

# EiceDRIVER™

High voltage gate driver IC

## Evaluation Board

Application Note

EVAL\_6EDL04N02PR

## Application Note

Revision 1.0, 2013-07-26

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| Page or Item | Subjects (major changes since last revision) |
|--------------|----------------------------------------------|
|--------------|----------------------------------------------|

**Previous Version: 1.0**

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#### Warnings



The described board is an evaluation board dedicated for laboratory environment only. It operates at high voltages. This board must be operated by qualified, skilled personnel familiar with all applicable safety standards.

## 1 Introduction

The gate driver evaluation board EVAL\_6EDL04N02PR was developed to show the functionalities and key features of the Infineon MOSFET gate driver 6EDL04N02PR.

The board is available from Infineon in sampling quantities. The properties of this part are described in the datasheet chapter of this document, whereas the remaining paragraphs provide information intended to enable the customer to copy, modify and qualify the design for production, according to their own specific requirements.

The design of the EVAL\_6EDL04N02PR was performed with respect to the environmental conditions described in this document. The design was tested as described in this document, but not qualified regarding manufacturing, lifetime or over the full ambient operating conditions.

The boards provided by Infineon are subjected to functional testing only.

Due to their purpose Evaluation Boards are not subjected to the same procedures regarding Returned Material Analysis (RMA), Process Change Notification (PCN) and Product Discontinuation (PD) as regular products. These Evaluation Boards are used for development support only and should not be used as reference design for volume production.

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## 2 Design feature

This chapter provides an overview of the main features, key datas, pin assignments and mechanical dimensions

### 2.1 Main features

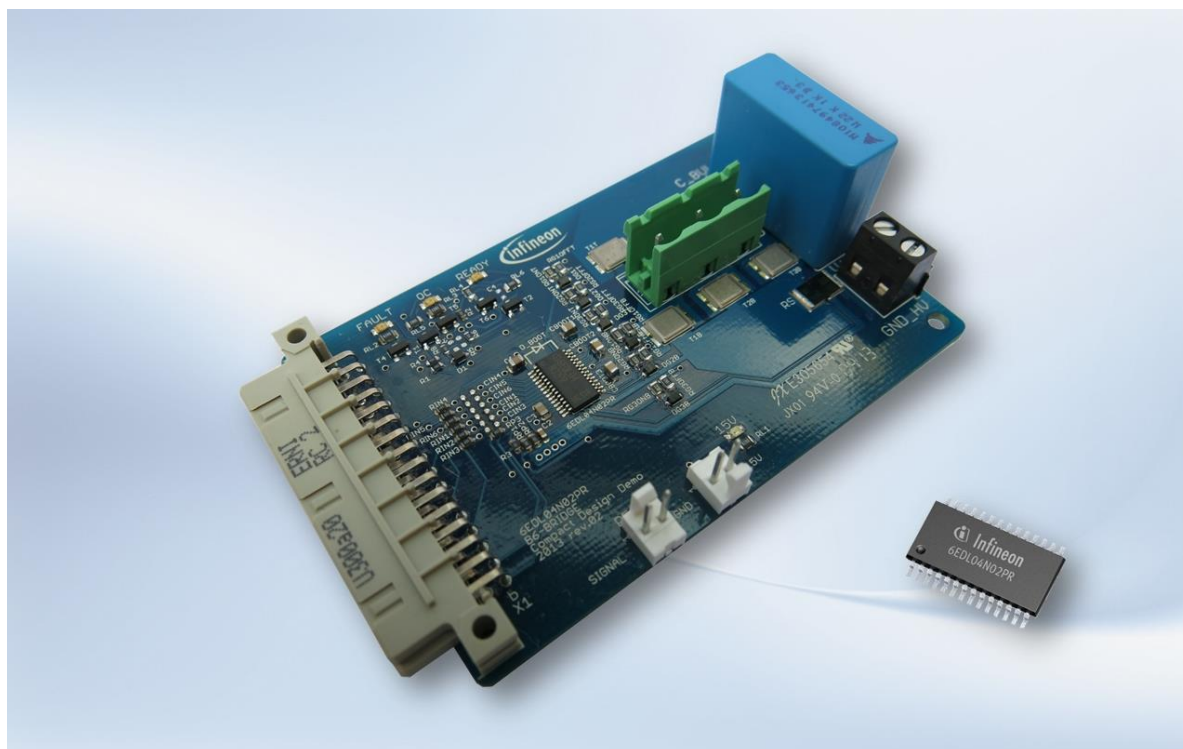


Figure 2-1 top view of the EVAL\_6EDL04N02PR

The EVAL\_6EDL04N02PR contains an Infineon MOSFET full bridge gate driver 6EDL04N02PR in TSSOP package and six Infineon MOSFETs BSB044N08NN3G.

