TLE9250xx

Z8F57889423

Family overview   Support

Preface

Scope and purpose

This document provides application information for the transceiver TLE9250xx from Infineon Technologies AG as physical medium attachment within a Controller Area Network (CAN).

This document contains information about:

- Detailed TLE9250xx pin description, see ***Pin description***
- Power supply concepts, see ***Transceiver supply***
- Current consumption aspects, see ***Current consumption***
- Mode control hints, see ***Mode control***
- Quiescent current savings, see ***Mode control***

This document refers to the datasheet of the Infineon Technologies AG CAN transceiver TLE9250xx.

Note: The following information is given as a hint for the implementation of our devices only and shall not be regarded as a description or warranty of a certain functionality, condition or quality of the device.

Intended audience

This document is intended for engineers who develop applications.

For further information or further support please refer to ***Infineon Support Webpage***.

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1 Pin description

1.1 V_{CC} pin

The V_{CC} pin supplies the transmitter output stage. Place a 100 nF capacitor directly at V_{CC} pin to ground.

Table 1 Transmitter state depending on V_{CC}

V_{CC}	Transmitter state	Note
$V_{CC} < V_{CC\_UV}$	Disabled	3.8 V < V_{CC_UV} < 4.3 V
$V_{CC\_UV} < V_{CC}$ < 4.5 V	Enabled; parameters may be outside the specified range	–
4.5 V < V_{CC} < 5.5 V	Enabled	–
5.5 V < V_{CC} < 6 V	Enabled; parameters may be outside the specified range	–
V_{CC} > 6 V	Damage of TLE9250xx possible	–

1.2 GND pin

The GND pin must be connected as close as possible to module ground in order to reduce ground shift. It is not recommended to place filter elements or an additional resistor between GND pin and module ground. Use the same GND for transceiver, microcontroller and the HS CAN bus system.

1.3 RxD pin

RxD is an output pin. In normal-operating mode the device displays the data stream received from the HS CAN bus on the RxD output pin. Do not use a series resistor within the RxD line between transceiver and microcontroller. A series resistor may add delay, which has impact on the timing symmetry and delay timings, especially in high data rate applications with CAN FD.

1.4 TxD pin

TxD is an input pin. The TxD pin receives the data stream from the microcontroller. If in normal-operating mode $V_{CC} > V_{CC\_UV}$, the device transmits the data stream to the HS CAN bus. In all other modes the TxD input pin is blocked. A "low" signal causes a dominant state on the bus and a "high" signal causes a recessive state on the bus. The TxD input pin has an integrated pull-up resistor to V_{CC}. If TxD is permanently "low", for example due to a short circuit to GND, then the TxD time-out feature blocks the signal on the TxD input pin. Do not use a series resistor within the TxD line between transceiver and microcontroller. A series resistor may add delay, which degrades the performance of the transceiver, especially in high data rate applications.

1.5 NEN and NRM pins

The NEN pin and the NRM set the mode of TLE9250xx. NEN and NRM are usually directly connected to output ports of a microcontroller. If these mode pins are not connected and TLE9250xx is supplied by V_{CC}, the device enters the power-save mode due to the internal pull-up resistor to V_{CC} on NEN and NRM. ***Table 2*** shows mode changes via the NEN and NRM pins, assuming $V_{IO} > V_{IO\_UV}$. ***Table 2*** on page 4 describes features and modes of operation.

Table 2 **Mode selection via NEN and NRM**

Mode of operation	NEN	NRM	V_{CC}	Receiver	Transmitter
Power-save mode	"high"	"X"[1]	"X"	Disabled	Disabled
Receive-only mode	"low"	"low"	"X"	Enabled	Disabled
Normal-operating mode	"low"	"high"	> V_{CC_UV}	Enabled	Enabled

Power-save mode is the low-power mode of TLE9250xx. In power-save mode both the transmitter and the receiver are disabled and current consumption is reduced to a minimum.

The user can deactivate the transmitter of TLE9250xx in the following ways:

- Set NEN pin to "high"
- Set NRM pin to "low"

This can be used to implement two different fail safe paths.

For disconnected mode pins or microcontroller ports in tristate the TLE9250xx has an integrated pull-up resistor to V_{CC}. For minimum current consumption the device is in power-save mode by default.

1.5.1 NRM pin not connected

If an application does not use the receive-only mode, then the NRM input pin can be left unconnected. The internal pull-up resistor to V_{CC} then sets the NRM signal to "high". Depending on the input signal on the NEN pin the device enters either power-save mode or normal-operating mode, see *Table 2*.

