

# EiceDRIVER™

High voltage gate driver IC

## Evaluation Board

Application Note

### EVAL-2EDL05I06PF

## Application Note

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Page or Item	Subjects (major changes since last revision)
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**Previous Version: 1.0**

all	editorial changes, format update, waveform update
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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-2EDL05I06PF was developed to show the functionalities and key features of the Infineon IGBT gate driver 2EDL05I06PF.

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-2EDL05I06PF 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.

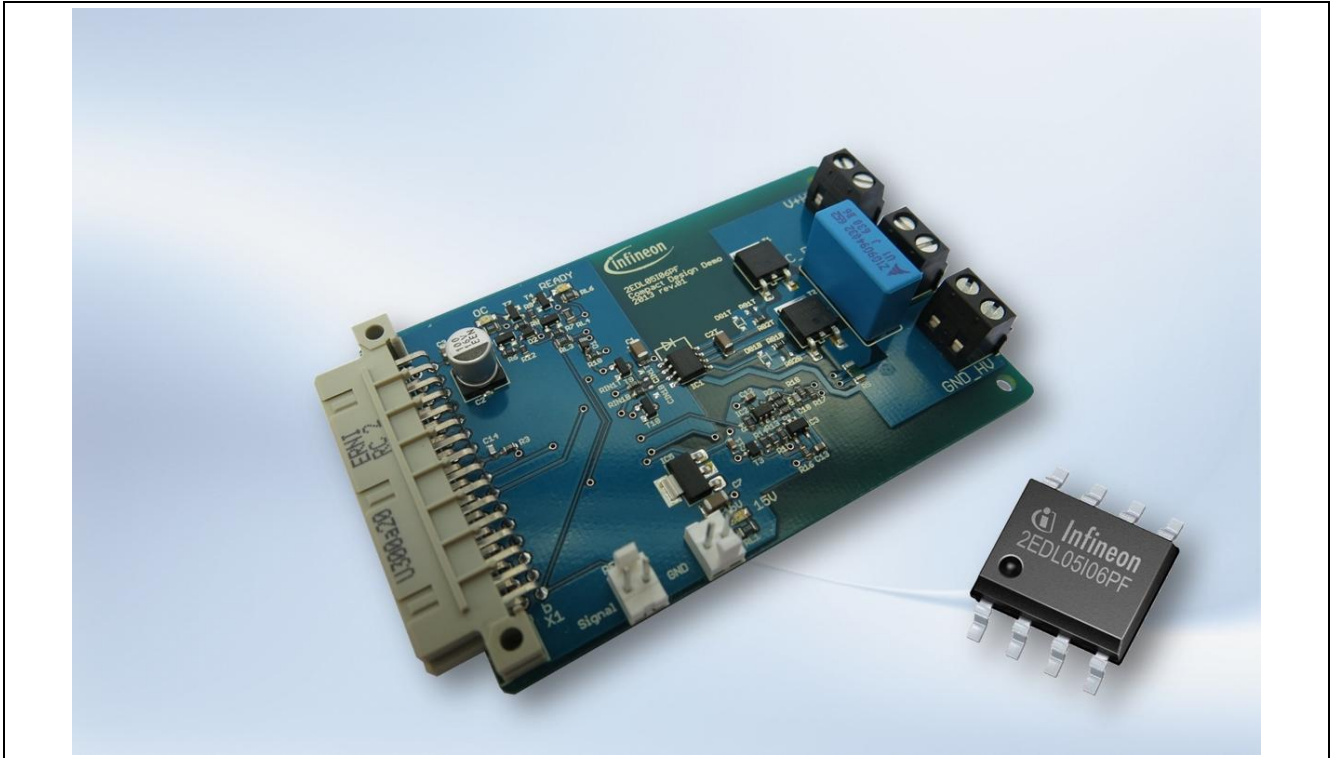
The boards provided by Infineon are subjected to functional testing only.

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

### 2.1 Main features



**Figure 1 Top view of the EVAL-2EDL05I06PF**

The EVAL-2EDL05I06PF contains an Infineon IGBT gate half bridge driver 2EDL05I06PF and two Infineon IGBTs IKD04N60RF.

The evaluation board provides the following main features

- Short circuit protection by shunt measurement and comparator
- Current measurement with operational amplifier
- Under voltage lock out
- Bootstrap functionality for high side IGBT by using the internal ultra-fast bootstrap diode of the 2EDL05I06PF
- Deadtime and interlock function integrated in the IGBT gate driver.
- Connector for 15V supply, Reset, High voltage supply, external load
- Internal voltage regulator for 5V supply
- Status LED for 15V supply, ready and over current
- DC link capacitor

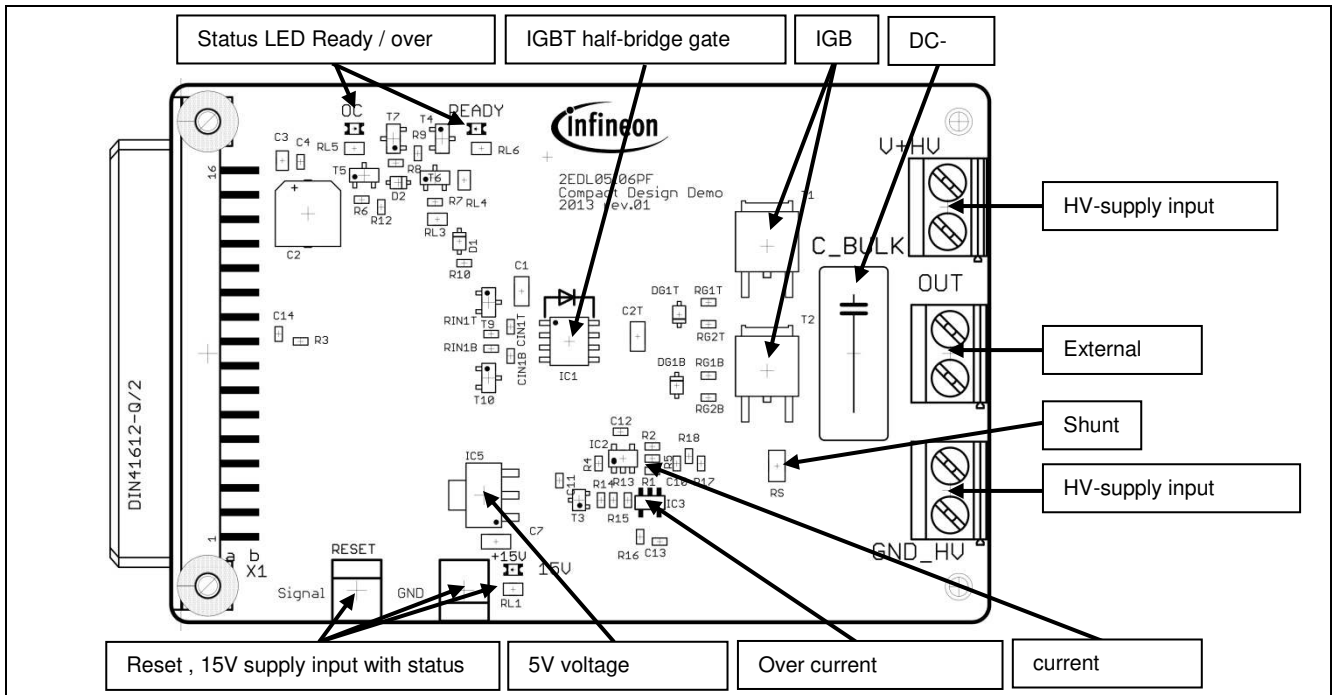


Figure 2 Overview functionalities on top-side

## 2.2 Board specifications

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

Table 1 Board specifications

Parameter	Description	Typ.	Min.	Max.	Unit
$V_{DD}$	15V voltage supply	15	13.2	17.5	V
$V_{DC}$	High voltage supply	320		450	V
$I_{Out,pk}$	Single pulse peak output current	-	-	4	A
$I_{Out,rms}$	RMS output current	-	-	1	A
$f_p$	Switching frequency	16	-	50	kHz

