

# TLE7250V

High Speed CAN-Transceiver

TLE7250VLE  
TLE7250VSJ

## Data Sheet

Rev. 1.0, 2015-08-12

Automotive Power

## Table of Contents

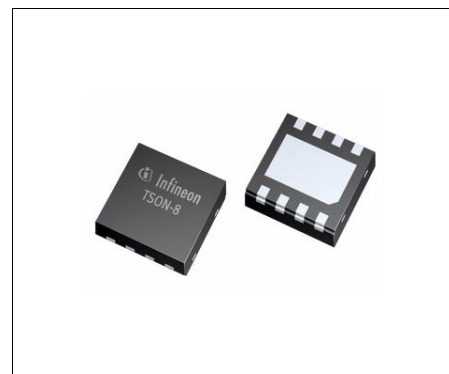
	<b>Table of Contents</b>	2
<b>1</b>	<b>Overview</b>	3
<b>2</b>	<b>Block Diagram</b>	5
<b>3</b>	<b>Pin Configuration</b>	6
3.1	Pin Assignment	6
3.2	Pin Definitions	6
<b>4</b>	<b>Functional Description</b>	8
4.1	High Speed CAN Physical Layer	8
4.2	Modes of Operation	10
4.2.1	Normal-operating Mode	10
4.2.2	Power-save Mode	10
4.3	Power-up and Undervoltage Condition	11
4.3.1	Power-down State	12
4.3.2	Forced Power-save Mode	12
4.3.3	Power-up	12
4.3.4	Undervoltage on the Digital Supply $V_{IO}$	13
4.3.5	Undervoltage on the Transmitter Supply $V_{CC}$	14
4.3.6	Voltage Adaption to the Microcontroller Supply	14
<b>5</b>	<b>Fail Safe Functions</b>	15
5.1	Short Circuit Protection	15
5.2	Unconnected Logic Pins	15
5.3	TxD Time-out Function	15
5.4	Overtemperature Protection	16
5.5	Delay Time for Mode Change	16
<b>6</b>	<b>General Product Characteristics</b>	17
6.1	Absolute Maximum Ratings	17
6.2	Functional Range	18
6.3	Thermal Resistance	18
<b>7</b>	<b>Electrical Characteristics</b>	19
7.1	Functional Device Characteristics	19
7.2	Diagrams	24
<b>8</b>	<b>Application Information</b>	26
8.1	ESD Robustness according to IEC61000-4-2	26
8.2	Application Example	27
8.3	Examples for Mode Changes	28
8.3.1	Mode Change while the TxD Signal is "low"	29
8.3.2	Mode Change while the Bus Signal is "dominant"	30
8.4	Further Application Information	31
<b>9</b>	<b>Package Outline</b>	32
<b>10</b>	<b>Revision History</b>	33



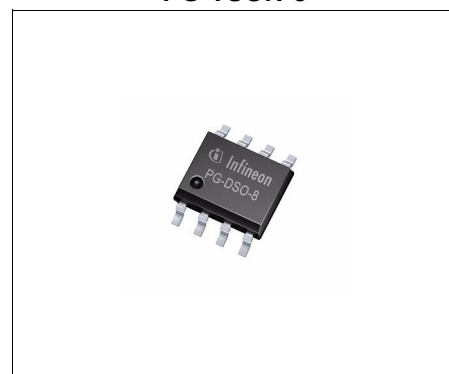
## 1 Overview

### Features

- Fully compatible to ISO 11898-2
- 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
- Power-save mode
- Transmitter supply  $V_{CC}$  can be turned off in power-save mode
- Green Product (RoHS compliant)
- Two package variants: PG-TSON-8 and PG-DSO-8
- AEC Qualified



**PG-TSON-8**



**PG-DSO-8**

### Description

The TLE7250V 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 TLE7250V 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 TLE7250V provides a very low level of electromagnetic emission (EME) within a wide frequency range.

The TLE7250V 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 TLE7250VLE and the TLE7250VSJ are fulfilling or exceeding the requirements of the ISO11898-2.

The TLE7250V provides a digital supply input  $V_{IO}$  and a power-save 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 TLE7250V provides an excellent passive behavior in power-down state. These and other features make the TLE7250V exceptionally suitable for

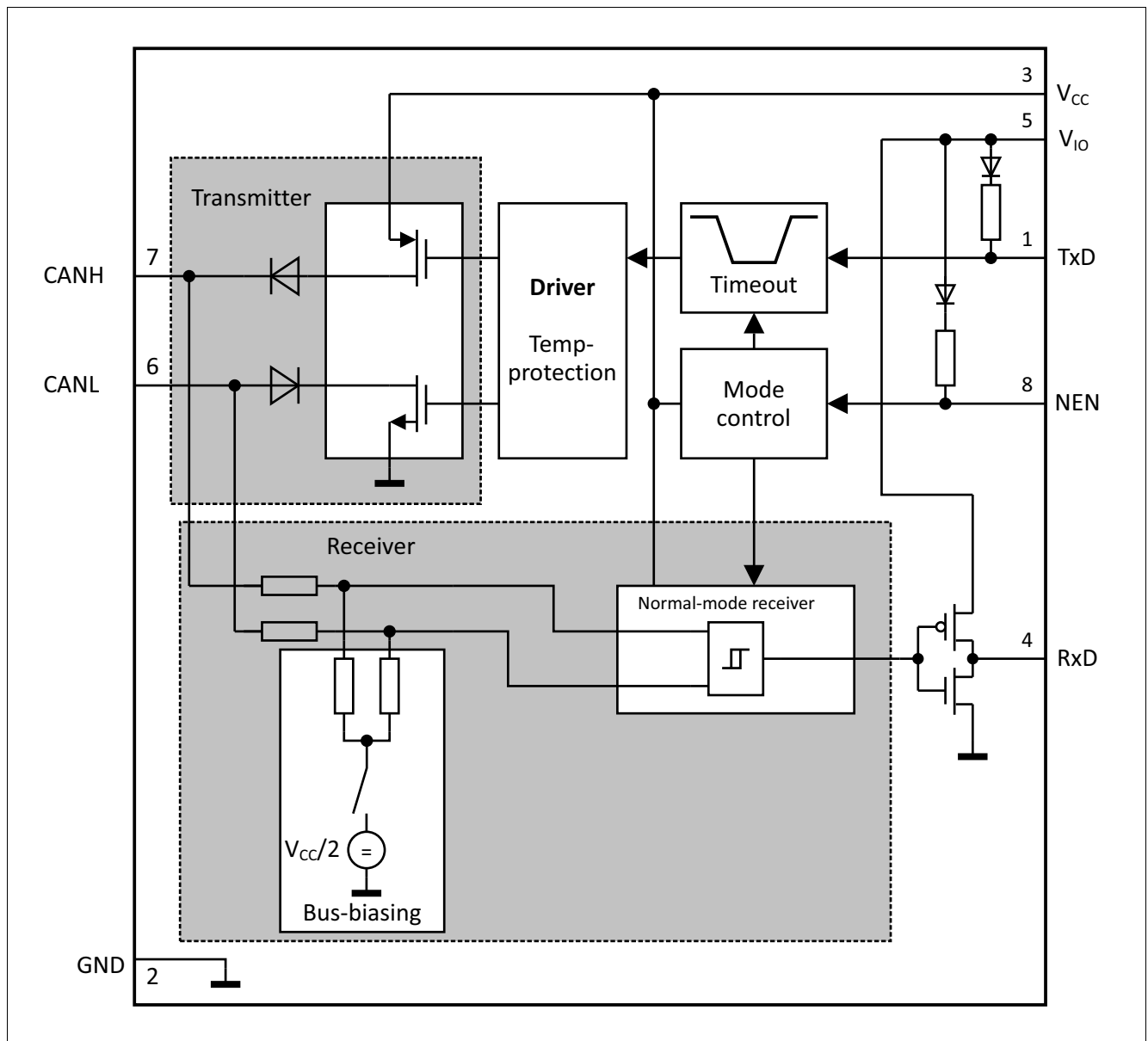
Type	Package	Marking
TLE7250VLE	PG-TSON-8	7250V
TLE7250VSJ	PG-DSO-8	7250V

mixed supply HS CAN networks.

Based on the Infineon Smart Power Technology SPT, the TLE7250V provides excellent ESD immunity together with a very high electromagnetic immunity (EMI). The TLE7250V 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 TLE7250V the ideal choice for large HS CAN networks with high data transmission rates.

## 2 Block Diagram



**Figure 1      Functional block diagram**

## 3 Pin Configuration

### 3.1 Pin Assignment

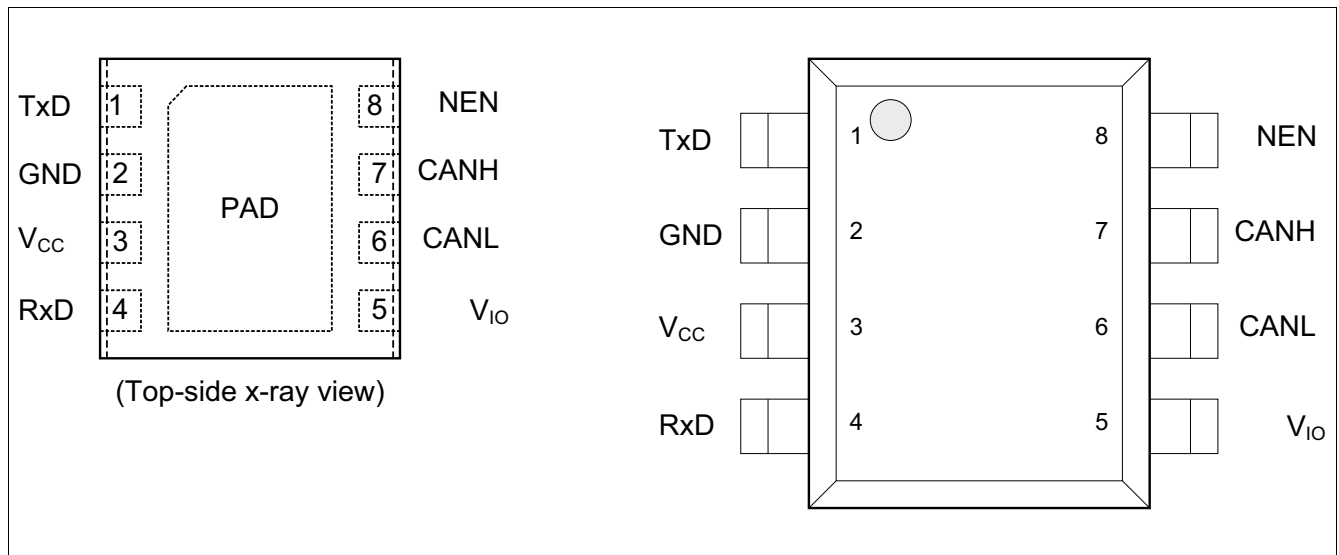


Figure 2 Pin configuration

### 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 power-save 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, 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.

