

# TLE7251V

## High Speed CAN-Transceiver with Bus Wake-up



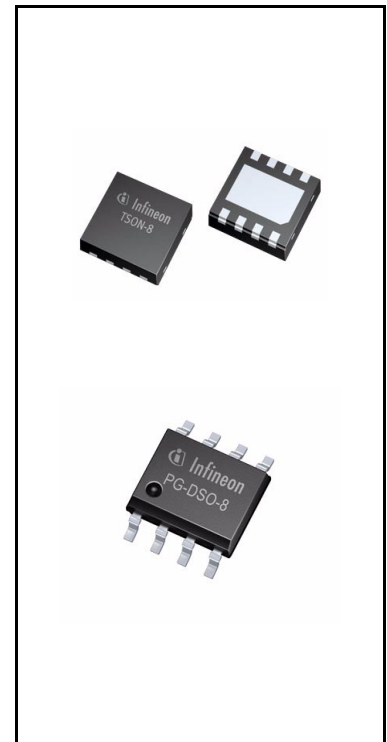
RoHS



### 1 Overview

#### Features

- Fully compatible to ISO 11898-2/-5
- Wide common mode range for electromagnetic immunity (EMI)
- Very low electromagnetic emission (EME)
- Excellent ESD robustness
- Guaranteed loop delay symmetry to support CAN FD data frames up to 2 MBit/s
- $V_{IO}$  input for voltage adaption to the microcontroller supply
- Extended supply range on  $V_{CC}$  and  $V_{IO}$  supply
- CAN short circuit proof to ground, battery and  $V_{CC}$
- TxD time-out function
- Low CAN bus leakage current in power-down state
- Overtemperature protection
- Protected against automotive transients
- Stand-by mode with remote wake-up function
- Wake-up indication on the RxD output
- Transmitter supply  $V_{CC}$  can be turned off in stand-by mode
- Green Product (RoHS compliant)
- Two package variants: PG-TSON-8 and PG-DSO-8



#### Potential applications

- Gateway modules
- Body Control Modules (BCM)
- Engine Control Unit (ECUs)

#### Product validation

Qualified for automotive applications. Product validation according to AEC-Q100/101.

## Overview

## Description

The TLE7251V is a transceiver designed for HS CAN networks in automotive and industrial applications. As an interface between the physical bus layer and the CAN protocol controller, the TLE7251V drives the signals to the bus and protects the microcontroller against interferences generated within the network. Based on the high symmetry of the CANH and CANL signals, the TLE7251V provides a very low level of electromagnetic emission (EME) within a wide frequency range.

The TLE7251V is available in a small, leadless PG-TSON-8 package and in a PG-DSO-8 package. Both packages are RoHS compliant and halogen free. Additionally the PG-TSON-8 package supports the solder joint requirements for automated optical inspection (AOI). The TLE7251VLE and the TLE7251VSJ are fulfilling or exceeding the requirements of the ISO11898-2.

The TLE7251V provides a digital supply input  $V_{IO}$  and a stand-by mode. It is designed to fulfill the enhanced physical layer requirements for CAN FD and supports data rates up to 2 MBit/s.

On the basis of a very low leakage current on the HS CAN bus interface the TLE7251V provides an excellent passive behavior in power-down state. These and other features make the TLE7251V exceptionally suitable for mixed supply HS CAN networks.

Based on the Infineon Smart Power Technology SPT, the TLE7251V provides excellent ESD immunity together with a very high electromagnetic immunity (EMI). The TLE7251V and the Infineon SPT technology are AEC qualified and tailored to withstand the harsh conditions of the automotive environment.

Two different operating modes, additional fail-safe features like a TxD time-out and the optimized output slew rates on the CANH and CANL signals make the TLE7251V the ideal choice for large HS CAN networks with high data transmission rates.

Type	Package	Marking
TLE7251VLE	PG-TSON-8	7251V
TLE7251VSJ	PG-DSO-8	7251V

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Block diagram

2 Block diagram

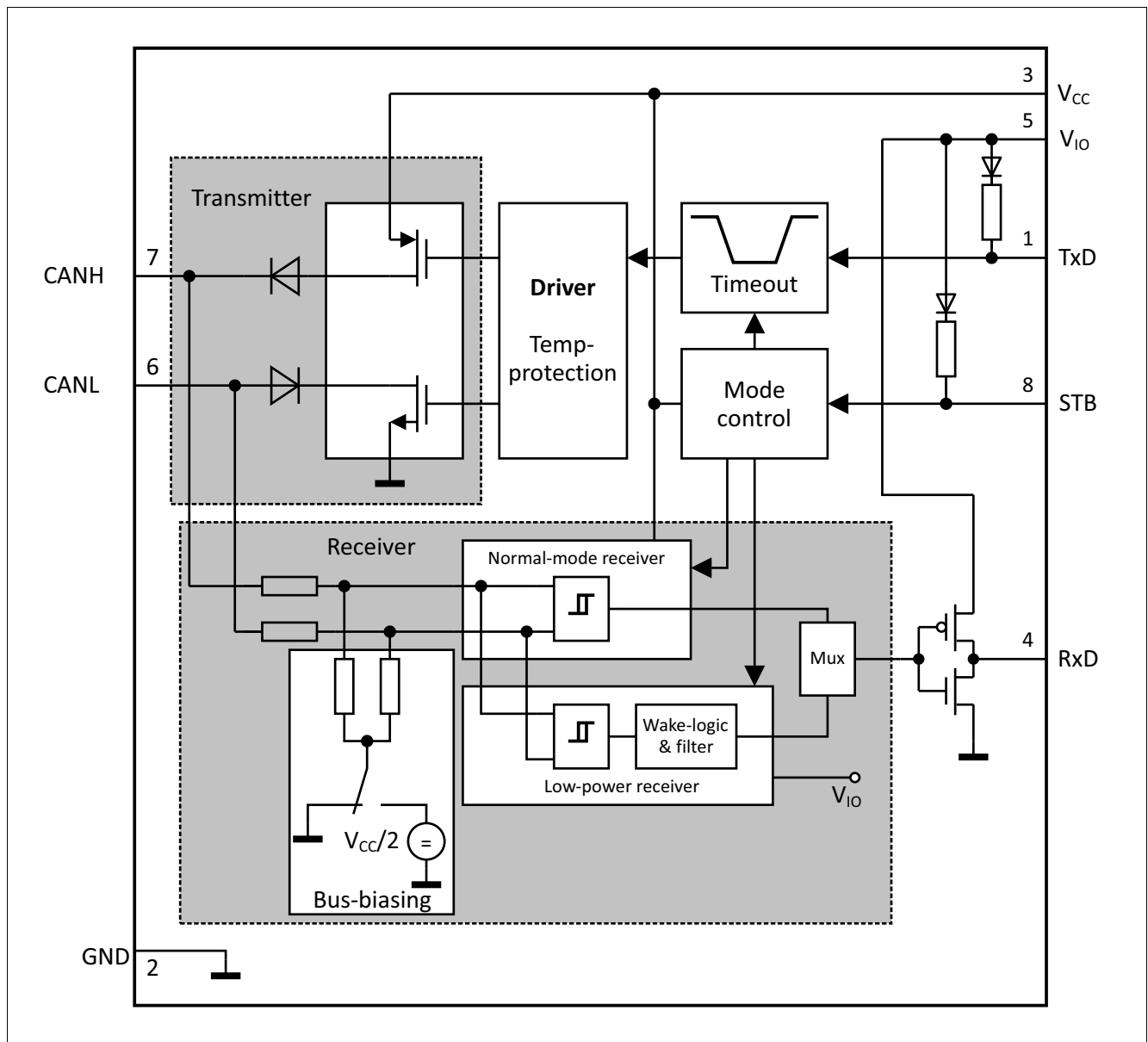
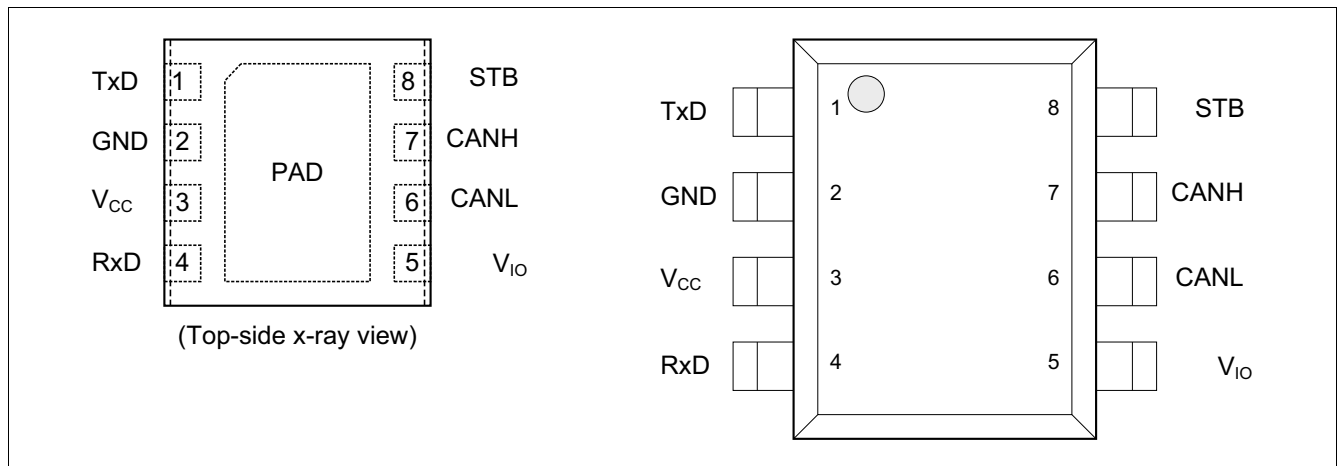


Figure 1 Functional block diagram

**Pin configuration**

**3 Pin configuration**

**3.1 Pin assignment**



**Figure 2 Pin configuration**

**3.2 Pin definitions**

**Table 1 Pin definitions and functions**

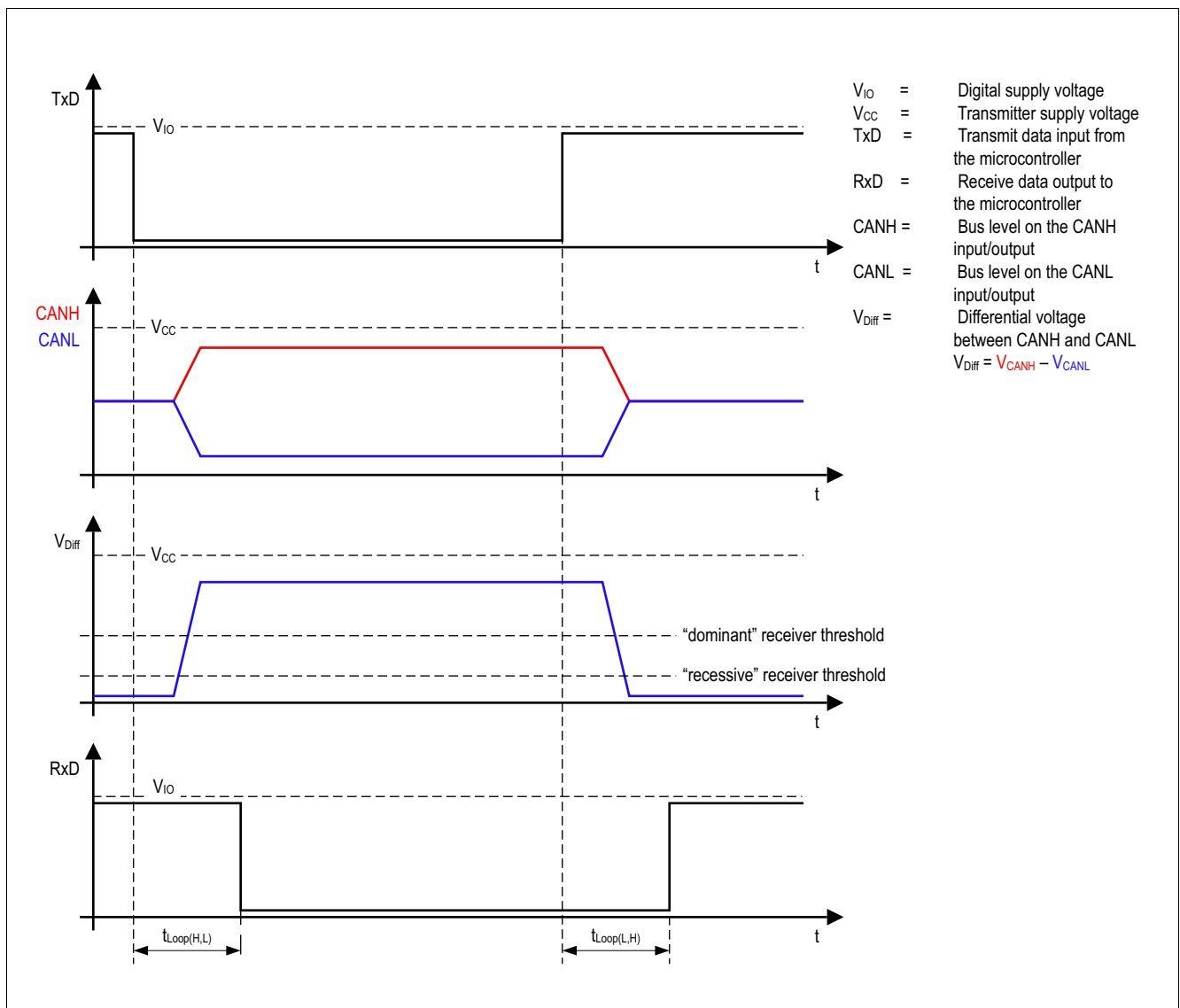
Pin No.	Symbol	Function
1	TxD	<b>Transmit data input;</b> Internal pull-up to $V_{IO}$ , “low” for “dominant” state.
2	GND	<b>Ground</b>
3	$V_{CC}$	<b>Transmitter supply voltage;</b> 100 nF decoupling capacitor to GND required, $V_{CC}$ can be turned off in stand-by mode.
4	RxD	<b>Receive data output;</b> “Low” in “dominant” state.
5	$V_{IO}$	<b>Digital supply voltage;</b> Supply voltage input to adapt the logical input and output voltage levels of the transceiver to the microcontroller supply, supply for the low-power receiver, 100 nF decoupling capacitor to GND required.
6	CANL	<b>CAN bus low level I/O;</b> “Low” in “dominant” state.
7	CANH	<b>CAN bus high level I/O;</b> “High” in “dominant” state.
8	STB	<b>Stand-by input;</b> Internal pull-up to $V_{IO}$ , “low” for normal-operating mode.
PAD	–	Connect to PCB heat sink area. Do not connect to other potential than GND.

