Application Note

PCB Layout Recommendations for TLE9255W

About this document

Scope and purpose

This document provides application information for the transceiver TLE9255W from Infineon Technologies AG as Physical Medium Attachment within a Controller Area Network (CAN).

This document contains information about:

- PCB recommendations for CAN FD applications (see **Chapter 1**)
- PCB Footprint Dimensions (see **Chapter 2**)
- State of Logic I/O pins in case V_{IO} is switched off ($V_{IO} < V_{IO\_UV}$) (see **Chapter 3**)
- Pin Behavior Assessment (see **Chapter 4**)

This document refers to the data sheet of the Infineon Technologies AG CAN Transceiver TLE9255W.

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.

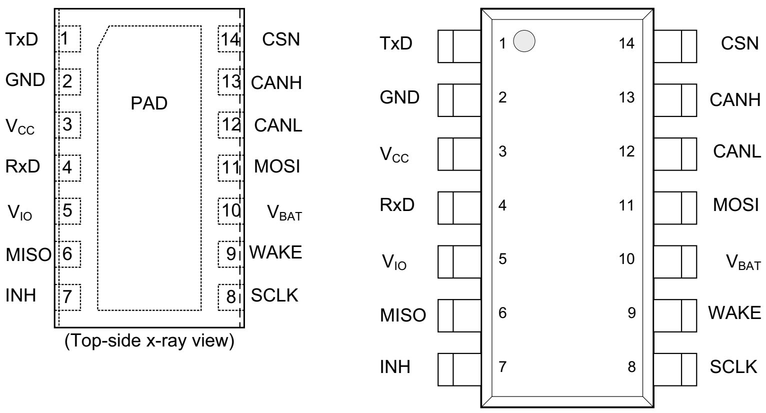

Figure 1 Pin Configuration of the TLE9255W

The main features of the TLE9255W are:

- Baud rate up to 5Mbit/s for CAN Flexible Data Rate
- CAN Partial Networking functionality according to ISO11898-2: 2016
- Very low current consumption in Stand-by and Sleep Mode (20µA)
- Very low Electromagnetic Emission (EME) and high Electromagnetic Immunity (EMI)
- Excellent ESD performance according to HBM (+/-8 kV) and IEC 61000-4-2 (+/-8 kV)
- Bus wake-up pattern feature with optimized filter timing (0.5µs < t_{Filter} < 1.8µs) and Local Wake-up feature
- INH output pin to control external circuitry
- Undervoltage detection on V_{BAT}, V_{CC} and V_{IO}
- Control input levels compatible with 3.3 V and 5 V devices
- Advanced bus biasing according to ISO11898-2: 2016

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1 PCB Layout Recommendations for TLE9255W

The following layout rules should be considered to achieve best performance of the transceiver and the ECU. An example PCB Layout is given in **Figure 2**:

- TxD and RxD connections to microcontroller should be as short as possible.
- For each microcontroller the TxD driver output stage current capability may vary depending on the selected port and pin. The driver output stage current capability should be strong enough to guarantee a maximum propagation delay from µC port to transceiver TxD pin of less than 30ns.
- Place three individual 100nF capacitors close to V_{BAT}, V_{CC} and V_{IO} pins for local decoupling. Due to their low resistance and lower inductance compared to other capacitor types, it is recommended to use ceramic capacitors.
- If a common mode choke is used, it has to be placed as close as possible to the bus pins CANH and CANL.
- Avoid routing CANH and CANL in parallel to fast-switching lines or off-board signals in order to reduce noise injection to the bus.
- It is recommended to place the transceiver as close as possible to the ECU connector in order to minimize track length of bus lines.
- Avoid routing digital signals in parallel to CANH and CANL.
- CANH and CANL tracks should have the same length. They should be routed symmetrically close together with smooth edges.
- GND connector should be placed as close as possible to the transceiver.
- Avoid routing transceiver GND and microcontroller GND in series in order to reduce coupled noise to the transceiver. This also applies for high current applications, where the current should not flow through the GND line of transceiver and microcontroller in serial.
- Avoid routing transceiver V_{CC} supply and microcontroller V_{CC} supply in series in order to reduce coupled noise to the transceiver.
- Same dimensions and lengths for all wire connections from the transceiver to CMC and/or termination.
- If the WAKE pin is not used, it is recommend to connect it directly to GND in order to avoid unwanted wake-up pulses. If Local Wake-up function is used it is recommended to place a 3.3K and 10nF at WAKE input.
- For CAN FD it is recommended to use a Common Mode Choke 100µH impedance and a Split termination of two times 60Ω with a capacitance of 4.7nF in order to achieve excellent EME performance in automotive applications.
- High ohmic pull-down resistor on inhibit 100kΩ recommended, if INH-control device does not have internal pull-down resistor.
- For the SPI it is recommended to have short lines between TLE9255W and microcontroller. Avoid crossings of SPI signal traces on PCB and multiple layer routings. Optionally serial resistances (100Ω- 1kΩ) can be used (MISO close to TLE9255W/ SCLK, MOSI, CSN close to microcontroller).
- If using the TLE9255WLC (TSON-14 Package), the exposed pad should not be connected to other potential than GND.