The evaluation board provides the following main features

- Over-current detection with shunt voltage measurement, latch and reset functionality
- Under voltage lock out
- Bootstrap functionality for high side MOSFETs
- Use of the Internal ultra fast bootstrap diodes of the 6EDL04N02PR
- 15V supply, Reset, High voltage supply, external load
- Status LED for 15V supply, ready, fault and overcurrent status
- DC link capacitor

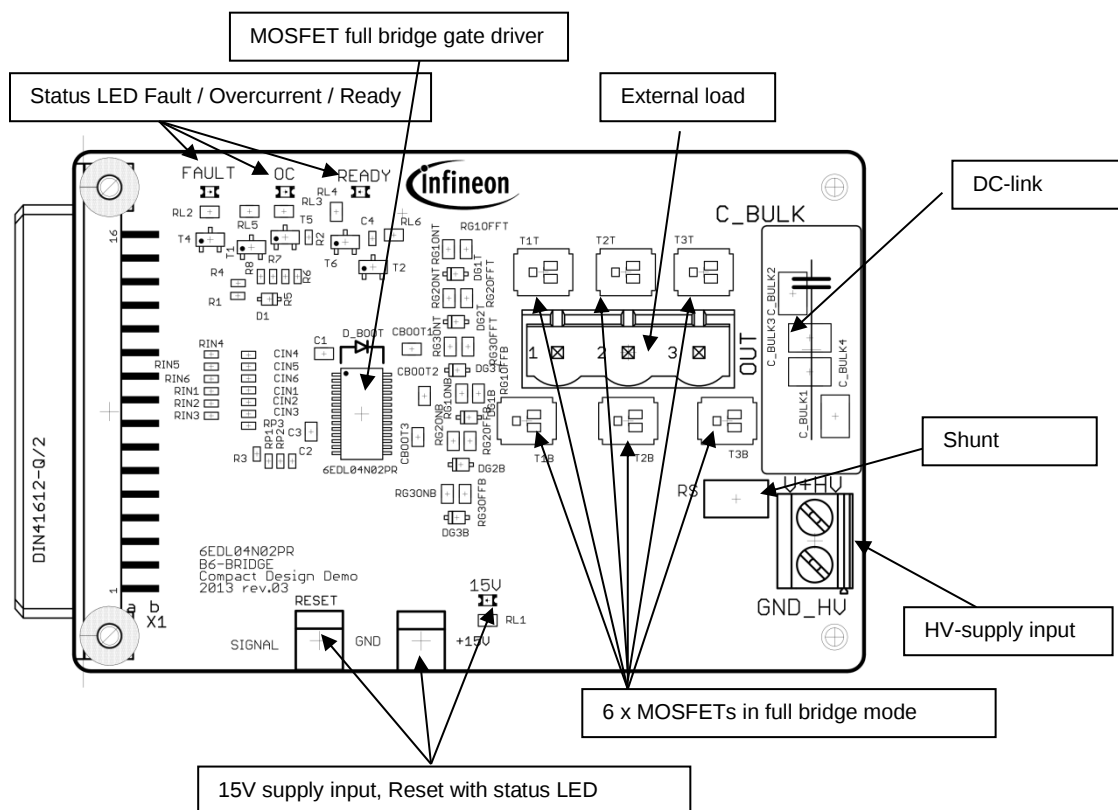


Figure 2-2 overview functionalities on top-side

## 2.2 Key data

All values are values at an ambient temperature of 25°C.

Table 2-1

| Parameter                   | Description                                                | Typ. | Min. | Max. | Unit |
|-----------------------------|------------------------------------------------------------|------|------|------|------|
| <b>+15V</b>                 | 15V voltage supply                                         | 13.5 | 10   | 17.5 | V    |
| <b>HV</b>                   | High voltage supply                                        | -    | -    | 80   | V    |
| <b>I<sub>Out</sub></b>      | Output current                                             | -    | -    | 10   | A    |
| <b>f<sub>p</sub></b>        | Switching frequency                                        | 20   | -    | 200  | kHz  |
| <b>R<sub>Gmin_on</sub></b>  | Min. gate resistor to limit gate driver output at turn on  | -    | 73   | -    | Ω    |
| <b>R<sub>Gmin_off</sub></b> | Min. gate resistor to limit gate driver output at turn off | -    | 42   | -    | Ω    |
|                             |                                                            |      |      |      |      |

\* Please make sure that the maximum rated values never get exceeded. Also the performance and quality can not be guaranteed when using the board with all parameters in maximum rated value at the same time.

