

EiceDRIVER™

High voltage gate driver IC

Evaluation Board

Application Note

EVAL-6EDL04I06PT

Application Note

Revision 2.0, 2014-04-14

Edition 2014-04-14

Published by

Infineon Technologies AG

81726 Munich, Germany

**© 2014 Infineon Technologies AG
All Rights Reserved.**

LEGAL DISCLAIMER

THE INFORMATION GIVEN IN THIS APPLICATION NOTE IS GIVEN AS A HINT FOR THE IMPLEMENTATION OF THE INFINEON TECHNOLOGIES COMPONENT ONLY AND SHALL NOT BE REGARDED AS ANY DESCRIPTION OR WARRANTY OF A CERTAIN FUNCTIONALITY, CONDITION OR QUALITY OF THE INFINEON TECHNOLOGIES COMPONENT. THE RECIPIENT OF THIS APPLICATION NOTE MUST VERIFY ANY FUNCTION DESCRIBED HEREIN IN THE REAL APPLICATION. INFINEON TECHNOLOGIES HEREBY DISCLAIMS ANY AND ALL WARRANTIES AND LIABILITIES OF ANY KIND (INCLUDING WITHOUT LIMITATION WARRANTIES OF NON-INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS OF ANY THIRD PARTY) WITH RESPECT TO ANY AND ALL INFORMATION GIVEN IN THIS APPLICATION NOTE.

Information

For further information on technology, delivery terms and conditions and prices, please contact the nearest Infineon Technologies Office (www.infineon.com).

Warnings

Due to technical requirements, components may contain dangerous substances. For information on the types in question, please contact the nearest Infineon Technologies Office.

Infineon Technologies components may be used in life-support devices or systems only with the



Revision History: 2014-04 Rev.2.0

Page or Item	Subjects (major changes since last revision)
Previous Version: 1.0	
all	editorial changes, format update, waveform update

Trademarks of Infineon Technologies AG

AURIX™, C166™, CanPAK™, CIPOS™, CIPURSE™, EconoPACK™, CoolMOS™, CoolSET™, CORECONTROL™, CROSSAVE™, DAVE™, DI-POL™, EasyPIM™, EconoBRIDGE™, EconoDUAL™, EconoPIM™, EconoPACK™, EiceDRIVER™, eupec™, FCOS™, HITFET™, HybridPACK™, I²RF™, ISOFACE™, IsoPACK™, MIPAQ™, ModSTACK™, my-d™, NovalithIC™, OptiMOS™, ORIGA™, POWERCODE™, PRIMARION™, PrimePACK™, PrimeSTACK™, PRO-SIL™, PROFET™, RASIC™, ReverSave™, SatRIC™, SIEGET™, SINDRION™, SIPMOS™, SmartLEWIS™, SOLID FLASH™, TEMPFET™, thinQ!™, TRENCHSTOP™, TriCore™.

Other Trademarks

Advance Design System™ (ADS) of Agilent Technologies, AMBA™, ARM™, MULTI-ICE™, KEIL™, PRIMECELL™, REALVIEW™, THUMB™, μVision™ of ARM Limited, UK. AUTOSAR™ is licensed by AUTOSAR development partnership. Bluetooth™ of Bluetooth SIG Inc. CAT-iq™ of DECT Forum. COLOSSUS™, FirstGPS™ of Trimble Navigation Ltd. EMV™ of EMVCo, LLC (Visa Holdings Inc.). EPCOS™ of Epcos AG. FLEXGO™ of Microsoft Corporation. FlexRay™ is licensed by FlexRay Consortium. HYPERTERMINAL™ of Hilgraeve Incorporated. IEC™ of Commission Electrotechnique Internationale. IrDA™ of Infrared Data Association Corporation. ISO™ of INTERNATIONAL ORGANIZATION FOR STANDARDIZATION. MATLAB™ of MathWorks, Inc. MAXIM™ of Maxim Integrated Products, Inc. MICROTEC™, NUCLEUS™ of Mentor Graphics Corporation. MIPI™ of MIPI Alliance, Inc. MIPS™ of MIPS Technologies, Inc., USA. muRata™ of MURATA MANUFACTURING CO., MICROWAVE OFFICE™ (MWO) of Applied Wave Research Inc., OmniVision™ of OmniVision Technologies, Inc. Openwave™ Openwave Systems Inc. RED HAT™ Red Hat, Inc. RFMD™ RF Micro Devices, Inc. SIRIUS™ of Sirius Satellite Radio Inc. SOLARIS™ of Sun Microsystems, Inc. SPANSION™ of Spansion LLC Ltd. Symbian™ of Symbian Software Limited. TAIYO YUDEN™ of Taiyo Yuden Co. TEAKLITE™ of CEVA, Inc. TEKTRONIX™ of Tektronix Inc. TOKO™ of TOKO KABUSHIKI KAISHA TA. UNIX™ of X/Open Company Limited. VERILOG™, PALLADIUM™ of Cadence Design Systems, Inc. VLYNQ™ of Texas Instruments Incorporated. VXWORKS™, WIND RIVER™ of WIND RIVER SYSTEMS, INC. ZETEX™ of Diodes Zetex Limited.

Last Trademarks Update 2011-11-11

Table of Contents

1	Introduction	5
2	Design feature	6
2.1	Main features.....	6
2.2	Board specifications	7
2.3	Pin assignment.....	8
3	Electrical features	9
3.1	Supply voltage +15V	9
3.2	Under voltage lockout.....	9
3.3	Over-current detection.....	9
3.4	IGBT turn - on / off.....	10
3.5	DC-Link capacitor	12
3.6	Input Signals.....	12
4	Board design details	13
4.1	Schematic	13
4.2	Layout	15
4.2.1	Layout top	15
4.2.2	Layout bottom.....	15
4.2.3	Top place	16
4.3	Bill of material.....	17

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-6EDL04I06PT was developed to show the functionalities and key features of the Infineon IGBT gate driver 6EDL04I06PT.