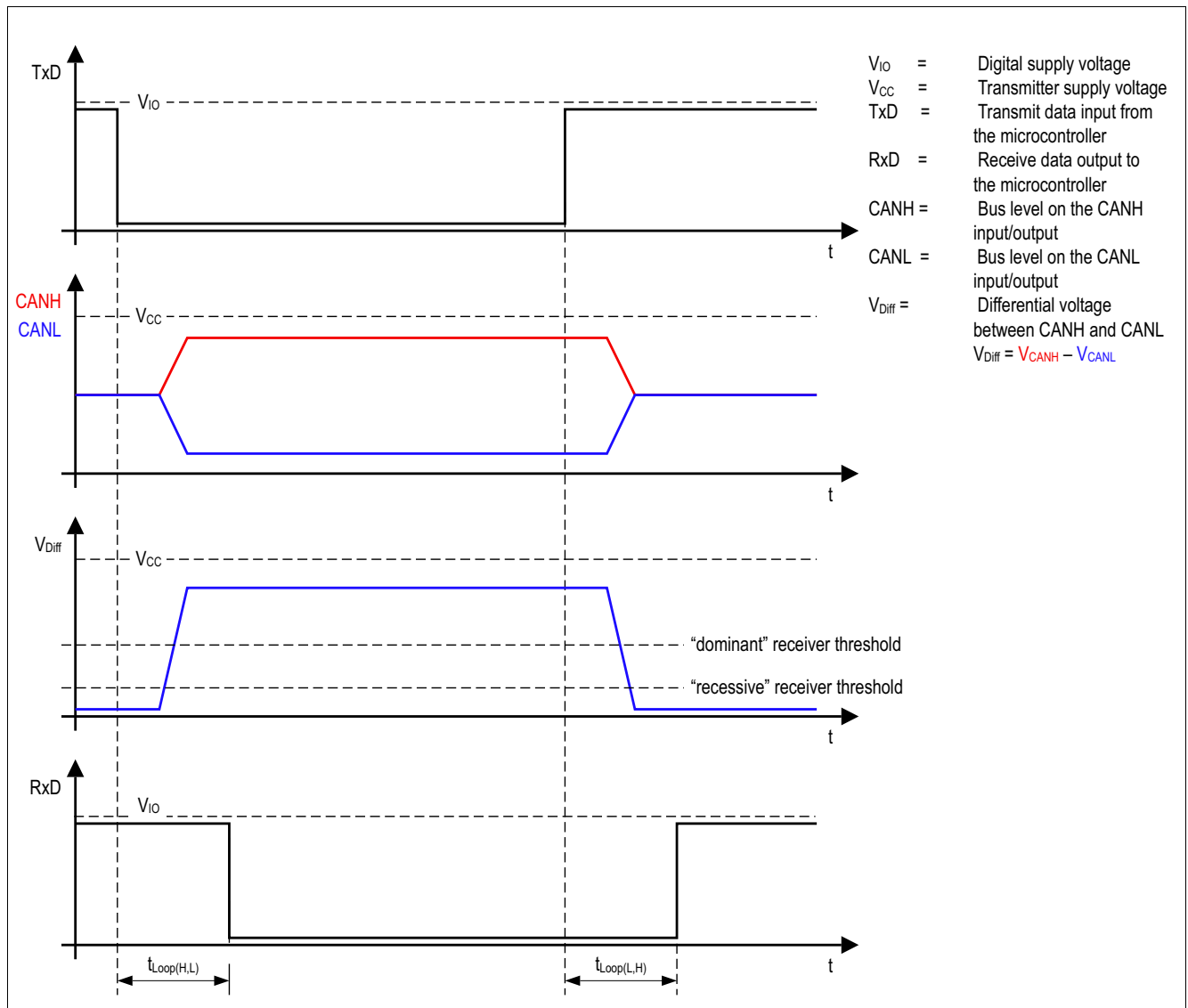
**Table 1** Pin definitions and functions (cont'd)

Pin No.	Symbol	Function
8	NEN	<b>Not Enable 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.

## 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 TLE7250V is a High Speed CAN transceiver without a wake-up function and defined by the international standard ISO 11898-2.

### 4.1 High Speed CAN Physical Layer



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



The TLE7250V 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 TLE7250V. 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 NEN 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 TLE7250V 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 NEN) and also the RxD output voltage are adapted to the digital power supply  $V_{IO}$ .

## 4.2 Modes of Operation

The TLE7250V supports two different modes of operation, power-save mode and normal-operating mode while the transceiver is supplied according to the specified functional range. The mode of operation is selected by the NEN input pin (see [Figure 4](#)).

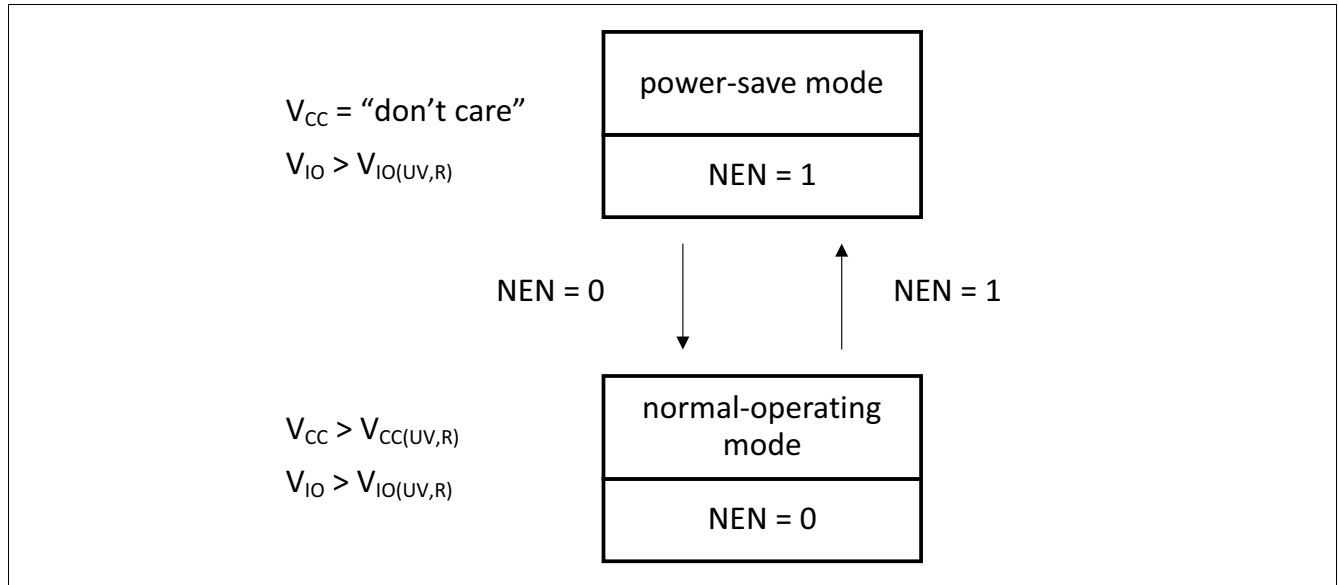


Figure 4 Mode state diagram

### 4.2.1 Normal-operating Mode

In normal-operating mode the transmitter and the receiver of the HS CAN transceiver TLE7250V 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 NEN 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 Power-save Mode

The power-save mode is an idle mode of the TLE7250V with optimized power consumption. In power-save mode the transmitter and the normal-mode receiver are turned off. The TLE7250V can not send any data to the CAN bus nor receive any data from the CAN bus.

The RxD output pin is permanently "high" in the power-save mode.

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

In power-save mode the bus input pins are not biased. Therefore the CANH and CANL input pins are floating and the HS CAN bus interface has a high resistance.

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

### 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 TLE7250V 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 power-save mode, or remains in power-save mode (details see [Figure 5](#)).