## 2.3 Pin assignment

Table 2-2

| Connector name | Pin no.                                                         | Pin name | Description                                                                |
|----------------|-----------------------------------------------------------------|----------|----------------------------------------------------------------------------|
| RESET          | Left terminal                                                   | /RST     |                                                                            |
|                | Right terminal                                                  | GND      |                                                                            |
| +15V (VDD)     | Right terminal                                                  | +15V     | positive 15V supply                                                        |
|                | Left terminal                                                   | GND      |                                                                            |
| X1             | B1                                                              | EN       | input – 0V to disable circuit, integrated pull up                          |
|                | B2                                                              | /FLT     | open drain output with pull up to 15V                                      |
|                | B3                                                              | HIN3     | non-inverting input T3T IGBT; 0V off, 5V on                                |
|                | B4                                                              | LIN3     | non-inverting input T3B IGBT; 0V off, 5V on                                |
|                | B5                                                              | HIN2     | non-inverting input T2T IGBT; 0V off, 5V on                                |
|                | B6                                                              | LIN2     | non-inverting input T2B IGBT; 0V off, 5V on                                |
|                | B7                                                              | HIN1     | non-inverting input T1T IGBT; 0V off, 5V on                                |
|                | B8                                                              | LIN1     | non-inverting input T1B IGBT; 0V off, 5V on                                |
|                | Please reference all input signals to the GND of the 15V supply |          |                                                                            |
| GND_HV         |                                                                 |          | reference for high voltage supply (Power-GND, internally connected to GND) |
| V+HV           |                                                                 |          | positive high voltage supply (up to 400V related to GND_HV)                |
| OUT            |                                                                 |          | Output HV 3phase bridge (related to GND_HV)                                |

## **3 Electrical features**

### **3.1 Supply voltage +15V**

The supply voltage for the digital part and for the driver output (+15V VCC) has to be supplied externally over the dedicated connector. The evaluation board does not provide an over voltage supply monitoring, therefore the user has to ensure that the voltages are in the correct range. Voltages above the max. values will lead to damages of the MOSFET driver. The availability of the supply voltages is visible over the green status LEDs.

The high-Side gate driver outputs are supplied over internal bootstrap diodes and the bootstrap capacitors CBOOT1,2,3. To ensure that the bootstrap capacitor is charged before the high side MOSFET is switched on, the low side MOSFET has to be switched on for a dedicated time.

### **3.2 Under voltage lockout**

The +15V supply VCC is monitored by the 6EDL04N02PR. In case of an undervoltage the driver output is switched off. The thresholds are typically  $V_{CCUV+} = 9\text{ V}$  (positive going) and  $V_{CCUV-} = 8.1\text{ V}$  (negative going). This status is visible over the red FAULT LED. If the FAULT LED is on and the OC LED is off, an undervoltage is detected.

### **3.3 Over-current detection**

The 6EDL04N02PR provides an over-current detection function by connecting the ITRIP input with the load feedback current. The shunt voltage drop is connected to the ITRIP comparator which has a threshold of typically 0.44V.

With the Shunt resistor value of 20mOhm the ITRIP is triggered at a current of typically 22A.

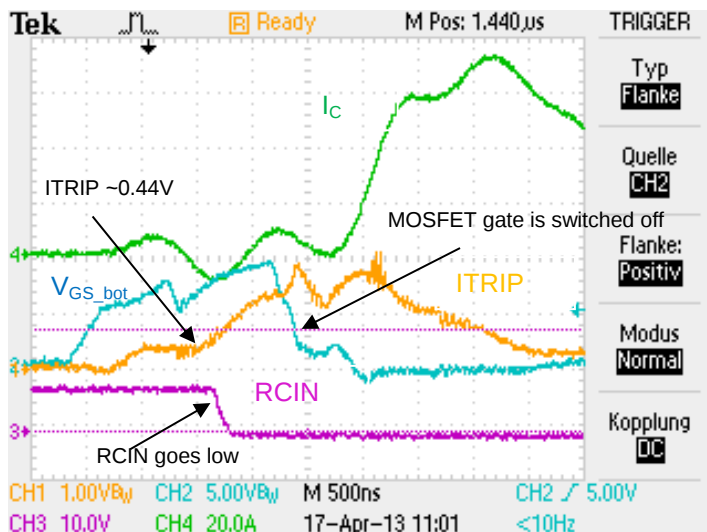
The over-current event generates a hard shut down of all gate driver outputs and provides a latched fault feedback at /FAULT pin and the capacitor at pin RCIN will be discharged. The fault is latched till the capacitor at RCIN is re-charged and the voltage level reaches a value of typically 5.2V.

In the EVAL\_6EDL04N02PR a logic keeps the capacitor at RCIN discharged till a LOW pulse at the RESET pin occurs.

An over-current event is shown by the LED "OC" and LED "FAULT" together.

At power up the logic has an undefined state. If only the LED "OC" is on after power up it is recommend to reset the logic with a LOW pulse at RESET.