\* 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 Pin assignment

Connector name	Pin no.	Pin name	Description
RESET	Left terminal	/RST	same as X1-B1
	Right terminal	GND	same as X1-A16

+15V (VDD)	Right terminal	+15V	positive 15V supply
	Left terminal	GND	

X1	A16	GND	reference for 15V supply and input signals
	B1	/RST	input – 0V to reset circuit
	B2	/FLT	output over current; OC, 0..15V
	B7	IN_T	non-inverting input top IGBT; 0V off; 5V on
	B8	IN_B	non-inverting input bottom IGBT; 0V off; 5V on
	B16	+5V	positive 5V supply generated from 15V

\*see Figure 23 for connector pin numbering

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 half bridge (related to GND_HV)



### 3 Electrical features

#### 3.1 Supply voltages +5V and +15V

The supply voltage for the driver output (+15V VCC) has to be supplied externally over the dedicated connector. The digital 5V supply voltage is generated internally by an Infineon voltage regulator. 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 IGBT drivers. The availability of the supply voltage is visible over the green status LED.

The high-Side gate driver is supplied over the internally ultra-fast bootstrap diode of the 2EDL05I06PF. To ensure that the bootstrap capacitor is charged before the high side IGBT is switched on, the low side IGBT has to be switched on for a dedicated time.

#### 3.2 Under voltage lockout

The +15V supply VCC is monitored by the 2EDL05I06PF. In case of an undervoltage the driver output is switched off. The thresholds for the low side are typically  $V_{CCUV+} = 12.5\text{ V}$  (positive going) and  $V_{CCUV-} = 11.6\text{ V}$  (negative going). The thresholds for the high side are typically  $V_{BSUV+} = 11.6\text{ V}$  (positive going) and  $V_{BSUV-} = 10.7\text{ V}$  (negative going).

#### 3.3 Short circuit detection

The 2EDL05I06PF evaluation board provides short circuit detection by measuring the voltage drop over a 20mΩ shunt. This voltage drop is compared to a fixed voltage level of 454,5mV. If the current reaches a value of typ. 22,7A a short circuit is detected, the gate driver inputs HIN and LIN are switched to ground and the driver outputs are switched off. This status is reported by the OC LED. The OC event is latched by the flip-flop circuit shown in Figure 20 and must be reset by switching the RESET signal to ground.

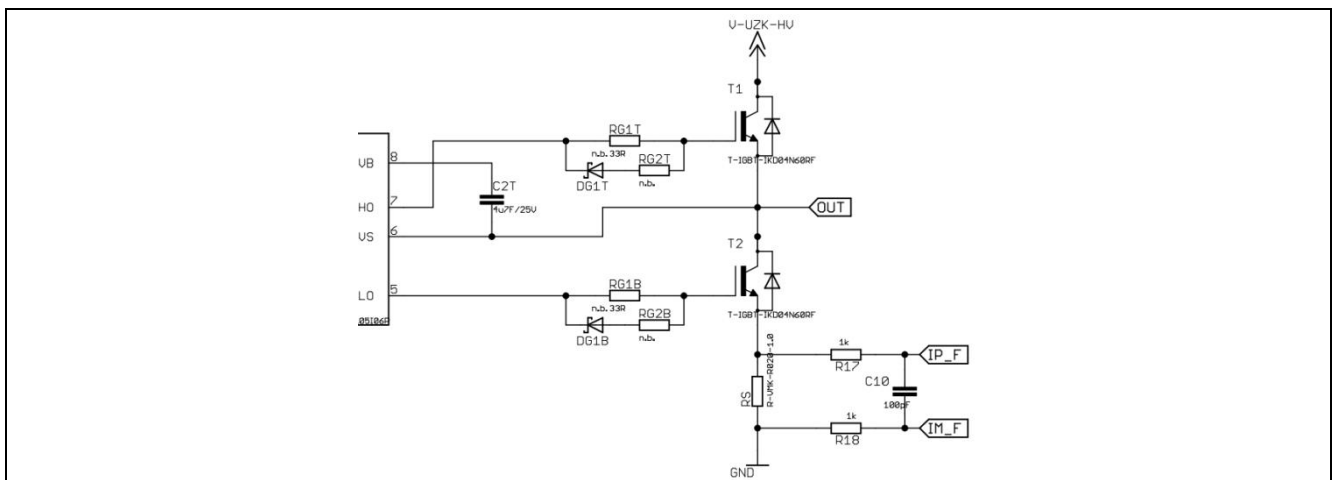
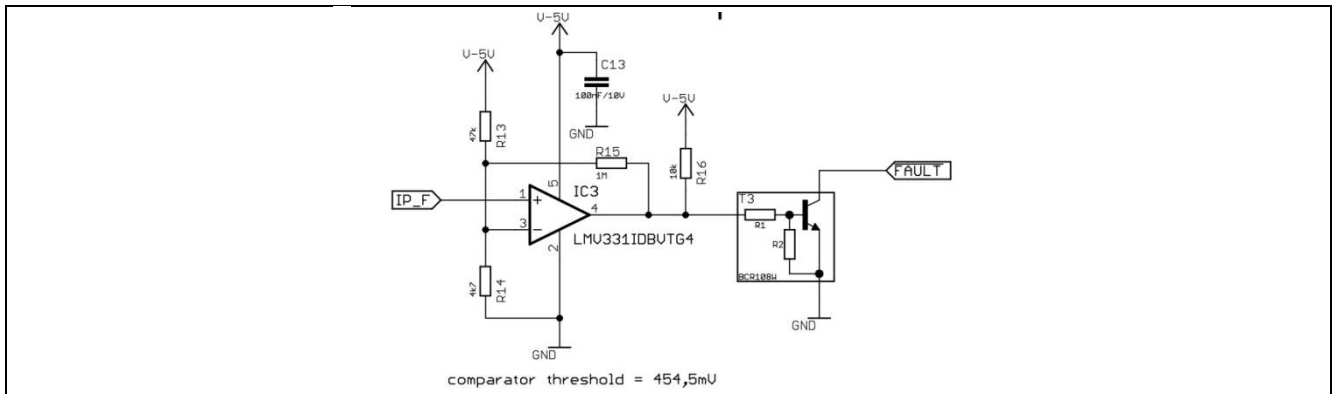
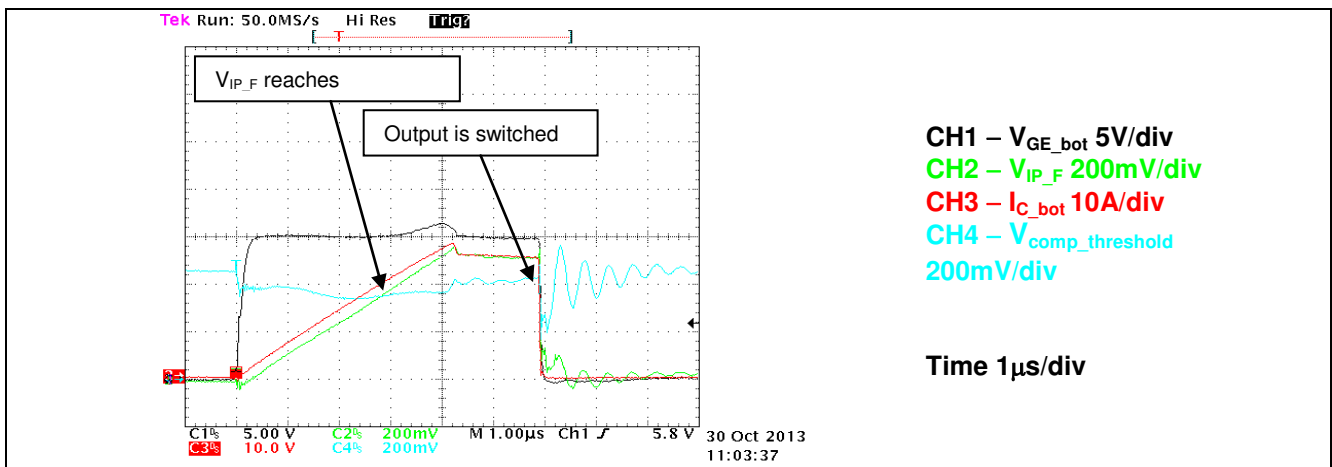


