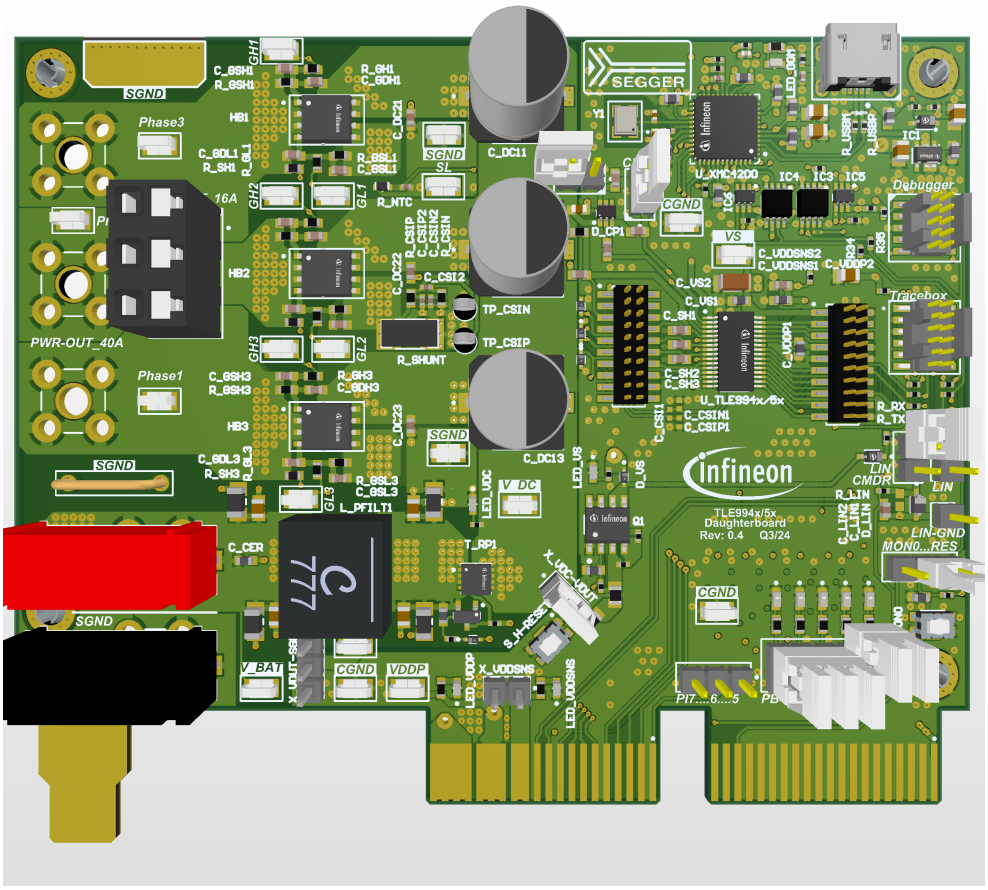
TLE994x_995x boards user guide

User guide

Hardware: TLE994x_995x_Daughterboard_rev0_4



About this document

Scope and purpose

This user guide is intended to help users operating the TLE994x_995x daughterboard. This board is designed to evaluate the hardware and software features of the MOTIX™ MCU TLE994x and TLE995x family.

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 TLE994x_995x daughterboard.

Evaluation board

This board will be used during design in, for the evaluation and testing of the MOTIX™ MCU TLE994x and TLE995x family features.

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

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Safety precautions

Attention**: **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 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 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 TLE994x/5x family. It can be operated by standard laboratory equipment and it is protected against reverse polarity of the input voltage supply. An LED indicates that the board is connected to the supply correctly.

The socket for the device provides the possibility to evaluate multiple devices without needing to re-solder them if a device gets damaged or a different variant needs to be tested.

Three Infineon MOSFET half-bridges are placed on the board to drive a motor. The board is ready to be connected to a car supply or similar device, and it offers an on-board debugger and *serial wire debug (SWD)* interface.

1.1 Delivery content

The TLE994x/5x daughterboard is delivered with the socket on the board. A TLE994x/5x device is not included in the delivery package.

1.2 Block diagram

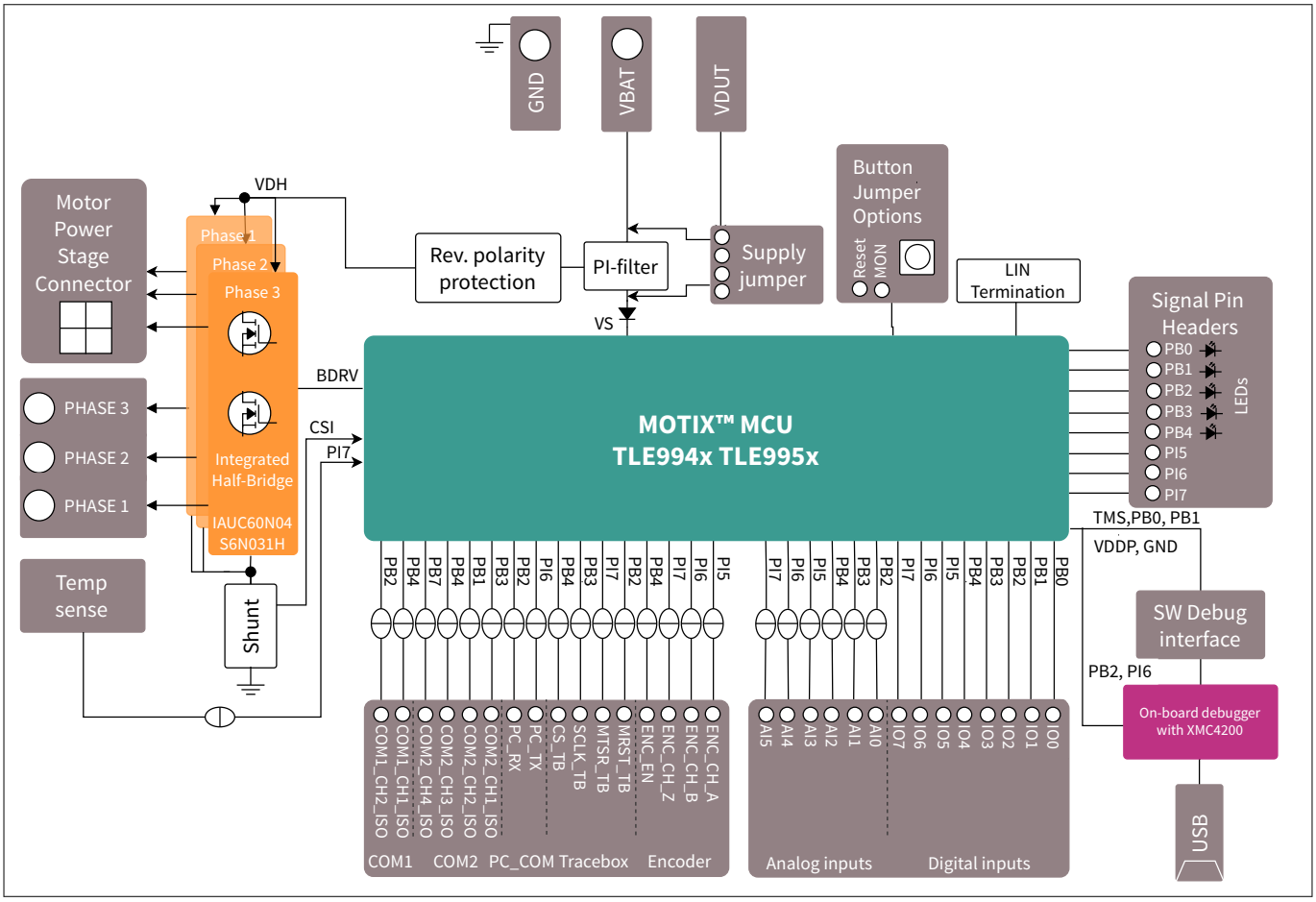

Figure 1 Block diagram

1 The board at a glance

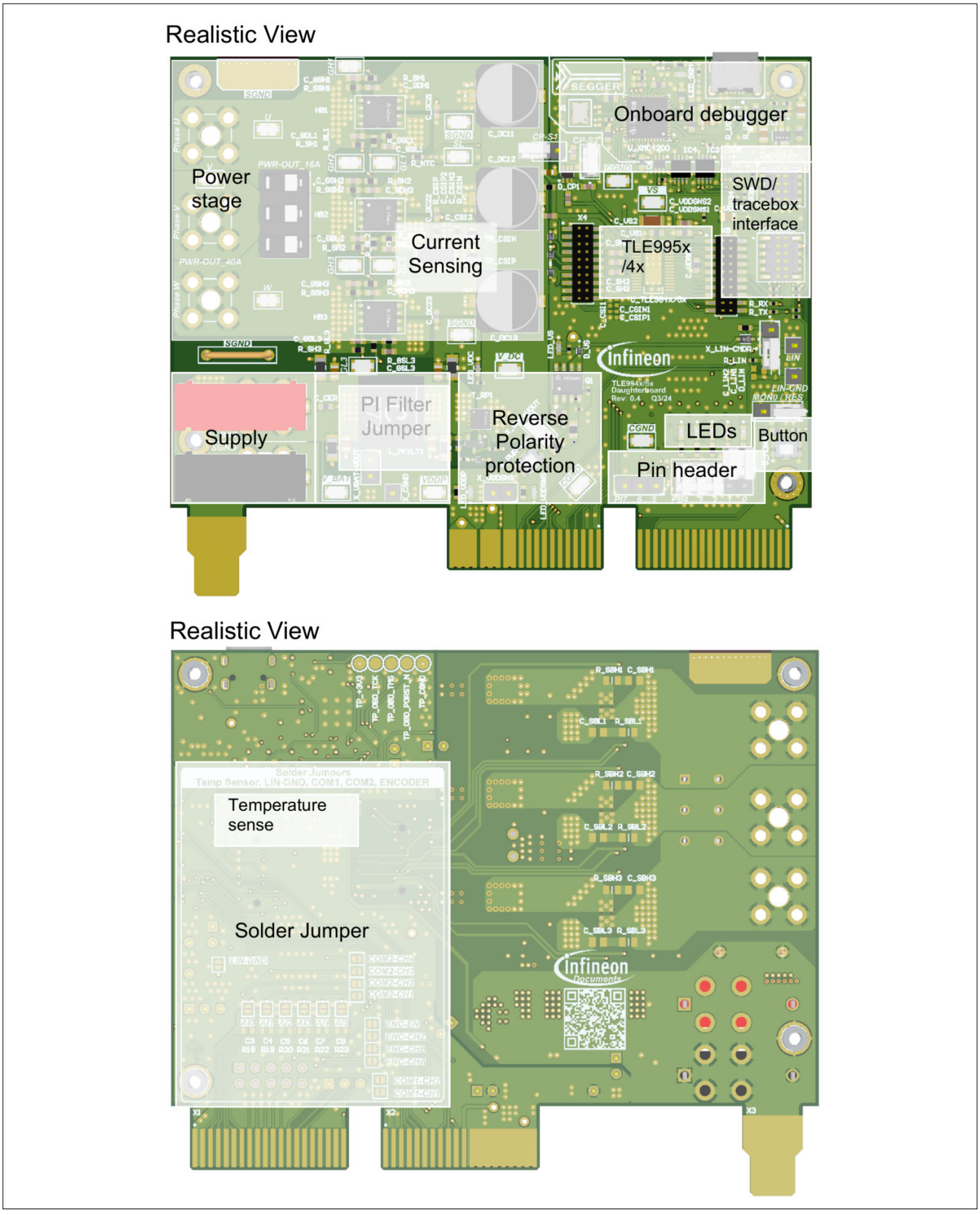

Figure 2 Functional blocks on the TLE994x_995x daughterboard

1.3 Main features

- Socket to easily replace the device as well as direct placement option
- Motor power stage including three Infineon MOSFET half-bridges
- On-board connectors for BLDC motors
- Shunt resistor for measuring current
- PI-filter and reverse polarity protection for the supply
- LIN connection with option for LIN master termination
- Single configurable push button for *MON* and *RESET* pins
- LEDs for supply voltage, DC-link voltage, +5V supply and for GPIOs
- On-board debugger to enable plug and play
- Connectors for debugger and trace box connections
- On-board temperature sensor
- Solder jumpers for configuration

1.4 Technical data

Technical data is specified in Table 2. The current capability is limited by the banana jacks and the 7 W shunt resistor. For details on battery and motor connectors, refer to Table 3 and Motor power stage. 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) 4)]
Pin ports P0.x, P1.x, P2.x	5 V [2)]

1) Specified by design
2) Limited by the functional range of the TLE994x/5x. Refer to the device datasheet for further information
3) Further limited by the thermal dissipation capabilities of the board, MOSFETs and shunt
4) Limited by the nominal current of XMOT1. If XMOT2 is used instead for connecting the motor, the maximum supply current will be 40 A

2 System and functional description

2.1 Board information

2.1.1 Connectors

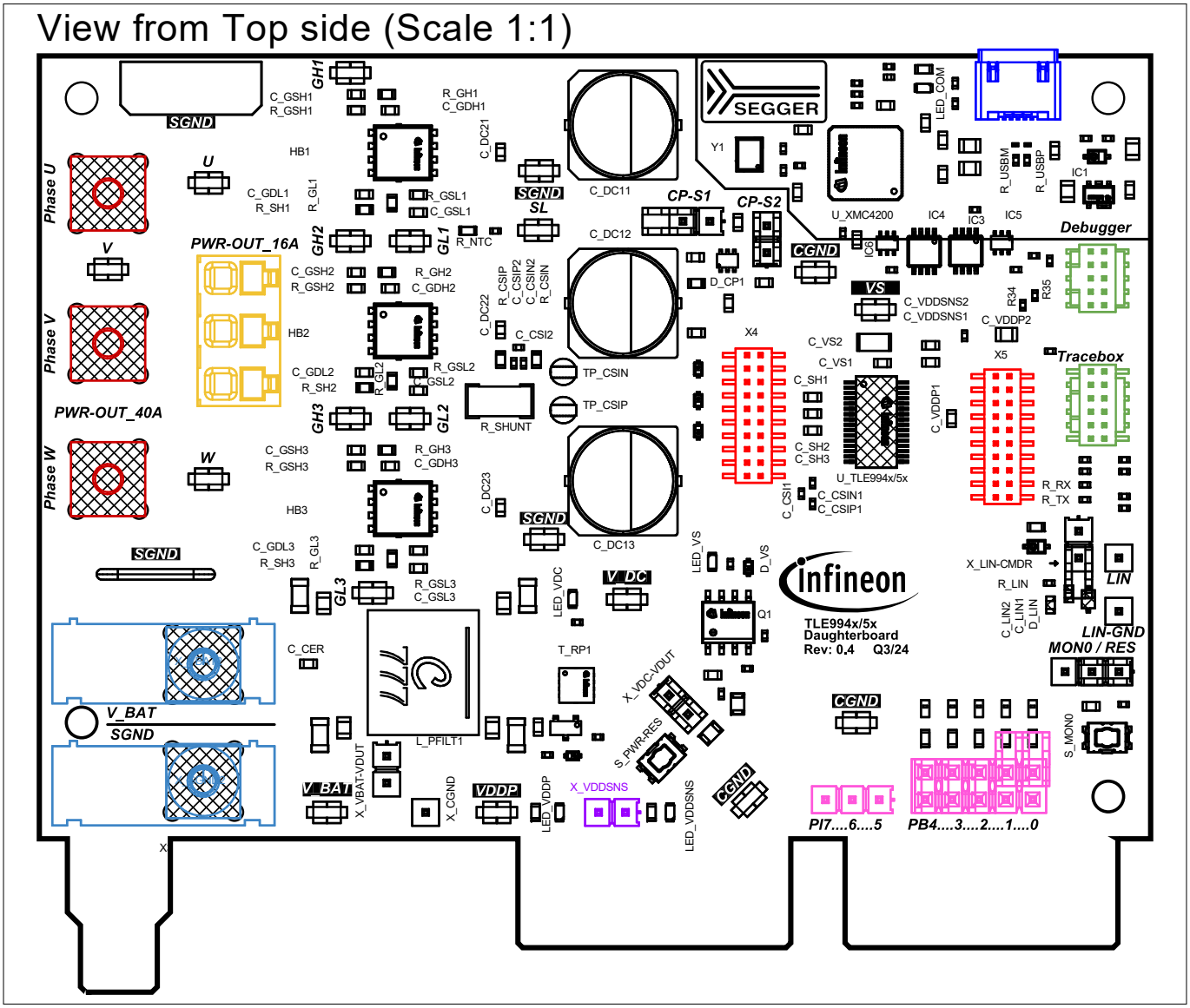

Figure 3 Connectors

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

(table continues...)

