Application Note - PCB Layout & PIN Behavior Assessment

Scope and purpose

This document provides application information for the transceiver TLE9252V 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**)
- PIN Behavior Assessment (see **Chapter 3**)

This document refers to the data sheet of the Infineon Technologies AG CAN Transceiver TLE9252V.

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.

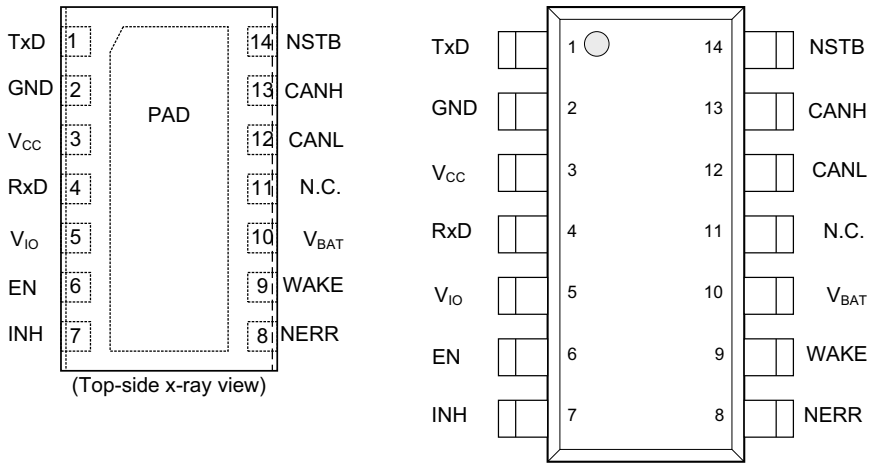

Figure 1 Pin Configuration of the TLE9252V

The main features of the TLE9252V are:

- Baud rate up to 5Mbit/s for CAN Flexible Data Rate
- Very low Electromagnetic Emission (EME) and high Electromagnetic Immunity (EMI)
- Excellent ESD performance according to HBM (+/-10 kV) and IEC (+/-8 kV)
- Bus wake-up and Local Wake-up
- INH output pin to control external circuitry
- Undervoltage detection on V_S, V_{CC} and V_{IO}
- Lowest current consumption in Stand-by and Sleep Mode
- Transmit data (TxD) dominant time-out feature
- Advanced diagnostics via NERR output pin

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1 TLE9252V PCB Layout Recommendations

The following layout rules should be considered to achieve best performance of the transceiver and the ECU:

- 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.
- In case an external ESD protection circuit is used, make sure the total capacitance is lower than 70pF. Use equal ESD protection for CANH and CANL in order to improve signal symmetry.
- For CAN FD it is recommended to use a Common Mode Choke 100µH impedance and a Split termination with a capacitance of 4.7nF in order to achieve excellent EME performance in automotive applications.
- If the tiny TSON-14 package is used (TLE9252VLC) the exposed PAD shall not be connected to any other potential than GND.

