

Generic Power Board for 12 V applications

OptiMOS™-7 40 V sTOLL MOSFETs and MOTIX™ MCU TLE9879QXA40

Design Overview

This document outlines the Generic Power Board for 12V applications, suitable for automotive inverter applications to control fans or pumps driven by BLDC motors. The system is controlled by a system-on-chip MOTIX™ MCU, which features integrated MOSFET drivers in combination with OptiMOS™-7 40V leadless MOSFETs.

The design is capable of driving loads up to 400W, powered by a 12 V battery.

This manual includes a detailed description of the design, along with schematics and measurement reports.

Highlighted Components

- TLE9879QXA40
- IAUAN04S7N008

Target Applications

- Automotive fans and pumps
- Radiator fans, water pumps
- 400 W BLDC Motor for 12 V application

Highlighted Design Aspects



P_{out}
400 W

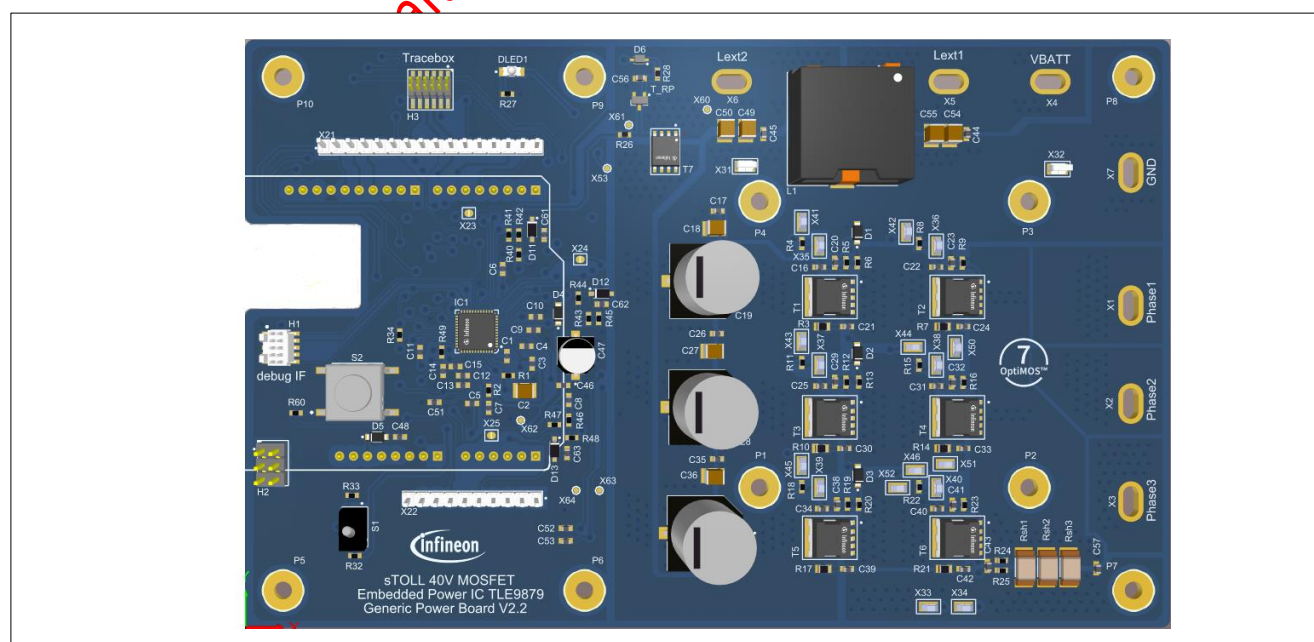


EMC
optimized



Thermally
optimized

Generic Power Board: Top View



Generic Power Board: Overview

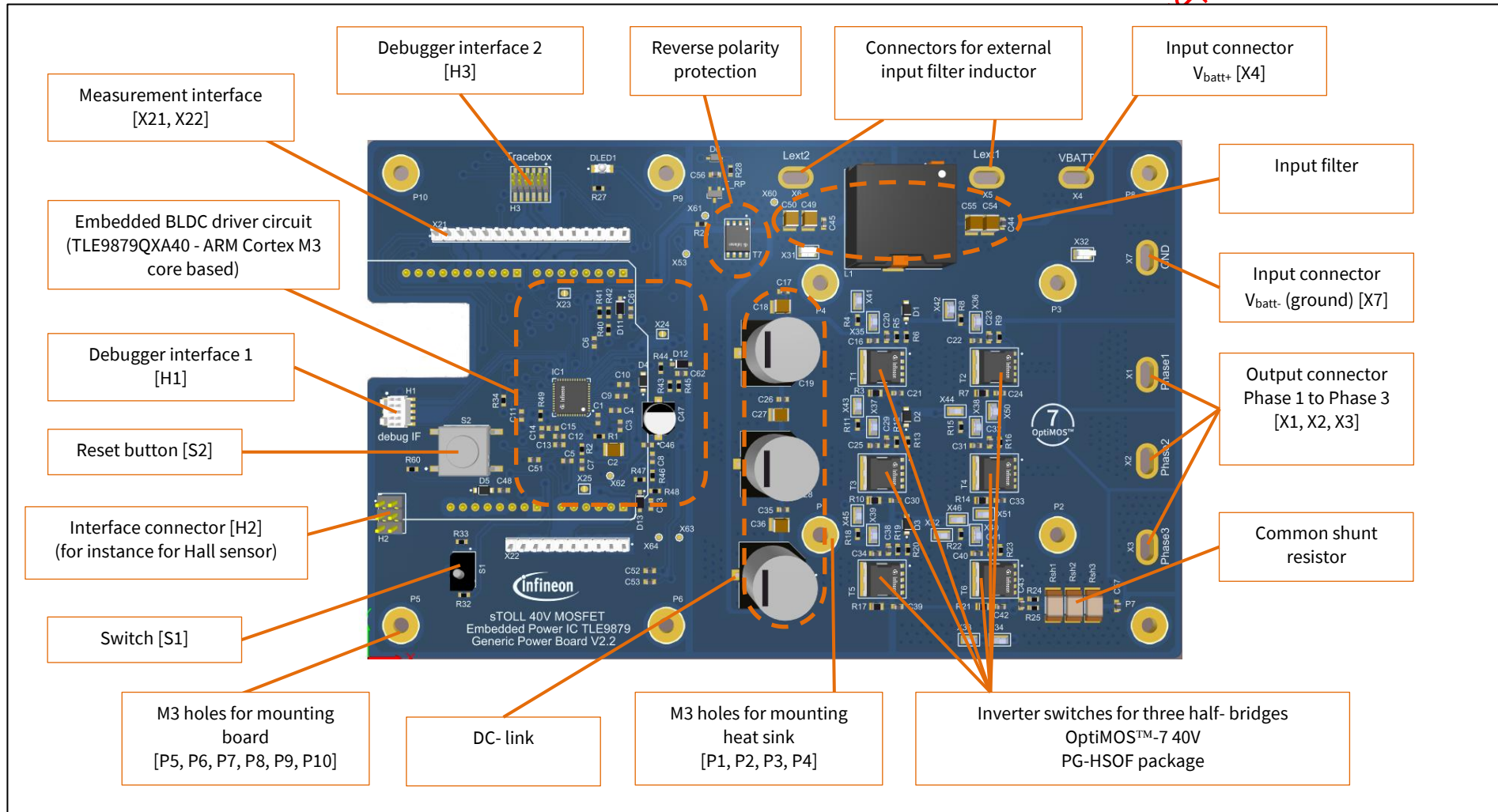


Table of contents