Table 3 (continued) Connectors

Functionality	Description
PWR-OUT_40A	Power terminal for motor connections Phase W, Phase V and Phase U. These terminals are provided to connect high-power motors due to their high current capability (up to 40 A). The phases of the motor should be connected either to this connector or to the one listed below. For more information refer to Motor power stage
PWR-OUT_16A	Power terminal for motor connections Phase W (bottom), Phase V (middle) and Phase U (top). The phases of the motor should be connected either to this connector or to the one listed above. For more information refer to Motor power stage
X4, X5	Connectors for the socket board connection
X_VDDSNS	Connector used to measure the VDDSNS and *ground (GND)*
IO 0…7	*input/output (I/O)* connector for PB0 to PB4 along with LEDs and PI5 to PI7
Debugger	Debugging interface to connect the external debugger
TraceBox	12-pin connector for the TraceBox connection (should be enabled by solder jumpers, refer to Solder jumpers)
USB	USB connector for micro-USB cable to connect the on-board debugger to a PC for the debugging and virtual COM port

***Note**: The USB connector cannot be used for the Virtual COM port due to swapped pins. An FTDI cable should be used if universal asynchronous receiver transmitter (UART) communication to the PC is needed.*

2.1.2 Test points

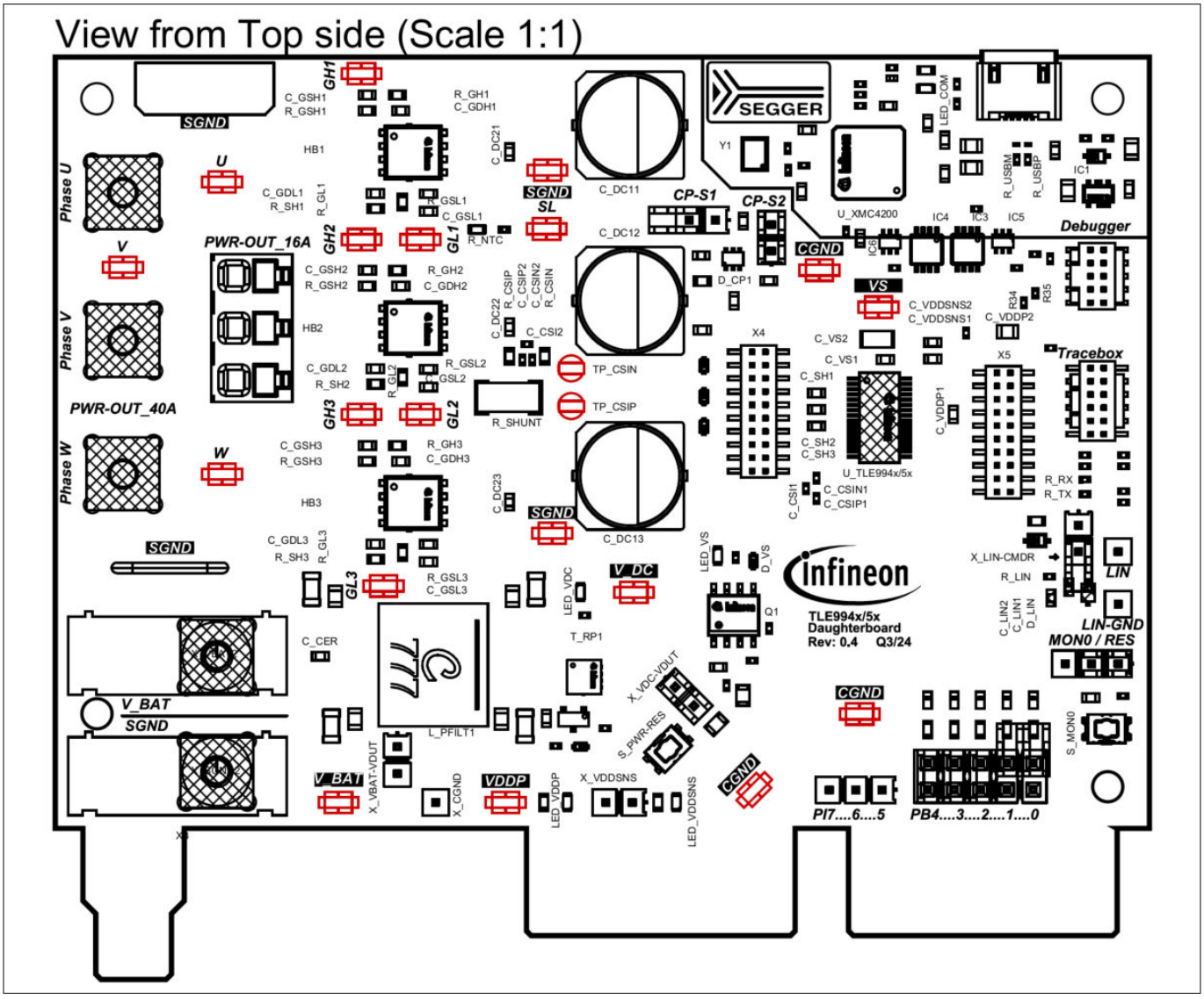

Figure 4 Test points

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
VDDSNS	Test point to measure the device VDDSNS voltage
CGND	Test points to connect to digital *GND*
SGND	Test points to connect to power GND
U, V, W	Test points to measure the motor phase voltages

(table continues...)

Table 4 (continued) Test points

Signal	Description
GH1, GH2, GH3	Test points to measure the gate voltage GHSx at the device pin generated for the high side MOSFETs
GL1, GL2, GL3	Test points to measure the gate voltage GLSx at the device pin generated for the low side MOSFETs
SL	Test point to measure the device *SL* pin voltage
TP_CSIP, TP_CSIN	Test points to measure differential voltage at the device's current sense amplifier inputs

2.1.3 LEDs

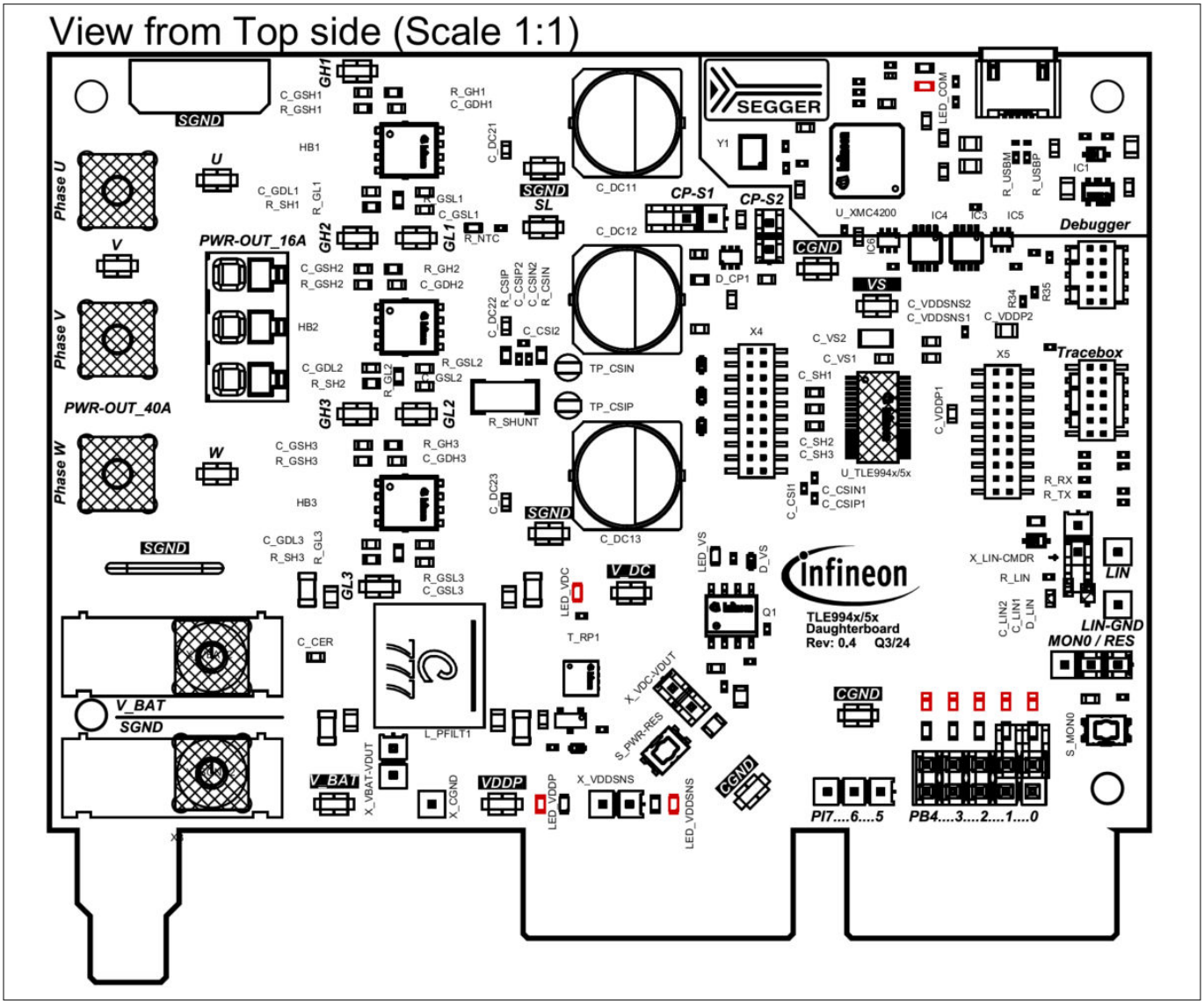

Figure 5 LEDs

Table 5 LEDs

Designator	Description
LED_VDC	Indicates that there is a positive voltage at DC-link (V_DC)
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 *general purpose input output (GPIO)* PB0 with jumper
D3	Can be connected to GPIO PB1 with jumper

(table continues...)

Table 5 (continued) LEDs

Designator	Description
D4	Can be connected to GPIO PB2 with jumper
D5	Can be connected to GPIO PB3 with jumper
D6	Can be connected to GPIO PB4 with jumper

2.1.4 Jumpers

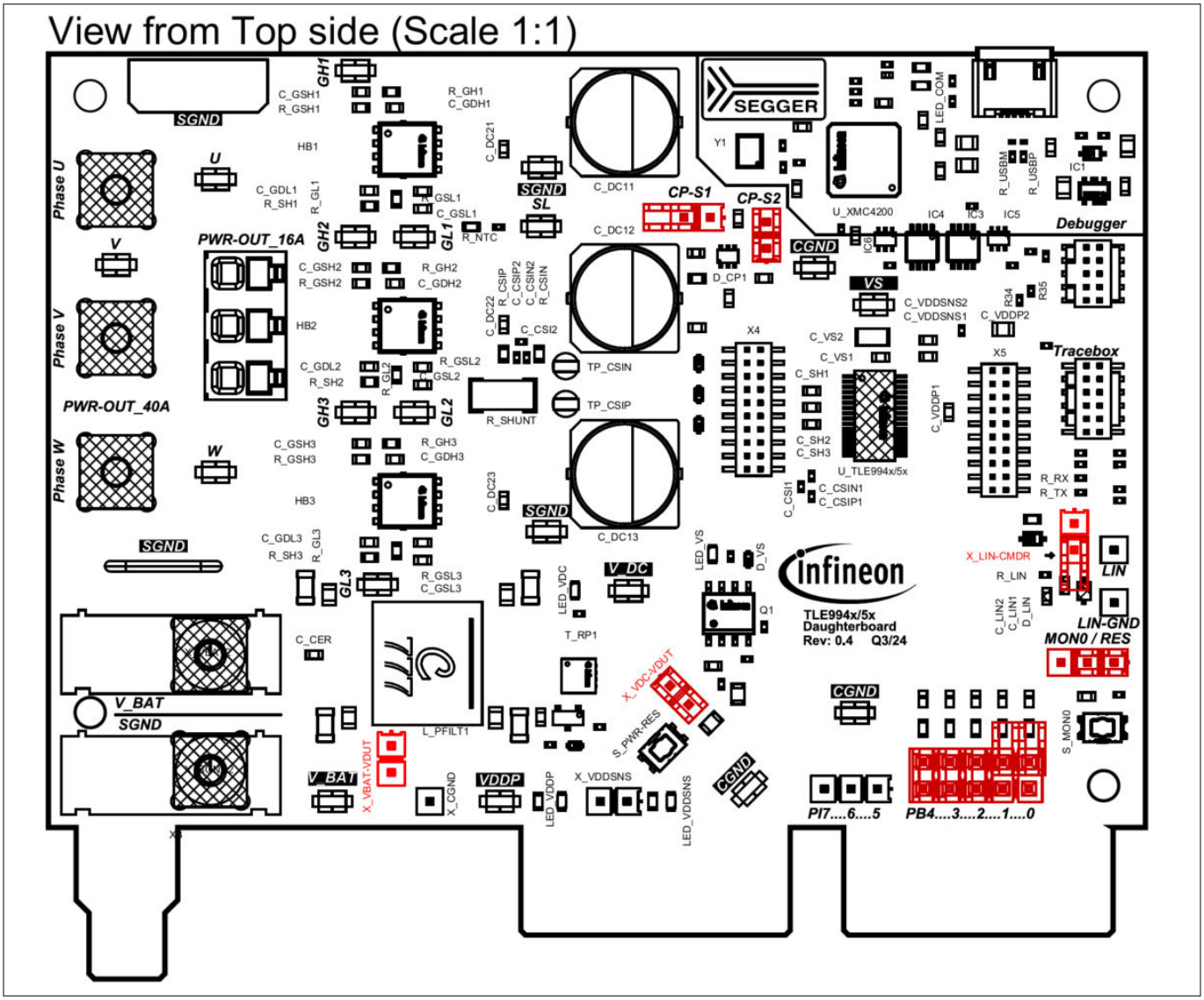

Figure 6 Jumpers

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 add external 1 kΩ pull-up resistor for LIN commander if needed. Remove the jumper 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 to use the button for Reset (right two pins)

(table continues...)

