TLE9251xx

Z8F68005268

Family overview Support

Preface

Scope and purpose

This document provides application information for the transceiver TLE9251xx from Infineon Technologies AG as physical medium attachment within a Controller Area Network (CAN).

This document contains information about:

- Detailed TLE9251xx pin description, see ***Pin description***
- Power supply concepts, see ***Transceiver supply***
- Current consumption in stand-by mode, 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 TLE9251xx.

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 TLE9251xx 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 STB pin

The STB pin sets the mode of TLE9251xx and is usually directly connected to an output port of a microcontroller. If the mode pin is not connected and TLE9251xx is supplied by V_{CC}, then the device enters stand-by mode due to the internal pull-up resistor to V_{CC}. The purpose of the stand-by mode is to reduce current consumption, while the TLE9251xx can detect a bus wake-up. To put the device into normal-operating mode, the STB pin must be set to "low". ***Table 2*** shows mode changes by the STB pin, assuming $V_{CC} > V_{CC\_UV}$.

Table 2 Mode selection by STB

Mode of operation	STB	V_{CC}	Note	Low-power Receiver	Receiver	Transmitter
Stand-by mode	"high"	> V_{CC_U} V	TLE9251xx monitors the bus for a valid wake-up pattern and indicates wake-up detection on the RxD output pin.	Enabled	Disabled	Disabled
Normal-operating mode	"low"	> V_{CC_U} V	–	Disabled	Enabled	Enabled

1.6 CANH and CANL pins

CANH and CANL are the CAN bus input and output pins. The TLE9251xx 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

1.7 N.C. pin

The N.C. pin has no function. Leave it open or connect it to ground.

2 Transceiver supply

The V_{CC} pin supplies the internal logic of the TLE9251xx. 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 TLE9251xx.

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 TLE9251xx 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 Current consumption

Current consumption depends on the mode of operation.

Normal-operating mode

Maximum current consumption of TLE9251xx on the V_{CC} supply is specified as 60 mA in dominant state and 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 TLE9251xx 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.

2.4 Loss of battery (transceiver unsupplied)

When TLE9251xx 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, theTLE9251xx behaves like a 1 MΩ resistor towards the bus. Therefore the device perfectly fits applications that use both clamp 15 and clamp 30.

2.5 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.

