Hardware design guide for TLE92108/4

About this document

Scope and purpose

This application note provides information about the dimensioning of external components for the TLE92108/4 devices.

This document should be used in conjunction with the corresponding datasheet, which contains full technical details on the device specification and operation.

Intended audience

Developers working with the TLE92108/4.

Table of contents

1 Introduction

The TLE92108/4 are Multiple MOSFET drivers, dedicated to control up to sixteen n-channel MOSFETs. They integrate eight half-bridge drivers (TLE92108), respectively four half-bridge drivers (TLE92104) for DC motor control applications such as automotive power seats, power lift gates, cargo cover, sunroof, door lock, window lifts.

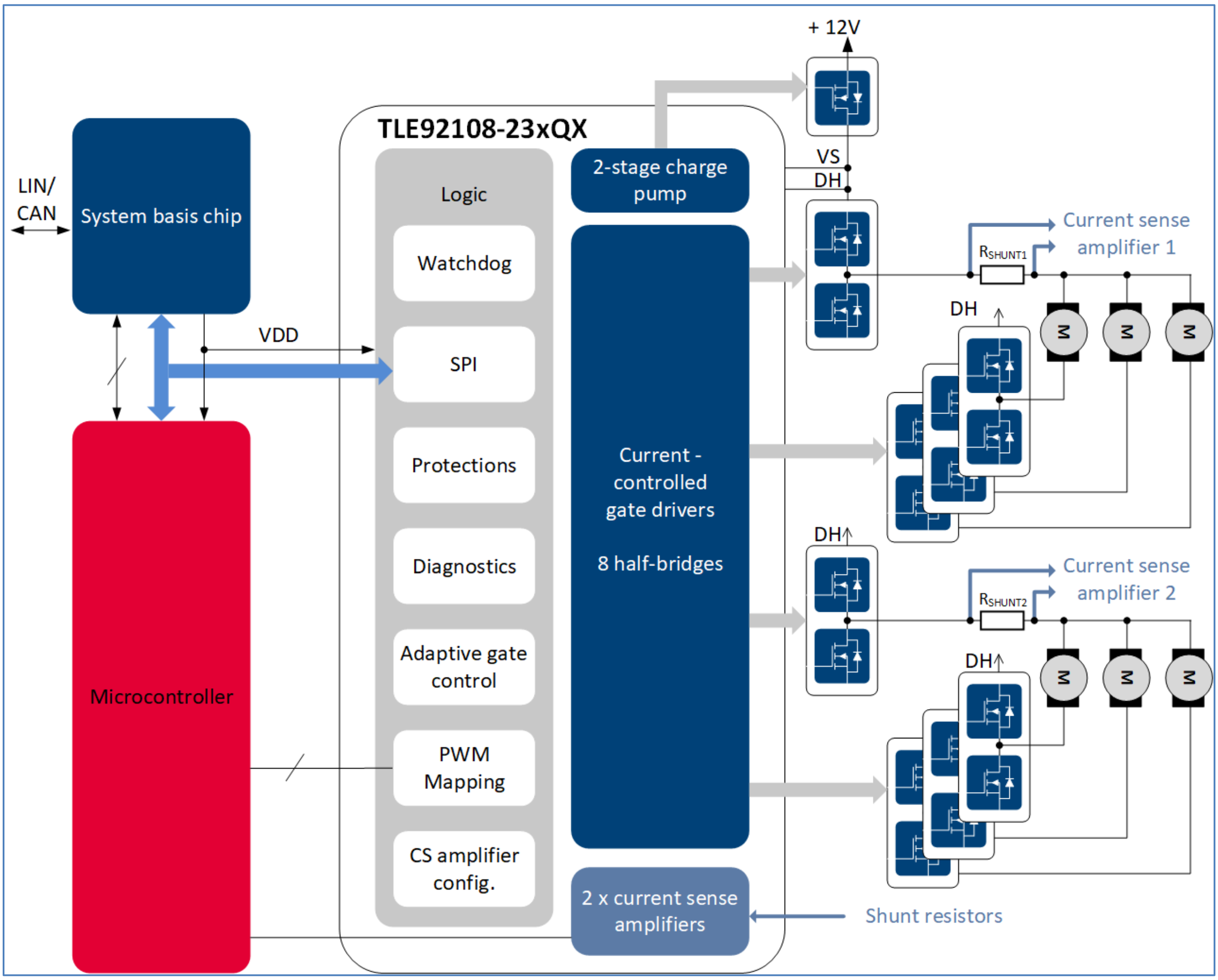

Figure 1 TLE92108 simplified block diagram in one of the possible half-bridge configurations

2 Oberview of symbols

Symbol	Description
HB	Half bridge
DC	Direct current
CP	Charge pump
CSA	Current sense amplifier
PCB	Printed circuit board
DH	Drain input for high-sides
DS	Drain-source
HS	High side
LS	Low side

3 Recommendation for external components

3.1 Application diagram

The following application diagram shows the gate drivers for one HB with the (partially optional) external components, which are described in this chapter.