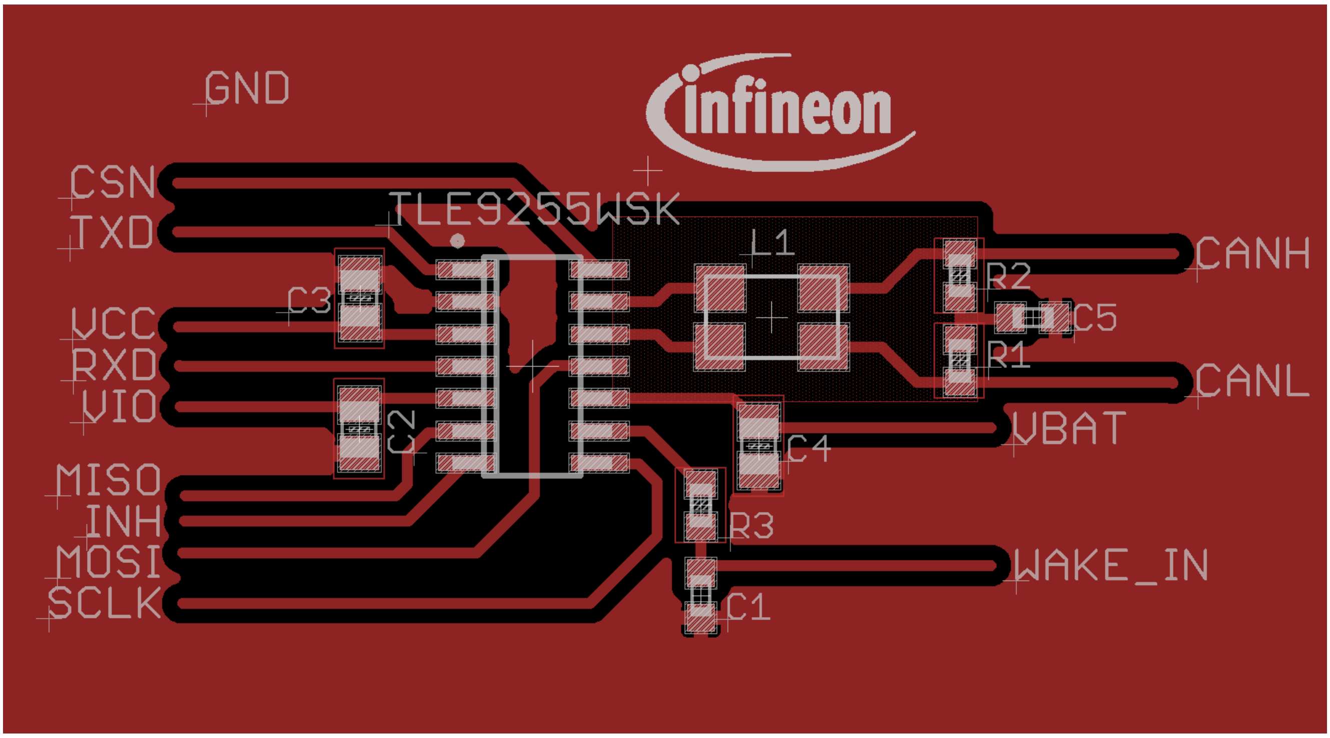

Figure 2 Example CAN transceiver PCB layout

2 TLE9255W Footprint Dimensions for PCB Design

Figure 3 and **Figure 4** show the footprint dimensions for TLE9255W in DSO-14 and TSON-14 package. For further package information (for example packing) please visit **Infineon Packages Webpage**.

