MOTIX™ TLE9140EQW EVAL TRV evaluation board

Hardware user guide

Z8F80784399

About this document

Scope and purpose

This user guide contains information about the MOTIX™ TLE9140EQW motor gate driver *integrated circuit (IC)* evaluation board (MOTIX™ TLE9140EQW EVAL TRV), which is designed to evaluate hardware and software functionality of the MOTIX™ TLE9140EQW motor gate driver integrated circuit (IC). This user guide provides extensive information about the board's layout, jumper settings, interfaces and debug options.

The MOTIX™ TLE9140EQW EVAL TRV evaluation board can be used during design-in, for evaluation and measurement of characteristics, and to test features and configuration options.

***Note**: PCB and auxiliary circuits are NOT optimized for final customer design.*

Intended audience

This document is intended for power supply design engineers, system engineers, and embedded power designers.

Table 1 Supplementary links and document references sensor interface

Reference	Description
TLE9140EQW datasheet	Datasheet contains reference information for the 48 V MOTIX™ 3-phase gate driver TLE9140EQW
Traveo CYT2B7 product page	All information of Traveo™ MUC

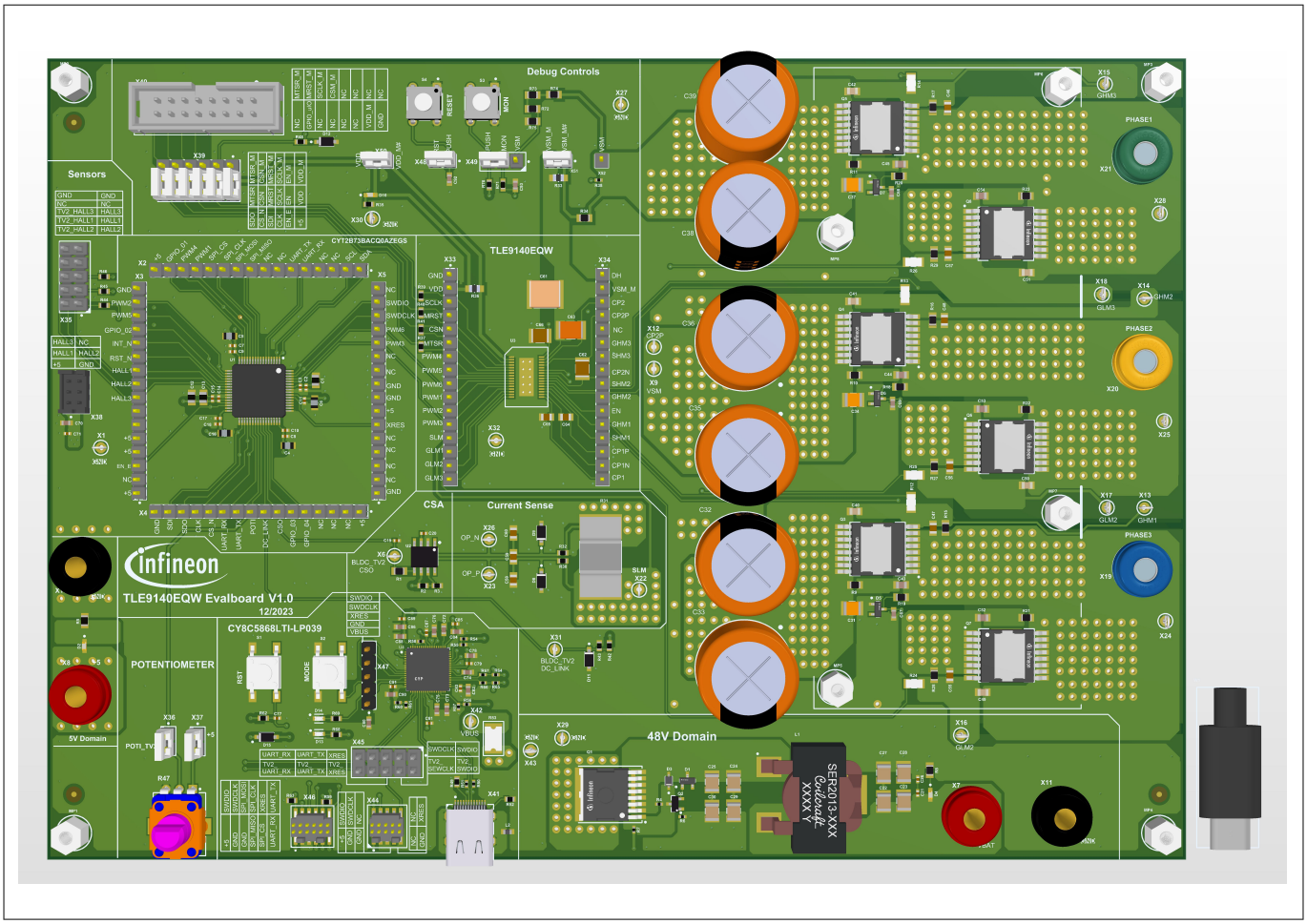

Figure 1 **TLE9140EQW EVAL TRV evaluation board 3D view**

Important notice

“Evaluation Boards and Reference Boards” shall mean products embedded on a printed circuit board (PCB) for demonstration and/or evaluation purposes, which include, without limitation, demonstration, reference and evaluation boards, kits and design (collectively referred to as “Reference Board”).

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 has been 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.

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

Safety precautions

***Note**: Please note the following warnings regarding the hazards associated with development systems.*

Table 2 Safety precautions

	**Warning:** *The evaluation or reference board contains DC bus capacitors which take time to discharge after removal of the main supply. Before working on the drive system, wait five minutes for capacitors to discharge to safe voltage levels. Failure to do so may result in personal injury or death. Darkened display LEDs are not an indication that capacitors have discharged to safe voltage levels.*
	**Warning:** *Remove or disconnect power from the drive before you disconnect or reconnect wires, or perform maintenance work. Wait five minutes after removing power to discharge the bus capacitors. Do not attempt to service the drive until the bus capacitors have discharged to zero. Failure to do so may result in personal injury or death.*
	**Caution:** *The heat sink and device surfaces of the evaluation or reference board may become hot during testing. Hence, necessary precautions are required while handling the board. Failure to comply may cause injury.*
	**Caution:** *Only personnel familiar with the drive, power electronics and associated machinery should plan, install, commission and subsequently service the system. Failure to comply may result in personal injury and/or equipment damage.*
	**Caution:** *The evaluation or reference board contains parts and assemblies sensitive to electrostatic discharge (ESD). Electrostatic control precautions are required when installing, testing, servicing or repairing the assembly. Component damage may result if ESD control procedures are not followed. If you are not familiar with electrostatic control procedures, refer to the applicable ESD protection handbooks and guidelines.*
	**Caution:** *A drive that is incorrectly applied or installed can lead to component damage or reduction in product lifetime. Wiring or application errors such as undersizing the motor, supplying an incorrect or inadequate AC supply, or excessive ambient temperatures may result in system malfunction.*
	**Caution:** *The evaluation or reference board is shipped with packing materials that need to be removed prior to installation. Failure to remove all packing materials that are unnecessary for system installation may result in overheating or abnormal operating conditions.*

Table of contents

1 Evaluation board introduction

The MOTIX™ TLE9140EQW EVAL TRV evaluation board can be used to evaluate MOTIX™ 48 V gate driver TLE9140EQW in a motor control design, providing all required discrete components on the board.

1.1 Concept of the evaluation board

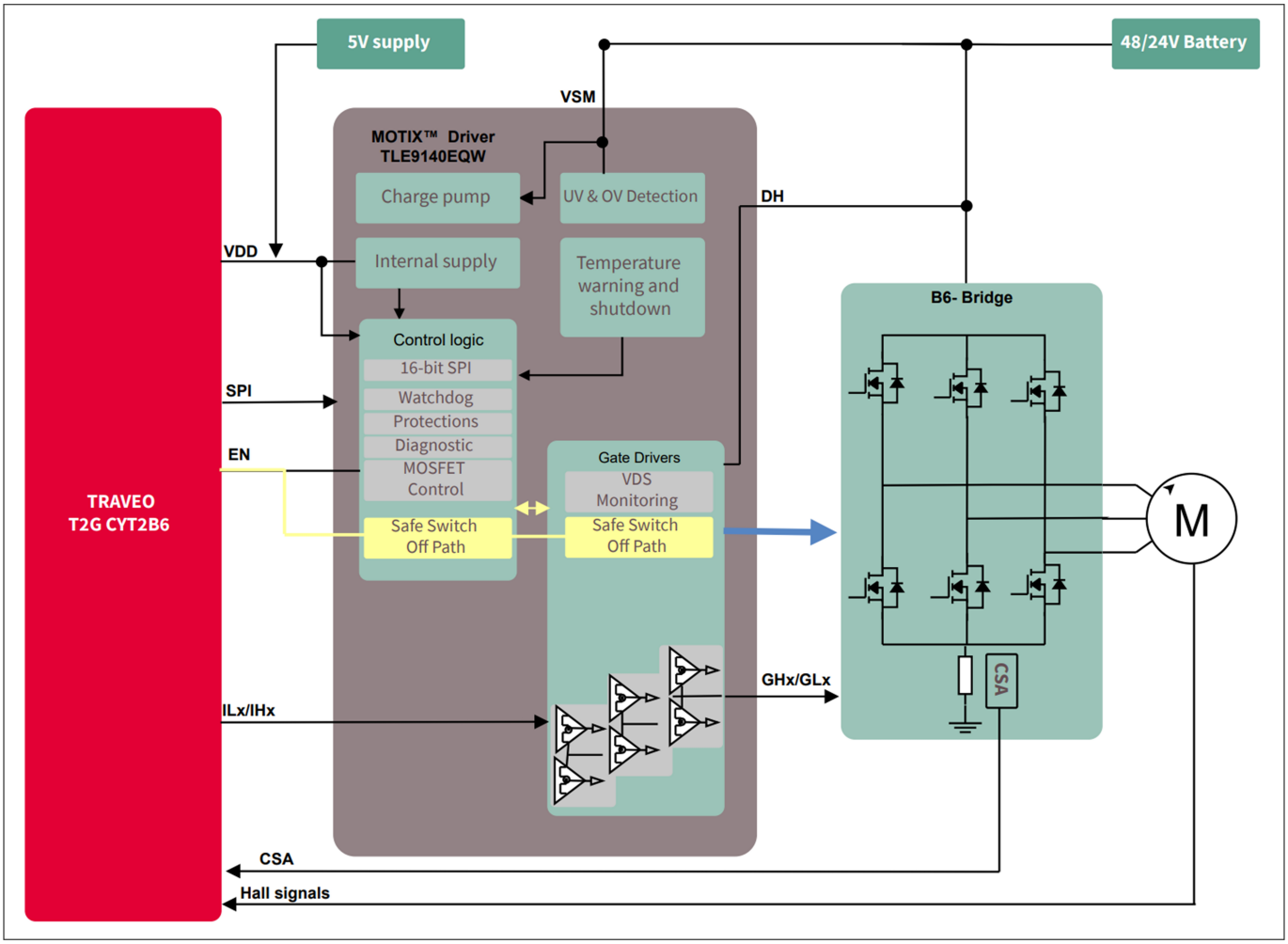

Figure 2 Application diagram of BLDC motor control with the evaluation board

This evaluation board contains the TLE9140EQW gate driver *IC*, Traveo™ CYT2B7 *microcontroller unit (MCU)* and their typical application circuits including three half-bridges to drive a *brushless direct current (BLDC)* motor. The jumper X39 provide the possibilities to either connect the TLE9140EQW to uIO-Stick or to the Traveo™ CYT2B7 MCU. All pins of the TLE9140EQW device and the Traveo™ CYT2B7 MCU are connected to pin headers for easy measurement.