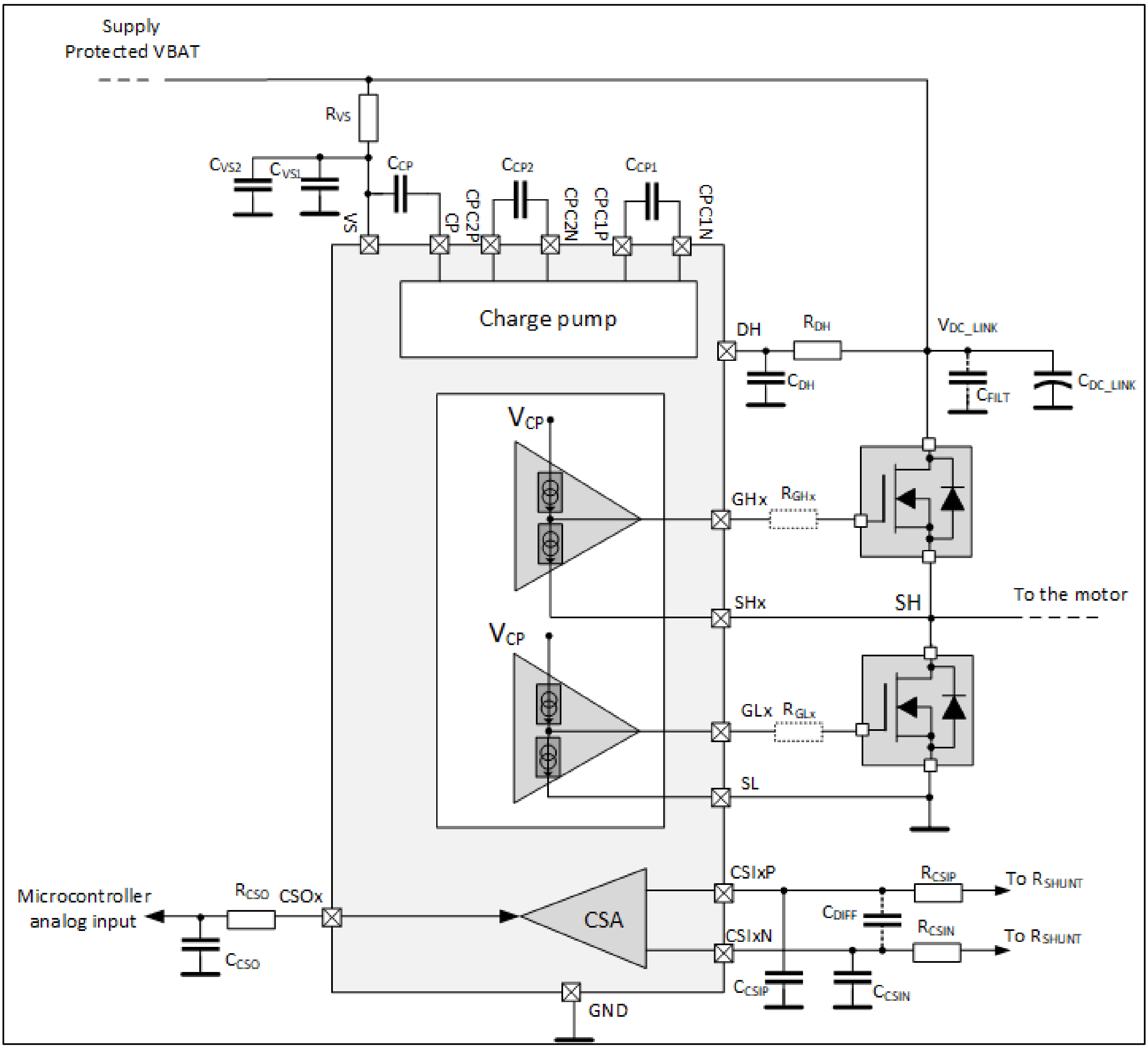

Figure 2 Gate drivers for one half bridge with external components

3.2 External Components for the bridge driver and current sense amplifier

3.2.1 Overview of components

Component	Short description	Recommended value
R_{GHx}, R_{GLx}	**Gate resistor (optional):** Suppresses potential oscillations between PCB line inductances and MOSFET capacitances	2 … 10 Ω
C_{DC_LINK}	**DC link capacitor:** Buffers DC link voltage	Depend on application requirements
C_{FILT}	**Filter capacitor (optional):** Suppresses high frequency noise from the DC link voltage	
R_{DH}, C_{DH}	**Low-pass filter at VDH pin:** Anti-aliasing filter, suppresses high-frequency components of DC link voltage	e.g. 100 to 330 Ω, 1 nF
R_{VS}, C_{VS1}, C_{VS2}	**Low pass filter at VS pin:** Attenuates voltage variation at the VS pin Other functions of C_{VS1}, C_{VS2} C_{VS1} : Filter capacitor for high frequency noise coming from the VS pin C_{VS2} : Filter capacitor for the charge pump	R_{VS}: 2.2 Ohm C_{VS1}: 100 nF C_{VS2}: 2.2 µF
C_{CP}	**Charge pump:** Buffer capacitor	470 nF
C_{CP1}, C_{CP2}	**Charge pump:** Flying capacitors	220 nF
R_{CSIP}, R_{CSIN}	**CSA input filter:** RC filter resistors necessary for noise immunity	3.3 Ω
C_{CSIP}, C_{CSIN}	**CSA input filter:** RC filter capacitors necessary for noise immunity	22 nF
C_{DIFF}	**CSA input filter (optional):** Capacitor for differential filtering	1.5 nF
R_{CSO}	**CSA output filter:** RC filter resistor to filter high frequency noise from the motor	1 kΩ
C_{CSO}	**CSA output filter:** RC filter capacitor to filter high frequency noise from the motor	47 nF

Table 1 External components related to the bridge driver and the current sense amplifiers

3.2.2 Gate driver

3.2.2.1 Gate resistors (optional)

The gate resistors R_{GLx} and R_{GHx} suppress potential oscillations between the PCB line inductances and the MOSFET capacitances. These two components can build up a LC oscillator, which can be stimulated by fast transients during the MOSFET switching. The value of R_{GLx} and R_{GHx} depend on the PCB layout, the MOSFET parasitics and the switching speed. R_{GLx} and R_{GHx} may not exceed 10 Ω, to avoid affecting the charge and discharge currents.

