

1. DESCRIPTION

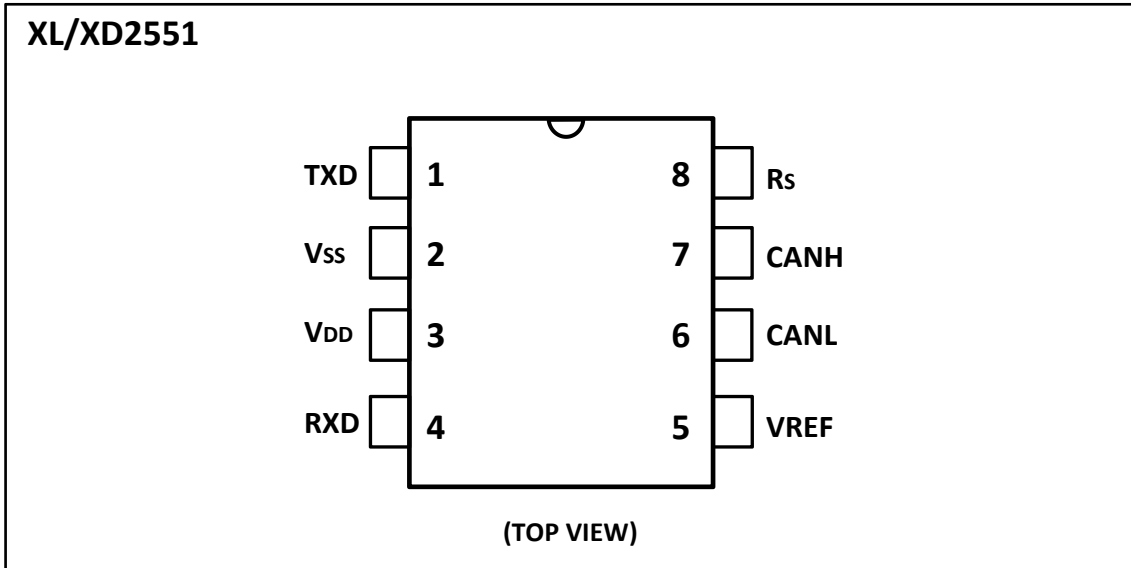
The XL/XD2551 is a high-speed CAN, fault-tolerant device that serves as the interface between a CAN protocol controller and the physical bus. The XL/XD2551 device provides differential transmit and receive capability for the CAN protocol controller, and is fully compatible with the ISO-11898 standard, including 24V requirements. It will operate at speeds of up to 1 Mb/s.

Typically, each node in a CAN system must have a device to convert the digital signals generated by a CAN controller to signals suitable for transmission over the bus cabling (differential output). It also provides a buffer between the CAN controller and the high-voltage spikes that can be generated on the CAN bus by outside sources (EMI, ESD, electrical transients, etc.).

2. FEATURES

- Supports 1 Mb/s operation
- Implements ISO-11898 standard physical layer requirements
- Suitable for 12V and 24V systems
- Externally-controlled slope for reduced RFI emissions
- Detection of ground fault (permanent Dominant) on TXD input
- Power-on Reset and voltage brown-out protection
- An unpowered node or brown-out event will not disturb the CAN bus
- Low current standby operation
- Protection against damage due to short-circuit conditions (positive or negative battery voltage)
- Protection against high-voltage transients
- Automatic thermal shutdown protection
- High-noise immunity due to differential bus implementation
- Temperature ranges: -40°C to +85°C

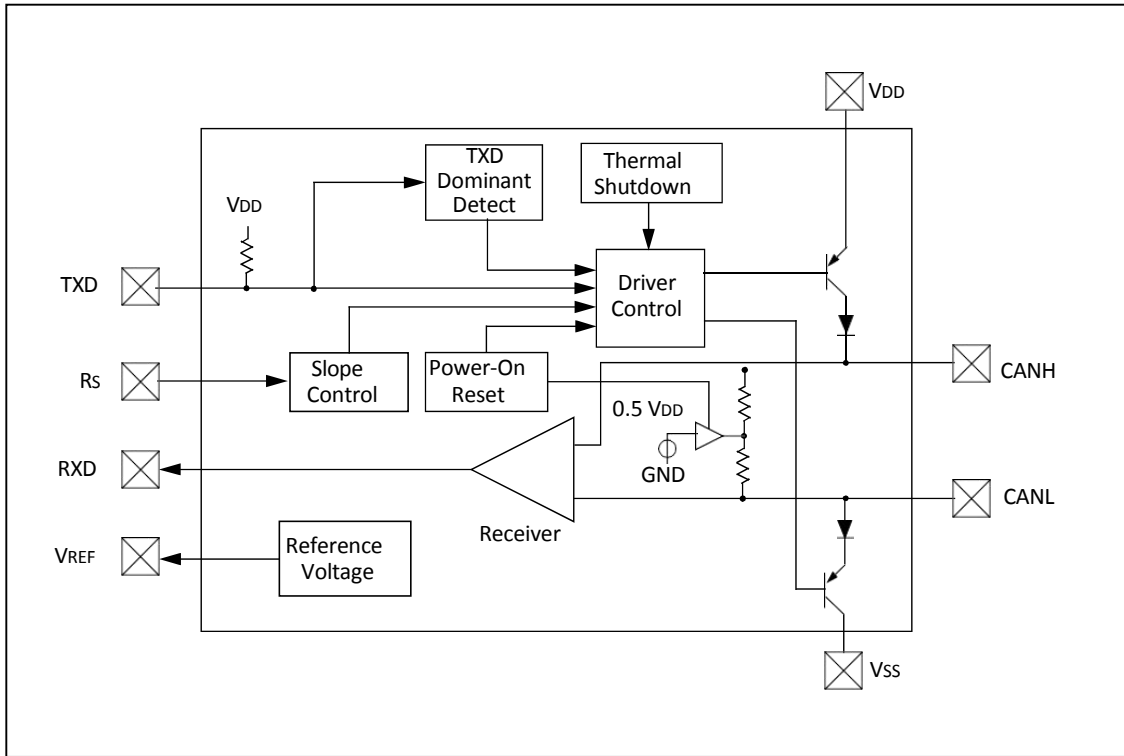
3. PIN CONFIGURATIONS AND FUNCTIONS



Pin Functions

Pin Number	Pin Name	Pin Function
1	TXD	Transmit Data Input
2	VSS	Ground
3	VDD	Supply Voltage
4	RXD	Receive Data Output
5	VREF	Reference Output Voltage
6	CANL	CAN Low-Level Voltage I/O
7	CANH	CAN High-Level Voltage I/O
8	Rs	Slope-Control Input

