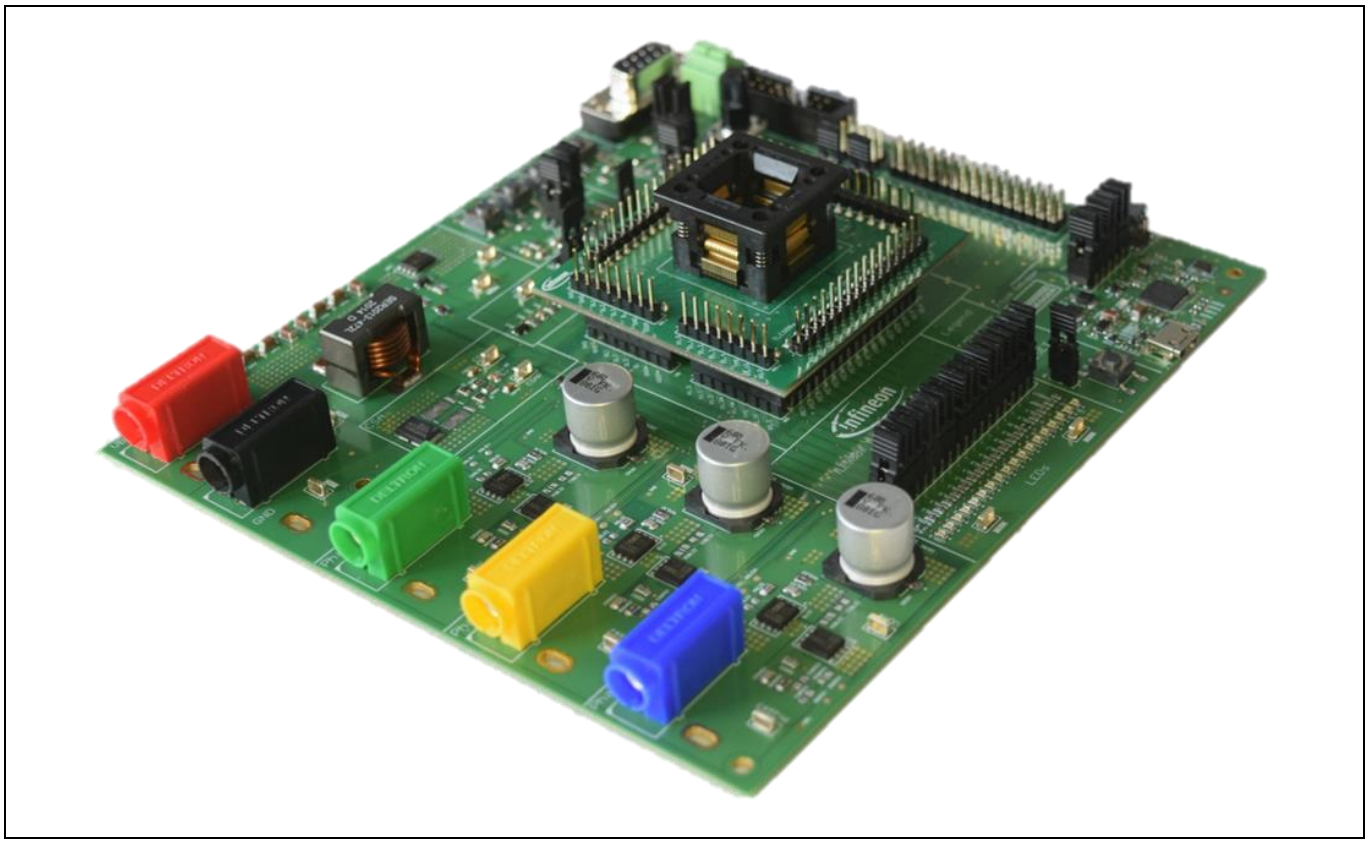
TLE989x EvalBoard with TQFP/LQFP spring socket v01_1 User Guide



About this document

Scope and purpose

This user guide is intented to help users operating the TLE989x EvalBoard with TQFP/LQFP spring socket, which is designed to evaluate hardware and software functionalities of the MOTIX™ MCU TLE988x and TLE989x family.

Additional information is provided about the board's layout, jumper settings, interface and debug options. It introduces the evaluation platform as well as how to write software and download it to the MOTIX™ MCU TLE988x or TLE989x.

Intended audience

This document is intended for anyone using the TLE989x EvalBoard with TQFP/LQFP spring socket.

Evaluation Board

This board will be used during design in, for evaluation and measurement of characteristics, and proof of data sheet specifications.

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.*

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1 The board at a glance

This board is designed to provide a simple, easy-to-use tool for getting familiar with Infineon's MOTIX™ MCU IC TLE988x and TLE989x devices.

Sockets for LQFP64 and TQFP48 package provide the possibility to test and evaluate all ICs of the MOTIX™ MCU TLE988x and TLE989x family. LQFP64 variants of the IC can also be soldered directly onto the Evalboard. The board is compatible for both 3-phase and 2-phase variants. Every pin of the IC is connectable via rows of pin headers.

The board is protected against reverse polarity of the input voltage supply. A battery LED indicates that the board is connected to the supply in the correct way. Otherwise, reverse polarity protection secures the board from damage by cross connection.

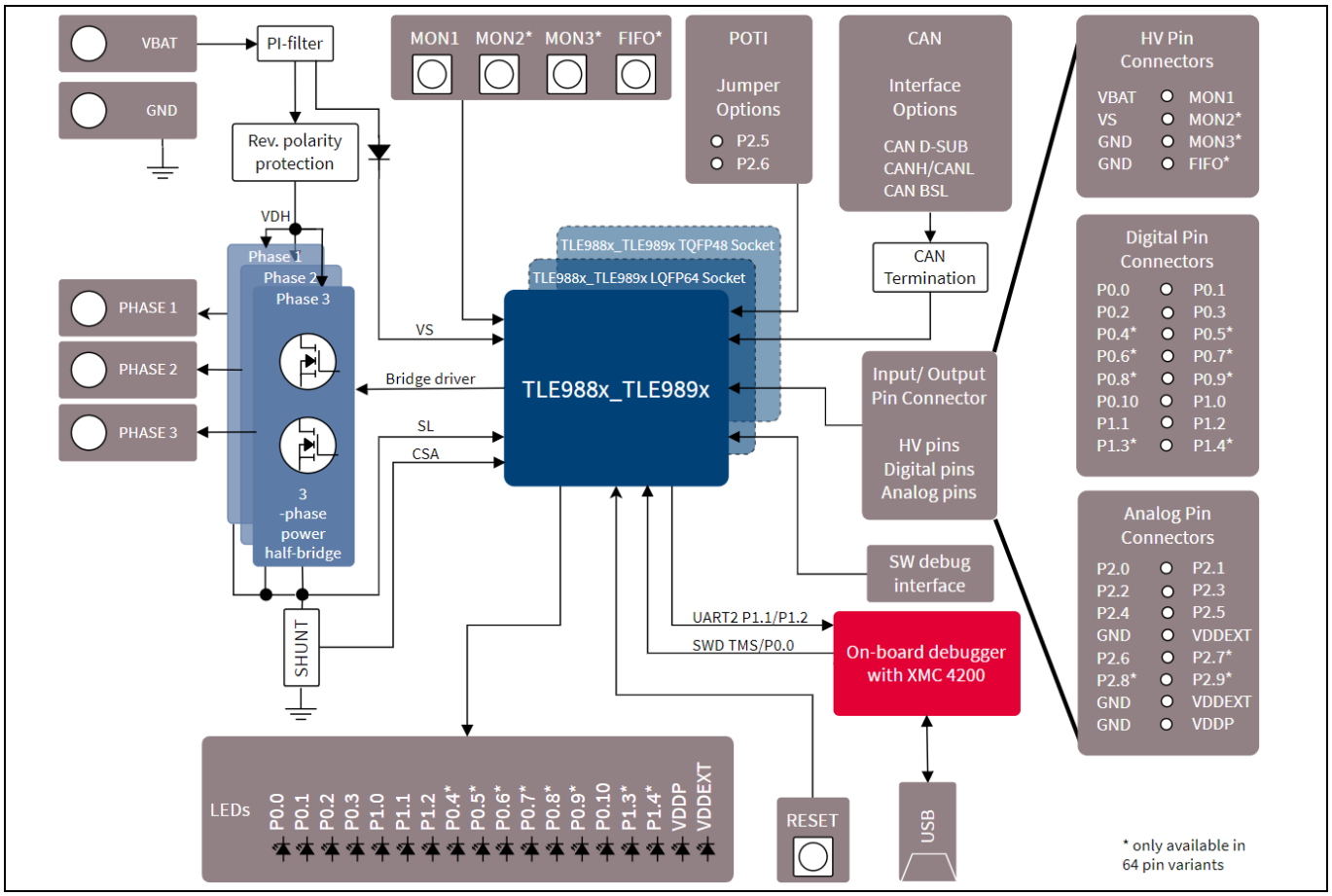
Three MOSFET half bridges are placed on the board to drive a motor. The board is ready to be connected to a car supply or similar and offers a USB port to use the on-board SWD debugger.

The evaluation board can be operated by standard laboratory equipment.

1.1 Delivery content

The TLE989x EvalBoard with TQFP/LQFP spring socket board is delivered together with one socket board, either for LQFP64 pin package or for TQFP48 pin package devices, and a USB cable to connect the board to a PC. A MOTIX™ MCU TLE988x or TLE989x device is not included.

1.2 Block diagram



The board at a glance

Figure 1 Block Diagram

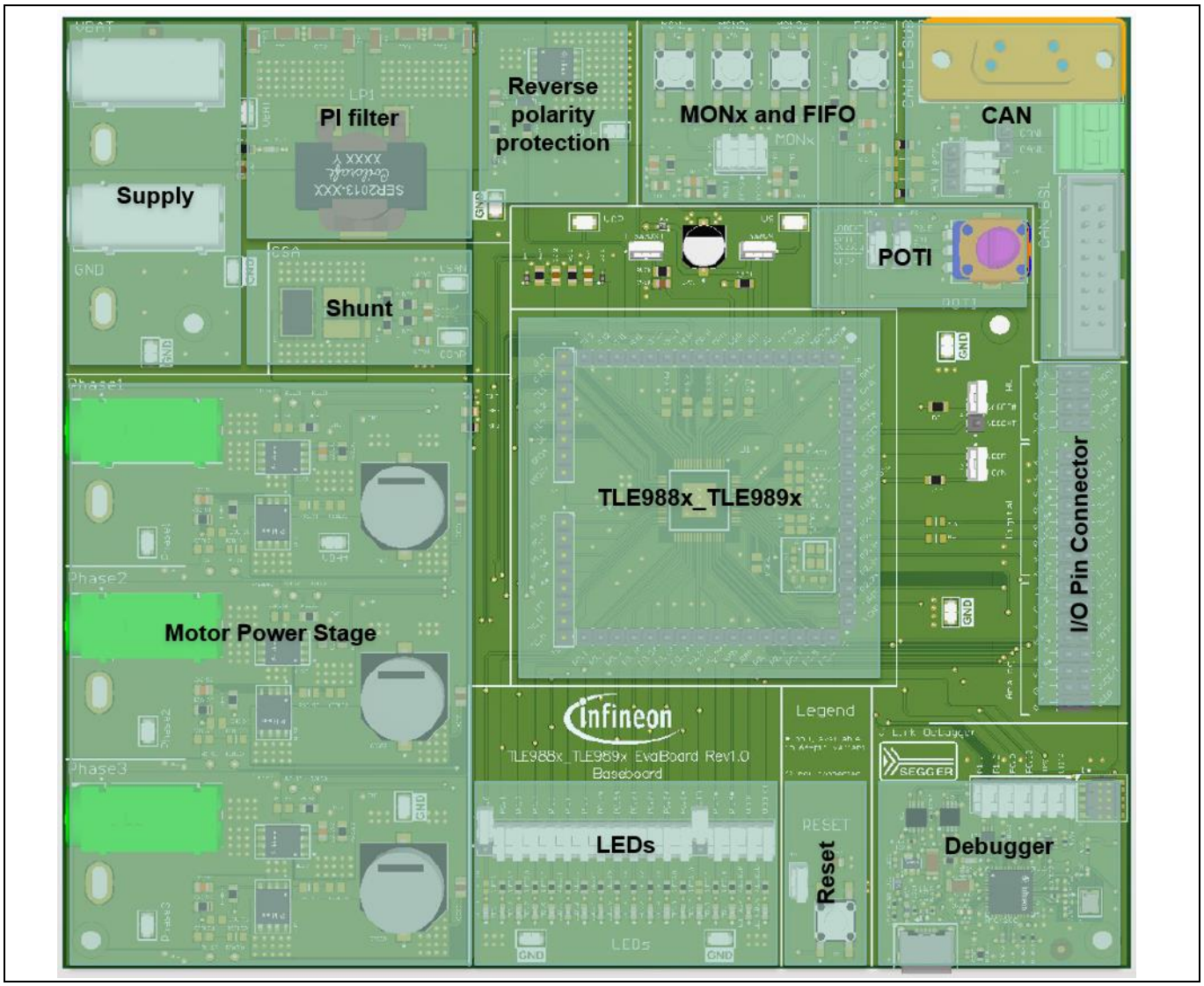


Figure 2 Hardware Implementation

1.3 Main features

- Compatible connector for socket board of LQFP64 pin package and TQFP48 pin package
- Direct placement option for LQFP64 pin package device
- SEGGER J-Link on-board debugger
- Motor power stage including three mosfet half-bridges and motor connectors
- Two placement options for different shunt resistors
- Supply voltage including PI filter and reverse polarity protection
- Multiple CAN connection options (CAN D-SUB, CAN-BSL, CANH/L) and option for CAN termination
- Push buttons are available for MON, FIFO and Reset pins
- LEDs are available for all GPIOs

1.4 Technical data

Technical data is specified in **Table 2**. Current capability is limited by the default assembly of banana plugs and the 10 W shunt resistor. Higher current capability up to 30 A can be reached by adjusting the battery and motor connectors, as well as replacing the shunt resistor. For placement options of the shunt resistor, refer to chapter about **Current Sense Amplifier (CSA)**. For details on battery and motor connectors, refer to **Table 3** and chapter about **Motor Power Stage**. According savety measures need to be applied, if working with higher currents than the specified maximum ratings.

Table 2 Technical data

Voltage supply	Max. 28 V [1)]
Motor current	Max. 25 A [1)]
Power	Max. 330 W [1)]
Pin ports	5 V

1) Specified by design

2 System and functional description

2.1 Board Information

2.1.1 Connectors

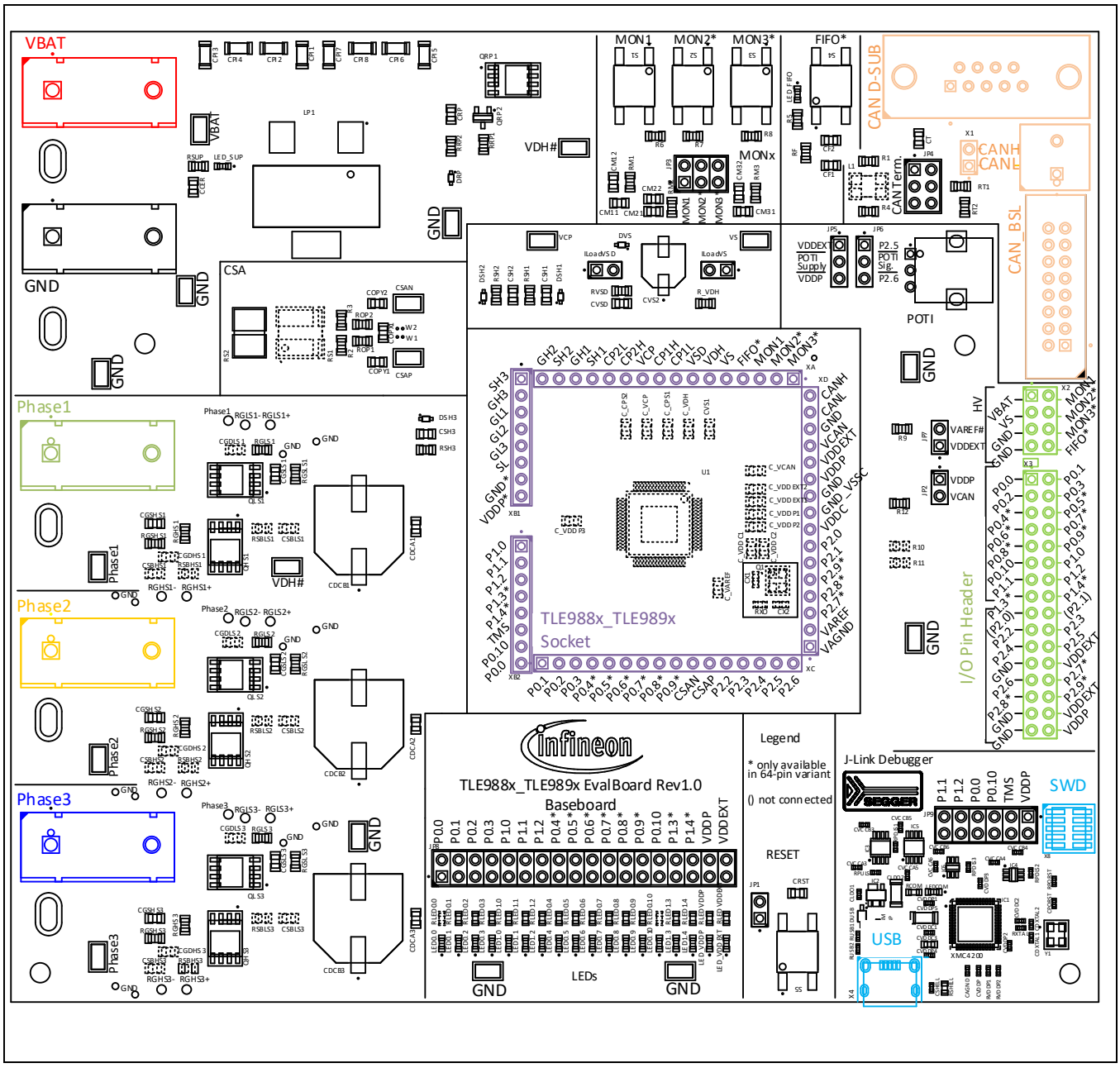


Figure 3 Connectors

Table 3 Connectors

VBAT, GND	Banana jacks for power supply (red) and ground (black). For applications with high current, cables can also be soldered directly to pads next to the banana jacks
Phase 1, 2, 3	Banana jacks for motor connection. The three jacks for Phase1 (green), Phase 2 (yellow) and Phase3 (blue) provide access to the **Motor Power Stage** and are intended to

	connect a motor. For applications with high current, cables can also be soldered directly to pads next to the banana jacks
TLE988x_TLE989x Socket	Pin headers to connect on of the TLE988x_TLE989x **Socket boards**
CAN D-SUB	Standard D-SUB DE-09 connector to connect **CAN** communication lines to the device
CANH/ CANL	Terminal block with clamps to connect **CAN** cables to the device. For jumper cables the pin header X1 can be used.
CAN BSL	Bootstrap loader (BSL) interface to connect **CAN** communication lines to the device
I/O Pin Header	Two row pin header to access all **High voltage, digital and analog Inputs/ Outputs** of the device
SWD	**Debugging** interface to connect external debugger
USB	USB connector for micro-USB cable to connect the on-board debugger to a PC for **Debugging**