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-6EDL04I06PT 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.

See Legal Disclaimer and Warnings for further restrictions on Infineons warranty and liability.

2 Design feature

2.1 Main features

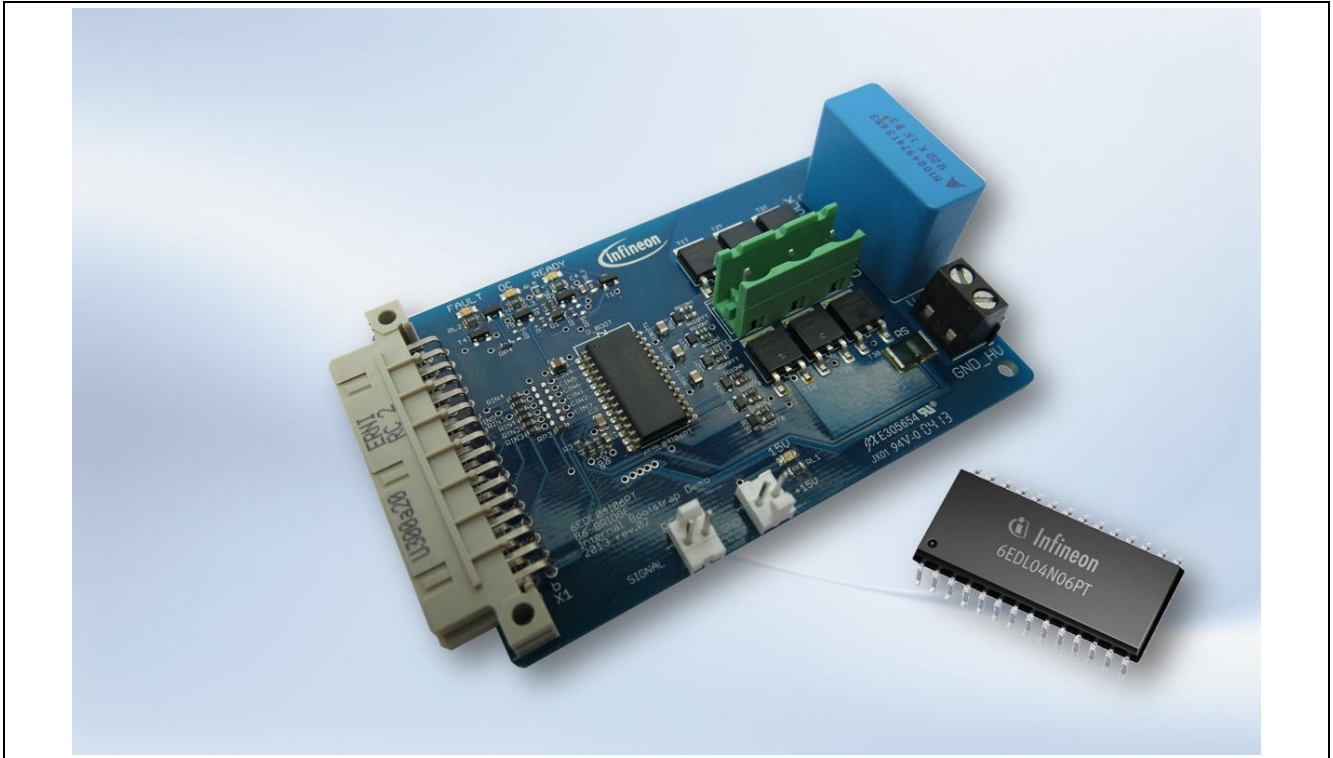


Figure 1 Top view of the EVAL-6EDL04I06PT

The EVAL-6EDL04I06PT contains an Infineon IGBT full bridge gate driver 6EDL04I06PT in PG-DSO-28 package and six Infineon IGBTs IKD04N60R

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 IGBTs
- Use of the Internal ultra fast bootstrap diodes of the 6EDL04I06PT
- 15V supply, Reset, High voltage supply, external load
- Status LED for 15V supply, ready, fault and overcurrent status
- DC link capacitor

