Generic Power Board for 12 V applications

OptiMOS™-7 40 V SSO8 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.

EMC compliance has been tested in line with the CISPR25 standard and an analysis of the thermal performance is also provided.

Highlighted Components

- TLE9879QXA40
- IAUCN04S7N009
- IAUCN04S7N005

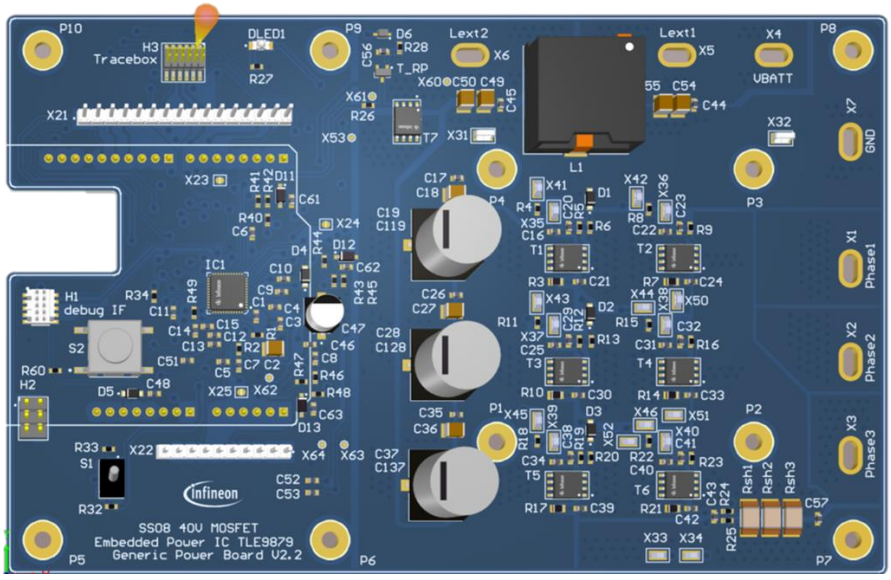
Target Applications

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

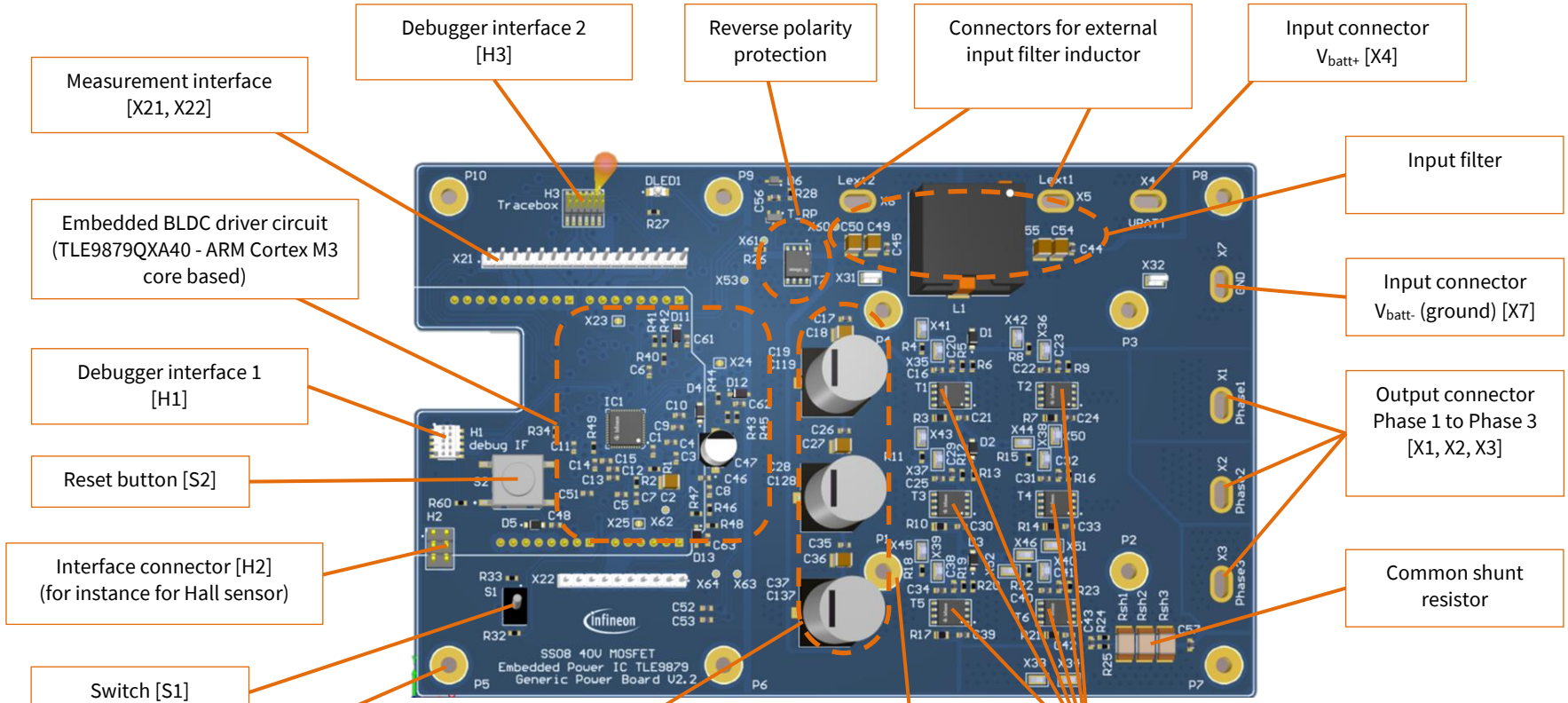
Highlighted Design Aspects

P_{out} 400 W | EMC optimized | Thermally optimized