Table 6 (continued) Jumpers

Designator	Description
CP-S1	Set jumper to have 2 flying capacitors at charge pump. Remove if using 3 flying capacitors
CP-S2	Set jumper to have 3 flying capacitors at charge pump. Remove if using 2 flying capacitors

***Note**: Either CP-S1 or CP-S2 should be set, but not both.*

2.1.5 Push buttons

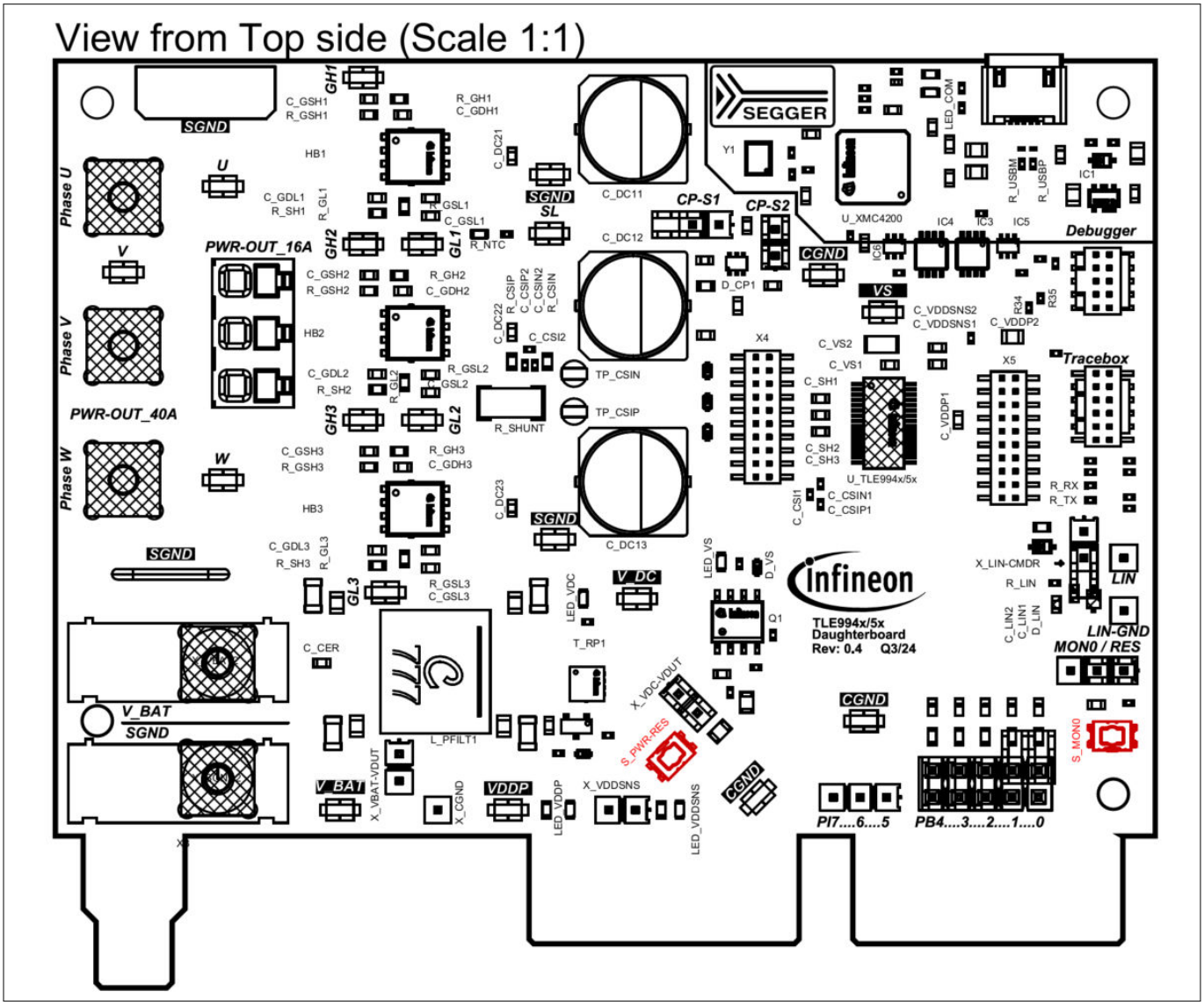

Figure 7 Push buttons

Table 7 Push buttons

Designator	Description
S_MON0	S_MON0 is a normally-opened push button that can be used for both MON input and Reset, depending on the jumper setting. For more information refer to 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 that can be used to make a connection by soldering two pads. They are provided to offer additional configuration options for the user.

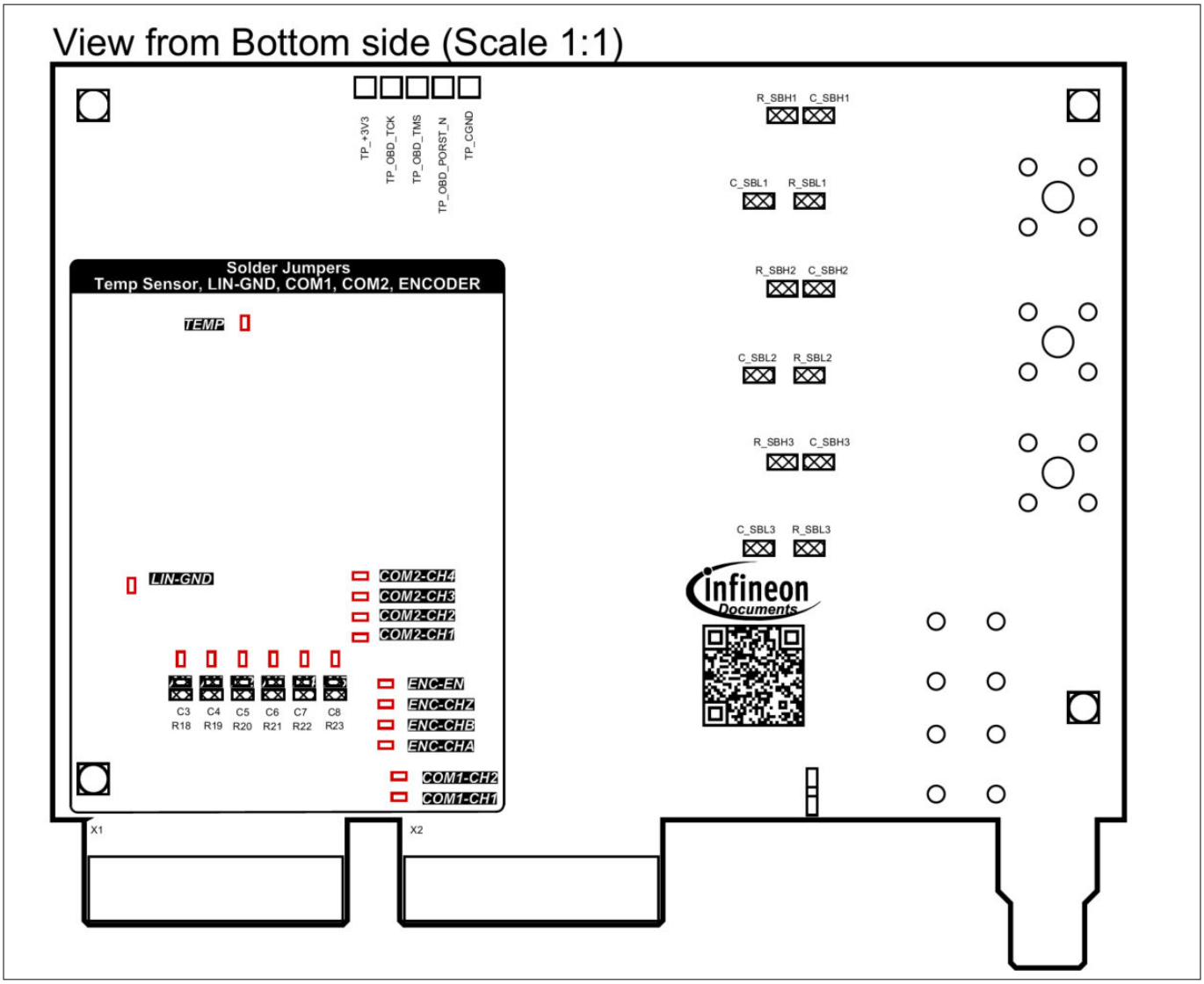

Figure 8 Solder jumpers

Table 8 Solder jumpers

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

2.2 Interfaces

2.2.1 Motor power stage

Three MOSFET half-bridges are placed on the board to drive a motor. Every HBx integrates a half-bridge, consisting of two N-channel MOSFETs inside the package. The following components are placed and connected externally to each HBx: gate-source resistors (R_GSHx, R_GSLx), gate-source capacitors (C_GSHx, C_GSLx) and gate resistors (R_GHx, R_GLx). At V_DC for each motor phase, one decoupling capacitor (C_DC2_x), as well as a DC link buffer capacitor (C_DC1_x) are placed.

Additionally, there are placement options for snubbers (R_SBHx + C_SBHx, R_SBLx + C_SBLx), as well as for gate-drain capacitors (C_GDHx, C_GDLx).

With a differential probe, the user can measure the differential voltage at a gate resistor (R_GHx, R_GLx) in order to indirectly analyze the gate current (I_GHx, I_GLx) sourced or sunk by the device's bridge driver.

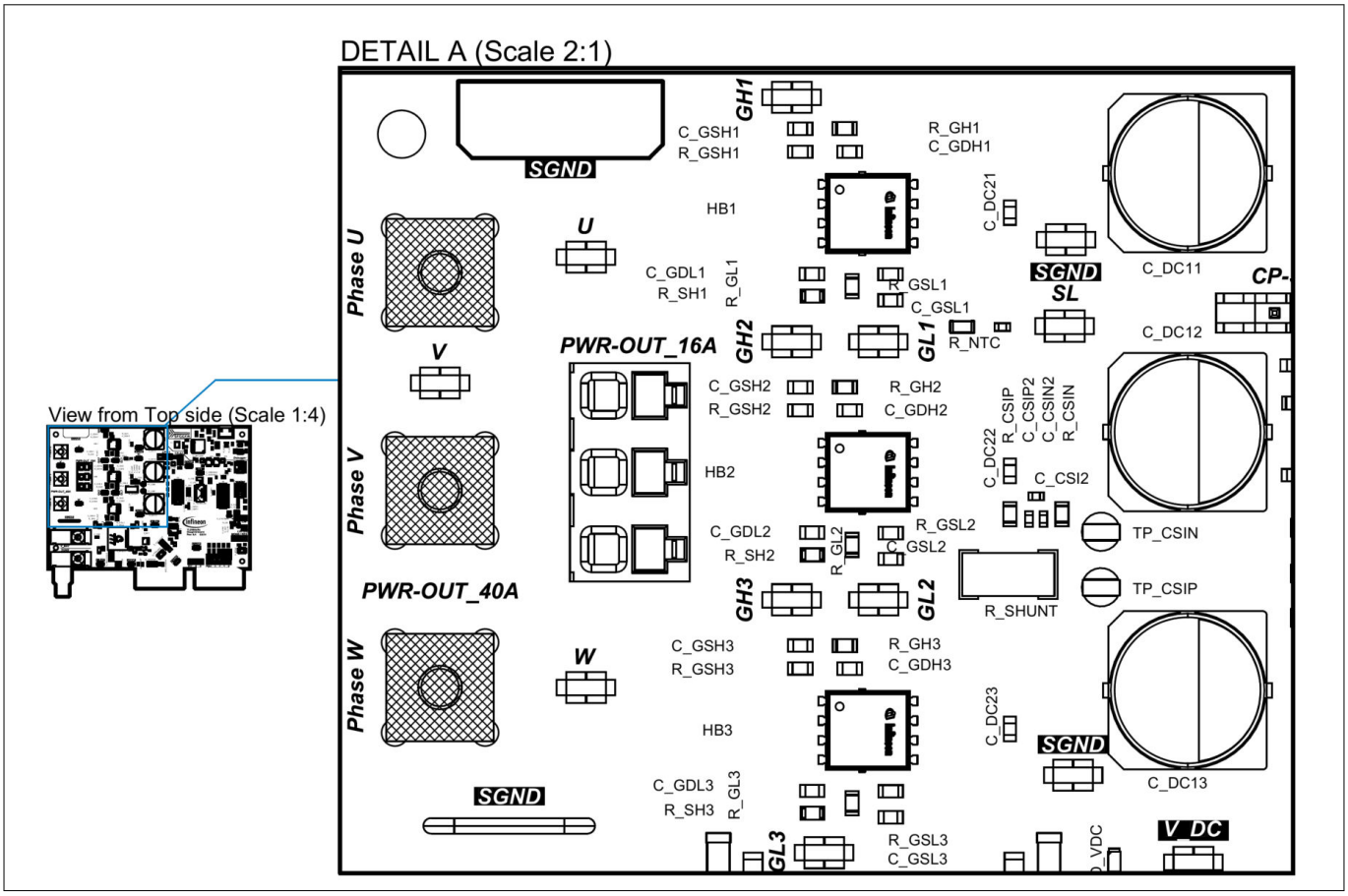

Figure 9 Motor power stage

To connect the motor phases, either the PWR-OUT_40A or PWR-OUT_16A terminals can be used, depending on the power class. The pinout of the PWR-OUT_16A connector is shown in Figure 10. It can be used for easy connection to and evaluation of the motor. A description and manufacturer number of the terminals used for the board can be found in TLE994x_995x daughterboard bill of materials.

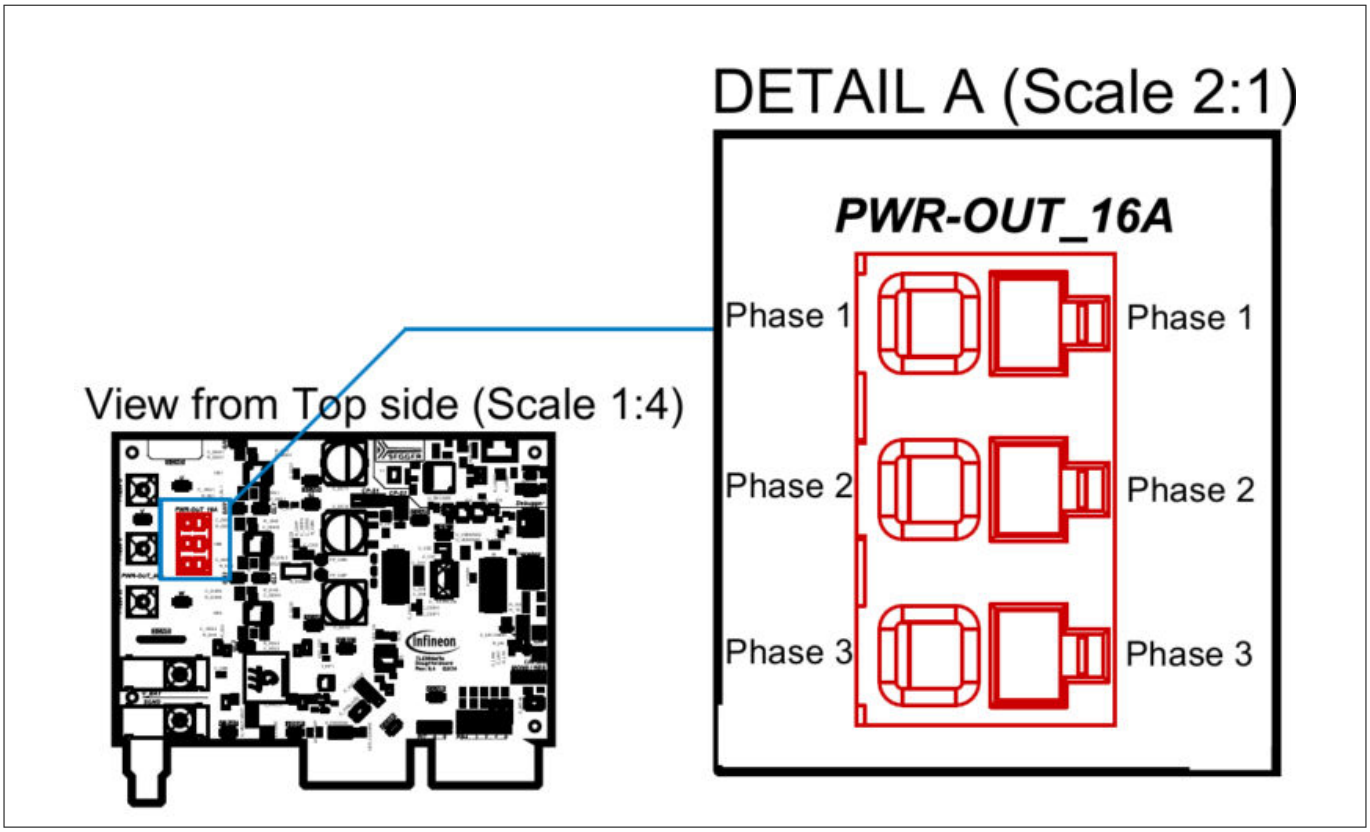

Figure 10 Pinout of PWR-OUT_16A

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 *GND*. It allows indirect measuring of the motor current consumption 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 that exceed the maximum ratings given in Technical data, the maximum current ratings of the shunt resistor being used must be considered.

