

# TLE7259G

LIN Transceiver

Automotive Power



Never stop thinking



## 1 Overview

### Features

- Transmission rate up to 20 kBaud
- Compliant to LIN specification 1.2, 1.3, 2.0 and 2.1
- Support of K-line function (ISO 9141)
- Very high ESD Robustness
- Very low Electromagnetic Emission (EME)
- Very High Electromagnetic Immunity (EMI)
- Very low current consumption in sleep mode
- Very low leakage current on the BUS output
- Control output for voltage regulator
- Wake up source recognition (local/remote)
- For 3.3 V and 5 V micro controller I/O
- Suitable for 12V and 24V board-net
- Bus short to  $V_{BAT}$  protection
- Bus short to GND handling
- Over temperature protection
- AEC Qualified



P-DSO-8

### Description

The TLE7259G is a transceiver for the Local Interconnect Network (LIN) with integrated wake-up and protection features. It is designed for in-vehicle networks using data transmission rates from 2.4 kBaud to 20 kBaud. The TLE7259G functions as a bus driver between the protocol controller and the physical bus inside the LIN network. Compliant to all LIN standards and with a wide operational supply range the TLE7259G can be used in all automotive applications.

Different operation modes and the INH output allow the TLE7259G to control external components, like voltage regulators. In Sleep-mode the TLE7259G draws less than 8  $\mu$ A of quiescent while still being able to wake up off of LIN bus traffic and a local wake-up input. The very low leakage current on the BUS pin makes the TLE7259G especially suitable for "Mixed Power Supply" applications and supports the low quiescent current requirements of the LIN network.

Based on the Infineon Smart Power Technology SPT<sup>®</sup>, the TLE7259G provides excellent ESD Robustness together with a very high electromagnetic immunity (EMI). The TLE7259G reaches a very low level of electromagnetic emission (EME) within a broad frequency range and independent from the battery voltage.

The Infineon Smart Power Technology SPT<sup>®</sup> allows bipolar and CMOS control circuitry in accordance with DMOS power devices existing on the same monolithic circuit. The TLE7259G and the Infineon SPT<sup>®</sup> technology are AEC qualified and tailored to withstand the harsh condition of the Automotive Environment.

Type	Package	Marking
TLE7259G	P-DSO-8	7259G

## 2 Block Diagram

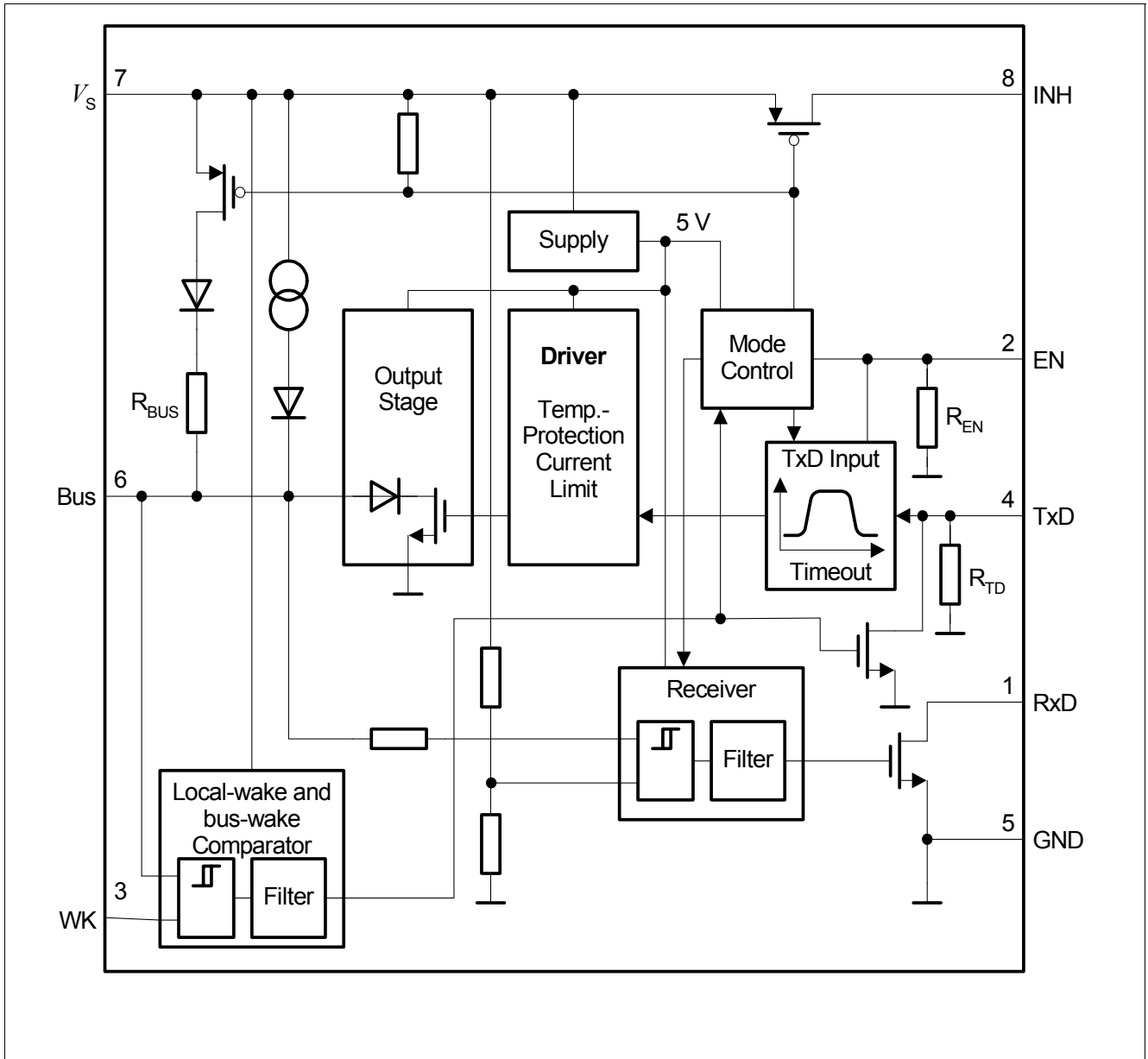


Figure 1 Functional Block Diagram

### 3 Pin Configuration

#### 3.1 Pin Assignment

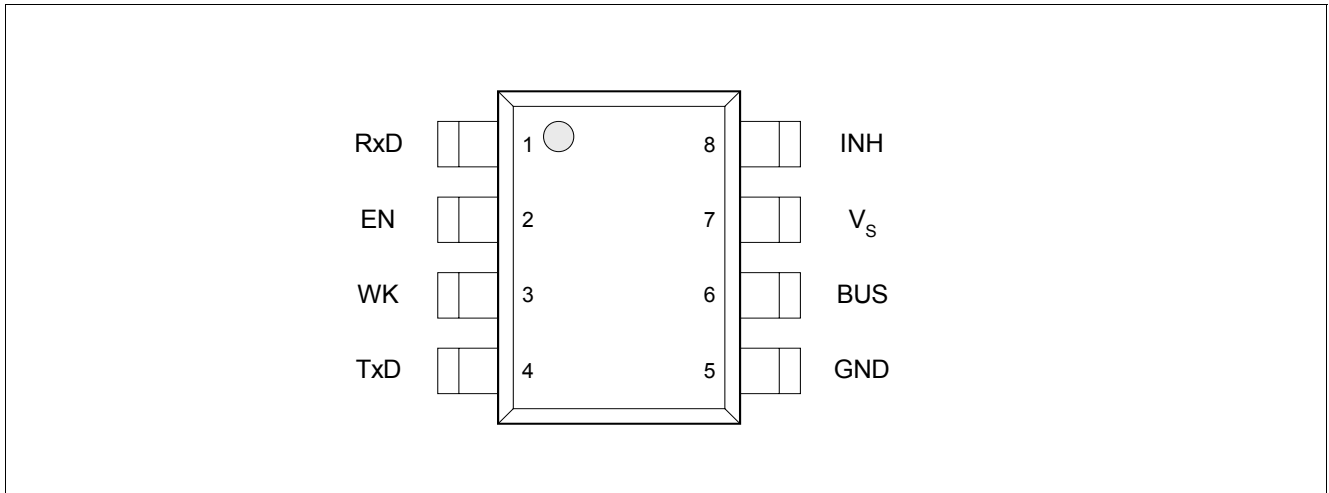


Figure 2 Pin Configuration (top view)

#### 3.2 Pin Definitions and Functions

Table 1 Pin Definitions and Functions

Pin No.	Symbol	Function
1	RxD	<b>Receive data output;</b> External Pull Up necessary LOW in dominant state, active LOW after a wake-up event at Bus or WK pin
2	EN	<b>Enable input;</b> integrated pull-down, device in normal operation mode when HIGH
3	WK	<b>Wake input;</b> active LOW, negative edge triggered, internal pull-up
4	TxD	<b>Transmit data input;</b> integrated pull-down, LOW in dominant state; active LOW after wake-up via WK pin
5	GND	<b>Ground</b>
6	Bus	<b>Bus output/input;</b> LIN bus line input/output LOW in dominant state Internal pull-up
7	$V_S$	<b>Battery supply input</b>
8	INH	<b>Inhibit output;</b> battery supply related output HIGH ( $V_S$ ) in Normal and Stand-By operation mode can be used to control an external voltage regulator can be used to control external bus termination resistor when the device will be used as Master node



**Table 2 Operating modes**

Mode	EN	INH	TxD	RxD	LIN Bus Termination	Comments
Sleep	Low	Floating	Low	High <sup>1)</sup>	High Impedance	No wake-up request detected
Stand-By	Low	High	Low <sup>2)</sup> High <sup>3)</sup>	Low High <sup>1)</sup>	30 kΩ (typical)	RxD “Low” after local or bus wake-up RxD “High” after power-up TxD strong pull down after local wake-up (WK pin) <sup>2)</sup> TxD weak pull down after bus wake-up or power-up <sup>3)</sup>
Normal	High	High	Low High	Low High	30 kΩ (typical)	RxD reflects the signal on the LIN bus TxD driven by the micro controller

1) Pull-up resistor to micro controller power supply ( $V_{IO}$ ) required (see [Figure 11](#) and [Figure 12](#)).