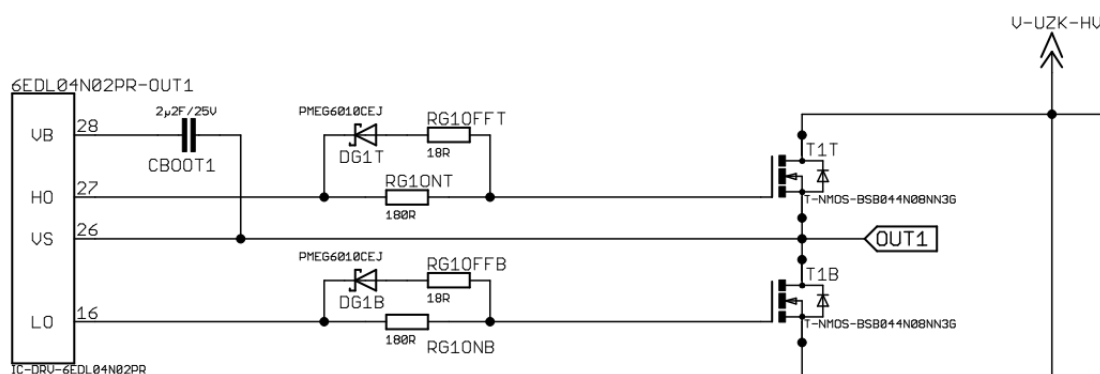
The shunt resistor value may be adjusted, when operating the board with different HV supply voltage in order to guarantee a proper detection of short circuit events.



**Figure 3-1 over-current detection signals during shoot through**  
(Ic curve with 1.2μs delay due to slow current probe)

### 3.4 MOSFET turn - on / off

The switching characteristic of the MOSFETs is defined by the gate resistors RGxONT, RGxONB, RGxOFFT, RGxOFFB and the diodes DGxT and DGxB. Where “x” means 1,2,3 for the three output stages.



**Figure 3-2 gate driver output of the 6EDL04N02PR. Exemplarily only output 1 pictured**

The gate resistors are adapted to the max. gate driver output current of the 6EDL04N02PR for turn-on and turn-off. There is the possibility to adapt the switching characteristic to specific applications or to different MOSFETs by replacing the resistor values. The use of RGxOFFT and RGxOFFB together with DGxT and DGxB makes it possible to change the on-switching and the off-switching slopes of the MOSFET independent to each other.

To avoid a shoot through between top- and bottom MOSFET, the operator needs ensure sufficient dead time. With this setup the deadtime should be  $> 0.5\mu\text{s}$ .

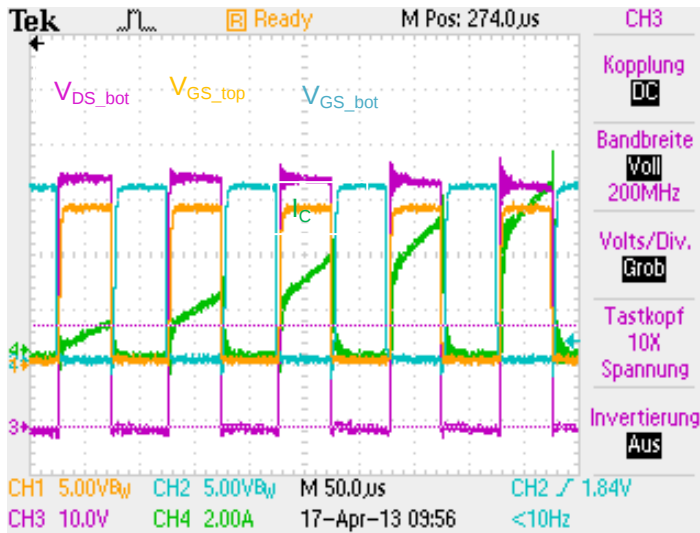


Figure 3-3 switching sequence

Switching sequence with 5 pulses and the following parameters:

Supply Input: 45V

Duty cycle = 50% referred to the top MOSFET

Load = R/L with about 1700µH and 2.30Ω

Load connected between OUT and GND\_HV

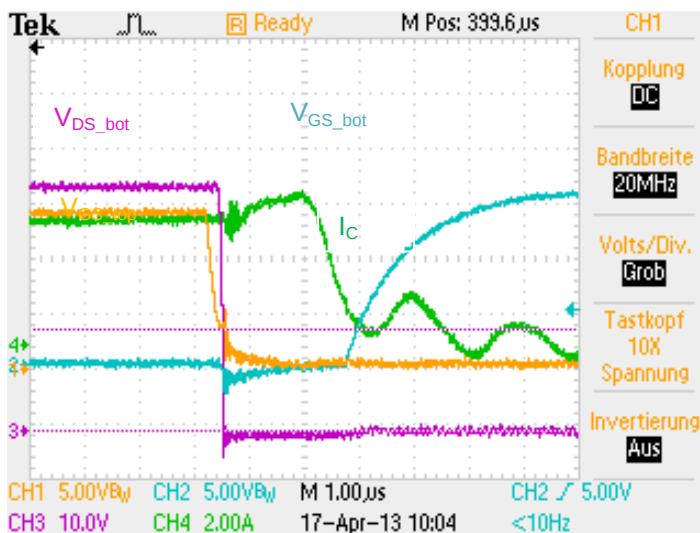


Figure 3-4 turning off top MOSFET with 2.5µs dead time

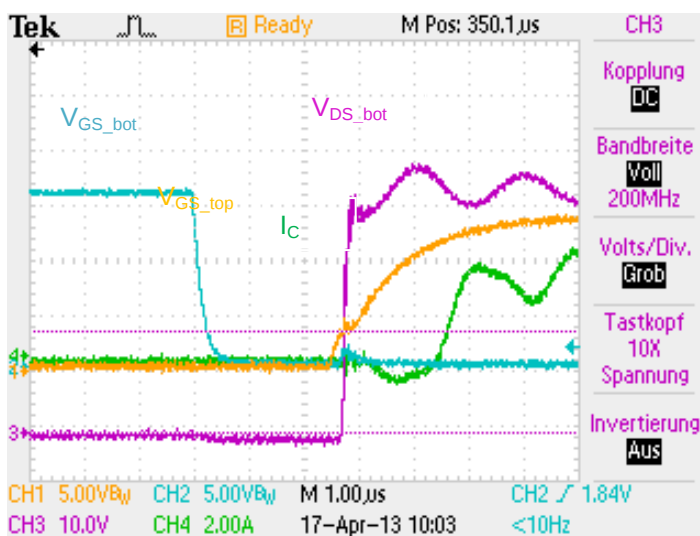
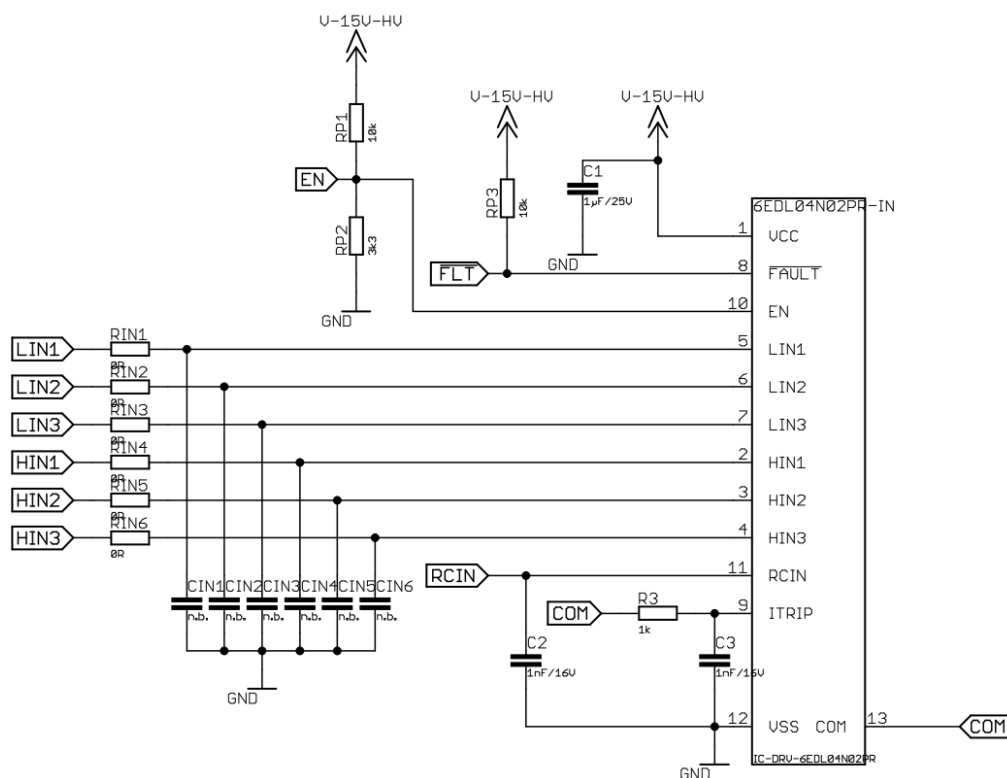


Figure 3-5 turning on top MOSFET with 2.5µs dead time

### 3.5 DC-Link capacitor

Due to the available space there is only a small DC-Link capacitor of 220nF available. If a bigger DC-Link capacity is necessary it has to be connected externally to the connectors V+HV and GND\_HV.

### 3.6 Input Signals



**Figure 3-6 Driver input Signals**

There is the possibility to use low pass filters inside the PWM input signals LIN1,2,3 and HIN1,2,3 to avoid an undesired switch on a MOSFET by disturbances. This feature is not used in this evaluation board, but there is the possibility to test it by changing the resistors RIN1,2,3,4,5,6 and the capacitors CIN1,2,3,4,5,6.

