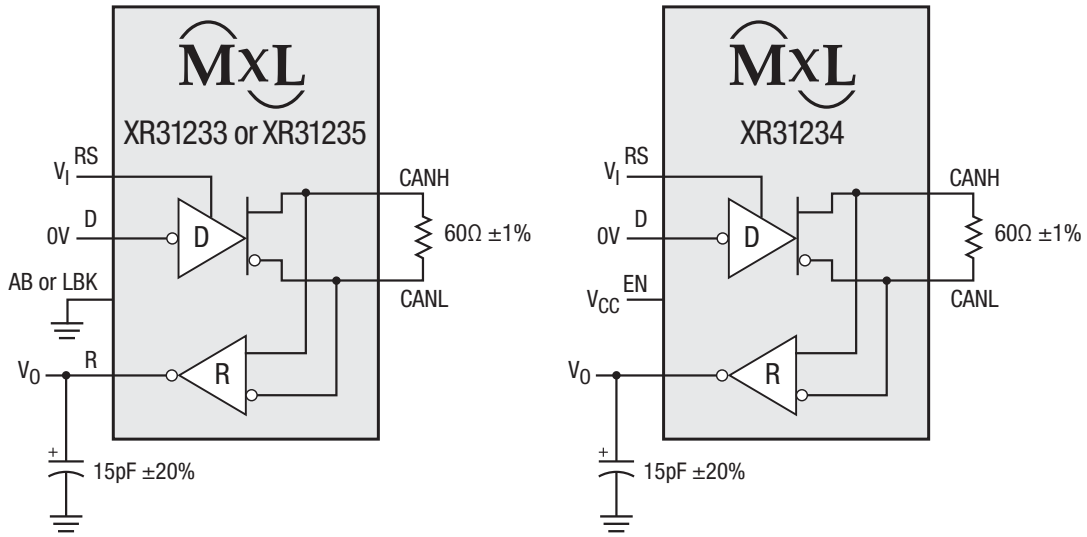


Figure 2: Functional Diagram

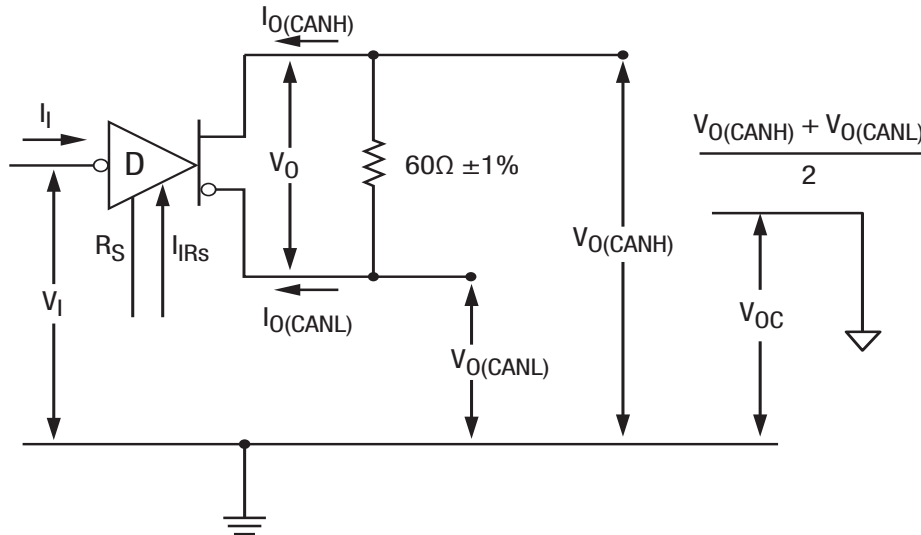


Figure 3: Driver Voltage, Current and Test Definition

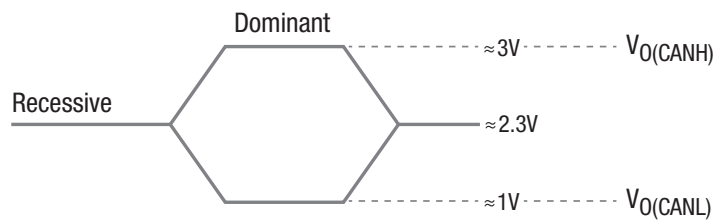


Figure 4: Bus Logic State Voltage Definitions

Applications Information (Continued)

