SL65HVD233

3.3V, Diagnostic Loopback, High Speed CAN Transceiver

FEATURES

➢ Operates with a single 3.3V supply

➢ Compatible with ISO 11898-2 standard

➢ Bus pin ESD protection exceeds ±12kV HBM

➢ High input impedance allows for up to 120 nodes

➢ Adjustable driver transition times for improved emissions performance

➢ Low current standby mode: 650μA typical

➢ Designed for data rates up to 1Mbps

➢ Thermal shutdown protection

➢ Open circuit fail-safe design

➢ Glitch free power up and power down protection for hot plugging applications
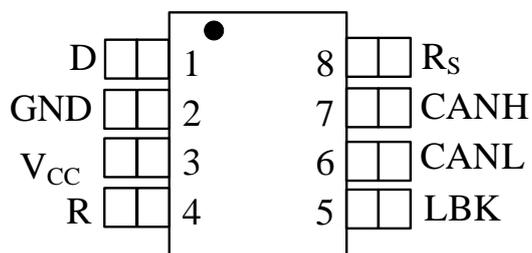
PRODUCT APPERANCE
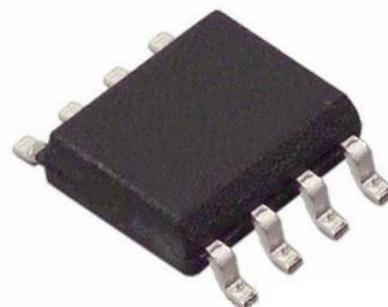
Provide green and environmentally friendly lead-free package

DESCRIPTION

The SL65HVD233 is the interface between the Controller Area Network (CAN) protocol controller and the physical bus. It is designed for use with the 3.3V μPs, MCUs and DSPs with CAN controllers, or with equivalent protocol controller devices. It is used in industrial automation, control, sensors and drive systems, motor and robotic control, building and climate control (HVAC), telecom and base station control and status. The devices are intended for use in applications employing the CAN serial communication physical layer in accordance with the ISO 11898 standard.

PARAMETER	SYMBOL	CONDITION	MIN.	MAX.	UNIT
Supply voltage	V_{cc}		3	3.6	V
Maximum transmission rate	$1/t_{bit}$	Non-return to zero code	1		Mbaud
CANH, CANL input or output voltage	V_{can}		-36	+36	V
Bus differential voltage	V_{diff}		1.5	3.0	V
Virtual junction temperature	T_j		-40	125	°C

PIN CONFIGURATION

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          ┌──●──────────┐
   D  ──┤ 1          8 ├──  R_S
  GND ──┤ 2          7 ├──  CANH
  V_CC ─┤ 3          6 ├──  CANL
   R  ──┤ 4          5 ├──  LBK
          └─────────────┘
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PINNING

PIN	SYMBOL	DESCRIPTION
1	D	CAN transmit data input (LOW for dominant and HIGH for recessive bus states), also called TXD, driver input.
2	GND	Ground.
3	VCC	Transceiver 3.3V supply voltage.
4	R	CAN receive data output (LOW for dominant and HIGH for recessive bus states), also called RXD, receiver output.
5	LBK	Loopback mode input pin
6	CANL	Low level CAN bus line.
7	CANH	High level CAN bus line.
8	R_S	Mode select pin: strong pull down to GND=high speed mode, strong pull up to V_{CC}=low power mode,10kΩ to 100kΩ pull down to GND=slope control mode.

LIMITING VALUES

PARAMETER	SYMBOL	VALUE	UNIT
Supply voltage	V_{CC}	-0.3~+6	V
DC voltage on D/R pins	D, R	-0.5~VCC+0.5	V
Voltage range at any bus terminal (CANH, CANL)	CANL, CANH	-36~36	V
Transient voltage on pins CANH, CANL (test with 100Ω) See Fig 10	V_{tr}	-40~+40	V
Receiver output current	I_O	-11~11	mA
Storage temperature	T_{stg}	-40~150	°C
Virtual junction temperature	T_j	-40~125	°C
Welding temperature range		300	°C

The maximum limit parameters mean that exceeding these values may cause irreversible damage to the device. Under these conditions, it is not conducive to the normal operation of the device. The continuous operation of the device at the maximum allowable rating may affect the reliability of the device. The reference point for all voltages is ground.

DRIVER ELECTRICAL DC CHARACTERISTICS

SYMBOL	PARAMETER		CONDITION	MIN.	TYP.	MAX.	UNIT
$V_{O(D)}$	output voltage (Dominant)	CANH	VI=0V, R_S=0V, R_L=60Ω (Fig1, Fig 2)	2.45		VCC	V
		CANL		0.5		1.25	
$V_{OD(D)}$	Differential output voltage (Dominant)		VI=0V, R_S=0V, R_L=60Ω (Fig 1)	1.5	2	3	V
			VI=0V, R_L=60Ω, R_S =0V (Fig 3)	1.2	2	3	V
$V_{O(R)}$	output voltage (Recessive)	CANH	VI=3V, R_S=0V, R_L=60Ω (Fig 1)		2.3		V
		CANL			2.3		
$V_{OD(R)}$	Differential output voltage (Recessive)		VI=3V, R_S=0V	-0.12		0.012	V
			VI=3V, R_S=0V, No load	-0.5		0.05	V
I_{IH}	High-level input current		VI=2V	-30		30	μA
I_{IL}	Low-level input current		VI=0.8V	-30		30	μA
I_{OS}	Short-circuit output current		CANH=-7V	-250			mA
			CANH=12V			1	
			CANL=-7V	-1			
			CANL=12V			250	
C_O	Output capacitance		See receiver				
I_{CC}	Supply current		Standby		650	950	μA
			V_I=0V (Dominant), No load			6	mA
			V_I=VCC (Recessive), No load			6	mA