2) TxD indicates logical “Low” in case the micro controller output is set to “High” and the micro controller output current is limited to less than 1.9 mA.

3) TxD indicates logical “High” in case the micro controller output is set to “High”.

## 4.2 Normal Operation Mode

The TLE7259G enters the normal mode after the micro controller sets EN = high (see [Figure 3](#)). In Normal operation mode the LIN bus receiver and the LIN bus transmitter are active. Data from the micro controller is transmitted to the LIN bus via the TxD pin, the receiver detects the data stream on the LIN bus and outputs it to the RxD pin.

## 4.3 Stand-By Mode

The Stand-By mode is entered automatically after:

- A power-up event on the supply  $V_S$ .
- A wake-up event on the LIN bus.
- A local wake-up event on the pin WK.
- A power on reset caused by power supply  $V_S$  dropping below  $V_{S,UV,PON}$  ( $V_S < V_{S,UV,PON}$ ).

In Stand-By mode no communication on the LIN Bus is possible. The output stage is disabled and the LIN Bus termination remains activated. The RxD and TxD pins are indicating the wake-up source. The RxD pin remains “Low” after a local and bus wake-up event. A power-up event is indicated by a logical “High” on RxD pin. The signal on the TxD pin indicates the wake-up source, a weak pull-down signals a bus wake-up event and a strong pull-down signals a local wake-up event caused by the WK pin (see [Table 2](#)). In order to detect a wake-up event via the TxD pin, the external micro controller needs outputs needs to provide a logical “high” signal. The wake-up flags indicating the wake-up source on the pins TxD and RxD are reset by changing the operation mode to Normal operation.

The signal on the EN pin remains “Low” due to an internal pull-down resistor. Setting the EN pin to “High”, by the micro controller the device returns to Normal operation mode. Entering the Stand-By mode switches the INH output to  $V_S$ . Depending on the operation mode of the TLE7259G external circuitry, like a voltage regulator, can be controlled by the INH output.

#### 4.4 Sleep Mode

In order to reduce the current consumption the TLE7259G offers a Sleep mode. In Sleep mode the quiescent current on  $V_S$  and the leakage current on the pin Bus, are cut back to a minimum.

Switching the TLE7259G from Normal operation mode to Sleep mode, the EN pin needs to be set to “Low”. A logical “High” on the EN pin sets the device direct back to Normal operation mode (see [Figure 3](#)).

While the TLE7259G is in Sleep mode the following functions are available:

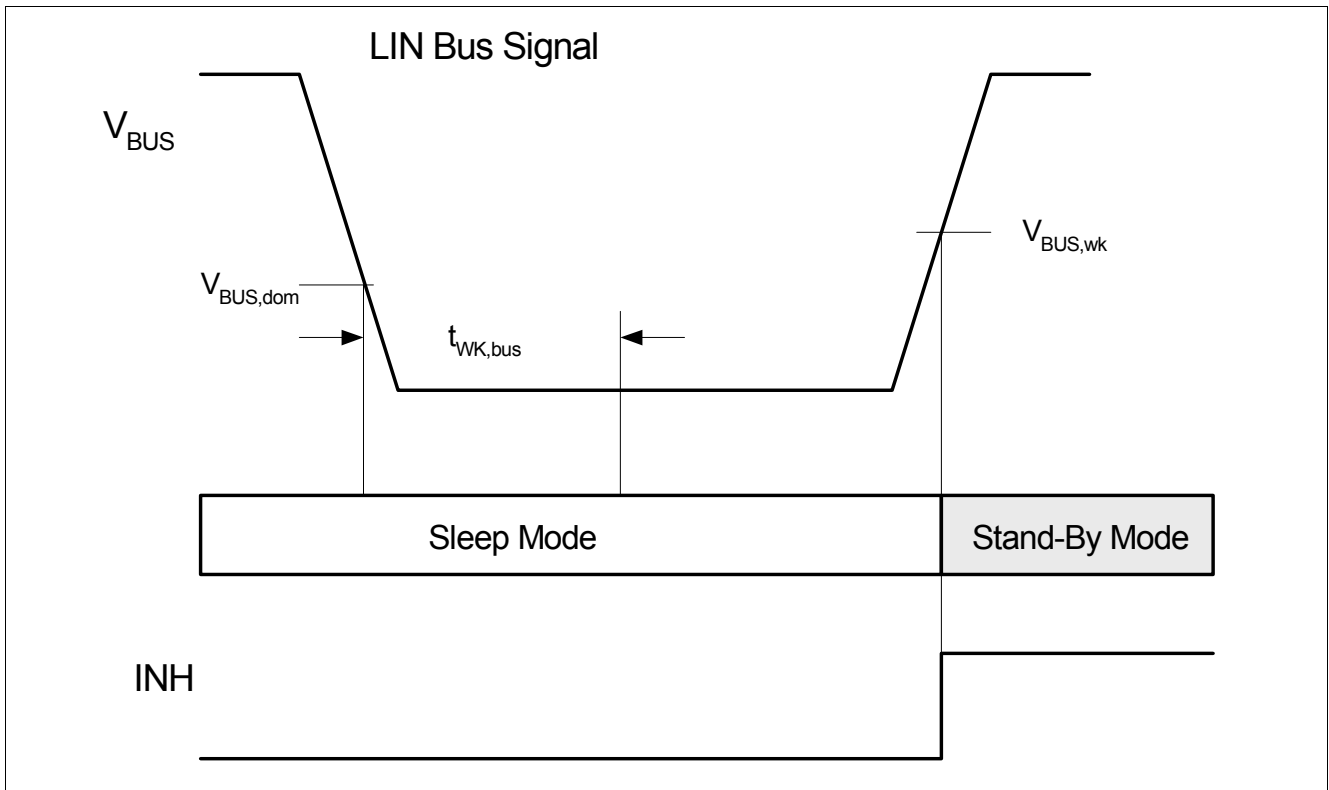
- The output stage is disabled and the internal bus termination is switched off (High Impedance on the Bus pin). An internal current source on the Bus pin ensures that the level on the Bus pin remains dominate and protects the LIN network against accidental bus wake-up events.
- The receiver is turned off
- RxD and TxD pins are disabled. The logical state on the TxD pin is low, due to the internal pull-down resistor. The RxD pin is “High” driven by the external pull-up resistor
- The INH output is switched off and floating.
- The BUS wake-up comparator is active and turns the TLE7259G to Stand-By mode in case of a bus wake-up.
- The WK pin is active and turns the TLE7259G to Stand-By mode in case of a local wake-up.
- The EN pin remains active, switching EN pin to “High” changes the operation mode to Normal operation.

#### 4.5 Wake-up Events

There are 3 different ways to wake-up the TLE7259G from Sleep mode.

- Bus or also called remote wake-up via a dominate signal on the LIN bus.
- Local wake-up via a minimum dominant time ( $t_{WK}$ ) on the WK pin.
- Mode change from Sleep mode to Normal operation mode, by setting EN pin to logical “High”.