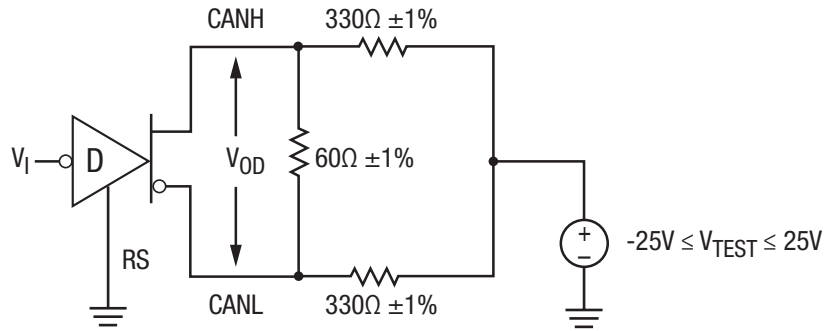
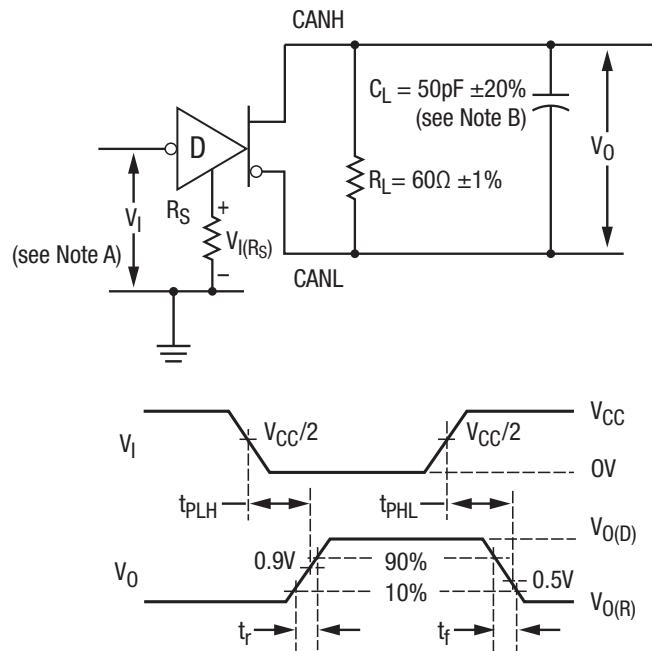


Figure 5: Driver  $V_{OD}$



NOTES:

- A. Pulse input:  $\leq 125\text{kHz}$ , 50% duty cycle,  $t_r \leq 6\text{ns}$ ,  $t_f \leq 6\text{ns}$ ,  $Z_0 = 50\Omega$
- B.  $C_L$  includes fixture and instrumentation capacitance