Table of contents	3
Important Notice	4
1 System Description	5
1.1 Design Specifications	5
1.2 Overview	7
1.3 Highlighted Products	8
1.3.1 OptiMOS™-7 40 V sTOLL (HSOF-5) MOSFET	8
1.3.2 3-Phase Bridge Driver IC with Integrated Arm® Cortex®-M3	9
2 Getting Started	10
2.1 Toolchain Installation	10
2.1.1 Configuration	10
3 System Design	11
3.1 Electrical Design and Components	12
3.1.1 Input Filter	12
3.1.2 Reverse Polarity Protection	13
3.1.3 DC-link Electrolytic Capacitor	14
3.1.4 Shunt Resistor	14
3.1.5 Snubber	15
3.1.6 Gate Driver	15
3.1.7 Gate driver circuit	16
3.1.8 Heatsink	17
3.2 Switching Performance	19
4 Project Collaterals	23
4.1 Schematics	23
4.2 Bill of Material	28
4.3 Layout	30
4.3.1 PCB Stack	30
4.3.2 Layout Printing	31
5 Abbreviations and definitions	33
6 Reference documents	34
Revision history	35

Important Notice

The Evaluation Boards and Reference Boards and the information in this document are solely intended to support designers of applications to evaluate the use of products of Infineon Technologies in the intended application.