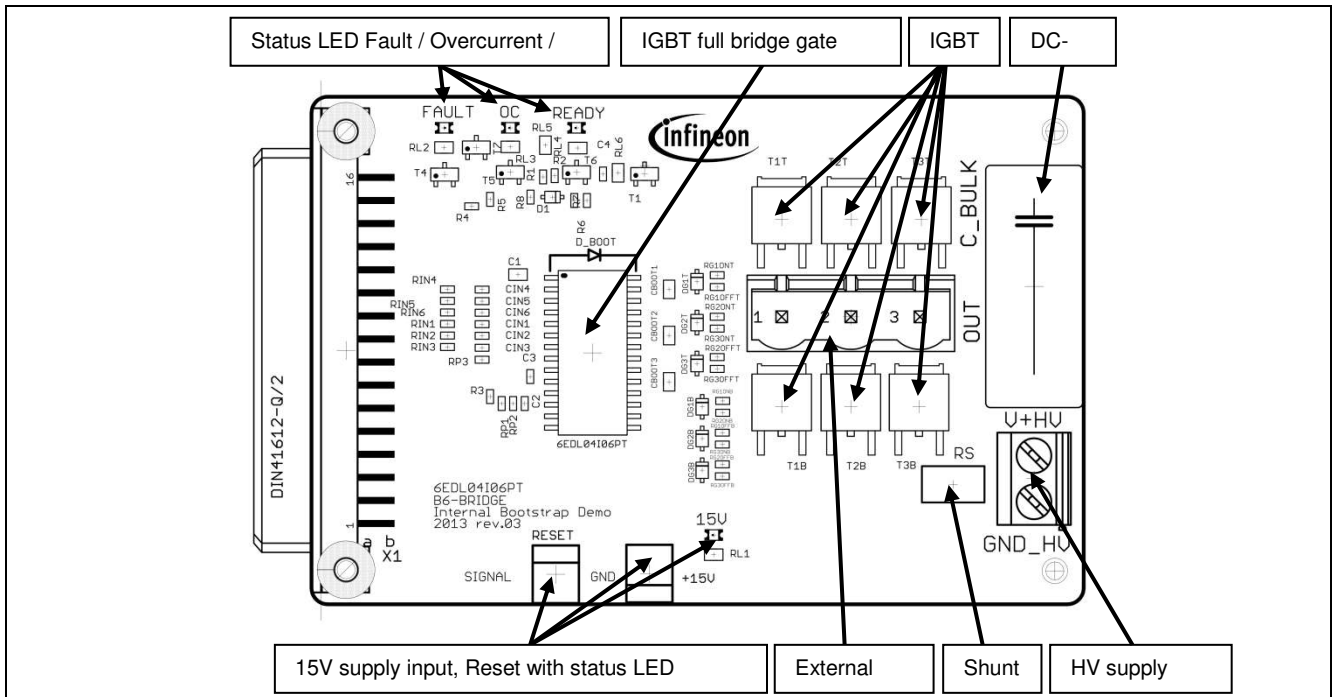


Figure 2 Overview functionalities on top-side

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	
	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			

*see Figure 16 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 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 maximum values may damage the IGBT 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 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 6EDL04I06PT. In case of an undervoltage the driver output is switched off. The thresholds are typically $V_{CCUV+} = 11.7\text{ V}$ (positive going) and $V_{CCUV-} = 9.8\text{ V}$ (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 6EDL04I06PT provides an over-current detection function by connecting the ITRIP input with the load feedback current. In case of the EVAL-6EDL04I06PT, this is done by using a resistive shunt for current measurements. The shunt voltage is connected to the ITRIP comparator. The ITRIP comparator detects the over-current if the voltage exceeds the threshold of typically 0.44V.

With the shunt resistor value of 20mOhm as used in EVAL-6EDL04I06PT, the ITRIP comparator is triggered at a current of approximately 22A.

An over-current event generates a hard shut down of all gate driver outputs and provides a latched fault feedback at /FAULT pin. In the same time, the RC network (only C used in case of EVAL-6EDL04I06PT) connected at pin RCIN is discharged. The fault is latched by the gate driver internally till the capacitor at RCIN is re-charged and the voltage level reaches a value of typically 5.2V. In case of the EVAL-6EDL04I06PT, logic circuit implemented on the board keeps the capacitor at RCIN discharged till a LOW pulse at the RESET pin occurs. This must be done by pulling the RESET signal low manually or by an external circuit.

An over-current event is indicated by the LED "OC" and LED "FAULT" lighting up together.

At power up, the implemented logic circuit may be in an undefined state. If only the LED "OC" is lit after a power up, it is recommend to reset the logic with a LOW pulse at RESET signal.

The overcurrent detection is designed for HV supply voltages of 320V and above. The shunt resistor value may be adjusted, when operating the board with less than 320V in order to guarantee a proper detection of short circuit events.

Relevant waveforms in case of a simulated short circuit are shown in Figure 3-1. Notice that there is approximately 1.5 μs delay between the overcurrent detection and the gate shut down. During this time interval, the current continues to rise as shown in the figure and therefore this delay must be considered to assure a safe use of the EVAL-6EDL04I06PT board.

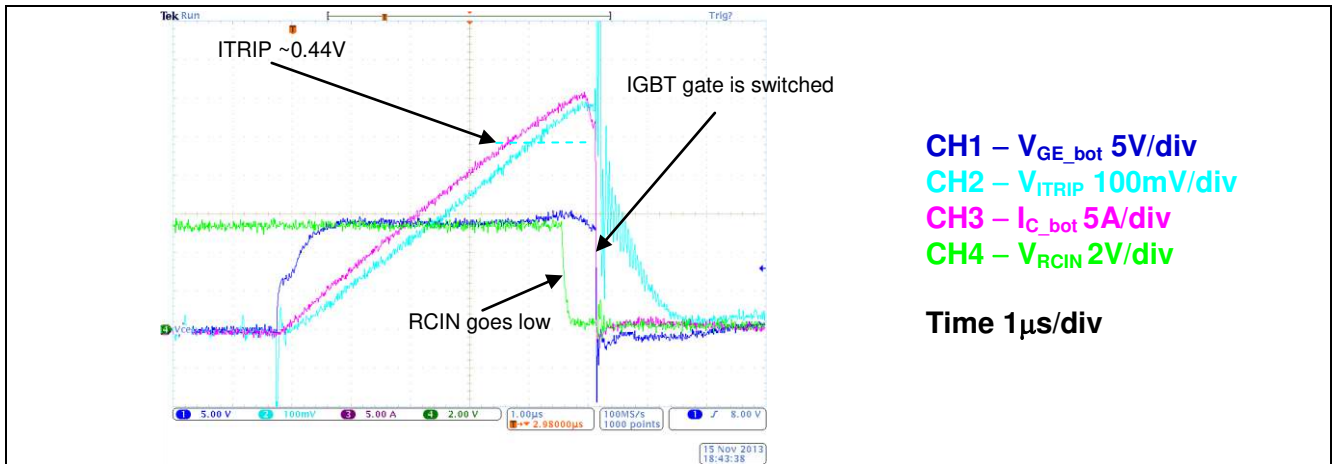


Figure 3 Over-current detection signals during a simulated short circuit

3.4 IGBT turn - on / off

The switching characteristic of the IGBTs 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.