The evaluation board is supplied by 5 V and 48 V/24 V power supply via banana jacks.

An SWD interface is available for J-Linker. There are two battery LEDs (5 V and 48 V) to indicate that the board is supplied correctly.

***Note**: The ground (GND) of 5 V and the* GND *of 48 V are shorted together, which makes a single* GND *for the complete board.*

1.2 Features of the evaluation board

The evaluation board has the following features:

- The TLE9140EQW can be controlled by the on board Traveo™ CYT2B7 MUC or uIO-Stick (config wizard) with additional inputs signals
- Drive 24 V/48 V *direct current (DC)* or *BLDC* motors
- High voltage capability: robustness up to 110 V
- Capable of high frequency PWM, for example 20 kHz
- Adjustable charge and discharge currents for optimized EMC performance
- High voltage compatible inputs
- An *serial peripheral interface (SPI)* communication
- Protections and diagnostics, for example against overtemperature, overcurrent, undervoltage, timeout watchdog and off–state diagnostic

As a starting point for the evaluation board the application diagram, shown in Figure 2, was used. All input pins of TLE9140EQW are connected to the power stage. The SPI ports are connected to the *general purpose input output (GPIO)* pins of the Traveo™ CYT2B7 *MCU*.

1.3 Specification

Input and output at normal operation

- *DC* input voltage 24 to 60 V, nominal 48 V
- Maximum input current 104 A
- Output voltage three-phase FOC
- Maximum output current per phase 150 ARMS
- Maximum output continuous power 5000 W

Control scheme

- Sensorless FOC
- Switching frequency 20 kHz
- Current shunt: single shunt

2 Evaluation board description

For the evaluation of the motor control design, the board is populated with discrete components. They can be adapted to the dedicated motor control applications.

2.1 Interconnects

In Figure 3 the interconnects of the MOTIX™ TLE9140EQW EVAL TRV evaluation board are shown.

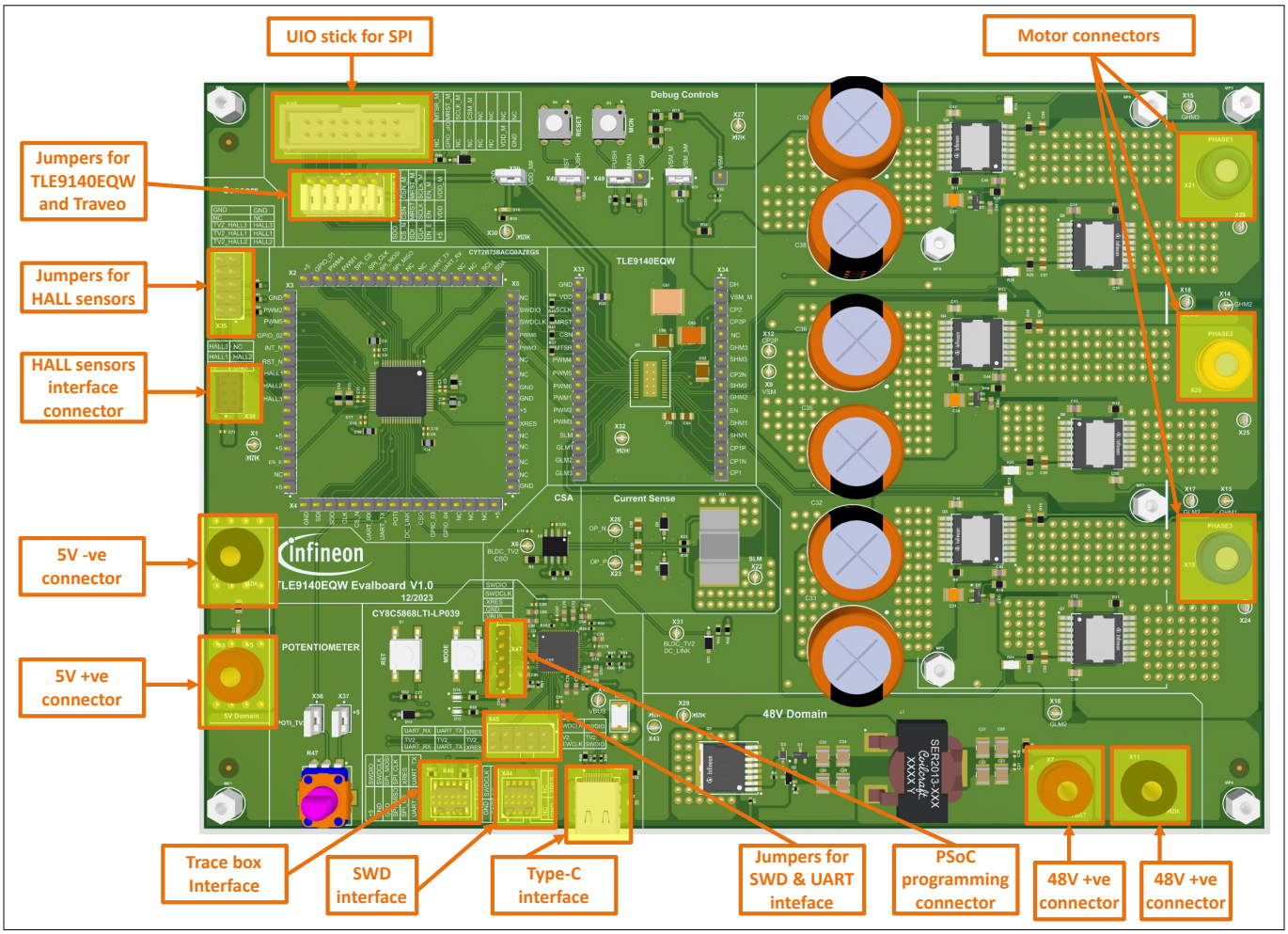

Figure 3 Interconnects of the evaluation board

Power supply

- X7 connector for VBAT supply +ve connection
- X11 connector for VBAT supply -ve connection
- X8 connector for 5V control supply +ve connection
- X10 connector for 5V control supply -ve connection

Motor connectors

- X19 connector for motor U-phase
- X20 connector for motor V-phase
- X21 connector for motor W-phase

Hall sensor interface

X38 is the interface of hall sensor, as shown in the following table. X35 is the jumper setting to connect the hall interface to the Traveo™ MCU.

Table 3 Hall sensor interface X38

Pin 6 - NC	Pin 4 - HALL3	Pin 2 - GND
Pin 5 - HALL3	Pin 3 - HALL1	Pin 1 - +5 V

Table 4 Jumpers selection X35

Hall sensor interface	HALL2	HALL1	HALL3	NC	GND
Traveo™ interface	BLDC TV2 HALL2	BLDC TV2 HALL1	BLDC TV2 HALL3	NC	GND

USB connector for on-board debugger

The on-board debugger can be accessed by connecting an *universal serial bus (USB)*-C cable to a PC.

Jumpers to select different use cases

X39 can be used to select different use cases. For the use case “Traveo™ + TLE9140EQW” the last two rows (TLE9140EQW and Traveo™) should be connected via jumpers. For the use case “Evaluate TLE9140EQW with config wizard” the first two rows (uIO-Stick and TLE9140EQW) should be connected via jumpers.

Table 5 X35 Jumpers selection X35

uIO-Stick	P15	P9	P13	P11	P1	P4
TLE9140EQW	MTS	CSN	MRST	SCLK	E	VD
Traveo MCU	P13.	P13.	P13.0	P13.2	P1	5 V

Interface for debugger

The on-board debugger can be accessed by X41 USB-C connector available between PC USB & X41 connector on the PCB.

An SWD interface connector is available to use the J-Link.

The on-board debugger can be accessed by connecting an USB-C cable to a PC & X41 USB connector and external debugger (example J-Link) can be connected to X44 with SWD interface.

2.2 Jumper settings

The following table summarize the flexible configurations provided by jumpers:

Table 6 Jumper settings

X35	HALL interface with Traveo™	default open
X36	POT interface with Traveo™	default short
X36	5 V interface to POT	default short
X39	Select Traveo™ or uIO-Stick to configure TLE9140EQW	default 39B & 39C should be shorted
X45	PSoC™ and Traveo™ SWDIO & UART interface	default short

2.3 Test points

The TLE9140EQW is used to drive the 3-phase half-bridges. All pins of the TLE9140EQW and Traveo™ CYT2B7 *MCU* can be tested via the headers. The test points for 3 phases are available on board for easy measurement. Test points OP_P and OP_N are used to measure the voltage drops across the shunt resistance.

2.4 Component list

This evaluation board offers two different supply concepts:

1. VBAT supply for the main inverter to drive the motor
2. 5 V control supply for the Traveo™ *MCU* and MOTIX™ TLE9140EQW gate driver

Table 7 Bill of materials

Item	Quantity	Designator	Manufacturer	Manufacturer Order Number
1	24	C2, C3, C7, C8, C9, C10, C11, C14, C15, C17, C18, C19, C20, C21, C26, C71, C77, C79, C81, C83, C85, C87, C89, C91	MuRata	GRM155R71H104KE14D
2	2	C92, C93	MuRata	GRM188R71H102JA01
3	3	C67, C68, C69	MuRata	GRM188R72A102KA01
4	13	C70, C72, C73, C74, C75, C76, C78, C80, C82, C84, C86, C88, C90	Samsung	CL10B105KA8NNNC
5	4	C4, C5, C6, C16	Wurth Elektronik	8.85012E+11
6	6	C46, C47, C48, C55, C56, C57	MuRata	GRM2165C2A331JA01
7	3	C58, C59, C60	MuRata	GCM216R71H102KA37
8	6	C43, C44, C45, C52, C53, C54	AVX	08055F472KAT2A
9	1	C65	MuRata	GRM219R7YA105KA12
10	6	C40, C41, C42, C49, C50, C51	MuRata	GRM21A5C2D330JW01
11	1	C64	MuRata	GRM21BR71H474KA88
12	3	C1, C12, C13	Yageo	CC0805MKX7R8BB475
13	1	C66	MuRata	GRM329R72A243KA01
14	3	C31, C34, C37	AVX	12101C104K4Z2A
15	1	C62	MuRata	GRM32DR72D224KW01
16	8	C22, C23, C24, C25, C27, C28, C29, C30	Kemet	C1210C106K5RACTU
17	1	C63	MuRata	GRM43DR72D474KW01
18	1	C61	TDK Corporation	C5750X7S2A226M280KB
19	6	C32, C33, C35, C36, C38, C39	TDK Corporation	B41858C9567M000
20	12	Jumper1, Jumper2, Jumper3, Jumper4, Jumper5, Jumper6, Jumper7, Jumper8, Jumper9, Jumper10, Jumper11, Jumper12	Samtec	SNT-100-BK-G-H

(table continues...)