Environmental conditions have been considered in the design of the Evaluation Boards and Reference Boards provided by Infineon Technologies. The design of the Evaluation Boards and Reference Boards is **tested by** Infineon Technologies only as described in this document. The design is not qualified in terms of safety requirements, manufacturing and operation over the entire operating temperature range or lifetime.

The Evaluation Boards and Reference Boards provided by Infineon Technologies are **subject to functional testing only under typical load conditions**. Evaluation Boards and Reference Boards are not subject to the same procedures as regular products regarding returned material analysis (RMA), process change notification (PCN) and product discontinuation (PD).

Evaluation Boards and Reference Boards are not commercialized products and are **solely intended to be used for evaluation and testing purposes**. They shall in particular not be used for reliability testing or production. Hence, the Evaluation Boards and Reference Boards may not comply with CE or similar standards (including but not limited to the EMC Directive 2004/EC/108 and the EMC Act) and may not fulfill other requirements of the country in which they are operated by the customer. The customer shall ensure that each Evaluation Boards and Reference Board will be handled in a way which is compliant with all relevant requirements and standards in the country in which they are operated.

The Evaluation Boards and Reference Boards and any information in this document are addressed **only to qualified and skilled technical staff, for laboratory usage**, and shall be used and managed according to the terms and conditions set forth in this document and in any other related documentation provided with the respective Evaluation Boards or Reference Board.

It is the **responsibility of customer's technical departments to evaluate the suitability** of the Evaluation Boards and Reference Boards for the intended application and the completeness and correctness of the information provided in this document with respect to such application.

The customer accepts that the Evaluation Boards and Reference Boards are not intended to be used for life-endangering applications such as medical, nuclear, military, life-critical or other applications, where failure of the Evaluation Boards and Reference Boards or any results from the use thereof can reasonably be expected to result in personal injury.

The Evaluation Boards and Reference Boards and any information in this document is provided "as is" and Infineon Technologies disclaims any and all warranties, express or implied, including but not limited to warranties of non-infringement of third-party rights and implied warranties of fitness for any purpose, or for merchantability.

Infineon Technologies shall not be responsible for any damages resulting from the use of the Evaluation Boards and Reference Boards and/or from any information provided in this document. The customer is obliged to defend, indemnify and hold harmless Infineon Technologies from and against any claims or damages arising out of or resulting from any use thereof.

Infineon Technologies reserves the right to change this document and/or any information provided herein at any time without further notice.

1 System Description

The inverter design described in this document presents a solution for an engine cooling fan with power capability up to 400W. It is also applicable to similar systems with equal or lower power requirements. This solution can be used for similar applications with smaller or equal output power. The circuit features an integrated 3-phase motor control solution. The system-on-chip microcontroller belongs to the MOTIX™ MCU family, combining an Arm® Cortex®-M3 microcontroller with application specific modules, including an integrated 3-phase MOSFET driver, power supply and LIN-transceiver. Paired with the OptiMOS™-7 40V MOSFETs in PG-HSOF-5 package (sTOLL) the board system is optimized for minimal PCB size within this power class. The reference design aims to use standard PCB materials and processes.

1.1 Design Specifications

The design specifications correspond to the used components and related design considerations. These specifications should align with the values provided in the product datasheets. In case of discrepancies, the values in the datasheets shall take precedence.

Table 1 Design Specifications

Parameter	Symbol	Values			Unit	Comment
		Min.	Typ.	Max.		
System Parameters						
Input voltage	V _{IN}	-0.3	12	40	V	P_1.1.1 (TLE9879QXA40)
Functional input voltage	V _{IN}	7	12	18	V	Specified for Design
Output current peak	I _{OUT}	-		44	A	Peak current (<10 s), air cooling attached (>1.3 m/s)
Output current continuous	I _{OUT}	-	20	35	A	Specified for Design
Hall Sensor Inputs	V _{HALL}	-0.3	5	5.5	V	Specification related to GPIO Port 0,1
LIN interface	V _{LIN}	-28	12	40	V	P_1.1.7 (TLE9879QXA40)
ADC Inputs	V _{ADC}	-0.3	5	5.5	V	Specification related to GPIO Port 2
Phase 1, 2, 3	V _{SH}	-8.0	12	48	V	P_1.1.11 (TLE9879QXA40)
Thermal						
Operating temperature	T _A	-40	25	105	°C	Specified for Design