Figure 3 Shunt connection in the power circuit



**Figure 4 Overcurrent comparator circuit**

Figure 5 shows the signals of the bottom side driver and IGBT during a simulated short circuit. As shown, there is a delay of approximately  $2.7\mu\text{s}$  between the overcurrent detection and the output being switched off. During this delay time, the current continues to rise until the IGBT desaturates and the current is clamped to a level corresponding to the used gate voltage. In case of the 15V supply and IKD04N60RF IGBT, the IGBT desaturates at 28 - 30 A as shown in Figure 5. In case of a lower supply voltage the desaturation current may be below the overcurrent detection level. In such a case, as well as in case of regular usage of the overcurrent protection (e.g. in case of short circuit respectively shoot through protection tests), it is recommended to replace the  $20\text{m}\Omega$  shunt (as supplied with the demo board) for a  $50\text{m}\Omega$  shunt. This will reduce the current detection level to approx. 9.1A which would allow reliable overcurrent detection in the whole supply voltage range 13.2 - 17.5 V and earlier overcurrent detection.



**Figure 5 Over-current detection signals during simulated short circuit (current measured by Rogowski coil)**

### 3.4 Current amplifier

The EVAL-2EDL05I06PF provides an operational amplifier which amplifies the voltage drop over the shunt with a gain of 10. The amplified voltage is available for the user at connector X1 pins A9 and B9. The amplified voltage is calculated with  $V = I_{\text{shunt}} \times R_{\text{shunt}} \times 10$ . Due to inherent component tolerances, the amplifier output should be calibrated in case of using it for a critical current control.

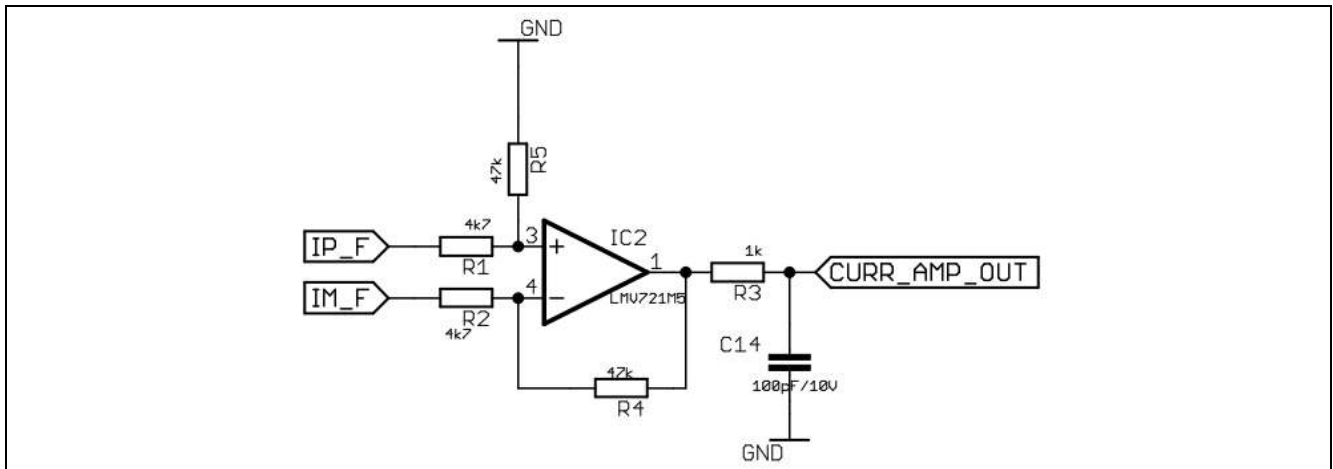


Figure 6 Current amplifier

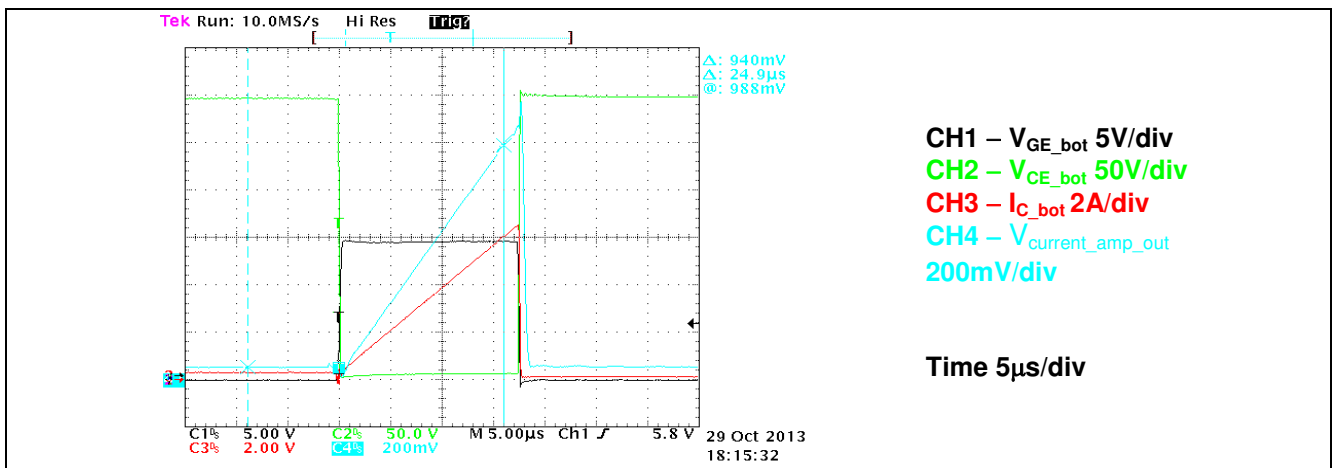


Figure 7 Current amplifier output and corresponding collector current (current measured by Rogowski coil)

### 3.5 Deadtime and interlock function

The IC provides a hardware fixed deadtime of typ 380ns. An additional interlock function prevents the two outputs from being activated simultaneously. Hardware deadtime does not block shoot-through. It is a basic item to avoid deep shoot through. The general recommendation for dead time is to be approx. 1µs.

### 3.6 IGBT turn - on / off

The switching characteristic of the IGBTs is defined by the gate resistors RG1B, RG1T, RG2B and RG2T. It is adapted to get as fast as possible voltage slopes at the output without to overload the gate driver output. There is the possibility to adapt the switching characteristic to specific applications or to different IGBTs by replacing the values of RG1B and RG1T. The use of RG2B and RG2T together with DG1B and DG1T makes it possible to change the on-switching and the off-switching slopes of the IGBT independent to each other.