#### 4.6 Bus Wake-up



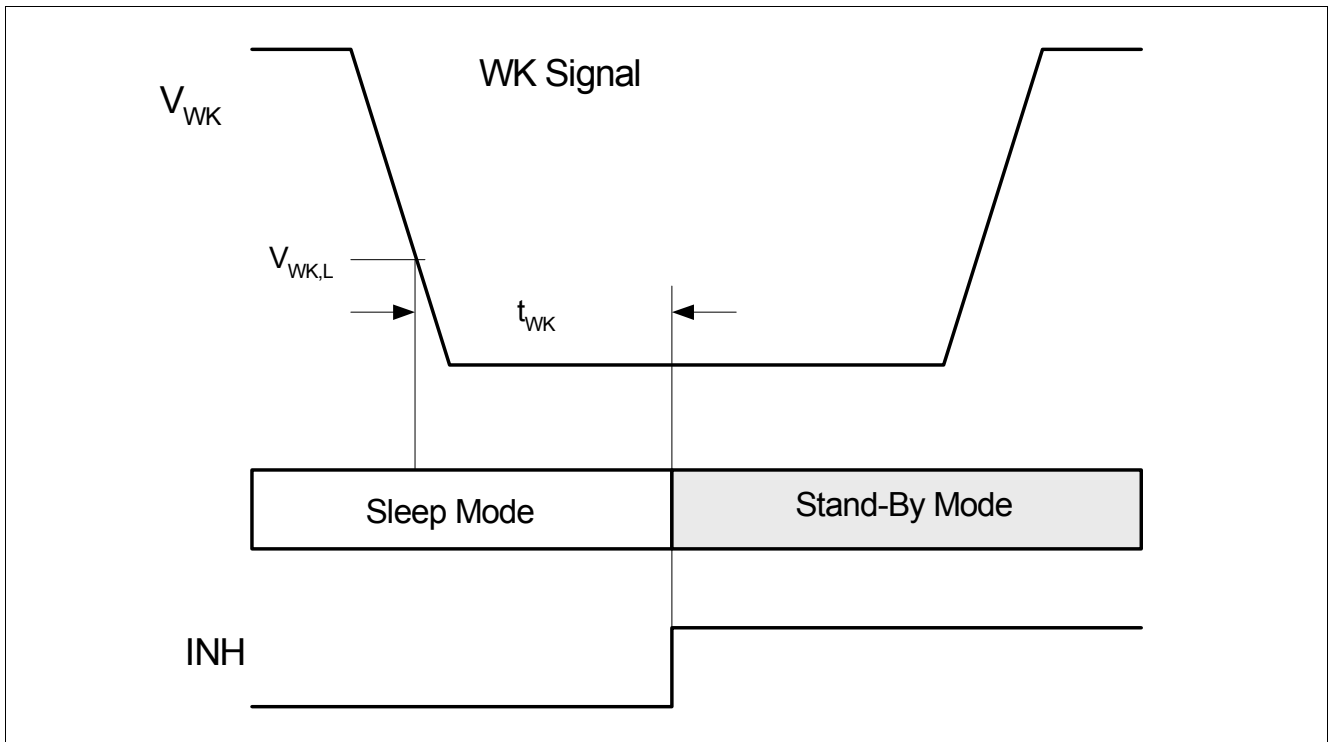
**Figure 4 Bus wake-up behavior**

The bus wake-up, often called remote wake-up, changes the operation mode from Sleep mode to Stand-By mode. A falling edge on the LIN bus, followed by a dominate bus signal  $t > t_{WK,bus}$  results in a bus wake-up. The mode change to Stand-By mode becomes active with the following rising edge on the LIN bus. The TLE7259G remains in Sleep mode until it detects a change from dominate to recessive on the LIN bus (see [Figure 4](#)).

In Stand-By mode the TxD pin indicates the source of the wake-up event. A weak pull-down on the pin TxD indicates a bus wake-up event (see [Figure 3](#)). The RxD pin signals if a wake-up event occurred or the power-up event. A logical “Low” on the RxD pin reports a local or bus wake-up event, a logical “High” signal on RxD indicates a power-up event.



### 4.7 Local Wake-up

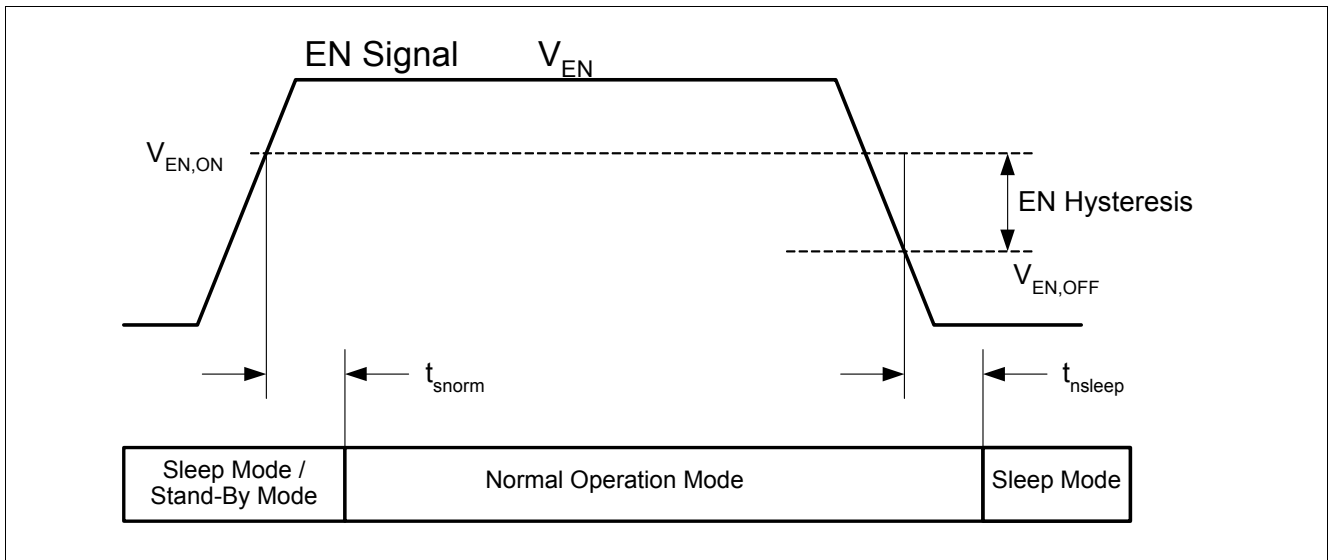


**Figure 5 Local wake-up behavior**

Beside the remote wake-up, a wake-up of the TLE7259G via the WK pin is possible. This wake-up event is called local wake up. A falling edge on the WK pin followed by a logical “Low” for  $t > t_{WK}$  results in a local wake up (see [Figure 5](#)) and change the operation mode to Stand-By Mode.

In Stand-By mode the TxD pin indicates the source of the wake-up event. A strong pull down on the pin TxD indicates a local wake-up event via the pin WK (see [Figure 3](#)). The RxD pin signals if a wake-up event occurred or the power-up event. A logical “Low” on the RxD pin reports a local or bus wake-up event, a logical “High” signal on RxD indicates a power-up event.

### 4.8 Mode Transition via EN pin

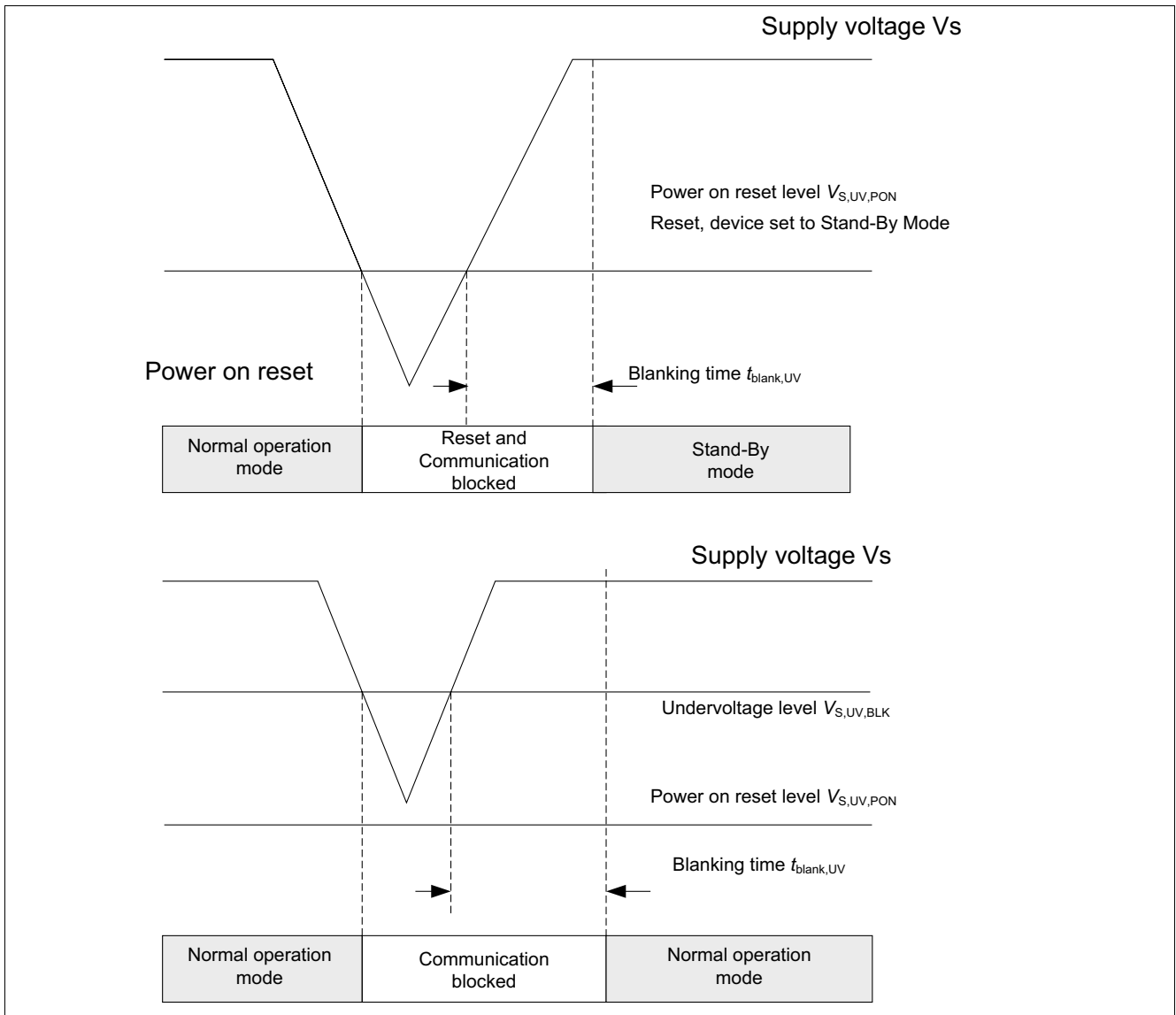


**Figure 6 Mode transition via EN pin**

It is also possible to change from Sleep mode to Normal operation mode by setting the EN pin to logical “Low”. This feature is useful if the external micro controller is continuously powered and not connected to the INH pin. The EN pin has an integrate pull-down resistor to ensure the device remains in Sleep or Stand-By mode even if the voltage on the EN pin is floating. The EN pin has an integrated hysteresis (see [Figure 6](#)).

A transition from logical “High” to logical “Low” on the EN pin changes the operation mode from Normal operation mode to Sleep mode. If the TLE7259G is already in Sleep mode, changing the EN from “Low” to “High” results into a mode change from Sleep mode to Normal operation mode. If the device is in Stand-By mode a change from “Low” to “High” on the EN pin changes the mode to Normal operation mode (see [Figure 3](#)).