4. FUNCTIONAL BLOCK DIAGRAM



Block Diagram

5. SPECIFICATIONS

5.1. Absolute Maximum Ratings

SYMBOL	PARAMETER	MIN	MAX	UNIT
V _{DD}	Supply voltage range	-	7	V
V _{D1}	DC Voltage at TXD, RXD, VREF and VS	V	V _{DD} + 0.3	V
V _{D2}	DC Voltage at CANH, CANL (Note 1)	-35	+ 35	V
V _T	Transient Voltage on Pins 6 and 7 (Note 2)	-250	- 250	mA
T _{stg}	Storage temperature range	-50	+125	°C
T _{oat}	Operating ambient temperature	-40	+85	°C
T _{Vj}	Virtual Junction Temperature, (Note 3)	-40	+125	°C
T _{stl}	Soldering temperature of leads (10 seconds)	-	+300	°C
V _{ESD1}	ESD protection on CANH and CANL pins (Note 4)	-	4	kV
V _{ESD2}	ESD protection on all other pins (Note 4)	-	4	kV

Note :

- [1] Short-circuit applied when TXD is High and Low.
- [2] In accordance with ISO-7637.
- [3] In accordance with IEC 60747-1.
- [4] Classification A: Human Body Model.

NOTICE:

- [1] Stresses above those listed under “Maximum ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

5.2. DC Characteristics

DC Specifications			Electrical Characteristics: TAMB = -40°C to +85°C VDD = 4.5V to 5.5V			
Param No.	Sym	Characteristic	Min	Max	Units	Conditions
Supply						
D1	IDD	Supply Current	—	75	mA	Dominant; VTXD = 0.8V; VDD
D2			—	10	mA	Recessive; VTXD = +2V; RS = 47 kW
D3			—	500	μA	Standby; (Note 2)
D4	VPORH	High-level of the Power-on Reset comparator	3.8	4.3	V	CANH, CANL outputs are active when VDD > VPORH
D5	VPORL	Low-level of the Power-on Reset comparator	3.4	4.0	V	CANH, CANL outputs are not active when VDD < VPORL
D6	VPORD	Hysteresis of Power-on Reset comparator	0.3	0.8	V	Note 1
Bus Line (CANH; CANL) Transmitter						
D7	$V_{CANH(r)}$; $V_{CANL(r)}$	CANH, CANL Recessive bus voltage	2.0	3.0	V	VTXD = VDD; no load.
D8	$I_{O(CANH)(reces)}$ $I_{O(CANL)(reces)}$	Recessive output current	-2	+2	mA	$-2V < V(CAHL, CANH) < +7V$, $0V < VDD < 5.5V$
D9			-10	+10	mA	$-5V < V(CANL, CANH) < +40V$, $0V < VDD < 5.5V$
D10	$V_{O(CANH)}$	CANH Dominant output voltage	2.75	4.5	V	VTXD = 0.8V
D11	$V_{O(CANL)}$	CANL Dominant output voltage	0.5	2.25	V	VTXD = 0.8V
D12	$V_{DIFF(r)(o)}$	Recessive differential output voltage	-500	+50	mV	VTXD = 2V; no load
D13	$V_{DIFF(d)(o)}$	Dominant differential output voltage	1.5	3.0	V	VTXD = 0.8V; VDD = 5V 40W < RL < 60W (Note 2)
D14	$I_{O(SC)(CANH)}$	CANH short-circuit output current	—	-200	mA	VCANH = -5V
D15			—	-100 (typical)	mA	VCANH = -40V, +40V. (Note 1)
D16	$I_{O(SC)(CANL)}$	CANL short-circuit output current	—	200	mA	VCANL = -40V, +40V. (Note 1)
D17	$V_{DIFF(r)(i)}$	Recessive differential input voltage	-1.0	+0.5	V	$-2V < V(CANL, CANH) < +7V$ (Note 3)
			-1.0	+0.4	V	$-12V < V(CANL, CANH) < +12V$ (Note 3)

Note :

- [1] This parameter is periodically sampled and not 100% tested.
- [2] ITXD = IRXD = IVREF = 0 mA; $0V < V_{CANL} < VDD$; $0V < V_{CANH} < VDD$; VRS = VDD.
- [3] This is valid for the receiver in all modes; High-speed, Slope-control and Standby.

DC Characteristics(Continued)

