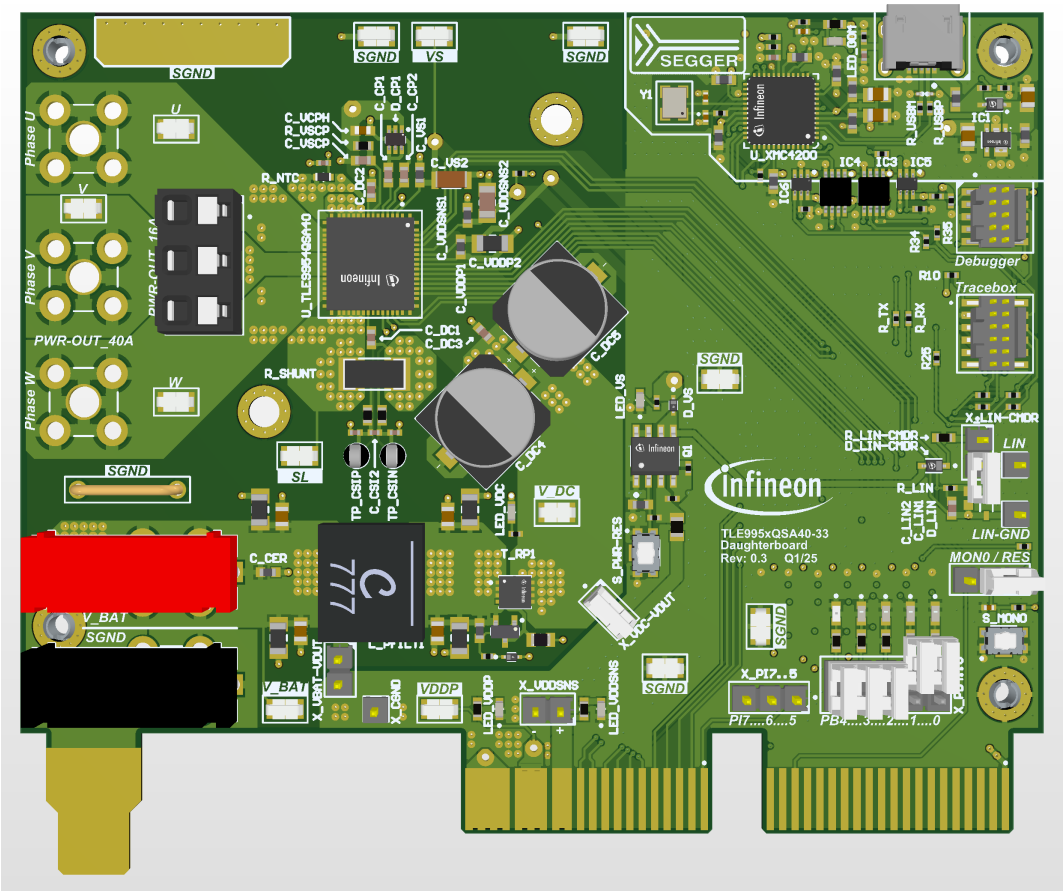
Board user guide

For MOTIX™ TLE9954QS

Evaluation kit

Hardware: TLE9954QSA40_33_daughterboard_rev0_3



About this document

Scope and purpose

This user guide is intended to help users operate the TLE9954QSA40-33 evaluation kit. The evaluation kit is designed to evaluate the hardware and software features of the MOTIX™ *microcontroller unit (MCU)* TLE9954QSA40-33.

This document provides information about the daughterboard's functionality, interfaces, jumper settings, assembled components, configurations through optional resistors and debugging options. In addition, it includes the default *bill of materials (BOM)*, schematics, and layout of the board.

Intended audience

This document is intended for anyone using the TLE9954QSA40-33 daughterboard.

Evaluation kit

The TLE9954QSA40-33 device is soldered on the board of the evaluation kit, so a socket board is not necessary.

This evaluation kit will be used during design-in for the evaluation and testing of the MOTIX™ MCU TLE9954QSA40-33 features.

***Note**: The printed circuit board (PCB) and auxiliary circuits are NOT optimized for final customer design.*

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Safety precautions

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

Table 1 Safety precautions

	**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 DC 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 The board at a glance

This board is designed to provide a simple, easy-to-use set-up for getting familiar with Infineon's MOTIX™ *MCU* TLE9954QSA40-33.

The board is protected against reverse polarity of the input voltage supply. A *light-emitting diode (LED)* indicates that the board is connected to the supply in the correct way.

The board offers an on-board debugger and *serial wire debug (SWD)* interface.

1.1 Delivery content

The TLE9954QSA40-33 daughterboard is delivered with a TLE9954QSA40-33 device soldered on the board.

1.2 Block diagram

The block diagram and realistic views of the functional blocks show the layout of the daughterboard.

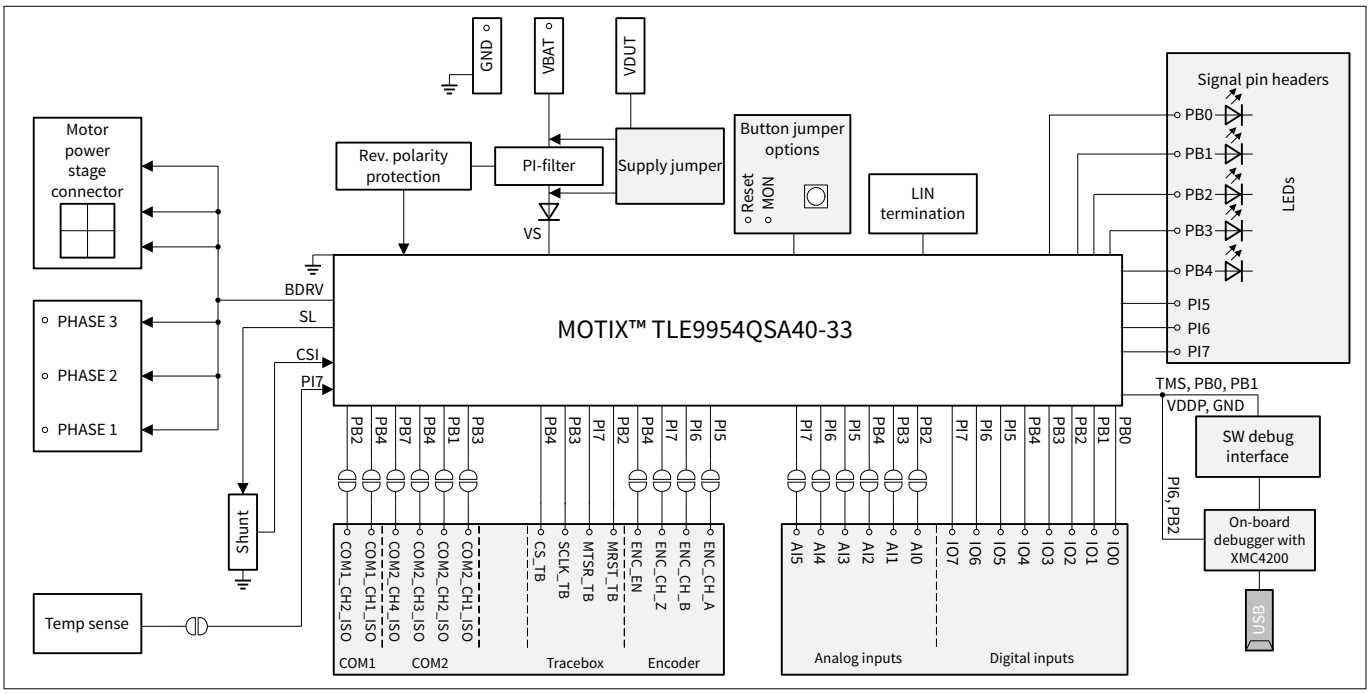

Figure 1 Block diagram

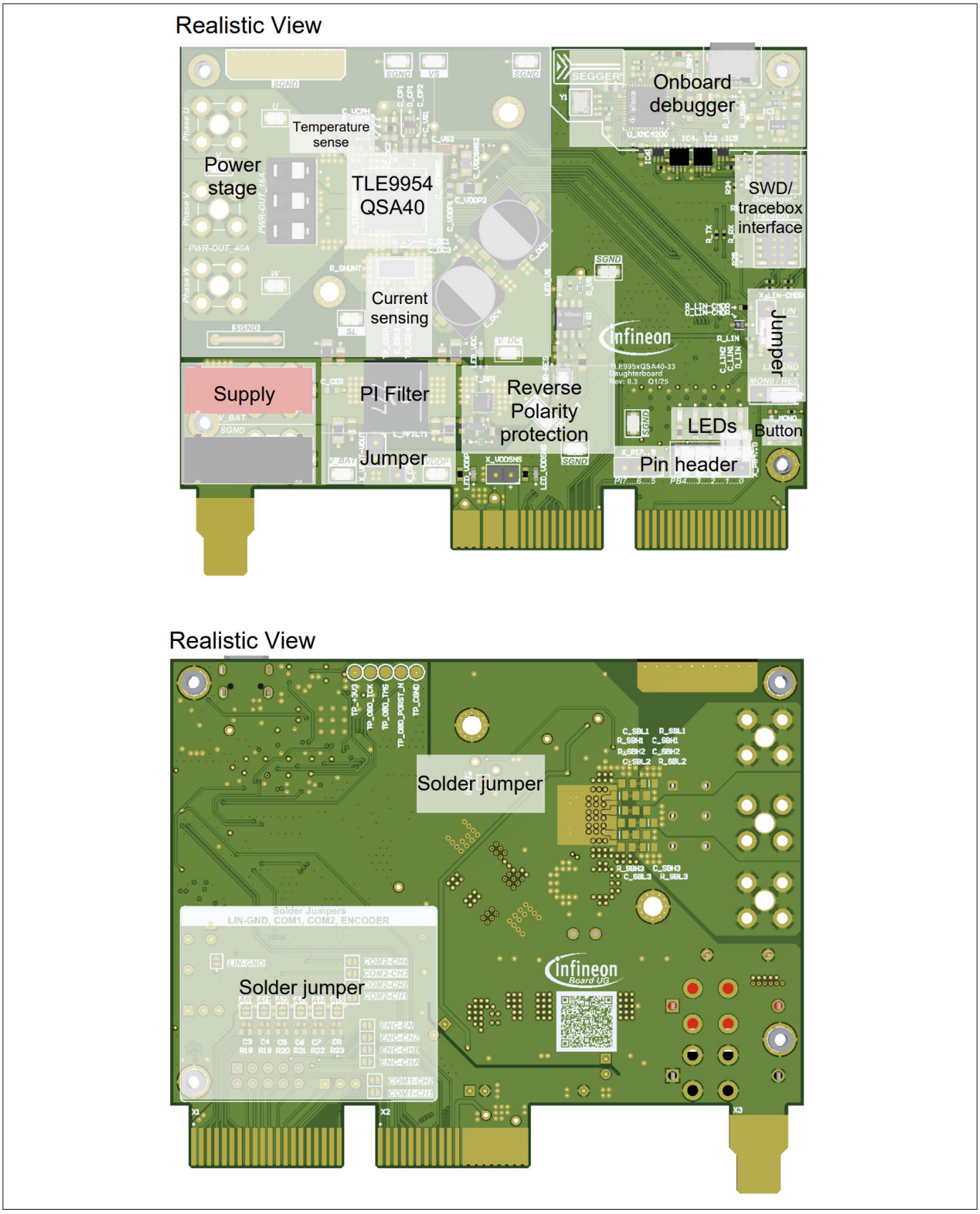

Figure 2 Functional blocks on the TLE9954QSA40-33 daughterboard

1.3 Main features

This list provides an outline of the essential features of the TLE9954QSA40-33 daughterboard.

- On-board connectors for *brushless direct current (BLDC)* motors
- Shunt resistor for current measurement
- PI-filter and reverse polarity protection for the supply
- A *local interconnect network (LIN)* connection with option for LIN master termination
- Single configurable push button for the *MON* and *RESET* pins
- LEDs for supply voltage, DC-link voltage, +5 V supply and for the *general purpose input output (GPIO)*s
- Connectors for the debugger and Tracebox connections
- On-board temperature sensor
- Solder jumpers for additional configuration

1.4 Technical data

The technical data of the TLE9954QSA40-33 daughterboard is specified in the table below.

The current capability is limited by the banana jacks and the 3 W shunt resistor. For details on battery and motor connectors, refer to Table 3 and the Motor power stage chapter. If working with higher currents than the specified maximum ratings, safety measures need to be applied accordingly.

Table 2 Technical data

Voltage supply	Max. 29 V[1) 2) 3)]
Supply current	Max. 16 A [1) 3)]
Power class	200 W[1) 2) 3)]
Pin ports P0.x, P1.x, P2.x	5 V[2)]
Temperature	25°C

1) Specified by design
2) Limited by the functional range of the TLE9954QSA40-33. Refer to the device datasheet for further information
3) Limited by the thermal dissipation capabilities of the board

2 System and functional description

2.1 Board information

2.1.1 Connectors

The connectors on the daughterboard are used for *BLDC* motors, debugger and Tracebox connections, and other purposes.

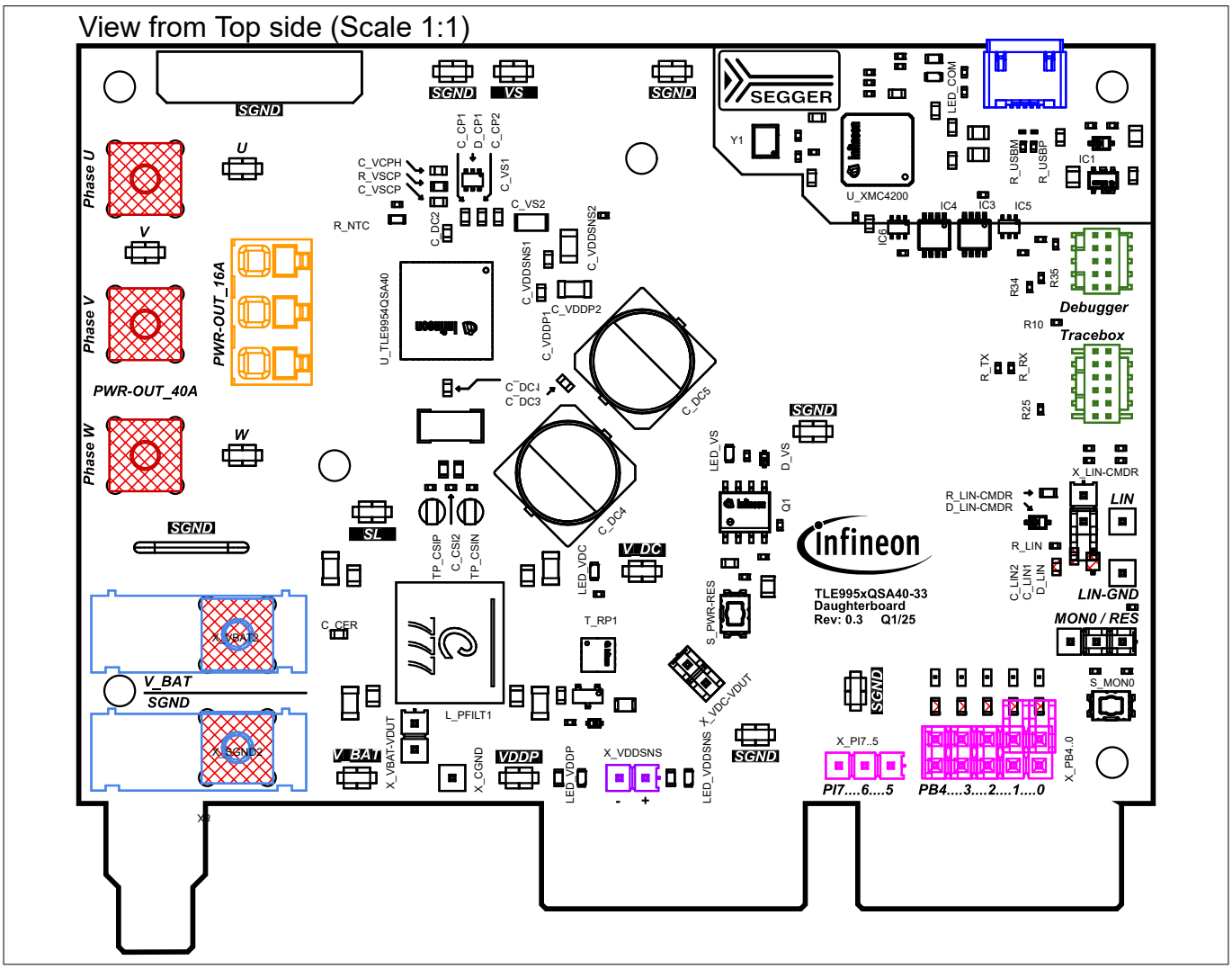

Figure 3 Connectors

Table 3 Connectors

Functionality	Description
V_BAT, SGND	Banana jacks for power supply (red) and ground (black)
X_VBAT2, X_SGND2	Power terminals for power supply
PWR-OUT_16A	Power terminal for motor connections Phase U (top), Phase V (middle), and Phase W (bottom). The phases of the motor should be connected either to this connector or to the one listed above. See Motor power stage for more information

(table continues...)

