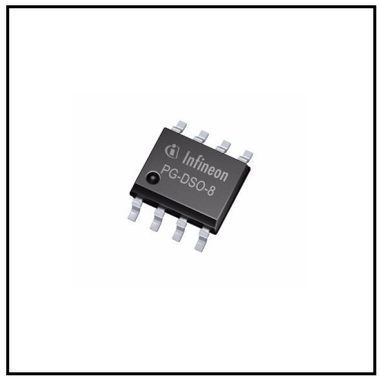
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# TLE9351SJ

## High speed CAN FD transceiver




## Features

- Fully compliant to ISO 11898-2:2016 and SAE J2284-4/-5
- Loop delay symmetry for CAN FD data frames up to 5 MBit/s
- Certified according to VeLIO (Vehicle LAN Interoperability and Optimization) test requirements
- Very low electromagnetic emission (EME) allows the use without additional common mode choke
- Bus wake-up pattern (WUP) function with optimized filter time for worldwide OEM usage
- Stand-by mode with minimized quiescent current
- Excellent ESD robustness
- TxD time-out function
- Very low CAN bus leakage current in power-down state
- Overtemperature protection
- Protected against automotive transients according to ISO 7637 and SAE J2962-2
- Green Product (RoHS compliant)

## Potential applications

- Engine control units (ECU)
- Gateway modules
- Body control modules (BCM)

## Product validation

Qualified for automotive applications. Product validation according to AEC-Q100.

## Description

The TLE9351SJ is a high speed CAN transceiver, used in HS CAN systems for automotive applications as well as for industrial applications. It is designed to fulfill the requirements of ISO 11898-2:2016 physical layer specification as well as SAE J1939 and SAE J2284.

The TLE9351SJ is available in a RoHS compliant, halogen free PG-DSO-8 package.

As an interface between the physical bus layer and the HS CAN protocol controller, the TLE9351SJ is designed to protect the microcontroller against interferences generated inside the network. A very high ESD robustness

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and the optimized RF immunity allows the use in automotive applications without additional protection devices, such as suppressor diodes or common mode chokes.

Based on the high symmetry of the CANH and CANL output signals, the TLE9351SJ provides a very low level of electromagnetic emission (EME) within a wide frequency range. The TLE9351SJ fulfills even stringent EMC test limits without an additional external circuit, such as a common mode choke.

The optimized transmitter symmetry combined with the optimized delay symmetry of the receiver enables the TLE9351SJ to support CAN FD data frames. The device supports data transmission rates up to 5 MBit/s, depending on the size of the network and the inherent parasitic effects.

Dedicated low-power modes, such as stand-by mode, provide very low quiescent current during power-up of the device. In stand-by mode the typical quiescent current on $V_{CC}$ is less than 10 µA while the device can still wake up by a bus signal on the HS CAN bus.

Fail-safe features, such as overtemperature protection, output current limitation or the TxD time-out feature are designed to protect the TLE9351SJ and the external circuitry from irreparable damage.

| Type | Package | Marking |
|---|---|---|
| TLE9351SJ | PG-DSO-8 | 9351 |

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# 1 Block diagram

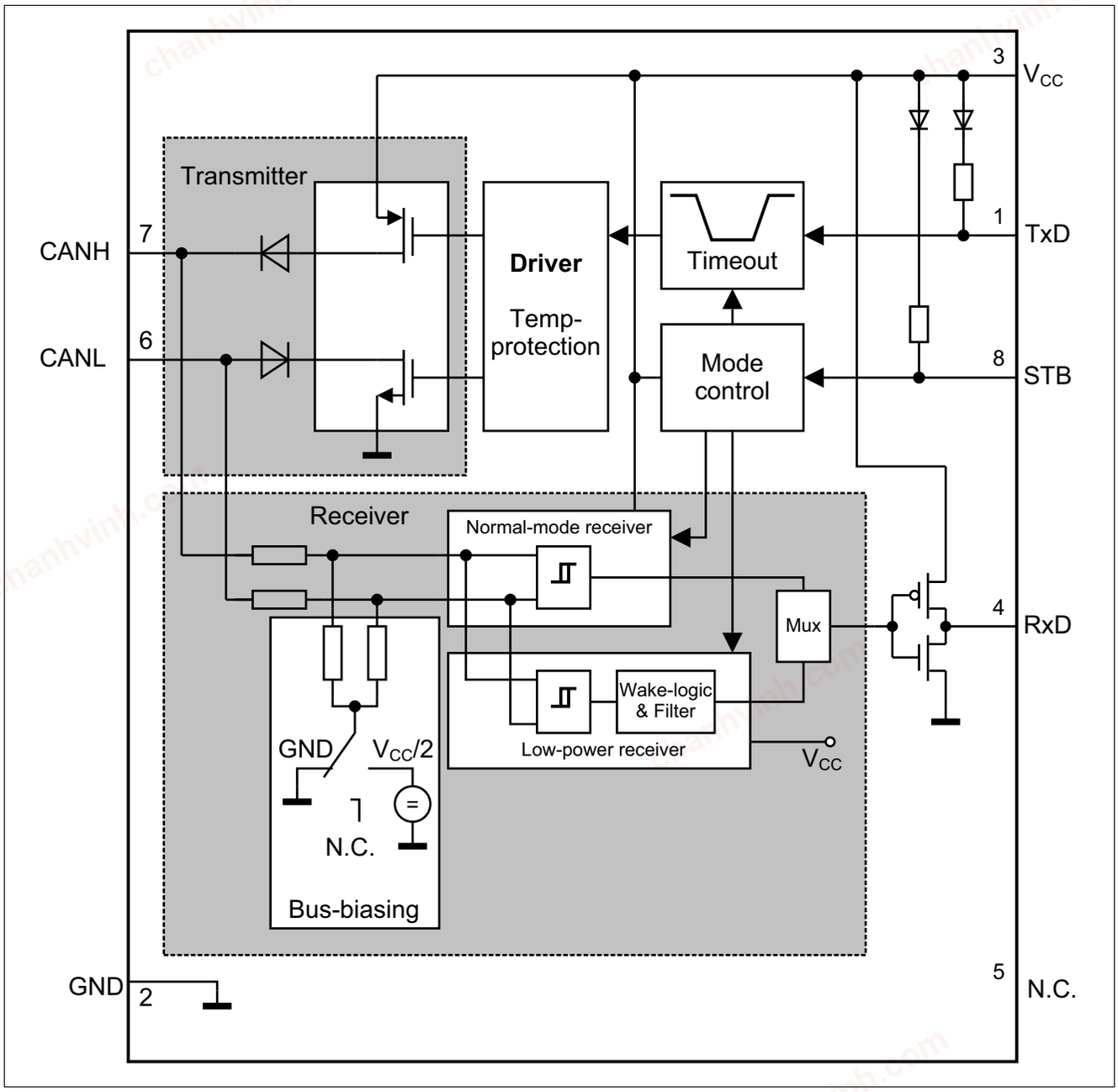



**Figure 1 Block diagram**

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# 2 Pin configuration

## 2.1 Pin assignment

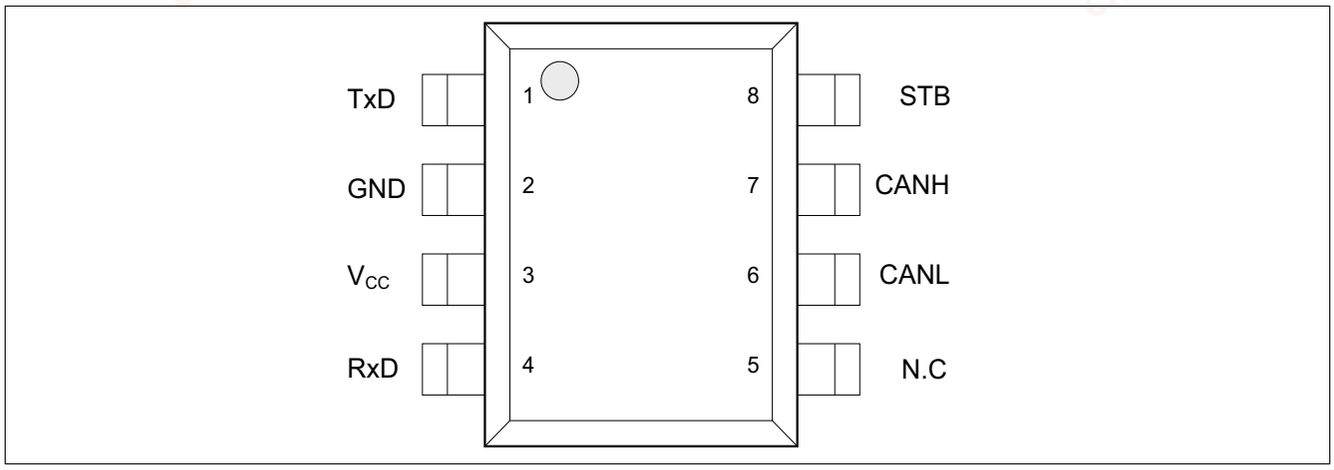



**Figure 2 Pin assignment**

## 2.2 Pin definitions

**Table 1 Pin definitions and functions**

| Pin No. | Symbol | Function |
|---|---|---|
| 1 | TxD | **Transmit data input;**<br>Internal pull-up to $V_{CC}$, "low" for dominant state. |
| 2 | GND | **Ground** |
| 3 | $V_{CC}$ | **Transmitter supply voltage;**<br>A decoupling capacitor of 1 µF to GND is recommended. |
| 4 | RxD | **Receive data output;**<br>"Low" in dominant state. |
| 5 | N.C. | **Not Connected;**<br>This pin is without function, not connected internally. |
| 6 | CANL | **CAN bus low level I/O;**<br>Bus level on the CANL input/output. |
| 7 | CANH | **CAN bus high level I/O;**<br>Bus level on the CANH input/output. |
| 8 | STB | **Stand-by input;**<br>Internal pull-up to $V_{CC}$, "low" for normal-operating mode. |

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# 3 General product characteristics

