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TLE9252VSK

High Speed CAN FD Transceiver

TLE9252VLC

TLE9252VSK

HS CAN Transceiver

Product Proposal

Rev. 0.72 2017-02-06

Preliminary Version - Subject to Change!

Automotive Power

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1 Overview

Features

- Fully compatible to ISO 11898-2 (2016)
- Support HS CAN standard data rates up to 1MBit/s
- Support CAN FD data rates up to 5MBit/s
- Wide common mode range for electromagnetic immunity (EMI)
- Very low electromagnetic emission (EME) for chokeless usage
- Excellent ESD robustness, ± 8 kV according to ISO 61000-4-2
- Very low current consumption in Sleep Mode
- Fail safe features like TxD-timeout, RxD Recessive Clamping and Overtemperature shut-down
- Extended supply range on V_{CC} and V_{IO} supply
- CAN short circuit proof to ground, battery and V_{CC}
- Undervoltage detection on V_{BAT} , V_{CC} and V_{IO}
- Receive-only Mode for node failure analysis
- Advanced bus biasing according to ISO 11898-2 (2016)
- Bus Wake-up (WUP) and Local Wake-up
- INH output to control external circuitry
- Improved robust local failure diagnosis via NERR output pin
- Green Product (RoHS compliant) and AEC Qualified

Description

The TLE9252VSK is a transceiver designed for HS CAN networks up to 5Mbit/s in automotive and industrial applications. As an interface between the physical bus layer and the CAN protocol controller, the TLE9252VSK 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 TLE9252VSK provides very low electromagnetic emission allowing the operation without a common mode choke. The non-low power modes (Normal-operating Mode and Receive-only Mode) and low power modes (Sleep Mode and Stand-by Mode) are optimized for reduced current consumption based on the required functionality. Even in Sleep Mode with a quiescent current below 30 μ A over the full temperature range, the TLE9252VSK is able to detect a wake-up pattern (WUP) on the HS CAN bus. The V_{IO} voltage reference input is used to support 3.3 V and 5 V supplied



PG-TSON-14



PG-DSO-14

Type	Package	Marking
TLE9252VSK	PG-DSO-14	9252V
TLE9252VLC	PG-TSON-14	9252V

Overview

microcontrollers. The TLE9252VSK is integrated in an RoHS compliant PG-DSO-14 or PG-TSON-14 package and fulfills the requirements of the ISO11898-2 (2016).

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Block Diagram

2 Block Diagram

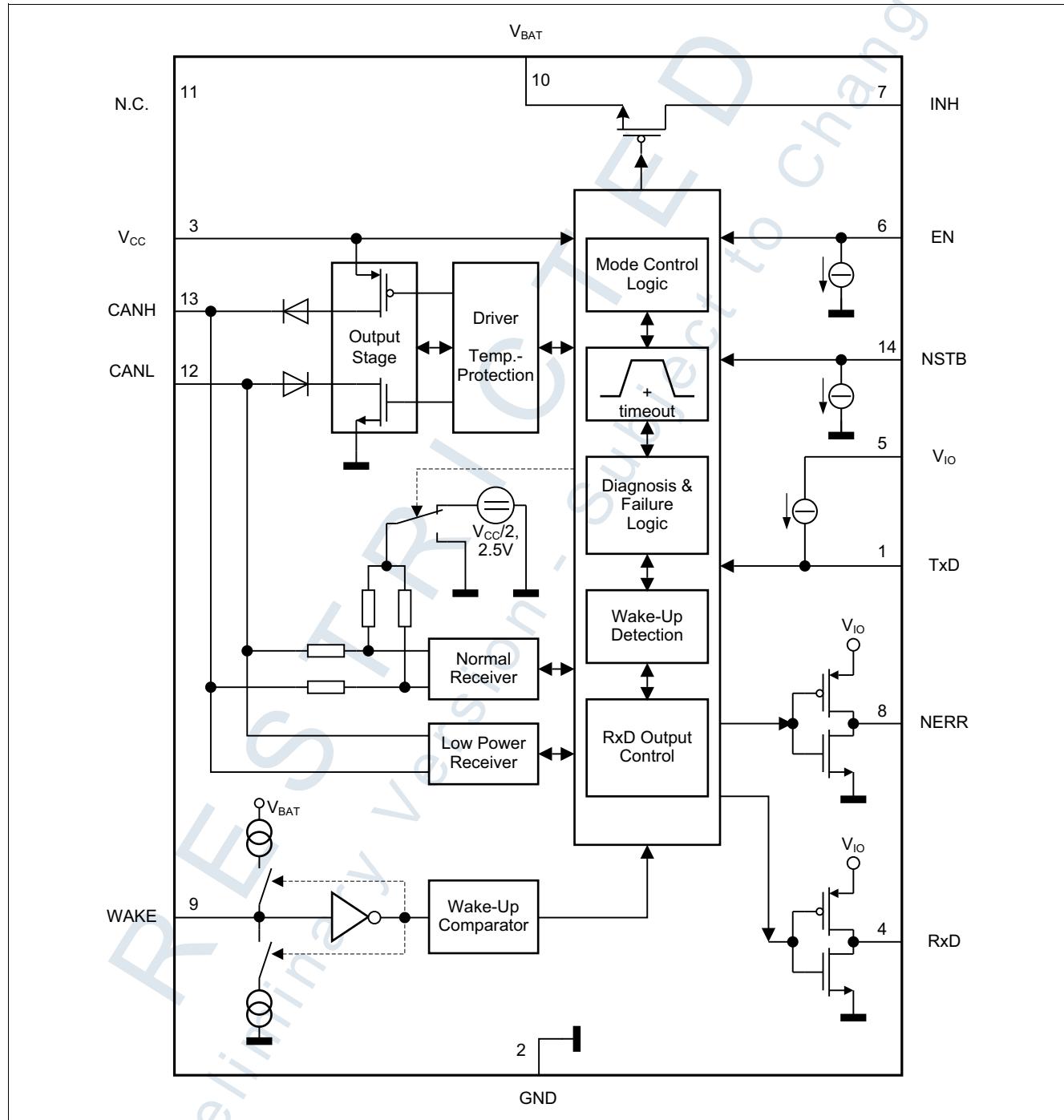


Figure 1 Block Diagram

Pin Configuration

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3 Pin Configuration

3.1 Pin Assignment

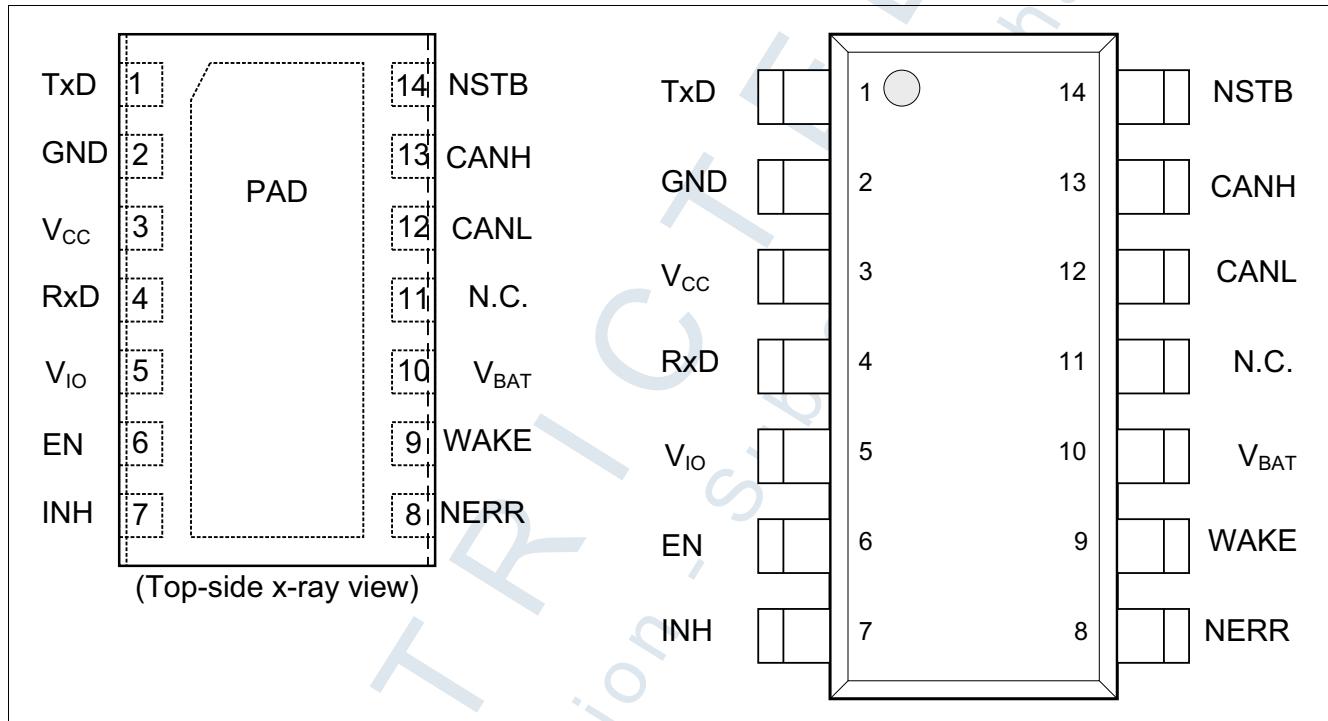


Figure 2 Pin configuration

3.2 Pin Definitions

Table 1 Pin definitions and functions

Pin	Symbol	Function
1	TxD	Transmit Data Input Integrated “pull-up” current source to V_{IO} , Logical “low” to drive a “dominant” signal on CANH and CANL.
2	GND	Ground
3	V_{CC}	Transmitter Supply Voltage 100 nF decoupling capacitor to GND recommended.
4	RxD	Receive Data Output Logical “low” while a “dominant” signal is on the HS CAN bus; Output voltage adapted to the voltage on the V_{IO} level shift input.
5	V_{IO}	Level Shift Input Reference voltage for the digital input and output pins; 100 nF decoupling capacitor to GND recommended.

Pin Configuration

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Table 1 Pin definitions and functions (cont'd)

Pin	Symbol	Function
6	EN	Mode Control Input Integrated “pull-down” current source to GND; Logical “high” for Normal-operating Mode.
7	INH	Inhibit Output Open drain output to control external circuitry; High impedance in Sleep Mode.
8	NERR	Error Flag Output Failure and Wake-up indication output; Active “low”.
9	WAKE	Wake-up Input Local wake-up input, terminated against GND and V_{BAT} ; Wake-up input sensitive on rising and falling edge.
10	V_{BAT}	Battery Supply Voltage 100 nF decoupling capacitor to GND recommended.
11	N.C.	Not Connected
12	CANL	Low-level HS CAN Bus Line
13	CANH	High-level HS CAN Bus Line
14	NSTB	Stand-by Control Input Integrated “pull-down” current source to GND; Logical “high” for Normal-operating Mode.

High Speed CAN Functional Description

4 High Speed CAN Functional Description

HS CAN is a serial bus system which 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 specifications of a CAN network. The CAN transceiver is part of the physical layer specification. The TLE9252VSK supports both standard bus wake-up functionality and Local Wake-up as defined by the ISO 11898-2/-5. Additionally, the TLE9252VSK supports CAN Flexible data rate (CAN FD) transmission up to 5 Mbps.

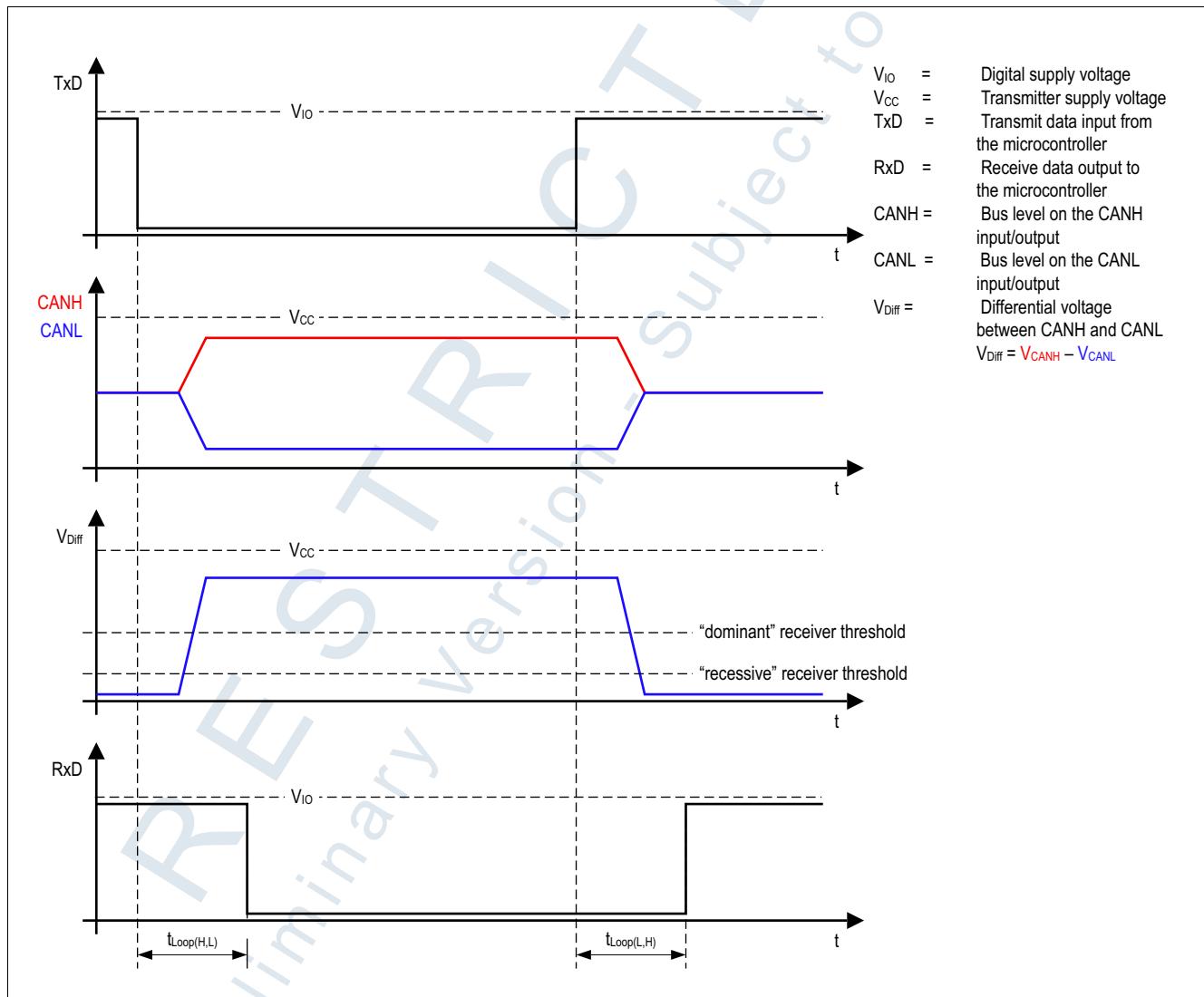


Figure 3 High speed CAN bus signals and logic signals

High Speed CAN Functional Description

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The TLE9252VSK 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 up to 5 MBit/s. The characteristic for a HS CAN network are the two signal states on the CAN bus: "dominant" and "recessive" (see [Figure 3](#)).

The CANH and CANL pins are the interface to the CAN bus and operate as an input and output. The RxD and TxD pins are the interface to the microcontroller. The TxD pin is the serial data input from the CAN controller. The RxD pin is the serial data output to the CAN controller. As shown in the HS CAN transceiver TLE9252VSK includes a receiver and a transmitter unit, allowing the transceiver to send data to the bus medium and monitors the data from the bus medium at the same time. The HS CAN transceiver TLE9252VSK converts the serial data stream which is available on the transmit data input TxD, into a differential output signal on the CAN bus, provided by the CANH and CANL pins. The receiver stage of the TLE9252VSK monitors the data on the CAN bus and converts it to a serial, single-ended signal on the RxD output pin. A logical "low" signal on the TxD pin creates a "dominant" signal on the CAN bus, followed by a logical "low" signal on the RxD pin (see [Figure 3](#)). The feature, broadcasting data to the CAN bus and listening to the data traffic on the CAN bus simultaneously is essential to support the bit-to-bit arbitration within CAN networks.

The voltage levels for HS CAN transceivers are defined in ISO 11898-2. Whether a data bit is "dominant" or "recessive" depends on the voltage difference between the CANH and CANL pins:

$$V_{\text{Diff}} = V_{\text{CANH}} - V_{\text{CANL}}$$

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

In partially supplied CAN networks, participants have different power supply status. Some nodes are powered, other nodes are unpowered, or some other nodes are in Low-Power Mode. Therefore the TLE9252VSK provides the Sleep Mode in which the device is still able to recognize a wake-up pattern or a local wake-up and signals the wake-up event to the external microcontroller via NERR output pin. The INH output pin allows to control an external device e.g. a voltage regulator. For permanently supplied ECU's, the HS CAN transceiver TLE9252VSK provides the Stand-by Mode for optimized current consumption.

The voltage level on the digital input TxD and the digital output RxD is determined by the reference supply level at the V_{IO} pin. Depending on the voltage level at the V_{IO} pin, the signal levels on the logic pins (EN, NERR, NSTB, TxD and RxD) are compatible with microcontrollers having a 5 V or 3.3 V I/O supply. Usually the digital power supply V_{IO} of the transceiver is connected to the I/O power supply of the microcontroller.

Modes of Operation

5 Modes of Operation

The TLE9252VSK supports five different Modes of operation (see [Figure 4](#)). Each mode with specific characteristics in terms of quiescent current, data transmission or failure diagnostic. For the mode selection the digital input pins EN and NSTB are used. Both digital input pins are event triggered. A mode change via the mode selection pins EN and NSTB is only possible if the power supply voltages V_{BAT} OR V_{cc} AND the digital reference voltage V_{IO} is in the functional range.

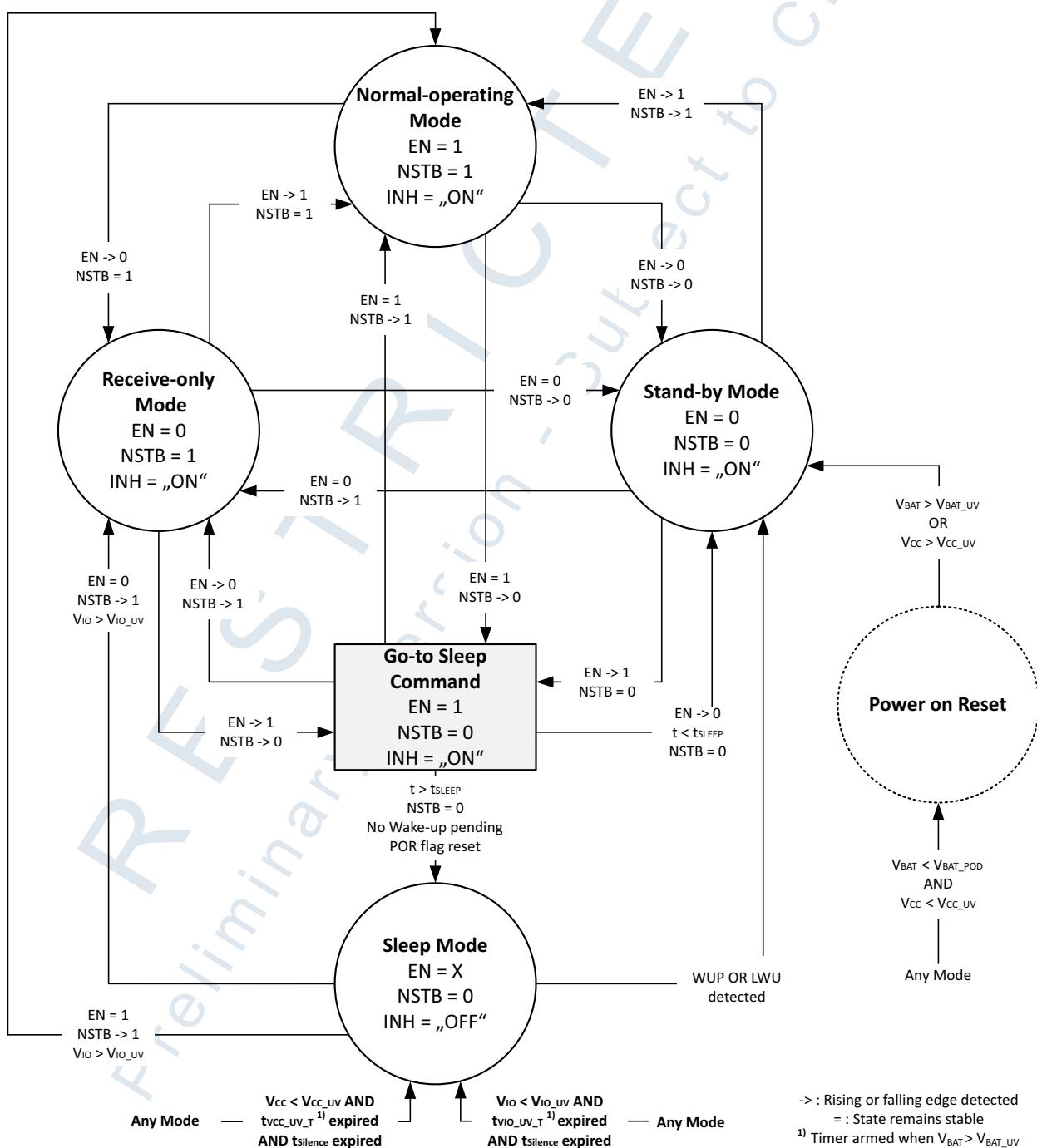


Figure 4 Modes of operation

Modes of Operation

The following operation modes are available on the TLE9252VSK:

- Normal-operating Mode ([Chapter 5.1](#))
- Receive-only Mode ([Chapter 5.2](#))
- Stand-by Mode ([Chapter 5.3](#))
- Sleep Mode ([Chapter 5.5](#))
- Go-to-Sleep Command ([Chapter 5.4](#))

Depending on the mode, the output driver stage, the receiver stage and the bus biasing are active or inactive.