Table 3 (continued) Connectors

Functionality	Description
PWR-OUT_40A	Power terminal for motor connections Phase U (top), Phase V (middle), and Phase W (bottom). These terminals are provided to connect high power motors due to their high current (up to 40 A) capability. The phases of the motor should be connected either to this connector or to the PWR-OUT_16A listed below. See Motor power stage for more information
X_VDDSNS	Connector to measure the VDDSNS and GND
IO 0…7	IO connector for PB0 to PB4 along with LEDs and PI5 to PI7
Debugger	Debugging interface to connect an external debugger
Tracebox	12-pin connector for Tracebox connection
USB	USB connector for micro-USB cable to connect the on-board debugger to a PC for Debugging and Virtual COM Port

2.1.2 Test points

The TLE9954QSA40-33 daughterboard contains a number of test points, shown in Figure 4 and Table 4.

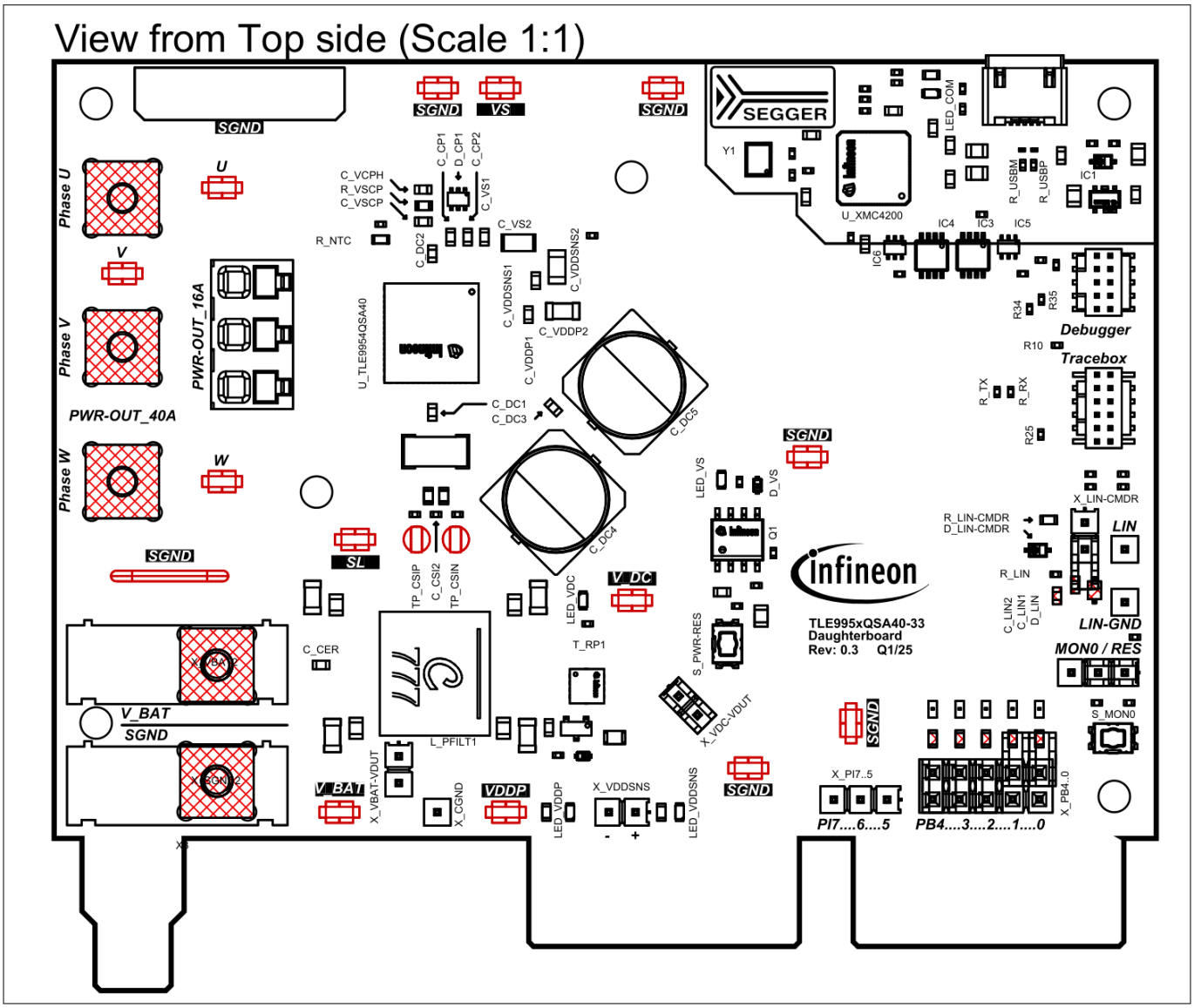

Figure 4 Test points

Table 4 Test points

Signal	Description
V_BAT	Test point to measure the board supply voltage
V_DC	Test point to measure the DC-link voltage
VS	Test point to measure the device *VS* pin voltage
VDDP	Test point to measure the device VDDP voltage
SGND	Test points to connect to power ground
U, V, W	Test points to measure the motor phase voltages
SL	Test point to measure the device *SL* pin voltage

(table continues...)

Table 4 (continued) Test points

Signal	Description
TP_CSIP, TP_CSIN	Test points to measure differential voltage at current sense amplifier inputs of the device

2.1.3 LEDs

The LEDs and potential connectors are shown in Figure 5 and described in Table 5.

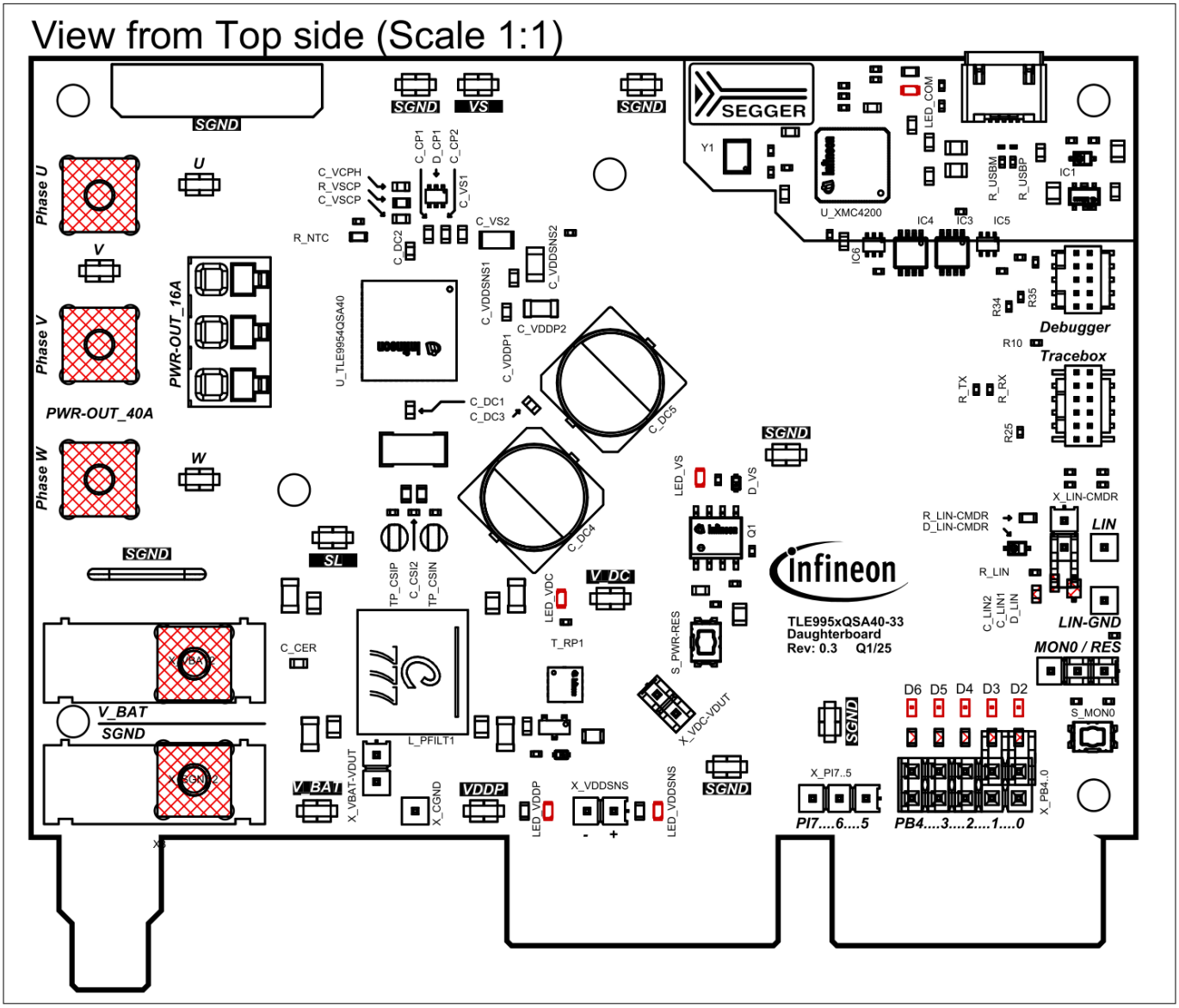

Figure 5 LEDs

Table 5 LEDs

Designator	Description
LED_VDC	Indicates that there is a positive voltage at DC-link (V_DC)
LED_VS	Indicates that there is a positive voltage at VS

(table continues...)

Table 5 (continued) LEDs

Designator	Description
LED_VDDP	Indicates that there is a positive voltage at VDDP
LED_VDDSNS	Indicates that there is a positive voltage at VDDSNS
LED_COM	Indicates that there is a communication with the on-board debugger
D2	Can be connected to the *GPIO* PB0 with a jumper
D3	Can be connected to the GPIO PB1 with a jumper
D4	Can be connected to the GPIO PB2 with a jumper
D5	Can be connected to the GPIO PB3 with a jumper
D6	Can be connected to the GPIO PB4 with a jumper

2.1.4 Jumpers

Jumper setting options for the daughterboard are described in Table 6 and visualized in Figure 6.

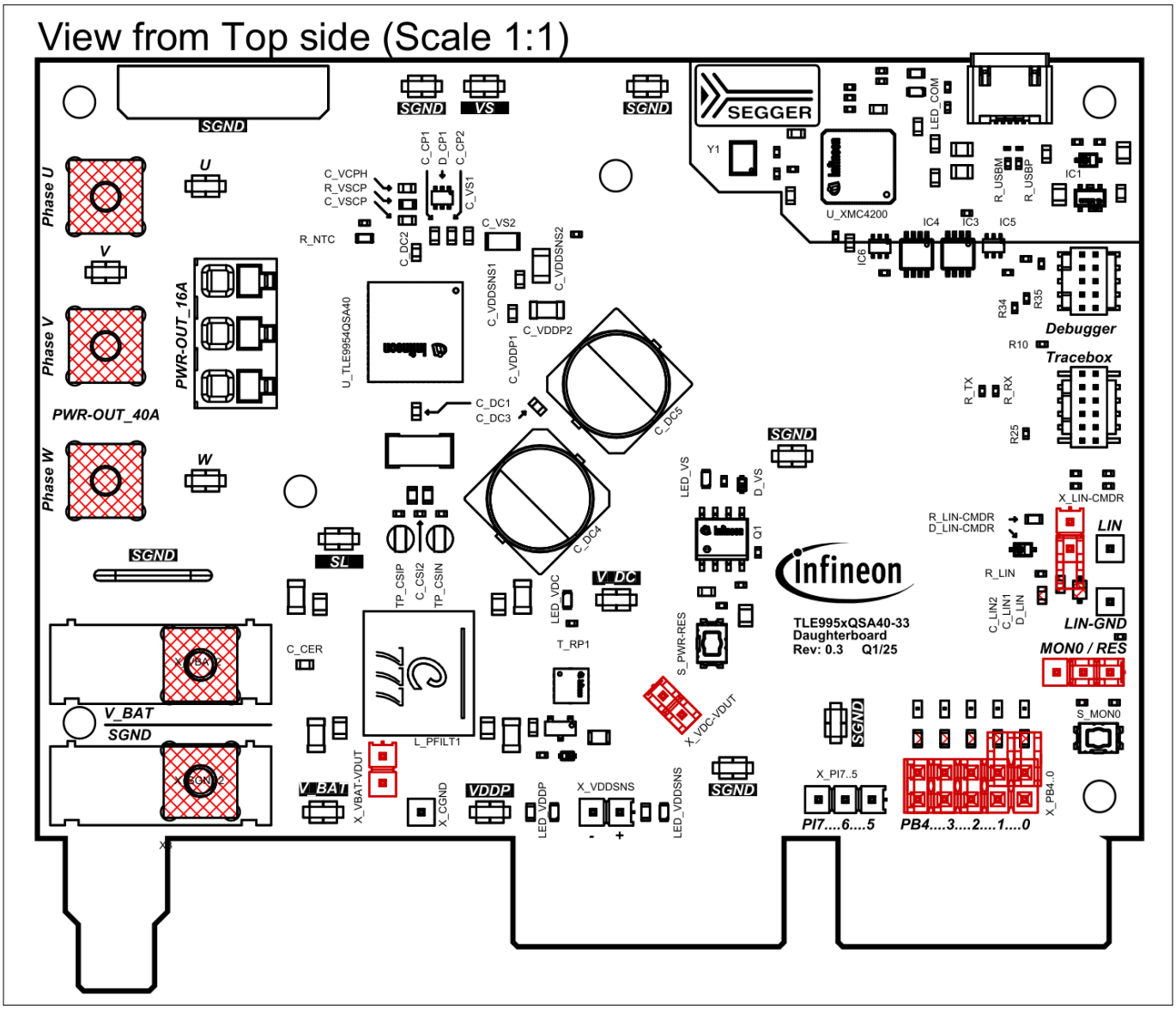

Figure 6 Jumpers

Table 6 Jumpers

Designator	Description
X_VBAT-VDUT	Set jumper to connect V_BAT to V_DUT
X_VDC-VDUT	Set jumper to connect V_DC to V_DUT
PB4…3…2…1…0	Set jumper to connect the LEDs to PBx
X_LIN-CMDR	Set jumper to pin 1 and pin 2 (refer to marking) to add an external 1 kΩ pull-up resistor for LIN master if needed. Set jumper to pin 2 and pin 3 to remove external pull-up
MON0/RES	Set jumper to pin 2 and pin 3 (left two pins) to use the button for *MON* pin input. Set jumper to pin 1 and pin 2 (right two pins) to use the button for *RESET*

2.1.5 Push buttons

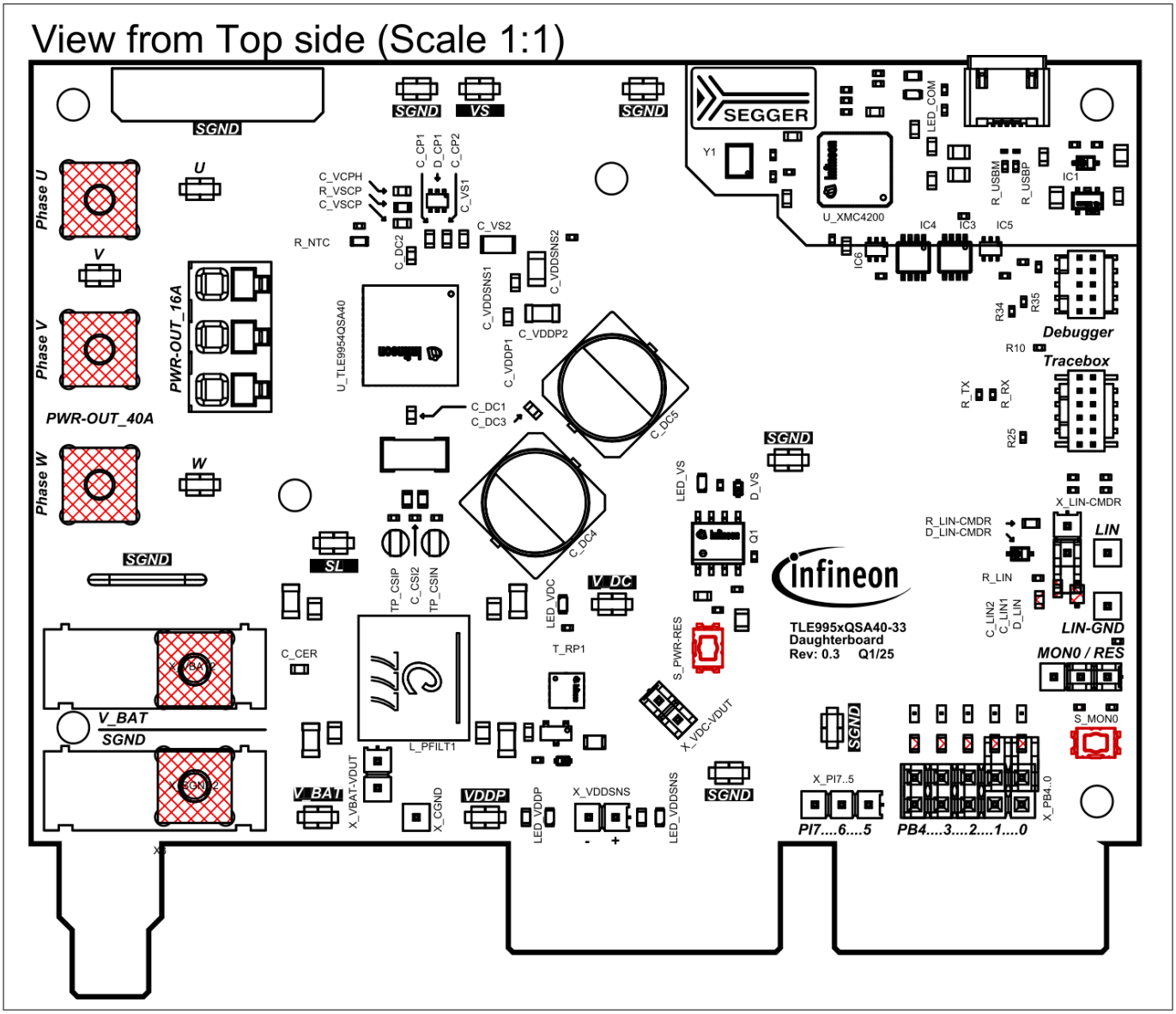

Figure 7 Push buttons

Table 7 Push buttons

Designator	Description
S_MON0	S1 is a normally opened push button that can be used for both, *MON* input and *RESET*, depending on the jumper setting, see Jumpers
S_PWR-RES	S_PWR-RES is a normally opened push button that can be used to create a power-on reset without turning off the power supply

2.1.6 Solder jumpers

Solder jumpers are connectors which can be used to make connections by soldering two pads. They are provided to offer additional configuration to the user. The interconnection for certain functionality is illustrated in schematic sheet Figure 20. Only solder jumpers TEMP and LIN-GND are implemented on the board, while the others come from the MOTIX™ *MCU* motherboard.

