# TLE92104 APPKIT


## About this document

### Scope and purpose

This user manual is intended to help users using the TLE92104 APPKIT. This APPKIT is designed to evaluate hardware and software functionalities of the TLE92104.

This manual provides additional information about the board's layout, jumper settings, interface and how to use the GUI.

### Intended audience

This document is for everyone who works with the TLE92104 APPKIT.

# Abbreviations

| | |
|---|---|
| CSN | Chip select |
| CSIx | Current Sense Input x |
| CSOx | Current Sense Output |
| DC | Direct Current or Duty Cycle |
| EN | TLE92104 enable pin |
| GH1-4 | Gate high-side MOSFET for half-bridge 1-4 |
| GL1-4 | Gate low-side MOSFET for half-bridge 1-4 |
| GND | Ground |
| GUI | Graphic User Interface |
| MOSFET | Metal-Oxide-Semiconductor Field-Effect Transistor |
| N.C. | Not connected |
| OC | Overcurrent |
| OV | Overvoltage |
| PWM1-3 | Pulse Width Modulation channel 1-3 |
| SCLK | Serial Clock |
| SDI | Serial Data In |
| SDO | Serial Data Out |
| SPI | Serial Periphery Interface |
| TJ | Junction temperature |
| UV | Undervoltage |
| VBAT | Battery supply voltage |
| VCP | Charge pump voltage |
| VDD | Logic supply voltage |
| VDH | Voltage drain of high-side MOSFET |
| VS | Battery supply voltage |
| VSP | Half-bridge supply voltage |

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# 1 Concept

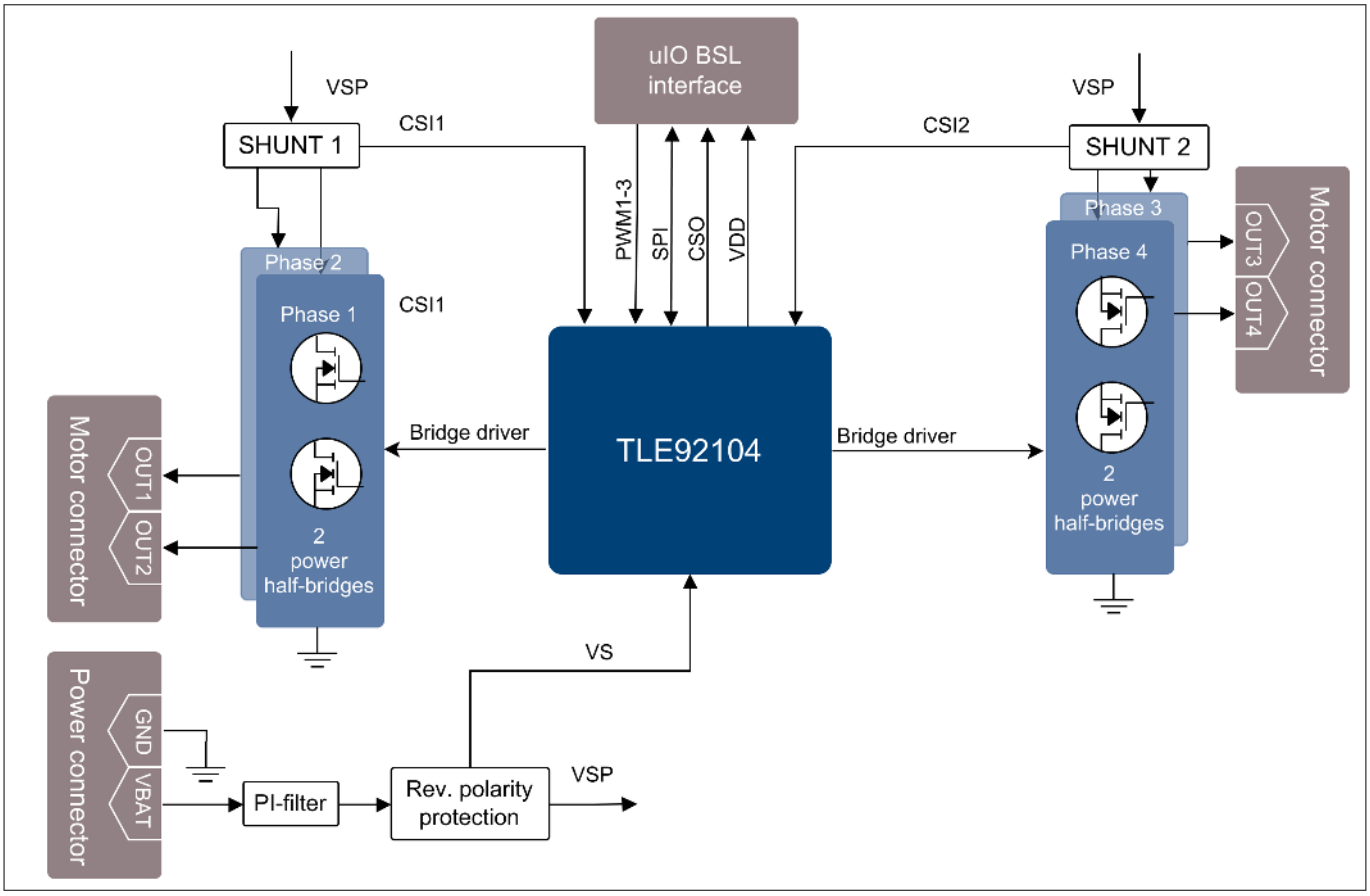


Figure 1 Block diagram

The TLE92104 APPKIT board provides a simple, easy-to-use tool to get familiar with Infineon's Multi MOSFET Driver TLE92104-232QX (TLE92104).

It contains the TLE92104 and a typical application circuit including 4 MOSFET half-bridges to drive up to 4 DC motors. The board is ready to be connected to a vehicle level power supply and is controlled over SPI.

All pins relevant to control the device can be accessed via the dedicated 8 × 2 header using the uIO-stick by hitex EMBEDDED TOOLS & SOLUTIONS (http://www.hitex.com/uIO).

The board is powered by the power connector and provides an active on-board reverse-polarity protection for fastest response time in case of reverse polarity with minimal power-loss during normal operation.

The board allows control of Phase 1-4 which can be used to control up to 4 motors independently that can be connected to OUT1-4 with the 2 screw terminal block motor connectors.

2 high-side shunts provide load current measurement and monitoring.

# 2 PCB layout

Infineon's TLE92104 is a Multi-MOSFET driver IC providing control of up to 8 n-channel MOSFETs. It supports up to 4 half-bridges for DC motor control applications such as automotive power seat control or other multi-motor applications (Datasheet of TLE92104-232QX).

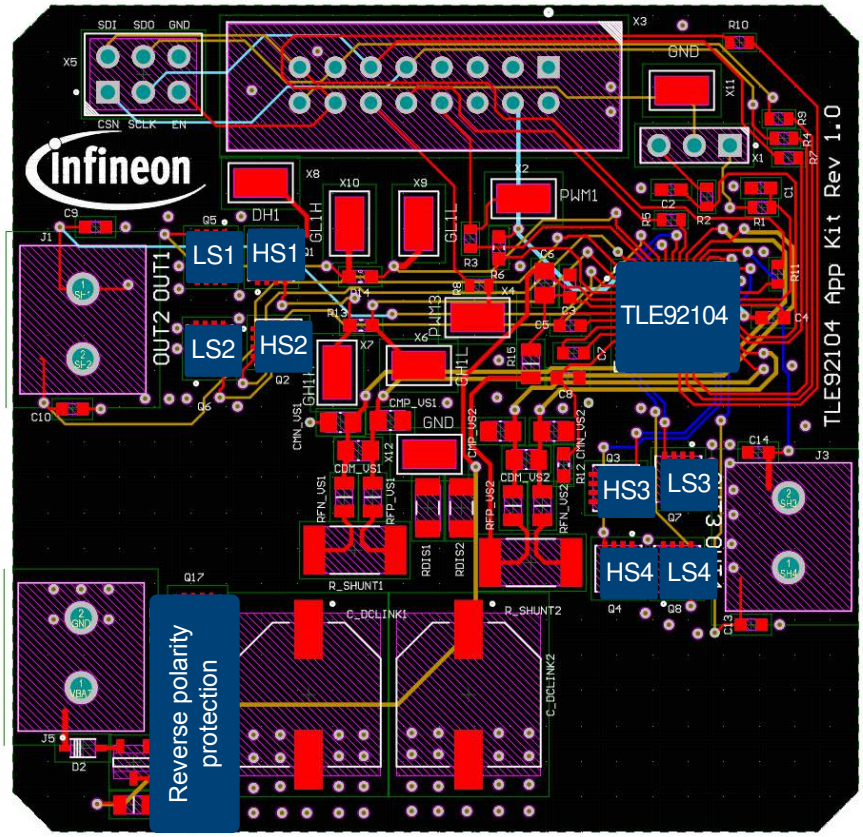


Figure 2 PCB layout

### HS1-4, LS1-4

Infineon's new OptiMOS™5 40 V product family in S3O8 package combines leading power MOSFET technology with 3.3 × 3.3 mm$^2$ leadless power package for very compact and robust automotive system solutions (Datasheet of IPZ40N04S5-3R1).

### Reverse polarity protection

The active reverse polarity protection is based on the design documented in the "Reverse Polarity Protection for Embedded Power ICs" Application Note (Z864338247).

# 3 Connections

Several external connections are available on the TLE92104 APPKIT.