(If not otherwise specified, V_{CC}=3.3V±10%, Temp=T_{MIN}~T_{MAX}, Typical: VCC=+3.3V, Temp=25°C)

DRIVER SWITCHING CHARACTERISTICS

SYMBOL	PARAMETER	CONDITION	MIN.	TYP.	MAX.	UNIT
t_{PLH}	Propagation delay time（low-to-high-level ）	R=0, Short circuit (Fig 4)		35	85	ns
		R=10kΩ		70	125	
		R=100kΩ		500	870	

SYMBOL	PARAMETER	CONDITION	MIN.	TYP.	MAX.	UNIT
t_{PHL}	Propagation delay time（high-to-low-level）	R=0, Short circuit (Fig 4)		70	120	ns
		R=10kΩ		130	180	
		R=100kΩ		870	1200	
$t_{sk(p)}$	Pulse skew （| t_{PLH} - t_{PHL} |）	R=0, Short circuit (Fig 4)		35		ns
		R=10kΩ		60		
		R=100kΩ		370		
t_r	Differential output signal rise time	R=0, Short circuit (Fig 4)	20		80	ns
		R=10kΩ	30		160	
		R=100kΩ	300		1400	
t_f	Differential output signal fall time	R=0, Short circuit (Fig 4)	20		80	ns
		R=10kΩ	30		160	
		R=100kΩ	300		1400	

(If not otherwise specified, V_{CC}=3.3V±10%, Temp=T_{MIN}~T_{MAX}, Typical: VCC=+3.3V, Temp=25℃)

RECEIVER ELECTRICAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITION	MIN.	TYP.	MAX.	UNIT
V_{IT+}	Positive-going input threshold voltage	Table 1		750	900	mV
V_{IT-}	Negative-going input threshold voltage	Table 1	500	650		mV
V_{hys}	Hysteresis voltage	VIT+- VIT-		100		mV
V_{OH}	High-level output voltage	-6V<V_{ID}<500mV I_O=-8mA (Fig5)	2.4			V
V_{OL}	Low-level output voltage	900mV<V_{ID}<6V I_O=8mA (Fig5)			0.4	V
I_i	Bus input current	VIH=12V, VCC=0V	100		600	μA
I_i		VIH=12V, VCC=3.3V	100		500	μA
I_i		VIH=-7V, VCC=0V	-450		-20	μA
I_i		VIH=-7V, VCC=3.3V	-610		-30	μA
R_i	Bus input resistance	Corresponding standards of ISO 11898-2	20	35	50	kΩ

SYMBOL	PARAMETER	CONDITION	MIN.	TYP.	MAX.	UNIT
R_{diff}	Differential input resistance	Corresponding standards of ISO 11898-2	40		100	kΩ
C_i	Bus input capacitance	Corresponding standards of ISO 11898-2		40		pF
C_{diff}	Differential input capacitance	Corresponding standards of ISO 11898-2		20		pF

(If not otherwise specified, V_{CC}=3.3V±10%, Temp=T_{MIN}~T_{MAX}, Typical: VCC=+3.3V, Temp=25°C)

RECEIVER SWITCHING CHARACTERISTICS

SYMBOL	PARAMETER	CONDITION	MIN.	TYP.	MAX.	UNIT
t_{PLH}	Propagation delay time (low-to-high-level)	Fig 6		35	60	ns
t_{PHL}	Propagation delay time (high-to-low-level)	Fig 6		35	60	ns
t_{sk}	Pulse skew	$\| t_{PHL} - t_{PLH} \|$			10	ns
t_r	Output signal rise time	Fig 6		1.5		ns
t_f	Output signal fall time	Fig 6		1.5		ns

(If not otherwise specified, V_{CC}=3.3V±10%, Temp=T_{MIN}~T_{MAX}, Typical: VCC=+3.3V, Temp=25°C)

DEVICE SWITCHING CHARACTERISTICS

SYMBOL	PARAMETER	CONDITION	MIN.	TYP.	MAX.	UNIT
$t_{(LOOP1)}$	Total loop delay, driver input to receiver output, recessive to dominant	R=0, Short circuit (Fig 8)		70	135	ns
		R=10 kΩ		105	190	
		R=100 kΩ		535	1000	
$t_{(LOOP2)}$	Total loop delay, driver input to receiver output, dominant to recessive	R=0, Short circuit (Fig 8)		70	165	ns
		R=10 kΩ		105	190	
		R=100 kΩ		535	1000	
$t_{(LBK)}$	Lookback delay, driver input to receiver output	Fig 9		7.5	12	ns