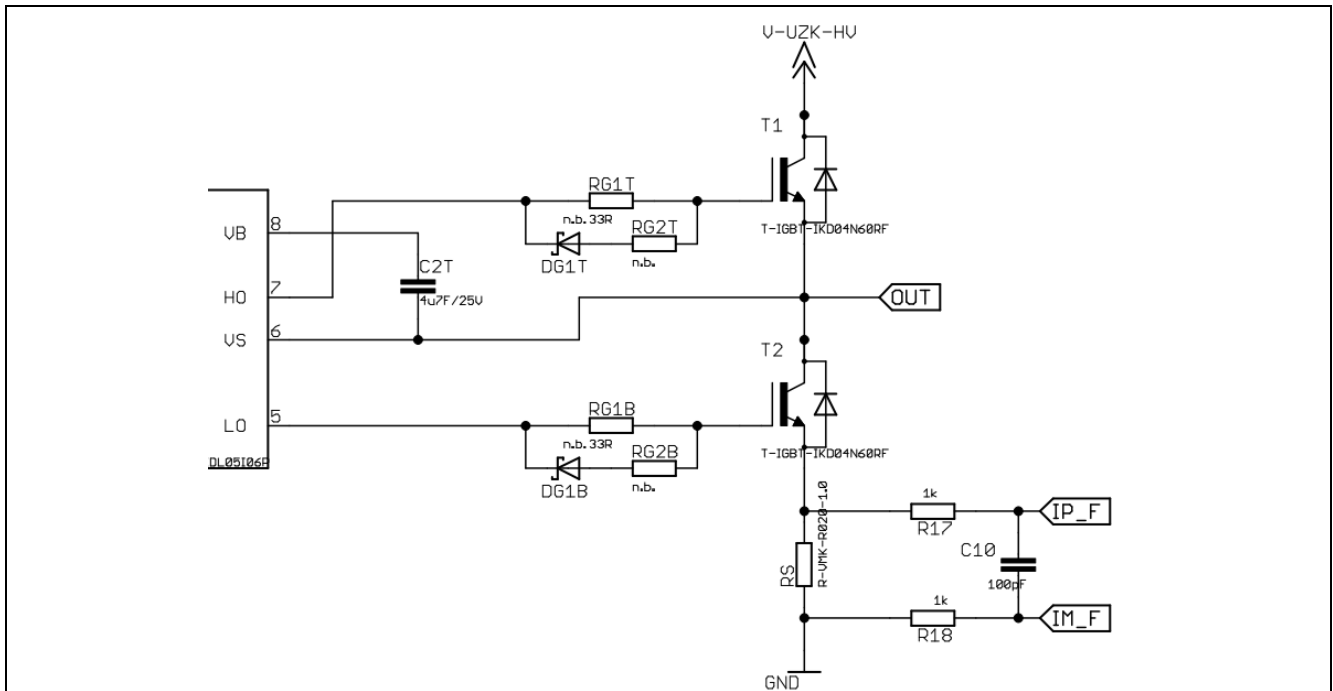


Figure 8 2EDL05I06PF gate driver output

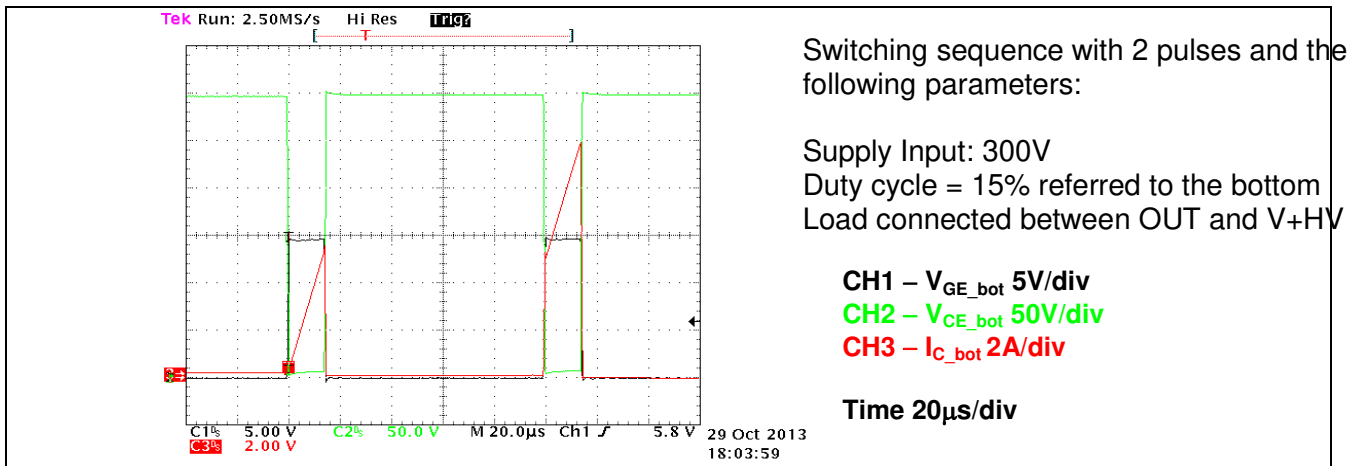


Figure 9 Example of waveforms during double pulse switching sequence

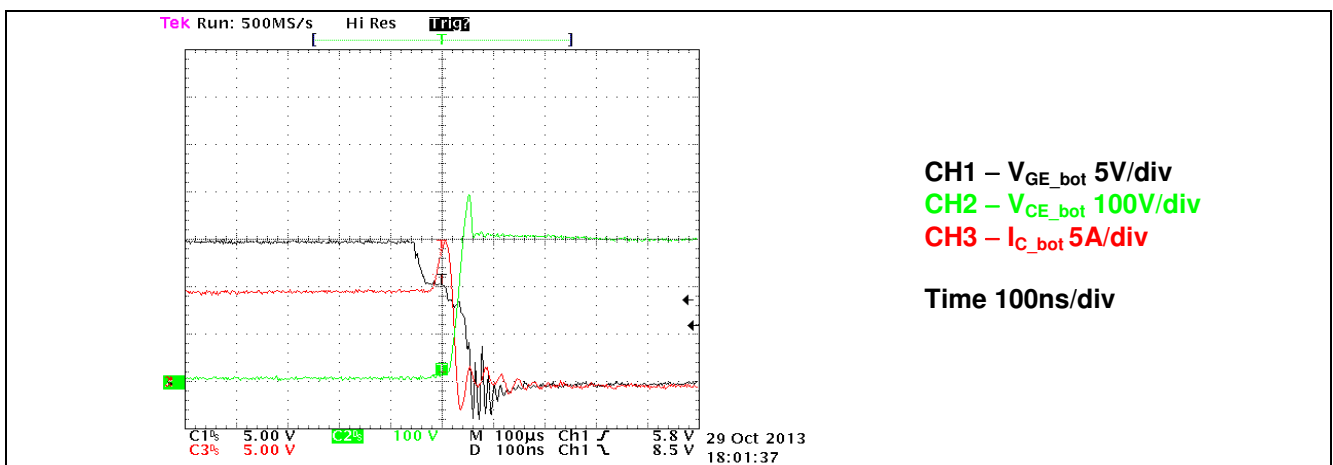
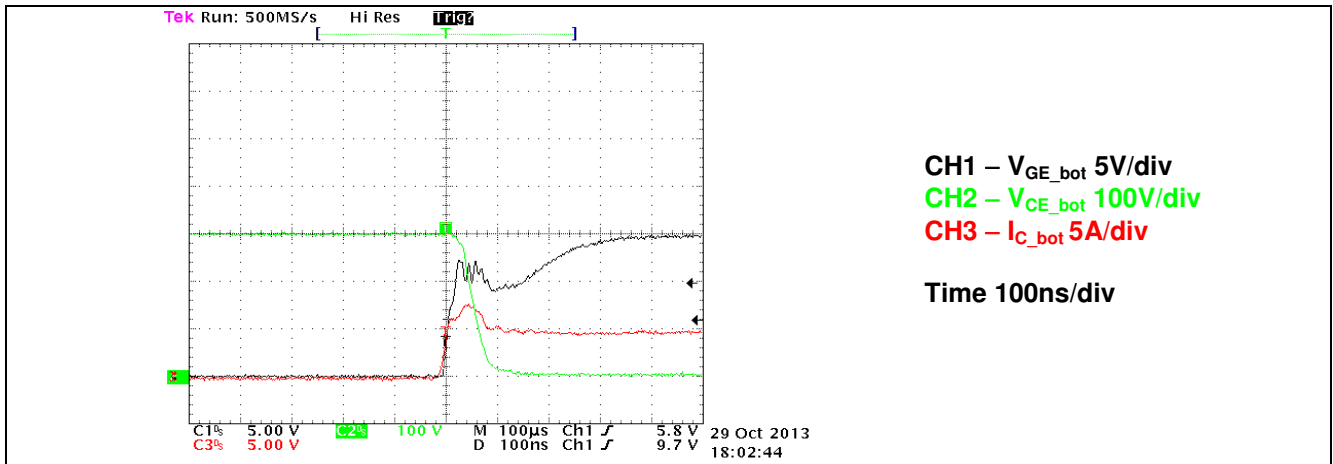
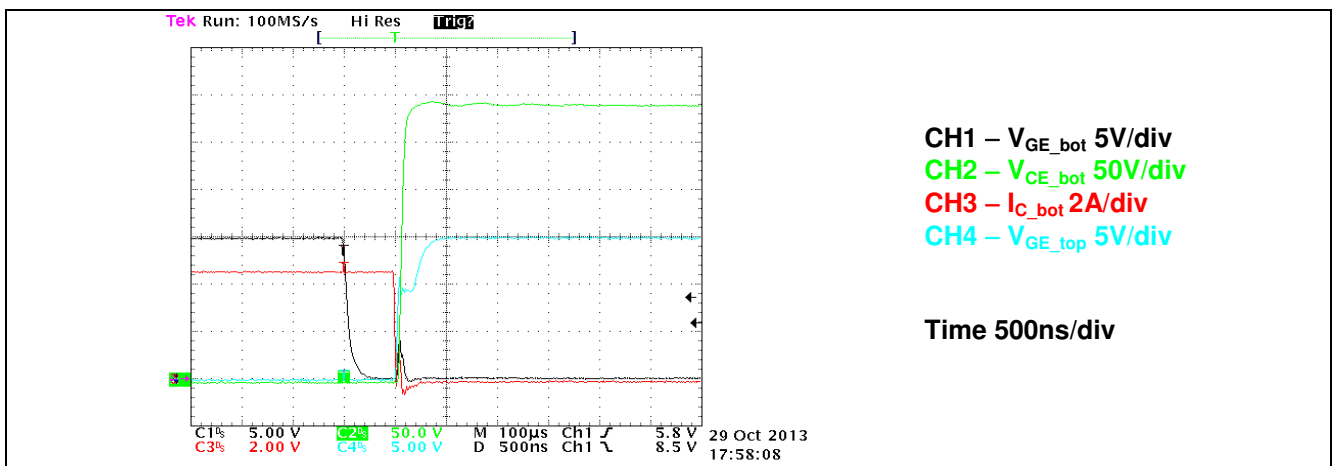


Figure 10 Turning off bottom IGBT, time scale 100ns/div (current measured by Rogowski coil)



**Figure 11** Turning on bottom IGBT, time scale 100ns/div (current measured by Rogowski coil)

The internal deadtime generation of typ. 380ns of the 2EDL05I06PF ensures that there will be no shoot through between top - and bottom – IGBT. If necessary, a higher deadtime can be generated by the input signals LIN and HIN. Figure 3-10 shows waveform for bottom IGBT turn-off and top IGBT turn-on with the deadtime of 500ns.