Table 7 (continued) Bill of materials

Item	Quantity	Designator	Manufacturer	Manufacturer Order Number
21	1	X19	Hirschmann Test & Measurement	930 176-102
22	1	X20	Hirschmann Test & Measurement	930 176-103
23	1	X21	Hirschmann Test & Measurement	930 176-104
24	2	X10, X11	Hirschmann Test & Measurement	930176700
25	2	X7, X8	Hirschmann Test & Measurement	930176701
26	1	X44	Samtec	FTSH-105-01-L-DV-K-A-TR
27	1	X46	Samtec	FTSH-106-01-L-DV-K
28	1	X47	Wurth Elektronik	61300511121
29	1	X38	Hirose Connectors	DF11-6DP-2DSA(08)
30	2	X36, X37	Samtec	HTSW-102-07-G-S
31	1	X40	Sullins	SBH11-PBPC-D08-ST-BK
32	1	X52	Samtec	TSW-101-22-L-S
33	1	X39	Samtec	TSW-106-07-G-T
34	1	X49	Samtec	HTSW-103-07-G-S
35	23	X1, X6, X9, X12, X13, X14, X15, X16, X17, X18, X22, X23, X24, X25, X26, X27, X28, X29, X30, X31, X32, X42, X43	Keystone Electronics Corp.	5020
36	1	X41	Wurth Elektronik	6.32723E+11
37	2	S1, S2	Tyco Electronics	FSM2JSMA
38	3	X48, X50, X51	Samtec	HTSW-102-07-L-S
39	2	X35, X45	Samtec	TSW-105-07-L-D
40	6	X2, X3, X4, X5, X33, X34	Samtec	TSW-116-07-L-S
41	1	L2	MuRata	BLM18PG600SN1D
42	1	L1	Coilcraft	SER2013-472MLB
43	1	D13	OSRAM Opto Semiconductors	LG Q396-PS-35
44	1	D14	OSRAM Opto Semiconductors	LY Q396-P1Q2-36
45	3	D2, D4, D10	OSRAM Opto Semiconductors	LG Q971-KN-1
46	1	R53	Bourns	MF-MSMF030-2
47	1	U3		
48	1	R47	ALPS	RK09K1130AAU

(table continues...)

Table 7 (continued) Bill of materials

Item	Quantity	Designator	Manufacturer	Manufacturer Order Number
49	1	U4	Cypress Semiconductor	CY8C5868LTI-LP039
50	1	U1	Cypress Semiconductor	CYT2B73BACQ0AZEGS
51	2	R66, R67	Yageo	RC0402JR-070RL
52	1	R38	Vishay	CRCW040224R0FK
53	2	R50, R51	Vishay	CRCW040222R0FK
54	2	R64, R65	Vishay	CRCW04022K20FK
55	2	R6, R7	Vishay	CRCW040210K0FK
56	2	R56, R60	Vishay	CRCW040215K0FK
57	2	R57, R61	Vishay	CRCW040230K0FK
58	2	R54, R55	Vishay	CRCW040249K9FK
59	2	R4, R58	Vishay	CRCW0402100KFK
60	2	R48, R71	Yageo	RC0603FR-0710KL
61	1	R35	Vishay	CRCW06035K60FK
62	1	R2	Vishay	CRCW060318K7FK
63	1	R42	Vishay	CRCW060352K3FKTA
64	2	R30, R32	Vishay	CRCW060312R0FK
65	2	R68, R69	Vishay	CRCW0603750RFK
66	2	R49, R52	Vishay	CRCW06035K10FK
67	2	R59, R63	Vishay	CRCW060310K0FKEA
68	3	R44, R45, R46	Vishay	CRCW0603330RFK
69	3	R3, R43, R62	Vishay	CRCW06034K70FK
70	5	R37, R39, R40, R41, R70	Vishay	CRCW06031K00FK
71	1	R5	Yageo	RC0805FR-0710KL
72	2	R33, R36	Panasonic	ERJ-6CWDR010V
73	1	R34	Vishay	CRCW08052R20FK
74	1	R75	Vishay	CRCW080534K0FK
75	1	R8	Vishay	CRCW080539K0FK
76	3	R18, R19, R20	Vishay	CRCW08050000Z0EA
77	3	R72, R73, R74	Vishay	CRCW0805102KFK
78	13	R1, R9, R10, R11, R15, R16, R17, R21, R22, R23, R27, R28, R29	Vishay	CRCW0805100KFKEA
79	6	R12, R13, R14, R24, R25, R26	Vishay	CRCW12062R20FKEAHP
80	1	R31	Vishay	WSLP59311L000FEA
81	1	D3	Diodes Incorporated	BZT52C12S-7-F

(table continues...)

Table 7 (continued) Bill of materials

Item	Quantity	Designator	Manufacturer	Manufacturer Order Number
82	1	D15	ON Semiconductor	MBR0520LT1G
83	1	D12	ON Semiconductor	MMSZ5V6T1G
84	3	D8, D9, D11	ON Semiconductor	MMSZ6V8T1G
85	6	Q3, Q4, Q5, Q6, Q7, Q8	Infineon Technologies	IAUS300N08S5N011T
86	1	U2	ON Semiconductor	NCV7041D3G020R2G
87	1	Q2	ON Semiconductor	BC846ALT1G
88	4	D1, D5, D6, D7	Infineon Technologies	BAS21E6327HTSA1
89	8	MP1, MP2, MP3, MP4, MP5, MP6, MP7, MP8	Harwin	R30-1611100
90	1	Q1	Infineon Technologies	IAUT300N08S5N011
91	2	S3, S4	Omron	B3W-1000