Table 2 shows the different operation modes depending on the logic signal on the input pins EN and NSTB with the related status of the INH pin and the bus biasing.

Table 2 Overview Operation Modes

Operation mode	EN	NSTB	INH	Bus Biasing
Normal-operating Mode	1	1	V_{BAT}	$V_{CC}/2$
Receive-only Mode	0	1	V_{BAT}	$V_{CC}/2$
Stand-by Mode	0	0	V_{BAT}	GND ¹⁾
Go-to-Sleep Command	1	0	V_{BAT} ²⁾	GND ¹⁾
Sleep Mode	0	0	High-Z	GND ¹⁾
Power on Reset	0	0	follows V_{BAT}	Floating

1) Valid if $t_{Silence}$ has expired. The Bus biasing follows the Autonomous Bus Biasing described in [Chapter 5.7](#).

2) INH stays connected to V_{BAT} as long as t_{SLEEP} has not expired OR if a wake-up is pending OR if the POR flag is set. If t_{SLEEP} expires AND no Wake-up is pending AND the POR flag is reset the INH is High Z.

Modes of Operation

5.1 Normal-operating Mode

In Normal-operating Mode all functions of the TLE9252VSK are available and the device is fully functional. Data can be received from the HS CAN bus as well as transmitted to the HS CAN bus.

- The transmitter is active and drives data stream on the TxD input pin to the bus pins CANH and CANL.
- The receiver is active and converts the signals from the bus to a serial data stream on the RxD output pin.
- The bus biasing is connected to $V_{CC}/2$.
- The TxD timeout function is enabled (see [Chapter 6.4](#)).
- The overtemperature protection is enabled (see [Chapter 6.5](#)).
- The RxD Recessive Clamping detection is enabled (see [Chapter 6.6](#))
- The undervoltage detection on V_{BAT} , V_{CC} and V_{IO} are enabled (see [Chapter 6.2](#)).
- The local Wake-up pin is disabled.
- The INH output pin is connected to V_{BAT} .
- Local failure detection is active and failures are indicated at the NERR output pin (see [Chapter 7](#)).

The TLE9252VSK enters Normal-operating Mode by setting the mode selection pins EN and NSTB to logical “high” (see [Figure 4](#) and [Table 2](#)). Normal-operating Mode can be entered if V_{BAT} or V_{CC} is in the functional range and the reference voltage V_{IO} is in the functional range.

Possible mode changes are described in [Figure 5](#)

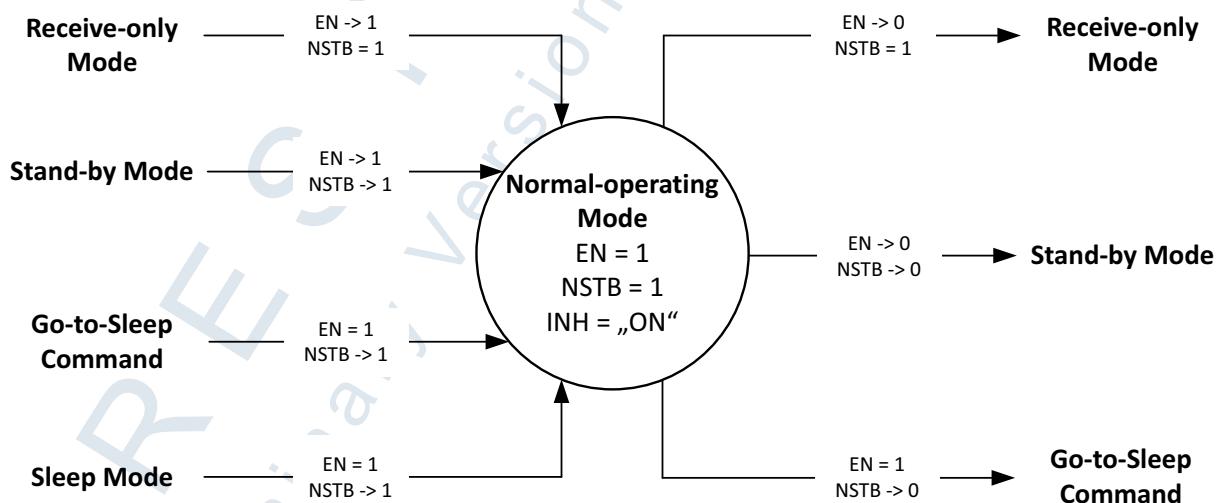


Figure 5 Mode changes in Normal-operating Mode

Modes of Operation

5.2 Receive-only Mode

In Receive-only Mode the transmitter is disabled and the receiver is enabled. The TLE9252VSK can receive data from the HS CAN bus, but cannot transmit data to the HS CAN bus.

- The transmitter is disabled and the data available on the TxD input is blocked.
- The receiver is active and converts the signals from the bus to a serial data stream on the RxD output pin.
- The bus biasing is connected to $V_{CC}/2$.
- The TxD timeout function is disabled.
- The RxD Recessive Clamping detection is disabled.
- The overtemperature protection is disabled.
- The undervoltage detection on V_{BAT} , V_{CC} and V_{IO} is enabled (see [Chapter 6.2](#)).
- The INH output pin is connected to V_{BAT} .
- The local Wake-up pin is disabled.
- The Power-up flag is signalled at the pin NERR when coming from Standby, Sleep or Go-to Sleep Command mode.
- The V_{CC} undervoltage detection is active and an undervoltage is indicated at the NERR output pin when coming from Normal-operating Mode (see [Chapter 7](#)).

Conditions for Entering Receive-only Mode:

The TLE9252VSK enters Receive-only Mode by setting the mode selection pin EN to logical “low” and the NSTB to logical “high” (see [Figure 4](#) and [Table 2](#)). Receive-only Mode can only be entered if V_{BAT} or V_{CC} is in the functional range and the reference voltage V_{IO} is in the functional range.

Possible mode changes are described in [Figure 6](#).

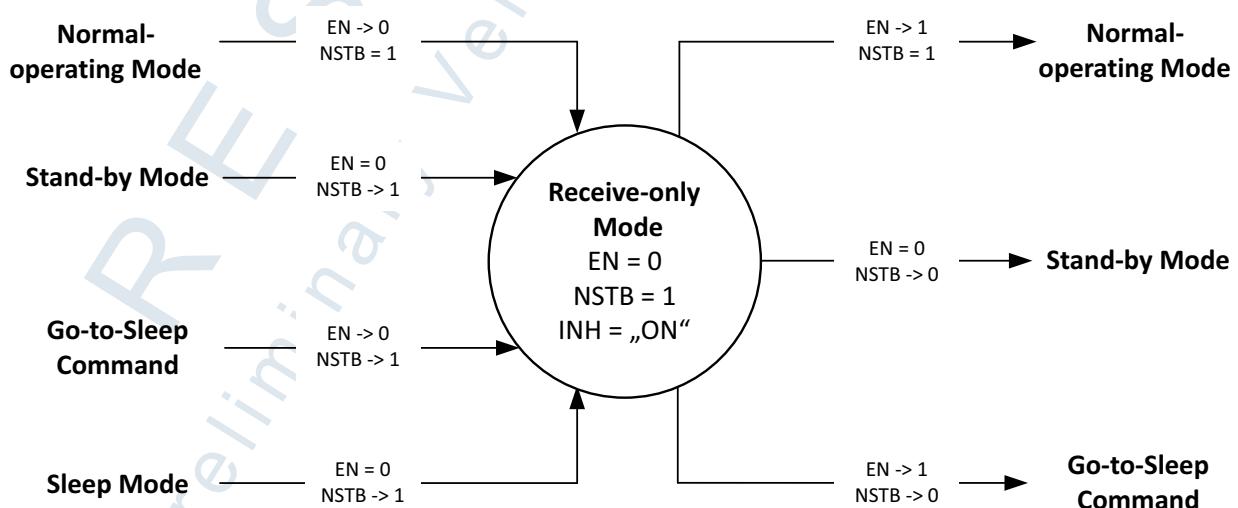


Figure 6 Mode changes in Receive-only Mode

Modes of Operation

5.3 Stand-by Mode

Stand-by Mode is a low power mode of the TLE9252VSK and the transmitter and the receiver are disabled. In Stand-by Mode the transceiver can neither send data to the HS CAN bus nor receive data from the HS CAN bus:

- The transmitter is disabled and the data available on the TxD input is blocked.
- The low power receiver is enabled and monitors the HS CAN bus for a valid wake-up pattern. The RxD output pin and NERR display a wake-up event ([Chapter 5.9](#)). After Power-On-Reset RxD and NERR output pins are logical “high”. The default value of the RxD and NERR output pins are logical “high” if no wake-up event is pending.
- The local wake-up (LWU) pin is active.
- After Power on Reset the bus biasing connected to GND. The conditions for the bus biasing are defined in [Chapter 5.7](#).
- TxD Dominant timeout function is disabled.
- RxD Recessive Clamping detection is disabled
- The overtemperature protection is disabled
- The undervoltage detection on V_{BAT} , V_{CC} and V_{IO} is enabled (see [Chapter 6.2](#)).
- The INH output pin is connected to V_{BAT} .
- Local failure detection on NERR pin is disabled.

Conditions for entering the Stand-by Mode:

- After Power on Reset if V_{BAT} or V_{CC} is in the functional range for at least t_{PON} the TLE9252VSK will enter Stand-by Mode. Mode changes by host command are only possible if V_{IO} is in the functional range.
- Stand-by Mode will be entered if a wake-up (WUP or LWU) has been detected in Sleep Mode or Go-to-Sleep Command
- The device is in Go-to-Sleep Command and the EN pin goes logical “low” before the time $t < t_{SLEEP}$ has expired.
- The device is in Normal-operating Mode or Receive-only Mode and the input pins EN and NSTB are set to logical “low”.

Possible mode changes are described in [Figure 7](#)

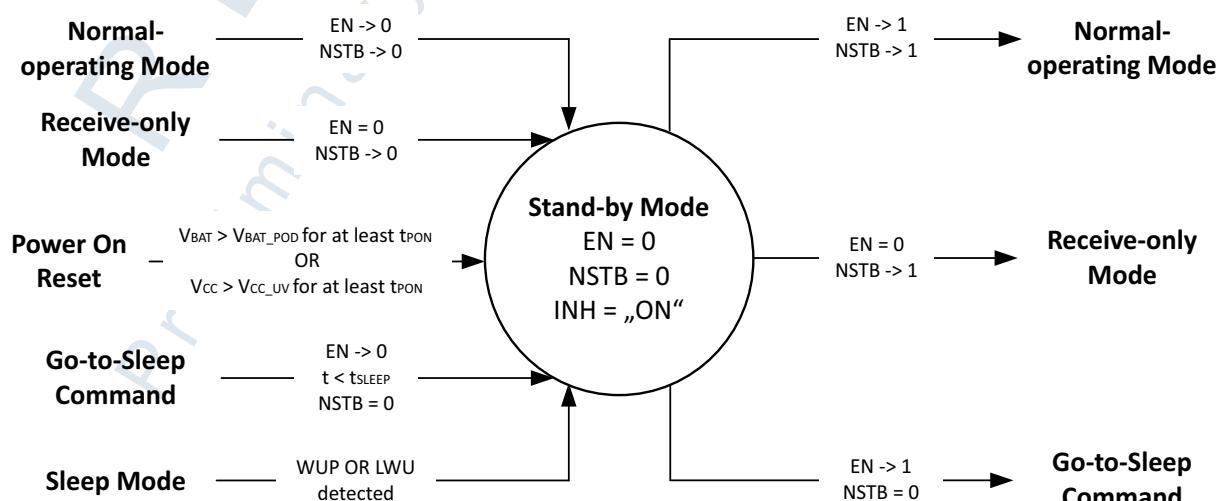


Figure 7 Mode changes in Stand-by Mode

Modes of Operation

5.4 Go-to-Sleep Command

Go-to-Sleep command is a transition mode allowing external circuitry like a microcontroller to prepare the ECU to go to Sleep Mode. The TLE9252VSK stays for the maximum time $t = t_{SLEEP}$ in Go-to-Sleep command. After exceeding the time t_{SLEEP} the device changes to Sleep Mode if no wake-up is pending AND the POR flag has been reset. If a wake-up is pending OR the POR flag is set the device remains in Go-to-Sleep Command and INH is connected to V_{BAT} . A wake-up is indicated on the RxD and NERR output pins. A mode change to Sleep Mode via Host Command is only possible via the Go-to-Sleep command. The following conditions are valid for the Go-to-Sleep command:

- The transmitter is disabled and the data available on the TxD input is blocked.
- The low power receiver is enabled and monitors the HS CAN bus for a valid wake-up pattern. The RxD output pin and NERR indicate a wake-up event ([Chapter 5.9](#)). The default value of the RxD and NERR output pin are logical “high” if no wake-up event is pending.
- The local Wake-up pin is active.
- The bus biasing is GND if $t_{Silence}$ is expired. The conditions for the bus biasing are defined in [Chapter 5.7](#).
- The TxD timeout function is disabled.
- The RxD Recessive Clamping detection is disabled.
- The overtemperature protection is disabled.
- The undervoltage detection on V_{BAT} , V_{CC} and V_{IO} are enabled (see [Chapter 6.2](#)).
- The INH output pin is connected to V_{BAT} if the timer t_{SLEEP} is not expired OR a wake-up is pending OR the POR is set. If t_{SLEEP} is expired and no wake-up is pending and the POR Flag is reset, the INH output pin is high impedance.

Conditions for entering the Go-to-Sleep Command:

Go-to-Sleep Command is entered from Normal-operating Mode, Receive-only Mode and Stand-by Mode by setting the NSTB input pin to logical “low” AND EN input pin to logical “high”.

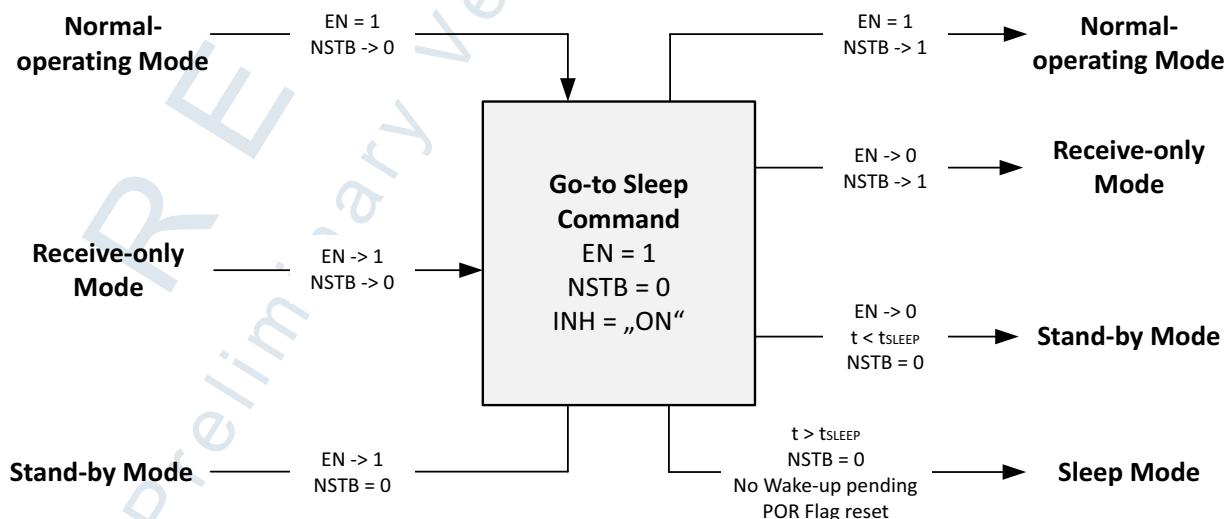


Figure 8 Mode changes in Go-to-Sleep Command

Modes of Operation

5.5 Sleep Mode

Sleep Mode is a low power mode of the TLE9252VSK. In Sleep Mode the current consumption is reduced to a minimum while the device is still able to detect a wake-up pattern (WUP) on the HS CAN Bus OR a local wake-up event on the WAKE pin. The following conditions are valid for the Sleep Mode:

- The transmitter is disabled and the data available on the TxD input is blocked.
- The low power receiver is enabled and monitors the HS CAN bus for a valid wake-up pattern.
- The default value of the RxD and NERR output pin are logical “high” if no wake-up event is pending AND V_{IO} is in the functional range (see [Chapter 7](#)).
- The local Wake-up pin is active.
- The bus biasing is connected to GND. The conditions for the bus biasing are defined in [Chapter 5.7](#).
- The TxD timeout function is disabled.
- The RxD Recessive Clamping detection is disabled.
- The overtemperature protection is disabled.
- The undervoltage detection on V_{BAT} is disabled.
- The undervoltage detection on V_{CC} is disabled.
- The undervoltage detection on V_{IO} is enabled (see [Chapter 6.2.3](#)).
- The INH output pin is High-Z.

Conditions for entering the Sleep Mode:

- The Sleep Mode will be entered if $V_{IO} < V_{IO_UV}$ AND $t_{VIO_UV_T}$ AND $t_{Silence}$ has been expired in Normal-operating Mode, Receive-only Mode, Stand-by Mode and Go-to-Sleep Command.
- The Sleep Mode will be entered if $V_{CC} < V_{CC_UV}$ AND $t_{VCC_UV_T}$ AND $t_{Silence}$ has been expired in Normal-operating Mode, Receive-only Mode, Stand-by Mode and Go-to-Sleep Command.
- The Sleep Mode can be entered through Go-to-Sleep Command if NSTB is set to logical “low” AND t_{SLEEP} is expired AND no wake-up is pending AND the POR flag is reset.