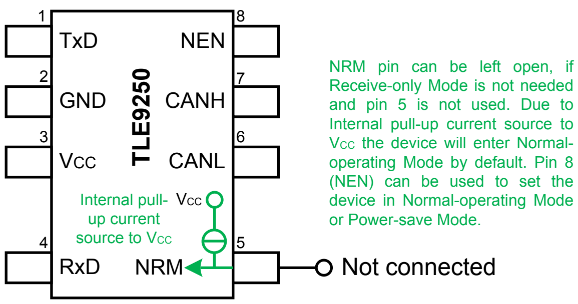

Figure 1 **NRM pin not connected**

1.5.2 Secondary safety path option

With the mode pins NEN and NRM of TLE9250xx , safety relevant applications can implement separate input signal paths from:

- The host microcontroller, for example ***AURIX™ 32 bit multicore microcontroller***
- A safety system supply, for example TLF35584, which monitors the host microcontroller

If the host microcontroller is damaged or running out of control, then the safety watchdog or safety system supply can deactivate the transmitter of the transceiver: Setting the NRM pin to "low"puts the TLE9250xx in the receive-only mode. This feature can be used in order to prevent the host microcontroller from sending corrupted messages to the CAN bus and to block the communication on the CAN bus. A possible scenario is for example a babbling idiot.

1 "X": not relevant.

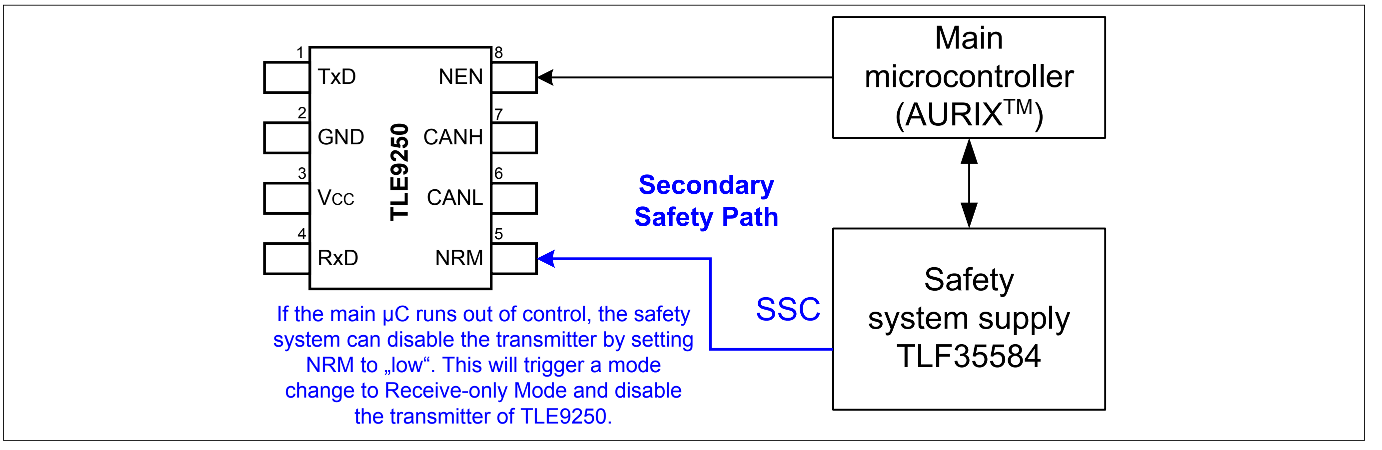

Figure 2 Example application with AURIX™ 32 bit multicore microcontroller and safety system supply TLF35584

1.6 CANH and CANL pins

CANH and CANL are the CAN bus input and output pins. The TLE9250xx is connected to the bus via pin CANH and CANL. Both transmitter output stage and the receiver are connected to CANH and CANL.

Data on the TxD pin is

- Transmitted to CANH and CANL
- Simultaneously received by the receiver input and signalled on the RxD output pin

To achieve optimum electromagnetic emission performance, transitions from dominant to recessive and from recessive to dominant are performed as smooth as possible also at high data rate. Due to the excellent ESD robustness on CANH and CANL no external ESD components are necessary to fulfill OEM requirements.

ESD robustness:

- HBM (Human Body Model): ±8 kV
- IEC 61000-4-2 Gun Test: ±11 kV, see EMC Test Report Nr. 01-07-2017 and Nr. 06-08-2017

2 Transceiver supply

The V_{CC} pin supplies the internal logic of the TLE9250xx. The V_{CC} pin 5 V supply is used to create the CANH and CANL signal. The V_{CC} pin supplies the transmitter output stage as well. The V_{IO} pin supplies the receiver. This chapter describes aspects of power consumption and voltage supply concepts of TLE9250xx.