**Functional description**

**4 Functional description**

HS CAN is a serial bus system that connects microcontrollers, sensors and actuators for real-time control applications. The use of the Controller Area Network (abbreviated CAN) within road vehicles is described by the international standard ISO 11898. 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 available CAN nodes within the network. The physical layer specification of a CAN bus system includes all electrical and mechanical specifications of a CAN network. The CAN transceiver is part of the physical layer specification. Several different physical layer standards of CAN networks have been developed in recent years. The TLE7251V is a high speed CAN transceiver with a dedicated bus wake-up function and defined by the international standard ISO 11898-5.

**4.1 High speed CAN physical layer**



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

## Functional description

The TLE7251V is a high speed CAN transceiver, operating as an interface between the CAN controller and the physical bus medium. A HS CAN network is a two wire, differential network which allows data transmission rates for CAN FD frames up to 2 MBit/s. Characteristic for HS CAN networks are the two signal states on the HS CAN bus: “dominant” and “recessive” (see [Figure 3](#)).

$V_{CC}$ ,  $V_{IO}$  and GND are the supply pins for the TLE7251V. The pins CANH and CANL are the interface to the HS CAN bus and operate in both directions, as an input and as an output. RxD and TxD pins are the interface to the CAN controller, the TxD pin is an input pin and the RxD pin is an output pin. The STB pin is the input pin for the mode selection (see [Figure 4](#)).

By setting the TxD input pin to logical “low” the transmitter of the TLE7251V drives a “dominant” signal to the CANH and CANL pins. Setting TxD input to logical “high” turns off the transmitter and the output voltage on CANH and CANL discharges towards the “recessive” level. The “recessive” output voltage is provided by the bus biasing (see [Figure 1](#)). The output of the transmitter is considered to be “dominant”, when the voltage difference between CANH and CANL is at least higher than 1.5 V ( $V_{Diff} = V_{CANH} - V_{CANL}$ ).

Parallel to the transmitter the normal-mode receiver monitors the signal on the CANH and CANL pins and indicates it on the RxD output pin. A “dominant” signal on the CANH and CANL pins sets the RxD output pin to logical “low”, vice versa a “recessive” signal sets the RxD output to logical “high”. The normal-mode receiver considers a voltage difference ( $V_{Diff}$ ) between CANH and CANL above 0.9 V as “dominant” and below 0.5 V as “recessive”.

To be conform with HS CAN features, like the bit to bit arbitration, the signal on the RxD output has to follow the signal on the TxD input within a defined loop delay  $t_{Loop} \leq 255$  ns.

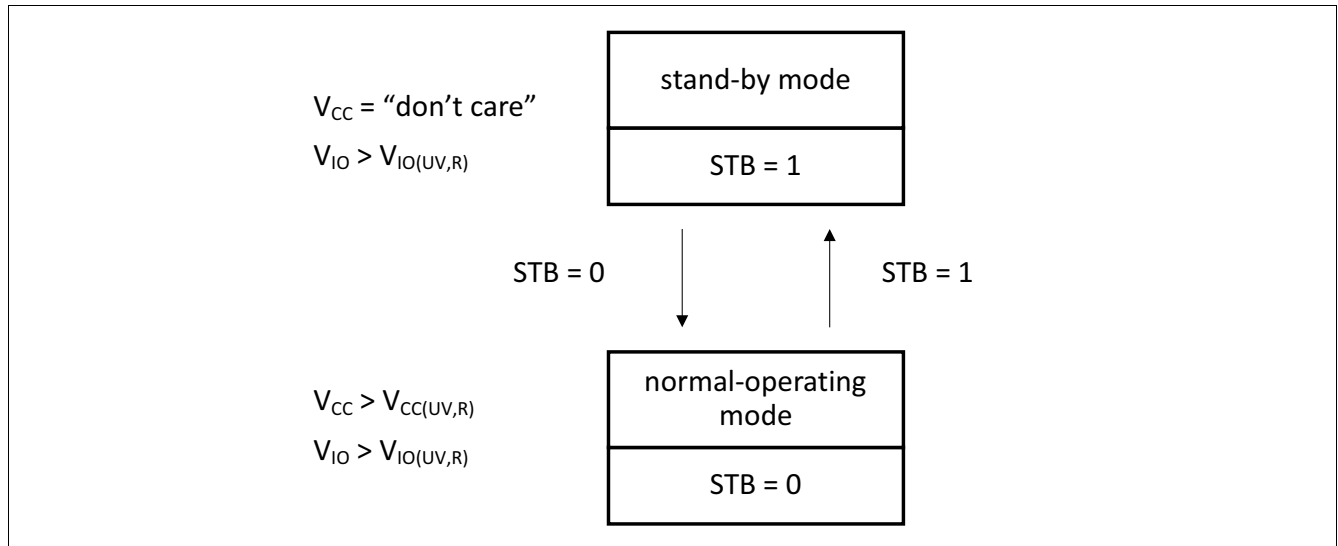
The thresholds of the digital inputs (TxD and STB) and also the RxD output voltage are adapted to the digital power supply  $V_{IO}$ .



**Functional description**

**4.2 Modes of operation**

The TLE7251V supports two different modes of operation, stand-by mode and normal-operating mode while the transceiver is supplied according to the specified functional range. The mode of operation is selected by the STB input pin (see [Figure 4](#)).



**Figure 4 Mode state diagram**

**4.2.1 Normal-operating mode**

In normal-operating mode the transmitter and the receiver of the HS CAN transceiver TLE7251V are active (see [Figure 1](#)). The HS CAN transceiver sends the serial data stream on the TxD input pin to the CAN bus. The data on the CAN bus is displayed at the RxD pin simultaneously. A logical “low” signal on the STB pin selects the normal-operating mode, while the transceiver is supplied by  $V_{CC}$  and  $V_{IO}$  (see [Table 2](#) for details).

**4.2.2 Stand-by mode**

The stand-by mode is an idle mode of the TLE7251V with optimized power consumption. In stand-by mode the transmitter and the normal-mode receiver are turned off. The TLE7251V can not send any data to the CAN bus nor receive any data from the CAN bus.

The low-power receiver is connected to the bus lines. Wake-up signals are indicated on the RxD output pin. An additional filter, implemented inside the low-power receiver, ensures that only “dominant” and recessive” signals on the CAN bus, which are longer than the CAN activity filter time  $t_{Filter}$ , are indicated at the RxD output pin (see [Figure 8](#)).

A logical “high” signal on the STB pin selects the stand-by mode, while the transceiver is supplied by the digital supply  $V_{IO}$  (see [Table 2](#) for details).

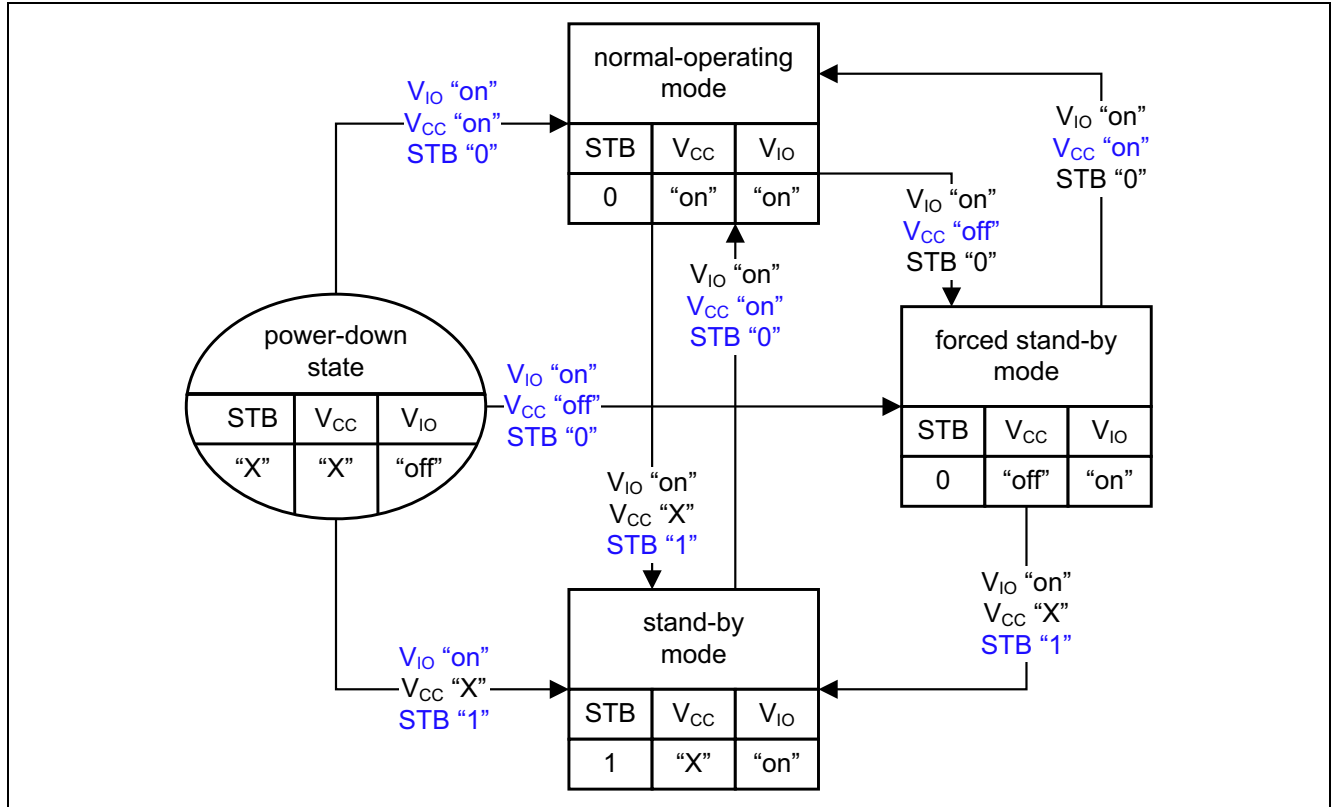
In stand-by mode the bus input pins are biased to GND via the receiver input resistors  $R_i$ .

The undervoltage detection on the transmitter supply  $V_{CC}$  is turned off, allowing to switch off the  $V_{CC}$  supply in stand-by mode.

**Functional description**

**4.3 Power-up and undervoltage condition**

By detecting an undervoltage event, either on the transmitter supply  $V_{CC}$  or the digital supply  $V_{IO}$ , the transceiver TLE7251V changes the mode of operation. Turning off the digital power supply  $V_{IO}$ , the transceiver powers down and remains in the power-down state. While switching off the transmitter supply  $V_{CC}$ , the transceiver either changes to the forced stand-by mode, or remains in stand-by mode (details see **Figure 5**).



**Figure 5 Power-up and undervoltage**

**Table 2 Modes of operation**

Mode	STB	$V_{IO}$	$V_{CC}$	Bus Bias	Transmitter	Normal-mode receiver	Low-power receiver
Normal-operating	"low"	"on"	"on"	$V_{CC}/2$	"on"	"on"	"off"
Stand-by	"high"	"on"	"X"	GND	"off"	"off"	"on"
Forced stand-by	"low"	"on"	"off"	GND	"off"	"off"	"on"
Power-down state	"X"	"off"	"X"	floating	"off"	"off"	"off"

## Functional description

### 4.3.1 Power-down state

Independent of the transmitter supply  $V_{CC}$  and of the STB input pin, the TLE7251V is in power-down state when the digital supply voltage  $V_{IO}$  is turned off (see [Figure 5](#)).

In the power-down state the input resistors of the receiver are disconnected from the bus biasing  $V_{CC}/2$ . The CANH and CANL bus interface of the TLE7251V is floating and acts as a high-impedance input with a very small leakage current. The high-ohmic input does not influence the “recessive” level of the CAN network and allows an optimized EME performance of the entire HS CAN network (see also [Table 2](#)).