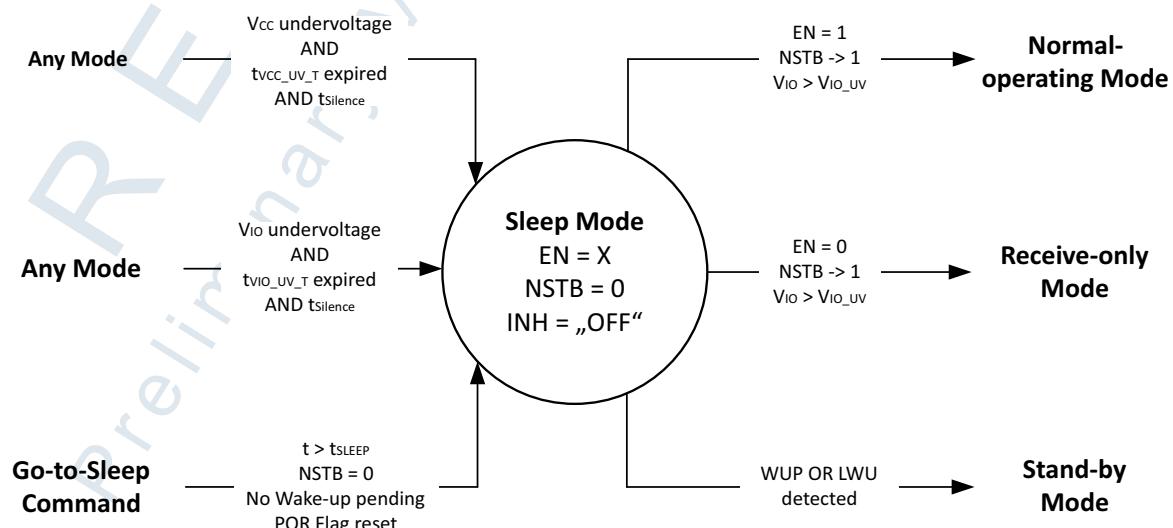
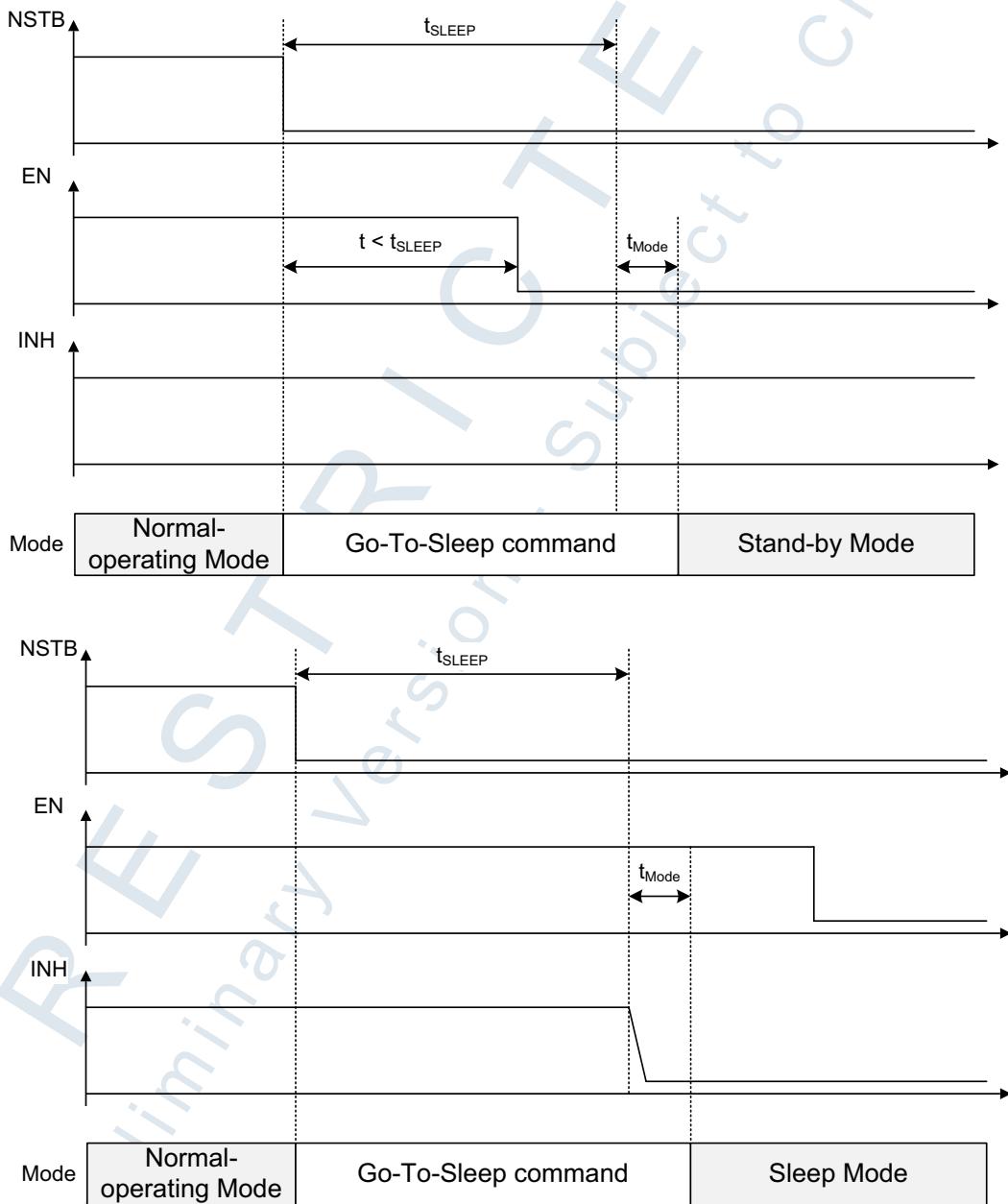


Figure 9 Mode changes in Sleep Mode

Modes of Operation

5.5.1 Mode change to Sleep Mode or Stand-by Mode

If the logical signal on the EN pin goes “low” before the transition time $t < t_{SLEEP}$ has been reached, the TLE9252VSK enters Stand-by Mode and the INH pin remains connected to V_{BAT} . In the case the logical signal on the EN pin goes “low” after the transition time $t > t_{SLEEP}$, the TLE9252VSK enters Sleep Mode with the expiration of t_{SLEEP} . The signal on the HS CAN bus has no impact to the mode change. The mode of operation can be changed regardless if the CAN bus is “dominant” or “recessive”.



Assuming VIO and VCC in functional range AND no wake-up is pending AND POR flag is reset

Figure 10 Mode change to Stand-by Mode or Sleep Mode

Modes of Operation

5.5.2 Mode Change via EN and NSTB pin

Besides a mode change from Sleep Mode to Stand-by Mode issued by a wake-up event, the mode of operation can be changed by changing the signals on the EN and NSTB input pins. Therefore the reference voltage V_{IO} has to be in the functional range. According to the mode diagram (see [Figure 4](#)) the mode of operation can be changed directly from Sleep Mode to Receive-only Mode or Normal-operating Mode. In Sleep Mode once a rising edge on the pin NSTB is detected ($V_{IO} > V_{IO_UV}$) either Normal-operating Mode or Receive-only Mode will be entered, depending on the signal on the EN pin. The device will stay in Sleep Mode regardless of the signal on the EN input pin if NSTB is statically logical “low”. A mode change to from Sleep Mode to Stand-by Mode is only possible via a wake-up event.

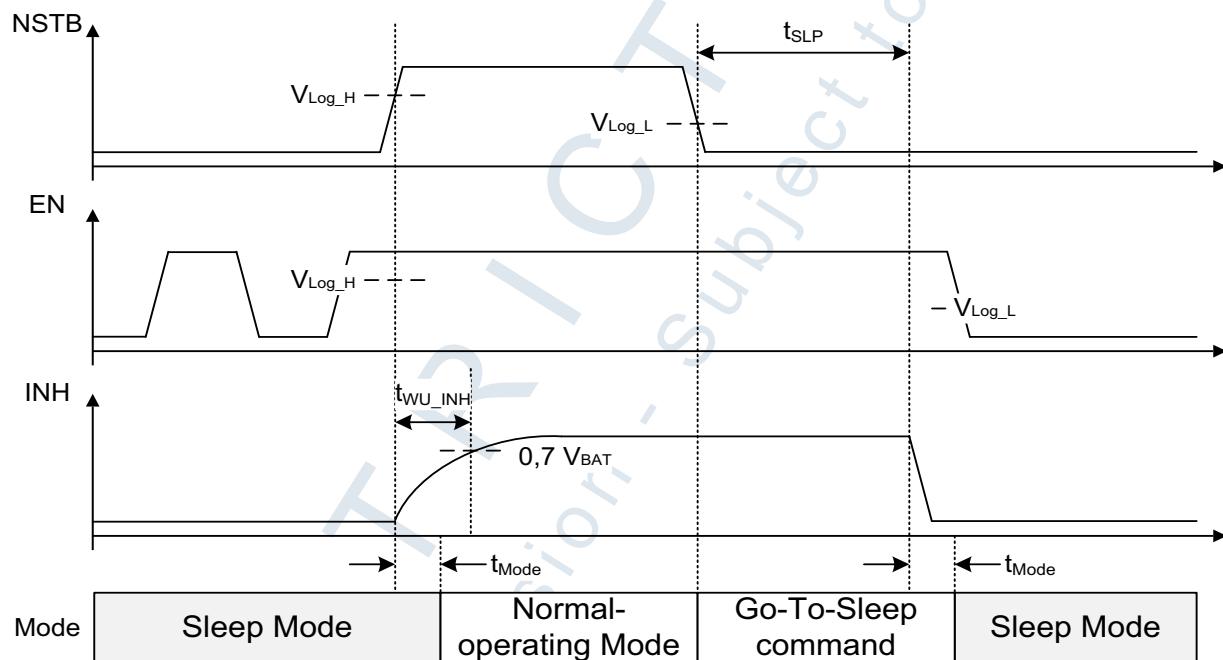


Figure 11 Mode change via EN and NSTB in Sleep Mode

Modes of Operation

5.6 Power On Reset

In Power on Reset all functions of the TLE9252VSK are disabled and the device is switched off.

- The transmitter and receiver are disabled.
- The bus biasing is connected to High impedance.
- The RxD Recessive Clamping detection is disabled
- The TxD timeout function is disabled.
- The overtemperature protection is disabled.
- The undervoltage detection on V_{BAT} , V_{CC} and V_{IO} is disabled.
- The logical input pins are blocked.
- RxD and NERR output pins are high impedance.
- Local wake up is disabled
- TxD pin is blocked
- The INH output pin is connected to V_{BAT} if $V_{BAT} > V_{BAT_POD}$ OR $V_{CC} > V_{CC_UV}$.

Conditions for entering the Power on Reset:

- V_{BAT} is below the V_{BAT_POD} AND V_{CC} is below V_{CC_UV} threshold.

Conditions for leaving the Power on Reset:

- Once the power supply voltage V_{BAT} OR V_{CC} is within the functional range the transceiver enters Stand-by Mode within t_{PON} .

The internal Power On Reset Flag will be set. After Power on Reset the TLE9252VSK enters Stand-by Mode.

Power up and power down transition is described in **Figure 12**:

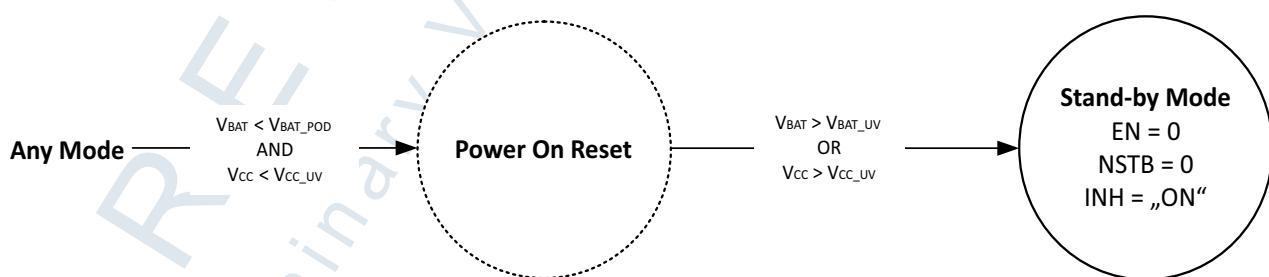


Figure 12 Power down and power up behavior

Modes of Operation

5.7 Autonomous Bus Voltage Biasing

The autonomous bus voltage biasing was introduced for improving complete network EMC performance and increasing the reliability of communication performance in networks using CAN partial networking. The autonomous bus voltage biasing is enabled only in all low power modes, the biasing unit will work independently from other transceiver functions and only depend on the status of detected network activity ($t_{Silence}$).

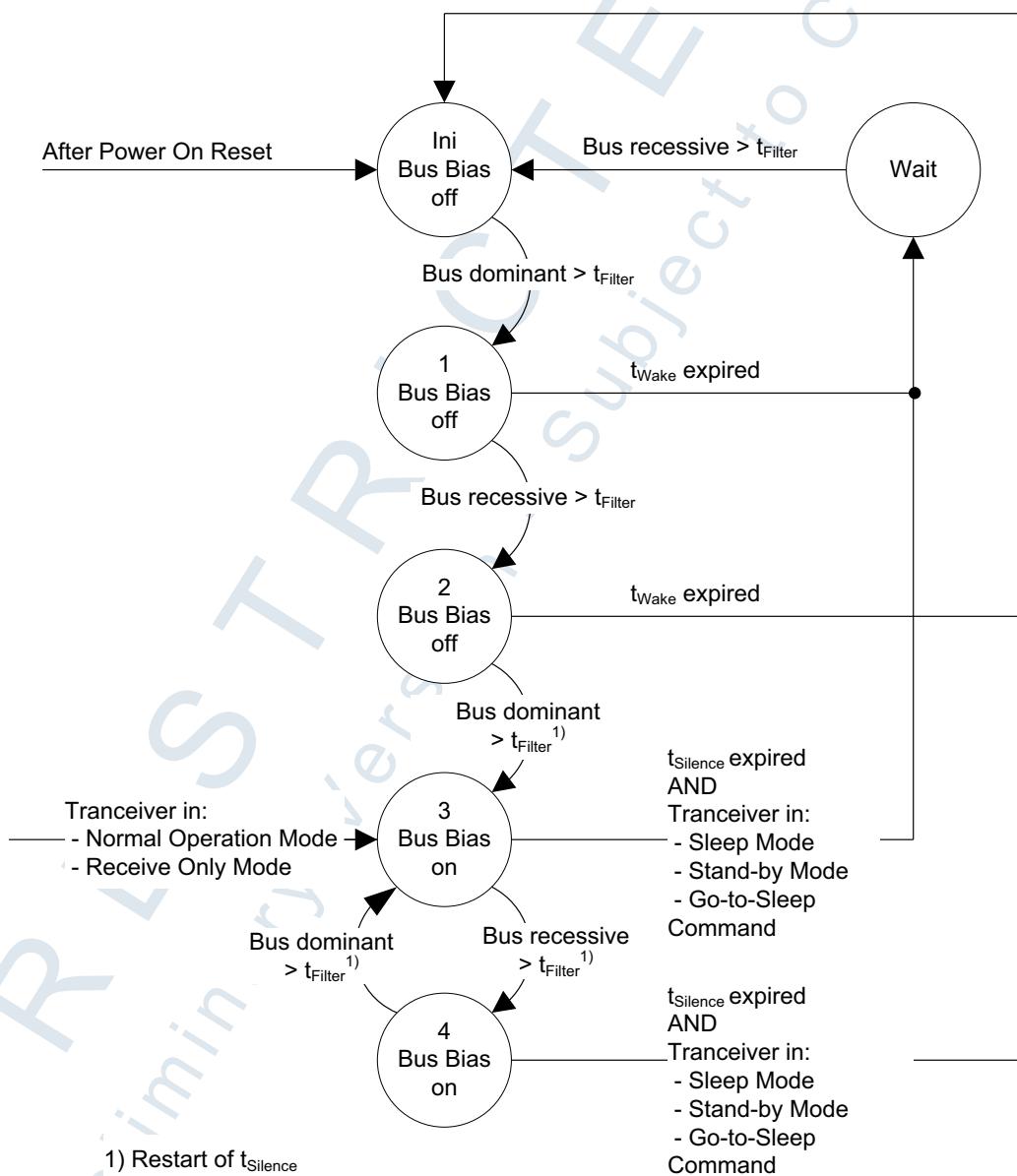


Figure 13 Autonomous Bus Voltage Biasing

If there has been no activity on the bus for longer than $t_{Silence}$, the bus pins are biased towards GND via the internal resistors. With the detection of a valid wake-up pattern (WUP), the internal biasing gets enabled and the biasing is stabilized via internal resistors towards 2.5 V. This activation is being performed within the time $t > t_{WU_Bias}$ after the WUP detection.

Modes of Operation

5.8 Wake up Functions

There are several possibilities for a mode change from Sleep Mode to another operation mode:

- Wake up pattern (WUP).
- Local Wake-Up (LWU).

In typical applications the power supplies V_{CC} and V_{IO} are turned off in Sleep Mode. This means a mode change can only be caused by an external event as WUP OR LWU. The detection of a valid WUP or LWU triggers a mode change from Sleep Mode to Stand-by Mode.

5.8.1 Wake up pattern (WUP)

Within the maximum wake-up time t_{WAKE} , the wake-up pattern consists of a “dominant” signal with the pulse width $t > t_{Filter}$, followed by a “recessive” signal with the pulse width $t > t_{Filter}$ and another “dominant” signal with the pulse width $t > t_{Filter}$ (see [Figure 14](#)).

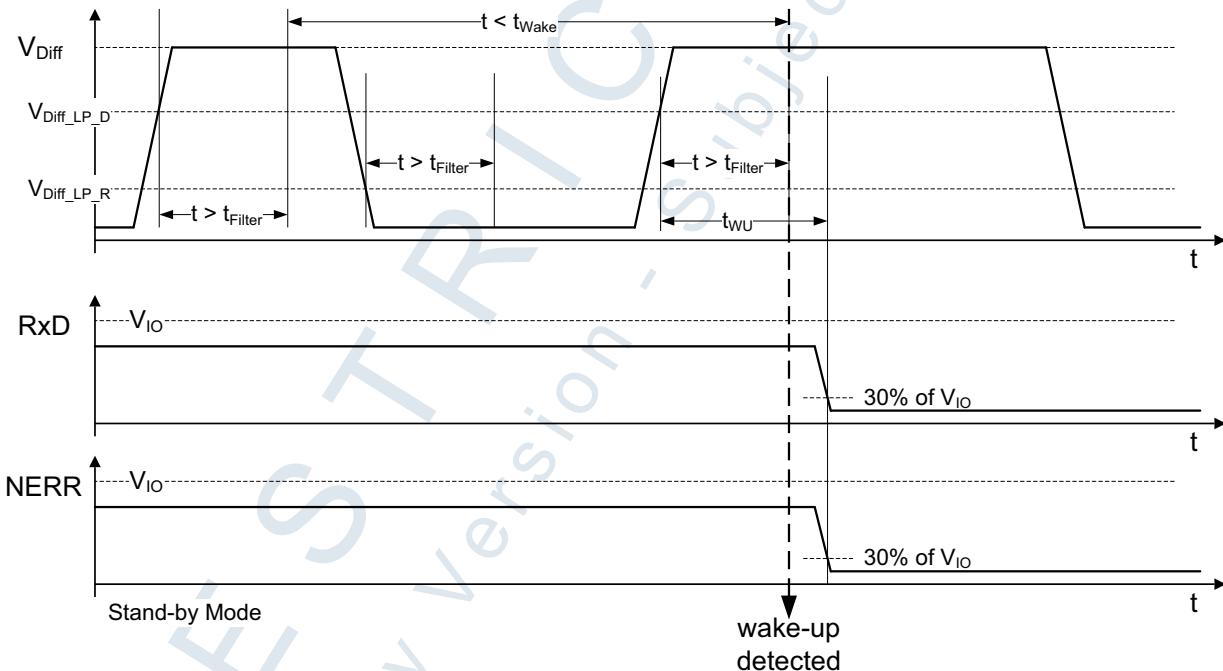


Figure 14 Wake up pattern (WUP)

The diagnostic output NERR and RxD will indicate a valid wake up pattern on the HS CAN bus.

A wake-up pattern is not valid under the following conditions:

- A mode change to Normal-operating Mode OR Receive-only Mode is performed during the wake-up pattern.
- The maximum wake-up time t_{WAKE} expires before a valid WUP has been detected.
- The transceiver is powered down ($V_{BAT} < V_{BAT_POD}$ AND $V_{CC} < V_{CC_POD}$).

In Stand-by Mode the RxD output pin and the NERR diagnostic pin display the WUP detection (Details see [Chapter 7](#)).