## 4 Schematic and Layout

### 4.1 Schematic

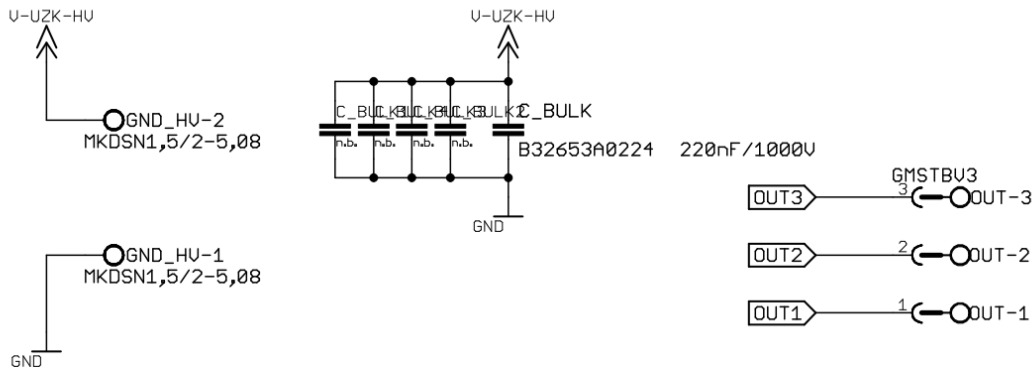


Figure 4-1 HV supply input, DC-Link and load connector

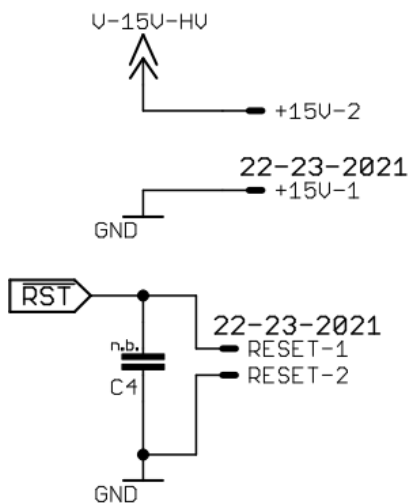