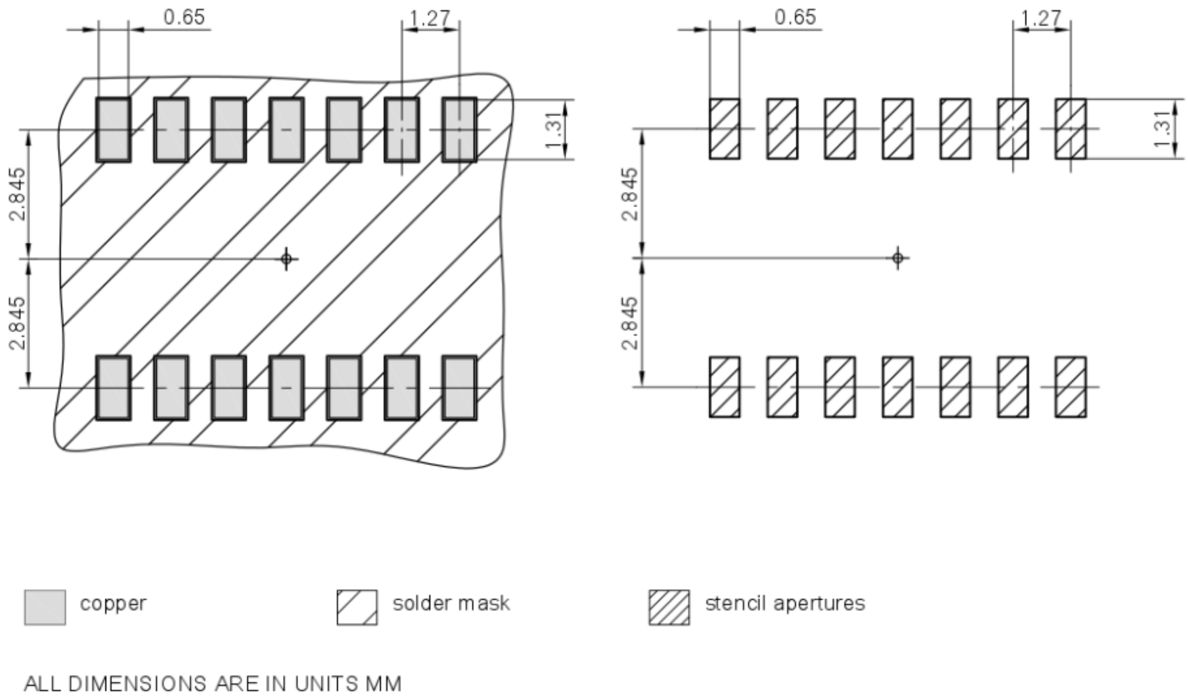

Figure 3 TLE9255W footprint dimensions for DSO-14 package

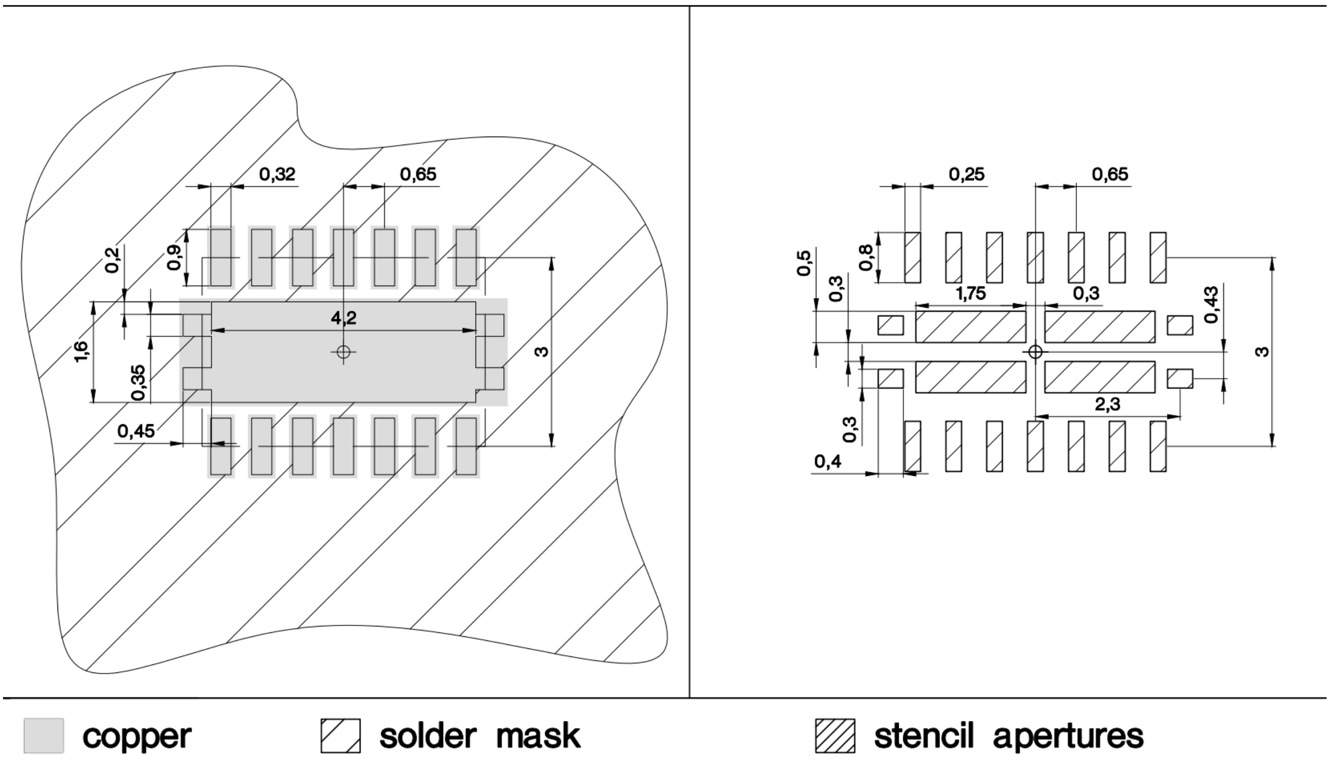

Figure 4 TLE9255W footprint dimensions for TSON-14 package

3 State of Logic I/O pins for $V_{IO} < V_{IO\_UV}$

For robust behavior and defined voltage state, all logic input pins of TLE9255W do have either a pull-down or pull-up current source implemented. These current sources work as specified for all pins in case V_{IO} is in the functional range.

Table 1 Default current source implementation

I/O pin	Implemented current source
TxD	Pull-up current source to V_{IO}
CSN	Pull-up current source to V_{IO}
SCLK	Pull-down current source to V_{IO}
MOSI	Pull-down current source to V_{IO}
RxD	Works according to datasheet specification[1)]
MISO	Works according to datasheet specification[1)]

1) Logic output pins do not have a pull-up or pull-down current source. Logic output pins do have a push-pull output stage.

In case the V_{IO} supply voltage drops the pull-up current sources are disabled and the input state changes to High-Z. Possible scenario for V_{IO} supply voltage drops are:

- V_{IO} power supply controlled by INH pin and TLE9255W in Sleep Mode (V_{IO} supply switched off)
- V_{IO} supply not connected to V_{IO} pin
- V_{IO} supply shorted circuit to GND