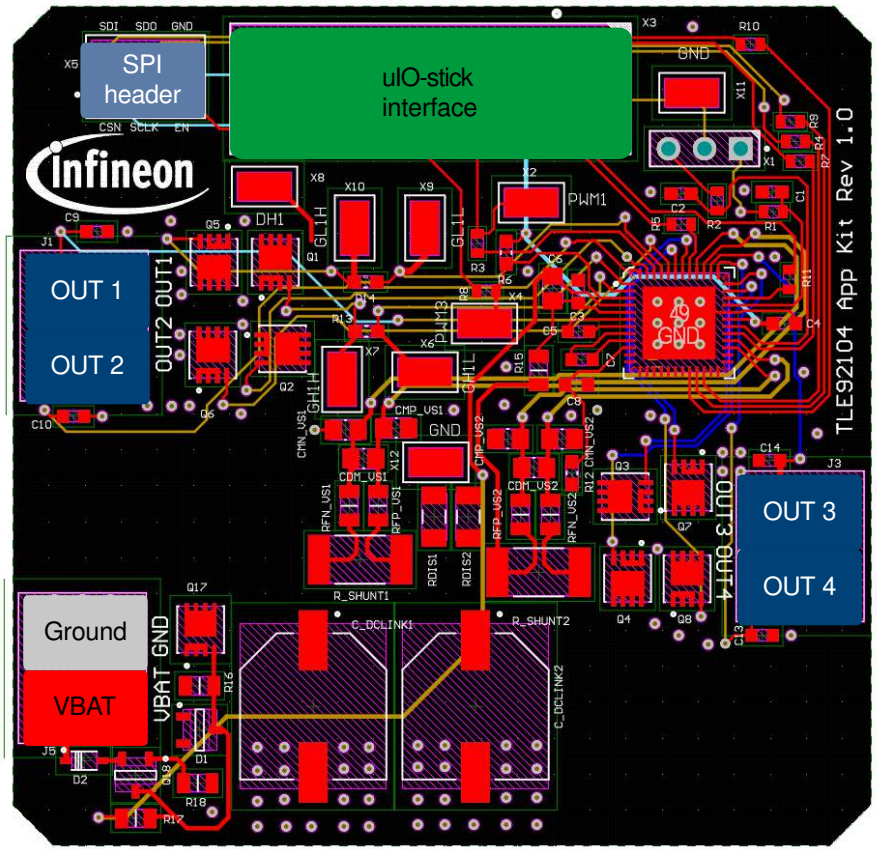


Figure 3 Connections

## uIO-stick interface

The uIO-stick interface can be used to establish communication with the TLE92104 for programming of the SFRs and motor control. Setting up the interface can be found in APPKIT setup. The pinout is shown in Figure 4.

| SDI | SDO | SCLK | CSN | N.C. | N.C. | N.C. | NC. |
|---|---|---|---|---|---|---|---|
| 15 | 13 | 11 | 9 | 7 | 5 | 3 | 1 |
| 16 | 14 | 12 | 10 | 8 | 6 | 4 | 2 |
| CSOx | EN | PWM3 | PWM2 | PWM1 | N.C. | VDD | GND |

Figure 4 Pin configuration of uIO-stick

## 3 Connections

### Motor connectors

The screw terminal blocks can be used to connect DC motors in multiple topologies, some examples are shown in Figure 5.

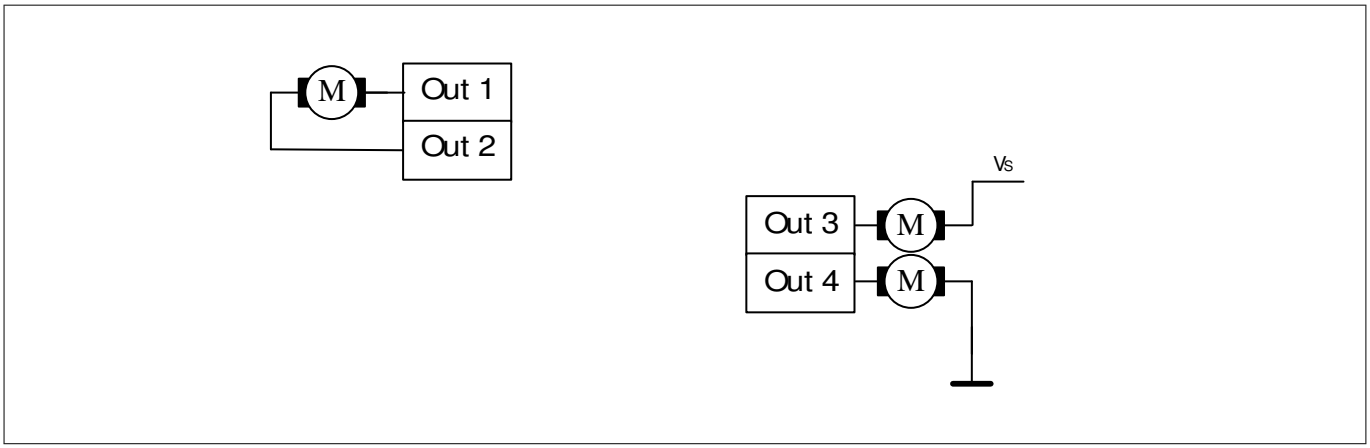


Figure 5 Motor connectors and topologies

### Power connector

The screw terminal blocks are used to connect the supply voltage to VBAT and ground to GND.

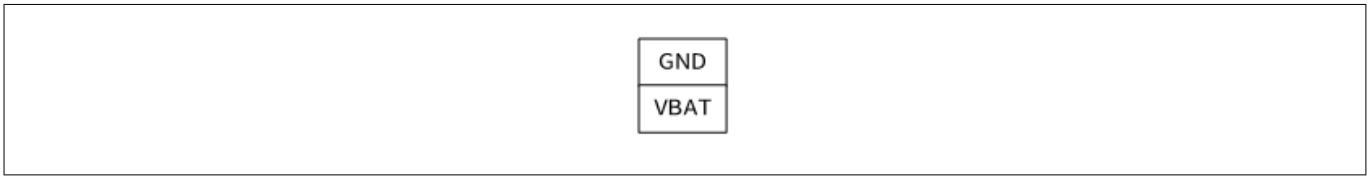


Figure 6 Power connector

### SPI header

The 3 × 2 header can be used for SPI debugging. The pinout is shown in Figure 7.

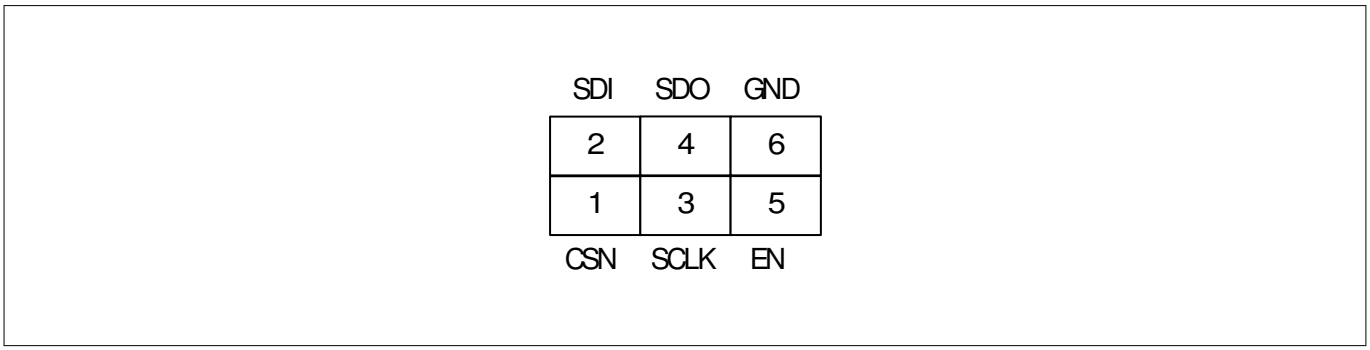


Figure 7 SPI header pinout

# 4 Current Sense Output (CSO) jumper setting

The Current Sense Output jumper selects which IC current sense output is connected to the uIO interface. The signal is routed to the uIO-stick interface pin 16. The pinout is shown in Figure 9.

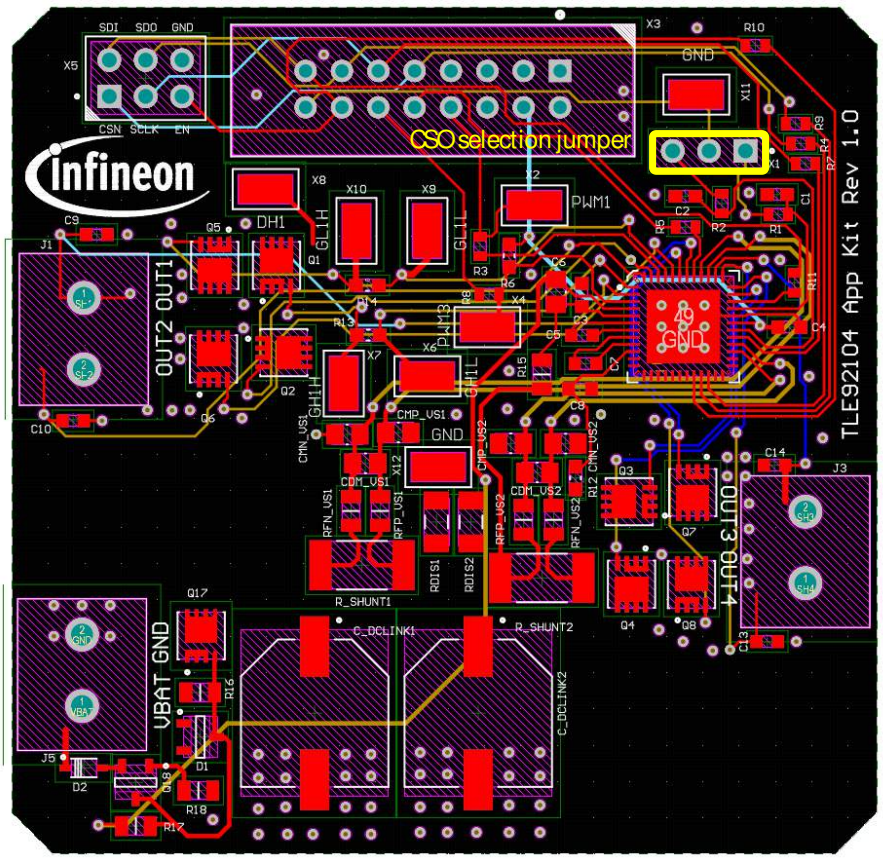


Figure 8 Current Sense Output selection jumper


Figure 9 CSO selection jumper pinout

# 5 SMD test points

The TLE92104 APPKIT provides 9 SMD test points for evaluation and testing.