2.1 Voltage regulator

It is recommended to use one of the following Infineon low drop output voltage regulators:

- 5 V V_{CC} power supply: TLS850D0TAV50 (500 mA), ***TLS850F0TA V50*** (500 mA), ***TLS810D1EJ V50*** (100 mA), ***TLS810B1LD V50*** (100 mA), ***TLE4266-2*** (150 mA)
- Dual 5 V voltage power supply: ***TLE4473G V55***

Refer to ***Infineon Linear Voltage Regulators*** for voltage regulator portfolio, data sheets and app notes.

2.2 External circuitry on V_{CC}

In order to reduce electromagnetic emission and to improve the stability of the input voltage level on V_{CC} of the transceiver, it is recommended to place capacitors on the PCB. During sending a dominant bit to the HS CAN bus, the current consumption of TLE9250xx is higher than during sending a recessive bit. Data transmission changes the load profile on V_{CC}, which may reduce the load regulation of V_{CC}. If several CAN transceivers are connected in parallel and are supplied by the same V_{CC} power supply, for example from a LDO, then the impact on the load regulation of V_{CC} is even stronger. It is required to place a 100 nF capacitor directly at V_{CC} pin to ground. Without 100 nF decoupling capacitance higher electromagnetic emission has to be expected. Ceramic capacitors are recommended due to their low ESR. The output of the V_{CC} power supply has to be stabilized by a capacitor in the range of 1 to 50 µF, depending on the load profile.

2.3 V_{CC} (5 V) power supply concept

The TLE9250xx offers a V_{CC} input pin, which supplies the internal logic and the transmitter. V_{CC} must be connected to a 5 V voltage supply. Also the microcontroller must be supplied with 5 V in order to adapt the digital signals and output levels of the microcontroller to the transceiver. A single voltage regulator can supply both the transceiver and the microcontroller. It is possible to use two separate 5 V voltage regulators. If other components are connected to the 5 V voltage regulator that cause noise and transients on the V_{CC} voltage output of the voltage regulator, two separate 5 V voltage regulators are recommended. Transients disturb the HS CAN signal and may also increase electromagnetic emission.

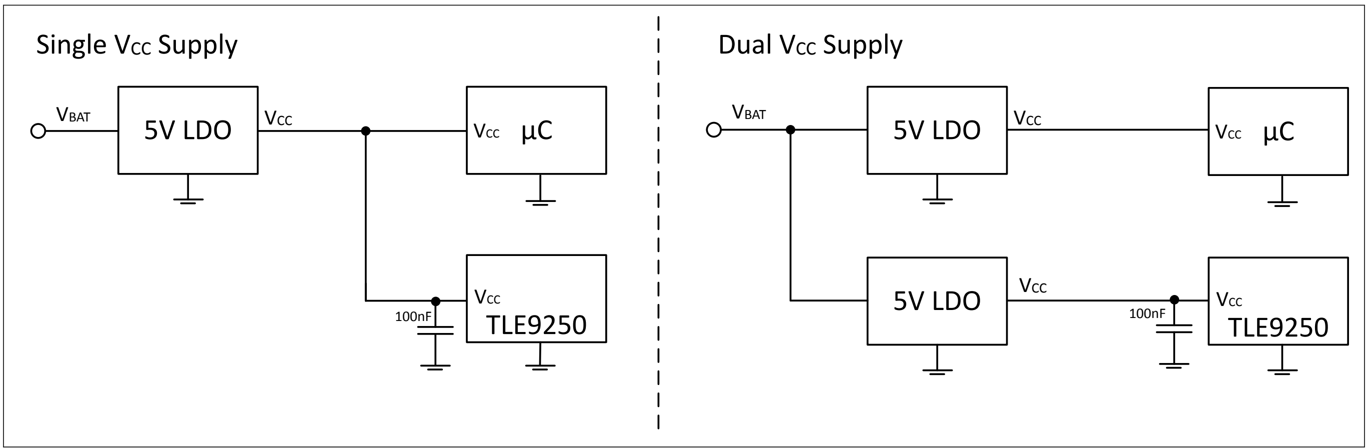

Figure 3 Single and dual V_{CC} (5 V) power supply for TLE9250xx

2.4 Current consumption

Current consumption depends on the mode of operation.

Normal-operating mode

Maximum current consumption of TLE9250xx on the V_{CC} supply is specified as 60 mA in dominant state and 4 mA in recessive state. To estimate theoretical current consumption in normal-operating mode, a duty cycle of 50% can be assumed, with fully loaded bus communication of 50% dominant state and 50% recessive state. In normal-operating mode the TLE9250xx consumes worst case maximum:

$$I_{CC\_AVG} = \frac{I_{CC\_REC} + I_{CC\_DOM}}{2} = 32.75\ \text{mA}$$

Equation 1

Typically the current consumption is less than 15 mA.