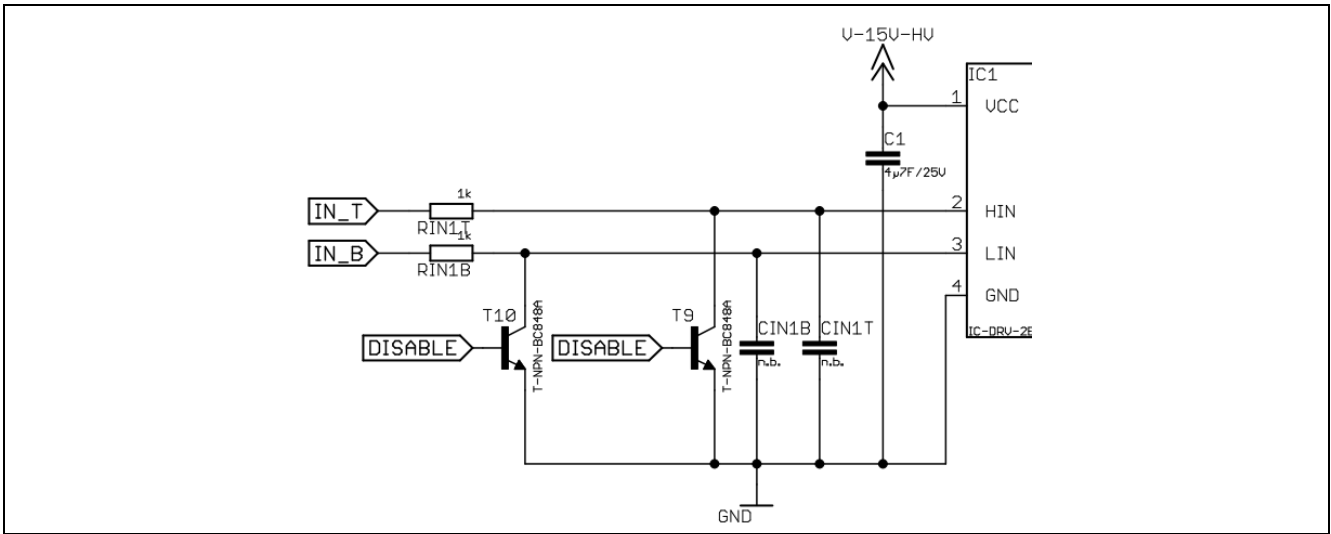


**Figure 12** Turning off bottom IGBT and turning on top IGBT with delay of 500ns, load connected between OUT and GND\_HV, time scale 500ns/div (current measured by Rogowski coil)

### 3.7 DC-Link capacitor

Due to the available space there is only a small DC-Link capacitor of 100nF available. If a bigger DC-Link capacity is necessary it has to be connected externally to the connectors V+HV and GND\_HV.

### 3.8 Input PWM-Signals



**Figure 13** 2EDL05I06PF gate driver input

There is a possibility to use low pass filters inside the PWM input signals to avoid a undesired switch on of an IGBT by disturbances. This feature is not used in this evaluation board, but there is the possibility to test it by changing the resistors RIN1T, RIN1B and the capacitors CIN1T, CIN1B.