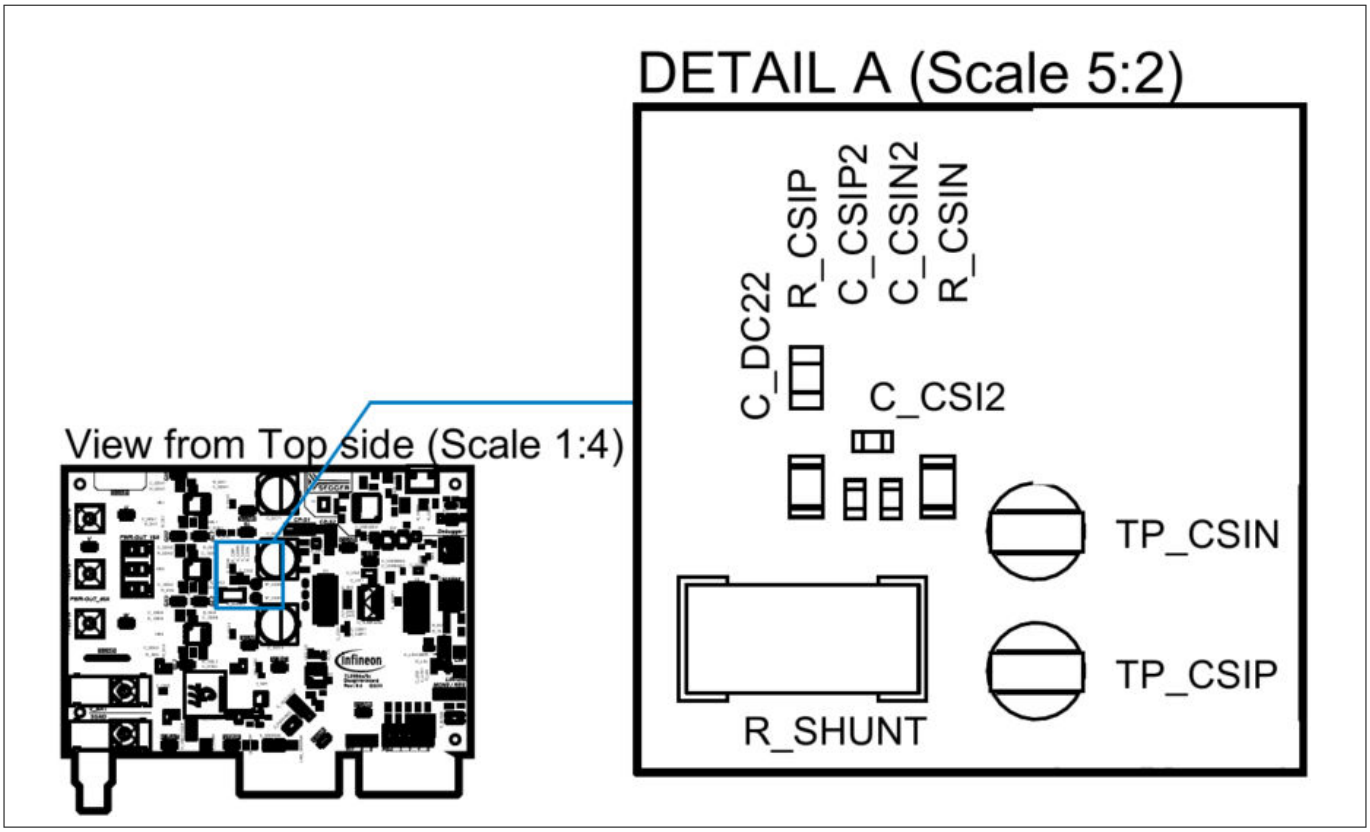

Figure 11 Motor current sensing

2.2.3 Pin headers

There are two pin headers on the board which allow access to the *GPIO*s of the device. Two headers are located at the bottom right of the board, where the *I/O* 0…4 are for PB0…PB4, which can also be connected to the LEDs. The I/O 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 Figure 12.

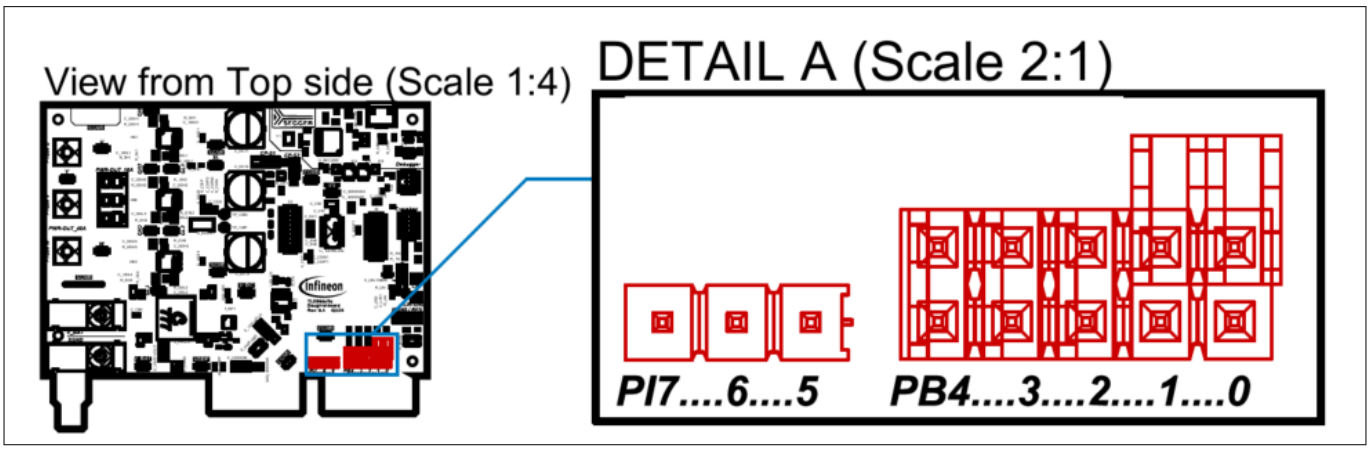

Figure 12 Pinout of pin headers

2.2.4 Debugging

On the board, a SEGGER J-Link debugger is available for debugging, which can be connected via a USB cable. Additionally, there are two connectors available for debugging and flashing the device. The “Debugger” connector is a standard 10-pin connector that can be used for external debuggers, such as the ARM® KEIL ULINK2 or an XMC™ Link. The “TraceBox” 12-pin connector is specifically intended to be used with the TraceBox, which is available from Moteon. The pinout of the connectors is depicted in Figure 13.

The external debuggers and the TraceBox are not delivered with the board.

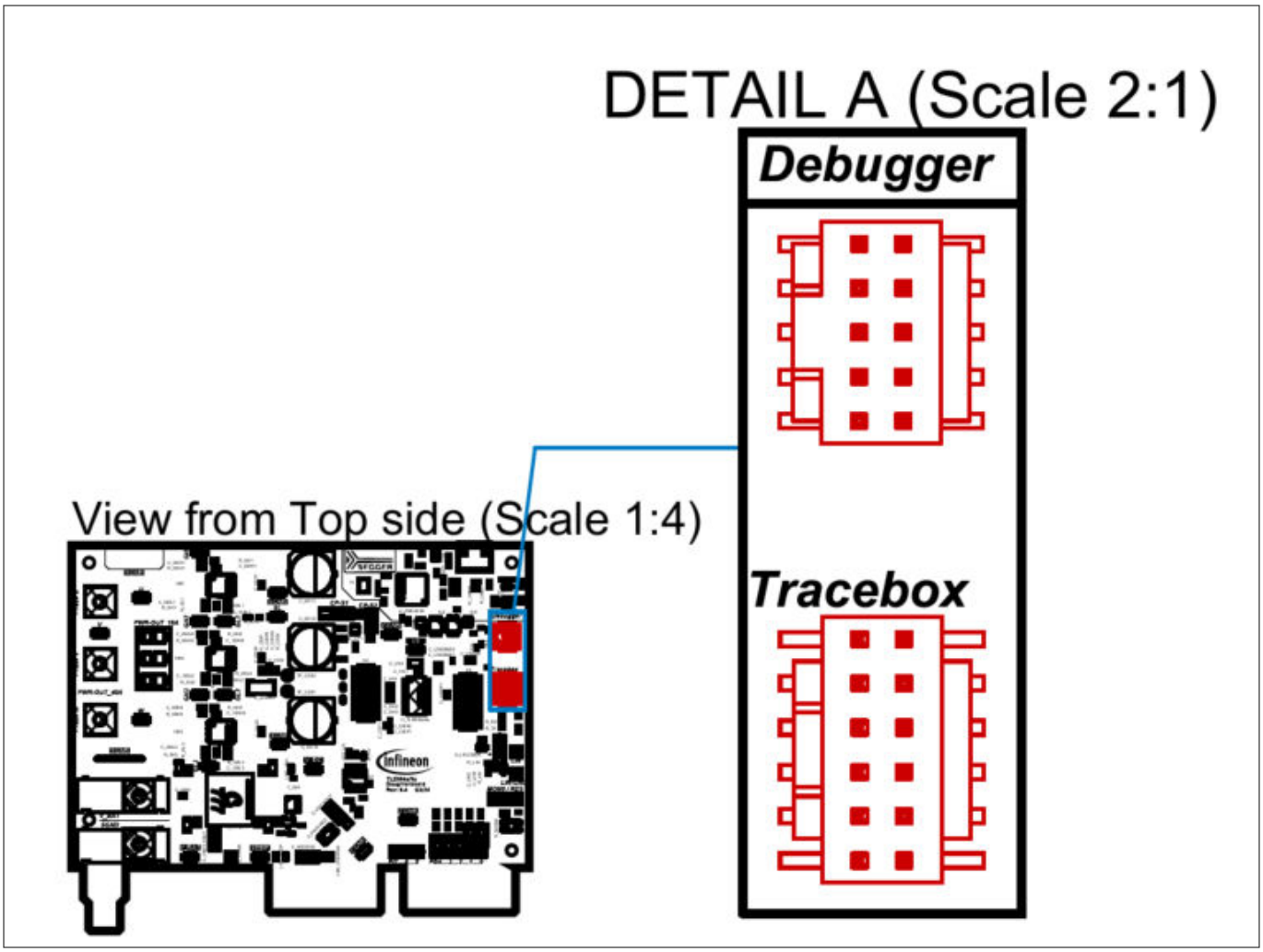

Figure 13 Debugger and TraceBox connectors

2.2.5 Card edge connector

On the board, there is also a card edge connector interface which can be used to interface the daughterboard to the motherboard. The motherboard offers several interfaces that can be used for additional debug features. The card edge connector interface can be seen 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.*

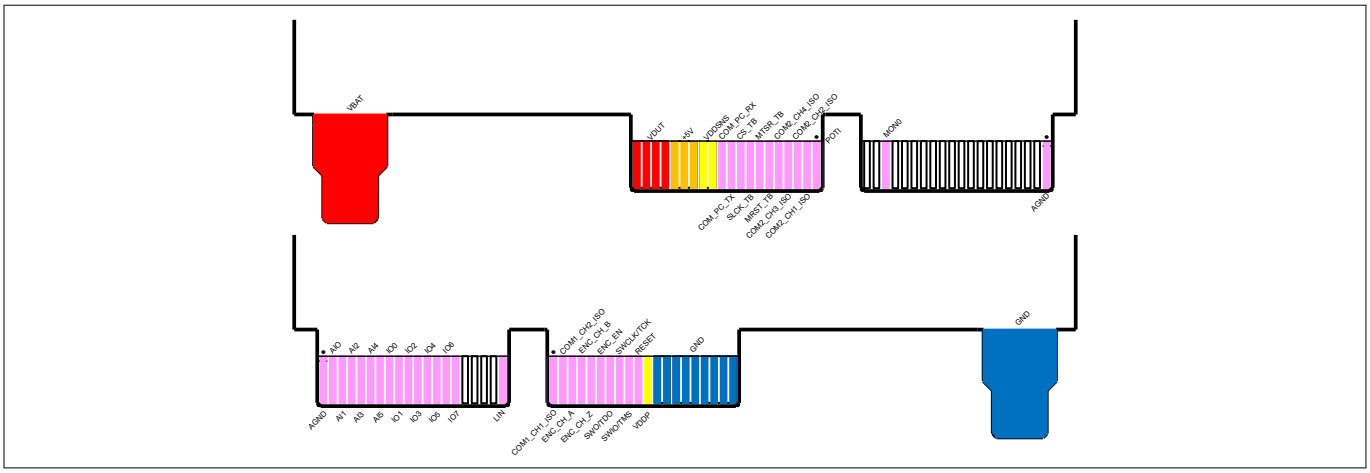

Figure 14 Card edge connector

2.2.6 Socket board

A socket board is available for the TLE994x_995x daughterboard with TSDSO-32 spring socket.

Devices of the same package can be exchanged with the plastic spring socket on the socket board. Measurements can be performed close to the device pins at the pin headers. VS and VDDP LEDs, test points, as well as an external debugger connector are placed on the board. The top and bottom view of the socket are shown below.

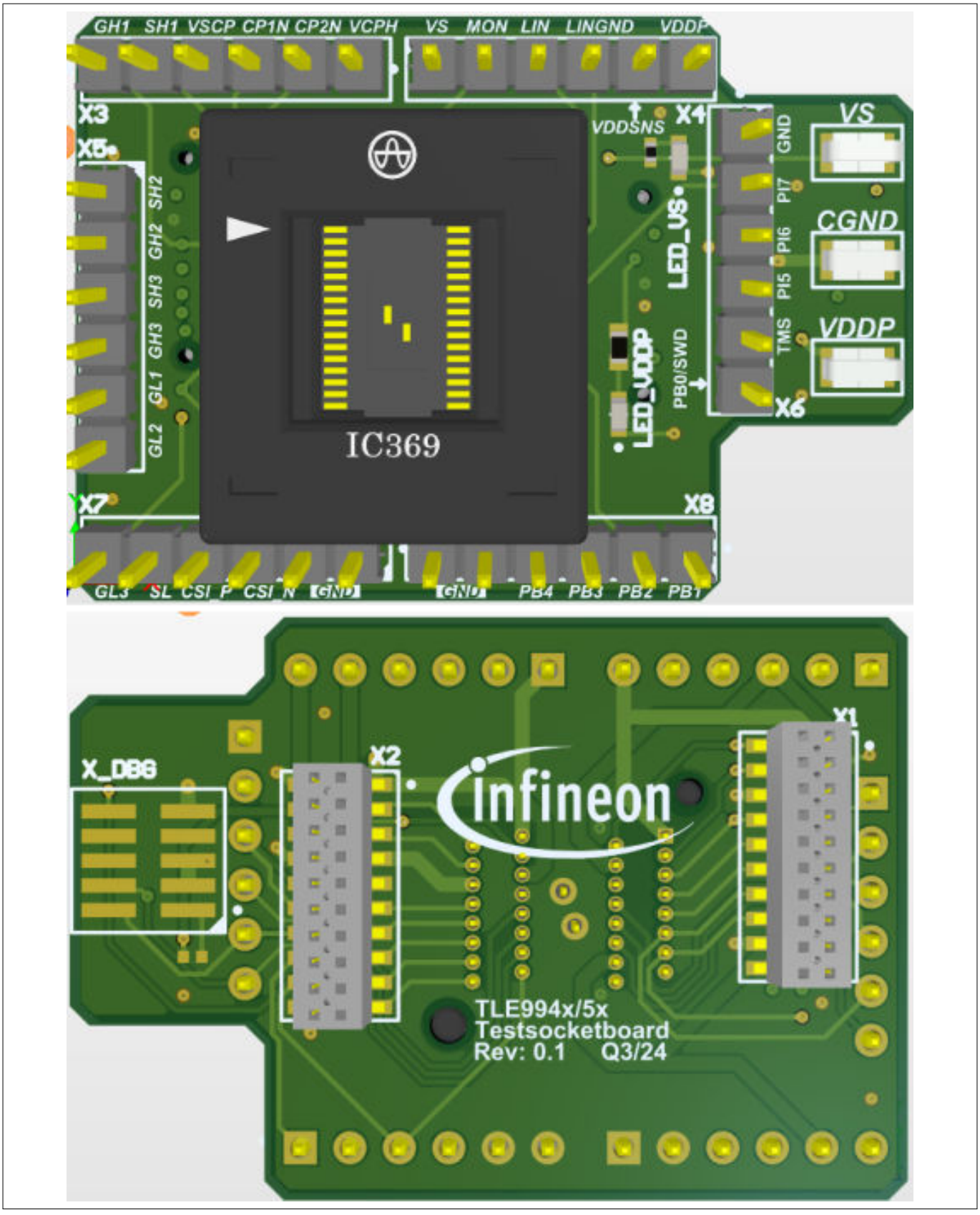

Figure 15 Socket board top and bottom view

3 Assembly options

On the board there are components that are not assembled by default, but which can be soldered by the user if necessary. These components are highlighted in red in Figure 16 and are listed in Table 9. The highlighted components which are not mentioned in Table 9 have different values in the high power assembly variant.