Receive-only mode and forced receive-only mode

In receive-only mode the TLE9250xx has a worst case maximum current consumption of I_{ROM} = 1.5 mA. Typically the current consumption is less than 800 µA.

Power-save mode and forced-power-save mode

In power-save mode most of the functions are turned off. V_{CC} can be switched off. The maximum current consumption is specified as 20 µA.

2.5 Loss of battery (transceiver unsupplied)

When TLE9250xx is unsupplied, CANH and CANL act as high impedance. The leakage current $I_{CANH,lk}$, $I_{CANL,lk}$ at CANH pin or CANL pin is limited to ±5 µA in worst case. When unsupplied, theTLE9250xx behaves like a 1 MΩ resistor towards the bus. Therefore the device perfectly fits applications that use both clamp 15 and clamp 30.

2.6 Loss of ground

If loss of ground occurs, the transceiver is unsupplied and behaves like in unpowered state. In applications with inductive load connected to the same GND, for example a motor, loss of ground can damage the transceiver. Excessive current can flow through the CAN transceiver when the inductor demagnetizes after loss of ground. The ESD structure of the transceiver cannot withstand that kind of electrical overstress (EOS). In order to protect the transceiver and other components of the module, an inductive load must be equipped with a free wheeling diode.

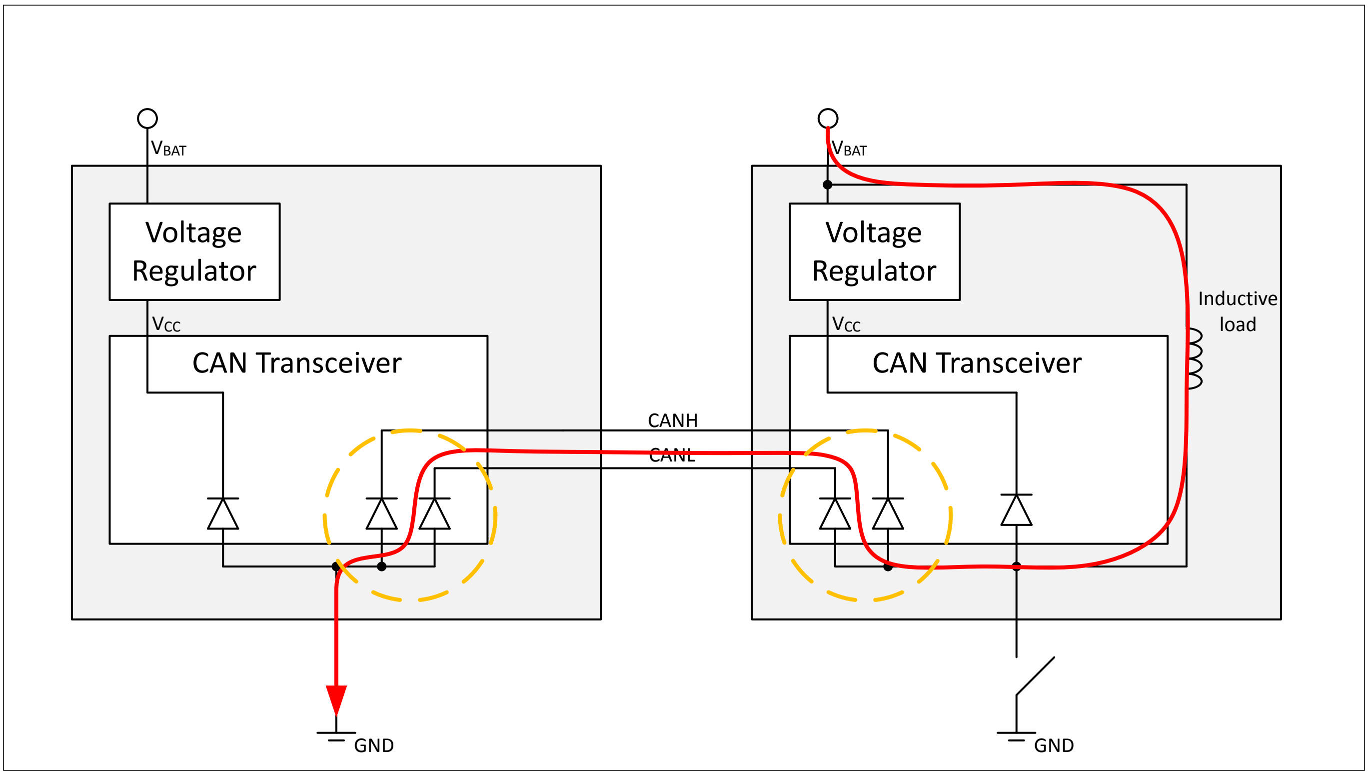

Figure 4 **Loss of ground with inductive load**

2.7 Ground shift

