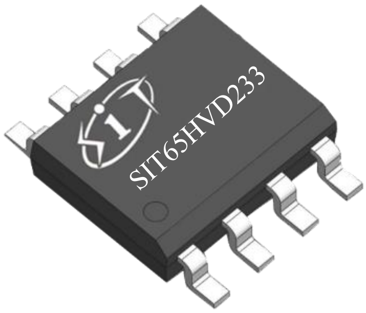
## FEATURES

- 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



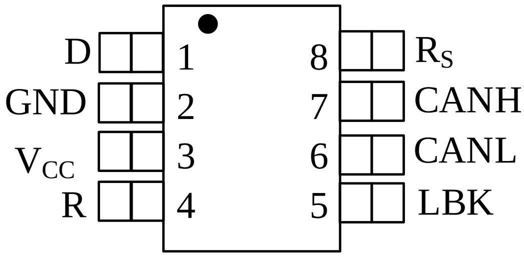

Provide green and environmentally friendly lead-free package

## DESCRIPTION

The SIT65HVD233 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 | ℃ |

## PIN CONFIGURATION




## 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 | ℃ |
| Virtual junction temperature | $T_j$ | -40~125 | ℃ |
| Welding temperature range | | 300 | ℃ |

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℃)

## 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 | ℃ |

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

## 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<$V_{RS}$<$V_{CC}$ | 0.75$V_{CC}$ | | $V_{CC}$ | 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℃)

## 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℃)

## 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 | $V_{OL}$ |
| 900mV | 12V | 11.1V | L | |
| 6V | -1V | -7V | L | |
| 6V | 12V | 6V | L | |
| 500mV | -6.5V | -7V | H | $V_{OH}$ |
| 500mV | 12V | 11.5V | H | |
| -6V | -7V | -1V | H | |
| -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 | >0.75$V_{CC}$ | Z | Z | Recessive |
| L | L or Open | <0.33$V_{CC}$ | H | L | Dominant |
| H or Open | X | | Z | Z | Recessive |
| X | H | 0.33$V_{CC}$ | 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}\geq$0.9V | L or open | X | L |
| Recessive | $V_{ID}\leq$0.5V or open | L or open | H or Open | H |
| ? | 0.5<$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