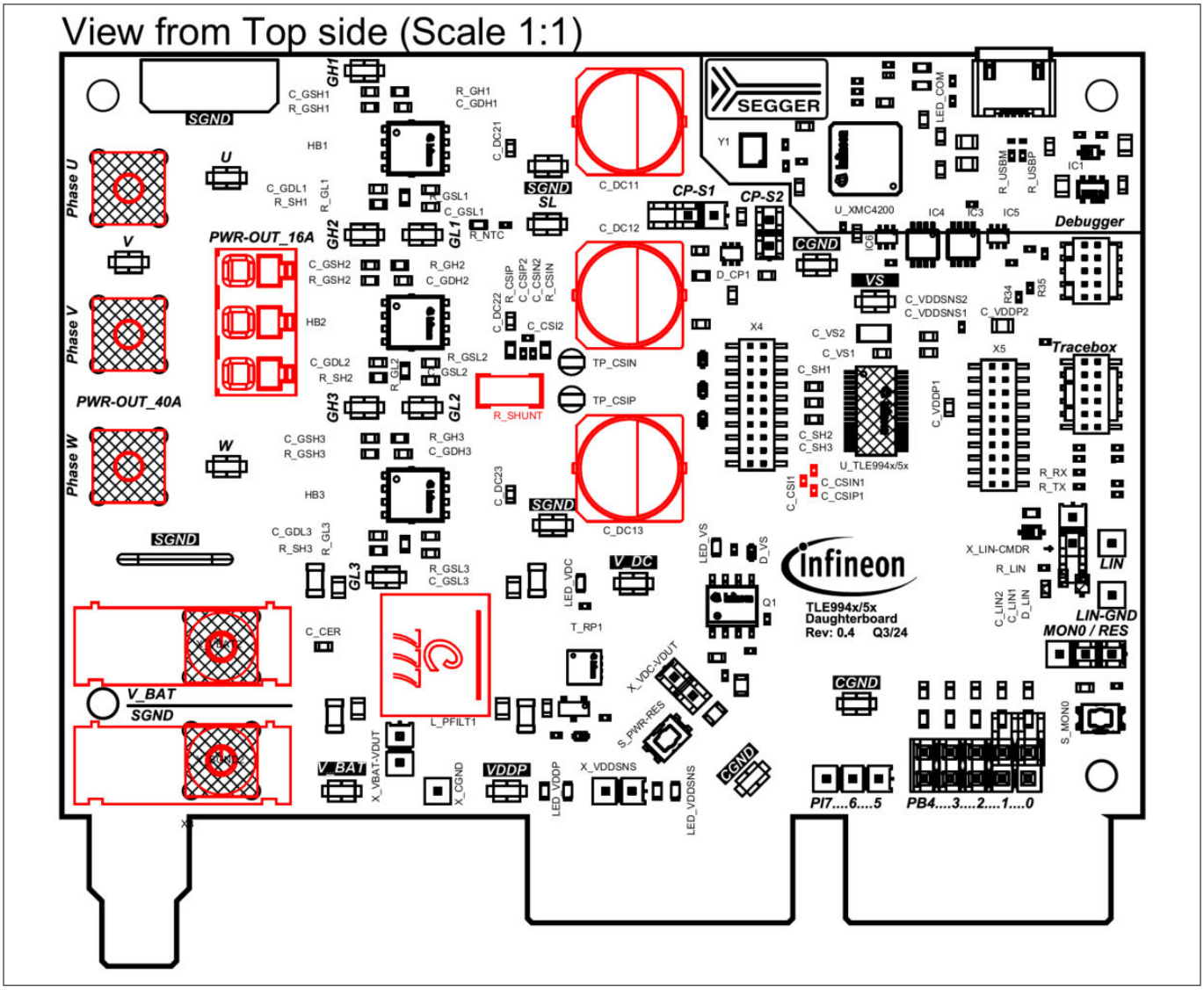

Figure 16 Overview placement positions

Values for these optional additional placements have to be determined depending on the application. The recommended components and values can be found TLE994x_995x daughterboard bill of materials.

Table 9 Additional placements

Designator	Description
X_VBAT2, X_SGND2	Power terminals for power supply
PWR-OUT_40A	Power terminal for motor connections Phase W, Phase V, and Phase U
C_CSIN1	
C_CSIP1	

(table continues...)

Table 9 (continued) Additional placements

Designator	Description
C_CSI1	
C_LIN1	Additional capacitor placeholder for LIN communication

4 Software toolchain

The software toolchain can be installed by following the instructions in http://www.infineon.com/tle987x in the Getting Started Guide.

5 Design files

5.1 TLE994x_995x daughterboard bill of materials

Automotive qualified components are preferable for the use in the TLE994x_995x daughterboard. The complete *BOM* is shown below, including non-mounted components.

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

Table 10 BOM TLE994x_995x daughterboard

#	Design	Fitted	Quantity	Manufacturer Order number	Manufacturer	Value	Combined parameters
1	C_CP1, C_CP2_1, C_CP2_2	Fitted	3	GCM188R71H224KA64	MuRata	220 nF	TC:X7R (EIA);Tol.:-10%/+10%;Vdc:50V
2	C_CSI1, C_CSIN1, C_CSIP1	Varied	0	CGA2B2NP01H102J050BA	TDK Corporation	1 nF	TC:C0G (EIA) / NP0;Tol.:-5%/+5%;Vdc:50V
3	C_DC11, C_DC12, C_DC13	Varied	0	EEEFT1V561AP	Panasonic	560 uF	TC:-;Tol.:-20%/+20%;Vdc:35V
4	C_DC11, C_DC12, C_DC13	Varied	3	PCR1V331MCL1GS	Nichicon	330uF	TC:Aluminiumelectrolytic;Tol.:-20%/+20%;Vdc:35V
5	C_DC21, C_DC22, C_DC23	Fitted	3	CGA3E3X8R1H104K080AB	TDK Corporation	100nF	TC:X8R (EIA);Tol.:-10%/+10%;Vdc:50V
6	C_DVDDC3, C_VDDP2	Fitted	2	GRM21BZ71H475KE15L	MuRata	4.7uF	TC:X7R (EIA);Tol.:-10%/+10%;Vdc:50V

(table continues...)

Table 10 (continued) BOM TLE994x_995x daughterboard

#	Design	Fitted	Quantity	Manufacturer Order number	Manufacturer	Value	Combined parameters
7	C_DVDDP5, C_LDO2, C_LDO3	Fitted	3	GCM21BR71A106KE22	MuRata	10uF	TC:X7R (EIA);Tol.:-10%/_P10%;Vdc:10V
8	C_DXTAL1, C_DXTAL2	Fitted	2	GCM1555C1H120JA16	MuRata	12pF	TC:C0G (EIA) / NP0;Tol.:-5%/+5%;Vdc:50V
9	C_GDH1, C_GDH2, C_GDH3, C_GDL1, C_GDL2, C_GDL3	Fitted	6	GCM1885C1H301FA16	MuRata	300pF	TC:C0G (EIA) / NP0;Tol.:-1%/+1%;Vdc:50V
10	C_GSH1, C_GSH2, C_GSH3, C_GSL1, C_GSL2, C_GSL3, C_SH1, C_SH2, C_SH3	Fitted	9	GCM1885C1H102FA16	MuRata	1nF	TC:C0G (EIA) / NP0;Tol.:-1%/+1%;Vdc:50V
11	C_LIN1, C_LIN2	Varied	0	CGA3E2C0G1H221J080AA	TDK Corporation	220pF	TC:C0G (EIA) / NP0;Tol.:-5%/+5%;Vdc:50V
12	C_PFILT1, C_PFILT2, C_PFILT7, C_PFILT8	Fitted	4	CGA5L3X7R1H475K160AB	TDK Corporation	4.7uF	TC:X7R (EIA);Tol.:-10%/+10%;Vdc:50V
13	C_PFILT3, C_PFILT4, C_PFILT5, C_PFILT6	Fitted	4	GRM216R71H471KA01	MuRata	470pF	TC:X7R (EIA);Tol.:-10%/+10%;Vdc:50V
14	C_PORST1	Fitted	1	C0402C103K4RECAUTO	Kemet	10nF	TC:X7R (EIA);Tol.:-10%/+10%;Vdc:16V
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:50V

(table continues...)

Table 10 (continued) BOM TLE994x_995x daughterboard

#	Design	Fitted	Quantity	Manufacturer Order number	Manufacturer	Value	Combined parameters
16	C_SHELL, CVDDP	Fitted	2	CGA2B3X7R1H104K050BB	TDK Corporation	100nF	TC:X7R (EIA);Tol.:-10%/_P10%;Vdc:50V, TC:X7R (EIA);Tol.:-10%/+10%;Vdc:50V
17	C_VCPH	Fitted	1	CGA3E3X7R1H474K080AE	TDK Corporation	470nF	TC:X7R (EIA);Tol.:-10%/+10%;Vdc:50V
18	C_VDDSNS2, C_VSCP	Fitted	2	CC0603KRX7R9BB105	Yageo	1uF	TC:X7R (EIA);Tol.:-10%/+10%;Vdc:50V
19	C_VS2	Fitted	1	C3216X5R1V226M160AC	TDK Corporation	22uF	TC:X5R (EIA);Tol.:-20%/+20%;Vdc:35V
20	C1, C2, 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	15	C0603C104K5RACAUTO	Kemet	100nF	TC:X7R (EIA);Tol.:-10%/+10%;Vdc:50V
21	C3, C4, C5, C6, C7, C8	Varied	0	CBR04C101F3GAC	Kemet	100pF	TC:C0G (EIA) / NP0;Tol.:-1%/+1%;Vdc:25V

(table continues...)

Table 10 (continued) BOM TLE994x_995x daughterboard

#	Design	Fitted	Quantity	Manufacturer Order number	Manufacturer	Value	Combined parameters
22	C9, C_CSI2, C_CSIN2, C_CSIP2	Fitted	4	CGA2B2NP01H102J050BA	TDK Corporation	1nF	TC:C0G (EIA) / NP0;Tol.:-5%/+5%;Vdc:50V
23	D_CP1	Fitted	1	BAT54XY,115	Nexperia	30V	Vf:400mV;If:200mA;Ur:30V;Ir:2uA;Pmax:220mW
24	D_LIN	Varied	0	PESD1IVN27-A	Nexperia	PESD1IVN27-A	Vf:-;If:-;Ur:27V;Ir:50nA;Pmax:-
25	D_LIN-CMDR	Fitted	1	BAS21-03W	Infineon Technologies	BAS21-03W	Vf:1.25V;If:250mA;Ur:200V;Ir:-;Pmax:250mW
26	D_RP1, D_VS	Fitted	2	BAS52-02V	Infineon Technologies	BAS52-02V	Vf:500mV;If:200mA;Ur:45V;Ir:10uA;Pmax:500mW
27	D_SH1, D_SH2, D_SH3	Fitted	3	BAS52-02V	Infineon Technologies	BAS52-02V	Vf:500mV;If:200mA;Ur:45V;Ir:10uA;Pmax:500mW
28	D_USB	Fitted	1	BAT60A	Infineon Technologies	BAT60A	Vf:300mV;If:3A;Ur:10V;Ir:2.6mA;Pmax:1.35W
29	D_USBM, D_USBP	Fitted	2	ESD231-B1-W0201	Infineon Technologies	ESD231-B1-W0201	Vf:-;If:-;Ur:5.5V;Ir:20nA;Pmax:-
30	D1, D2, D3, D4, D5	Fitted	5	TLMS1100-GS08	Vishay	Red	Vf:3V;If:20mA;Ur:12V;Ir:10uA;Pmax:90mW
31	HB1, HB2, HB3	Fitted	3	IAUCN04S7N040H	Infineon Technologies		
32	IC1	Fitted	1	TLS202B1MBV33	Infineon Technologies	TLS202B1MBV33	Linear Not applicable _N;Vo:3.3V to 3.3V
33	IC3, IC4	Fitted	2	SN74LVC2T45DCTT	Texas Instruments	SN74LVC2T45DCTT	
34	IC5, IC6	Fitted	2	SN74LVC1T45DCKR	Texas Instruments	SN74LVC1T45DCKR	Industrial Interface/ Transceiver;Vdc min/max:1.65V/5.5V;Iout:32mA;Fmax:-

(table continues...)

Table 10 (continued) BOM TLE994x_995x daughterboard

#	Design	Fitted	Quantity	Manufacturer Order number	Manufacturer	Value	Combined parameters
35	L_PFILT1	Varied	0	XAL1010-102MED	Coilcraft	1uH	Tol.:-20%/ +20%;Rdc:1.1mR;Idc :43.5A;Fres:42MHz
36	L_PFILT1	Varied	1	XAL1010-472MED	Coilcraft	4.7uH	Tol.:-20%/ +20%;Rdc:5.2mR;Idc :25.4A;Fres:19MHz
37	LED_COM , LED_VDC , LED_VDD P, LED_VDD SNS, LED_VS	Fitted	5	LG L29K-G2J1-24	OSRAM Opto Semiconducto rs	Green	Vf:2.2V;If:20mA;Ur:12 V;Ir:10nA;Pmax:-
38	LUSB1	Fitted	1	BLM18PG600SN1D	MuRata	60R	Tol.:_N;Rdc:100mR;I dc:1A;Fres:_N
39	MP1, MP2, MP3, MP4	Fitted	4	702916000	Wurth Elektronik	70291600 0	- Round -x4 Spacers
40	Q_RP1	Fitted	1	BC817K-40R	Nexperia	BC817K-4 0R	NPN;Uce:45V;Ic:500 mA;P:775mW;F:100 MHz
41	Q1	Fitted	1	AUIRF7343Q	Infineon Technologies	AUIRF734 3Q	N-Channel Enhancement;Uds:5 5V;Id:4.7A;Rds:105R; P:2W
42	R_CSIN, R_CSIP	Fitted	2	CRCW06034R70FK	Vishay	4.7R	TCR:100ppm/ K;Tol.:-1%/ +1%;Vdc:75V;Idc:-;P: 100mW
43	R_GH1, R_GH2, R_GH3, R_GL1, R_GL2, R_GL3, R_VSCP	Fitted	7	CRCW06032R00FK	Vishay	2R	TCR:100ppm/ K;Tol.:-1%/ +1%;Vdc:75V;Idc:-;P: 100mW

(table continues...)

Table 10 (continued) BOM TLE994x_995x daughterboard

#	Design	Fitted	Quantity	Manufacturer Order number	Manufacturer	Value	Combined parameters
44	R_GSH1, R_GSH2, R_GSH3, R_GSL1, R_GSL2, R_GSL3	Fitted	6	ERA-3AEB104V	Panasonic	100k	TCR:25ppm/K;Tol.:-0.1%/+0.1%;Vdc:-;Idc:-;P:100mW
45	R_NTC	Fitted	1	NTCG164KF104FTDS	TDK Corporation	100k	TCR:-;Tol.:-1%/+1%;Vdc:-;Idc:-;P:100mW
46	R_PULS1, R_USB1, R_VDDP1, R_VDDP2	Fitted	4	CRCW04024K70FK	Vishay	4.7k	TCR:100ppm/K;Tol.:-1%/+1%;Vdc:50V;Idc:-;P:63mW, TCR:100ppm/K;Tol.:-1%/_P1%;Vdc:50V;Idc:-;P:63mW
47	R_SBH1, R_SBH2, R_SBH3, R_SBL1, R_SBL2, R_SBL3	Varied	0	CRCW08052R00FKEAHP	Vishay	2R	TCR:100ppm/K;Tol.:-1%/+1%;Vdc:150V;Idc:-;P:500mW
48	R_SH1, R_SH2, R_SH3	Fitted	3	TNPW060310R0BEEA	Vishay	10R	TCR:25ppm/K;Tol.:-0.1%/+0.1%;Vdc:75V;Idc:-;P:100mW
49	R_SHELL	Fitted	1	CRCW04021M00FK	Vishay	1MEG	TCR:100ppm/K;Tol.:-1%/+1%;Vdc:50V;Idc:-;P:63mW
50	R_SHUNT	Varied	0	ERJMS4SF2M0U	Panasonic	2mR	TCR:75ppm/K;Tol.:-1%/+1%;Vdc:-;Idc:-;P:3W
51	R_SHUNT	Varied	1	ERJMS4HF5M0U	Panasonic	5mR	TCR:75ppm/K;Tol.:-1%/+1%;Vdc:-;Idc:-;P:3W
52	R_SHUNT	Varied	0	ERJMS4HF5M0U	Panasonic	5mR	TCR:75ppm/K;Tol.:-1%/+1%;Vdc:-;Idc:-;P:3W

(table continues...)

