

# Generic power evaluation board design for 12 V application - SSO8 and TLE9879QXA40

OptiMOS-6™ 40 V SSO8 MOSFET, MOTIX™ MCU TLE9879QXA40

## Design Overview

This documentation describes the Generic Power evaluation board for 12V fit for the implementation of an automotive inverter application for controlling fans or pumps driven by BLDC motors. The system is controlled by a system- on-chip MOTIX™ MCU with integrated MOSFET drivers in combination with OptiMOS™-6 leadless MOSFETs.

The design is capable to drive loads up to 400W supplied by a battery voltage of 12 V.

This design guide contains a description of the design, schematics and measurement reports.

EMC is tested according to the CISPR25 standard. Thermal performance information is given and discussed.

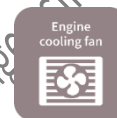
## Highlighted Components

- TLE9879QXA40
- IAUC120N04S6N006
- IAUC120N04S6N010

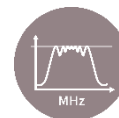
## Target Application

- Automotive Fan and Pump
- Radiator fan, Water pump
- 400 W BLDC Motor for 12 V application

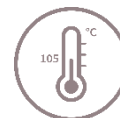
## Highlighted Design Aspects



400 W  
functional

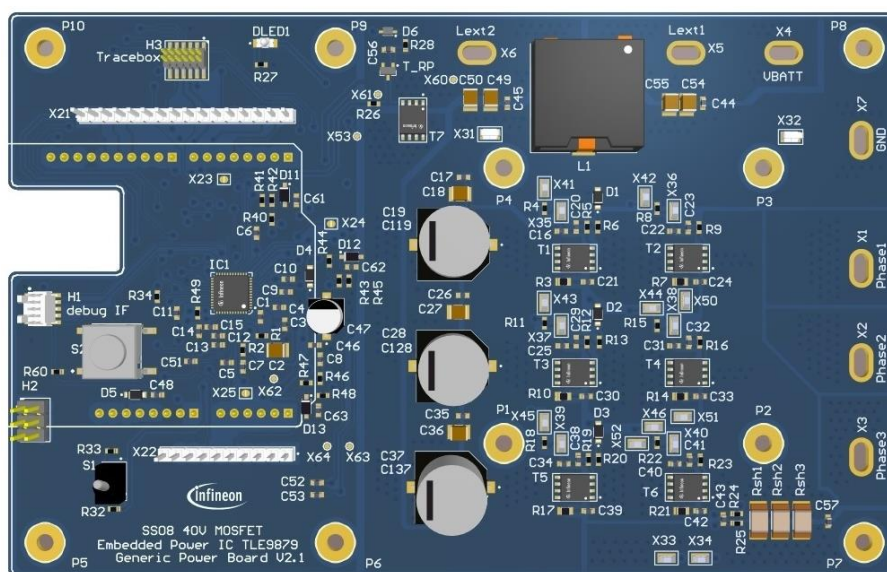


EMC  