### 4.3.2 Forced stand-by mode

The forced stand-by mode is a fail-safe mode to avoid any disturbance on the HS CAN bus, while the TLE7251V faces a loss of the transmitter supply  $V_{CC}$ .

In forced stand-by mode, the transmitter and the normal-mode receiver are turned off and therefore the transceiver TLE7251V can not disturb the bus media.

Similar to the stand-by mode, the low-power receiver is connected to the bus lines and wake-up signals on the CAN bus are indicated at the RxD output pin (see [Figure 8](#)).

In forced stand-by mode the bus is also biased to GND (details see [Table 2](#)) via the receiver input resistors.

The forced stand-by mode can only be entered when the transmitter supply  $V_{CC}$  is not available, either by powering up the digital supply  $V_{IO}$  only or by turning off the transmitter supply in normal-operating mode. While the transceiver TLE7251V is in forced stand-by mode, switching the STB input pin to logical “high” triggers a mode change to stand-by mode (see [Figure 5](#)).

### 4.3.3 Power-up

The HS CAN transceiver TLE7251V powers up if at least the digital supply  $V_{IO}$  is connected to the device. By default the device powers up in stand-by mode, due to the internal pull-up resistor on the STB pin to  $V_{IO}$ .

In case the device needs to power-up to normal-operating mode, the STB pin needs to be pulled active to logical “low” and the supplies  $V_{IO}$  and  $V_{CC}$  have to be connected.

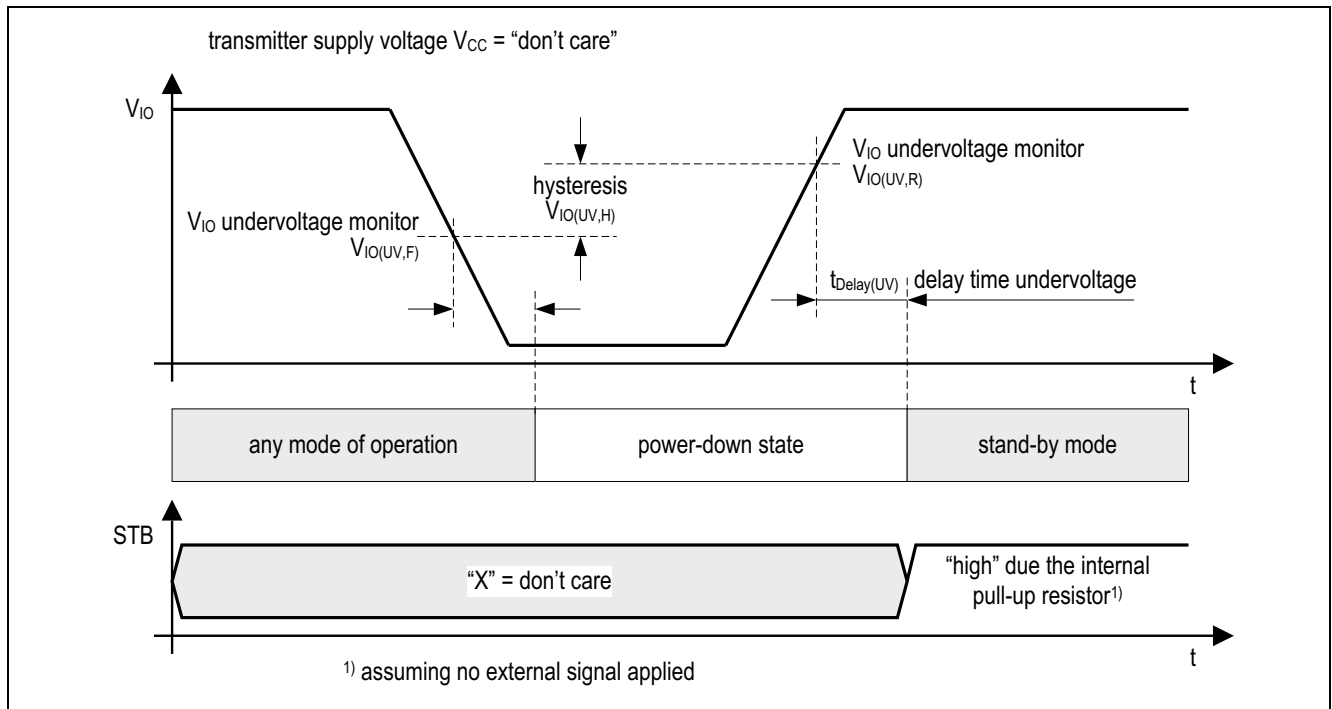
By supplying only the digital power supply  $V_{IO}$  the TLE7251V powers up either in forced stand-by mode or stand-by mode, depending on the signal of the STB input pin. (see [Figure 5](#)).

**Functional description**

**4.3.4 Undervoltage on the digital supply  $V_{IO}$**

If the voltage on  $V_{IO}$  supply input falls below the threshold  $V_{IO} < V_{IO(UV,F)}$ , the transceiver TLE7251V powers down and changes to the power-down state.

The undervoltage detection on the digital supply  $V_{IO}$  has the highest priority. It is independent of the transmitter supply  $V_{CC}$  and also independent of the currently selected operating mode. An undervoltage event on  $V_{IO}$  always powers down the TLE7251V.



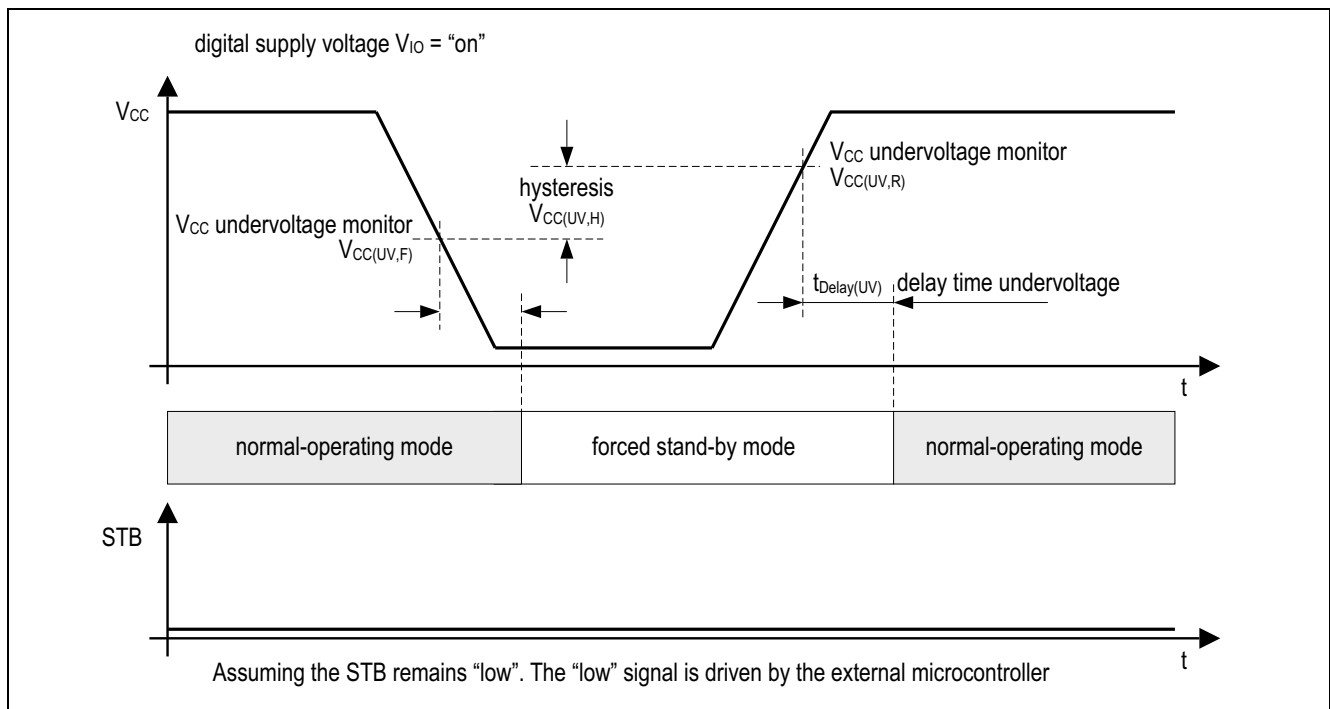
**Figure 6 Undervoltage on the digital supply  $V_{IO}$**

**Functional description**

**4.3.5 Undervoltage on the transmitter supply  $V_{CC}$**

In case the transmitter supply  $V_{CC}$  falls below the threshold  $V_{CC} < V_{CC(UV,F)}$ , the transceiver TLE7251V changes the mode of operation to forced stand-by mode. The transmitter and also the normal-mode receiver of the TLE7251V are powered by the  $V_{CC}$  supply. In case of an insufficient  $V_{CC}$  supply, the TLE7251V can neither transmit the CANH and CANL signals correctly to the bus, nor can it receive them properly. Therefore the TLE7251V blocks the transmitter and the receiver in forced stand-by mode. The low-power receiver is active in forced stand-by mode (see **Figure 7**).

The undervoltage detection on the transmitter supply  $V_{CC}$  is only active in normal-operating mode (see **Figure 5**).



**Figure 7 Undervoltage on the transmitter supply  $V_{CC}$**

**4.3.6 Voltage adaption to the microcontroller supply**

The HS CAN transceiver TLE7251V has two different power supplies,  $V_{CC}$  and  $V_{IO}$ . The power supply  $V_{CC}$  supplies the transmitter and the normal-mode receiver. The power supply  $V_{IO}$  supplies the digital input and output buffers, the low-power receiver, the wake-up logic and it is also the main power domain for the internal logic. To adjust the digital input and output levels of the TLE7251V to the I/O levels of the external microcontroller, connect the power supply  $V_{IO}$  to the microcontroller I/O supply voltage (see **Figure 14**).

*Note:* In case the digital supply voltage  $V_{IO}$  is not required in the application, connect the digital supply voltage  $V_{IO}$  to the transmitter supply  $V_{CC}$ .

**Functional description**

**4.4 Remote wake-up**

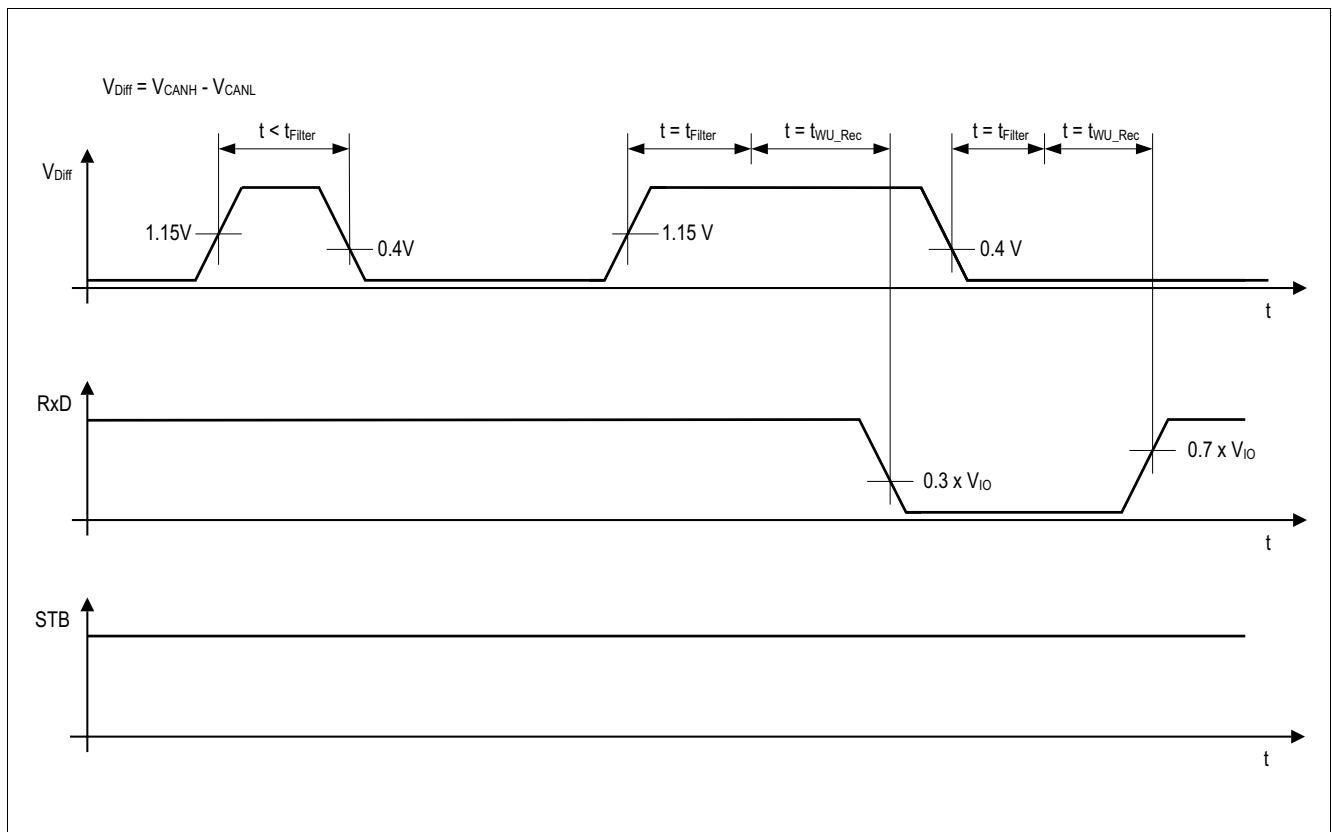
The TLE7251V has a remote wake-up feature, also called bus wake-up feature. In both stand-by mode and forced stand-by mode, the low-power receiver monitors the activity on the CAN bus and in case it detects a wake-up signal, the TLE7251V indicates the wake-up signal on the RxD output pin.