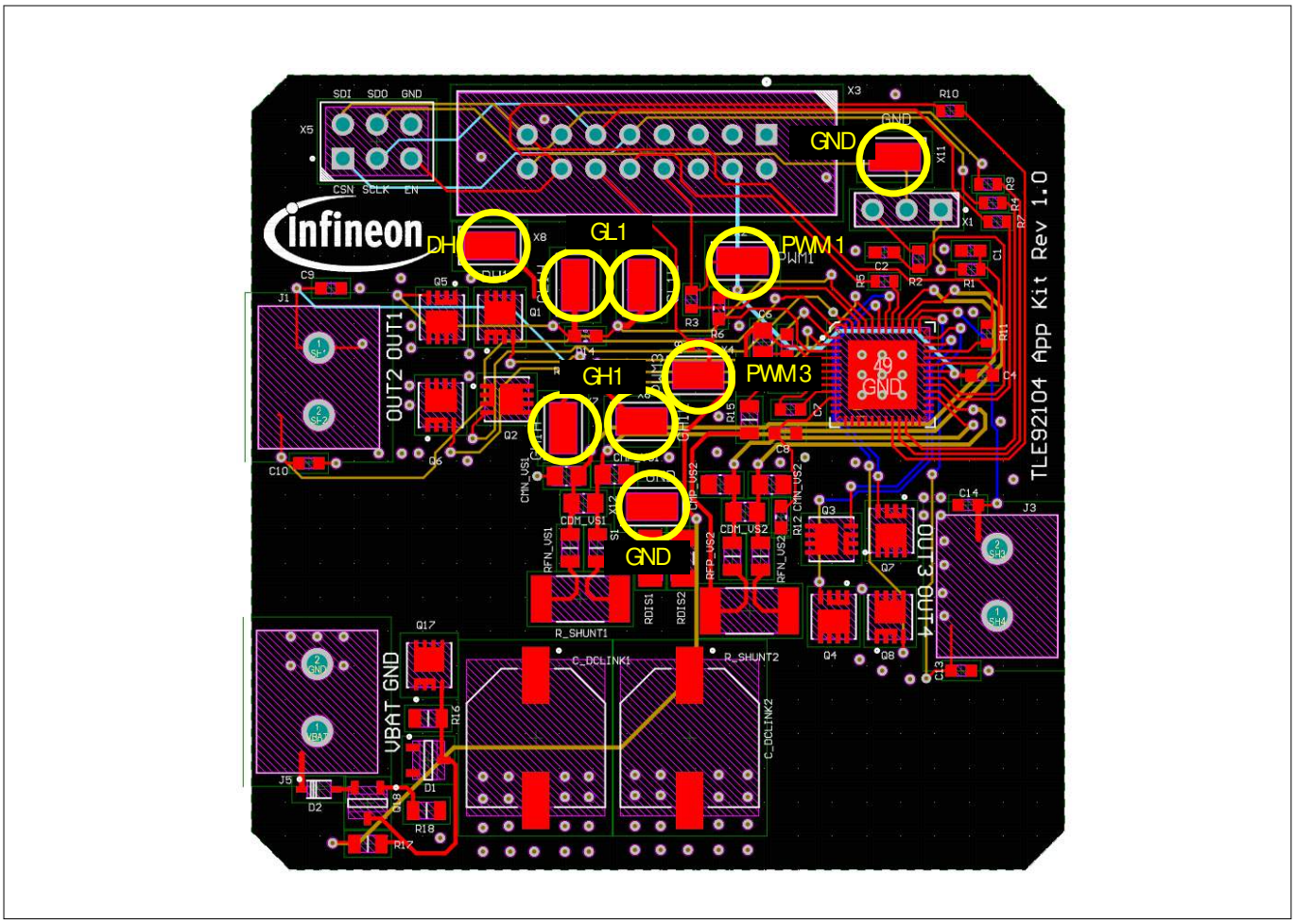


Figure 10 SMD test points

The TLE92104 APPKIT includes test points for:

- 2× GND
- 1× VDH
- 2× GL1
- 2× GH1
- 1× PWM1
- 1× PWM3

# 6 Bill of material

Table 1 Bill of material

| Designator | Value |
|---|---|
| C1, C2 | 100 pF |
| C3, C4, C8 | 100 nF |
| C5, C7 | 220 nF |
| C6 | 470 nF |
| C9, C10, C13, C14 | 22 nF |
| C_DCLINK1, C_DCLINK2 | 560 uF |
| CDM_VS1, CDM_VS2 | 1.50 nF |
| CMN_VS1, CMN_VS2, CMP_VS1, CMP_VS2 | 22 nF |
| D1 | BZX84C16LT1G |
| D2 | BAS21 |
| J1, J3, J5 | 20020316-G021B01LF |
| Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8 | IPZ40N04S5-3R1 |
| Q17 | BCR141 |
| Q18 | IPZ40N04S5L-2R8 |
| R1, R2, R3, R4, R5, R7, R8, R9, R10, R11 | 1 kR |
| R6 | 47 kR |
| R12 | 2 R |
| R13, R14 | 10 R |
| R15 | 2.20 R |
| R16 | 100 kR |
| R17 | 4.7 kR |
| R18 | 47 kR |
| R_SHUNT1, R_SHUNT2 | 5 mR |
| RDIS1, RDIS2 | 15 kR |
| RFN_VS1, RFN_VS2, RFP_VS1, RFP_VS2 | 4.70 R |
| U1 | TLE92104-233QX |
| X1 | Header 3 |
| X2, X4, X6, X7, X8, X9, X10, X11, X12 | connector_1_f |
| X3 | Header 8X2 |
| X5 | Header 3X2A |

# 7 TLE92104-232 pinout

The TLE92104 comes in a space saving 7 × 7 $mm^2$ VQFN 48 pin package and is AEQ-Q100 qualified up to a junction temperature $T_J$ of 150°C.

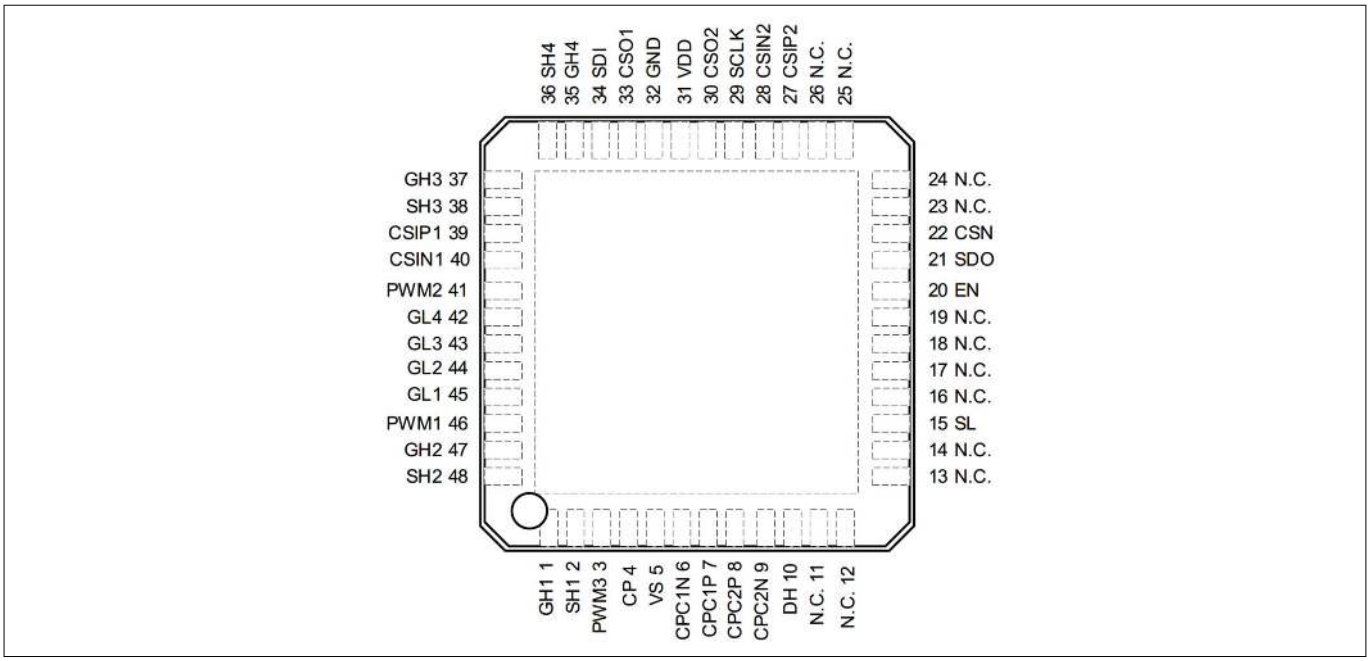


Figure 11 TLE92104 pinout

# 8 APPKIT setup

The APPKIT can be controlled with the uIO-stick which provides an interface between the PC GUI and the APPKIT's uIO connector is able to translate message between the APPKIT and the GUI available for PC.

## 8.1 Installing the GUI

The GUI is installed the Infineon Toolbox following the steps below:

1. Go to: www.infineon.com/toolbox.
2. Follow the instructions provided on the toolbox installation webpage. Also see the "Download Getting Started Infineon Toolbox Guide" link for additional user information.
3. Launch the Infineon Toolbox on your PC:
4. Select Manage Tools.
5. Search and install the tool: Config Wizard for Multi MOSFET Driver.
6. Start the Config Wizard for Multi MOSFET Driver.
7. Click on TLE92104 APPKIT.

## 8.2 Establishing communication

To establish communication between the GUI and the TLE92104 APPKIT you must:

- Connect the TLE92104 Appkit to a power-supply.
- Connect the uIO-stick to the TLE92104 APPKIT.
- Connect the uIO-stick to a USB port of your PC.
- Turn on the power supply.
- Start the GUI.

Note: The GUI requires the uIO-sticks'-firmware to be of version 2.21 or above.

The GUI can be used to update the uIO-stick firmware to the latest version:

1. Open the GUI.
2. Click Extras.
3. Click Update uIO ….
4. A window will pop up, click Yes.
5. Select uIO_v221.hex or above.
6. Click Open.

Note: It is recommended to remove and reinsert the uIO-stick to reboot the uIO hardware.

## 8.3 Using the GUI

The GUI consists of three panels/tabs:

- Motor Control
- Detailed Settings
- PWM and Diagnostic

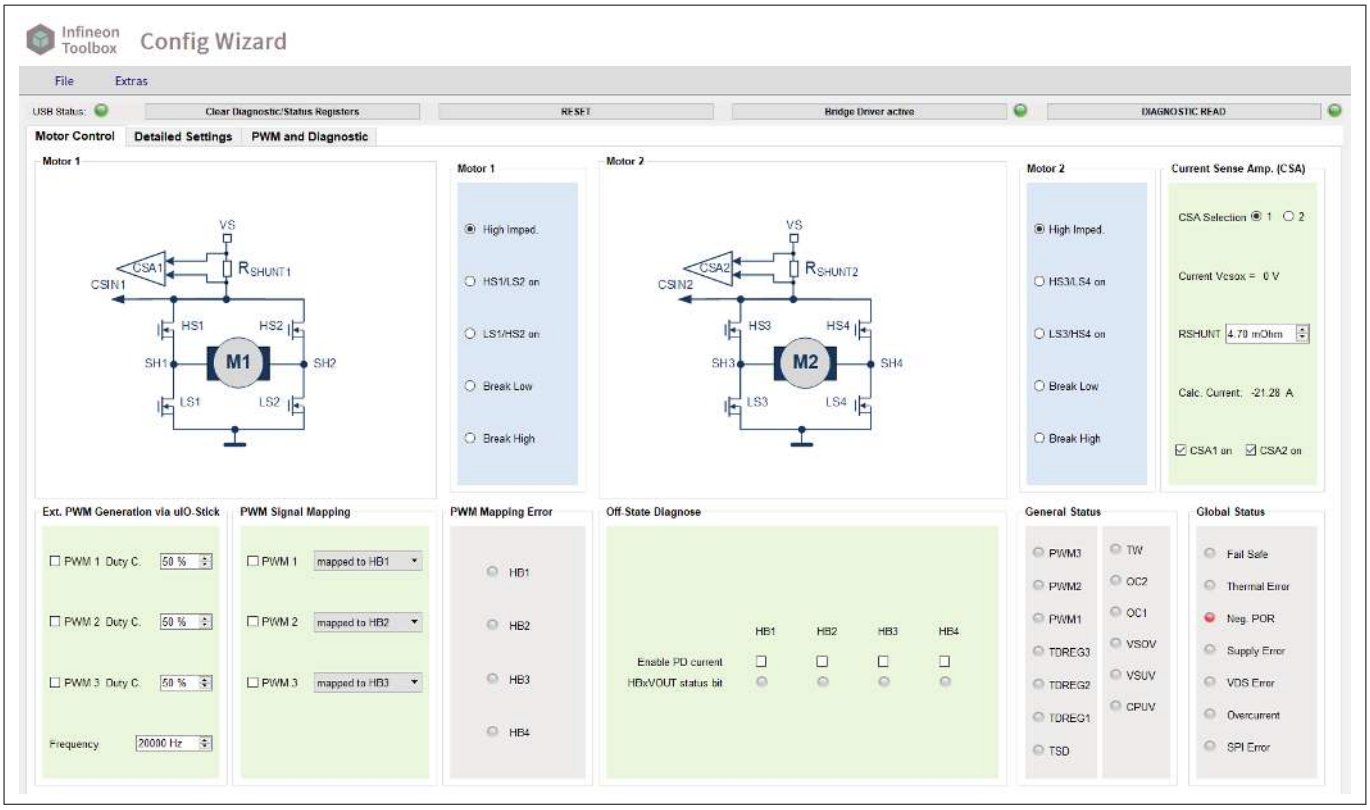


Figure 12 TLE92104 APPKIT GUI

Additionally the status of the USB connection, bridge driver and diagnostic read is shown on the top of the display:

Everything is up and running.

There seems to be a problem.

The GUI provides buttons to Clear Diagnosis, to Clear Status Registers and to RESET the device.

### Motor Control

In this panel it is possible to:

- Configure the PWM channels 1-3 with 0-100% DC and up to 25 kHz which are generated by the uIO-stick.
- Map the PWM to half-bridges 1-4.
- Set the HB state in either cascade or H bridge configuration.
- Select and disable the CSAs and see the current VCSOx output.
- See the General Status register and Global Status byte.
- Perform off-state diagnosis.

### Detailed Settings

In this panel it is possible to:

- Enable and configure the charge pump and set OV and UV thresholds.
- Configure passive mode settings.
- Configure the CSAs and enable OC shutdown.
- Configure gate driver timings (cross-current-protection and blank time), hold and static currents.
- Configure DS overvoltage.
- Map gate drive timings and static currents to half-bridge.

### PWM and Diagnostic

In this panel it is possible to:

- Enable adaptive MOSFET control, set filter, enable generator mode detection or deep adaption.
- Set dis/charge currents for active and free-wheeling MOSFET, configure adaptive currents, set target turn-on delay and pre dis/charge time for PWM channel 1-3.
- Read PWM switching characteristics.
- Check Global Status Byte, General Status register, PWM mapping error and drain-source overvoltage.

# 9 How to use the GUI (examples)

## 9.1 Example - PWM DC motor control using half-bridge 1 and 2

In this example a DC motor will be controlled by half-bridge 1 and 2. The half-bridge 1 output will be configured for 20 kHz PWM with 50% DC and the load current can be monitored using CSA1.

### Setup

Before you configure the GUI you will need to:

- Connect a DC motor to OUT1 and OUT2.
- Establish communication between the Appkit and the GUI as described in Establishing communication.

### Configure the GUI

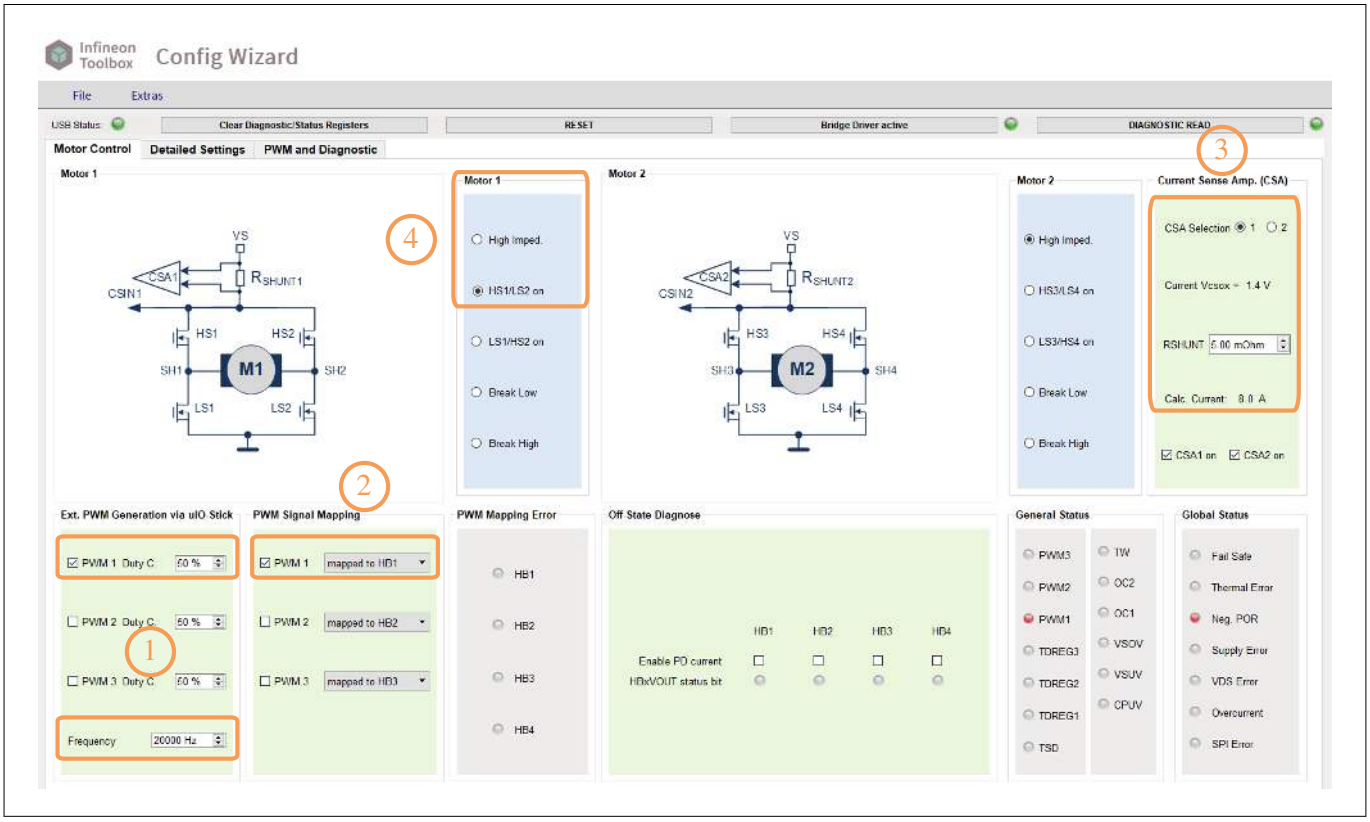


Figure 13 Control your first DC motor

To start the motor you will need to:

1. Set PWM 1 to 20 kHz and 50% DC (default values).
2. Map PWM 1 to HB1.
3. CSA1/2 are on and CSA 1 is selected by default. The PCB on-board jumper should connect CSO1 and CSO1/2 as described in Current Sense Output (CSO) jumper setting. For correct current sensing the value of RSHUNT should be set to 5 mΩ to match the PCB hardware.
4. Set Motor 1 to HS1/LS2 on.

The motor should start running with 20 kHz HS PWM at 50%.

The output of CSO1 can be seen in the CSA window (3).

## 9 How to use the GUI (examples)

The load current can be calculated accordingly:

$$I_{Load} = \frac{V_{CSOx} - V_{REF}}{R_{SHUNT} \times GAIN}$$

Table 2 CSA $V_{REF}$

| | Unidirectional mode | Bidirectional mode |
|---|---|---|
| VREF | VDD/5 | VDD/2 |

Table 3 CSA GAIN

| GENCTRL1.CSAGx | GAIN |
|---|---|
| b00 | 10 |
| b01 | 20 |
| b10 | 40 |
| b11 | 80 |

The VCSO output depends on the CSA configuration (Uni- or Bidirectional) and the Gain setting. The CSA can be configured as follows:

1. Go to Detailed Settings.
2. Set CSA Level, Gain, Unidirectional Threshold, Bidirectional Threshold and Overcurrent Filter (overcurrent detection filter time). (See datasheet for overcurrent monitoring and protection details).