(If not otherwise specified, V_{CC}=3.3V±10%, Temp=T_{MIN}~T_{MAX}, Typical: VCC=+3.3V, Temp=25°C)

OVER TEMPERATURE PROTECTION

SYMBOL	PARAMETER	CONDITION	MIN.	TYP.	MAX.	UNIT
$T_{j(sd)}$	Thermal shutdown temperature		155	165	180	°C

(If not otherwise specified, V_{CC}=3.3V±10%, Temp=T_{MIN}~T_{MAX}, Typical: VCC=+3.3V, Temp=25°C)

CONTROL-PIN CHARACTERISTICS

SYMBOL	PARAMETER	CONDITION	MIN.	TYP.	MAX.	UNIT
T_{WAKE}	wake-up time from standby mode	R_S adds square wave （Fig7）		0.55	1.5	μs
I_{RS}	Input current for high-speed	V_{RS}<1V	-450		0	μA
V_{RS}	Input voltage for standby/sleep	0<V_{RS}<V_{CC}	0.75V_{CC}		V_{CC}	V
I_{off}	Power-off leakage current	V_{CC}=0V, V_{CANH}=V_{CANL}=5V	-250		250	μA

(If not otherwise specified, V_{CC}=3.3V±10%, Temp=T_{MIN}~T_{MAX}, Typical: VCC=+3.3V, Temp=25°C)

SUPPLY CURRENT

SYMBOL	PARAMETER	CONDITION	MIN.	TYP.	MAX.	UNIT
I_{CC}	Power consumption in standby mode	R_S=VCC, V_I=VCC		650	950	μA
I_{CC}	Dominant power consumption	V_I=0V, R_S=0V, LOAD=60Ω		50	70	mA
I_{CC}	Recessive power consumption	V_I=VCC, R_S=0V, No load			6	mA

(If not otherwise specified, V_{CC}=3.3V±10%, Temp=T_{MIN}~T_{MAX}, Typical: VCC=+3.3V, Temp=25°C)

FUNCTION TABLE

Table 1 Receiver characteristics in common mode（$V_{(RS)}$=1.2V）

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

(1) H=High level; L=Low level; X=Irrelevant.

Table2.Driver Function

INPUTS			OUTPUTS		
D	LBK	R_S	CANH	CANL	BUS STATE
X	X	>0.75V_{CC}	Z	Z	Recessive
L	L or Open	<0.33V_{CC}	H	L	Dominant
H or Open	X		Z	Z	Recessive
X	H	0.33V_{CC}	Z	Z	Recessive

(1) H= High level; L=Low level; Z=High impedance.

Table3. Receiver Function

INPUTS				OUTPUT
BUS STATE	VID=CANH-CANL	LBK	D	R
Dominant	$V_{ID}\geq0.9V$	L or open	X	L
Recessive	$V_{ID}\leq0.5V$ or open	L or open	H or Open	H
?	0.5<V_{ID}<0.9V	L or open	H or Open	?
X	X	H	L	L
X	X	H	H	H