While entering stand-by mode, the RxD output pin is set to logical “high”, regardless of the signal on the CAN bus. The low-power receiver of the TLE7251V requires a signal change from “recessive” to “dominant” on the CAN bus before the RxD output is enabled to follow the signals on the HS CAN bus.

HS CAN bus signals, “dominant” or “recessive”, with a pulse width above the CAN activity filter time  $t > t_{Filter}$  are indicated on the RxD output pin. Glitches with a pulse width below the CAN activity filter time  $t < t_{Filter}$  are ignored and not considered as a valid wake-up signal. The RxD output reacts within the reaction time  $t_{WU\_Rec}$  after detecting a wake-up signal (see **Figure 8**).

*Note: A wake-up event on the CAN bus is only indicated on the RxD output, no automatic change of the operating mode is applied. To enter normal-operating mode, the external microcontroller needs to change the signal on the STB pin.*

The wake-up logic is supplied by the power supply  $V_{IO}$  (see **Figure 1**). In case the TLE7251V is in stand-by mode the power supply  $V_{CC}$  can be turned off, while the TLE7251V is still able to detect a wake-up signal on the HS CAN bus (see also **Figure 4**).



**Figure 8 Wake-up pattern**

## 5 Fail safe functions

### 5.1 Short circuit protection

The CANH and CANL bus outputs are short circuit proof, either against GND or a positive supply voltage. A current limiting circuit protects the transceiver against damages. If the device is heating up due to a continuous short on the CANH or CANL, the internal overtemperature protection switches off the bus transmitter.

### 5.2 Unconnected logic pins

All logic input pins have an internal pull-up resistor to  $V_{IO}$ . In case the  $V_{IO}$  supply is activated and the logical pins are open, the TLE7251V enters into the stand-by mode by default. In stand-by mode the transmitter of the TLE7251V is disabled, the bus bias is turned off and the input resistors of CANH and CANL are connected to GND.

### 5.3 TxD time-out function

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 logical “low” signal on the TxD pin for the time  $t > t_{TxD}$  enables the TxD time-out feature and the TLE7251V disables the transmitter (see [Figure 9](#)). The receiver is still active and the data on the bus continues to be monitored by the RxD output pin.

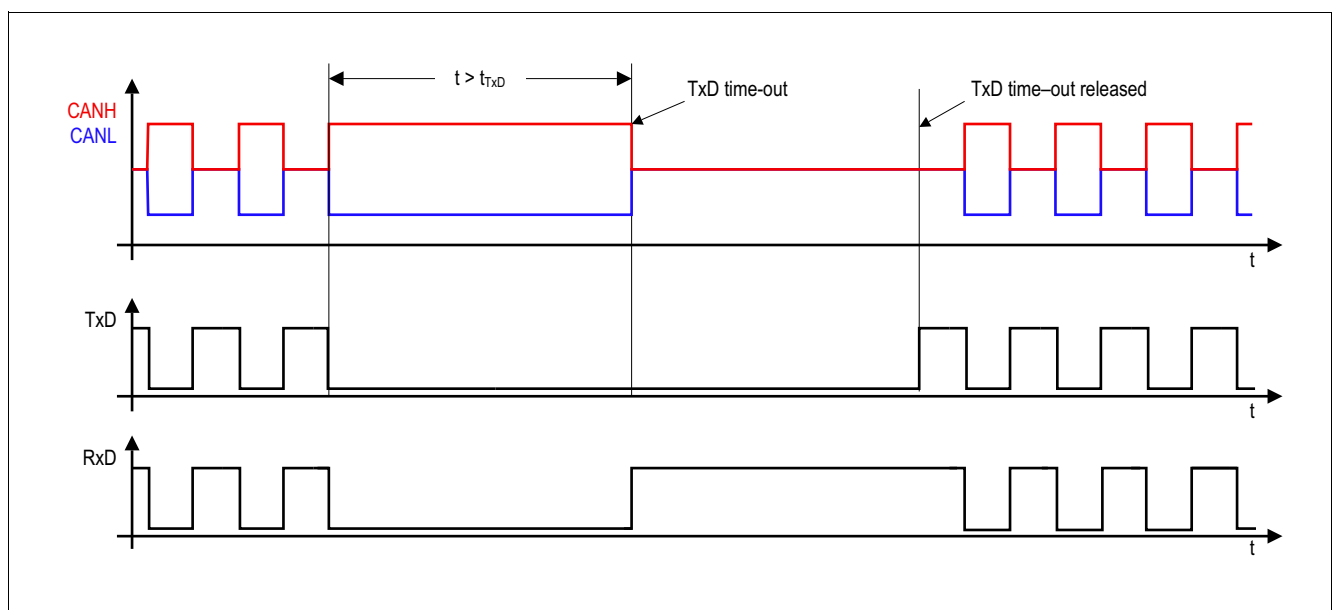


Figure 9 TxD time-out function

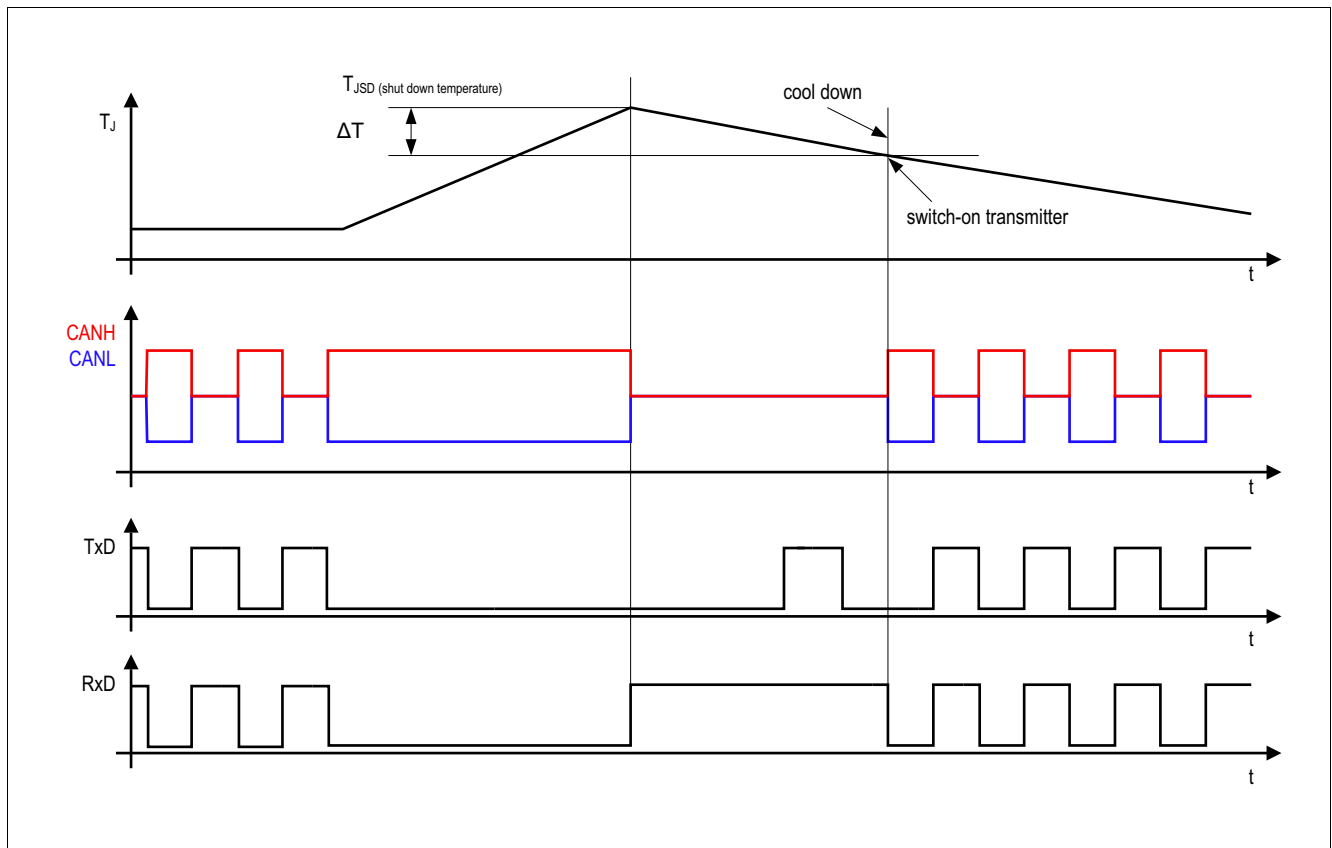
**Figure 9** illustrates how the transmitter is deactivated and activated again. A permanent “low” signal on the TxD input pin activates the TxD time-out function and deactivates the transmitter. To release the transmitter after a TxD time-out event the TLE7251V requires a signal change on the TxD input pin from logical “low” to logical “high”.

**Fail safe functions**

**5.4 Overtemperature protection**

The TLE7251V has an integrated overtemperature detection to protect the TLE7251V against thermal overstress of the transmitter. The overtemperature protection is active in normal-operating mode and disabled in stand-by mode. In case of an overtemperature condition, the temperature sensor will disable the transmitter (see [Figure 1](#)) while the transceiver remains in normal-operating mode.

After the device has cooled down the transmitter is activated again (see [Figure 10](#)). A hysteresis is implemented within the temperature sensor.



**Figure 10 Overtemperature protection**

**5.5 Delay time for mode change**

The HS CAN transceiver TLE7251V changes the mode of operation within the time window  $t_{Mode}$ . During the mode change the RxD output pin is permanently set to logical “high” and does not reflect the status on the CANH and CANL input pins.

While changing the mode of operation from normal-operating mode to stand-by mode, the transceiver TLE7251V turns off the transmitter and switches from the normal-mode receiver to the low-power receiver.

After the mode change is completed, the transceiver TLE7251V releases the RxD output pin (see as an example [Figure 16](#) and [Figure 17](#)).



**General product characteristics**

## 6 General product characteristics

### 6.1 Absolute maximum ratings

**Table 3 Absolute maximum ratings voltages, currents and temperatures<sup>1)</sup>**

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.			
<b>Voltages</b>							
Transmitter supply voltage	$V_{CC}$	-0.3	–	6.0	V	–	P_6.1.1
Digital supply voltage	$V_{IO}$	-0.3	–	6.0	V	–	P_6.1.2
CANH DC voltage versus GND	$V_{CANH}$	-40	–	40	V	–	P_6.1.3
CANL DC voltage versus GND	$V_{CANL}$	-40	–	40	V	–	P_6.1.4
Differential voltage between CANH and CANL	$V_{CAN\_Diff}$	-40	–	40	V	–	P_6.1.5
Voltages at the input pins: STB, TxD	$V_{MAX\_IN}$	-0.3	–	6.0	V	–	P_6.1.6
Voltages at the output pin: RxD	$V_{MAX\_OUT}$	-0.3	–	$V_{IO}$	V	–	P_6.1.7
<b>Currents</b>							
RxD output current	$I_{RxD}$	-20	–	20	mA	–	P_6.1.8
<b>Temperatures</b>							
Junction temperature	$T_j$	-40	–	150	°C	–	P_6.1.9
Storage temperature	$T_S$	-55	–	150	°C	–	P_6.1.10
<b>ESD resistivity</b>							
ESD immunity at CANH, CANL versus GND	$V_{ESD\_HBM\_CAN}$	-9	–	9	kV	HBM (100 pF via 1.5 kΩ) <sup>2)</sup>	P_6.1.11
ESD immunity at all other pins	$V_{ESD\_HBM\_ALL}$	-2	–	2	kV	HBM (100 pF via 1.5 kΩ) <sup>2)</sup>	P_6.1.12
ESD immunity to GND	$V_{ESD\_CDM}$	-750	–	750	V	CDM <sup>3)</sup>	P_6.1.13

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 EIA/JESD22-C101 or ESDA STM5.3.1.

*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.*

**General product characteristics**

**6.2 Functional range**

**Table 4 Functional range**

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
<b>Supply voltages</b>							
Transmitter supply voltage	$V_{CC}$	4.5	–	5.5	V	–	P_6.2.1
Digital supply voltage	$V_{IO}$	3.0	–	5.5	V	–	P_6.2.2
<b>Thermal parameters</b>							
Junction temperature	$T_j$	-40	–	150	°C	1)	P_6.2.3

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.

**6.3 Thermal resistance**

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

**Table 5 Thermal resistance<sup>1)</sup>**

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
<b>Thermal resistances</b>							
Junction to Ambient PG-TSON-8	$R_{thJA}$	–	55	–	K/W	2) TLE7251VLE	P_6.3.1
Junction to Ambient PG-DSO-8	$R_{thJA}$	–	130	–	K/W	2) TLE7251VSJ	P_6.3.4
<b>Thermal shutdown (junction temperature)</b>							
Thermal shutdown temperature	$T_{JSD}$	150	175	200	°C	–	P_6.3.2
Thermal shutdown hysteresis	$\Delta T$	–	10	–	K	–	P_6.3.3

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 (TLE7251V) was simulated on a 76.2 x 114.3 x 1.5 mm board with 2 inner copper layers (2 x 70  $\mu$ m Cu, 2 x 35  $\mu$ m Cu).