Figure 6: Driver Test Circuit and Voltage Waveforms

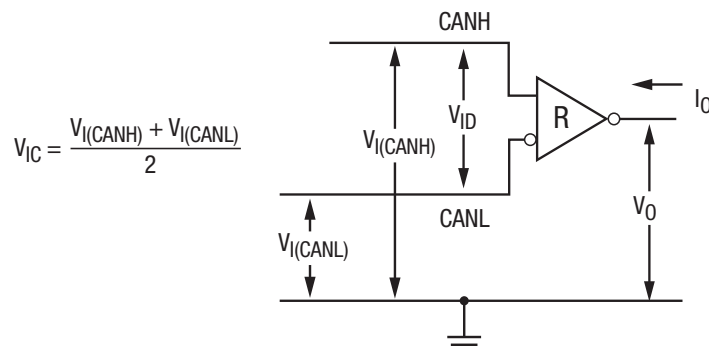
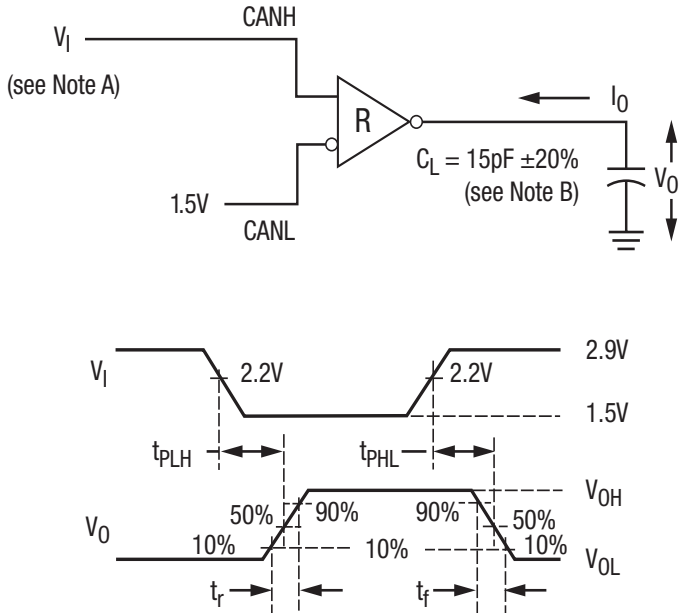


Figure 7: Receiver Voltage and Current Definitions

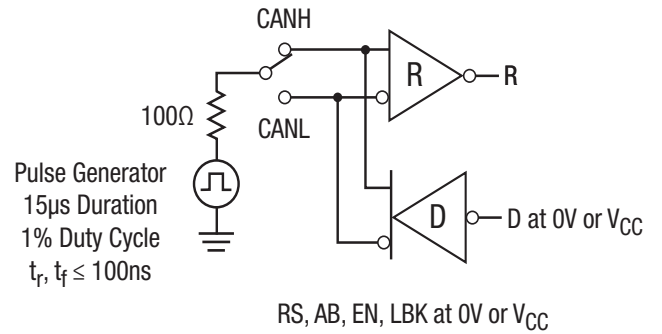
**Applications Information (Continued)**



**NOTES:**

- A. Pulse input: ≤125kHz, 50% duty cycle, t<sub>r</sub> ≤ 6ns, t<sub>f</sub> ≤ 6ns, Z<sub>O</sub> = 50Ω
- B. C<sub>L</sub> includes fixture and instrumentation capacitance