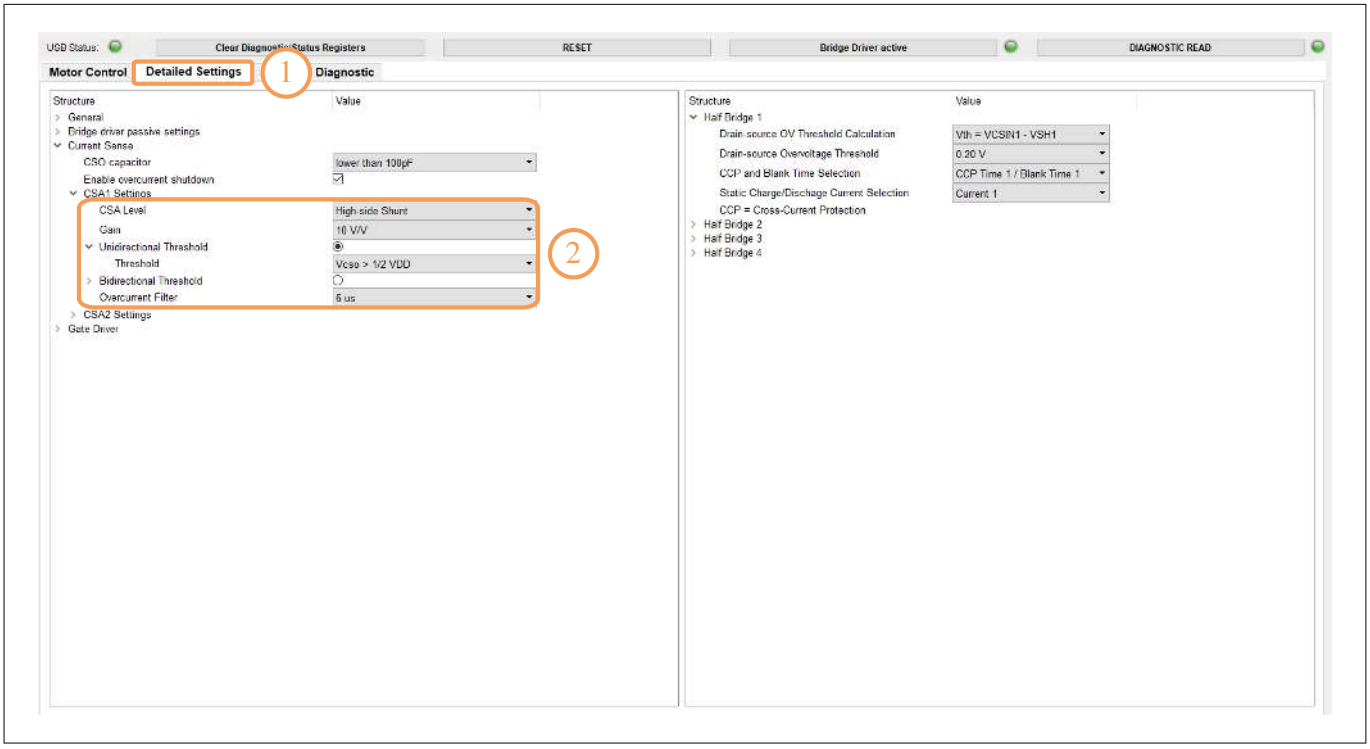


Figure 14 Configure CSA and overcurrent detection

## 9.2 Example - Enabling Adaptive MOSFET Control

One of the main features of the TLE92104 is Adaptive MOSFET Control. It can easily be configured as shown below. See the datasheet for a detailed description of operation and configuration options.

1. Go to PWM and Diagnostic.
2. Configure Adaptive Gate Control settings. Here features like deep adaption or generator mode detection can be enabled.
3. Set the desired turn-on/off delay and MOSFET gate drive characteristics.

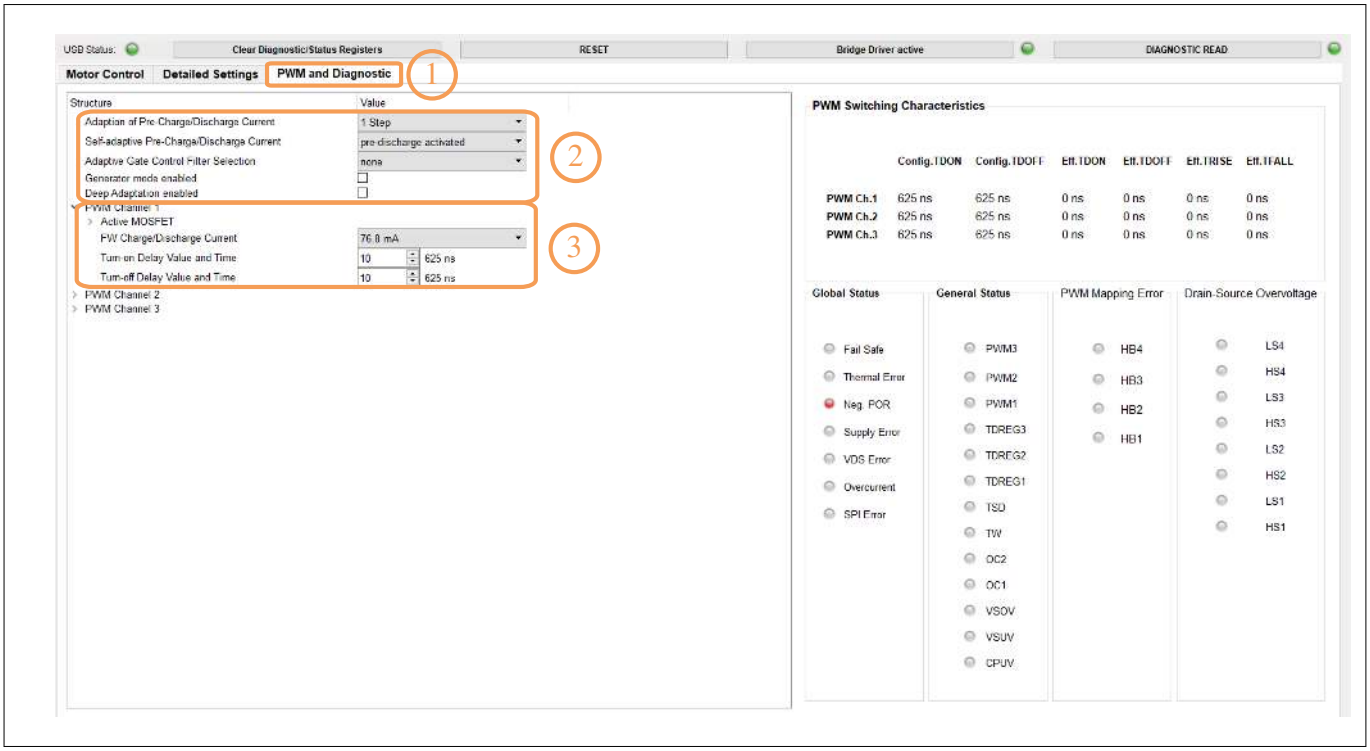


Figure 15 Enable Adaptive MOSFET Control

## 9.3 Example - Setting blanking, cross-current protection and drain-source monitoring

The TLE92014 has several active protection features cross-current protection and VDS overvoltage protection.

1. Go to Detailed Settings.
2. Configure Active CCP and FW CCP and make sure it is mapped to the correct half-bridge.
3. Configure Active Blank Time and FW Blank Time and make sure it is mapped to the correct half-bridge.
4. Configure Drain-source Monitoring Filter Time and set the Drain-source Overvoltage Threshold for the addressed half-bridge.

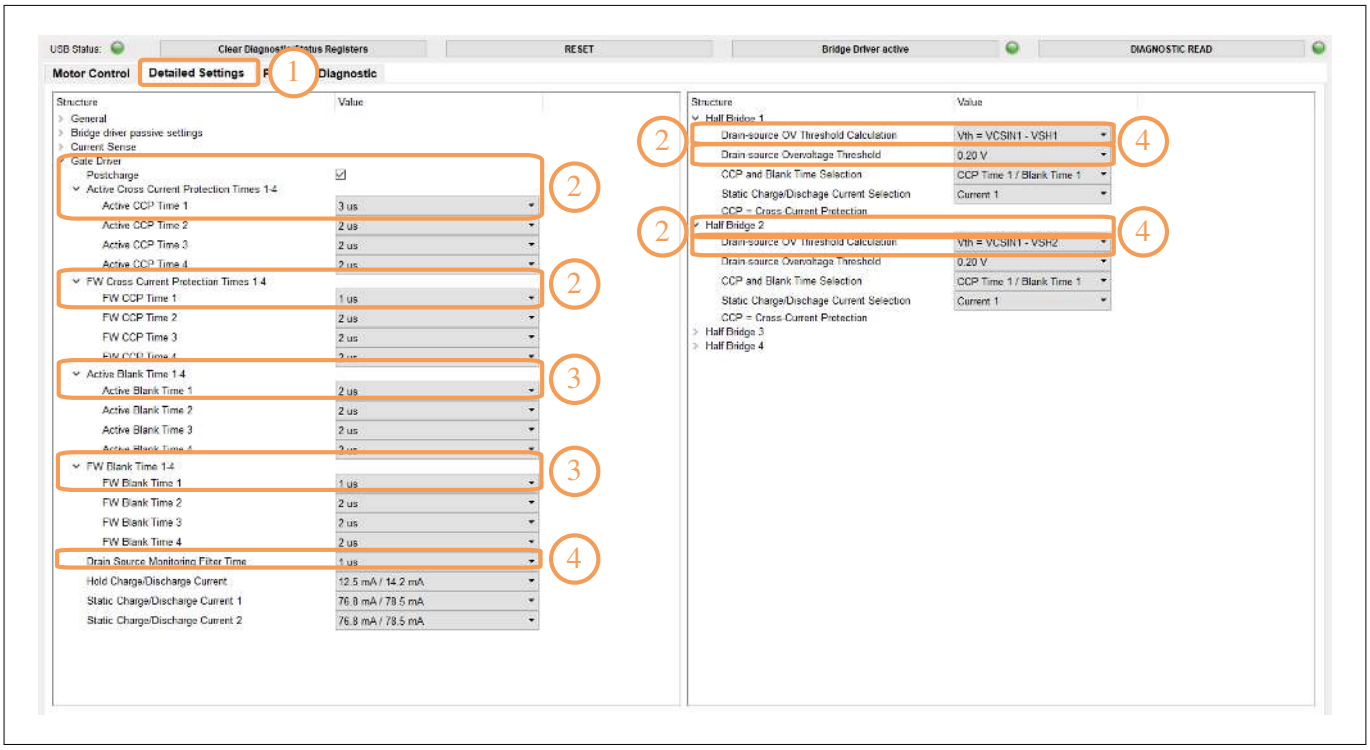


Figure 16 TCCP, TBLANK and VDS monitoring

## 9.4 Example - Off-state diagnostics on half-bridge 1 and 2

Off-state diagnostics can be used to detect short to battery/ground or open wire without activating the motor.

Note: The Drain-Source Overvoltage threshold (as shown in Example - Setting blanking, cross-current protection and drain-source monitoring.) for the addressed half-bridge must be set to 2.0 V for proper detection.

1. Go to Motor Control.
2. Set Motor 1 to High Imped.
3. Enable pull-down current sources for HB1 and HB2

Refer to the Off-state diagnostics Application Note for a detailed description of diagnosis operation.