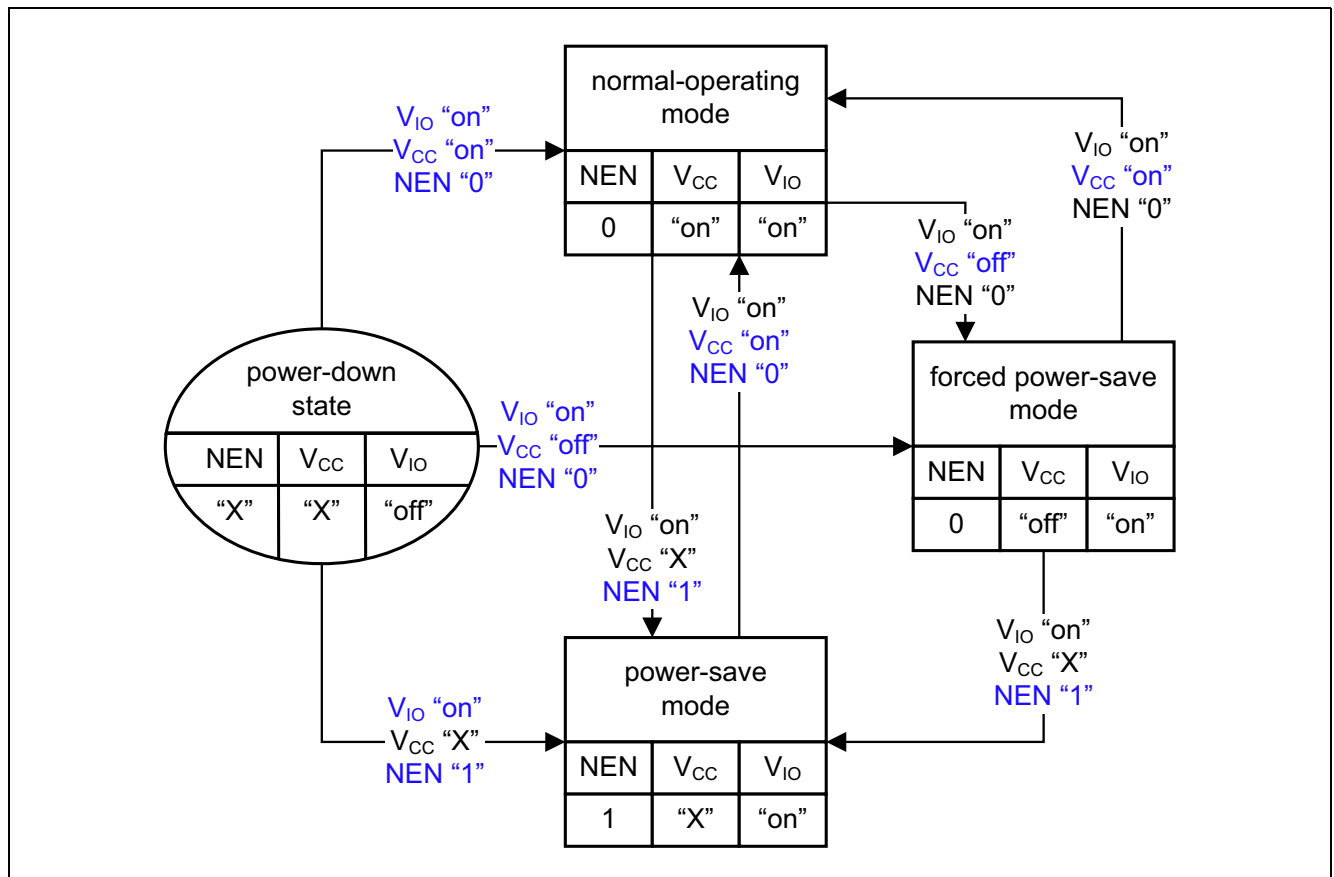


Figure 5 Power-up and undervoltage

Table 2 Modes of operation

Mode	NEN	$V_{IO}$	$V_{CC}$	Bus Bias	Transmitter	Normal-mode Receiver	Low-power Receiver
Normal-operating	"low"	"on"	"on"	$V_{CC}/2$	"on"	"on"	not available
Power-save	"high"	"on"	"X"	floating	"off"	"off"	not available
Forced power-save	"low"	"on"	"off"	floating	"off"	"off"	not available
Power-down state	"X"	"off"	"X"	floating	"off"	"off"	not available

#### 4.3.1 Power-down State

Independent of the transmitter supply  $V_{CC}$  and of the NEN input pin, the TLE7250V 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 TLE7250V 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 Power-save Mode

The forced power-save mode is a fail-safe mode to avoid any disturbance on the HS CAN bus, while the TLE7250V faces a loss of the transmitter supply  $V_{CC}$ .

In forced power-save mode, the transmitter and the normal-mode receiver are turned off and therefore the transceiver TLE7250V can not disturb the bus media.

The RxD output pin is permanently set to logical “high”. The bus biasing is floating (details see [Table 2](#)).

The forced power-save 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 TLE7250V is in forced power-save mode, switching the NEN input to logical “high” triggers a mode change to power-save mode (see [Figure 5](#)).

#### 4.3.3 Power-up

The HS CAN transceiver TLE7250V powers up if at least the digital supply  $V_{IO}$  is connected to the device. By default the device powers up in power-save mode, due to the internal pull-up resistor on the NEN pin to  $V_{IO}$ .

In case the device needs to power-up to normal-operating mode, the NEN 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 TLE7250V powers up either in forced power-save mode or in power-save mode, depending on the signal of the NEN input pin (see [Figure 5](#)).

#### 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 TLE7250V 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 TLE7250V.

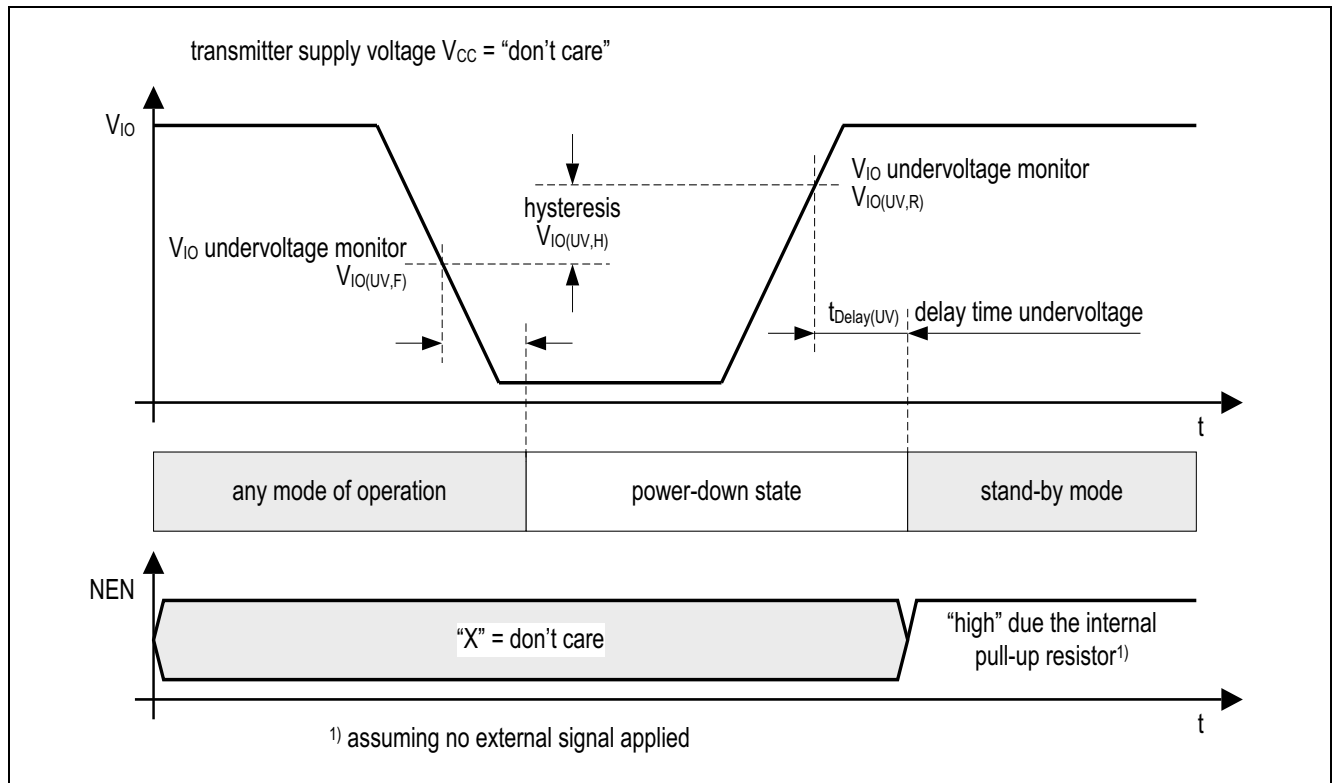


Figure 6 Undervoltage on the digital supply  $V_{IO}$

#### 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 TLE7250V changes the mode of operation to forced power-save mode. The transmitter and also the normal-mode receiver of the TLE7250V are powered by the  $V_{CC}$  supply. In case of an insufficient  $V_{CC}$  supply, the TLE7250V can neither transmit the CANH and CANL signals correctly to the bus, nor can it receive them properly. Therefore the TLE7250V blocks the transmitter and the receiver in forced power-save mode (see [Figure 7](#)).

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

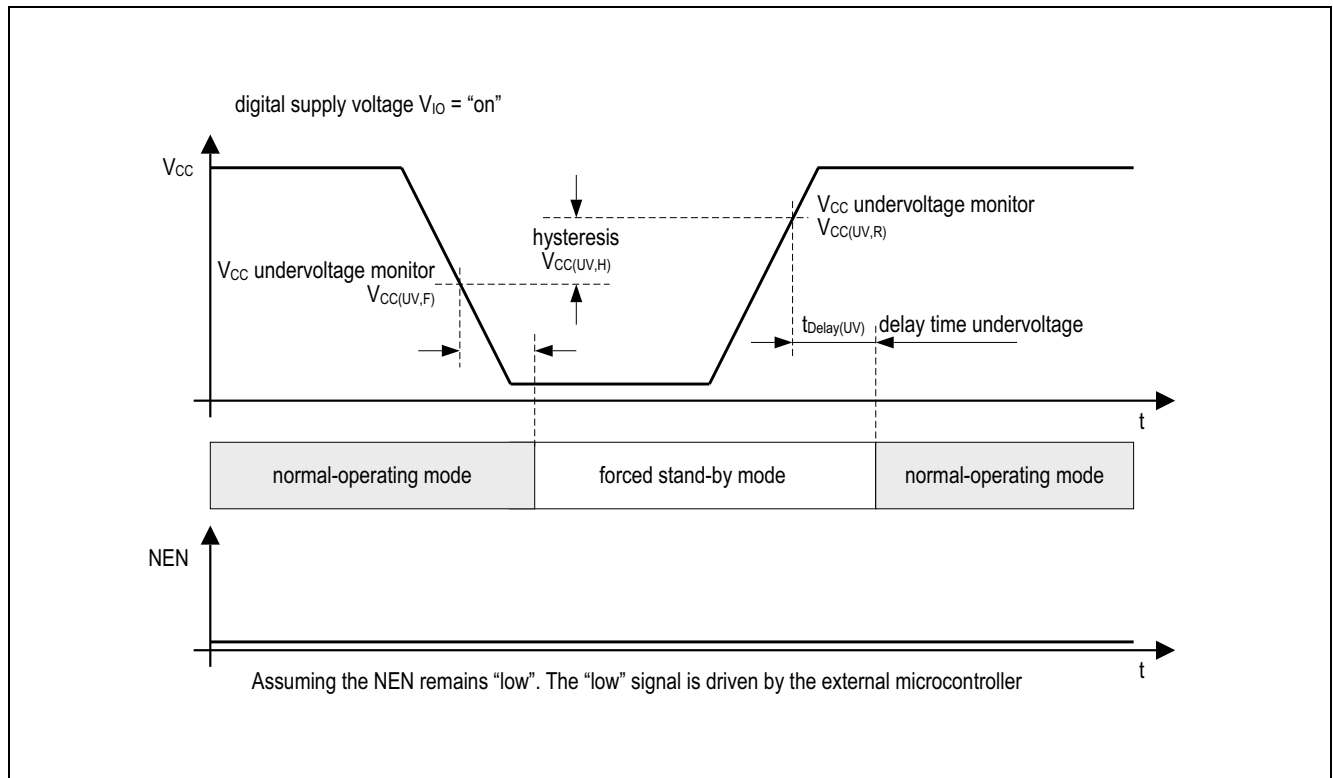


Figure 7 Undervoltage on the transmitter supply  $V_{CC}$

#### 4.3.6 Voltage Adaption to the Microcontroller Supply

The HS CAN transceiver TLE7250V 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 and it is also the main power domain for the internal logic.