**Electrical characteristics**

**7 Electrical characteristics**

**7.1 Functional device characteristics**

**Table 6 Electrical characteristics**

4.5 V <  $V_{CC}$  < 5.5 V; 3.0 V <  $V_{IO}$  < 5.5 V;  $R_L = 60 \Omega$ ;  $-40 \text{ }^\circ\text{C} < T_j < 150 \text{ }^\circ\text{C}$ ; 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.			
<b>Current consumption</b>							
Current consumption at $V_{CC}$ normal-operating mode	$I_{CC}$	–	2.6	4	mA	“recessive” state, $V_{TXD} = V_{IO}$ , $V_{STB} = 0 \text{ V}$ ;	P_7.1.1
Current consumption at $V_{CC}$ normal-operating mode	$I_{CC}$	–	38	60	mA	“dominant” state, $V_{TXD} = V_{STB} = 0 \text{ V}$ ;	P_7.1.2
Current consumption at $V_{IO}$ normal-operating mode	$I_{IO}$	–	–	1	mA	$V_{STB} = 0 \text{ V}$ ;	P_7.1.3
Current consumption at $V_{CC}$ stand-by mode	$I_{CC(STB)}$	–	–	5	$\mu\text{A}$	$V_{TXD} = V_{STB} = V_{IO}$ ;	P_7.1.4
Current consumption at $V_{IO}$ stand-by mode	$I_{IO(STB)}$	–	8	14	$\mu\text{A}$	$V_{TXD} = V_{STB} = V_{IO}$ , $0 \text{ V} < V_{CC} < 5.5 \text{ V}$ ;	P_7.1.5
<b>Supply resets</b>							
$V_{CC}$ undervoltage monitor rising edge	$V_{CC(UV,R)}$	3.8	4.0	4.3	V	–	P_7.1.58
$V_{CC}$ undervoltage monitor falling edge	$V_{CC(UV,F)}$	3.65	3.85	4.3	V	–	P_7.1.6
$V_{CC}$ undervoltage monitor hysteresis	$V_{CC(UV,H)}$	–	150	–	mV	<sup>1)</sup>	P_7.1.7
$V_{IO}$ undervoltage monitor rising edge	$V_{IO(UV,R)}$	2.0	2.5	3.0	V	–	P_7.1.59
$V_{IO}$ undervoltage monitor falling edge	$V_{IO(UV,F)}$	1.8	2.3	3.0	V	–	P_7.1.8
$V_{IO}$ undervoltage monitor hysteresis	$V_{IO(UV,H)}$	–	200	–	mV	<sup>1)</sup>	P_7.1.9
$V_{CC}$ and $V_{IO}$ undervoltage delay time rising edge	$t_{\text{Delay}(UV)}$	–	–	100	$\mu\text{s}$	<sup>1)</sup> (see <b>Figure 6</b> and <b>Figure 7</b> );	P_7.1.10
<b>Receiver output RxD</b>							
“High” level output current	$I_{RD,H}$	–	-4	-2	mA	$V_{\text{RxD}} = V_{IO} - 0.4 \text{ V}$ , $V_{\text{Diff}} < 0.5 \text{ V}$ ;	P_7.1.11
“Low” level output current	$I_{RD,L}$	2	4	–	mA	$V_{\text{RxD}} = 0.4 \text{ V}$ , $V_{\text{Diff}} > 0.9 \text{ V}$ ;	P_7.1.12

**Electrical characteristics**

**Table 6 Electrical characteristics (cont'd)**

4.5 V <  $V_{CC}$  < 5.5 V; 3.0 V <  $V_{IO}$  < 5.5 V;  $R_L = 60 \Omega$ ;  $-40 \text{ }^\circ\text{C} < T_j < 150 \text{ }^\circ\text{C}$ ; 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.			
<b>Transmission input TxD</b>							
“High” level input voltage threshold	$V_{TxD,H}$	–	0.5 $\times V_{IO}$	0.7 $\times V_{IO}$	V	“recessive” state;	P_7.1.13
“Low” level input voltage threshold	$V_{TxD,L}$	0.3 $\times V_{IO}$	0.4 $\times V_{IO}$	–	V	“dominant” state;	P_7.1.14
Pull-up resistance	$R_{TxD}$	10	25	50	k $\Omega$	–	P_7.1.15
Input hysteresis	$V_{HYS(TxD)}$	–	450	–	mV	1)	P_7.1.16
Input capacitance	$C_{TxD}$	–	–	10	pF	1)	P_7.1.17
TxD permanent “dominant” time-out	$t_{TxD}$	4.5	–	16	ms	normal-operating mode;	P_7.1.18
<b>Stand-by input STB</b>							
“High” level input voltage threshold	$V_{STB,H}$	–	0.5 $\times V_{IO}$	0.7 $\times V_{IO}$	V	stand-by mode;	P_7.1.19
“Low” level input voltage threshold	$V_{STB,L}$	0.3 $\times V_{IO}$	0.4 $\times V_{IO}$	–	V	normal-operating mode;	P_7.1.20
Pull-up resistance	$R_{STB}$	10	25	50	k $\Omega$	–	P_7.1.21
Input capacitance	$C_{STB}$	–	–	10	pF	1)	P_7.1.22
Input hysteresis	$V_{HYS(STB)}$	–	200	–	mV	1)	P_7.1.23
<b>Bus receiver</b>							
Differential receiver threshold “dominant” normal-operating mode	$V_{Diff\_D}$	–	0.75	0.9	V	2)	P_7.1.24
Differential receiver threshold “recessive” normal-operating mode	$V_{Diff\_R}$	0.5	0.66	–	V	2)	P_7.1.25
Differential receiver threshold “dominant” stand-by mode	$V_{Diff\_D\_STB}$	–	0.75	1.15	V	2)	P_7.1.26
Differential receiver threshold “recessive” stand-by mode	$V_{Diff\_R\_STB}$	0.4	0.72	–	V	2)	P_7.1.27
Common mode range	CMR	-12	–	12	V	$V_{CC} = 5 \text{ V}$ ;	P_7.1.28
Differential receiver hysteresis normal-operating mode	$V_{Diff,hys}$	–	90	–	mV	1)	P_7.1.29
CANH, CANL input resistance	$R_i$	10	20	30	k $\Omega$	“recessive” state;	P_7.1.30
Differential input resistance	$R_{Diff}$	20	40	60	k $\Omega$	“recessive” state;	P_7.1.31
Input resistance deviation between CANH and CANL	$\Delta R_i$	-1	–	1	%	1) “recessive” state;	P_7.1.32

## Electrical characteristics

**Table 6** Electrical characteristics (cont'd)

4.5 V <  $V_{CC}$  < 5.5 V; 3.0 V <  $V_{IO}$  < 5.5 V;  $R_L = 60 \Omega$ ;  $-40 \text{ }^\circ\text{C} < T_j < 150 \text{ }^\circ\text{C}$ ; 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.			
Input capacitance CANH, CANL versus GND	$C_{In}$	–	20	40	pF	<sup>1)</sup> $V_{TxD} = V_{IO}$ ;	P_7.1.33
Differential input capacitance	$C_{In\_Diff}$	–	10	20	pF	<sup>1)</sup> $V_{TxD} = V_{IO}$ ;	P_7.1.34
<b>Bus transmitter</b>							
CANL/CANH “recessive” output voltage normal-operating mode	$V_{CANL/H}$	2.0	2.5	3.0	V	$V_{TxD} = V_{IO}$ , no load;	P_7.1.35
CANH, CANL “recessive” output voltage difference normal-operating mode	$V_{Diff\_NM}$	-500	–	50	mV	$V_{TxD} = V_{IO}$ , no load;	P_7.1.36
CANH, CANL “recessive” output voltage difference stand-by mode	$V_{Diff\_STB}$	-0.1	–	0.1	V	no load;	P_7.1.37
CANL “dominant” output voltage normal-operating mode	$V_{CANL}$	0.5	–	2.25	V	$V_{TxD} = 0 \text{ V}$ ;	P_7.1.38
CANH “dominant” output voltage normal-operating mode	$V_{CANH}$	2.75	–	4.5	V	$V_{TxD} = 0 \text{ V}$ ;	P_7.1.39
CANH, CANL “dominant” output voltage difference normal-operating mode according to ISO 11898-2 $V_{Diff} = V_{CANH} - V_{CANL}$	$V_{Diff}$	1.5	–	3.0	V	$V_{TxD} = 0 \text{ V}$ , $50 \Omega < R_L < 65 \Omega$ , $4.75 < V_{CC} < 5.25 \text{ V}$ ;	P_7.1.40
CANH, CANL “dominant” output voltage difference normal-operating mode $V_{Diff} = V_{CANH} - V_{CANL}$	$V_{Diff\_R45}$	1.4	–	3.0	V	$V_{TxD} = 0 \text{ V}$ , $45 \Omega < R_L < 50 \Omega$ , $4.75 < V_{CC} < 5.25 \text{ V}$ ;	P_7.1.56
Driver “dominant” symmetry normal-operating mode $V_{SYM} = V_{CANH} + V_{CANL}$	$V_{SYM}$	4.5	5	5.5	V	$V_{CC} = 5.0 \text{ V}$ , $V_{TxD} = 0 \text{ V}$ ;	P_7.1.41
CANL short circuit current	$I_{CANLsc}$	40	75	100	mA	$V_{CANLshort} = 18 \text{ V}$ , $V_{CC} = 5.0 \text{ V}$ , $t < t_{TxD}$ , $V_{TxD} = 0 \text{ V}$ ;	P_7.1.42
CANH short circuit current	$I_{CANHsc}$	-100	-75	-40	mA	$V_{CANHshort} = 0 \text{ V}$ , $V_{CC} = 5.0 \text{ V}$ , $t < t_{TxD}$ , $V_{TxD} = 0 \text{ V}$ ;	P_7.1.43

**Electrical characteristics**

**Table 6 Electrical characteristics (cont'd)**

4.5 V < V<sub>CC</sub> < 5.5 V; 3.0 V < V<sub>IO</sub> < 5.5 V; R<sub>L</sub> = 60 Ω; -40 °C < T<sub>j</sub> < 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.			
Leakage current, CANH	I <sub>CANH,lk</sub>	-5	-	5	μA	V <sub>CC</sub> = V <sub>IO</sub> = 0 V, 0 V < V <sub>CANH</sub> < 5 V, V <sub>CANH</sub> = V <sub>CANL</sub> ;	P_7.1.44
Leakage current, CANL	I <sub>CANL,lk</sub>	-5	-	5	μA	V <sub>CC</sub> = V <sub>IO</sub> = 0 V, 0 V < V <sub>CANL</sub> < 5 V, V <sub>CANH</sub> = V <sub>CANL</sub> ;	P_7.1.45

**Dynamic CAN-transceiver characteristics**

Propagation delay TxD-to-RxD “low” (“recessive to “dominant”)	t <sub>Loop(H,L)</sub>	-	180	255	ns	C <sub>L</sub> = 100 pF, 4.75 V < V <sub>CC</sub> < 5.25 V, C <sub>RxD</sub> = 15 pF;	P_7.1.46
Propagation delay TxD-to-RxD “high” (“dominant” to “recessive”)	t <sub>Loop(L,H)</sub>	-	180	255	ns	C <sub>L</sub> = 100 pF, 4.75 V < V <sub>CC</sub> < 5.25 V, C <sub>RxD</sub> = 15 pF;	P_7.1.47
Propagation delay extended load TxD-to-RxD “low” (“recessive to “dominant”)	t <sub>Loop_Ext(H,L)</sub>	-	-	300	ns	<sup>1)</sup> C <sub>L</sub> = 200 pF, R <sub>L</sub> = 120 Ω, 4.75 V < V <sub>CC</sub> < 5.25 V, C <sub>RxD</sub> = 15 pF;	P_7.1.61
Propagation delay extended load TxD-to-RxD “high” (“dominant” to “recessive”)	t <sub>Loop_Ext(L,H)</sub>	-	-	300	ns	<sup>1)</sup> C <sub>L</sub> = 200 pF, R <sub>L</sub> = 120 Ω, 4.75 V < V <sub>CC</sub> < 5.25 V, C <sub>RxD</sub> = 15 pF;	P_7.1.62
Propagation delay TxD “low” to bus “dominant”	t <sub>d(L,T)</sub>	-	90	140	ns	C <sub>L</sub> = 100 pF, 4.75 V < V <sub>CC</sub> < 5.25 V, C <sub>RxD</sub> = 15 pF;	P_7.1.48
Propagation delay TxD “high” to bus “recessive”	t <sub>d(H,T)</sub>	-	90	140	ns	C <sub>L</sub> = 100 pF, 4.75 V < V <sub>CC</sub> < 5.25 V, C <sub>RxD</sub> = 15 pF;	P_7.1.49
Propagation delay bus “dominant” to RxD “low”	t <sub>d(L,R)</sub>	-	90	140	ns	C <sub>L</sub> = 100 pF, 4.75 V < V <sub>CC</sub> < 5.25 V, C <sub>RxD</sub> = 15 pF;	P_7.1.50
Propagation delay bus “recessive” to RxD “high”	t <sub>d(H,R)</sub>	-	90	140	ns	C <sub>L</sub> = 100 pF, 4.75 V < V <sub>CC</sub> < 5.25 V, C <sub>RxD</sub> = 15 pF;	P_7.1.51