(1) H=High level; L=Low level; ?=uncertain; X=Irrelevant.
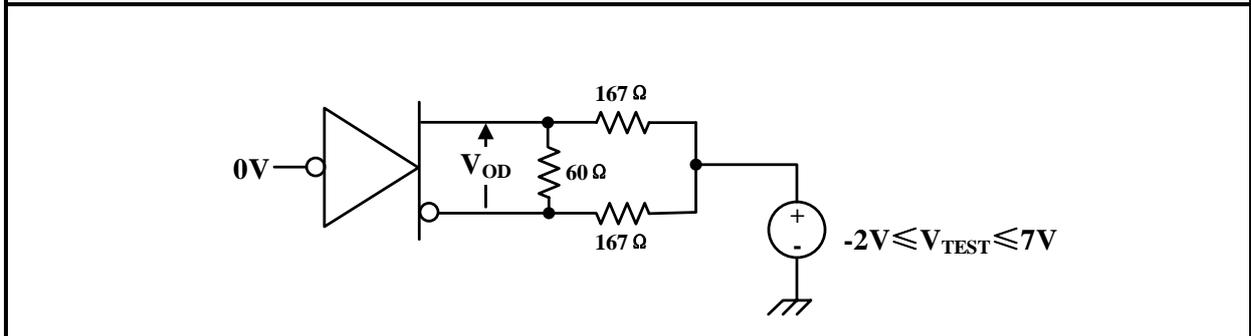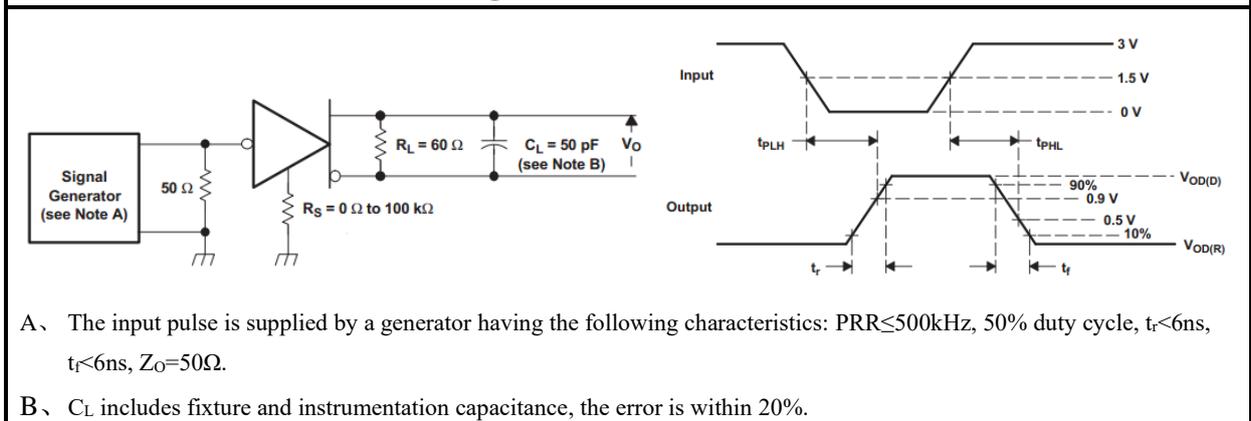
TEST CIRCUIT
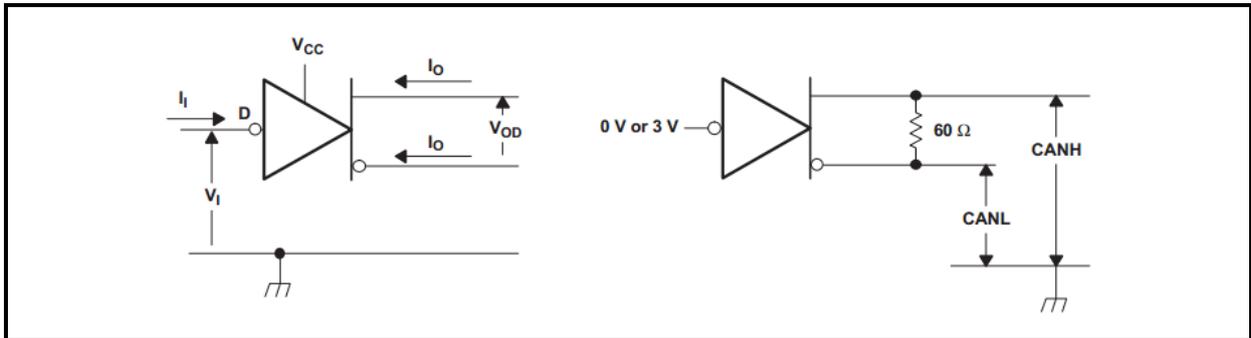
Fig.1 Driver voltage, current and test definition
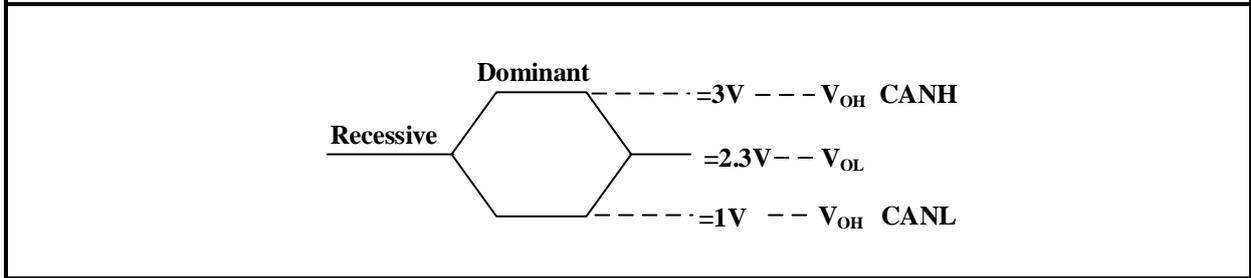
Fig.2 Bus logic state voltage definitions

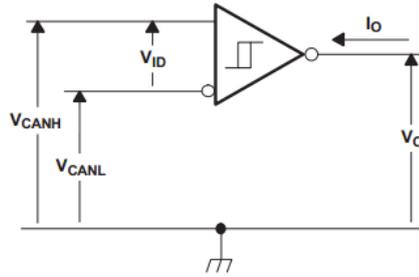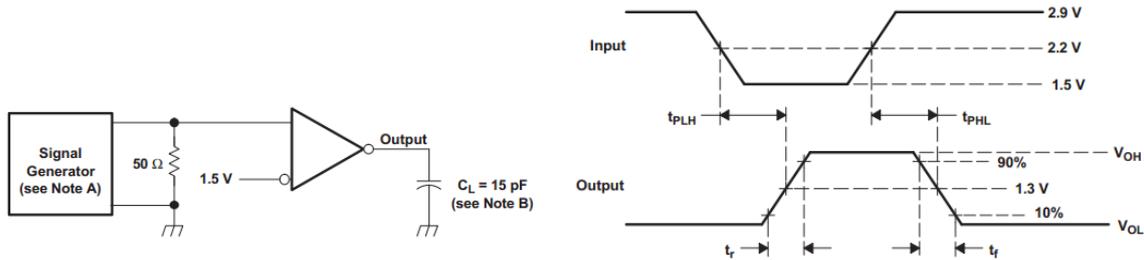**Fig.3 Driver V$_{OD}$ test circuit**

A、 The input pulse is supplied by a generator having the following characteristics: PRR≤500kHz, 50% duty cycle, t$_r$<6ns, t$_f$<6ns, Z$_O$=50Ω.