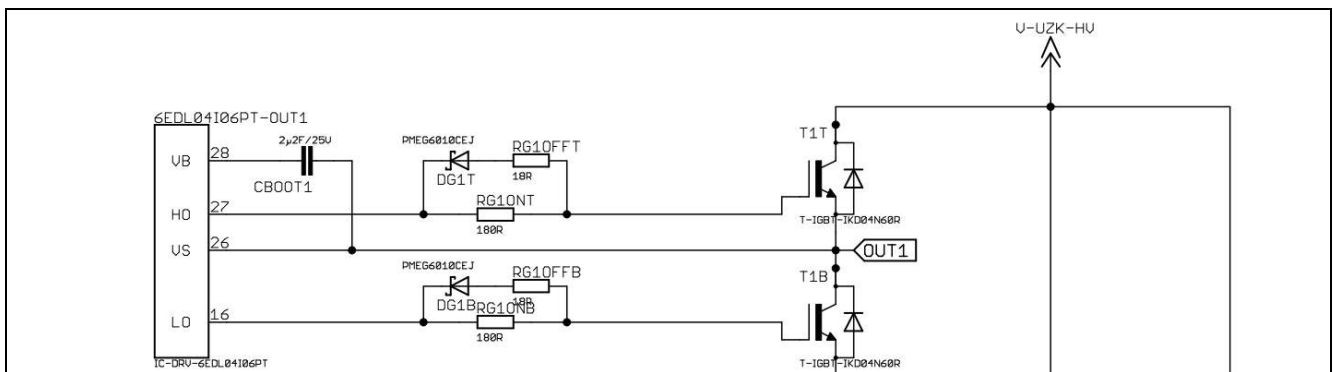


Figure 4 Gate driver output of the 6EDL04I06PT. Exemplarily only 1 phase output pictured

The gate resistors are adapted to the max. gate driver output current of the 6EDL04I06PT for turn-on and turn-off. There is the possibility to adapt the switching characteristic to specific applications or to different IGBTs 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 IGBT independent to each other.

To avoid a shoot through between top- and bottom IGBT, the operator needs to ensure a sufficient dead time. With this setup the deadtime should be $> 1\mu s$.