**Delay times**

Delay time for mode change	t <sub>Mode</sub>	-	-	20	μs	<sup>1)</sup> (see <a href="#">Figure 16</a> );	P_7.1.52
RxD reaction delay, stand-by mode to normal- operating mode,	t <sub>RxD_Rec</sub>	-	-	5	μs	<sup>1)</sup> (see <a href="#">Figure 17</a> );	P_7.1.57
CAN activity filter time	t <sub>Filter</sub>	0.5	-	5	μs	(see <a href="#">Figure 8</a> );	P_7.1.53
Wake-up reaction time	t <sub>WU_Rec</sub>	-	-	5	μs	<sup>1)</sup> (see <a href="#">Figure 8</a> );	P_7.1.60

**Electrical characteristics**

**Table 6 Electrical characteristics (cont'd)**

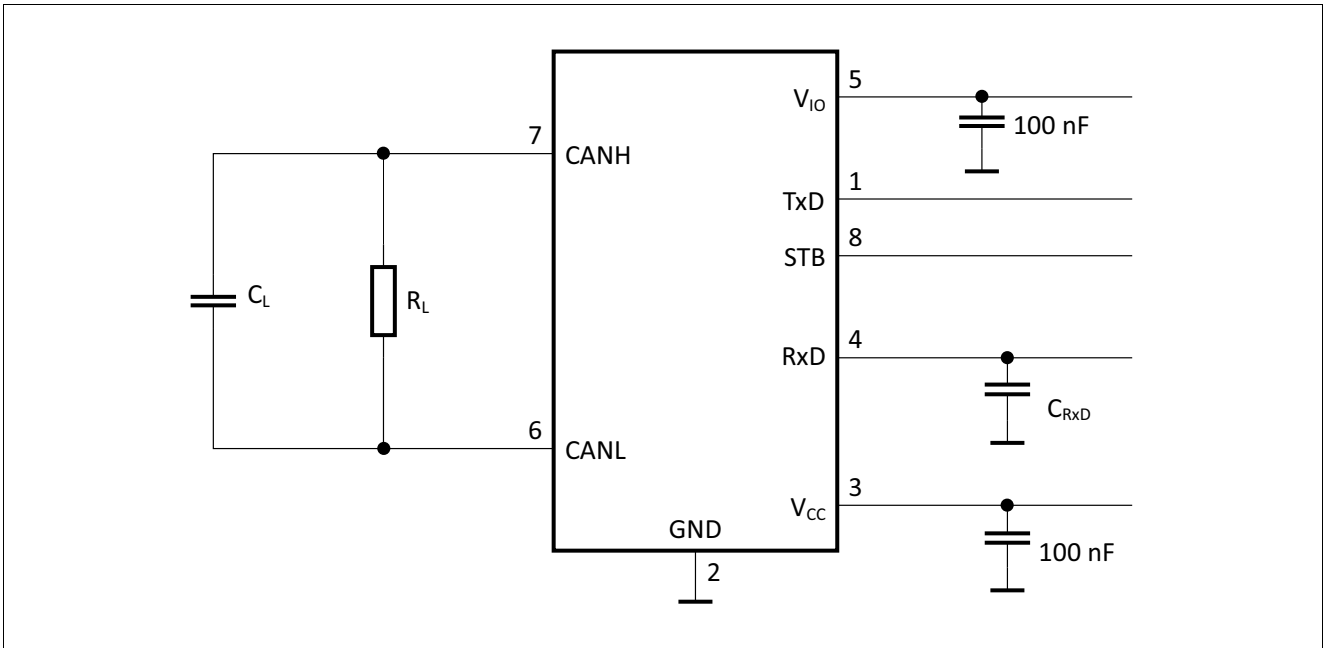
4.5 V < V<sub>CC</sub> < 5.5 V; 3.0 V < V<sub>IO</sub> < 5.5 V; R<sub>L</sub> = 60 Ω; -40 °C < T<sub>j</sub> < 150 °C; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
<b>CAN FD Characteristics -</b>							
Received recessive bit width at 2 MBit/s	$t_{\text{Bit(RxD)}\_2}$ MB	400	500	550	ns	C <sub>L</sub> = 100 pF, 4.75 V < V <sub>CC</sub> < 5.25 V, C <sub>RxD</sub> = 15 pF, t <sub>Bit</sub> = 500 ns, (see <b>Figure 13</b> );	P_7.1.54
Transmitted recessive bit width at 2 MBit/s	$t_{\text{Bit(Bus)}\_2}$ MB	435	500	530	ns	C <sub>L</sub> = 100 pF, 4.75 V < V <sub>CC</sub> < 5.25 V, C <sub>RxD</sub> = 15 pF, t <sub>Bit</sub> = 500 ns, (see <b>Figure 13</b> );	P_7.1.63
Receiver timing symmetry at 2 MBit/s $\Delta t_{\text{Rec}} = t_{\text{Bit(RxD)}} - t_{\text{Bit(Bus)}}$	$\Delta t_{\text{Rec\_2MB}}$	-65	-	40	ns	C <sub>L</sub> = 100 pF, 4.75 V < V <sub>CC</sub> < 5.25 V, C <sub>RxD</sub> = 15 pF, t <sub>Bit</sub> = 500 ns, (see <b>Figure 13</b> );	P_7.1.64

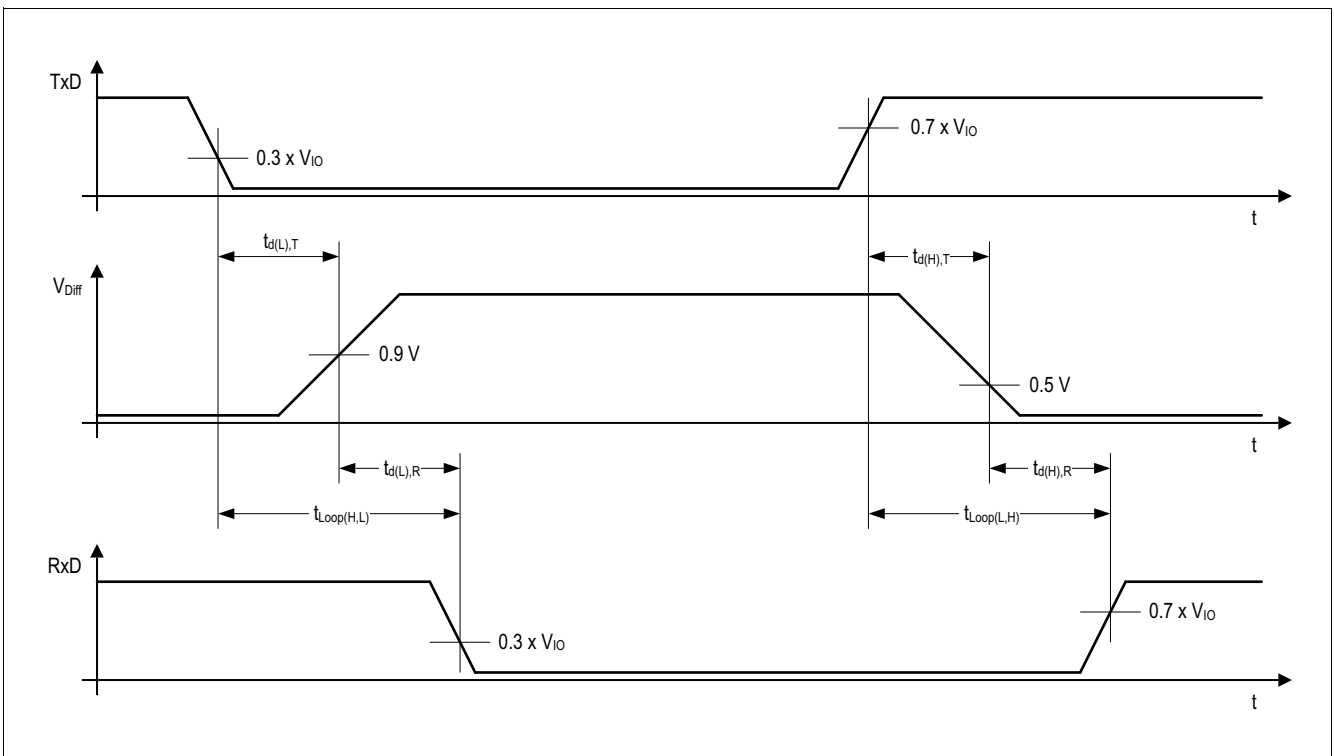
- 1) Not subject to production test, specified by design.
- 2) In respect to common mode range.

**Electrical characteristics**

**7.2 Diagrams**



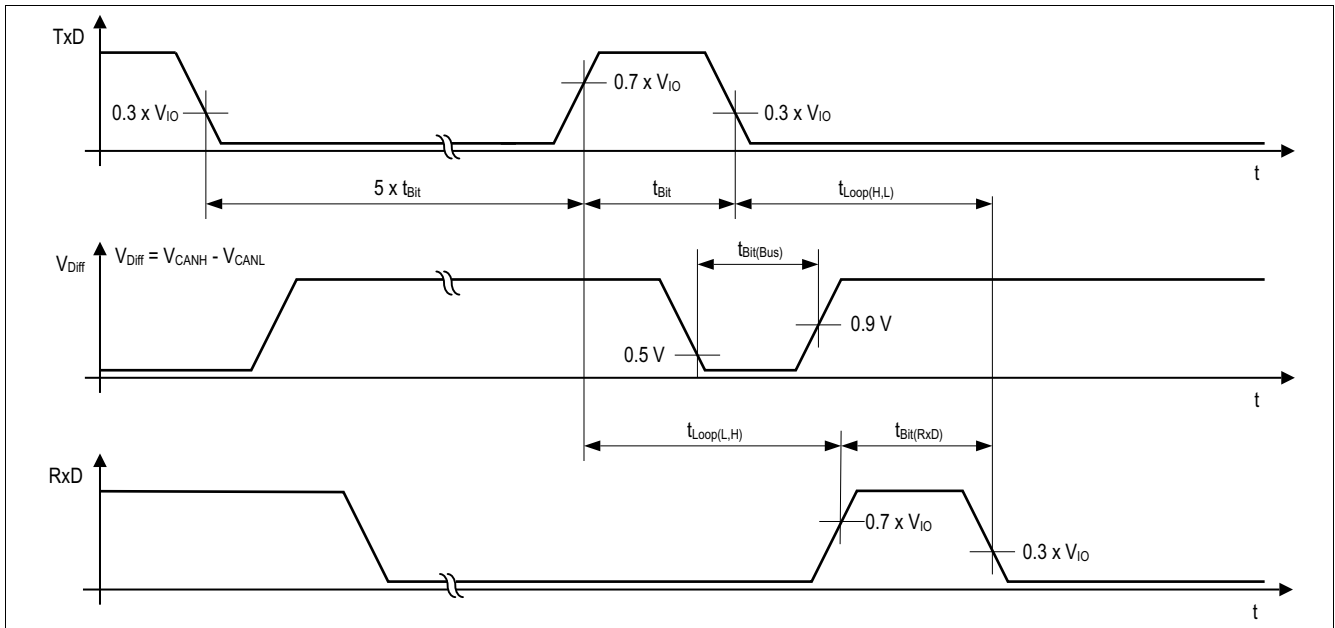
**Figure 11 Test circuits for dynamic characteristics**



**Figure 12 Timing diagrams for dynamic characteristics**



**Electrical characteristics**



**Figure 13** “Recessive” bit time - five “dominant” bits followed by one “recessive” bit

**Application information**

## **8 Application information**

### **8.1 ESD robustness according to IEC61000-4-2**

Test for ESD robustness according to IEC61000-4-2 “Gun test” (150 pF, 330 Ω) have been performed. The results and test conditions are available in a separate test report.