DC Specifications (Continued)			Electrical Characteristics: T _{AMB} = -40°C to +85°C V _{DD} = 4.5V to 5.5V			
Param No.	Sym	Characteristic	Min	Max	Units	Conditions
Bus Line (CANH; CANL) Receiver: [TXD = 2V; pins 6 and 7 externally driven]						
D18	VDIFF(d)(i)	Dominant differential input voltage	0.9	5.0	V	-2V < V(CANL, CANH) < +7V (Note 3)
			1.0	5.0	V	-12V < V(CANL, CANH) < +12V (Note 3)
D19	VDIFF(h)(i)	Differential input hysteresis	100	200	mV	See Figure 5-3 (Note 1)
D20	R _{IN}	CANH, CANL Commonmode input resistance	5	50	kΩ	
D21	R _{IN} (d)	Deviation between CANH and CANL Commonmode input resistance	-3	+3	%	V _{CANH} = V _{CANL}
Bus Line (CANH; CANL) Receiver: [TXD = 2V; pins 6 and 7 externally driven]						
D22	R _{DIFF}	Differential input resistance	20	100	kΩ	
D24	I _{LI}	CANH, CANL input leakage current	—	150	μA	V _{DD} < V _{POR} ; V _{CANH} = V _{CANL} = +5V
Transmitter Data Input (TXD)						
D25	V _{IH}	High-level input voltage	2.0	V _{DD}	V	Output Recessive
D26	V _{IL}	Low-level input voltage	V _{SS}	+0.8	V	Output Dominant
D27	I _{IH}	High-level input current	-1	+1	μA	V _{TXD} = V _{DD}
D28	I _{IL}	Low-level input current	-100	-400	μA	V _{TXD} = 0V
Receiver Data Output (RXD)						
D31	V _{OH}	High-level output voltage	0.7 V _{DD}	—	V	I _{OH} = 8 mA
D32	V _{OL}	Low-level output voltage	—	0.8	V	I _{OL} = 8 mA
Voltage Reference Output (VREF)						
D33	V _{REF}	Reference output voltage	0.45 V _{DD}	0.55 V _{DD}	V	-50 μA < I _{VREF} < 50 μA
Standby/Slope-Control (RS pin)						
D34	V _{STB}	Input voltage for standby mode	0.75 V _{DD}	—	V	
D35	I _{SLOPE}	Slope-control mode current	-10	-200	μA	
D36	V _{SLOPE}	Slope-control mode voltage	0.4 V _{DD}	0.6 V _{DD}	V	
Thermal Shutdown						
D37	T _{J(sd)}	Shutdown junction temperature	155	180	°C	Note 1
D38	T _{J(h)}	Shutdown temperature hysteresis	20	30	°C	-12V < V(CANL, CANH) < +12V (Note 3)

Note :

- [1] This parameter is periodically sampled and not 100% tested.
- [2] I_{TXD} = I_{RXD} = I_{VREF} = 0 mA; 0V < V_{CANL} < V_{DD}; 0V < V_{CANH} < V_{DD}; V_{RS} = V_{DD}.
- [3] This is valid for the receiver in all modes; High-speed, Slope-control and Standby.