Modes of Operation

5.8.2 Local Wake up (LWU)

The WAKE input pin works bi-sensitive, meaning it is able to detect a rising and falling edge as a wake-up event. Designed to withstand up to 40V the WAKE pin can be directly connected to V_{BAT} . The Local Wake-up detection works for $V_{BAT} > V_{BAT_UV}$. The local wake up timings and behavior is described in [Figure 15](#).

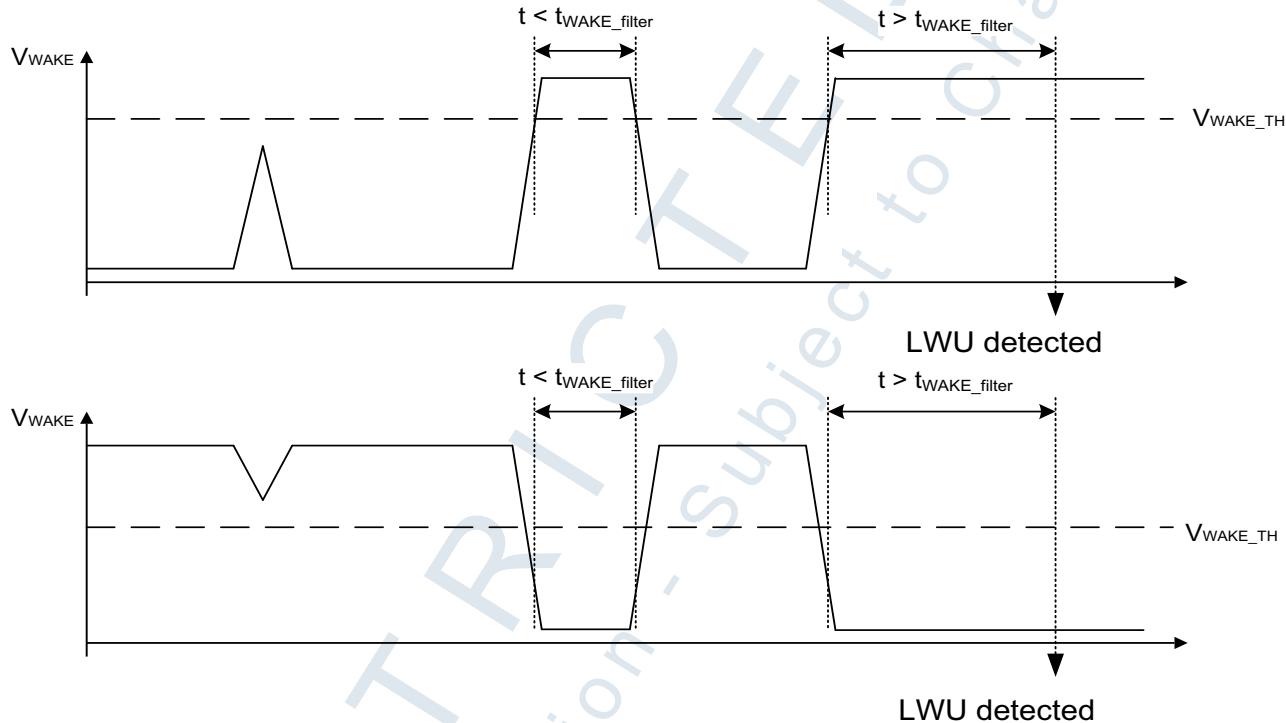


Figure 15 Local wake-up

The filter time t_{WAKE_filter} is implemented to protect the TLE9252VSK against unintended Wake-Ups, caused by spikes on the WAKE pin. The wake-up thresholds V_{WAKE_TH} depend on the level of the V_{BAT} power supply. In Stand-by Mode the RxD output pin and the NERR diagnostic pin display the wake-up event (Details see [Chapter 7](#)). Once a LWU has been recognized in Sleep Mode the device goes to Stand-by mode and the INH output pin is connected to V_{BAT} .

Modes of Operation

5.9 Wake-up: RxD and NERR behavior

The RxD and NERR output pin will signal a wake up event to the microcontroller (see [Chapter 7](#)). In Sleep Mode, Stand-by Mode and Go-to-Sleep Command by default values of RxD and NERR are logical “high” when no wake-up event has been detected. If a valid wake up pattern (WUP) is detected, RxD and NERR will be logical “low”. If a local wake-up (LWU) is detected the RxD will be logical “low” and NERR will be logical “high”. If both, LWU and WUP have been detected, then the WUP detection has higher priority and RxD and NERR pin are set to logical “low”, regardless if a LWU event is pending.

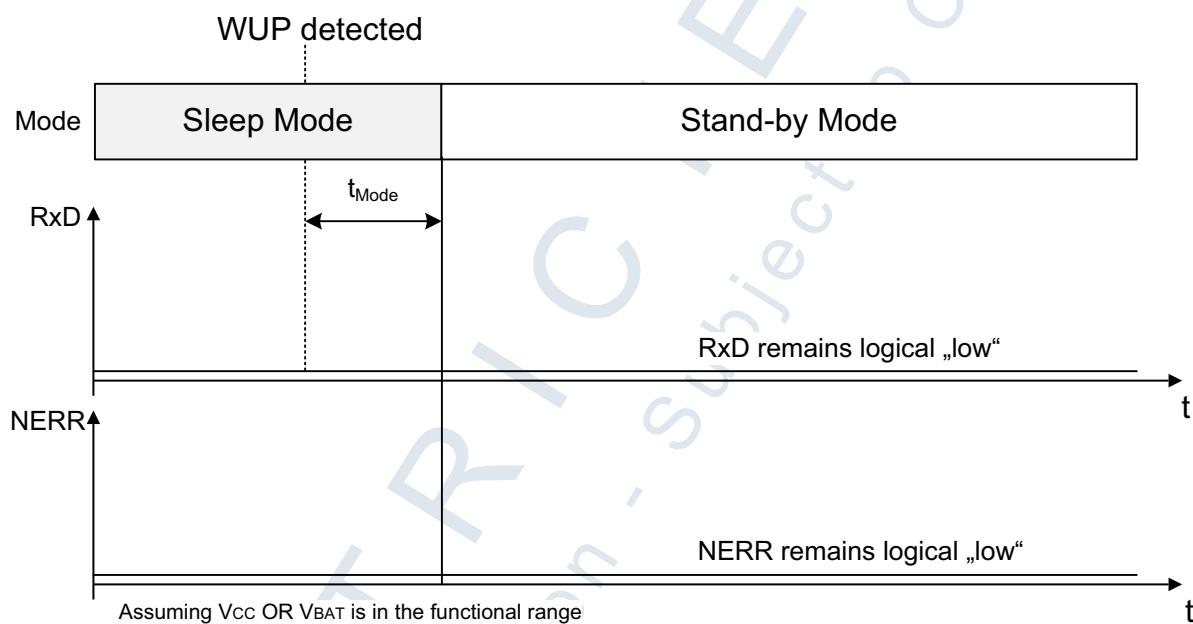


Figure 16 RxD and NERR: WUP detection (V_{IO} not supplied)

Modes of Operation

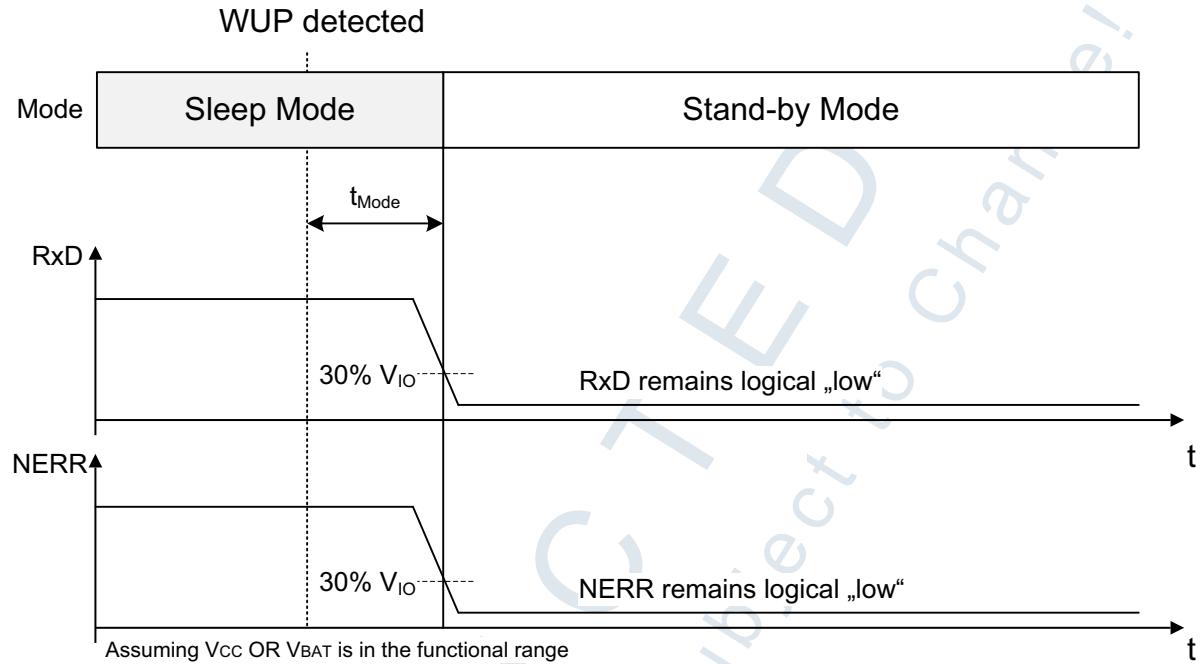


Figure 17 RxD and NERR: WUP detection (permanently supplied V_{IO})

Modes of Operation

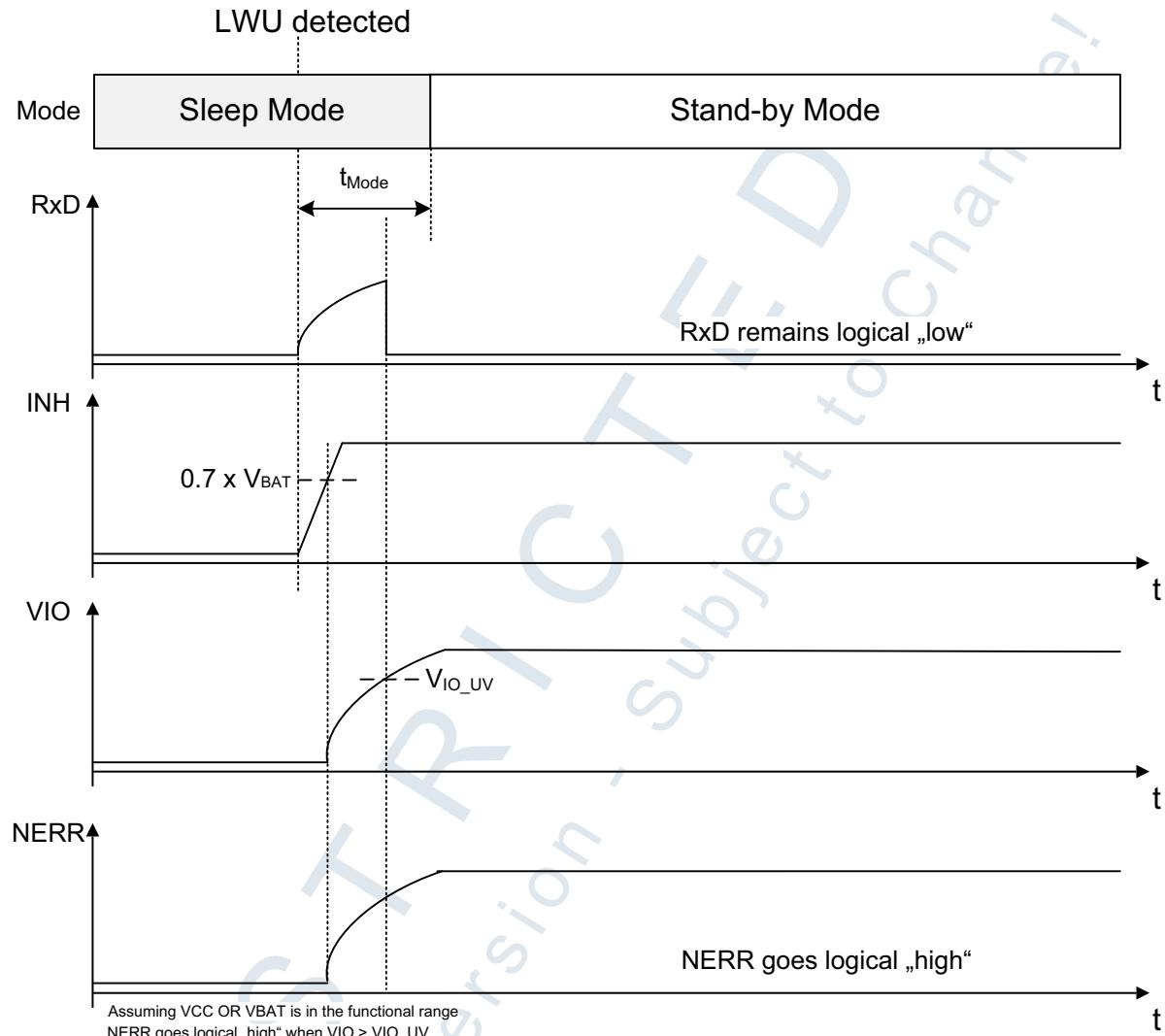


Figure 18 RxD and NERR: LWU detection (V_{IO} not supplied)

Modes of Operation

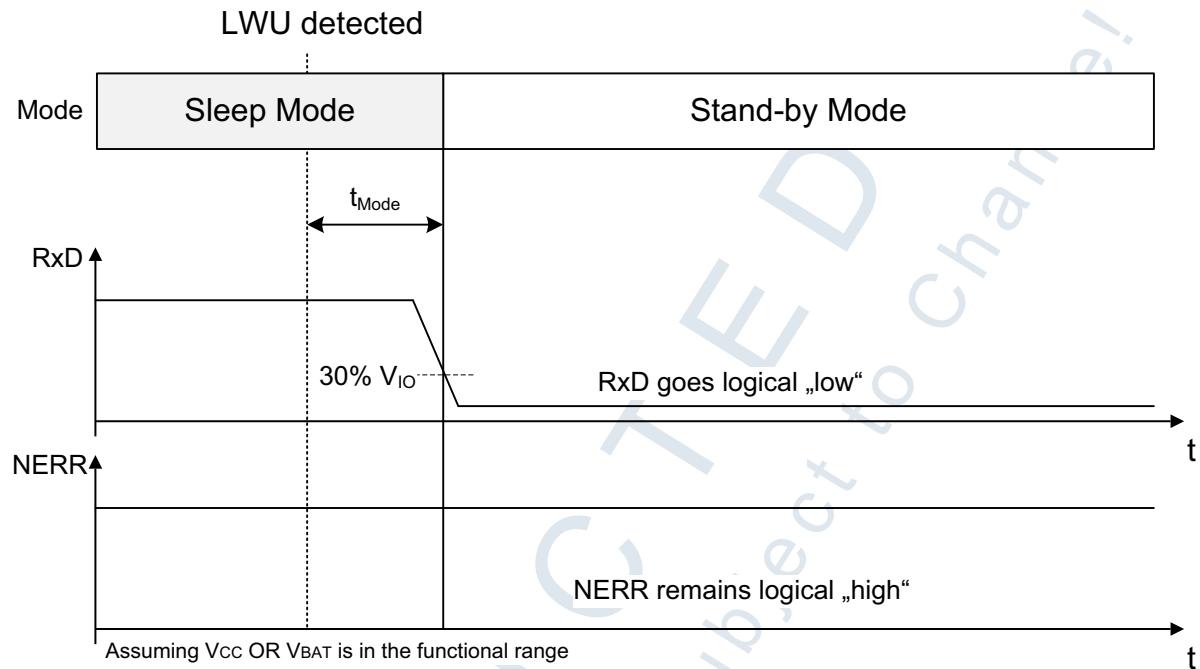


Figure 19 RxD and NERR: LWU detection (permanently supplied V_{IO})

6 Fail Safe Functions

6.1 Short Circuit Protection

The CANH and CANL bus pins are proven to withstand a short circuit fault against GND and against the supply voltages. A current limiting circuit protects the transceiver against damages.

6.2 Undervoltage detection

The TLE9252VSK has three independent undervoltage detections on V_{BAT} , V_{CC} and V_{IO} . These undervoltage events may have impact on the functionality of the device and also may change the mode of operation (see [Chapter 5](#)).

6.2.1 Undervoltage and Power Down detection on V_{BAT}

The power down is detected if the power supply V_{BAT} is below V_{BAT_POD} for more than the glitch filter time $t_{V_{BAT_filter}}$. This glitch filter is implemented in order to prevent an undervoltage detection due to short voltage transients on V_{BAT} . In case of an power down detection on V_{BAT} the TLE9252VSK is switched off (Power On Reset). If V_{BAT} recovers the TLE9252VSK enters by default Stand-by Mode. [Figure 20](#) shows the undervoltage scenario.

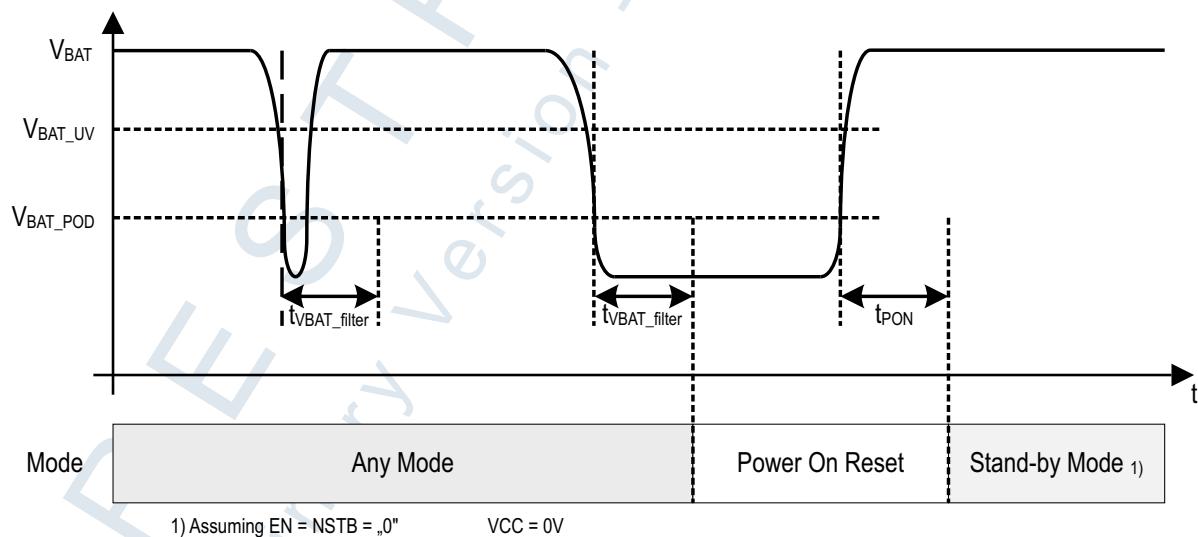


Figure 20 V_{BAT} power down undervoltage detection (V_{CC} not available)

In case of an undervoltage detection on $V_{BAT} < V_{BAT_UV}$ for $t > t_{V_{BAT_filter}}$ the Local Wake-up evaluation is disabled (see [Figure 21](#)).