***Note**: This effect is layout dependent. Such oscillations have not been observed by Infineon so far.Therefore, it is recommended to use 0 Ohm resistors for the first prototype. If no oscillations are observed, then these gate resistors can be removed for the final version of the board.*

3.2.2.2 DH low-pass filter

The DH input pin can be configured as the reference voltage for the drain of the high-side MOSFETs, which is used for the drain-source overvoltage detection.

The low-pass filter R_{DH} and C_{DH} at the DH pin is an anti-aliasing filter which suppresses high-frequency noise from the DC link voltage.

The voltage shift between the DC link voltage and the DH pin (V_{DC_LINK} - V_{DH}) should be limited during the oscillation of the battery voltage. A too high voltage shift between V_{DC_LINK} and V_{DH} can lead to a wrong DS overvoltage detection of the high-side MOSFETs.

The DS comparator of the HS MOSFETs monitors the voltage difference:

$$V_{DH} - V_{SHx} = V_{DH} - V_{DC\_LINK} + V_{DC\_LINK} - V_{SHx}$$

Where the term $V_{DH} - V_{DC\_LINK}$ represents the voltage shift caused by the RC filter during the variation of the V_{DC_LINK}.

It is recommended to design a RC time constant that is significantly lower than the DS monitoring filter time (t_{FVDS}). If t_{FVDS} = 1…2 µs, it is recommended to keep the RC time constant in the range of 100 to 400 ns. For example:

- R_{DH} = 100 to 330 Ω
- C_{DH} = 1 nF

3.2.3 Supply voltage

The DC link capacitors C_{DC_LINK} and C_{FILT} are implemented in the circuitry:

- C_{DC_LINK}: a big capacitor, which works as a buffer capacitor.
- C_{FILT}: a multi-layer ceramic capacitor, which suppresses high frequency noise from the DC link voltage.

The dimension of C_{DC_LINK}:

- Depends on the allowed DC link voltage ripple caused by PMW operation, and on additional application-specific requirements. It is recommended to limit the voltage ripple to 1 V peak-to-peak.
- Must be big enough to store the motor energy in the case of an emergency shutdown of the MOSFETs when the motors is running.

It is recommended to choose capacitors with low ESR and low self-inductance. C_{DC_LINK} and C_{FILT} should be close to correponding HS MOSFETs to minimize stray inductances in the high-current path.