To adjust the digital input and output levels of the TLE7250V to the I/O levels of the external microcontroller, connect the power supply  $V_{IO}$  to the microcontroller I/O supply voltage (see [Figure 13](#)).

*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  $V_{CC}$ .*

## 5 Fail Safe Functions

### 5.1 Short Circuit Protection

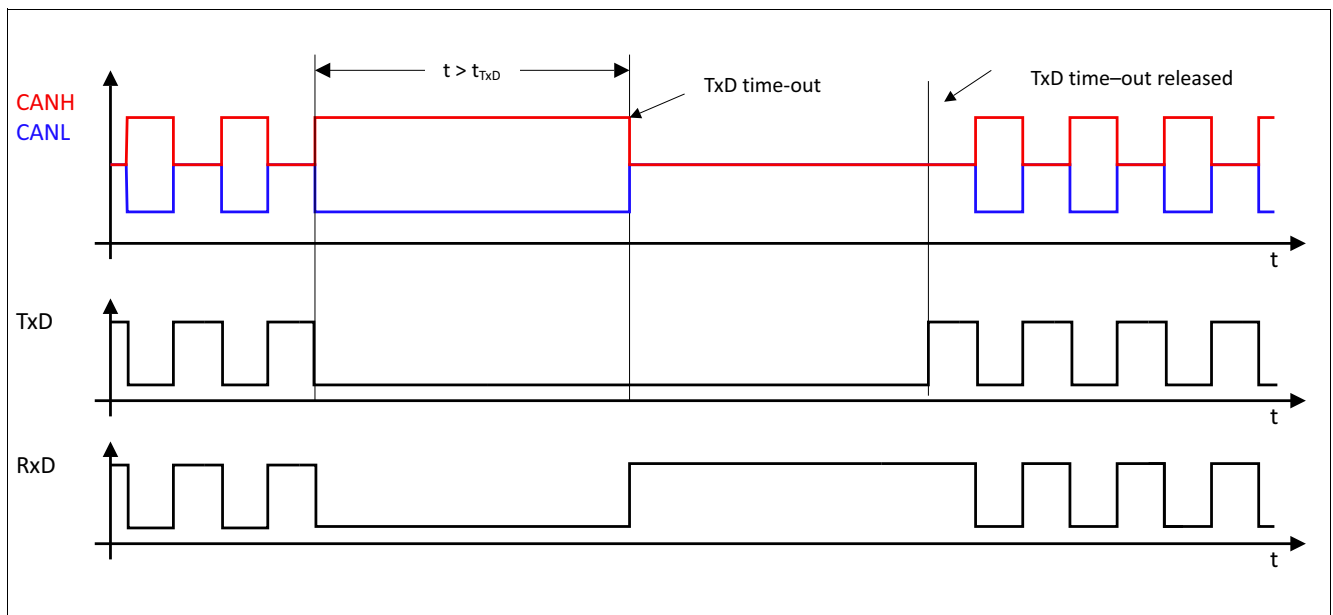
The CANH and CANL bus outputs are short circuit proof, either against GND or a positive supply voltage. A current limiting circuit protects the transceiver against damages. If the device is heating up due to a continuous short on the CANH or CANL, the internal overtemperature protection switches off 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 TLE7250V enters into the power-save mode by default. In power-save mode the transmitter of the TLE7250V is disabled and the bus bias is floating.

### 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 TLE7250V disables the transmitter (see [Figure 8](#)). The receiver is still active and the data on the bus continues to be monitored by the RxD output pin.



**Figure 8** TxD time-out function

**Figure 8** 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 TLE7250V requires a signal change on the TxD input pin from logical “low” to logical “high”.

## 5.4 Overtemperature Protection

The TLE7250V has an integrated overtemperature detection to protect the TLE7250V against thermal overstress of the transmitter. The overtemperature protection is active in normal-operating mode and disabled in power-save 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 9](#)). A hysteresis is implemented within the temperature sensor.

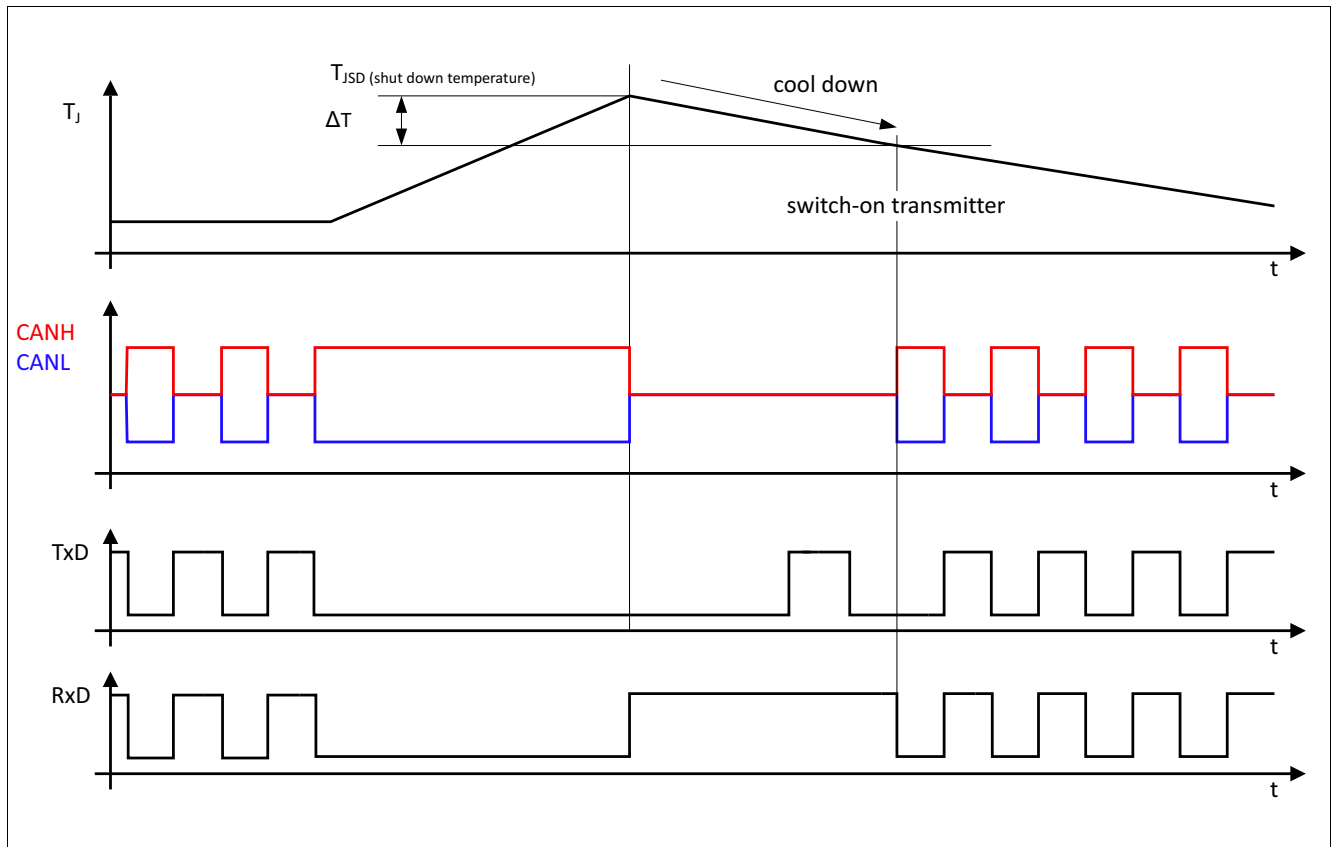


Figure 9 Overtemperature protection

## 5.5 Delay Time for Mode Change

The HS CAN transceiver TLE7250V changes the mode of operation within the time window  $t_{\text{Mode}}$ . 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 (see as an example [Figure 14](#) and [Figure 15](#)).



## 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 / Test Condition	Number
		Min.	Typ.	Max.			
Voltages							
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: NEN, 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
Currents							
RxD output current	$I_{RxD}$	-20	–	20	mA	–	P_6.1.8
Temperatures							
Junction temperature	$T_j$	-40	–	150	°C	–	P_6.1.9
Storage temperature	$T_S$	-55	–	150	°C	–	P_6.1.10
ESD Resistivity							
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.*

## 6.2 Functional Range

**Table 4 Functional range**

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
Supply Voltages							
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
Thermal Parameters							
Junction temperature	$T_j$	–40	–	150	°C	<sup>1)</sup>	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 / Test Condition	Number
		Min.	Typ.	Max.			
Thermal Resistances							
Junction to Ambient PG-TSON-8	$R_{thJA}$	–	55	–	K/W	<sup>2)</sup> TLE7250VLE	P_6.3.1
Junction to Ambient PG-DSO-8	$R_{thJA}$	–	130	–	K/W	<sup>2)</sup> TLE7250VSJ	P_6.3.2
Thermal Shutdown (junction temperature)							
Thermal shutdown temperature	$T_{JSD}$	150	175	200	°C	–	P_6.3.3
Thermal shutdown hysteresis	$\Delta T$	–	10	–	K	–	P_6.3.4

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 (TLE7250V) was simulated on a 76.2 x 114.3 x 1.5 mm board with 2 inner copper layers (2 x 70µm Cu, 2 x 35µm Cu).