Fail Safe Functions

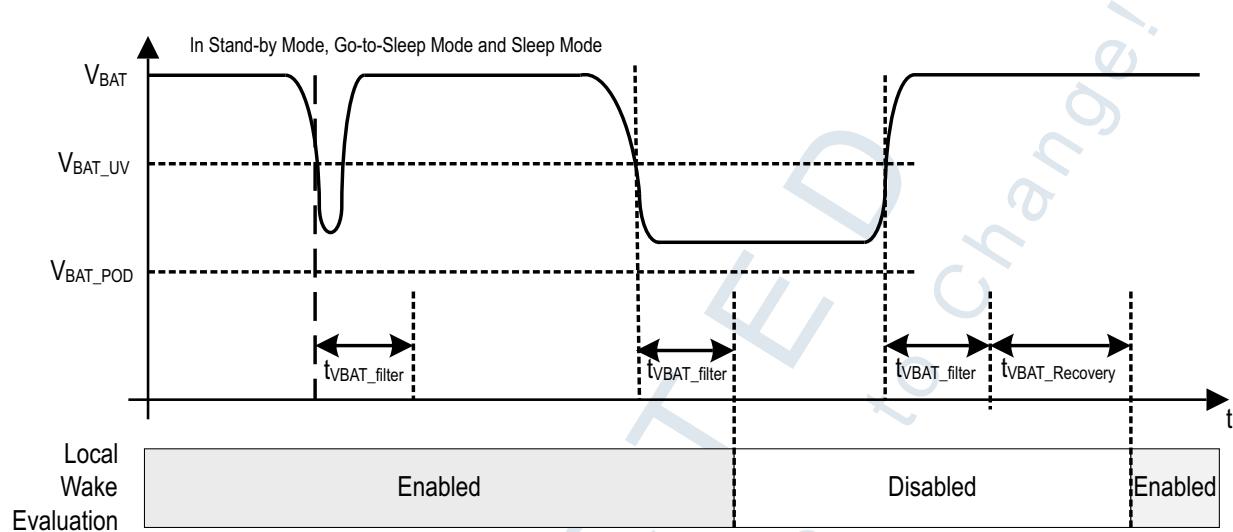


Figure 21 V_{BAT} undervoltage detection

Fail Safe Functions

6.2.2 Undervoltage detection on V_{CC}

An undervoltage on V_{CC} is detected if the V_{CC} supply is below V_{CC_UV} for more than the glitch filter time t_{VCC_filter} . This glitch filter is implemented in order to prevent an undervoltage detection due to short voltage transients on V_{CC} . The following actions will be performed if a undervoltage has been detected:

- The NERR pin switches from logical “high” to “low” (In Normal-operating Mode and Receive-only Mode).
- The transmitter is disabled (Normal-operating Mode).

The transmitter will be re-enabled if the $V_{CC} > V_{CC_UV}$ for more than the glitch filter time $t > t_{VCC_filter} + t_{VCC_RECOVERY}$ in Normal-operating Mode.

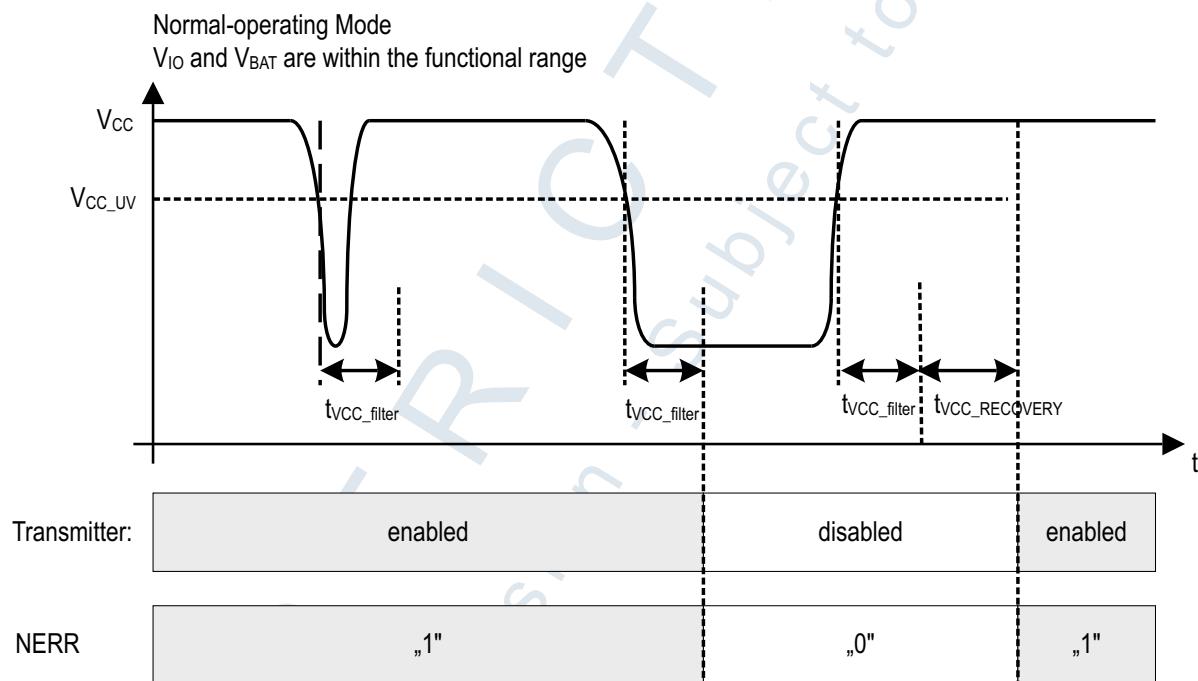
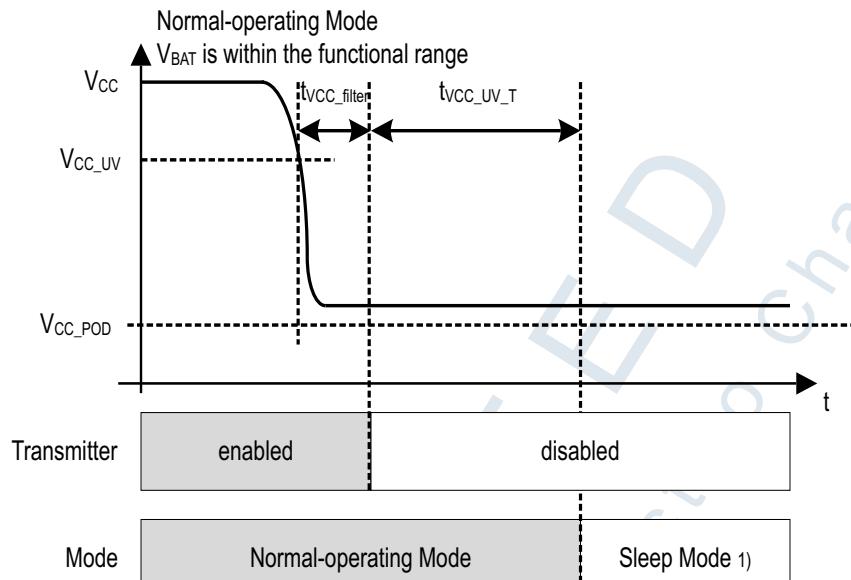


Figure 22 V_{CC} shortterm undervoltage detection (V_{BAT} in functional range)

Fail Safe Functions



1) Assuming no bus communication monitored and t_{Silence} expired

Figure 23 V_{cc} long-term undervoltage detection

The V_{cc} long-term undervoltage timer $t_{\text{VCC_UV_T}}$ is armed once V_{BAT} is in the functional range. If the V_{cc} voltage drops below $V_{\text{cc_uv}}$ for longer than $t > t_{\text{VCC_UV_T}}$ AND no communication is monitored on the HS CAN Bus (t_{Silence} is expired), this will trigger a mode change from any mode to Sleep Mode. If during the undervoltage event, communication is monitored and t_{Silence} does not expire, the device remains in the current mode of operation.

6.2.3 Undervoltage detection on V_{IO}

An undervoltage on V_{IO} is detected if the power supply V_{IO} is below $V_{\text{IO_UV}}$. As long as $V_{\text{IO}} < V_{\text{IO_UV}}$ any signal on the logic input pins EN, NSTB and TxD will be blocked (see [Figure 24](#)).

The default value of NERR and RxD if $V_{\text{IO}} < V_{\text{IO_UV}}$ is logical "high".

Fail Safe Functions

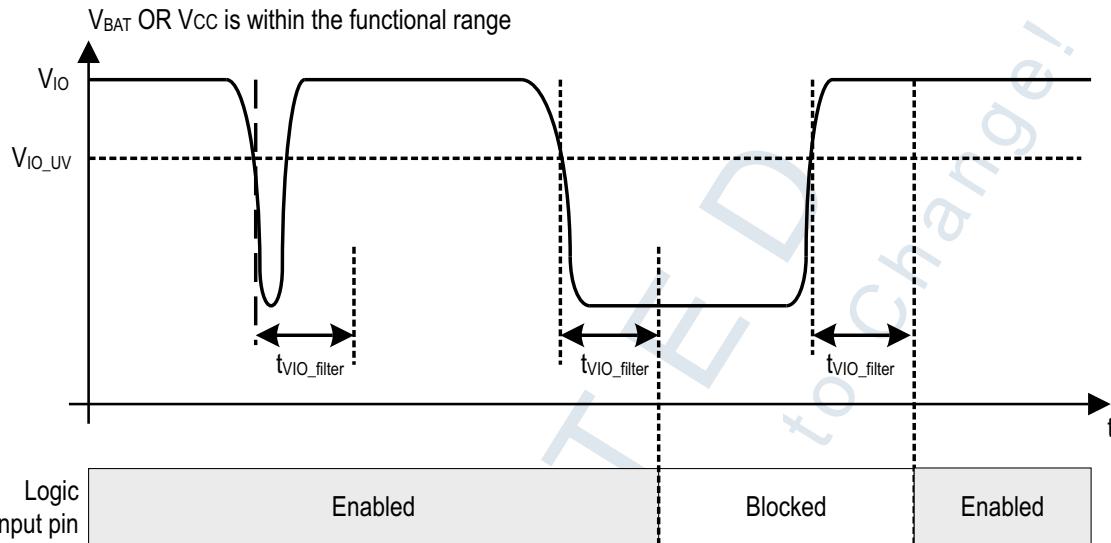
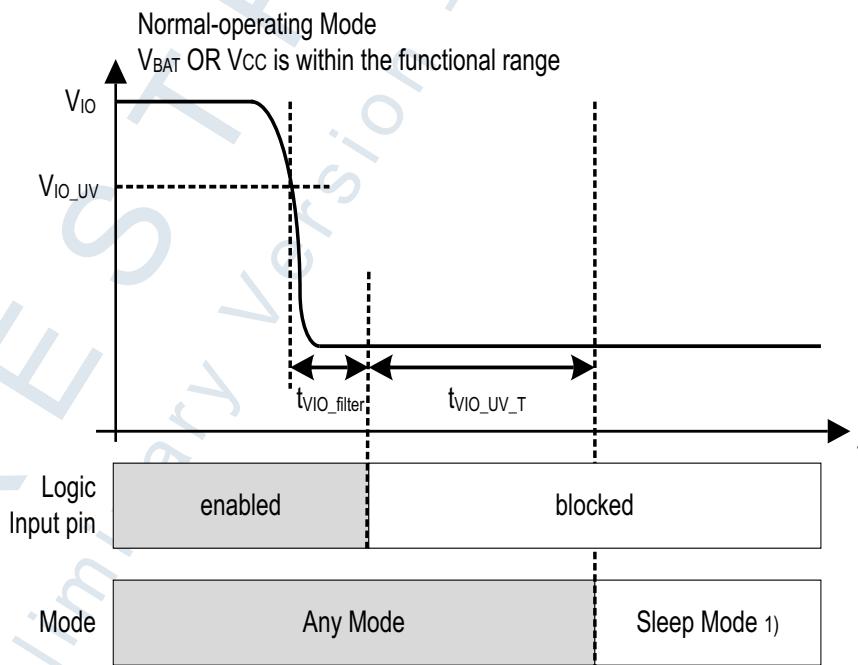


Figure 24 V_{IO} short-term undervoltage detection

The V_{IO} long-term undervoltage timer $t_{VIO_UV_T}$ is armed once V_{BAT} is in the functional range. If the V_{IO} voltage drops below V_{IO_UV} for longer than $t > t_{VIO_UV_T}$ AND no communication is monitored on the HS CAN Bus ($t_{Silence}$ is expired), this will trigger a mode change to Sleep Mode (see **Figure 25**). If during the undervoltage event, communication is monitored and $t_{Silence}$ does not expire, the device does not enter Sleep Mode.



1) Assuming no bus communication monitored and $t_{Silence}$ expired

Figure 25 V_{IO} long-term undervoltage detection

6.3 Unconnected Logic Pins

The integrated pull-up and pull-down resistors at the digital input pins force the TLE9252VSK into fail safe behavior if the input pins are not connected and floating (see **Table 3**).

Fail Safe Functions

Table 3 Logical Inputs when unconnected

Input Signal	Default State	Comment
TxD	“high”	“pull-up” current source to V_{IO}
EN	“low”	“pull-down” current source to GND
NSTB	“low”	“pull-down” current source to GND

6.4 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 $t > t_{TxD_TO}$ enables the TxD time-out feature and the TLE9252VSK disables the transmitter (see [Figure 26](#)) and sets the NERR output pin to logical “low”. The receiver is still active and the data on the bus continues to be monitored by the RxD output pin.

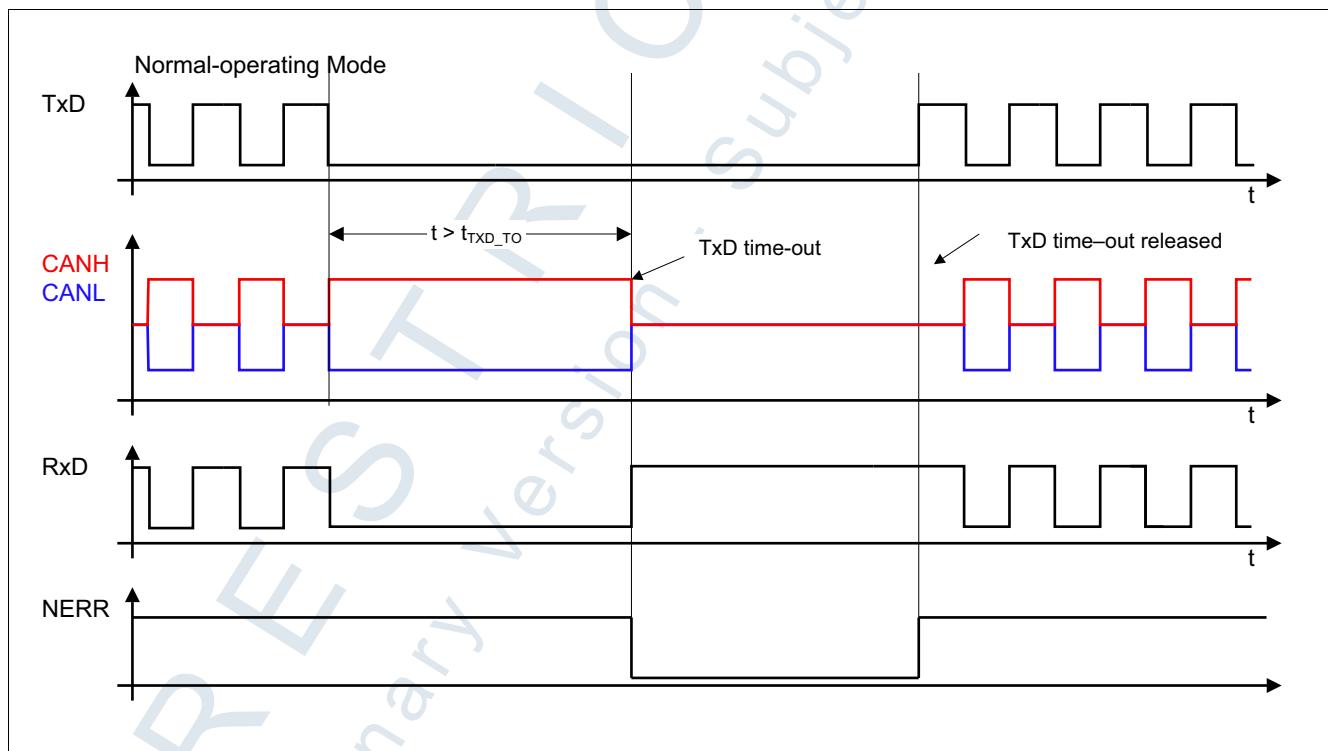


Figure 26 TxD time-out function

[Figure 26](#) illustrates how the transmitter is deactivated and re-activated. To release the transmitter after a TxD time-out event, the TLE9252VSK requires a signal change on the TxD input pin from logical “low” to logical “high”.

6.5 Overtemperature Protection

The TLE9252VSK has an integrated overtemperature detection to protect the TLE9252VSK against thermal overstress of the transmitter. The overtemperature protection is active in Normal-operating Mode and is disabled in all other Modes. The temperature sensor provides one temperature threshold: T_{JSD} . When the temperature exceeds the threshold T_{JSD} the transmitter is disabled. This overtemperature event will be

Fail Safe Functions

signaled as logical “low” on the NERR output pin in Normal-operating Mode. After the device has cooled down, the transmitter is re-enabled and NERR returns to logical “high”. A hysteresis is implemented within the temperature sensor.

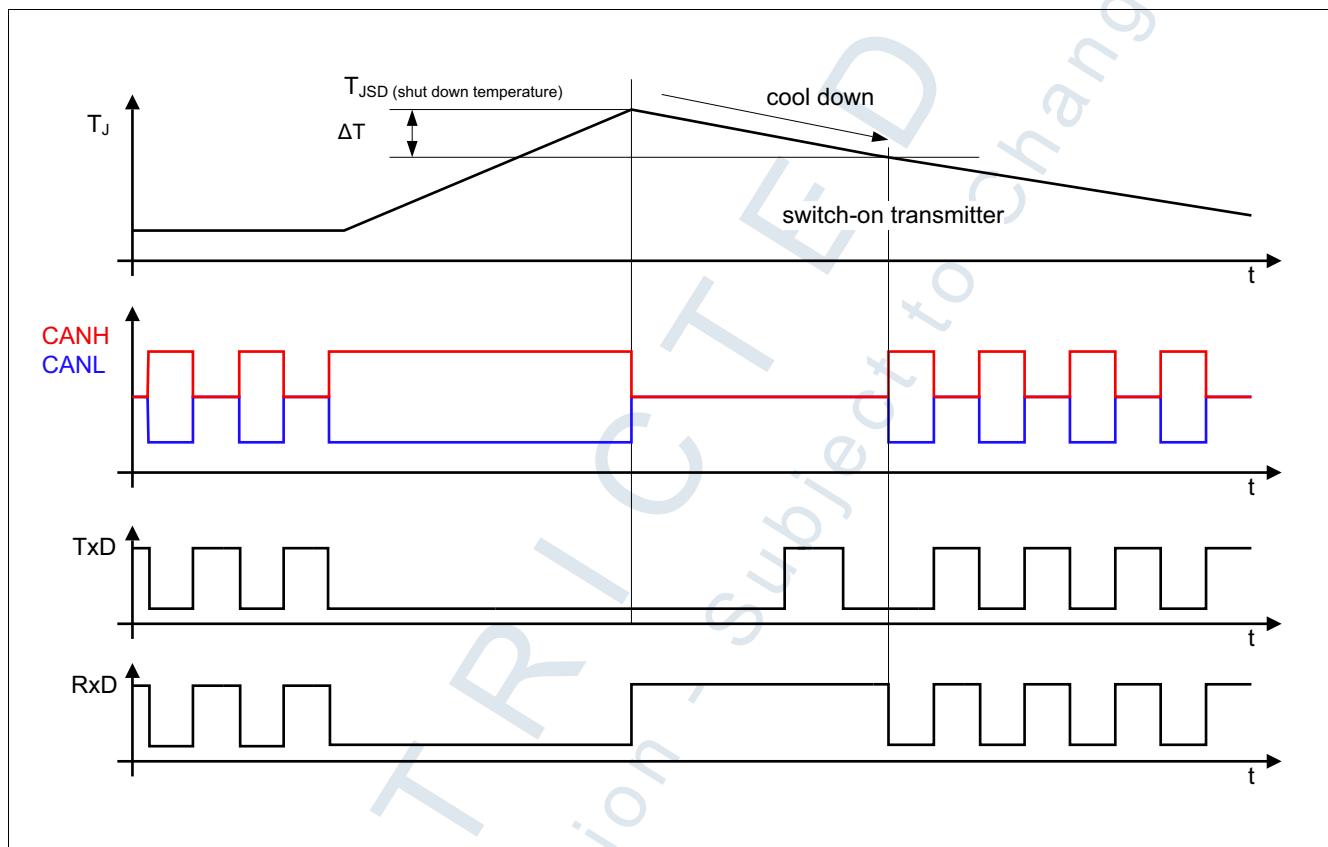


Figure 27 Overtemperature protection

6.6 RxD Recessive Clamping Detection

The RxD Recessive Clamping detection is only active in Normal-operating Mode. In Normal-operating mode a permanent logical “high” signal on the RxD pin indicates the external microcontroller, there is no communication on the HS CAN bus. The microcontroller then can transmit a message to the CAN bus, only if the bus is in “recessive” state. In case the logical “high” signal on the RxD pin is caused by a failure, like a short circuit RxD to V_{IO} , the RxD signal does not reflect the signal on the HS CAN bus. In this case the microcontroller is able to place a message on the CAN bus at any time and corrupts the CAN messages on the bus. If the TLE9252VSK detects a logical “high” signal on the RxD pin while the bus is dominant for $t > t_{RRC}$ the RxD Recessive Clamping flag is set along with disabling the transmitter in Normal-operating Mode. In order to avoid any data collision on the CAN bus, the transmitter is disabled in Normal-operating Mode as long as the RxD-Recessive Clamping is present. In Normal-operating Mode the TLE9252VSK indicates the RxD clamping by a logical “low” signal on the NERR pin. On detection the transmitter is disabled immediately, so that the corrupted, non-synchronized node is prevented from disturbing the remaining bus traffic. The corrupted node is then excluded from communication. The TLE9252VSK releases the failure flag and the output stage if the RxD clamping failure disappears. Whenever the pin RxD becomes dominant while the bus signal is “dominant” for $t > t_{RRC}$ the RxD Recessive Clamping flag is reset along with enabling the transmitter again in Normal-operating Mode.

