Miniature comfort motor control reference design with SiP

Product overview

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About this document

Design overview

The user guide describes the Miniature comfort motor control reference design with SiP (REF_MINI_CMFRT_SIP) using the TLE9954QSW40-33 MOTIX™ MCU System in package (SiP). The 3-phase bridge driver TLE9954QSW40-33 is used for automotive motor control for example *brushless direct current (BLDC)* seat adjustment or auxiliary pumps and fans in thermal management systems. The reference design is designed to drive 100 W loads at a battery voltage of 12 V.

The guide includes the schematics of the design, electrical, thermal, and *electromagnetic compatibility (EMC)* measurements according to the CISPR25 standard.

Highlighted components

1. MOTIX™ MCU TLE9954QSW40-33
2. OptiMOS™ 7 IAUZN04S7N026
3. XENSIV™ TLE5572-AE04E1-R-E0001

Applications

- BLDC seat adjustment
- Auxiliary water pump
- Oil pump

Highlighted design aspects

- Space optimization
- Cost optimization
- Thermal optimization

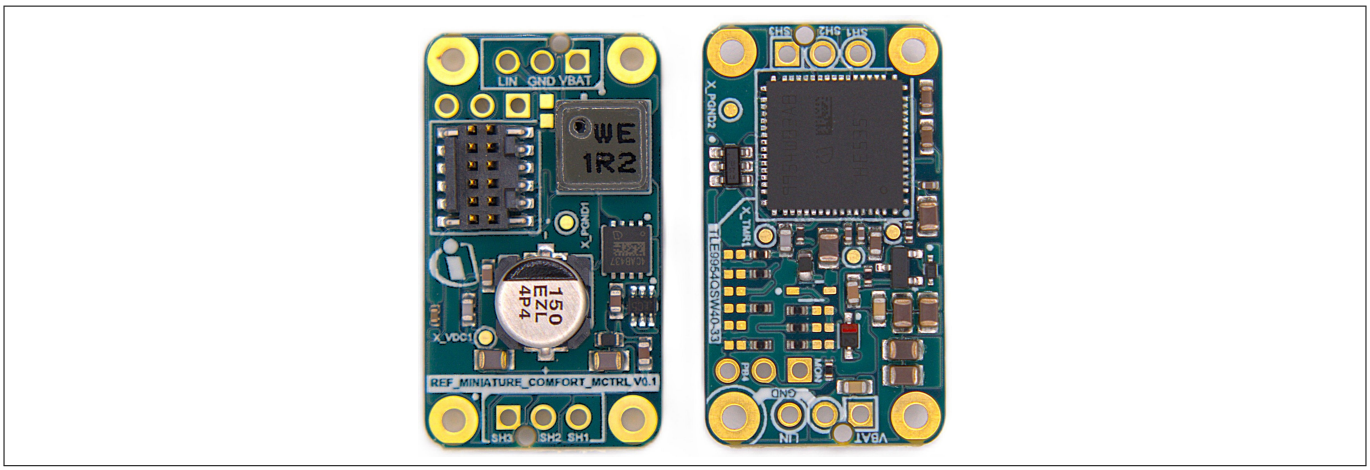

Figure 1 Reference design

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1 System offerings

Infineon's system offering for automotive 3-phase motor control with TLE9954QSW40-33 System-in-Package device encompasses a range of components that work together to provide a comprehensive solution.

Key Components:

- **TLE9954QSW40-33 DUT board:** A robust hardware foundation for efficient integration with a MOTIX™ MCU TLE9954QSW40-33, a OptiMOS™ 7 MOSFET, on board debugger, and several other interfaces
- **REF_WATERPUMP_SiP:** An optimized *printed circuit board (PCB)* for size, thermal and *EMC* performance. It highlights the size and PCB cost improvements against a traditional gate driver with discrete MOSFETs
- **REF_MINI_CMFRT_SiP:** Compact automotive solution with Infineon's fully integrated System-in-Package, optimized for minimal PCB size, and faster time-to-market
- **MOTIX™ TLE994_5x SDK Evaluation edition:** Evaluation edition of Software Development Kit (SDK) for MOTIX™ TLE994x and 995x including Peripheral Driver Library (PDL), Code examples, and Device Configurator settings. CMSIS Pack file
- **Infineon Automotive Power Explorer:** The Infineon Automotive Power Explorer is a powerful tool designed to provide a comprehensive and detailed analysis of Infineon products, enabling users to make informed decisions and optimize their designs. It offers a range of analysis features that enable users to evaluate and compare the performance of different products under various operating conditions
- **MOTIX™ MCU Solution Designer** The MOTIX™ MCU Solution Designer is a graphical configuration tool to analyze, debug, and tune your motor control application. The intuitive *graphical user interface (GUI)* helps to develop a field-oriented motor control application based on Infineon's MOTIX™ MCU families

2 Two reference designs for two different purposes with MOTIX™ MCU TLE9954QSW40-33

There are two reference designs for TLE9954QSW40-33 in the list above. Both reference designs are designed very differently and serve very different purposes.

2.1 Value of moving from discrete MOSFETs to System-in-Package

The REF_WATERPUMP_SiP was designed as a 1 to 1 replacement for the REF_WATERPUMP150W. The REF_WATERPUMP150W uses the traditional architecture with MOTIX™ MCU TLE995x and OptiMOS™ 7 integrated half-brigde MOSFETs. The integration of the MOSFETs allows for different improvements on the *PCB* listed below:

- **Reduction of PCB area by 40%:** Both PCBs were designed for the identical water pump and identical feature set. On the REF_WATERPUMP_SiP, the unutilized PCB space was cut away to show the saving in PCB area which resulted in a 40% reduction in PCB area. At the same time, both reference designs are capable of driving 150 W of continuous power
- **Simplification of 4 layer PCB down to 2 layer PCB:** The easier layout of the REF_WATERPUMP_SiP allows a better PCB layout on only 2 layers. This results in a cheaper PCB
- **Simplified layout:** As the routing in the commutation path is already integrated in the package of the System-in-Package, the layout gets much easier. First-time-right design with optimized *EMC* performance can be achieved due to low parasitic inductance

Below figure shows both REF_WATERPUMP150W (left) and REF_WATERPUMP_SiP (right) side by side.