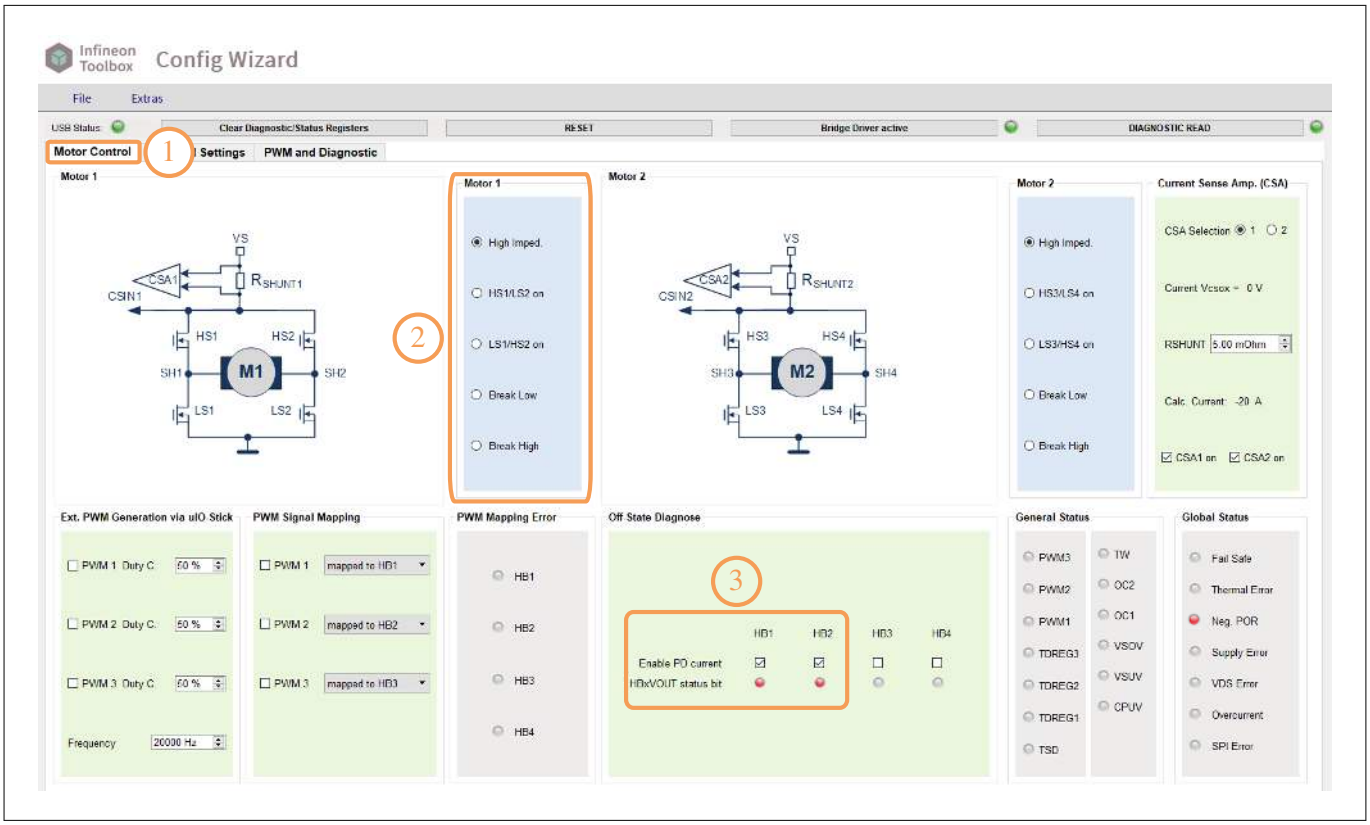


Figure 17 Off-state diagnostics

# 10 Schematics and layout

## 10.1 Schematics

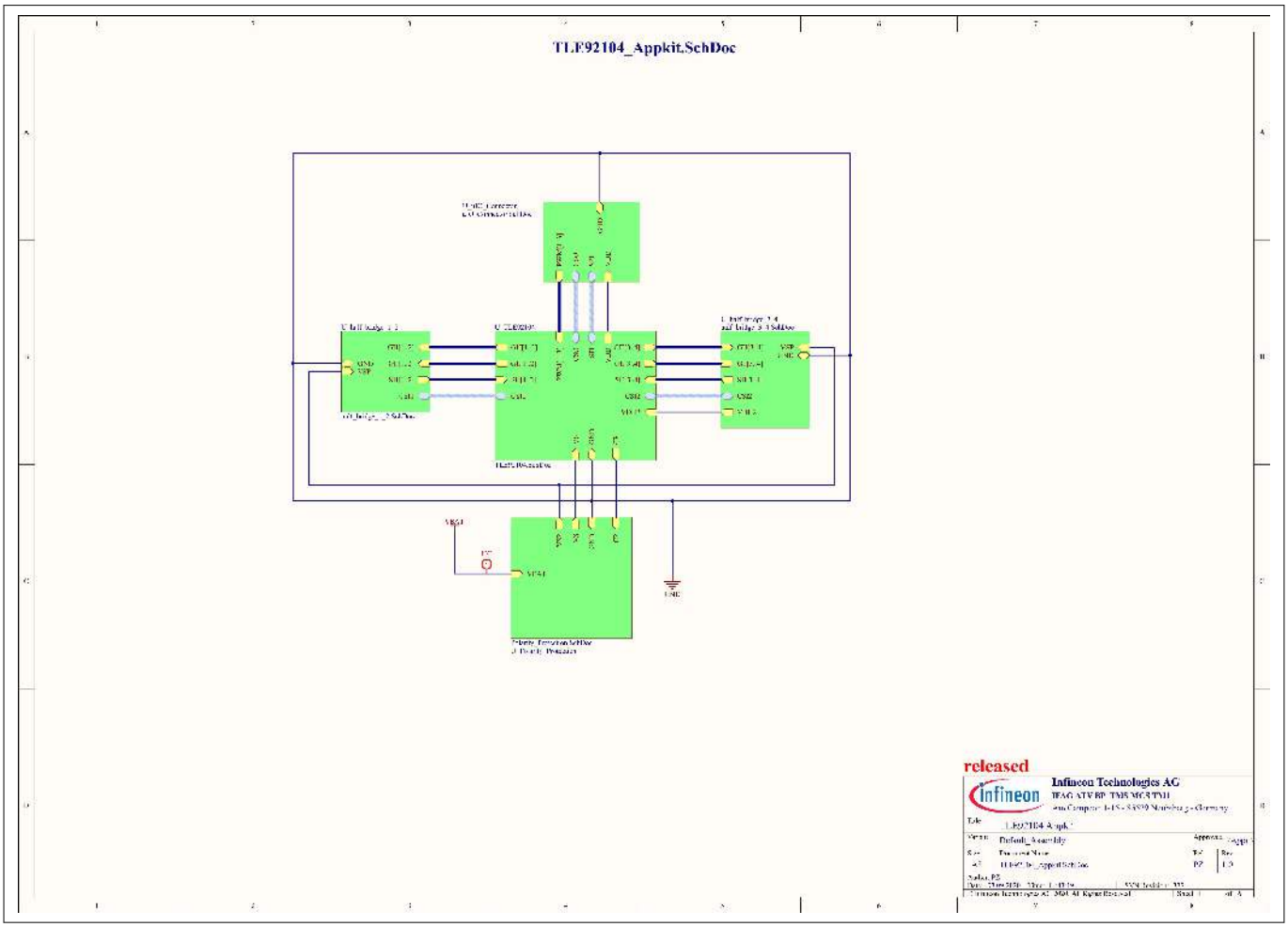


Figure 18 Schematic page 1

## 10 Schematics and layout

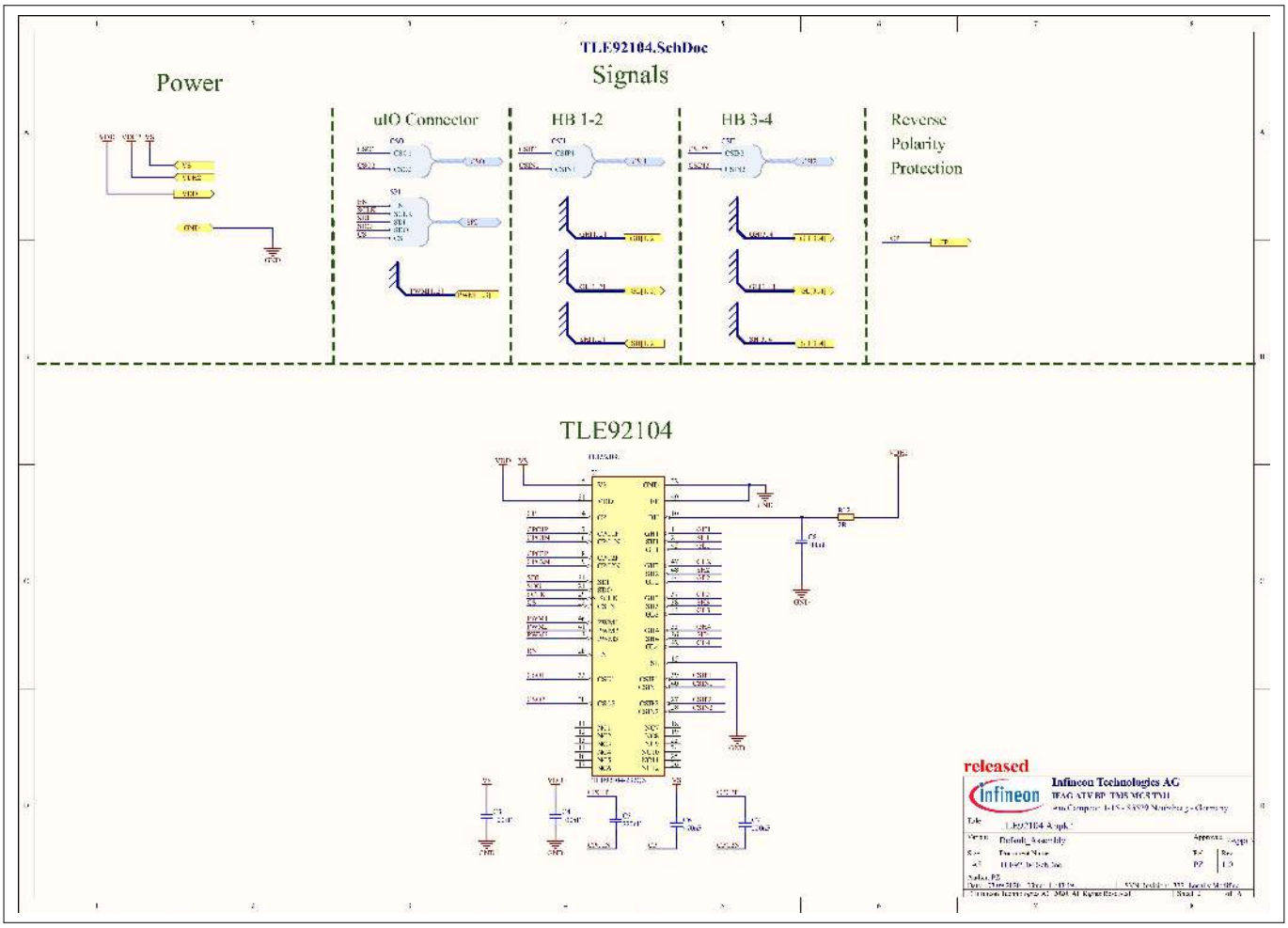


Figure 19 Schematic page 2

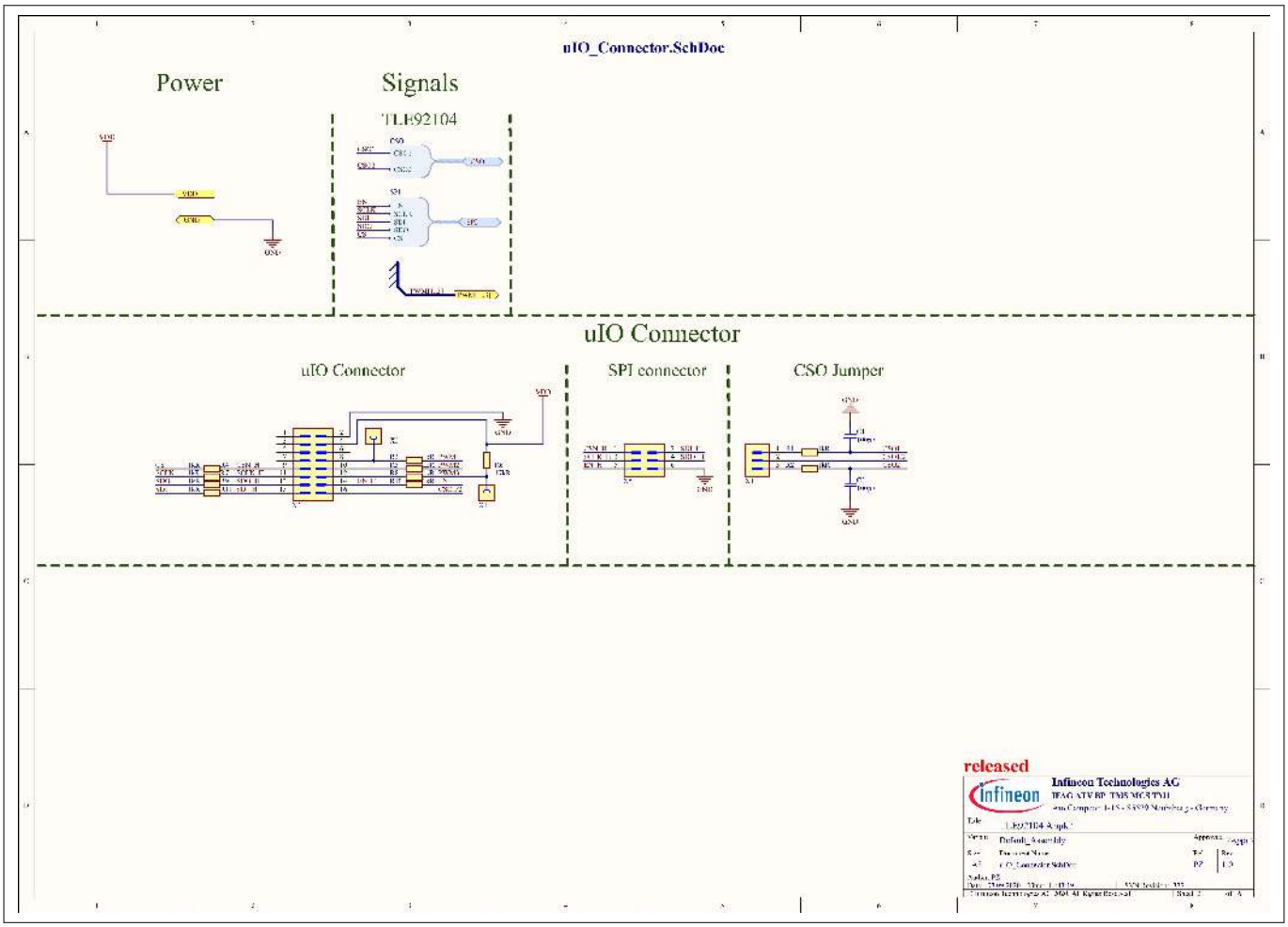