Fail Safe Functions

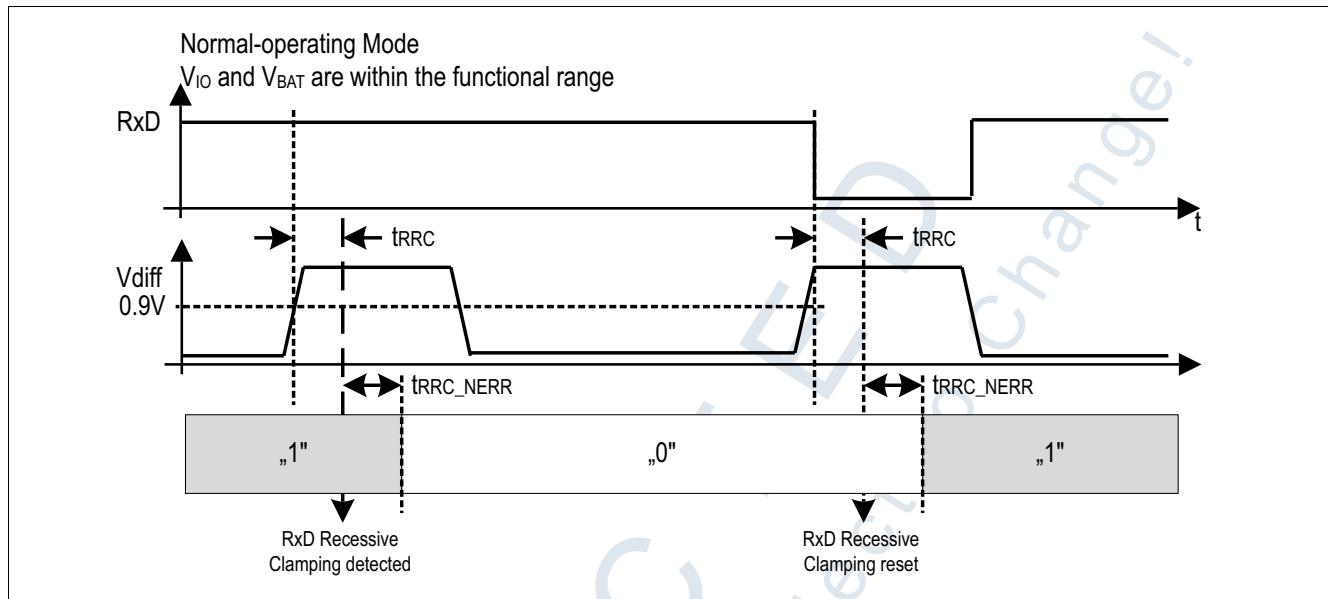


Figure 28 RxD Recessive Clamping in Normal-operating Mode

6.7 Delay Time for Mode Change

The HS CAN transceiver TLE9252VSK changes the modes of operation within the time window t_{Mode} . During mode changes from low-power mode to Normal-operating Mode or low-power mode to Receive-only Mode, the RxD output pin is set to logical “high” and does not reflect the status on the CANH and CANL input pins.

7 Diagnosis-Flags at NERR and RxD

Table 4 Diagnosis-Flags at NERR and RxD

NSTB	EN	INH	Mode	Event	NERR ¹⁾	RxD ¹⁾
1	1	V_{BAT}	Normal-operating	No failure detected	1	"Low": bus dominant, "High": bus recessive
				<ul style="list-style-type: none"> • V_{CC} undervoltage • Overtemperature • TxD timeout • RxD recessive clamping 	0	
1	0	V_{BAT}	Receive-only	No failure detected	1	"Low": bus dominant, "High": bus recessive
				<ul style="list-style-type: none"> • Power-Up-Flag²⁾ OR • V_{CC} undervoltage 	0	
0	0	V_{BAT}	Stand-by	WUP detected	0	0
				LWU detected	1	0
				No Wake-up event detected	1	1
0	0	High-Z	Sleep	No Wake-up event detected	1	1
				No Wake-up event detected ³⁾	0	0

1) Only valid if VIO is in the functional range.

2) Power-Up flag only available if VBAT or VCC is in the functional range for at least tPON. Power-Up flag will be cleared when entering Normal-operating mode.

3) Valid if VIO = 0V

Diagnosis-Flags at NERR and RxD

Whenever the pin RXD becomes dominant while The HS CAN Bus is Dominant for $t > t_{RRC}$, the RXD Recessive Clamping Flag is reset. Whenever the pin TxD Is dominant for $t > t_{TxDO}$, the TxD Dominant Flag is set. If VCC < VCC_UV for $t > t_{VCC_filter}$ the VCC undervoltage flag is set. If VCC recovers for $t > t_{VCC_filter} + t_{VCC_Recovery}$ Normal-operating Mode the NERR goes high and the VCC undervoltage flag is reset. If an overtemperature is detected the Overtemperature flag is set. If no overtemperature is detected the Overtemperature flag is reset. In Normal-operating mode And Receive-only mode failure recovery is reflected on the pin NERR going HIGH again.

Local Failure Flags are: VCC Undervoltage, RxD Recessive Clamping, TxD Dominant Timeout, Overtemperature

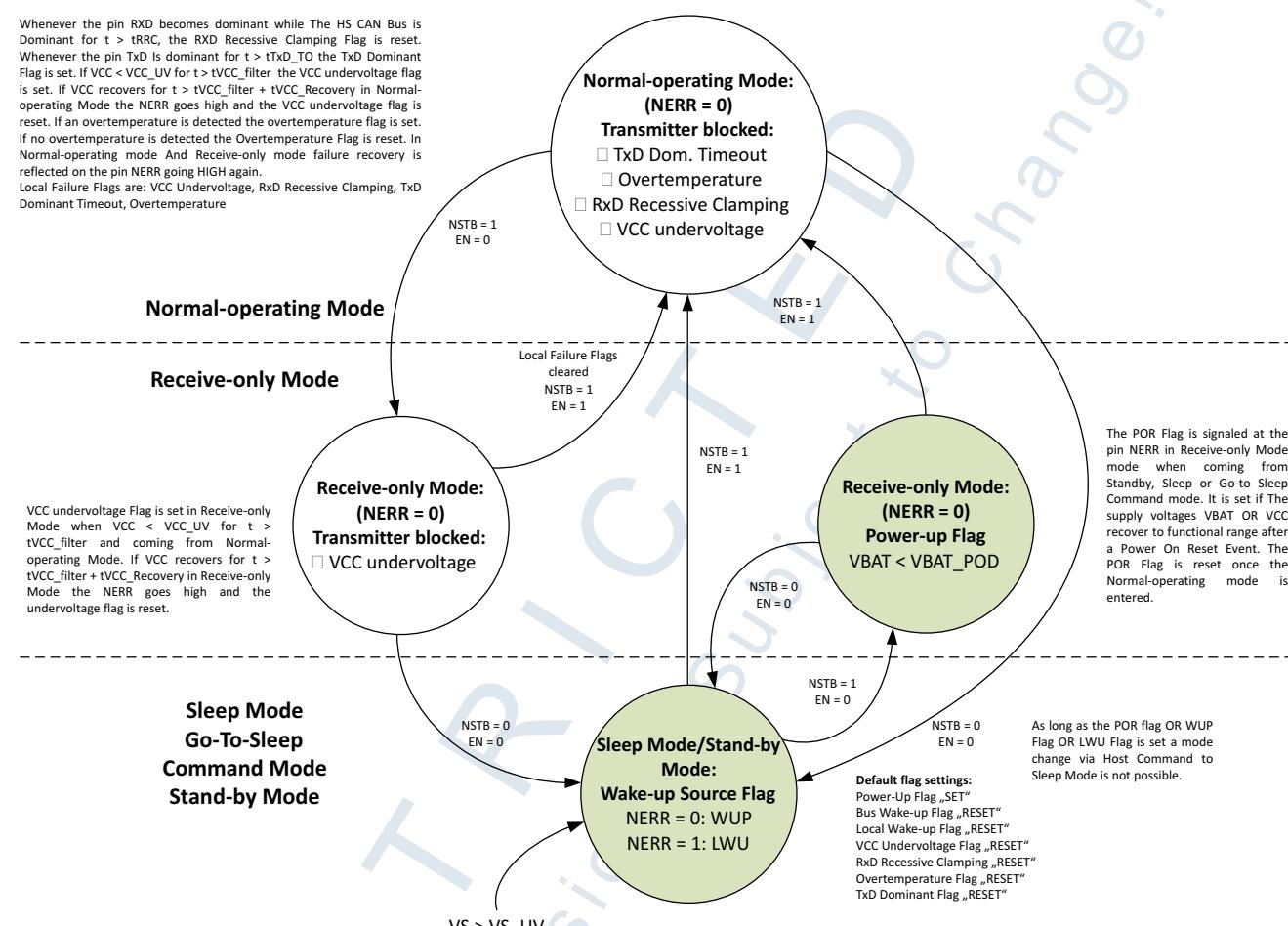


Figure 29 Diagnosis Flowchart

General Product Characteristics

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8 General Product Characteristics

8.1 Absolute Maximum Ratings

Table 5 Absolute Maximum Ratings¹⁾

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							
Battery supply voltage	V_{BAT}	-0.3	-	40	V	-	P_8.1.1
Transmitter supply voltage	V_{CC}	-0.3	-	6.0	V	-	P_8.1.2
Digital voltage reference	V_{IO}	-0.3	-	6.0	V	-	P_8.1.3
CANH DC voltage versus GND	V_{CANH}	-40	-	40	V	-	P_8.1.4
CANL DC voltage versus GND	V_{CANL}	-40	-	40	V	-	P_8.1.5
Differential voltage between CANH and CANL	V_{CAN_DIFF}	-40	-	40	V	-	P_8.1.6
Voltages at pin WAKE	V_{WAKE}	-27	-	40	V	-	P_8.1.7
Voltages at pin INH	V_{INH}	-0.3	-	$V_{BAT} + 0.3$	V	-	P_8.1.8
Voltages at pin digital input pins: EN, NSTB, TxD	V_{Max_In}	-0.3	-	$V_{IO} + 0.3V$	V	-	P_8.1.9
Voltages at pin digital output pins: NERR, RxD	V_{Max_Out}	-0.3	-	$V_{IO} + 0.3$	V	-	P_8.1.10
Currents							
Max. output current on INH	I_{INH_Max}	-5	-	-	mA	-	P_8.1.11
Max. output current on NERR and RxD	I_{Out_Max}	-5	-	5	mA	-	P_8.1.12
Temperatures							
Junction Temperature	T_j	-40	-	150	°C	-	P_8.1.13
Storage Temperature	T_{stg}	-55	-	150	°C	-	P_8.1.14
ESD Resistivity							
ESD immunity at CANH, CANL, WAKE and V_{BAT} versus to GND	$V_{ESD_HBM_CA_N}$	-8	-	8	kV	HBM ²⁾	P_8.1.15
ESD immunity at all other pins	V_{ESD_HBM}	-2	-	2	kV	HBM ²⁾	P_8.1.16
ESD immunity at corner pins	$V_{ESD_CDM_CP}$	-750	-	750	V	CDM ³⁾	P_8.1.17
ESD immunity at any pin	$V_{ESD_CDM_OP}$	-500	-	500	V	CDM ³⁾	P_8.1.18

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

2) ESD susceptibility, Human Body Model "HBM" according to ANSI/ESDA/JEDEC JS001 (1.5k Ω, 100 pF.)

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3) ESD susceptibility, Charged Device Model "CDM" according to EIA/JESD22-C101 or ESDA STM 5.3.1.

Notes

1. 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.
2. 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.

8.2 Functional Range

Table 6 Functional range

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
Supply Voltages							
Battery supply voltage	V_{BAT}	5.5	–	40	V	–	P_8.2.1
Transmitter supply voltage	V_{CC}	4.5	–	5.5	V	–	P_8.2.2
Digital voltage reference	V_{IO}	3.0	–	5.5	V	–	P_8.2.3
Thermal Parameters							
Junction Temperature	T_j	-40	–	150	°C	–	P_8.2.4

Note: Within the functional or operating range, the IC operates as described in the circuit description. The electrical characteristics are specified within the conditions given in the Electrical Characteristics table.

8.3 Thermal Resistance

Note: This thermal data was generated according to JEDEC JESD51 standards. Please visit www.jedec.org.

Table 7 Thermal resistance¹⁾

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
Thermal Resistance							
Junction to ambient	R_{thJA_DS014}	–	130	–	K/W	²⁾	P_8.3.1
Thermal Shutdown Junction Temperature							
Thermal shut-down temperature	T_{JSD}	170	180	190	°C	–	P_8.3.3
Thermal shutdown hysteresis	ΔT	5	10	20	K	–	P_8.3.4

1) Not subject to production test, specified by design

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- 2) Specified R_{thJA} value is according to Jedec JESD51-2,-7 at natural convection on FR4 2s2p board; The Product (Chip+Package) was simulated on a 76.2 × 114.3 × 1.5 mm board with 2 inner copper layers (2 × 70 mm Cu, 2 × 35 mm Cu).

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Electrical Characteristics

9 Electrical Characteristics

9.1 General Timing Parameter

Table 8 General Timing Parameter

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
Power up delay time	t_{PON}	-	-	500	μs	see Figure 20	P_9.1.1
Delay time for mode change	t_{Mode}	-	-	20	μs	-	P_9.1.2
CAN Bus Silence timeout	$t_{Silence}$	0.6	0.9	1.2	s	-	P_9.1.3
Min. hold time in Go-to-Sleep Command	t_{Sleep}	10	25	50	μs	see Figure 10	P_9.1.4
RxD Recessive Clamping detection time	t_{RRC}	-)	1.2	1.8	μs	see Figure 28	P_9.1.5
RxD Recessive Clamping indication delay	t_{RRC_NERR}	-	-	1	μs	see Figure 28	P_9.1.6

9.2 Power Supply Interface

9.2.1 Current Consumptions

Table 9 Current Consumptions

$4.5 \text{ V} < V_{CC} < 5.5 \text{ V}$; $3.0 \text{ V} < V_{IO} < 5.5 \text{ V}$; $5.5 \text{ V} < V_{BAT} < 40 \text{ V}$; $R_L = 60 \Omega$; $-40^\circ\text{C} < T_J < 150^\circ\text{C}$;
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.			
Normal-operating Mode							
V_{BAT} supply current	I_{BAT_NM}	-	3.0	6.0	mA	INH = not connected;	P_9.2.1
V_{CC} supply current “dominant” bus signal	$I_{CC_NM_D}$	-	35	60	mA	-	P_9.2.2
V_{CC} supply current “recessive” bus signal	$I_{CC_NM_R}$	-	2.0	4.0	mA	-	P_9.2.3
V_{IO} supply current	I_{IO_NM}	-	1.0	5.0	μA	steady state, $\text{TxD} = V_{IO}$;	P_9.2.4
Receive-only Mode							

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Table 9 Current Consumptions (cont'd)

$4.5 \text{ V} < V_{CC} < 5.5 \text{ V}$; $3.0 \text{ V} < V_{IO} < 5.5 \text{ V}$; $5.5 \text{ V} < V_{BAT} < 40 \text{ V}$; $R_L = 60 \Omega$; $-40^\circ\text{C} < T_J < 150^\circ\text{C}$;
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.			
V_{BAT} supply current	I_{BAT_ROM}	–	3.0	6.0	mA	INH = not connected;	P_9.2.5
V_{CC} supply current	I_{CC_ROM}	–	2.0	6.0	mA	$\text{TxD} = V_{IO}$;	P_9.2.6
V_{IO} supply current	I_{IO_ROM}	–	1.0	5.0	μA	steady state, $\text{TxD} = V_{IO}$;	P_9.2.7
Stand-by Mode							
V_{BAT} supply current	I_{BAT_STB}	–	16	50	μA	INH = n.c., $V_{BAT} < 18\text{V}$; $t_{Silence}$ expired; WAKE = GND;	P_9.2.8
V_{CC} supply current	I_{CC_STB}	–	2.0	8.0	μA	$\text{TxD} = V_{IO}$, $V_{BAT} > 12\text{V}$;	P_9.2.11
V_{IO} supply current	I_{IO_STB}	–	1.0	5.0	μA	$\text{TxD} = V_{IO}$;	P_9.2.12
Sleep Mode							
V_{BAT} supply current	I_{BAT_SLP}	–	15.0	30.0	μA	$V_{CC} = V_{IO} = 0 \text{ V}$, $V_{BAT} < 18\text{V}$ bus biasing = GND, INH = n.c.;	P_9.2.13
V_{CC} supply current	I_{CC_SLP}	–	1.0	5.0	μA	$\text{TxD} = V_{IO}$, $V_{BAT} > 12\text{V}$,	P_9.2.16
V_{IO} supply current	I_{IO_SLP}	–	1.0	5.0	μA	$\text{TxD} = V_{IO}$;	P_9.2.17

9.2.2 Undervoltage Detection

Table 10 Undervoltage Detection

$4.5 \text{ V} < V_{CC} < 5.5 \text{ V}$; $3.0 \text{ V} < V_{IO} < 5.5 \text{ V}$; $5.5 \text{ V} < V_{BAT} < 40 \text{ V}$; $R_L = 60 \Omega$; $-40^\circ\text{C} < T_J < 150^\circ\text{C}$;
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.			
Undervoltage Detection V_{BAT}							
Undervoltage detection threshold	V_{BAT_UV}	4.8	5.1	5.5	V	–	P_9.2.18
Power down threshold	V_{BAT_POD}	3	4.4	4.8	V	falling edge; $V_{CC} = 0\text{V}$;	P_9.2.20
V_{BAT} Undervoltage glitch filter	t_{VBAT_filter}	–	–	50	μs	(see Figure 20)	P_9.2.22

Electrical Characteristics

Table 10 Undervoltage Detection (cont'd)

$4.5 \text{ V} < V_{\text{CC}} < 5.5 \text{ V}$; $3.0 \text{ V} < V_{\text{IO}} < 5.5 \text{ V}$; $5.5 \text{ V} < V_{\text{BAT}} < 40 \text{ V}$; $R_L = 60 \Omega$; $-40^\circ\text{C} < T_J < 150^\circ\text{C}$;
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.			
Undervoltage Detection V_{CC}							
Undervoltage detection threshold	$V_{\text{CC_UV}}$	4.0	4.25	4.5	V	(see Figure 22)-	P_9.2.24
Undervoltage glitch filter	$t_{\text{VCC_filter}}$	-	-	10	μs	(see Figure 22)	P_9.2.27
Undervoltage recovery time	$t_{\text{VCC_RECOVERY}}$	15	25	35	μs	(see Figure 22)	P_9.2.28
Response time V_{CC} for long-term undervoltage detection	$t_{\text{VCC_UV_T}}$	250	400	550	ms	(see Figure 23)	P_9.2.29
Undervoltage Detection V_{IO}							
Undervoltage detection threshold	$V_{\text{IO_UV}}$	2.5	2.75	3.0	V	(see Figure 24)	P_9.2.30
Undervoltage glitch filter	$t_{\text{VIO_filter}}$	-	-	10	μs	(see Figure 24)	P_9.2.32
Response time V_{IO} for long-term undervoltage detection	$t_{\text{VIO_UV_T}}$	250	400	550	ms	(see Figure 25)	P_9.2.33

Electrical Characteristics

9.2.3 INH Output

Table 11 INH Output

$4.5 \text{ V} < V_{CC} < 5.5 \text{ V}$; $3.0 \text{ V} < V_{IO} < 5.5 \text{ V}$; $5.5 \text{ V} < V_{BAT} < 40 \text{ V}$; $R_L = 60 \Omega$; $-40^\circ\text{C} < T_J < 150^\circ\text{C}$;
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.			
Analog Output INH							
Output voltage INH enabled	V_{INH}	$V_{BAT} - 0.8$	-	-	V	$I_{INH} = -0.2 \text{ mA}$, Normal-operating Mode Receive-only Mode Stand-by Mode, Go-to-Sleep Command;	P_9.2.34
Absolute leakage current	I_{INH_Leak}	-5.0	-	-	μA	$V_{INH} = 0 \text{ V}$, Sleep Mode;	P_9.2.35

9.3 EN, NSTB and NERR

Table 12 EN, NSTB and NERR

$4.5 \text{ V} < V_{CC} < 5.5 \text{ V}$; $3.0 \text{ V} < V_{IO} < 5.5 \text{ V}$; $5.5 \text{ V} < V_{BAT} < 40 \text{ V}$; $R_L = 60 \Omega$; $-40^\circ\text{C} < T_J < 150^\circ\text{C}$;
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.			