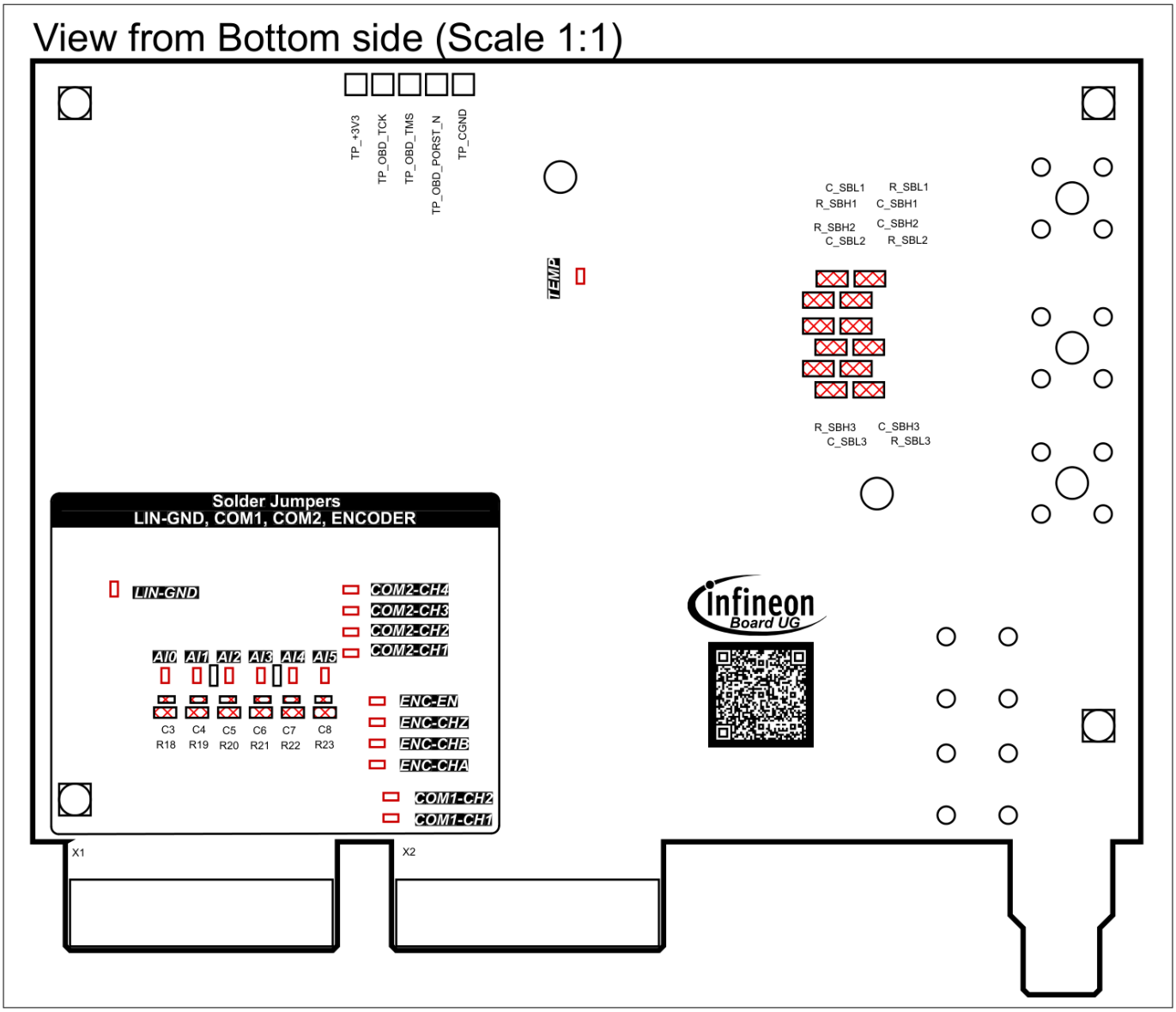

Figure 8 Solder jumpers

Table 8 Solder jumpers

Designator	Description
AI0…AI5	Solder these jumpers to connect analog inputs from motherboard
TEMP	Solder this jumper for the temperature sensor connection
LIN GND	Solder this to connect *LIN ground (GND)* to common GND (CGND)
ENC-EN… ENC-CHA	Solder these jumpers for the Encoder connection from the motherboard
COM2-CH1… COM2-CH4	Solder these jumpers for COM2 connections from the motherboard
COM1-CH1, COM1-CH2	Solder these jumpers for COM1 connections from the motherboard

2.2 Interfaces

2.2.1 Motor power stage

Three MOSFET half-bridges are integrated into the device to drive a motor. At V_DC for each motor phase, one decoupling capacitor (C_DC1_x), as well as a DC link buffer capacitor (C_DC2_x) are placed in the device. To connect the motor phases, the output terminals can be used.

Furthermore, there are placement options available for snubbers (R_SBHx + C_SBHx, R_SBLx + C_SBLx) on the backside, refer to Figure 16.

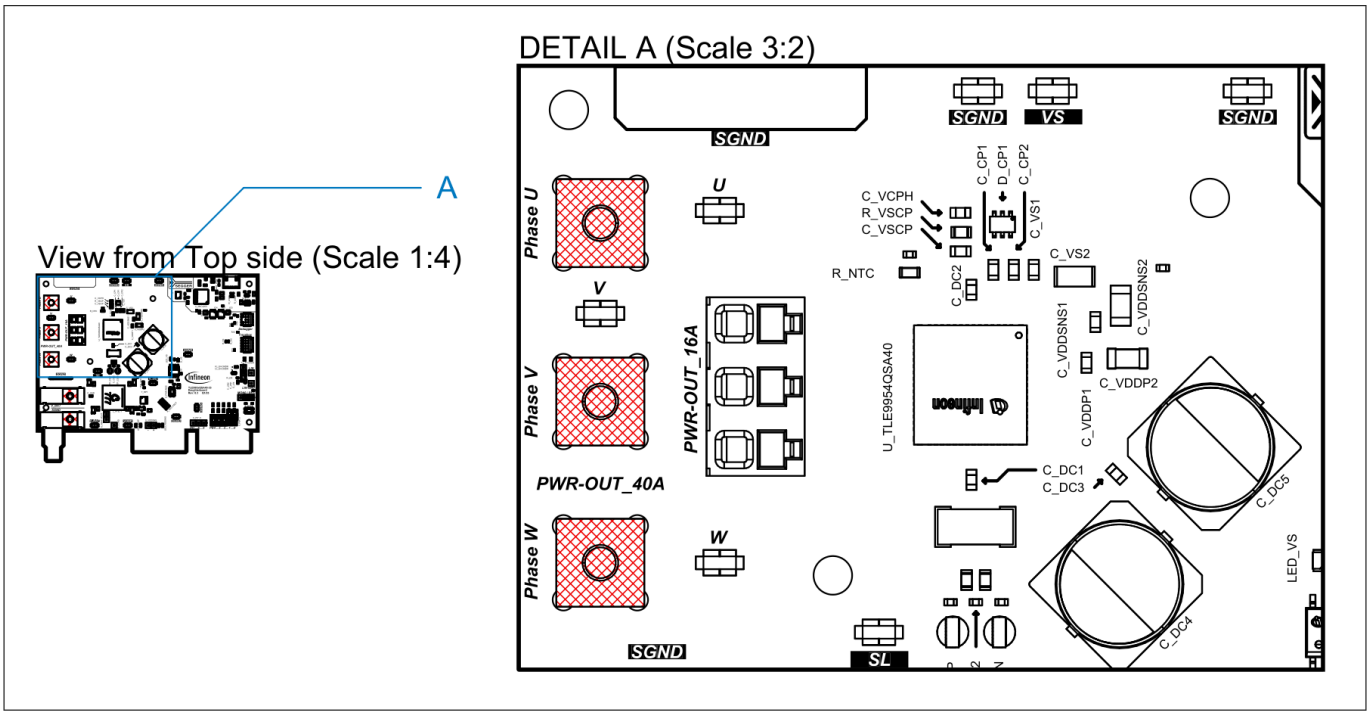

Figure 9 Motor power stage

To connect the motor phases, the PWR-OUT_16A or PWR-OUT_40A output terminals can be used depending on the power class. The pinout of the PWR-OUT_16A connector is shown in Figure 10 which can be used for easy connection and evaluation of the motor with solid conductors up to 1.5mm^2.

If the user wants to use the 40 A interface, the red cubes PWR-OUT_40A shown in Figure 9 must be soldered properly. Additionally, the red cubes on the input terminal should be soldered instead of the 16 A banana connector on V_BAT, refer to Figure 15.

A description and manufacturer number of the terminals used for the board can be found in the BOM in BOM for the TLE9954QSA40-33 daughterboard.

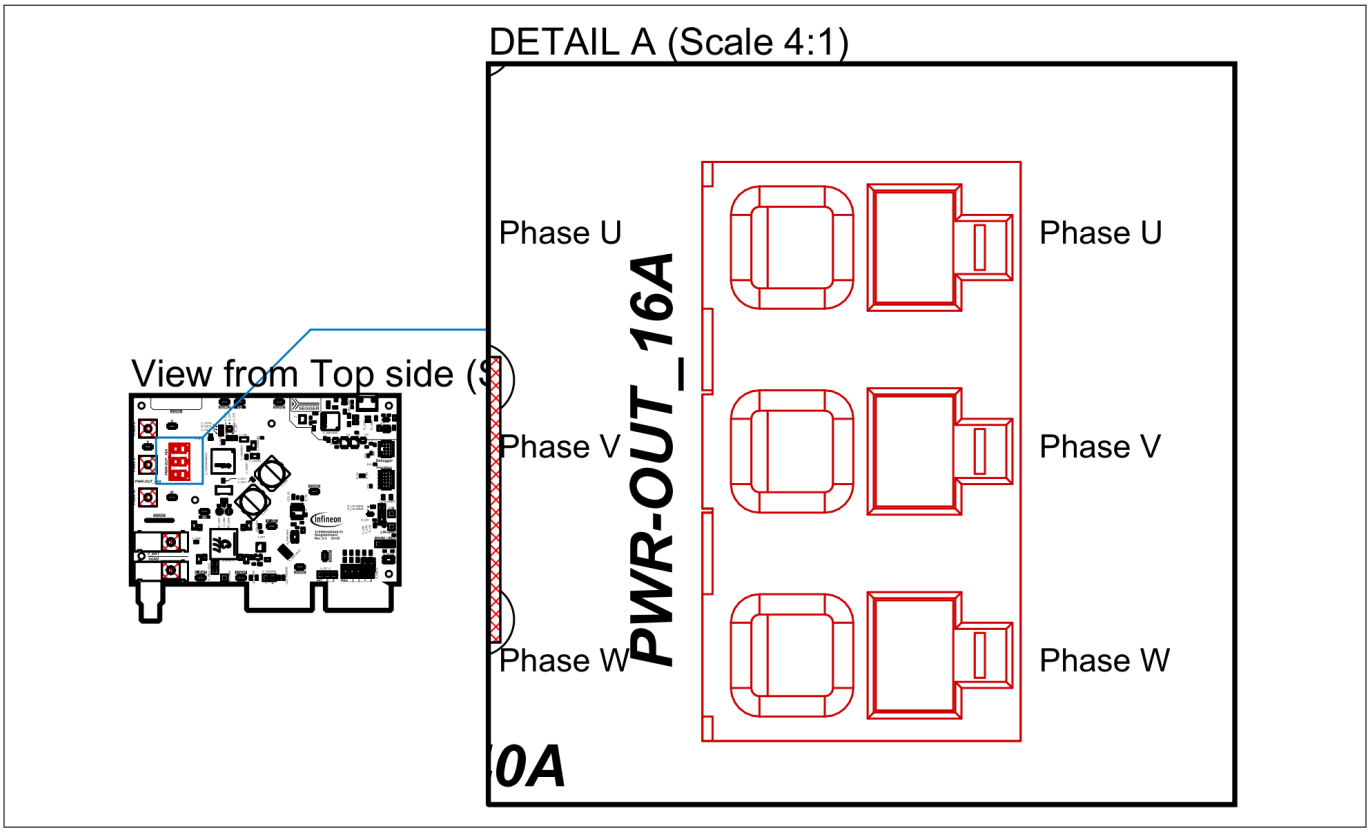

Figure 10 Pinout of PWR-OUT_16A

2.2.2 Motor current sensing

A single shunt resistor R_SHUNT is placed on the board between the *SL* pin of the device and the *GND*. It enables the indirect measuring of the motor current consumption.

This is done via the *CSIP* and *CSIN* pins of the device, together with R-C networks for filtering, as shown in Figure 11.

If motor currents are applied which exceed the maximum ratings given in Technical data, the maximum current rating of the shunt resistor being used needs to be considered. The specified power rating P_{shunt} of shunt resistor can be found in the manufacturer's datasheet, and the maximum current I_{shunt}can be calculated as follows:

$$I_{shunt} = \sqrt{\frac{P_{shunt}}{R_{shunt}}}$$

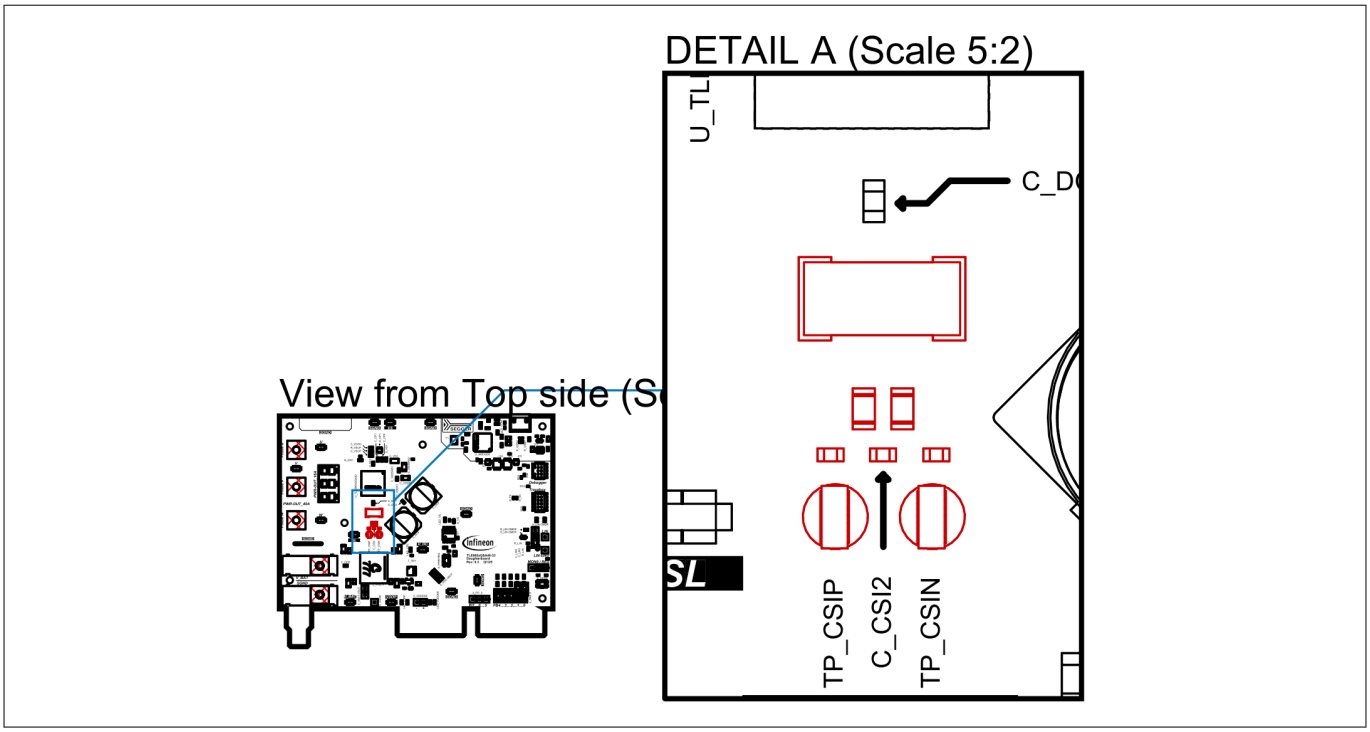

Figure 11 Motor current sensing

2.2.3 Pin headers

There are two pin headers on the board which allow access to the *input/output (I/O)* ports of the device. There are two headers located at the bottom right of the board, where I/O 0…4 are for PB0…PB4 which can also be connected to the LEDs. IO 5…7 are for PI5…PI7 of the device and can be used to input an analog signal.