## 4 Board design details

### 4.1 Schematic

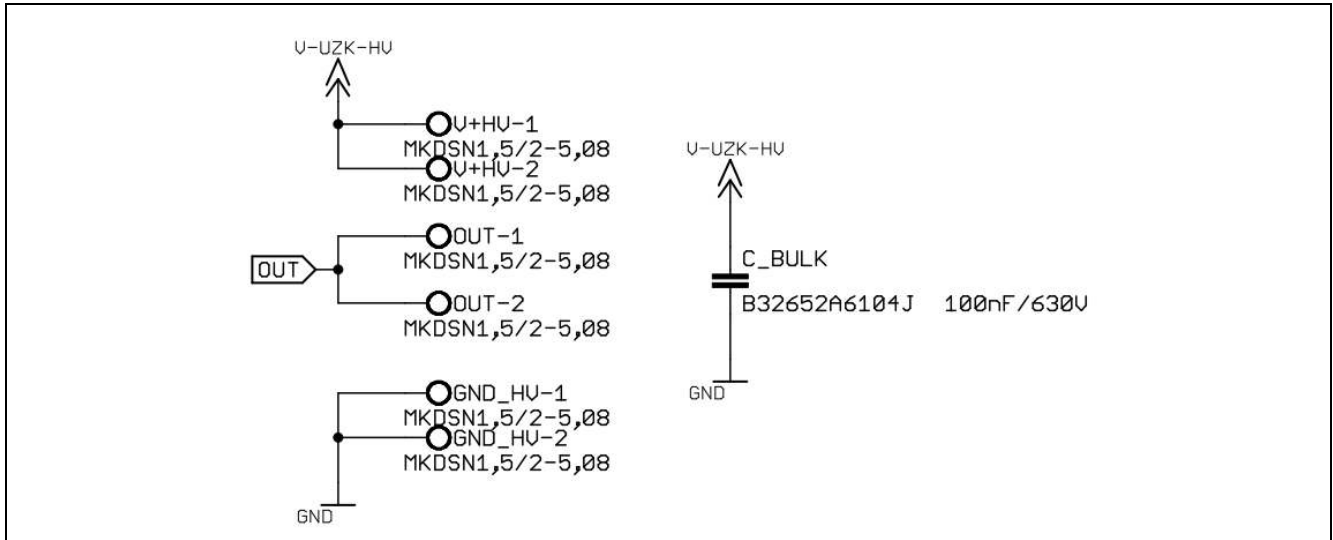


Figure 14 HV supply input and DC-Link

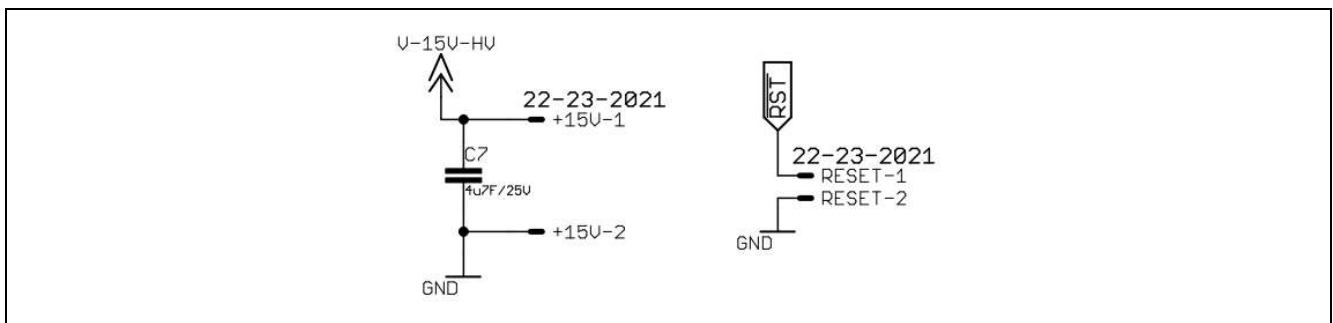


Figure 15 LV Supply and Reset Input

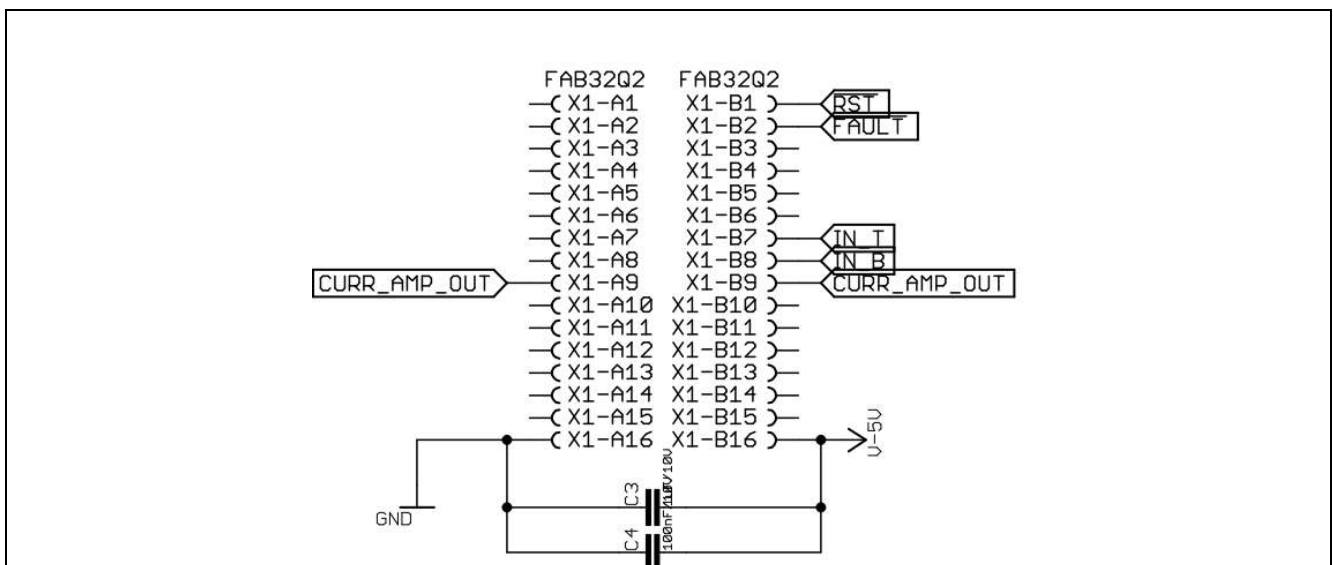


Figure 16 Connector X1

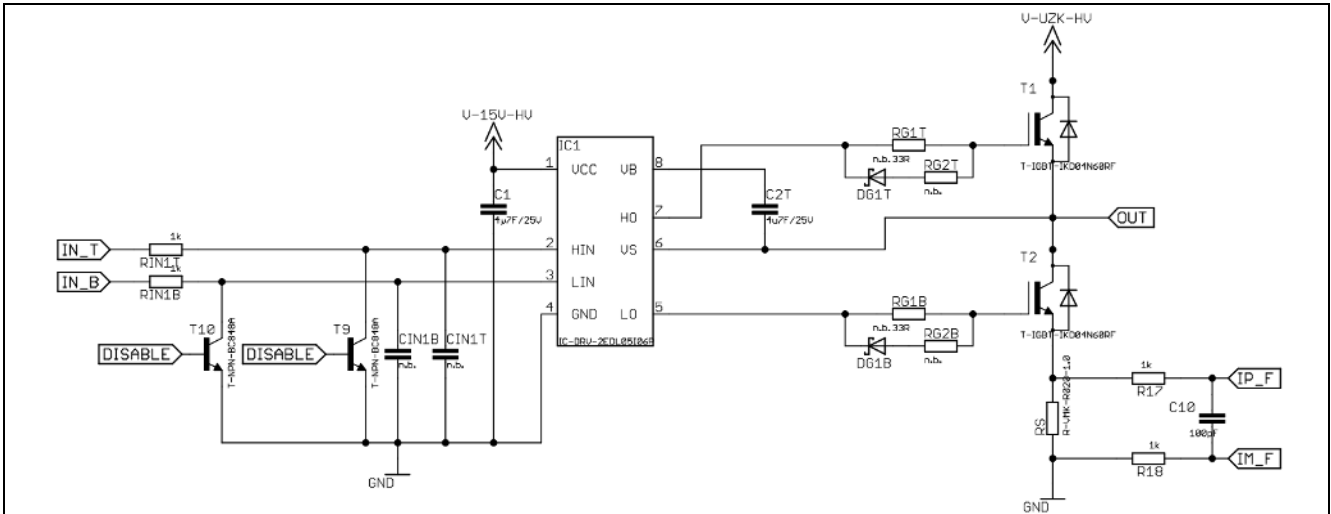


Figure 17 Infineon driver 2EDL05I06PF with shunt measurement

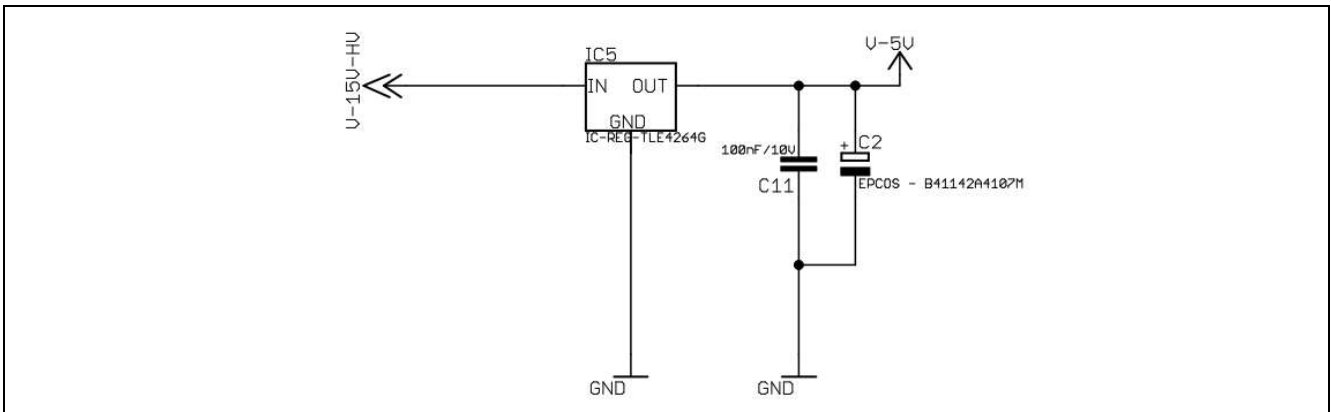


Figure 18 5V voltage regulator

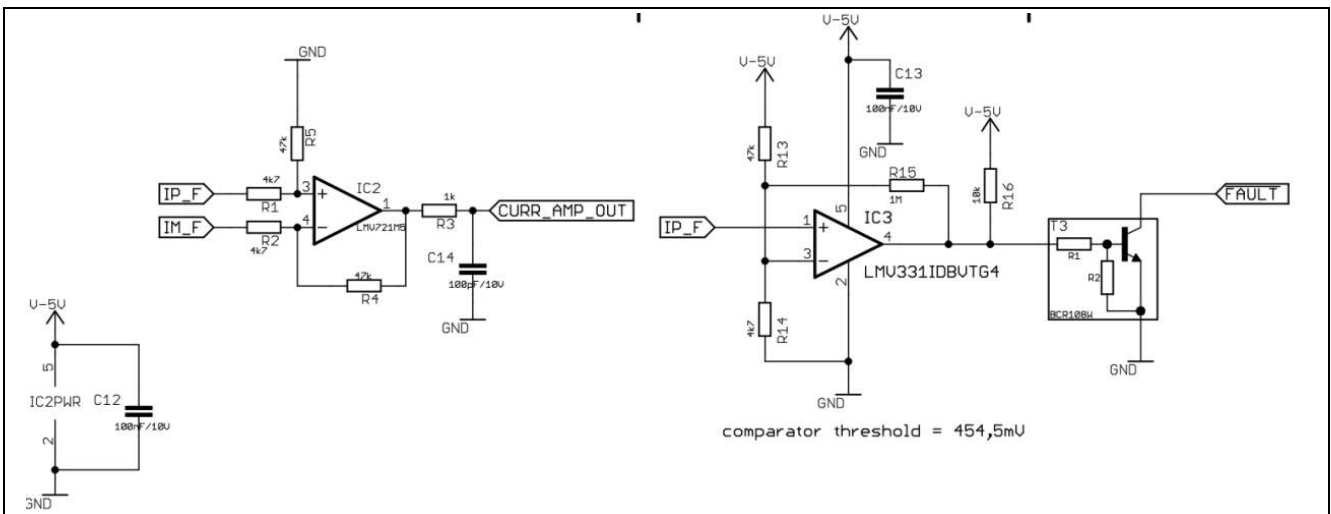


Figure 19 Current amplifier and overcurrent comparator



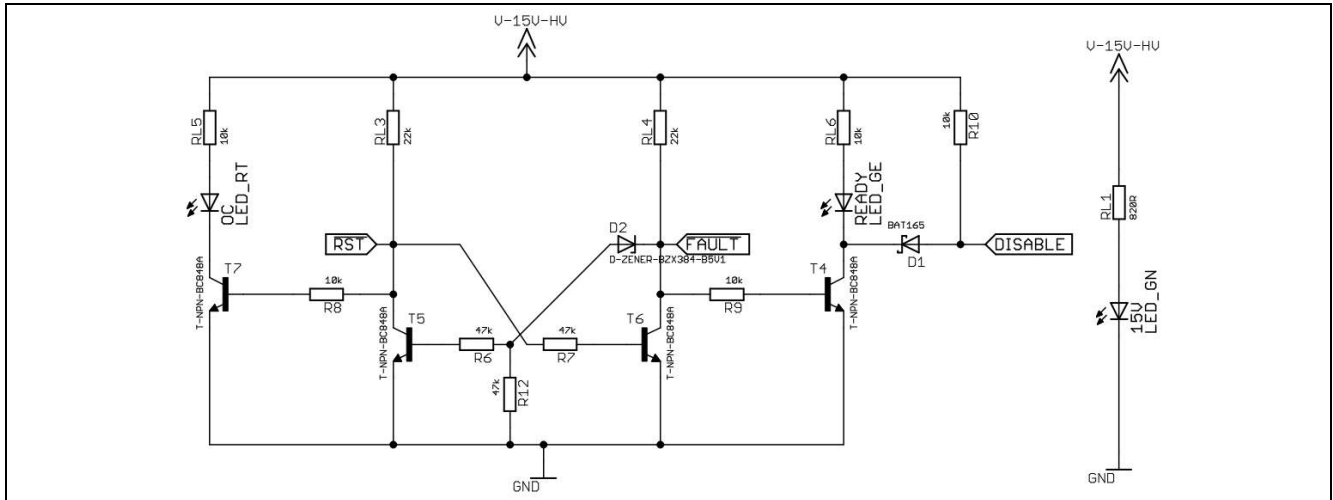


Figure 20 LEDs, FAULT and over current logic