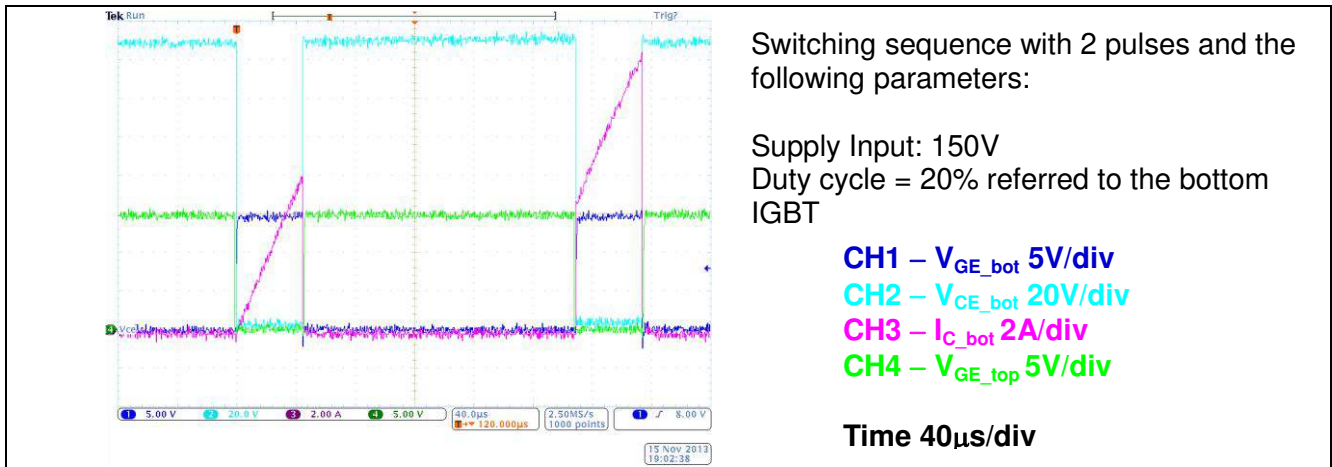


Figure 5 Switching sequence with 1µs dead time

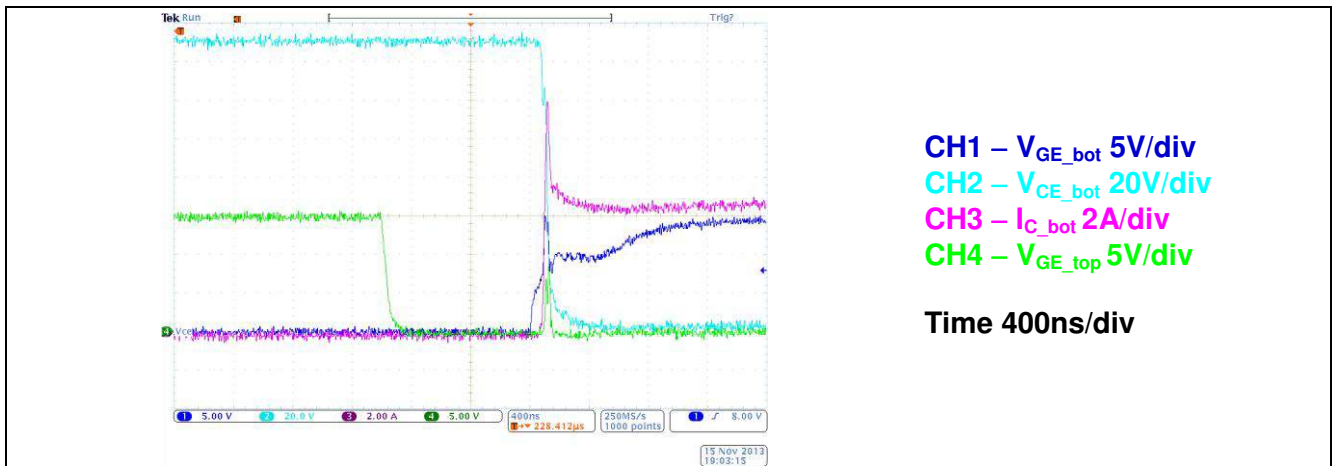


Figure 6 Turning off top IGBT with 1µs dead time

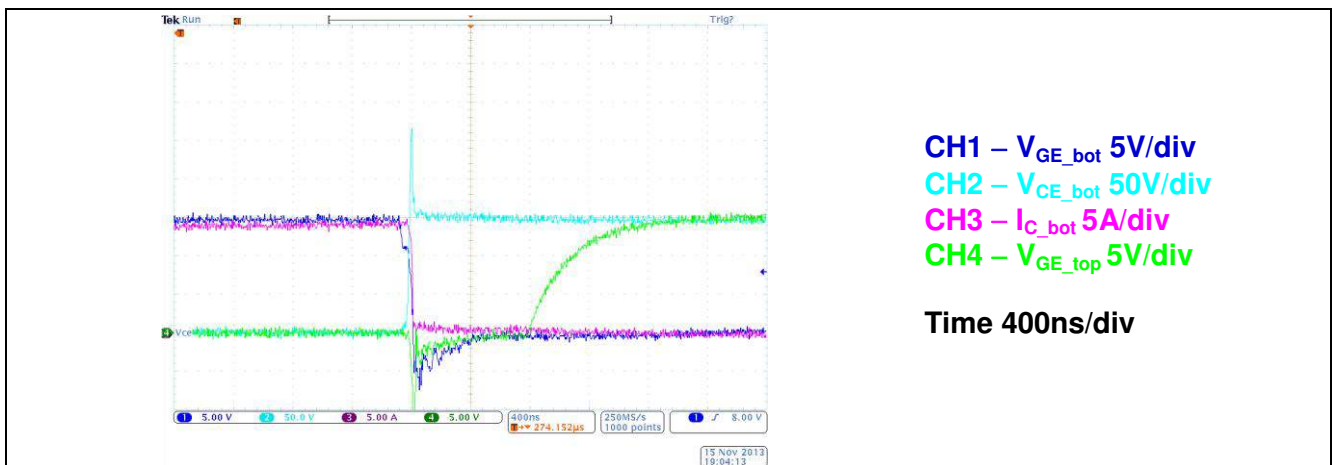


Figure 7 Turning on top IGBT with 1µs dead time

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

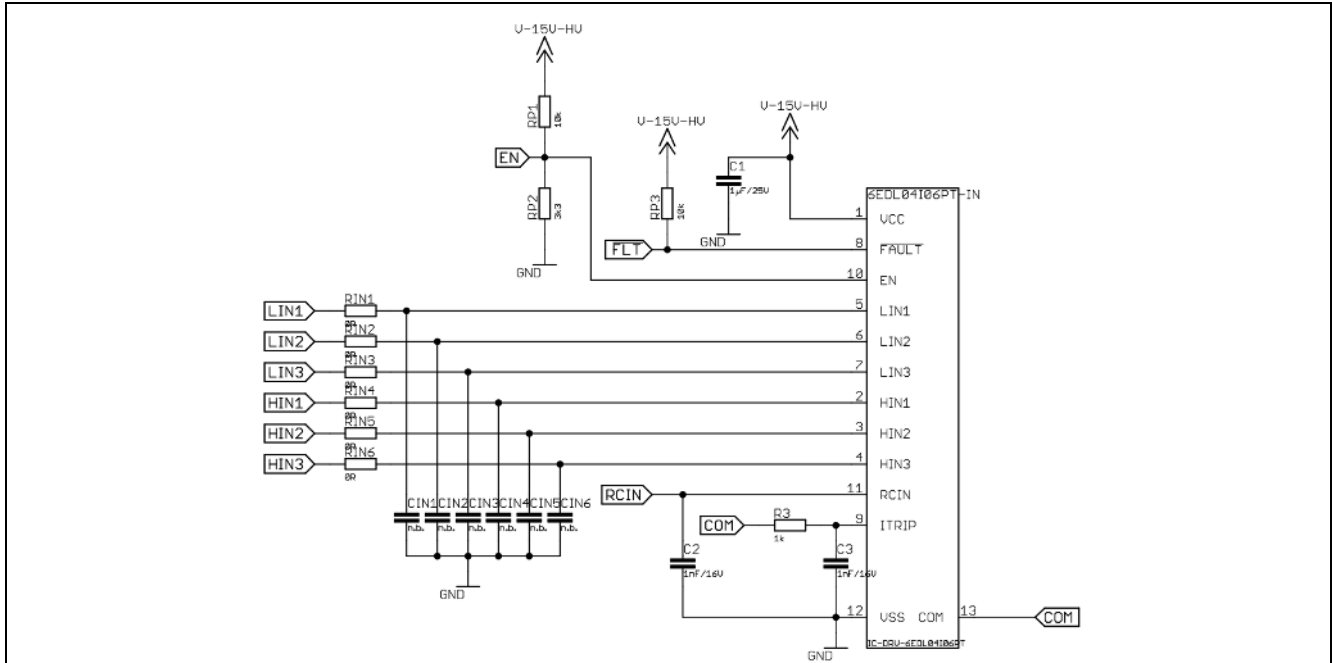


Figure 8 Gate driver inputs

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 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 RIN1,2,3,4,5,6 and the capacitors CIN1,2,3,4,5,6.