B、 C$_L$ includes fixture and instrumentation capacitance, the error is within 20%.

Fig.4 Driver test circuit and waveforms

Fig.5 Receiver voltage and current definitions

$$V_{IC} = \frac{V_{CANH} + V_{CANL}}{2}$$

A、 The input pulse is supplied by a generator having the following characteristics: PRR≤500kHz, 50% duty cycle, t_r<6ns, t_f<6ns, Zo=50Ω

B、 C_L includes fixture and instrumentation capacitance, the error is within 20%.
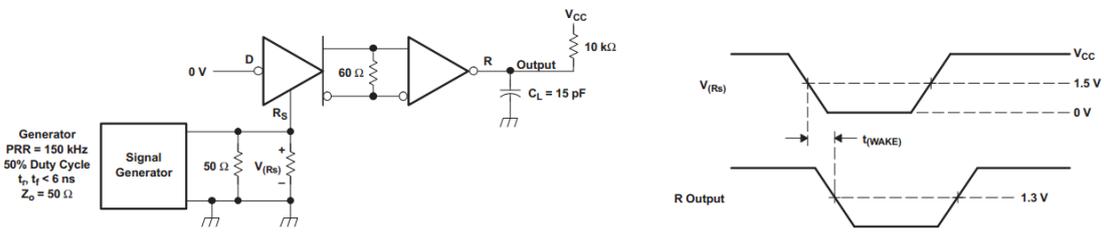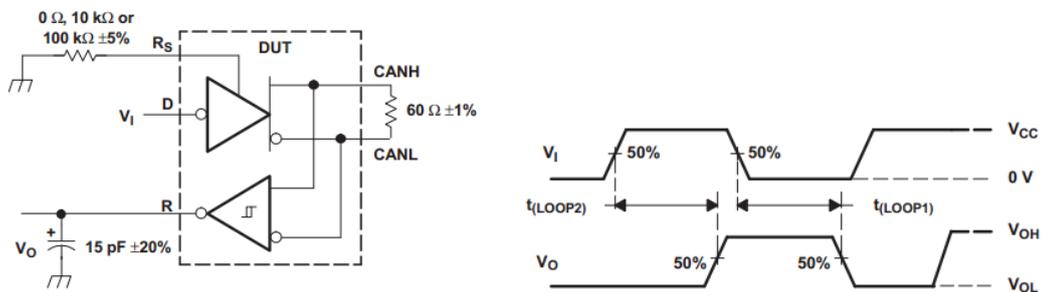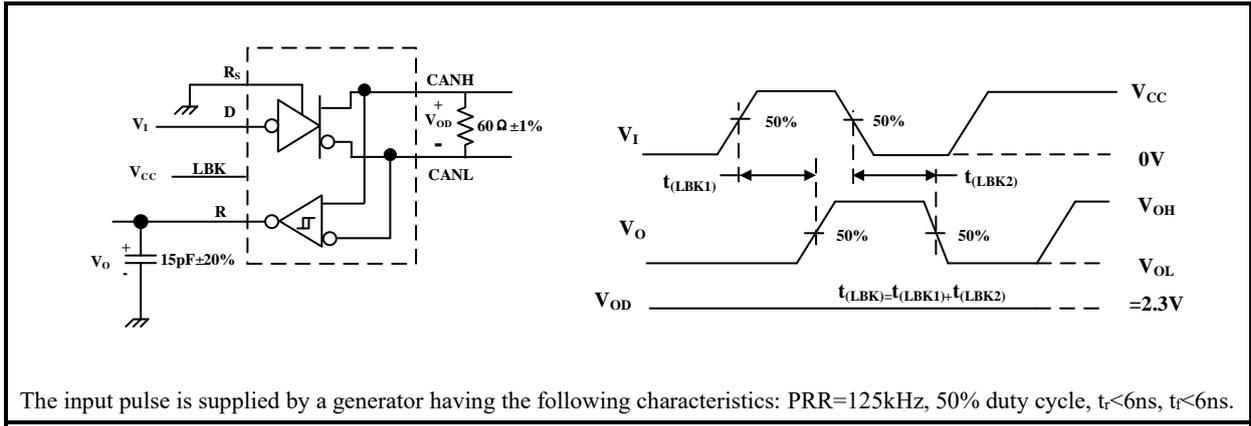
Fig.6 Receiver test circuit and waveform


Fig.7 t(WAKE) test circuit and waveform

The input pulse is supplied by a generator having the following characteristics: PRR≤125kHz, 50% duty cycle, t_r<6ns, t_f<6ns, Zo=50Ω.

