MOTIX™ MCU TLE9893-2QK

Evaluation kit user guide

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About this document

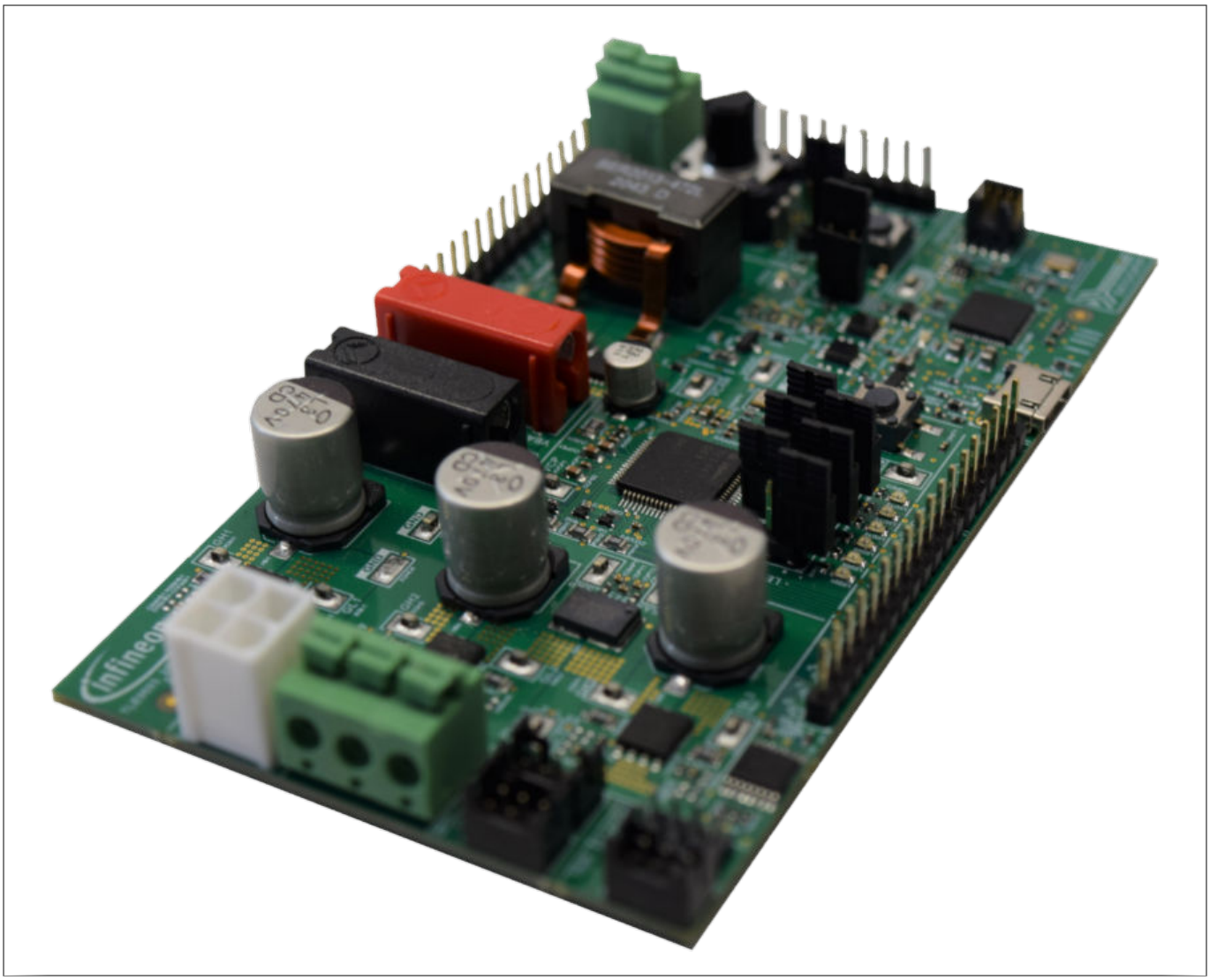

Figure 1 MOTIX™ MCU TLE9893-2QK evaluation kit

Scope and purpose

This user guide is intended to help users operating the MOTIX™ MCU TLE9893-2QK evaluation kit. This kit is designed to evaluate the hardware and software features of the TLE9893-2QKW62S.

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

Intended audience

This document is intended for anyone using the MOTIX™ MCU TLE9893-2QK evaluation kit.

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

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").

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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 TLE9893-2QKW62S.

The board is protected against reverse polarity of the input voltage supply. A battery LED indicates that the board is correctly connected to the supply.

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 and has a USB port to use the on-board SWD debugger.

The evaluation kit can be operated using standard laboratory equipment.

1.1 Delivery content

The MOTIX™ MCU TLE9893-2QK evaluation kit board is delivered together with a USB cable to connect the board to a PC.

1.2 Block diagram

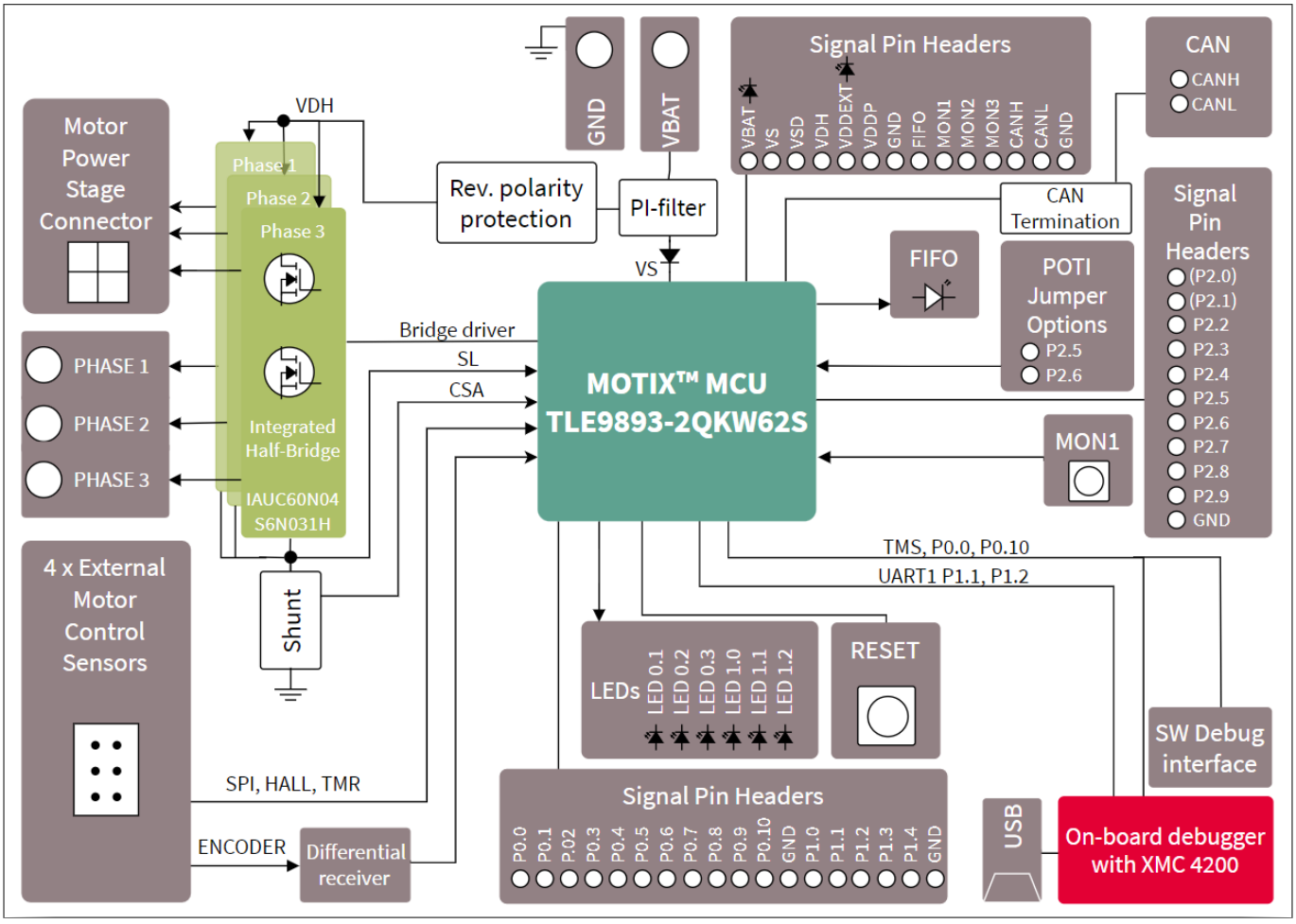

Figure 2 Block diagram

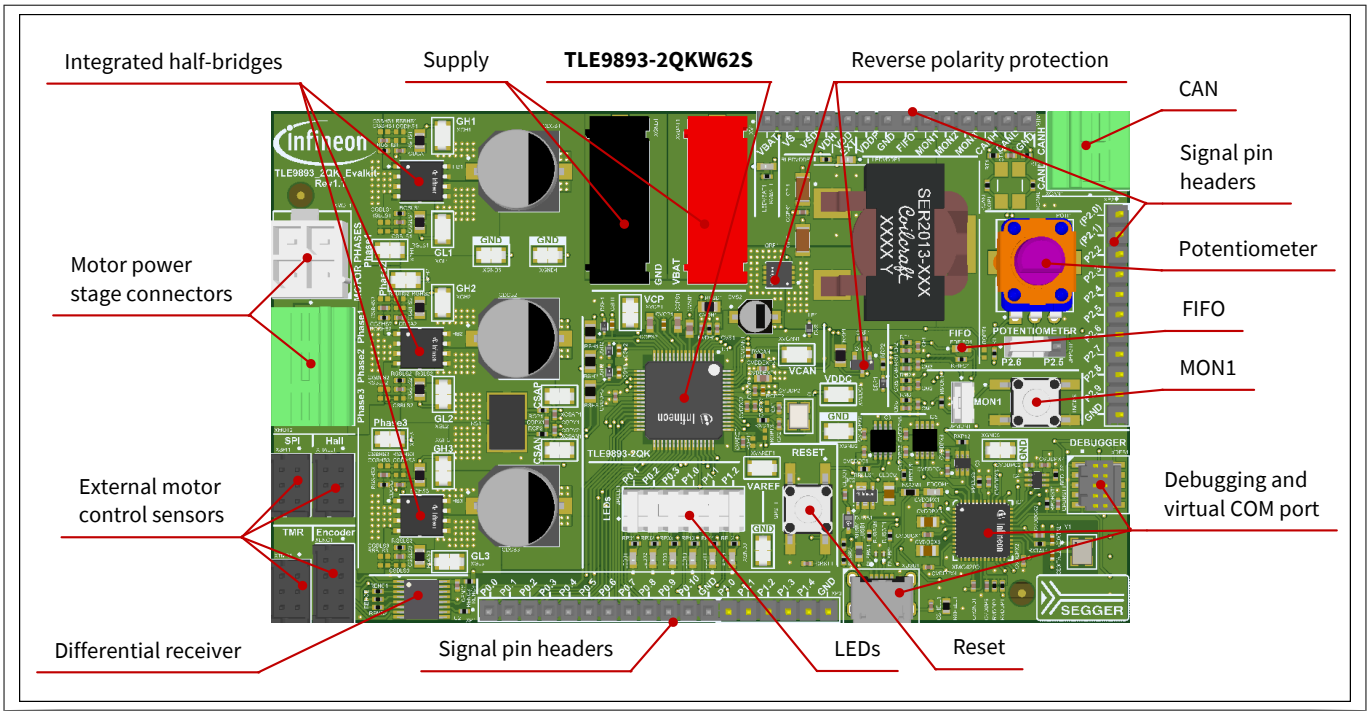

Figure 3 Functional blocks on the evaluation kit

1.3 Main features

- Soldered TLE9893-2QKW62S, which is an LQFP64 pin package device
- Motor power stage, including three Infineon MOSFET half-bridges
- On-board connectors for BLDC motors and motor control sensors
- PI filter and reverse polarity protection for the supply
- CAN connector for twisted pair cables and an option for CAN termination
- Push buttons for MON1 and reset pins
- LEDs for showing the state of the supply voltage, GPIOs, FIFO (Fail-in/ Fail-out pin) and of one of the TLE9893-2QKW62S voltage regulators
- Potentiometer with selectable reference voltage and analog device input
- SEGGER J-Link on-board debugger with virtual COM port

1.4 Technical data

The dimensions of the evaluation kit are 110 mm x 65 mm.

Technical data is specified in the table below. The current capability is limited by the banana jacks and the 7 W shunt resistor. For more information 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. 28 V [1)2)3)]
Supply current	Max. 13 A [1)3)4)]
Pin ports P0.x, P1.x, P2.x	Max. 5 V [2)]

1. Specified by design
2. Limited by the functional range of the TLE9893-2QKW62S. Refer to the TLE989x/TLE988x datasheet for further information

3. Further limited by the thermal dissipation capabilities of the evaluation kit, MOSFETs and 7 W mounted shunt
4. Limited by the nominal current of XMOT1. If XMOT2 is used instead for connecting the motor, the maximum supply current is 16 A

2 System and functional description

2.1 Board information

2.1.1 Connectors

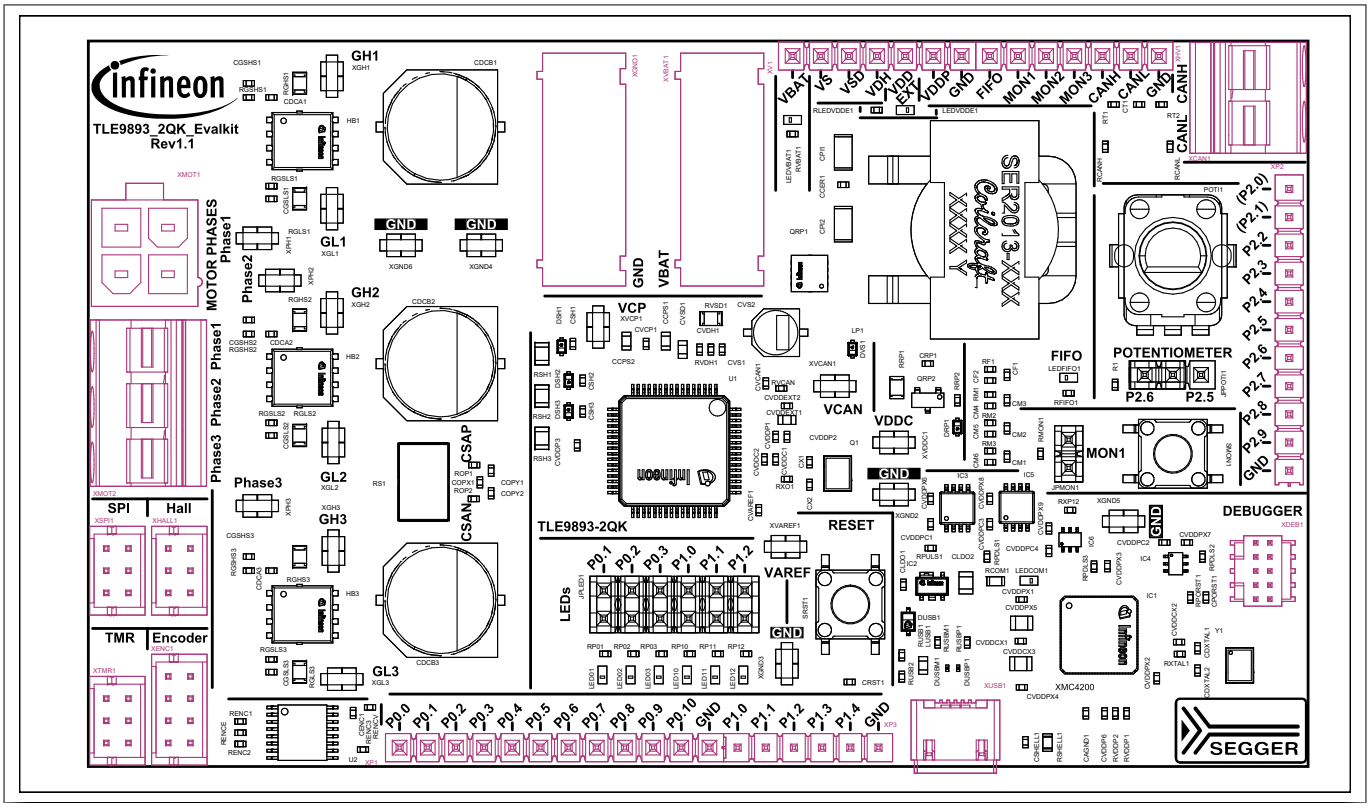

Figure 4 Connectors

Table 3 Connectors

Functionality	Designator	Description
VBAT, GND	XVBAT1, XGND1	Banana jacks for power supply (red) and ground (black).
Phase 1, 2, 3	XMOT2	Push-in connector for motor connection with Phase 1 (top pin), Phase 2 (middle pin) and Phase 3 (bottom pin).The phases of the motor are to be connected to either to this connector or to the one listed below. For more information, refer to Motor power stage.
MOTOR PHASES	XMOT1	Vertical PCB header socket, which can be used to connect the phases of a motor with a receptacle loaded with crimp terminals. 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

(table continues...)