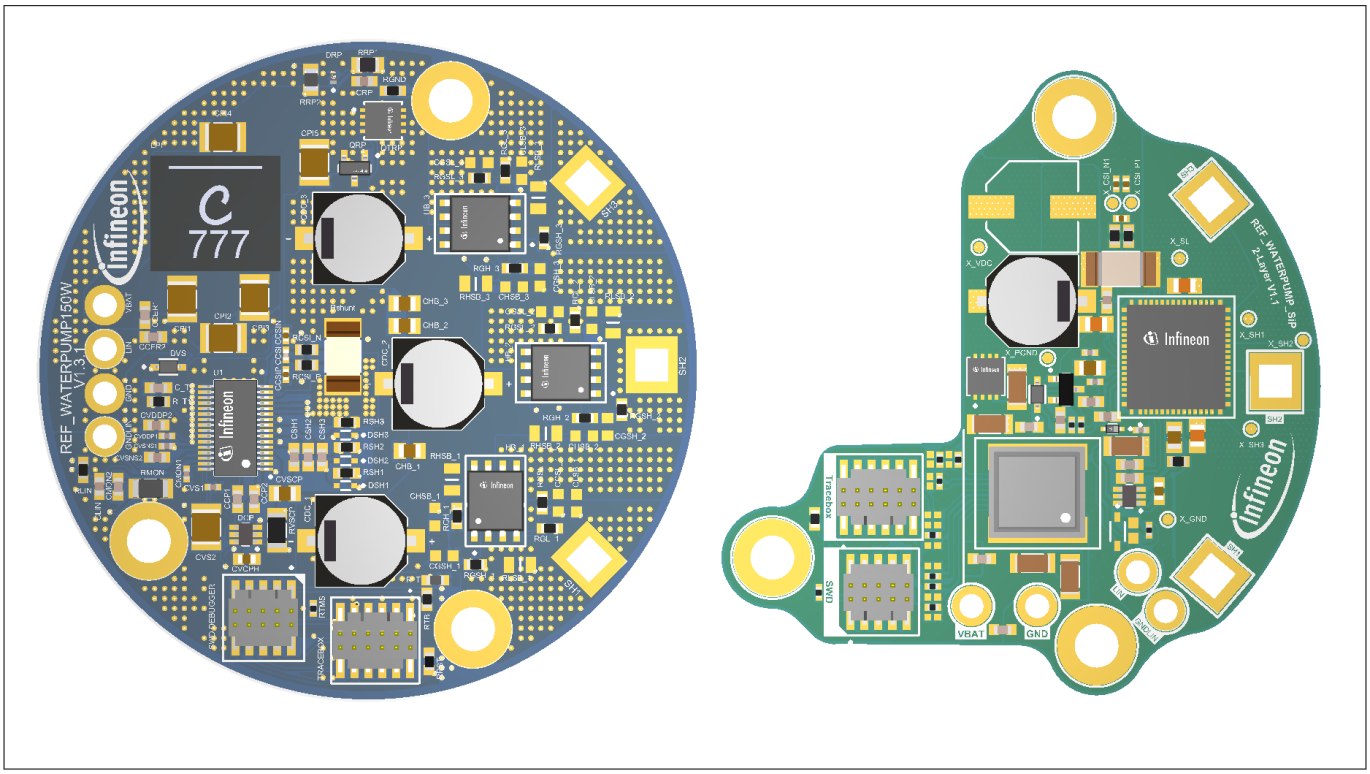

Figure 2 Comparison of REF_WATERPUMP150W (left) and REF_WATERPUMP_SiP (right)

For more details on the REF_WATERPUMP_SiP, refer to the board user guide of REF_WATERPUMP_SiP on the Infineon homepage.

2.2 Utilizing MOTIX™ MCU TLE9954QSW40-33 for extremely space constraint environments in comfort applications

Utilizing MOTIX™ MCU TLE9954QSW40-33 for extremely space constraint environments in comfort applications

The REF_MINI_CMFRT_SIP was designed to reduce the *PCB* size as much as possible. To achieve this small size of 30 mm x 17 mm, a double-sided assembly on a 4-layer board was utilized. The device is cooled via the topside of the mold compound of the MOTIX™ MCU TLE9954QSW40-33.

The figure below shows the REF_WATERPUMP_SiP (left) next to the REF_MINI_CMFRT_SIP (right) in correct relative scale.