Generic Power Board for 12 V applications

OptiMOS-7™ 40 V sTOLL MOSFETs and MOTIX™ MCU TLE9879QXA40



Electromagnetic Compatibility

Conducted emissions	Class 2	CISPR25, 150 kHz -108 MHz
---------------------	---------	---------------------------

Mechanical Specification

Dimensions	168 mm x 107 mm x 15 mm (L x W x H) ¹
PCB	6-layer, top/bottom layer 2 oz, inner layers 1 oz, standard FR4, 168mm x 107 mm (L x W), thickness 1.6 mm

¹ A possibly mounted heatsink is not considered. The overall high is given by using C19, C28 and C37 in circuit DC link.

1.2 Overview

Figure 1 presents the 3D CAD view of the system. The board is equipped with six MOSFETs equipped in a PG-HSOF-5 package (sTOLL), one microcontroller with LIN and integrated 3-phase BLDC MOSFET gate driver. The board allows for the configuration of the common low-side shunt-resistor of the B6-bridge using three resistors connected in parallel. All active components, including the seven MOSFETs and the driver IC, are arranged over a large area on the board to distribute heat evenly across the PCB. The shunt resistors, serving as passive components, also act as additional heat sources, collecting all return current from the three legs of the bridge. The board is designed to dissipate heat from the shunt resistors effectively through thermal pads. As the power circuitry part of the PCB does not have any surface-mounted components on the bottom side, a simple flat heatsink can be attached to the underside of the board. Only the controller side features through-hole connectors and a switch.