Table 3 (continued) Connectors

Functionality	Designator	Description
SPI	XSPI1	Vertical PCB header socket, which can be used to connect an SPI sensor for motor control with a receptacle loaded with crimp terminals. For more information, refer to External motor control sensors
HALL	XHALL1	Vertical PCB header socket, which can be used to connect a Hall sensor for motor control with a receptacle loaded with crimp terminals. For more information, refer to External motor control sensors
TMR	XTMR1	Vertical PCB header socket, which can be used to connect a TMR sensor for motor control with a receptacle loaded with crimp terminals. For more information, refer to External motor control sensors.
ENCODER	XENC1	Vertical PCB header socket, which can be used to connect an encoder for motor control with a receptacle loaded with crimp terminals. For more information, refer to External motor control sensors
CANH/CANL	XCAN1	Terminal block with clamps to connect **CAN** cables to the device. For jumper cables the pin header XHV1 can be used.
Signal pin Headers	XP1, XP2, XP3, XV1, XHV1	Pin headers to access relevant signals of the board. For more information, refer to Signal pin headers
SWD	XDEB1	**Debugging** interface to connect external debugger
USB	XUSB1	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

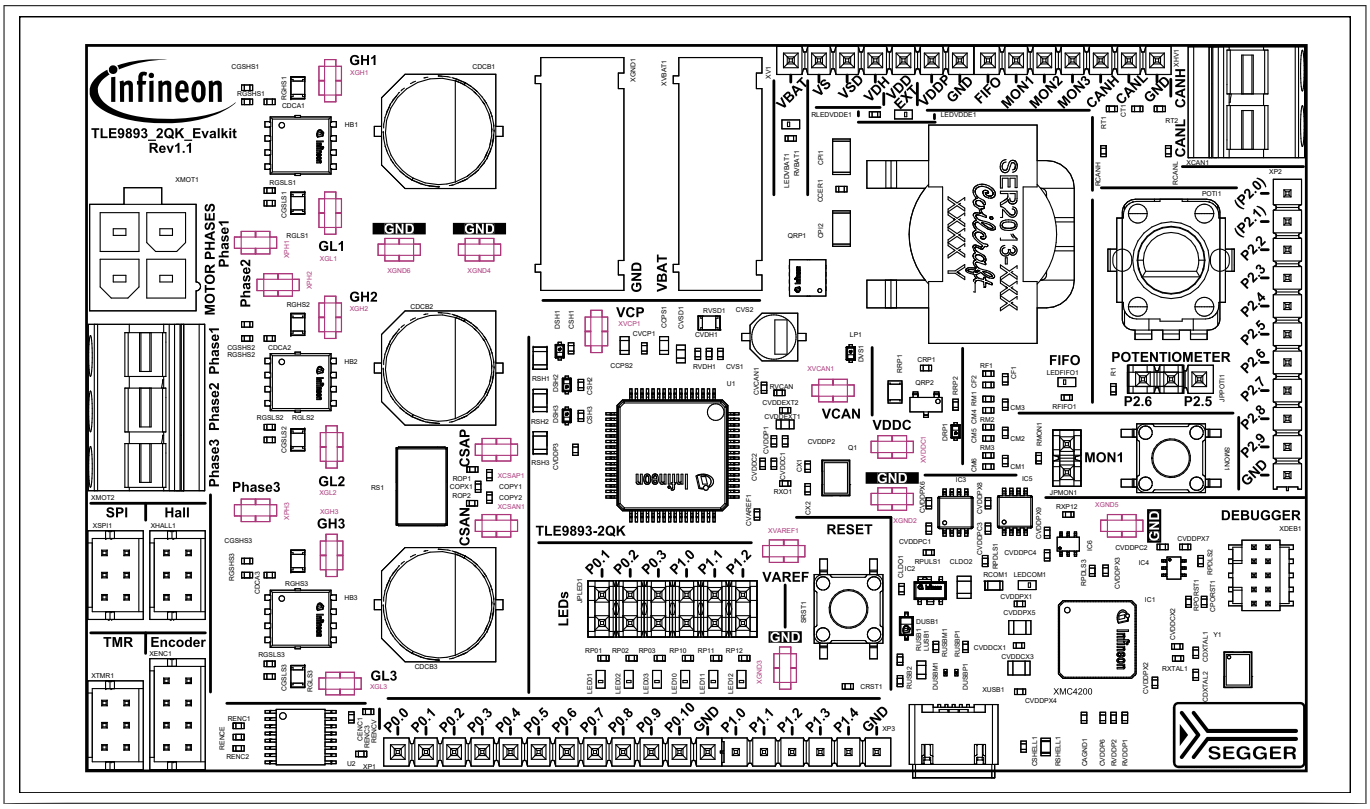

Figure 5 Test points

Table 4 Test points

Signal	Designator	Description
VDDC	XVDDC1	Test point to measure the output of the VDDC regulator
VAREF	XVAREF1	Test point to measure the output of the VREF5V regulator
VCAN	XVCAN1	Test point to measure the supply of the CAN transceiver
VCP	XVCP1	Test point to measure charge pump voltage
GND	XGND2, XGND3, XGND4, XGND5, XGND6	Test points to connect to ground
CSAN, CSAP	XCSAN1, XCSAP1	Test points to measure the differential voltage at the low side shunt, which is connected to the inputs of the current sense amplifier of the device
Phase1, 2, 3	XPH1, XPH2, XPH3	Test points to measure the motor phase voltages

(table continues...)

Table 4 (continued) Test points

Signal	Designator	Description
GH1, GH2, GH3	XGH1, XGH2, XGH3	Test points to measure the gate voltage GHSx at the TLE9893-2QKW62S pin generated for the high side MOSFETs
GL1, GL2, GL3	XGL1, XGL2, XGL3	Test points to measure the gate voltage GLSx at the TLE9893-2QKW62S pin generated for the low side MOSFETs

2.1.3 LEDs

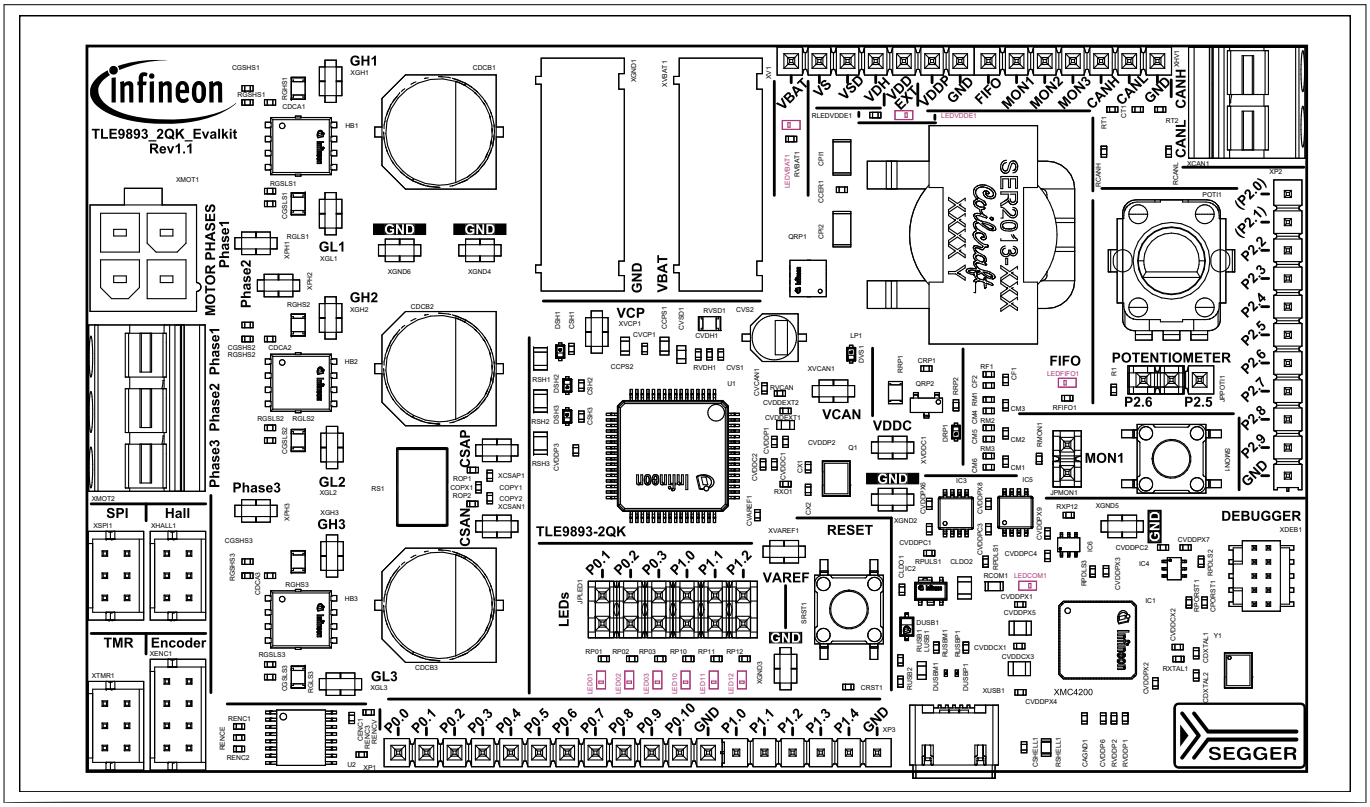

Figure 6 LEDs

Table 5 LEDs

Designator	Description
LEDVBAT1	Indicates that there is a positive voltage at VBAT
LEDFIFO1	Indicates FIFO is active
LEDCOM1	Indicates on-board debugger communication is active
LED01	Can be connected to GPIO P0.1 with jumper JPLED1, as described in Chapter Jumpers
LED02	Can be connected to GPIO P0.2 with jumper JPLED1, as described in Chapter Jumpers
LED03	Can be connected to GPIO P0.3 with jumper JPLED1, as described in Chapter Jumpers

(table continues...)

Table 5 (continued) LEDs

Designator	Description
LED10	Can be connected to GPIO P1.0 with jumper JPLED1, as described in Chapter Jumpers
LED11	Can be connected to GPIO P1.1 with jumper JPLED1, as described in Chapter Jumpers
LED12	Can be connected to GPIO P1.2 with jumper JPLED1, as described in Chapter Jumpers
LED_VDDE1	Indicates that VDDEXT is on

2.1.4 Jumpers

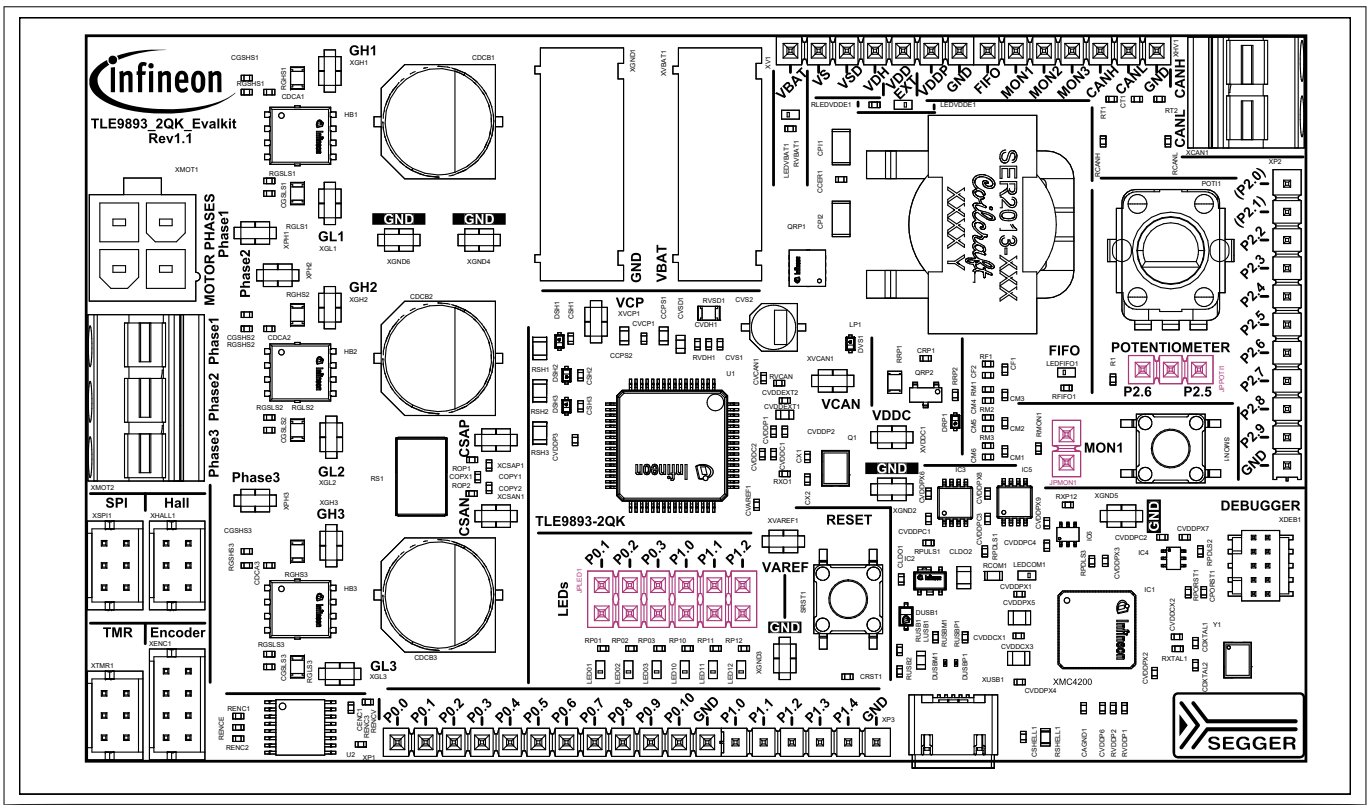

Figure 7 Jumpers

Table 6 Jumpers

Designator	Description
JPMON1	Set jumper to connect the MON1 push button to the MON1 pin of the device. Open it to disconnect the MON1 push button from the MON1 pin (pin 1 of jumper, see marking). Jumper is set by default
JPPOTI1	Set jumper to connect the **Potentiometer**signal either to the P2.5 or P2.6 analog pin of the device. Open it to disconnect **Potentiometer**signal from the analog pin of device. Jumper is set to P2.6 by default
JPLED1	Set jumpers to connect GPIOs to **LEDs.** Jumpers are set by default

2.1.5 Push buttons

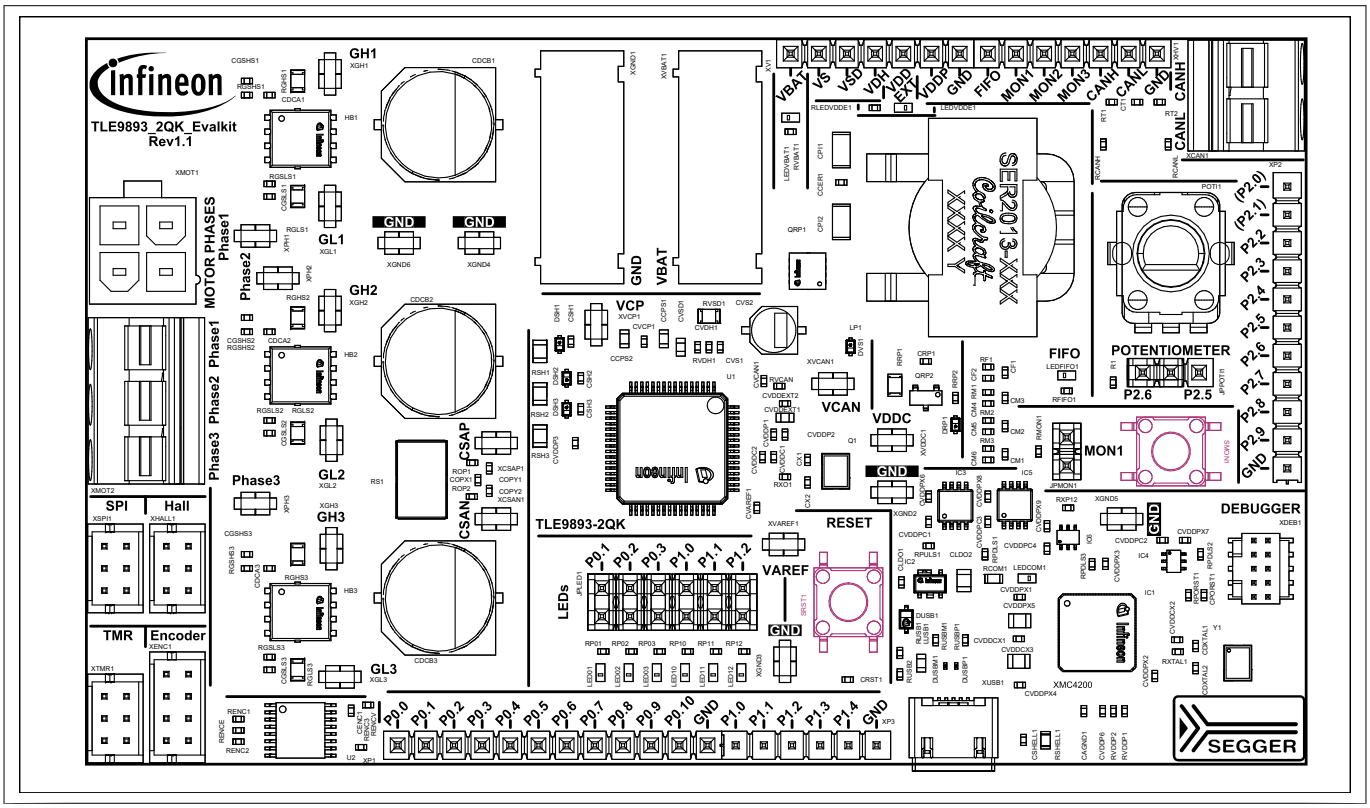

Figure 8 Push buttons

Table 7 Push buttons

Designator	Description
SMON1	SMON1 is a push button that is normally open and can be connected to the MON1 pin of the device with jumper JPMON1, as described in Jumpers. When pushing SMON1, MON1 is connected to ground. Otherwise, MON1 is connected to VBAT voltage over the RMON1 pull up.
SRST1	SRST1 is a push button that is normally open and connected to the P0.10 pin of the device. When pushing SRST1, P0.10 is connected to ground. If P0.10 is configured in the device to generate a reset, pushing this button resets the device.