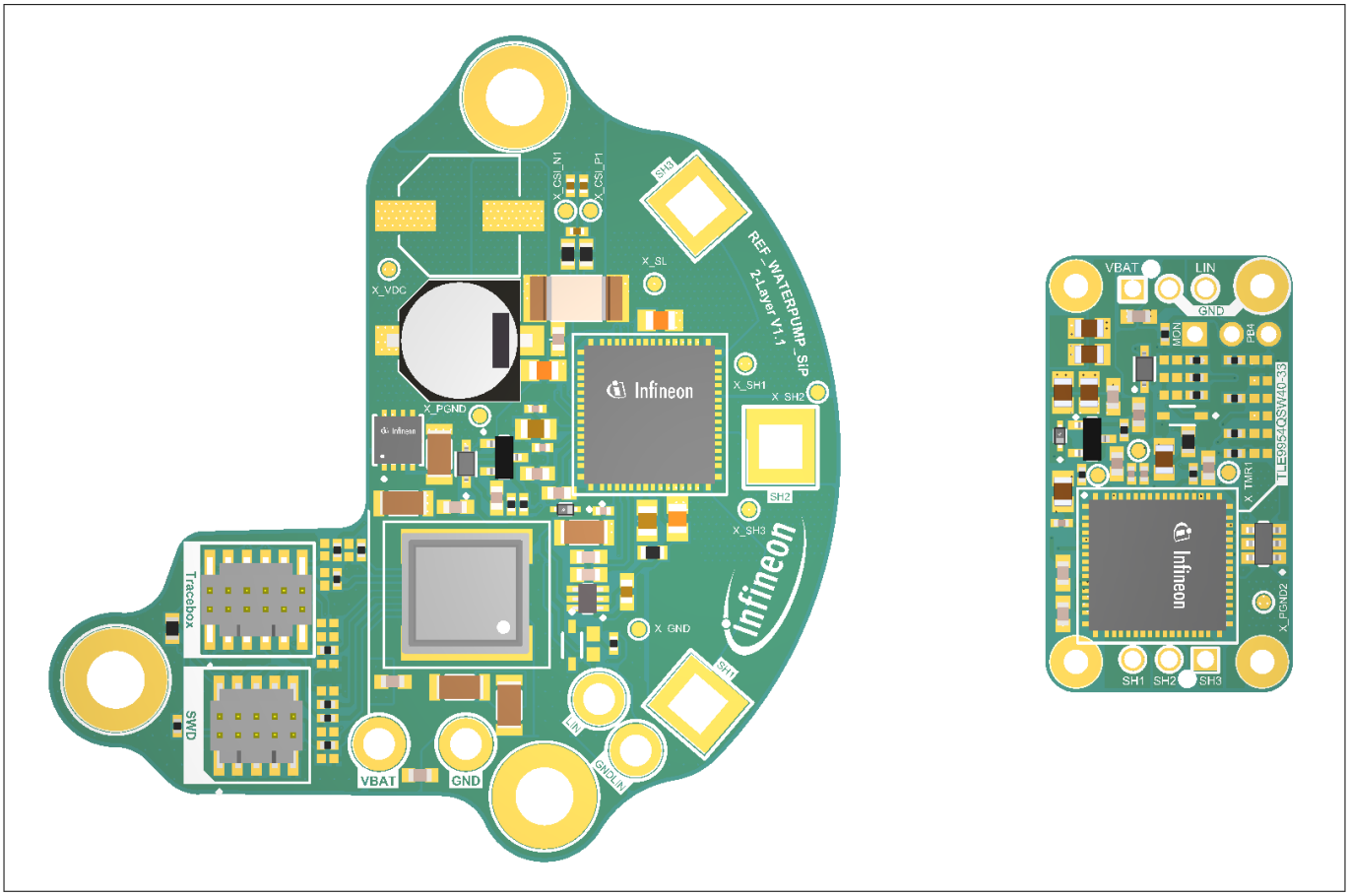

Figure 3 Comparison of REF_WATERPUMP_SiP (left) and REF_MINI_CMFRT_SIP (right)

To reduce the power losses even further, this design does not use a shunt resistor for current sensing. Instead, the XENSIV™ TLE5572 *tunnel magnetoresistance (TMR)* current sensor is used to measure the current flowing through the copper planes inside the PCB.

2.3 Key takeaway

The REF_MINI_CMFRT_SIP *PCB* showcases a highly compact PCB design enabled by the TLE9954QSW40-33 SiP. This user guide illustrates the performance capabilities of such a compact design, which features double-sided component placement optimized for top-side cooling, covering electrical and thermal characteristics as well as providing an initial indication of *EMC* behavior.

3 In detail: REF_MINI_CMFRT_SIP

The REF_MINI_CMFRT_SIP serves as a reference design for 100 W *brushless DC motor (BLDC motor)* comfort applications, such as BLDC motor seat adjustment, and can also be applied to other highly space constraint BLDC motor applications. The reference board has been developed using standard *PCB* materials and manufacturing processes.