2.1.2 Test points

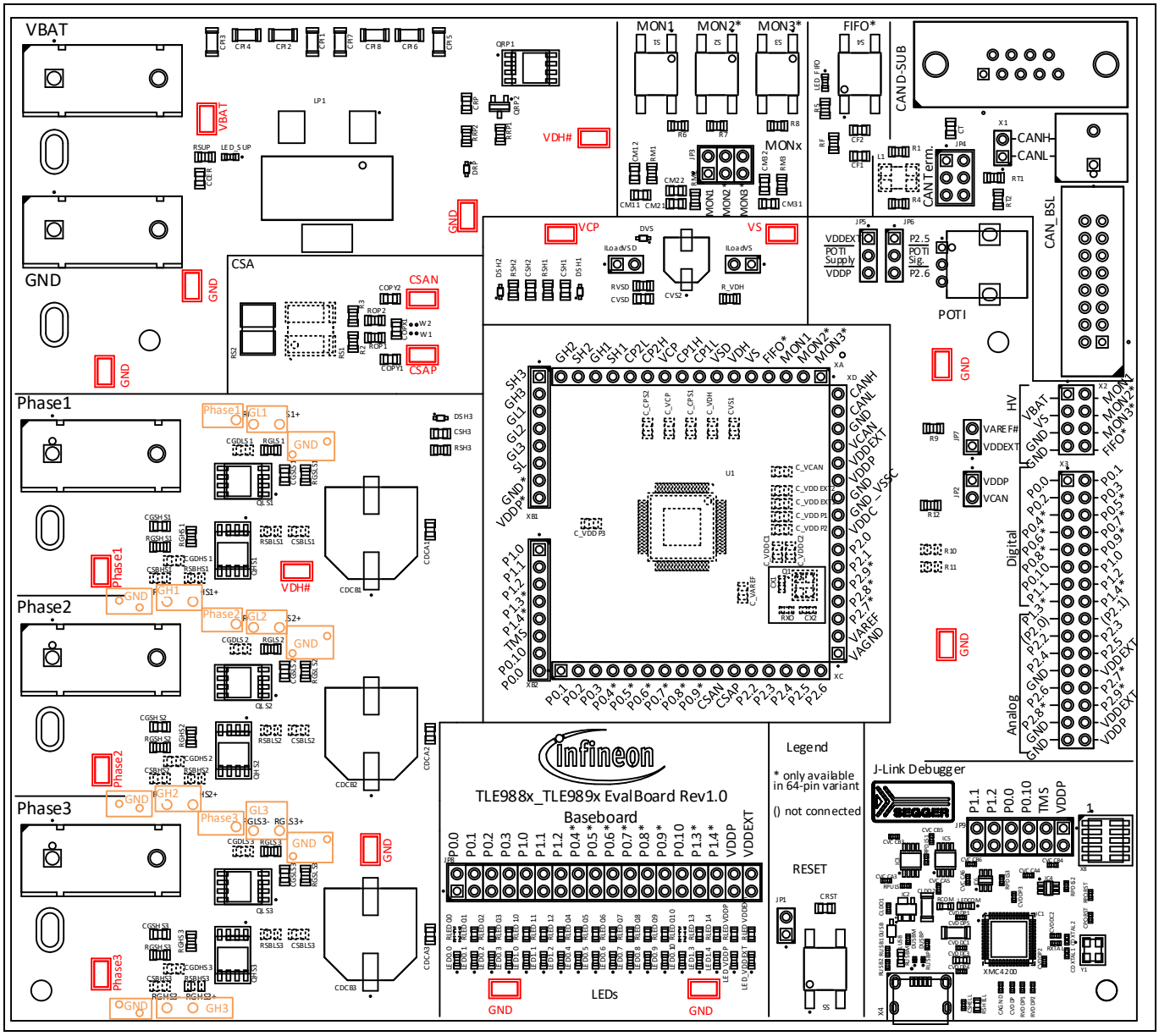


Figure 4 Test Points

Table 4 Test Points

VBAT	Test point to measure battery voltage
VS	Test point to measure device supply voltage
VCP	Test point to measure charge pump voltage
8 x GND	Test points to connect to ground
2 x VDH#	Test points to measure VDH# voltage at the drain of the high side mosfets. To measure VDH at the pin of the device, use the socket pin header. Between VDH# node on the board and VDH pin of the device there is a resistor R_VDH.
CSAN, CSAP	Test points to measure differential voltage at current sense amplifier inputs of the device
Phase 1, 2, 3	Test points to measure motor phase voltages

Phase 1, 2, 3 and 12 x GND (indicated in orange in **Figure 4**)	Vias which can be used as testpoints to measure motor phase voltages with a probe tip and GND spring
GH1, GH2, GH3 (indicated in orange in **Figure 4**)	Vias which can be used as testpoints to measure gate current over gate resistor RGHSx of high side mosfets with a probe tip, or to solder extension cables to measure with a differential probe
GL1, GL2, GL3 (indicated in orange in **Figure 4**)	Vias which can be used as testpoints to measure gate current over gate resistor RGLSx of low side mosfets with a probe tip, or to solder extension cables to measure with a differential probe

2.1.3 LEDs

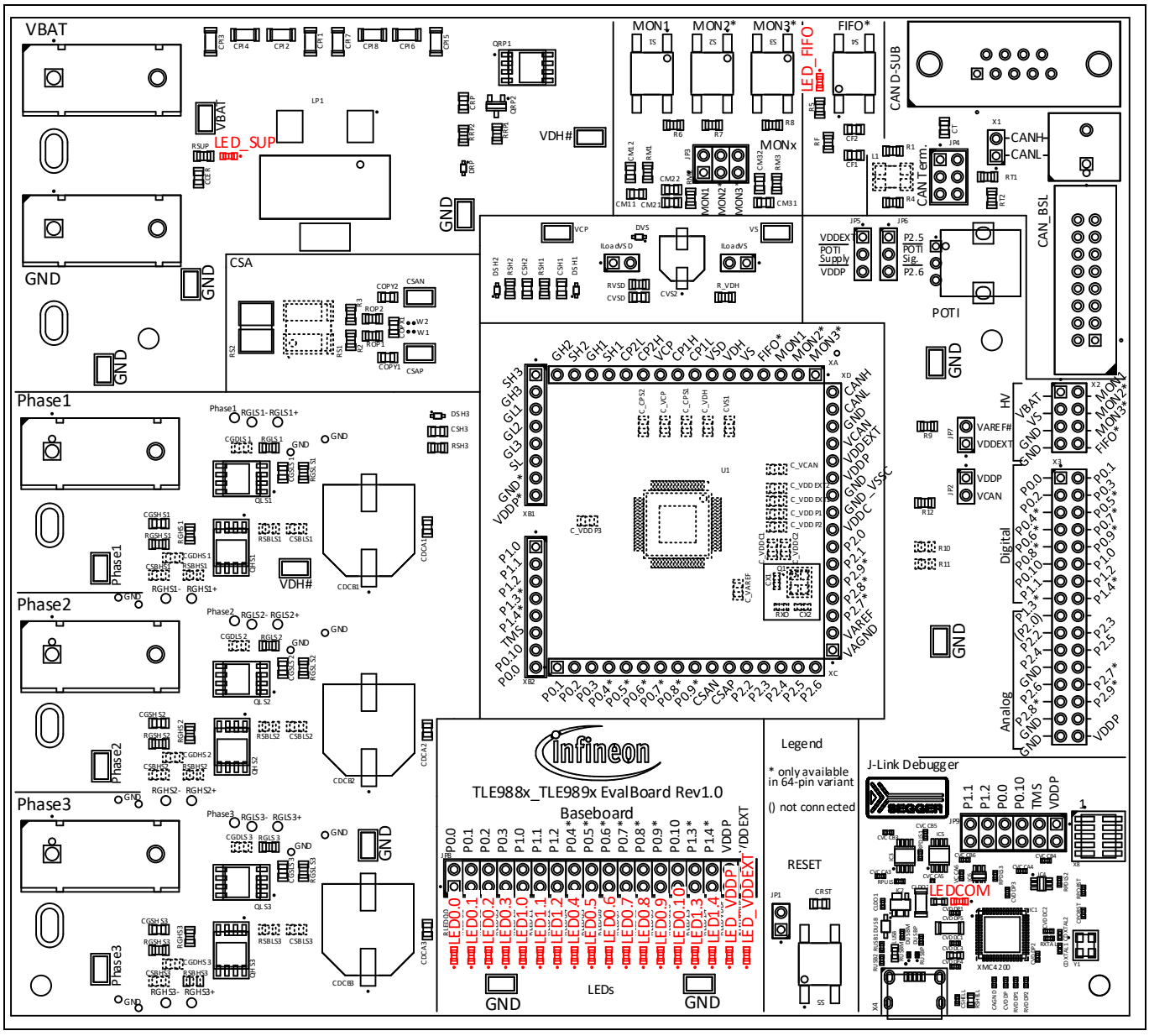


Figure 5 LEDs

Table 5 LEDs

LED_SUP	Indicates supply voltage is active
LED_FIFO	Indicates FIFO is active
LEDCOM	Indicates on-board debugger communication is active
LED0.0	Can be connected to GPIO P0.0 with jumper JP8, as described in **2.1.4**. Since this pin is used for programming the device, it is disconnected by default; connecting resistor RLED0.0 is not populated
LED 0.1	Can be connected to GPIO P0.1 with jumper JP8, as described in **2.1.4**
LED 0.2	Can be connected to GPIO P0.2 with jumper JP8, as described in **2.1.4**
LED 0.3	Can be connected to GPIO P0.3 with jumper JP8, as described in **2.1.4**
LED 1.0	Can be connected to GPIO P1.0 with jumper JP8, as described in **2.1.4**
LED 1.1	Can be connected to GPIO P1.1 with jumper JP8, as described in **2.1.4**
LED 1.2	Can be connected to GPIO P1.2 with jumper JP8, as described in **2.1.4**
LED 0.4	Can be connected to GPIO P0.4 with jumper JP8, as described in **2.1.4** (only available in 64 pin variant of MOTIX™ MCU TLE988x/TLE989x)
LED 0.5	Can be connected to GPIO P0.5 with jumper, as described in **2.1.4** (only available in 64 pin variant of MOTIX™ MCU TLE988x/TLE989x)
LED 0.6	Can be connected to GPIO P0.6 with jumper JP8, as described in **2.1.4** (only available in 64 pin variant of MOTIX™ MCU TLE988x/TLE989x)
LED 0.7	Can be connected to GPIO P0.7 with jumper JP8, as described in **2.1.4** (only available in 64 pin variant of MOTIX™ MCU TLE988x/TLE989x)
LED 0.8	Can be connected to GPIO P0.8 with jumper JP8, as described in **2.1.4** (only available in 64 pin variant of MOTIX™ MCU TLE988x/TLE989x)
LED 0.9	Can be connected to GPIO P0.9 with jumper JP8, as described in **2.1.4** (only available in 64 pin variant of MOTIX™ MCU TLE988x/TLE989x)
LED 0.10	Can be connected to GPIO P0.10 with jumper JP8, as described in **2.1.4**. Since this pin is used for programming the device, it is disconnected by default; connecting resistor RLED0.10 is not populated
LED 1.3	Can be connected to GPIO P1.3 with jumper JP8, as described in **2.1.4** (only available in 64 pin variant of MOTIX™ MCU TLE988x/TLE989x)
LED 1.4	Can be connected to GPIO P1.4 with jumper JP8, as described in **2.1.4** (only available in 64 pin variant of MOTIX™ MCU TLE988x/TLE989x)
LED_VDDP	Can be connected to VDDP with jumper JP8, as described in **2.1.4**. Indicates VDDP is active
LED_VDDEXT	Can be connected to VDDEXT with jumper JP8, as described in **2.1.4**. Indicates VDDEXT is active

2.1.4 Jumpers

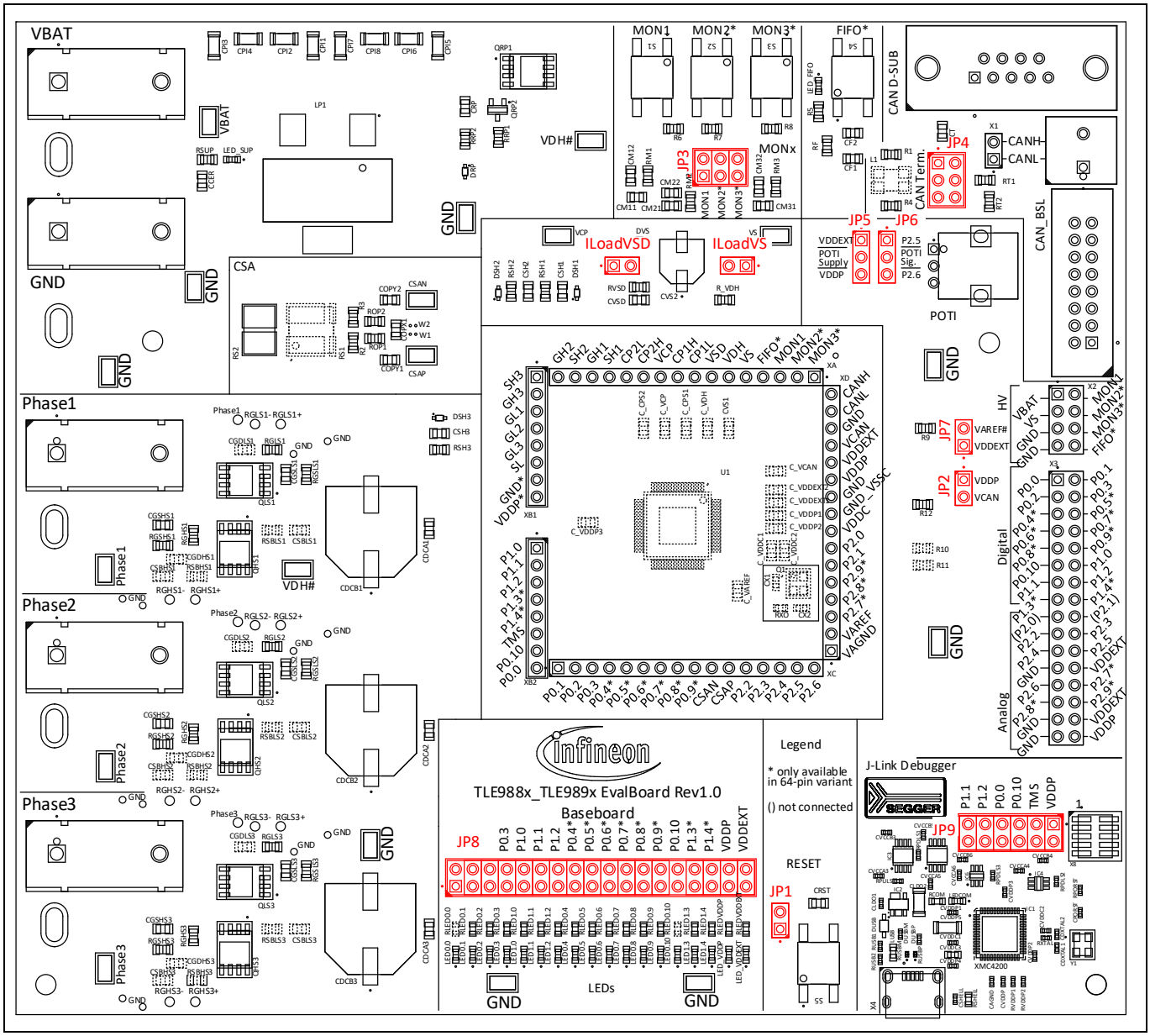


Figure 6 Jumpers

Table 6 Jumpers

JP1	Set jumper to connect RESET button to RESET pin. Open it to disconnect RESET button from RESET pin. Jumper is closed by default
JP2	Set jumper to connect VDDP to VCAN pin in order to supply CAN with VDDP. Open it to disconnect VDDP from VCAN pin. Jumper is closed by default
JP3	Set jumper to connect MONx button to MONx pin. Open it to disconnect MONx button from MONx pin. Jumpers are closed by default
JP4	Set jumper to temerminate **CAN** communication line. Jumpers are open by default
JP5	Set jumper to select **Potentiometer** supply. Open it to disconnect **Potentiometer** from supply. Jumper is set to VDDP by default

JP6	Set jumper to select analog pin of device for the **Potentiometer** signal. Open it to disconnect **Potentiometer** signal from analog pin of device. Jumper is set to P2.6 by default
JP7	Set jumper to connect VDDEXT to VAREF# in order to supply VAREF with VDDEXT. Open it to disconnect VDDEXT from VAREF#. Note that there is a resistor R9 between VAREF# node on the board and VAREF pin of the device. Jumper is open by default
ILoadVSD	Set jumper to connect VSD pin to the board supply. Open it to use the header to connect a multimeter to measure the charge-pump current consumption. Without any connection the charge-pump is not supplied. Jumper is closed by default
ILoadVS	Set jumper to connect VS pin to the board supply. Open it to use the header to connect a multimeter to measure the device current consumption. Without any connection the device is not supplied. Jumper is closed by default
JP8	Set jumpers to connect GPIOs to **LEDs.** Jumpers are closed by default, except for LED0.0 and LED0.10
JP9	Set jumpers to use on-board debugger for **Debugging**. Open them to disconnect on-board debugger, if pins are used for different purpose. Jumpers are closed by default