Due to ground shift the GND levels of CAN transceivers within a network may vary. Ground shift occurs in high current applications or in modules with long GND wires. Because the transmitting node has its GND shifted to V_{Shift}, the recessive voltage level V_{rec} from the chassis ground is no longer 2.5 V but V_{rec} + V_{shift}. The same ground shift voltage V_{Shift} must be taken into account for the dominant signal. Because CAN uses a differential signal and because of the wide common mode range of ±12 V for Infineon transceivers, any CANH and CANL DC works. Only the difference voltage (CAN_H - CAN_L) is relevant for the receiver. ***Figure 5*** shows a typical CAN signal with a DC ground shift of +2V.

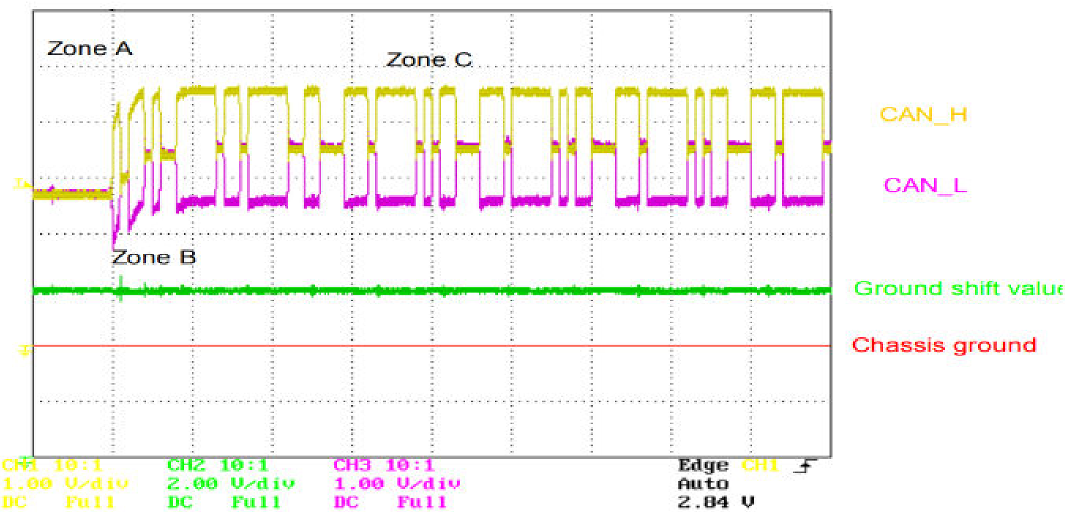

Figure 5 **DC ground shift signal**

Zone A : Shows the recessive voltage of the system, close to the nominal recessive value of 2.5 V. Zone B : When the transmitter starts to communicate the signal rises quickly. Zone C : The communication is stabilized, and the recessive voltage reaches the value, as computed on equation below. The recessive CAN bus level V_{rec} during a ground shifted node transmitting is equal to the average recessive voltage level of all transceivers:

$$V_{rec} = \frac{V_{rec\_1} + V_{Shift\_1} + V_{rec\_2} + V_{Shift\_2} + V_{rec\_3} + V_{Shift\_3} + \dots + \dots + V_{rec\_n} + V_{Shift\_n}}{n}$$

Equation 2

n: number of connected CAN nodes

V_{rec_1}, V_{rec_2}, .., V_{rec_n}: specific recessive voltage level of the transceiver at nodes 1, 2, .. n

V_{Shift_1}, V_{Shift_2}, ..., V_{Shift_n}: specific ground shift voltage level of the transceiver at nodes 1, 2, .. n