4 Board design details

4.1 Schematic

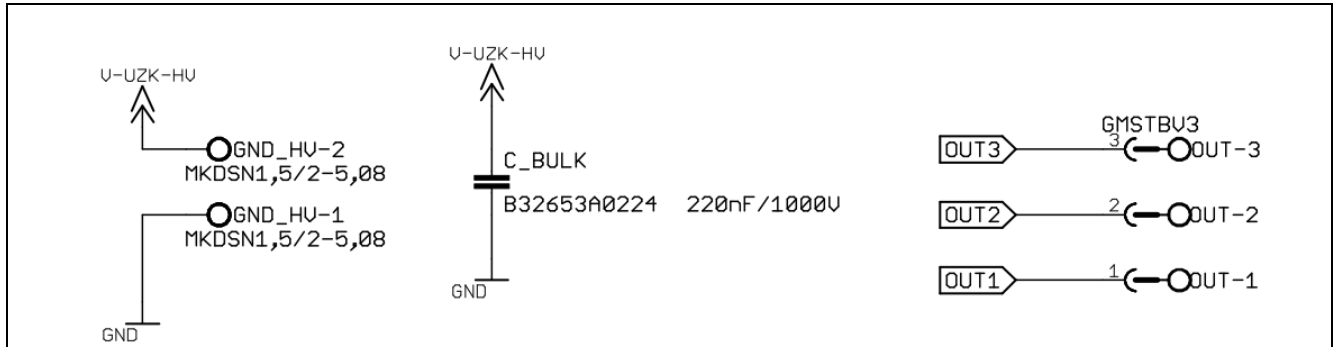


Figure 9 HV supply input, DC-Link and load connector

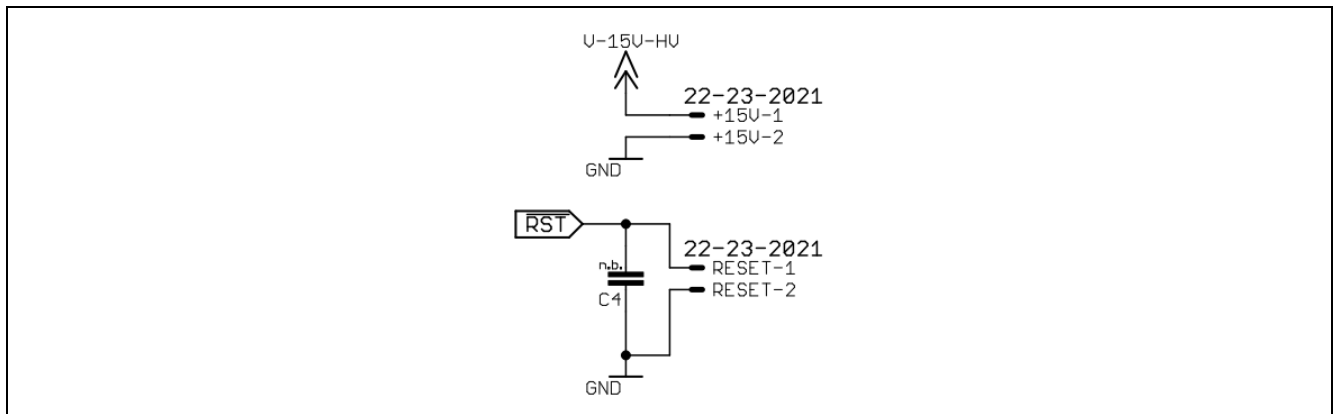


Figure 10 LV Supply and Reset Input

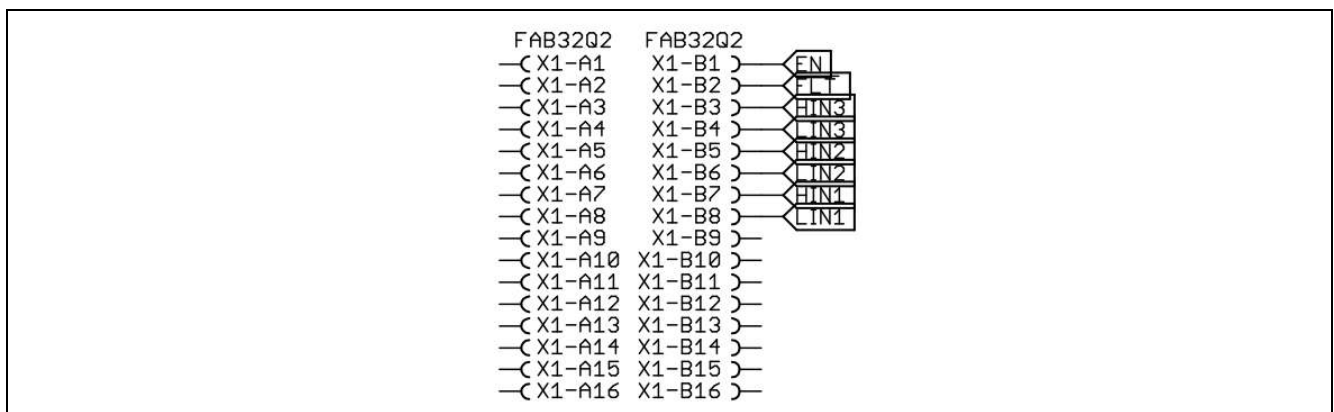


Figure 11 Connector X1

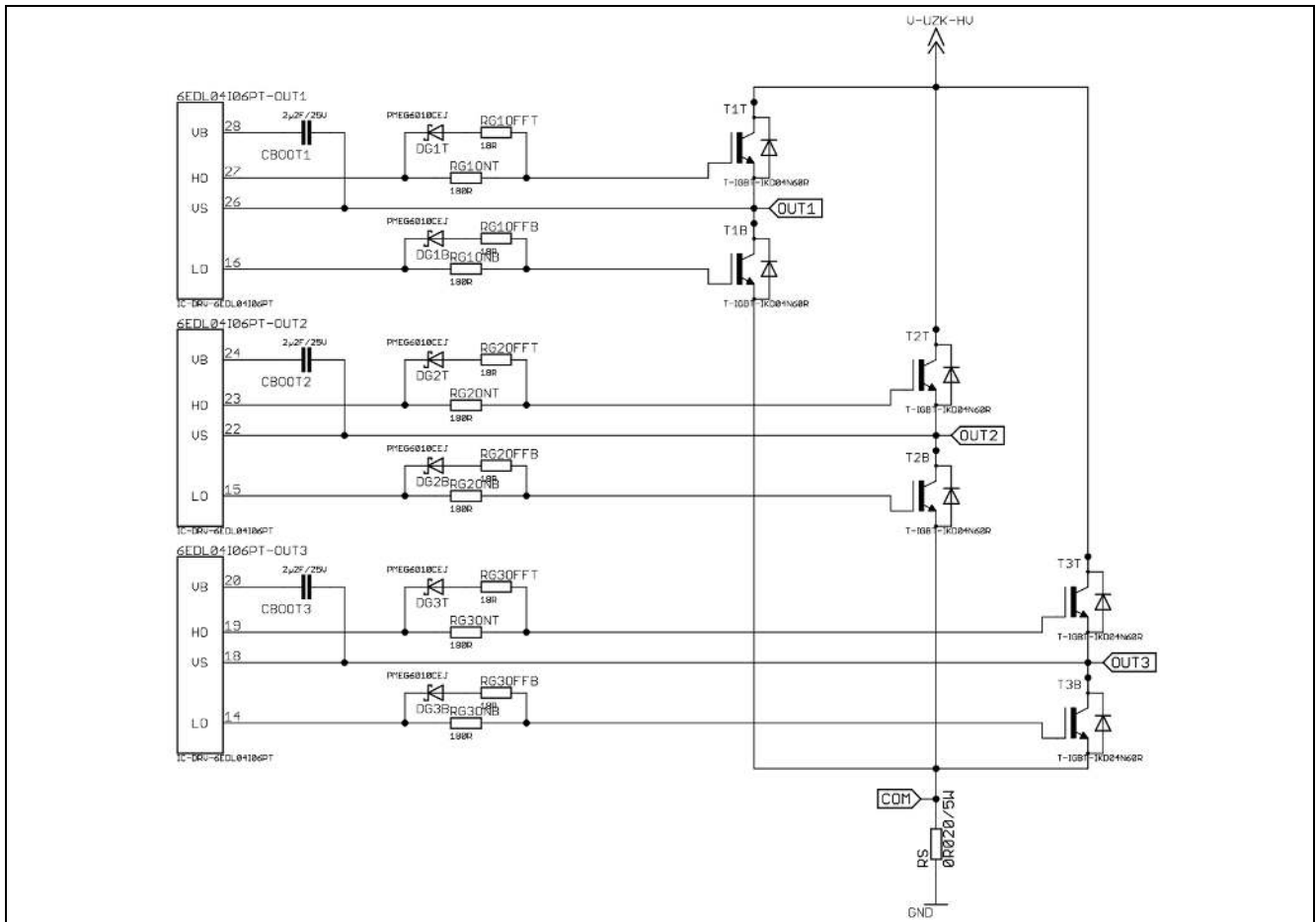


Figure 12 Infineon driver 6EDL04I06PT outputs

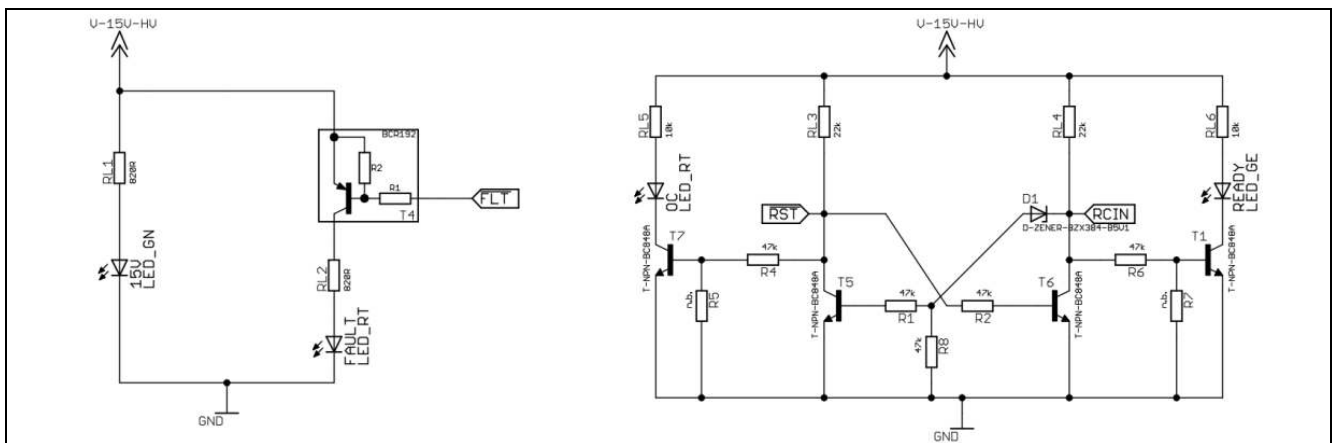


Figure 13 LEDs, FAULT and READY logic

4.2 Layout

4.2.1 Layout top