## 3.1 Absolute maximum ratings

**Table 2 Absolute maximum ratings voltages, currents and temperatures[1)]**

All voltages with respect to ground; positive current flowing into pin;
(unless otherwise specified)

| Parameter | Symbol | Values | | | Unit | Note or Test Condition | Number |
|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | | |
| **Voltages** | | | | | | | |
| Transmitter supply voltage | $V_{CC}$ | -0.3 | – | 6.0 | V | – | P_7.1.1 |
| CANH and CANL DC voltage versus GND | $V_{CANH}$ | -40 | – | 40 | V | – | P_7.1.3 |
| Differential voltage between CANH and CANL | $V_{CAN_Diff}$ | -40 | – | 40 | V | – | P_7.1.4 |
| Voltage at the digital input pins:<br>STB, TxD | $V_{MAX_IO}$ | -0.3 | – | 6.0 | V | – | P_7.1.5 |
| Voltage at the digital output pin:<br>RxD | $V_{MAX_RxD}$ | -0.3 | – | $V_{CC}$ +0.3 | V | – | P_7.1.9 |
| **Currents** | | | | | | | |
| RxD output current | $I_{RxD}$ | -5 | – | 5 | mA | – | P_7.1.6 |
| **Temperatures** | | | | | | | |
| Junction temperature | $T_j$ | -40 | – | 150 | °C | – | P_7.1.7 |
| Storage temperature | $T_S$ | -55 | – | 150 | °C | – | P_7.1.8 |
| **ESD immunity** | | | | | | | |
| ESD immunity at CANH, CANL versus GND | $V_{ESD_HBM_CAN}$ | -10 | – | 10 | kV | HBM;<br>(100 pF via 1.5 kΩ)[2)] | P_7.1.10 |
| ESD immunity at all other pins | $V_{ESD_HBM_ALL}$ | -2 | – | 2 | kV | HBM;<br>(100 pF via 1.5 kΩ)[2)] | P_7.1.11 |
| ESD immunity corner pins | $V_{ESD_CDM_CP}$ | -750 | – | 750 | V | CDM[3)] | P_7.1.14 |
| ESD immunity all other pins | $V_{ESD_CDM_OP}$ | -500 | – | 500 | V | CDM[3)] | P_7.1.12 |

1) Not subject to production test, specified by design.
2) ESD susceptibility, Human Body Model (HBM) according to ANSI/ESDA/JEDEC JS-001.
3) ESD susceptibility, Charge Device Model (CDM) according to ANSI/ESDA/JEDEC JS-002.

*Note: Stresses above the ones listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Integrated protection functions are designed to prevent IC destruction under fault conditions described in the data sheet. Fault conditions are considered as outside normal-operating range. Protection functions are not designed for continuous repetitive operation.*

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## 3.2 Functional range

**Table 3 Functional range**

| Parameter | Symbol | Values | | | Unit | Note or Test Condition | Number |
|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | | |
| **Supply voltages** | | | | | | | |
| Transmitter supply voltage | $V_{CC}$ | 4.75 | – | 5.25 | V | – | P_7.2.1 |
| **Thermal parameters** | | | | | | | |
| Junction temperature | $T_j$ | -40 | – | 150 | °C | 1) | P_7.2.3 |

1) Not subject to production test, specified by design.

*Note: Within the functional range the IC operates as described in the circuit description. The electrical characteristics are specified within the conditions given in the related electrical characteristics table.*

## 3.3 Thermal resistance

*Note: This thermal data was generated in accordance with JEDEC JESD51 standards. For more information, please visit **www.jedec.org**.*

**Table 4 Thermal resistance[1)]**

| Parameter | Symbol | Values | | | Unit | Note or Test Condition | Number |
|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | | |
| **Thermal resistance** | | | | | | | |
| Junction to ambient PG-DSO-8 | $R_{thJA_DSO8}$ | – | 120 | – | K/W | 2) | P_7.3.2 |
| **Thermal shutdown (junction temperature)** | | | | | | | |
| Thermal shutdown temperature, rising | $T_{JSD}$ | 170 | 180 | 190 | °C | temperature falling: minimum 150°C | P_7.3.3 |
| Thermal shutdown hysteresis | $\Delta T$ | 5 | 10 | 20 | K | | P_7.3.4 |

1) Not subject to production test, specified by design.

2) Specified $R_{thJA}$ value is according to JEDEC JESD51-2,-7 at natural convection on FR4 2s2p board. The product was simulated on a 76.2 × 114.3 × 1.5 mm³ board with two inner copper layers (2 × 70µm Cu, 2 × 35 µm Cu).

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# 4 High speed CAN functional description

HS CAN is a serial bus system that connects microcontrollers, sensors and actuators for real-time control applications. ISO 11898 describes the use of the controller area network (CAN) within road vehicles. According to the 7-layer OSI reference model the physical layer of a HS CAN bus system specifies the data transmission from one CAN node to all other CAN nodes available within the network. The physical layer specification of a CAN bus system includes all electrical specifications of a CAN. The CAN transceiver is part of the physical layer specification. The TLE9351SJ is a high speed CAN transceiver with a dedicated bus wake-up function according to ISO 11898-2:2016.

## 4.1 High speed CAN physical layer

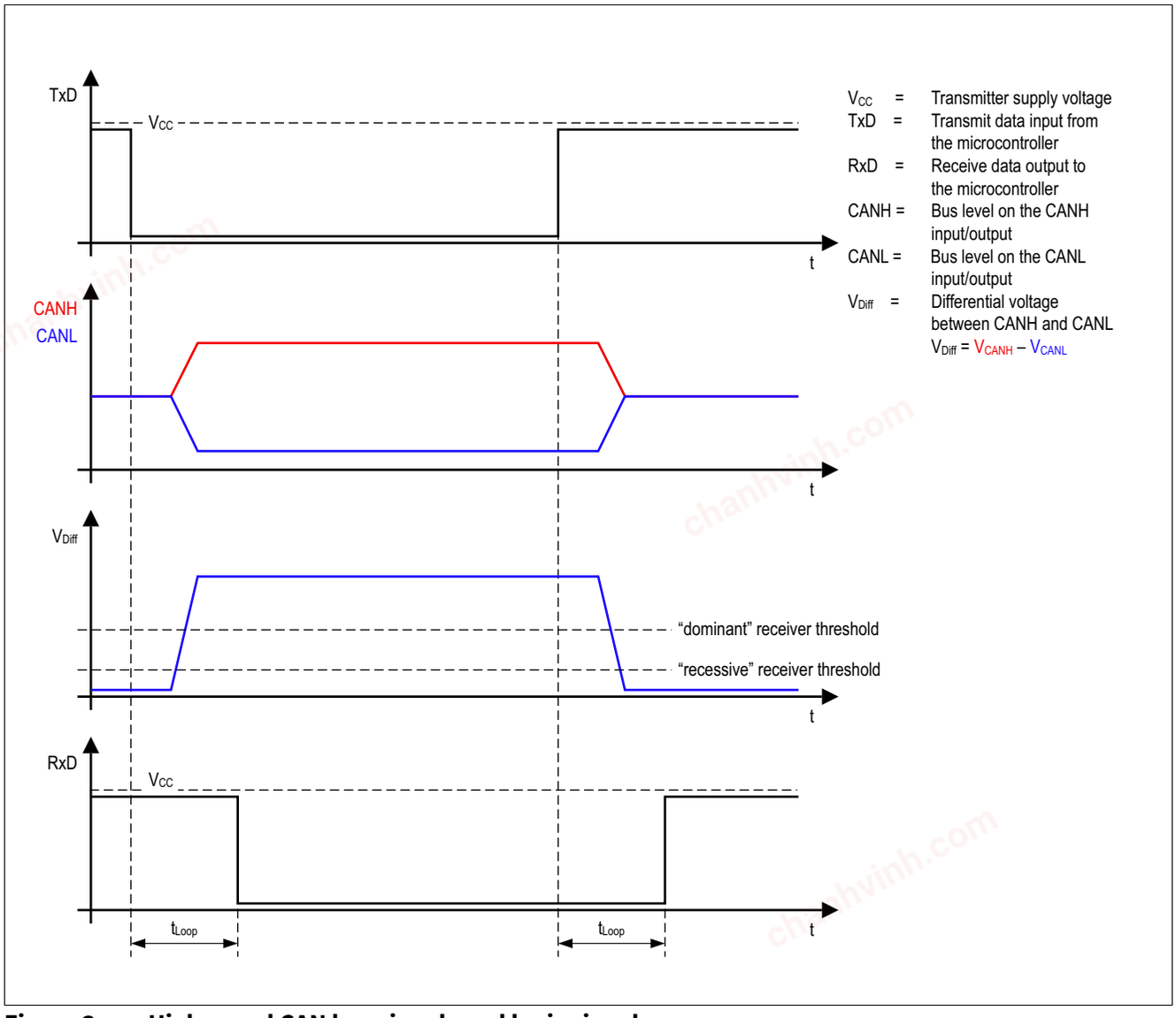



**Figure 3 High speed CAN bus signals and logic signals**

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The TLE9351SJ operates as an interface between the CAN controller and the physical bus medium. A HS CAN is a two wire differential network which allows data transmission rates up to 5 MBit/s. The characteristics for a HS CAN are the two signal states on the CAN bus: dominant and recessive (see **Figure 3**).

The CANH and CANL pins are the interface to the CAN bus and both pins operate as an input and output simultaneously. The RxD and TxD pins are the interface to the microcontroller. The pin TxD is the serial data input from the CAN controller, the RxD pin is the serial data output to the CAN controller. As shown in **Figure 1**, the TLE9351SJ includes a receiver and a transmitter unit, allowing the transceiver to send data to the bus medium and monitor the data from the bus medium at the same time. The TLE9351SJ converts the serial data stream which is available on the transmit data input TxD, into a differential output signal on the CAN bus, provided by the CANH and CANL pins. The receiver stage of the TLE9351SJ monitors the data on the CAN bus and converts them to a serial, single-ended signal on the RxD output pin. A "low" signal on the TxD pin creates a dominant signal on the CAN bus, followed by a logical "low" signal on the RxD pin (see **Figure 3**). The feature of broadcasting data to the CAN bus and listening to the data traffic on the CAN bus simultaneously is essential to support the bit-to-bit arbitration within CAN.

ISO 11898-2:2016 specifies the voltage levels for HS CAN transceivers. Whether a data bit is dominant or recessive depends on the voltage difference between the CANH and CANL pins ($V_{Diff} = V_{CANH} - V_{CANL}$).

To transmit a dominant signal to the CAN bus the amplitude of the differential signal $V_{Diff}$ is higher than or equal to 1.5 V. To receive a recessive signal from the CAN bus the amplitude of the differential $V_{Diff}$ is lower than or equal to 0.5 V.