### 4.9 Power-On Reset



**Figure 7 Power-on reset and Undervoltage situation**

A drooping power supply  $V_S$  on a local ECU can effect the communication of the whole LIN network. To avoid any blocking of the LIN network by a local ECU the TLE7259G has an integrated power-on reset and undervoltage detection. In case the supply voltage is dropping below the power on reset level  $V_S < V_{S,U,V,PON}$ , the TLE7259G changes the operation mode to Stand-By mode. In Stand-By mode the output stage of the TLE7259G is disabled and no communication to the LIN bus is possible. The internal bus termination remains active as well as the INH pin (see [Figure 7](#)).

In Stand-By mode the RxD pin signals the low power supply condition with a logical “High” Signal. A logical “High” on the EN pin changes the operation mode back to Normal operation mode.

In case the supply voltage  $V_S$  is dropping below the specified operation range (see [Table 5](#)), the TLE7259G disables the output and receiver stages. The feature secures the communication on the LIN bus, even if the local ECU power supply of the TLE7259G drops below the specified operating range. If the power supply reaches a higher level as the undervoltage level  $V_S > V_{S,U,V,PON}$  the TLE7259G continues with normal operation. A mode change only apply if the power supply  $V_S$  drops below the power on reset level ( $V_S < V_{S,U,V,PON}$ ).

#### 4.10 TxD time out function

If the TxD signal is dominant for a time  $t > t_{\text{timeout}}$  the TxD time-out function deactivates the transmission of the LIN signal to the bus. This is realized to prevent the bus from being permanently blocked by a permanent “Low” signal on the TxD pin due to an error.

The transmission is released again, after a rising edge at TxD has been detected.

#### 4.11 Over temperature protection

The TLE7259G has an integrated over temperature sensor, to protect the device against thermal overstress. In case of an over temperature event, the temperature sensor will disable the output stage. An over temperature event will not cause any mode change nor will it be signaled by either the RxD pin or the TxD pin. When the junction temperature falls below the thermal shut down level  $T_J < T_{jSD}$ , the output stage is re-enabled and data communication can start again. A10°C hysteresis avoids toggling during the temperature shut down.

#### 4.12 3.3 V and 5 V Logic Capability

The TLE7259G can be used for 3.3 V and 5 V micro controllers. The inputs (TxD, EN) take the reference voltage from the connected micro controller pins. The RxD output must have an external pull-up resistor to the micro controller supply, to define the output voltage level.

#### 4.13 BUS Short to GND Feature

The TLE7259G has a feature implemented to protect the battery from running out of charge in the case the LIN bus is shorted to GND.

In this failure case a normal master termination, a 1 kΩ resistor and a diode connected between the Bus pin and the power supply  $V_S$ , would cause a constant current between  $V_S$  and GND, even in sleep mode. The resulting resistance between  $V_S$  and GND of this LIN bus short to GND is lower than 1 kΩ. To avoid this current during a generator off state, like in a parked car, the TLE7259G has a Bus Short to GND feature implemented. This feature is only applicable, if the master termination is connected to the INH pin, instead of the  $V_S$  power supply (see [Figure 11](#) and [Figure 12](#)). In Sleep mode the INH pin is switched off and no current can flow between  $V_S$  and GND. The internal 30 kΩ bus termination is also switched off (see [Figure 1](#) and [Table 2](#)) to minimize the discharge current.

#### 4.14 LIN Specifications 1.2, 1.3, 2.0 and 2.1

The device fulfills the Physical Layer Specification of LIN 1.2, 1.3, 2.0 and 2.1.

The differences between LIN specification 1.2 and 1.3 is mainly the physical layer specification. The reason was to improve the compatibility between the nodes.

The LIN specification 2.0 is a super set of the 1.3 version. The 2.0 version offers new features. However, it is possible to use the LIN 1.3 slave node in a 2.0 node cluster, as long as the new features are not used. Vice versa it is possible to use a LIN 2.0 node in the 1.3 cluster without using the new features.

In terms of the physical layer the LIN 2.1 Specification doesn't include any changes and is fully compliant to the LIN Specification 2.0.

LIN 2.1 is the latest version of the LIN specification, released in December 2006.

## 5 General Product Characteristics

### 5.1 Absolute Maximum Ratings

**Table 3 Absolute Maximum Ratings Voltages, Currents and Temperatures<sup>1)</sup>**

$T_j = -40\text{ °C}$  to  $150\text{ °C}$ ; all voltages with respect to ground; positive current flowing into pin;  
(unless otherwise specified)

Pos.	Parameter	Symbol	Limit Values		Unit	Remarks
			Min.	Max.		
<b>Voltages</b>						
5.1.1	Battery supply voltage	$V_S$	-0.3	40	V	LIN Spec 2.1 Param. 10
5.1.2	Bus input voltage versus GND versus $V_S$	$V_{BUS,G}$	-40	40	V	$t < 1\text{ s}$
		$V_{BUS,Vs}$	-40	40	V	
5.1.3	Wake input versus GND Wake input versus $V_S$	$V_{WK,G}$	-40	40	V	–
		$V_{WK,Vs}$	-40	40	V	
5.1.4	Logic voltages at EN, TxD, RxD	$V_{logic}$	-0.3	5.5	V	–
5.1.5	Inhibit Voltage versus GND Versus $V_S$	$V_{INH,G}$	-0.3	40	V	
		$V_{INH,Vs}$	-40	0,3	V	
<b>Currents</b>						
5.1.6	Output current at INH	$I_{INH}$	-150	80	mA	<sup>2)</sup>
<b>Temperatures</b>						
5.1.7	Junction temperature	$T_j$	-40	150	°C	–
5.1.8	Storage temperature	$T_S$	-55	150	°C	–

1) Not subject to production test specified by design

2) Output current is internally limited to -150 mA

**Table 4 Absolute Maximum Ratings ESD Resistivity<sup>1)</sup>**

Pos.	Parameter	Symbol	Limit Values		Unit	Remarks
			Min.	Max.		
5.1.9	Electrostatic discharge voltage at $V_S$ , Bus, Wk versus GND	$V_{ESD}$	-6	6	kV	Human Body Model <sup>2)</sup> (100 pF via 1.5 kΩ)
5.1.10	Electrostatic discharge voltage except $V_S$ versus Bus	$V_{ESD}$	-2	2	kV	Human Body Model <sup>2)</sup> (100 pF via 1.5 kΩ)
5.1.11	Electrostatic discharge voltage at Bus versus $V_S$	$V_{ESD}$	-1	1	kV	Human Body Model (100 pF via 1.5 kΩ) <sup>2)</sup>

1) Not subject to production test specified by design

2) ESD susceptibility HBM according to EIA / JESD 22-A 114B

*Note: Maximum ratings are absolute ratings; exceeding any one of these values may cause irreversible damage to the integrated circuit.*

## 5.2 Functional Range

**Table 5 Operating Range**

Pos.	Parameter	Symbol	Limit Values		Unit	Remarks
			Min.	Max.		
5.2.1	Supply Voltage range $V_S$	$V_S$	6	40	V	LIN Spec 2.1 Param. 10

### Thermal parameters

5.2.2	Junction temperature	$T_j$	-40	150	°C	1)
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1) Not subject to production test, specified by design

## 5.3 Thermal Resistance

**Table 6 Thermal Resistance<sup>1)</sup>**

Pos.	Parameter	Symbol	Limit Values		Unit	Remarks
			Min.	Max.		
5.3.1	Junction to Ambient	$R_{thJA}$	–	185	K/W	2)

1) Not subject to production test, specified by design

2) JESD 51-2, 51-3, FR4 76,2 mm x 114,3 mm x 1,5 mm, 70µm, Cu, minimal footprint,  $T_A = 27^\circ\text{C}$

## 5.4 Electrical Characteristics

**Table 7 Electrical Characteristics**

7.0 V <  $V_S$  < 27 V;  $R_L = 500 \Omega$ ;  $V_{EN} > V_{EN,ON}$ ;  $-40^\circ\text{C} < T_j < 125^\circ\text{C}$ ; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

Pos.	Parameter	Symbol	Limit Values			Unit	Remarks
			Min.	Typ.	Max.		

### Current Consumption

5.4.1	Current consumption at $V_S$ in recessive state	$I_{S,rec}$	0.1	0.8	1.5	mA	recessive state, without $R_L$ ; $V_{TXD} = V_{CC}$
5.4.2	Current consumption at $V_S$ in dominant state	$I_{S,dom}$	0.1	1.3	2.5	mA	dominant state, without $R_L$ ; $V_{TXD} = 0\text{ V}$
5.4.3	Current consumption in sleep mode	$I_{S,sleep}$	1	–	14	µA	sleep mode, $V_{WK} = V_S$ ; $V_{BUS} = V_S$
5.4.4	Current consumption in sleep mode	$I_{S,sleep,typ}$	1	–	8	µA	sleep mode, $T_j=85^\circ\text{C}$ $V_{WK} = V_S$ ; $V_{BUS} = V_S$
5.4.5	Current consumption in stand-by mode	$I_{S,stby}$	0.1	–	1.5	mA	stand-by mode, $V_{WK} = V_S$ ; $V_{BUS} = V_S$
5.4.6	Current consumption in sleep mode, bus shorted to ground	$I_{S,sleep,short}$	5	10	60	µA	sleep mode, $V_{WK} = V_S$ ; $V_{BUS} = 0V$

**General Product Characteristics**
**Table 7 Electrical Characteristics (cont'd)**

7.0 V <  $V_S$  < 27 V;  $R_L = 500 \Omega$ ;  $V_{EN} > V_{EN,ON}$ ;  $-40 \text{ }^\circ\text{C} < T_j < 125 \text{ }^\circ\text{C}$ ; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