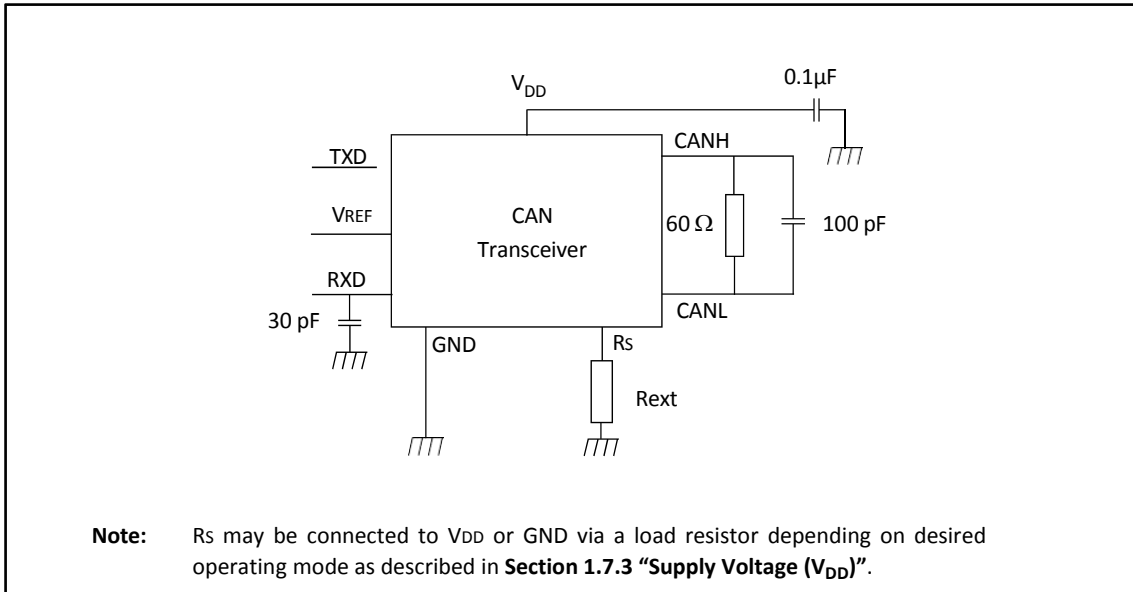


FIGURE 5-1 : TEST CIRCUIT FOR ELECTRICAL CHARACTERISTICS

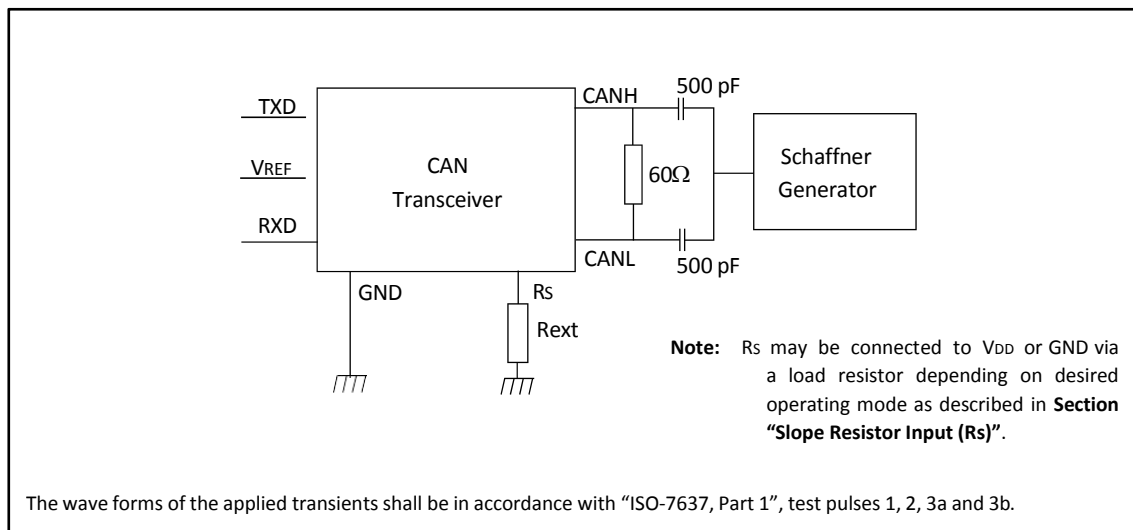


FIGURE 5-2 : TEST CIRCUIT FOR TRANSIENTS

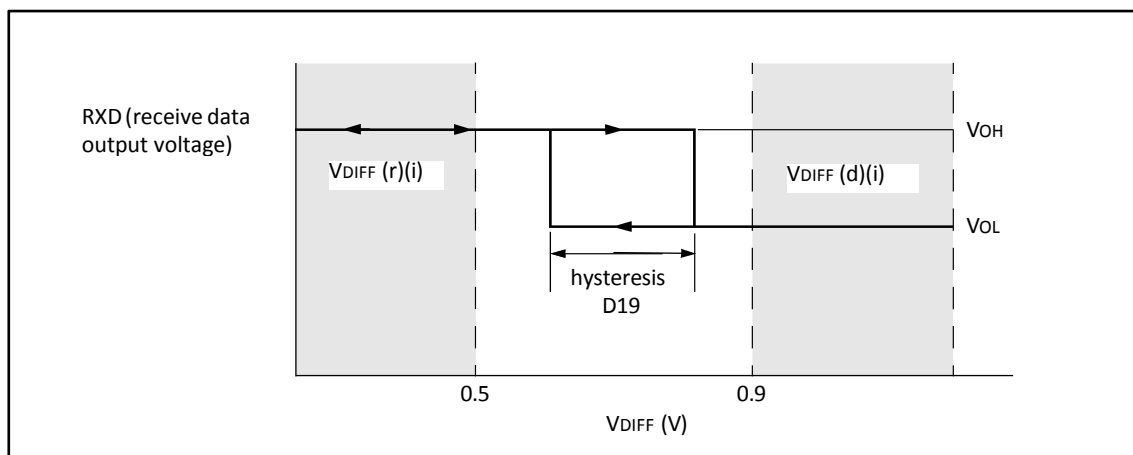


FIGURE 5-3 : HYSTERESIS OF THE RECEIVER

5.3. AC Characteristics

AC Specifications			Electrical Characteristics: Industrial (I): TAMB = -40°C to +85°C VDD = 4.5V to 5.5V			
Param No.	Sym	Characteristic	Min	Max	Units	Conditions
1	tBIT	Bit time	1	62.5	μs	VRS = 0V
2	fBIT	Bit frequency	16	1000	kHz	VRS = 0V
3	TtxH2bus(r)	Delay TXD to bus inactive	—	125	ns	-40°C ≤ TAMB ≤ +85°C, VRS = 0V
4	TtxH2rx(r)	Delay TXD to receiver inactive	—	175	ns	-40°C ≤ TAMB ≤ +85°C, VRS = 0V
			—	225	ns	-40°C ≤ TAMB ≤ +85°C, RS = 47 kΩ
5	SR	CANH, CANL slew rate	5.5	8.5	V/μs	Refer to Figure 5-1 ; RS = 47 kΩ, (Note 1)
6	tWAKE	Wake-up time from standby (Rs pin)	—	5	μs	See Figure 5-5
7	TbusD2rx(s)	Bus Dominant to RXD Low (Standby mode)	—	550	ns	VRS = +4V; (See Figure 5-6)
8	CIN(CANH) CIN(CANL)	CANH; CANL input capacitance	—	20 (typical)	pF	1 Mb/s data rate; VTXD = VDD, (Note 1)
9	CDIFF	Differential input capacitance	—	10 (typical)	pF	1 Mb/s data rate (Note 1)
10	TtxL2busZ	TX Permanent Dominant Timer Disable Time	1.25	4	ms	
11	TtxR2pdt(res)	TX Permanent Dominant Timer Reset Time	—	1	μs	Rising edge on TXD while device is in permanent Dominant state

Note :

[1] This parameter is periodically sampled and not 100% tested.