Generic Power Board: Top View



Generic Power Board: Overview



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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-TDSON-8 package (SSO8) 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

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 seven MOSFETs equipped in a PG-TDSON-8 package (SSO8), 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.

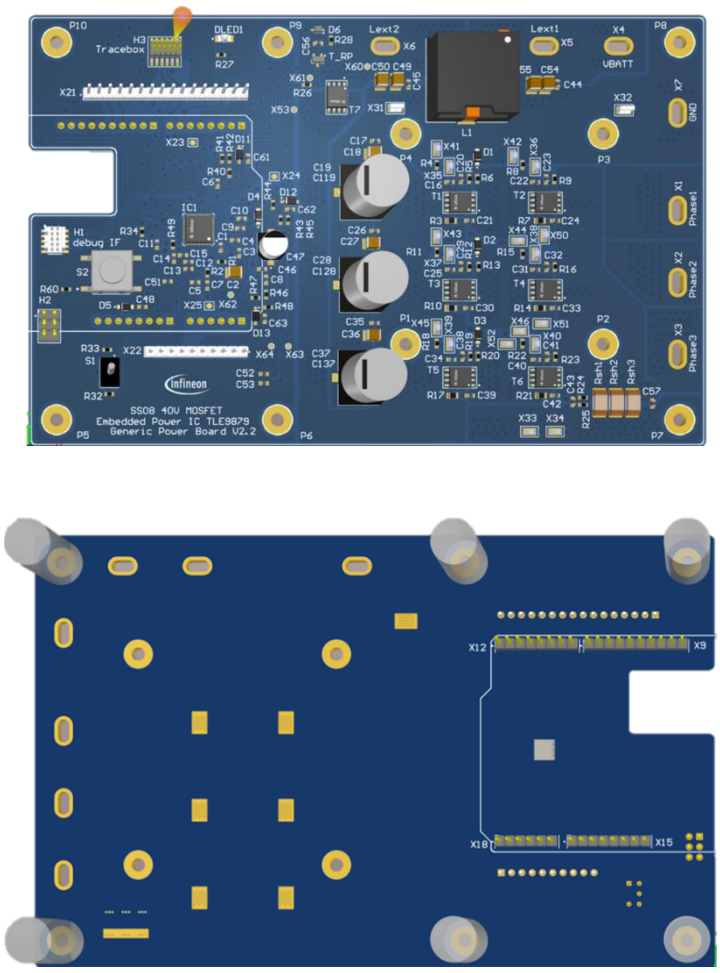

Figure 1 View to the evaluation Generic Power Board (top and bottom view)