2.5 Schematics

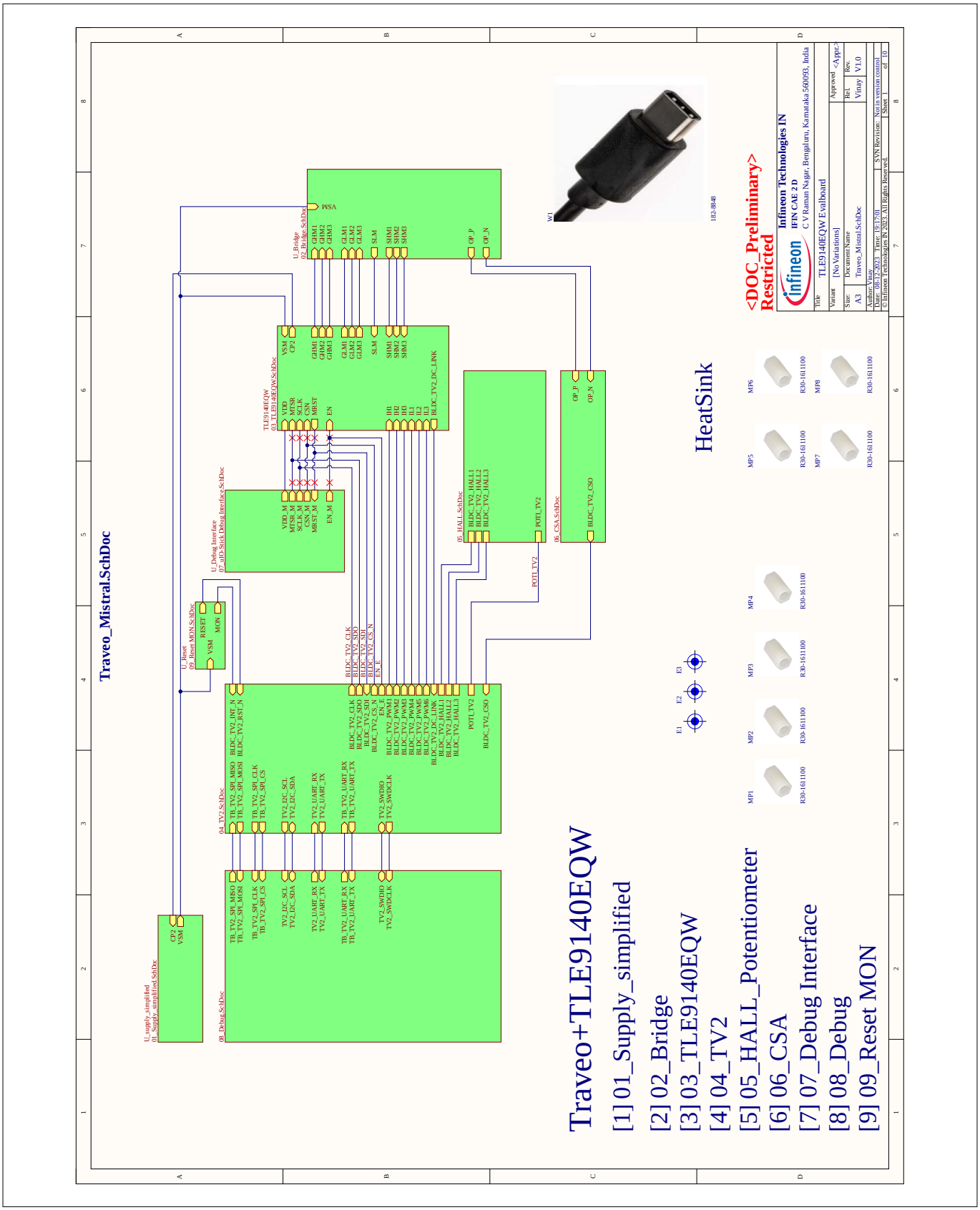

Figure 4 Schematics of the evaluation board - cover sheet

2 Evaluation board description

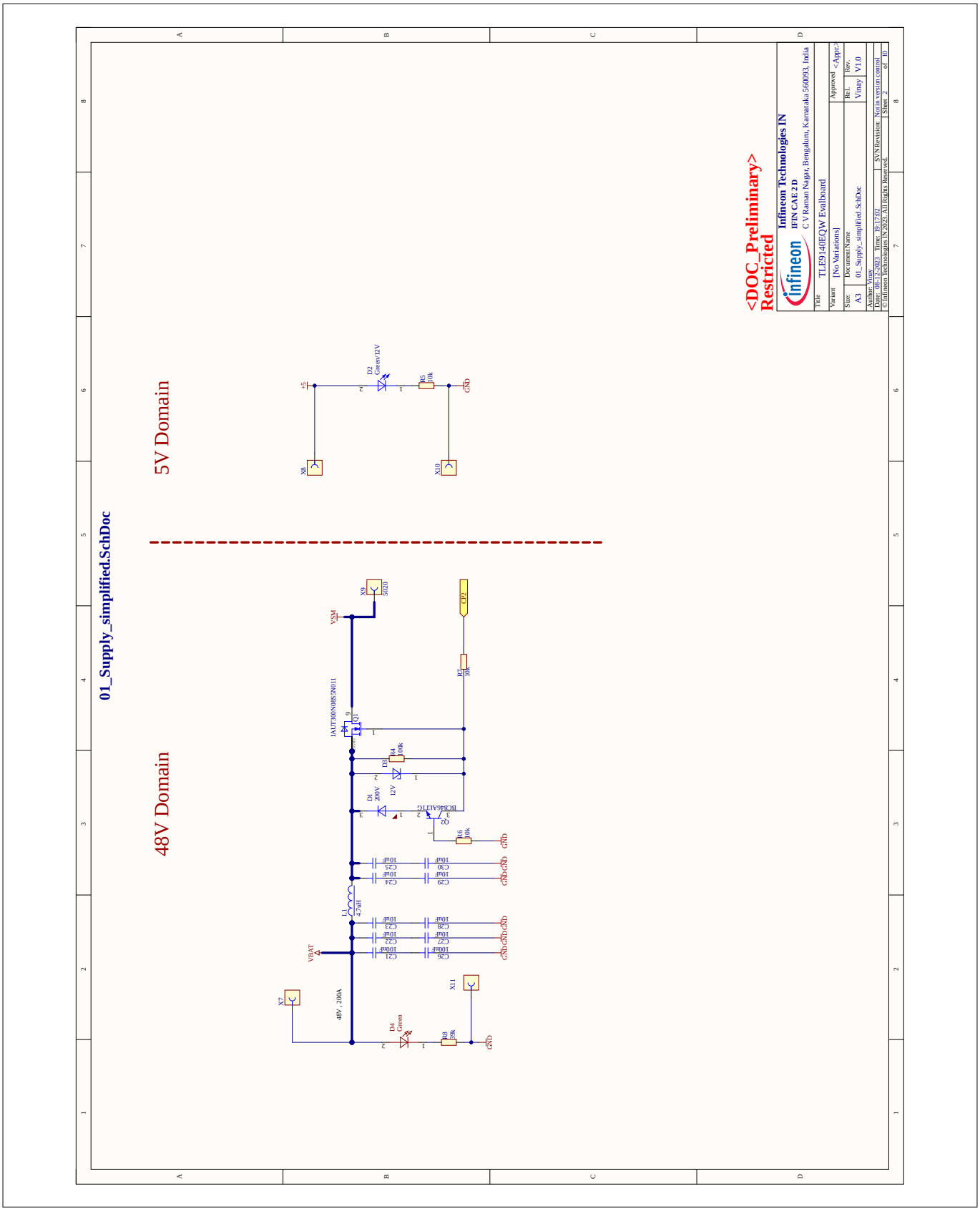

Figure 5 Schematics of the evaluation board - sheet 1 - supply simplified

2 Evaluation board description

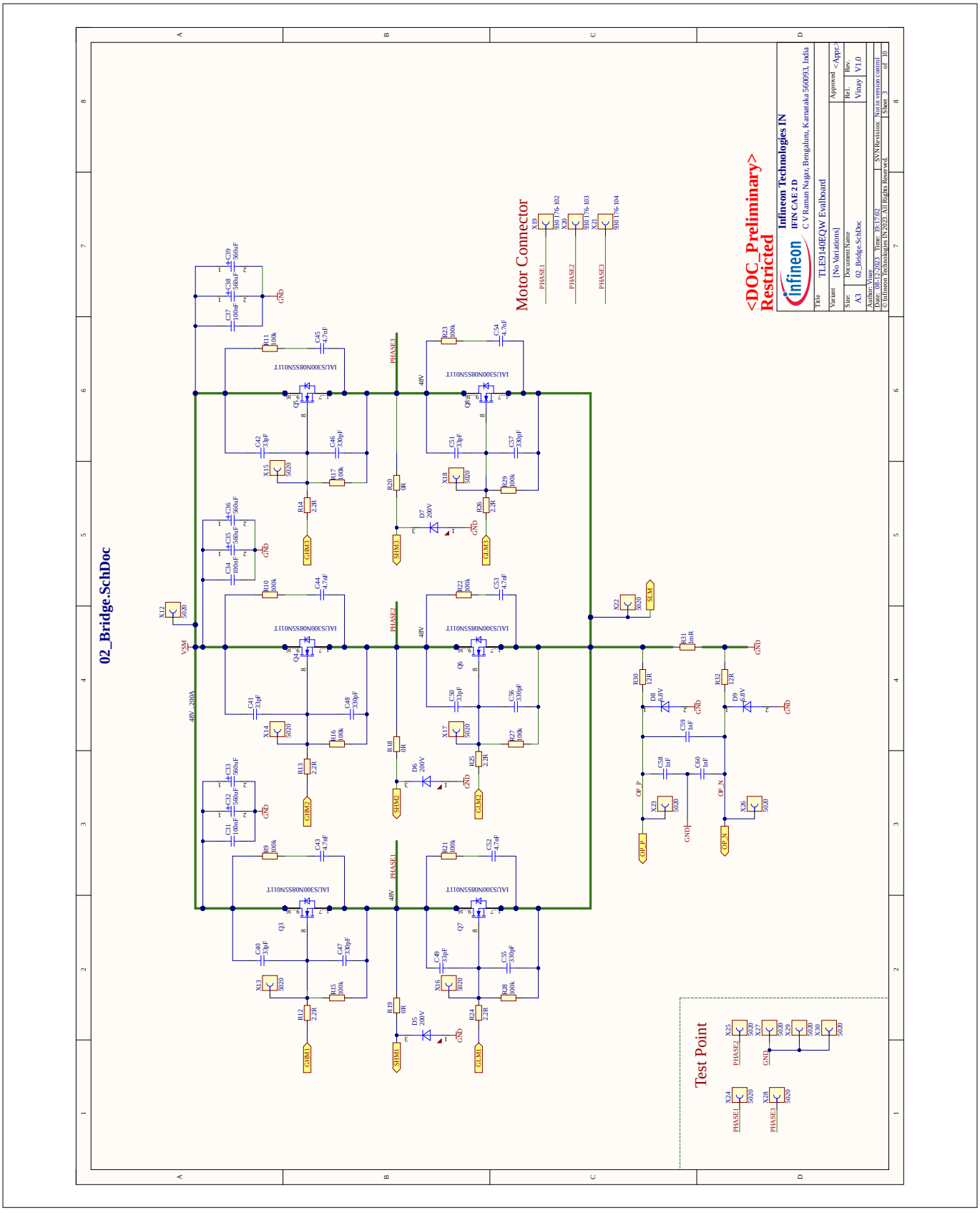

Figure 6 Schematics of the evaluation board - sheet 2 - bridge

2 Evaluation board description

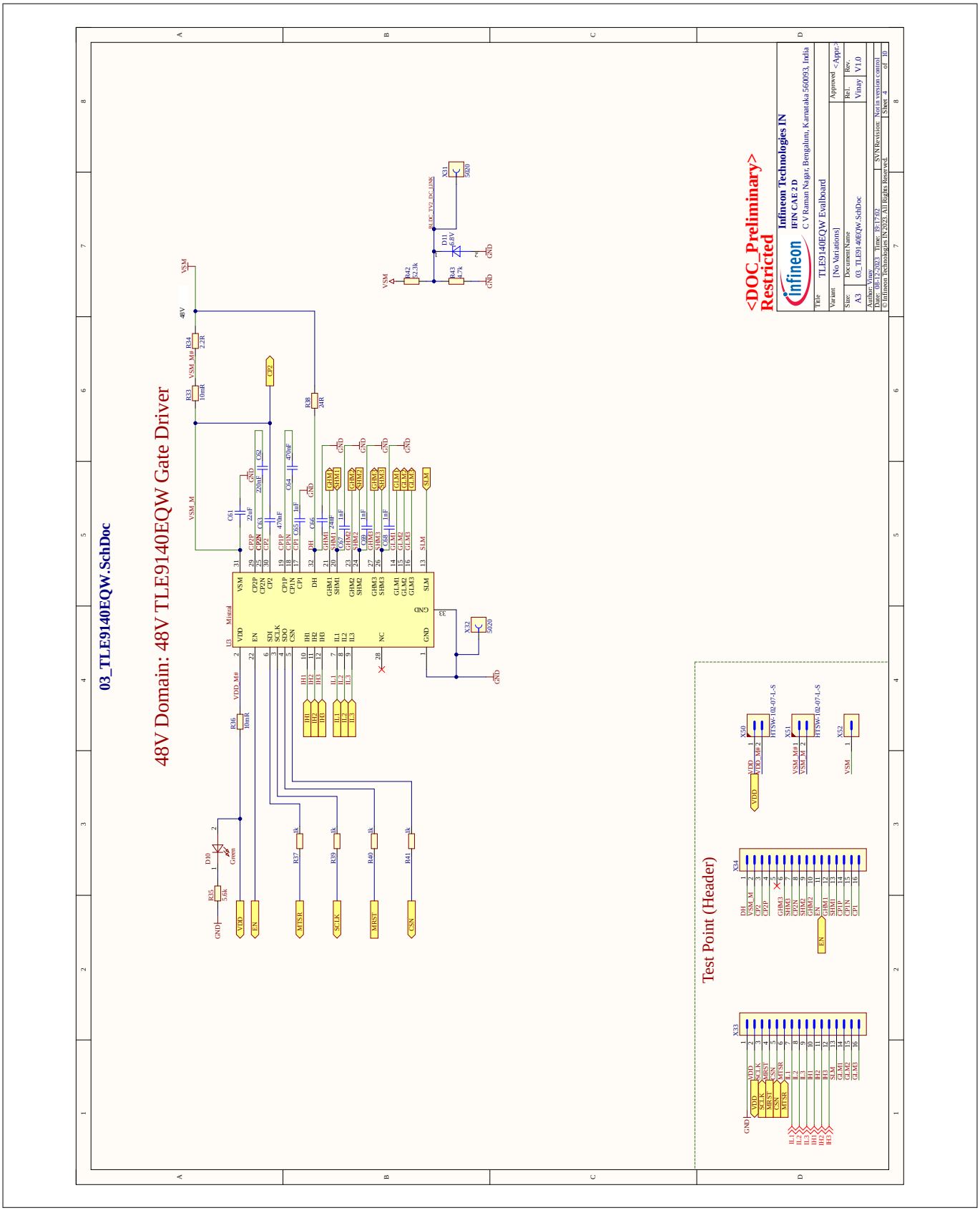