## 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;  $R_L = 60 \Omega$ ;  $-40^\circ\text{C} < T_j < 150^\circ\text{C}$ ; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
Current Consumption							
Current consumption at $V_{CC}$ normal-operating mode	$I_{CC}$	–	2.6	4	mA	“recessive” state, $V_{TxD} = V_{IO}$ , $V_{NEN} = 0\text{ V}$ ;	P_7.1.1
Current consumption at $V_{CC}$ normal-operating mode	$I_{CC}$	–	38	60	mA	“dominant” state, $V_{TxD} = V_{NEN} = 0\text{ V}$ ;	P_7.1.2
Current consumption at $V_{IO}$ normal-operating mode	$I_{IO}$	–	–	1	mA	$V_{NEN} = 0\text{ V}$ ;	P_7.1.3
Current consumption at $V_{CC}$ power-save mode	$I_{CC(PSM)}$	–	–	5	$\mu\text{A}$	$V_{TxD} = V_{NEN} = V_{IO}$ ;	P_7.1.4
Current consumption at $V_{IO}$ power-save mode	$I_{IO(PSM)}$	–	5	8	$\mu\text{A}$	$V_{TxD} = V_{NEN} = V_{IO}$ , $0\text{ V} < V_{CC} < 5.5\text{ V}$ ;	P_7.1.5
Supply Resets							
$V_{CC}$ undervoltage monitor rising edge	$V_{CC(UV,R)}$	3.8	4.0	4.3	V	–	P_7.1.6
$V_{CC}$ undervoltage monitor falling edge	$V_{CC(UV,F)}$	3.65	3.85	4.3	V	–	P_7.1.7
$V_{CC}$ undervoltage monitor hysteresis	$V_{CC(UV,H)}$	–	150	–	mV	<sup>1)</sup>	P_7.1.8
$V_{IO}$ undervoltage monitor rising edge	$V_{IO(UV,R)}$	2.0	2.5	3.0	V	–	P_7.1.9
$V_{IO}$ undervoltage monitor falling edge	$V_{IO(UV,F)}$	1.8	2.3	3.0	V	–	P_7.1.10
$V_{IO}$ undervoltage monitor hysteresis	$V_{IO(UV,H)}$	–	200	–	mV	<sup>1)</sup>	P_7.1.11
$V_{CC}$ and $V_{IO}$ undervoltage delay time	$t_{\text{Delay(UV)}}$	–	–	100	$\mu\text{s}$	<sup>1)</sup> (see <a href="#">Figure 6</a> and <a href="#">Figure 7</a> );	P_7.1.12
Receiver Output RxD							
“High” level output current	$I_{RD,H}$	–	-4	-2	mA	$V_{RxD} = V_{IO} - 0.4\text{ V}$ , $V_{\text{Diff}} < 0.5\text{ V}$ ;	P_7.1.13
“Low” level output current	$I_{RD,L}$	2	4	–	mA	$V_{RxD} = 0.4\text{ V}$ , $V_{\text{Diff}} > 0.9\text{ V}$ ;	P_7.1.14

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

4.5 V <  $V_{CC}$  < 5.5 V; 3.0 V <  $V_{IO}$  < 5.5 V;  $R_L = 60 \Omega$ ;  $-40^\circ\text{C} < T_j < 150^\circ\text{C}$ ; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
Transmission Input TxD							
“High” level input voltage threshold	$V_{\text{TxD,H}}$	–	$0.5 \times V_{\text{IO}}$	$0.7 \times V_{\text{IO}}$	V	“recessive” state;	P_7.1.15
“Low” level input voltage threshold	$V_{\text{TxD,L}}$	$0.3 \times V_{\text{IO}}$	$0.4 \times V_{\text{IO}}$	–	V	“dominant” state;	P_7.1.16
Pull-up resistance	$R_{\text{TxD}}$	10	25	50	kΩ	–	P_7.1.17
Input hysteresis	$V_{\text{HYS(TxD)}}$	–	450	–	mV	<sup>1)</sup>	P_7.1.18
Input capacitance	$C_{\text{TxD}}$	–	–	10	pF	<sup>1)</sup>	P_7.1.19
TxD permanent “dominant” time-out	$t_{\text{TxD}}$	4.5	–	16	ms	normal-operating mode;	P_7.1.20
Not Enable Input NEN							
“High” level input voltage threshold	$V_{\text{NEN,H}}$	–	$0.5 \times V_{\text{IO}}$	$0.7 \times V_{\text{IO}}$	V	power-save mode;	P_7.1.21
“Low” level input voltage threshold	$V_{\text{NEN,L}}$	$0.3 \times V_{\text{IO}}$	$0.4 \times V_{\text{IO}}$	–	V	normal-operating mode;	P_7.1.22
Pull-up resistance	$R_{\text{NEN}}$	10	25	50	kΩ	–	P_7.1.23
Input capacitance	$C_{\text{NEN}}$	–	–	10	pF	<sup>1)</sup>	P_7.1.24
Input hysteresis	$V_{\text{HYS(NEN)}}$	–	200	–	mV	<sup>1)</sup>	P_7.1.25
Bus Receiver							
Differential receiver threshold “dominant” normal-operating mode	$V_{\text{Diff\_D}}$	–	0.75	0.9	V	<sup>2)</sup>	P_7.1.26
Differential receiver threshold “recessive” normal-operating mode	$V_{\text{Diff\_R}}$	0.5	0.66	–	V	<sup>2)</sup>	P_7.1.27
Common mode range	CMR	-12	–	12	V	$V_{\text{CC}} = 5 \text{ V}$ ;	P_7.1.28
Differential receiver hysteresis normal-operating mode	$V_{\text{Diff,hys}}$	–	90	–	mV	<sup>1)</sup>	P_7.1.29
CANH, CANL input resistance	$R_{\text{i}}$	10	20	30	kΩ	“recessive” state;	P_7.1.30
Differential input resistance	$R_{\text{Diff}}$	20	40	60	kΩ	“recessive” state;	P_7.1.31
Input resistance deviation between CANH and CANL	$\Delta R_{\text{i}}$	- 1	–	1	%	<sup>1)</sup> “recessive” state;	P_7.1.32
Input capacitance CANH, CANL versus GND	$C_{\text{In}}$	–	20	40	pF	<sup>1)</sup> $V_{\text{TxD}} = V_{\text{IO}}$ ;	P_7.1.33
Differential input capacitance	$C_{\text{In Diff}}$	–	10	20	pF	<sup>1)</sup> $V_{\text{TxD}} = V_{\text{IO}}$ ;	P_7.1.34

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

4.5 V <  $V_{CC}$  < 5.5 V; 3.0 V <  $V_{IO}$  < 5.5 V;  $R_L = 60 \Omega$ ;  $-40^\circ\text{C} < T_j < 150^\circ\text{C}$ ; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
Bus Transmitter							
CANL/CANH “recessive” output voltage normal-operating mode	$V_{\text{CANL/H}}$	2.0	2.5	3.0	V	$V_{\text{TxD}} = V_{\text{IO}}$ , no load;	P_7.1.35
CANH, CANL “recessive” output voltage difference normal-operating mode	$V_{\text{Diff\_NM}}$	-500	—	50	mV	$V_{\text{TxD}} = V_{\text{IO}}$ , no load;	P_7.1.36
CANL “dominant” output voltage normal-operating mode	$V_{\text{CANL}}$	0.5	—	2.25	V	$V_{\text{TxD}} = 0 \text{ V}$ ;	P_7.1.37
CANH “dominant” output voltage normal-operating mode	$V_{\text{CANH}}$	2.75	—	4.5	V	$V_{\text{TxD}} = 0 \text{ V}$ ;	P_7.1.38
CANH, CANL “dominant” output voltage difference normal-operating mode according to ISO 11898-2 $V_{\text{Diff}} = V_{\text{CANH}} - V_{\text{CANL}}$	$V_{\text{Diff}}$	1.5	—	3.0	V	$V_{\text{TxD}} = 0 \text{ V}$ , $50 \Omega < R_{\text{L}} < 65 \Omega$ , $4.75 < V_{\text{CC}} < 5.25 \text{ V}$ ;	P_7.1.39
CANH, CANL “dominant” output voltage difference normal-operating mode $V_{\text{Diff}} = V_{\text{CANH}} - V_{\text{CANL}}$	$V_{\text{Diff\_R45}}$	1.4	—	3.0	V	$V_{\text{TxD}} = 0 \text{ V}$ , $45 \Omega < R_{\text{L}} < 50 \Omega$ , $4.75 < V_{\text{CC}} < 5.25 \text{ V}$ ;	P_7.1.40
Driver “dominant” symmetry normal-operating mode $V_{\text{SYM}} = V_{\text{CANH}} + V_{\text{CANL}}$	$V_{\text{SYM}}$	4.5	5	5.5	V	$V_{\text{CC}} = 5.0 \text{ V}$ , $V_{\text{TxD}} = 0 \text{ V}$ ;	P_7.1.41
CANL short circuit current	$I_{\text{CANLsc}}$	40	75	100	mA	$V_{\text{CANLshort}} = 18 \text{ V}$ , $V_{\text{CC}} = 5.0 \text{ V}$ , $t < t_{\text{TxD}}$ , $V_{\text{TxD}} = 0 \text{ V}$ ;	P_7.1.42
CANH short circuit current	$I_{\text{CANHsc}}$	-100	-75	-40	mA	$V_{\text{CANHshort}} = 0 \text{ V}$ , $V_{\text{CC}} = 5.0 \text{ V}$ , $t < t_{\text{TxD}}$ , $V_{\text{TxD}} = 0 \text{ V}$ ;	P_7.1.43
Leakage current, CANH	$I_{\text{CANH,ik}}$	-5	—	5	μA	$V_{\text{CC}} = V_{\text{IO}} = 0 \text{ V}$ , $0 \text{ V} < V_{\text{CANH}} < 5 \text{ V}$ , $V_{\text{CANH}} = V_{\text{CANL}}$ ;	P_7.1.44
Leakage current, CANL	$I_{\text{CANL,ik}}$	-5	—	5	μA	$V_{\text{CC}} = V_{\text{IO}} = 0 \text{ V}$ , $0 \text{ V} < V_{\text{CANL}} < 5 \text{ V}$ , $V_{\text{CANH}} = V_{\text{CANL}}$ ;	P_7.1.45