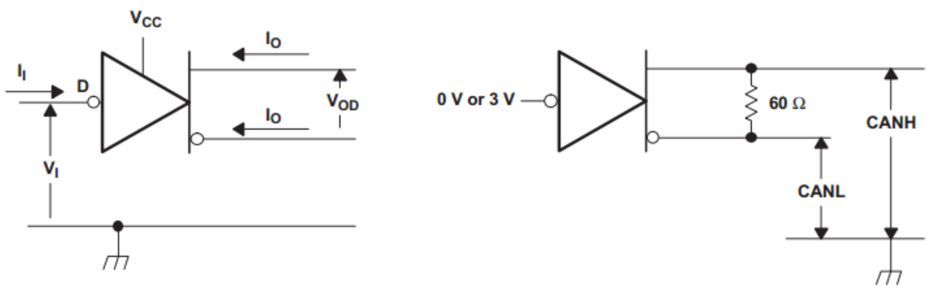



Fig.1 Driver voltage, current and test definition

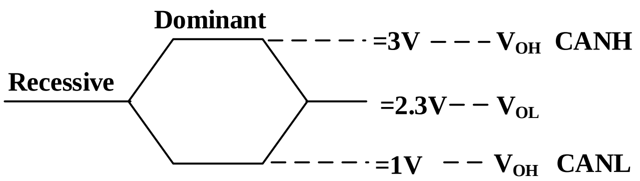



Fig.2 Bus logic state voltage definitions

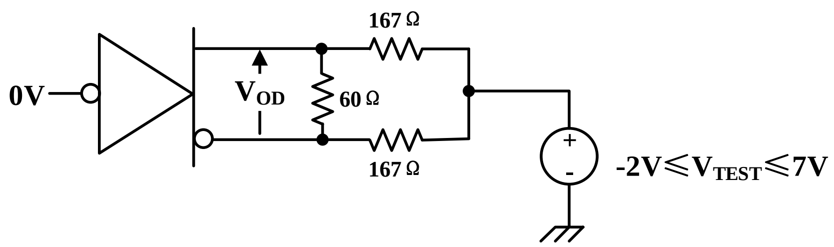
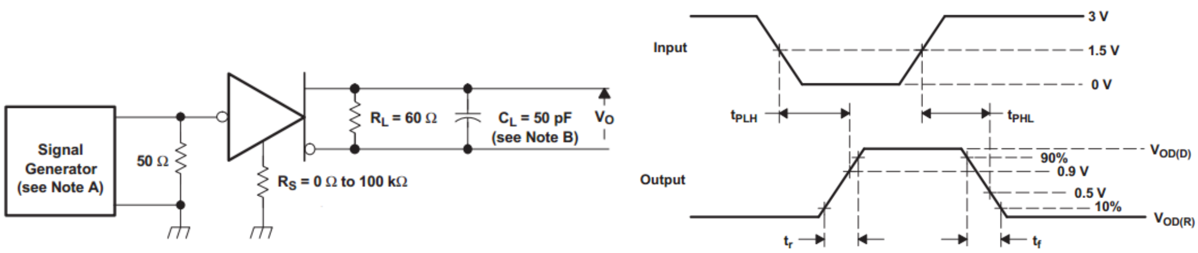



Fig.3 Driver $V_{OD}$ test circuit




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

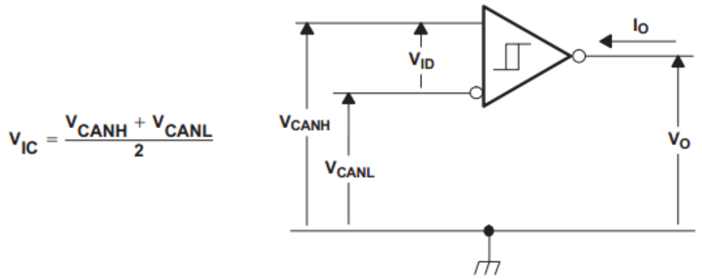
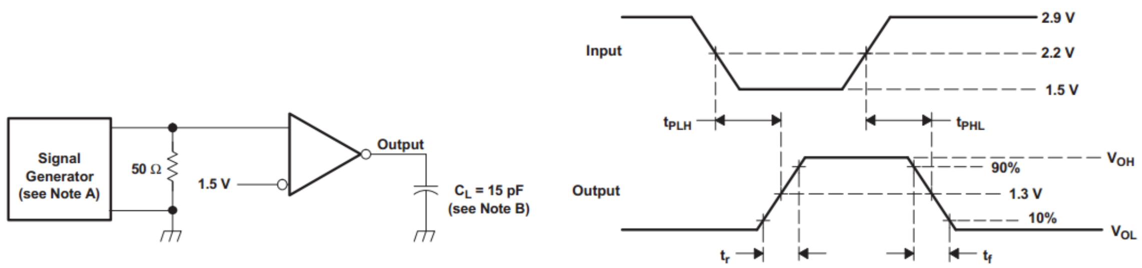