Figure 7 Schematics of the evaluation board - sheet 3 - TLE9140EQW

2 Evaluation board description

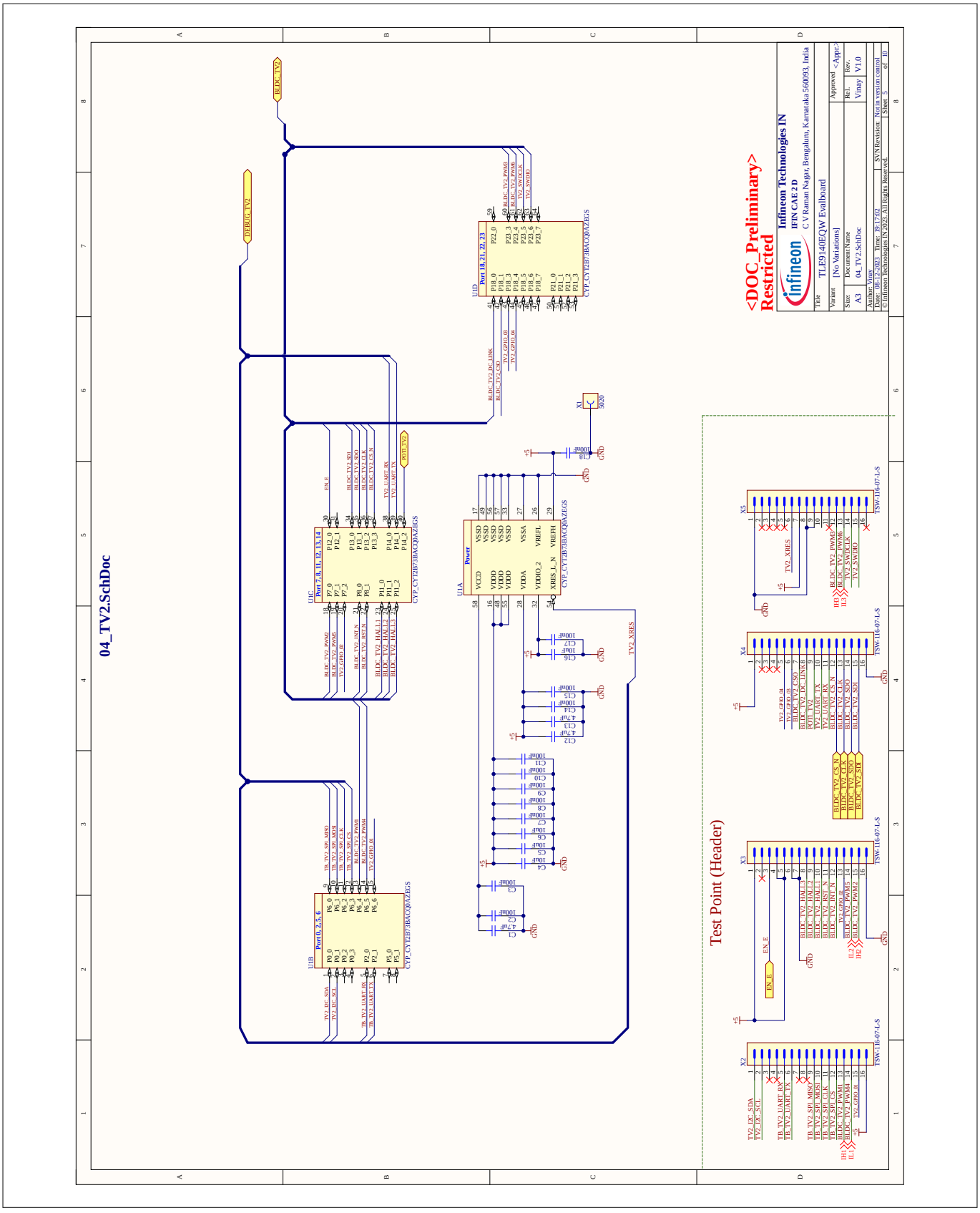

Figure 8 Schematics of the evaluation board - sheet 4 - TV2

2 Evaluation board description

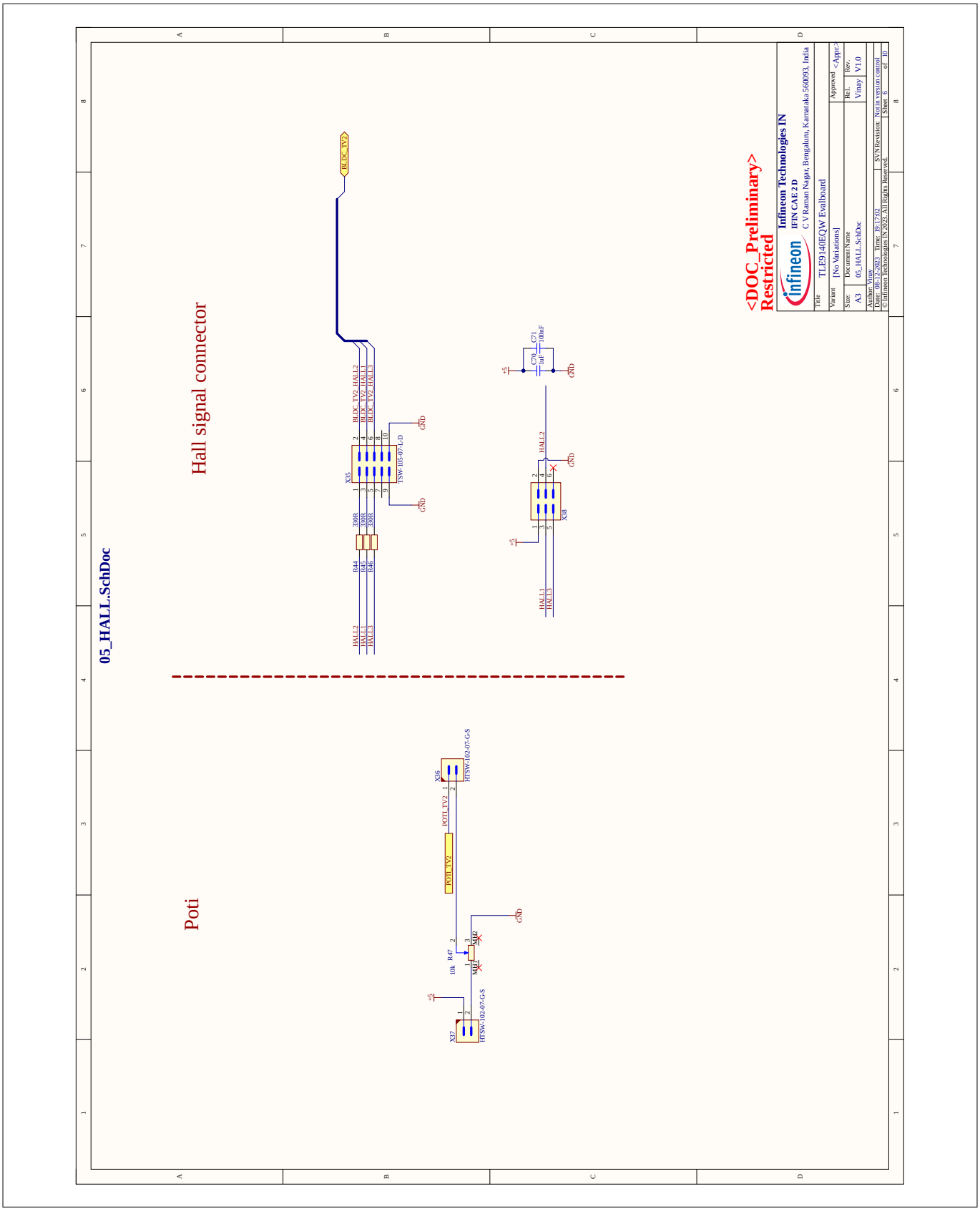

Figure 9 Schematics of the evaluation board - sheet 5 - Hall

2 Evaluation board description

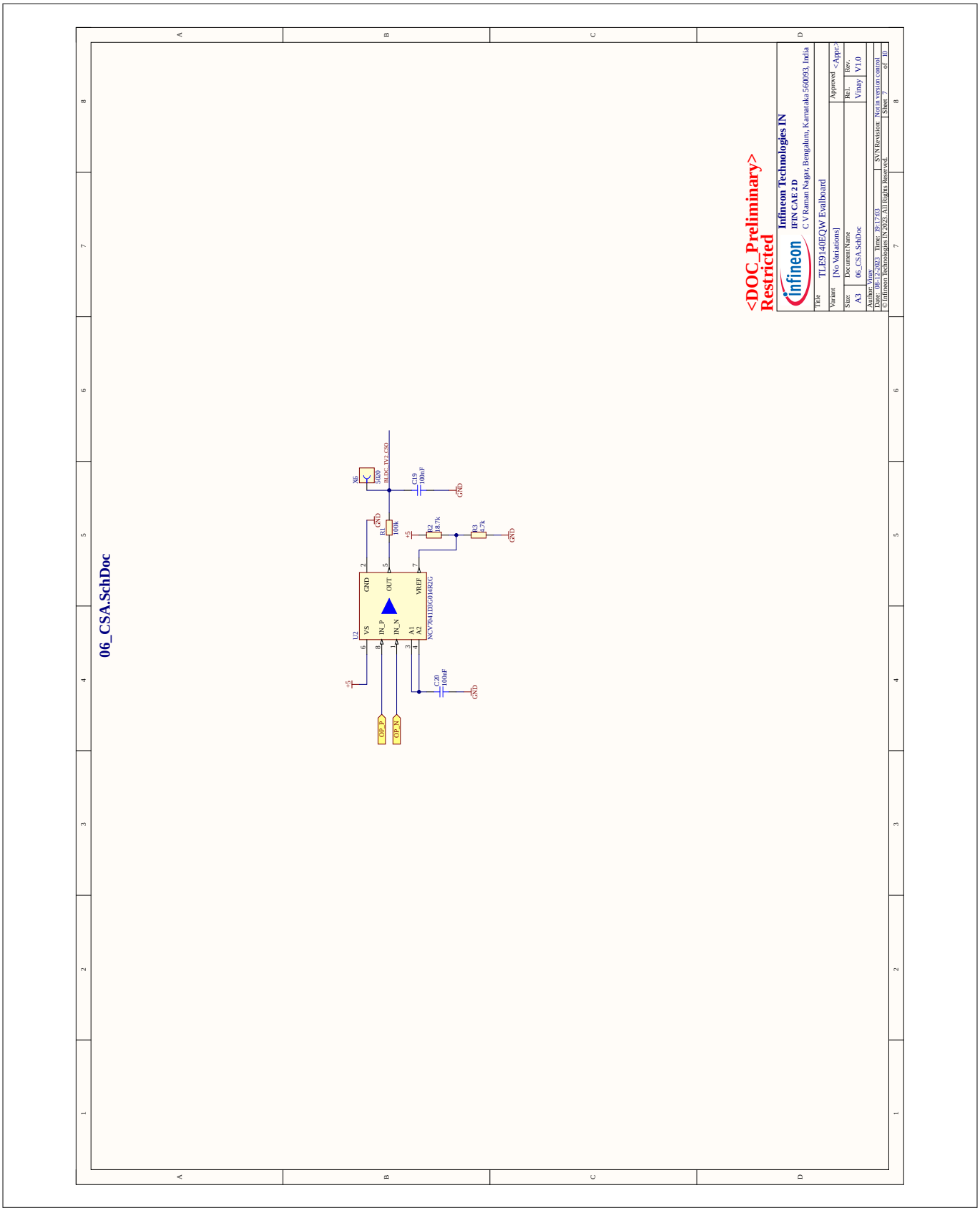

Figure 10 Schematics of the evaluation board - sheet 6 - CSA

2 Evaluation board description