In this case the pull-up current sources are disabled and following configuration of the I/O pins is valid:

Table 2 Current source implementation if $V_{IO} < V_{IO\_UV}$

I/O pin	Implemented current source
TxD	High-Z
CSN	High-Z
SCLK	Pull-down current source to V_{IO}
MOSI	Pull-down current source to V_{IO}
RxD	High-Z[1)]
MISO	High-Z[1)]

1) Output pins do not have pull-down or pull-up current source implemented. In case of V_{IO} undervoltage the output pins are set to High-Z.

4 Pin Behavior Assessment

This chapter provides an Pin behavior assessment for typical failure situations. Typical failure scenarios for dedicated pins of TLE9255W are:

- Short circuit to battery voltageV_{BAT}
- Short circuit to supply voltage V_{CC}
- Short circuit to reference voltage V_{IO}
- Short circuit to PCB GND
- Short circuit between neighbored pins
- Pin is unconnected

The possible failures are classified according to possible failure effects (see **Table 3** and **Table 4**)

Table 3 Classification of failure effects

Class	Possible effects
A	- Transceiver damaged - HS CAN bus affected
B	- No damage to transceiver - No CAN bus communication possible
C	- No damage to the transceiver - CAN Bus communication possible - Affected node excluded from communication
D	- No damage to the transceiver - HS CAN bus communication possible - Reduced functionality of transceiver