Pos.	Parameter	Symbol	Limit Values			Unit	Remarks
			Min.	Typ.	Max.		
<b>Reset Levels</b>							
5.4.7	Blocking Undervoltage Detection at $V_S$	$V_{S,UV,BLK}$	5	–	6		Communication blocked (see <a href="#">Figure 7</a> )
5.4.8	Power on reset	$V_{S,UV,PON}$	–	2.4	4	V	Device reset to Stand-by-Mode (see <a href="#">Figure 7</a> )
5.4.9	Blanking time power on reset detection	$t_{blank,UV}$	–	10	–	$\mu\text{s}$	<sup>1)</sup>
<b>Thermal Shutdown (Junction Temperature)</b>							
5.4.10	Thermal shutdown temp.	$T_{JSD}$	150	170	190	$^\circ\text{C}$	<sup>1)</sup>
5.4.11	Thermal shutdown temp.	$\Delta T$	–	10	–	K	<sup>1)</sup>
<b>Receiver Output RxD</b>							
5.4.12	HIGH level leakage current	$I_{RD,H}$	-5	0	5	$\mu\text{A}$	$V_{RXD} = 5 \text{ V}$ ; $V_{BUS} = V_S$
5.4.13	LOW level output current	$I_{RD,L}$	1.3	–	10	mA	$V_{RXD} = 0.9 \text{ V}$ ; $V_{BUS} = 0 \text{ V}$
<b>Transmission Input TxD</b>							
5.4.14	HIGH level input voltage threshold	$V_{TD,H}$	–	–	$0.7 \times V_{EN}$	V	recessive state $3.0 \text{ V} < V_{EN} < 5.5 \text{ V}$
5.4.15	TxD input hysteresis	$V_{TD,hys}$	–	$0.12 \times V_{EN}$	–	mV	$3.0 \text{ V} < V_{EN} < 5.5 \text{ V}$
5.4.16	LOW level input voltage threshold	$V_{TD,L}$	$0.3 \times V_{EN}$	–	–	V	dominant state $3.0 \text{ V} < V_{EN} < 5.5 \text{ V}$
5.4.17	TxD pull-down resistance	$R_{TD}$	100	350	800	k $\Omega$	$V_{TXD} = 5 \text{ V}$
5.4.18	TxD low level leakage current Wake = $V_S$	$I_{TD}$	-1	–	10	$\mu\text{A}$	$V_{EN} = 0 \text{ V}$ ; $V_{TXD} = 0 \text{ V}$ $V_{BUS} = V_S$
5.4.19	TxD dominant current Wake = 0 V; $V_S = 12 \text{ V}$ ; standby mode	$I_{TD,L}$	1.5	3	6	mA	$V_{TXD} = 0.9 \text{ V}$ $V_{BUS} = V_S$
<b>Enable Input EN</b>							
5.4.20	HIGH level input voltage threshold	$V_{EN,on}$	0.95	–	2	V	normal mode see <a href="#">Figure 6</a>
5.4.21	LOW level input voltage threshold	$V_{EN,off}$	0.8	–	1.85	V	low power mode see <a href="#">Figure 6</a>
5.4.22	EN input hysteresis	$V_{EN,hys}$	150	300	450	mV	–
5.4.23	EN pull-down resistance	$R_{EN}$	15	30	60	k $\Omega$	–
5.4.24	Enable inhibit high current	$I_{EN, hc}$	50	–	400	$\mu\text{A}$	$V_{EN} = 5 \text{ V}, 3 \text{ V}$

**General Product Characteristics**
**Table 7 Electrical Characteristics (cont'd)**

7.0 V <  $V_S$  < 27 V;  $R_L = 500 \Omega$ ;  $V_{EN} > V_{EN,ON}$ ;  $-40 \text{ }^\circ\text{C} < T_j < 125 \text{ }^\circ\text{C}$ ; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

Pos.	Parameter	Symbol	Limit Values			Unit	Remarks
			Min.	Typ.	Max.		
<b>Inhibit Output INH</b>							
5.4.25	Inhibit $R_{on}$ resistance	$R_{INH,on}$	22	36	50	$\Omega$	$I_{INH} = -15 \text{ mA}$
5.4.26	Maximum INH output current	$I_{INH}$	-150	–	-40	mA	$V_{INH} = 0 \text{ V}$
5.4.27	Leakage current	$I_{INH,lk}$	-5.0	–	5.0	$\mu\text{A}$	sleep mode; $V_{INH} = 0 \text{ V}$
<b>Wake Input WK</b>							
5.4.28	High level input voltage	$V_{WK,H}$	$V_S - 1$	–	$V_S + 3$	V	–
5.4.29	Low level input voltage	$V_{WK,L}$	-0.3	–	$V_S - 3.3 \text{ V}$	V	–
5.4.30	Pull-up current	$I_{WK,PU}$	-60	-30	-3	$\mu\text{A}$	–
5.4.31	High level leakage current	$I_{WK,L}$	-5	–	5	$\mu\text{A}$	$V_S = 0 \text{ V}$ ; $V_{WK} = 40 \text{ V}$
5.4.32	Dominant time for wake-up	$t_{WK}$	30	–	150	$\mu\text{s}$	–
<b>Bus Receiver</b>							
5.4.33	Receiver threshold voltage, recessive to dominant edge	$V_{th,rd}$	$0.4 \times V_S$	$0.48 \times V_S$	–	V	–
5.4.34	Receiver dominant state	$V_{BUSdom}$	0	–	$0.4 \times V_S$	V	LIN Spec 2.1 Param. 17
5.4.35	Receiver threshold voltage, dominant to recessive edge	$V_{th,dr}$	–	$0.52 \times V_S$	$0.6 \times V_S$	V	$V_{BUS,rec} < V_{BUS} < 27 \text{ V}$
5.4.36	Receiver recessive state	$V_{BUSrec}$	$0.6 \times V_S$	–	$V_S$	V	LIN Spec 2.1 Param. 18
5.4.37	Receiver center voltage	$V_{BUS\_CNT}$	$0.475 \times V_S$	$0.5 \times V_S$	$0.525 \times V_S$	V	LIN Spec 2.1 Param. 19
5.4.38	Receiver hysteresis	$V_{HYS}$	$0.02 \times V_S$	$0.04 \times V_S$	$0.1 \times V_S$	V	LIN Spec 2.1 Param. 20 <sup>2)</sup>
5.4.39	Wake-up threshold voltage	$V_{BUS,wk}$	$0.40 \times V_S$	$0.5 \times V_S$	$0.6 \times V_S$	V	–
5.4.40	Dominant time for bus wake-up	$t_{WK,bus}$	30	–	150	$\mu\text{s}$	–



**General Product Characteristics**
**Table 7 Electrical Characteristics (cont'd)**

7.0 V <  $V_S$  < 27 V;  $R_L = 500 \Omega$ ;  $V_{EN} > V_{EN,ON}$ ;  $-40 \text{ }^\circ\text{C} < T_j < 125 \text{ }^\circ\text{C}$ ; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

Pos.	Parameter	Symbol	Limit Values			Unit	Remarks
			Min.	Typ.	Max.		
<b>Bus Transmitter</b>							
5.4.41	Bus recessive output voltage	$V_{BUS,ro}$	$0.8 \times V_S$	–	$V_S$	V	$V_{TXD} = \text{high Level}$
5.4.42	Bus dominant output voltage maximum load	$V_{BUS,do}$	0.6 0.8	– –	1.2 $0.2 \times V_S$ 2.0	V	$V_{TXD} = 0 \text{ V}$ ; $R_L = 500 \Omega$ ; $6.0 \text{ V} \leq V_S \leq 7.3 \text{ V}$ $7.3 \text{ V} < V_S \leq 10 \text{ V}$ $10 \text{ V} < V_S \leq 18 \text{ V}$
5.4.43	Bus dominant output voltage minimum load	$V_{BUS,do}$	0.6 0.8	– –	1.2 2.0	V	$V_{TXD} = 0 \text{ V}$ ; $R_L = 1000 \Omega$ ; $V_S = 7.3 \text{ V}$ ; $V_S = 18 \text{ V}$ ;
5.4.44	Bus short circuit current	$I_{BUS\_LIM}$	40	100	150	mA	$V_{BUS} = 13.5 \text{ V}$ ; LIN Spec 2.1 Param. 12
5.4.45	Leakage current	$I_{BUS\_NO\_GND}$	-500	-70	0	$\mu\text{A}$	$V_S = 0 \text{ V}$ ; $V_{BUS} = -12\text{V}$ ; LIN Spec 2.1 Param. 15
5.4.46	Leakage current	$I_{BUS\_NO\_BAT}$	–	5	8	$\mu\text{A}$	$V_S = 0 \text{ V}$ ; $V_{BUS} = 18 \text{ V}$ ; LIN Spec 2.1 Param. 16
5.4.47	Leakage current	$I_{BUS\_PAS\_dom}$	-1	–	–	mA	$V_S = 18 \text{ V}$ ; $V_{BUS} = 0 \text{ V}$ ; LIN Spec 2.1 Param. 13
5.4.48	Leakage current	$I_{BUS\_PAS\_rec}$	–	–	20	$\mu\text{A}$	$V_S = 8 \text{ V}$ ; $V_{BUS} = 18 \text{ V}$ ; LIN Spec 2.1 Param. 14
5.4.49	Bus pull-up resistance	$R_{SLAVE}$	20	30	47	k $\Omega$	Normal mode LIN Spec 2.1 Param. 26
5.4.50	LIN output current	$I_{BUS}$	-60	-30	-5	$\mu\text{A}$	Sleep mode $V_S = 12\text{V}$ ; $EN = 0\text{V}$