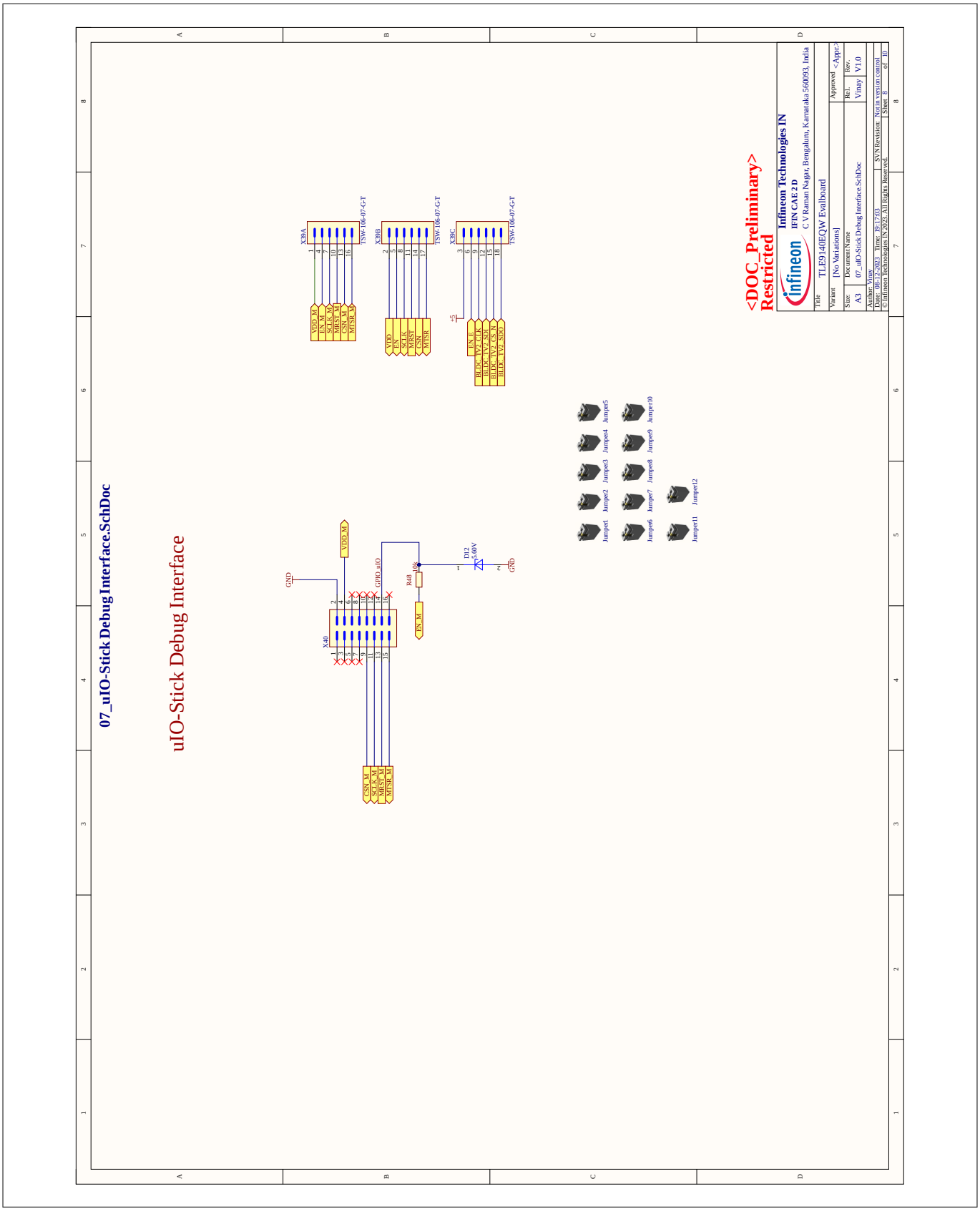

Figure 11 Schematics of the evaluation board - sheet 7 - uIO-Stick debug interface

2 Evaluation board description

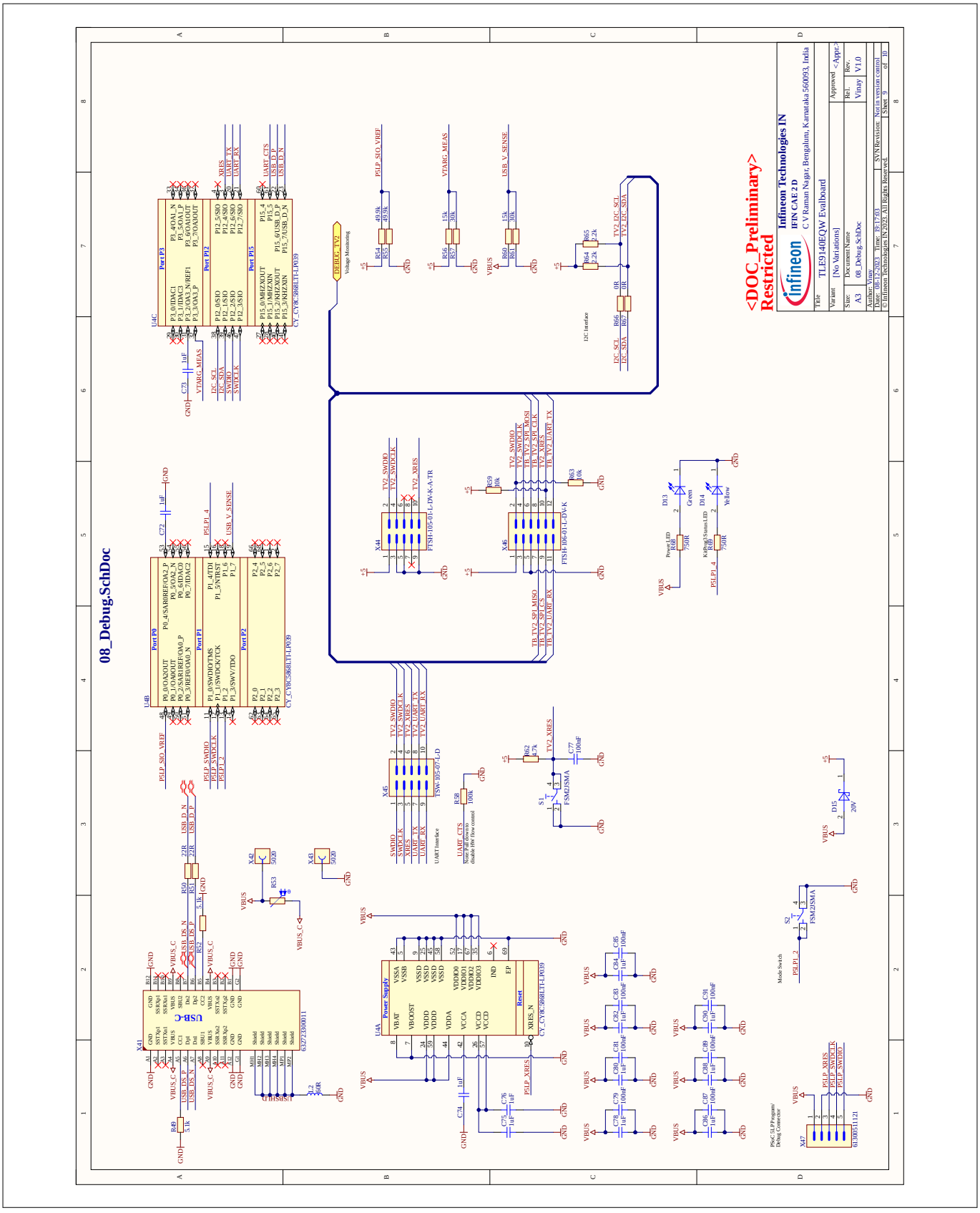

Figure 12 Schematics of the evaluation board - sheet 8 - debug

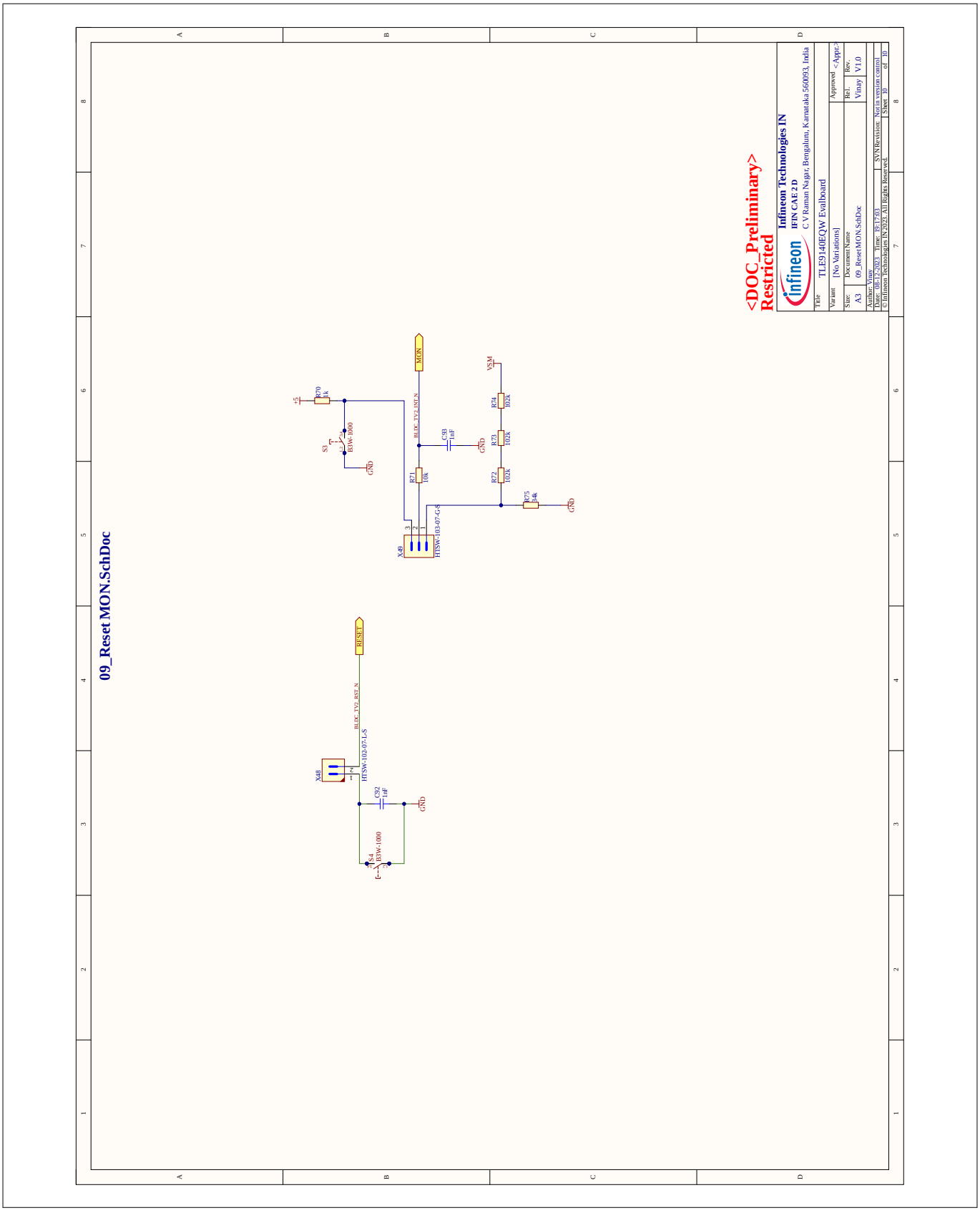

Figure 13 Schematics of the evaluation board - sheet 9 - reset MON

2.6 Board layout

The following PCB layout guidelines are recommended for the 5 kW Traveo™ and TLE9140EQW evaluation board are as follows:

Minimizing noise and inductance

The current sense resistor (SLM and *GND*) lines are designed as differential lines, running in parallel to reduce noise and electromagnetic interference. The ground point from the shunt resistor is taken directly, rather than from the GND plane, to further minimize noise.

Reducing loop inductance

Gate driver components are placed near the TLE9140EQW to minimize the length of gate driving signals, thereby reducing loop inductance.

Optimizing DC link loop

The *DC* link loop is designed to be as short as possible, reducing parasitic inductance.

Proximity for efficient gate driving

MOSFET gate driving components are placed near MOSFETs.

DC link capacitors for efficient energy storage

DC link capacitors are placed near the MOSFET inverter bridge.

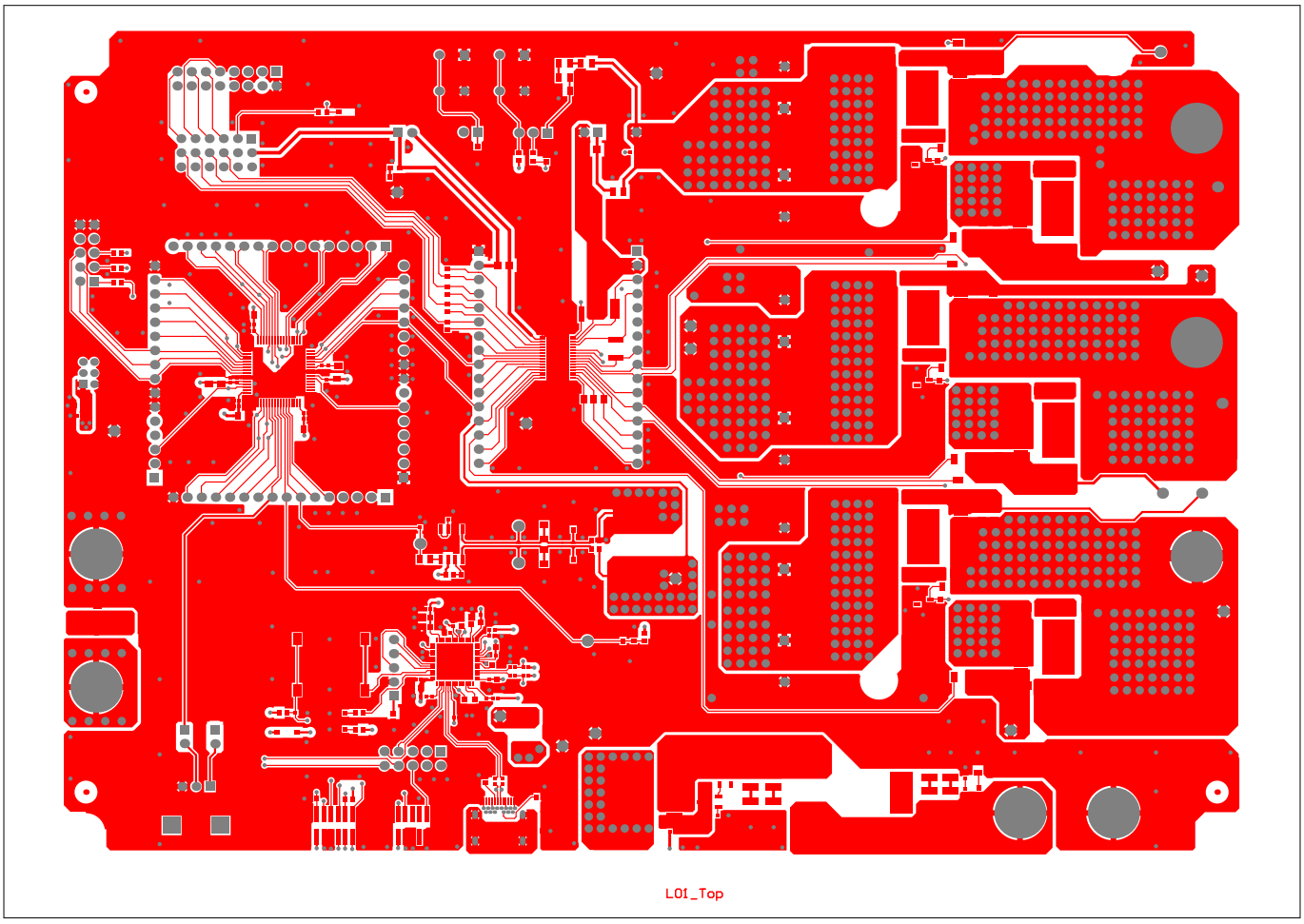

Figure 14 Layout of the evaluation board - layer 1 - TOP

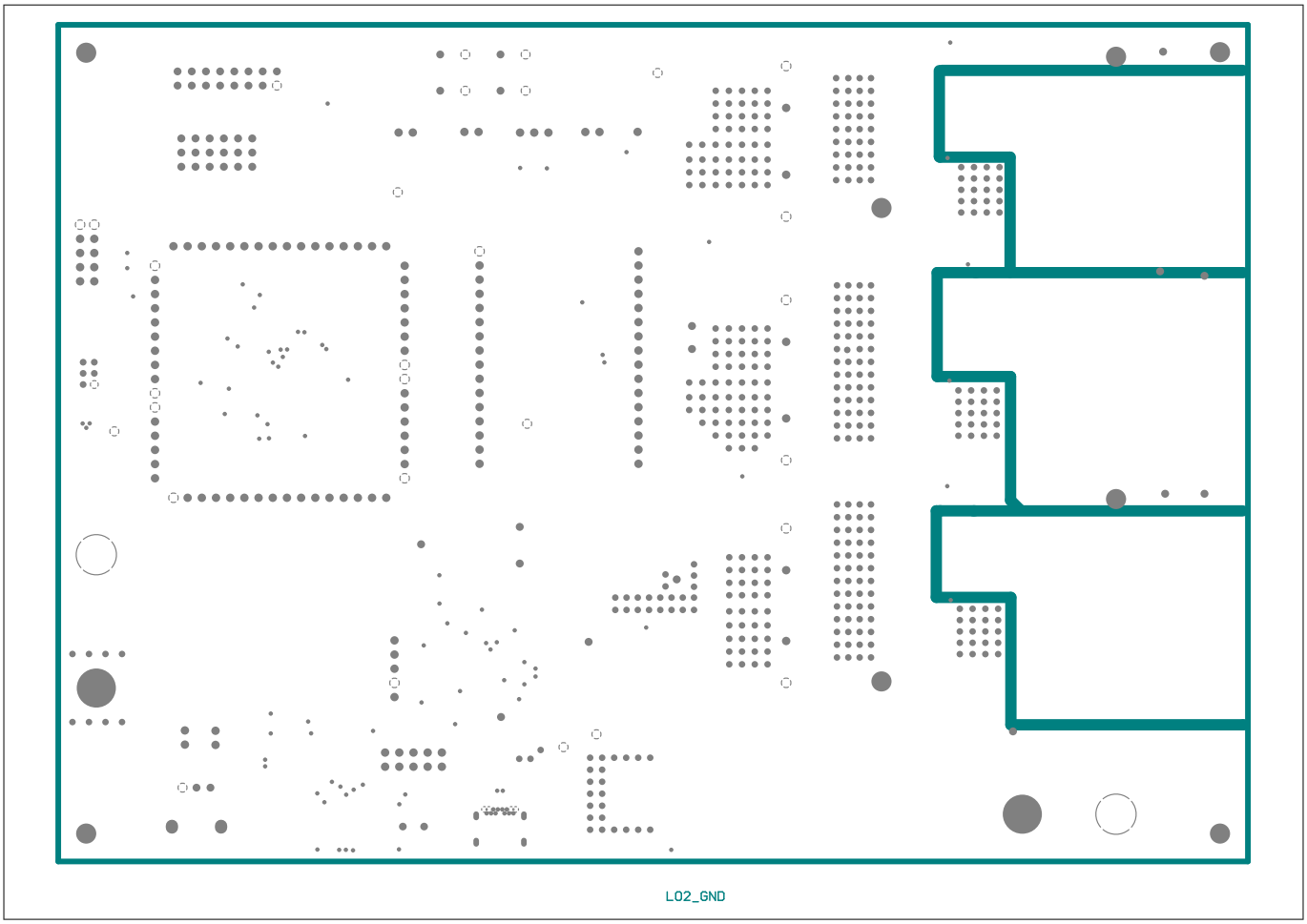

Figure 15 Layout of the evaluation board - layer 2 - GND

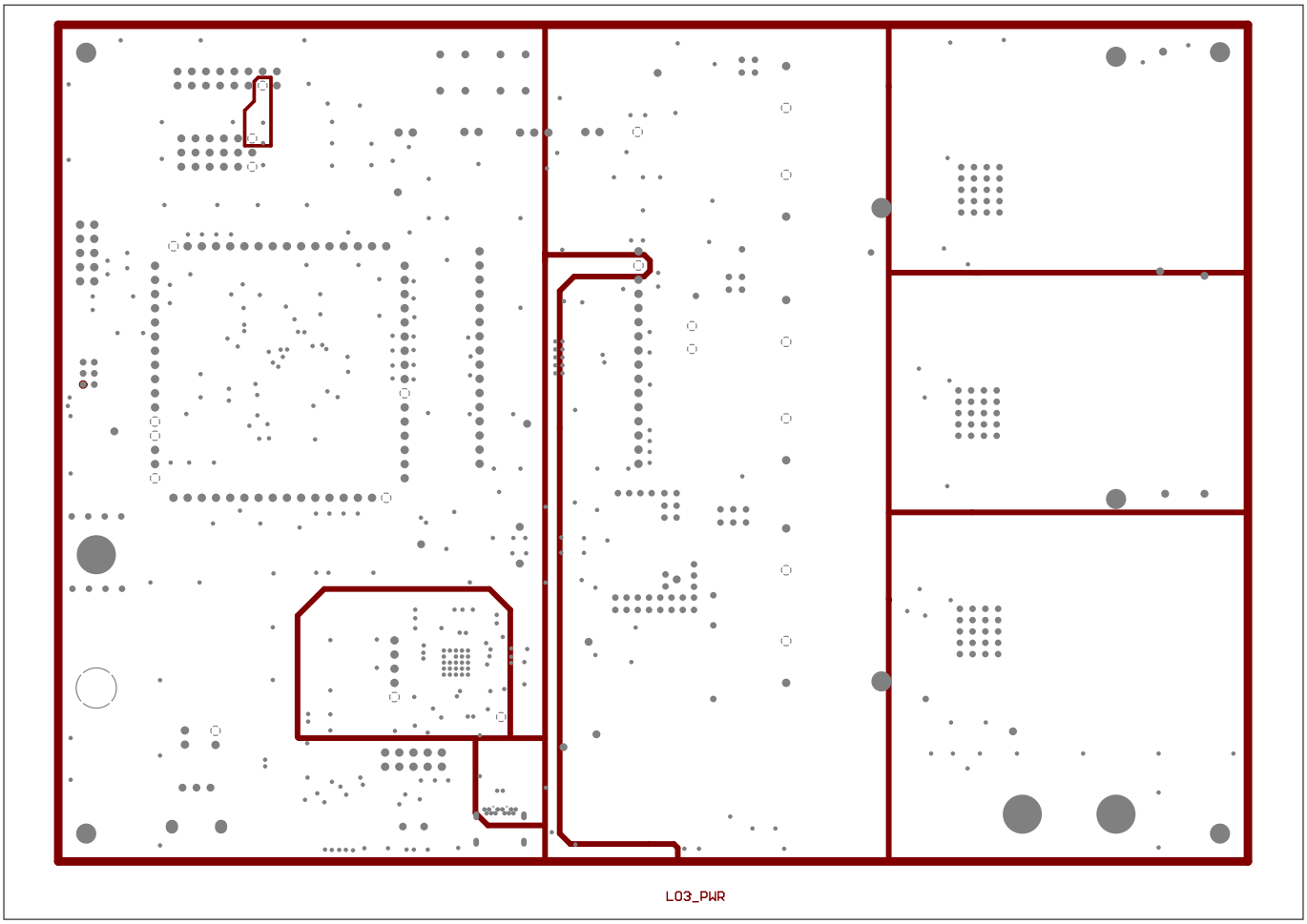

Figure 16 Layout of the evaluation board - layer 3 - PWR

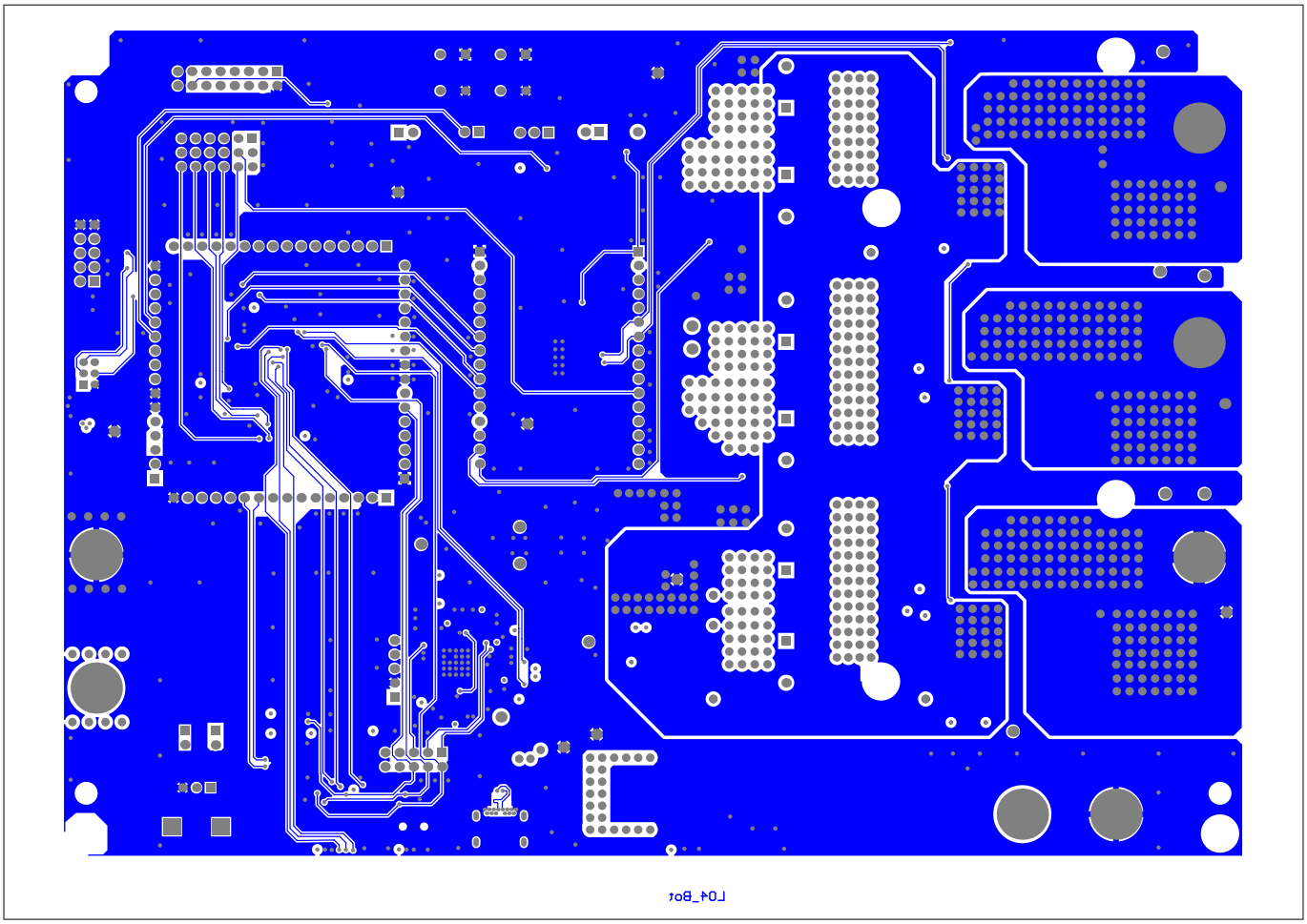

Figure 17 Layout of the evaluation board - layer 4 - BOT

3 Getting started

3.1 Target applications

The target application of MOTIX™ TLE9140EQW EVAL TRV evaluation board is 48 V/24 V *DC* and *BLDC* motor control. In the evaluation board the TLE9140EQW, with required external components, is available to support the evaluation of the device itself and the applications.

3.2 Evaluation setups

Two setups can be used to evaluate the TLE9140EQW device with the evaluation board:

- Example code is available for the setup “TLE9140EQW + Traveo” to support the evaluation
- The configuration wizard can be used to have an easy evaluation for the setup. (refer to the MOTIX™ MCU Configuration Wizard)

Refer to the “Infineon-TLE9140EQW EVAL TRV_Software_User_Guide” document for more information.

3.3 Getting started: TLE9140EQW EVAL TRV

The getting started steps are based on an application software example provided in the delivery package, named Traveo™ FOC sensorless example with TLE9140. This application example integrates the relevant software components of the motor control demo for TLE9140EQW and the low level driver to run on the evaluation board with TLE9140EQW and Traveo™ in IAR Embedded Workbench for Arm software project. This software example is designed to drive a motor in two configurable control modes:

- Sensorless FOC mode
- V to F (voltage to frequency) mode

Hardware setup

- VBAT supply: a 48 V bipolar (4Q) power supply with adjustable VBAT voltage (24 V, 36 V, 48 V) that is capable to back supply (in generator mode) and to deliver a current sufficient for turning the designed motor
- 5 V control supply
- The evaluation board with TLE9140EQW and Traveo™ connected to the VBAT and 5 V control supply and connected to the PC via *USB*-C cable
- Specific hardware settings