3.2.4 Charge pump

The charge pump is designed to supply the bridge driver integrated in the TLE9210x devices. The voltage V_{CP} is generated by a dual stage charge pump, as a multiplying effect of the input voltage VS using two flying capacitors C_{CP1} and C_{CP2}. The capacitor C_{CP} acts as buffer capacitor between CP and VS.

***Note**: C_{CP1} and C_{CP2} should be placed to the device as close as possible to reduce the electromagnetic emission.*

It is recommended to use:

- Low ESR ceramics capacitors
- 50 V rated capacitors to minimize the DC-bias effect on the effective capacitance
- 220 nF for C_{CP1}, C_{CP2}
- 470 nF for CCP

3.2.5 Current sense amplifier

The Current Sense Amplifier (CSA) is an analog circuit capable to amplify the differential input voltage by a programmable gain.

3.2.5.1 Current sense amplifier inputs

An input filter is necessary for noise immunity. The following values are recommended:

- R_{CSIP} = R_{CSIN} = 2.2 or 3.3 Ω. A higher value affects the gain accuracy
- C_{SIP} = C_{SIN} = 22 nF
- C_{DIFF} (optional) = 1.5 nF

3.2.5.2 Current sense amplifier output

It is recommended to use a RC filter consisting of R_{CSO} and C_{CSO} at the outputs of the current sense amplifiers (CSOx pins) to filter high frequency noise (for example caused by the motor commutations and by the charge pump switching activity).

The time constant of the filter should be at least 4 µs in order to filter transients and noise coming from the charge pump (typ. 250 kHz).

For example:

- R_{CSO} = 1 kOhm
- C_{CSO} = 47 nF

4 Reverse battery protection

The reverse battery protection circuit prevents the device from being damaged when the polarity of the battery is inverted.