Figure 4-2 LV Supply and Reset Input

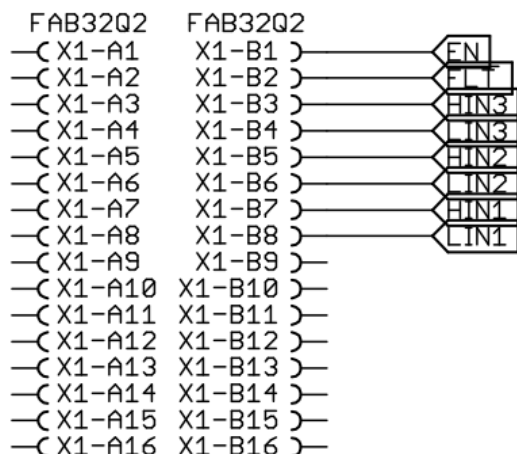


Figure 4-3 connector X1

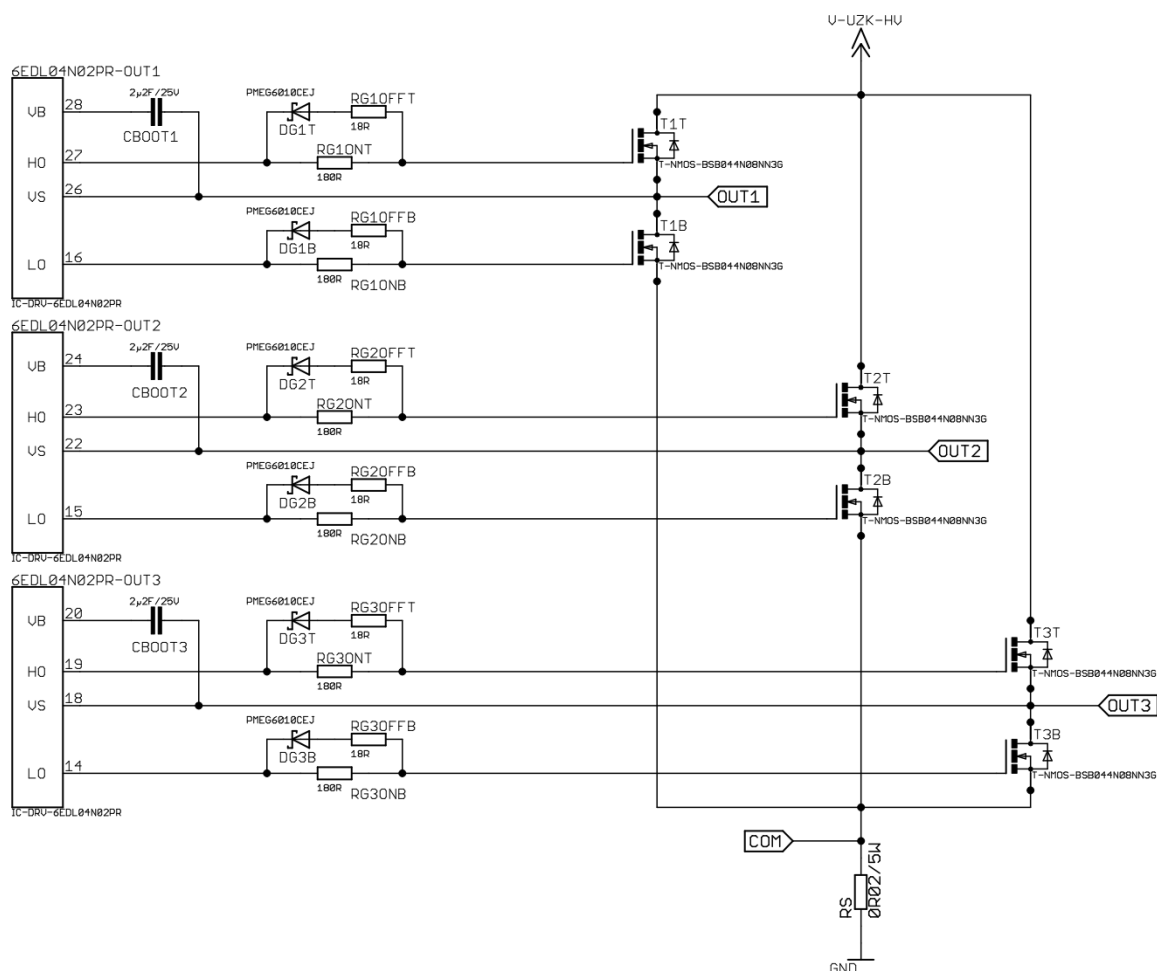
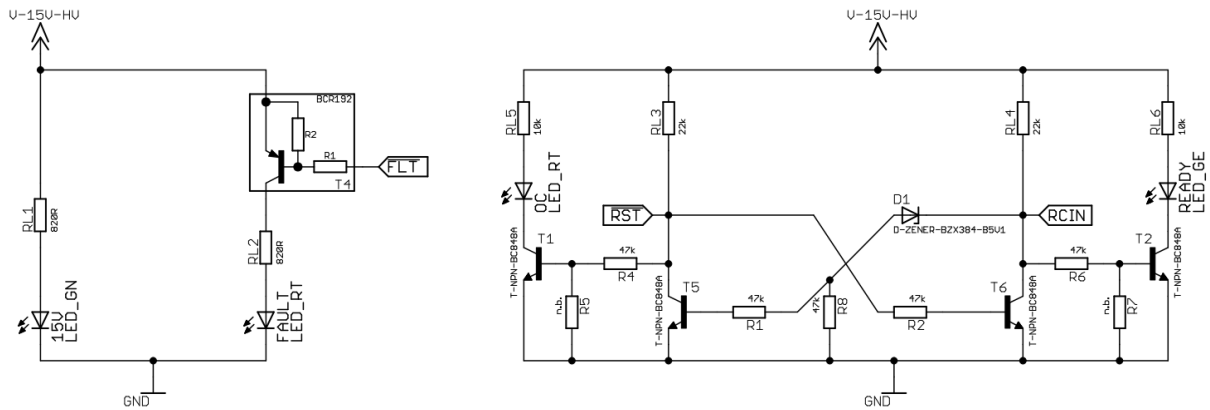