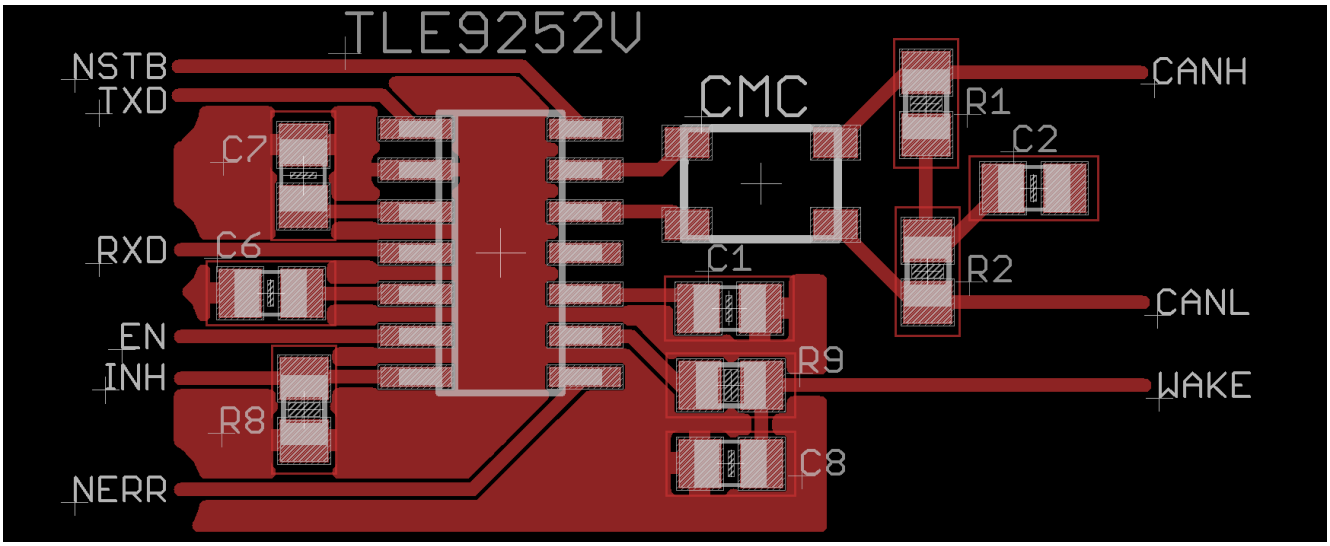

Figure 2 Example CAN transceiver PCB layout

2 TLE9252V Footprint Dimensions for PCB Design

Figure 3 and Figure 4 show the footprint dimensions for TLE9252V in DSO-8 and TSON-8 package. For further package information (e.g. packing) please visit Infineon Packages Webpage.