Fig.8 t(LOOP) test circuit and waveform

The input pulse is supplied by a generator having the following characteristics: PRR=125kHz, 50% duty cycle, t$_r$<6ns, t$_f$<6ns.

Fig.9 t$_{(LBK)}$ test circuit and waveform

A, D, RS, LBK input state is 0 or V$_{CC}$.
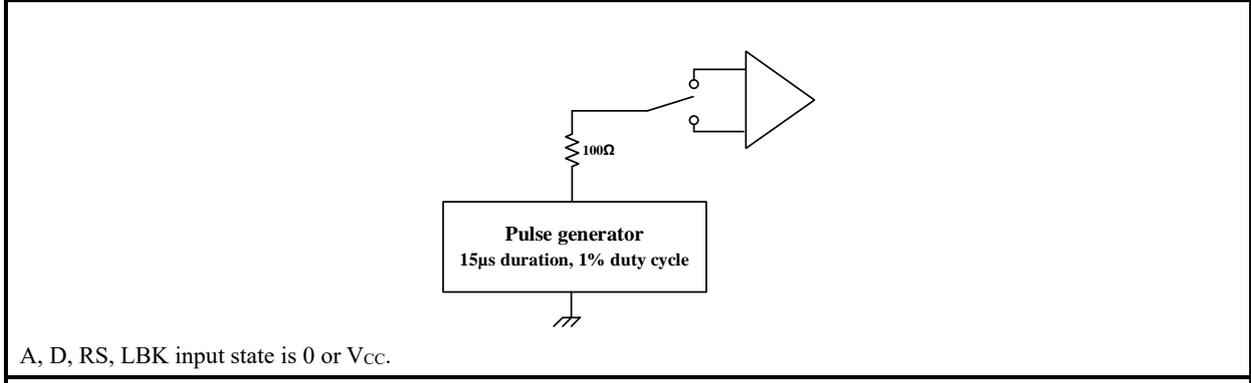
Fig.10 Overvoltage protection

ADDITIONAL DESCRIPTION

1 Sketch

The SL65HVD233 is the interface between the Controller Area Network (CAN) protocol controller and the physical bus. It is designed for use with the 3.3V µPs, MCUs and DSPs with CAN controllers, or with equivalent protocol controller devices. It is used in industrial automation, control, sensors and drive systems, motor and robotic control, building and climate control (HVAC), telecom and base station control and status. It supports programmable data rates up to 1 Mbps. The devices are intended for use in applications employing the CAN serial communication physical layer in accordance with the ISO 11898 standard.

2 Current protection

A current-limiting circuit protects the transmitter output stage from damage caused by accidental short-circuit to either positive or negative supply voltage, although power dissipation increases during this fault condition.

3 Over temperature protection

SL65HVD233 has the function of over temperature protection. After the over temperature protection is triggered, the current of the driving stage will be reduced, because the driving tube is the main energy consuming part. The current reduction can reduce the power consumption and thus reduce the chip temperature. At the same time, other parts of the chip still work normally.

4 Transient protection

Electrical transients often occur in automotive application environment, CANH, CANL of SL65HVD233 have the function of preventing electrical transient damage.

5 Operating modes

The R_S pin mode, slop (pin 8) of the SL65HVD233 provides three different modes of operation: high-speed mode, slope-control mode, and low-power mode.

5.1 High-Speed Mode

The high-speed mode can be selected by applying a logic low to the R_S pin (pin 8). The high-speed mode of operation is commonly employed in industrial applications. High-speed allows the output to switch as fast as possible with no internal limitation on the output rise and fall slopes. If the high-speed transitions are a concern for emissions performance slope control mode can be used.

If both high-speed mode and the low-power standby mode is to be used in the application, direct connection to a µP, MCU or DSP general purpose output pin can be used to switch between a logic-low level (<1.2V) for high-speed operation, and the logic-high level (>0.75VCC) for standby.