2.2 Interfaces

Some pins of the TLE9893-2QKW62S are connected to multiple interfaces and connectors; hence, only certain interfaces and connectors can be used simultaneously. The table below shows which interfaces and connectors are connected to which pin of the TLE9893-2QKW62S. This table also shows which interfaces and connectors can be used at the same time. For example, XSPI1 can be used together with the XTMR1 but not with the Virtual COM port, since P1.1 can be either multiplexed to SSC1.MTSR or UART1.TXD in the device.

Table 8 TLE9893-2QKW62S's alternate functions of Px.y pins used by interfaces and connectors

	P0.1	P0.2	P0.3	P0.10	P1.0	P1.1	P1.2	P2.0	P2.1	P2.2	P2.3	P2.4	P2.5	P2.6
XSPI1		SSC1.CS0			SSC1.SCLK	SSC1.MTSR								SSC1.MRSTC
XTMR1										SDADC.IN0NA	SDADC.IN1NA	SDADC.IN0PA	SDADC.IN1PA	
XHALL1					CCU7.CCPOS2A	CCU7.CCPOS1A	CCU7.CCPOS0A							
XENC1			OUT (U2EN)				GPT12.T4INA			GPT12.T3INB		GPT12.T3EUDB		
LED01 jumper	OUT													
LED02 jumper		OUT												
LED03 jumper			OUT											
LED10 jumper					OUT									
LED11 jumper						OUT								
LED12 jumper							OUT							
Q1 XTAL CAN								SCU.XTALI						
Q1 XTAL CAN									SCU.XTALO					

(table continues...)

Table 8 (continued) TLE9893-2QKW62S's alternate functions of Px.y pins used by interfaces and connectors

	P0.1	P0.2	P0.3	P0.10	P1.0	P1.1	P1.2	P2.0	P2.1	P2.2	P2.3	P2.4	P2.5	P2.6
Reset button										PMU.RESET				
Potentiometer P2.5 jumper													ADC1.AN24	
Potentiometer P2.6 jumper														ADC1.AN25
Virtual COM port						UART1.TXD	UART1.RXDB							

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 (RGSHSx, RGSLSx), gate-source capacitors (CGSHSx, CGSLSx), and gate resistors (RGHSx, RGLSx). For each motor phase, a decoupling capacitor (CDCAx) and a DC link capacitor (CDCBx) capacitor are mounted at VDH#.

In addition, there are placement options for snubbers (RSBHSx + CSBHSx, RSBLSx + CSBLSx), and gate-drain capacitors (CGDHSx, CGDLSx). These components are not populated by default and are colored in gray in Figure 9.

Tip: The user can use a differential probe to measure the differential voltage at a gate resistor (RGHSx, RGLSx) to indirectly analyze the gate current (IGHSx, IGLSx) sourced or sunk by the TLE9893-2QKW62S's bridge driver.

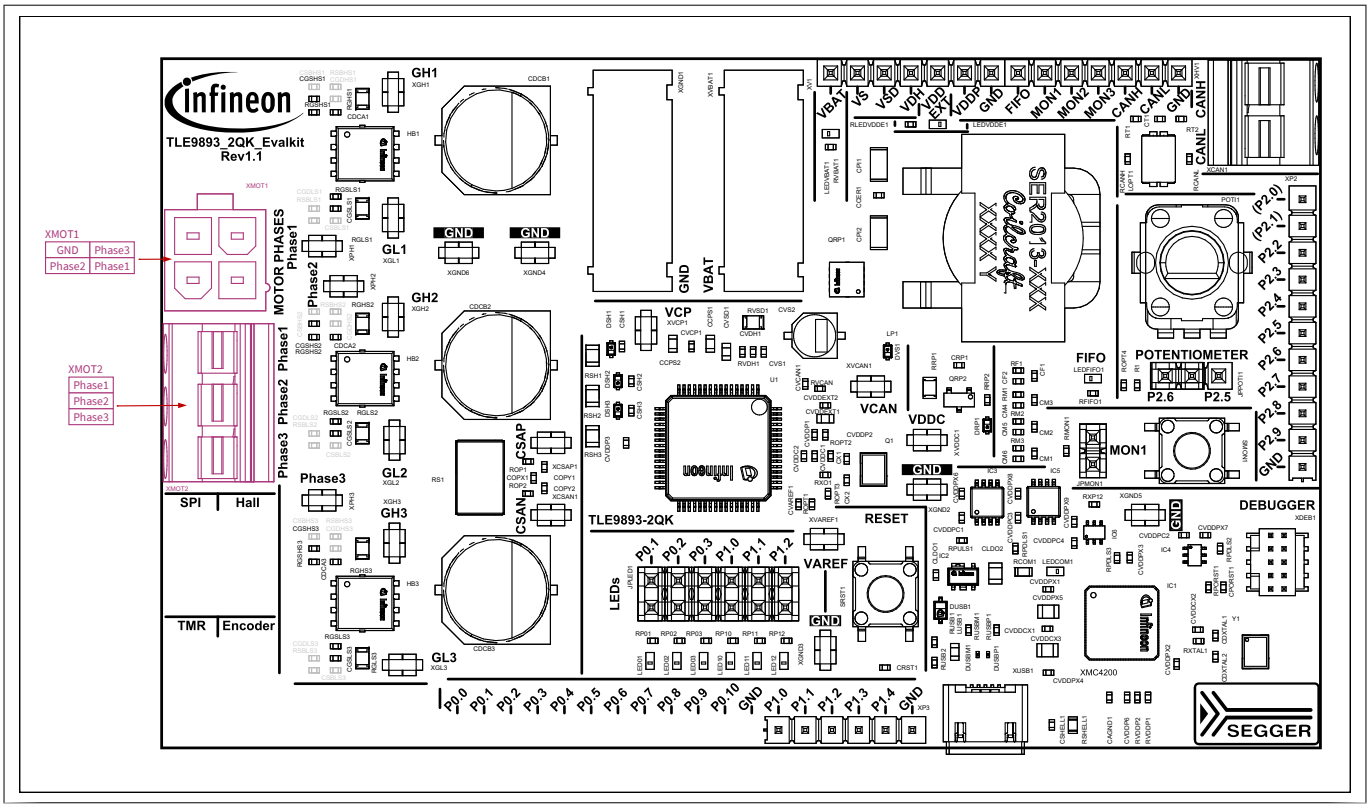

Figure 9 **Motor power stage: placement options (gray =not mounted), connectors and their pinouts (violet)**

To connect the motor phases, either the vertical PCB header socket XMOT1 with the label MOTOR PHASES or the push-in connector XMOT2 with the labels Phase1, Phase2 and Phase3 can be used.

The pinout of XMOT1 is depicted in Figure 9. The GND terminal can be optionally used for shielding.

The characteristics of the PCB header socket XMOT1 and the related parts that can be connected to it are listed in Table 9.

Table 9 **Characteristics and related parts of XMOT1**

Component	Manufacturer part number	Characteristics
PCB header socket	Molex Mini-Fit Plus 46015-0402	Vertical PCB header socket, dual row, 4 circuits, pitch 4.2 mm, max. current 13 A [5].
Crimp receptacle housing	Molex Mini-Fit Jr 39-01-2045	Receptacle housing, dual row, 4 circuits, pitch 4.2mm, max. current 13 A [5]. The crimp terminals attached to the motor phases cables should be introduced into this receptacle. This component is not delivered with the evaluation kit.

(table continues...)

Table 9 (continued) Characteristics and related parts of XMOT1

Component	Manufacturer part number	Characteristics
Crimp terminals	Molex Mini-Fit Plus 45750-1111	Crimp terminal, 18-20 AWG, max. current 13 A [5]. These terminals should be crimped to the motor phases cables and introduced into the crimp receptacle housing. This component is not delivered with the evaluation kit.

Note: 5) www.molex.com

The push-in PCB terminal block XMOT2 can be used to connect the motor phases cables directly, without needing any crimped cables, connectors, or screw driver.

The pinout of XMOT2 is depicted in Figure 9.

The characteristics of the PCB terminal block XMOT2 are listed in Table 10.

Table 10 Characteristics of XMOT2

Component	Manufacturer part number	Characteristics
PCB terminal block	Phoenix contact 1792876	Push-in spring PCB socket, one row, 3 circuits, pitch 5 mm, nominal current 16 A, cable AWG from 26 to 14 [6].

Note: 6) www.phoenixcontact.com

For more information, and manufacturer numbers of A more detailed description and manufacturer XMOT1 and XMOT2 refer to the BOM in BOM for MOTIX™ MCU TLE9893-2QK evaluation kit.

2.2.2 External motor control sensors

External SPI, TMR, Hall sensors and encoders can be connected to the PCB header sockets XSPI1, XTMR1, XHALL1 and XENC1 respectively for motor control. They can be observed in Figure 10.

Since some pins of the TLE9893-2QKW62S are connected to multiple interfaces and connectors, only certain interfaces and connectors can be used simultaneously. Refer to Table 8 for further information.

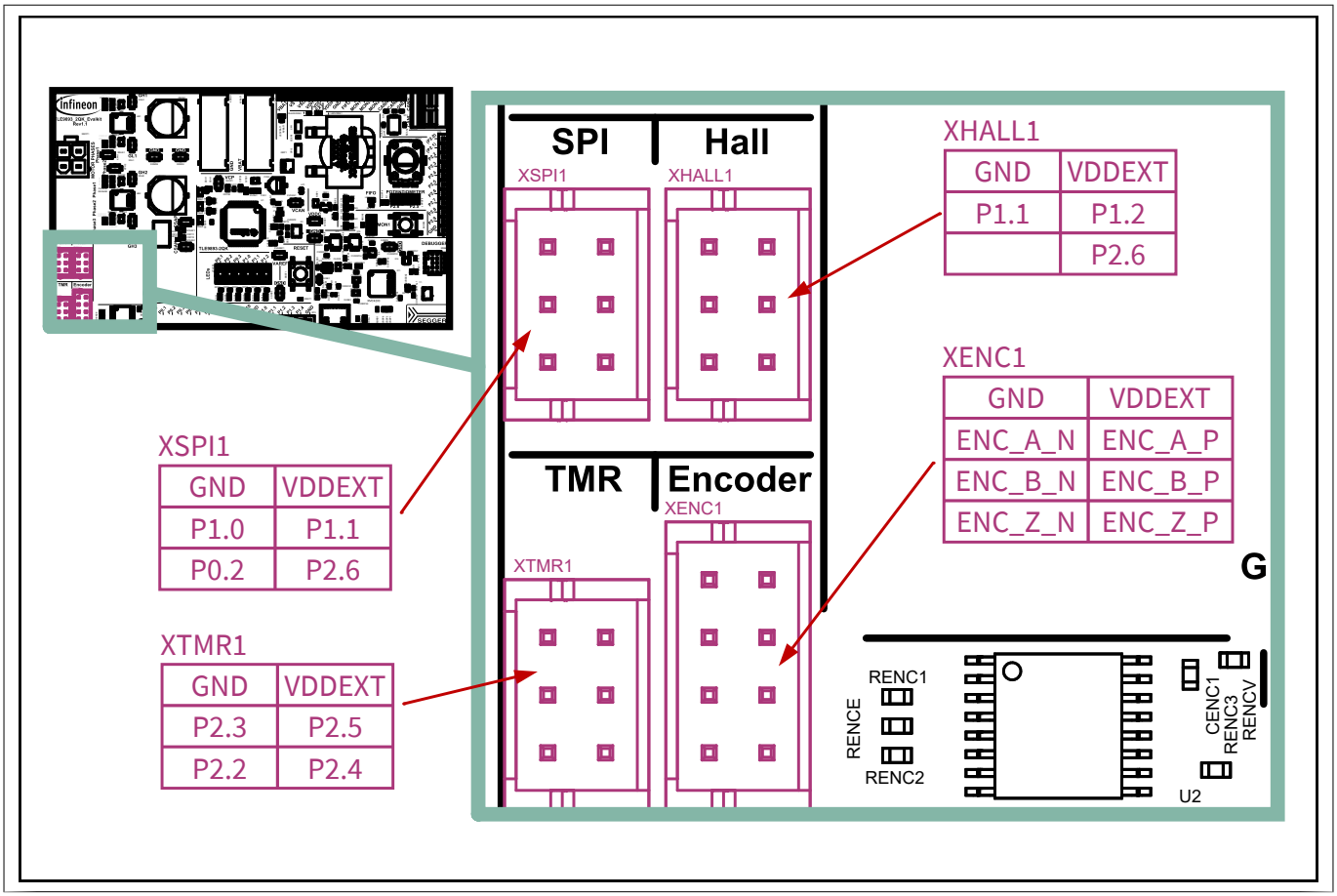

Figure 10 External motor control sensors: connectors and their pinouts (violet)

XSPI1

XSPI1, labeled on the PCB as “SPI”, presents the pinout depicted in Figure 10.

The characteristics of the PCB header socket XSPI1 and the counter parts that can be connected to it are listed in Table 11.

Table 11 Characteristics and counter parts of XSPI1

Component	Manufacturer part number	Characteristics
PCB header socket	Hirose DF11-6DP-2DSA(08)	Vertical PCB header socket, dual row, 6 circuits, pitch 2 mm, nominal current 2 A [7].
Crimp receptacle housing	Hirose DF11-6DS-2C	Receptacle housing, dual row, 6 circuits, pitch 2mm, nominal current 2 A [7]. The crimp terminals attached to the SPI sensor should be introduced into this receptacle. This component is not delivered with the evaluation kit.

(table continues...)

Table 11 (continued) Characteristics and counter parts of XSPI1

Component	Manufacturer part number	Characteristics
Crimp terminals	Hirose DF11-2428SC	Crimp terminal, 24-28 AWG, max. current 13 A [7]. These terminals should be crimped to the SPI sensor cables and introduced into the crimp receptacle housing. This component is not delivered with the evaluation kit.

Note: 7) www.hirose.com

XHALL1

XHALL1, labeled on the PCB as “HALL”, presents the pinout depicted in Figure 10.
The characteristics of the PCB header socket XHALL1 and the counter parts that can be connected to it are listed in Table 12.

Table 12 Characteristics and counter parts of XHALL1

Component	Manufacturer part number	Characteristics
PCB header socket	Hirose DF11-6DP-2DSA(08)	Vertical PCB header socket, dual row, 6 circuits, pitch 2 mm, nominal current 2 A [8].
Crimp receptacle housing	Hirose DF11-6DS-2C	Receptacle housing, dual row, 6 circuits, pitch 2mm, nominal current 2 A [8]. The crimp terminals attached to the Hall sensors should be introduced into this receptacle. This component is not delivered with the evaluation kit.
Crimp terminals	Hirose DF11-2428SC	Crimp terminal, 24-28 AWG, max. current 13 A [8]. These terminals should be crimped to the Hall sensor cables and introduced into the crimp receptacle housing. This component is not delivered with the evaluation kit.

Note: 8) www.hirose.com

XTMR1

XTMR1, labeled on the PCB as “TMR”, presents the pinout depicted in Figure 10
The characteristics of the PCB header socket XTMR1 and the counter parts that can be connected to it are listed in Table 13.

Table 13 Characteristics and counter parts of XTMR1

Component	Manufacturer part number	Characteristics
PCB header socket	Hirose DF11-6DP-2DSA(08)	Vertical PCB header socket, dual row, 6 circuits, pitch 2 mm, nominal current 2 A [9].
Crimp receptacle housing	Hirose DF11-6DS-2C	Receptacle housing, dual row, 6 circuits, pitch 2mm, nominal current 2 A [9]. The crimp terminals attached to the TMR sensor should be introduced into this receptacle. This component is not delivered with the evaluation kit.
Crimp terminals	Hirose DF11-2428SC	Crimp terminal, 24-28 AWG, max. current 13 A [9]. These terminals should be crimped to the TMR sensor cables and introduced into the crimp receptacle housing. This component is not delivered with the evaluation kit.

Note: 9) www.hirose.com

XENC1

XENC1, labeled on the PCB as “ENCODER”, presents the pinout depicted in Figure 10.

Some of these signals are not connected directly to the TLE9893-2QKW62S but to an RS-422 differential receiver. This receiver is supplied by VDDEXT and converts the differential signals from the encoder (maximum +/-14V) [10] connected at XENC1 to single ended signals (referenced to VDDEXT) connected to the TLE9893-2QKW62S, as shown in Table 14.

To enable the transceiver, P0.3 must be set to high, since P0.3 is connected to the EN pin of the differential receiver.

Note: 10) www.st.com

Table 14 Mapping of XENC1, RS-422 differential receiver and TLE9893-2QKW62S

Pin XENC1	Supply and input signals at RS-422 receiver	Resistors between differential receiver and TLE9893-2QKW62S	Single ended signal at TLE9893-2QKW62S
1	VDDEXT	RENCV (0 Ω)	VDDEXT
2	GND		GND
3	ENC_A_P	RENC1 (1 kΩ)	P2.2 (GPT12.T3INB)
4	ENC_A_N		
5	ENC_B_P	RENC2 (1 kΩ)	P2.4 (GPT12.T3EUDB)
6	ENC_B_N		
7	ENC_Z_P	RENC3 (1 kΩ)	P1.2 (GPT12.T4INA)
8	ENC_Z_N		

(table continues...)

Table 14 (continued) Mapping of XENC1, RS-422 differential receiver and TLE9893-2QKW62S

Pin XENC1	Supply and input signals at RS-422 receiver	Resistors between differential receiver and TLE9893-2QKW62S	Single ended signal at TLE9893-2QKW62S
NA	EN	RENCE (0 Ω)	P0.3 (GPIO, OUTPUT)
NA	EN_N	RENCV (0 Ω)	VDDEXT

The characteristics of the PCB header socket XENC1 and the counter parts that can be connected to it are listed in Table 15.