1.3 Highlighted Products

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

1.3.1 OptiMOS™-7 40 V SSO8 (TDSON-8) MOSFET

The SSO8 package features a compact 33mm² footprint and provides and drain-to-source on-state resistance $R_{DS(on)}$ typically ranging from 0.42 mΩ to 3 mΩ. Its current rating is up to 3 times higher than that of the S3O8 (TSDSON-8) package. When combined with Infineon's OptiMOS™-7 40 V power MOS technology, the TDSON package delivers a compact yet powerful solution for automotive 3-phase motor drives up to 400W, maintaining Infineon's renowned quality and robustness for automotive packages.

Table 2 Automotive SSO8 MOSFET with 40 V OptiMOS™-7

Package	Silicon Technology	Product	Max $R_{DS(on)}$ [mΩ]
SSO8 (TDSON-8)	OptiMOS™-7	IAUCN04S7L005	0.5
		IAUCN04S7L006	0.6
		IAUCN04S7L009	0.9
		IAUCN04S7L011	1.1
		IAUCN04S7L014	1.4
		IAUCN04S7L019	1.9
		IAUCN04S7L028	2.8
		IAUCN04S7N005	0.5
		IAUCN04S7N006	0.6
		IAUCN04S7N009	0.9
		IAUCN04S7N012	1.2
		IAUCN04S7N015	1.5
		IAUCN04S7N020	2.0
		IAUCN04S7N030	3.0

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 µVision software is a development tool provided by Arm® Keil®. Although the shareware version of µVision 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 µVision 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 µVision 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 µVision5 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 µVision5, 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

3.1 Electrical Design and Components

3.1.1 Input Filter

3.1.2 Reverse Polarity Protection

3.1.3 DC-link Electrolytic Capacitor

3.1.4 Shunt Resistor

3.1.5 Snubber

.

3.1.6 Gate Driver

3.1.7 Gate driver circuit

3.1.8 Heatsink

3.2 Switching Performance

3.3 EMC performance

3.3.1 Measurement configuration

3.3.2 Measurement results

3.4 Thermal performance

4 Project Collaterals

4.1 Schematics

4.2 Bill of Material

4.3 Layout

4.3.1 PCB Stack

4.3.2 Layout Printing

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
BOM	Bill of material
CISPR	Comité International Spécial des Perturbations Radioélectriques
DC	Direct Current
DIL	Dual-In-Line
DUT	Device Under Test
ECU	Electrical Control Unit
ECF	Engine Cooling Fan
EMC	Electromagnetic Compatibility
ESR	Equivalent Series Resistant
FOC	Field Oriented Control
GPIO	General Purpose Input/Output
IC	Integrated Circuit
LIN	Local Interconnect Network
LISN	Line Impedance Stabilization 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
RBP	Reverse Battery Protection
RC	Resistor-Capacitor
RISC	Reduced Instruction Set Computer
RMS	Root-Mean-Square value
S3O8	Shrink Super Small-Outline 8 pin
SDK	Software Development Kit
SMD	Surface-Mounted Device
SMT	Surface-Mounted Technology
SoC	System On a Chip

SOA	Safe Operating Area
SSO8	Super Small-Outline 8 pin
TIM	Thermal Interface Material
TH	Through Hole

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-Application-Hints_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=8ac78c8c8900bb5701890621ba151fdb

[5] IAUCN04S7N009 datasheet, Infineon Technologies AG https://www.infineon.com/dgdl/Infineon-IAUCN04S7N009-DataSheet-v01_00-EN.pdf?fileId=8ac78c8c8d1b852e018d21fc142b1f38

[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, Nanotc 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 - SSO8 and TLE9879QXA40

https://www.infineon.com/dgdl/Infineon-EvaluationDesignGuide_MOSFET_GenericPowerBoard_V10.pdf-UserManual-v01_00-EN.pdf?fileId=8ac78c8c850f4bee0185babcb612156d

Revision history

Major changes since the last revision

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