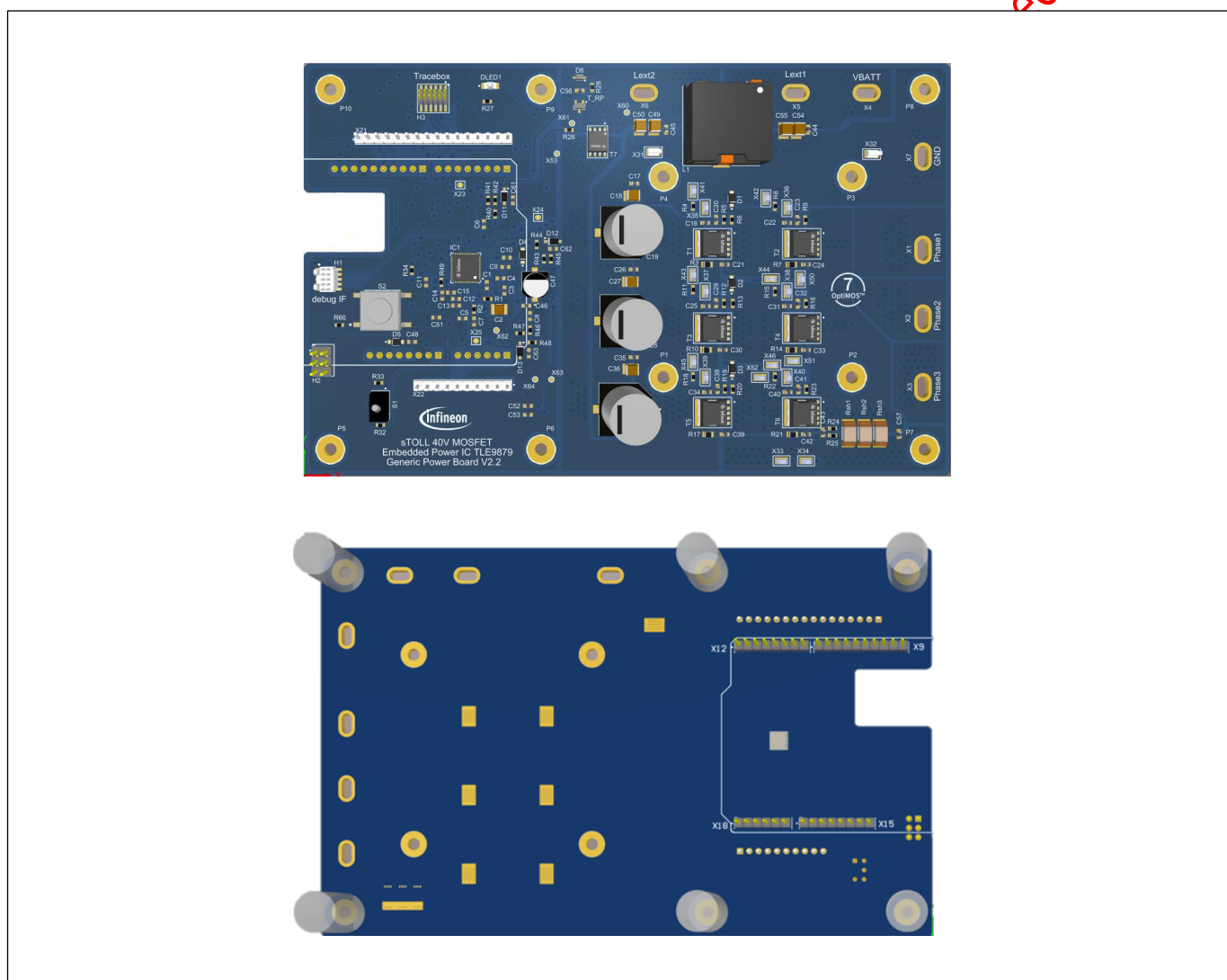


Figure 1 View to the evaluation Generic Power Board (top and bottom view)

1.3 Highlighted Products

The component highlighted with a grey background are used on the Generic Power Board.

1.3.1 OptiMOS™-7 40 V sTOLL (HSOF-5) MOSFET

The sTOLL package features a compact footprint of 55mm². In the leading edge power MOSFET technology OptiMOS™-7 40 V, this package offers a drain-to-source on-state resistance ($R_{DS(on)}$) that typically ranges from 0.39 mΩ to 0.82 mΩ. Notably, it reaches the highest avalanche current rating ever in a Trench FET technology combined with the lowest $R_{DS(on)}$. These outstanding characteristics make it an excellent choice for automotive 3-phase motor drives up to 400W, maintaining Infineon's renowned quality and robustness for automotive packages.

Table 2 Automotive sTOLL MOSFET with 40 V OptiMOS™-7

Package	Silicon Technology	Product	Max $R_{DS(on)}$ [mΩ]
sTOLL (HSOF-5)	OptiMOS™-7	IAUAN04S7N004	0.39
		IAUAN04S7N005	0.51
		IAUAN04S7N006	0.57
		IAUAN04S7N007	0.72
		IAUAN04S7N008	0.82

1.3.2 3-Phase Bridge Driver IC with Integrated Arm® Cortex®-M3

The TLE987x family caters to a broad spectrum of start 3-phase brushless DC motor control applications, including auxiliary pumps and fans. It provides a high level of integration and low system cost, optimizing these application segments. Additionally, it offers scalability with varying flash memory sizes and MCU system clock frequencies, supporting a wide array of motor control algorithms, both sensor-based and sensor-less. For further details about the product family, please visit Infineon's website at the link provided below.

- www.infineon.com/tle987x

Table 3 Product Family of 3-Phase Bridge Driver IC with Integrated Arm® Cortex®-M3

Grade	Product	Flash	RAM	Frequency	Interface	Tjmax
Grade-0	TLE9873QXW40	48 kByte	3 kByte	40 MHz	PWM + LIN	175 °C
	TLE9877QXW40	64 kByte	6 kByte	40 MHz	PWM + LIN	175 °C
	TLE9879QXW40	128 kByte	6 kByte	40 MHz	PWM + LIN	175 °C
Grade-1	TLE9871QXA20	36 kByte	3 kByte	24 MHz	PWM	150 °C
	TLE9872QXA40	256 kByte	8 kByte	40 MHz	PWM + LIN	150 °C
	TLE9872-2QXA40	256 kByte	8 kByte	40 MHz	PWM + LIN	150 °C
	TLE9877QXA20	64 kByte	6 kByte	24 MHz	PWM + LIN	150 °C
	TLE9877QXA40	64 kByte	6 kByte	40 MHz	PWM + LIN	150 °C
	TLE9879QXA20	128 kByte	6 kByte	24 MHz	PWM + LIN	150 °C
	TLE9879-2QXA40	128 kByte	6 kByte	40 MHz	PWM + LIN	150 °C
	TLE9879QXA40	128 kByte	6 kByte	40 MHz	PWM + LIN	150 °C