Table 4 Pin behavior assessment overview

Pin	Potential Failure	Potential Effects of Failure	Class
TxD	open	No damage to the transceiver. Due to the internal pull-up resistor to V_{IO} the TxD input pin stays “recessive”.	C
TxD	Short Circuit to GND	No damage to the transceiver. Transmitter is disabled after TxD dominant time-out. HS CAN bus communication blocked for t_{TXD_TO}. If failure does not recover transmitter will stay disabled and node cannot transmit data to the HS CAN bus. The receiver works as specified in the datasheet.	B
TxD	Short Circuit to V_{BAT}	Violation of absolute maximum ratings. Device gets damaged.	A
TxD	Short Circuit to V_{IO}	No damage to the transceiver. TxD remains permanently “recessive”.	C
TxD	Short Circuit to $V_{CC} = V_{IO}$	No damage to the transceiver. TxD remains permanently “recessive”.	C
TxD	Short Circuit to $V_{CC} > V_{IO}$	Violation of absolute maximum ratings. Device gets damaged	A
GND	open	No damage to the transceiver. Transceiver stays unsupplied and is passive to the HS CAN Bus.	C

Table 4 Pin behavior assessment overview

Pin	Potential Failure	Potential Effects of Failure	Class
GND	Short Circuit to V_{BAT}	No damage to the transceiver. Transceiver stays unsupplied and is passive to the HS CAN Bus.	C
GND	Short Circuit to V_{CC}	Transmitter is disabled due to V_{CC} undervoltage event. .	C
GND	Short Circuit to V_{IO}	All logic input pins are blocked and the transceiver enter Stand-by Mode by default.	C
V_{CC}	open	No damage to the transceiver. Transmitter is disabled.	C
V_{CC}	Short Circuit to V_{BAT}	Violation of absolute maximum ratings. Device gets damaged.	A
V_{CC}	Short to RxD ($V_{CC} = V_{IO}$)	RxD remains recessive and does not reflect communication on the Bus. RxD Recessive Clamping feature is triggered and disables transmitter. NERR pin indiactes RxD Recessive Clamping in Normal-operating Mode.	C
V_{CC}	Short to RxD (V_{CC} = 5V, V_{IO} = 3.3V)	Violation of absolute maximum ratings. Device gets damaged.	A
V_{CC}	Short to (V_{IO} = 3.3V)	No transmition possible since the device encounter a Vcc undervoltage event. In case V_{IO} = 5V, the device operates normally.	C
RxD	open	No damage to the transceiver.The microcontroller does not receive messages from the 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.	B
RxD	Short Circuit to GND	Degradation over lifetime. Device gets damaged.	A
RxD	Short Circuit to V_{BAT}	Violation of absolute maximum ratings. Device gets damaged.	A
RxD	Short Circuit to V_{IO}	RxD remains “recessive”. The RxD signal does not reflect the signal on the 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.	C
V_{IO}	open	In case other logic input pins are still supplied a violation of absolute maximum ratings occurs. Device gets damaged.	A
V_{IO}	Short Circuit to V_{BAT}	Violation of absolute maximum ratings. Device gets damaged.	A
V_{IO}	Short Circuit to MISO	If NSTB = 1 then the device is in Normal-operating Mode. If NSTB = 0, then the device is set to Go-to-Sleep Command.	D
MISO	open	No SPI transmission to microcontroller	D
MISO	Short Circuit to GND	No SPI transmission to microcontroller. Violation of absolute maximum ratings as MISO is internally connected to V_{IO})	A
MISO	Short Circuit to V_{BAT}	Violation of absolute maximum ratings. Device gets damaged.	A
MISO	Short Circuit to INH	Violation of absolute maximum ratings. Device gets damaged..	A
MISO	Short Circuit to V_{CC} = 5V (V_{IO} = 3.3V)	No SPI transmission to microcontroller. Violation of absolute maximum ratings. Device gets damaged.	A
MISO	Short Circuit to $V_{CC} = V_{IO}$	No SPI transmission to microcontroller. Violation of absolute maximum ratings.	A