Figure 20 Schematic page 3

## 10 Schematics and layout

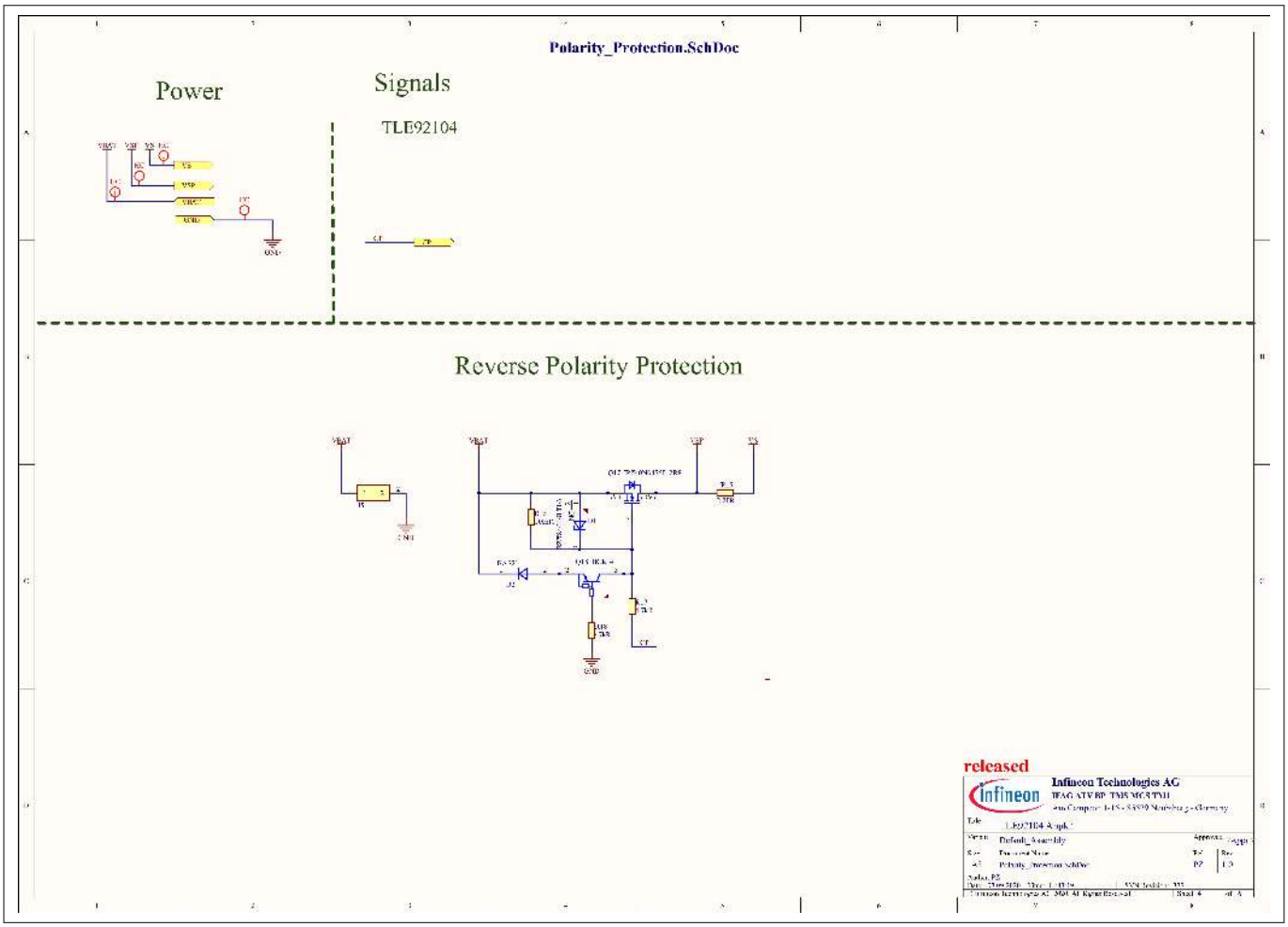


Figure 21 Schematic page 4

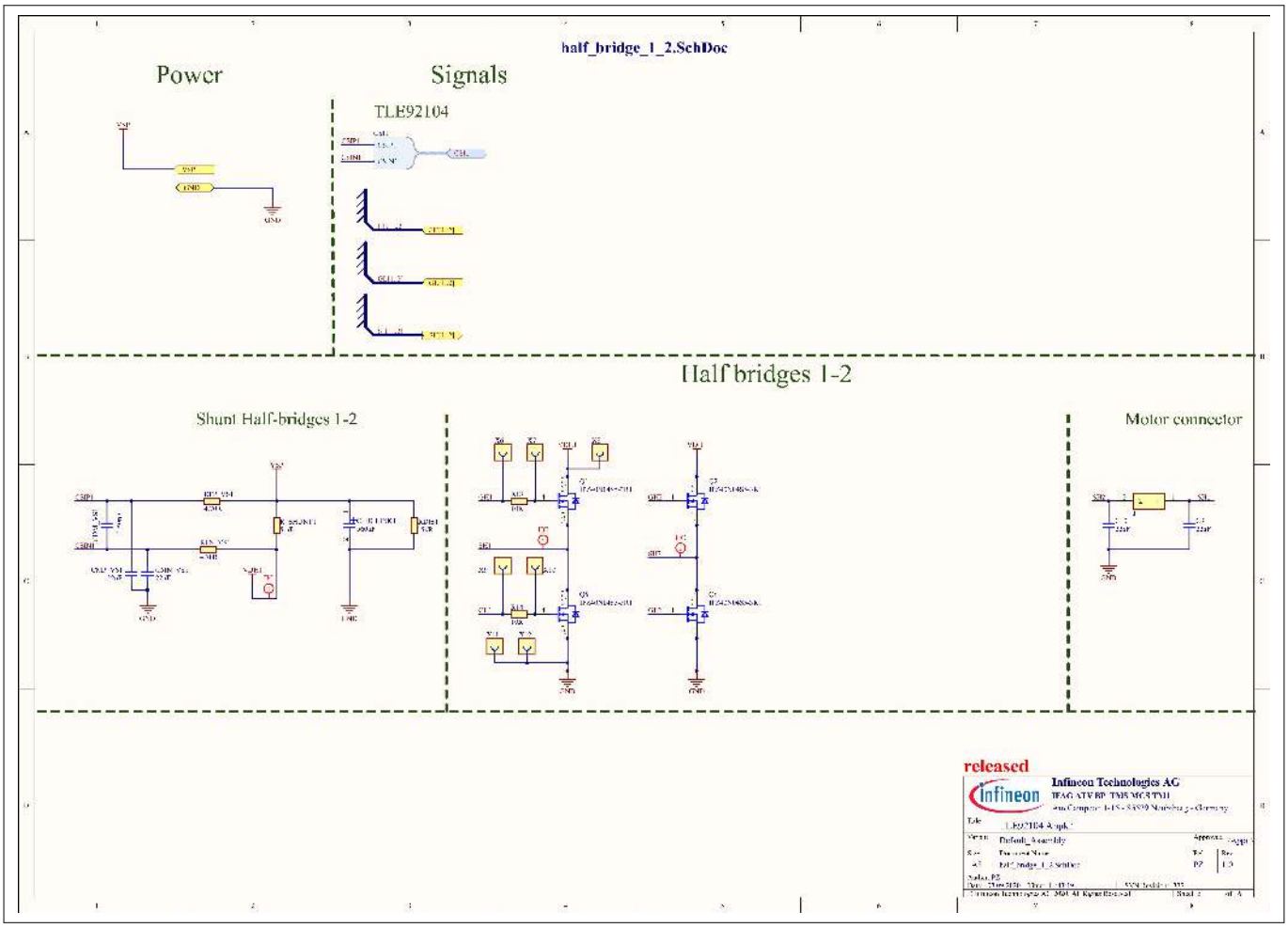


Figure 22 Schematic page 5

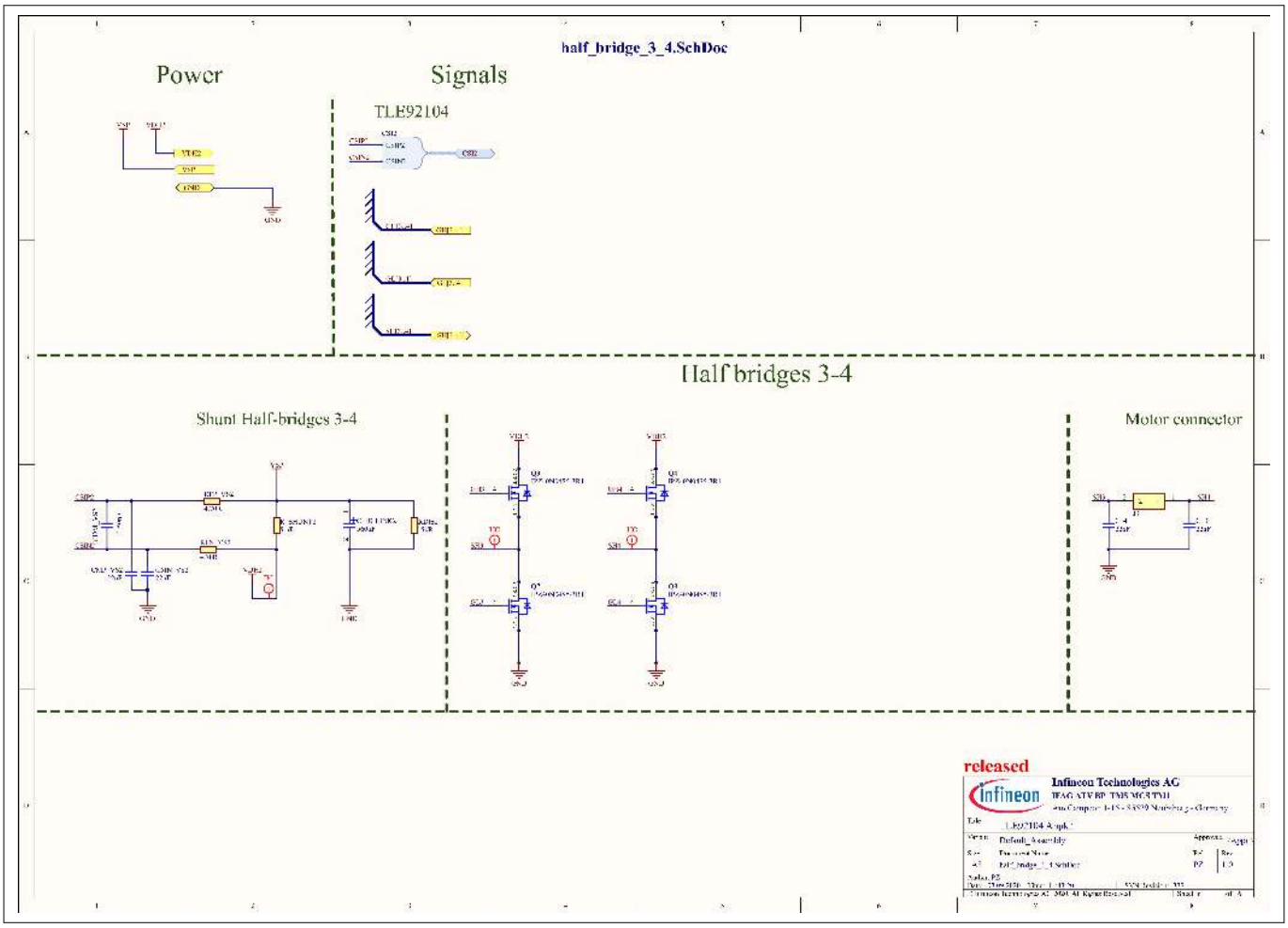


Figure 23 Schematic page 6

## 10.2 Layout

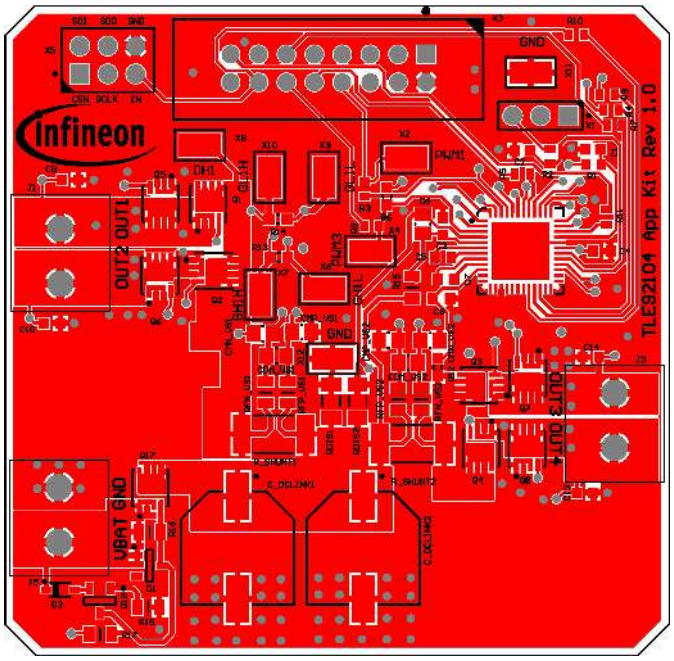


Figure 24 Top layer