Table 15 Characteristics and related parts of XENC1

Component	Manufacturer part number	Characteristics
PCB header socket	Hirose DF11-8DP-2DSA(08)	Vertical PCB header socket, dual row, 8 circuits, pitch 2 mm, nominal current 2 A [11].
Crimp receptacle housing	Hirose DF11-8DS-2C	Receptacle housing, dual row, 8 circuits, pitch 2mm, nominal current 2 A [11]. The crimp terminals attached to the encoder should be introduced into this receptacle. This component is not delivered with the evaluation kit.
Crimp terminals	Hirose DF11-2428SC	Crimp terminal, 24-28 AWG, max. current 13 A [11]. These terminals should be crimped to the encoder cables and introduced into the crimp receptacle housing. This component is not delivered with the evaluation kit.

Note: 11) www.hirose.com

2.2.3 Motor current sensing

A single shunt resistor RS1 is placed on the board between the SL pin of the device and ground. The user indirectly measure the motor current consumption via the CSAP and CSAN pins of the device, together with R-C networks for filtering, as shown in .

If motor currents are applied that exceed the maximum ratings given in BOM for MOTIX™ MCU TLE9893-2QK evaluation kit, the maximum current ratings of the shunt resistor being used must be considered.

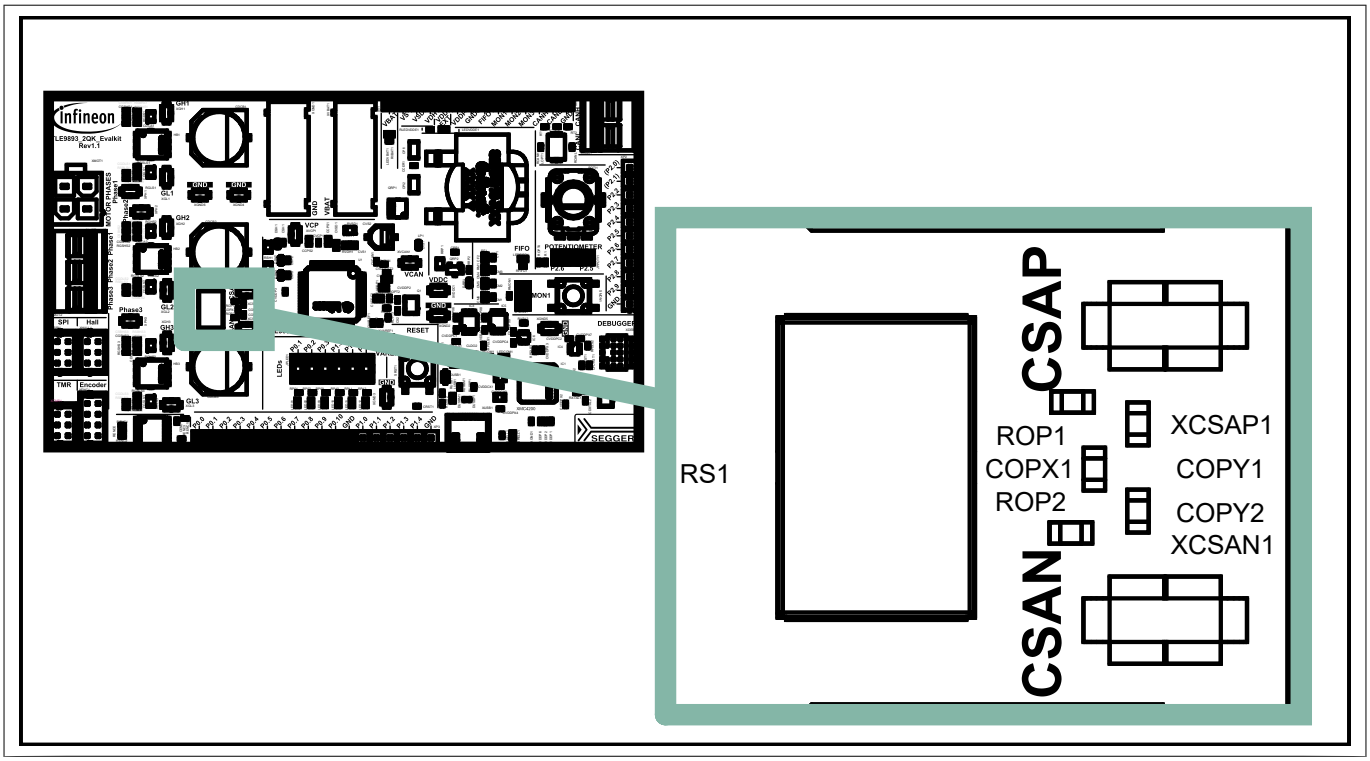

Figure 11 Motor current sensing

2.2.4 CAN

The XCAN1 PCB terminal block can be used to connect the CANH and CANL cables with clamps. The pinout for XCAN1 is depicted in Figure 12.

The CAN termination resistors RT1 and RT2 are mounted by default. Additionally, the capacitor CT1 is mounted between the resistors. A placement option is available to solder a common mode choke LOPT1, colored in gray in Figure 12. If LOPT1 is placed, the 0Ω resistors RCANH and RCANL must be removed.

By default, the VCAN pin of the TLE9893-2QKW62S is supplied by VDDP over the 0 Ω resistor RVCAN. Details are shown in Figure 12.

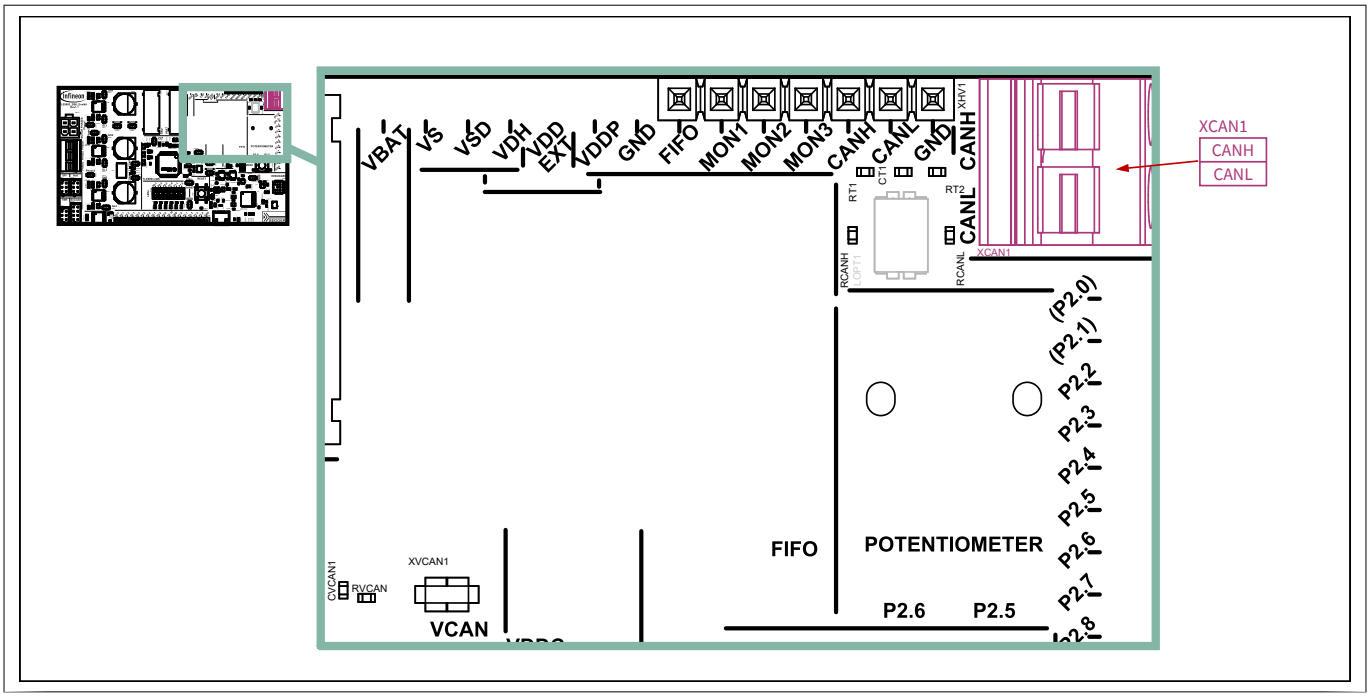

Figure 12 CAN: placement options (gray = not mounted), connector and pinout (violet)

2.2.5 Potentiometer

A potentiometer is available on the board. By default, VDDP provides the voltage for the potentiometer over R1. Optionally, R1 can be unsoldered and ROPT4 can be soldered to supply the voltage for the potentiometer over VDDEXT instead. As colored in gray in Figure 13, ROPT4 is not assembled.

By setting JPPOT1, either the TLE9893-2QKW62S's analog input P2.5 or P2.6 is connected to the adjustable wiper of the potentiometer.

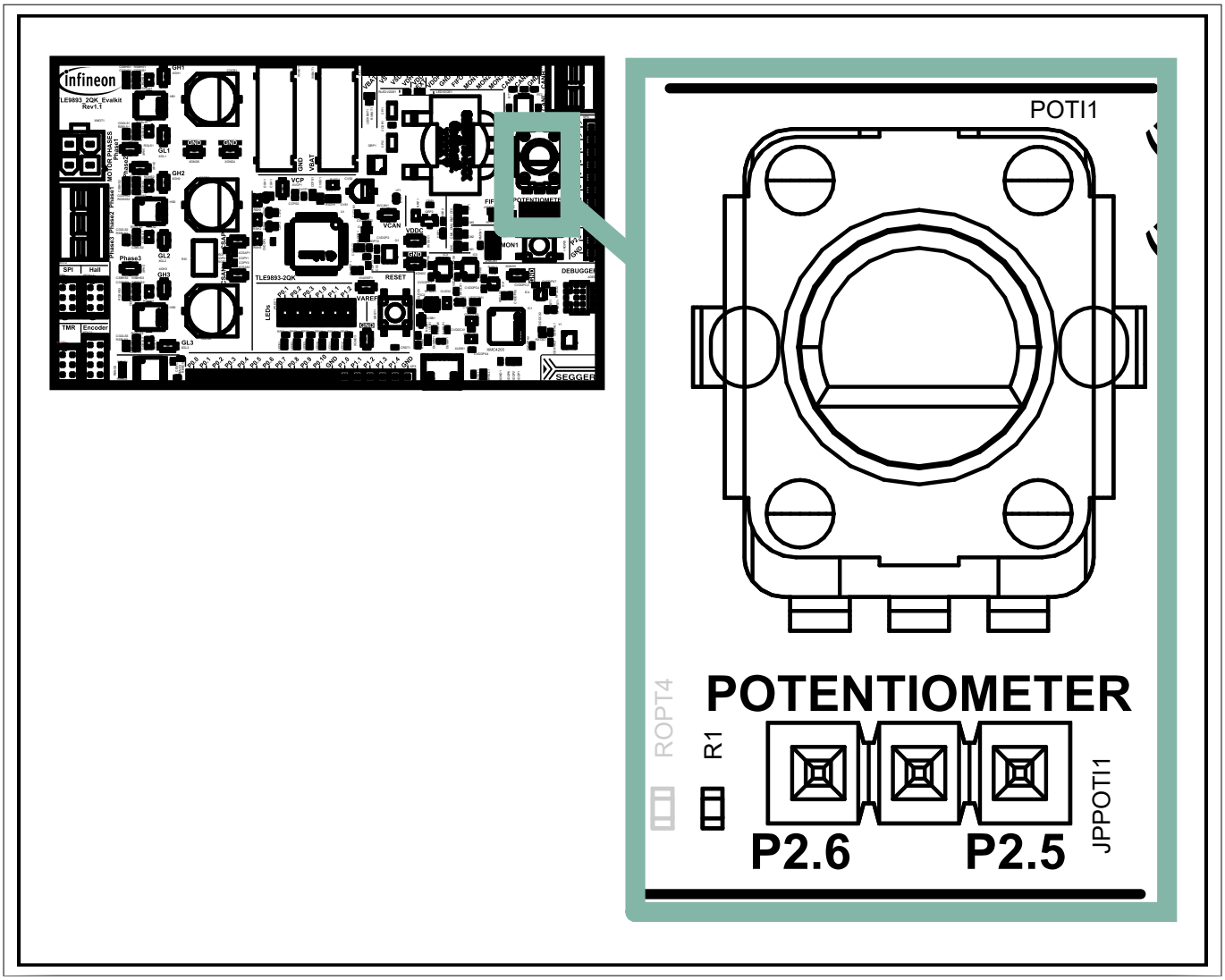

Figure 13 Pinout of JPPOT1 and placement option for potentiometer

2.2.6 Signal pin headers

The signal pin Header XV1 contains some of the voltage domains available on the evaluation kit.

XHV1 contains high voltage inputs and outputs and the CAN signals.

XP2 contains analog inputs which also can be used as digital inputs.

XP3 and XP1 contain digital inputs and outputs.

The pin headers have a standard pitch of 2.54mm and are placed close to the edges of the evaluation kit. The pinouts of these headers are shown in Figure 14.

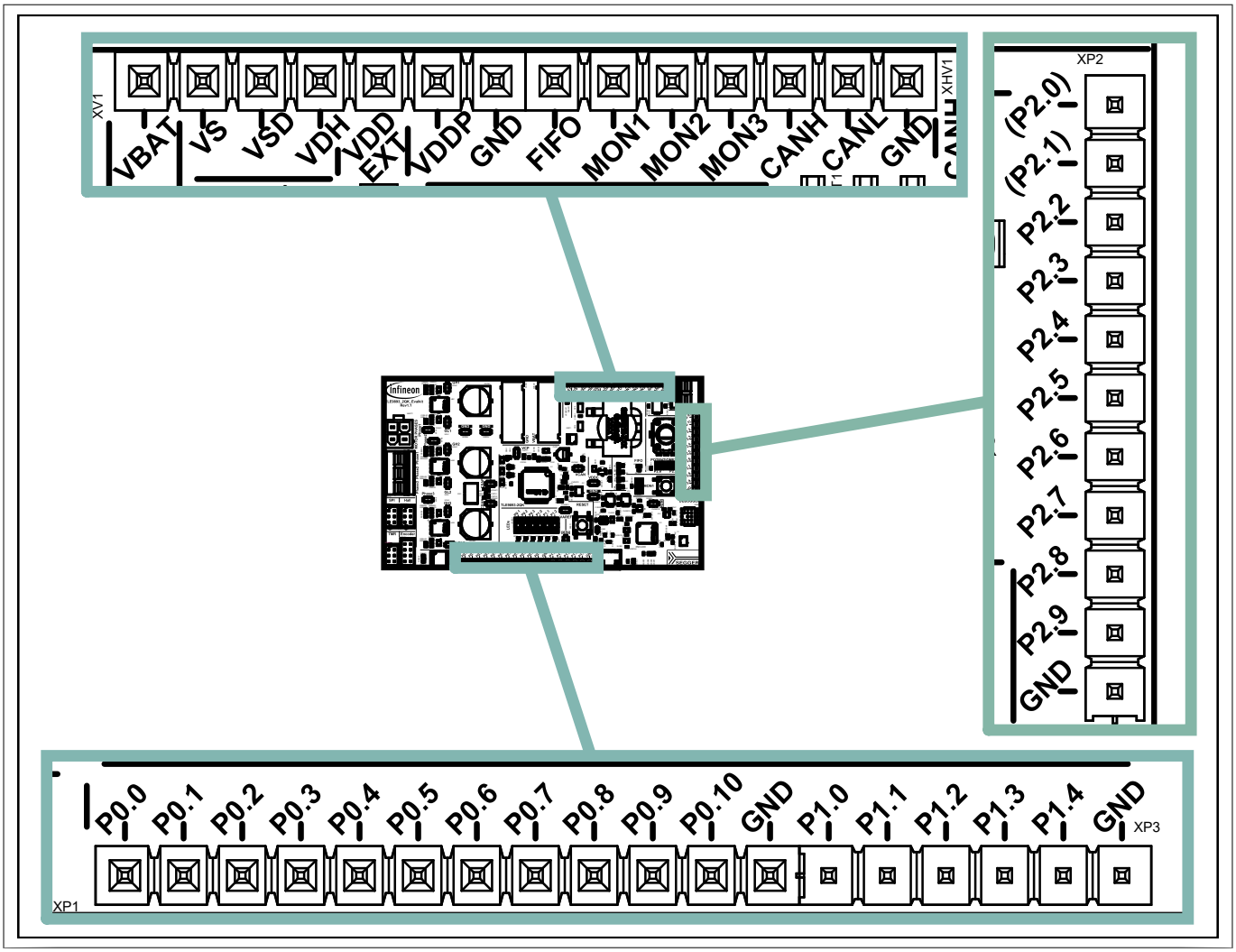

Figure 14 Pinout of XV1, XHV1, XP1, XP2, and XP3 (from top left to bottom right)

Pin P2.0 and P2.1 of the TLE9893-2QKW62S are not connected to the pin header XP2 by default, because they are routed to the external oscillator Q1 (high precision oscillator for CAN communication). For this reason, their labels include a parenthesis at XP2. To connect them to the pin header, a placement option for 0Ω resistors ROPT2 and ROPT3 is available, as colored in gray in Figure 15.