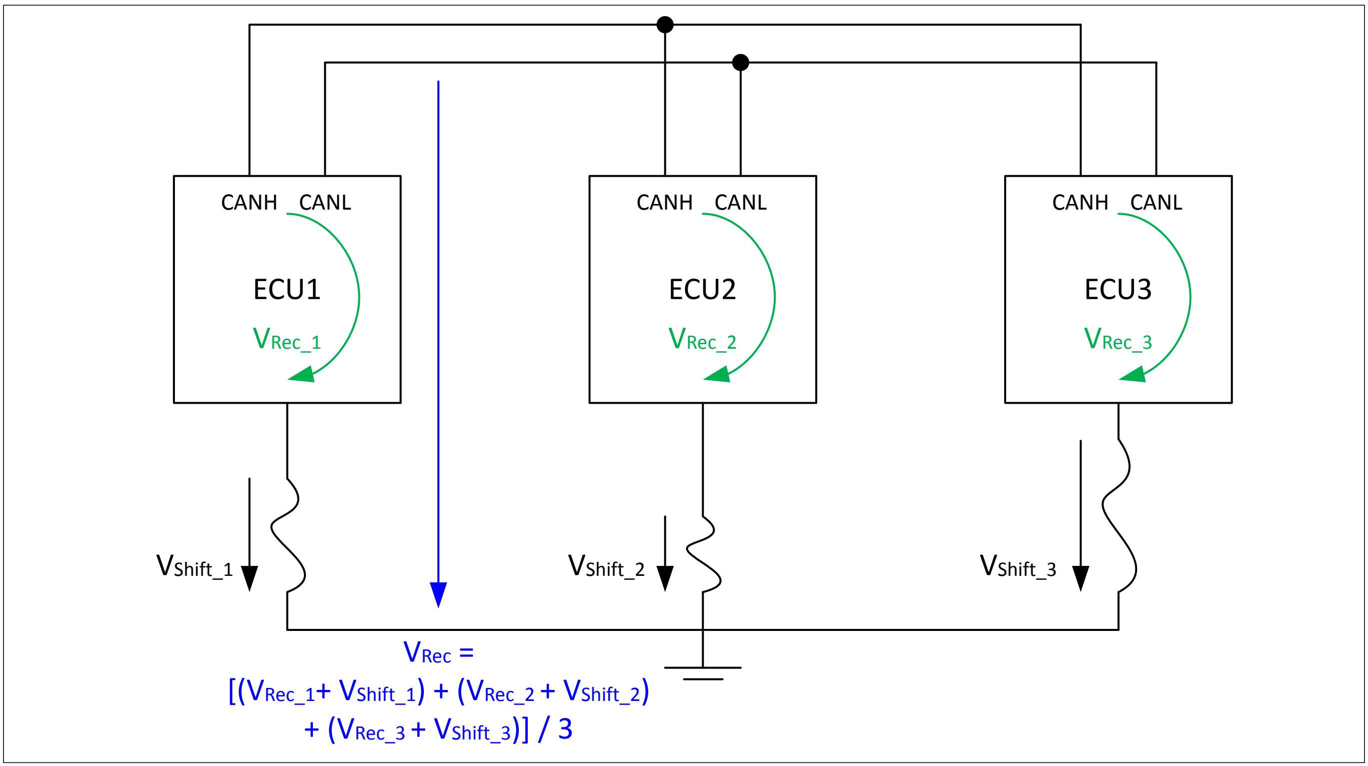

Figure 6 **Ground shift on three nodes (system view)**

3 Mode control

The modes of the TLE9250xx are controlled by the pinsNEN, NRM.

3.1 Mode change by NEN, NRM

The mode selection pins NEN, NRM set the mode of operation. By default the NRM input pin and the NEN input pin are "high" due to the internal pull-up current source to V_{CC}.

The TLE9250xx is in power-save mode independent of the status of NRM. In order to change the mode to receive-only mode, NEN and NRM must be switched to "low". In order to change the mode to normal-operating mode, NEN must be switched to "low" and NRM must be "high".

3.2 Mode change delay

The HS CAN transceiver TLE9250xx changes the mode of operation within the transition time period t_{Mode}. The transition time period t_{Mode} must be considered in developing software for the application. During the mode change from power-save mode to a non-low power mode the receiver and transmitter is enabled,. During the period t_{Mode} the RxD output pin is set to "high" and does not reflect the status on the CANH and CANL input pins. In addition, during t_{Mode}, the TxD path is blocked as well. When the mode change is completed, the TLE9250xx releases the RxD output pin. ***Figure 7*** shows this scenario.