Table 10 (continued) BOM TLE994x_995x daughterboard

#	Design	Fitted	Quantity	Manufacturer Order number	Manufacturer	Value	Combined parameters
53	R_USBM, R_USBP	Fitted	2	CRCW040222R0FK	Vishay	22R	TCR:100ppm/K;Tol.:-1%/+1%;Vdc:50V;Idc:-;P:63mW
54	R_XTAL1	Fitted	1	CRCW0402150RFK	Vishay	150R	TCR:100ppm/K;Tol.:-1%/+1%;Vdc:50V;Idc:-;P:63mW
55	R1, R2	Fitted	2	CRCW08052R00FKEAHP	Vishay	2R	TCR:100ppm/K;Tol.:-1%/+1%;Vdc:150V;Idc:-;P:500mW
56	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:50V;Idc:-;P:100mW
57	R13, R14, R15, R16, R17, R_LIN-CMDR	Fitted	6	RC0603FR-071KL	Yageo	1k	TCR:100ppm/K;Tol.:-1%/+1%;Vdc:75V;Idc:-;P:100mW
58	R18, R19, R20, R21, R22, R23	Varied	0	TNPW06031K00BEEA	Vishay	1k	125mW;0,1%;25PPM/C;75V
59	R3, R4, R5, R11, R_PDLS1, R_PDLS2, R_PDLS3, R_PORST, R_RP1, R_RP2, R_USB2	Fitted	11	CRCW040210K0FK	Vishay	10k	TCR:100ppm/K;Tol.:-1%/+1%;Vdc:50V;Idc:-;P:63mW
60	R32	Fitted	1	CRCW04024K02FK	Vishay	4.02k	TCR:100ppm/K;Tol.:-1%/+1%;Vdc:50V;Idc:-;P:63mW

(table continues...)

Table 10 (continued) BOM TLE994x_995x daughterboard

#	Design	Fitted	Quantity	Manufacturer Order number	Manufacturer	Value	Combined parameters
61	R6, R7	Fitted	2	CRCW04022K20FK	Vishay	2.2k	TCR:100ppm/K;Tol.:-1%/+1%;Vdc:50V;Idc:-;P:63mW
62	R8, R9, R_COM	Fitted	3	AC0603FR-07680RL	Yageo	680R	TCR:100ppm/K;Tol.:-1%/+1%;Vdc:75V;Idc:-;P:100mW
63	S_MON0, S_PWR-RES	Fitted	2	435451019820	Wurth Elektronik	435451019820	
64	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
65	T_RP1	Fitted	1	IPZ40N04S5-3R1	Infineon Technologies	IPZ40N04S5-3R1	N-Channel Enhancement;Uds:40V;Id:40A;Rds:3.1mR;P:71W
66	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

(table continues...)

Table 10 (continued) BOM TLE994x_995x daughterboard

#	Design	Fitted	Quantity	Manufacturer Order number	Manufacturer	Value	Combined parameters
67	TP_CGND1, TP_CGND2, TP_CGND3, TP_GH1, TP_GH2, TP_GH3, TP_GL1, TP_GL2, TP_GL3, TP_Phase-U, TP_Phase-V, TP_Phase-W, TP_SGND1, TP_SGND2, TP_SL1, TP_VBAT, TP_VDC, TP_VDDP, TP_VS	Fitted	19	5019	Keystone Electronics Corp.	5019	Board-to-Cable None (onboard);1x1;Mounting:SMT;Orient:None (onboard);Shielded:No
68	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
69	TP_SGND3	Fitted	1	D3082-05	Harwin	D3082-05	- None (onboard);-x-;Mounting:THT;Orient:None (onboard);Shielded:No
70	U_TLE994x/5x	Varied	0	TLE994_5X	Infineon Technologies		

(table continues...)

Table 10 (continued) BOM TLE994x_995x daughterboard

#	Design	Fitted	Quantity	Manufacturer Order number	Manufacturer	Value	Combined parameters
71	U_XMC4200	Fitted	1	XMC4200Q48K256ABXUMA1	Infineon Technologies	IFX_XMC4200Q48K256ABXUMA1	App.:Industrial;-;Vdc min/max:3.13V/3.63V;Fmax:80MHz;RAM:40KB;ROM:-;Flash:256KB
72	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
73	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
74	X_CP-S1, X_CP-S2, X_LIN-CMDR, X_VBAT-VDUT, X_VDC-VDUT, X_VDDSNS	Fitted	6	TSW-102-07-L-S	Samtec	TSW-102-07-L-S	Board-to-Board Header (male);2x1;Mounting:THT;Orient:0° (vertical);Shielded:No
75	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:-

(table continues...)

Table 10 (continued) BOM TLE994x_995x daughterboard

#	Design	Fitted	Quantity	Manufacturer Order number	Manufacturer	Value	Combined parameters
76	X_JP-BTN, X_JP-CP-S1, X_JP-CP-S2, X_JP-LIN, X_JP-PX0, X_JP-PX1, X_JP-PX2, X_JP-PX3, X_JP-PX4, X_JP-VDUT	Fitted	10	SNT_N100_NBK_NG_NH	Samtec	SNT_N100_NBK_NG_NH	_N Socket (female);_Nx_N;Mounting:_N;Orient:_N;Shielded:_N
77	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
78	X_PWR-OUT_16A	Varied	1	2086-3103	WAGO	2086-3103	Board-to-Cable Socket (female);3x2;Mounting:THT;Orient:0° (vertical);Shielded:No
79	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
80	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

(table continues...)

Table 10 (continued) BOM TLE994x_995x daughterboard

#	Design	Fitted	Quantity	Manufacturer Order number	Manufacturer	Value	Combined parameters
81	X_SGND2, X_VBAT2	Varied	0	74650174R	Wurth Elektronik	74650174R	Board-to-Board Socket (female);2x2;Mounting:THT;Orient:0° (vertical);Shielded:No
82	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
83	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
84	X1, X2	Fitted	2	461130401_Edge Card	Molex	461130401_Edge Card	Edge Header (male);-x-;Mounting:SMT;Orient:0° (vertical);Shielded:No
85	X3	Fitted	1	461120201_Edge card	Molex	461120201_Edge card	Edge Header (male);-x-;Mounting:SMT;Orient:0° (vertical);Shielded:No
86	X4, X5	Varied	2	FTSH-110-01-L-DV-A	Samtec	FTSH-110-01-L-DV-A	Board-to-Board Header (male);10x2;Mounting:SMT;Orient:0° (vertical);Shielded:No
87	X7	Fitted	1	629105150521	Wurth Elektronik	629105150521	Board_Nto_NCable Socket (female);5x1;Mounting:SMT;Orient:90Â° (right angle);Shielded:Yes
88	Y1	Fitted	1	CX3225CA12000D0HSSCC	Kyocera	12MHz	Standard Standard Crystal;Tol.:-50%/+50%