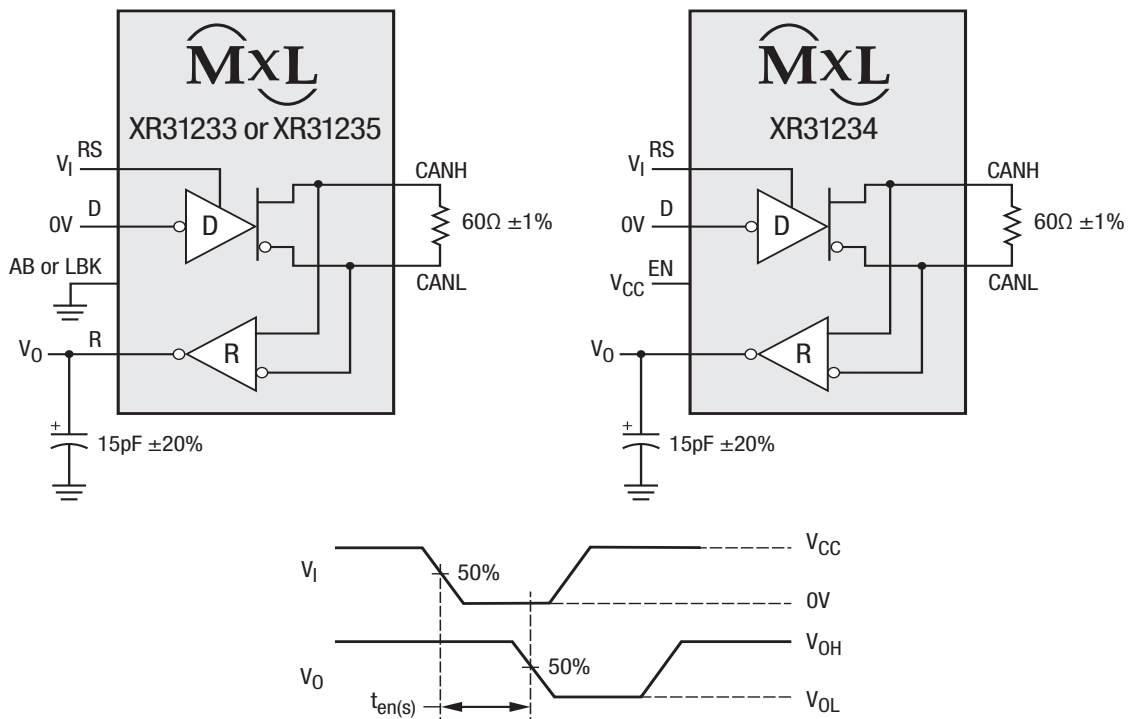
Figure 8: Receiver Test Circuit and Voltage Waveforms



**NOTE:**

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

Figure 9: Test Circuit, Transient Overvoltage Test

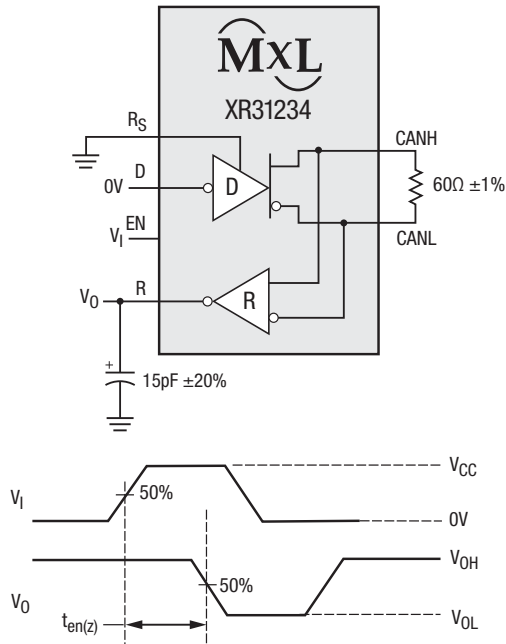


**NOTES:**

- V<sub>I</sub> Pulse input: ≤125kHz, 50% duty cycle, t<sub>r</sub> ≤ 6ns, t<sub>f</sub> ≤ 6ns, Z<sub>O</sub> = 50Ω

Figure 10: Ten(s) Test Circuit and Voltage Waveforms

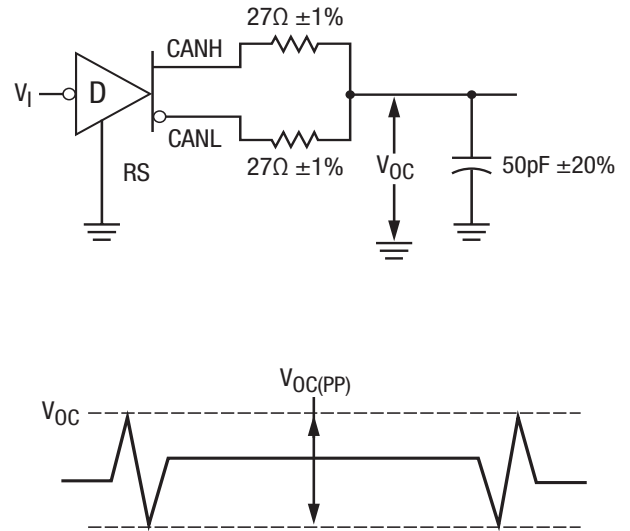
Applications Information (Continued)