**General Product Characteristics**
**Table 7 Electrical Characteristics (cont'd)**

7.0 V <  $V_S$  < 27 V;  $R_L = 500 \Omega$ ;  $V_{EN} > V_{EN,ON}$ ;  $-40 \text{ }^\circ\text{C} < T_j < 125 \text{ }^\circ\text{C}$ ; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

Pos.	Parameter	Symbol	Limit Values			Unit	Remarks
			Min.	Typ.	Max.		
<b>Dynamic Transceiver Characteristics</b>							
5.4.51	Slew rate falling edge	$t_{fslope}$	-3	–	-1	V/ $\mu$ S	<sup>3)</sup> 60% > $V_{bus}$ > 40%; $1 \mu\text{s} < (\tau = R_L \times C_{BUS}) < 5 \mu\text{s}$ ; $V_S = 13.5 \text{ V}$ ; normal mode;
5.4.52	Slew rate rising edge	$t_{rslope}$	1	–	3	V/ $\mu$ S	<sup>3)</sup> 40% < $V_{bus}$ < 60%; $1 \mu\text{s} < (\tau = R_L \times C_{BUS}) < 5 \mu\text{s}$ ; $V_S = 13.5 \text{ V}$ ; normal mode;
5.4.53	Slope symmetry	$t_{slopesym}$	-5	–	5	$\mu$ S	$t_{fslope} - t_{rslope}$ ; $V_S = 13.5 \text{ V}$ ;
5.4.54	Propagation delay TxD LOW to bus	$t_{d(L),T}$	0.1	1	4	$\mu$ S	$V_{EN} = 5 \text{ V}$ ;
5.4.55	Propagation delay TxD HIGH to bus	$t_{d(H),T}$	0.1	1	4	$\mu$ S	$V_{EN} = 5 \text{ V}$ ;
5.4.56	Propagation delay bus dominant to RxD LOW	$t_{d(L),R}$	0.1	1	6	$\mu$ S	$V_{CC} = 5 \text{ V}$ ; $C_{RxD} = 20 \text{ pF}$ ; $R_{RxD} = 2.4 \text{ k}\Omega$ ;
5.4.57	Propagation delay bus recessive to RxD HIGH	$t_{d(H),R}$	0.1	1	6	$\mu$ S	$V_{CC} = 5 \text{ V}$ ; $C_{RxD} = 20 \text{ pF}$ ; $R_{RxD} = 2.4 \text{ k}\Omega$ ;
5.4.58	Receiver delay symmetry	$t_{sym,R}$	-2	–	2	$\mu$ S	$t_{sym,R} = t_{d(L),R} - t_{d(H),R}$ ;
5.4.59	Transmitter delay symmetry	$t_{sym,T}$	-2	–	2	$\mu$ S	$t_{sym,T} = t_{d(L),T} - t_{d(H),T}$
5.4.60	Delay time for change sleep/stand by mode - normal mode	$t_{snorm}$	0.1	–	10	$\mu$ S	–
5.4.61	Delay time for change normal mode - sleep mode	$t_{nsleep}$	0.1	–	10	$\mu$ S	–
5.4.62	TxD dominant time out	$t_{timeout}$	6	12	20	ms	$V_{TxD} = 0 \text{ V}$
5.4.63	TxD dominant time out recovery time	$t_{torec}$	1	5	10	$\mu$ S	<sup>1)</sup>

**Table 7 Electrical Characteristics (cont'd)**

7.0 V <  $V_S$  < 27 V;  $R_L = 500 \Omega$ ;  $V_{EN} > V_{EN,ON}$ ;  $-40 \text{ }^\circ\text{C} < T_j < 125 \text{ }^\circ\text{C}$ ; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

Pos.	Parameter	Symbol	Limit Values			Unit	Remarks
			Min.	Typ.	Max.		
5.4.64	Duty cycle D1 (for worst case at 20 kBit/s)	$t_{duty1}$	0.396	–	–		duty cycle 1 <sup>3)</sup> $TH_{Rec(max)} = 0.744 \times V_S$ ; $TH_{Dom(max)} = 0.581 \times V_S$ ; $V_S = 7.0 \dots 18 \text{ V}$ ; $t_{bit} = 50 \mu\text{s}$ ; $D1 = t_{bus\_rec(min)}/2 t_{bit}$ ; LIN Spec 2.1 Param. 27
5.4.65	Duty cycle D2 (for worst case at 20 kBit/s)	$t_{duty2}$	–	–	0.581		duty cycle 2 <sup>3)</sup> $TH_{Rec(max)} = 0.422 \times V_S$ ; $TH_{Dom(max)} = 0.284 \times V_S$ ; $V_S = 7.6 \dots 18 \text{ V}$ ; $t_{bit} = 50 \mu\text{s}$ ; $D2 = t_{bus\_rec(max)}/2 t_{bit}$ ; LIN Spec 2.1 Param. 28