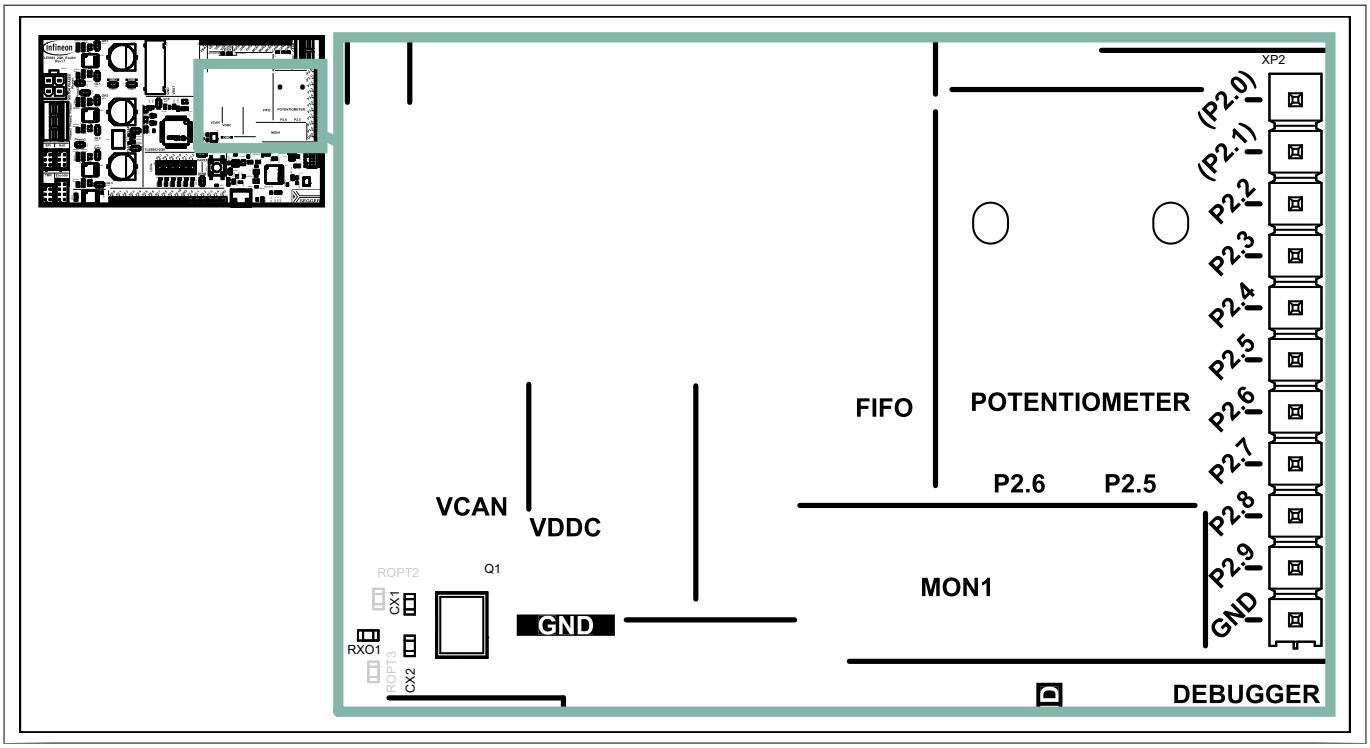

Figure 15 Placement option for using P2.0 and P2.1 at the signal pin header XP2

2.2.7 Debugging and virtual COM port

On the board, a SEGGER J-Link debugger is provided, and can be connected using a USB cable. Alternatively, an off-board debugger, such as the ARM®KEIL ULINK2 or the XMC™ Link can be used via the SWD interface. The on-board debugger also provides a virtual COM port for UART communication over P1.1 (UART1.TXD) and P1.2 (UART1.RXDB) of the TLE9893-2QKW62S.

Since the idle state of UART communication is high, P1.2 stays high once it has been driven by the on-board debugger by the virtual COM port (for example with a PC serial console). P1.2 stays high until the USB cable is disconnected and connected again. This pin is not driven if the on-board debugger is only used to flash the TLE9893-2QKW62S. If the user wants to disconnect P1.2 from the on-board debugger, the resistor RXP12 can be unsoldered. The on-board debugger with the USB socket and the SWD interface is shown in Figure 16.

If the on-board debugger is not available or cannot be used, an off-board debugger like the ARM®KEIL ULINK2 or an XMC™ Link can be connected via the SWD interface XDEB1. It consists of a 10-pin header (2 x 5) with 1.27 mm pitch. The pinout of the SWD interface is depicted in Figure 16.

These off-board debuggers are not delivered with the evaluation kit.

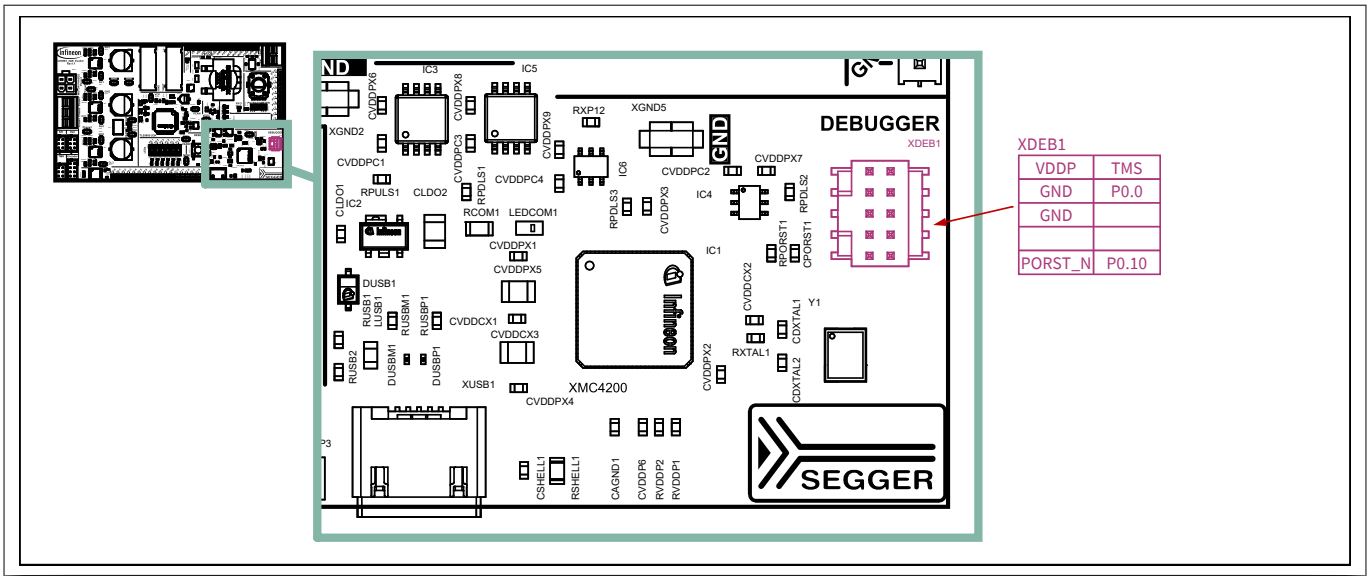

Figure 16 On-board debugger and virtual COM port, connector and pinout (violet)

3 Assembly options

The evaluation kit has components that are not assembled by default, which can be soldered by the user if necessary. These components are highlighted in red in Assembly options and are listed in Table 16.

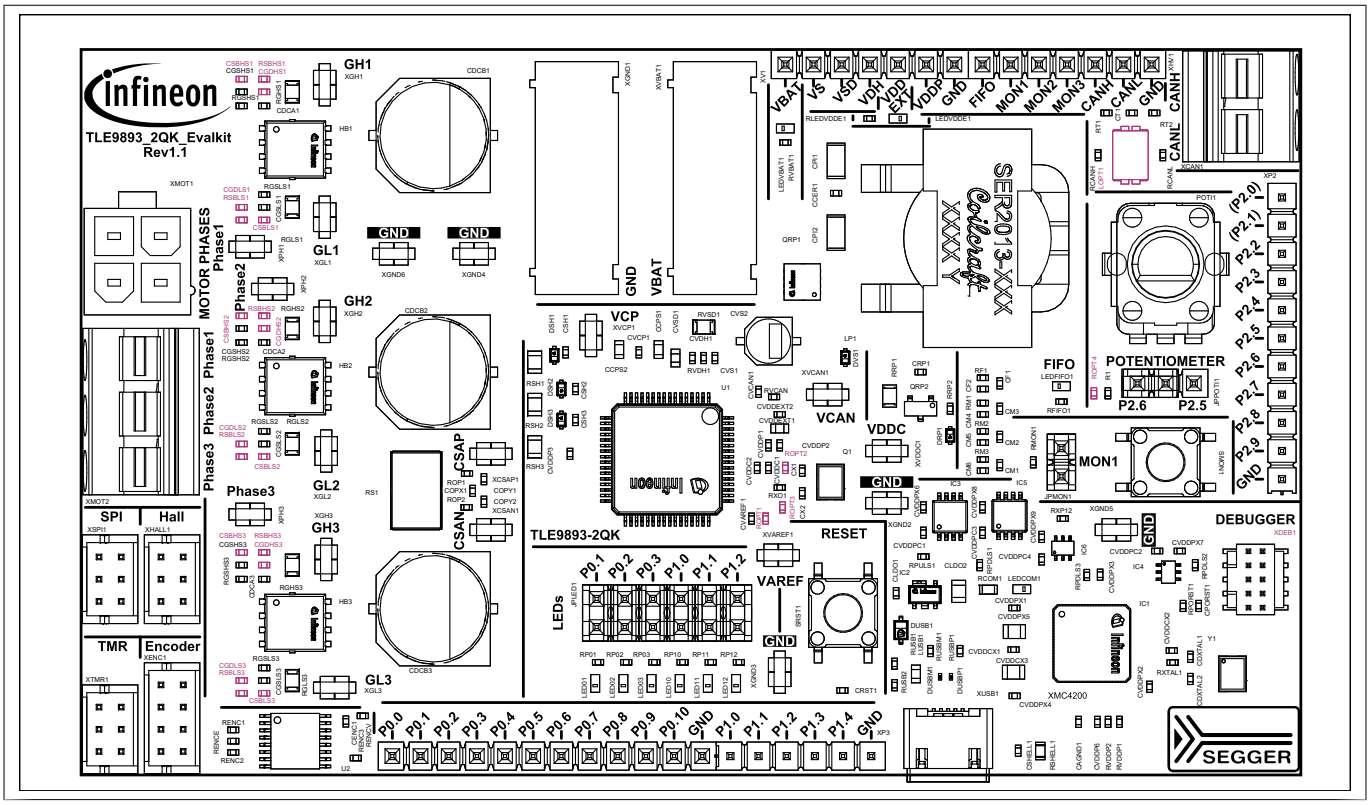

Figure 17 Overview placement positions

Values for these optional additional placements must be determined depending on the application. The recommended components and values can be found in the BOM in BOM for MOTIX™ MCU TLE9893-2QK evaluation kit.

Table 16 Additional placements

Designator	Description
CGDHS1	Gate-drain capacitor high-side MOSFET phase 1
CSBHS1	Capacitor snubber high-side MOSFET phase 1
RSBHS1	Resistor snubber high-side MOSFET phase 1
CGDLS1	Gate-drain capacitor low-side MOSFET phase 1
CSBLS1	Capacitor snubber low-side MOSFET phase 1
RSBLS1	Resistor snubber low-side MOSFET phase 1
CGDHS2	Gate-drain capacitor high-side MOSFET phase 2
CSBHS2	Capacitor snubber high-side MOSFET phase 2
RSBHS2	Resistor snubber high-side MOSFET phase 2
CGDLS2	Gate-drain capacitor low-side MOSFET phase 2
CSBLS2	Capacitor snubber low-side MOSFET phase 2
RSBLS2	Resistor snubber low-side MOSFET phase 2
CGDHS3	Gate-drain capacitor high-side MOSFET phase 3

(table continues...)

Table 16 (continued) Additional placements

Designator	Description
CSBHS3	Capacitor snubber high-side MOSFET phase 3
RSBHS3	Resistor snubber high-side MOSFET phase 3
CGDLS3	Gate-drain capacitor low-side MOSFET phase 3
CSBLS3	Capacitor snubber low-side MOSFET phase 3
RSBLS3	Resistor snubber low-side MOSFET phase 3
LOPT1	CAN common mode choke. If placed, remove RCANH and RCANL
ROPT1	Resistor that connects the pin VAREF to VDDEXT. If placed, the device must be configured so that it does not generate VAREF internally
ROPT2	Resistor that connects the pin P2.0 with the signal pin header XP2. If placed, the external oscillator Q2 cannot be used (high precision oscillator for CAN communication)
ROPT3	Resistor that connects the pin P2.1 with the signal pin header XP2. If placed, the external oscillator Q2 cannot be used (high precision oscillator for CAN communication)
ROPT4	Resistor that connects the pin VDDEXT to the potentiometer POTI1. If placed, remove the resistor R1 (that connects the pin VDDP to POTI1).

4 Software toolchain

To install the toolchain, refer to www.infineon.com/tle989x and follow the instructions in the Getting started guide.

5 Design files

5.1 BOM for MOTIX™ MCU TLE9893-2QK evaluation kit

Mostly automotive-qualified components have used for the MOTIX™ MCU TLE9893-2QK evaluation kit. The complete BOM is shown below and includes non-mounted components.

Notice that due to components shortage, some of the components below might differ slightly from those mounted.

Table 17 BOM MOTIX™ MCU TLE9893-2QK evaluation kit

Designator	Description	Quantity	Manufacturer order number
CAGND1, CCER1, CDCA1, CDCA2, CDCA3, CENC1, CLDO1, CRP1, CSHELL1, CVAREF1, CVDDC1, CVDDCX1, CVDDCX2, CVDDEXT2, CVDDP1, CVDDP3, CVDDP6, CVDDPC1, CVDDPC2, CVDDPC3, CVDDPC4, CVDDPX1, CVDDPX2, CVDDPX3, CVDDPX4, CVDDPX6, CVDDPX7, CVDDPX8, CVDDPX9, CVS1	Multilayer Ceramic Chip Capacitor	30	CGA2B3X7R1H104K050BB
CCPS1, CCPS2	CAP / CERA / 220nF / 50V / 10% / X7R (EIA) / -55°C to 125°C / 0603(1608) / SMD / -	2	GCM188R71H224KA64
CDCB1, CDCB2, CDCB3	Aluminum electrolytic capacitor, FT Series,Type V	3	EEEFT1V561AP
CDXTAL1, CDXTAL2	Chip monolithic ceramic capacitor	2	GCM1555C1H120JA16
CF1, CM1, CM2, CM3, CPORST1	Multilayer ceramic chip capacitor 10000 pF 50 V ±10%, CAP / - / 10nF / 50V / 10% / X7R (EIA) / -55°C to 125°C / 0402 (1005) / SMD / -	5	CGA2B3X7R1H103K050BB

(table continues...)

Table 17 (continued) BOM MOTIX™ MCU TLE9893-2QK evaluation kit

Designator	Description	Quantity	Manufacturer order number
CF2, CM4, CM5, CM6, COPX1, COPY1, COPY2, CRST1, CVDH1	Multilayer ceramic chip capacitor 0.001uF 50V C0G 5%, CAP / - / 1nF / 50V / 5% / C0G (EIA) / NP0 / -55°C to 150°C / 0402 (1005) / SMD / -	9	CGA2B2NP01H102J050BA
CGSHS1, CGSHS2, CGSHS3, CGSLS1, CGSLS2, CGSLS3, CT1	Multilayer ceramic chip capacitor 0.0047uF 50Vdc X7R 10%	7	CGA2B2X7R1H472K050BA
CLDO2, CVDDPX5	CAP / CERA / 10uF / 10V / 10% / X7R (EIA) / -55°C to 125°C / 0805(2012) / SMD / -	2	GCM21BR71A106KE22
CPI1, CPI2	CGA series multilayer ceramic chip capacitor	2	CGA5L1X7R1H106K160AC
CSH1, CSH2, CSH3	Chip monolithic ceramic capacitor	3	GCM1555C1H471JA16
CVCAN1, CVDDP2	Chip monolithic ceramic capacitor,1 µF ,10V	2	GCM155C71A105KE38D
CVCP1	Multilayer ceramic chip capacitor,470 nF, 10 V	1	CGA2B3X7S1A474K050BE
CVDDC2	Multilayer ceramic chip capacitor,330 nF ,10V	1	CGA2B3X7S1A334K050BB
CVDDCX3	CAP / CERA / 4.7uF / 16V / 10% / X7R (EIA) / -55°C to 125°C / 0805(2012) / SMD / -	1	GCM21BR71C475KA73
CVDDEXT1, CVSD1	Multilayer ceramic chip capacitor	2	CGA3E3X5R1H105K080AB
CVS2	Aluminum electrolytic capacitor 22 µF, 35V	1	EEEFT1V220AR
CX1, CX2	Multilayer ceramic chip capacitor 10pF 50V C0G 0.5pF	2	CGA2B2NP01H100D050BA
DRP1, DSH1, DSH2, DSH3, DVS1	Silicon Schottky diode	5	BAS52-02V
DUSB1	Silicon Schottky diode	1	BAT60A
DUSBM1, DUSBP1	Bi-directional TVS Protection Device, 5.5V, 3.5pF	2	ESD231-B1-W0201
HB1, HB2, HB3		3	IAUC60N04S6N031H

(table continues...)

Table 17 (continued) BOM MOTIX™ MCU TLE9893-2QK evaluation kit

Designator	Description	Quantity	Manufacturer order number
IC1	Microcontroller with ARM Cortex-M4 Core with powerful on-chip peripheral subsystems, temp range(-40°C to 125°C)	1	XMC4200Q48K256ABXUMA1
IC2	Fixed linear voltage post regulator, 3.3V	1	TLS202B1MBV33
IC3, IC5	Dual-bit, dual-supply voltage bus transceiver with configurable voltage translation and 3-state outputs	2	SN74LVC2T45DCTT
IC4, IC6	Single-bit non-inverting bus transceiver	2	SN74LVC1T45DCKR
JPLED1	Through hole .025'' SQ Post Header, 2.54mm pitch, 12 pin, vertical, double row	1	TSW-106-05-L-D
JPMON1	Through hole .025'' SQ Post Header, 2.54mm pitch, 2 pin, vertical, single row	1	HTSW-102-07-L-S
JPPOTI1	Through hole .025'' SQ Post Header, 2.54mm pitch, 3 pin, vertical, single row	1	HTSW-103-07-L-S
Jumper1, Jumper2, Jumper3, Jumper4, Jumper5, Jumper6, Jumper7, Jumper8	Jumper, 1x2-Positions, Pitch 2,54mm, Body 5,08x2,54mm, black, Au, with handle	8	SNT-100-BK-G-H
LED01, LED02, LED03, LED10, LED11, LED12, LEDCOM1, LEDFIFO1, LEDVBAT1, LEDVDDE1	Standard 0603 SMD LED, 2.1V red, luminous Intensity 63 mcd, low current 0603 SMD LED	10	TLMS1100-GS08, TLMS1000-GS08
LP1	Shielded power	1	SER2013-472MLB
LUSB1	chip ferrite beads BLM series	1	BLM18PG600SN1D
MP1	USB 4P(A)/M - MICRO USB 5P(B)/M	1	3025033-01

(table continues...)