2.1.5 Push Buttons

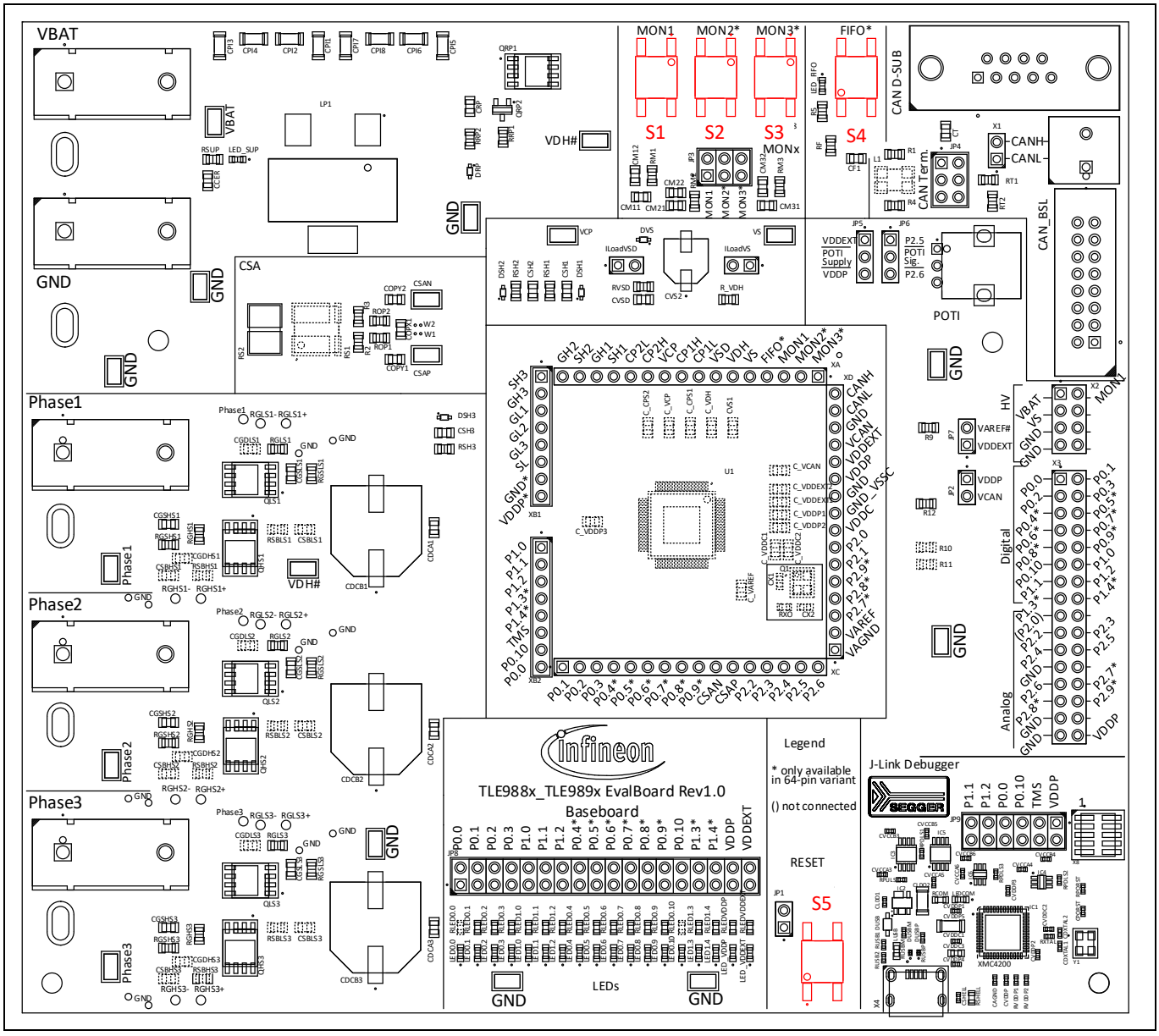


Figure 7 Push Buttons

Table 7 Push Buttons

S1	MON1 push button can be connected to MON 1 pin of the device with jumper JP3, as described in **2.1.4**
S2	MON2 push button can be connected to MON 2 pin of the device with jumper, as described in **2.1.4** (only available in 64 pin variant of MOTIX™ MCU TLE988x/TLE989x)
S3	MON3 push button can be connected to MON 3 pin of the device with jumper JP3, as described in **2.1.4** (only available in 64 pin variant of MOTIX™ MCU TLE988x/TLE989x)
S4	FIFO push button is connected to FIFO pin of the device (only available in 64 pin variant of MOTIX™ MCU TLE988x/TLE989x)
S5	RESET push button can be connected to RESET pin of the device with jumper JP1, as described in **2.1.4**

2.2 Interfaces

2.2.1 Socket boards

Two different socket boards are available for the TLE989x EvalBoard with TQFP/LQFP spring socket, one for LQFP64 package and one for TQFP48 package. Devices of the same package can be exchanged with the plastic spring socket on the socket boards. Measurements can be performed close to the devices pins at the pin headers. On the bottom of the socket boards, capacitors as well as an external oscillator are placed, which need to be close to the devices pins. A top view of the sockets is shown in **Figure 8** and **Figure 9**. The socket boards can only be used, if there are no components assembled inside the socket area of the base board.

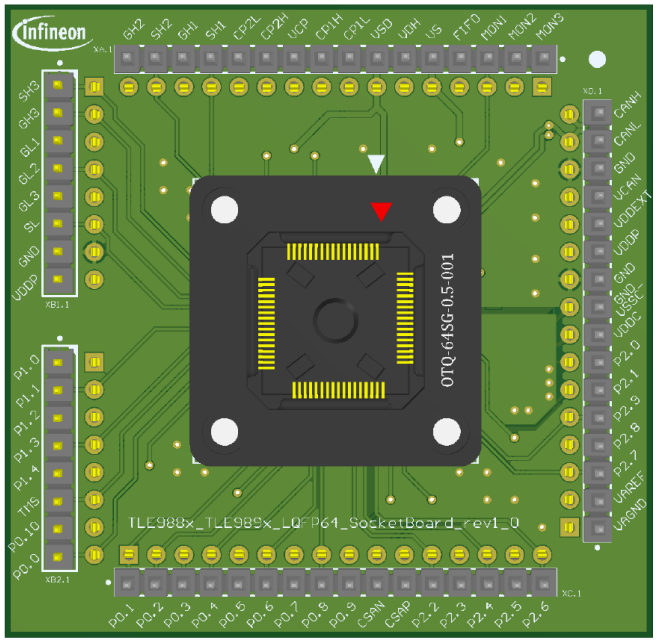


Figure 8 TLE988x_TLE989x LQFP64 Socketboard (top view)

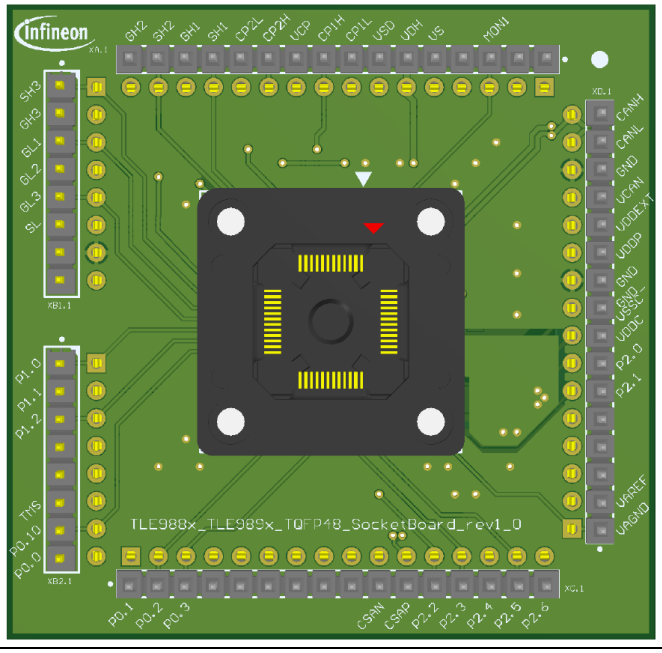


Figure 9 TLE988x_TLE989x TQFP48 Socketboard (top view)

System and functional description

For the LQFP64 package there is the option to solder the device directly onto the base board. If the device is placed, all passive components inside the socket area and the external oscillator need to be placed as well. If components are assembled inside the socket area on the base board, no socket board can be used. Details are shown in **Figure 10**. A list of all assembly options is given in **Table 8**.

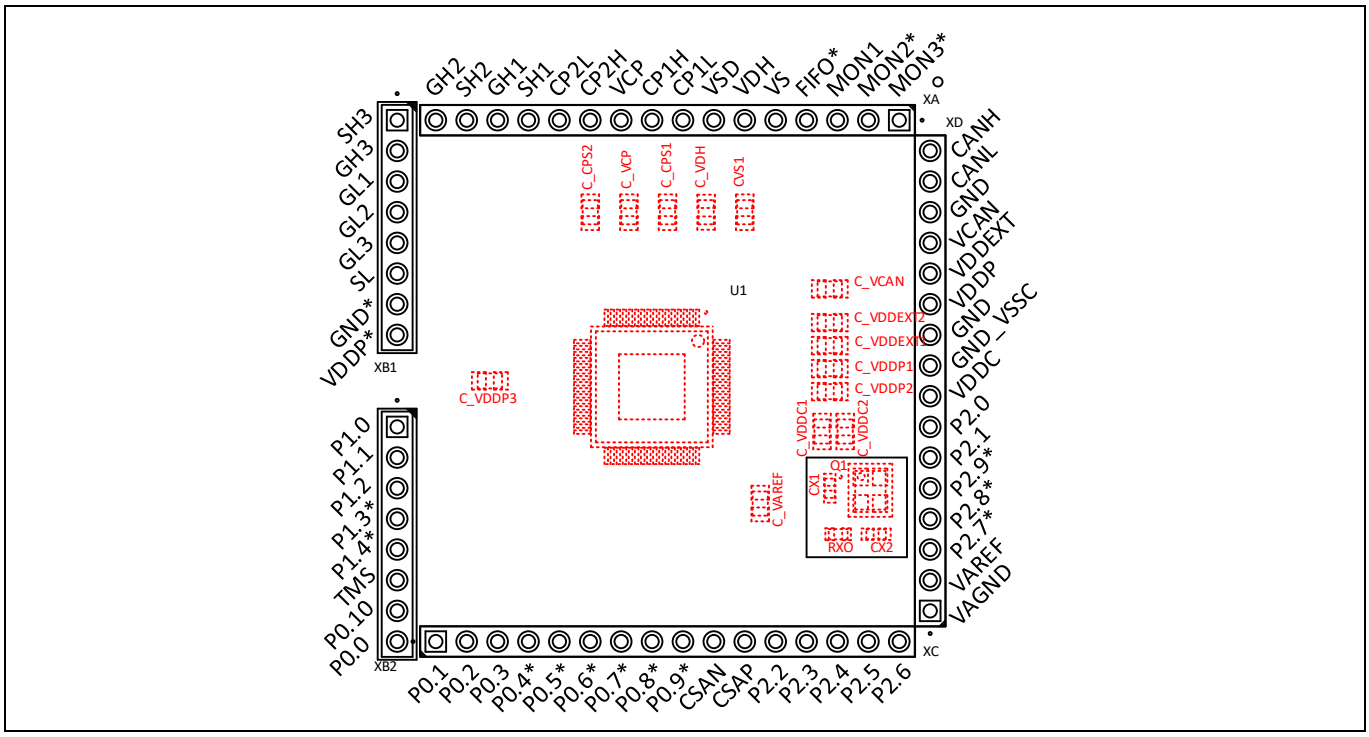


Figure 10 Placement option for LQFP64 device

Please note that if a socket board is used, the current for the charge pump capacitor is drawn over VSD. However, if a device is soldered directly onto the TLE989x EvalBoard with TQFP/LQFP spring socket, the current for the charge pump capacitor is drawn directly from the board supply. This means that depending on wether a socket board is used or not, the VSD current measurement at ILoadVSD jumper will be different. For details on the circuit refer to **Figure 27** for the schematics of the placement option of the device, to **Figure 36** for the schematics of LQFP64 Socketboard or to **Figure 39** for the schematics of TQFP48 Socketboard.

2.2.2 Motor Power Stage

Three MOSFET half bridges are placed on the board to drive a motor. Every half bridge consists of two N-channel MOSFETS (QHSx, QLSx) with according gate resistor (RGHSx, RGLSx), gate-source resistor (RGSHSx, RGSLSx) and gate-source capacitor (CGSHSx, CGSLSx). At VDH# for each motor phase a decoupling capacitor (CDCAx) is placed as well as a DC link capacitor (CDCBx).

In addition, there are placement options for snubbers (RSBHSx + CSBHSx, RSBLSx + CSBLSx), as well as for gate-drain capacitors (CGDHSx, CGDLSx). These components are not populated by default. Details are shown in **Figure 11**.

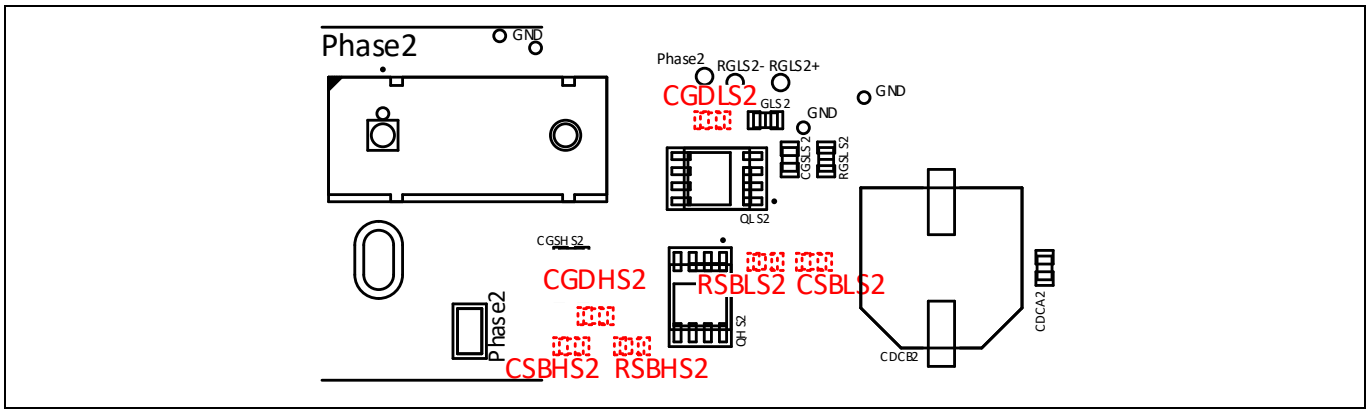


Figure 11 Placement options for MOSFET half bridges (half bridge 2)

To connect motor phases, either the banana plugs can be used or cables can be soldered directly to the pads next to the banana plugs. If the current consumption of the motor is higher than the maximum current capability of the banana plugs, the pads should be used. A description and manufacturer number of the banana plugs used for the board can be found in the BOM in chapter **5.1**.

2.2.3 CAN

The CANH and CANL pins of the device can be connected in four different ways: via the CAN D-SUB interface, the CAN_BSL interface, the CANH/L terminal block or pin header X1. The pinout for the CAN D-SUB interface is depicted in the figure **below**.

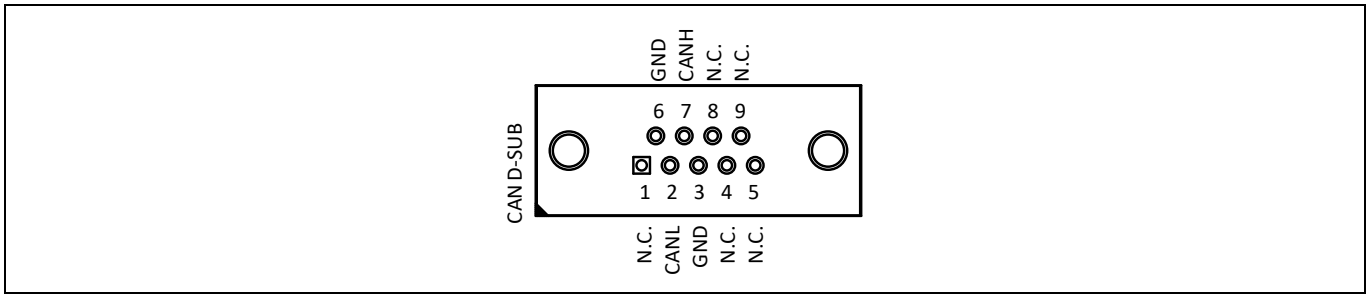


Figure 12 Pinout of CAN D-SUB interface

The CAN_BSL interface is a 16-pin header (2 x 8) with 2.54 mm pitch and can be used to program the device via CAN with the Infineon uIO stick (see www.infineon.com/uio or www.hitex.com/uio). The pinout for the CAN_BSL interface is depicted in the figure **below**.

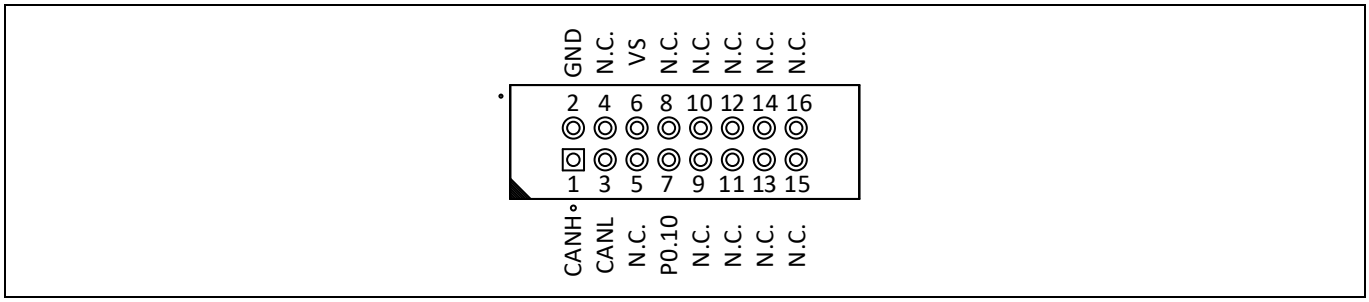


Figure 13 Pinout of CAN_BSL interface

System and functional description

The CANH/L terminal block can be used to connect CANH and CANL cables with clamps. If jumper cables are used, they can also be connected directly to pin header X1. The pinout for X1 and the CANH/L terminal block is depicted in the figure **below**.

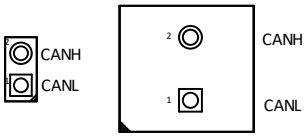


Figure 14 Pinout of X1 (left) and CANH/L terminal block (right)

An option is available to add CAN termination resistors RT1 and RT2 with jumper JP4, which add up to 124 Ω in series. Additionally, a capacitor can be connected between the resistors. The pinout of JP4 is depicted in the figure **below**. For more details on the circuit, refer to the schematics in **Figure 30**.