5.2 TLE994x_995x daughterboard schematics

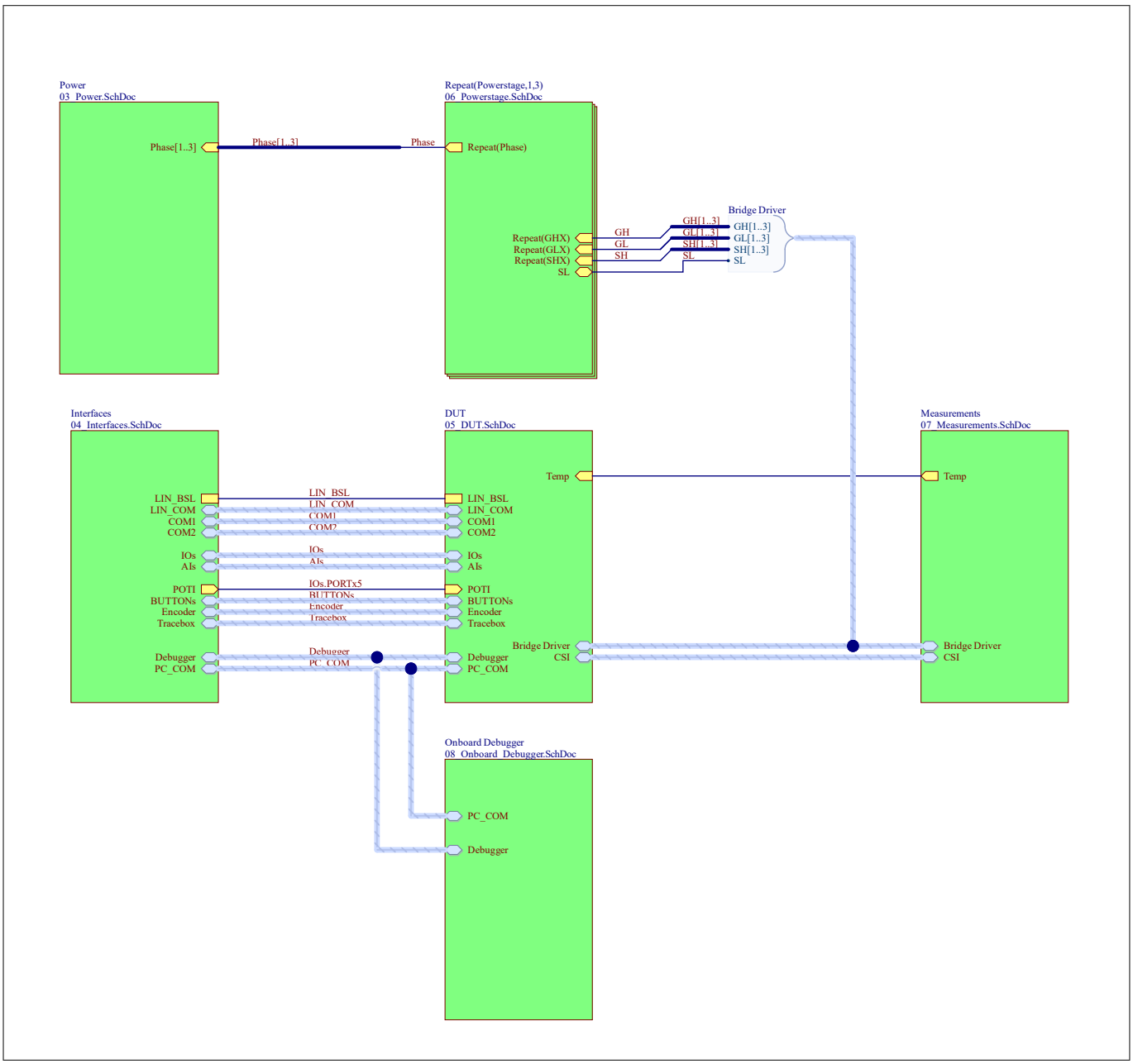

Figure 17 TLE994x_995x daughterboard, Top_Level

5 Design files

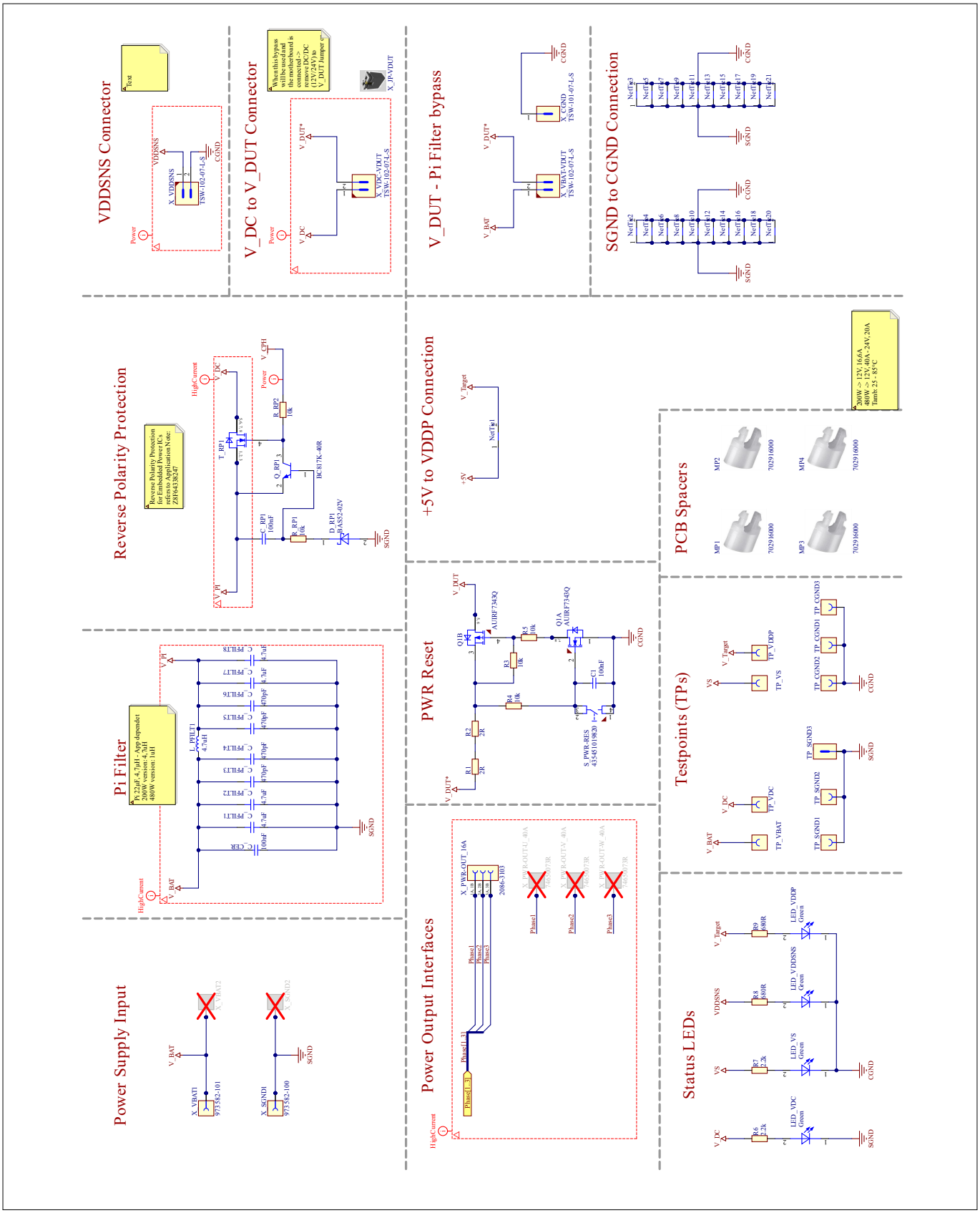

Figure 18 TLE994x_995x daughterboard, Power

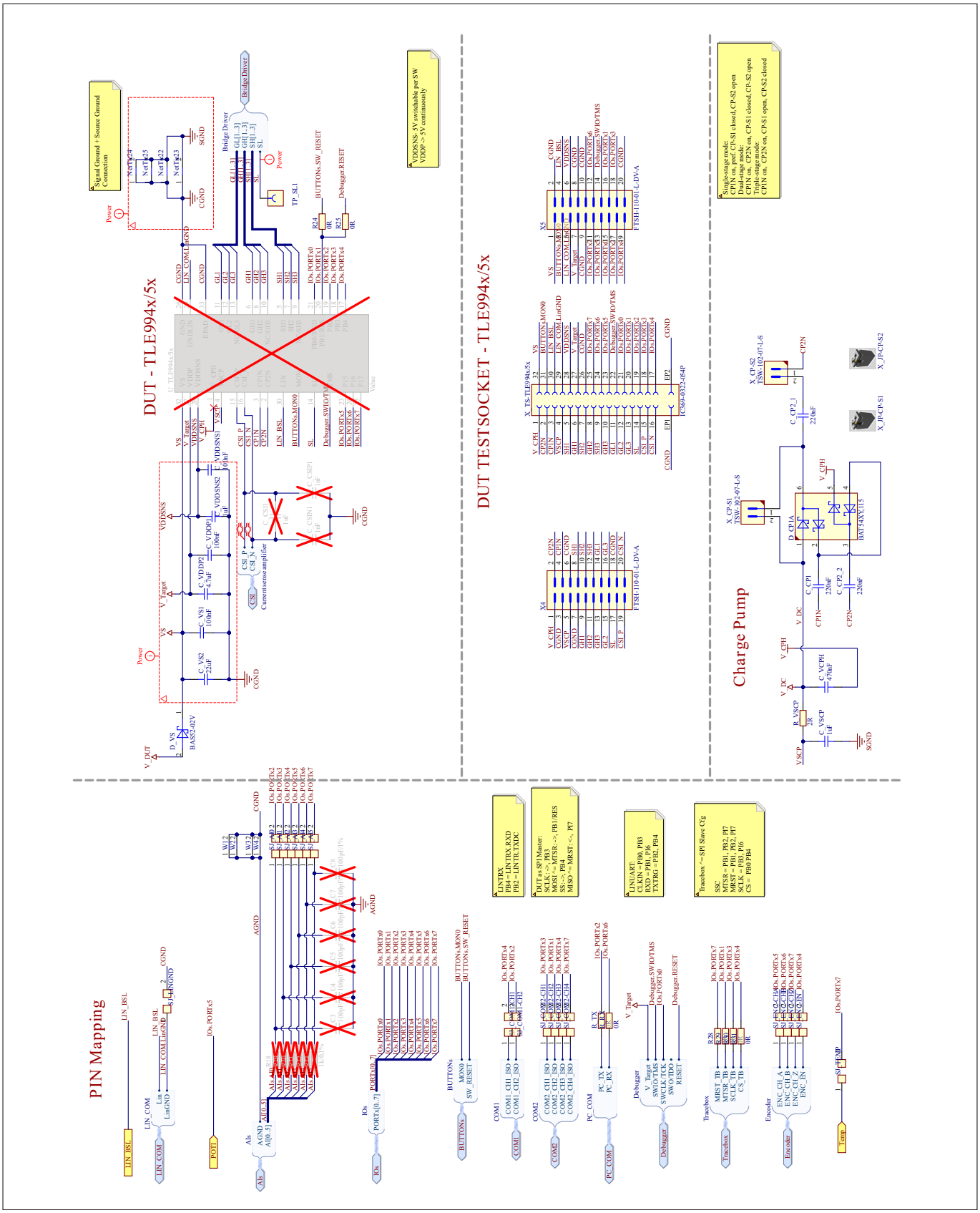

Figure 19 TLE994x_995x daughterboard, DUT

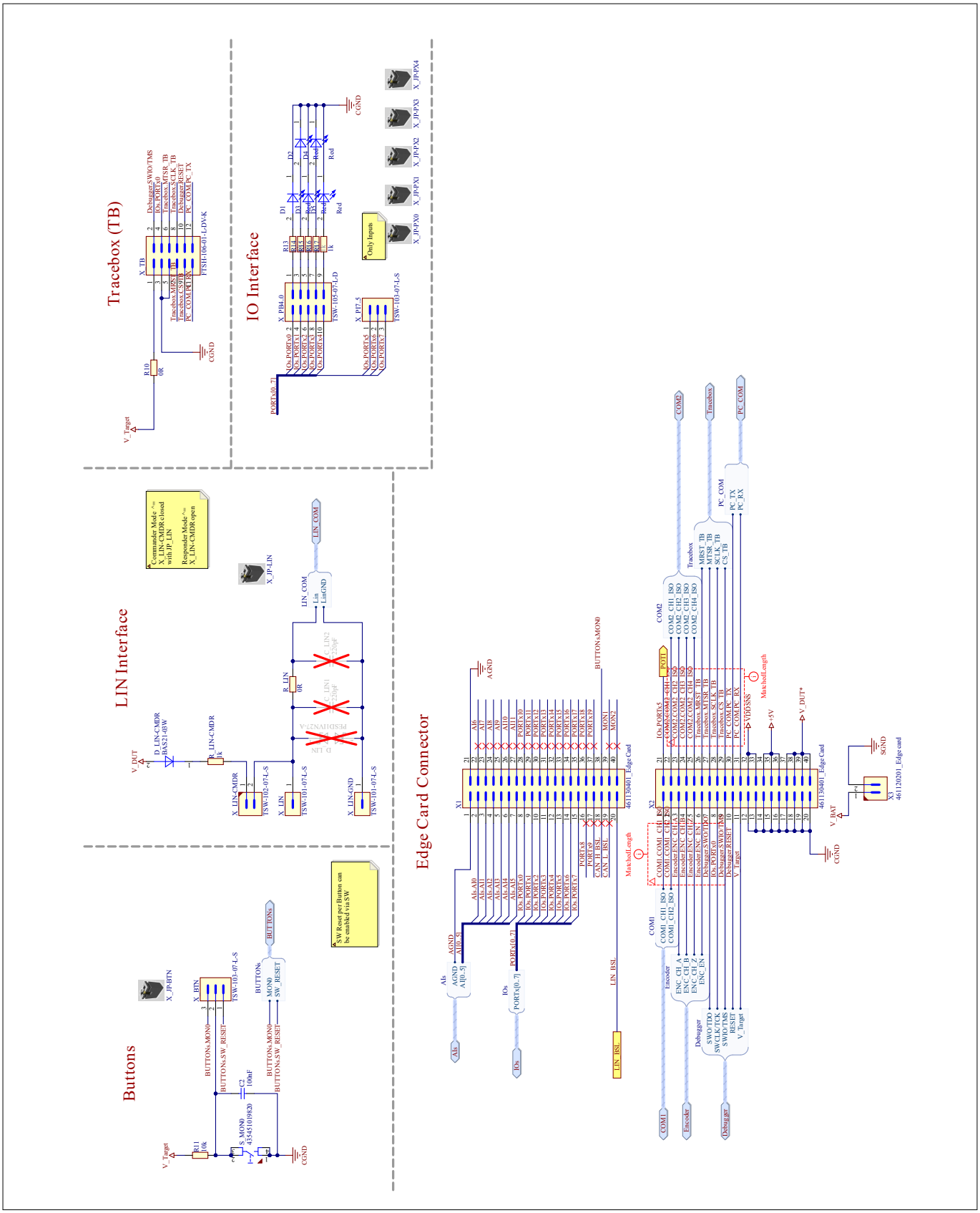

Figure 20 TLE994x_995x daughterboard, Interfaces

5 Design files

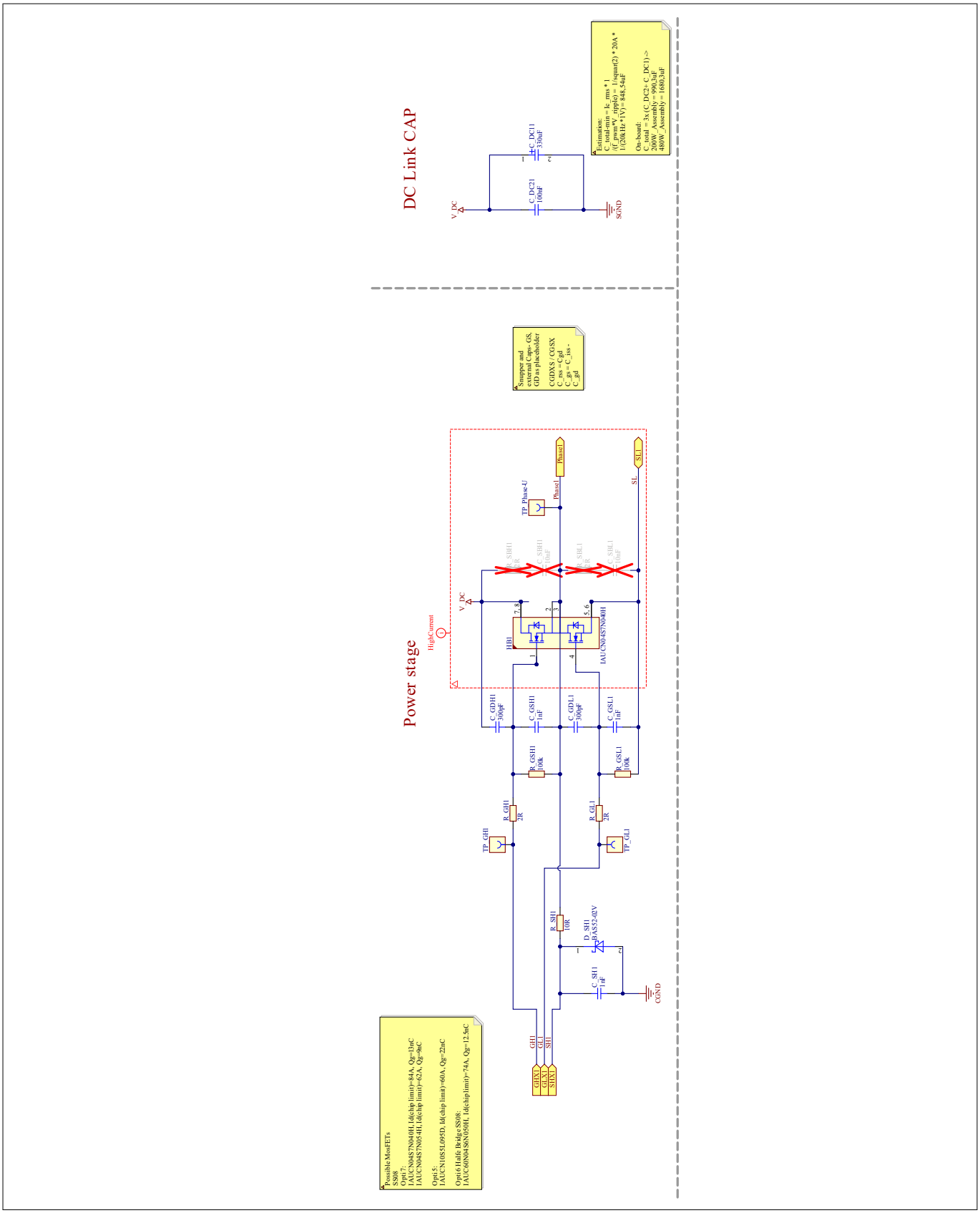

Figure 21 TLE994x_995x daughterboard, 3_Phase_Bridges

5 Design files

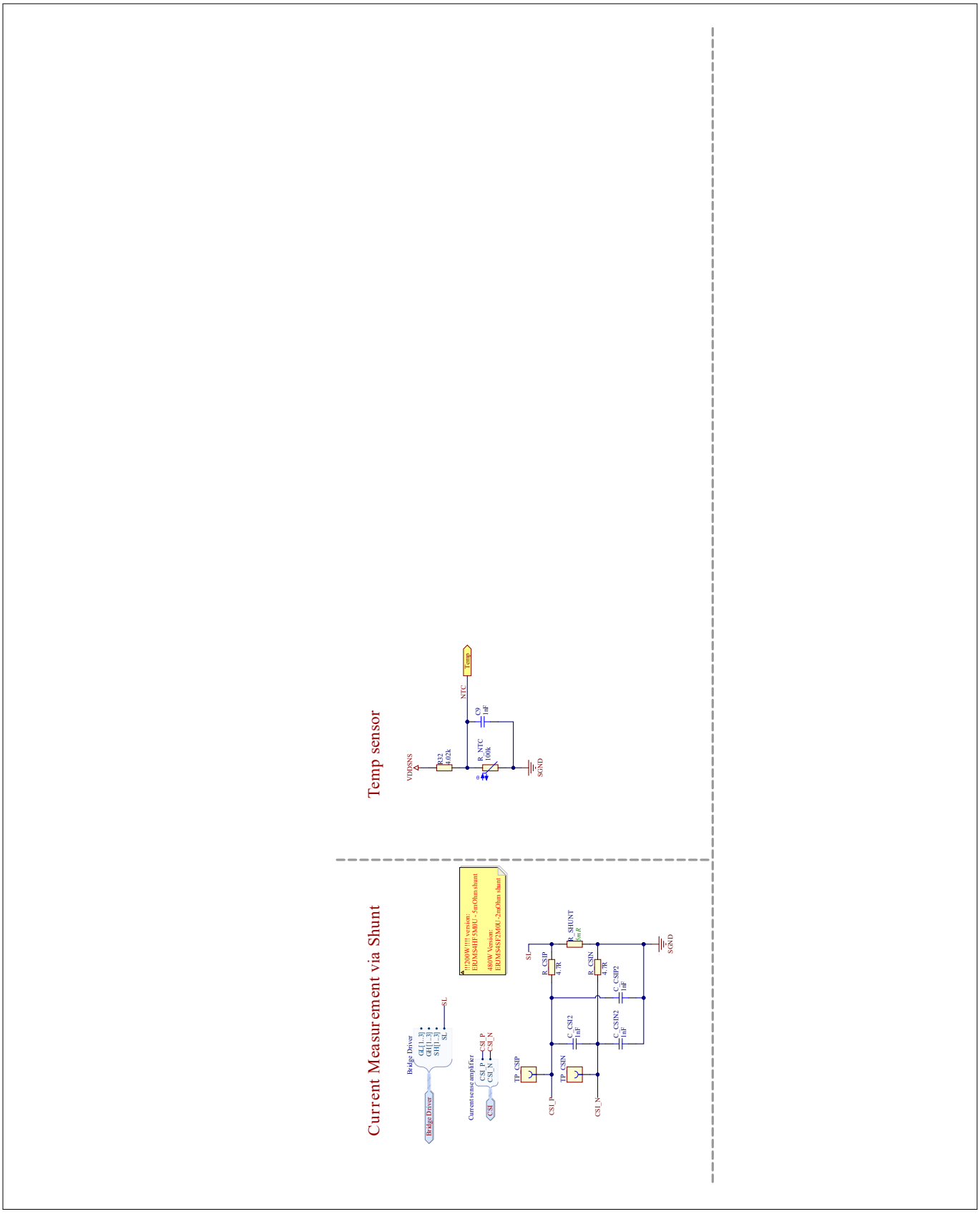

Figure 22 TLE994x_995x daughterboard, Measurements

5 Design files

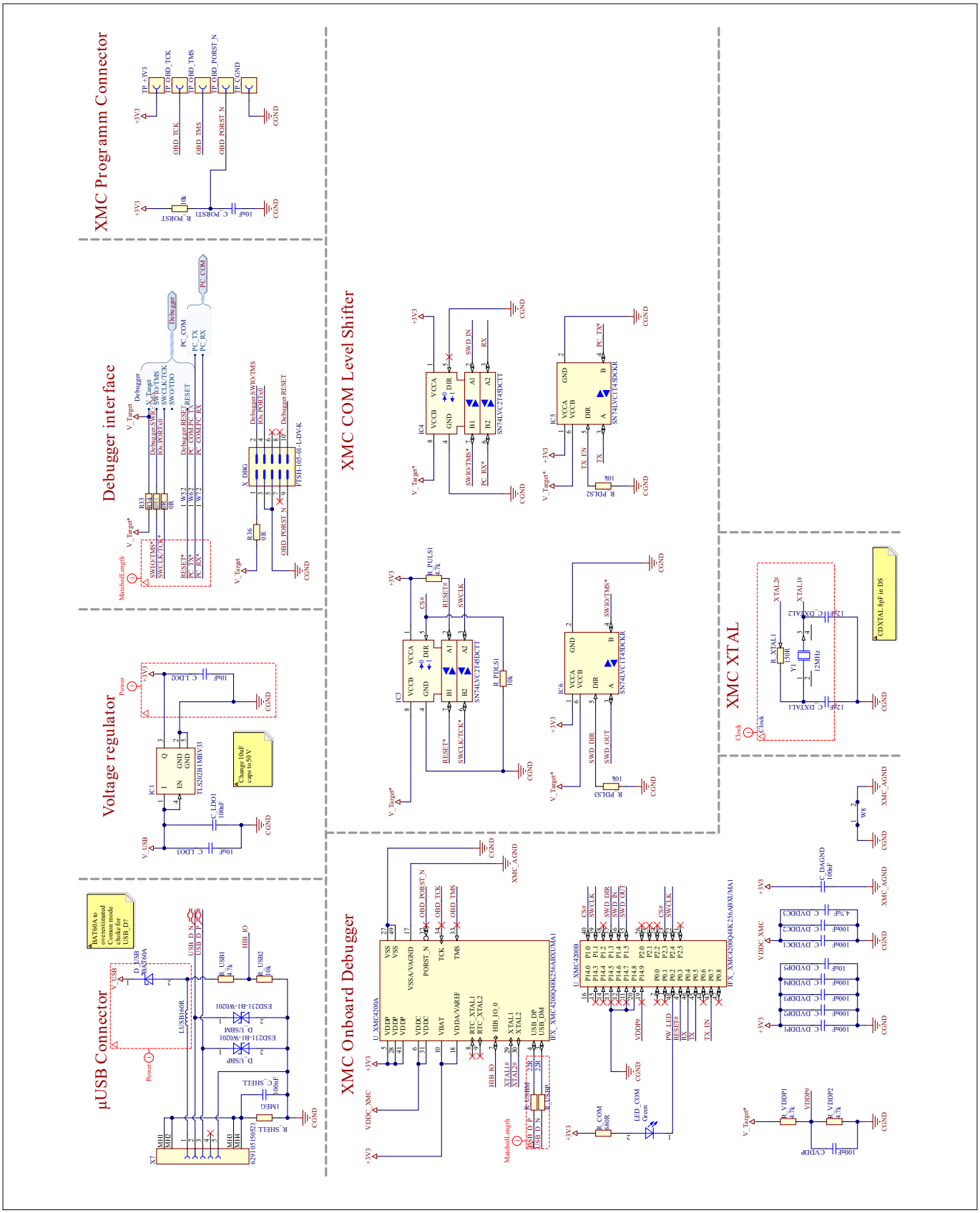

Figure 23 TLE994x_995x daughterboard, Onboard debugger

5.3 TLE994x_995x daughterboard layout

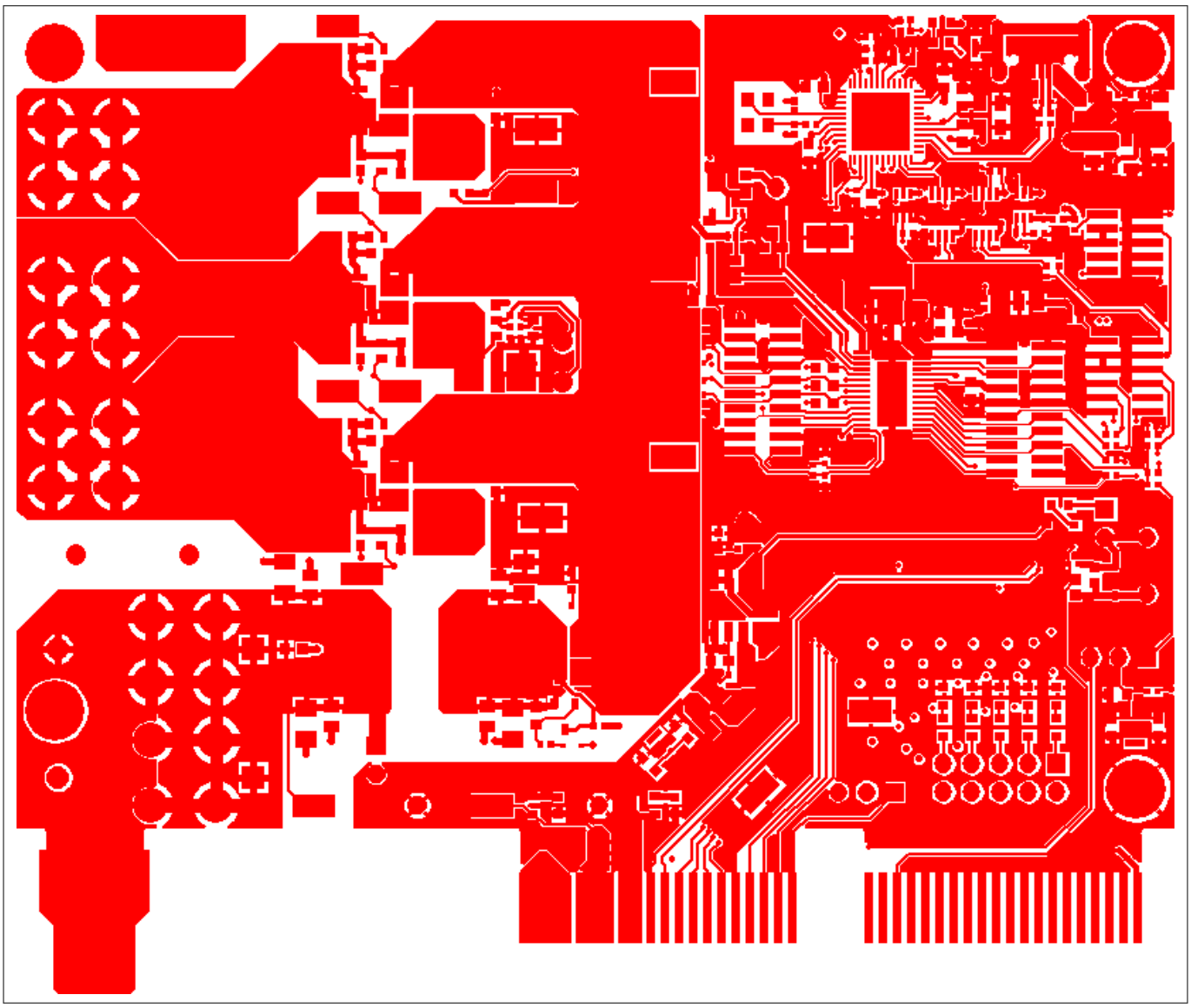

Figure 24 TLE994x_995x daughterboard, layer1 (Top layer, signal)

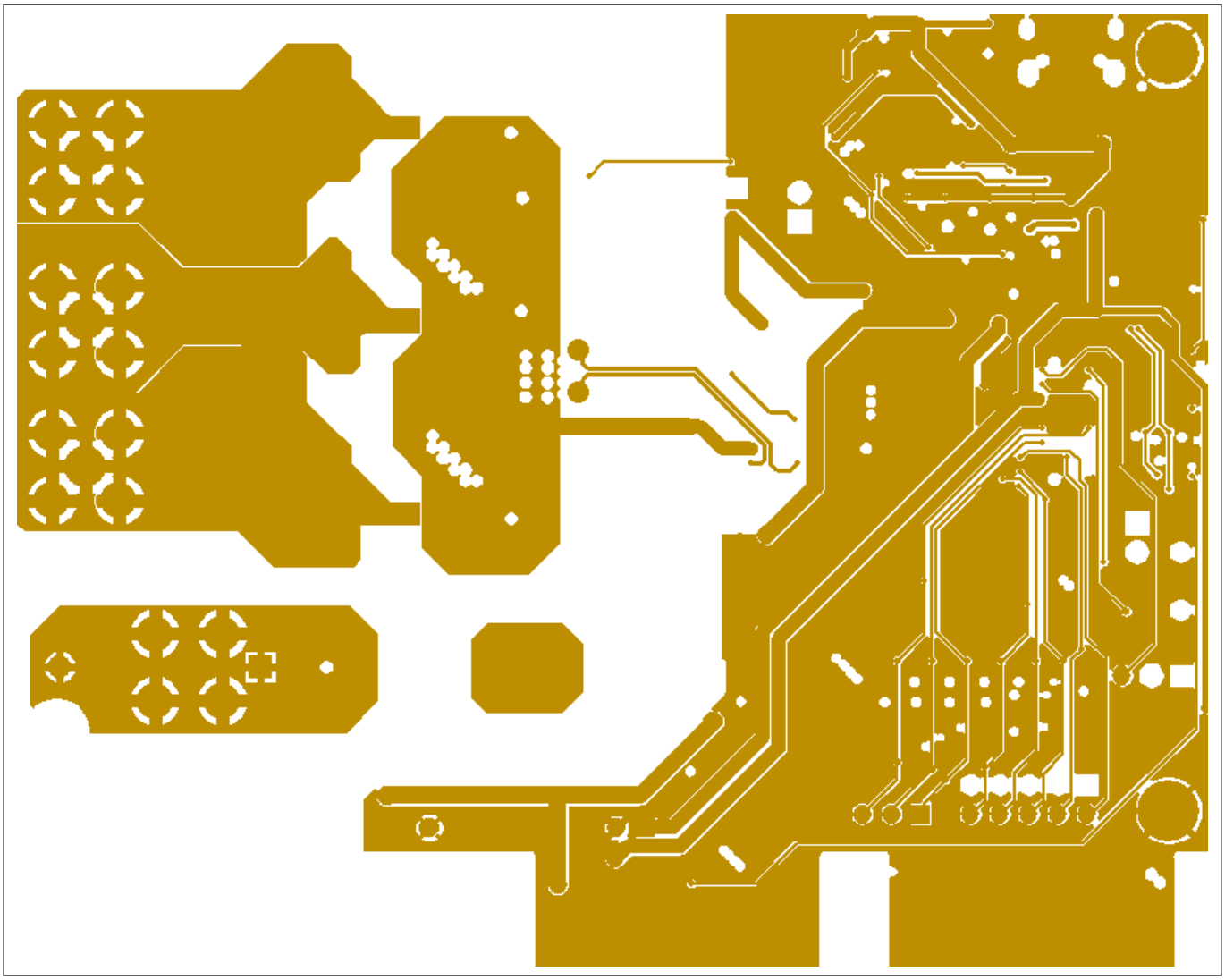

Figure 25 **TLE994x_995x daughterboard, layer2 (Middle layer, power)**

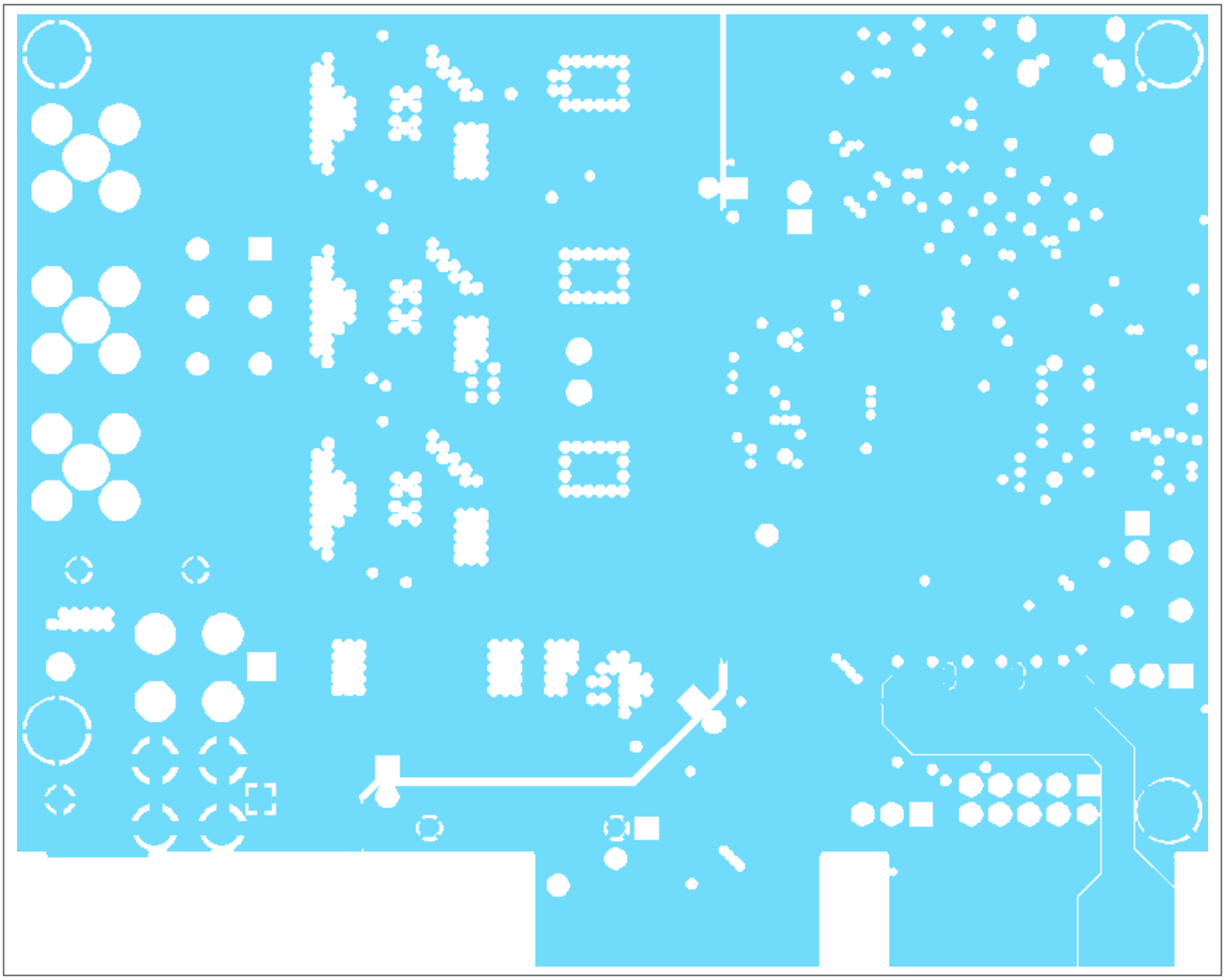