In partially-supplied high speed CAN the bus nodes of one common network have different power supply conditions. Some nodes are connected to the power supply, while other nodes are disconnected from the power supply and in power-down state. Regardless of whether the CAN bus subscriber is supplied or not, each subscriber connected to the common bus media must not interfere with the communication. The TLE9351SJ is designed to support partially-supplied networks. In power-down state, the receiver input resistors are switched off and the transceiver input has a high resistance.

For permanently supplied ECUs, the HS CAN transceiver TLE9351SJ provides a stand-by mode. In stand-by mode, the power consumption of the TLE9351SJ is optimized to a minimum, while the device is still able to recognize wake-up patterns on the CAN bus and signal the wake-up event to the external microcontroller.

The voltage level on the digital input TxD and the digital output RxD is determined by the power supply level at the $V_{CC}$ pin. Depending on the voltage level at the $V_{CC}$ pin, the signal levels on the logic pins (STB, TxD and RxD) are compatible with microcontrollers having a 5 V I/O supply.

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# 5 Modes of operation

The TLE9351SJ supports the following modes of operation):

- Normal-operating mode
- Stand-by mode

The mode selection input pin STB triggers mode changes. If a wake-up event occurs on the HS CAN bus, then the device indicates that on the RxD output pin in stand-by mode, but it does not trigger a mode change. An power-down event on the supply $V_{CC}$ powers down the device.

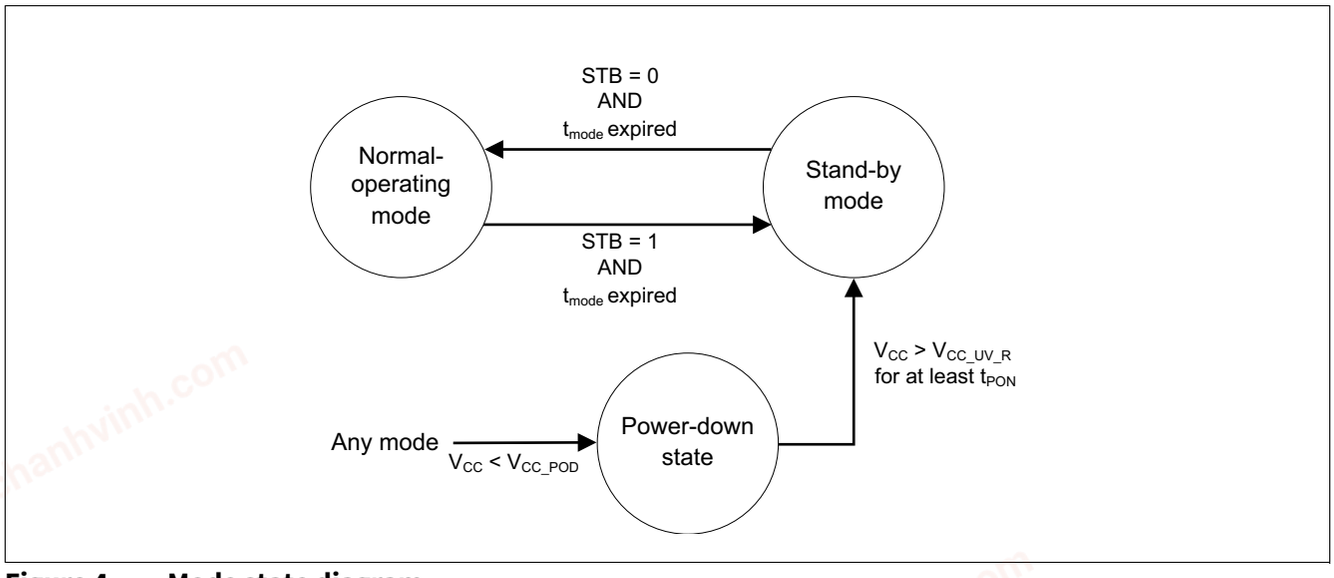



**Figure 4 Mode state diagram**

## 5.1 Normal-operating mode

In normal-operating mode all functions of the device are available and the device is fully functional. Data can be received from the HS CAN bus as well as transmitted to the HS CAN bus.

- The transmitter is enabled and drives the serial data stream on the TxD input pin to the bus pins CANH and CANL
- The receiver is enabled and converts the signal from the bus to a serial data stream on the RxD output pin
- The bus biasing is active
- The TxD time-out function is enabled (see **Chapter 6.4**)
- The overtemperature protection is enabled (see **Chapter 6.6**)
- The undervoltage detection on $V_{CC}$ is enabled (see **Chapter 6.3**)

The device enters normal-operating mode by setting the mode selection pin STB to "low", see **Figure 4**. Normal-operating mode can be entered if the device supply $V_{CC}$ is higher than $V_{CC_POD}$. The device enters normal-operating mode after $t_{mode}$ expires.

*Note: If the device recognizes a recessive signal on the TxD input pin during a mode change from any mode to normal-operating mode, then it enables the transmit path after the mode change.*
*If the device recognizes a a dominant signal on the TxD input pin during a mode change to normal-operating mode, then it keeps the transmit path disabled and it blocks the dominant signal in order to not disturb the bus communication . As soon as the device recognizes a recessive signal on the TxD input pin, it enables the transmit path again.*

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## 5.2 Stand-by mode

The stand-by mode is a low-power mode of the TLE9351SJ. In stand-by mode the transceiver can neither send data to the HS CAN bus nor receive data from the HS CAN bus. In stand-by mode the current consumption is reduced to a minimum while the device can still detect a wake-up pattern (WUP) on the HS CAN bus.

- The transmitter is disabled and the data available on the TxD input is blocked
- The low-power receiver is enabled and monitors the HS CAN bus for a valid wake-up pattern (WUP). The RxD output pin indicates the detection of a valid wake-up pattern (**Chapter 5.4**). As long as no wake-up event is detected, the default of the RxD output is "high". After detecting a wake-up, the RxD follows the bus with a certain delay (see **Figure 7**)
- TxD time-out function is disabled
- The overtemperature protection is disabled
- The power-down detection on $V_{CC}$ is enabled (see **Chapter 6.3**).

The stand-by mode can be entered from normal-operating mode by setting the STB pin to "high".

To enter stand-by mode the supply $V_{CC}$ must be available ($V_{CC} > V_{CC_POD}$). The device enters stand-by mode after $t_{mode}$ expires.

## 5.3 Power-down state

If the supply voltage $V_{CC} < V_{CC_POD}$, then the device powers down independent of STB (see **Figure 5**). In power-down state all functions of the device are disabled and the device is switched off. The input resistors of the receiver are disconnected. The CANH and CANL bus interface of the device is floating and acts as a high impedance input with a very low leakage current. The high impedance input does not influence the recessive level of the CAN and allows an optimized EME performance of the entire network. In power-down state the transceiver is an invisible node to the bus. $t_{pon}$ must expire as a prerequisite for the device to exit power-down state.

- The transmitter and receiver are disabled
- The bus biasing is connected to high impedance
- The TxD time-out function is disabled
- The overtemperature protection is disabled
- The power-down detection on $V_{CC}$ is enabled

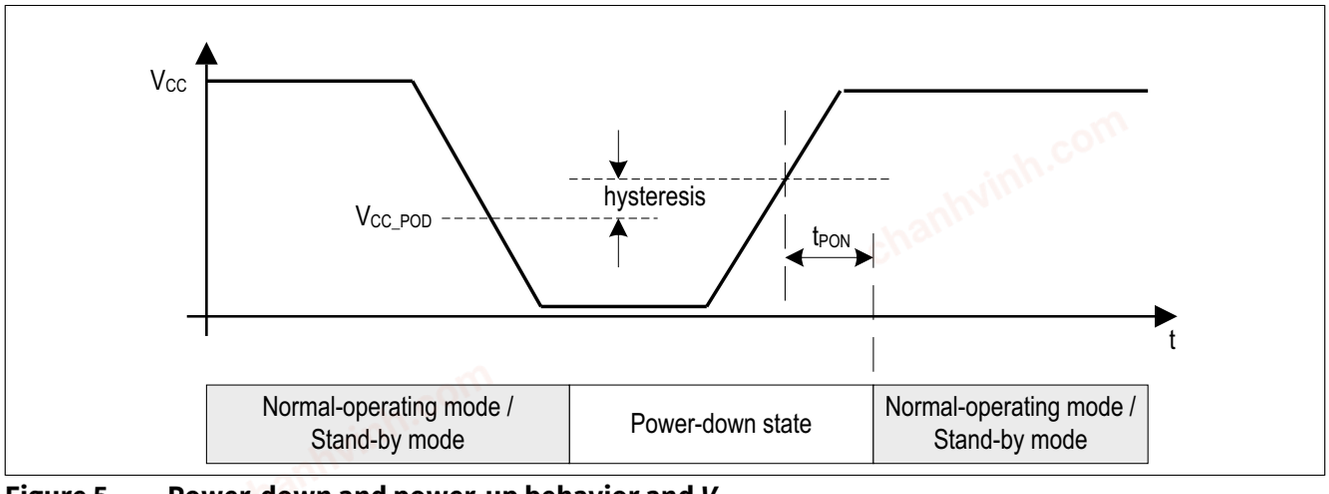



**Figure 5 Power-down and power-up behavior and $V_{CC}$**

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## 5.4 Wake-up pattern (WUP) detection

In stand-by mode the TLE9351SJ offers the wake-up pattern (WUP) detection according to the ISO 11898-2:2016. In stand-by mode the low-power receiver monitors the activity on the CAN bus. If it detects a wake-up pattern, then it indicates the wake-up event on the RxD output pin.

In stand-by mode the device indicates a wake-up event on the HS CAN bus on the RxD output pin. The transceiver remains in its current mode of operation. The device does not perform a mode change due to the wake-up event.

The wake-up pattern contains the following sequence of signals:

- Dominant with the pulse width $t > t_{Filter}$
- Recessive with the pulse width $t > t_{Filter}$
- Dominant with the pulse width $t > t_{Filter}$

The subsequent recessive and dominant pulses must occur within $t_{Wake}$ to fulfill a wake-up pattern. $t_{Wake}$starts with the first valid dominant pulse that has a pulse width > $t_{Filter}$.

See **Figure 6**.