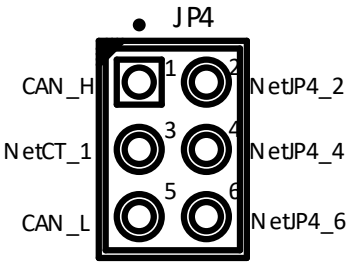


Figure 15 Pinout of JP4

By default, VCAN is supplied by VDDP. Refer to setting of JP2 in **Table 6**. In case there is noise coupling from CAN to VDDP, a ferrite bead can be placed instead of 0R resistor R12. Details are shown in the figure **below**.

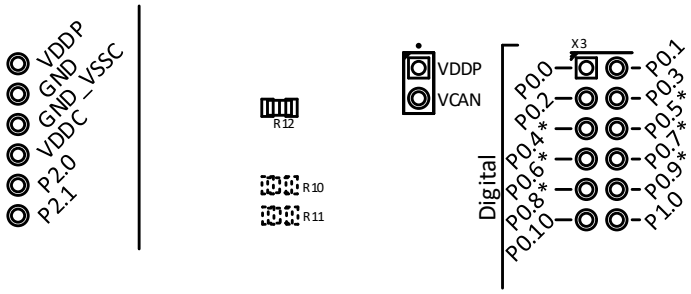


Figure 16 VCAN supply

A placement option is available to solder a common mode choke L1. If L1 is placed, the 0Ω resistors R1 and R4 need to be removed. Details are shown in **Figure 17**.

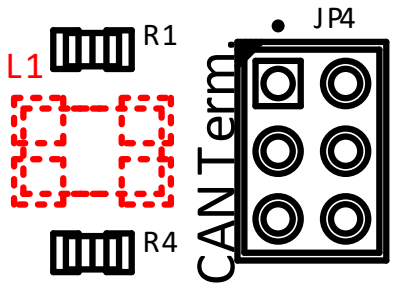


Figure 17 Placement option for common mode choke

2.2.4 Potentiometer

A potentiometer is available on the board, which can either be supplied by VDDEXT or VDDP of the device. Set jumper JP5 accordingly. By setting JP6, either P2.5 or P2.6 can be selected as analog input of the device for the potentiometer signal. The pinouts of JP5 amd JP6 are depicted in the figure **below**.

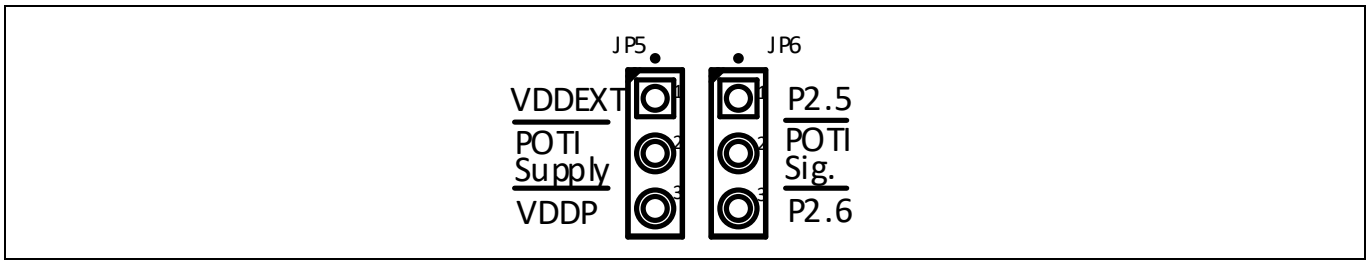


Figure 18 Pinout of JP5 (left) and JP6 (right)

2.2.5 Current Sense Amplifier (CSA)

Between the SL pin of the device and ground a single shunt resistor RS1 is placed on the board to measure the motor current consumption via CSAN and CSAP pins of the device. For high precision purposes such as applications with current commutation, there is the option to place a precision resistor RS2 by Isabellenhütte instead. If RS1 is placed, RS2, R2 and R3 need to be removed. Details are shown in **Figure 19**.

If motor currents are applied which exceed the maximum ratings given in the **Technical data**, maximum current ratings of the shunt resistor being used need to be considered.

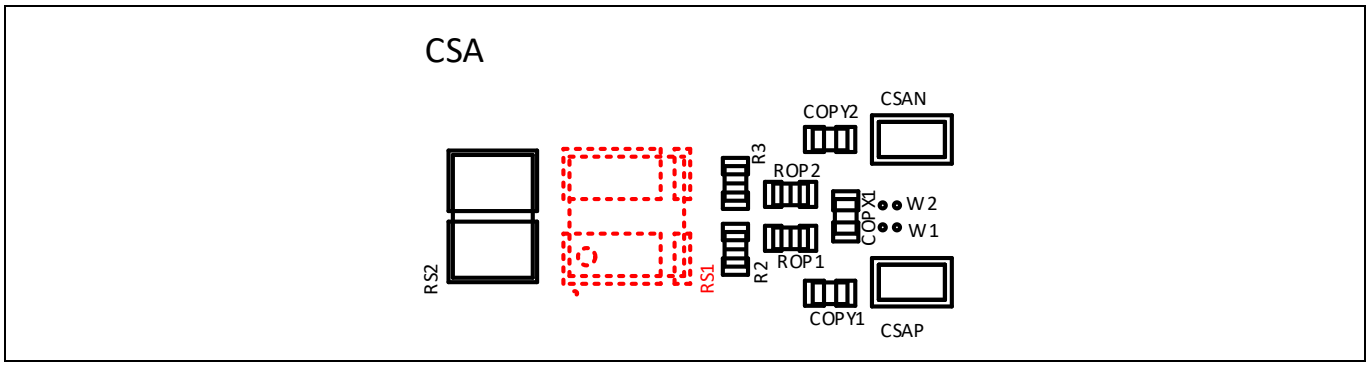


Figure 19 Placement option for shunt resistor

2.2.6 High voltage, digital and analog Inputs/ Outputs

All high voltage, digital and analog pins of the device are available on pin headers X2 and X3 for measurement or connection with jumper cables. The pin headers have a standard pitch of 2.54mm and are placed close to the edge of the Evalboard, so it is possible to connect a breadboard for prototyping. Pin labels marked with * are only available in 64 pin variant of the device. The analog inputs are grouped in such way that sensors can be easily connected and supplied via VDDEXT. The pinouts of X2 and X3 are depicted in the figure **below**.

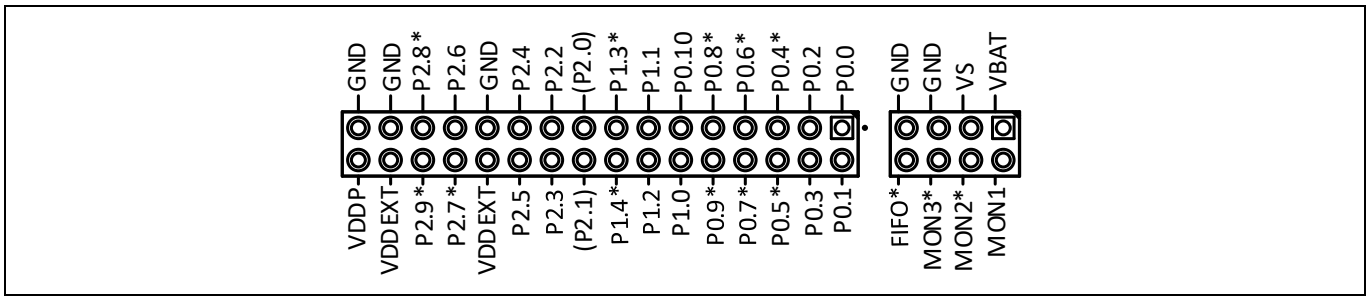


Figure 20 Pinout of X2 (left) and X3 (right)

Pin P2.0 and P2.1 are not connected to the device by default. To connect them a placement option for 0Ω resistors R10 and R11 is available. Details are shown in **Figure 21**.

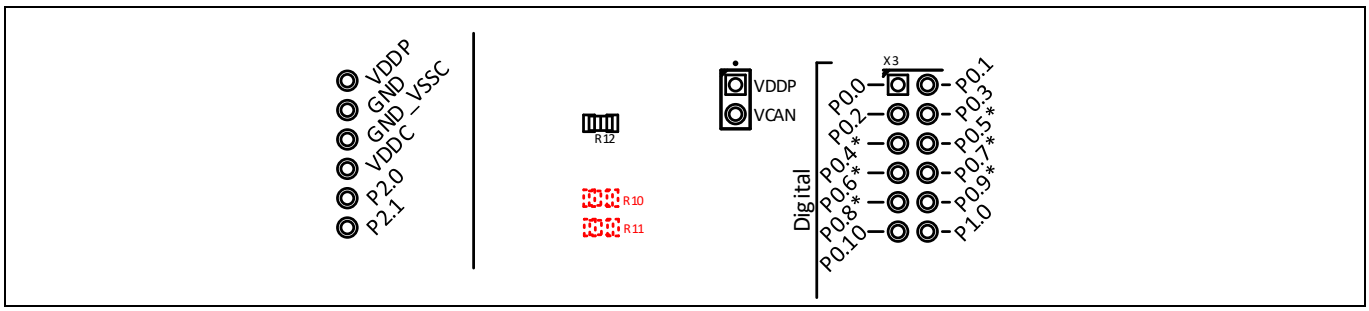


Figure 21 Placement option for R10 and R11

2.2.7 Debugging

On the board a SEGGER J-Link debugger is available for debugging, which can be connected via an USB cable. Alternatively, an off-board debugger like the ARM®KEIL ULINK2 or the XMC™ Link can be used via the SWD interface.

To use the SEGGER J-Link on-board debugger the jumpers on JP9 must be set. The pinout of JP9 is depicted in the figure **below**. In case the virtual COM port is not used, it is recommended to disconnect P1.2. If a serial console of the PC opens a virtual COM port, the on-board debugger drives P1.2 high and this pin cannot be driven low by any other device.

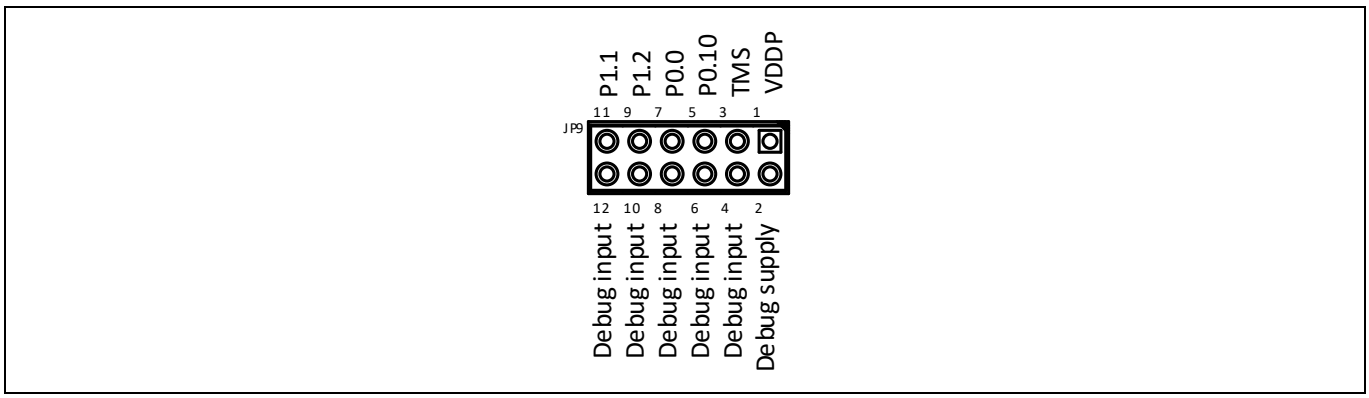


Figure 22 Pinout of JP9

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 X8 which consists of a 10-pin header (2 x 5) with 1.27 mm pitch. The pinout of the SWD interface is depicted in the figure **below**.

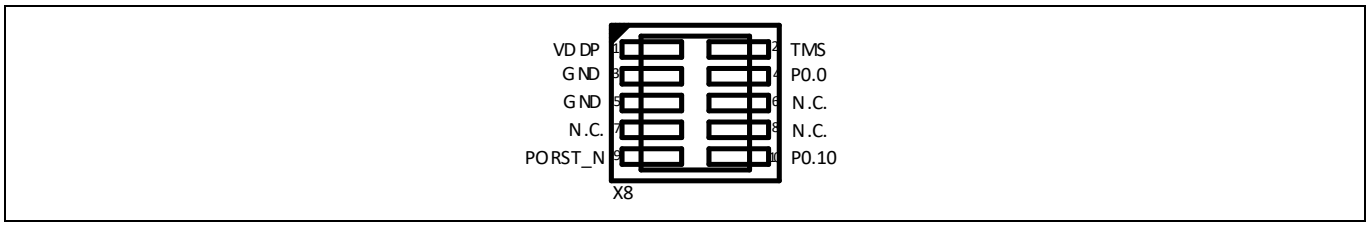


Figure 23 Pinout of SWD interface X8

3 Assembly Options

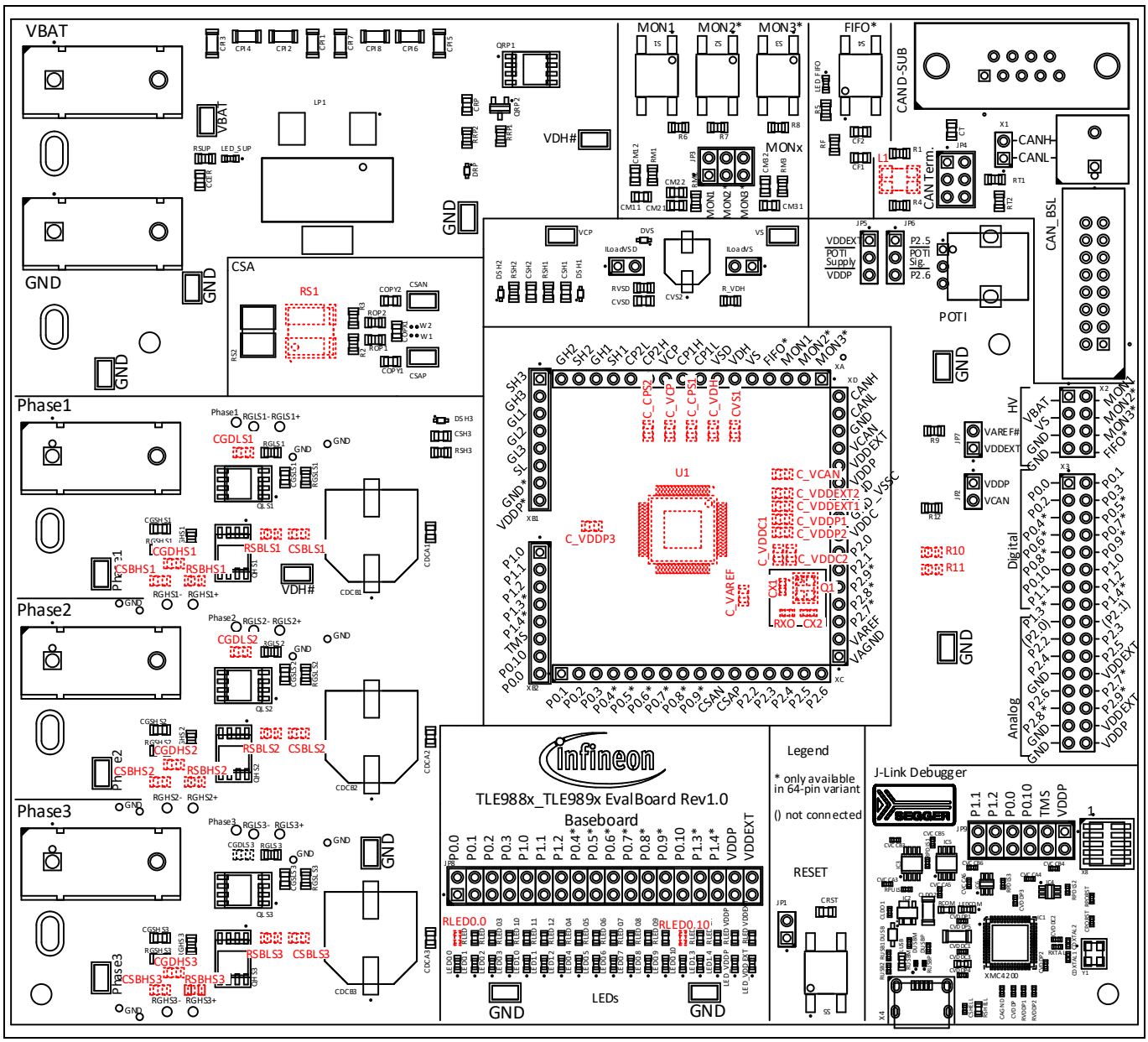


Figure 24 Additional placements' positions

Values for these optional additional placements have to be determined depending on application. Recommended values can be found in the BOM in chapter **5.1**.