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

4.5 V <  $V_{CC}$  < 5.5 V; 3.0 V <  $V_{IO}$  < 5.5 V;  $R_L = 60 \Omega$ ;  $-40^\circ\text{C} < T_j < 150^\circ\text{C}$ ; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
Dynamic CAN-Transceiver Characteristics							
Propagation delay TxD-to-RxD “low” (“recessive to “dominant”)	$t_{\text{Loop(H,L)}}$	—	180	255	ns	$C_{\text{L}} = 100 \text{ pF}$ , $4.75 \text{ V} < V_{\text{CC}} < 5.25 \text{ V}$ , $C_{\text{RxD}} = 15 \text{ pF}$ ;	P_7.1.46
Propagation delay TxD-to-RxD “high” (“dominant” to “recessive”)	$t_{\text{Loop(L,H)}}$	—	180	255	ns	$C_{\text{L}} = 100 \text{ pF}$ , $4.75 \text{ V} < V_{\text{CC}} < 5.25 \text{ V}$ , $C_{\text{RxD}} = 15 \text{ pF}$ ;	P_7.1.47
Propagation delay extended load TxD-to-RxD “low” (“recessive to “dominant”)	$t_{\text{Loop\_Ext(H,L)}}$	—	—	300	ns	<sup>1)</sup> $C_{\text{L}} = 200 \text{ pF}$ , $R_{\text{L}} = 120 \text{ }\Omega$ , $4.75 \text{ V} < V_{\text{CC}} < 5.25 \text{ V}$ , $C_{\text{RxD}} = 15 \text{ pF}$ ;	P_7.1.53
Propagation delay extended load TxD-to-RxD “high” (“dominant” to “recessive”)	$t_{\text{Loop\_Ext(L,H)}}$	—	—	300	ns	<sup>1)</sup> $C_{\text{L}} = 200 \text{ pF}$ , $R_{\text{L}} = 120 \text{ }\Omega$ , $4.75 \text{ V} < V_{\text{CC}} < 5.25 \text{ V}$ , $C_{\text{RxD}} = 15 \text{ pF}$ ;	P_7.1.54
Propagation delay TxD “low” to bus “dominant”	$t_{\text{d(L),T}}$	—	90	140	ns	$C_{\text{L}} = 100 \text{ pF}$ , $4.75 \text{ V} < V_{\text{CC}} < 5.25 \text{ V}$ , $C_{\text{RxD}} = 15 \text{ pF}$ ;	P_7.1.48
Propagation delay TxD “high” to bus “recessive”	$t_{\text{d(H),T}}$	—	90	140	ns	$C_{\text{L}} = 100 \text{ pF}$ , $4.75 \text{ V} < V_{\text{CC}} < 5.25 \text{ V}$ , $C_{\text{RxD}} = 15 \text{ pF}$ ;	P_7.1.49
Propagation delay bus “dominant” to RxD “low”	$t_{\text{d(L),R}}$	—	90	140	ns	$C_{\text{L}} = 100 \text{ pF}$ , $4.75 \text{ V} < V_{\text{CC}} < 5.25 \text{ V}$ , $C_{\text{RxD}} = 15 \text{ pF}$ ;	P_7.1.50
Propagation delay bus “recessive” to RxD “high”	$t_{\text{d(H),R}}$	—	90	140	ns	$C_{\text{L}} = 100 \text{ pF}$ , $4.75 \text{ V} < V_{\text{CC}} < 5.25 \text{ V}$ , $C_{\text{RxD}} = 15 \text{ pF}$ ;	P_7.1.51
Delay Times							
Delay time for mode change	$t_{\text{Mode}}$	—	—	20	$\mu\text{s}$	<sup>1)</sup> (see <a href="#">Figure 14</a> and <a href="#">Figure 15</a> );	P_7.1.52

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 °C <  $T_j$  < 150 °C; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
CAN FD Characteristics							
Received recessive bit width at 2 MBit/s	$t_{\text{Bit(RxD)}\_2\text{MB}}$	400	500	550	ns	$C_L = 100\text{ pF}$ , $4.75\text{ V} < V_{CC} < 5.25\text{ V}$ , $C_{\text{RxD}} = 15\text{ pF}$ , $t_{\text{Bit}} = 500\text{ ns}$ , (see <a href="#">Figure 12</a> );	P_7.1.55
Transmitted recessive bit width at 2 MBit/s	$t_{\text{Bit(Bus)}\_2\text{MB}}$	435	500	530	ns	$C_L = 100\text{ pF}$ , $4.75\text{ V} < V_{CC} < 5.25\text{ V}$ , $C_{\text{RxD}} = 15\text{ pF}$ , $t_{\text{Bit}} = 500\text{ ns}$ , (see <a href="#">Figure 12</a> );	P_7.1.56
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	$C_L = 100\text{ pF}$ , $4.75\text{ V} < V_{CC} < 5.25\text{ V}$ , $C_{\text{RxD}} = 15\text{ pF}$ , $t_{\text{Bit}} = 500\text{ ns}$ , (see <a href="#">Figure 12</a> );	P_7.1.57

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

2) In respect to common mode range.