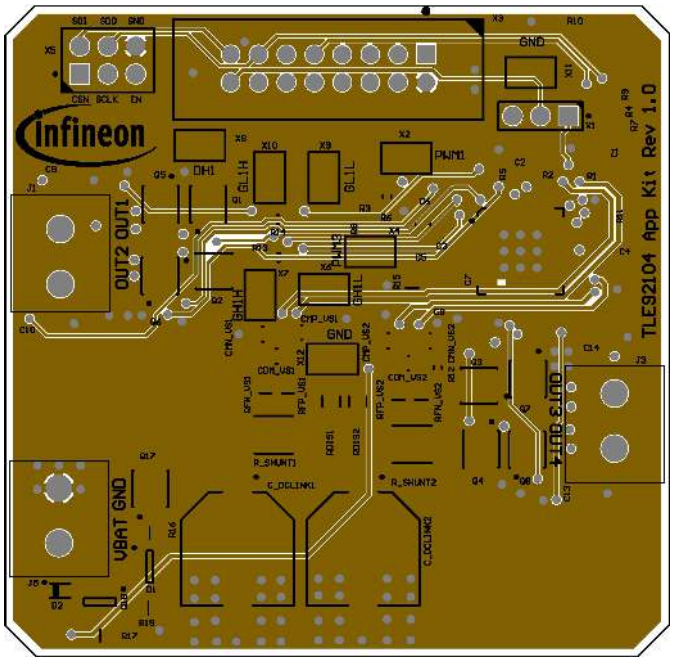


Figure 25 Layer 2

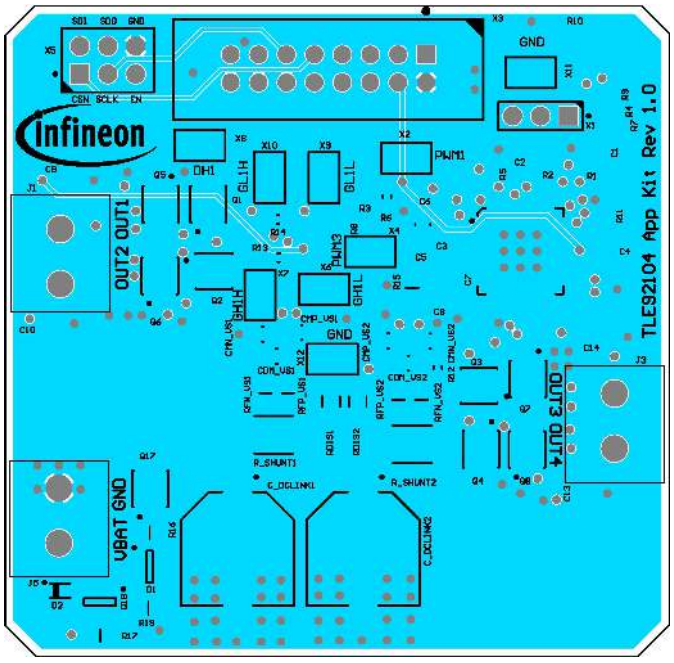


Figure 26 Layer 3

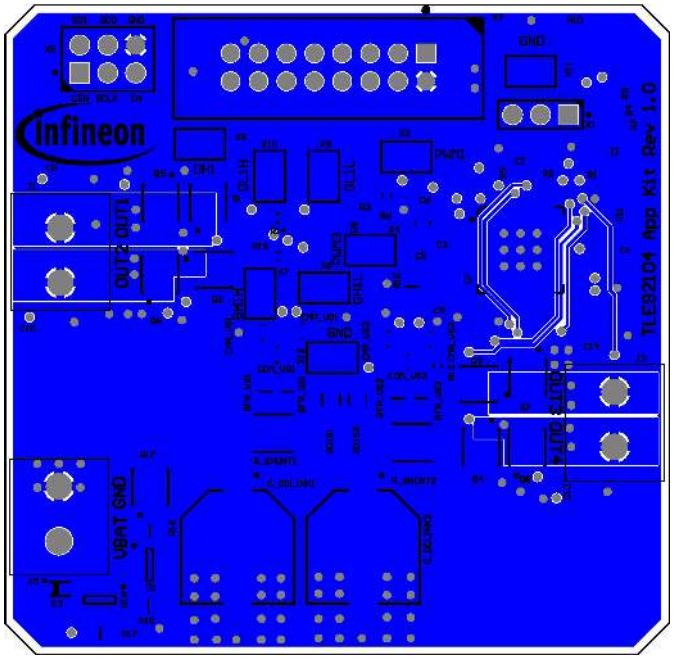


Figure 27 Bottom layer

# 11 Revision history

| Revision | Date | Changes |
|---|---|---|
| v1.0 | 2020-12-28 | Initial creation. |

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