Table 8 Additional placements

Component	Description
U1	MOTIX™ MCU TLE988x/TLE989x 64 pin variant. Needs to be assembled, if no socketboard is used
V_CP	Charge pump capacitor. Needs to be assembled, if no socketboard is used
V_CPS1	Charge pump capacitor stage 1. Needs to be assembled, if no socketboard is used
V_CPS2	Charge pump capacitor stage 2. Needs to be assembled, if no socketboard is used

Assembly Options

Component	Description
C_VDH	VDH decoupling capacitor. Needs to be assembled, if no socketboard is used
CVS1	VS decoupling capacitor. Needs to be assembled, if no socketboard is used
Q1	External oscillator. Needs to be assembled, if no socketboard is used
RX02	Oscillator resistor. Needs to be assembled, if no socketboard is used
CX1	Oscillator capacitor 1. Needs to be assembled, if no socketboard is used
CX2	Oscillator capacitor 2. Needs to be assembled, if no socketboard is used
C_VAREF	VAREF stability capacitor. Needs to be assembled, if no socketboard is used
C_VDDC1	VDDC decoupling capacitor. Needs to be assembled, if no socketboard is used
C_VDDC2	VDDC decoupling capacitor. Needs to be assembled, if no socketboard is used
C_VDDP1	VDDP decoupling capacitor. Needs to be assembled, if no socketboard is used
C_VDDP2	VDDP stability capacitor. Needs to be assembled, if no socketboard is used
C_VDDP3	VDDP stability capacitor. Needs to be assembled, if no socketboard is used
C_VDDEXT1	VDDEXT decoupling capacitor 1. Needs to be assembled, if no socketboard is used
C_VDDEXT2	VDDEXT stability capacitor 2. Needs to be assembled, if no socketboard is used
C_VCAN	CAN decoupling capacitor. Needs to be assembled, if no socketboard is used
L1	CAN common mode choke
RS1	Precision resistor by Isabellenhütte
RSBHS1	Resistance snubber high-side MOSFET phase 1
CSBHS1	Capacitor snubber high-side MOSFET phase 1
CGDHS1	Gate-drain capacitor high-side MOSFET phase 1
RSBLS1	Resistance snubber low-side MOSFET phase 1
CSBLS1	Capacitor snubber low-side MOSFET phase 1
CGDLS1	Gate-drain capacitor low-side MOSFET phase 1
RSBHS2	Resistance snubber high-side MOSFET phase 2
CSBHS2	Capacitor snubber high-side MOSFET phase 2
CGDHS2	Gate-drain capacitor high-side MOSFET phase 2
RSBLS2	Resistance snubber low-side MOSFET phase 2
CSBLS2	Capacitor snubber low-side MOSFET phase 2
CGDLS2	Gate-drain capacitor low-side MOSFET phase2
RSBHS3	Resistance snubber high-side MOSFET phase 3
CSBHS3	Capacitor snubber high-side MOSFET phase 3
CGDHS3	Gate drain capacitor high-side MOSFET phase 3
RSBLS3	Resistance snubber low-side MOSFET phase 3
CSBLS3	Capacitor snubber low-side MOSFET phase 3
CGDLS3	Gate-drain capacitor low-side MOSFET phase 3
R10	0Ω resistor to connect P2.0 to X3
R11	0Ω resistor to connect P2.1 to X3
RLED0.0	Resistor to connect LED0.0 to JP8
RLED0.10	Resistor to connect LED0.10 to JP8

4 Software toolchain

The Software toolchain can be installed following the explanation below or goto **www.infineon.com/tle987x** and search for Tools & Software.

4.1 Keil µVision 5

The recommended Integrated Software Development Environment is Keil® µVision5®.

Infineon's MOTIX™ MCU family is supported. For more information about the installation process, go to **www.keil.com**.

4.2 Infineon Config Wizard

In addition to the IDE, Infineon provides a solution to speed-up the IC programming, the Config Wizard. This tool is designed for code configuration in combination with the IDE. Infineon "Config Wizard for MOTIX™ MCU" can be downloaded via the Infineon Toolbox. The Infineon Toolbox is a central place to download and update all your Infineon tools. It can be downloaded from **www.infineon.com/toolbox**.

4.3 TLE988x_9x SDK

All MOTIX™ MCU products can be installed to Keil® µVision5® via "Pack Installer". Browsing to the Infineon chapter in "All Devices" will lead to the "TLE98xx Series". The ".pack" file comes with startup files, functions to access the registers of the device, and several code examples to provide an easy start up and speed up software development.

4.4 Debug connection setup

For a proper Flash and Debug Connection, install V5.10 (or newer) from: **www.segger.com/jlink-software.html**. Keil® µVision5® has to be configured in the IDE Menu "Options for Target". After connecting the USB-cable and power up the EvalBoard, go to the "Debug" register-card, choose "J-LINK / J-TRACE Cortex" and press "Settings".

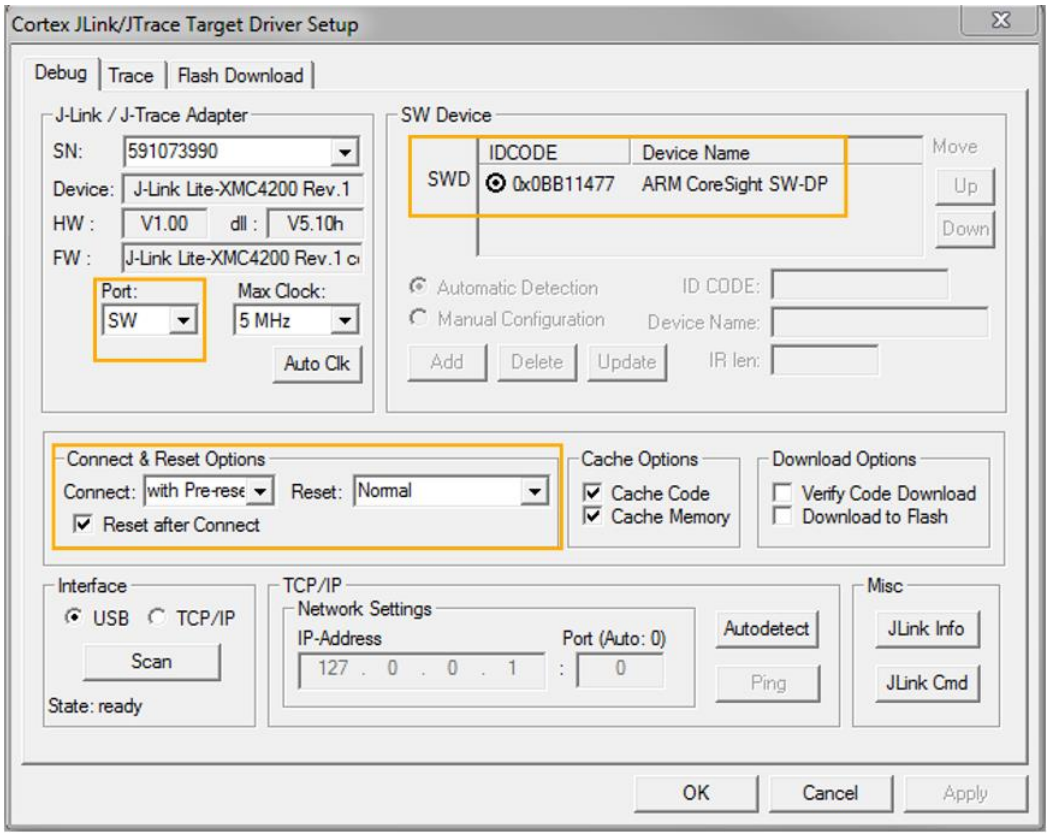


Figure 25 Debug and flash configuration

If the board is connected successfully, the Arm® IDCODE will be visible in the SW Device Window. If connection fails, “Connect & Reset Options” and “Port” window has to be checked.

5 Design Files

5.1 BOM of the TLE989x EvalBoard with TQFP/LQFP spring socket

For the design of the TLE989x EvalBoard with TQFP/LQFP spring socket automotive qualified components are used. The complete BOM is shown below including non-fitted components.

Designator	Description	Quantity	Manufacturer Order Number	Automotive Qualified
C_CPS1, C_CPS2	High temperature multilayer ceramic chip capacitor, 0805, 220nF	0	CGA4J3X8R1H224K125AB	AEC Q200
C_VAREF, C_VDDC1, C_VDDEXT1, C_VDDP1, C_VDDP3, CCER, CDCA1, CDCA2, CDCA3, CRP, CVS1	High temperature multilayer ceramic chip capacitor, 0805, 100nF	5	CGA4J2X8R1H104K125AA	AEC Q200
C_VCAN, C_VDDEXT2, C_VDDP2, CVSD	Multilayer ceramic chip capacitor, 0805, 1uF	1	CGA4J3X7R1H105K125AB	AEC Q200
C_VCP	Multilayer ceramic chip capacitor, 0805, 470nF	0	CGA4J3X7R1H474K125AB	AEC Q200
C_VDDC2	TDK multilayer ceramic chip capacitor automotive grade CGA series, 0805, 330nF	0	CGA4J2X7R1H334K125AA	AEC Q200
C_VDH, CF1, CM11, CM21, CM31, COPX1, COPY1, COPY2, CRST	Chip Monolithic Ceramic Capacitor, 1nF, 0805	8	GCM216R71H102KA37	AEC Q200
CAGND, CLDO1, CSHELL, CVCCA3, CVCCA4, CVCCA5, CVCCA6, CVCCB3, CVCCB4, CVCCB5, CVCCB6, CVDDC1, CVDDC2, CVDDP, CVDDP1, CVDDP2, CVDDP3, CVDDP4	Multilayer Ceramic Chip Capacitor, 100nF, 0402	18	CGA2B3X7R1H104K050BB	AEC Q200
CAN D-SUB	D-Sub 9 Poles, Female, Straight, with Solder Pins 2,9 and nuts	1	09 66 111 7502	No
CAN_BSL	Through hole .100'' Male Shrouded Box Header, 16 pin, vertical, double row	1	SBH11-PBPC-D08-ST-BK	No
CANH/L	PCB terminal block, nominal current: 16 A, rated voltage: 400 V, 2 Positions, THT	1	1792863	No
CDCB1, CDCB2, CDCB3	Aluminum Electrolytic Capacitors, SMD, 680uF	3	EEEFK1V681AQ	AEC Q200
CDXTAL1, CDXTAL2	Chip Monolithic Ceramic Capacitor, 12pF, 0402	2	GCM1555C1H120JA16	AEC Q200

Design Files

Designator	Description	Quantity	Manufacturer Order Number	Automotive Qualified
CF2, CM12, CM22, CM32, CSBHS1, CSBHS2, CSBHS3, CSBLS1, CSBLS2, CSBLS3	High temperature multilayer ceramic chip capacitor, 0805, 10nF	4	CGA4C2NP01H103J060AA	AEC Q200
CGDHS1, CGDHS2, CGDHS3, CGDLS1, CGDLS2, CGDLS3	Capacitor, SMD, High Temperature, 0805, 33pF	0	C0805C330J5HACAUTO	AEC Q200
CGSHS1, CGSHS2, CGSHS3, CGSLS1, CGSLS2, CGSLS3, CT	High temperature multilayer ceramic chip capacitor, 0805, 4.7nF	7	CGA4C2NP01H472J060AA	AEC Q200
CLDO2, CPI1, CPI2, CPI3, CPI4, CPI5, CPI6, CPI7, CPI8, CVDDP5	CGA series multilayer ceramic chip capacitor, 1206, 10uF	10	CGA5L1X7R1H106K160AC	AEC Q200
CPORST	Temperature Stable Ceramic Capacitor, 0402, 10nF	1	C0402C103K4RECAUTO	AEC Q200
CSAN, CSAP, GND1, GND2, GND3, GND4, GND5, GND6, GND7, GND8, Phase_TP1, Phase_TP2, Phase_TP3, VBAT1, VCP, VDH1, VDH2, VS	Test Point, Compact, Surface Mount, Finish- Silver Plate, SMD	18	5019	No
CSH1, CSH2, CSH3	Chip Monolithic Ceramic Capacitor, 0805, 470pF	3	GCM2165C1H471JA16	AEC Q200
CVDDC3	Chip Monolithic Ceramic Capacitor, 0603, 4.7uF	1	GRM188R61E475KE11D	No
CVS2	Aluminum Electrolytic Capacitor, SMD, 22uF	1	EEE-HC1V220P	AEC Q200
CX1, CX2	Multilayer ceramic chip capacitor, 0603, 10pF	0	CGA3E2C0G1H100D080AA	AEC Q200
DRP, DSH1, DSH2, DSH3, DVS	Silicon Schottky Diode, SC-79	5	BAS52-02V	AEC Q101
DUSB	Silicon Schottky Diode, SOD323	1	BAT60A	AEC Q101
DUSBM, DUSBP	Bi-directional TVS Protection Device, 5.5V, 3.5pF	2	ESD231-B1-W0201	No
GND	Banana Socket, Black, 15.3mm Pitch	1	571-0100	No
IC1	Infineon XMC4200 with ARM Cortex-M4 Core, VQFN-48	1	XMC4200Q48K256ABXUMA1	No
IC2	Fixed Linear Voltage Post Regulator, 3.3V	1	TLS202B1MBV33	Yes
IC3, IC5	Dual-Bit, Dual-Supply Voltage Bus Transceiver with Configurable Voltage Translation and 3-State Outputs	2	SN74LVC2T45DCTT	No

Design Files

Designator	Description	Quantity	Manufacturer Order Number	Automotive Qualified
IC4, IC6	Single-bit noninverting bus transceiver	2	SN74LVC1T45DCKR	No
ILoadVS, ILoadVSD, JP1, JP2, JP7, X1	Through hole .025'' SQ Post Header, 2.54mm pitch, 2 pin, vertical, single row	6	HTSW-102-07-L-S	No
JP3, JP4	Through hole .025'' SQ Post Header, 2.54mm pitch, 6 pin, vertical, double row	2	TSW-103-07-L-D	No
JP5, JP6	Through hole .025'' SQ Post Header, 2.54mm pitch, 3 pin, vertical, single row	2	HTSW-103-07-L-S	No
JP8	Through hole .025'' SQ Post Header, 2.54mm pitch, 36 pin, vertical, double row	1	TSW-118-23-L-D	No
JP9	Through hole .025'' SQ Post Header, 2.54mm pitch, 12 pin, vertical, double row	1	TSW-106-05-L-D	No
Jumper1, Jumper2, Jumper3, Jumper4, Jumper5, Jumper6, Jumper7, Jumper8, Jumper9, Jumper10, Jumper11, Jumper12, Jumper13, Jumper14, Jumper15, Jumper16, Jumper17, Jumper18, Jumper19, Jumper20, Jumper21, Jumper22, Jumper23, Jumper24, Jumper25, Jumper26, Jumper27, Jumper28, Jumper29, Jumper30, Jumper31, Jumper32, Jumper33, Jumper34, Jumper35, Jumper36, Jumper37	Jumper, 1x2-Positions, Pitch 2,54mm, black, Au, with handle	37	SNT-100-BK-G-H	No
L1	Data and signal line common mode choke, Operating temperature -55/+125°C, tinned terminals, SMD, 100uH	0	B82789C0104N002	AEC Q200
LED0.0, LED0.1, LED0.10, LED0.2, LED0.3, LED0.4, LED0.5, LED0.6, LED0.7, LED0.8, LED0.9, LED1.0, LED1.1, LED1.2, LED1.3, LED1.4,	Standard SMD LED, 0603, Red	19	TLMS1100-GS08, TLMS1000-GS08	AEC Q101

Design Files

Designator	Description	Quantity	Manufacturer Order Number	Automotive Qualified
LED_FIFO, LED_SUP, LEDCOM				
LED_VDDEXT, LED_VDDP	Standard SMD LED, 0603, Green	2	TLMP1100-GS08	AEC Q101
LPI	Inductor, IND / STD / 6.8uH / 36A / 20% / -40°C to 125°C / 4.6mR / SMD	1	XAL1510-682MED	AEC Q200
LUSB	Chip ferrite beads BLM series, 0603, 60R	1	BLM18PG600SN1D	No
Phase1, Phase2, Phase3	PCB Mounted Insulated Socket, Green, 50 V ac, Contact Resistance & Omega 10 mO max, THT	3	571-0400	No
POTI	Compact type potentiometer, THT, 10k	1	RK09K1130AAU	No
Q1	Surface Mount Compact Crystal Unit, SMD, 16MHz	0	NX3225GA-16.000M-STD-CRG-2	AEC Q200
QHS1, QHS2, QHS3, QLS1, QLS2, QLS3, QRP1	OptiMOS-5 N-Channel Enhancement Mode - Normal Level Power Transistor	7	IPC70N04S5-4R6	AEC Q101
QRP2	NPN general-purpose transistor	1	BC817K-40R	AEC Q101
R1, R2, R3, R4, R10, R11, R12	Standard Thick Film Chip Resistor, 0805, 0R	5	CRCW08050000Z0	AEC Q200
R5, R6, R7, R8, RRP2	Standard Thick Film Chip Resistor, 0805, 10k	5	CRCW080510K0FK	AEC Q200
R9	Standard Thick Film Chip Resistor, 0805, 200R	1	CRCW0805200RFK	AEC Q200
R_VDH, RF, RM1, RM2, RM3	Standard Thick Film Chip Resistor, 0805, 1k	5	CRCW08051K00FK	AEC Q200
RCOM	Automotive Grade Thick Film Chip Resistor, 0603, 680R	1	AC0603FR-07680RL	AEC Q200
RGHS1, RGHS2, RGHS3, RGLS1, RGLS2, RGLS3	Standard Thick Film Chip Resistor, 0805, 2R	6	CRCW08052R00FKEAHP	AEC Q200
RGSHS1, RGSHS2, RGSHS3, RGSLS1, RGSLS2, RGSLS3	Standard Thick Film Chip Resistor, 0805, 100k	6	CRCW0805100KFK	AEC Q200
RLED0.0, RLED0.1, RLED0.10, RLED0.2, RLED0.3, RLED0.4, RLED0.5, RLED0.6, RLED0.7, RLED0.8, RLED0.9, RLED1.0, RLED1.1, RLED1.2, RLED1.3, RLED1.4, RLEDVDDEXT, RLEDVDDP	Standard Thick Film Chip Resistor, 0603, 1.5k	16	CRCW06031K50FK	AEC Q200