2 Getting Started

2.1 Toolchain Installation

To prepare the board for operation, the software listed in Table 4 must be installed. The μ Vision software is a development tool provided by Arm® Keil®. Although the shareware version of μ Vision has a code length limitation, it still allows for editing, compiling and debugging. The Infineon Config Wizard is used to configure the peripherals of the Embedded Power IC. This tool can be accessed from the μ Vision pull-down menu, enabling users to adjust parameters through its user interface and subsequently generate the corresponding software code. Infineon also provides standard motor drive software codes for the Embedded Power IC, which can be downloaded via the Pack Installer within the μ Vision software.

Table 4 Software Toolchain Installation Guide

Steps	Company	Description
STEP1 Download and Install Keil® μVision5	Arm® Keil®	- Arm® Keil® μVision is an integrated development environment which consists of code editor, compiler and debugger. - To learn how to use Arm® Keil® μVision 5, check out our video "Get your motor spinning"
STEP2 Download Config Wizard	Infineon Technologies	- Infineon provides the Config Wizard free of charge, which is designed for configuration of chip modules. Config Wizard supports easy configuring of Embedded Power IC peripherals. - Config Wizard can be installed via the Infineon Developer Center. If you don't have this Infineon toolbox yet, please go to Infineon Developer Center Launcher and enjoy the release management for updates.
STEP3 Download and Install Segger J-Link Driver	XMC™ Link based on SEGGER J-Link technology	- XMC™ Link is a debug probe for all XMC microcontrollers - The debug probe is based on Segger J-Link debug firmware, which enables use with DAVE and all major third-party compiler/IDEs known from the wide ARM® ecosystem
STEP4 Download the SDK via μ Vision5 Pack Installer	Infineon Technologies	The Embedded Power Software Development Kit (SDK) is a low-level driver library which can be downloaded within Keil® μVision via the "Pack Installer"

For the toolchain installation and free motor drive software, please visit the website at the link below.

[Getting Started - Toolchain Installation Guide for TLE987X EVALB](#)

For more information about the tool chain installation steps, please watch the video at the link below.

[Getting Started - Toolchain Installation Guide for TLE987X EVALB - Video](#)

2.1.1 Configuration

To configure the system, follow these steps: open a motor drive code project in μ Vision5, then navigate to "Tools" and select "Config Wizard". Next, set up the parameters for the motor, speed/current controller and the TLE987x peripherals. Given that the Embedded Power IC employs a current-source gate driving scheme, the switching speed is set by the "Gate Charge/Discharge" parameters in the BDRV tap of the peripherals, rather than by the gate resistors. For further configuration details, please visit the Infineon website for Embedded Power ICs.

3 System Design

Full content available after board serial number registration on Infineon website

3.1 Electrical Design and Components

3.1.1 Input Filter

Full content available after board serial number registration on Infineon website

3.1.2 Reverse Polarity Protection

Full content available after board serial number registration on Infineon website

3.1.3 DC-link Electrolytic Capacitor

3.1.4 Shunt Resistor

Full content available after board serial number registration on Infineon website

3.1.5 Snubber

3.1.6 Gate Driver

Full content available after board serial number registration on Infineon website

3.1.7 Gate driver circuit

Full content available after board serial number registration on Infineon website

3.1.8 Heatsink

Full content available after board serial number registration on Infineon website

Generic Power Board for 12 V applications

OptiMOS-7™ 40 V sTOLL MOSFETs and MOTIX™ MCU TLE9879QXA40



Full content available after board serial number registration on Infineon website

3.2 Switching Performance

Full content available after board serial number registration on Infineon website

Generic Power Board for 12 V applications

OptiMOS-7™ 40 V sTOLL MOSFETs and MOTIX™ MCU TLE9879QXA40



Full content available after board serial number registration on Infineon website

Generic Power Board for 12 V applications

OptiMOS-7™ 40 V sTOLL MOSFETs and MOTIX™ MCU TLE9879QXA40



Full content available after board serial number registration on Infineon website