Figure 26 TLE994x_995x daughterboard, layer3 (Middle layer, GND)

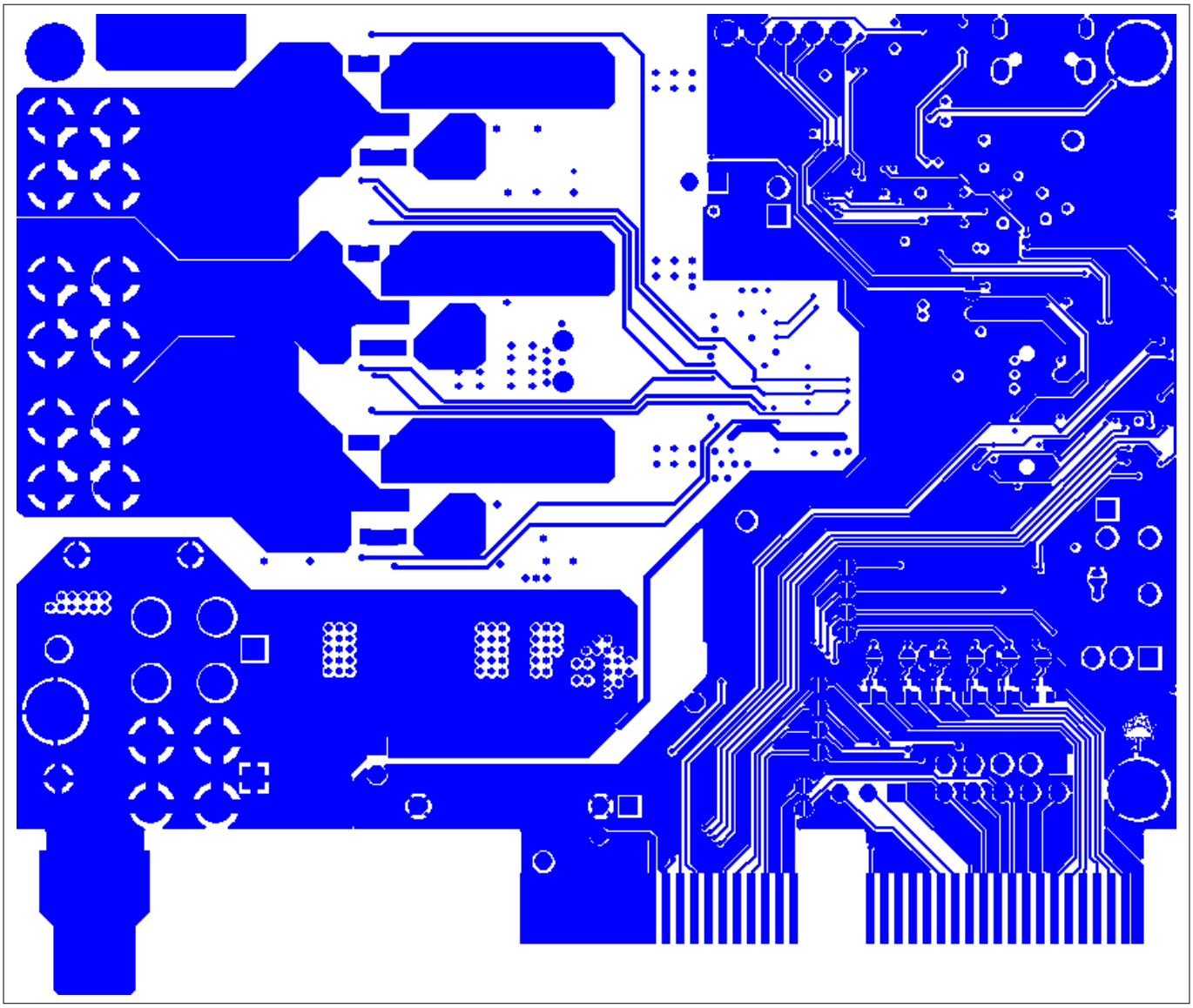

Figure 27 TLE994x_995x daughterboard, layer4 (Bottom layer, signal)

6 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
GH1-3	Gate high-side MOSFETs for phases 1-3
GL1-3	Gate low-side MOSFETs for phase 1-3
MON	High voltage monitoring input
SH1-3	Source high-side MOSFET 1-3
SL	Source low-side MOSFET
TMS	Test mode select

For abbreviations regarding the naming and functionalities of the TLE994x/5x family, refer to the User Manual of the device.

Glossary

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.

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.

UART

universal asynchronous receiver transmitter (UART)

A peripheral device or module for asynchronous serial communication in which the data format and transmission speeds are configurable.

Revision history

Document version	Date of release	Description of changes
01.00	2025-04-25	• Initial public document release

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