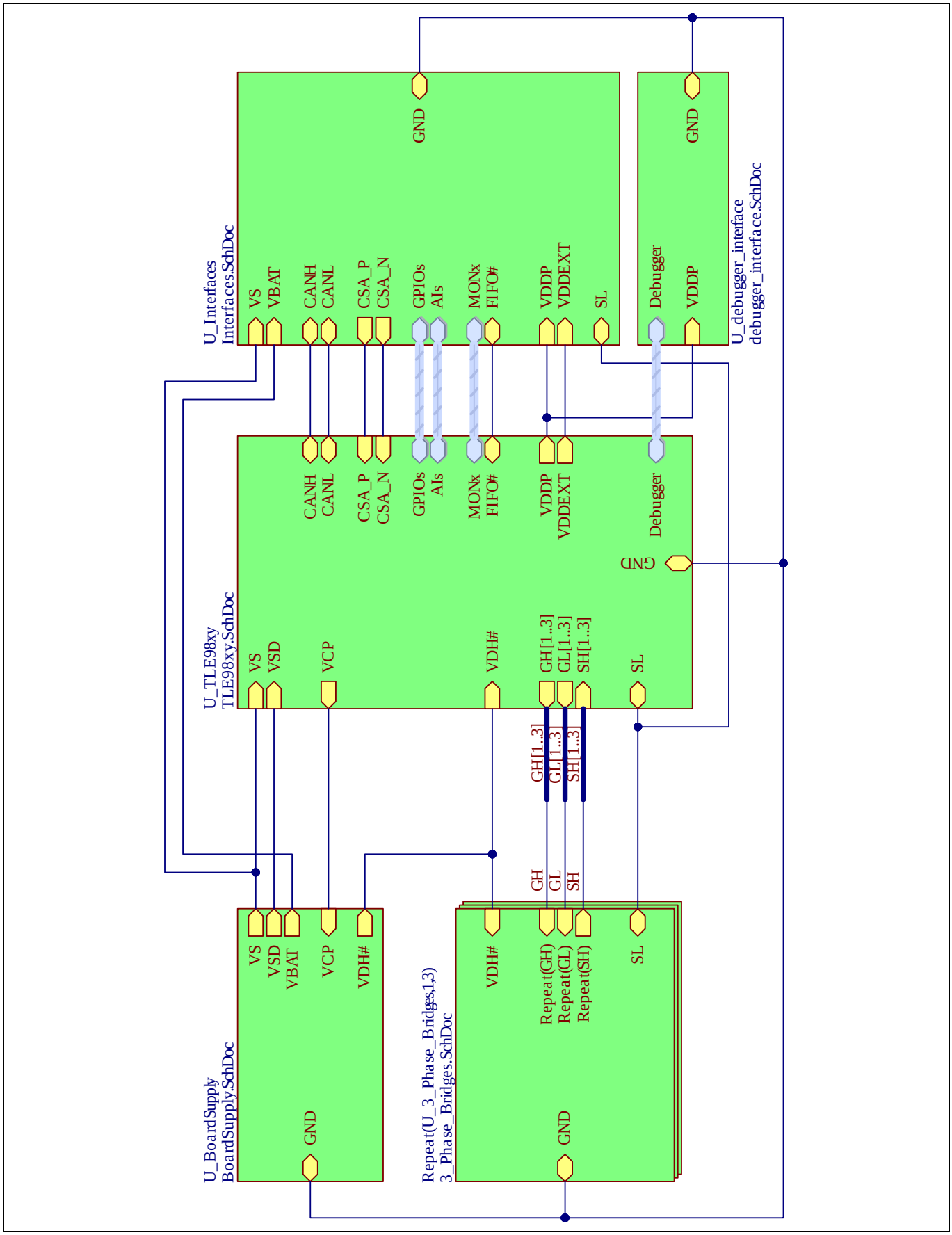
Design Files

Designator	Description	Quantity	Manufacturer Order Number	Automotive Qualified
ROP1, ROP2	Standard Thick Film Chip Resistor, 0805, 12R	2	CRCW080512R0FK	AEC Q200
RPDLS1, RPDLS2, RPDLS3, RPORST, RUSB2	Standard Thick Film Chip Resistor, 0402, 10k	5	CRCW040210K0FK	AEC Q200
RPULS, RUSB1, RVDDP1, RVDDP2	Standard Thick Film Chip Resistor, 0402, 4.7k	4	CRCW04024K70FK	AEC Q200
RRP1	Standard Thick Film Chip Resistor, 0805, 3.3k	1	CRCW08053K30FK	AEC Q200
RS1	Precision Resistor, BVB, size 2725, 5mR	0	BVB-I-R005	AEC Q200
RS2	Resistor, STD / 15mR / 10W / 1% / 75ppm/K / -65°C to 170°C / 2818 / SMD, 2818, 15mR	1	WSHP2818R0150FEA	AEC Q200
RSBHS1, RSBHS2, RSBHS3, RSBLS1, RSBLS2, RSBLS3, RVSD	Standard Thick Film Chip Resistor, 0805, 2R	1	CRCW08052R00FK	AEC Q200
RSH1, RSH2, RSH3	Standard Thick Film Chip Resistor, 0805, 10R	3	CRCW080510R0FKEA HP	AEC Q200
RSHELL	Standard Thick Film Chip Resistor, 0603, 1.1MEG	1	CRCW06031M10FK	AEC Q200
RSUP	Standard Thick Film Chip Resistor, 0805, 12k	1	CRCW080512K0FK	AEC Q200
RT1, RT2	Standard Thick Film Chip Resistor, 0805, 62R	2	CRCW080562R0FK	AEC Q200
RUSBM, RUSBP	Standard Thick Film Chip Resistor, 0402, 22R	2	CRCW040222R0FK	AEC Q200
RXO	Standard Thick Film Chip Resistor, 0603, 100R	0	CRCW0603100RFK	AEC Q200
RXTAL	Standard Thick Film Chip Resistor, 0402, 150R	1	CRCW0402150RFK	AEC Q200
S1, S2, S3, S4, S5	Switch, Normally open 1,3:2,4, SMD	5	430182043816	No
U1	MOTIX™ MCU TLE989X, LQFP-64	0	TLE989X_LQFP-64	AEC Q101ö
VBAT	Banana Socket, Red, 15.3mm Pitch	1	571-0500	No
X2	Through hole .025'' SQ Post Header, 2.54mm pitch, 8 pin, vertical, double row	1	TSW-104-07-F-D	No
X3	Through hole .025'' SQ Post Header, 2.54mm pitch, 32 pin, vertical, double row	1	TSW-116-07-L-D	No
X4	Micro USB 2.0 Type B - Horizontal - SMT	1	629105150521	No
X8	SMT Micro Header, 1.27mm pitch, 10 pin, vertical, double row	1	FTSH-105-01-L-DV-K	No

Design Files

Designator	Description	Quantity	Manufacturer Order Number	Automotive Qualified
XA, XC, XD	Through hole .025'' SQ Post Header, 2.54mm pitch, 16 pin, vertical, single row	3	TSW-116-07-L-S	No
XB1, XB2	Through hole .025'' SQ Post Header, 2.54mm pitch, 8 pin, vertical, single row	2	TSW-108-07-L-S	No
Y1	SMD Crystal, 12MHz, Temperature Range (-40°C to 125°C), SMD, 12MHz	1	CX3225CA12000D0HSSCC	AEC Q200

5.2 Schematics of the TLE989x EvalBoard with TQFP/LQFP spring socket



Design Files

Figure 26 TLE989x EvalBoard with TQFP/LQFP spring socket, sheet 1, TLE988x_TLE989x_baseBoard_v1_1

Design Files

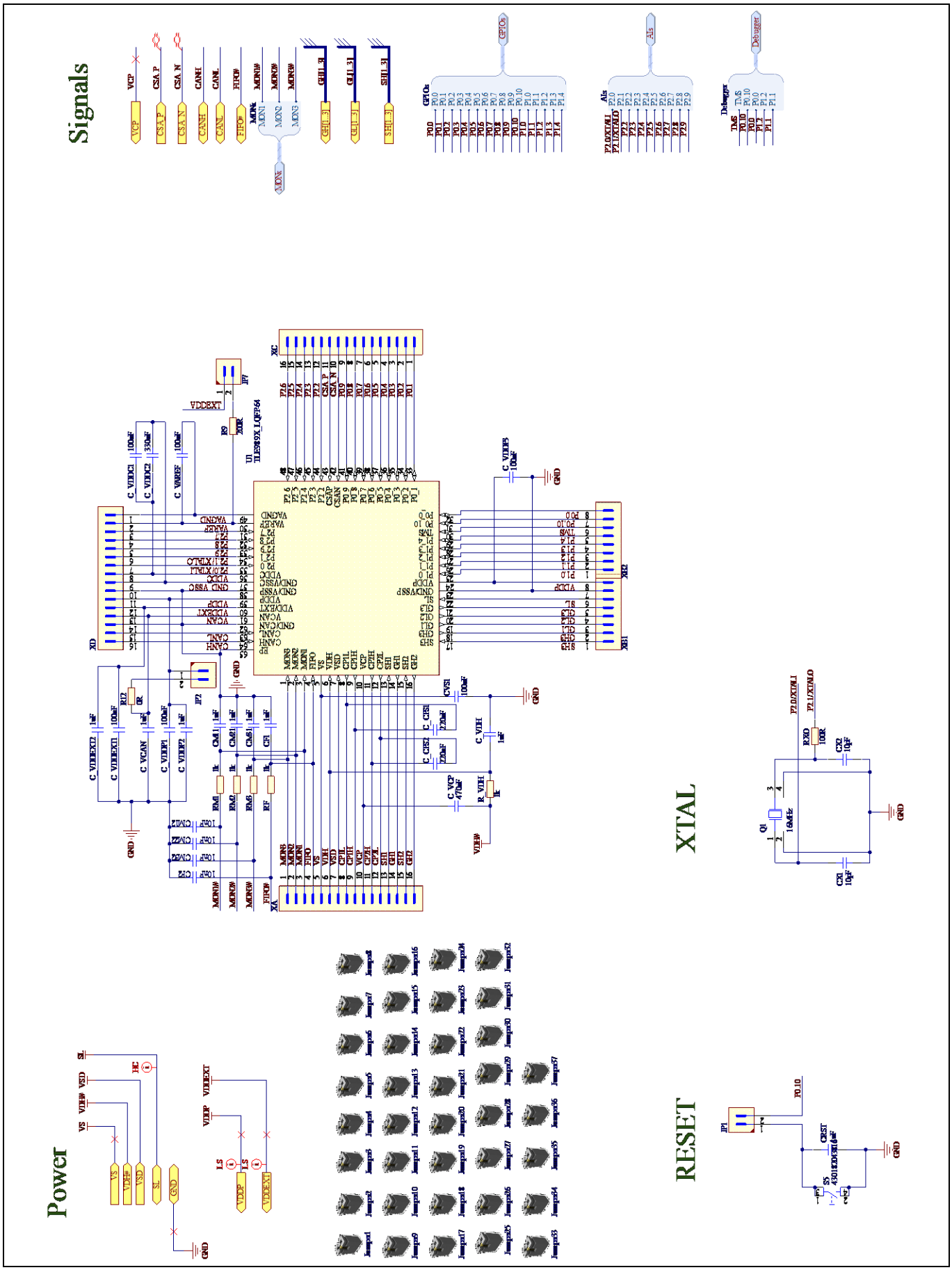


Figure 27 TLE989x EvalBoard with TQFP/LQFP spring socket, sheet 2, TLE98xy

Design Files

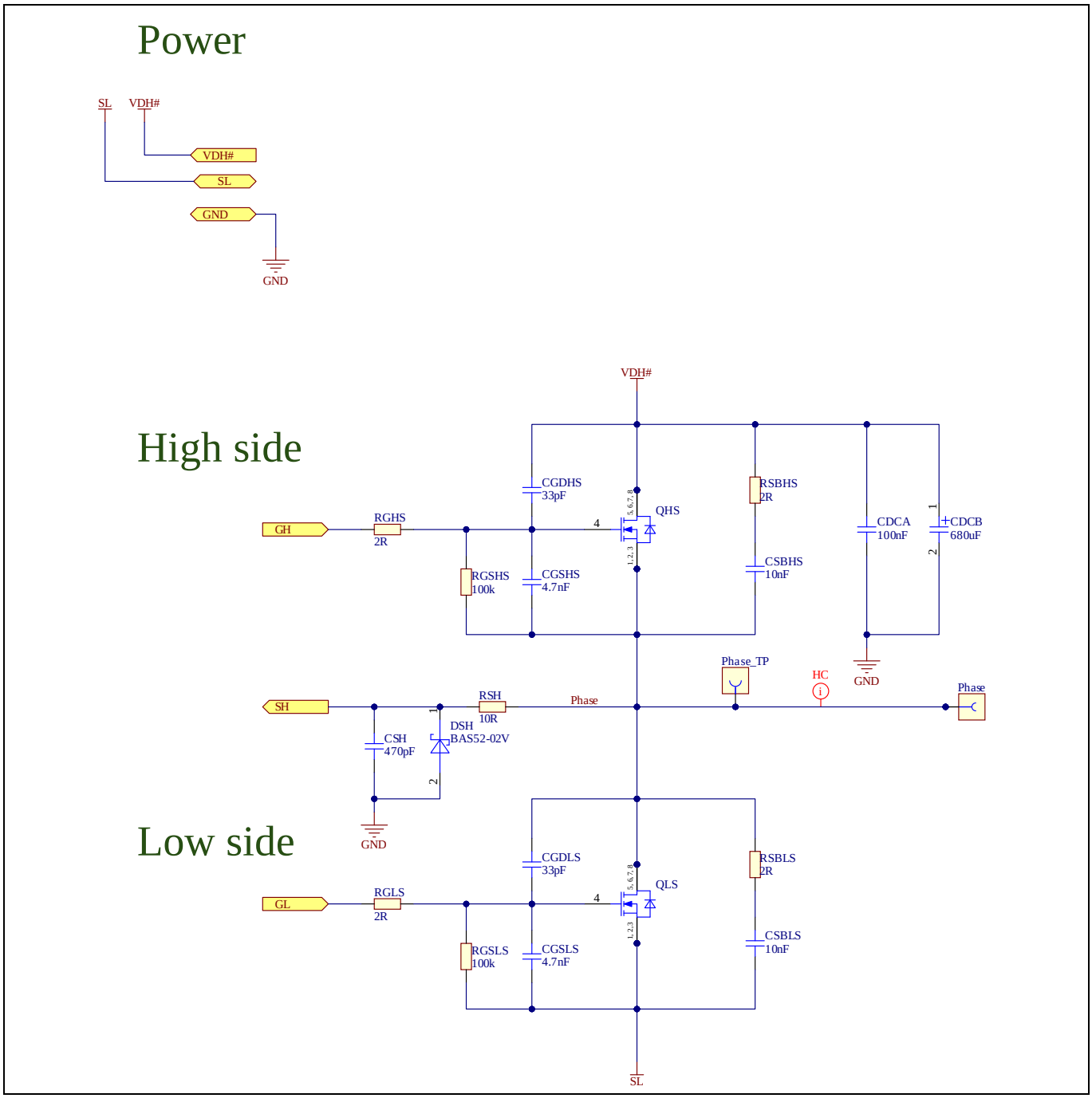


Figure 28 TLE989x EvalBoard with TQFP/LQFP spring socket, sheet 3, 3_Phase_Bridges

Design Files

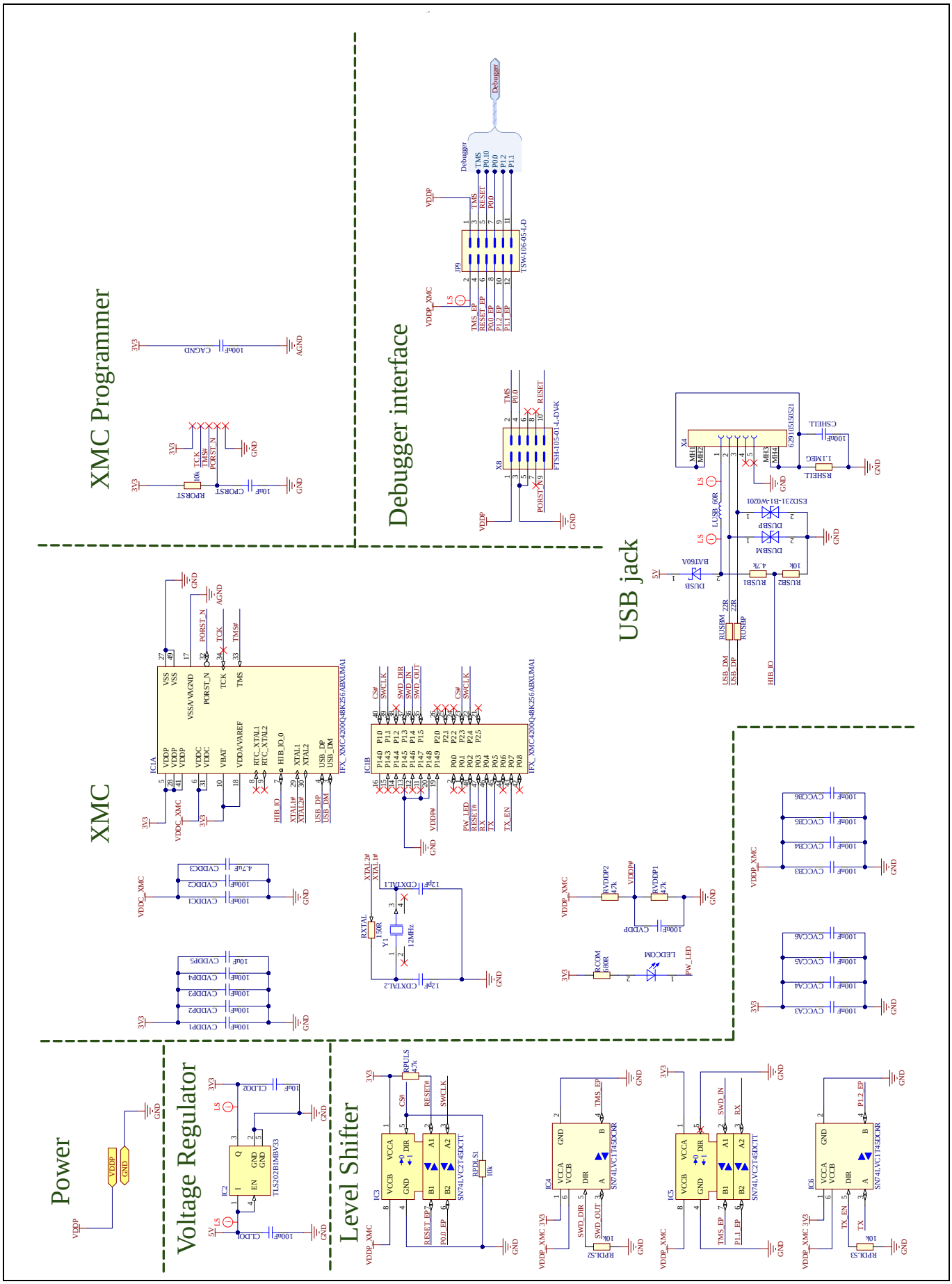


Figure 29 TLE989x EvalBoard with TQFP/LQFP spring socket, sheet 4, debugger_interface