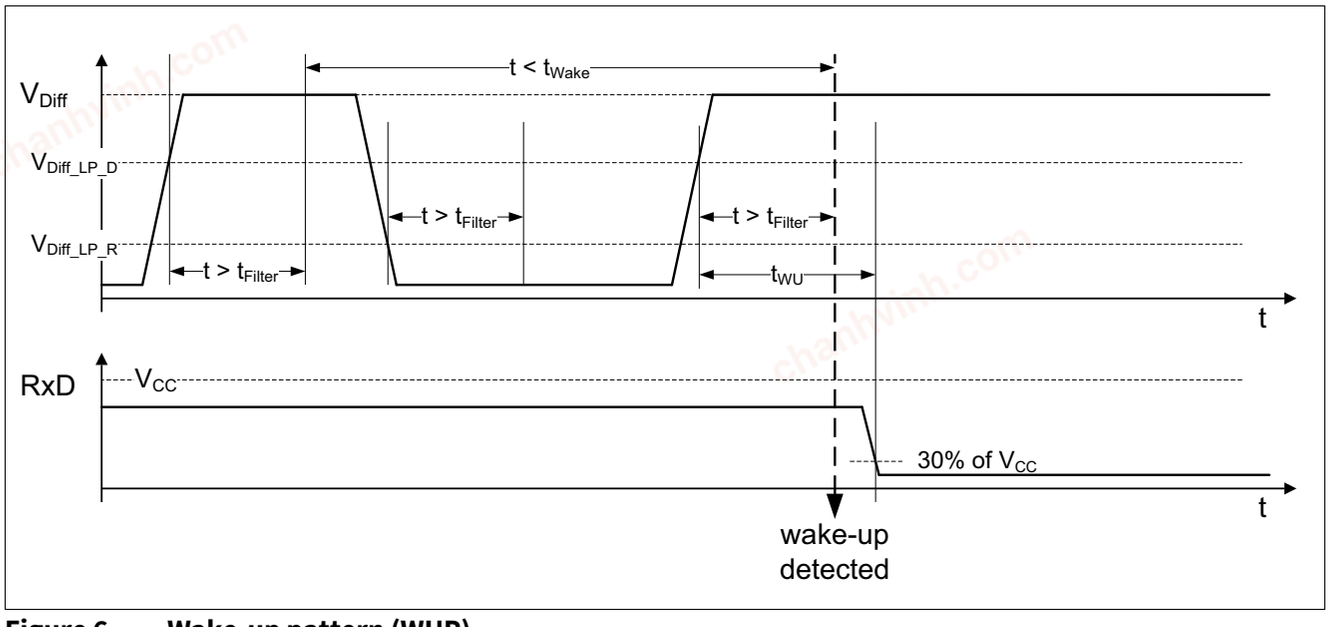



**Figure 6 Wake-up pattern (WUP)**

After the device detects a wake-up event the RxD output follows the CANH/CANL input pins. Dominant and recessive signals are indicated on the RxD output as "high" and "low" with the delay of $t_{WU}$ as long their pulse width exceeds the filter time $t_{Filter}$ (see also **Figure 7**).

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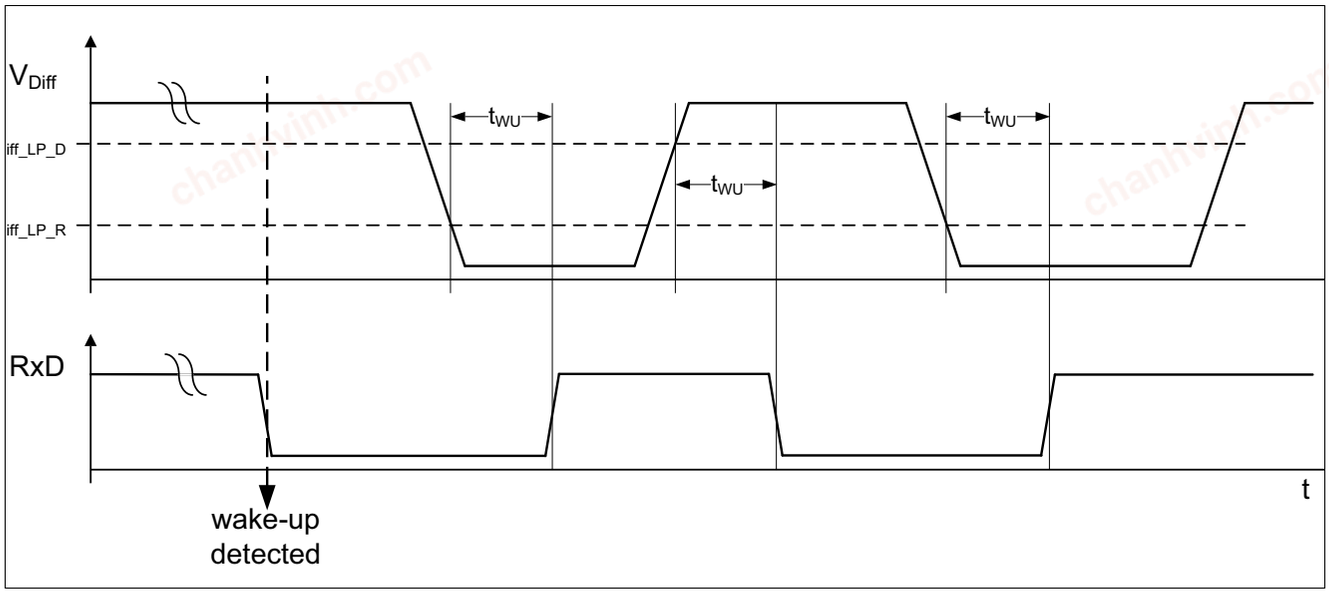



**Figure 7 RxD signal after wake-up detection**

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# 6 Fail safe functions

## 6.1 Short circuit protection

The CANH and CANL bus outputs are short circuit proof to GND and short circuit proof to a supply voltage. The current limiting circuit is designed to protect the transceiver from damage. If the device heats up due to a continuous short on the CANH or CANL, then the internal overtemperature protection switches off the bus transmitter.

## 6.2 Unconnected logic pins

All logic input pins have an internal pull-up resistor to $V_{CC}$. If the $V_{CC}$ supply is active and the logical pins are open, the device enters the stand-by mode by default.

## 6.3 $V_{CC}$ undervoltage

If the transmitter supply is in undervoltage condition $V_{CC} < V_{CC_UV_F}$, then the device might not be able to provide the correct bus levels on the CANH and CANL output pins. During this time the transmitter is blocked in normal-operating mode, to avoid any interference with the network.

During undervoltage condition $V_{CC} < V_{CC_UV_F}$, the bus biasing is switched to ground in normal-operating mode.

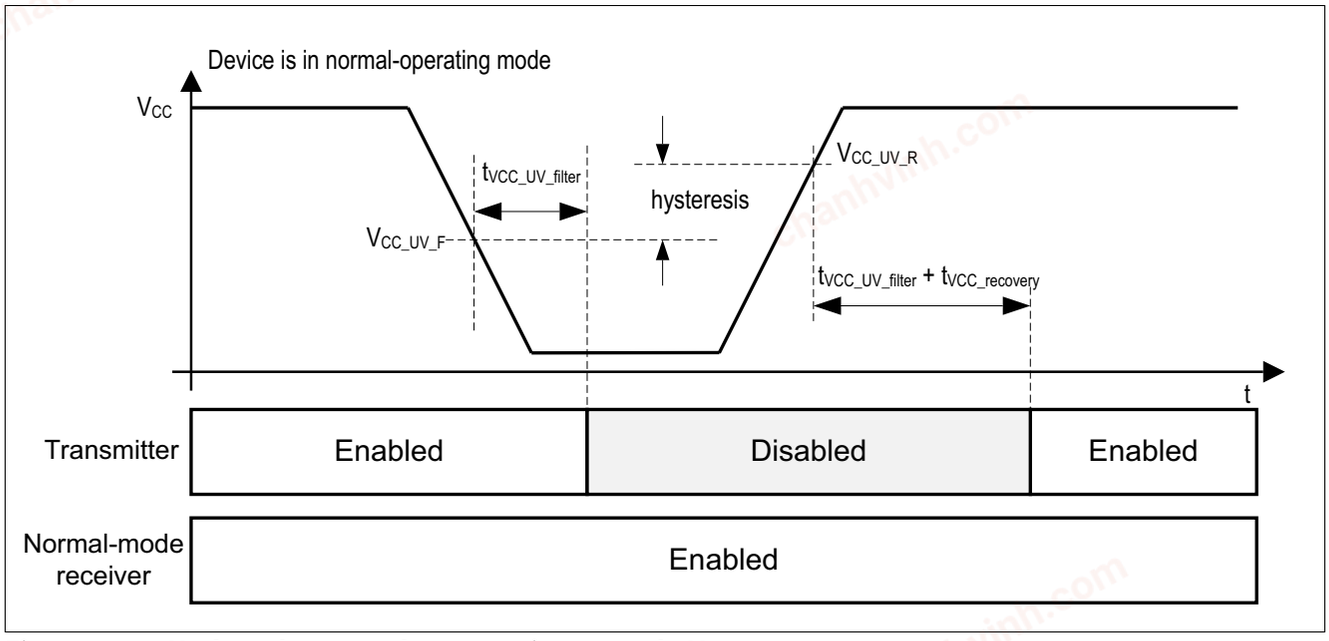



**Figure 8 Undervoltage on the transmitter supply $V_{CC}$**

## 6.4 TxD time-out feature

The TxD time-out feature protects the CAN bus against permanent blocking in case the logical signal on the TxD pin is continuously "low". A continuous "low" signal on the TxD pin might have its root cause in a locked-up microcontroller or in a short circuit on the printed circuit board, for example.

In normal-operating mode, a "low" signal on the TxD pin for the time $t > t_{TxD}$ enables the TxD time-out feature and the device disables the transmitter (see **Figure 9**). The receiver is still active and the device continues to monitor data on the bus via the RxD output pin.

