Application Note AN 2008-02
V1.3 Feb. 2011

Evaluation Driver Boards for EconoDUAL™3 and EconoPACK™+ modules

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Driver Boards for EconoDUAL™ 3 and EconoPACK™ +

Edition 2011-02-02
Published by
Infineon Technologies AG
59568 Warstein, Germany

AN 2008-02
Revision History: date (11-02-02) , V1.3
Previous Version: V1.2
Page: Subjects Improvement of the active gate clamping circuit

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Driver Boards for EconoDUAL™ 3 and EconoPACK™ +

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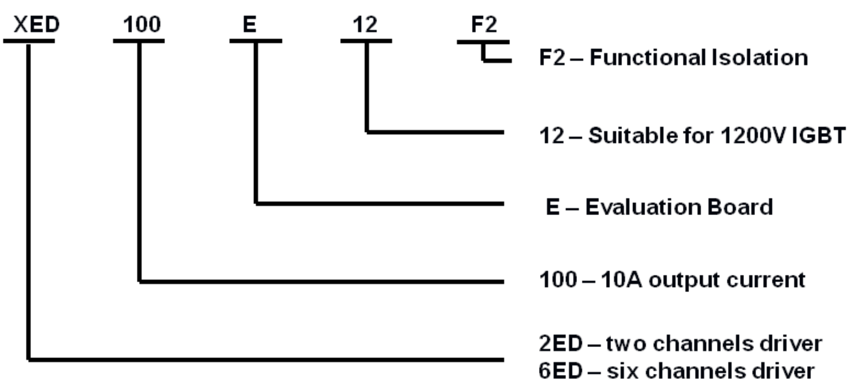
Part number explanation:



1 Introduction

The Evaluation Driver Board 2ED100E12-F2 for EconoDUAL™ 3 modules as can be seen in Figure 1 and the Evaluation Driver Board 6ED100E12-F2 for EconoPACK™ + modules, shown in Figure 2, were developed to support customers during their first steps designing applications with these modules. The basic version of each board is available from Infineon in small quantities. The properties of these parts are described in the following chapters 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 his specific requirements.

The design of the 2ED100E12-F2 and the 6ED100E12-F2 was performed with respect to the environmental conditions described as design target in this document. The requirements for lead-free reflow soldering have been considered when components were selected. The design was tested as described in this documentation but not qualified regarding manufacturing and operation in the whole operating ambient temperature range or lifetime.

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.

See Legal Disclaimer and Warnings for further restrictions on Infineon’s warranty and liability.

Figure 1 The 2ED100E12-F2 Evaluation Driver Board mounted on the top of the EconoDUAL™ 3 module

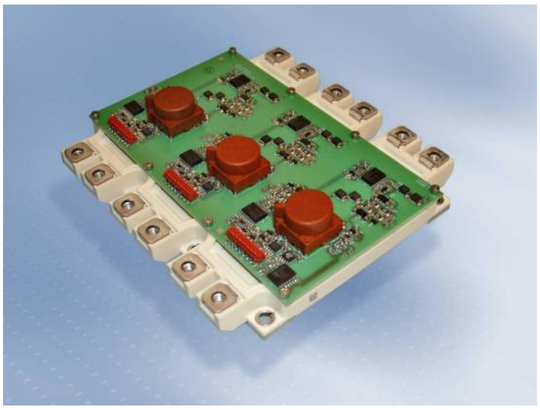


Figure 2 The 6ED100E12-F2 Evaluation Driver Board mounted on the top of the EconoPACK™ + module

2 Design features

The following sections provide an overview of the boards including main features, key data, pin assignments and mechanical dimensions.

2.1 Main features

The 2ED100E12-F2 and the 6ED100E12-F2 Evaluation Driver Board offer the following features:

- Dual channel IGBT driver in 2ED100E12-F2 version, adapted for use with IGBT4
- Six channel IGBT driver in 6ED100E12-F2 version
- Electrically and mechanically suitable for 600 V and 1200 V EconoDUAL™ 3 or EconoPACK™ + IGBT modules
- Includes DC/DC power supply with short circuit protection
- Isolated temperature measurement
- Short circuit protection with $t_{off} < 6$ µs
- Under Voltage Lockout of IGBT driver IC
- Positive logic with 5 V CMOS level for PWM and fault signals
- One fault output signal for each leg
- PCB is designed to fulfill the requirements of IEC61800-5-1, pollution degree 2, overvoltage category II

2.2 Key data

All values given in the table below are typical values, measured at T_A = 25 °C

Table 1 Key data and characteristic values (typical values)