  - TLE9140EQW can be configured by Traveo™ or by uIO-Stick with the Jumper X39. To configure the TLE9140EQW connect the jumpers between TLE9140EQW and Traveo™ with the head file (TLE914x_defines.h) generated from the config wizard
  - Jumpers X39 must be set for *SPI* communication between Traveo™ and TLE9140EQW to provide VDD (digital supply) of TLE9140EQW
  - Jumpers X45 are connected between PSoC™ and Traveo™ to connect onboard debugger
  - Connector X47 is used to program PSoC™ with a mini-prog 4 debugger

Software preparation

For the evaluation of the Traveo-Demo-TLE9140 Motor Control Library using the demo software example, the following software tool chain in MS Windows is required

- IAR Embedded Workbench for Arm, an integrated development environment (IDE)
- Traveo Sample driver library
- MOTIX™ BLDC Motor Gate Driver IC Configuration Wizard
- Kindly refer to the software guidelines given in the “Infineon-TLE9140EQW EVAL TRV_Software_User_Guide” document

Getting started steps

- Load the provided application software example project in IAR embedded workbench
- Choose the corresponding hardware target device in IAR
- Configure the motor parameters and base parameters in firmware from config wizard
- Rebuild all projects
- Expected result: compiled successfully without any error or warning
- Download and debug the IAR project
- Run the project and take the control on the software execution
  - Switch on "Enable power stage"
  - Switch on "Enable control"
  - Set a reference motor speed from the cursor
- Expected result: the motor starts turning

4 References

[1] MOTIX™ TLE9140EQW datasheet
[2] Infineon-TLE9140EQW EVAL TRV_Software_User_Guide document
[3] Contact Infineon support for the documents

Glossary

BLDC

brushless direct current (BLDC)

DC

direct current (DC)

One-directional flow of electric charge. An electrochemical cell is a prime example of DC power. Direct current may flow through a conductor such as a wire, but can also flow through semiconductors, insulators, or even through a vacuum as in electron or ion beams. The electric current flows in a constant direction, distinguishing it from alternating current (AC).

GND

ground (GND)

GPIO

general purpose input output (GPIO)

IC

integrated circuit (IC)

A miniature electronic circuit built on the surface of a thin substrate of a semiconductor material.

MCU

microcontroller unit (MCU)

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

SPI

serial peripheral interface (SPI)

A synchronous serial communication interface specification used for inter-chip communication, primarily in embedded systems.

USB

universal serial bus (USB)

An industry standard that defines cables, connectors, and communication protocols used in a bus for connection, communication, and power supply between computers and electronic devices.

Revision history

Document version	Date of release	Description of changes
1.00	2025-03-26	User guide available

Trademarks

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