Table 4 Pin behavior assessment overview

Pin	Potential Failure	Potential Effects of Failure	Class
INH	open	No damage of the device. TLE9252V fully functional. INH does not control external components (for example LDO)	D
INH	Short to GND	Violation of absolute maximum ratings. Device gets damaged.	A
INH	Short to V_{BAT}	No damage of the device. TLE9252V fully functional. INH does not control external components (for example LDO)	D
INH	Short to V_{CC} or V_{IO}	Violation of absolute maximum ratings. Device gets damaged.	A
INH	Short to SCLK	Violation of absolute maximum ratings. Device gets damaged.	A
SCLK	open	No SPI programming possible. No damage of the device.	D
SCLK	Short Circuit to GND	No SPI programming possible. No damage of the device.	D
SCLK	Short Circuit to V_{BAT}	Violation of absolute maximum ratings. Device gets damaged.	A
SCLK	Short Circuit to V_{IO}	No SPI programming possible. No damage of the device.	D
SCLK	Short Circuit to $V_{CC} > V_{IO}$	Violation of absolute maximum ratings. Device gets damaged.	A
SCLK	Short Circuit to WAKE	No damaged to the device. Local Wake-up functionality is corrupted.	D
WAKE	open	No damage of the device. TLE9255W fully functional. No Local Wake-up function available.	D
WAKE	Short Circuit to V_{BAT}	No damage of the device. TLE9252V fully functional. No Local Wake-up function available.	D
WAKE	Short Circuit to V_{IO}	No damage of the device. TLE9252V fully functional but false local wake-ups may be detected.	D
WAKE	Short Circuit to V_{CC}	No damage of the device. TLE9252V fully functional but false local wake-ups may be detected.	A
WAKE	Short Circuit to GND	No damage of the device. TLE9252V fully functional. Local Wake-up function is not available.	D
WAKE	Short Circuit to N.C.	No damage of the device. TLE9252V fully functional.	D
V_{BAT}	open ($V_{CC} > V_{CC\_UV}$)	Device is fully functional but no local wake-up can be detected.	D
V_{BAT}	open (V_{CC} unsupplied)	Device is unsupplied	C
V_{BAT}	Short Circuit to GND and V_{CC} in functional range	Device fully functional. Local Wake-up function not available.	D
V_{BAT}	Short Circuit to GND (V_{CC} unsupplied)	Device unsupplied.	C
V_{BAT}	Short Circuit to MOSI	Violation of absolute maximum ratings. Device gets damaged.	A
MOSI	Short Circuit to GND,	No SPI programming possible. No damage of the device.	D
MOSI	Short Circuit to $V_{CC} > V_{IO}$	Violation of absolute maximum ratings. Device gets damaged.	A
MOSI	Short Circuit to CANL	No SPI programming possible. CAN Communication gets disturbed whenever the microcontroller tries to access the SPI register of TLE9255W. No damage of the device.	B
CANL	Short Circuit to GND	No damage to the transceiver. Violation of bit timing parameters possible. Degraded EMC performance.	D

Table 4 Pin behavior assessment overview

Pin	Potential Failure	Potential Effects of Failure	Class
CANL	Short Circuit to V_{BAT}	No bus communication possible. No damage to the transceiver.	B
CANL	Short Circuit to V_{CC} / V_{IO}	No bus communication possible. No damage to the transceiver.	B
CANL	open	No damage to the transceiver. Device might be able to receive data but not transmit to the CAN bus.	C
CANL	Short Circuit to CANH	No damage to the transceiver. No bus communication possible.	B
CANH	open	No damage to the transceiver. No bus communication possible	B
CANH	Short Circuit to GND	No damage to the transceiver. No bus communication possible. May trigger thermal shutdown of the device.	B
CANH	Short Circuit to V_{BAT}	No damage to the transceiver. Violation of bit timing parameters possible. Degraded EMC performance.	D
CANH	Short Circuit to V_{CC} / V_{IO}	No damage to the transceiver. Violation of bit timing parameters possible. Degraded EMC performance.	D
CSN	open	No SPI programming possible. No damage of the device.	D
CSN	Short Circuit to GND	No SPI programming possible. No damage of the device.	D
CSN	Short Circuit to V_{BAT}	Violation of absolute maximum ratings. Device gets damaged.	A
CSN	Short Circuit to V_{CC} =V_{IO}	No SPI programming possible. No damage of the device.	
CSN	Short Circuit to V_{CC} = 5V (V_{IO} = 3.3V)	Violation of absolute maximum ratings. Device gets damaged.	A

5 Revision History

Revision	Date	Changes
1.1	2018-09-05	Application Note updated: • Editorial Changes • Added **Chapter 2**: Footprint Dimensions for TLE9255W • Added **Chapter 3**: State of Logic I/O pins in case V_{IO} is switched off (V_{IO} < V_{IO_UV}) • Added **Chapter 4**: Pin Behavior Assessment
1.0	2017-05-22	Application Note created

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