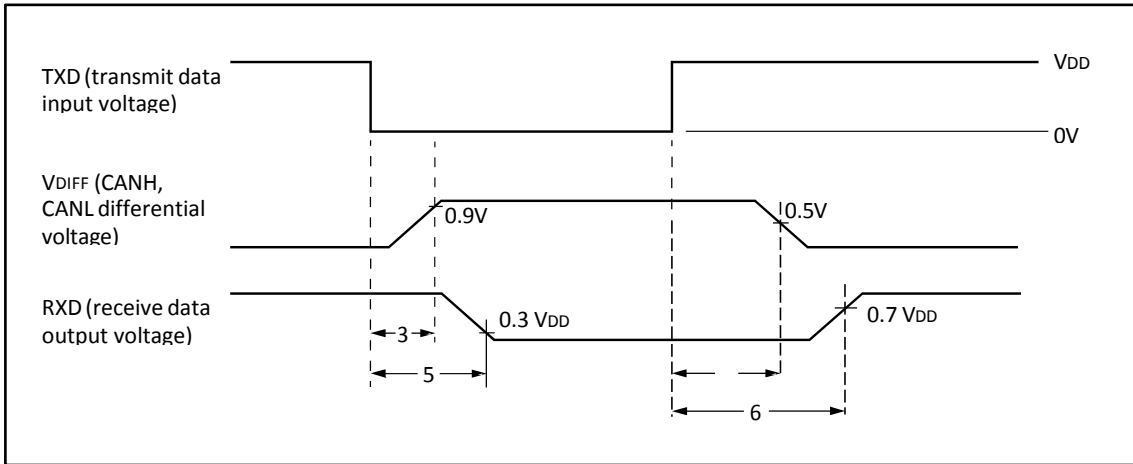


FIGURE 5-4 : TIMING DIAGRAM FOR AC CHARACTERISTICS

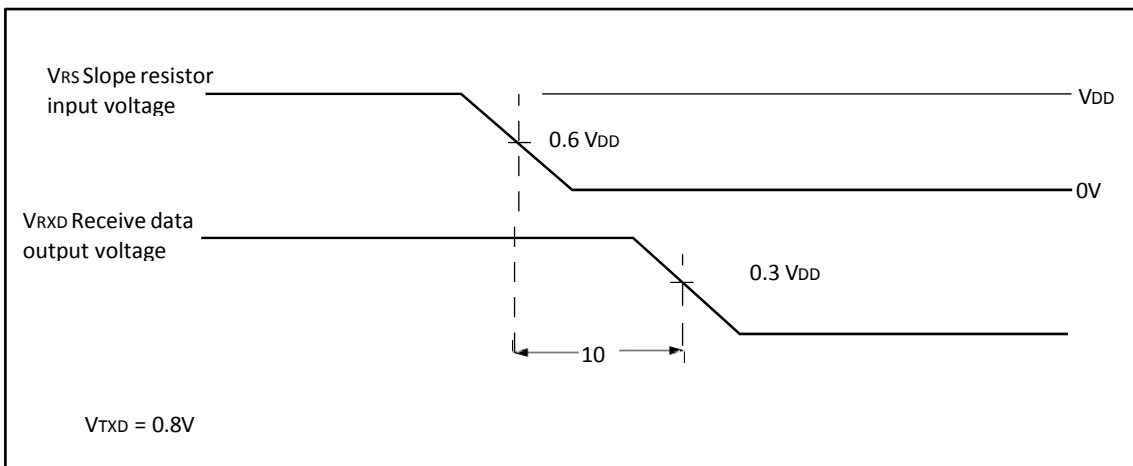


FIGURE 5-5 : TIMING DIAGRAM FOR WAKE-UP FROM STANDBY

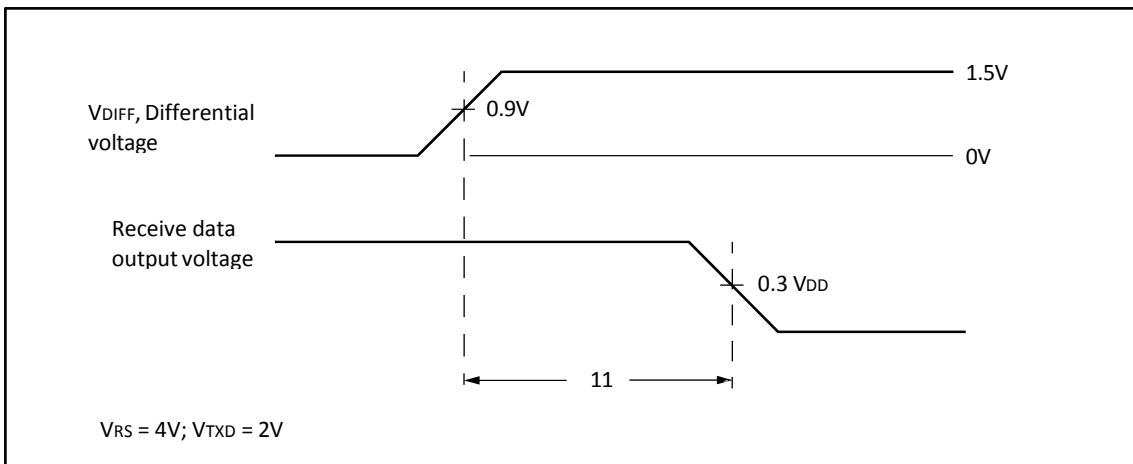


FIGURE 5-6 : TIMING DIAGRAM FOR BUS DOMINANT TO RXD LOW (STANDBY MODE)

6. FUNCTIONAL DESCRIPTION

6.1. Transmitter Function

The CAN bus has two states: Dominant and Recessive. A Dominant state occurs when the differential voltage between CANH and CANL is greater than a defined voltage (e.g., 1.2V). A Recessive state occurs when the differential voltage is less than a defined voltage (typically 0V). The Dominant and Recessive states correspond to the Low and High state of the TXD input pin, respectively. However, a Dominant state initiated by another CAN node will override a Recessive state on the CAN bus.

6.1.1. MAXIMUM NUMBER OF NODES

The XL/XD2551 CAN outputs will drive a minimum load of 45 Ω , allowing a maximum of 80 nodes to be connected (given a minimum differential input resistance of 20 k Ω and a nominal termination resistor value of 120 Ω).

6.2. Receiver Function

The RXD output pin reflects the differential bus voltage between CANH and CANL. The Low and High states of the RXD output pin correspond to the Dominant and Recessive states of the CAN bus, respectively.

6.3. Internal Protection

CANH and CANL are protected against battery short-circuits and electrical transients that can occur on the CAN bus. This feature prevents destruction of the transmitter output stage during such a fault condition.

The device is further protected from excessive current loading by thermal shutdown circuitry that disables the output drivers when the junction temperature exceeds a nominal limit of 165°C. All other parts of the chip remain operational, and the chip temperature is lowered due to the decreased power dissipation in the transmitter outputs. This protection is essential to protect against bus line short-circuit-induced damage.

6.4. Operating Modes

The RS pin allows three modes of operation to be selected:

- High-Speed
- Slope-Control
- Standby

These modes are summarized in Table 6-1.

When in High-Speed or Slope-Control mode, the drivers for the CANH and CANL signals are internally regulated to provide controlled symmetry in order to minimize EMI emissions.

Additionally, the slope of the signal transitions on CANH and CANL can be controlled with a resistor connected from pin 8 (RS) to ground. The slope must be proportional to the current output at RS, which will further reduce EMI emissions.

6.4.1. HIGH-SPEED

High-Speed mode is selected by connecting the RS pin to VSS. In this mode, the transmitter output drivers have fast output rise and fall times to support high-speed CAN bus rates.

6.4.2. SLOPE-CONTROL

Slope-Control mode further reduces EMI by limiting the rise and fall times of CANH and CANL. The slope, or slew rate (SR), is controlled by connecting an external resistor (REXT) between RS and VOL (usually ground). The slope is proportional to the current output at the RS pin. Since the current is primarily determined by the slope-control resistance value REXT, a certain slew rate is achieved by applying a specific resistance. Figure 6-1 illustrates typical slew rate values as a function of the slope-control resistance value.