NOTES:

V<sub>1</sub> Pulse input: ≤125kHz, 50% duty cycle, t<sub>r</sub> ≤ 6ns, t<sub>f</sub> ≤ 6ns, Z<sub>O</sub> = 50Ω

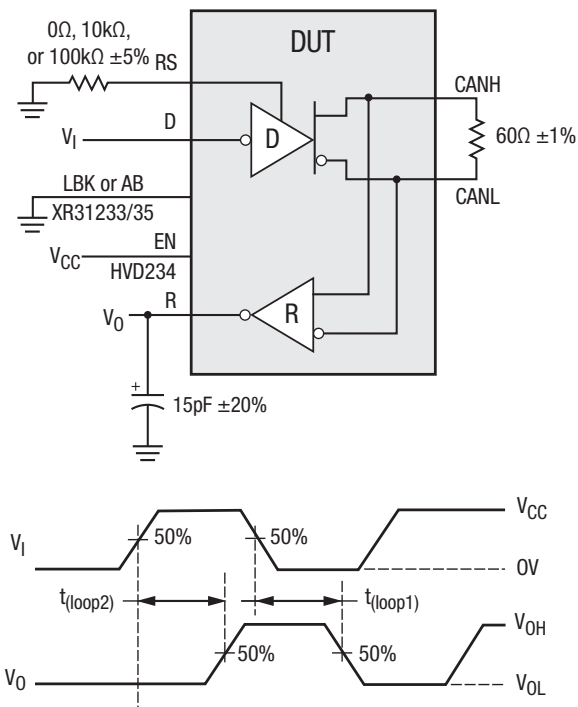
Figure 11: T<sub>en(z)</sub> Test Circuit and Voltage Waveforms



NOTES:

V<sub>1</sub> Pulse input: ≤125kHz, 50% duty cycle, t<sub>r</sub> ≤ 6ns, t<sub>f</sub> ≤ 6ns, Z<sub>O</sub> = 50Ω

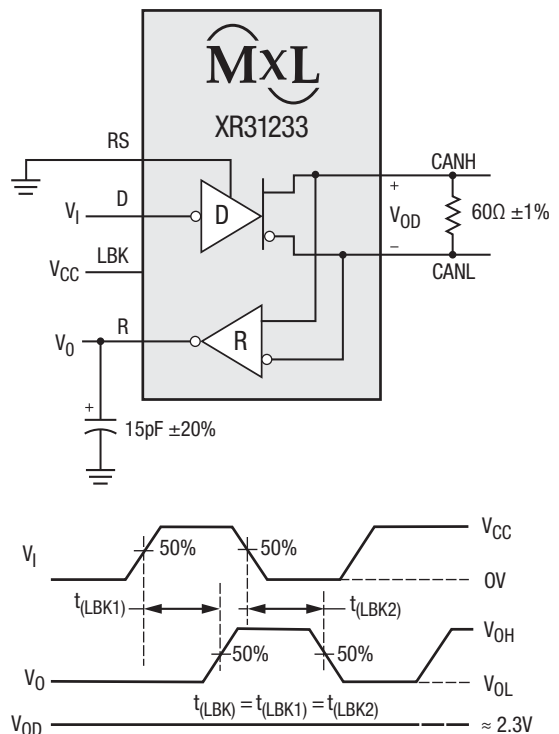
Figure 12: V<sub>OC(pp)</sub> Test Circuit and Voltage Waveforms



NOTES:

V<sub>1</sub> Pulse input: ≤125kHz, 50% duty cycle, t<sub>r</sub> ≤ 6ns, t<sub>f</sub> ≤ 6ns, Z<sub>O</sub> = 50Ω