5.2 Slope Control Mode

Electromagnetic compatibility is essential in many applications while still making use of unshielded twisted pair bus cable to reduce system cost. Slope control mode was added to the SL65HVD233 devices to reduce the electromagnetic interference produced by the rise and fall times of the driver and resulting harmonics. These rise and fall slopes of the driver outputs can be adjusted by connecting a resistor from R_S (pin 8) to ground or to a logic low voltage. The slope of the driver output signal is proportional to the pin's output current. This slope control is implemented with an external resistor value of 10kΩ to 100kΩ to achieve slew rate.
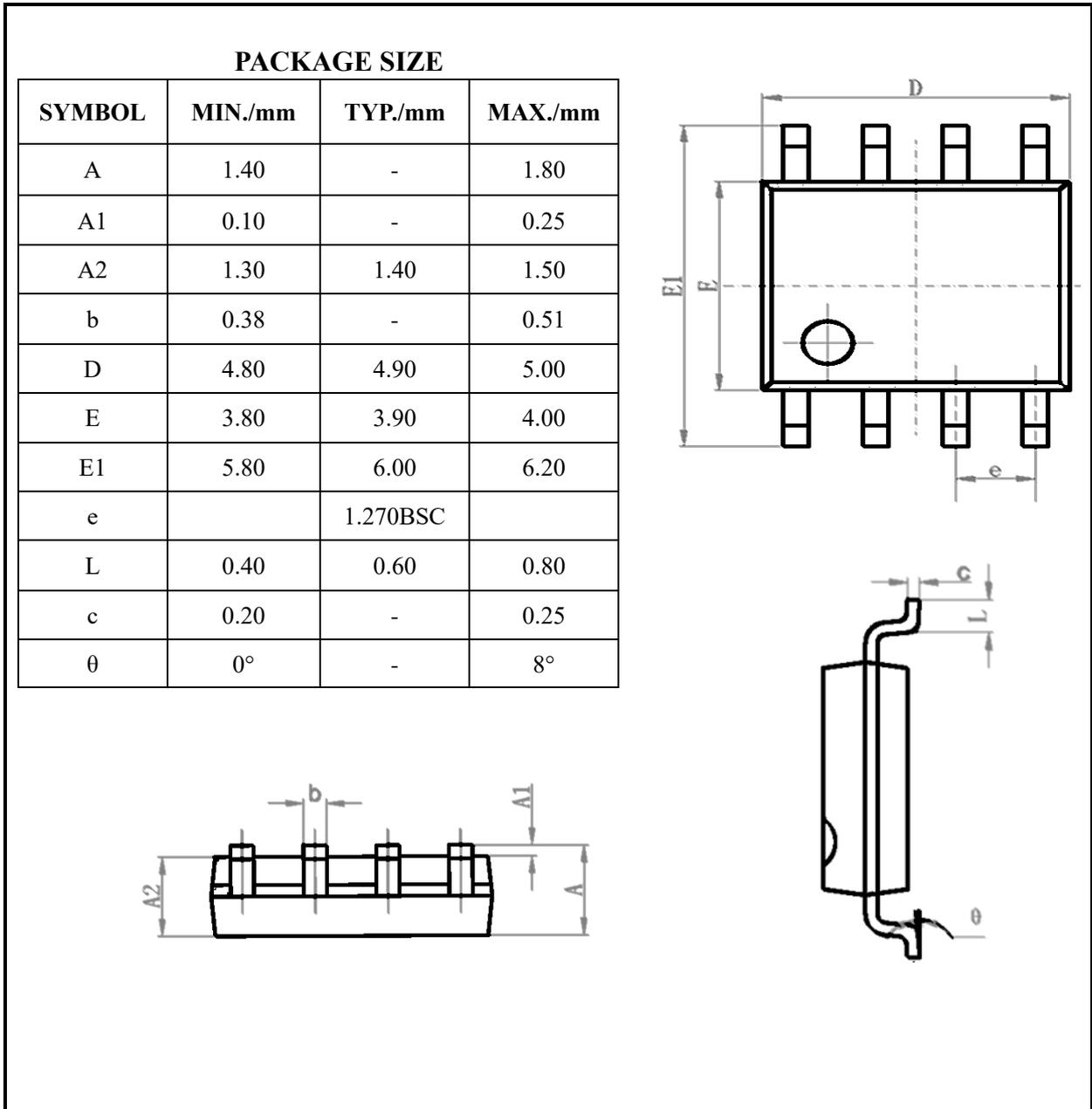
5.3 Standby Mode (Listen Only Mode)

If a logic high (>0.75VCC) is applied to R_S (pin 8), the circuit of the SL65HVD233 enters a low-current, listen only standby mode, during which the driver is switched off and the receiver remains active. In this listen only state, the transceiver is completely passive to the bus. It makes no difference if a slope control resistor is in place. The µP can reverse this low-power standby mode when the rising edge of a dominant state (bus differential voltage >900mV typical) occurs on the bus. The µP, sensing bus activity, reactivates the driver circuit by placing a logic low (<1.2V) on R_S (pin 8).

6 Diagnostic loopback function

The diagnostic loopback or internal loopback function of the SL65HVD233 is enabled with a high-level input on pin 5, LBK. This mode disables the driver output while keeping the bus pins biased to the recessive state. This mode also redirects the D data input (transmit data) through logic to the received data output pin, thus creating an internal loopback of the transmit to receive data path. This mimics the loopback that occurs normally with a CAN transceiver because the receiver loops back the driven output to the R (receive data) pin. This mode allows the host protocol controller to input and read back a bit sequence or CAN messages to perform diagnostic routines without disturbing the CAN bus.

If the LBK pin is not used it may be tied to ground (GND). However, it is pulled low internally (defaults to a low-level input) and may be left open if not in use.