optimized

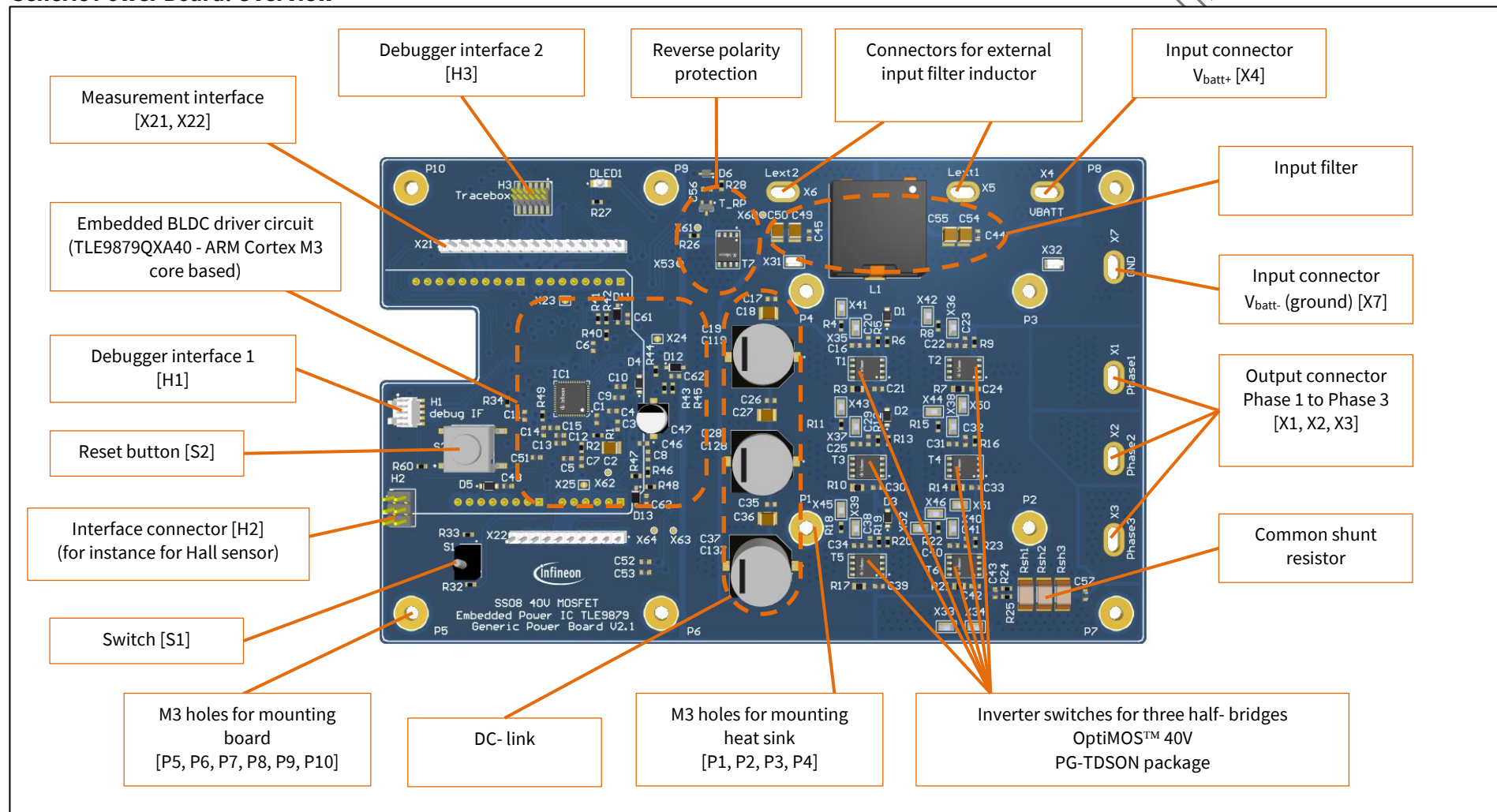


Thermally  
optimized

## Generic Power Board: Top View



## Generic Power Board: Overview



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## 1 System Description

The inverter design describes a solution for an engine cooling fan with a power capability up to 400W output power. This solution can be used for similar applications with smaller or equal output power. The circuit contains an integrated 3-phase motor control solution. The SoC microcontroller is a member of the MOTIX™ MCU family. It combines an Arm® Cortex®-M3 microcontroller with application specific modules like an integrated 3-phase MOSFET driver, power supply and LIN-transceiver. In combination with the OptiMOS™-6 40V MOSFETs in PG-TDSON-8 package (SS08) the board system is optimized for a minimum of PCB size for this power class. The focus of the demonstrator design is to use standard PCB materials and processes.

### 1.1 Design Specifications

The design specifications are related to the used components and design considerations. They shouldn't differ from the product datasheet values. In case of misalignment, the datasheet values of the products are valid.