The pin headers have a standard pitch of 2.54 mm and the pinouts of these headers can be observed in the figure below.

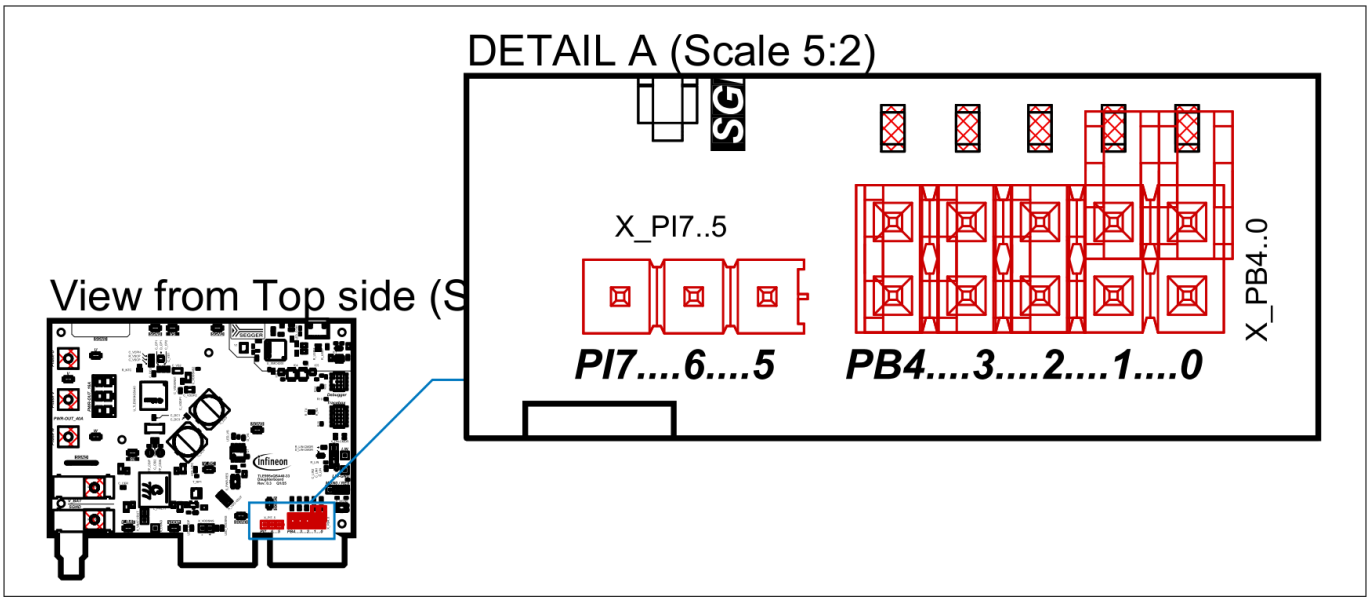

Figure 12 Pinout of pin headers

2.2.4 Debugging

On the board, a SEGGER J-Link debugger is available for debugging, which can be connected with a USB cable. Additionally, there are two connectors available for debugging and flashing the device. The Debugger connector is a standard 10-pin connector which can be used for external debuggers such as the Arm® KEIL ULINK2 or the XMC™ Link. The Tracebox 12-pin connector is specifically intended to be used with the Tracebox available from MOTEON. The pinout of the connectors is depicted below.

***Note**: The external debuggers or Tracebox are not delivered with the board.*

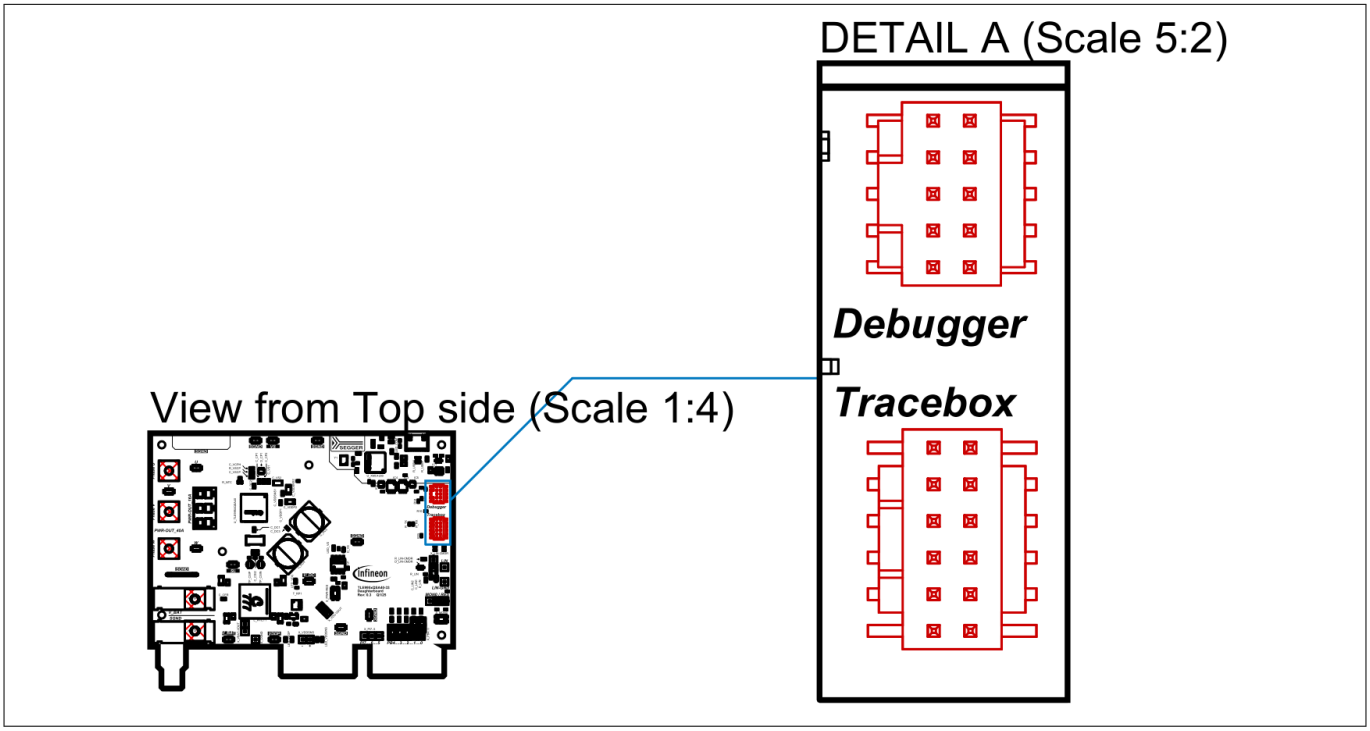

Figure 13 Debugger and Tracebox connectors

2.2.5 Card edge connector

There is also a card edge connector interface on the board that can be used to connect the daughterboard to the motherboard. The motherboard offers several additional debugging interfaces.

The card edge connector interface is shown in Figure 14.

***Note**: The motherboard is currently not available and will be made available at a later date. The motherboard is not provided with the daughterboard and has to be ordered separately if needed.*

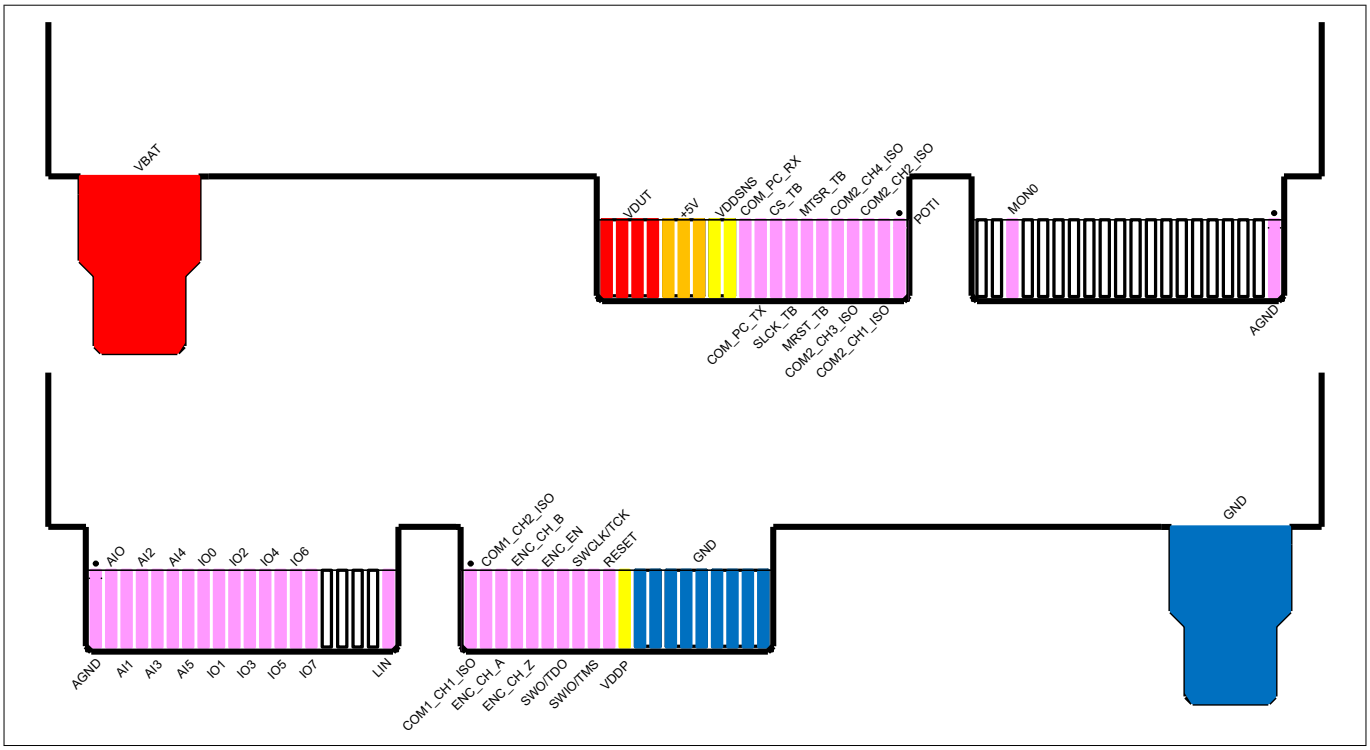

Figure 14 Card edge connector

3 Assembly options

Some components on the board are not assembled by default and can be soldered by the user if necessary. These components are highlighted in red in Figure 15, Figure 16, and are listed in Table 9.

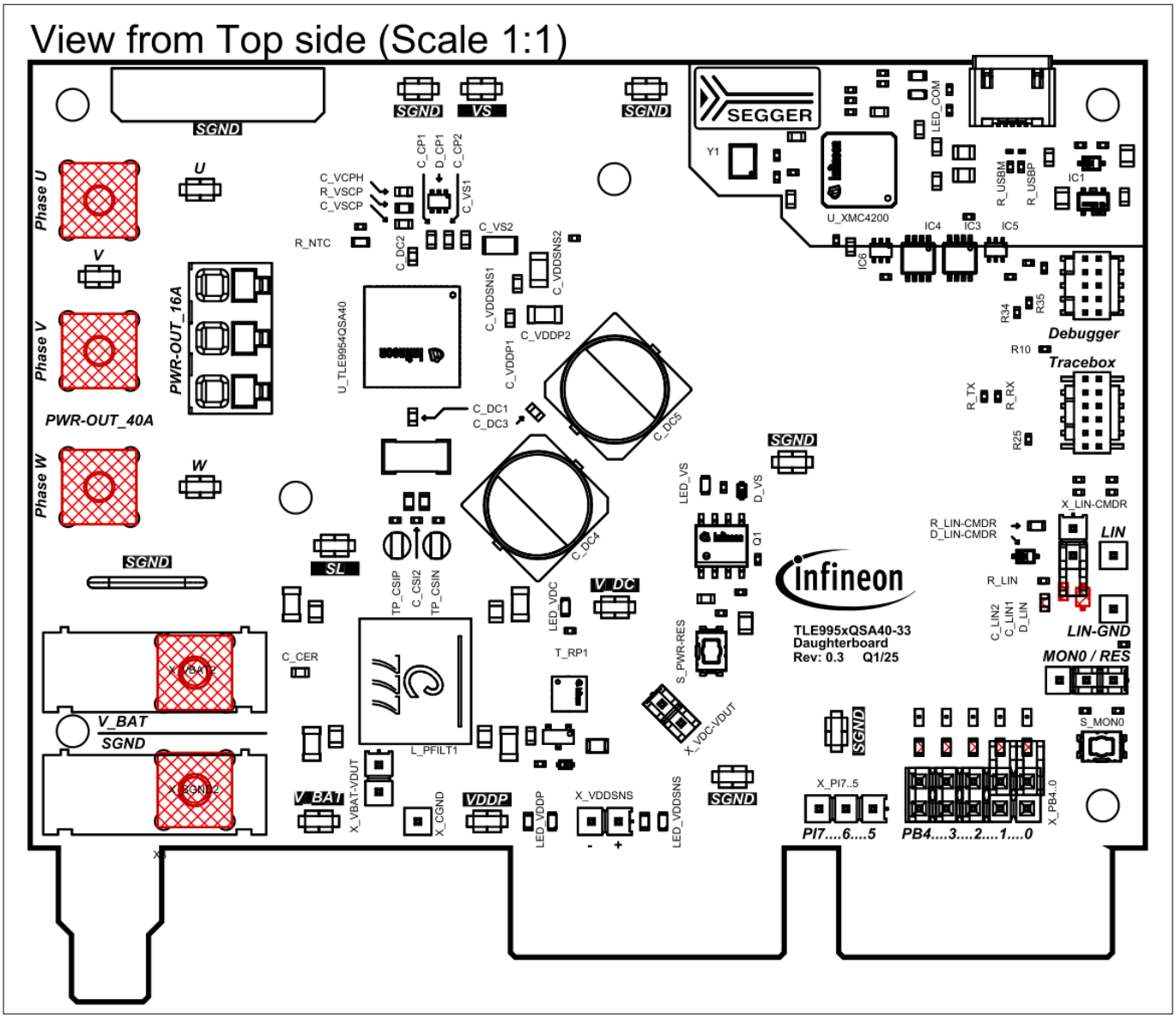

Figure 15 Overview placement options top

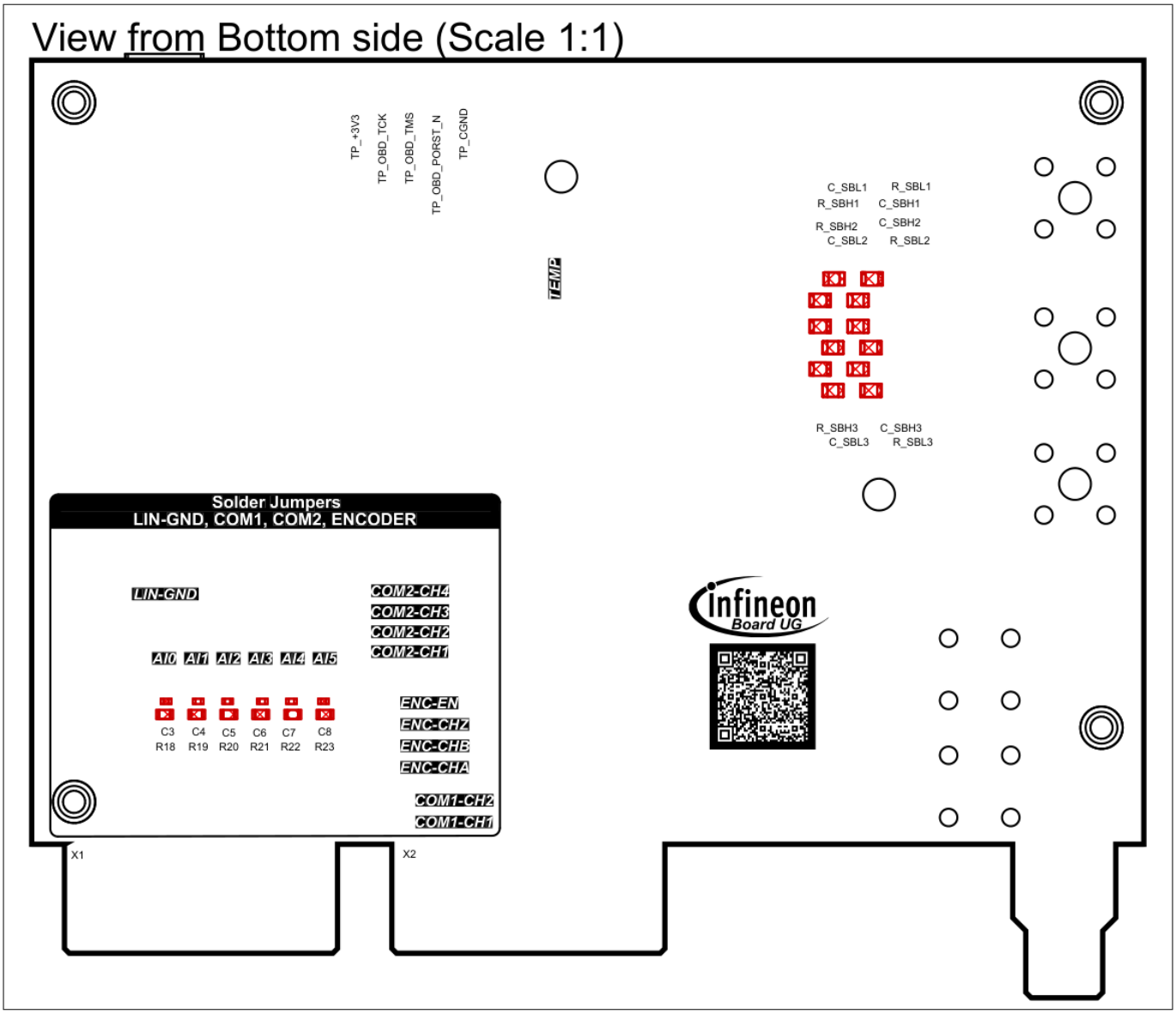

Figure 16 Overview placement options bottom

Values for these optional additional placements have to be determined depending on application. The recommended components and values can be found in the *BOM* in BOM for the TLE9954QSA40-33 daughterboard.