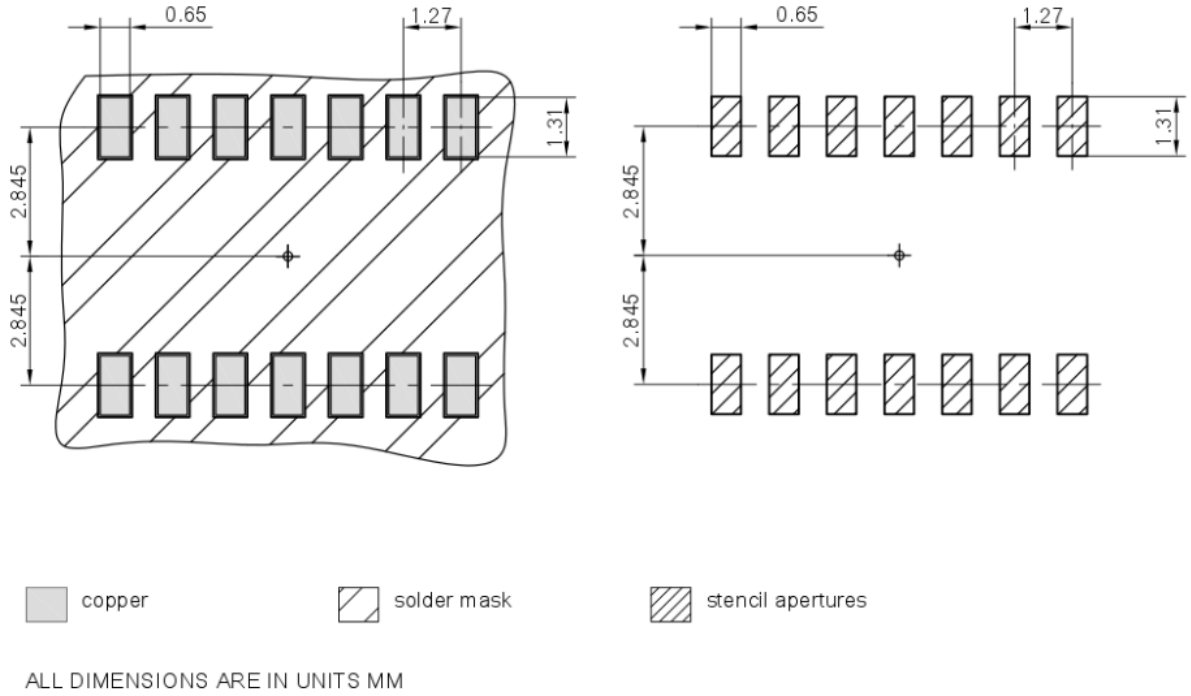

Figure 3 TLE9252V Footprint Dimensions for DSO-14 Package

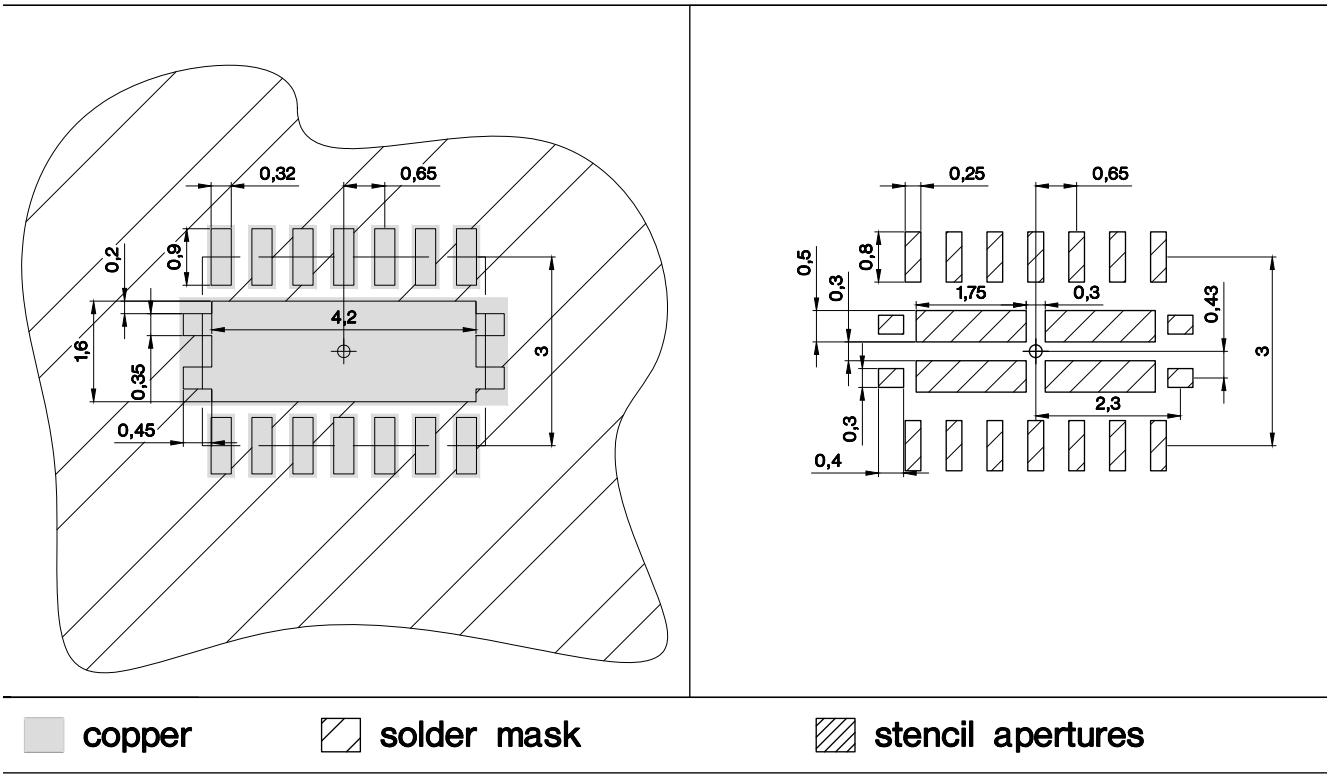

Figure 4 TLE9252V Footprint Dimensions for TSON-14 Package

3 Pin Behavior Assessment

This chapter provides an Pin behavior assessment for typical failure situations. Typical failure scenarios for dedicated pins of TLE9252V are:

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

The possible failures are classified according to possible failure effects (see **Table 1**)

Table 1 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 2 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 the TxD 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
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. NERR output pin indicates V_{CC} undervoltage in Normal-operating Mode and Receive-only Mode.	C