Mode Control Inputs EN, NSTB

“High” level input range	V_{MODE_H}	$0.7 \times V_{IO}$	-	$V_{IO} + 0.3\text{V}$	V		P_9.3.1
“Low” level input range	V_{MODE_L}	-0.3V	-	$0.3 \times V_{IO}$	V		P_9.3.2
“high” level input current	I_{MODE_H}	20	-	200	μA	$V_{Mode} = V_{IO}$;	P_9.3.3
“low” level input current	I_{MODE_L}	-2.0	-	2.0	μA	$V_{Mode} = 0 \text{ V}$	P_9.3.4

Diagnosis Output NERR

“High” level output current	I_{NERR_H}	-	-4.0	-1.0	mA	$V_{NERR} = V_{IO} - 0.4 \text{ V}$,	P_9.3.5
“Low” level output current	I_{NERR_L}	1.0	4.0	-	mA	$V_{NERR} = 0.4 \text{ V}$,	P_9.3.6

Electrical Characteristics

RESTRICTED

9.4 CAN Controller Interface

Table 13 CAN Controller Interface

$4.5 \text{ V} < V_{CC} < 5.5 \text{ V}$; $3.0 \text{ V} < V_{IO} < 5.5 \text{ V}$; $5.5 \text{ V} < V_{BAT} < 40 \text{ V}$; $R_L = 60 \Omega$; $-40^\circ \text{C} < T_J < 150^\circ \text{C}$;
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.			
Receiver Output RxD							
“high” level output current	I_{RxD_H}	–	-4.0	-1.0	mA	$V_{RxD} = V_{IO} - 0.4 \text{ V}$, $V_{Diff} < 0.5\text{V}$;	P_9.4.1
“low” level output current	I_{RxD_L}	1.0	4.0	–	mA	$V_{RxD} = 0.4 \text{ V}$, $V_{Diff} > 0.9\text{V}$;	P_9.4.2
Transmitter Input TxD							
“high” level input voltage threshold	V_{TxD_H}	–	$0.5 \times V_{IO}$	$0.7 \times V_{IO}$	V	“recessive” state;	P_9.4.4
“low” level input voltage threshold	V_{TxD_L}	$0.3 \times V_{IO}$	$0.4 \times V_{IO}$	–	V	“dominant” state;	P_9.4.5
“high” level input current	I_{TxD_H}	-2.0	–	2.0	μA	$V_{TxD} = V_{IO}$;	P_9.4.7
“low” level input current	I_{TxD_L}	-200	–	-20.0	μA	$V_{TxD} = 0 \text{ V}$;	P_9.4.8
TxD permanent “dominant” timeout	t_{TxD_TO}	1	–	4	ms	Normal-operating Mode, see Figure 26	P_9.4.9
Input capacitance	C_{TxD}	–	–	10	pF	1)	P_9.4.10

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

Electrical Characteristics

9.5 Transmitter

Table 14 Transmitter

$4.5 \text{ V} < V_{CC} < 5.5 \text{ V}$; $3.0 \text{ V} < V_{IO} < 5.5 \text{ V}$; $5.5 \text{ V} < V_{BAT} < 40 \text{ V}$; $R_L = 60 \Omega$; $-40^\circ\text{C} < T_J < 150^\circ\text{C}$;
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							
CANH, CANL “recessive” output voltage	$V_{CANL/H}$	2.0	2.5	3.0	V	Normal-operating Mode, Receive-only Mode, $V_{TXD} = V_{IO}$, No load;	P_9.5.1
CANH, CANL “recessive” output voltage difference	$V_{Diff_R_NM} = V_{CANH} - V_{CANL}$	-500	-	50	mV	$V_{TXD} = V_{IO}$, no load;	P_9.5.2
CANH “dominant” output voltage Normal-operating Mode	V_{CANH}	2.75	-	4.5	V	$V_{TXD} = 0 \text{ V}$, $50 \Omega < R_L < 65 \Omega$; $4.75 \text{ V} < V_{CC} < 5.25$;	P_9.5.3
CANL “dominant” output voltage Normal-operating Mode	V_{CANL}	0.5	-	2.25	V	$V_{TXD} = 0 \text{ V}$, $50 \Omega < R_L < 65 \Omega$; $4.75 \text{ V} < V_{CC} < 5.25$;	P_9.5.4
CANH “dominant” output voltage difference: $V_{Diff_D} = V_{CANH} - V_{CANL}$ Normal-operating Mode	V_{Diff_D}	1.5	2.0	3.0	V	$V_{TXD} = 0 \text{ V}$, $50 \Omega < R_L < 65 \Omega$; $4.75 \text{ V} < V_{CC} < 5.25$;	P_9.5.5
CANH “dominant” output voltage difference extended bus load $V_{Diff_D} = V_{CANH} - V_{CANL}$ Normal-operating Mode	$V_{Diff_D_EXT_BL}$	1.4	-	3.3	V	$V_{TXD} = 0 \text{ V}$, $R_L = 45 \Omega < R_L < 70 \Omega$; $4.75 \text{ V} < V_{CC} < 5.25$;	P_9.5.6
CANH, CANL “dominant” output voltage difference high extended bus load Normal-operating mode $V_{Diff} = V_{CANH} - V_{CANL}$	$V_{Diff_D_HEXT_BL}$	1.5	-	5.0	V	$V_{TXD} = 0 \text{ V}$, $R_L = 2240 \Omega^1$; $4.75 \text{ V} < V_{CC} < 5.25$; static behavior;	P_9.5.7
CANH, CANL “recessive” output voltage Sleep Mode	V_{CANL_H}	-0.1	-	0.1	V	no load;	P_9.5.8
CANH, CANL “recessive” output voltage difference Sleep Mode	V_{Diff_SLP}	-0.2	-	0.2	V	no load;	P_9.5.9

Electrical Characteristics

Table 14 Transmitter (cont'd)

4.5 V < V_{CC} < 5.5 V; 3.0 V < V_{IO} < 5.5 V; 5.5V < V_{BAT} < 40V; $R_L = 60 \Omega$; -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.			
Driver symmetry $V_{SYM} = V_{CANH} + V_{CANL}$	V_{SYM}	0.9 x V_{CC}	1.0 x V_{CC}	1.1 x V_{CC}	V	1) ²⁾	P_9.5.10
CANH short circuit current	I_{CANHSC}	-115	-75	-40	mA	$V_{CANHshort} = -3 \text{ V}$, $t < t_{TXD_TO}$, $V_{TXD} = 0 \text{ V}$;	P_9.5.11
CANL short circuit current	I_{CANLSC}	40	75	115	mA	$V_{CANLshort} = 18 \text{ V}$, $t < t_{TXD_TO}$, $V_{TXD} = 0 \text{ V}$;	P_9.5.12
Leakage current CANH	I_{CANH_lk}	-5	-	5	µA	$V_{CC} = V_{BAT} = V_{IO} = 0 \text{ V}^3)$, $0 \text{ V} < V_{CANH} < 5 \text{ V}$; $V_{CANH} = V_{CANL}$;	P_9.5.14
Leakage current CANL	I_{CANL_lk}	-5	-	5	µA	$V_{CC} = V_{BAT} = V_{IO} = 0 \text{ V}^3)$, $0 \text{ V} < V_{CANL} < 5 \text{ V}$; $V_{CANH} = V_{CANL}$;	P_9.5.15

1) Not subject to production test, specified by design

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

3) Additional requirement $V_{IO} = V_{CC}$ connected via 47 kΩ to GND

9.6 Receiver

Table 15 Receiver

4.5 V < V_{CC} < 5.5 V; 3.0 V < V_{IO} < 5.5 V; 5.5V < V_{BAT} < 40V; $R_L = 60 \Omega$; $t_{Bit(min)} = 500 \text{ ns}$; $t_{Bit(Flash)} = 200 \text{ ns}$;
-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.			
Bus Receiver							
Common Mode Range	V_{CMR}	-12	-	12	V	-	P_9.6.1
Differential receiver threshold "dominant" Normal-operating Mode Receive-only Mode	V_{Diff_D}	-	-	0.9	V	V_{CMR} ;	P_9.6.2
Differential range "dominant" Normal-operating Mode Receive-only Mode	$V_{Diff_D_Range}$	0.9	-	8.0	V	V_{CMR}^1 ;	P_9.6.3

Electrical Characteristics

Table 15 Receiver (cont'd)

$4.5 \text{ V} < V_{CC} < 5.5 \text{ V}$; $3.0 \text{ V} < V_{IO} < 5.5 \text{ V}$; $5.5 \text{ V} < V_{BAT} < 40 \text{ V}$; $R_L = 60 \Omega$; $t_{Bit(min)} = 500 \text{ ns}$; $t_{Bit(Flash)} = 200 \text{ ns}$;
 $-40^\circ\text{C} < T_J < 150^\circ\text{C}$;

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.			
Differential receiver threshold "recessive" Normal-operating Mode Receive-only Mode	V_{Diff_R}	0.5	-	-	V	V_{CMR} ;	P_9.6.4
Differential range "recessive" Normal-operating Mode, Receive-only Mode	$V_{Diff_R_Range}$	-3.0	-	0.5	V	$V_{CMR}^{1)}$;	P_9.6.5
Differential receiver hysteresis Normal-operating Mode, Receive-only Mode	V_{Diff_Hys}	-	30	-	mV	$V_{CMR}^{1)}$;	P_9.6.6
Single ended internal resistance	R_{CAN_H}, R_{CAN_L}	6	-	50	kΩ	"recessive" state $-2 \text{ V} < V_{CANH} < 7 \text{ V}$;	P_9.6.7
Input resistance deviation between CANH and CANL	ΔR_i	-3.0	-	3.0	%	"recessive" state $V_{CANH} = V_{CANL} = 5 \text{ V}$;	P_9.6.8
Differential internal resistance	R_{Diff}	12	-	100	kΩ	"recessive" state $-2 \text{ V} < V_{CANH} < 7 \text{ V}$;	P_9.6.9
Input capacitance CANH, CANL versus GND	C_{In}	-	20	40	pF	¹⁾	P_9.6.10
Differential input capacitance	C_{InDiff}	-	10	20	pF	¹⁾	P_9.6.11

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

Electrical Characteristics

9.7 Dynamic Transceiver Parameter

Table 16 Propagation Delay

$4.5 \text{ V} < V_{CC} < 5.5 \text{ V}$; $3.0 \text{ V} < V_{IO} < 5.5 \text{ V}$; $5.5 \text{ V} < V_{BAT} < 40 \text{ V}$; $R_L = 60 \Omega$; $t_{Bit(min)} = 500 \text{ ns}$; $t_{Bit(Flash)} = 200 \text{ ns}$;
 $-40^\circ\text{C} < T_J < 150^\circ\text{C}$;

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.			
Propagation Delay Characteristic							
Propagation delay, TxD to RxD	t_{Loop}	80	175	255	ns	$C_L = 100 \text{ pF}$, $C_{RxD} = 15 \text{ pF}$; (see Figure 31)	P_9.7.1

Electrical Characteristics

Table 17 CAN FD

$4.5V < V_{CC} < 5.5V$; $3.0V < V_{IO} < 5.5V$; $5.5V < V_{BAT} < 40V$; $R_L = 60\Omega$; $t_{Bit(min)} = 500\text{ ns}$; $t_{Bit(Flash)} = 200\text{ ns}$; $-40^\circ C < T < 150^\circ C$;

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	$t_{Bit(RxD)_2M}$	400	500	550	ns	$C_L = 100\text{ pF}$, $C_{RxD} = 15\text{ pF}$, $t_{Bit} = 500\text{ ns}$; (see Figure 32);	P_9.7.6
Received recessive bit width at 5 MBit/s	$t_{Bit(RxD)_5M}$	120	200	220	ns	$C_L = 100\text{ pF}$, $C_{RxD} = 15\text{ pF}$, $t_{Bit} = 200\text{ ns}$; (see Figure 32);	P_9.7.7
Transmitted recessive bit width at 2 MBit/s	$t_{Bit(Bus)_2M}$	435	500	530	ns	$C_L = 100\text{ pF}$, $C_{RxD} = 15\text{ pF}$, $t_{Bit} = 500\text{ ns}$; (see Figure 32);	P_9.7.8
Transmitted recessive bit width at 5 MBit/s	$t_{Bit(Bus)_5M}$	155	200	210	ns	$C_L = 100\text{ pF}$, $C_{RxD} = 15\text{ pF}$, $t_{Bit} = 200\text{ ns}$; (see Figure 32);	P_9.7.9
Receiver timing symmetry at 2 MBit/s $\Delta t_{Rec_2M} = t_{Bit(RxD)_2M} - t_{Bit(Bus)_2M}$	Δt_{Rec_2M}	-65		40	ns	$C_L = 100\text{ pF}$, $C_{RxD} = 15\text{ pF}$, $t_{Bit} = 500\text{ ns}$; (see Figure 32);	P_9.7.10
Receiver timing symmetry at 5 MBit/s $\Delta t_{Rec_5M} = t_{Bit(RxD)_5M} - t_{Bit(Bus)_5M}$	Δt_{Rec_5M}	-45		15	ns	$C_L = 100\text{ pF}$, $C_{RxD} = 15\text{ pF}$, $t_{Bit} = 200\text{ ns}$; (see Figure 32);	P_9.7.11

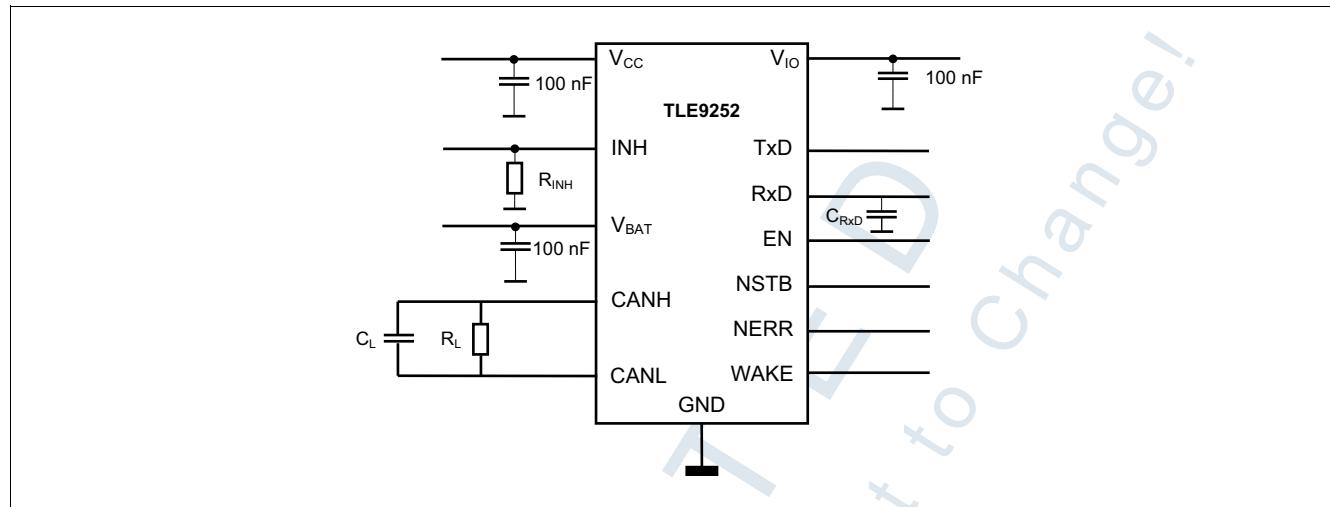


Figure 30 Test Circuit for dynamic characteristics

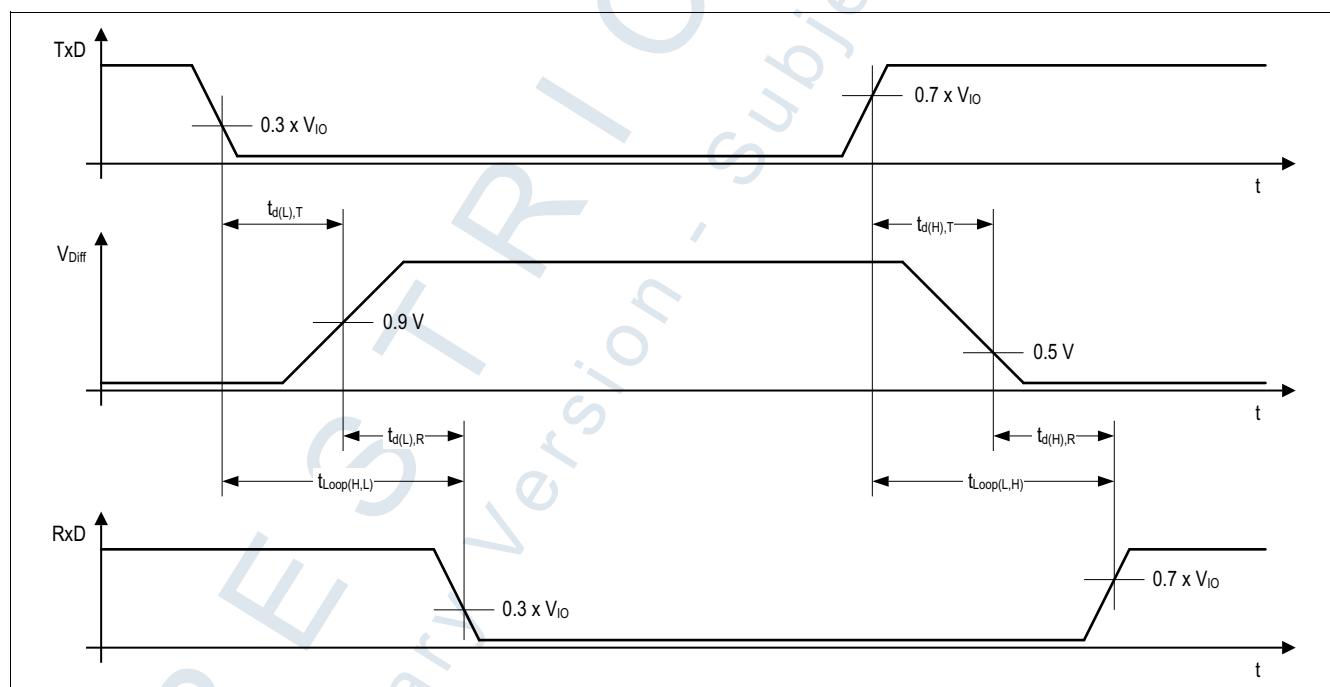


Figure 31 Timing diagrams for dynamic characteristics

Electrical Characteristics

Preliminary Version - Subject to Change!