Table 9 Placeholder for the additional assembly options

Designator	Description
X_VBAT2, X_SGND2	Power terminals for power supply
PWR-OUT_40A	Power terminal for motor connections Phase U, Phase V, and Phase W
C_LIN1	Second LIN bus resistor
D_LIN	LIN bus ESD diode
R18…R23	Resistor of RC filter for the IO pins
C3…C8	Capacitor of RC filter for the IO pins

(table continues...)

Table 9 (continued) Placeholder for the additional assembly options

Designator	Description
R_SBHx, C_SBHx, R_SBLx, C_SBLx	Snubber circuit

4 Software toolchain

There are software and tools available to be used with the daughterboard.

The software toolchain can be installed following the instructions in the Getting started guide in the Documents section.

5 Design files

5.1 BOM for the TLE9954QSA40-33 daughterboard

Automotive qualified components are preferred for use for the TLE9954QSA40-33 board.

The complete *BOM* is shown below, including components that are not fitted.

***Note**: Based on the availability of the components, some of the components below might differ slightly from the mounted ones.*

Table 10 BOM TLE9954QSA40-33 daughterboard

#	Designator	Fitted	Quantity	Manufacturer Order number	Manufacturer	Value	Combined parameters
1	C1, C_CER, C_DAGND, C_DVDDC1, C_DVDDC2, C_DVDDP1, C_DVDDP2, C_DVDDP3, C_DVDDP4, C_LDO1, C_RP1, C_VDDP1, C_VDDSNS1, C_VS1	Fitted	14	C0603C104K5RACAUTO	Kemet	100nF	TC: X7R (EIA); Tol.: -10%/+10%; Vdc: 50 V
2	C2, C_PORST1	Fitted	2	GRM155R71H103JA88	MuRata	10nF	TC: X7R (EIA); Tol.: -5%/+5%; Vdc: 50 V
3	C3, C4, C5, C6, C7, C8	Varied	0	CBR04C101F3GAC	Kemet	100pF	TC: C0G (EIA)/NP0; Tol.: -1%/+1%; Vdc: 25 V
4	C9, C_CSI2, C_CSIN2, C_CSIP2	Fitted	4	CGA2B2NP01H102J050BA	TDK Corporation	1nF	TC: C0G (EIA)/NP0; Tol.: -5%/+5%; Vdc: 50 V
5	C_CP1, C_CP2	Fitted	2	GCM188R71H224KA64	MuRata	220nF	TC: X7R (EIA); Tol.: -10%/+10%; Vdc: 50 V
6	C_DC1, C_DC2, C_DC3	Fitted	3	CGA3E3X8R1H104K080AB	TDK Corporation	100nF	TC: X8R (EIA); Tol.: -10%/+10%; Vdc: 50 V
7	C_DC4, C_DC5	Fitted	2	PCR1V331MCL1GS	Nichicon	330uF	TC: Aluminiumelectrolytic; Tol.: -20%/+20%; Vdc: 35 V

(table continues...)

Table 10 (continued) BOM TLE9954QSA40-33 daughterboard

#	Designator	Fitted	Quantity	Manufacturer Order number	Manufacturer	Value	Combined parameters
8	C_DVDDC3	Fitted	1	GRM21BZ71H475KE15L	MuRata	4.7uF	TC: X7R (EIA); Tol.: -10%/+10%; Vdc: 50 V
9	C_DVDDP5, C_LDO2, C_LDO3	Fitted	3	GCM21BR71A106KE22	MuRata	10uF	TC: X7R (EIA); Tol.: -10%/_P10%; Vdc: 10 V
10	C_DXTAL1, C_DXTAL2	Fitted	2	GCM1555C1H120JA16	MuRata	12pF	TC: C0G (EIA)/NP0; Tol.: -5%/+5%; Vdc: 50 V
11	C_LIN1	Varied	0	CGA3E2C0G1H221J080AA	TDK Corporation	220pF	TC: C0G (EIA)/NP0; Tol.: -5%/+5%; Vdc: 50 V
12	C_LIN2	Fitted	1	CGA3E2C0G1H221J080AA	TDK Corporation	220pF	TC: C0G (EIA)/NP0; Tol.: -5%/+5%; Vdc: 50 V
13	C_PFILT1, C_PFILT2, C_PFILT7, C_PFILT8, C_VDDP2	Fitted	5	CGA5L3X7R1H475K160AB	TDK Corporation	4.7uF	TC: X7R (EIA); Tol.: -10%/+10%; Vdc: 50 V
14	C_PFILT3, C_PFILT4, C_PFILT5, C_PFILT6	Fitted	4	GRM216R71H471KA01	MuRata	470pF	TC: X7R (EIA); Tol.: -10%/+10%; Vdc: 50 V
15	C_SBH1, C_SBH2, C_SBH3, C_SBL1, C_SBL2, C_SBL3	Varied	0	CGA4C2NP01H103J060AA	TDK Corporation	10nF	TC: C0G (EIA)/NP0; Tol.: -5%/+5%; Vdc: 50 V
16	C_SHELL, CVDDP	Fitted	2	CGA2B3X7R1H104K050BB	TDK Corporation	100nF	TC: X7R (EIA); Tol.: -10%/_P10%; Vdc: 50 V, TC: X7R (EIA); Tol.: -10%/+10%; Vdc: 50 V
17	C_VCPH	Fitted	1	CGA3E3X7R1H474K080AE	TDK Corporation	470nF	TC: X7R (EIA); Tol.: -10%/+10%; Vdc: 50 V

(table continues...)

Table 10 (continued) BOM TLE9954QSA40-33 daughterboard

#	Designator	Fitted	Quantity	Manufacturer Order number	Manufacturer	Value	Combined parameters
18	C_VDDSNS2	Fitted	1	CGA5L3X7R1H105K160AB	TDK Corporation	1uF	TC: X7R (EIA); Tol.: -10%/+10%; Vdc: 50 V
19	C_VS2	Fitted	1	C3216X5R1V226M160AC	TDK Corporation	22uF	TC: X5R (EIA); Tol.: -20%/+20%; Vdc: 35 V
20	C_VSCP	Fitted	1	CC0603KRX7R9BB105	Yageo	1uF	TC: X7R (EIA); Tol.: -10%/+10%; Vdc: 50 V
21	D2, D3, D4, D5, D6	Fitted	5	TLMS1100-GS08	Vishay	Red	Vf: 3 V; If: 20 mA; Ur: 12 V; Ir: 10 uA; Pmax: 90 mW
22	D_CP1	Fitted	1	BAT54XY,115	Nexperia	30V	Vf: 400 mV; If: 200 mA; Ur: 30 V; Ir: 2 uA; Pmax: 220 mW
23	D_LIN	Varied	0	PESD1IVN27-A	Nexperia	PESD1IVN27-A	Vf: -; If: -; Ur: 27 V; Ir: 50 nA; Pmax: -
24	D_LIN-CMDR	Fitted	1	BAS21-03W	Infineon Technologies	BAS21-03W	Vf: 1.25 V; If: 250 mA; Ur: 200 V; Ir: -; Pmax: 250 mW
25	D_RP1, D_VS	Fitted	2	BAS52-02V	Infineon Technologies	BAS52-02V	Vf: 500 mV; If: 200 mA; Ur: 45 V; Ir: 10 uA; Pmax: 500 mW
26	D_USB	Fitted	1	BAT60A	Infineon Technologies	BAT60A	Vf: 300 mV; If: 3 A; Ur: 10 V; Ir: 2.6 mA; Pmax: 1.35 W
27	D_USBM, D_USBP	Fitted	2	ESD231-B1-W0201	Infineon Technologies	ESD231-B1-W0201	Vf: -; If: -; Ur: 5.5 V; Ir: 20 nA; Pmax: -
28	IC1	Fitted	1	TLS202B1MBV33	Infineon Technologies	TLS202B1MBV33	Linear Not applicable _N; Vo: 3.3 V to 3.3 V

(table continues...)

Table 10 (continued) BOM TLE9954QSA40-33 daughterboard

#	Designator	Fitted	Quantity	Manufacturer Order number	Manufacturer	Value	Combined parameters
29	IC3, IC4	Fitted	2	SN74LVC2T45DCTT	Texas Instruments	SN74LVC2T45DCTT	
30	IC5, IC6	Fitted	2	SN74LVC1T45DCKR	Texas Instruments	SN74LVC1T45DCKR	Industrial Interface/ Transceiver; Vdc min/max: 1.65 V/5.5 V; Iout: 32 mA; Fmax: -
31	L_PFILT1	Varied	0	XAL1010-102MED	Coilcraft	1uH	Tol.: -20%/ +20%; Rdc: 1.1mR; Idc: 43.5 A; Fres: 42 MHz
32	L_PFILT1	Varied	1	XAL1010-472MED	Coilcraft	4.7uH	Tol.: -20%/ +20%; Rdc: 5.2 mR; Idc: 25.4 A; Fres: 19 MHz
33	LED_COM, LED_VDC, LED_VDDP, LED_VDDSNS, LED_VS	Fitted	5	LG L29K-G2J1-24	OSRAM Opto Semiconductors	Green	Vf: 2.2 V; If: 20 mA; Ur: 12 V; Ir: 10 nA; Pmax: -
34	LUSB1	Fitted	1	BLM18PG600SN1D	MuRata	60R	Tol.:_N; Rdc: 100 mR; Idc: 1 A; Fres:_N
35	MP1, MP2, MP3, MP4	Fitted	4	702916000	Wurth Elektronik	702916000	- Round -x4 Spacers
36	Q1	Fitted	1	AUIRF7343Q	Infineon Technologies	AUIRF7343Q	N-Channel Enhancement; Uds: 55 V; Id: 4.7 A; Rds: 105R; P: 2 W
37	Q_RP1	Fitted	1	BC817K-40R	Nexperia	BC817K-40R	NPN; Uce: 45 V; Ic: 500 mA; P: 775 mW; F: 100 MHz
38	R1	Fitted	1	CRCW08054R70FKEAHP	Vishay	4.7R	TCR: 100 ppm/K; Tol.: -1%/+1%; Vdc: 150 V; Idc: -; P: 500 mW

(table continues...)

Table 10 (continued) BOM TLE9954QSA40-33 daughterboard

#	Designator	Fitted	Quantity	Manufacturer Order number	Manufacturer	Value	Combined parameters
39	R3, R4, R5, R11, R_PDLS1, R_PDLS2, R_PDLS3, R_PORST, R_RP1, R_USB2	Fitted	10	CRCW040210K0FK	Vishay	10k	TCR: 100 ppm/K; Tol.: -1%/+1%; Vdc: 50 V; Idc: -; P: 63 mW
40	R6, R7	Fitted	2	CRCW04022K20FK	Vishay	2.2k	TCR: 100 ppm/K; Tol.: -1%/+1%; Vdc: 50 V; Idc: -; P: 63 mW
41	R8, R9, R_COM	Fitted	3	AC0603FR-07680RL	Yageo	680R	TCR: 100ppm/K; Tol.: -1%/+1%; Vdc: 75 V; Idc: -; P: 100 mW
42	R10, R24, R25, R28, R29, R30, R31, R33, R34, R35, R36, R_LIN, R_RX, R_TX	Fitted	14	ERJ2GE0R00X	Panasonic	0R	TCR: -; Tol.: -; Vdc: 50 V; Idc: -; P: 100 mW
43	R13, R14, R15, R16, R17, R_LIN-CMDR	Fitted	6	RC0603FR-071KL	Yageo	1k	TCR: 100 ppm/K; Tol.: -1%/+1%; Vdc: 75 V; Idc: -; P: 100 mW
44	R18, R20	Varied	0	TNPW06031K00BEEA	Vishay	1k	125 mW; 0,1%; 25 PPM/C; 75 V
45	R19, R21, R22, R23	Varied	0	TNPW06031K00BEEA	Vishay	1k	125 mW; 0,1%; 25 PPM/C; 75 V
46	R26	Fitted	1	CRCW04024K02FK	Vishay	4.02k	TCR: 100ppm/K; Tol.: -1%/+1%; Vdc: 50 V; Idc: -; P: 63 mW
47	R_CSIN, R_CSIP	Fitted	2	CRCW06034R70FK	Vishay	4.7R	TCR: 100 ppm/K; Tol.: -1%/+1%; Vdc: 75 V; Idc: -; P: 100 mW

(table continues...)

Table 10 (continued) BOM TLE9954QSA40-33 daughterboard

#	Designator	Fitted	Quantity	Manufacturer Order number	Manufacturer	Value	Combined parameters
48	R_NTC	Fitted	1	NTCG164KF104FTDS	TDK Corporation	100k	TCR: -; Tol.: -1%/+1%; Vdc: -; Idc: -; P: 100 mW
49	R_PULS1, R_USB1, R_VDDP1, R_VDDP2	Fitted	4	CRCW04024K70FK	Vishay	4.7k	TCR: 100 ppm/K; Tol.: -1%/+1%; Vdc: 50 V; Idc: -; P: 63 mW, TCR: 100 ppm/K; Tol.: -1%/ _P1%; Vdc: 50 V; Idc: -; P: 63 mW
50	R_RP2	Fitted	1	CRCW08053K30FK	Vishay	3.3k	TCR: 100 ppm/K; Tol.: -1%/+1%; Vdc: 150 V; Idc: -; P: 125 mW
51	R_SBH1, R_SBH2, R_SBH3, R_SBL1, R_SBL2, R_SBL3	Varied	0	CRCW08052R00FKEAHP	Vishay	2R	TCR: 100 ppm/K; Tol.: -1%/+1%; Vdc: 150 V; Idc: -; P: 500 mW
52	R_SHELL	Fitted	1	CRCW04021M00FK	Vishay	1MEG	TCR: 100ppm/K; Tol.: -1%/+1%; Vdc: 50 V; Idc: -; P: 63 mW
53	R_SHUNT	Varied	0	ERJMS4SF2M0U	Panasonic	2mR	TCR: 75 ppm/K; Tol.: -1%/+1%; Vdc: -; Idc: -; P: 3 W
54	R_SHUNT	Varied	1	ERJMS4HF5M0U	Panasonic	5mR	TCR: 75ppm/K; Tol.: -1%/+1%; Vdc: -; Idc: -; P: 3 W
55	R_USBM, R_USBP	Fitted	2	CRCW040222R0FK	Vishay	22R	TCR: 100 ppm/K; Tol.: -1%/+1%; Vdc: 50 V; Idc: -; P: 63 mW

(table continues...)