The reference design features the MOTIX™ TLE9954QSW40-33 SiP, which integrates a B6-bridge. Additionally, it includes an OptiMOS™ 7 IAUZN04S7N026 MOSFET for reverse polarity protection. Power is supplied via a 12 V battery terminal connection. The design incorporates an input PI filter and supports *local interconnect network (LIN)* communication. Current measurement through the bridge is enabled by the XENSIV™ TLE5572 TMR current sensor. Furthermore, flash and debug communication with the microcontroller can be established through the provided debug connectors.

3.1 Design specifications

The design specifications are related to the assembled components and design considerations. They should not differ from the product datasheet recommendations. In case of deviations, the datasheet values of the products are valid.

Table 1 Design specifications

Parameter	Symbol	Values			Unit	Comment
		Min.	Typ.	Max.		
System parameters						
Function input voltage	V_{IN}	8	13.5	18	V	Specified by Design
Peak input current	I_{IN}	-	-	20	A	Peak current (<10 s)
Nominal input current	I_{IN}	-	8	-	A	2000 rpm
LIN interface	V_{BUS}	-40	-	40	V	
Phase voltage 1, 2, 3	V_{SH}	-8	-	48	V	
Thermal						
Operating temperature	T_A	-40	25	125	°C	Specified by design
Electromagnetic compatibility						
Conducted emissions				Class 4		CISPR25, 150 kHz-108 MHz
Mechanical specification						
Dimensions PCB	30 mm x 17 mm x 10mm (Width x Length x Height)					

3.2 Highlighted products

3.2.1 OptiMOS-7™ 40 V IAUZN04S7N026 MOSFET

A high-current, low $R_{DS(on)}$ power MOSFET in a 3x3 mm^2 advanced leadless package with a Cu-Clip for low package R_{ON} and minimal stray inductance, offering high power density, low conduction losses, and optimized switching behavior, with a reduced form factor compared to traditional leaded packages, ideal for automotive applications, for example power distribution, body control modules, and electric motors. For further information, see IAUZN04S7N026.

3.2.2 MOTIX™ MCU | 32-bit motor control SiP with integrated 3-phase bridge driver

TLE9954QSW40-33 belongs to the TLE995x family of 32-bit motor control SiPs with integrated 3-phase bridge driver and support for *LIN*. The potential applications of TLE995x include automotive motor control for auxiliary drives like pumps and fans in thermal management. In addition, *microcontroller unit (MCU)* system clock frequency supporting a wide range of motor control algorithms, either sensor-based or sensorless. Further information of the product can be found here.

3.2.3 XENSIV™ TLE5572-AE04E1-R-E0001

The XENSIV™ TLx5572 is a monocell *TMR*-based current sensor in a small and cost-competitive SOT23 package, which can replace a shunt and an OpAmp with a single component. The TLx5572 offers intrinsic isolation from the external current rail, with the benefit of reducing insertion resistance and allowing direct in-phase current measurement in automotive and industrial drives. And with its ultra-fast response time, it also provides a suitable solution for fast protection.

Glossary

BLDC motor

brushless DC motor (BLDC motor)
A synchronous motor using a direct current electric power supply.

BLDC

brushless direct current (BLDC)

EMC

electromagnetic compatibility (EMC)
The ability of electrical equipment and systems to function acceptably in their electromagnetic environment, by limiting the unintentional generation, propagation and reception of electromagnetic energy which may cause unwanted effects such as electromagnetic interference (EMI) or even physical damage in operational equipment.

GUI

graphical user interface (GUI)

An interface that enables users to interact with electronic devices through icons and visual indicators.

LIN

local interconnect network (LIN)

MCU

microcontroller unit (MCU)

A small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals.

PCB

printed circuit board (PCB)

A board that mechanically supports and electrically connects electronic components using conductive tracks, pads, and other features etched from copper sheets laminated onto a non-conductive substrate.

TMR

tunnel magnetoresistance (TMR)
A magnetoresistive phenomenon that occurs in a magnetic tunnel junction, used for example, for sensors.

Revision history

Document version	Date of release	Description of changes
Rev. 1.00	2026-03-06	• Initial document release

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