**Table 1 Design Specifications**

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

# Generic power evaluation board design for 12 V application - SS08 and TLE9879QXA40



## System Description

### Electromagnetic Compatibility

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

### Mechanical Specification

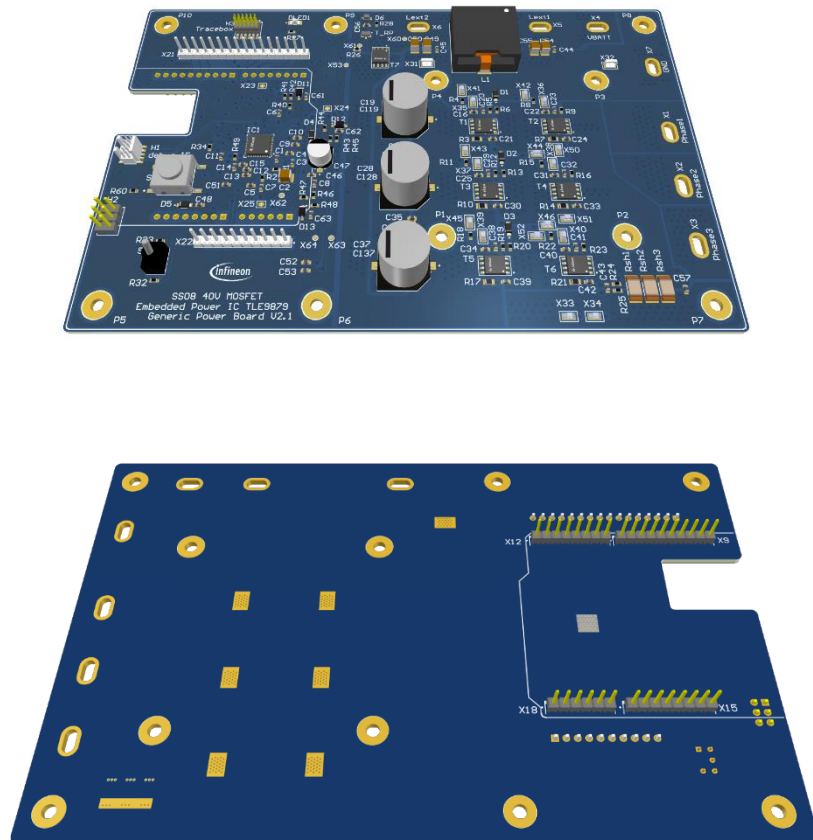
|            |                                                                                                           |
|------------|-----------------------------------------------------------------------------------------------------------|
| Dimensions | 168 mm x 107 mm x 15 mm (L x W x H) <sup>1</sup>                                                          |
| 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 |

<sup>1</sup> A possibly mounted heatsink is not considered. The overall high is given by using C19, C28 and C37 in circuit DC link.  
Evaluation Design Guide



### 1.2 Overview

Figure 1 shows the 3D CAD view of the system. The board has seven MOSFETs equipped in a PG-TDSON-8 package (SS08), one microcontroller with LIN and integrated 3-phase BLDC MOSFET gate driver. The board allows the configuration of the common low-side shunt-resistor of the B6- bridge by three resistors connected in parallel. All active components, including the seven MOSFETs and one driver IC, are large-area arranged on the board to distribute the heat over the whole area of the PCB. As passive components, the shunt resistors are additional heat sources. Those are collecting all return current from the three legs of the bridge. The board is designed to dissipate the heat of the shunts effectively through the thermal pads. As the power circuitry part of the PCB does not have any surface-mounted components on its bottom side, it is possible to attach a simple flat heatsink at the bottom of the board. Only controller side has through-hole connectors and a switch.