Parameter		Value	Unit
V_{DC}	primary DC/DC voltage supply	+15 ±0.5	V
V_{CC}	primary supply voltage for logic devices	+5 ±0.5	V
$V_{LogicIN}$	PWM signals for high side and low side IGBT	0 / +5	V
V_{FAULT}	/FAULT detection output	0 / +5	V
I_{FAULT}	max. /FAULT detection output load current	10	mA
V_{RST}	/RST input	0 / +5	V
I_{DC}	primary DC/DC current drawn per leg	40	mA
I_{CC}	primary current drawn for logic devices per leg	25	mA
V_{out}	drive voltage level for high side and Low side channel	+16 / -8	V
I_G	max. peak output current	±10	A
$P_{DC/DC}$	max. DC/DC output power high and low side	3	W
f_S	max. PWM signal frequency for high and low side 1)	100	kHz
t_{PDELAY}	propagation delay time	200	ns
t_{PDISTO}	input to output propagation distortion	15	ns
V_{Desat}	Desaturation reference level	9	V
d_{max}	max. duty cycle	100	%
V_{CES}	max. collector – emitter voltage on IGBT	600/1200	V
V_{TEMP}	temperature measurement output voltage	digital 0/5	V
I_{TEMP}	max. temperature measurement load current	5	mA
T_{op}	operating temperature design target 2)	-40…+85	°C
T_{sto}	storage temperature design target	-40…+85	°C
$U_{is,eff}$	Isolation voltage 3) Transformer Vacuumschmelze	500	V_{AC}
V_{IORM}	Maximum Repetitive Insulation Voltage 4) 1ED020I12-F Driver IC	1420	V_{peak}
V_{IORM}	Max. working insulation voltage 5) AD7400 Sigma-Delta Converter	891	V_{peak}

1) The maximum switching frequency for every EconoDUAL™ 3 or EconoPACK™ + module type should be calculated separately. Limitation factors are: max. DC/DC output power of 1.5 W per channel and max. PCB board temperature measured around gate resistors of 105 °C for used FR4 material. For detailed information see chapter 2.3
2) Maximum operating temperature strictly depends on load and cooling conditions. For detailed description see chapter 2.3
3) Values defined in datasheets: T60403-D4615-X054 date: 21.03.2000
4) 1ED020I12-F Datasheet, Version 2.2, December 2009
5) AD7400 1/11 – Revision C

2.3 Pin assignment

Except pin 14 of the connectors X1 and X2 of EconoPACK™ + driver board, all connectors for both EconoDUAL™ 3 and EconoPACK™ + board are configured as listed in Table 2.

Table 2 depicts the pin assignment of connector X3 shown in Figure 3.

Table 2 Inputs and outputs of 6ED100E12-F2 for connector X3

Pin	Label	Function
X3.1	MClock	Clock out for temperature measurement
X3.2	Supply	+15 V Primary voltage for DC/DC converter
X3.3	GND	Primary ground for DC/DC converter supply voltage
X3.4	Supply	+15 V Primary voltage for DC/DC converter
X3.5	TOP IN-	PWM signal for high side IGBT, negative logic
X3.6	TOP IN+	PWM signal for high side IGBT, positive logic
X3.7	TOP RDY	Ready signal for high side IGBT
X3.8	TOP /FLT	Fault detection output high side IGBT
X3.9	TOP/BOT /RST	Reset signal for high and low side IGBT -Driver
X3.10	BOT /FLT	Fault detection output low side IGBT
X3.11	BOT RDY	Ready signal for low side IGBT
X3.12	BOT IN-	PWM signal for low side IGBT, negative logic
X3.13	BOT IN+	PWM signal for low side IGBT, positive logic
X3.14	TEMP-Digital	Sigma / Delta signal for temperature measurement
X3.15	+5V	+5 V Voltage supply for logic devices
X3.16	Signal GND	Primary ground logic devices