**Fig.5 Receiver voltage and current definitions**




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**

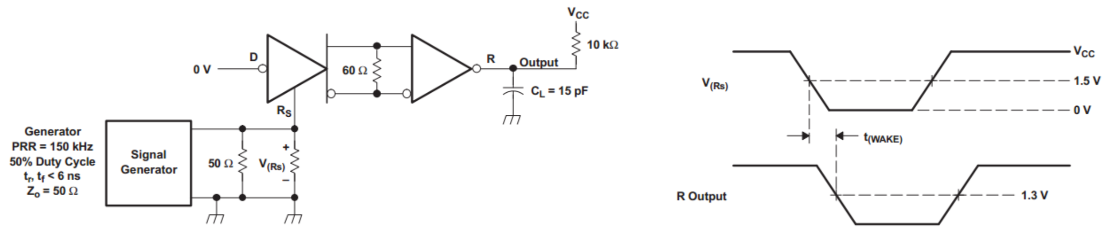
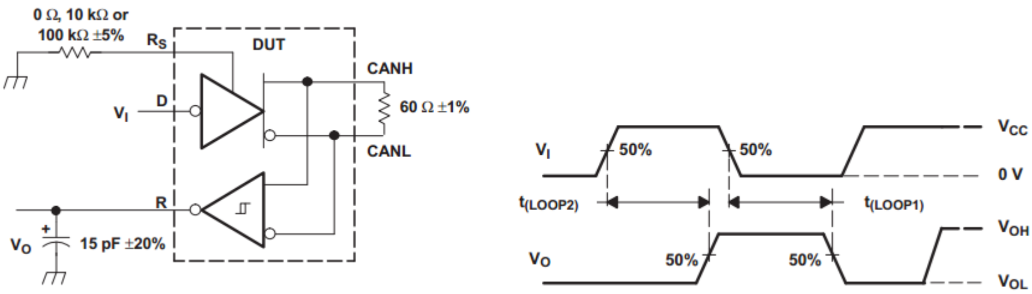
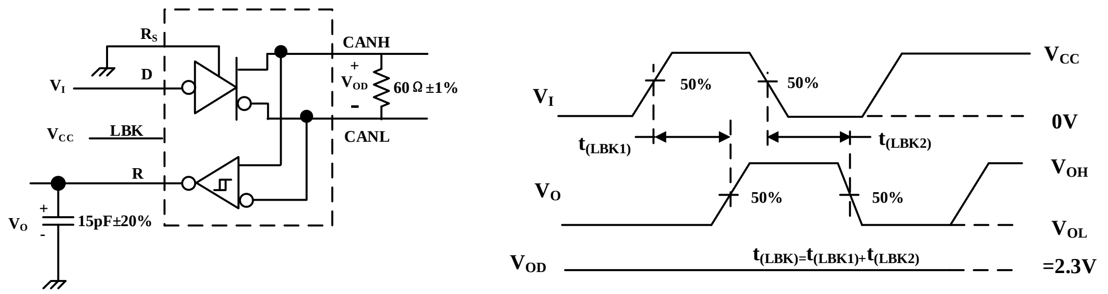



**Fig.7 $t_{(WAKE)}$ test circuit and waveform**



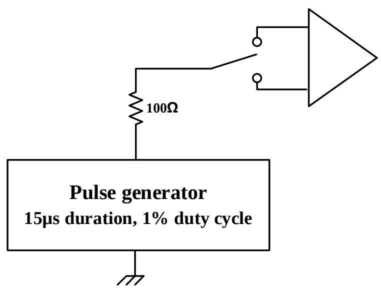

The input pulse is supplied by a generator having the following characteristics: PRR≤125kHz, 50% duty cycle, $t_r$<6ns, $t_f$<6ns, Zo=50Ω.

**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 SIT65HVD233 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

SIT65HVD233 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 SIT65HVD233 have the function of preventing electrical transient damage.

## 5 Operating modes

The $R_S$ pin mode, slop (pin 8) of the SIT65HVD233 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 SIT65HVD233 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 SIT65HVD233 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

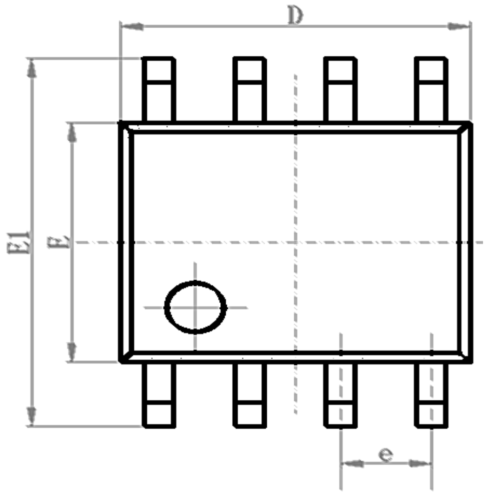
The diagnostic loopback or internal loopback function of the SN65HVD233 is enabled with a high-level input on pin 5, LBK. This mode disables the driver output while keeping the bus pins biased to the recessive state. This mode also redirects the D data input (transmit data) through logic to the received 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.