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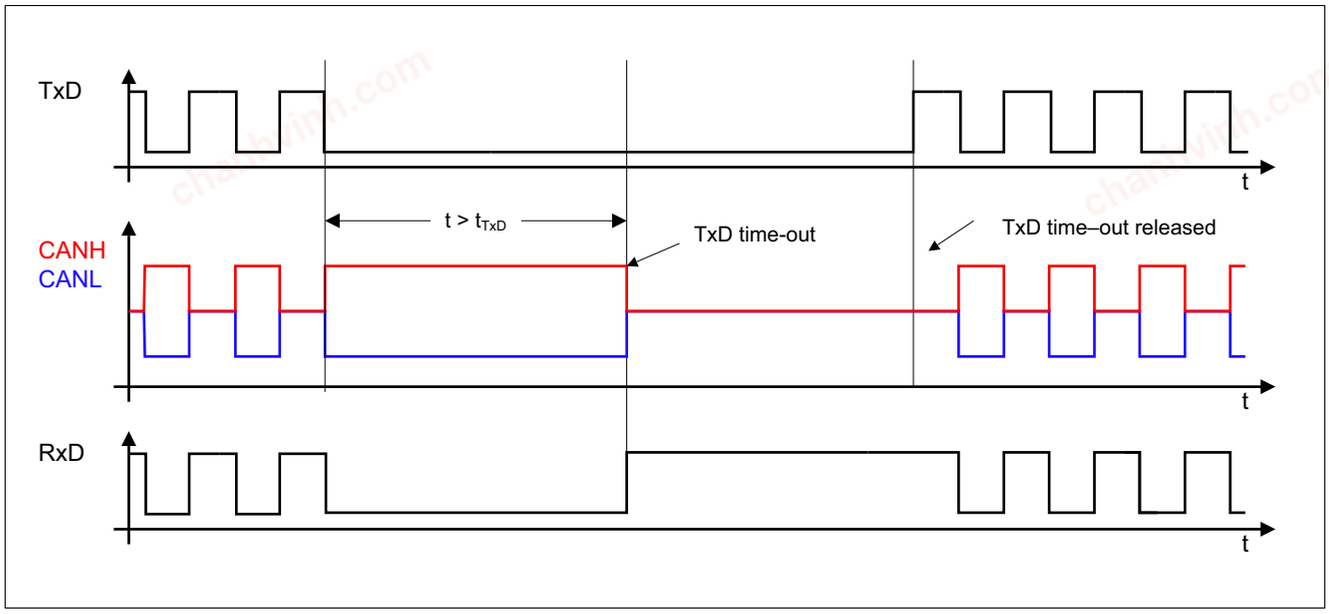



**Figure 9 TxD time-out function**

**Figure 9** shows how the transmitter is deactivated and activated again. A permanent "low" signal on the TxD input pin activates the TxD time-out and deactivates the transmitter. To release the transmitter after a TxD time-out event, the device requires a signal change on the TxD input pin from "low" to "high".

## 6.5 Delay time for mode change

The device changes the mode of operation within the time window $t_{Mode}$. During the mode change from stand-by mode to non-low power mode the device sets the RxD output "high" permanently, so it does not reflect the status on the CANH and CANL input pins.
After the mode change is completed, the device releases the RxD output pin.

## 6.6 Overtemperature protection

The TLE9351SJ has an integrated overtemperature detection, which is designed to protect the device against thermal overstress of the transmitter. The overtemperature protection is only active in normal-operating mode. In case of an overtemperature condition, the temperature sensor disables the transmitter while the transceiver remains in normal-operating mode. After the device cools down it enables the transmitter again (see **Figure 10**). A hysteresis is implemented within the temperature sensor.

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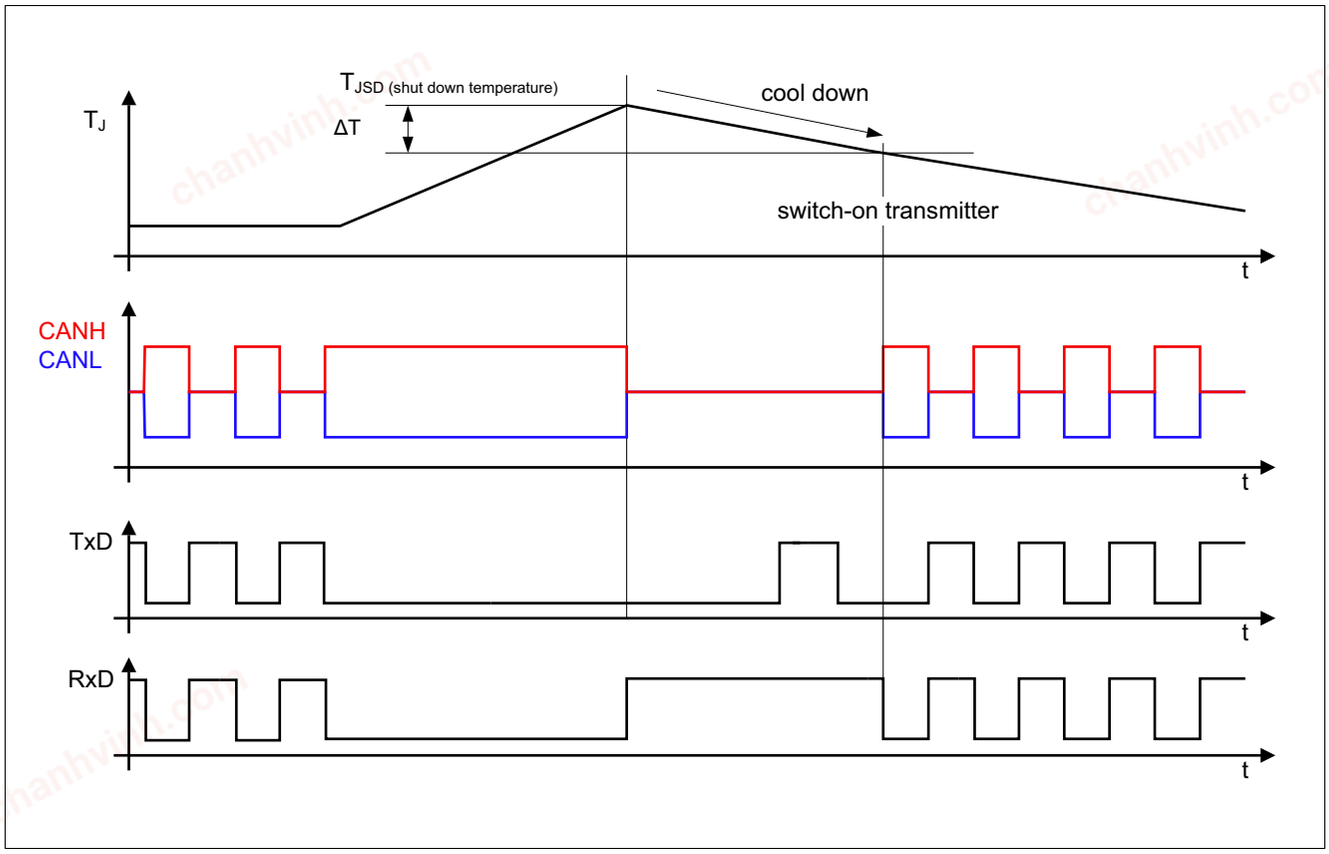



**Figure 10 Overtemperature protection**

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# 7 Electrical characteristics

## 7.1 Power supply interface

### 7.1.1 Electrical characteristics current consumption

**Table 5 Electrical characteristics current consumption**

4.75 V < $V_{CC}$ < 5.25 V; $R_L$ = 60 Ω; -40°C < $T_j$ < 150°C; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

| Parameter | Symbol | Values | | | Unit | Note or Test Condition | Number |
|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | | |
| Current consumption at $V_{CC}$ normal-operating mode, recessive state | $I_{CC_R}$ | – | 1.4 | 4 | mA | $V_{TxD} = V_{CC}$; $V = 0$ V; $V_{CANH} = V_{CANL} = V_{CC}/2$ | P_8.1.1 |
| Current consumption at $V_{CC}$ normal-operating mode, dominant state | $I_{CC_D}$ | – | 34 | 48 | mA | $V_{TxD} = V = 0$ V | P_8.1.2 |
| Current consumption at $V_{CC}$ stand-by mode | $I_{CC(STB)}$ | – | 5 | 20 | µA | $V_{TxD} = V_{STB} = V_{CC}$ | P_8.1.4 |

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### 7.1.2 Electrical characteristics undervoltage detection

**Table 6 Electrical characteristics undervoltage detection**

4.75 V < $V_{CC}$ < 5.25 V; $R_L$ = 60 Ω; -40°C < $T_j$ < 150°C; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

| Parameter | Symbol | Values | | | Unit | Note or Test Condition | Number |
|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | | |
| $V_{CC}$ undervoltage threshold rising edge | $V_{CC_UV_R}$ | 3.8 | 4.2 | 4.65 | V | [1] see **Figure 8** | P_8.1.11 |
| $V_{CC}$ undervoltage threshold falling edge | $V_{CC_UV_F}$ | 3.8 | 4.2 | 4.5 | V | [1] see **Figure 8** | P_8.1.21 |
| $V_{CC}$ undervoltage filter time | $t_{VCC_UV_filter}$ | 4 | 6 | 10 | µs | [2] **Figure 8** | P_8.1.13 |
| $V_{CC}$ undervoltage recovery time | $t_{VCC_recovery}$ | – | 7 | 70 | µs | [2] see **Figure 8** | P_8.1.14 |
| $V_{CC}$ power-down threshold | $V_{CC_POD}$ | 2.0 | 2.5 | 3.0 | V | see **Figure 5** | P_8.1.17 |
| $V_{CC}$ delay time power-up | $t_{PON}$ | – | 40 | 280 | µs | [2] see **Figure 5** | P_8.1.19 |

1) $V_{CC}$ undervoltage threshold for rising edge is always higher than undervoltage threshold for falling edge.
2) Not subject to production test, specified by design.

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## 7.2 Electrical characteristics CAN controller interface

**Table 7 Electrical characteristics CAN controller interface**

4.75 V < $V_{CC}$ < 5.25 V; $R_L$ = 60 Ω; -40°C < $T_j$ < 150°C; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

| Parameter | Symbol | Values | | | Unit | Note or Test Condition | Number |
|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | | |
| **Receiver output RxD** | | | | | | | |
| "High" level output current | $I_{RxD_H}$ | – | -2.5 | -1 | mA | $V_{RxD}$ = $V_{CC}$ -0.4 V; $V_{Diff}$ < 0.5 V | P_8.2.1 |
| "Low" level output current | $I_{RxD_L}$ | 1 | 2.5 | – | mA | $V_{RxD}$ = 0.4 V; $V_{Diff}$ > 0.9 V | P_8.2.2 |
| **Transmission input TxD** | | | | | | | |
| "High" level input voltage | $V_{TxD_H}$ | 0.7 × $V_{CC}$ | – | 6.0 | V | Recessive state | P_8.2.3 |
| "Low" level input voltage | $V_{TxD_L}$ | -0.3 | – | 0.3 × $V_{CC}$ | V | Dominant state | P_8.2.4 |
| Internal pull-up resistor TxD | $R_{TxD}$ | 35 | 55 | 70 | kΩ | – | P_8.2.7 |
| Input capacitance | $C_{TxD}$ | – | – | 10 | pF | 1) | P_8.2.8 |
| TxD permanent dominant time-out | $t_{TxD}$ | 1 | 2.3 | 4 | ms | Normal-operating mode | P_8.2.9 |
| **Stand-by input STB** | | | | | | | |
| "High" level input voltage | $V_{STB_H}$ | 0.7 × $V_{CC}$ | – | 6.0 | V | stand-by mode | P_8.2.13 |
| "Low" level input voltage | $V_{STB_L}$ | -0.3 | – | 0.3 × $V_{CC}$ | V | Normal-operating mode | P_8.2.14 |
| Internal pull-up resistor STB | $R_{STB}$ | 35 | 55 | 70 | kΩ | – | P_8.2.16 |
| Input capacitance | $C_{(STB)}$ | – | – | 10 | pF | 1) | P_8.2.20 |

1) Not subject to production test, specified by design.