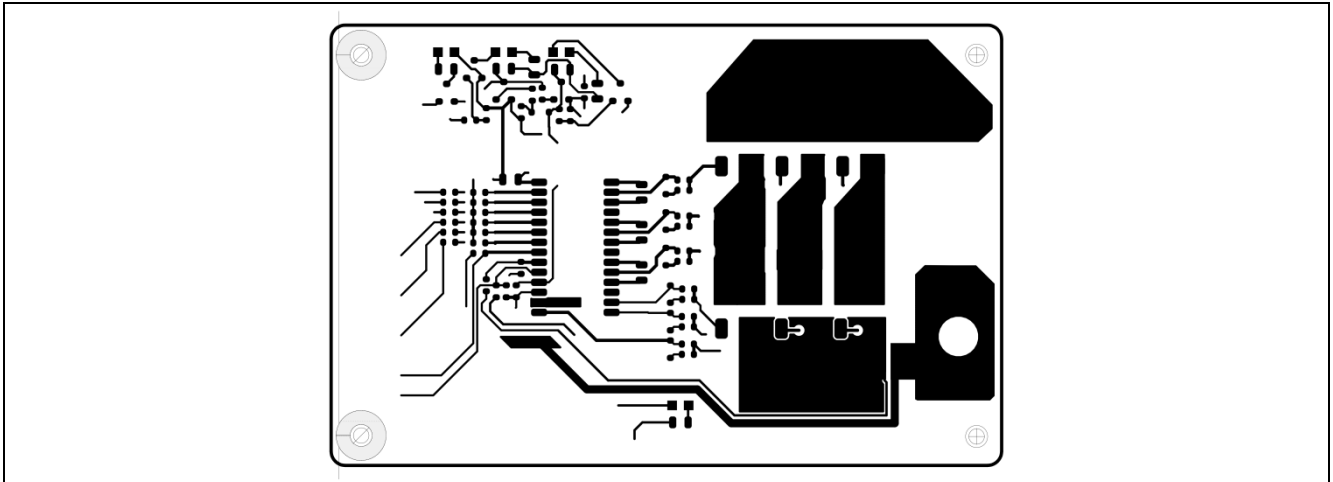


Figure 14 Layout top of the EVAL-6EDL04I06PT

4.2.2 Layout bottom

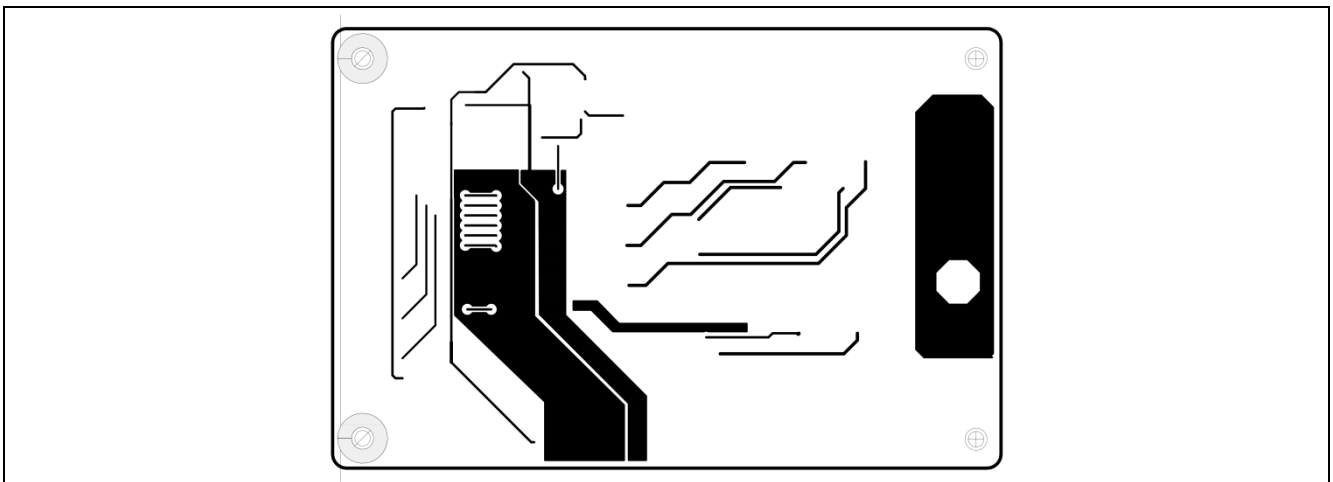


Figure 15 Layout bottom of the EVAL-6EDL04I06PT

4.2.3 Top place

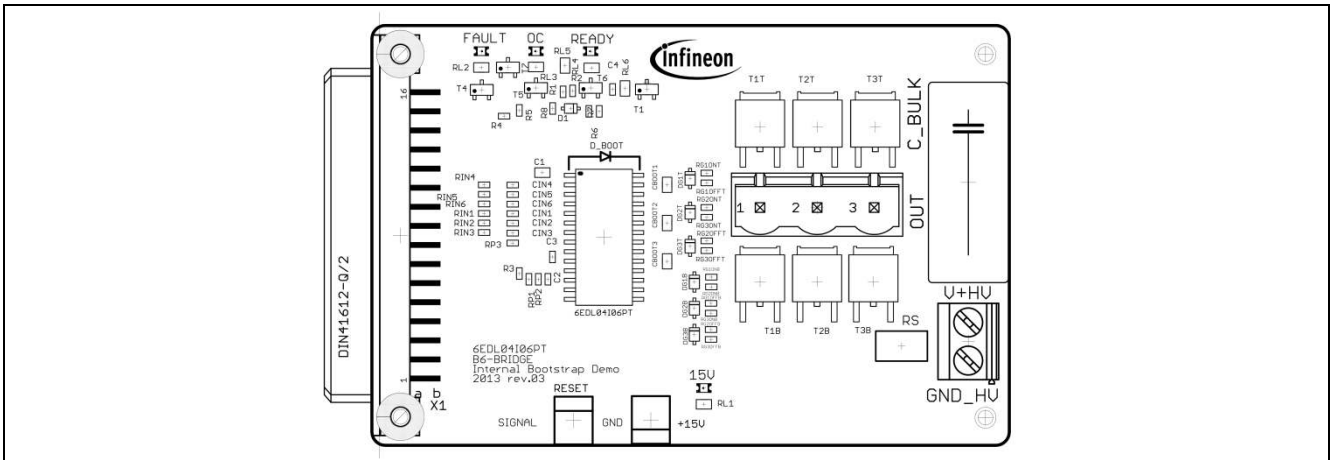


Figure 16 Top place view of the EVAL-6EDL04I06PT

4.3 Bill of material

Part	Value	Package
C1	1µF/25V	SMD0805
C2, C3	1nF/16V	SMD0603
CBOOT1, CBOOT2, CBOOT3	2µ2F/25V	SMD0805
C_BULK	B32653A0224 220nF/1000V	C22.5B10
D1	D-ZENER-BZX384-B5V1	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	SMD0603
RG1ONB, RG1ONT, RG2ONB RG2ONT, RG3ONB, RG3ONT	180R	SMD0603
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	0R020/5W	SMT-REF
6EDL04I06PT	IC-DRV-6EDL04I06PT	PG-DSO-28
T1, T5, T6, T7	T-NPN-BC848A	SOT23
T1B, T1T, T2B, T2T, T3B, T3T	T-IGBT-IKD04N60R	TO-252_DPAK
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	CHIPLELED_0805
15V	LED_GN	CHIPLELED_0805
READY	LED_GE	CHIPLELED_0805

www.infineon.com

Published by Infineon Technologies AG