6.4.3. STANDBY MODE

The device may be placed in Standby or SLEEP mode by applying a high-level to the RS pin. In SLEEP mode, the transmitter is switched off and the receiver operates at a lower current. The receive pin on the controller side (RXD) is still functional, but will operate at a slower rate. The attached microcontroller can monitor RXD for CAN bus activity and place the transceiver into normal operation via the RS pin (at higher bus rates, the first CAN message may be lost).

TABLE 6-1 : MODES OF OPERATION

Mode	Current at R _S Pin	Resulting Voltage at RS Pin
Standby	-IRS < 10 μA	VRS > 0.75 VDD
Slope-Control	10 μA < -IRS < 200 μA	0.4 VDD < VRS < 0.6 VDD
High-Speed	-IRS < 610 μA	0 < VRS < 0.3VDD

TABLE 6-2 : TRANSCEIVER TRUTH TABLE

VDD	VRS	TXD	CANH	CANL	Bus State ⁽¹⁾	RXD ⁽¹⁾
4.5V ≤ VDD ≤ 5.5V	VRS < 0.75 VDD	0	HIGH	LOW	Dominant	0
		1 or floating	Not Driven	Not Driven	Recessive	1
	VRS > 0.75 VDD	X	Not Driven	Not Driven	Recessive	1
VPOR < VDD < 4.5V (See Note 3)	VRS < 0.75 VDD	0	HIGH	LOW	Dominant	0
		1 or floating	Not Driven	Not Driven	Recessive	1
	VRS > 0.75 VDD	X	Not Driven	Not Driven	Recessive	1
0 < VDD < VPOR	X	X	ot Driven/ No Load	ot Driven/ No Load	High Impedance	X

Note :

- [1] If another bus node is transmitting a Dominant bit on the CAN bus, then RXD is a logic '0'.
- [2] X = "don't care".
- [3] Device drivers will function, although outputs are not ensured to meet the ISO-11898 specification.

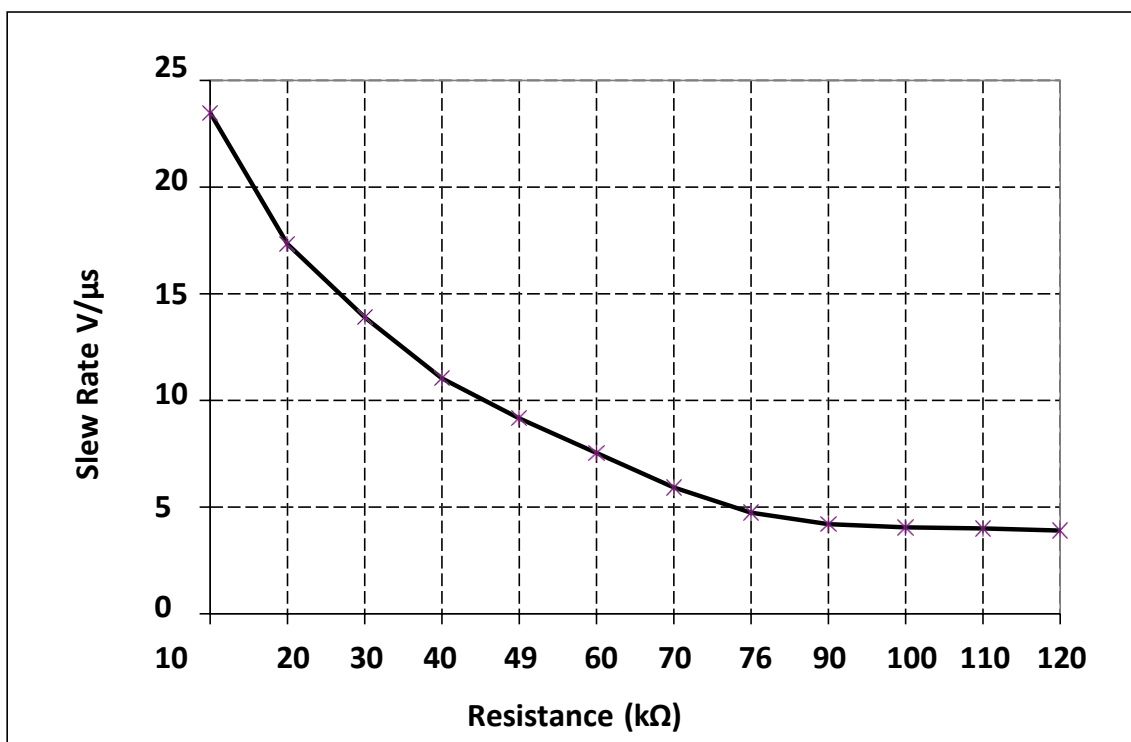


FIGURE 6-1 : SLEW RATE VS. SLOPE-CONTROL RESISTANCE VALUE

6.5. TXD Permanent Dominant Detection

If the XL/XD2551 detects an extended Low state on the TXD input, it will disable the CANH and CANL output drivers in order to prevent the corruption of data on the CAN bus. The drivers are disabled if TXD is Low for more than 1.25 ms (minimum). This implies a maximum bit time of 62.5 μs (16 kb/s bus rate), allowing up to 20 consecutive transmitted Dominant bits during a multiple bit error and error frame scenario. The drivers remain disabled as long as TXD remains Low. A rising edge on TXD will reset the timer logic and enable the CANH and CANL output drivers.

6.6. Power-on Reset

When the device is powered on, CANH and CANL remain in a high-impedance state until VDD reaches the voltage-level VPORH. In addition, CANH and CANL will remain in a high-impedance state if TXD is Low when VDD reaches VPORH. CANH and CANL will become active only after TXD is asserted High. Once powered on, CANH and CANL will enter a high-impedance state if the voltage level at VDD falls below VPORL, providing voltage brown-out protection during normal operation.

6.7. PIN DESCRIPTIONS

6.7.1. TRANSMITTER DATA INPUT (TXD)

TXD is a TTL-compatible input pin. The data on this pin is driven out on the CANH and CANL differential output pins. It is usually connected to the transmitter data output of the CAN controller device. When TXD is Low, CANH and CANL are in the Dominant state. When TXD is High, CANH and CANL are in the Recessive state, provided that another CAN node is not driving the CAN bus with a Dominant state. TXD has an internal pull-up resistor (nominal 25 k Ω to VDD).