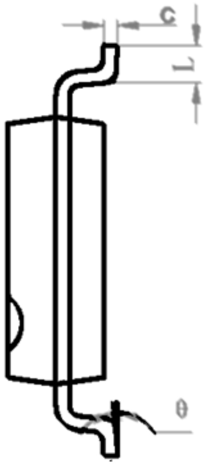
If the LBK pin is not used it may be tied to ground (GND). However, it is pulled low internally (defaults to a low-level input) and may be left open if not in use.

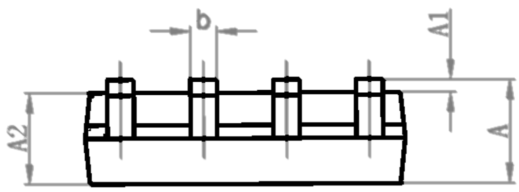
## SOP8 DIMENSIONS

**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° |



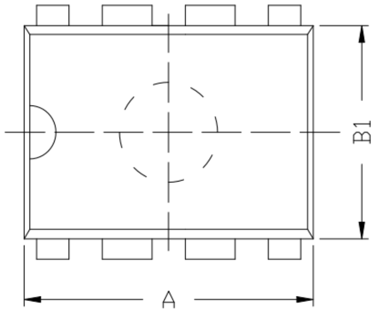



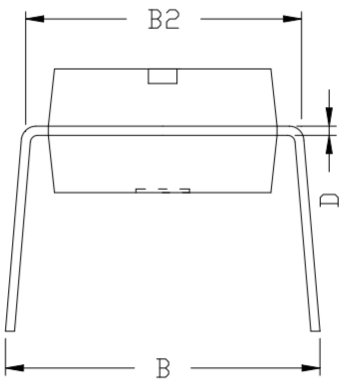



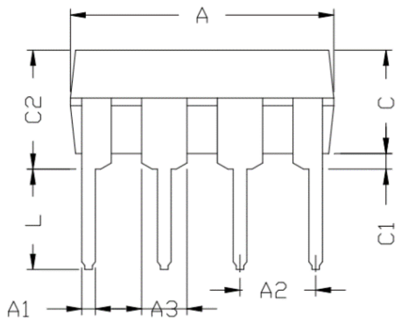
## DIP8 DIMENSIONS

**PACKAGE SIZE**

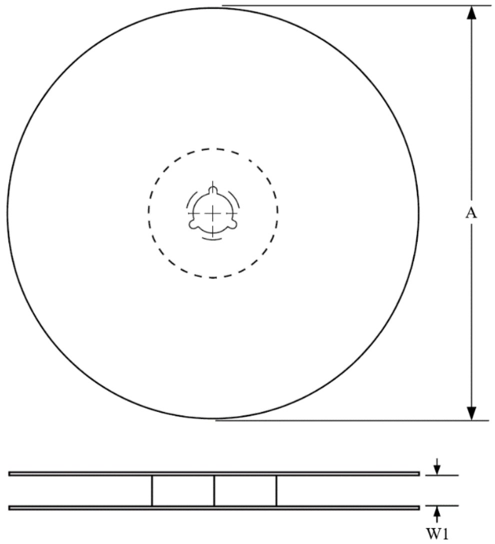
| SYMBOL | MIN./mm | TYP./mm | MAX./mm |
|---|---|---|---|
| A | 9.00 | 9.20 | 9.40 |
| A1 | 0.33 | 0.45 | 0.51 |
| A2 | 2.54TYP | | |
| A3 | 1.525TYP | | |
| B | 8.40 | 8.70 | 9.10 |
| B1 | 6.20 | 6.40 | 6.60 |
| B2 | 7.32 | 7.62 | 7.92 |
| C | 3.20 | 3.40 | 3.60 |
| C1 | 0.50 | 0.60 | 0.80 |
| C2 |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