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

### 1.3 Highlighted Products

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

#### 1.3.1 OptiMOS™-6 40 V SS08 (TDSO8-8) MOSFET

The SS08 package offers compact 33mm<sup>2</sup> footprint size with drain to source on-state resistance  $R_{DS(on)}$  ranging from typically 0.54 ~4.4 [mΩ]. Its current rating is up to 3 times bigger than the S308 (TSDSON-8) package. In combination with Infineon's OptiMOS™-6 40 V power MOS technology, the TDSO8 package offers a compact yet powerful solution for automotive 3-phase motor drive up to 400W at Infineon's well known quality level for robust automotive packages.

**Table 2 Automotive SS08 MOSFET with 40 V OptiMOS™-6**

| Package           | Silicon Technology | Product          | Max $R_{DS(on)}$ [mΩ] |
|-------------------|--------------------|------------------|-----------------------|
| SS08<br>(TDSO8-8) | OptiMOS™-6         | IAUC120N04S6L005 | 0.55                  |
|                   |                    | IAUC120N04S6N006 | 0.6                   |
|                   |                    | IAUC120N04S6N008 | 0.8                   |
|                   |                    | IAUC120N04S6L008 | 0.8                   |
|                   |                    | IAUC120N04S6N009 | 0.9                   |
|                   |                    | IAUC120N04S6L009 | 0.9                   |
|                   |                    | IAUC120N04S6N010 | 1.0                   |
|                   |                    | IAUC120N04S6L012 | 1.2                   |
|                   |                    | IAUC120N04S6N013 | 1.3                   |
|                   |                    | IAUC100N04S6L014 | 1.4                   |
|                   |                    | IAUC100N04S6N015 | 1.5                   |
|                   |                    | IAUC100N04S6L020 | 2.0                   |
|                   |                    | IAUC100N04S6N022 | 2.2                   |
|                   |                    | IAUC100N04S6L025 | 2.5                   |
|                   |                    | IAUC100N04S6N028 | 2.8                   |
|                   |                    | IAUC80N04S6L032  | 3.2                   |
|                   |                    | IAUC80N04S6N036  | 3.6                   |
|                   |                    | IAUC60N04S6L039  | 3.9                   |
|                   |                    | IAUC60N04S6N044  | 4.4                   |



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

The TLE987x family addresses a wide range of smart 3-phase brushless DC motor control applications such as auxiliary pumps and fans. It provides a high level of integration and low system cost to optimize the target application segments. In addition, it offers scalability in terms of flash memory sizes and MCU system clock frequency supporting a wide range of motor control algorithms, either sensor-based or sensor-less. For more information about the product, please visit Infineon's webpage linked below.

- [www.infineon.com/tle987x](http://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

In order to get the board ready and running, the software shown in Table 4 shall be installed.

The  $\mu$ Vision software is a development tool provided by Arm® Keil®. With code length limitation, the shareware version of the  $\mu$ Vision is still able to edit, compile and debug. The Infineon Config Wizard is a tool for configuring peripherals of the Embedded Power IC. The tool can be called from the pull-down menu of the  $\mu$ Vision and helps users changing parameters from its user interface and then generates the software code accordingly. Infineon provides standard motor drive software codes for the Embedded Power IC. It can be downloaded from the Pack Installer within the  $\mu$ Vision.