Table 17 (continued) BOM MOTIX™ MCU TLE9893-2QK evaluation kit

Designator	Description	Quantity	Manufacturer order number
POTI1	RES / VAR / 10k / 50mW / 20% / - / -10°C to 70°C / THT, 2.5 mm pitch, 5 Pins, 11.80 mm L X 11.40 mm W X 15 mm H body / THT / -	1	RK09K1130A6S
Q1	Surface mount compact crystal unit	1	NX3225GA-16.000M-STD-CRG-2
QRP1	OptiMOS™ T3 N-channel enhancement power-transistor	1	IPZ40N04S5-3R1
QRP2	NPN general-purpose transistor	1	BC817K-40R
R1, RCANH, RCANL, RENCE, RENCV, RVCAN, RXP12	Standard thick film chip resistor	7	CRCW04020000Z0
RCOM1	Automotive grade thick film chip resistor	1	AC0603FR-07680RL
RENC1, RENC2, RENC3, RF1, RM1, RM2, RM3, RVDH1	Standard thick film chip resistor	8	CRCW04021K00FK
RFIFO1, RMON1, RVBAT1	Standard thick film chip resistor	3	CRCW040222K0FK
RGHS1, RGHS2, RGHS3, RGLS1, RGLS2, RGLS3, RVSD1	2R/0.5W/1%, RES / STD / 2R / 500mW / 1% / 100ppm/K / - / 0805 (1210) / SMD / -	7	CRCW08052R00FKEAHP
RGSHS1, RGSHS2, RGSHS3, RGSLS1, RGSLS2, RGSLS3	Standard thick film chip resistor	6	CRCW0402100KFK
RLEDVDDE1, RP01, RP02, RP03, RP10, RP11, RP12	Standard thick film chip resistor	7	CRCW04021K50FK
ROP1, ROP2	Standard thick film chip resistor	2	CRCW040212R0FK
RPDLS1, RPDLS2, RPDLS3, RPORST1, RRP2, RUSB2	Standard thick film chip resistor	6	CRCW040210K0FK
RPULS1, RUSB1, RVDDP1, RVDDP2	Standard thick film chip resistor	4	CRCW04024K70FK
RRP1	RES / STD / 10k / 125mW / 1% / 100ppm/K / -55°C to 155°C / 0805 / SMD / -	1	CRCW080510K0FK

(table continues...)

Table 17 (continued) BOM MOTIX™ MCU TLE9893-2QK evaluation kit

Designator	Description	Quantity	Manufacturer order number
RS1	RES / STD / 15mR / 7W / 1% / - / -65°C to 170°C / 2818 / SMD / -	1	WSHM2818R0150FEA
RSH1, RSH2, RSH3	RES / STD / 10R / 500mW / 5% / 200ppm/K / - / 0805 (1210) / SMD / -	3	CRCW080510R0JNEAHP
RSHELL1	Standard thick film chip resistor	1	CRCW06031M10FK
RT1, RT2	Standard thick film chip resistor	2	CRCW040262R0FK
RUSBM1, RUSBP1	Standard thick film chip resistor	2	CRCW040222R0FK
RXO1	Standard thick film chip resistor	1	CRCW0402100RFK
RXTAL1	Standard thick film chip resistor	1	CRCW0402150RFK
SMON1, SRST1	WS-TASV SMT tact switch, normally open 1,3:2,4	2	430182043816
U1	Microcontroller with CAN-FD and NFET driver for BLDC applications	1	TLE9893-2QKW62S
U2	ST26C32A Series 5 V CMOS quad 3 state differential line driver	1	ST26C32ABTR
XCAN1	PCB terminal block, nominal current: 16 A, rated voltage : 400 V, 2 positions	1	1792863
XCSAN1, XCSAP1, XGH1, XGH2, XGH3, XGL1, XGL2, XGL3, XGND2, XGND3, XGND4, XGND5, XGND6, XPH1, XPH2, XPH3, XVAREF1, XVCAN1, XVCP1, XVDDC1	Test point, compact, surface mount, finish-silver plate	20	5019
XDEB1	SMT micro header, 1.27mm pitch, 10 pin, vertical, double row, keying shroud,DAP	1	FTSH-105-01-L-DV-K
XENC1	CONNECTOR HEADER VERTICAL 8 POSITION 2MM	1	DF11-8DP-2DSA(08)

(table continues...)

Table 17 (continued) BOM MOTIX™ MCU TLE9893-2QK evaluation kit

Designator	Description	Quantity	Manufacturer order number
XGND1	Banana Socket, black, 17.5mm Pitch	1	973 582-100
XHALL1, XSPI1, XTMR1	CONNECTOR HEADER VERTICAL 6 POSITION 2MM	3	DF11-6DP-2DSA(08)
XHV1, XV1	Through hole .025 SQ Post Header, 2.54mm pitch, 7 pin, vertical, single row	2	TSW-107-07-L-S
XMOT1	VERTICAL HEADER ASSEMBLY, 4 pins, double row	1	46015-0402
XMOT2	PCB terminal block, nominal current: 12 A, Nom. voltage: 400 V, 3 Positions	1	1792876
XP1	Through hole .025'' SQ Post Header, 2.54mm pitch, 12 pin, vertical, single row	1	TSW-112-07-L-S
XP2	Through hole .025'' SQ Post Header, 2.54mm pitch, 11 pin, vertical, single row	1	TSW-111-07-L-S
XP3	Through hole .025'' SQ Post Header, 2.54mm pitch, 6 pin, vertical, single row	1	TSW-106-07-L-S
XUSB1	Micro USB 2.0 Type B - horizontal - SMT	1	629105150521
XVBAT1	Banana Socket, Red, 17.5mm Pitch	1	973 582-101
Y1	SMD Crystal, 12 MHz, Temperature Range (-40°C to 125°C)	1	CX3225CA12000D0HSSCC