Generic Power Board for 12 V applications

OptiMOS-7™ 40 V sTOLL MOSFETs and MOTIX™ MCU TLE9879QXA40



Full content available after board serial number registration on Infineon website

4 Project Collaterals

4.1 Schematics

Full content available after board serial number registration on Infineon website

Generic Power Board for 12 V applications

OptiMOS-7™ 40 V sTOLL MOSFETs and MOTIX™ MCU TLE9879QXA40



Full content available after board serial number registration on Infineon website

Generic Power Board for 12 V applications

OptiMOS-7™ 40 V sTOLL MOSFETs and MOTIX™ MCU TLE9879QXA40



Full content available after board serial number registration on Infineon website

Generic Power Board for 12 V applications

OptiMOS-7™ 40 V sTOLL MOSFETs and MOTIX™ MCU TLE9879QXA40



Full content available after board serial number registration on Infineon website

Generic Power Board for 12 V applications

OptiMOS-7™ 40 V sTOLL MOSFETs and MOTIX™ MCU TLE9879QXA40



Full content available after board serial number registration on Infineon website

4.2 Bill of Material

Full content available after board serial number registration on Infineon website

Generic Power Board for 12 V applications

OptiMOS-7™ 40 V sTOLL MOSFETs and MOTIX™ MCU TLE9879QXA40



Full content available after board serial number registration on Infineon website

4.3 Layout

4.3.1 PCB Stack

Full content available after board serial number registration on Infineon website

4.3.2 Layout Printing

Full content available after board serial number registration on Infineon website

Generic Power Board for 12 V applications

OptiMOS-7™ 40 V sTOLL MOSFETs and MOTIX™ MCU TLE9879QXA40



Full content available after board serial number registration on Infineon website

5 Abbreviations and definitions

Table 5 Abbreviations

Abbreviation	Definition
AC	Alternating Current
ARM	Advanced RISK Machine
ADC	Analogue-to-Digital Conversion
BDRV	Bridge Driver Module of Embedded Power IC
BLDC	Brushless Direct Current
CISPR	Comité International Spécial des Perturbations Radioélectriques
DC	Direct Current
DIL	Dual-In-Line
EMC	Electromagnetic Compatibility
GPIO	General Purpose Input/Output
PG-HSOF	Plastic Green - Heatsink Small Outline Flat leads
IC	Integrated Circuit
LIN	Local Interconnect Network
MCU	Microcontroller Unit
MI	Modulation Index
MLCC	Multi-Layer-Ceramic Capacitor
MOSFET	Metal Oxide Semiconductor Field Effect Transistor
PCB	Printed Circuit Board
PG-TDSON	Plastic Green - Thin Dual Small-Outline Non-leaded
PWM	Pulse Width Modulation
RAM	Random Access Memory
RC	Resistor-Capacitor
RMS	Root-Mean-Square value
SDK	Software Development Kit
SMD	Surface-Mounted Device
SMT	Surface-Mounted Technology
SSO8	Super Small-Outline 8 pin
TIM	Thermal Interface Material

6 Reference documents

This document should be read in conjunction with the following documents:

- [1] TLE9879QXA40 data sheet, Infineon Technologies AG, https://www.infineon.com/dgdl/Infineon-TLE9879QXA40-DataSheet-v02_00-EN.pdf?fileId=8ac78c8c81ae03fc0181d840096a3c2f
- [2] XMC Link user's manual, Infineon Technologies AG, https://www.infineon.com/dgdl/Infineon-XMC_Link_Board_Users_Manual.pdf-UserManual-v01_00-EN.pdf?fileId=5546d462518ffd850152451695e45edc
- [3] TLE986x_ TLE987x Bridge Driver Application Note, 2022-05-02, Infineon Technologies AG, Rev.1.03 https://www.infineon.com/dgdl/Infineon-AppNote-TLE986x-TLE987x-FAQ-ApplicationNotes_3-ApplicationNotes-v01_03-EN.pdf?fileId=5546d4625b62cd8a015ba9870bd91373
- [4] IAUCN04S7N005 datasheet, Infineon Technologies AG, https://www.infineon.com/dgdl/Infineon-IAUCN04S7N005-DataSheet-v01_00-EN.pdf?fileId=8ac78c8c8900bb5701890620a151fdb
- [5] IAUAN04S7N008 datasheet, Infineon Technologies AG, https://www.infineon.com/dgdl/Infineon-IAUAN04S7N008-DataSheet--DataSheet-v01_00-EN.pdf?fileId=8ac78c8c8eeb092c018f190fa99f121f
- [6] Analytical calculation of the RMS current stress on the DC-link capacitor of voltage-PWM converter systems, 2006-07, IEE Proc.-Electr. Power Appl., Vol. 153, No. 4
- [7] Snubber Capacitors Application Guide, 2018-01, Cornell Dubilier
- [8] ERU chokes datasheet, TDK, https://www.tdk-electronics.tdk.com/inf/30/ds/B82559B_A019.pdf
- [9] Heat sink profile, RS-Online, <https://de.rs-online.com/web/p/kuhlkorper/1686330>
- [10] Thermal interface material TIM, DOWSIL™ TC-4060 Thermal Gel, <https://www.dow.com/en-us/pdp.dowsil-tc-4060-thermal-gel.512275z.html?productCatalogFlag=1&#tech-content>
- [11] Motor load, Nanotec DB42S02, <https://en.nanotec.com/products/635-db42s02>
- [12] Current controlled hysteresis break, Mobac HB-50-2DS, https://www.mobac.de/fileadmin/user_upload/Mobac/PDF/strom/strom-stand-bs.pdf
- [13] User Manual TLE987x Microcontroller with LIN and BLDC MOSFET driver for automotive applications https://www.infineon.com/dgdl/Infineon-TLE987x_UM-UserManual-v01_08-EN.pdf?fileId=8ac78c8c81ae03fc0181d38669525fab
- [14] Reverse Polarity Protection for Embedded Power ICs Application Note, https://www.infineon.com/dgdl/Infineon-Reverse_Polarity_Protection-AN-v01_00-EN.pdf?fileId=5546d46267c74c9a01684be08bf45dfb
- [15] Generic power evaluation board design for 12 V application - OptiMOS™ - 6 SSO8 and TLE9879QXA40, https://www.infineon.com/dgdl/Infineon-EvaluationDesignGuide_MOSFET_GenericPowerBoard_V10.pdf-UserManual-v01_00-EN.pdf?fileId=8ac78c8c850f4bee0185babcb612156d
- [16] Generic power evaluation board design for 12 V application – OptiMOS™ - 7 SSO8 and TLE9879QXA40, https://www.infineon.com/dgdl/Infineon-20240515_GenericPowerBoard_OptiMOS7_SSO8_V01_reduced.pdf-UserManual-v01_00-EN.pdf?fileId=8ac78c8c8eeb092c018fa5cc87f1703d

Generic Power Board for 12 V applications

OptiMOS-7™ 40 V sTOLL MOSFETs and MOTIX™ MCU TLE9879QXA40



Revision history

Major changes since the last revision

Date	Version	Description
2024/09/10	1.0	First revision

Full content available after board serial number registration on Infineon website

Trademarks

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

Edition 2024-09-10

Published by

Infineon Technologies AG

81726 Munich, Germany

© 2024 Infineon Technologies AG.

All Rights Reserved.

Do you have a question about this document?

Email: erratum@infineon.com

Document reference

Z8F80705532

IMPORTANT NOTICE

The information contained in this application note is given as a hint for the implementation of the product only and shall in no event be regarded as a description or warranty of a certain functionality, condition or quality of the product. Before implementation of the product, the recipient of this application note must verify any function and other technical information given herein in the real application. Infineon Technologies hereby disclaims any and all warranties and liabilities of any kind (including without limitation warranties of non-infringement of intellectual property rights of any third party) with respect to any and all information given in this application note.

The data contained in this document is exclusively intended for technically trained staff. It is the responsibility of customer's technical departments to evaluate the suitability of the product for the intended application and the completeness of the product information given in this document with respect to such application.

For further information on the product, technology, delivery terms and conditions and prices please contact your nearest Infineon Technologies office (www.infineon.com).

WARNINGS

Due to technical requirements products may contain dangerous substances. For information on the types in question please contact your nearest Infineon Technologies office.

Except as otherwise explicitly approved by Infineon Technologies in a written document signed by authorized representatives of Infineon Technologies, Infineon Technologies' products may not be used in any applications where a failure of the product or any consequences of the use thereof can reasonably be expected to result in personal injury.