Figure 13: T<sub>(loop)</sub> Test Circuit and Voltage Waveforms

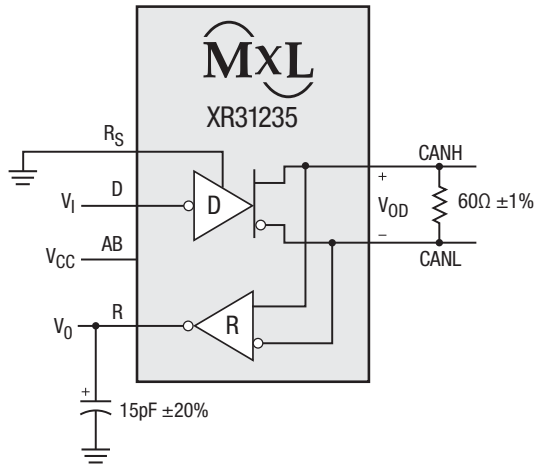


NOTES:

V<sub>1</sub> Pulse input: ≤125kHz, 50% duty cycle, t<sub>r</sub> ≤ 6ns, t<sub>f</sub> ≤ 6ns, Z<sub>O</sub> = 50Ω

Figure 14: T<sub>(LBK)</sub> Test Circuit and Voltage Waveforms

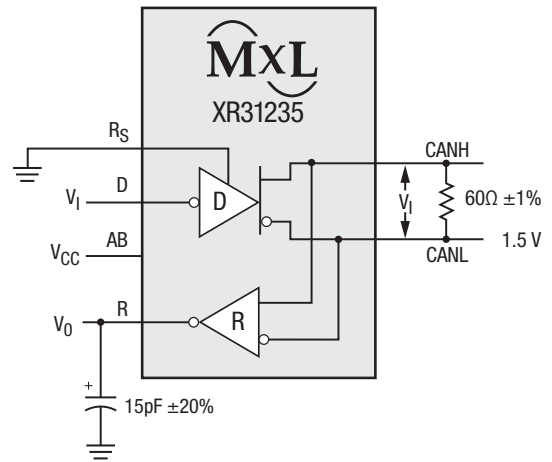
Applications Information (Continued)



NOTES:

V<sub>I</sub> Pulse input: ≤125kHz, 50% duty cycle, t<sub>r</sub> ≤ 6ns, t<sub>f</sub> ≤ 6ns, Z<sub>O</sub> = 50Ω

Figure 15: T<sub>(AB1)</sub> Test Circuit and Voltage Waveforms



NOTES:

V<sub>I</sub> Pulse input: ≤125kHz, 50% duty cycle, t<sub>r</sub> ≤ 6ns, t<sub>f</sub> ≤ 6ns, Z<sub>O</sub> = 50Ω

Figure 16: T<sub>(AB2)</sub> Test Circuit and Voltage Waveforms

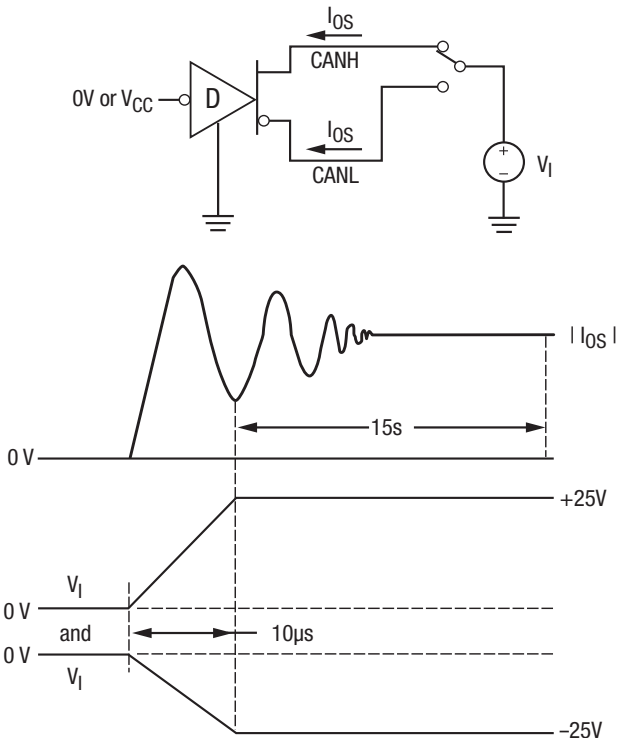
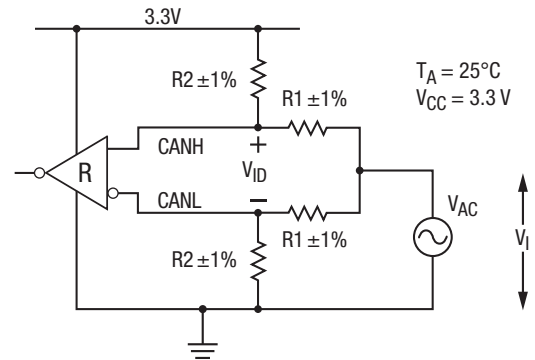