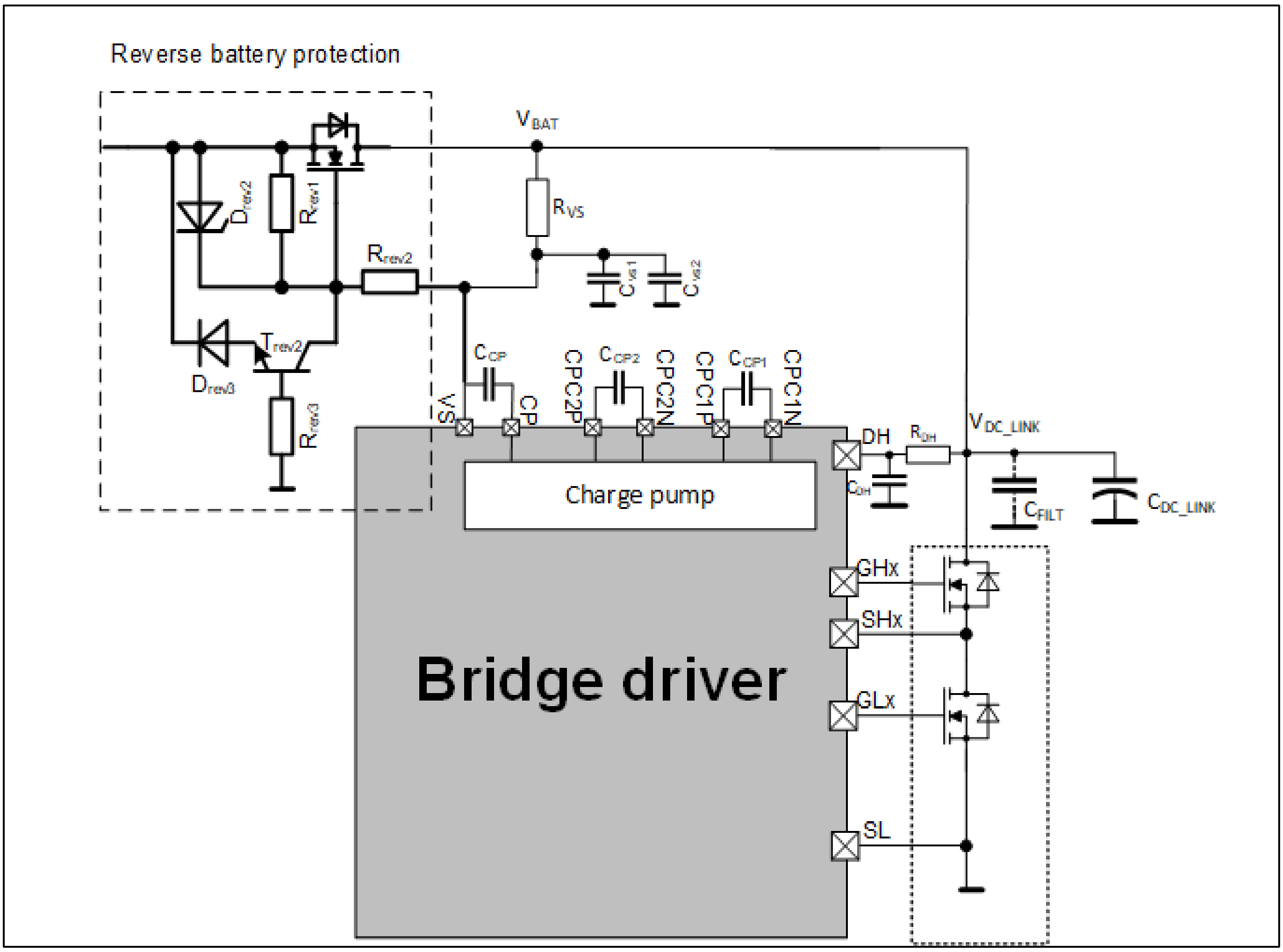

Figure 3 Reverse battery protection

When V_{BAT} is positive and within the device operating range: the body diode of T_{rev1} supplies VS, which is the input of the charge pump. This allows the charge pump to operate and to actively turn on T_{rev1} to minimize the power dissipation T_{rev1}.

When V_{BAT} is negative: T_{rev1} must be turned off by an external circuitry to protect the module

The zener diode D_{rev2} works as a gate-source overvoltage protection for T_{rev1}.The breakdown voltage of D_{rev2}:

- Should be lower than the absolute maximum rating of gate-source voltage of T_{rev1}
- Is ideally higher than V_{CP}-V_S to avoid consuming current from the charge pump in normal conditions

R_{rev1} prevents the gate of T_{rev1} from floating, when the CP pin is disconnected.

T_{rev2}, D_{rev3} and R_{rev3}.actively discharge the gate of T_{rev1} in case of reversed polarity connection:

- In reversed polarity conditions, T_{rev2} is turned on, ensuring a fast discharge of T_{rev1}. R_{rev3} limits the base current of T_{rev2}.
- In normal polarity conditions, T_{rev2} stays off. D_{rev3} ensures that the maximum rating of the emitter-to-basic voltage of T_{rev1} is not exceeded

R_{rev2} limits the current flowing out of the CP pin in the following conditions:

- Positive battery voltage and the zener voltage of D_{rev2} is lower than $V_{CP} – V_S$
- Reverse battery conditions, while T_{rev2} is conducting

Device	Positive battery voltage	Reverse battery conditions	Comments
T_{rev1}	Turned on by the charge pump	Turned by off T_{rev2}	The breakdown voltage of T_{rev1} must be compatible to the application negative voltage
D_{rev2}	T_{rev1} gate-source overvoltage protection		The breakdown voltage of D_{rev2} must be: - lower than the absolute maximum rating of gate-source of T_{rev1} - higher than V_{CP}-V_S
R_{rev1}	Prevents the gate of T_{rev1} from floating		100 kΩ
T_{rev2}	OFF	Actively discharges T_{rev1}	–
D_{rev3}	Prevents current flow into the emitter of T_{rev2}		The breakdown voltage of D_{rev3} must be must be higher than max. positive V_{BAT} voltage
R_{rev3}		Limits the base current of T_{rev2}	–
R_{rev2}	Limits current flowing out of CP if D_{rev2} breakdown	Limits current flowing out of CP when T_{rev2} is conducting	4.7 kΩ recommended 3.3 kΩ minimum

Table 2 Summary of components functions in the reverse battery protection circuitry

5 Unused pins

Recommendation for unused pins:

- GHx pins: should be left open
- SHx pins: should be connected to GND. Connecting SHx to GND while the brake mode is activated avoids a wrong drain-source overvoltage detection on the not connected LSx.
- GLx pins: should be left open

6 Conclusion

This application note shows how to choose and dimension passive components that are necessary or good-to-have in order that the half-bridge driver, charge pump and current sense amplifier of the TLE9210x work correctly and efficiently. Besides, this document explains how the reverse battery protection circuit works and which components it consists of. Finally, it gives recommendation on configuration of unused pins.

Revision history

Document version	Date of release	Description of changes
01.00	2021-08-11	First release
01.10	2022-07-20	Add a chapter on how to configure unused pins

Trademarks

All referenced product or service names and trademarks are the property of their respective owners.

Edition 2022-07-20

Published by

Infineon Technologies AG

81726 Munich, Germany

Do you have a question about this document?

Email: erratum@infineon.com

Document reference

Z8F80186205