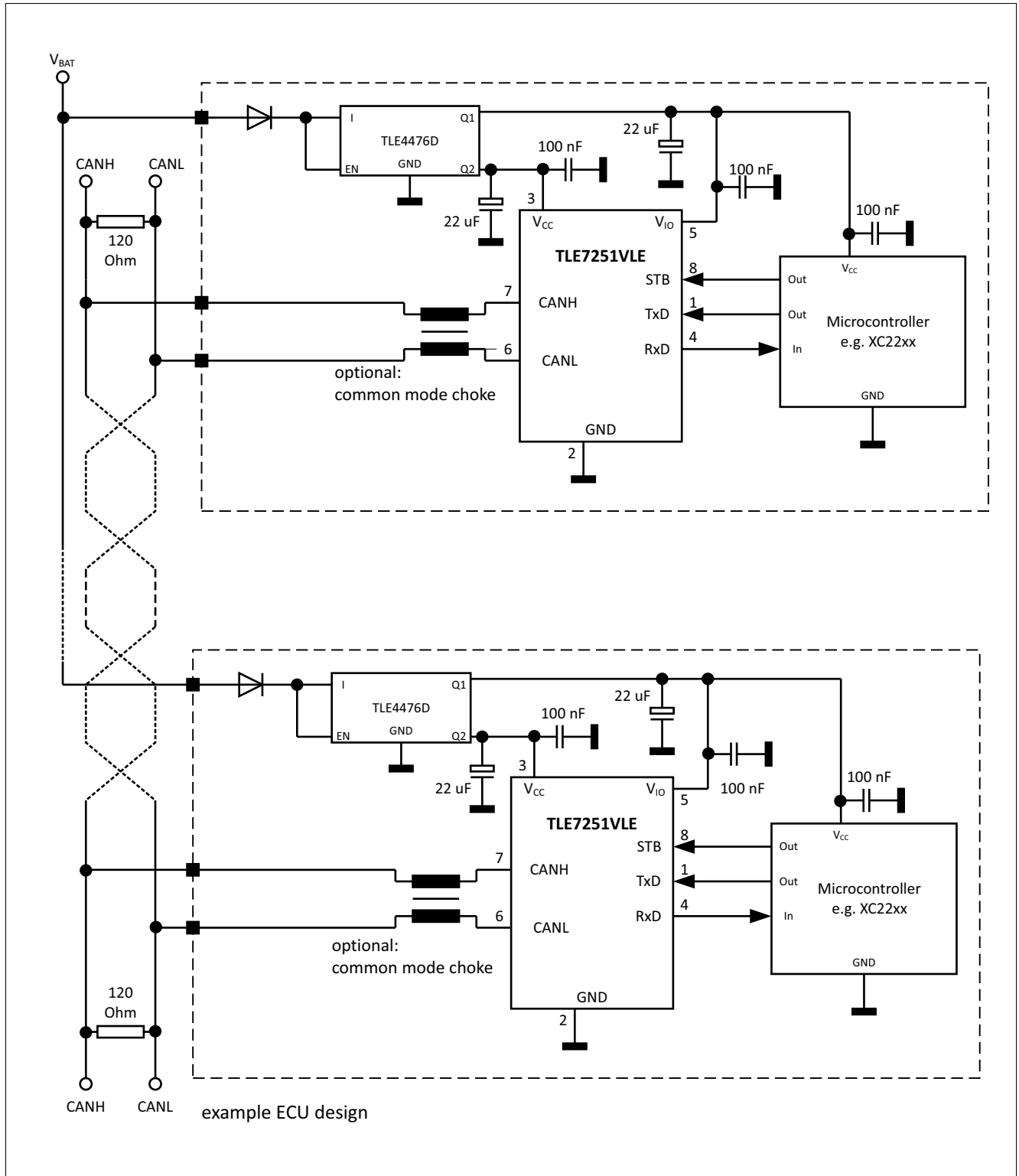
**Table 7 ESD robustness according to IEC61000-4-2**

<b>Performed Test</b>	<b>Result</b>	<b>Unit</b>	<b>Remarks</b>
Electrostatic discharge voltage at pin CANH and CANL versus GND	≥ +8	kV	<sup>1)</sup> Positive pulse
Electrostatic discharge voltage at pin CANH and CANL versus GND	≤ -8	kV	<sup>1)</sup> Negative pulse

- 1) ESD susceptibility “ESD GUN” according to GIFT / ICT paper: “EMC Evaluation of CAN Transceivers, version 03/02/IEC TS62228”, section 4.3. (DIN EN61000-4-2)  
Tested by external test facility (IBEE Zwickau, EMC test report no. TBD).

**Application information**

**8.2 Application example**



**Figure 14 Application circuit**

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**Application information**

### **8.3 Examples for mode changes**

Changing the status on the STB input pin triggers a change of the operating mode, disregarding the actual signal on the CANH, CANL and TxD pins (see also [Chapter 4.2](#)).

Mode changes are triggered by the STB pin, when the device TLE7251V is fully supplied. Setting the STB pin to logical “low” changes the mode of operation to normal-operating mode:

- The mode change is executed independently of the signal on the HS CAN bus. The CANH, CANL inputs may be either “dominant” or “recessive”. They can be also permanently shorted to GND or  $V_{CC}$ .
- A mode change is performed independently of the signal on the TxD input. The TxD input may be either logical “high” or “low”.

Analog to that, changing the STB input pin to logical “high” changes the mode of operation to the stand-by mode, independent on the signals at the CANH, CANL and TxD pins.

#### **Notes**

1. *In case the TxD signal is “low” setting the STB input pin to logical “low” changes the operating mode of the device to normal-operating mode and drives a “dominant” signal to the HS CAN bus.*
2. *The TxD time-out is only effective in normal-operating mode. The TxD time-out timer starts when the TLE7251V enters normal-operating mode and the TxD input is set to logical “low”.*

**Application information**

**8.3.1 Mode change to stand-by mode during a “dominant” bus signal**

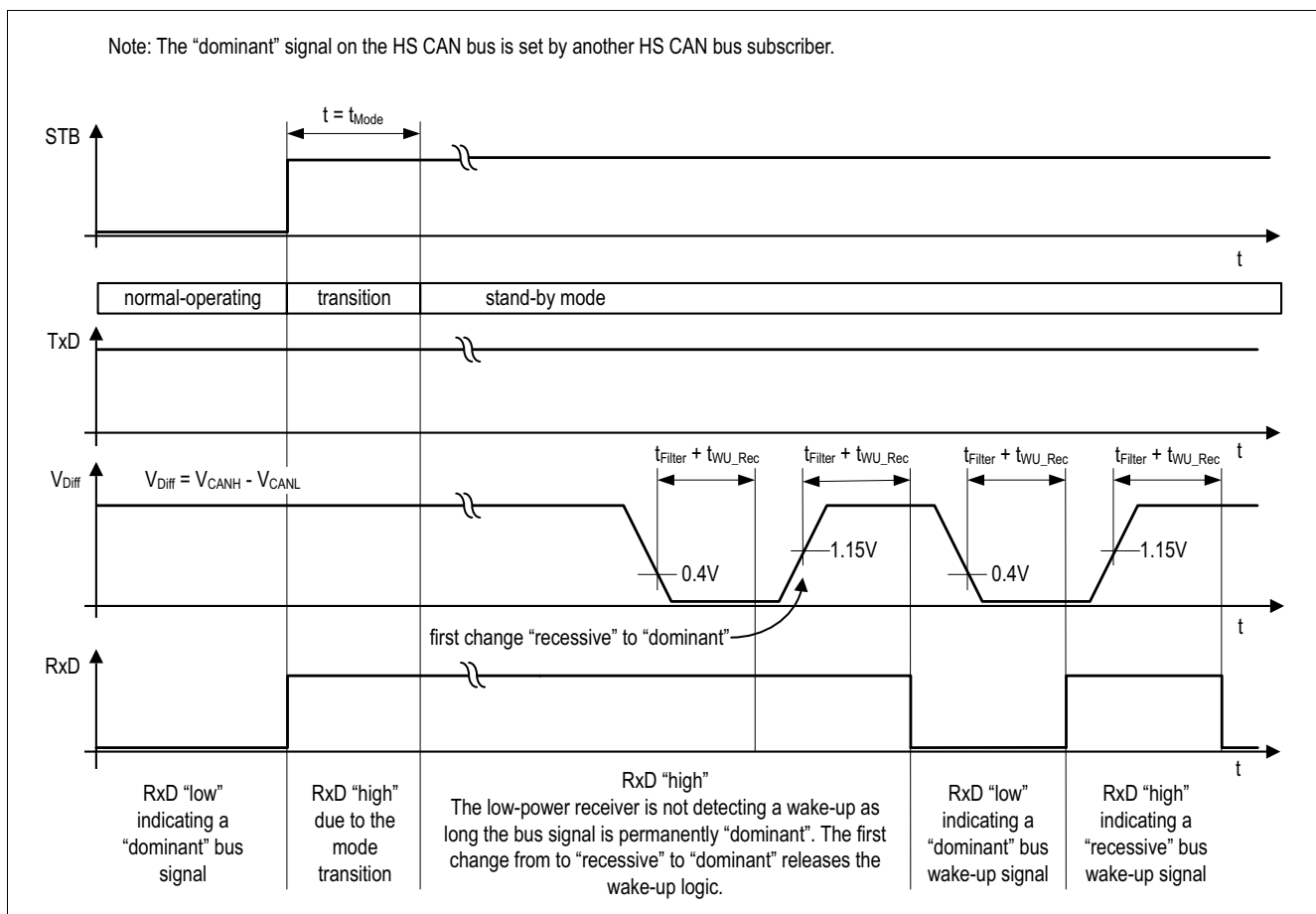
The example in **Figure 15** shows a mode change from normal-operating mode to stand-by mode while the signal on the HS CAN bus is “dominant”.

During the mode transition time  $t_{Mode}$ , the transceiver TLE7251V blocks the RxD output and provides a logical “high” on the RxD output pin. The internal receiver switches from the normal-mode receiver to the low-power receiver, while changing from normal-operating mode to stand-by mode.

After entering stand-by mode the transceiver TLE7251V continues to indicate a “high” signal on the RxD output as long as the HS CAN bus remains “dominant”. The permanent “dominant” bus signal is not considered as a wake-up event and therefore not indicated on the RxD output pin.

Detecting the first signal change from “recessive” to “dominant” on the HS CAN bus releases the internal wake-up logic. Within the wake-up reaction time  $t_{WU\_Rec}$ , a “recessive” CAN bus signal is indicated on the RxD output pin by a logical “high” signal and a “dominant” CAN bus signal is indicated by a logical “low” signal, as long the pulse width of the HS CAN bus signals is longer than the CAN activity filter time  $t > t_{Filter}$ .

Entering stand-by mode while the HS CAN bus signal is “recessive”, a release of the internal wake-up logic is not necessary and a “dominant” wake-up signal ( $t > t_{Filter}$ ) on the HS CAN bus is indicated on the RxD output pin within the wake-up reaction time  $t_{WU\_Rec}$  (compare to **Figure 8**).



**Figure 15 Change to stand-by mode during bus “dominant”**

**Application information**

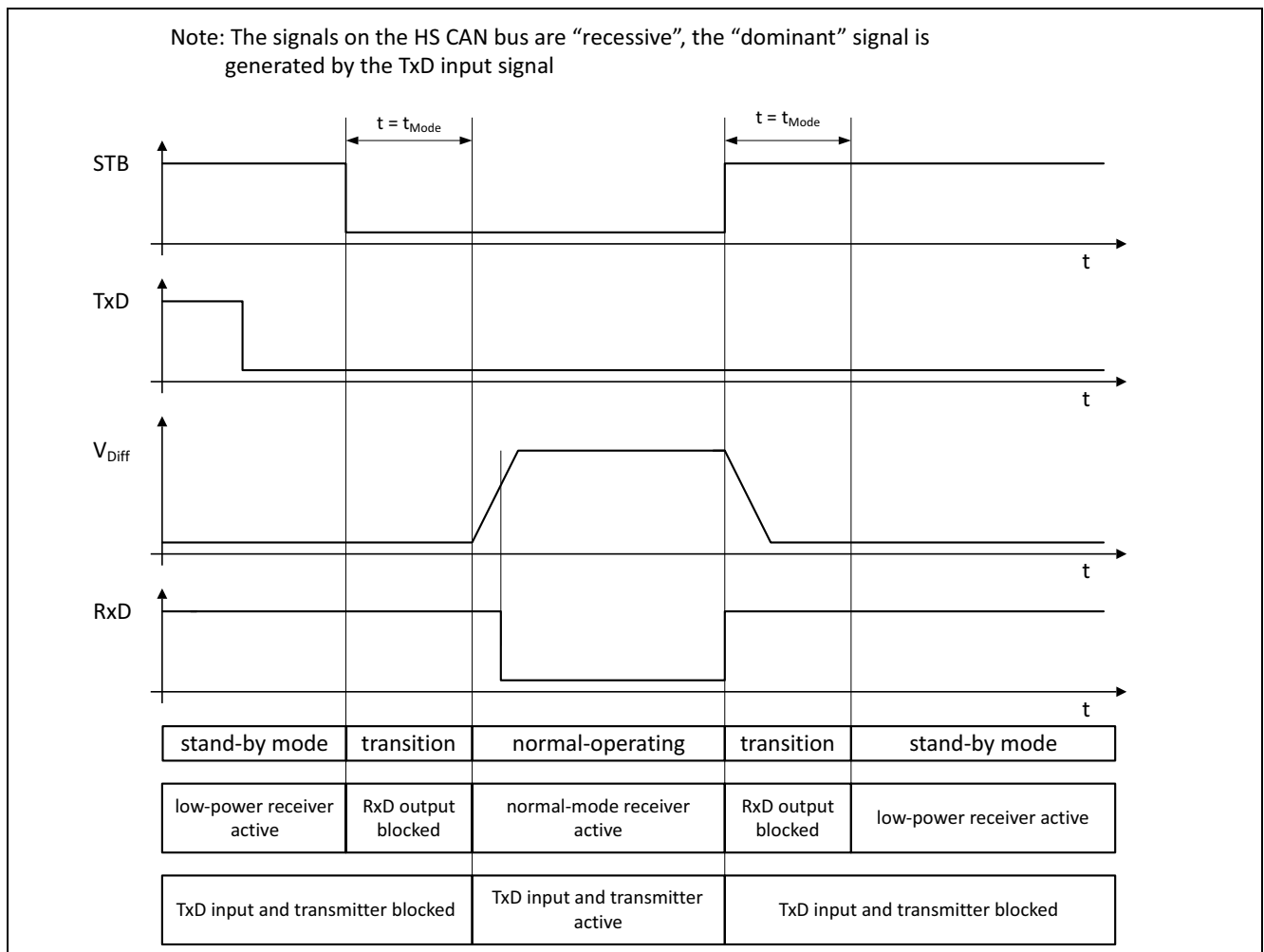
**8.3.2 Mode changes from stand-by mode to normal-operating mode**

**8.3.2.1 Mode change while the TxD Signal is “low”**

The example in **Figure 16** shows a mode change to normal-operating mode while the TxD input is logical “low”. The HS CAN signal is “recessive”, assuming all other HS CAN bus subscribers are also sending a “recessive” bus signal.