5.2 Schematics for MOTIX™ MCU TLE9893-2QK evaluation kit

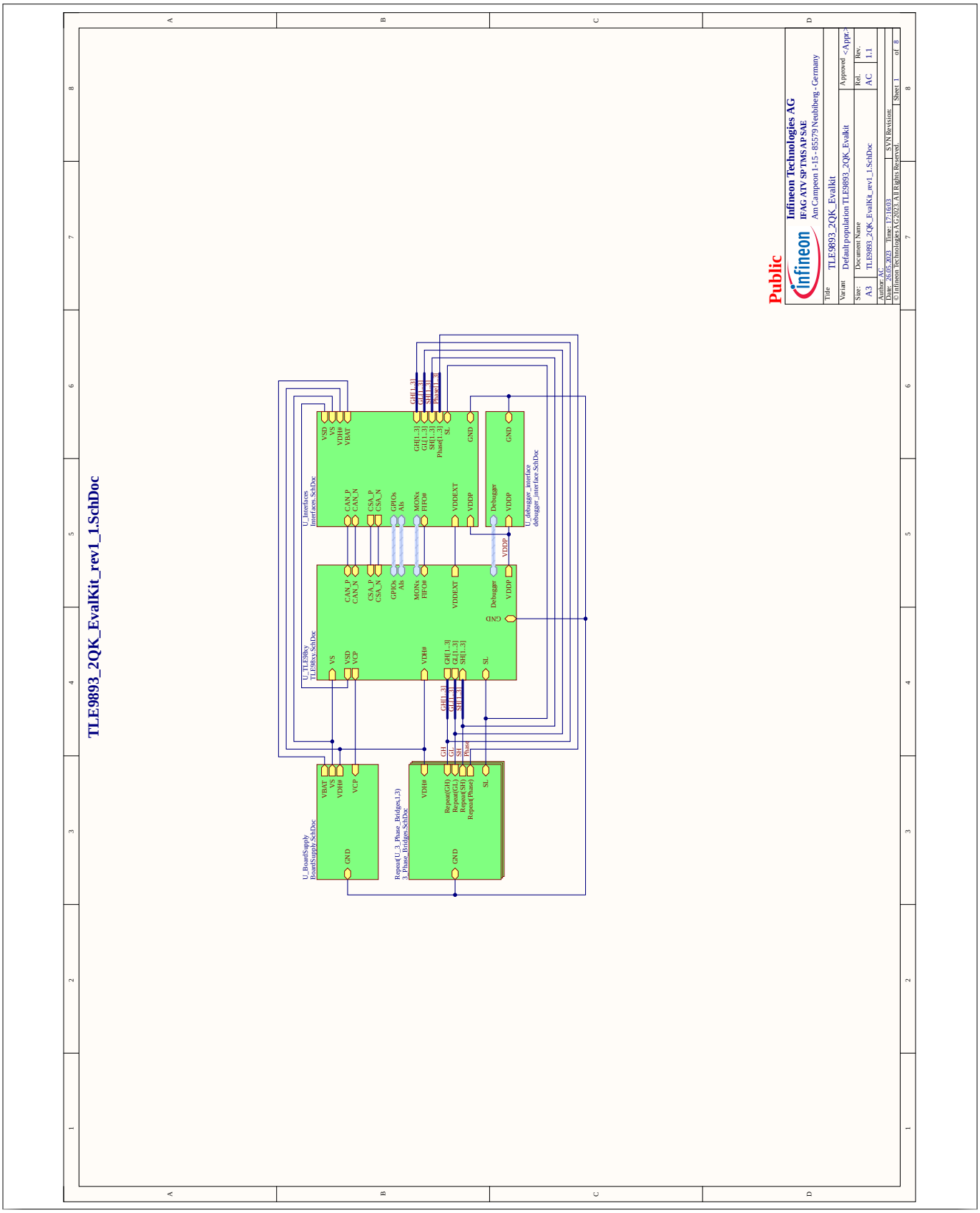

Figure 18 MOTIX™ MCU TLE9893-2QK evaluation kit, sheet 1

5 Design files

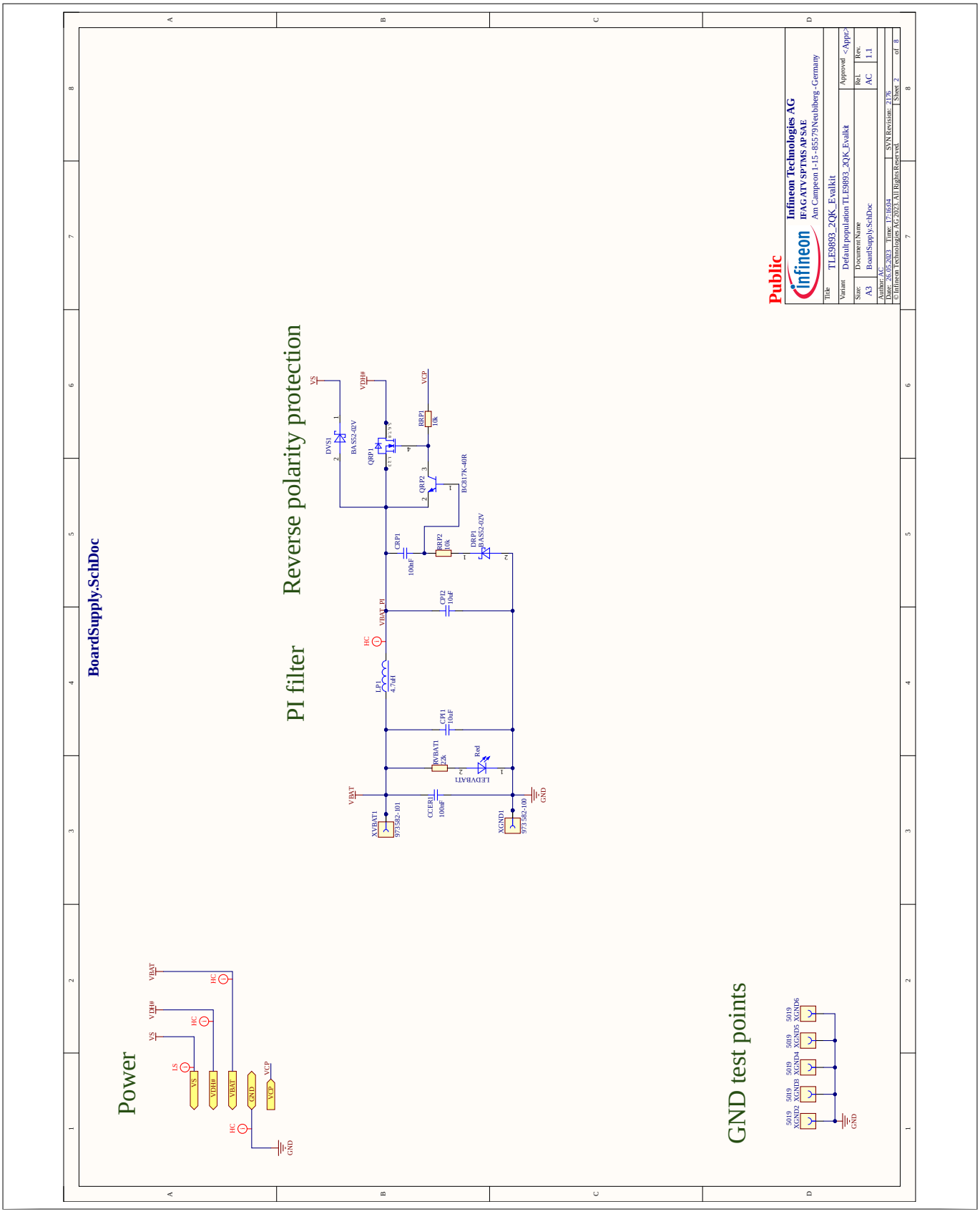

Figure 19 MOTIX™ MCU TLE9893-2QK evaluation kit, sheet 6, BoardSupply

5 Design files

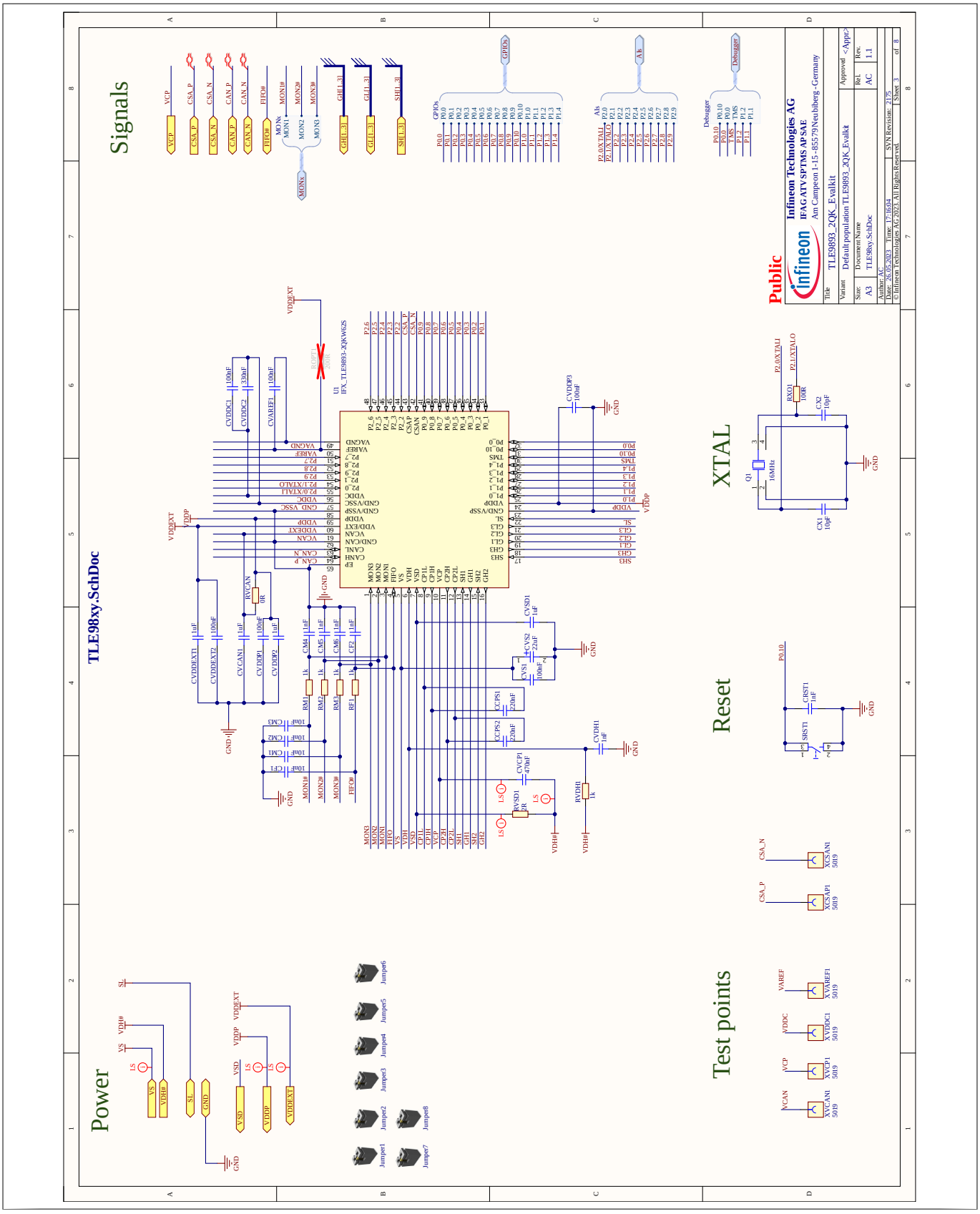

Figure 20 **MOTIX™ MCU TLE9893-2QK evaluation kit, sheet 2, TLE9893-2QKW62S**

5 Design files

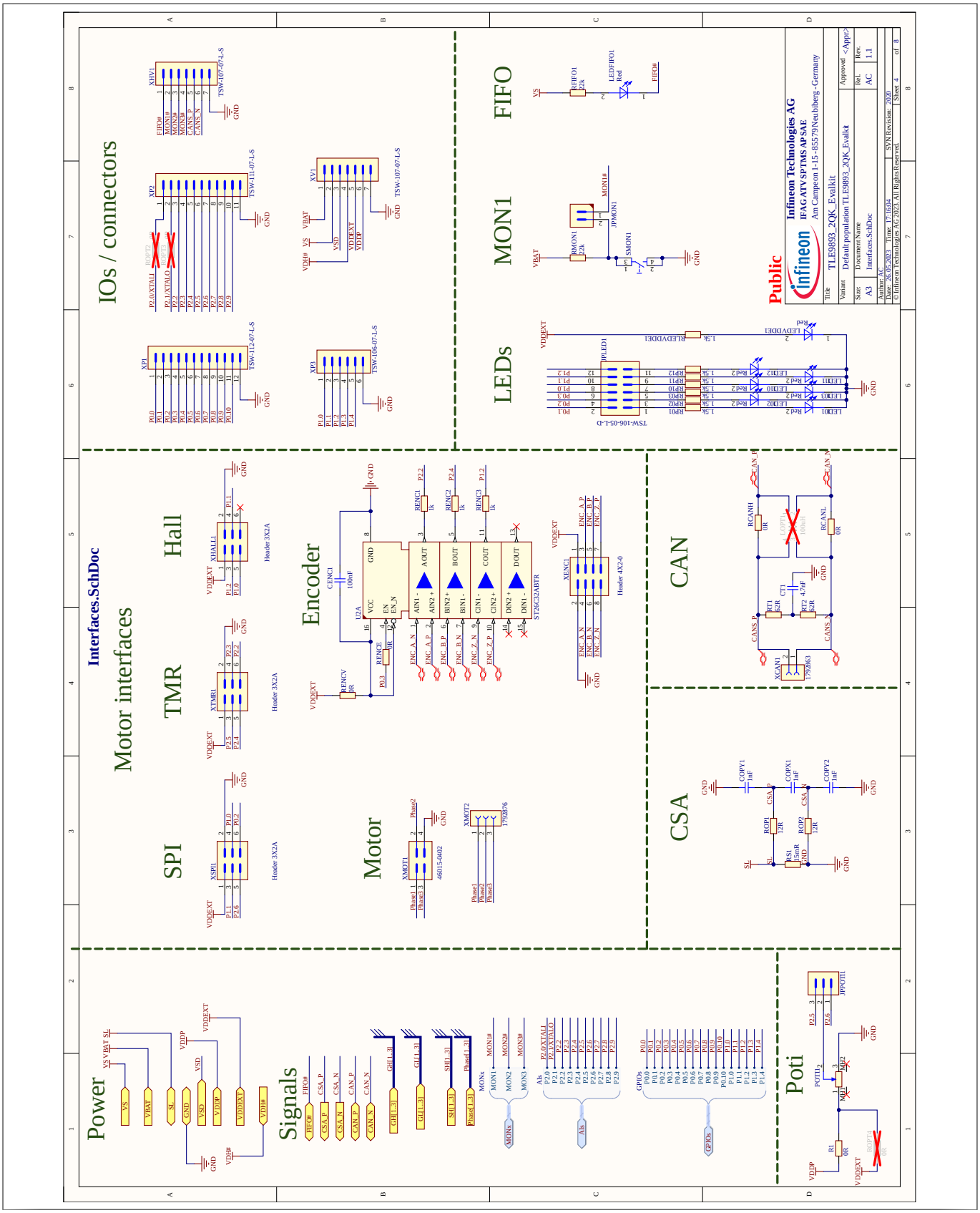

Figure 21 MOTIX™ MCU TLE9893-2QK evaluation kit, sheet 5, Interfaces

5 Design files

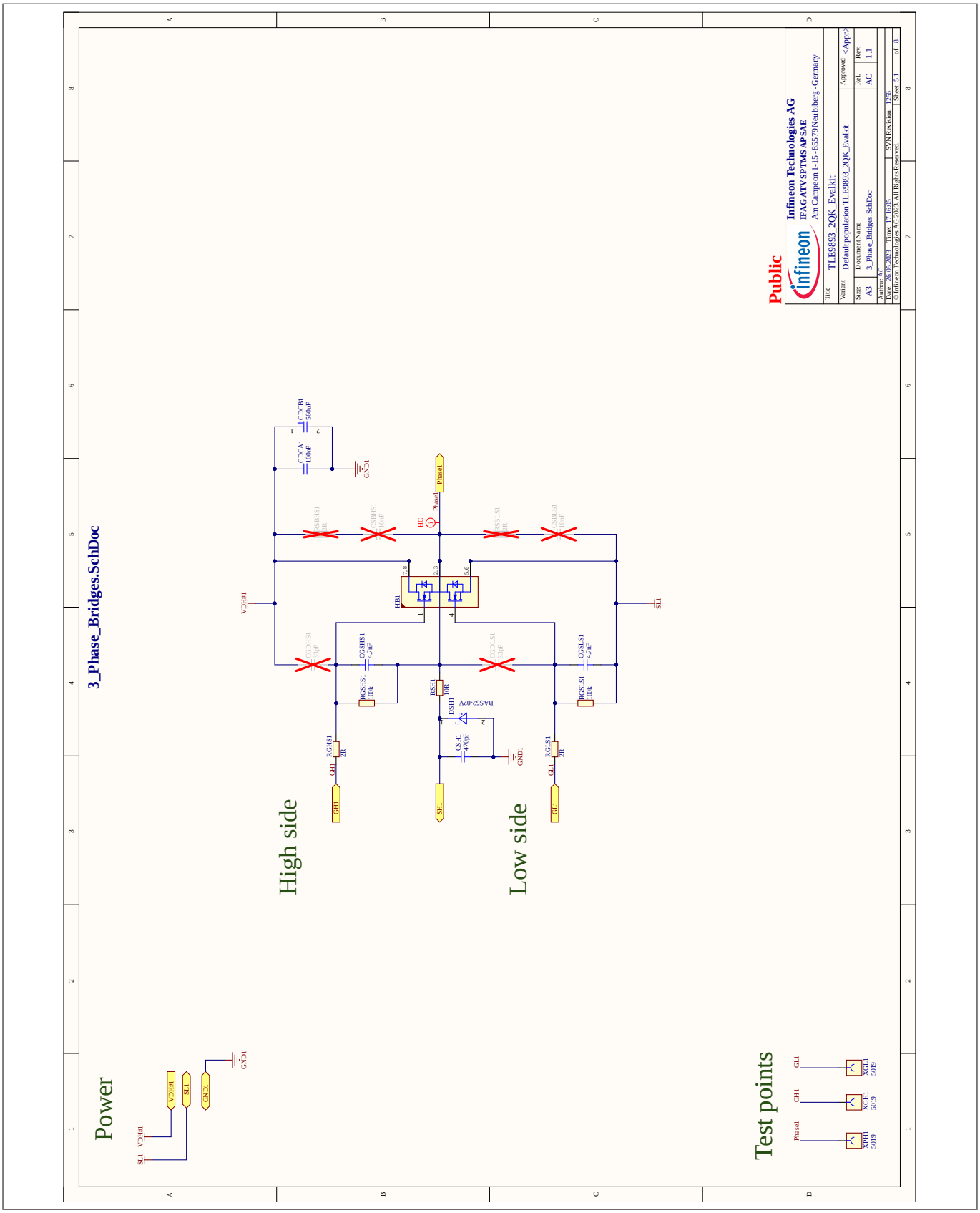

Figure 22 MOTIX™ MCU TLE9893-2QK evaluation kit, sheet 3.1, 3_Phase_Bridges

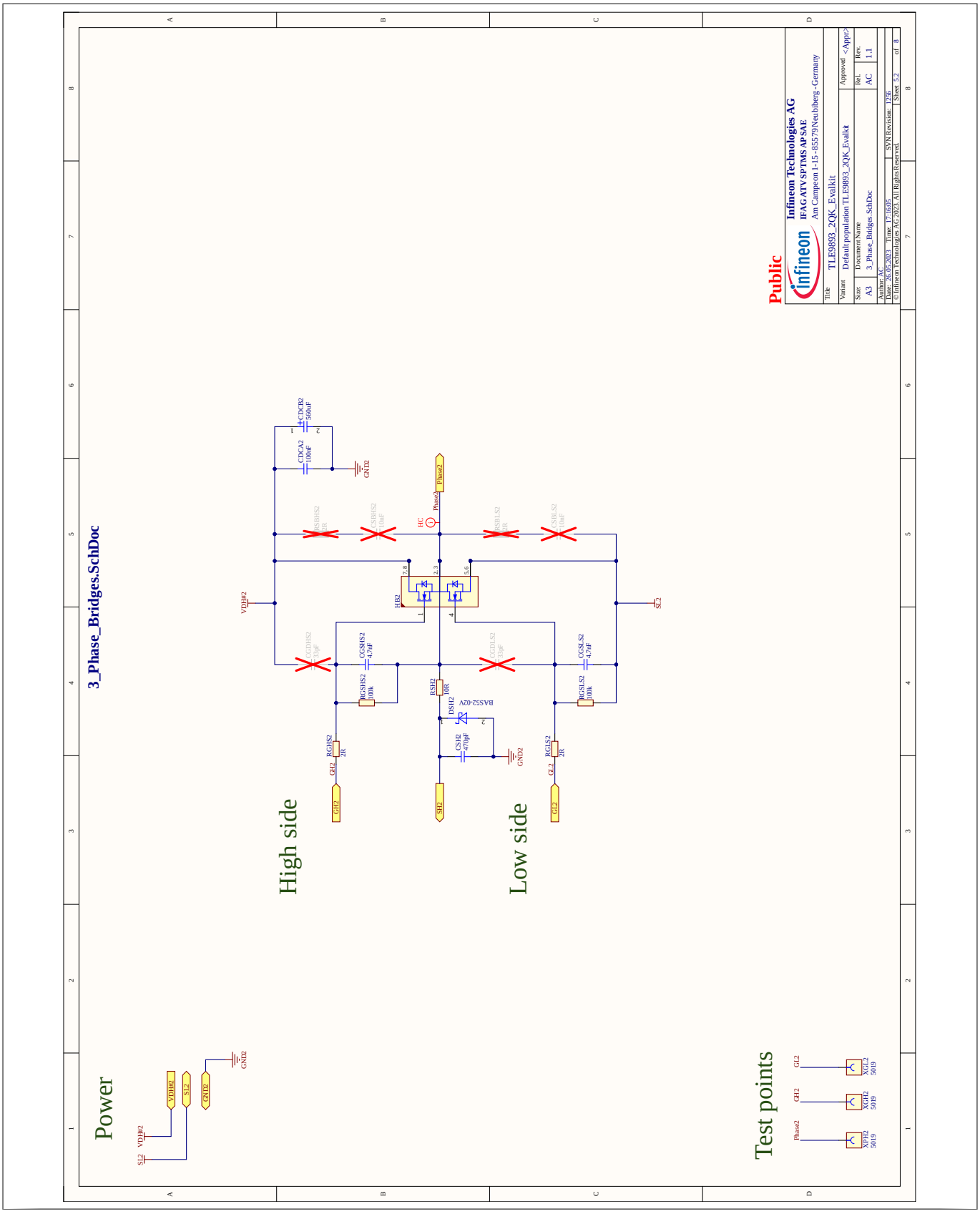

Figure 23 MOTIX™ MCU TLE9893-2QK evaluation kit, sheet 3.2, 3_Phase_Bridges

5 Design files

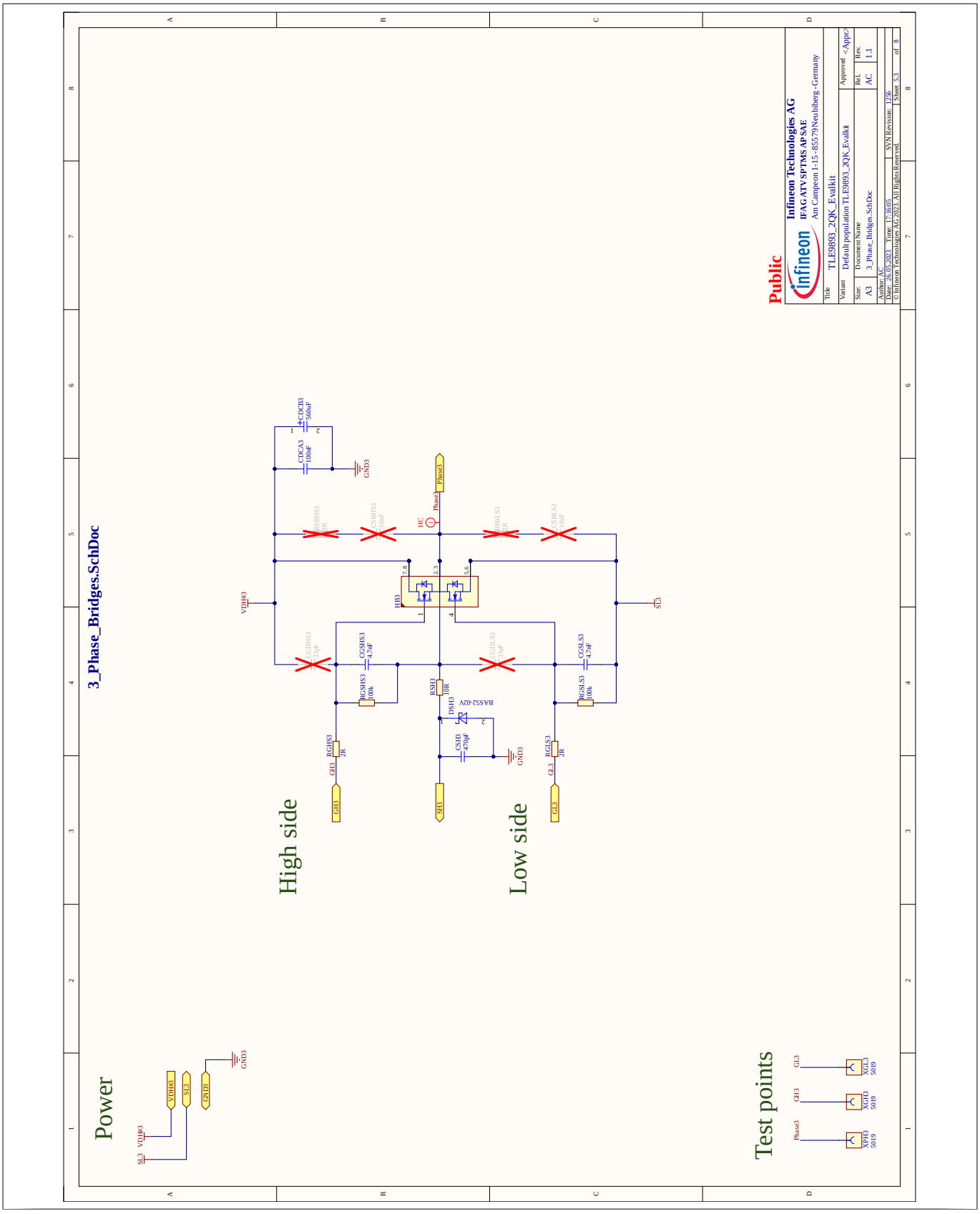

Figure 24 MOTIX™ MCU TLE9893-2QK evaluation kit, sheet 3.3, 3_Phase_Bridges

5 Design files

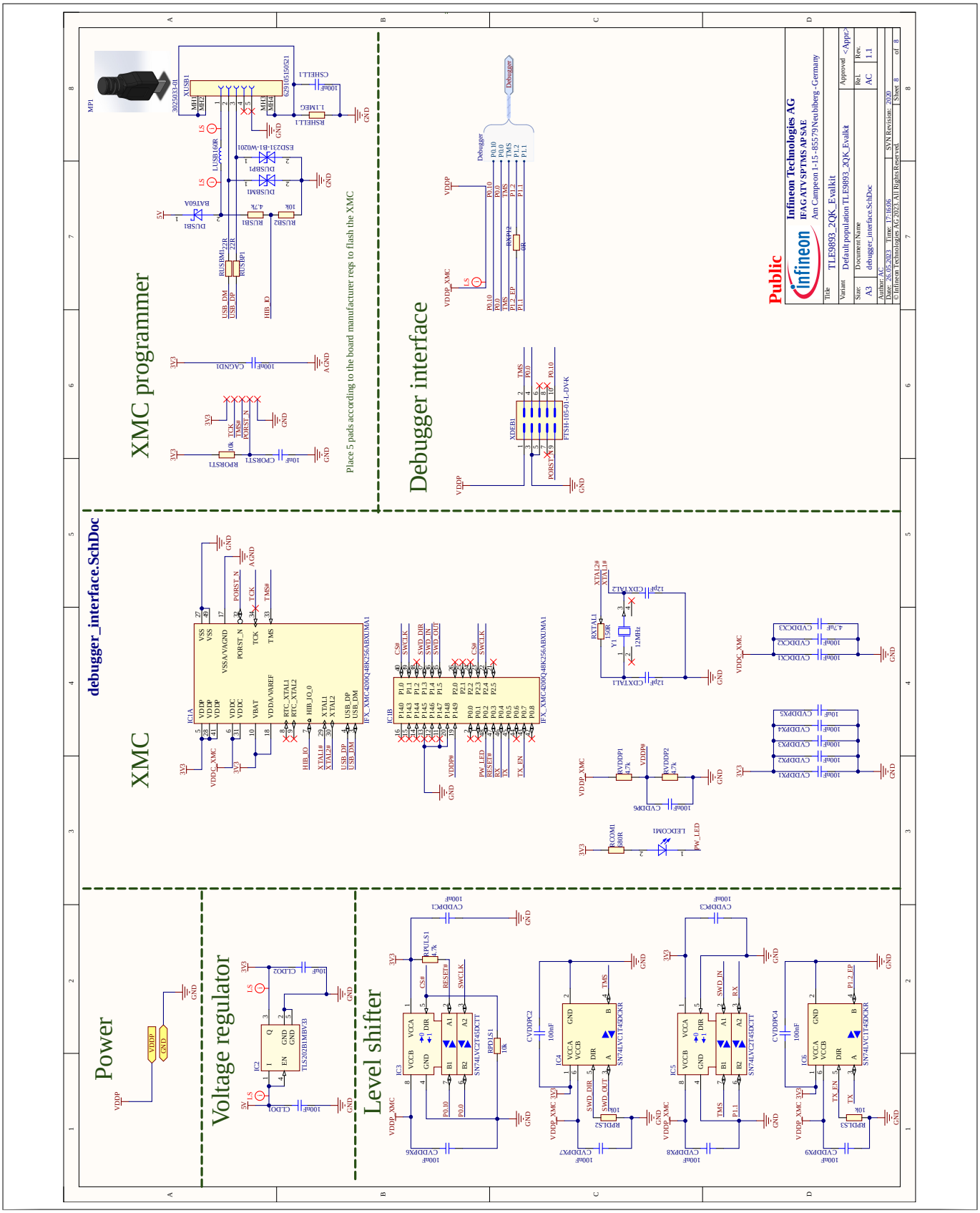

Figure 25 MOTIX™ MCU TLE9893-2QK evaluation kit, sheet 4, debugger_interface

5.3 Layout MOTIX™ MCU TLE9893-2QK evaluation kit

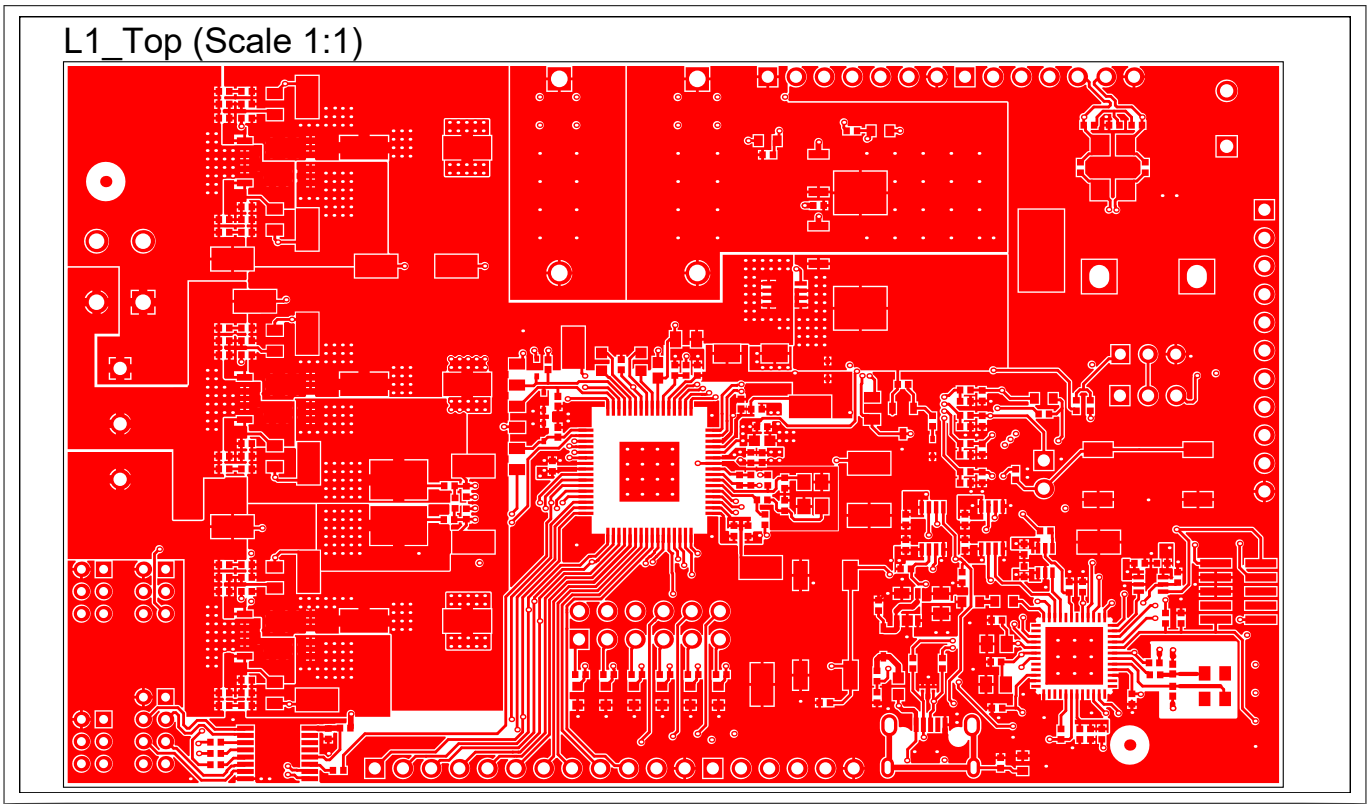

Figure 26 MOTIX™ MCU TLE9893-2QK evaluation kit, layer1 (Top layer, signal)

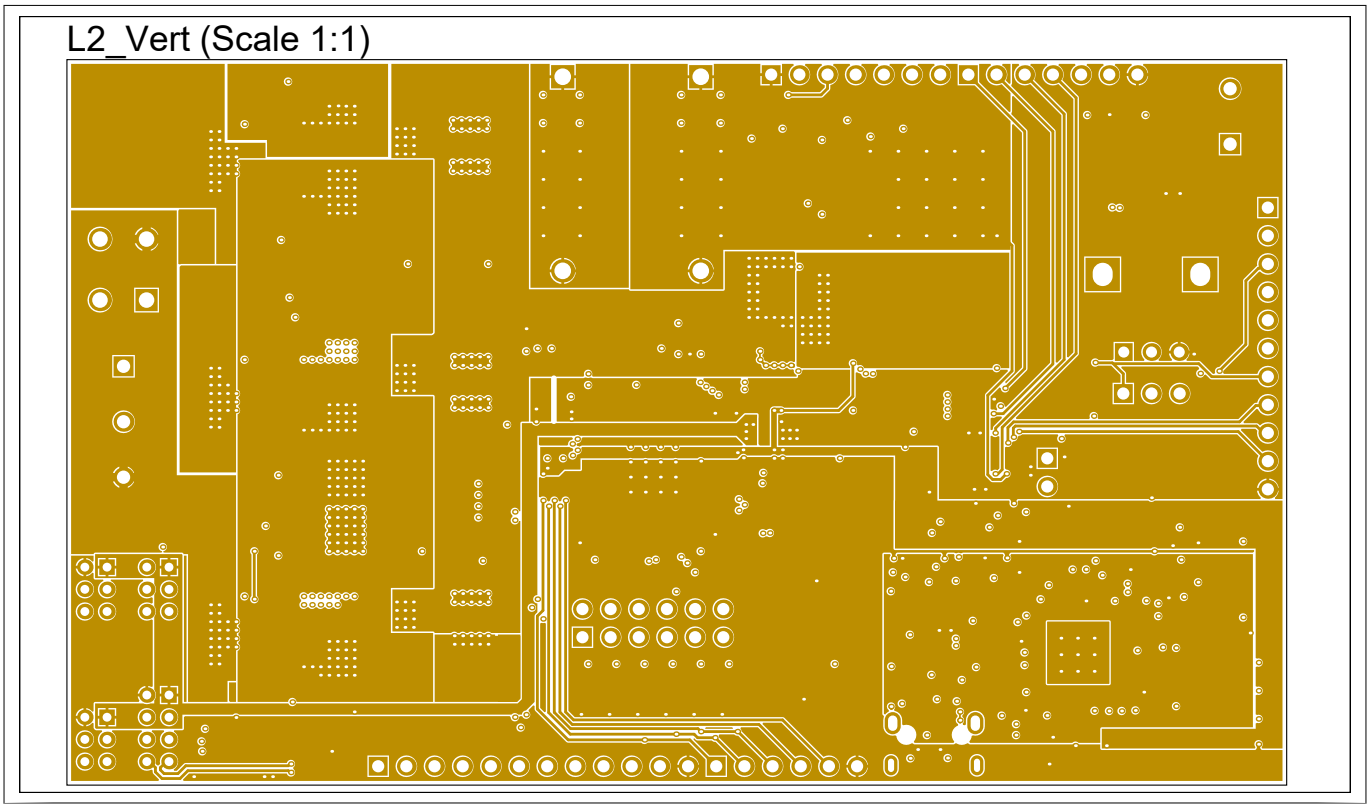

Figure 27 MOTIX™ MCU TLE9893-2QK evaluation kit, layer2 (Middle layer, power)

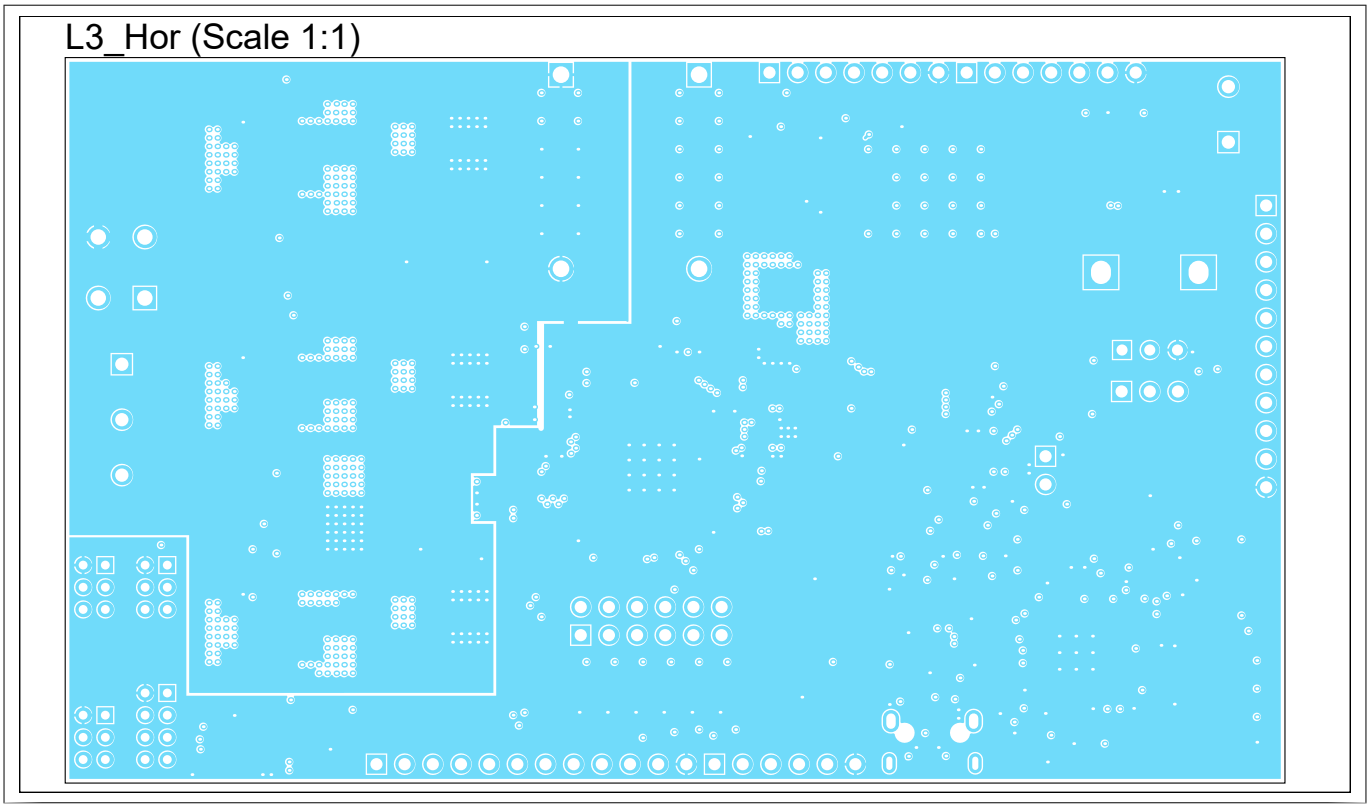