SOP8 DIMENSIONS

PACKAGE SIZE

SYMBOL	MIN./mm	TYP./mm	MAX./mm
A	1.40	-	1.80
A1	0.10	-	0.25
A2	1.30	1.40	1.50
b	0.38	-	0.51
D	4.80	4.90	5.00
E	3.80	3.90	4.00
E1	5.80	6.00	6.20
e		1.270BSC	
L	0.40	0.60	0.80
c	0.20	-	0.25
θ	0°	-	8°

DIP8 DIMENSIONS

PACKAGE SIZE

SYMBOL	MIN./mm	TYP./mm	MAX./mm
A	9.00	9.20	9.40
A1	0.33	0.45	0.51
A2	2.54TYP		
A3	1.525TYP		
B	8.40	8.70	9.10
B1	6.20	6.40	6.60
B2	7.32	7.62	7.92
C	3.20	3.40	3.60
C1	0.50	0.60	0.80
C2	3.71	4.00	4.31
D	0.20	0.28	0.36
L	3.00	3.30	3.60
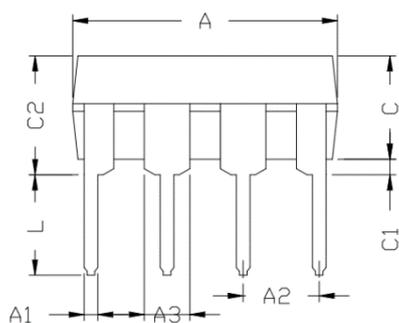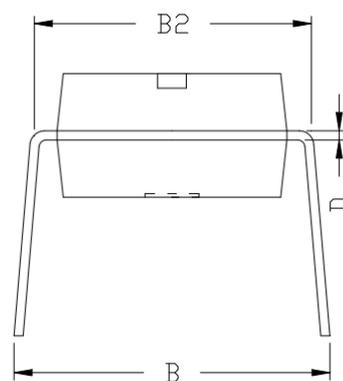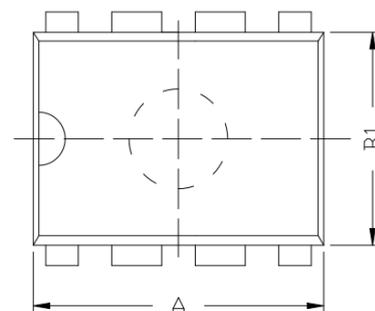
ORDERING INFORMATION

TYPE NUMBER	PACKAGE	PACKING
SL65HVD233DR	SOP8	Tape and reel
SL65HVD233P	DIP8	Tube

SOP8 is packed with 2500 pieces/disc in braided packaging. DIP8 is packed with 50 pieces/tube in tube packaging.

REFLOW SOLDERING
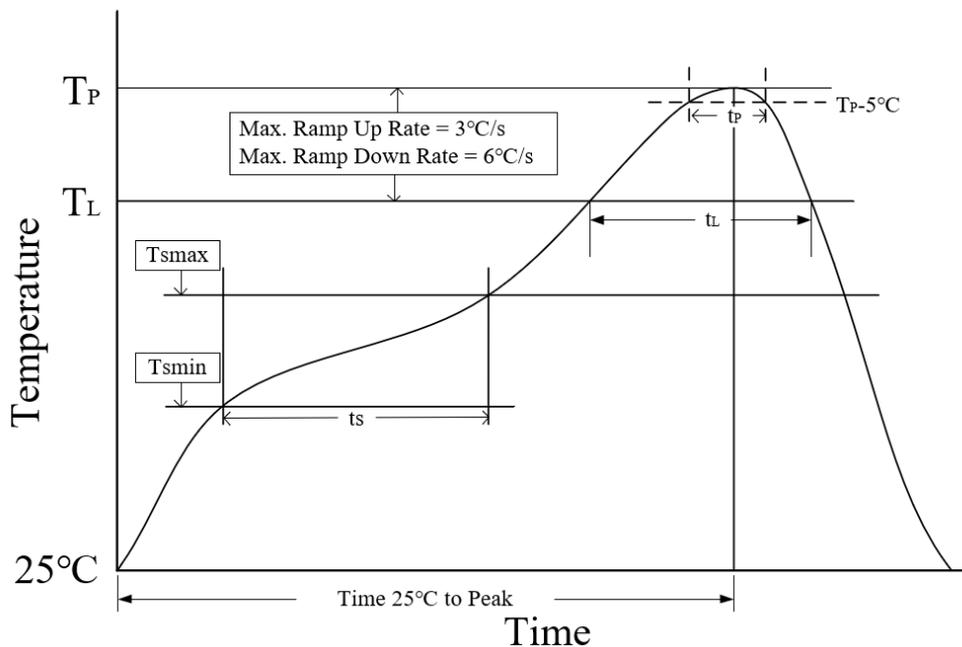
Parameter	Lead-free soldering conditions
Ave ramp up rate (T_L to T_P)	3°C/second max
Preheat time ts (T_{smin}=150°C to T_{smax}=200°C)	60-120 seconds
Melting time t_L (T_L=217°C)	60-150 seconds
Peak temp T_P	260-265°C
5°C below peak temperature t_P	30 seconds
Ave cooling rate (T_P to T_L)	6°C/second max
Normal temperature 25°C to peak temperature T_P time	8 minutes max