Table 10 (continued) BOM TLE9954QSA40-33 daughterboard

#	Designator	Fitted	Quantity	Manufacturer Order number	Manufacturer	Value	Combined parameters
56	R_VSCP	Fitted	1	CRCW06032R00FK	Vishay	2R	TCR: 100ppm/K; Tol.: -1%/+1%; Vdc: 75 V; Idc: -; P: 100 mW
57	R_XTAL1	Fitted	1	CRCW0402150RFK	Vishay	150R	TCR: 100ppm/K; Tol.: -1%/+1%; Vdc: 50 V; Idc: -; P: 63 mW
58	S_MON0, S_PWR-RES	Fitted	2	435451019820	Wurth Elektronik	435451019820	
59	SJ_AI0, SJ_AI1, SJ_AI2, SJ_AI3, SJ_AI4, SJ_AI5	Fitted	6	Solder Jumper 2 Pins	Infineon Technologies	Solder Jumper 2 Pins	- None (onboard); 2x1; Mounting: SMT; Orient: None (onboard); Shielded: No
60	T_RP1	Fitted	1	IPZ40N04S5-3R1	Infineon Technologies	IPZ40N04S5-3R1	N-Channel Enhancement; Uds: 40 V; Id: 40 A; Rds: 3.1 mR; P: 71 W
61	TP_+3V3, TP_CGND, TP_OBD_PORST_N, TP_OBD_TCK, TP_OBD_TMS	Fitted	5	TestPoint2mm	-	TestPoint 2mm	- Socket (female); 1x1; Mounting: SMT; Orient: -; Shielded: No
62	TP_CSIN, TP_CSIP	Fitted	2	20-2137	Vero Technologies	20-2137	Board-to-Cable None (onboard); 1x1; Mounting: THT; Orient: None (onboard); Shielded: No

(table continues...)

Table 10 (continued) BOM TLE9954QSA40-33 daughterboard

#	Designator	Fitted	Quantity	Manufacturer Order number	Manufacturer	Value	Combined parameters
63	TP_Phase-U, TP_Phase-V, TP_Phase-W, TP_SGND1, TP_SGND2, TP_SGND4, TP_SGND5, TP_SGND6, TP_SL, TP_VBAT, TP_VDC, TP_VDDP, TP_VS	Fitted	13	5019	Keystone Electronics Corp.	5019	Board-to-Cable None (onboard); 1x1; Mounting: SMT; Orient: None (onboard); Shielded: No
64	TP_SGND3	Fitted	1	D3082-05	Harwin	D3082-05	- None (onboard); -x-; Mounting: THT; Orient: None (onboard); Shielded: No
65	U_TLE9954QSA40	Fitted	1	TLE9954QSA40-33	Infineon Technologies		
66	U_XMC4200	Fitted	1	XMC4200Q48K256ABXUMA1	Infineon Technologies	IFX_XMC4200Q48K256ABXUMA1	App.: Industrial; -; Vdc min/max: 3.13 V/3.63 V; Fmax: 80 MHz; RAM: 40 KB; ROM: -; Flash: 256 KB
67	X1, X2	Fitted	2	461130401_Edge Card	Molex	461130401_Edge Card	Edge Header (male);-x-; Mounting: SMT; Orient: 0° (vertical); Shielded: No
68	X3	Fitted	1	461120201_Edge card	Molex	461120201_Edge card	Edge Header (male);-x-; Mounting: SMT; Orient: 0° (vertical); Shielded: No

(table continues...)

Table 10 (continued) BOM TLE9954QSA40-33 daughterboard

#	Designator	Fitted	Quantity	Manufacturer Order number	Manufacturer	Value	Combined parameters
69	X7	Fitted	1	629105150521	Wurth Elektronik	629105150521	Board_Nto_NCable Socket (female); 5x1; Mounting: SMT; Orient: 90Â° (right angle); Shielded: Yes
70	X_BTN, X_PI7..5	Fitted	2	TSW-103-07-L-S	Samtec	TSW-103-07-L-S	Board-to-Board Header (male); 3x1; Mounting: THT; Orient: 0° (vertical); Shielded: No
71	X_CGND, X_LIN, X_LIN-GND	Fitted	3	TSW-101-07-L-S	Samtec	TSW-101-07-L-S	Board-to-Board Header (male); 1x1; Mounting: THT; Orient: 0° (vertical); Shielded: No
72	X_DBG	Fitted	1	FTSH-105-01-L-DV-K	Samtec	FTSH-105-01-L-DV-K	Board-to-Board Header (male); 5x2; Mounting: SMT; Orient: 0° (vertical); Shielded: -
73	X_JP-BTN, X_JP-LIN, X_JP-PX0, X_JP-PX1, X_JP-PX2, X_JP-PX3, X_JP-PX4, X_JP-VDUT	Fitted	8	SNT_N100_NBK_NG_NH	Samtec	SNT_N100_NBK_NG_NH	_N Socket (female); _Nx_N; Mounting: _N; Orient: _N; Shielded: _N
74	X_LIN-CMDR, X_VBAT-VDUT, X_VDC-VDUT, X_VDDSNS	Fitted	4	TSW-102-07-L-S	Samtec	TSW-102-07-L-S	Board-to-Board Header (male); 2x1; Mounting: THT; Orient: 0° (vertical); Shielded: No

(table continues...)

Table 10 (continued) BOM TLE9954QSA40-33 daughterboard

#	Designator	Fitted	Quantity	Manufacturer Order number	Manufacturer	Value	Combined parameters
75	X_PB4..0	Fitted	1	TSW-105-07-L-D	Samtec	TSW-105-07-L-D	Board-to-Board Header (male); 5x2; Mounting: THT; Orient: 0° (vertical); Shielded: No
76	X_PWR-OUT_16A	Varied	1	2086-3103	WAGO	2086-3103	Board-to-Cable Socket (female); 3x2; Mounting: THT; Orient: 0° (vertical); Shielded: No
77	X_PWR-OUT-U_40A, X_PWR-OUT-V_40A, X_PWR-OUT-W_40A	Varied	0	74650073R	Wurth Elektronik	74650073R	Board-to-Board Socket (female); 2x2; Mounting: THT; Orient: 0° (vertical); Shielded: No
78	X_SGND1	Varied	1	973 582-100	Hirschmann Test & Measurement	973 582-100	Board-to-Cable Socket (female);-x-;Mounting:THT;Orient:90Â° (right angle);Shielded:No
79	X_SGND2, X_VBAT2	Varied	0	74651173R	Wurth Elektronik	74651173R	Board-to-Cable Header (male); -x-; Mounting: THT; Orient: 0° (vertical); Shielded: Yes
80	X_TB	Fitted	1	FTSH-106-01-L-DV-K	Samtec	FTSH-106-01-L-DV-K	Board-to-Board Header (male); 2x6; Mounting: SMT; Orient: 0° (vertical); Shielded: No

(table continues...)

Table 10 (continued) BOM TLE9954QSA40-33 daughterboard

#	Designator	Fitted	Quantity	Manufacturer Order number	Manufacturer	Value	Combined parameters
81	X_VBAT1	Varied	1	973 582-101	Hirschmann Test & Measurement	973 582-101	Board-to-Cable Socket (female); 2x1; Mounting: THT; Orient: 90Â° (right angle); Shielded: No
82	Y1	Fitted	1	CX3225CA12000D0HSSCC	Kyocera	12MHz	Standard Standard Crystal; Tol.: -50%/+50%