6.7.2. GROUND SUPPLY (VSS)

Ground supply pin.

6.7.3. SUPPLY VOLTAGE (VDD)

Positive supply voltage pin.

6.7.4. RECEIVER DATA OUTPUT (RXD)

RXD is a CMOS-compatible output that drives High or Low depending on the differential signals on the CANH and CANL pins and is usually connected to the receiver data input of the CAN controller device. RXD is High when the CAN bus is Recessive and Low in the Dominant state.

6.7.5. REFERENCE VOLTAGE (VREF)

Reference Voltage Output (defined as VDD/2).

6.7.6. CAN LOW (CANL)

The CANL output drives the Low side of the CAN differential bus. This pin is also tied internally to the receive input comparator.

6.7.7. CAN HIGH (CANH)

The CANH output drives the high-side of the CAN differential bus. This pin is also tied internally to the receive input comparator.

6.7.8. SLOPE RESISTOR INPUT (RS)

The R_S pin is used to select High-Speed, Slope-Control or Standby modes via an external biasing resistor.

7. ELECTRICAL CHARACTERISTICS

7.1. Terms and Definitions

A number of terms are defined in ISO-11898 that are used to describe the electrical characteristics of a CAN transceiver device. These terms and definitions are summarized in this section.

7.1.1. BUS VOLTAGE

VCANL and VCANH denote the voltages of the bus line wires CANL and CANH relative to ground of each individual CAN node.

7.1.2. COMMON MODE BUS VOLTAGE RANGE

Boundary voltage levels of VCANL and VCANH with respect to ground, for which proper operation will occur, if up to the maximum number of CAN nodes are connected to the bus.

7.1.3. DIFFERENTIAL INTERNAL CAPACITANCE, C_{DIFF} (OF A CAN NODE)

Capacitance seen between CANL and CANH during the Recessive state when the CAN node is disconnected from the bus (see Figure 7-1).

7.1.4. DIFFERENTIAL INTERNAL RESISTANCE, R_{DIFF} (OF A CAN NODE)

Resistance seen between CANL and CANH during the Recessive state when the CAN node is disconnected from the bus (see Figure 7-1).

7.1.5. DIFFERENTIAL VOLTAGE, V_{DIFF} (OF CAN BUS)

Differential voltage of the two-wire CAN bus, value $V_{DIFF} = V_{CANH} - V_{CANL}$.

7.1.6. INTERNAL CAPACITANCE, C_{IN} (OF A CAN NODE)

Capacitance seen between CANL (or CANH) and ground during the Recessive state when the CAN node is disconnected from the bus (see Figure 7-1).

7.1.7. INTERNAL RESISTANCE, R_{IN} (OF A CAN NODE)

Resistance seen between CANL (or CANH) and ground during the Recessive state when the CAN node is disconnected from the bus (see Figure 7-1).