## 7.2 Diagrams

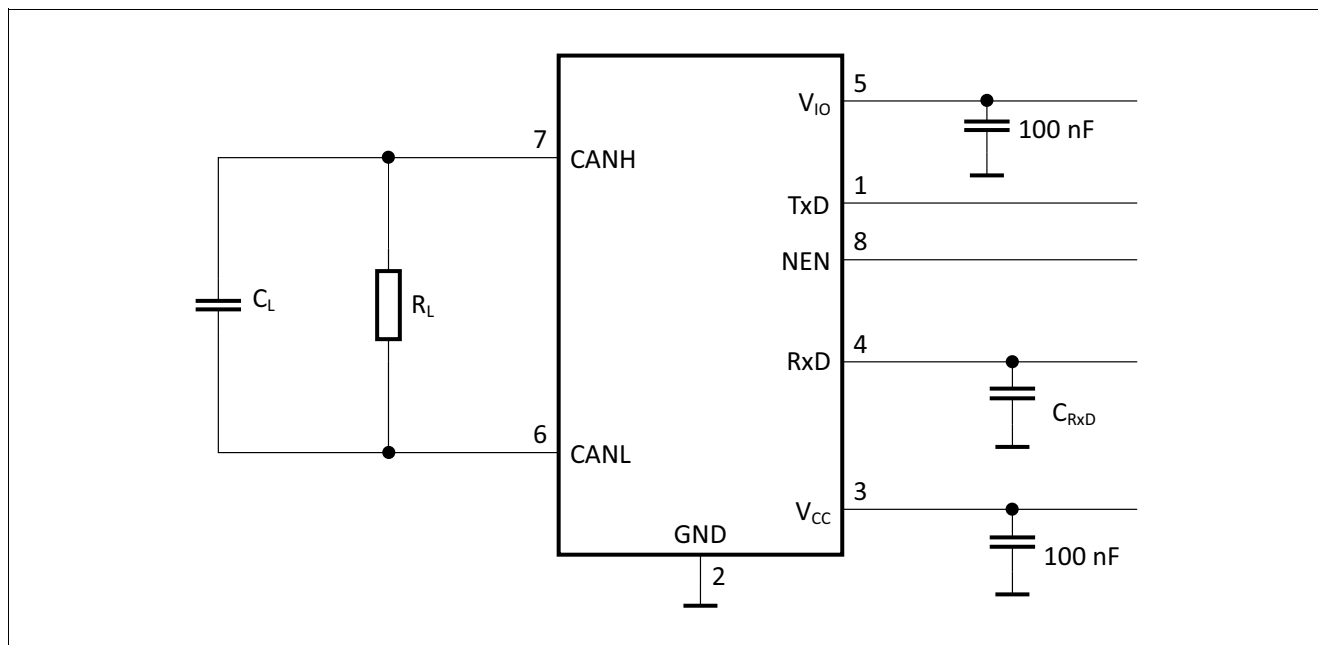


Figure 10 Test circuits for dynamic characteristics

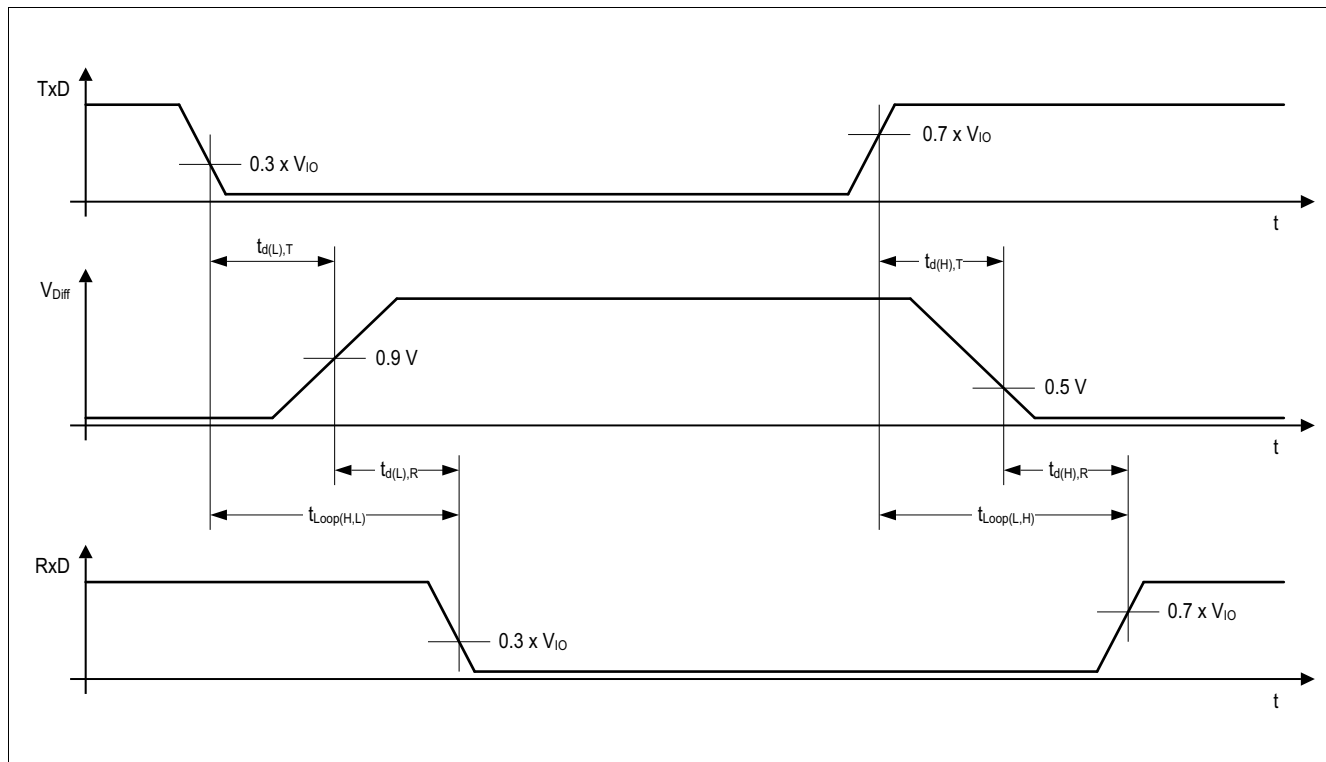


Figure 11 Timing diagrams for dynamic characteristics



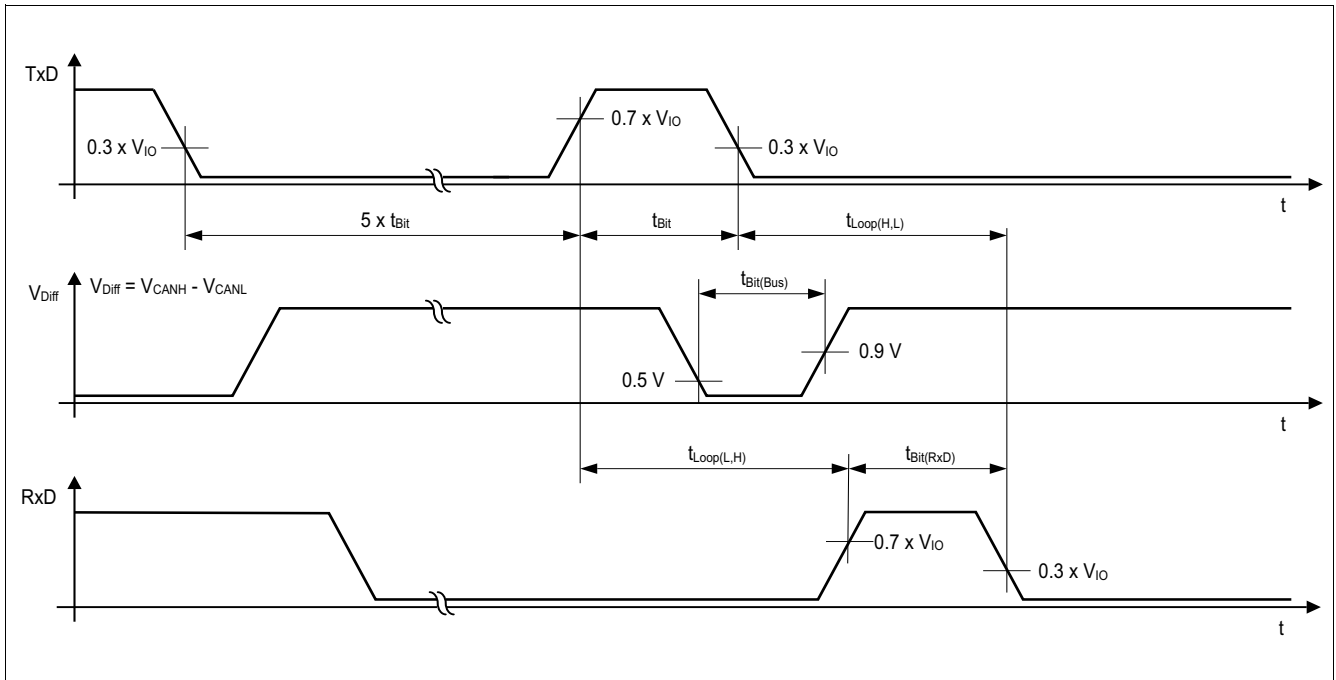


Figure 12 “Recessive” bit time - five “dominant” bits followed by one “recessive” bit

## 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  $\Omega$ ) have been performed. The results and test conditions are available in a separate test report.

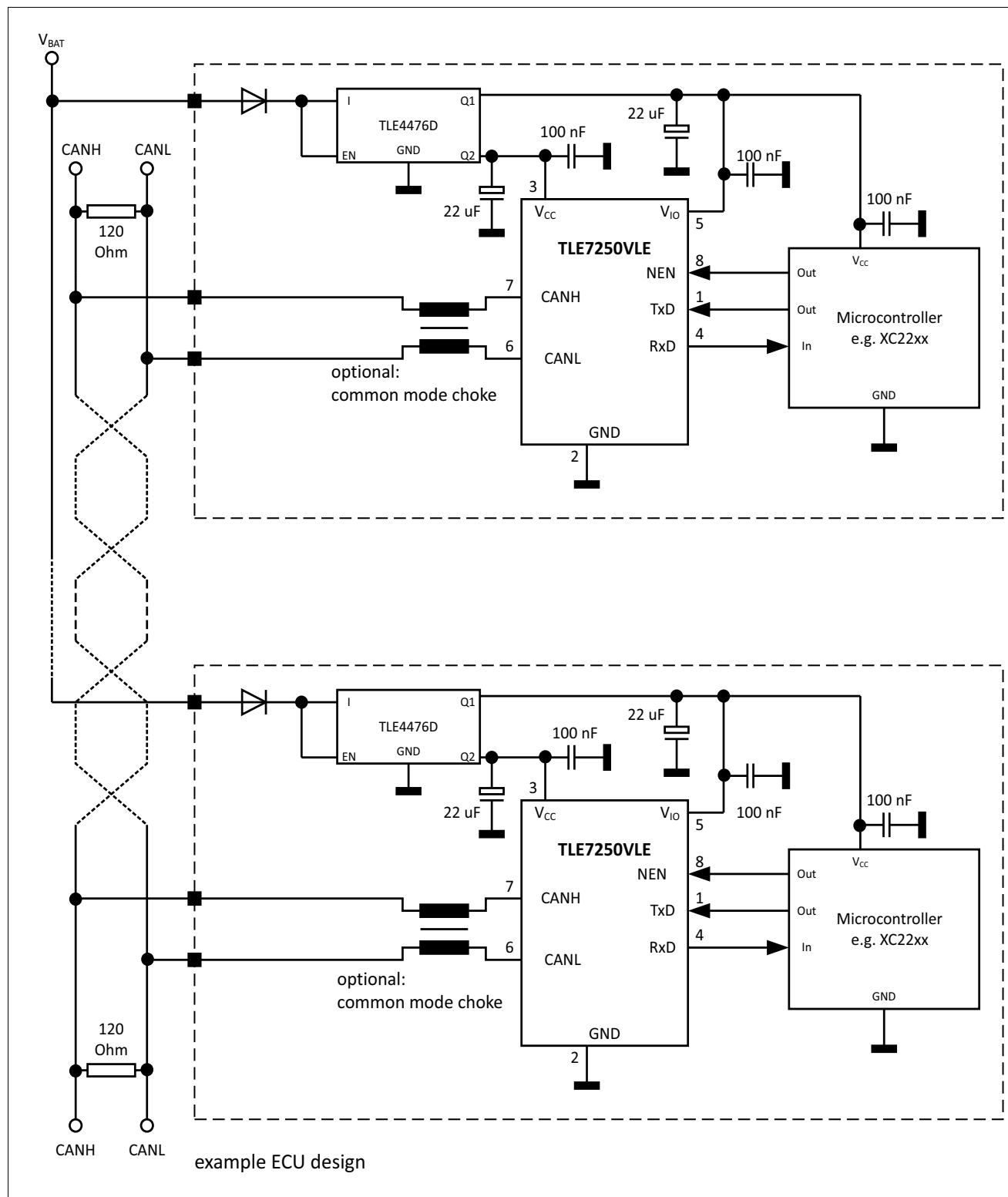
**Table 7 ESD robustness according to IEC61000-4-2**

Performed Test	Result	Unit	Remarks
Electrostatic discharge voltage at pin CANH and CANL versus GND	$\geq +8$	kV	<sup>1)</sup> Positive pulse
Electrostatic discharge voltage at pin CANH and CANL versus GND	$\leq -8$	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).

## 8.2 Application Example



**Figure 13** Application circuit

### 8.3 Examples for Mode Changes

Changing the status on the NEN 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 NEN pin, when the device TLE7250V is fully supplied. Setting the NEN 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 NEN input pin to logical “high” changes the mode of operation to the power-save mode independent on the signals at the CANH, CANL and TxD pins.

*Note: In case the TxD signal is “low” setting the NEN 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.*

*Note: The TxD time-out is only effective in normal-operating mode. The TxD time-out timer starts when the TLE7250V enters normal-operating mode and the TxD input is set to logical “low”.*

### 8.3.1 Mode Change while the TxD Signal is “low”

The example in [Figure 14](#) 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 TLE7250V is in power-save mode, the transmitter and the normal-mode receiver are turned off. The TLE7250V drives no signal to the HS CAN bus nor does it receive any signal from the HS CAN bus. Changing the NEN 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. 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 NEN 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”.