Figure 28 **MOTIX™ MCU TLE9893-2QK evaluation kit, layer3 (Middle layer, GND)**

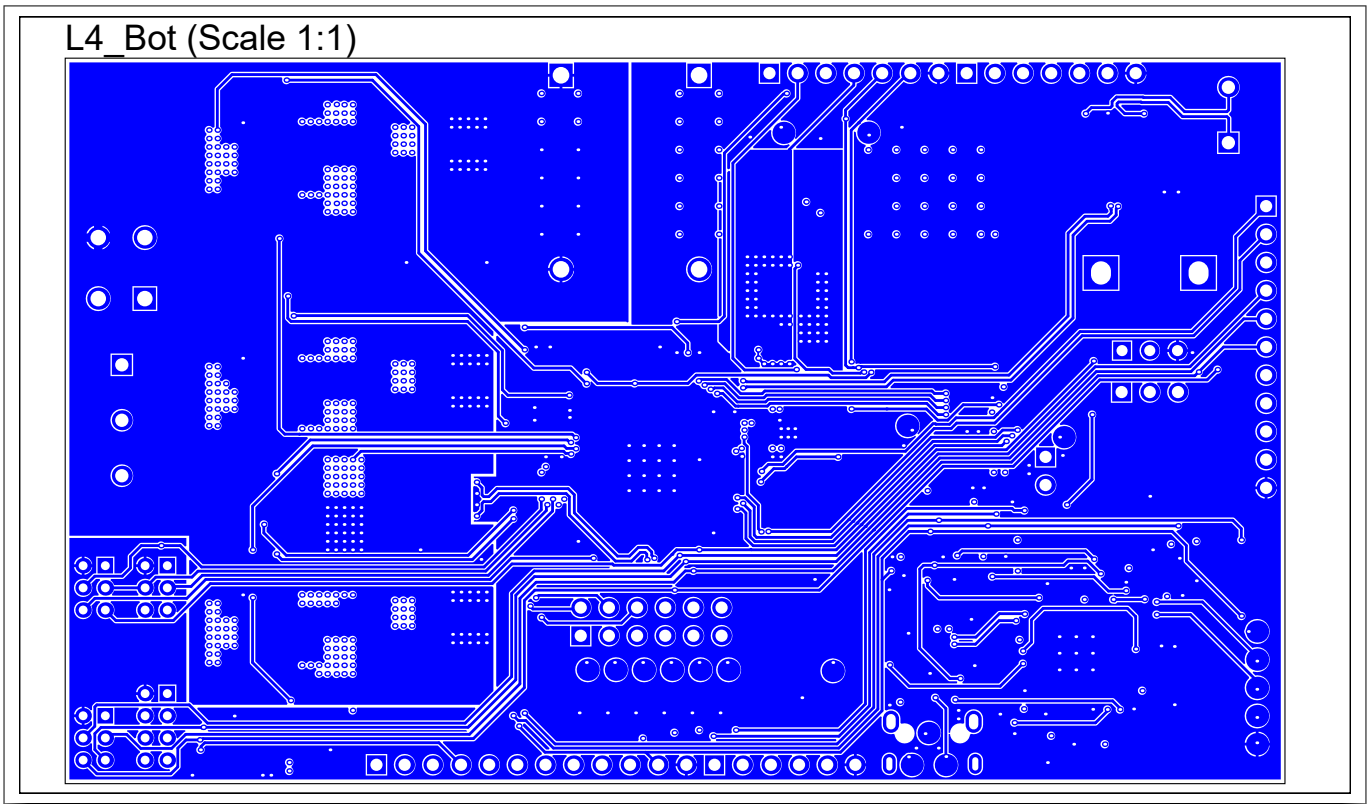

Figure 29 **MOTIX™ MCU TLE9893-2QK evaluation kit, layer4 (Bottom layer, signal)**

6 References and appendices

6.1 Abbreviations and definitions

Table 18 Abbreviations

Abbreviation	Meaning
BLDC	Brushless direct current
CSA	Current sense amplifier
CSAN	Negative terminal current sense amplifier input
CSAP	Positive terminal current sense amplifier input
FIFO	Fail in/fail out pin
GH1-3	Gate high-side MOSFETs for phases 1-3
GND	Ground
GL1-3	Gate low-side MOSFETs for phase 1-3
GPIO	General purpose input/output
LED	Light emitting diode
MON	High Voltage Monitoring Input
N.C.	Not connected
n/u	Not used
PCB	Printed circuit board
PORST	Power-on Reset
SH1-3	Source high-side MOSFET 1-3
SL	Source low-side MOSFET
SWD	Arm® serial wire debug
TMS	Test mode select
UART	Universal asynchronous receiver transmitter
USB	Universal serial bus
( )	Pins inside brackets are not connected to the IC by default
#	Nodes marked with # are connected to the corresponding ICs pin via a resistor

For abbreviations regarding the naming and functionalities of the TLE9893-2QKW62S‘s pins, refer to the user manual for the device.

Revision history

Table 19

PCB version	Date of release	Description of changes
Rev. 01.00	2023-06-12	Initial version

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