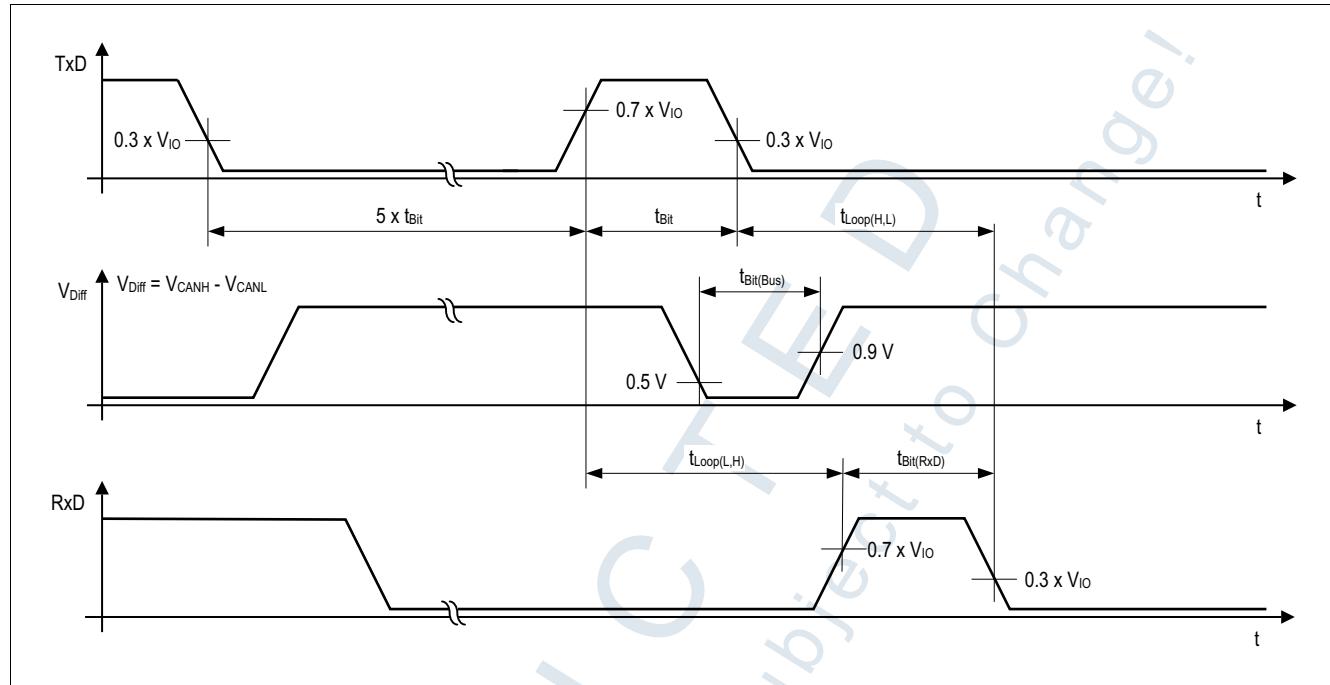


Figure 32 Recessive bit time for five “dominant” bits followed by one “recessive” bit

Electrical Characteristics

9.8 Wake Up

9.8.1 General Wake-up Timings

Table 18 General Wake-up Timings

$4.5 \text{ V} < V_{CC} < 5.5 \text{ V}$; $3.0 \text{ V} < V_{IO} < 5.5 \text{ V}$; $5.5 \text{ V} < V_{BAT} < 40 \text{ V}$; $R_L = 60 \Omega$; $-40^\circ\text{C} < T_J < 150^\circ\text{C}$;
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.			
INH wake-up delay time	t_{WU_INH}	–	–	30.0	μs	$V_{BAT} = 14.0 \text{ V}$, $R_{INH} = 100 \text{ k}\Omega$; see Figure 33	P_9.8.1
Bias reaction time	t_{WU_Bias}	–	–	100	μs	see Figure 33	P_9.8.2

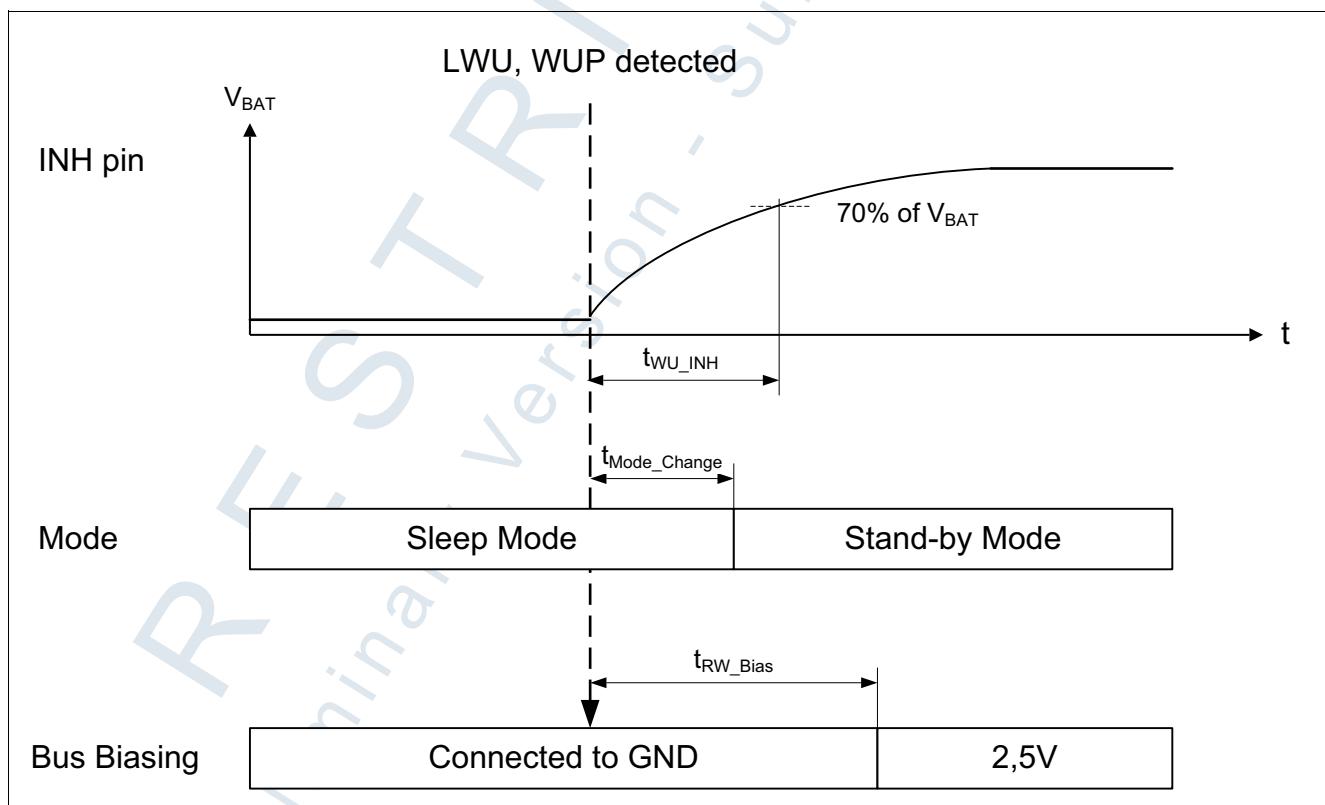


Figure 33 Wake-up detection

9.8.2 WUP detection Characteristics

Electrical Characteristics

Table 19 WUP detection

4.75 V < V_{CC} < 5.25 V; 3.0 V < V_{IO} < 5.5 V; 5.5V < V_{BAT} < 40V; $R_L = 60 \Omega$; -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.			
Differential range “dominant” low power modes	$V_{Diff_D_SLP_Ra}\nge$	1.15	-	8.0	V	$V_{CMR}^{(1)}$	P_9.8.4
Differential input threshold “dominant” low power modes	$V_{Diff_D_SLP}$	-	-	1.15	V	V_{CMR}	P_9.8.5
Differential range “recessive” low power modes	$V_{Diff_R_SLP_Ra}\nge$	-3.0	-	0.4	V	$V_{CMR}^{(1)}$	P_9.8.6
Differential input threshold “recessive” low power modes	$V_{Diff_R_SLP}$	0.4	-	-	V	V_{CMR}	P_9.8.7
CAN activity filter time	t_{Filter}	0.5	-	1.8	μs	Figure 14	P_9.8.9
Bus wake-up timeout	t_{WAKE}	0.8	-	10.0	ms	Figure 14	P_9.8.10
Bus wake-up delay time	t_{WU}	-	-	5.0	μs	Stand-by Mode, Figure 14	P_9.8.11

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

9.8.3 Local Wake Up

Table 20 Local Wake Up

4.75 V < V_{CC} < 5.5 V; 3.0 V < V_{IO} < 5.5 V; 5.5V < V_{BAT} < 40V; $R_L = 60 \Omega$; -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.			
Local wake-up detection threshold	V_{WAKE_TH}	0.35 x V_{BAT}	0.5 x V_{BAT}	0.65x V_{BAT}	V	5.5V < V_{BAT} < 32V	P_9.8.12
Local wake-up detection threshold	V_{WAKE_TH}	0.25 x V_{BAT}	0.5 x V_{BAT}	0.75 x V_{BAT}	V	32V < V_{BAT} < 40V	P_9.8.13
“high” level input current (pull-up)	I_{WAKE_H}	-20	-9	-2	μA		P_9.8.15
“low” level input current (pull-down)	I_{WAKE_L}	2	9	20	μA		P_9.8.16
Wake pulse filter time	t_{WAKE_Filter}	10	25	70	μs	Figure 15	P_9.8.17

Application Information

10 Application Information

10.1 ESD Robustness according to IEC61000-4-2

Tests 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 21 ESD robustness according to IEC61000-4-2

Performed Test	Result	Unit	Remarks
Electrostatic discharge voltage at pin CANH and CANL, V_{BAT} , WAKE versus GND	$\geq +8$	kV	¹⁾ Positive pulse
Electrostatic discharge voltage at pin CANH and CANL, V_{BAT} , WAKE versus GND	≤ -8	kV	¹⁾ 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).

10.2 Voltage Adaption to the Microcontroller Supply

To adapt the digital input and output levels of the TLE9252VSK to the I/O levels of the microcontroller, connect the power supply pin V_{IO} to the microcontroller voltage supply (see [Figure 34](#)).

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} .

Application Information

10.3 Application Example

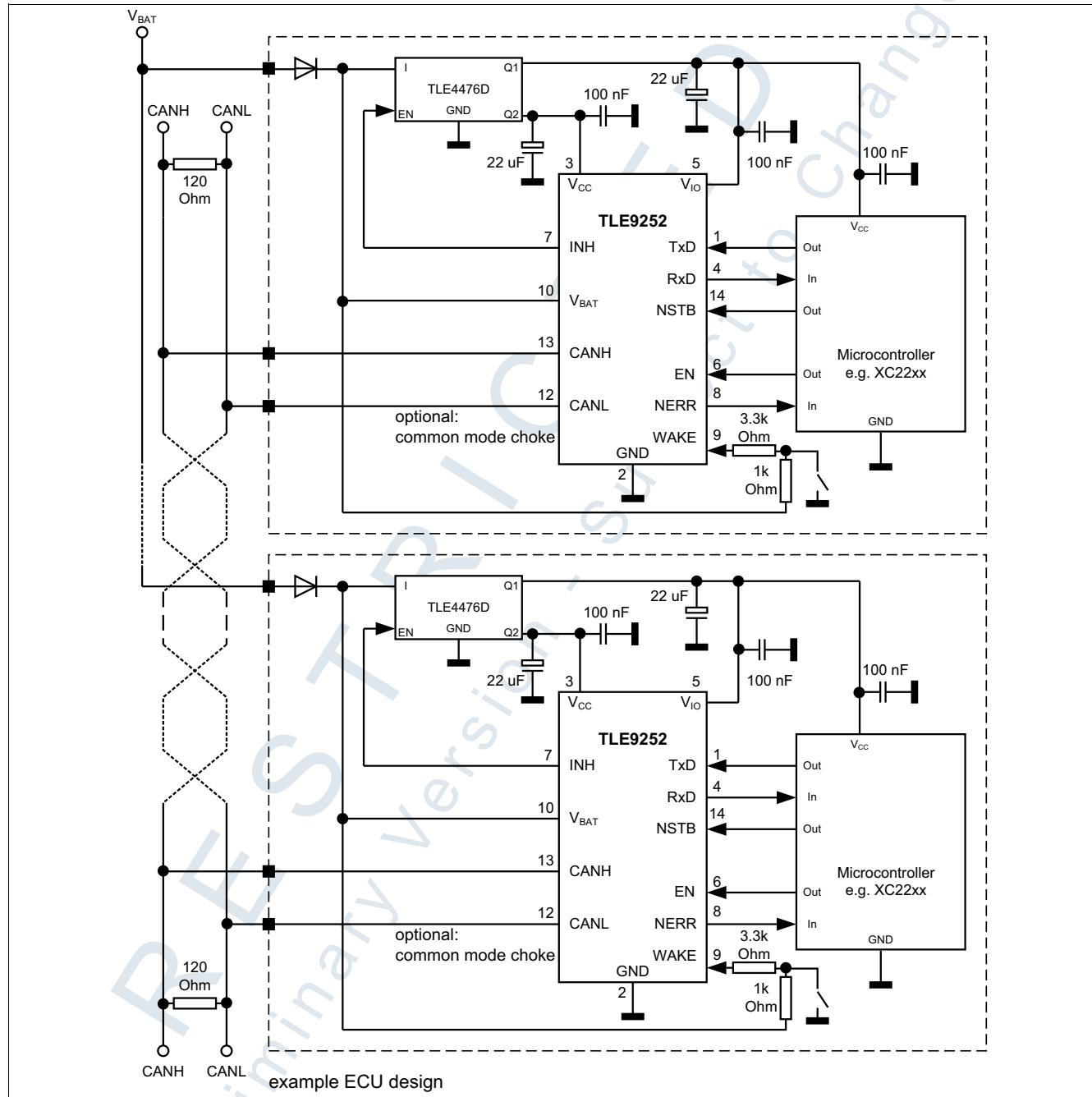


Figure 34 Application circuit

10.4 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/>

RESTRICTED
Preliminary Version - Subject to Change!

Package Outline

11 Package Outline

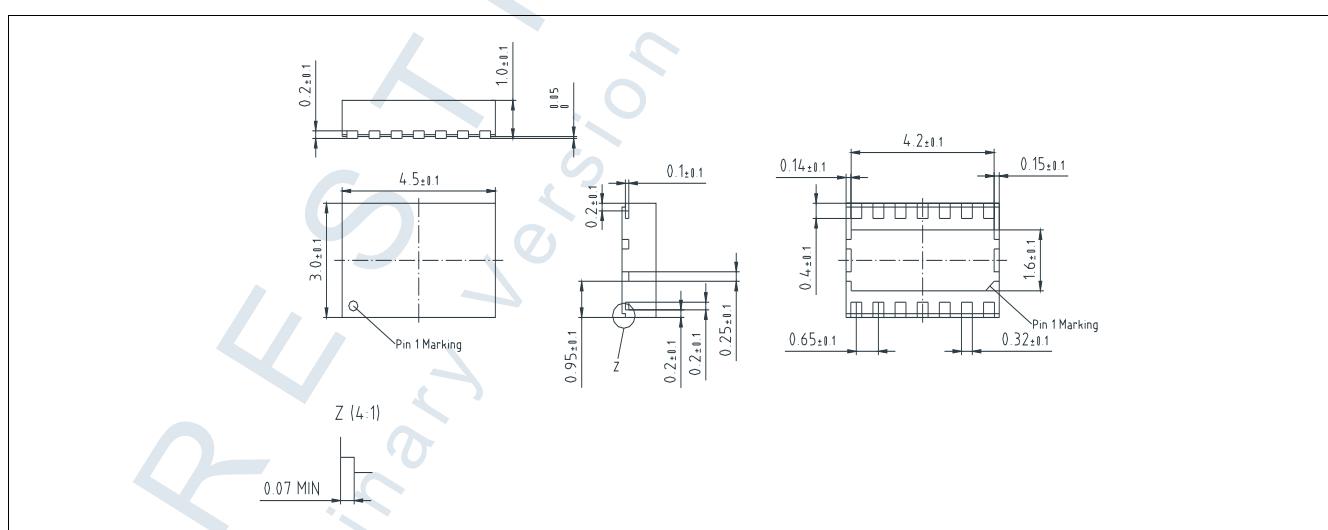
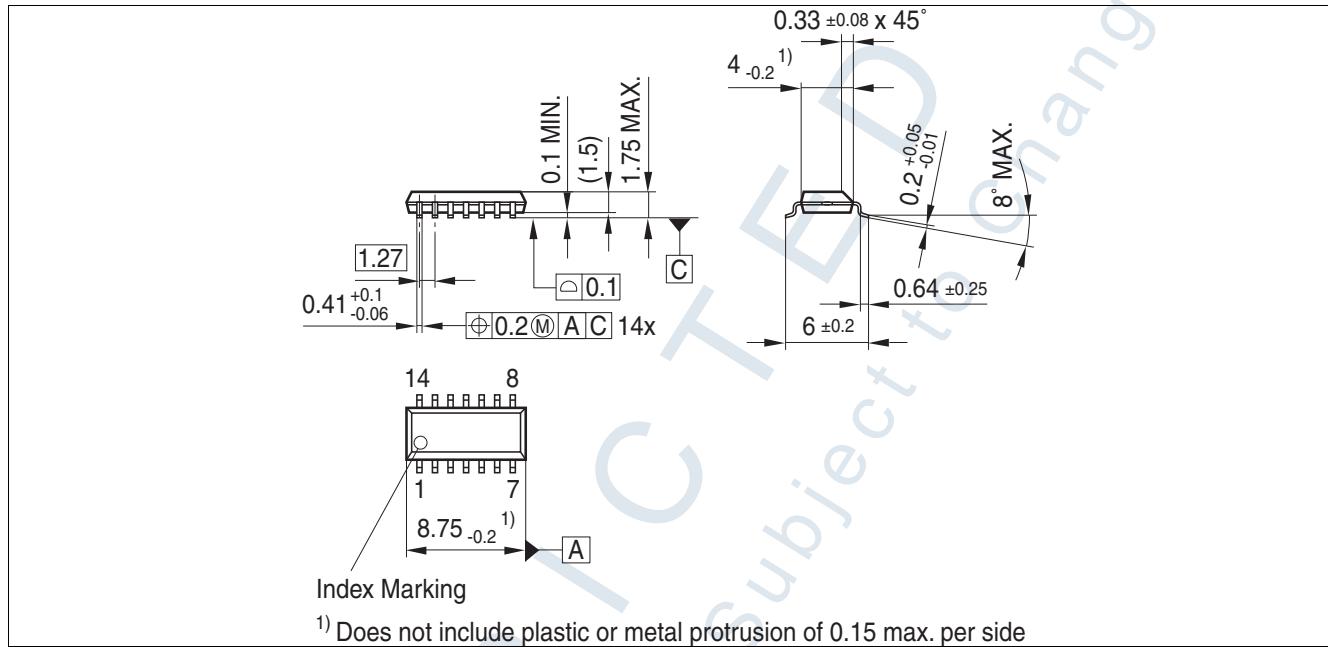


Figure 36 PG-TSON-14

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).

For further information on alternative packages, please visit our website:

<http://www.infineon.com/packages>.

Dimensions in mm

Revision History

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12 Revision History

Revision	Date	Changes
0.72	2016-02-06	Target Data Sheet updated
0.71	2016-01-17	Target Data Sheet updated according to ISO11898-2:2016
0.6	2016-10-28	<ul style="list-style-type: none">TSON drawing replaced (Figure 36)Modification of V_{BAT_POD} minimum from 3V to 4V.Modified Local Wake-up threshold specification P_9.8.12 & P_9.8.13
0.1	2016-05-02	Target Data Sheet created.

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Last Trademarks Update 2011-11-11

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