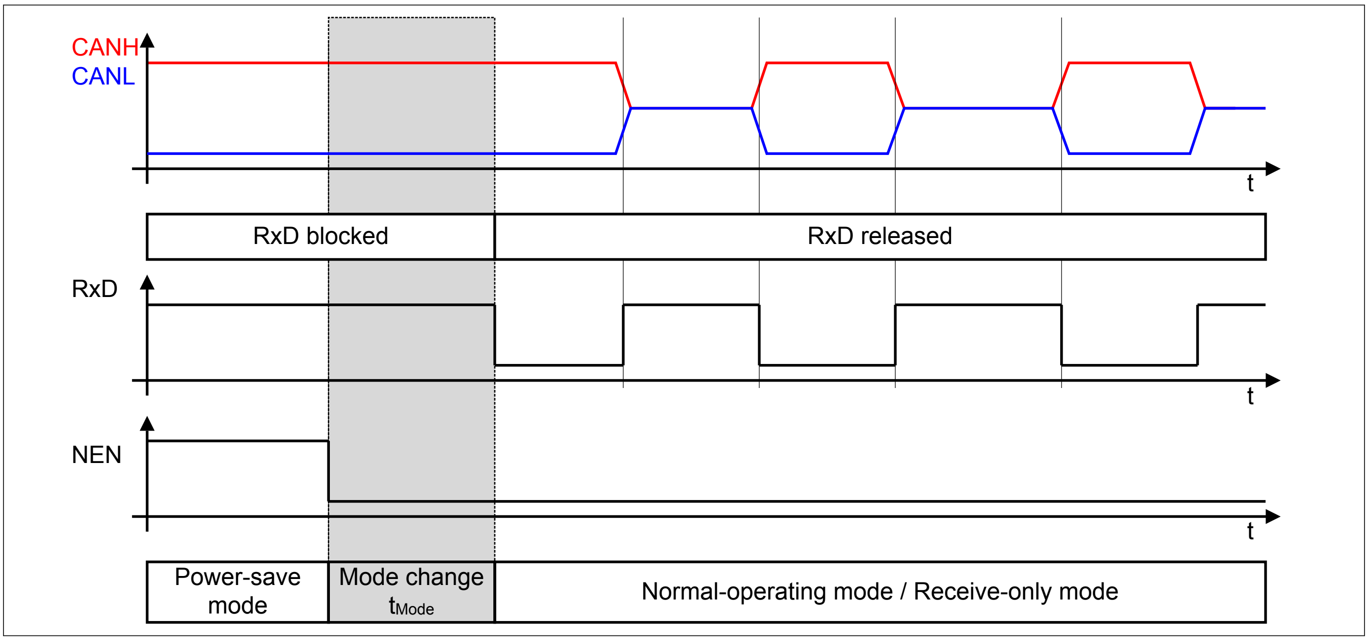

Figure 7 RxD behavior during mode change

The RxD output pin is not blocked nor set to "high" during the following mode changes:

- Normal-operating mode → receive-only mode
- Receive-only mode → normal-operating mode