Pin Behavior Assessment

Table 2 Pin Behavior Assessment Overview

Pin	Potential Failure	Potential Effects of Failure	Class
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	All logic input pins are blocked and the transceiver enter Stand-by Mode by default.	C
V_{IO}	Short Circuit to V_{BAT}	Violation of absolute maximum ratings. Device gets damaged.	A
V_{IO}	Short Circuit to EN	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
EN	open	Internal pull-down current source set EN = 0. If NSTB = 1 then the device is in Receive-only Mode if NSTB = 0, then the device is in Stand-by Mode. In both cases the transmitter is not turned on.	D
EN	Short Circuit to GND	If NSTB = 1 then the device is in Receive-only Mode if NSTB = 0, then the device is in Stand-by Mode. In both cases the transmitter is not turned on.	D
EN	Short Circuit to V_{BAT}	Violation of absolute maximum ratings. Device gets damaged.	A
EN	Short Circuit to INH	Violation of absolute maximum ratings. Device gets damaged..	A
EN	Short Circuit to V_{CC} = 5V (V_{IO} = 3.3V)	Violation of absolute maximum ratings. Device gets damaged.	A
EN	Short Circuit to V_{CC} = V_{IO}	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
INH	open	No damage of the device. TLE9252V fully functional. INH does not control external components (e.g. 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 (e.g. LDO)	D

Table 2 Pin Behavior Assessment Overview

Pin	Potential Failure	Potential Effects of Failure	Class
INH	Short to V_{CC} or V_{IO}	Violation of absolute maximum ratings. Device gets damaged.	A
INH	Short to NERR	Violation of absolute maximum ratings. Device gets damaged.	A
NERR	open	No damage of the device. TLE9252V fully functional. Diagnostic Flags are not indicated to the microcontroller.	D
NERR	Short Circuit to GND	Degradation over lifetime. Device gets damaged.	A
NERR	Short Circuit to V_{BAT}	Violation of absolute maximum ratings. Device gets damaged.	A
NERR	Short Circuit to V_{IO}	NERR remains “recessive”. The NERR signal does not indicated the diagnostic flags to the microcontroller.	D
NERR	Short Circuit to $V_{CC} > V_{IO}$	Violation of absolute maximum ratings. Device gets damaged. NERR remains “recessive”. The NERR signal does not indicated the diagnostic flags to the microcontroller.	A
NERR	Short Circuit to WAKE	No damaged to the device. Local Wake-up functionality is corrupted.	D
WAKE	open	No damage of the device. TLE9252V 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
N.C.	Short Circuit to GND, V_{BAT}, V_{CC}, V_{IO}, CANL	No damage of the device. TLE9252V fully functional.	D
CANL	Short Circuit to GND	No damage to the transceiver. Violation of bit timing parameters possible. Degraded EMC performance.	D
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

Table 2 Pin Behavior Assessment Overview

Pin	Potential Failure	Potential Effects of Failure	Class
CANH	Short Circuit to V_{CC} / V_{IO}	No damage to the transceiver. Violation of bit timing parameters possible. Degraded EMC performance.	D
NSTB	open	No damage to the transceiver. The device will enter Stand-by Mode or Go-to-Sleep Command, depending on the status of EN. In both cases the transmitter is turned off.	D
NSTB	Short Circuit to GND	No damage to the transceiver. The Device will enter Stand-by Mode or Go-to-Sleep Command, depending on the status of EN. In both cases the transmitter is turned off.	D
NSTB	Short Circuit to V_{BAT}	Violation of absolute maximum ratings. Device gets damaged.	A
NSTB	Short Circuit to V_{CC} =V_{IO}	If EN = 1 then the device is forced to Normal-operating Mode. If EN = 0, then the device is forced to Receive-only Mode.	D
NSTB	Short Circuit to V_{CC} = 5V (V_{IO} = 3.3V)	Violation of absolute maximum ratings. Device gets damaged.	A

4 Revision History

Revision	Date	Changes
1.0	2017-12-12	Application Note created

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