Design Files

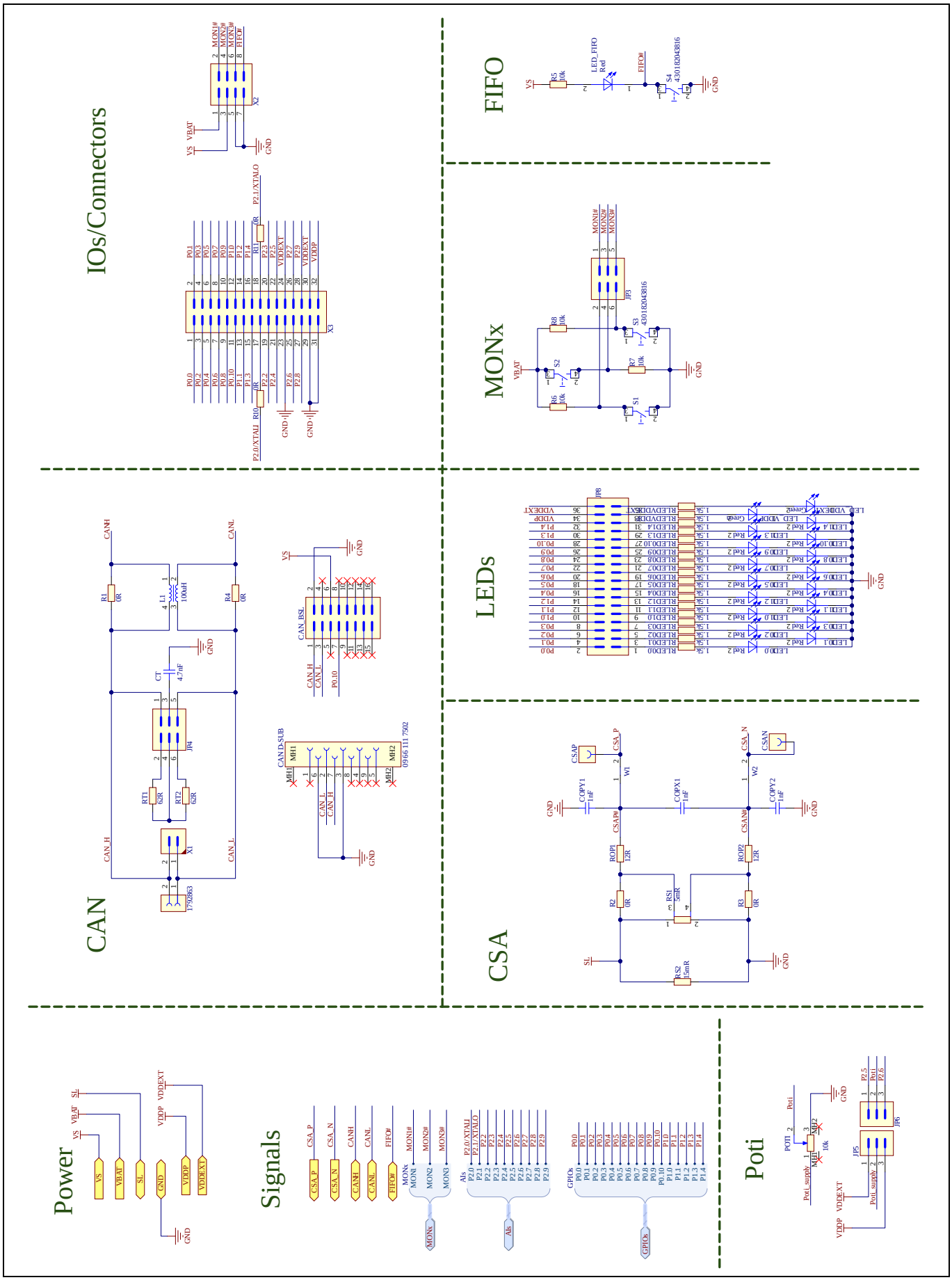


Figure 30 TLE989x EvalBoard with TQFP/LQFP spring socket, sheet 5, Interfaces

Design Files

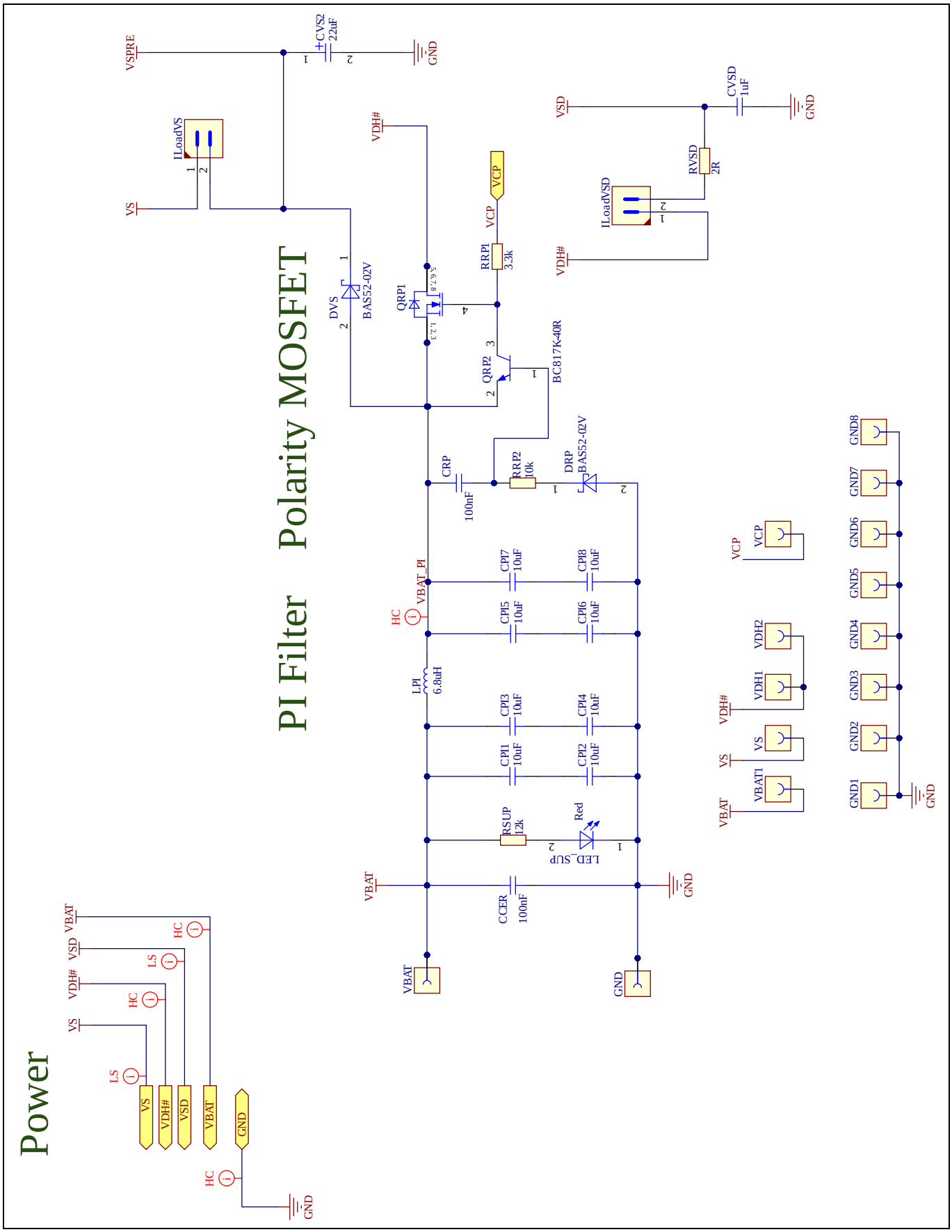


Figure 31 TLE989x EvalBoard with TQFP/LQFP spring socket, sheet 6, BoardSupply

5.3 Layout of the TLE989x EvalBoard with TQFP/LQFP spring socket

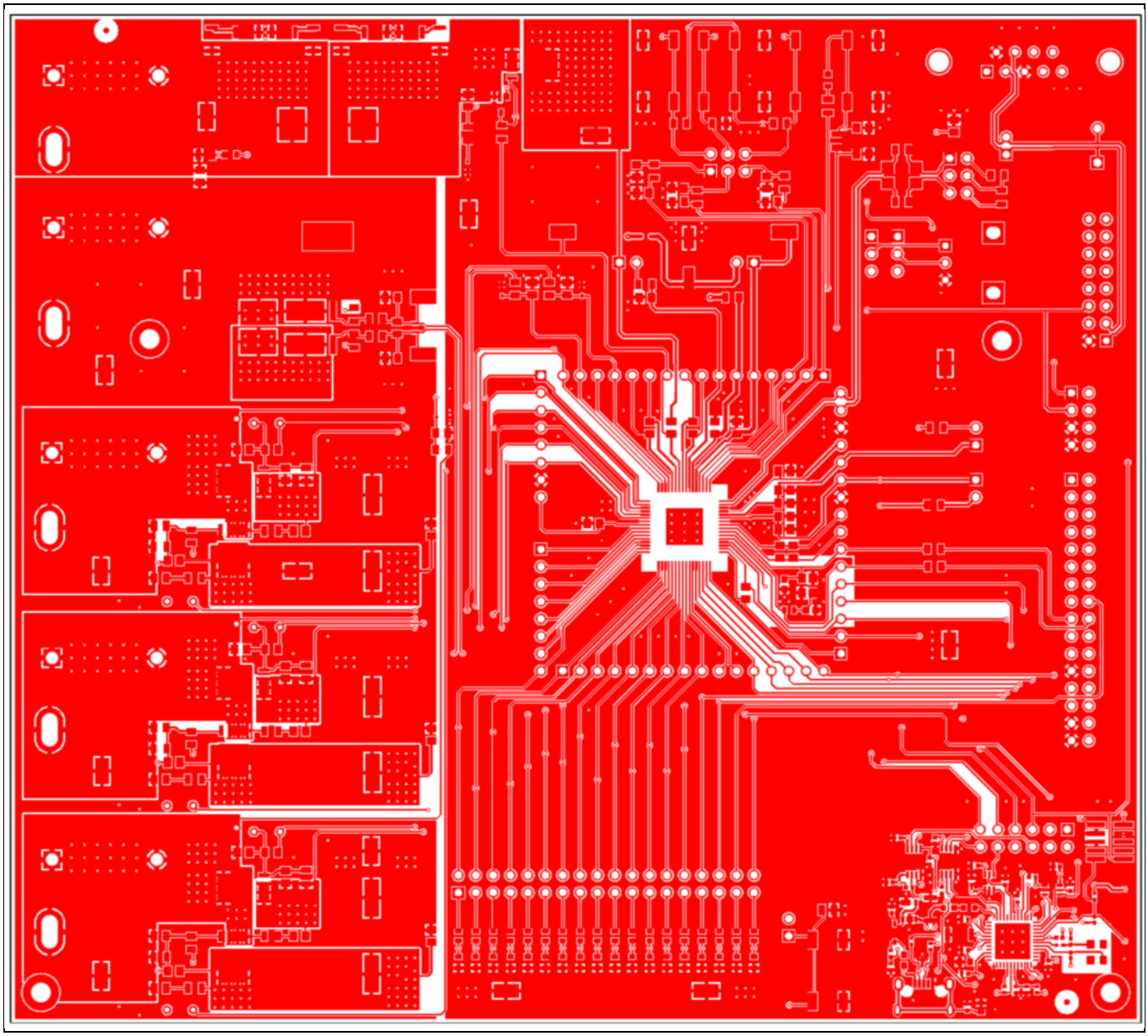


Figure 32 TLE989x EvalBoard with TQFP/LQFP spring socket, layer1 (Top layer, signal)

Design Files

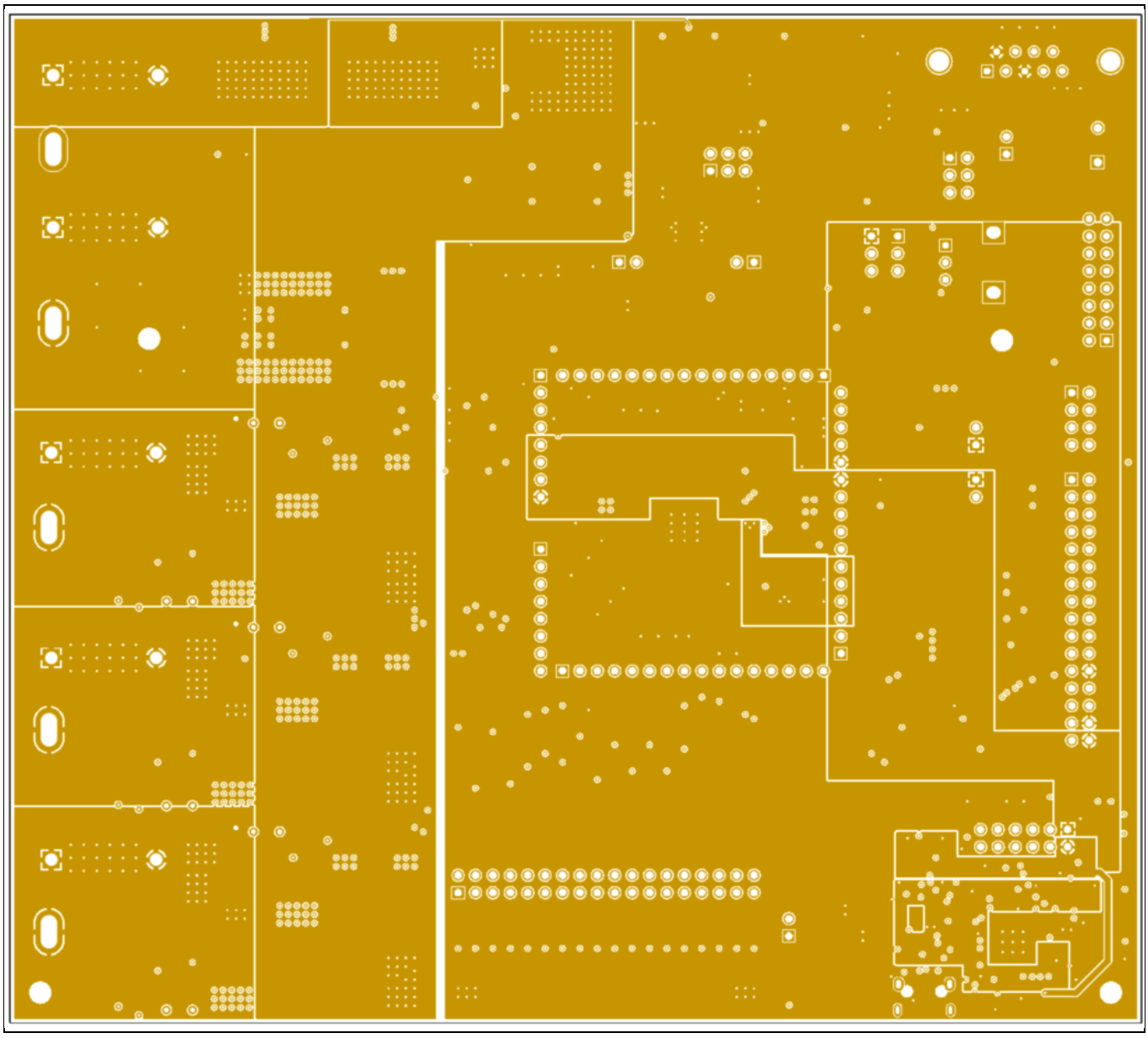


Figure 33 TLE989x EvalBoard with TQFP/LQFP spring socket, layer2 (Middle layer, power)

Design Files

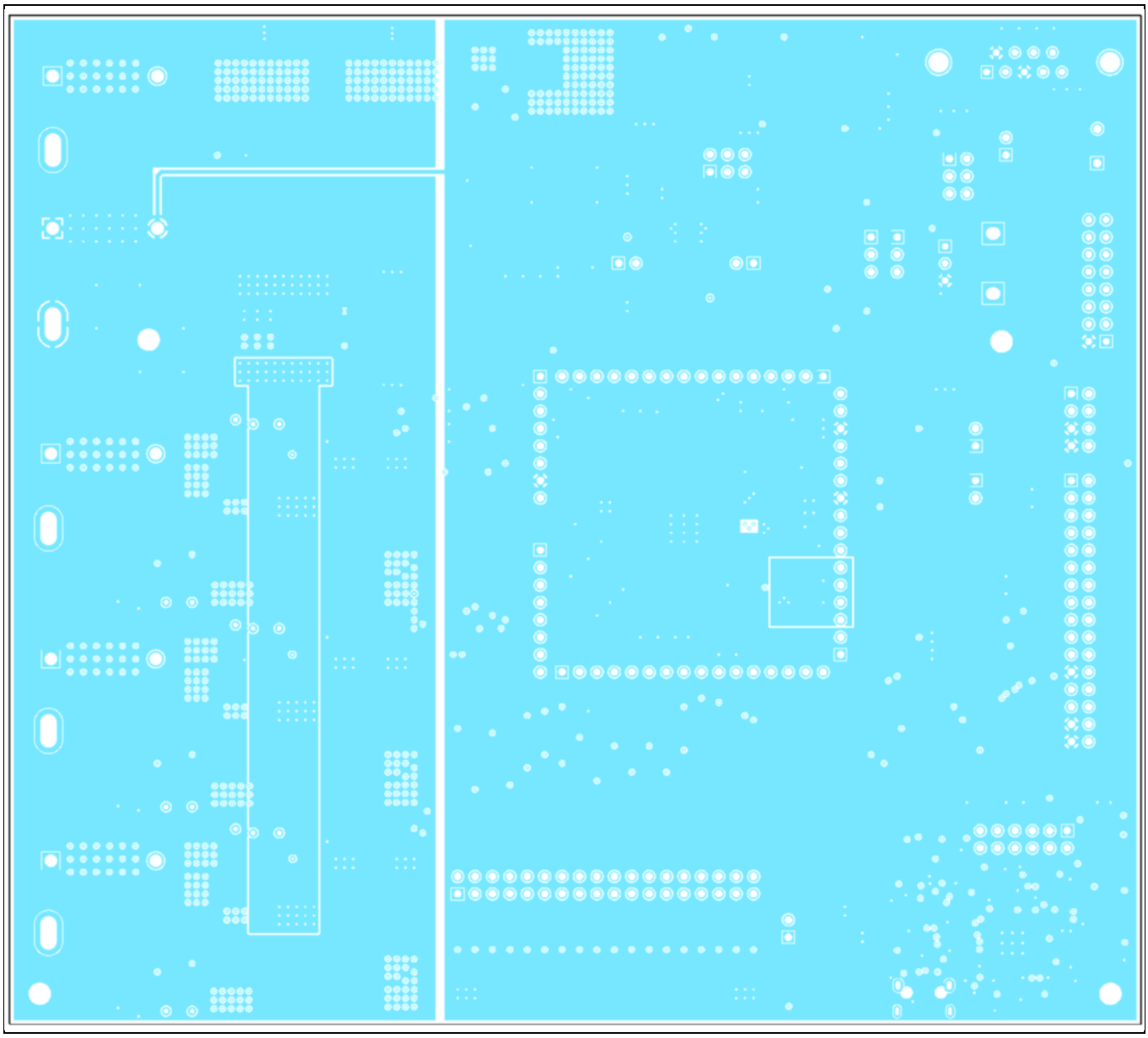


Figure 34 TLE989x EvalBoard with TQFP/LQFP spring socket, layer3 (Middle layer, GND)