1) Not subject to production test, specified by design

2)  $V_{HYS} = V_{BUSrec} - V_{BUSdom}$

3) Bus load concerning LIN Spec 2.1

Load 1 = 1 nF / 1 k $\Omega$  =  $C_{BUS} / R_{BUS}$

Load 2 = 6.8 nF / 660  $\Omega$  =  $C_{BUS} / R_{BUS}$

Load 3 = 10 nF / 500 $\Omega$  =  $C_{BUS} / R_{BUS}$

## 6 Diagrams

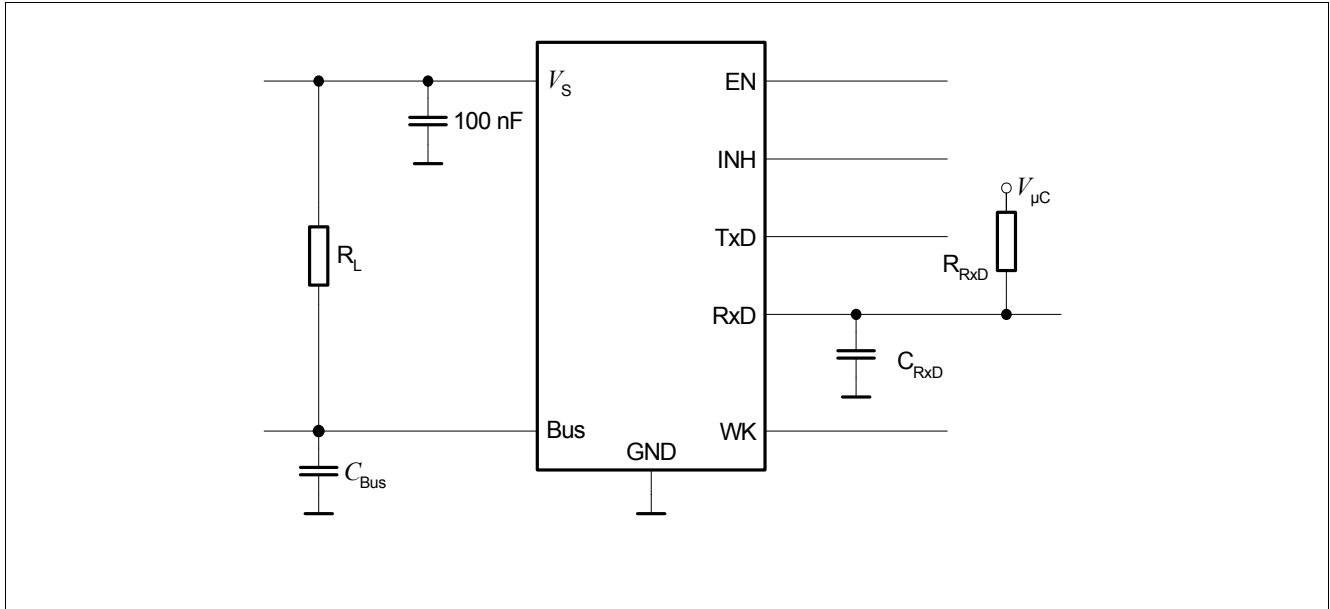


Figure 8 Test Circuits

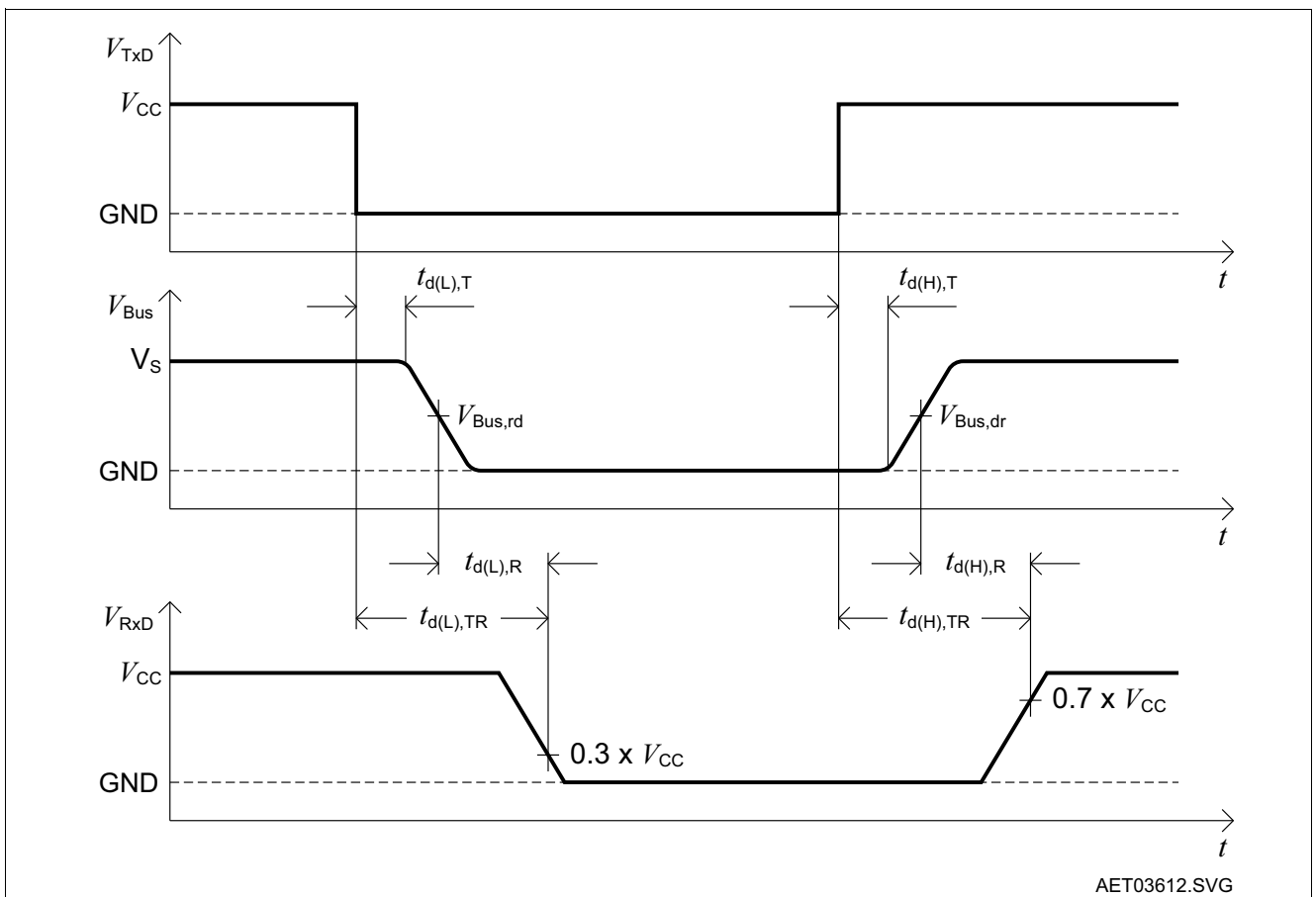


Figure 9 Timing Diagrams for Dynamic Characteristics according to LIN 1.3

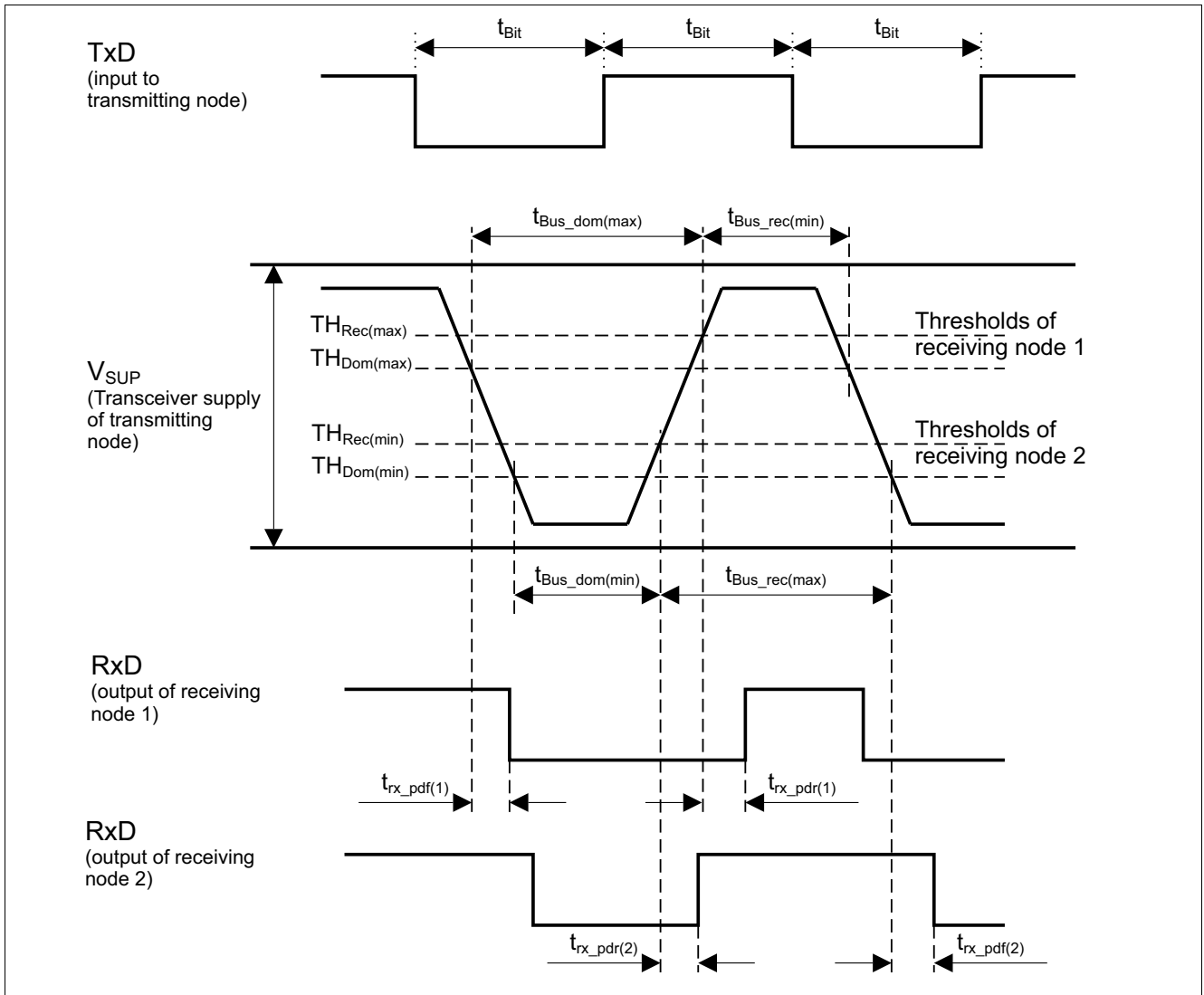


Figure 10 Timing Diagrams for Duty cycle measurements according to LIN 2.1

## 7 Application Information

### 7.1 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 8 ESD “Gun test”**

Performed Test	Result	Unit	Remarks
Electrostatic discharge voltage at pin $V_S$ , Bus, Wk versus GND	$\geq +8$	kV	<sup>1)</sup> Positive pulse
Electrostatic discharge voltage at pin $V_S$ , Bus, Wk versus GND	$\leq -8$	kV	<sup>1)</sup> Negative pulse

1) ESD susceptibility “ESD GUN” according LIN EMC 1.3 Test Specification, Section 4.3. (IEC 61000-4-2)-Tested by external testhouse (IBEE Zwickau, EMC Testreport Nr. 16-05-06).

### 7.2 Master Termination

To achieve the required timings for the dominant to recessive transition of the bus signal an additional external termination resistor of 1 kΩ is mandatory. It is recommended to place this resistor at the master node. To avoid reverse currents from the bus line into the battery supply line it is recommended to place a diode in series with the external pull-up. For small systems (low bus capacitance) the EMC performance of the system is supported by an additional capacitor of at least 1 nF in the master node (see [Figure 11](#) and [Figure 12](#), application circuit).

### 7.3 External Capacitors

A capacitor of 22 μF at the supply voltage input  $V_S$  buffers the input voltage. In combination with the required reverse polarity diode this prevents the device from detecting power down conditions in case of negative transients on the supply line.

The 100 nF capacitors close to the  $V_S$  pins of the TLE7259G and the voltage regulator help to improve the EMC behavior of the system.