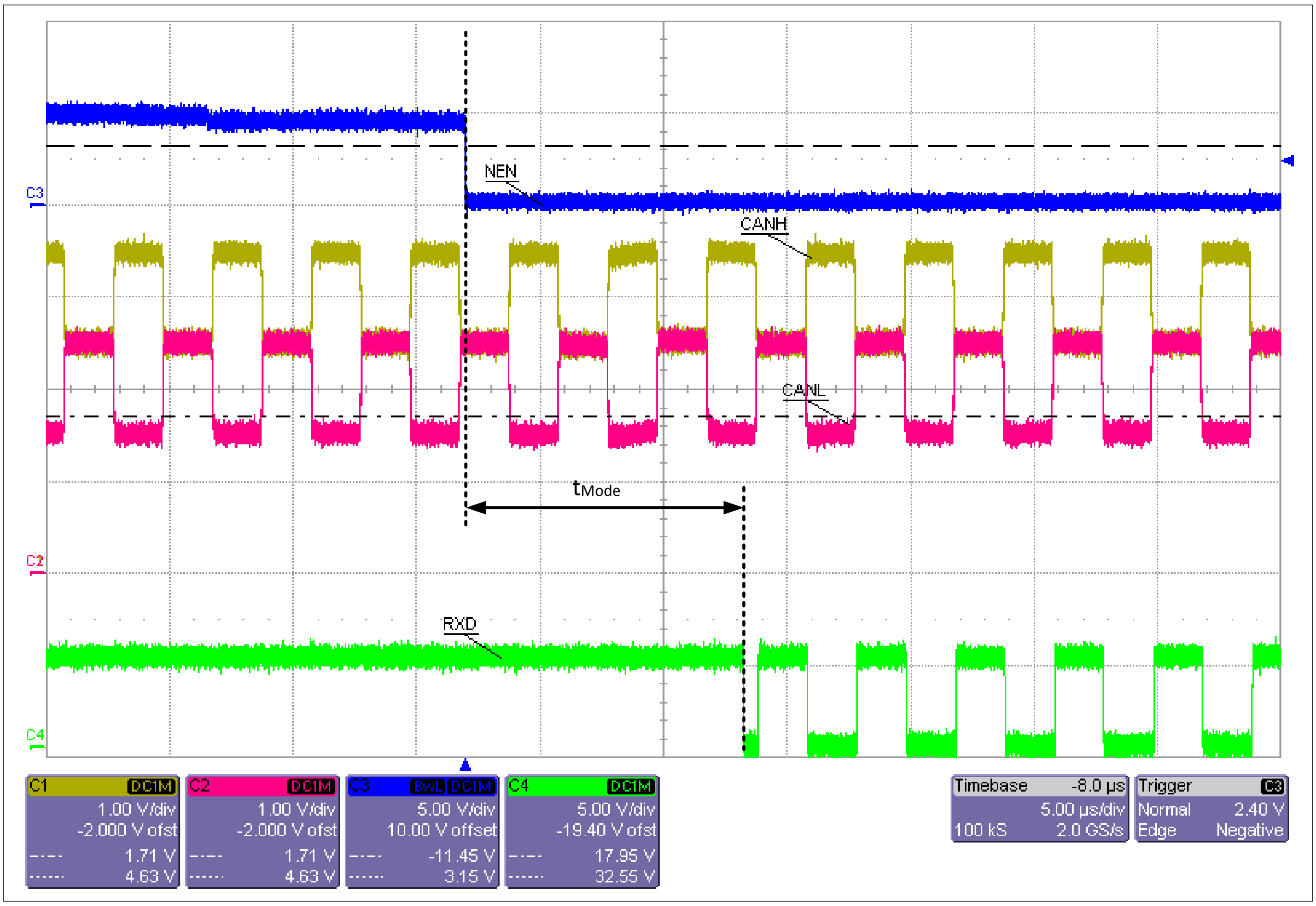

Figure 8 **Communication on the CAN bus: RxD behavior during mode change (power-save mode to normal-operating mode (NRM = "high"))**

In low-power mode the bus biasing is connected to GND. In normal-operating mode the bus biasing is connected to $V_{CC}/2$. When changing the mode of operation from low-power mode to normal-operating mode the bus biasing is changed from GND to $V_{CC}/2$. ***Figure 9*** shows an example measurement in a network when the bus biasing is enabled.

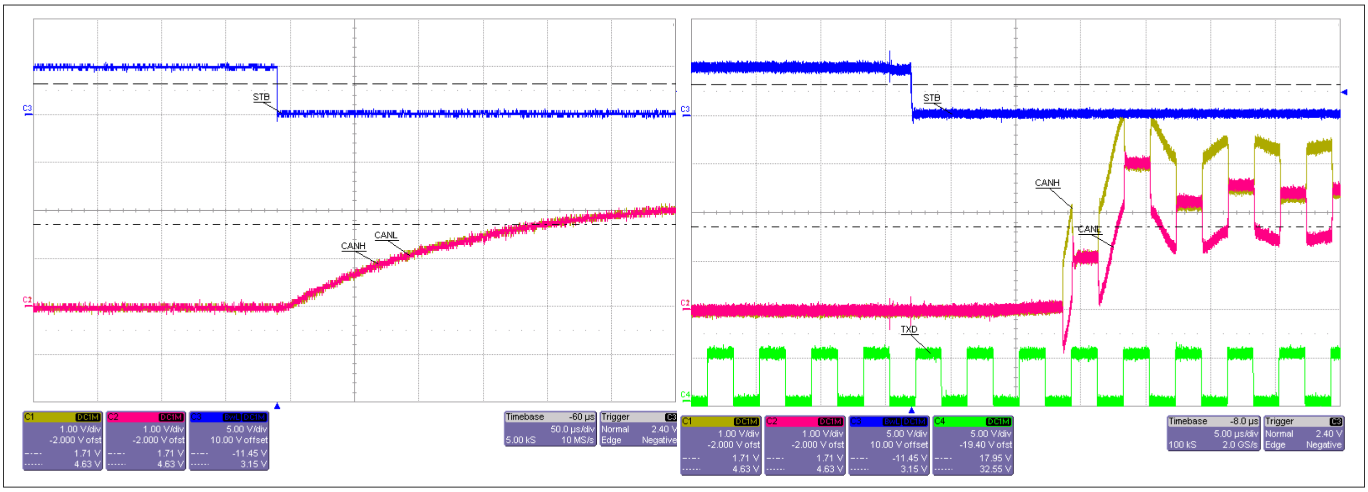

Figure 9 **Mode change low-power mode to normal-operating mode: bus biasing enabled**

4 Terms and abbreviations

Table 3 Terms and abbreviations

CMC	Common mode choke
EMC	Electromagnetic compatibility
EME	Electromagnetic emission
EMI	Electromagnetic interference
EOS	Electrical overstress
ESD	Electrostatic discharge
ESR	Equivalent Series Resistance
"high"	Logical high
"low"	Logical low
WUP	Wake-up pattern

Revision history

Revision	Date	Changes
1.41	2021-02-17	Editorial changes
1.4	2020-07-27	Editorial changes
1.3	2019-03-26	• Editorial changes
1.2	2018-07-13	• Editorial changes
1.1	2018-01-15	Added description for pin behavior assessment: • RxD short circuit to NRM • NRM short circuit to CANL • RxD short circuit to N.C. • N.C. short circuit to GND, V_{CC}, CANL Changed description for RxD short circuit to V_{CC} Rename pin FMEA to pin behavior assessment
1.0	2017-08-04	Document created

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