## 4.2 Layout

### 4.2.1 Layout top

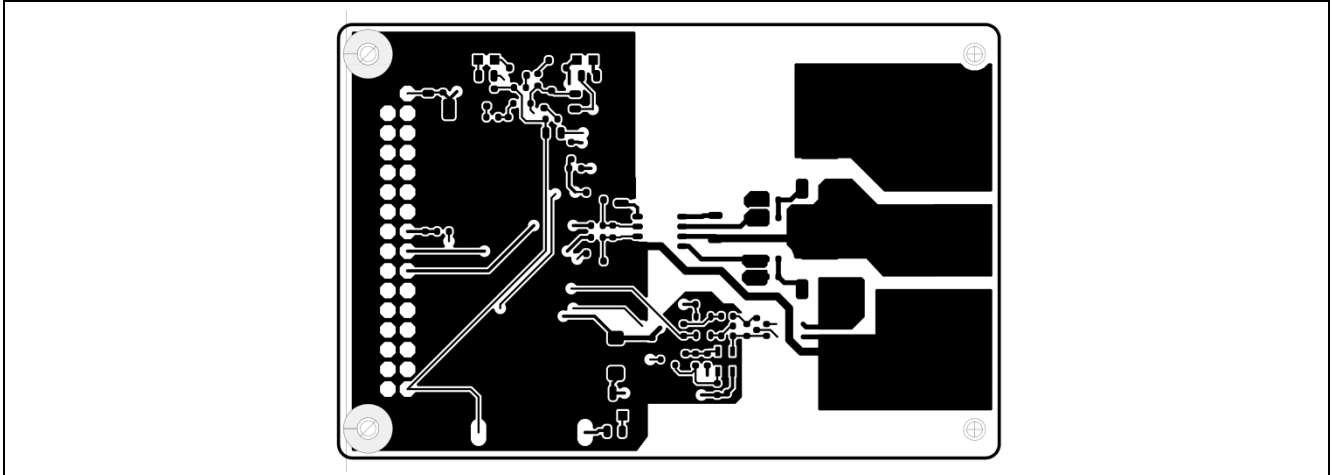


Figure 21 Layout top of the EVAL-2EDL05I06PF

### 4.2.2 Layout bottom

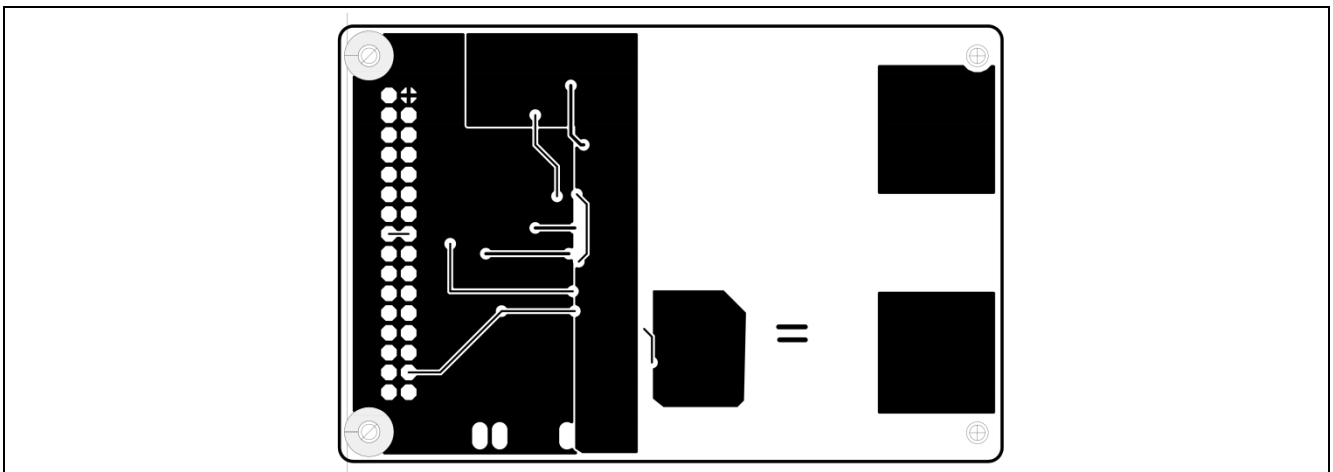


Figure 22 Layout bottom of the EVAL-2EDL05I06PF

### 1.1.1 Top place

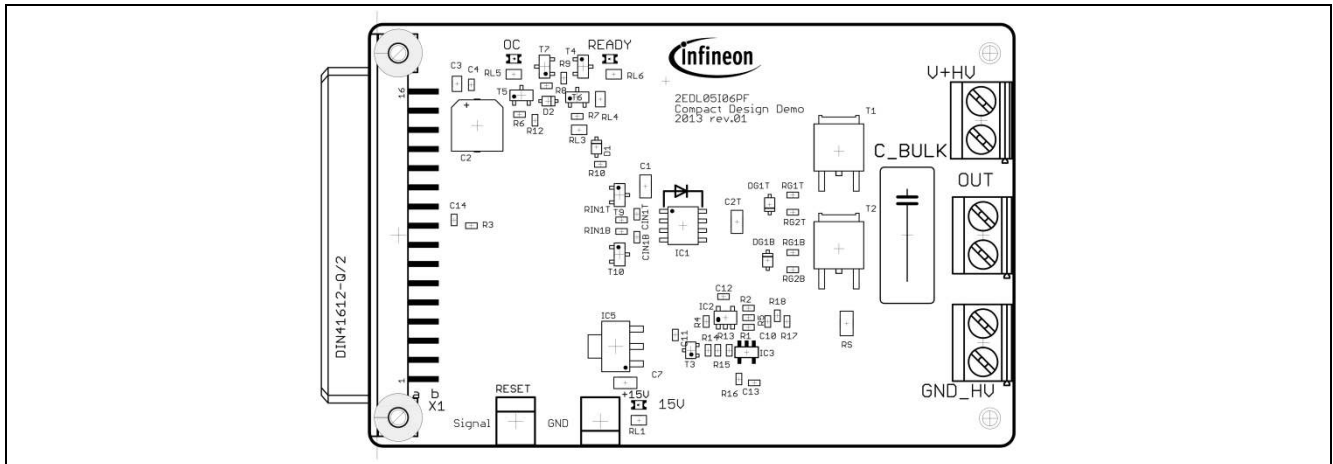


Figure 23 Top place view of the EVAL-2EDL05I06PF

### 4.3 Bill of material

Part	Value	Package
C1, C2T, C7	4u7F/25V	SMD1206
C2	100µF / 16V	6.3 x 6.3 x 7.7mm
C3	1uF/10V	SMD0805
C4, C11, C12, C13	100nF/10V	SMD0603
C10	100pF	SMD0603
C14	100pF/10V	SMD0603
C_BULK	B32652A6104J 100nF/630V	C15B7
D1	BAT165	SOD323
D2	D-ZENER-BZX384-B5V1	SOD323
R1, R2, R14	4k7	SMD0603
R3, R17, R18, RIN1B, RIN1T	1k	SMD0603
R4, R5, R6, R7, R12, R13	47k	SMD0603
R8, R9, R10, R16	10k	SMD0603
R15	1M	SMD0603
RG1B, RG1T	33R	SMD0603
RL1	820R	SMD0805
RL3, RL4	22k	SMD0805
RL5, RL6	10k	SMD0805
RS	R-VMK-R020-1.0	SMD1206_VMK
IC1	IC-DRV-2EDL05I06P	SO-8
IC2	LMV721M5	SOT23-5
IC3	LMV331IDBVTG4	SOT23-5
IC5	IC-REG-TLE4264G	SOT223
T1, T2	T-IGBT-IKD04N60RF	TO-252_DPAK
T3	BCR108W	SOT323
T4, T5, T6, T7, T9, T10	T-NPN-BC848A	SOT23
X1	FAB32Q2	FAB32Q2
+15V, RESET	22-23-2021	22-23-2021
GND_HV, OUT, V+HV	MKDSN1,5/2-5,08	MKDSN1,5/2-5,08
15V	LED_GN	CHIPLED_0805
READY	LED_GE	CHIPLED_0805
OC	LED_RT	CHIPLED_0805

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