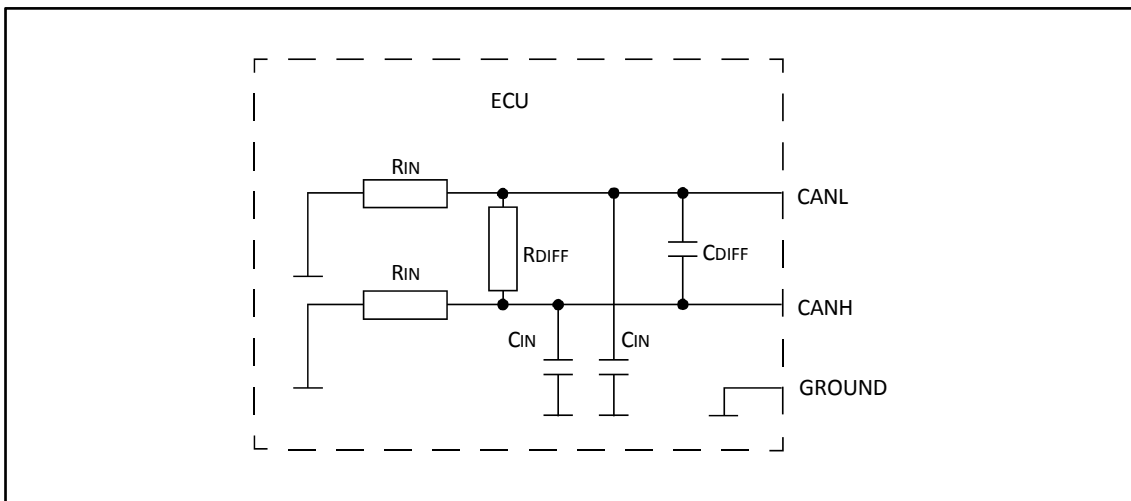


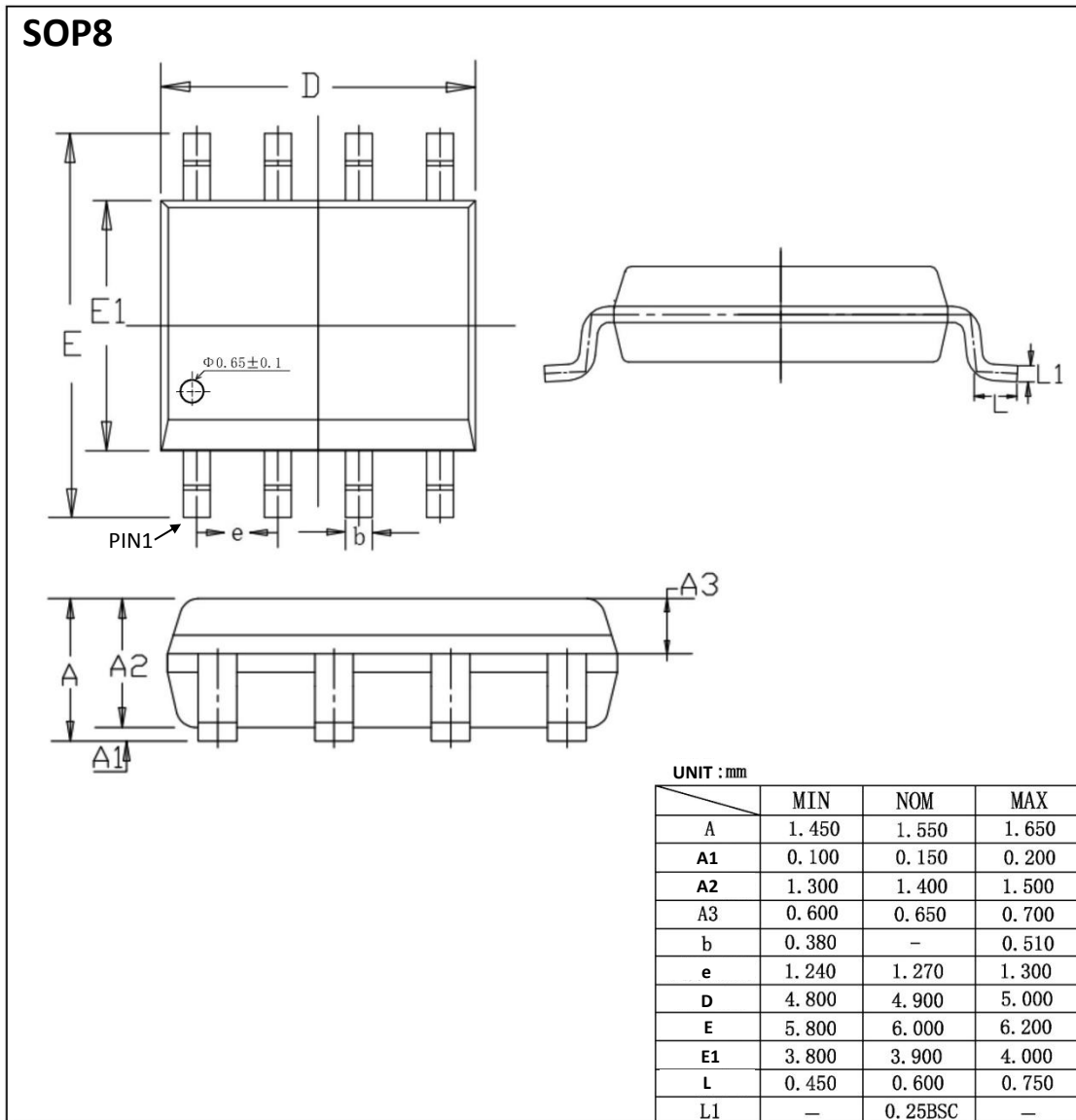
FIGURE 7-1 : PHYSICAL LAYER DEFINITIONS

8. ORDERING INFORMATION

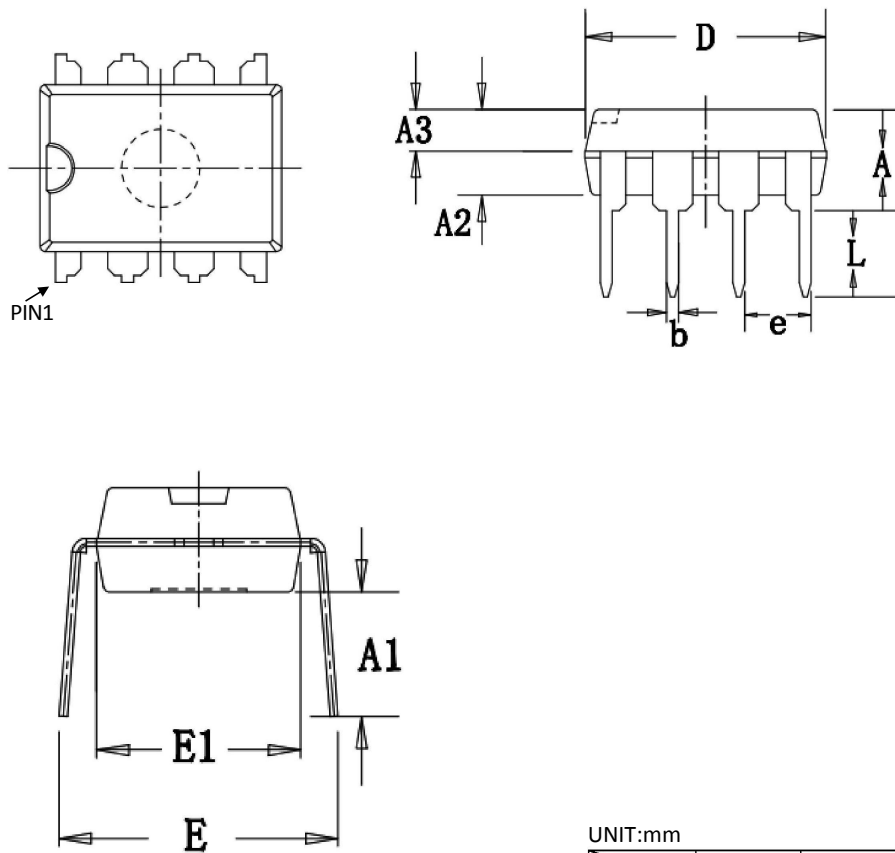
Ordering Information

Part Number	Device Marking	Package Type	Body size (mm)	Temperature (°C)	MSL	Transport Media	Package Quantity
XL2551	XL2551	SOP8	4.90 * 3.90	-40 to +85	MSL3	T&R	2500
XD2551	XD2551	DIP8	9.25 * 6.38	-40 to +85	MSL3	Tube 50	2000

9. DIMENSIONAL DRAWINGS



DIP8



UNIT:mm

	MIN	NOM	MAX
A	3.600	3.800	4.000
A1	3.786	3.886	3.986
A2	3.200	3.300	3.400
A3	1.550	1.600	1.650
b	0.440	—	0.490
e	2.510	2.540	2.570
D	9.150	9.250	9.350
E	7.800	8.500	9.200
E1	6.280	6.380	6.480
L	3.000	—	—