### 7.4 Application Example

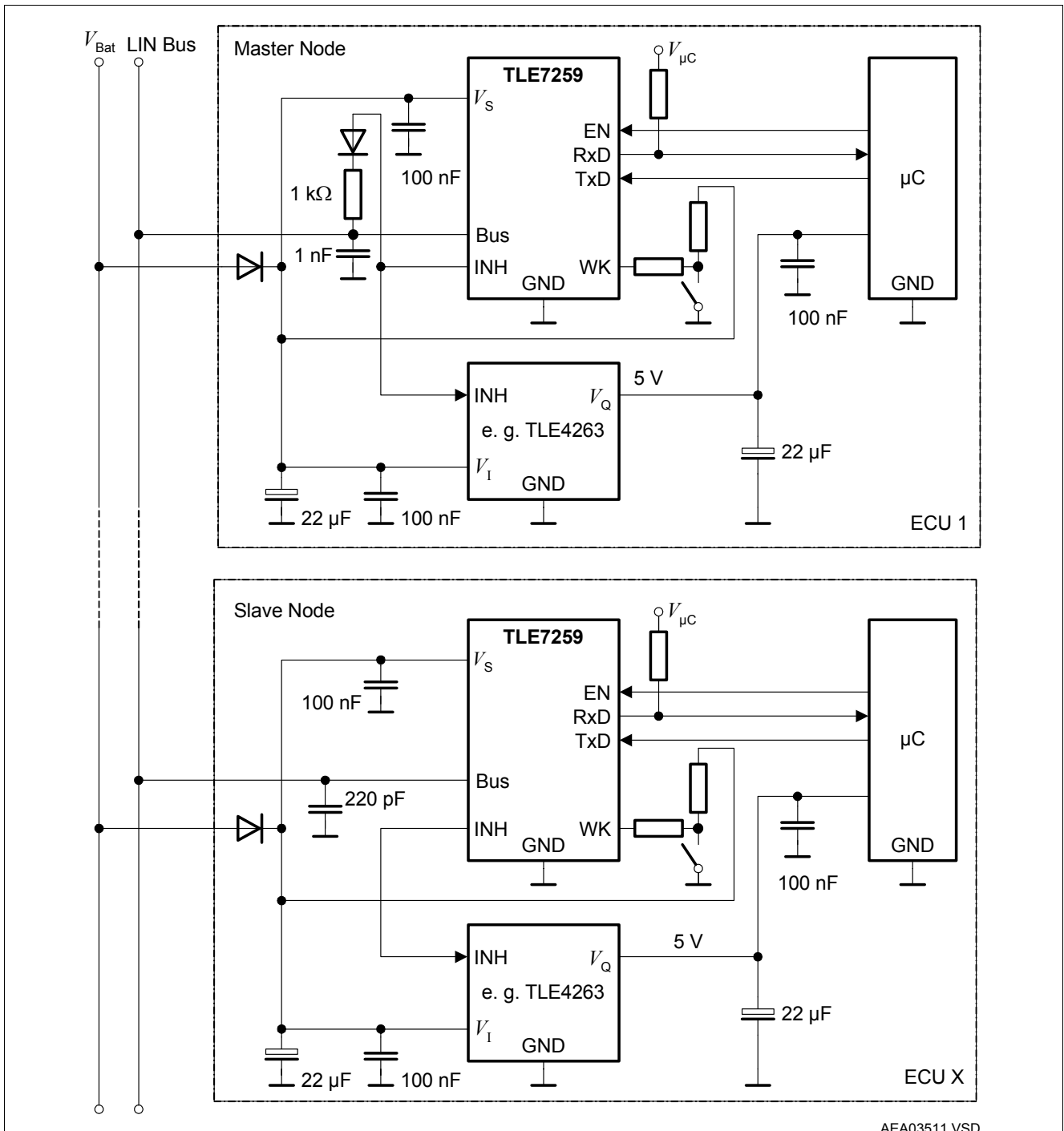


Figure 11 Application Circuit with Bus Short to GND Feature Applied

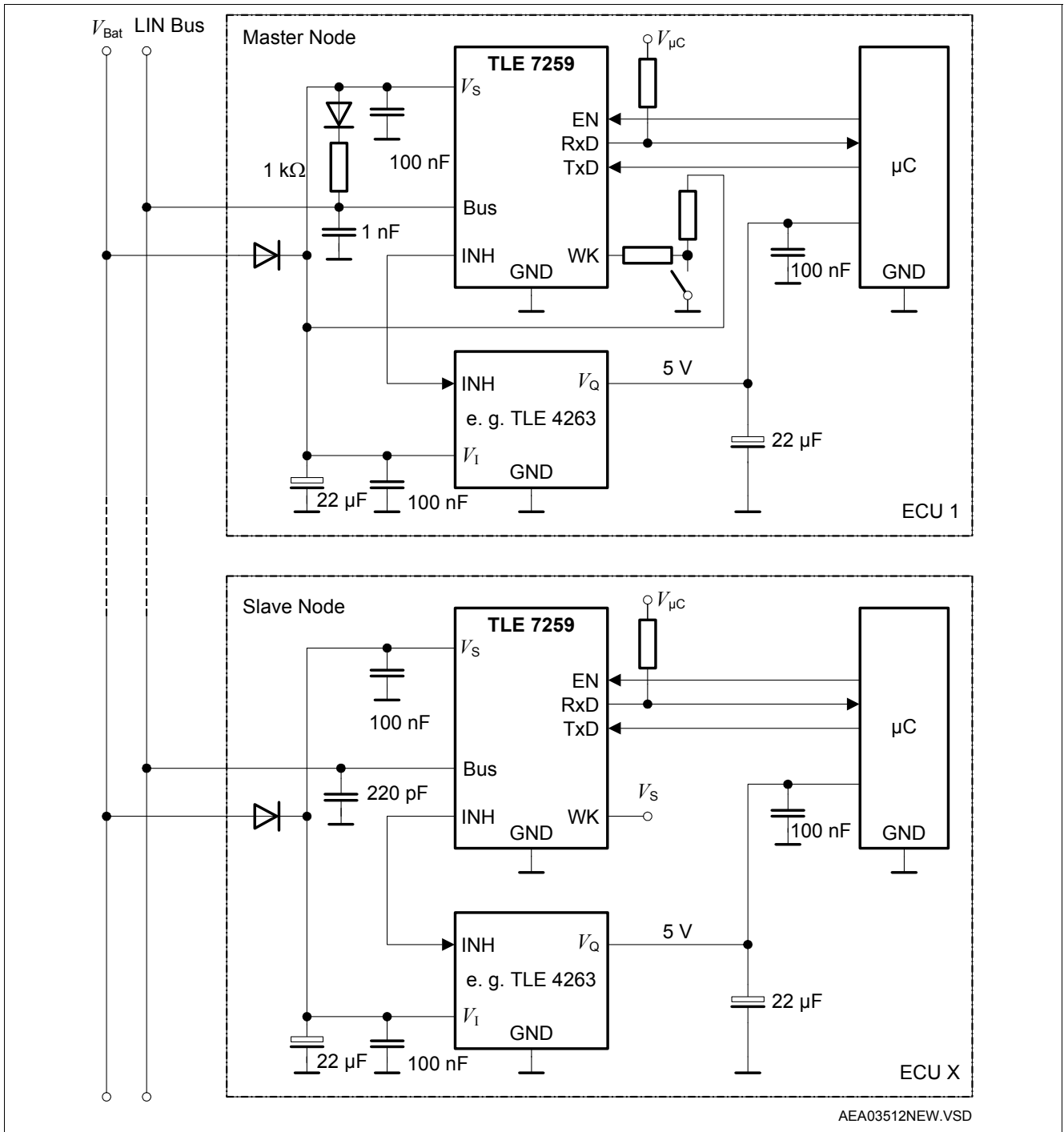


Figure 12 Application Circuit without Bus Short to GND Feature



8 Package Outlines

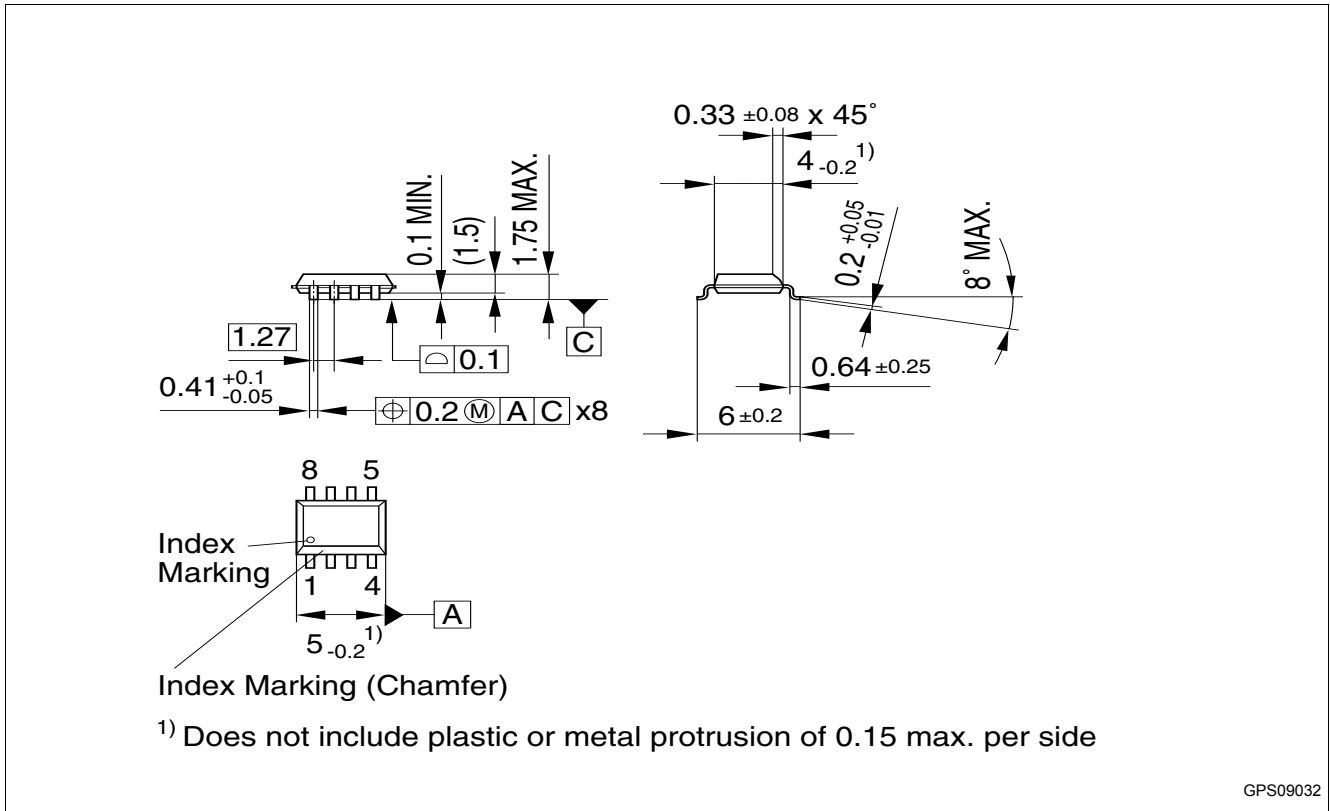


Figure 13 P-DSO-8 (Plastic Dual Small Outline)

For further information on alternative packages, please visit our website:  
<http://www.infineon.com/packages>

Dimensions in mm

## 9 Revision History

Version	Date	Changes
Rev 2.0	2006-07-19	Creation of Data sheet
Rev. 2.1	2007-04-30	Changes are described in a separate Delta Sheet for TLE7259G Revision 1.0

**Edition 2007-04-27**

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

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