Transceiver supply

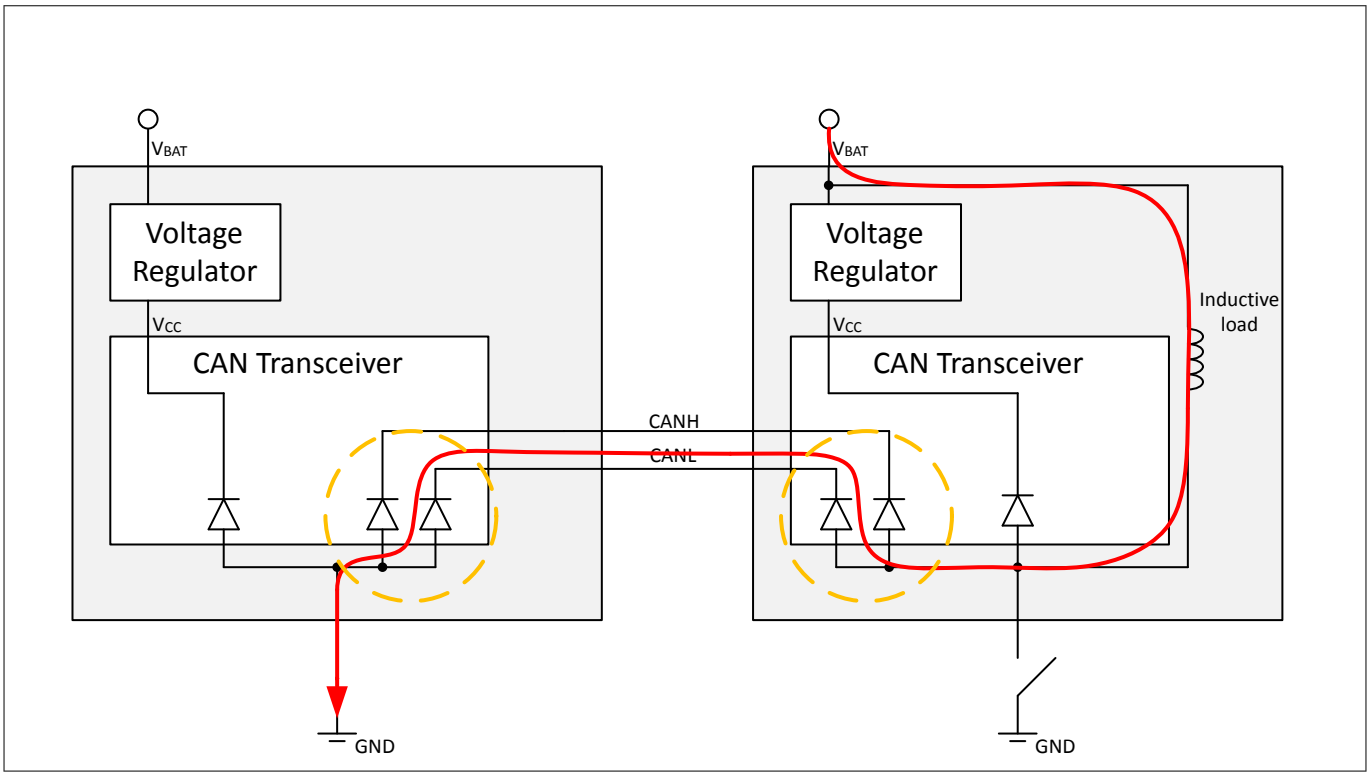

Figure 1 Loss of ground with inductive load

2.6 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 2*** shows a typical CAN signal with a DC ground shift of +2V.

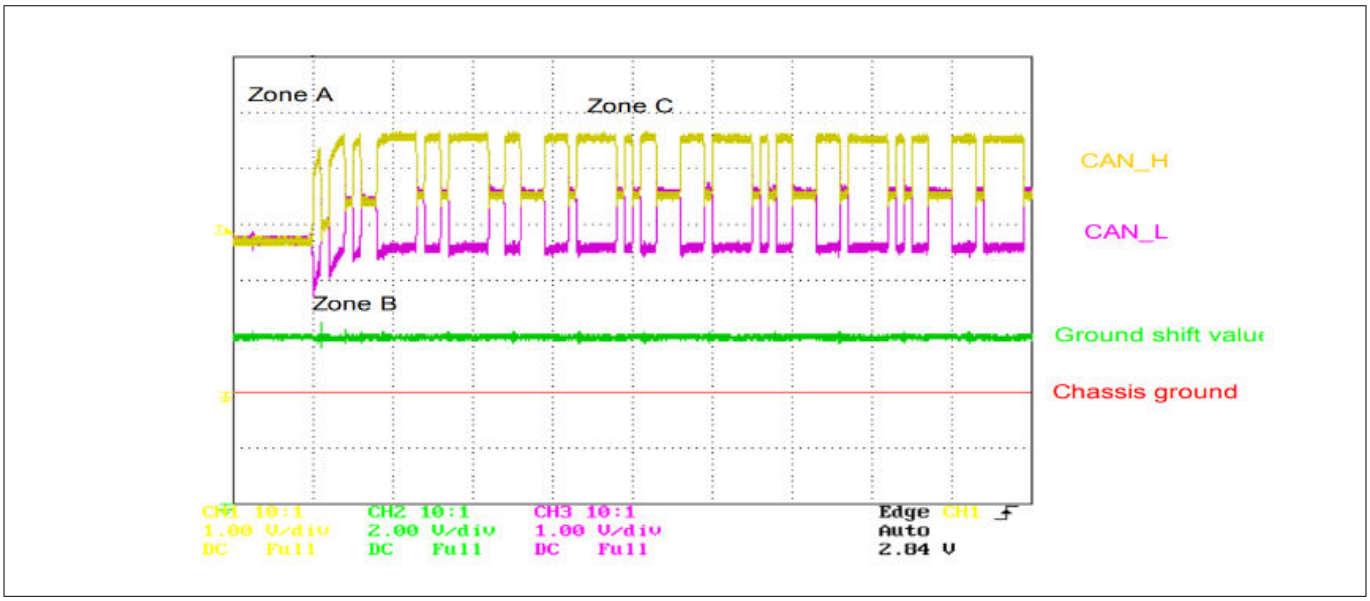

Figure 2 DC ground shift signal

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:

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

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

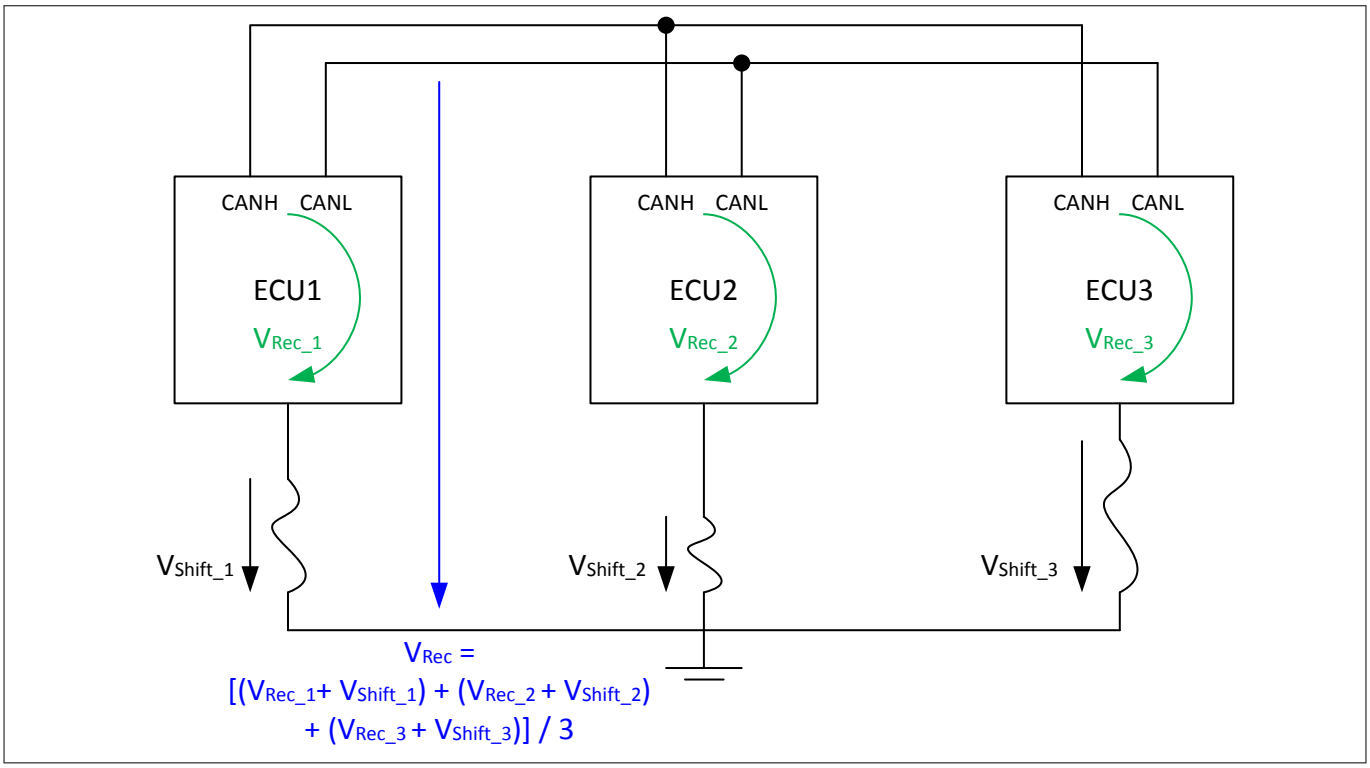

Figure 3 Ground shift on three nodes (system view)

3 Mode control

The modes of the TLE9251xx are controlled by the pin.

3.1 Mode change by

The mode selection pin sets the mode of operation.

3.2 Wake-up pattern (WUP) detection

In order to reduce current consumption of permanently supplied applications (clamp 30), ECUs can be set to a low power mode. Low power mode reduces quiescent current. Usually the microcontroller is in stop mode and the transceiver is in stand-by mode. In stand-by mode the transceiver can wake up the microcontroller in order to set the ECU back to normal operation.

The TLE9251xx has a wake-up pattern (WUP) feature. This is called bus wake-up in ISO 11898-2:2016. In stand-by mode the TLE9251xx monitors activity on the CAN bus. If the TLE9251xx detects a wake-up pattern, it indicates the wake-up signal on the RxD output pin. In stand-by mode the transmitter supply V_{CC} can be turned off. In stand-by mode a wake-up event on the HS CAN is indicated on the RxD output pin. The transceiver remains in the current mode of operation.