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## 7.3 Electrical characteristics receiver

**Table 8 Electrical characteristics receiver**

4.75 V < $V_{CC}$ < 5.25 V; $R_L$ = 60 Ω; -40°C < $T_j$ < 150°C; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

| Parameter | Symbol | Values | | | Unit | Note or Test Condition | Number |
|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | | |
| Differential range dominant normal-operating mode | $V_{Diff_D_Range}$ | 0.9 | – | 8.0 | V | 1) -12 V ≤ $V_{CMR}$ ≤ 12 V | P_8.3.3 |
| Differential range recessive normal-operating mode | $V_{Diff_R_Range}$ | -3.0 | – | 0.5 | V | 1) -12V ≤ $V_{CMR}$ ≤ 12 V | P_8.3.5 |
| Differential range dominant stand-by mode | $V_{Diff_D_STB_Range}$ | 1.15 | 3.0 | 8.0 | V | 1) -12 V ≤ $V_{CMR}$ ≤ 12 V | P_8.3.7 |
| Differential range recessive stand-by mode | $V_{Diff_R_STB_Range}$ | -3.0 | 0 | 0.4 | V | 1) -12 V ≤ $V_{CMR}$ ≤ 12 V | P_8.3.9 |
| Common mode range | $CMR$ | -12 | – | 12 | V | – | P_8.3.11 |
| Single ended internal resistance | $R_{CAN_H}$, $R_{CAN_L}$ | 6 | 40 | 50 | kΩ | 1) recessive state; -2 V ≤ $V_{CANH}$ ≤ 7 V; -2 V ≤ $V_{CANL}$ ≤ 7 V | P_8.3.12 |
| Differential internal resistance | $R_{Diff}$ | 12 | 80 | 100 | kΩ | 1) recessive state; -2 V ≤ $V_{CANH}$ ≤ 7 V; -2 V ≤ $V_{CANL}$ ≤ 7 V | P_8.3.14 |
| Input resistance deviation between CANH and CANL | $\Delta R_i$ | -3 | – | 3 | % | 1) recessive state; $V_{CANH}$ = $V_{CANL}$ = 5 V | P_8.3.16 |
| Input capacitance CANH, CANL versus GND | $C_{In}$ | – | – | 40 | pF | 1)2) recessive state; normal-operating mode | P_8.3.17 |
| Differential input capacitance | $C_{InDiff}$ | – | 4 | 20 | pF | 1)2) recessive state; normal-operating mode | P_8.3.18 |

1) Not subject to production test, specified by design.
2) S2P-Method; $f$ = 10 MHz.

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## 7.4 Electrical characteristics transmitter

**Table 9 Electrical characteristics transmitter**

4.75 V < $V_{CC}$ < 5.25 V; $R_L$ = 60 Ω; -40°C < $T_j$ < 150°C; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

| Parameter | Symbol | Values | | | Unit | Note or Test Condition | Number |
|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | | |
| CANL, CANH recessive output voltage normal-operating mode | $V_{CANL,H}$ | 2.0 | 2.5 | 3.0 | V | $V_{TxD}$ = $V_{CC}$; no load | P_8.4.1 |
| CANH, CANL recessive output voltage difference normal-operating mode | $V_{Diff_R_NM}$ = $V_{CANH}$ - $V_{CANL}$ | -500 | -10 | 50 | mV | $V_{TxD}$ = $V$; no load | P_8.4.2 |
| CANL dominant output voltage normal-operating mode | $V_{CANL}$ | 0.5 | 1.5 | 2.25 | V | $V_{TxD}$ = 0 V; 50 Ω < $R_L$ < 65 Ω | P_8.4.3 |
| CANH dominant output voltage normal-operating mode | $V_{CANH}$ | 2.75 | 3.4 | 4.5 | V | $V_{TxD}$ = 0 V; 50 Ω < $R_L$ < 65 Ω | P_8.4.4 |
| Differential voltage dominant normal-operating mode $V_{Diff}$ = $V_{CANH}$ - $V_{CANL}$ | $V_{Diff_D_NM}$ | 1.5 | 1.9 | 2.5 | V | $V_{TxD}$ = 0 V; 50 Ω < $R_L$ < 65 Ω | P_8.4.5 |
| Differential voltage dominant extended bus load normal-operating mode | $V_{Diff_EXT_BL}$ | 1.4 | 1.9 | 3.3 | V | $V_{TxD}$ = 0 V; 45 Ω < $R_L$ < 70 Ω | P_8.4.6 |
| Differential voltage dominant high extended bus load normal-operating mode | $V_{Diff_HEXT_BL}$ | 1.5 | 3.5 | 5.0 | V | [1] $V_{TxD}$ = 0 V; $R_L$ = 2240Ω; static behavior | P_8.4.7 |
| CANH, CANL recessive output voltage difference stand-by mode | $V_{Diff_STB}$ | -0.2 | 0.001 | 0.2 | V | No load | P_8.4.8 |
| CANL, CANH recessive output voltage stand-by mode | $V_{CANL,H_STB}$ | -0.1 | 0.01 | 0.1 | V | No load | P_8.4.9 |
| Driver symmetry ($V_{SYM}$ = $V_{CANH}$ + $V_{CANL}$) | $V_{SYM}$ | 0.9 × $V_{CC}$ | 1.0 × $V_{CC}$ | 1.1 × $V_{CC}$ | V | [1] [2] $C_1$ = 4.7 nF | P_8.4.10 |
| CANL short circuit current | $I_{CANLsc}$ | -115 | 90 | 115 | mA | [1] -3 $V$ < $V_{CANLshort}$ < 18 V; $t$ < $t_{TxD}$; $V_{TxD}$ = 0 V | P_8.4.11 |
| CANL short circuit current | $I_{CANLsc2}$ | 40 | 90 | 115 | mA | $V_{CANLshort}$ = 18 V; $t$ < $t_{TxD}$; $V_{TxD}$ = 0 V | P_8.4.23 |
| CANH short circuit current | $I_{CANHsc}$ | -115 | -90 | 115 | mA | [1] -3 V < $V_{CANHshort}$ = 18 V; $t$ < $t_{TxD}$; $V_{TxD}$ =0 V | P_8.4.13 |

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**Table 9 Electrical characteristics transmitter (Continued)**

4.75 V < $V_{CC}$ < 5.25 V; $R_L$ = 60 Ω; -40°C < $T_j$ < 150°C; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

| Parameter | Symbol | Values | | | Unit | Note or Test Condition | Number |
|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | | |
| CANH short circuit current | $I_{CANHsc2}$ | -115 | -90 | -40 | mA | $V_{CANHshort}$ = -3 V; $t < t_{TxD}$; $V_{TxD}$ =0 V | P_8.4.24 |
| Leakage current, CANH | $I_{CANH,lk}$ | -5 | 1 | 5 | µA | $V_{CC}$ = 0 V; 0 V < $V_{CANH}$ ≤ 5 V; $V_{CANH}$ = $V_{CANL;}$ | P_8.4.19 |
| Leakage current, CANL | $I_{CANL,lk}$ | -5 | 1 | 5 | µA | $V_{CC}$ = 0 V; 0 V < $V_{CANL}$ ≤ 5 V; $V_{CANH}$ = $V_{CANL}$ | P_8.4.20 |
| CANH, CANL output voltage difference slope, recessive to dominant | $V_{diff_slope_rd}$ | – | 42 | 70 | V/µs | [1] 30% to 70% of measured differential bus voltage, $C_2$ = 100 pF, $R_L$ = 60 Ω, 4.75 V < $V_{CC}$ < 5.25 V | P_8.4.21 |
| CANH, CANL output voltage difference slope, dominant to recessive | $V_{diff_slope_dr}$ | – | 42 | 70 | V/µs | [1] 70% to 30% of measured differential bus voltage, $C_2$ = 100 pF, $R_L$ = 60 Ω, 4.75 V < $V_{CC}$ < 5.25 V | P_8.4.22 |

1) Not subject to production test, specified by design.

2) $V_{SYM}$ is observed during dominant and recessive state and also during the transition from dominant to recessive state and vice versa, while TxD is stimulated by a square wave signal with a frequency of 1 MHz.