Figure 4-4 Infineon driver 6EDL02N04PR output



### Figure 4-5 LEDs, FAULT and READY logic

## 4.2 Layout

### 4.2.1 Layout top

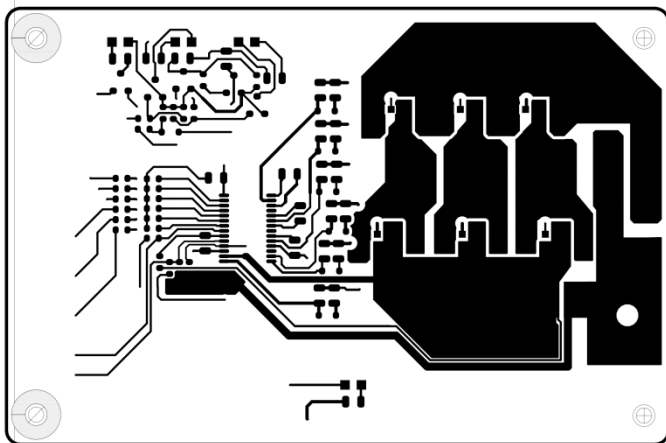


Figure 4-6 Layout top of the 6EDL02N04PR\_EVAL

### 4.2.2 Layout bottom

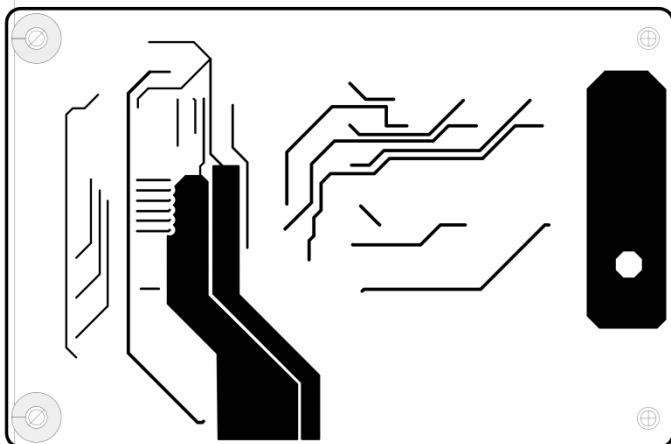
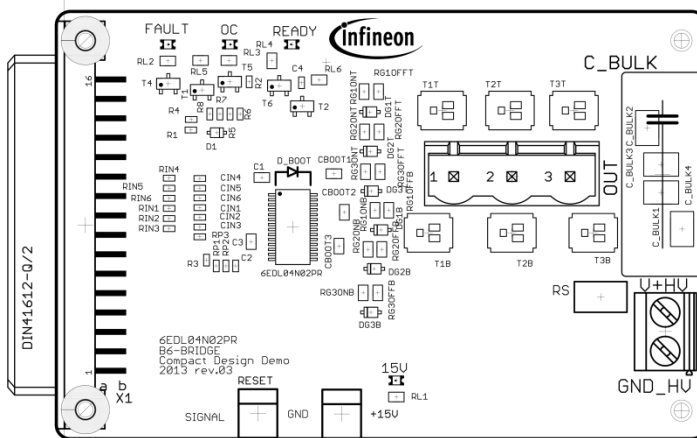


Figure 4-7 Layout bottom of the 6EDL02N04PR\_EVAL

### 4.2.3 Top place



### 4.3 Bill of material

| Part                                                 | Value                | Package          |
|------------------------------------------------------|----------------------|------------------|
| C1                                                   | 1μF/25V              | SMD0805          |
| C2                                                   | 1nF/16V              | SMD0603          |
| C3                                                   | 1nF/16V              | SMD0805          |
| CBOOT1, CBOOT2, CBOOT3                               | 2μF/25V              | SMD0805          |
| C_BULK                                               | 220nF/1000V          | C22.5B10         |
| D1                                                   | D-ZENER-BZX384-C5V1  | SOD323           |
| DG1B, DG1T, DG2B, DG2T, DG3B, DG3T                   | PMEG6010CEJ          | SOD323F          |
| R1, R2, R4, R6, R8                                   | 47k                  | SMD0603          |
| R3                                                   | 1k                   | SMD0603          |
| RG1OFFB, RG1OFFT, RG2OFFB, RG2OFFT, RG3OFFB, RG3OFFT | 18R                  | SMD0805          |
| RG1ONB, RG1ONT, RG2ONB, RG2ONT, RG3ONB, RG3ONT       | 180R                 | SMD0805          |
| RIN1, RIN2, RIN3, RIN4, RIN5, RIN6                   | 0R                   | SMD0603          |
| RL1, RL2                                             | 820R                 | SMD0805          |
| RL3, RL4                                             | 22k                  | SMD0805          |
| RL5, RL6                                             | 10k                  | SMD0805          |
| RP1, RP3                                             | 10k                  | SMD0603          |
| RP2                                                  | 3k3                  | SMD0603          |
| RS                                                   | 0R02/5W              | SMT-REF          |
| 6EDL04N02PR                                          | IC-DRV-6EDL04N02PR   | PG-TSSOP-28      |
| T1, T2, T5, T6                                       | T-NPN-BC848A         | SOT23            |
| T1B, T1T, T2B, T2T, T3B, T3T                         | T-NMOS-BSB044N08NN3G | CANPAK_MG-WDSO-2 |
| T4                                                   | BCR192               | SOT23            |
| X1                                                   | FAB32Q2              | FAB32Q2          |
| +15V, RESET                                          | 22-23-2021           | 22-23-2021       |
| GND_HV                                               | MKDSN1,5/2-5,08      | MKDSN1,5/2-5,08  |
| OUT                                                  | GMSTBV3              | GMSTBV3          |
| FAULT, OC                                            | LED_RT               | CHIPLED_0805     |
| 15V                                                  | LED_GN               | CHIPLED_0805     |
| READY                                                | LED_GE               | CHIPLED_0805     |

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