Figure 17: I<sub>OS</sub> Test Circuit and Waveforms



The R output state does not change during application of the input waveform

V <sub>ID</sub>	R1	R2
500mV	50Ω	280Ω
900mV	50Ω	130Ω

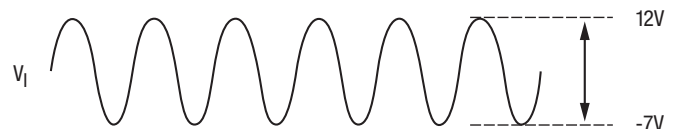
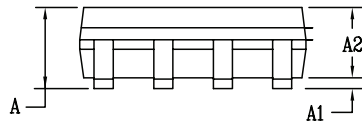
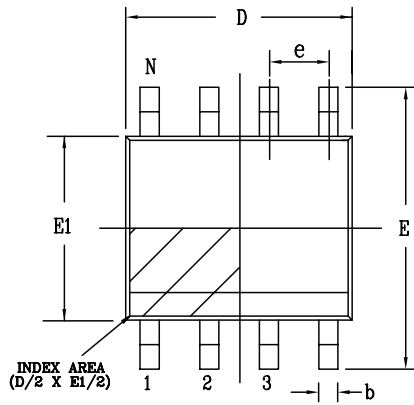


Figure 18: Common-Mode Voltage Rejection

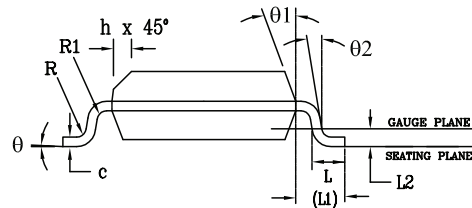
Mechanical Dimensions

NSOIC-8

Top View



Side View



Front View

PACKAGE OUTLINE NSOIC .150" BODY JEDEC MS-012 VARIATION AA						
SYMBOLS	COMMON DIMENSIONS IN MM (Control Unit)			COMMON DIMENSIONS IN INCH (Reference Unit)		
	MIN	NOM	MAX	MIN	NOM	MAX
A	1.35	—	1.75	0.053	—	0.069
A1	0.10	—	0.25	0.004	—	0.010
A2	1.25	—	1.65	0.049	—	0.065
b	0.31	—	0.51	0.012	—	0.020
c	0.17	—	0.25	0.007	—	0.010
E	6.00 BSC			0.236 BSC		
E1	3.90 BSC			0.154 BSC		
e	1.27 BSC			0.050 BSC		
h	0.25	—	0.50	0.010	—	0.020
L	0.40	—	1.27	0.016	—	0.050
L1	1.04 REF			0.041 REF		
L2	0.25 BSC			0.010 BSC		
R	0.07	—	—	0.003	—	—
R1	0.07	—	—	0.003	—	—
q	0°	—	8°	0°	—	8°
q1	5°	—	15°	5°	—	15°
q2	0°	—	—	0°	—	—
D	4.90 BSC			0.193 BSC		
N	8					

Drawing No: POD-0000108

Revision: A