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## 7.5 Electrical characteristics dynamic transceiver parameters

**Table 10 Electrical characteristics dynamic transceiver parameters**

4.75 V < $V_{CC}$ < 5.25 V; $R_L$ = 60 Ω; -40°C < $T_j$ < 150°C; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

| Parameter | Symbol | Values | | | Unit | Note or Test Condition | Number |
|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | | |
| Propagation delay TxD-to-RxD | $t_{Loop}$ | 80 | 150 | 255 | ns | $C_1$ = 0 pF, $C_2$ = 100 pF, $C_{RxD}$ = 15 pF; (see **Figure 12**) | P_8.5.1 |
| Propagation delay increased load TxD-to-RxD | $t_{Loop_150}$ | 80 | 180 | 330 | ns | $C_1$ = 0 pF, $C_2$ = 100 pF, $C_{RxD}$ = 15 pF, $R_L$ = 150 Ω [1] | P_8.5.2 |
| Propagation delay TxD to bus "low" to dominant | $t_{d(L)_T}$ | 30 | 70 | 140 | ns | $C_1$ = 0 pF, $C_2$ = 100 pF, $C_{RxD}$ = 15 pF; (see **Figure 12**) | P_8.5.3 |
| Propagation delay TxD to bus "high" to recessive | $t_{d(H)_T}$ | 30 | 90 | 140 | ns | $C_1$ = 0 pF, $C_2$ = 100 pF, $C_{RxD}$ = 15 pF; (see **Figure 12**) | P_8.5.4 |
| Propagation delay bus to RxD dominant to "low" | $t_{d(L)_R}$ | 30 | 90 | 140 | ns | $C_{RxD}$ = 15 pF, Independent of $t_{Bit}$; (see **Figure 12**) | P_8.5.5 |
| Propagation delay bus to RxD recessive to "high" | $t_{d(H)_R}$ | 30 | 100 | 140 | ns | $C_{RxD}$ = 15 pF, Independent of $t_{Bit}$; (see **Figure 12**) | P_8.5.6 |
| **Delay Times** | | | | | | | |
| Delay time for mode change | $t_{Mode}$ | – | 12 | 20 | µs | [1] | P_8.5.7 |
| CAN activity filter time | $t_{Filter}$ | 0.5 | 1.2 | 1.8 | µs | see **Figure 6** | P_8.5.10 |
| Bus wake-up time-out | $t_{Wake}$ | 0.8 | 1.5 | 10 | ms | [1] see **Figure 6** | P_8.5.11 |
| Bus wake-up delay time | $t_{WU}$ | – | 2.5 | 5 | µs | see **Figure 6** and **Figure 7** | P_8.5.12 |
| **CAN FD characteristics** | | | | | | | |
| Received recessive bit width at 2 MBit/s | $t_{Bit(RxD)_2M}$ | 420 | 450 | 520 | ns | $C_2$ = 100 pF; $C_{RxD}$ = 15 pF; $t_{Bit}$ = 500 ns; see **Figure 13** | P_8.5.13 |

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**Table 10 Electrical characteristics dynamic transceiver parameters (Continued)**

4.75 V < $V_{CC}$ < 5.25 V; $R_L$ = 60 Ω; -40°C < $T_j$ < 150°C; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

| Parameter | Symbol | Values | | | Unit | Note or Test Condition | Number |
|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | | |
| Received recessive bit width at 5 MBit/s | $t_{Bit(RxD)_5M}$ | 120 | 150 | 220 | ns | $C_2$ = 100 pF; $C_{RxD}$ = 15 pF; $t_{Bit}$ = 200 ns; see **Figure 13** | P_8.5.14 |
| Transmitted recessive bit width at 2 MBit/s | $t_{Bit(Bus)_2M}$ | 455 | 470 | 510 | ns | $C_2$ = 100 pF; $C_{RxD}$ = 15 pF; $t_{Bit}$ = 500 ns; see **Figure 13** | P_8.5.15 |
| Transmitted recessive bit width at 5 MBit/s | $t_{Bit(Bus)_5M}$ | 155 | 170 | 210 | ns | $C_2$ = 100 pF; $C_{RxD}$ = 15 pF; $t_{Bit}$ = 200 ns; see **Figure 13** | P_8.5.16 |
| Receiver timing symmetry at 2 MBit/s $\Delta t_{Rec_2M} = t_{Bit(RxD)_2M} - t_{Bit(Bus)_2M}$ | $\Delta t_{Rec_2M}$ | -45 | -23 | 15 | ns | $C_2$ = 100 pF; $C_{RxD}$ = 15 pF; $t_{Bit}$ = 500 ns; see **Figure 13** | P_8.5.17 |
| Receiver timing symmetry at 5 MBit/s $\Delta t_{Rec_5M} = t_{Bit(RxD)_5M} - t_{Bit(Bus)_5M}$ | $\Delta t_{Rec_5M}$ | -45 | -23 | 15 | ns | $C_2$ = 100 pF; $C_{RxD}$ = 15 pF; $t_{Bit}$ = 200 ns; see **Figure 13** | P_8.5.18 |

1) Not subject to production test, specified by design.

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## 7.6 Diagrams

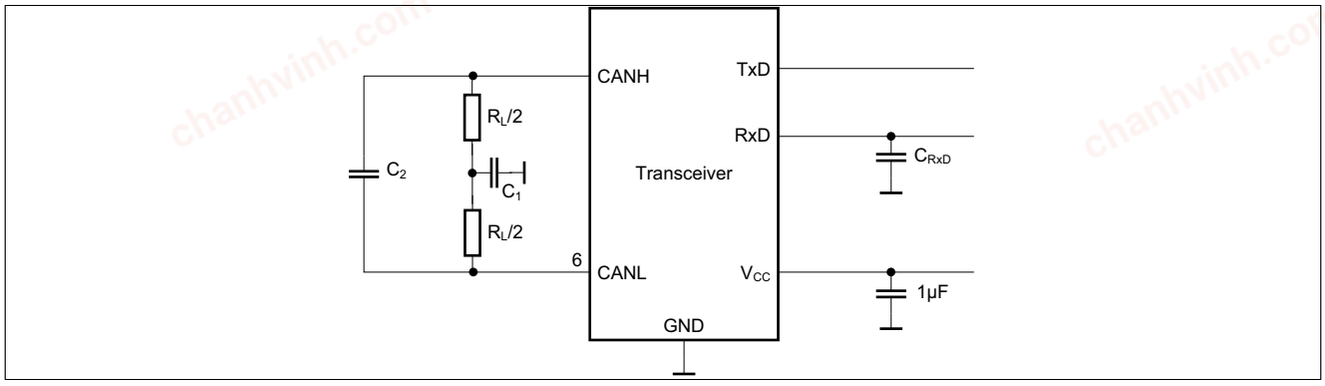



**Figure 11 Test circuit**

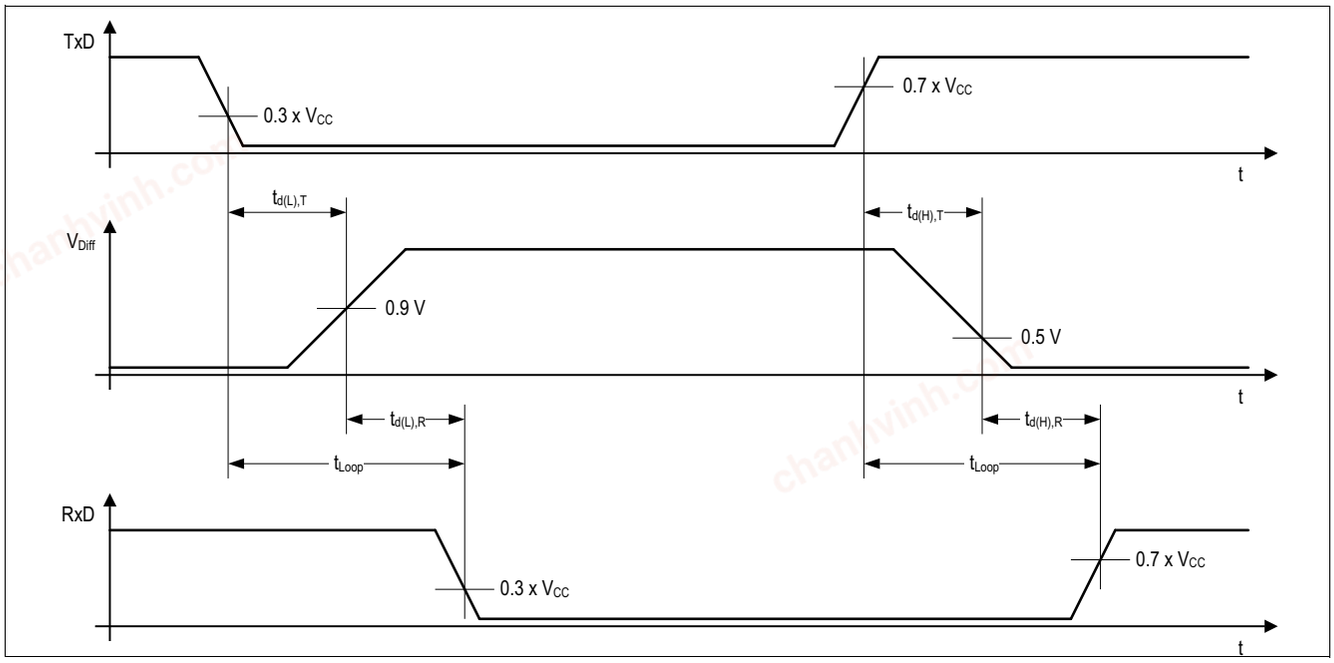



**Figure 12 Timing diagrams for dynamic characteristics**

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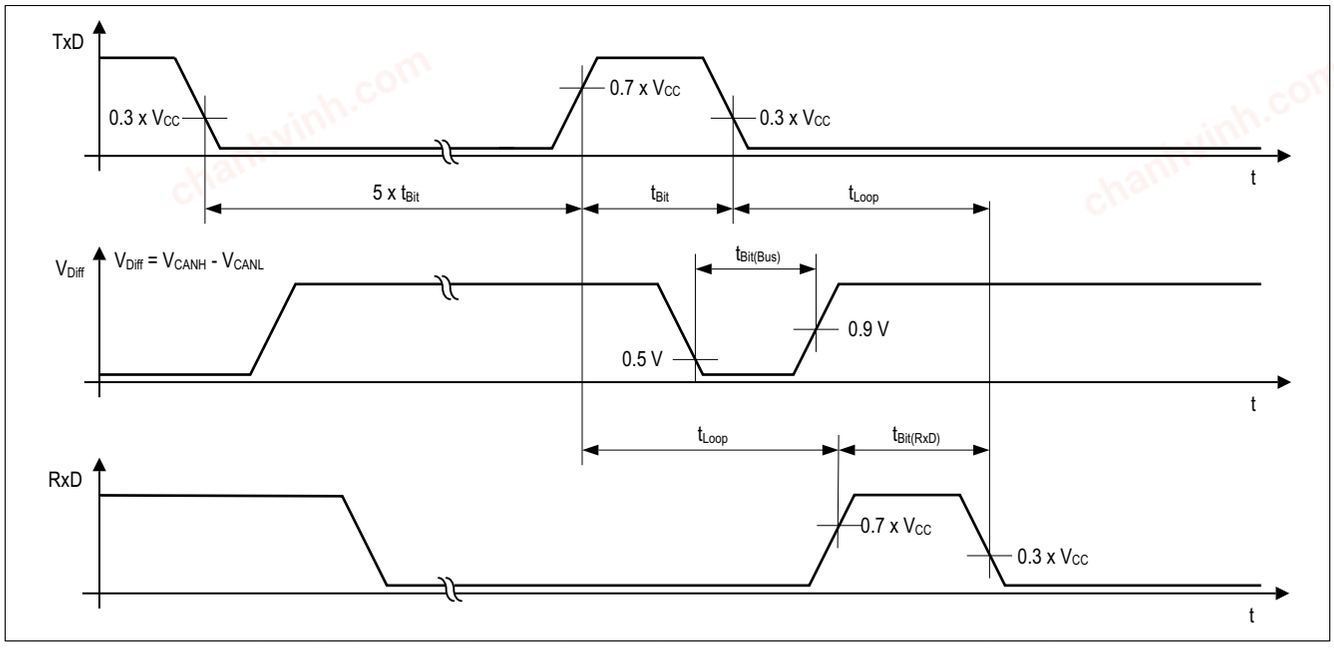



**Figure 13 Recessive bit time for five dominant bits followed by one recessive bit**

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# 8 Application information

## 8.1 ESD robustness according to IEC 61000-4-2

Tests for ESD robustness according to IEC 61000-4-2 Gun test (150 pF, 330 Ω) have been performed. The results and test conditions are available in a separate test report.