5.2 Schematics of the TLE9954QSA40 daughterboard

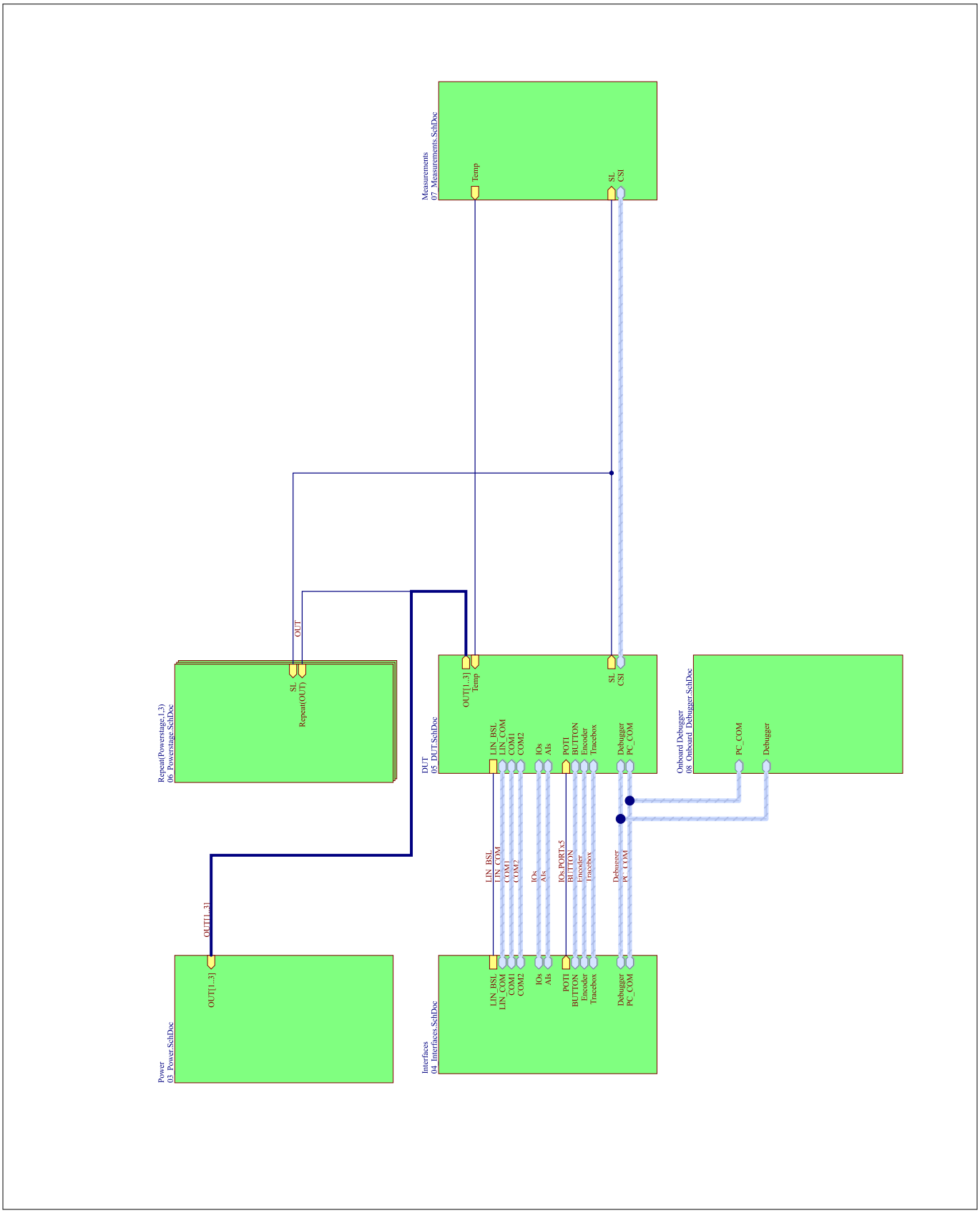

Figure 17 TLE9954QSA40 daughterboard, Top_Level schematic sheet

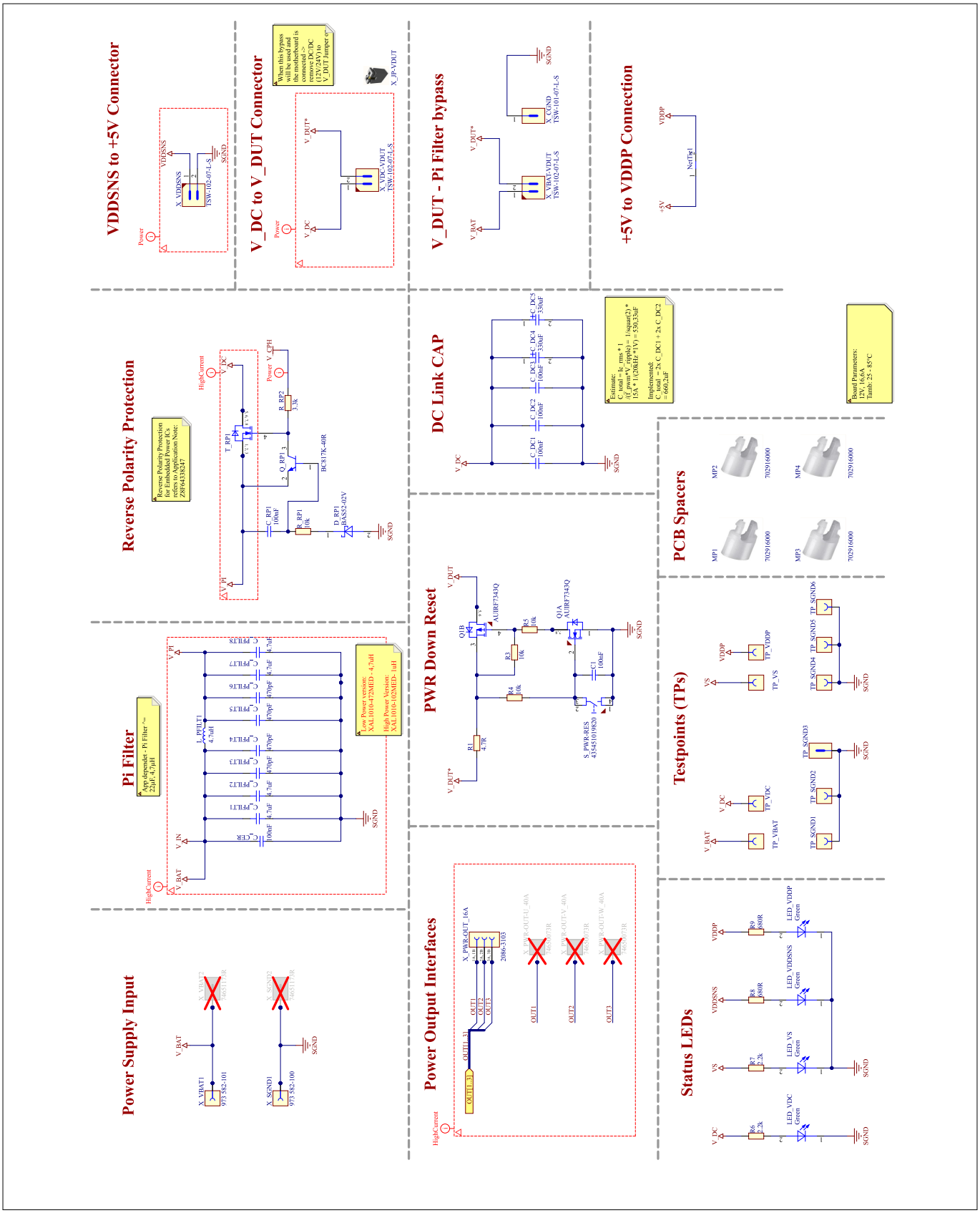

Figure 18 TLE9954QSA40 daughterboard, Power schematic sheet

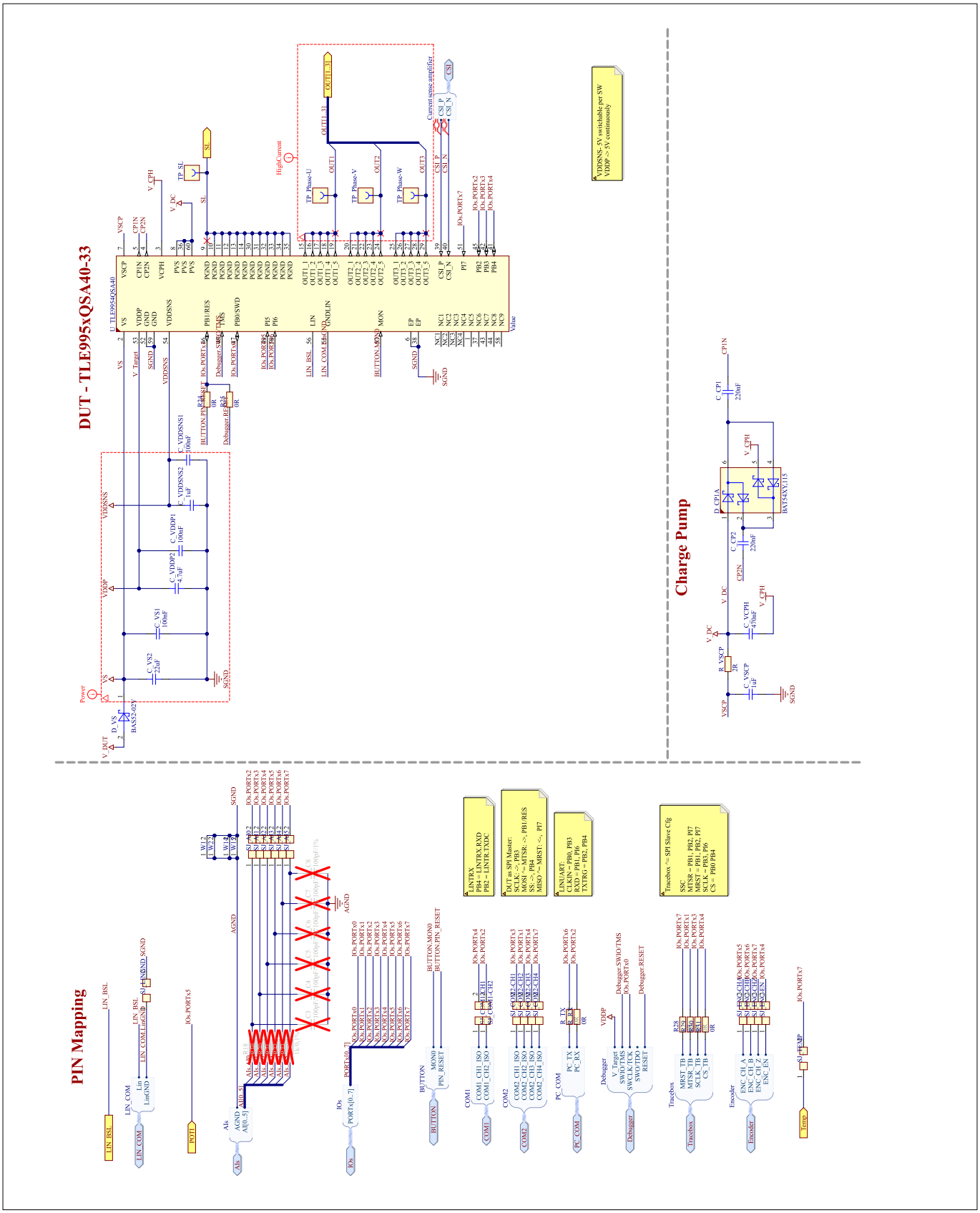

Figure 19 TLE9954QSA40 daughterboard, DUT schematic sheet

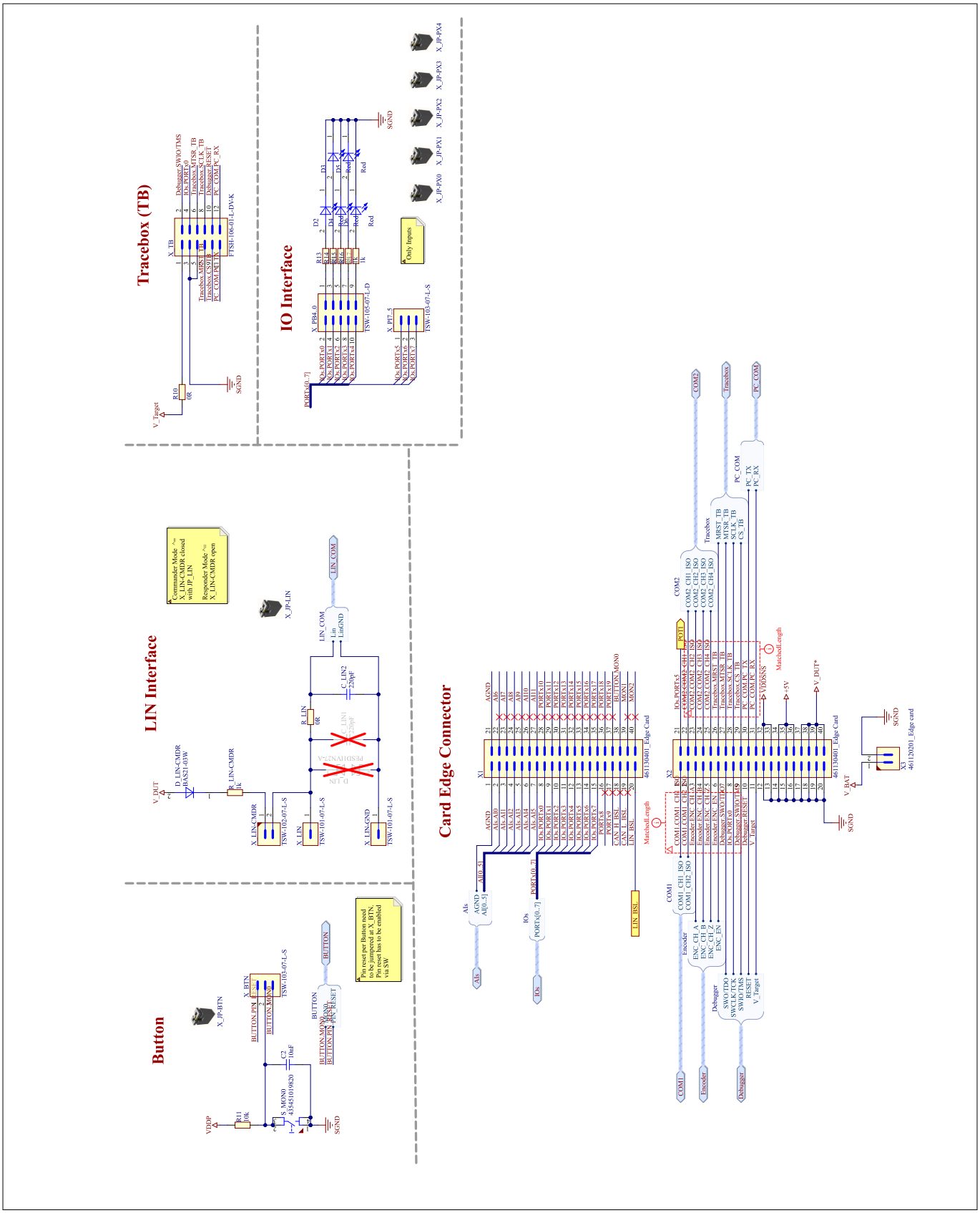

Figure 20 TLE9954QSA40 daughterboard, Interfaces schematic sheet

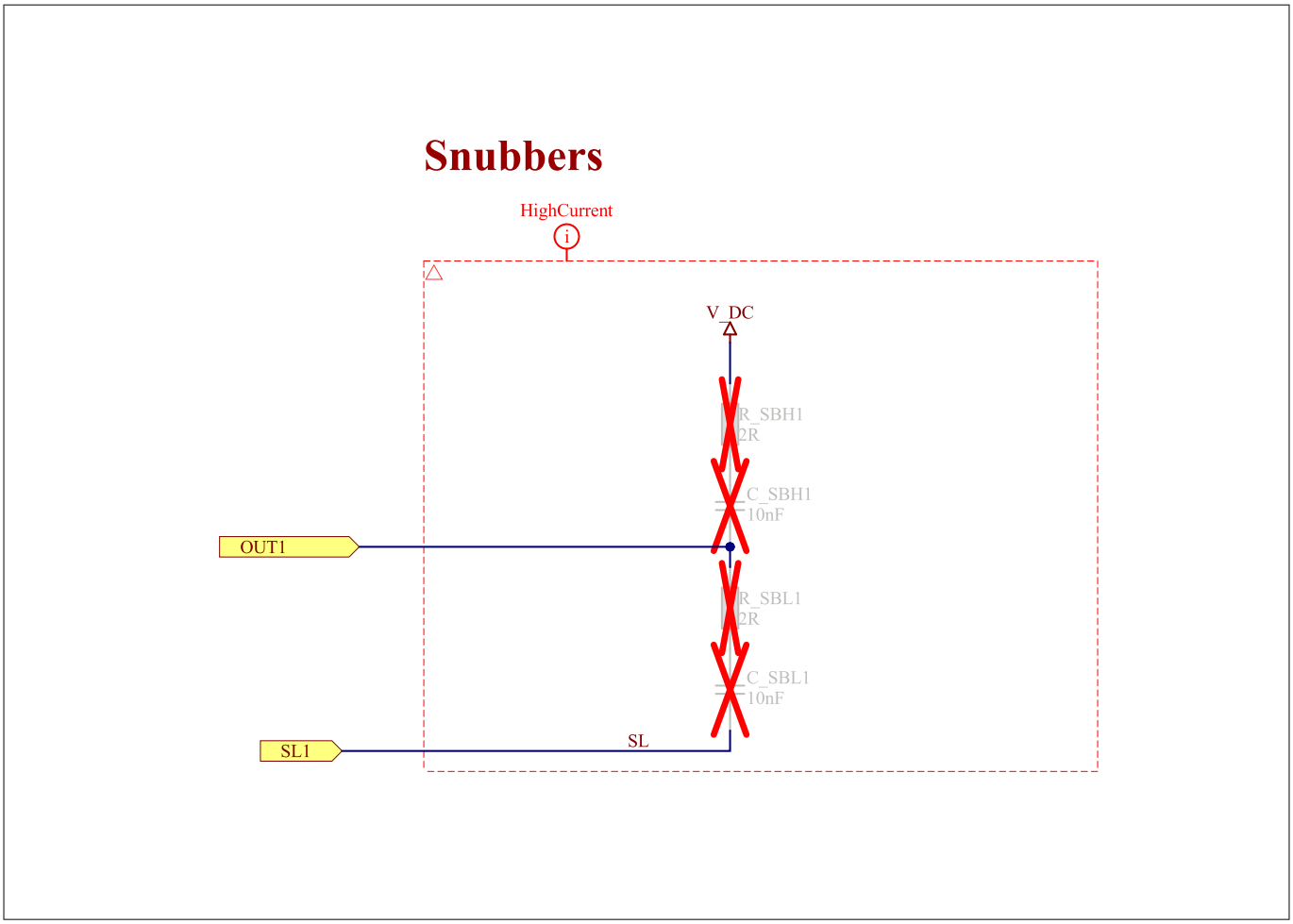

Figure 21 TLE9954QSA40 daughterboard, Power stage schematic sheet

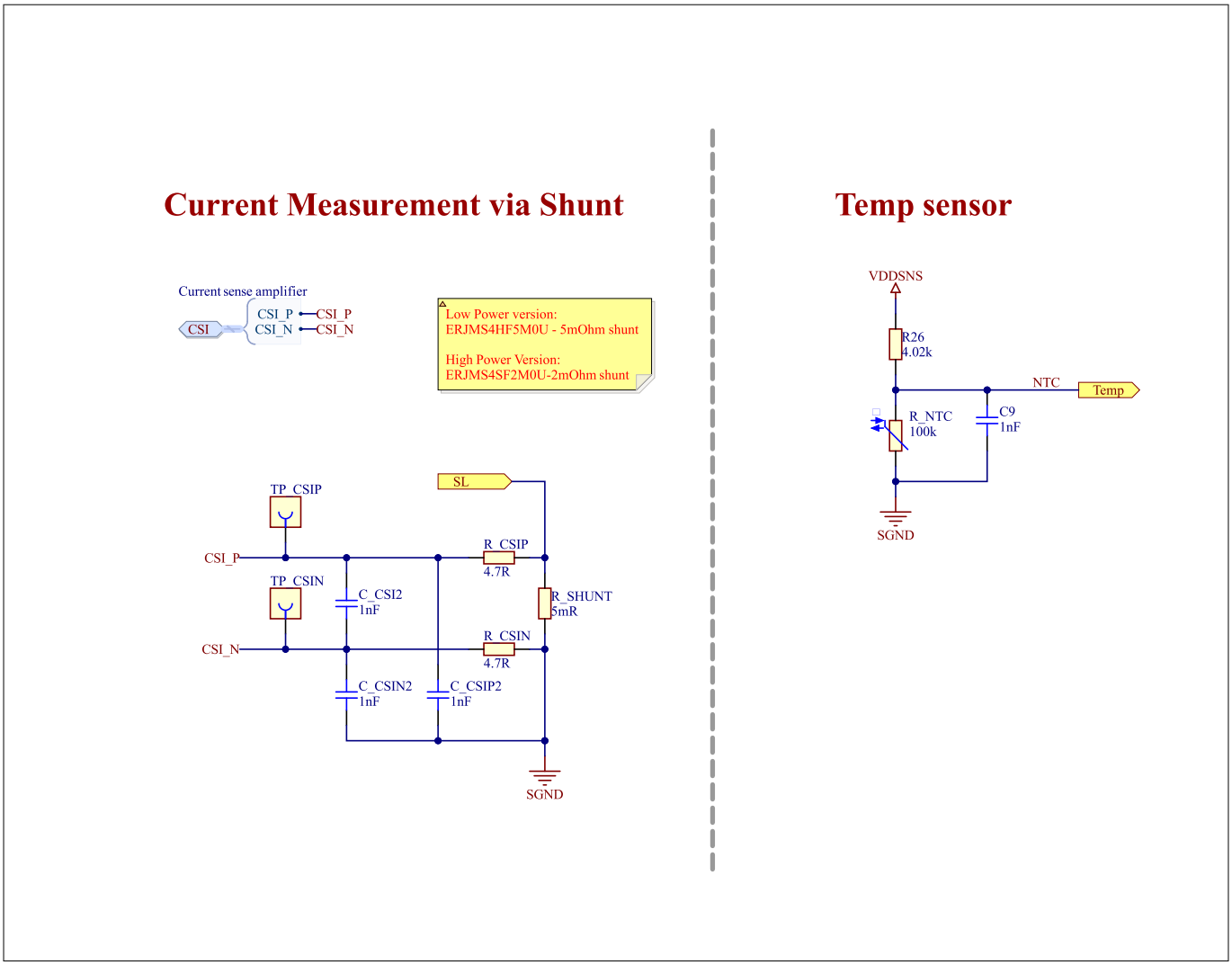

Figure 22 TLE9954QSA40 daughterboard, Measurements schematic sheet

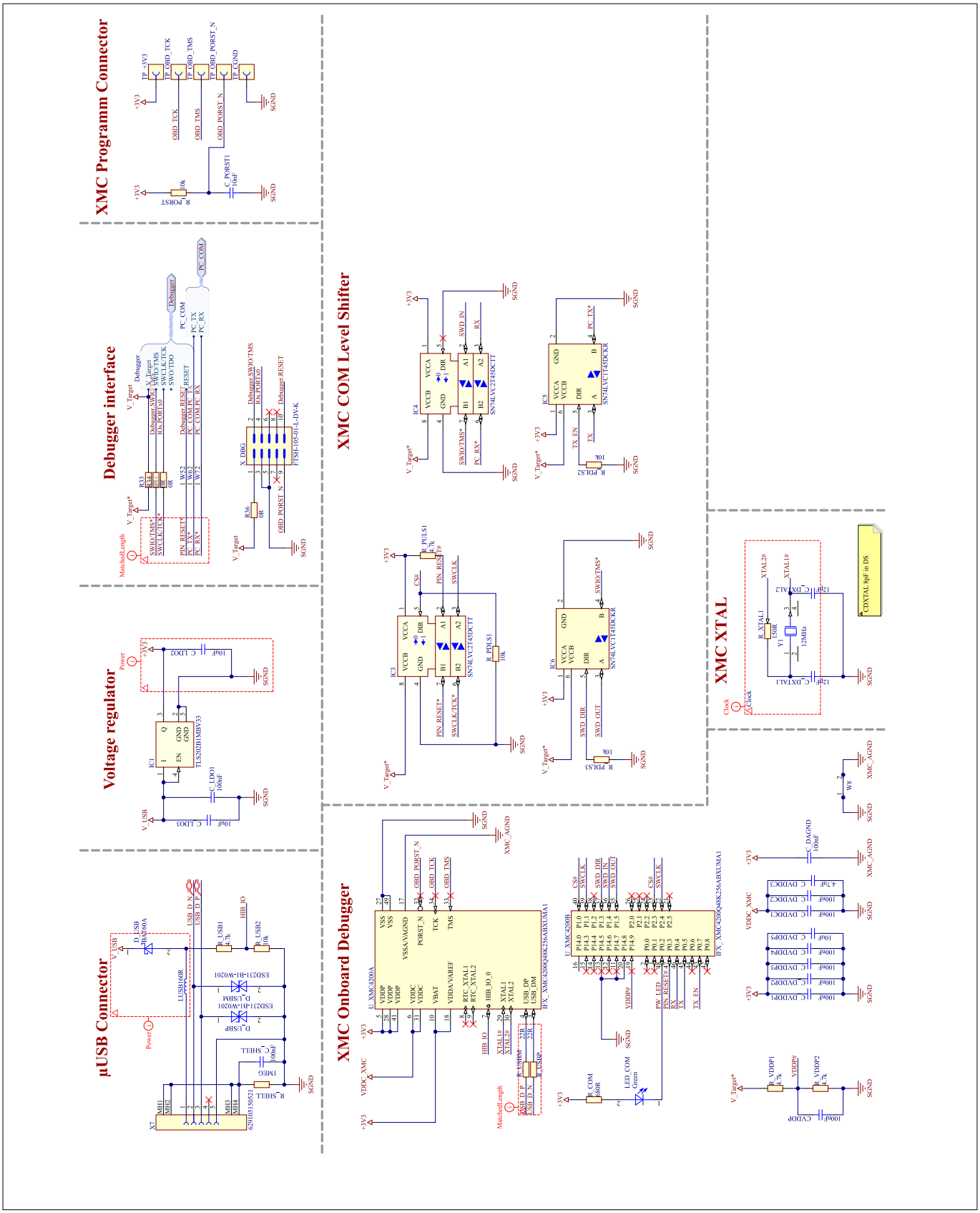

Figure 23 TLE9954QSA40 daughterboard, Onboard debugger schematic sheet

5.3 Layout of the TLE9954QSA40-33 daughterboard

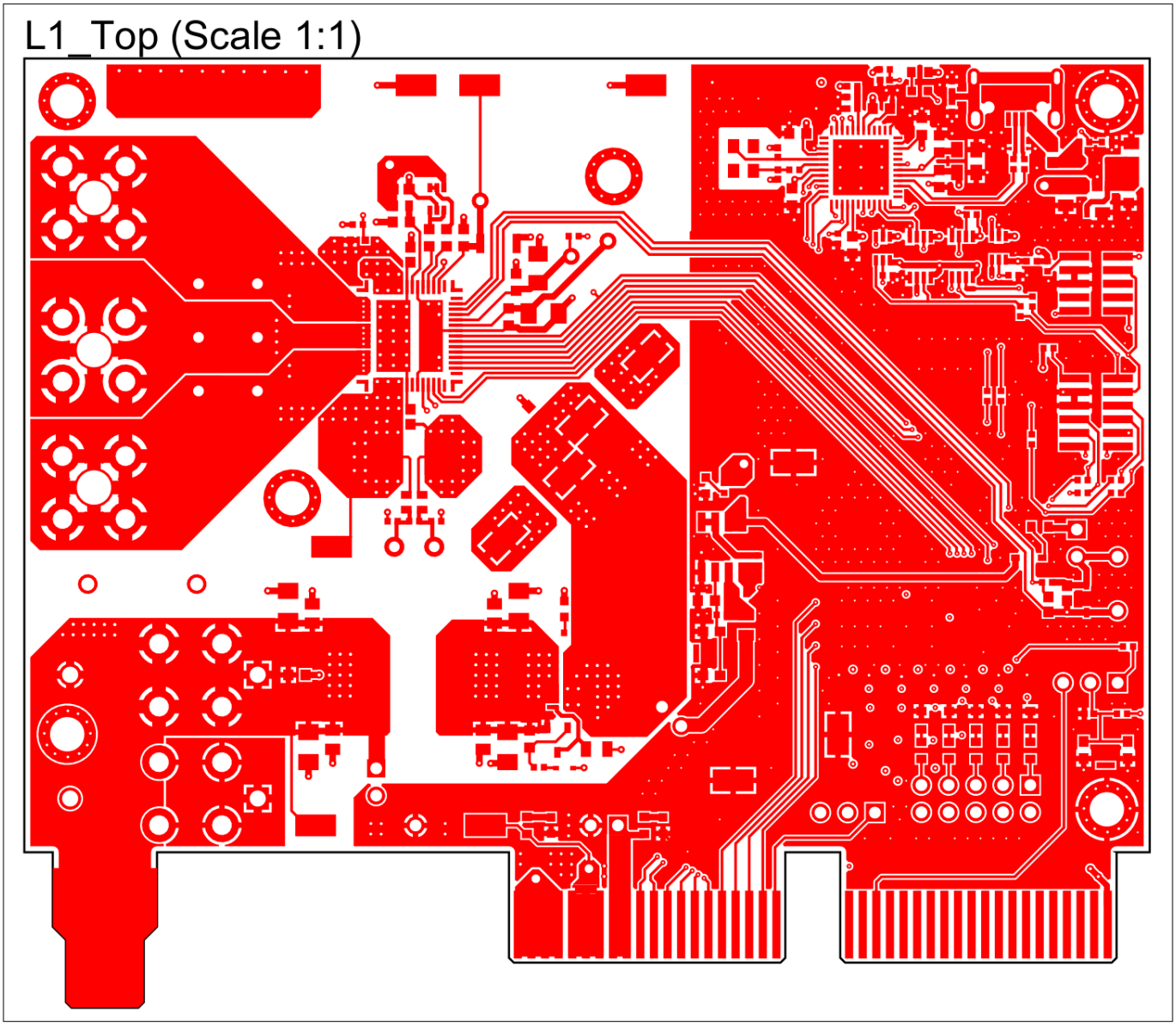

Figure 24 TLE9954QSA40-33 daughterboard, layer1 (top layer, signal)

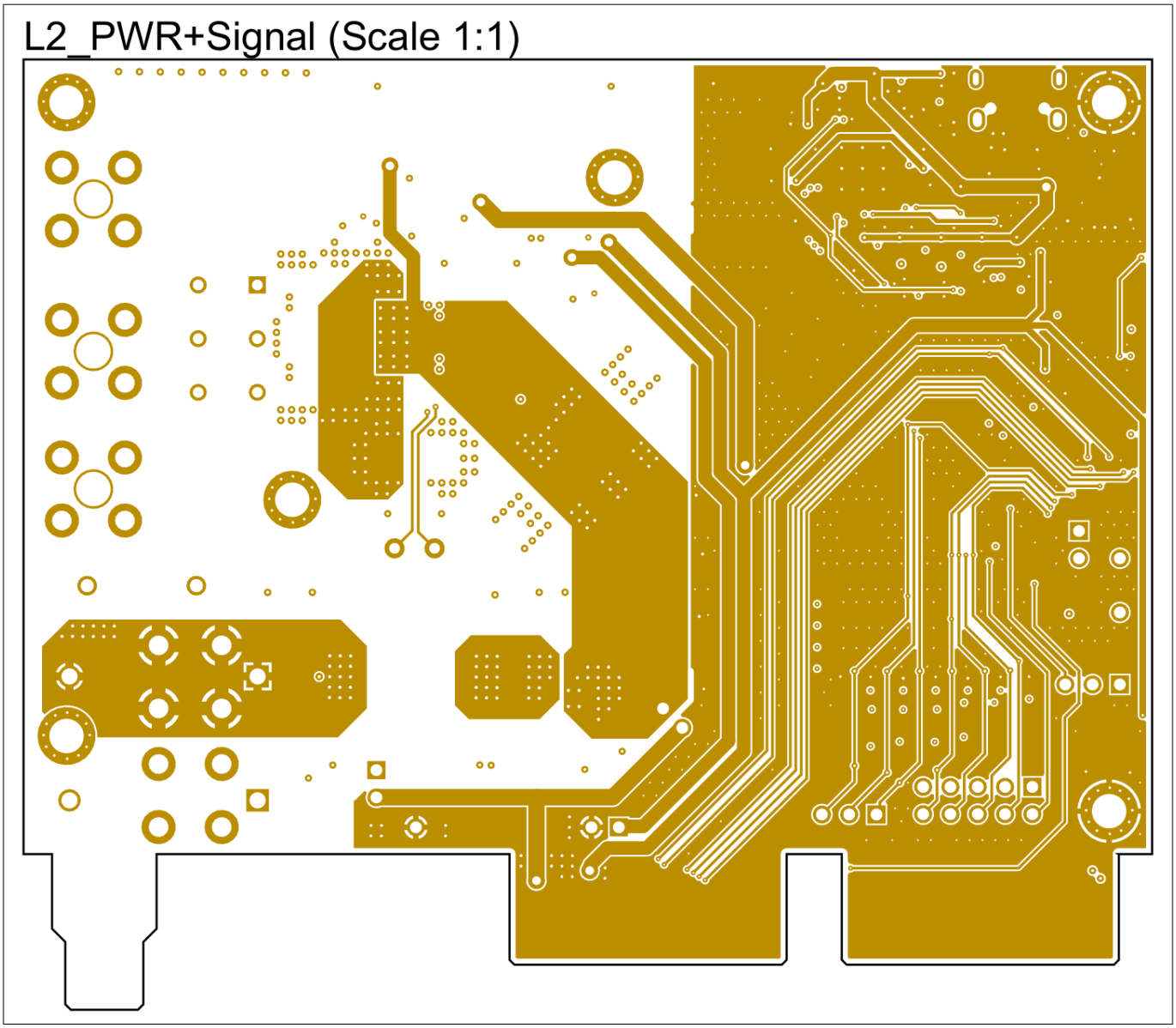

Figure 25 TLE9954QSA40-33 daughterboard, layer2 (middle layer, power)

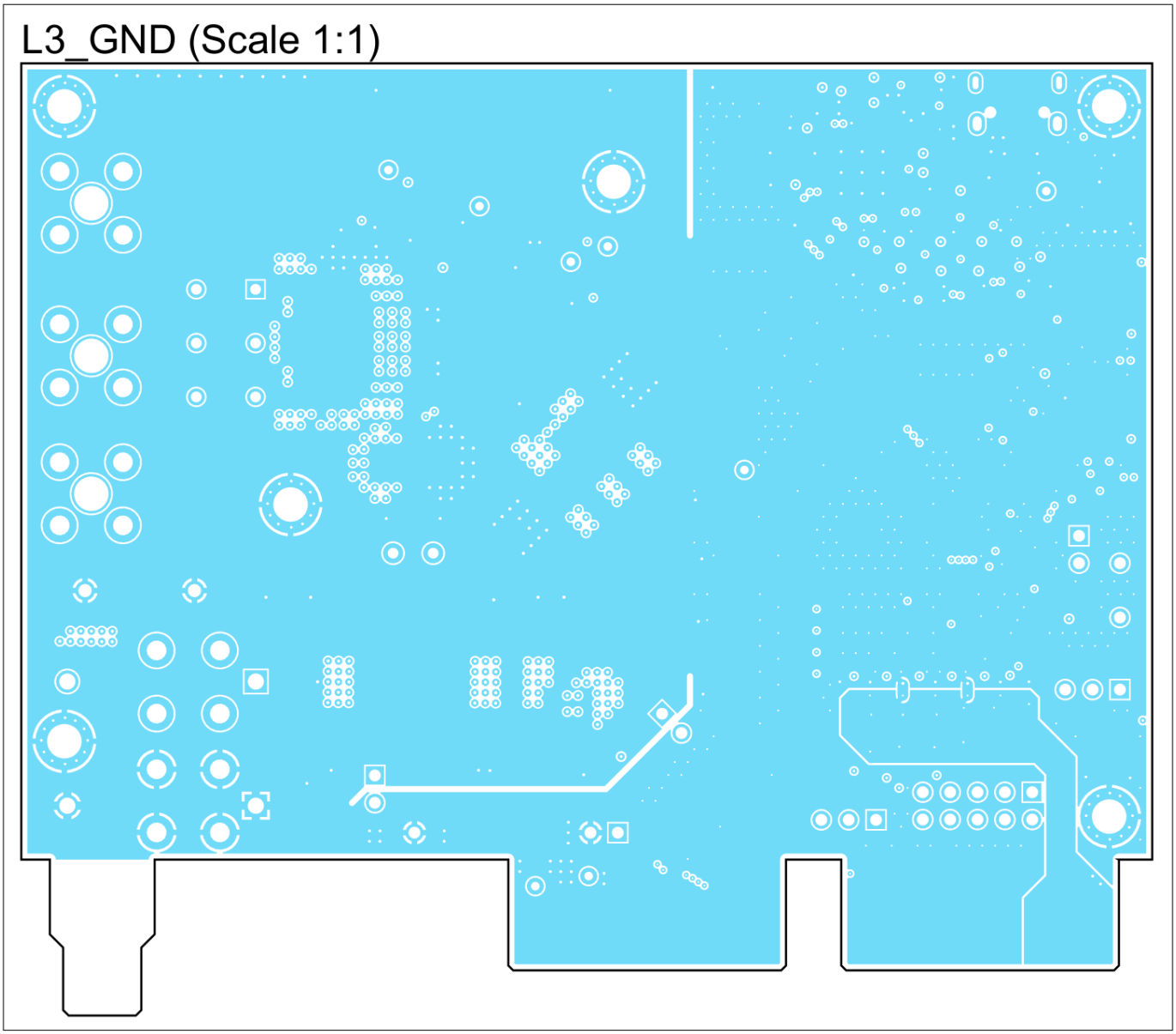

Figure 26 TLE9954QSA40-33 daughterboard, layer3 (middle layer, GND)

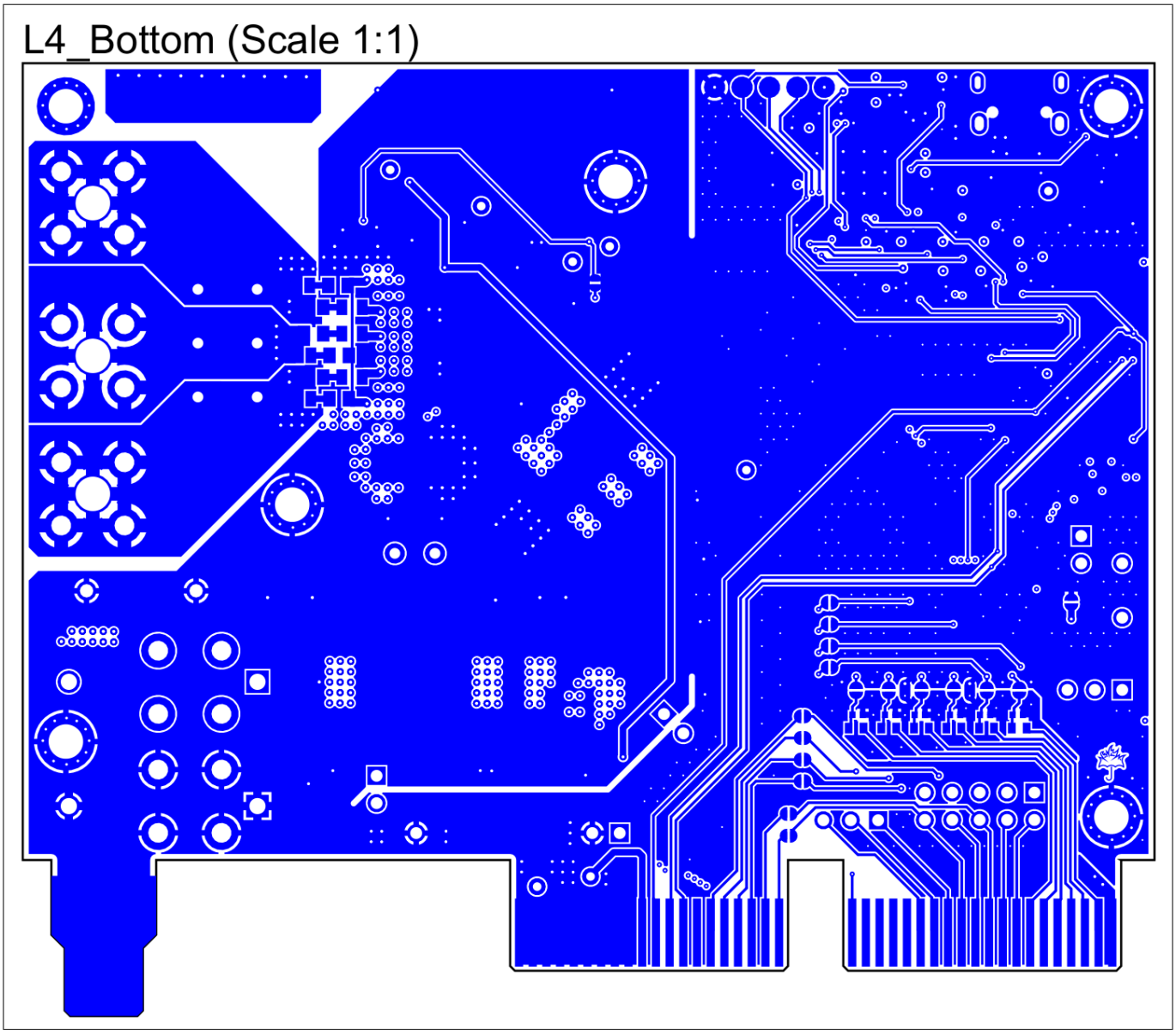

Figure 27 TLE9954QSA40-33 daughterboard, layer4 (bottom layer, signal)

6 References and appendices

6.1 Abbreviations and definitions

Table 11 Abbreviations

Abbreviation	Meaning
CSIN	Negative terminal current sense amplifier input
CSIP	Positive terminal current sense amplifier input
DUT	Device-under-test
MON	High voltage monitoring input
N.C.	Not connected
n/u	Not used
SL	Source low-side MOSFET
SWD	ARM® serial wire debug
TMS	Test mode select

For abbreviations regarding the naming and functionalities of the TLE9954QSA40-33, refer to the User manual of the device.

Glossary

BLDC

brushless direct current (BLDC)

BOM

bill of materials (BOM)

A list of the raw materials, sub-assemblies, intermediate assemblies, sub-components, parts, and the quantities of each that are needed to manufacture an end product.

GND

ground (GND)

GPIO

general purpose input output (GPIO)

I/O

input/output (I/O)

The communication between an information processing system and another information processing system.

LED

light-emitting diode (LED)

A semiconductor circuit that emits light when activated.

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.

SWD

serial wire debug (SWD)

A communication interface and protocol used for debugging and programming embedded systems, particularly microcontrollers and other integrated circuits.

Revision history

Document version	Date of release	Description of changes
Rev. 2.00	2026-02-10	• Entire document reworked for board rev0_3
Rev. 1.00	2025-12-05	• Initial public release

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Edition 2026-02-10

Published by

Infineon Technologies AG

81726 Munich, Germany

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Document reference
IFX-abe1737375427082

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