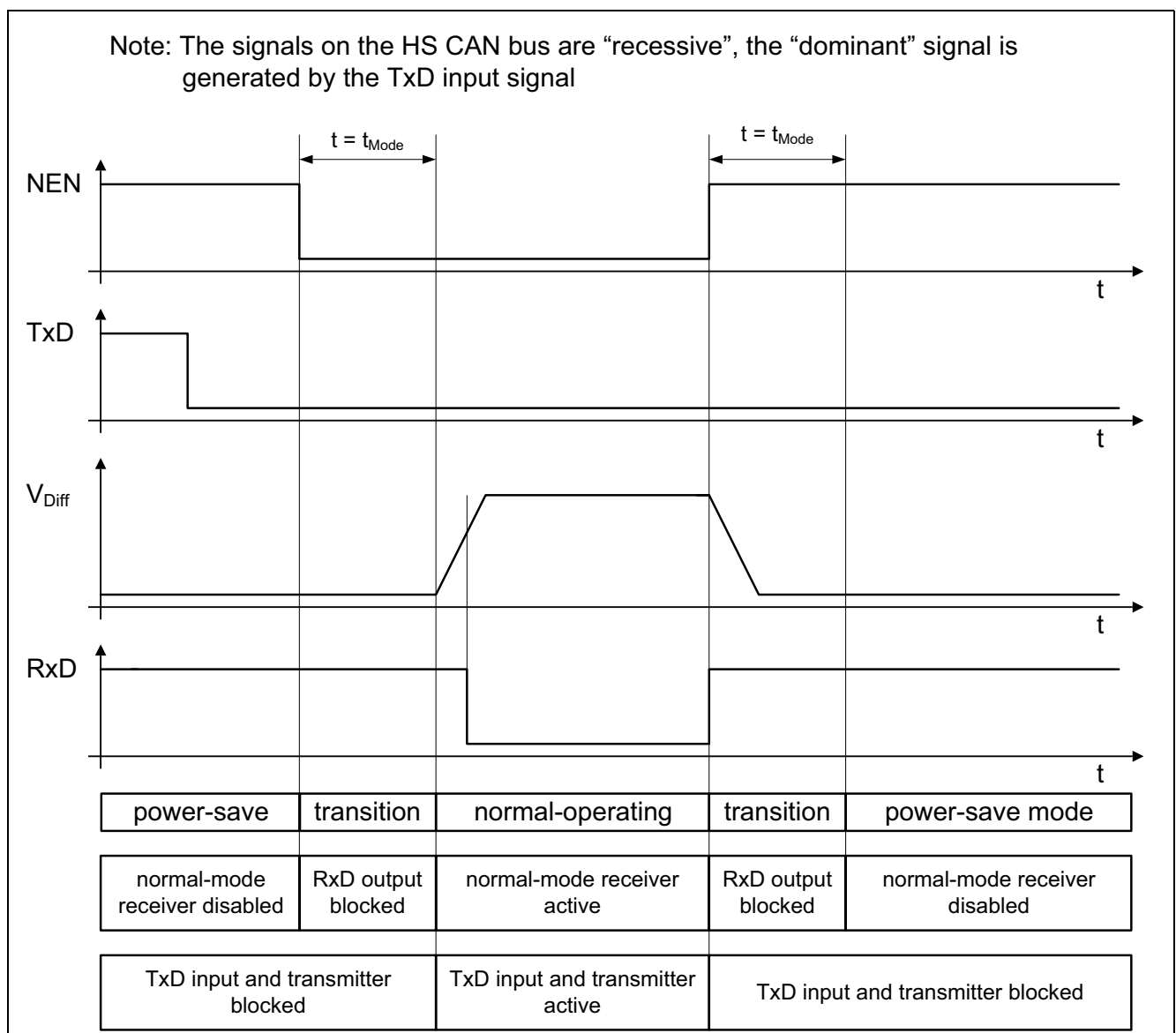


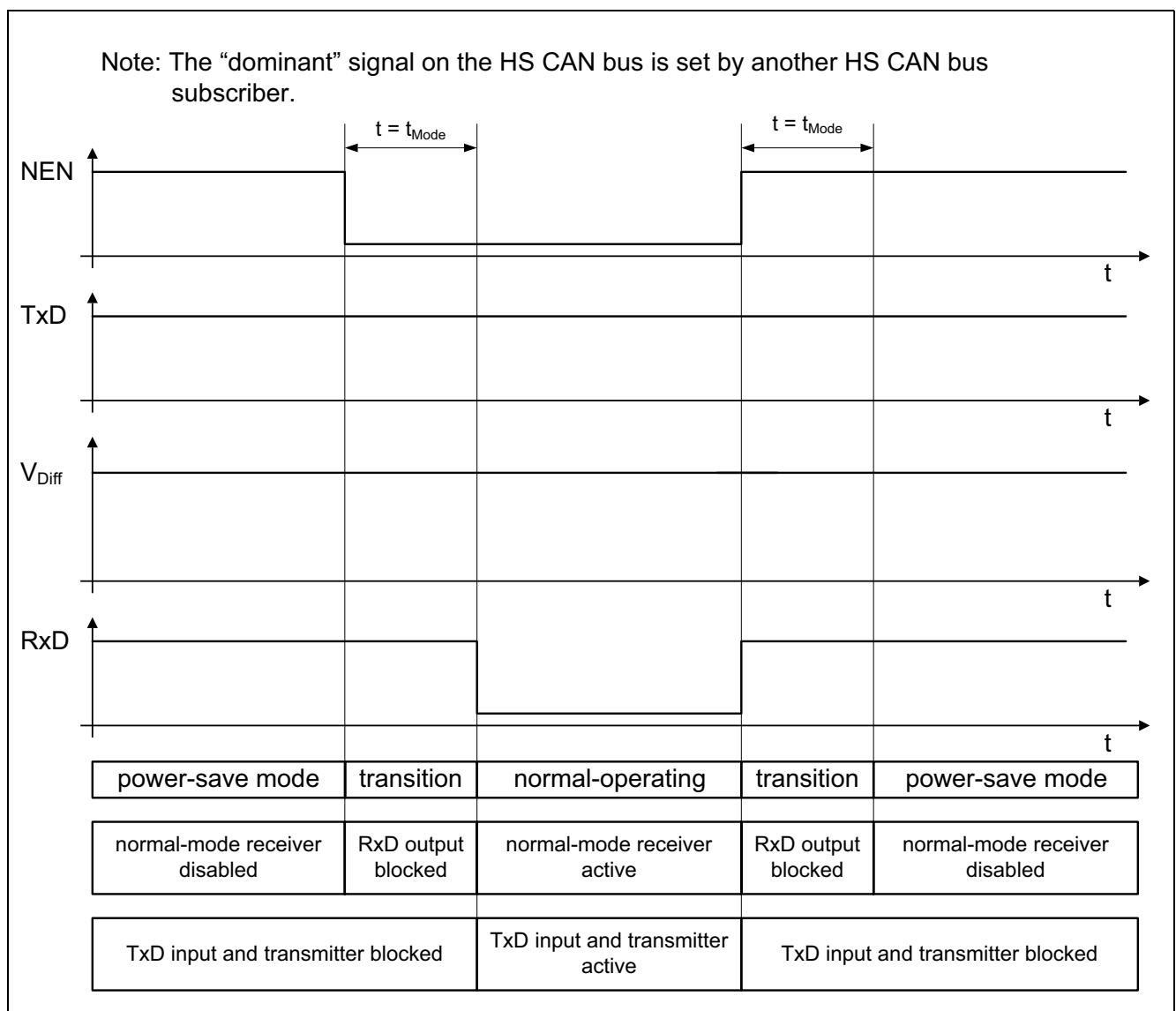
Figure 14 Example for a mode change while the TxD is “low”

### 8.3.2 Mode Change while the Bus Signal is “dominant”

The example in [Figure 15](#) shows a mode change while the bus is “dominant” and the TxD input signal is set to logical “high”.

While the transceiver TLE7250V is in power-save mode, the transmitter and the normal-mode receiver are turned off. The TLE7250V drives no signal to the HS CAN bus nor does it receive any signal from the HS CAN bus. Changing the NEN 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. In normal-operating mode the transmitter of TLE7250V remains “recessive”, because of the logical “high” signal on the TxD input. The normal-mode receiver becomes active and the RxD output signal changes to logical “low” following the “dominant” signal on the HS CAN bus.

Changing the NEN 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.



**Figure 15** Example for a mode change while the HS CAN is “dominant”

## 8.4 Further Application Information

- Please contact us for information regarding the pin FMEA.
- Existing application note.
- For further information you may visit: <http://www.infineon.com/>





## 10 Revision History

Revision	Date	Changes
1.00	2015-08-12	Data Sheet created.

**Edition 2015-08-12**

**Published by  
Infineon Technologies AG  
81726 Munich, Germany**

**© 2006 Infineon Technologies AG  
All Rights Reserved.**

### **Legal Disclaimer**

The information given in this document shall in no event be regarded as a guarantee of conditions or characteristics. With respect to any examples or hints given herein, any typical values stated herein and/or any information regarding the application of the device, Infineon Technologies hereby disclaims any and all warranties and liabilities of any kind, including without limitation, warranties of non-infringement of intellectual property rights of any third party.

### **Information**

For further information on technology, delivery terms and conditions and prices, please contact the nearest Infineon Technologies Office ([www.infineon.com](http://www.infineon.com)).

### **Warnings**

Due to technical requirements, components may contain dangerous substances. For information on the types in question, please contact the nearest Infineon Technologies Office.

Infineon Technologies components may be used in life-support devices or systems only with the express written approval of Infineon Technologies, if a failure of such components can reasonably be expected to cause the failure of that life-support device or system or to affect the safety or effectiveness of that device or system. Life support devices or systems are intended to be implanted in the human body or to support and/or maintain and sustain and/or protect human life. If they fail, it is reasonable to assume that the health of the user or other persons may be endangered.