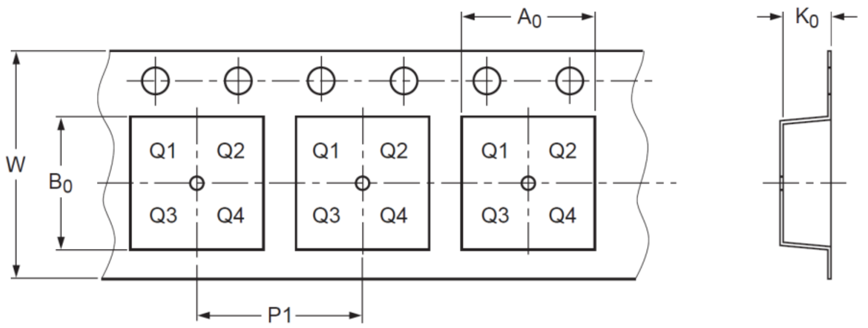



## TAPE AND REEL INFORMATION




| | |
|---|---|
| A0 | Dimension designed to accommodate the component width |
| B0 | Dimension designed to accommodate the component length |
| K0 | Dimension designed to accommodate the component thickness |
| W | Overall width of the carrier tape |
| P1 | Pitch between successive cavity centers |




Direction of Feed

PIN1 is in quadrant 1

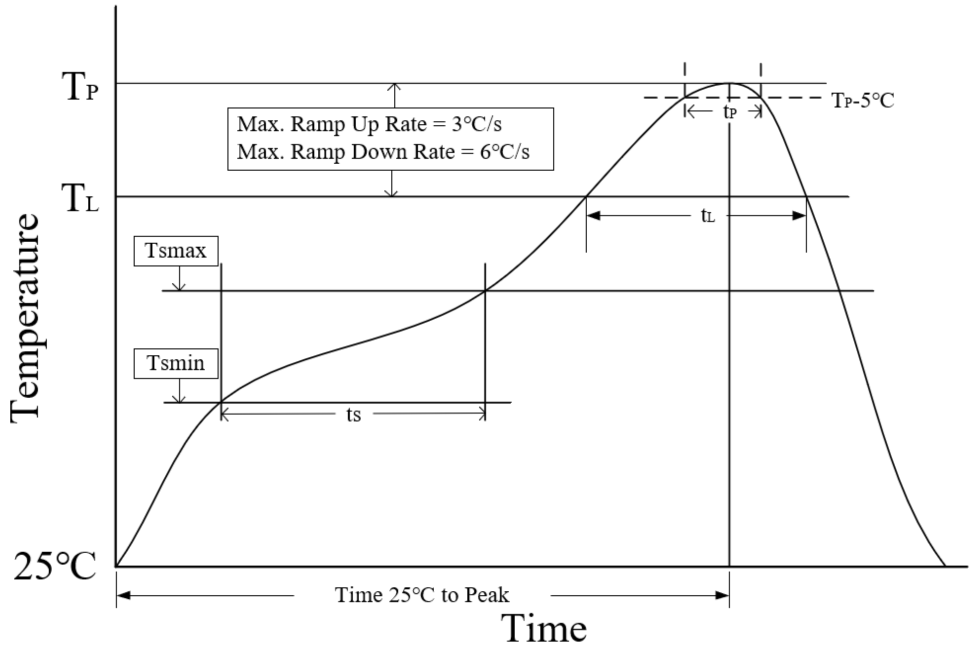
| Package Type | Reel Diameter A (mm) | Tape width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) |
|---|---|---|---|---|---|---|---|
| SOP8 | 330±2 | 12.4±0.40 | 6.50±0.1 | 5.30±0.10 | 2.05±0.1 | 8.00±0.1 | 12.00±0.1 |

## ORDERING INFORMATION

| **TYPE NUMBER** | PACKAGE | PACKING |
|---|---|---|
| SIT65HVD233DR | SOP8 | Tape and reel |
| SIT65HVD233P | 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 |

**Important statement**

SIT reserves the right to change the above-mentioned information without prior notice.

## VERSION HISTORY

| Version number | Data sheet status | Revision Date |
|---|---|---|
| V1.0 | Initial version. | October 2022 |