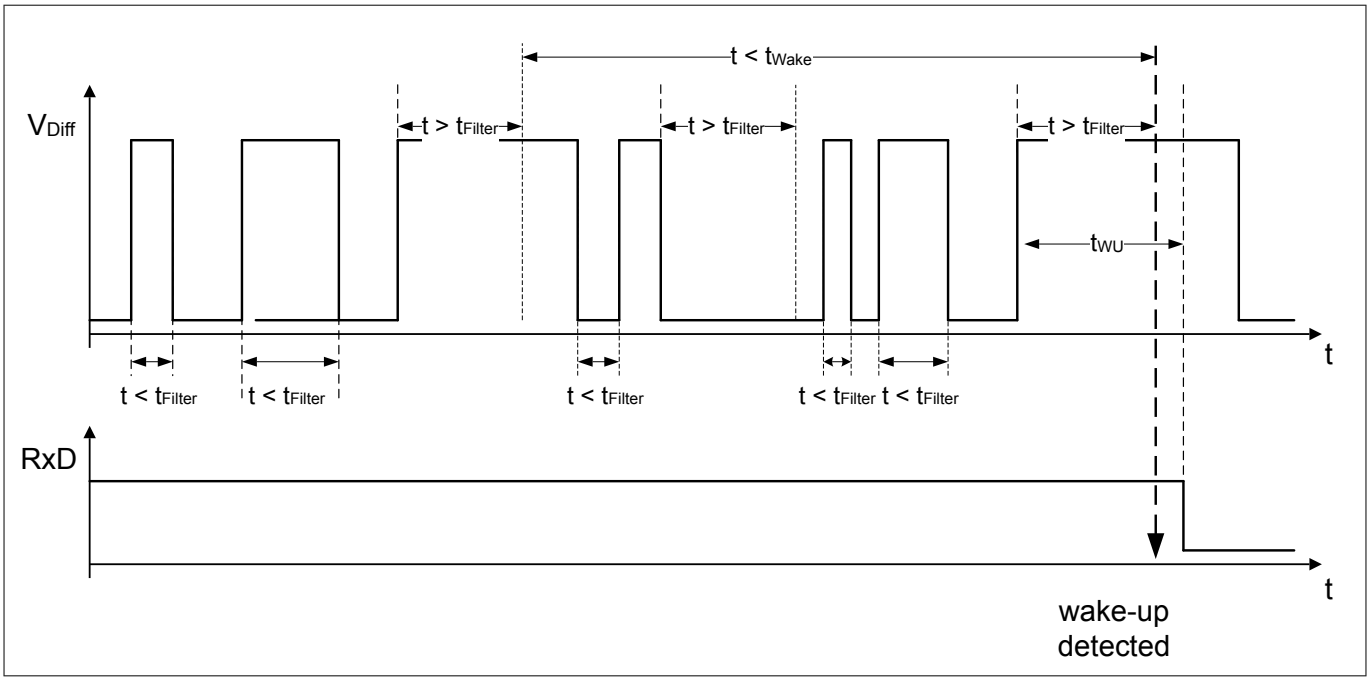

Figure 4 WUP detection

Within maximum wake-up time t_{WAKE}, the wake-up pattern must contain a dominant signal of pulse width t_{Filter}, followed by a recessive signal of pulse width t_{Filter} and another dominant signal of pulse width t_{Filter}. The device resets wake up pattern detection after t_{WAKE} expires. The wake-up pattern is valid also with additional dominant and recessive states shorter than t_{Filter}, which occur within the time period t_{WAKE}, see ***Figure 4***. The RxD output pin remains "high" until a valid wake-up pattern is detected.

In order to ensure robust wake-up pattern detection within CAN FD networks the new ISO 11898-2:2016 has introduced two new parameters:

- $t_{filter} < 1.8\ \mu s$
- $t_{WAKE} < 10$ ms

The TLE9251xx fulfills both of them according to ISO 11898-2:2016.

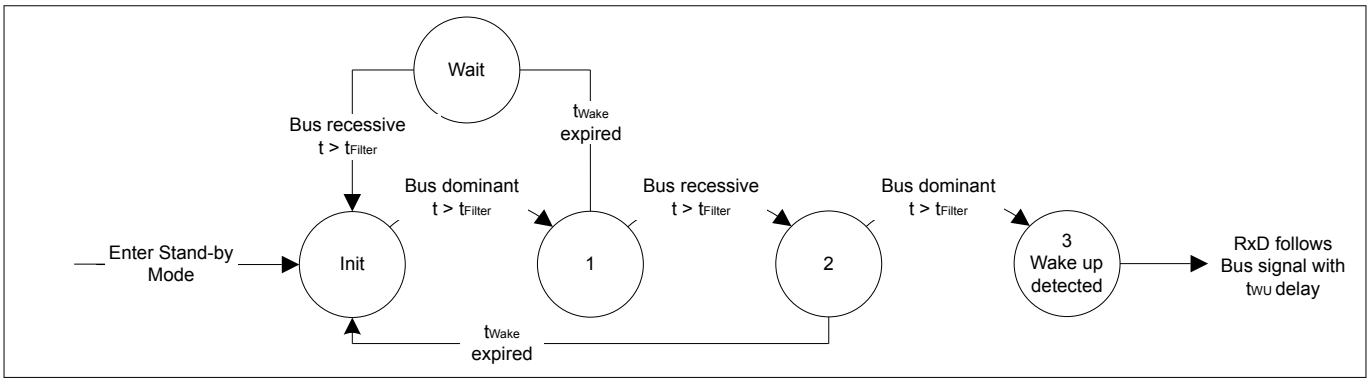

Figure 5 WUP detection according to ISO 11898-2:2016

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: • 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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