**Table 11 ESD robustness according to IEC 61000-4-2**

| Performed test | Result | Unit | Remarks |
|---|---|---|---|
| Electrostatic discharge voltage at pin CANH and CANL versus GND | ≥ +8 | kV | 1) positive pulse |
| Electrostatic discharge voltage at pin CANH and CANL versus GND | ≤ -8 | kV | 1) negative pulse |

1) Not subject to production test. ESD susceptibility "ESD GUN" according to GIFT/ICT paper: "EMC Evaluation of CAN Transceivers, version IEC TS62228", section 4.3. (DIN EN61000-4-2).
Tested by external test facility (IBEE Zwickau).

## 8.2 Application example

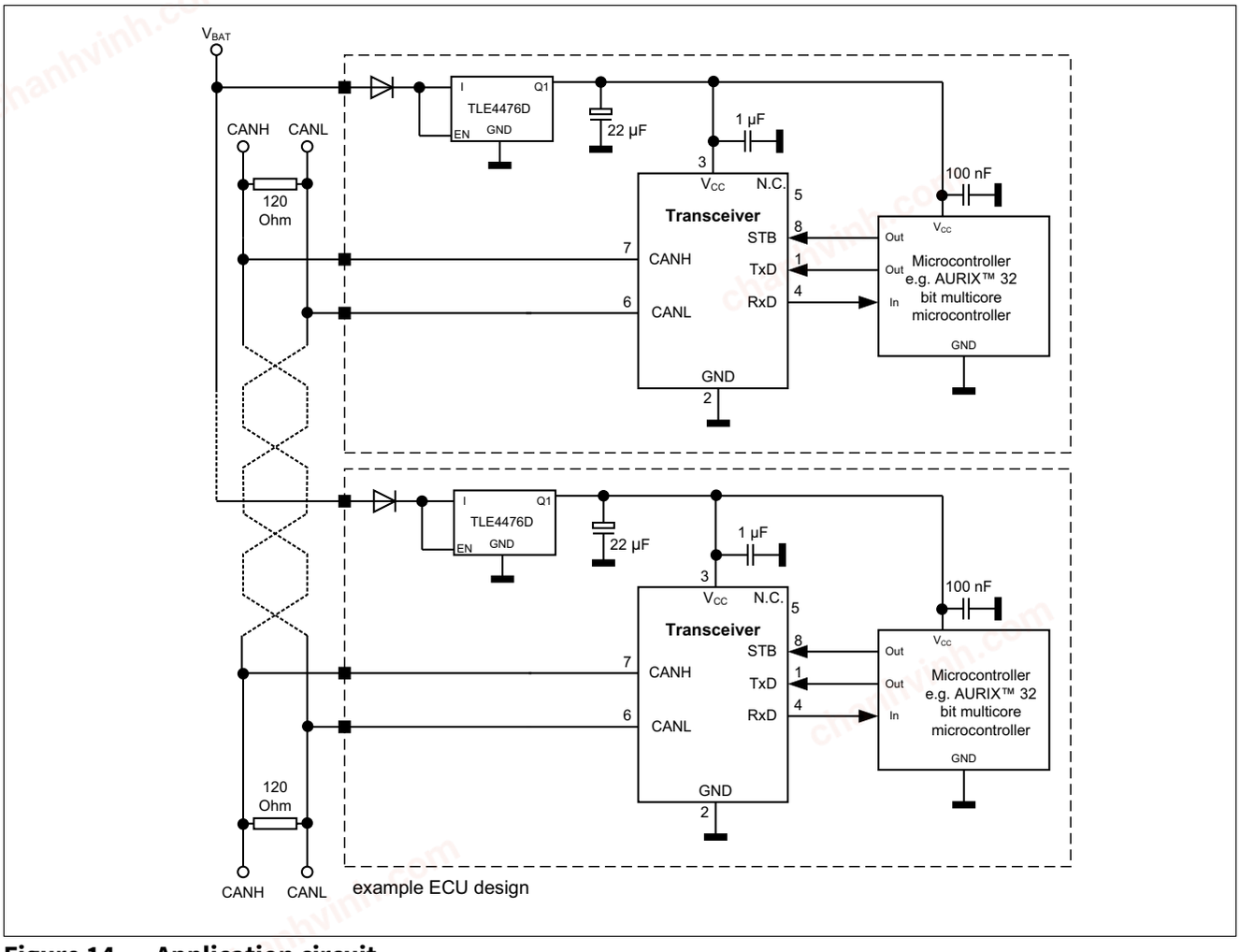



**Figure 14 Application circuit**

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## 8.3 Further application information

For further information you may visit: **https://www.infineon.com/automotive-transceiver**

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# 9 Package information

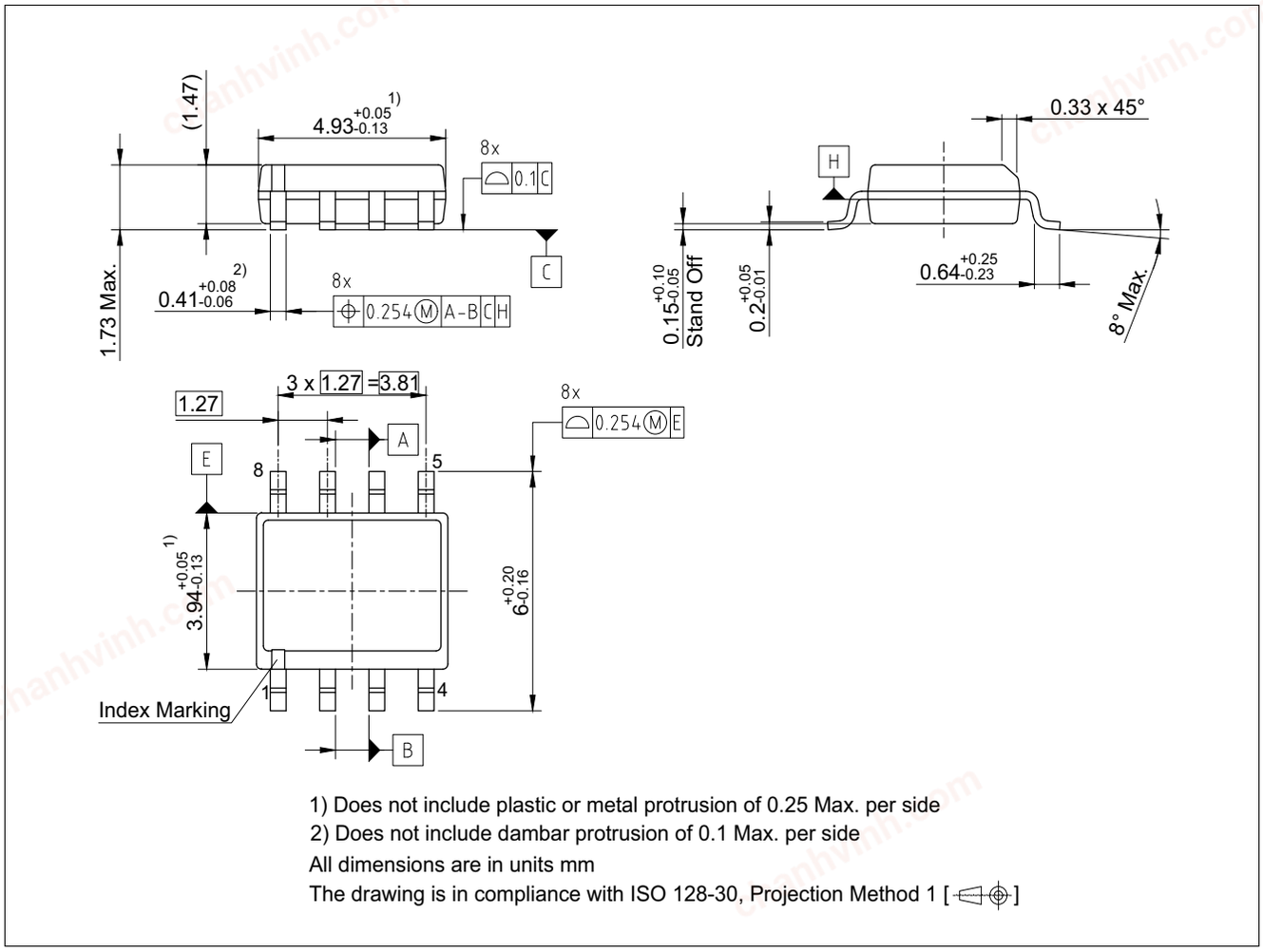



**Figure 15 PG-DSO-8**

### Green Product (RoHS compliant)

To meet the world-wide customer requirements for environmentally friendly products and to be compliant with government regulations the device is available as a green product. Green products are RoHS-Compliant (i.e. Pb-free finish on leads and suitable for Pb-free soldering according to IPC/JEDEC J-STD-020).

### Further information on packages

**https://www.infineon.com/packages**

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# 10 Revision history

| Revision | Date | Changes |
|---|---|---|
| 1.2 | 2022-03-18 | • Editorial changes |
| 1.1 | 2021-07-30 | • Minimum value for Parameter P_8.1.13 $V_{CC}$ undervoltage filter time specified<br>• $V_{CC}$ undervoltage threshold (P_8.1.11 and P_8.1.21) for rising and falling edge specified<br>• Updated description of $V_{CC}$ undervoltage detection<br>• Added new parameter P_8.4.23 and P_8.4.24<br>• Updated figure of application example |
| 1.0 | 2020-11-06 | Datasheet created |

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**Edition 2022-03-18**
**Published by**
**Infineon Technologies AG**
**81726 Munich, Germany**

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**Z8F65909450**

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