While the transceiver TLE7251V is in stand-by mode, the transmitter and the normal-mode receiver are turned off. In stand-by mode the low-power receiver is active. The TLE7251V drives no signal to the HS CAN bus, the RxD output is connected to the low-power receiver and follows only the HS\_CAN bus signals when its pulse width exceeds the CAN activity filter time  $t_{Filter}$ . Changing the STB to logical “low” turns the mode of operation to normal-operating mode, while the TxD input signal remains logical “low”. The transmitter and the normal-mode receiver remain disabled until the mode transition is completed. During the mode transition the RxD output is blocked and set to logical “high”. In normal-operating mode the transmitter and the normal-mode receiver are active. The “low” signal on the TxD input drives a “dominant” signal to the HS CAN bus and the RxD output becomes logical “low” following the “dominant” signal on the HS CAN bus.

Changing the STB pin back to logical “high”, disables the transmitter and normal-mode receiver again. The RxD output pin is blocked and set to logical “high” with the start of the mode transition. The TxD input and the transmitter are blocked and the HS CAN bus becomes “recessive”.



**Figure 16 Mode change from stand-by mode to normal-operating mode**

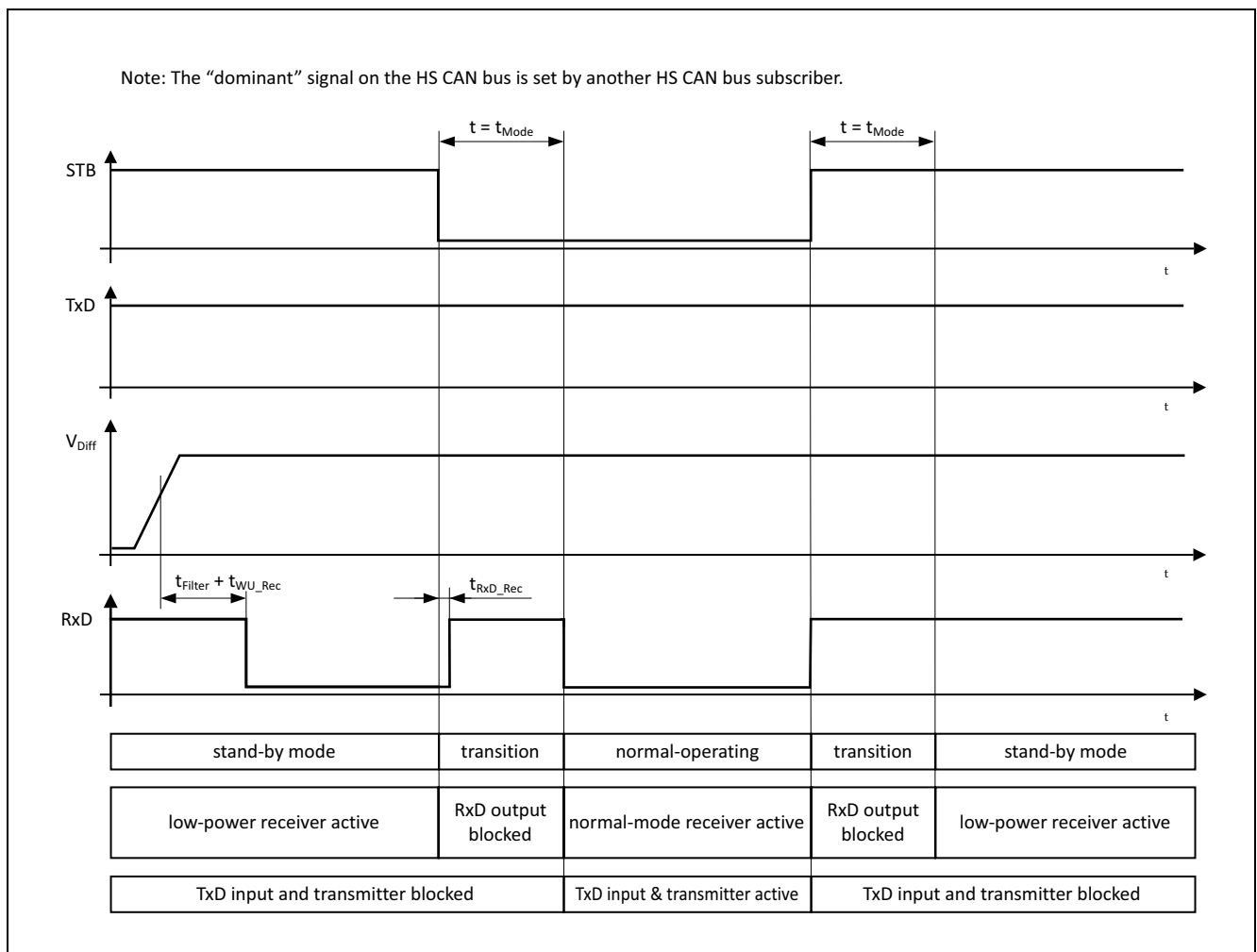
**Application information**

**8.3.2.2 Mode change while the bus signal is “dominant”**

The example in **Figure 17** shows a mode change while the bus is “dominant” and the TxD input signal is set to logical “high”.

While the transceiver TLE7251V is in stand-by mode, the transmitter and the normal-mode receiver are turned off. In stand-by mode the low-power receiver is active. The TLE7251V drives no signal to the HS CAN bus, the RxD output is connected to the low-power receiver and follows only the HS\_CAN bus signals when its pulse width exceeds the bus wake-up time  $t_{WU}$ . Changing the STB to logical “low” turns the mode of operation to normal-operating mode, while the TxD input signal remains logical “high”. The transmitter and the normal-mode receiver remain disabled until the mode transition is completed. During the mode transition the RxD output is blocked and set to logical “high”. In normal-operating mode the normal-mode receiver is active and the RxD output follows the “dominant” signal on the HS CAN bus by indicating a logical “low” signal.

Changing the STB pin back to logical “high”, disables the transmitter and normal-mode receiver again. The RxD output pin is blocked and set to logical “high” with the start of the mode transition. The low-power receiver is active in stand-by mode. The RxD output signal remains “high” as long the HS CAN bus remains “dominant”, only if the HS CAN bus changes to a “recessive” signal longer as the CAN activity time  $t_{Filter}$ , the RxD output follows the bus signal within the wake-up reaction time  $t_{WU\_Rec}$  (see also **Chapter 8.3.1**).



**Figure 17 Receiving a “dominant” signal from the bus during a mode change**

**Application information**

**8.4 Further application information**

- Please contact us for information regarding the pin FMEA.
- Existing application: [www.infineon.com/TLE7251V-AN](http://www.infineon.com/TLE7251V-AN)
- For further information you may visit: [www.infineon.com/automotive-transceivers](http://www.infineon.com/automotive-transceivers)



Package information

9 Package information

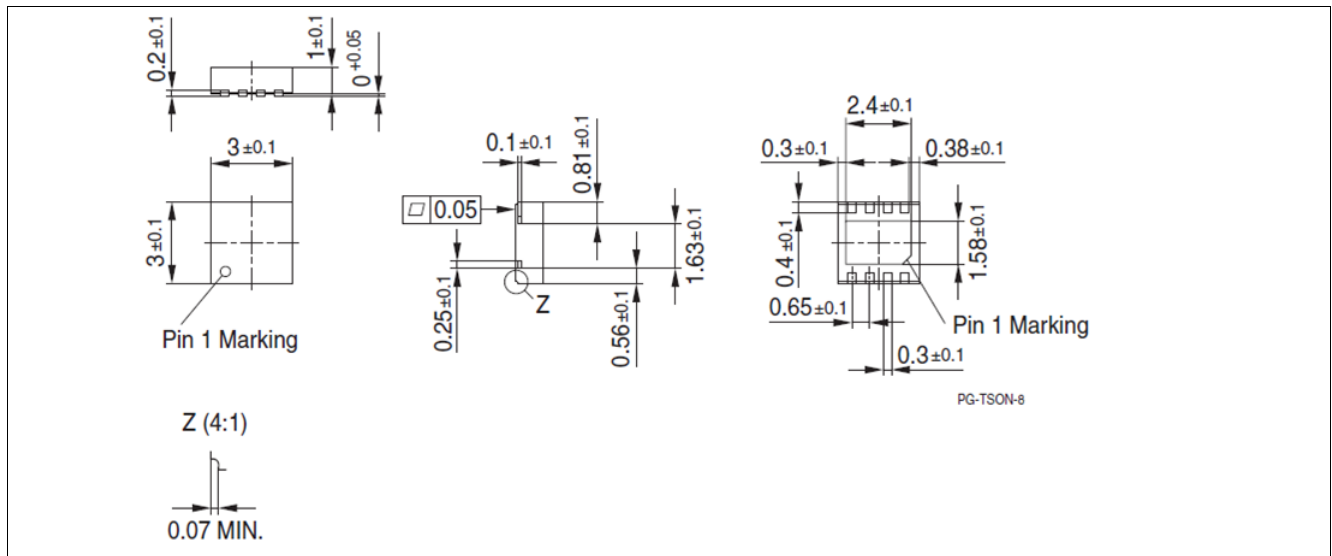


Figure 18 PG-TSON-8 (Plastic Thin Small Outline Nonleaded)<sup>1)</sup>

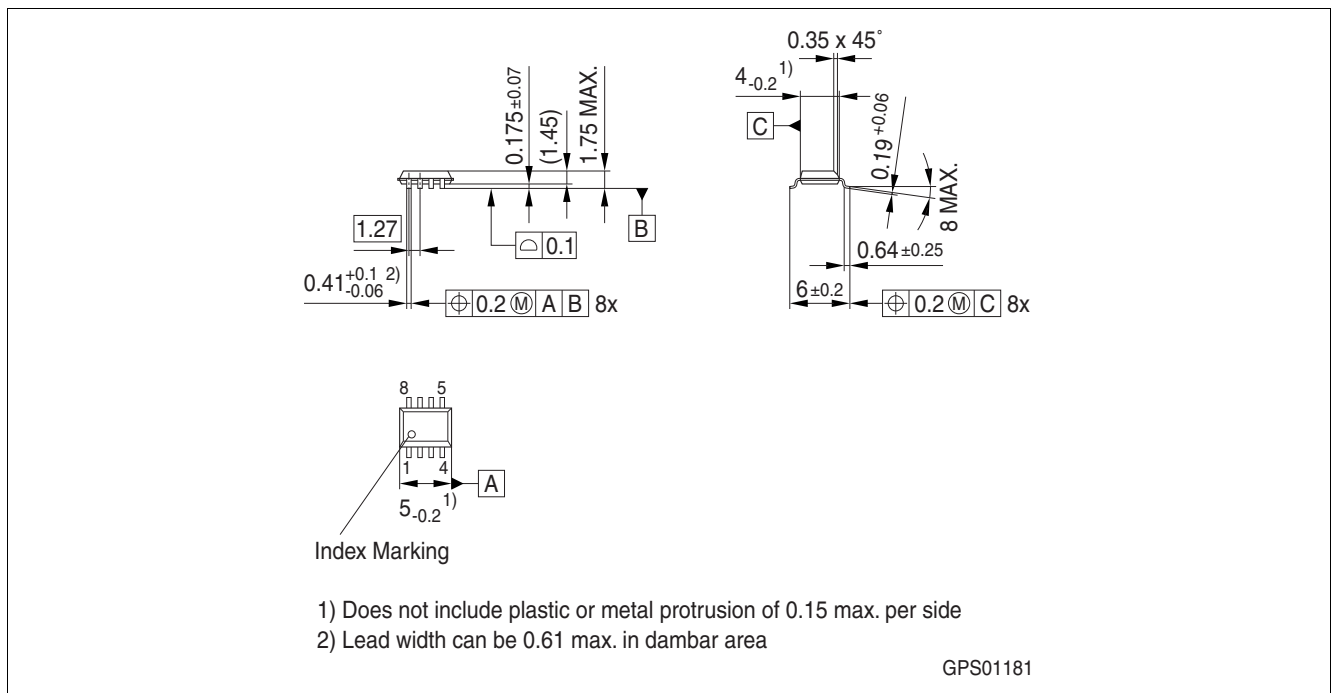


Figure 19 PG-DSO-8 (Plastic Dual Small Outline)<sup>1)</sup>

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>

1) Dimensions in mm

**Revision history**

## **10 Revision history**

<b>Revision</b>	<b>Date</b>	<b>Changes</b>
1.01	2018-09-06	Editorial changes.
1.0	2015-09-20	Data Sheet created.

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**Document reference**

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