**Table 4 Software Toolchain Installation Guide**

| Steps                                                                                 | Company                                     | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|---------------------------------------------------------------------------------------|---------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>STEP1</b><br>Download and Install<br><a href="#">Keil® <math>\mu</math>Vision5</a> | Arm® Keil®                                  | <ul style="list-style-type: none"> <li>Arm® Keil® <math>\mu</math>Vision is an integrated development environment which consists of code editor, compiler and debugger.</li> <li>To learn how to use Arm® Keil® <math>\mu</math>Vision 5, check out our video "<a href="#">Get your motor spinning</a>".</li> </ul>                                                                                                                                                        |
| <b>STEP2</b><br>Download<br>Config Wizard                                             | Infineon Technologies                       | <ul style="list-style-type: none"> <li>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.</li> <li>Config Wizard can be installed via the Infineon Developer Center. If you don't have this Infineon toolbox yet, please go to <a href="#">Infineon Developer Center Launcher</a> and enjoy the release management for updates.</li> </ul> |
| <b>STEP3</b><br>Download and Install<br><a href="#">Segger J-Link Driver</a>          | XMC™ Link based on SEGGER J-Link technology | <ul style="list-style-type: none"> <li>XMC™ Link is a debug probe for all XMC microcontrollers</li> <li>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</li> </ul>                                                                                                                                                                                        |
| <b>STEP4</b><br>Download the SDK via $\mu$ Vision5 Pack Installer                     | Infineon Technologies                       | <ul style="list-style-type: none"> <li>The Embedded Power Software Development Kit (SDK) is a low-level driver library which can be downloaded within Keil® <math>\mu</math>Vision via the "Pack Installer"</li> </ul>                                                                                                                                                                                                                                                     |

For the toolchain installation and free motor drive software, please check below link.

[www.infineon.com/embedded-power](http://www.infineon.com/embedded-power)

For more information about the tool chain installation steps, watch our video.

[Toolchain Installation for Embedded Power ICs / TLE98xx](#)

#### 2.1.1 Configuration

Open a motor drive code project in  $\mu$ Vision5 and go to "Tools" and open "Config Wizard". From there, setup the parameters of motor, speed/current controller and the peripherals of TLE987x. As the Embedded Power IC has a current-source gate driving scheme, the switching speed is not controlled by gate resistors, but by the "Gate Charge/Discharge" parameters in the BDRV tap of the peripherals. For more details about the configuration, please visit the Infineon website of Embedded Power ICs.

### **3            System Design**

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## **3.1 Electrical Design and Components**

### **3.1.1 Input Filter**

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### **3.1.2 Reverse Polarity Protection**

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### **3.1.3 DC-link Electrolytic Capacitor**

### **3.1.4 Shunt Resistor**

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### **3.1.5 Snubber**

### **3.1.6 Gate Driver**

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### **3.1.7 Gate driver circuit**

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### **3.1.8 Heatsink**

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## **3.2 Switching Performance**

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### **3.3 EMC performance**

#### **3.3.1 Measurement configuration**

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### **3.3.2 Measurement results**

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### **3.4 Thermal performance**

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## **4 Project Collaterals**

### **4.1 Schematics**

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## **4.2 Bill of Material**

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## **4.3        Layout**

### **4.3.1      PCB Stack**

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### **4.3.2      Layout Printing**

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### 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                                          |
| S308         | Shrink Super Small-Outline 8 pin                                |
| SDK          | Software Development Kit                                        |
| SMD          | Surface-Mounted Device                                          |
| SMT          | Surface-Mounted Technology                                      |

# Generic power evaluation board design for 12 V application - SS08 and TLE9879QXA40



## Abbreviations and definitions

|      |                            |
|------|----------------------------|
| SoC  | System On a Chip           |
| SOA  | Safe Operating Area        |
| SS08 | Super Small-Outline 8 pin  |
| TIM  | Thermal Interface Material |
| TH   | Through Hole               |

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## 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](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](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-ApplicationHints\\_3-ApplicationNotes-v01\\_03-EN.pdf?fileId=5546d4625b62cd8a015ba9870bd91373](https://www.infineon.com/dgdl/Infineon-AppNote-TLE986x-TLE987x-FAQ-ApplicationHints_3-ApplicationNotes-v01_03-EN.pdf?fileId=5546d4625b62cd8a015ba9870bd91373)
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## Revision history

### Major changes since the last revision

| Date       | Version | Description    |
|------------|---------|----------------|
| 2023/09/12 | 1.0     | First revision |
|            |         |                |
|            |         |                |

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