Design Files

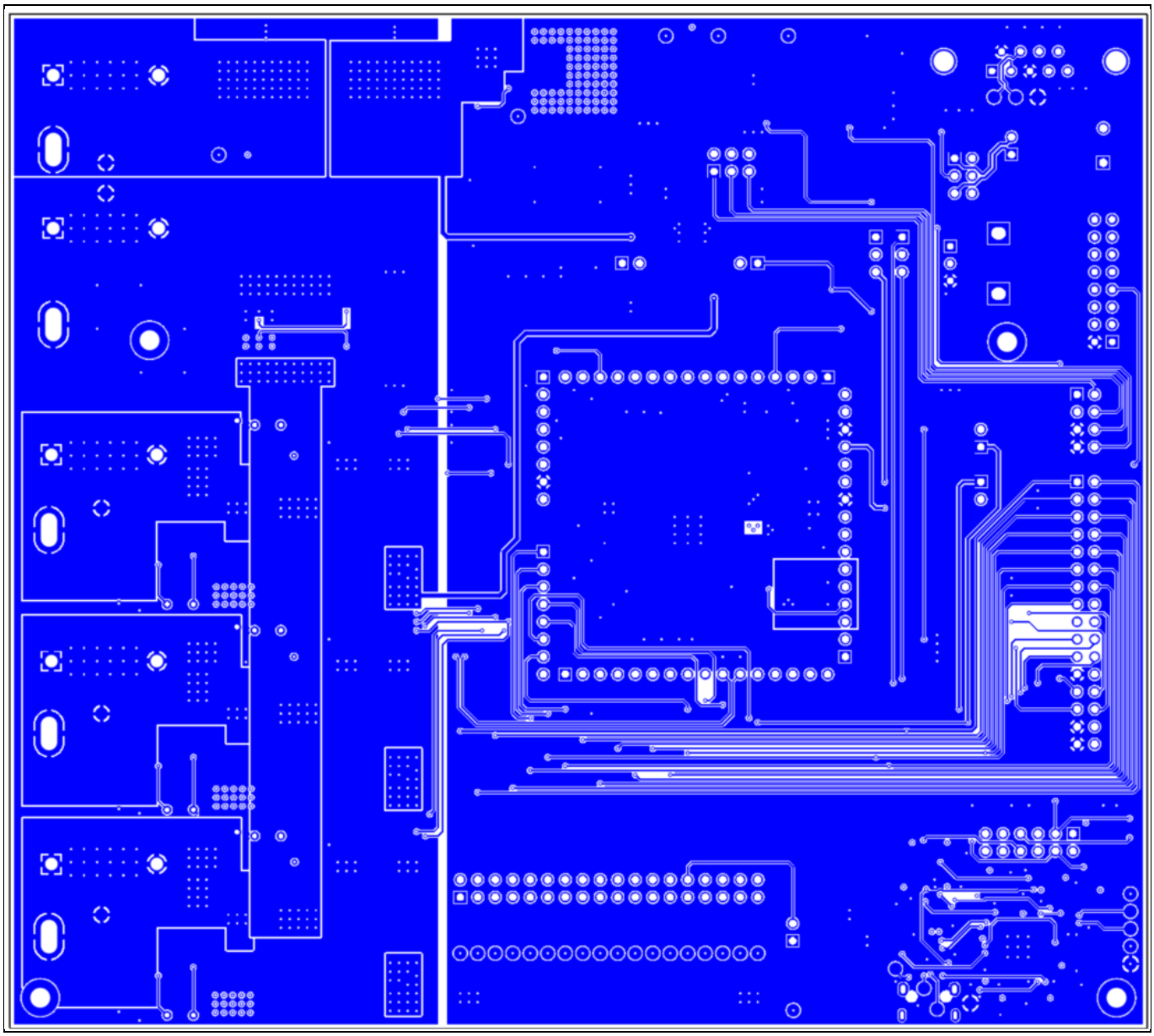


Figure 35 TLE989x EvalBoard with TQFP/LQFP spring socket, layer4 (Bottom layer, signal)

5.4 Schematics of the LQFP64 Socketboard

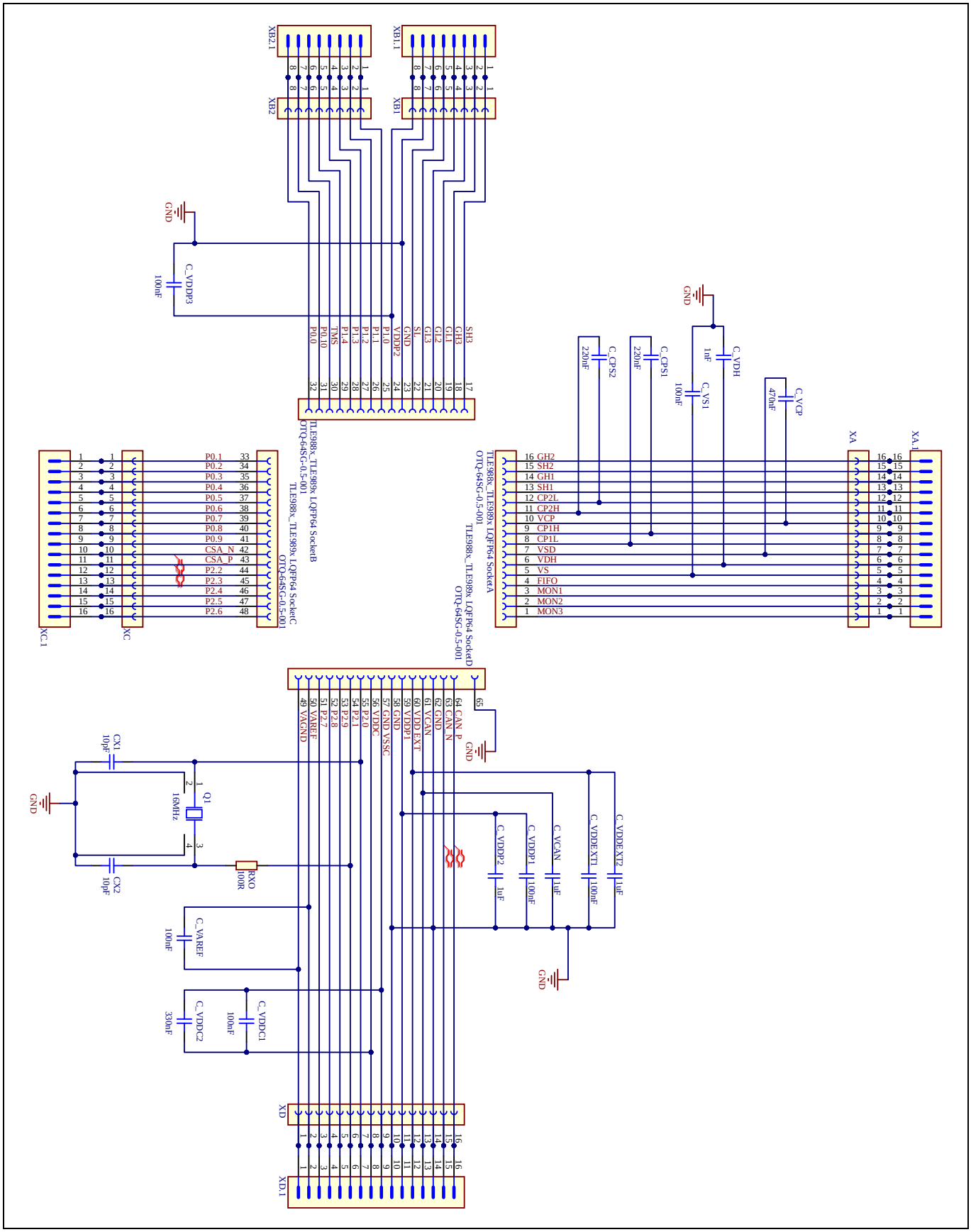


Figure 36 TLE988x_TLE989x LQFP64 Socketboard Schematics

5.5 Layout of the LQFP64 Socketboard

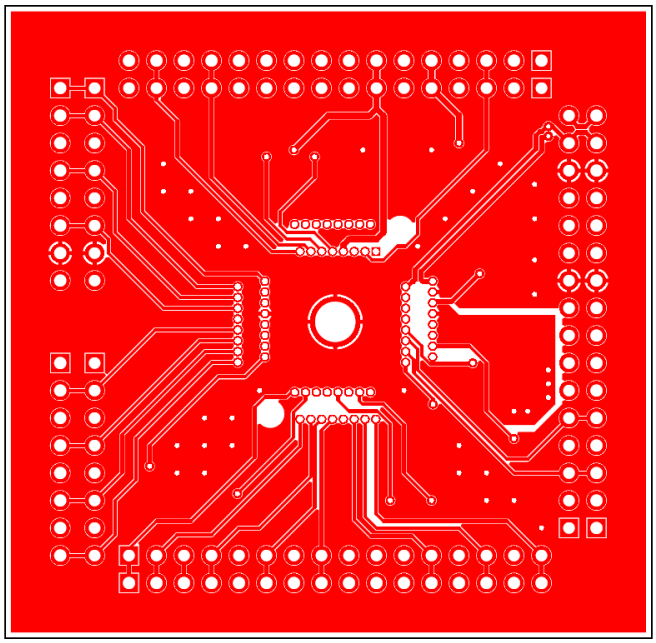


Figure 37 TLE988x_TLE989x LQFP64 Socketboard, Top layer

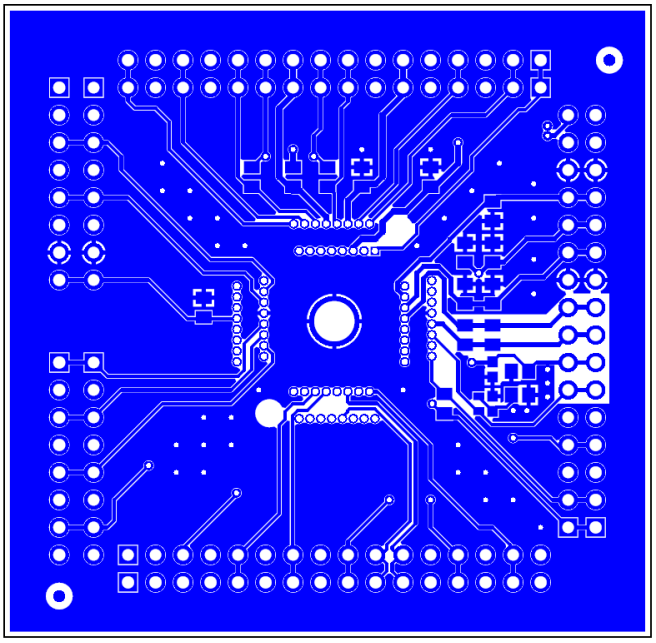


Figure 38 TLE988x_TLE989x LQFP64 Socketboard, Bottom layer

5.6 Schematics of the TQFP48 Socketboard

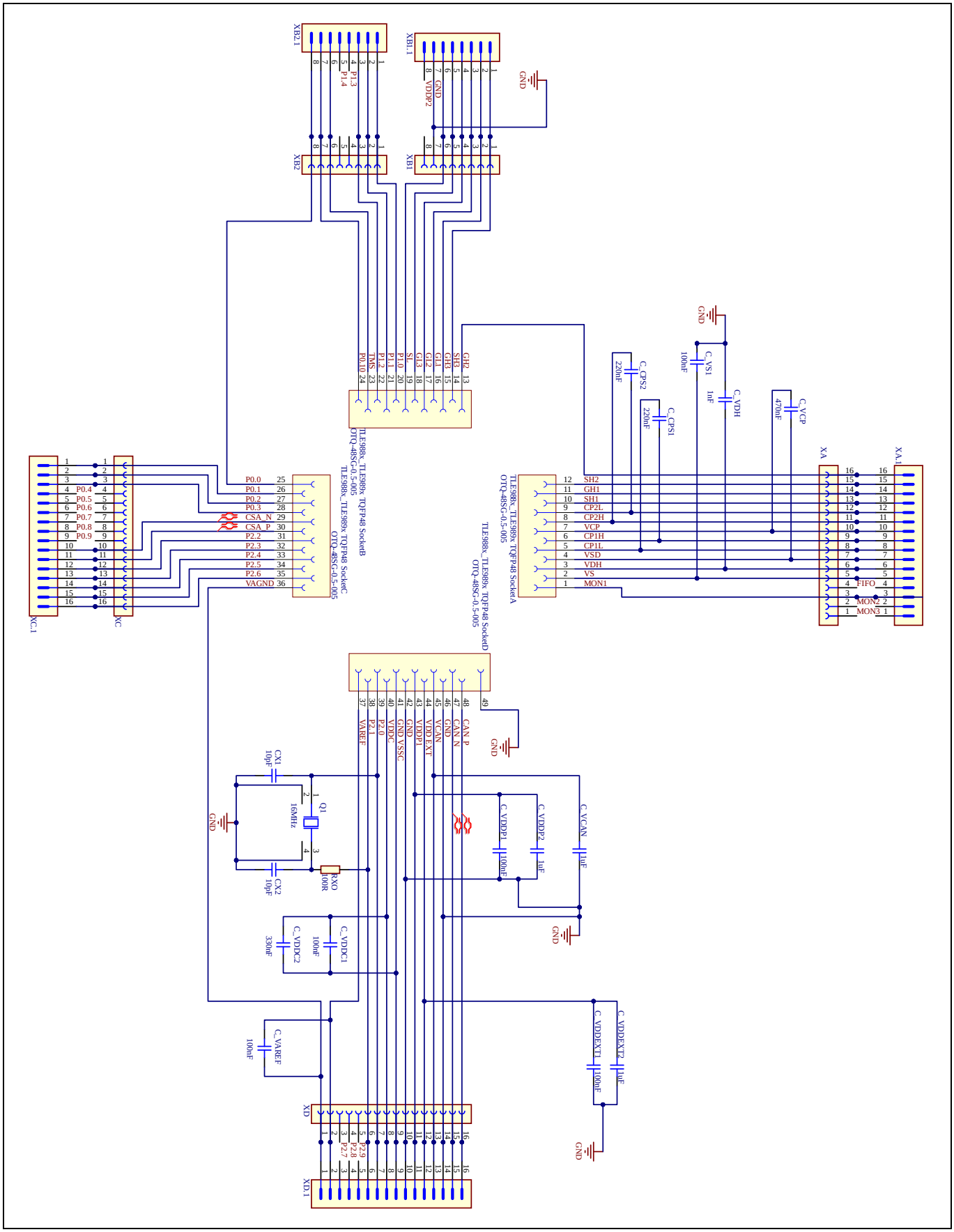


Figure 39 TLE988x_TLE989x TQFP48 Socketboard Schematics

5.7 Layout of the TQFP48 Socketboard

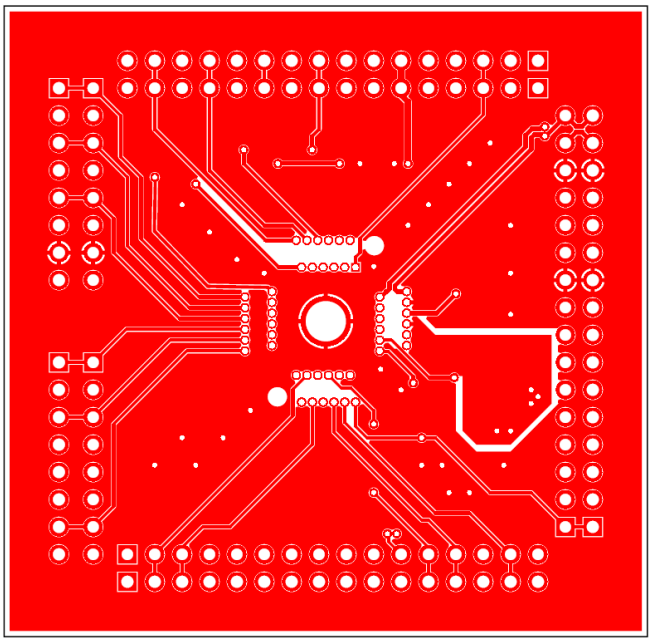


Figure 40 TLE988x_TLE989x TQFP48 Socketboard, Top layer

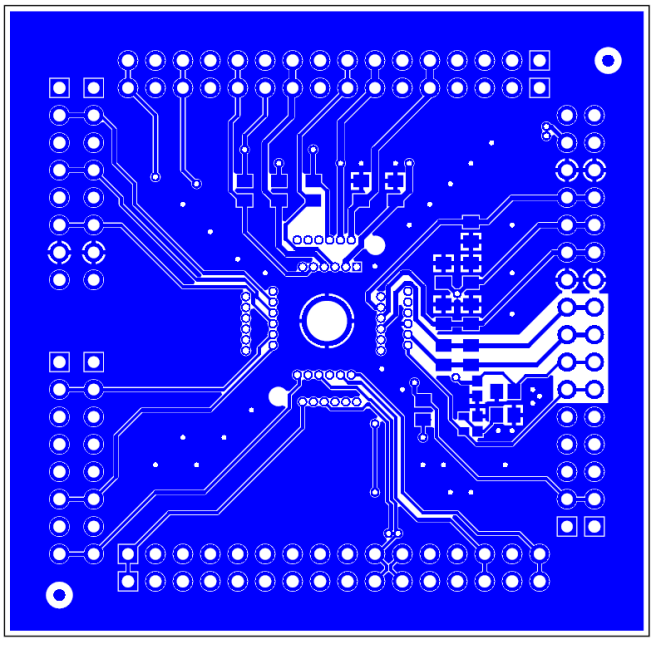


Figure 41 TLE988x_TLE989x TQFP48 Socketboard, Bottom layer

6 References and appendices

6.1 Abbreviations and definitions

Table 9 Abbreviations

Abbreviation	Meaning
BLDC	Brushless direct current
BSL	Bootstrap loader
CSA	Current sense amplifier
CSAN	Negative current sense amplifier input
CSAP	Positive current sense amplifier input
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
ISP	In-system programmer
LED	Light Emitting Diode
MON	Monitor
N.C.	Not connected
n/u	Not used
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
VAREF	Reference voltage
*	Pins marked with * are only available in 64 pin variant of IC
( )	Pins inside brakets are not connected to the IC by default
#	Nodes marked with # are connected to the according ICs pin via a resistor

Revision history

Document version	Date of release	Description of changes
1.0	13.10.2022	Initial release

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