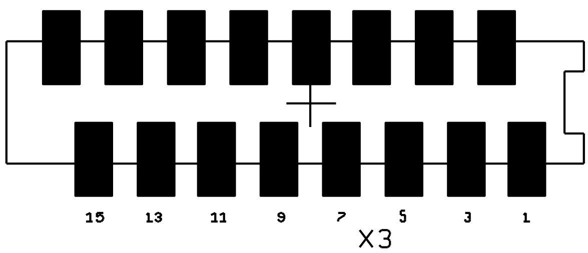


Figure 3 The 6ED100E12-F2 Evaluation Driver Board connector layout of X3

2.4 Mechanical dimensions of the EconoDUAL™ 3 Driver Board

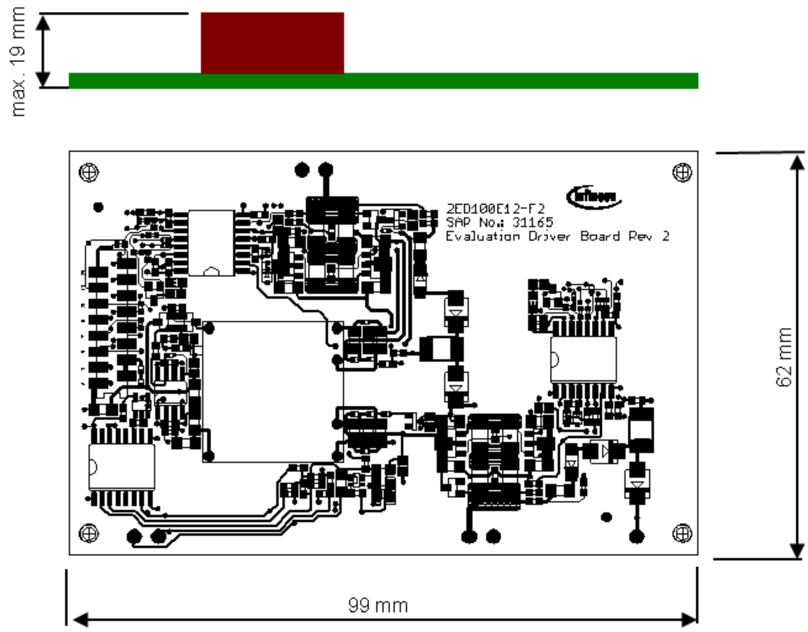


Figure 4 Dimensions of the 2ED100E12-F2 Driver Board

2.5 Mechanical dimensions of the EconoPACK™ + Driver Board

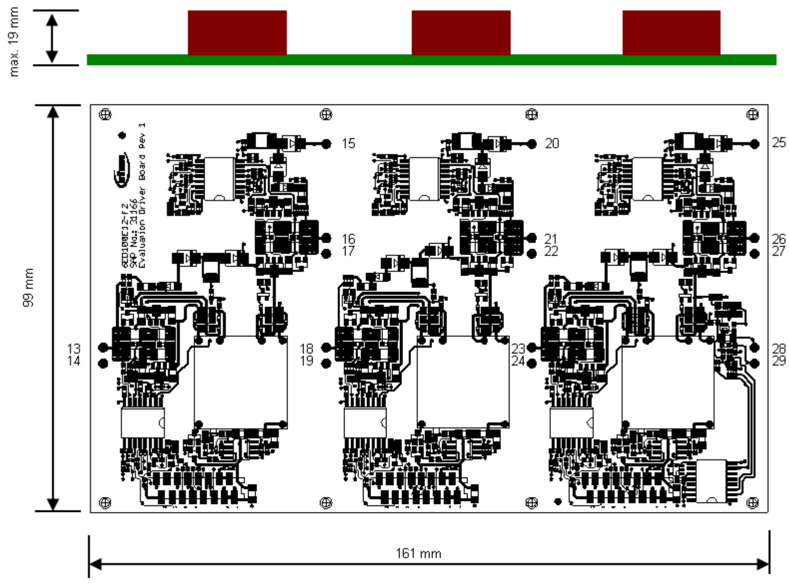


Figure 5 Dimensions of the 6ED100E12-F2 Driver Board

Both Driver Boards should be fastened by self taping screws and soldered to the auxiliary connectors on top of the IGBT module.

Clearance and creepage distances for EconoDUAL™ 3 and EconoPACK™ + Driver Boards:
Primary/Secondary is not less than 8 mm and Secondary/Secondary is not less than 4 mm.

3 Electrical Features

The following chapter describes the board´s operation in the evaluation setup. Please note that the following paragraphs describe the circuits of the 2ED100E12-F2 which has been modified compared to the last revision of this AN to drive IGBT4 modules and to reduce the susceptibility to erroneous triggering of the V_{cesat}-detection. The same changes also are applied to the 6ED100E12-12-F2, but layout and part list of this board as provided in chapter 7 still represent the initial design.

3.1 Power Supply

The 2ED100E12-F2 and the 6ED100E12-F2 have an integrated DC/DC converter for each leg, which generates the required secondary isolated unsymmetrical supply voltage of +16 V / -8 V. High and Low side driver voltages are independently generated by using one unipolar input voltage of 15 V. Additionally, the power supply is protected against gate – emitter short circuit of the IGBTs. In case of DC/DC converter overload, the output voltage drops. The Under Voltage Lock Out function ensures gate driver operation only to take place within specified IC supply voltages range. The fault is reported to the driver’s primary side.

3.2 Input logic – PWM signals

The Evaluation Driver Boards are dedicated to solderable IGBT modules. It is necessary to connect two separate PWM signals for EconoDUAL™ 3 IGBT modules and six separate PWM signals in case of EconoPACK™ + IGBT modules. An individual signal for each IGBT channel is necessary. Parts of the schematic for a single driver are depicted in Figure 6. The signals dedicated to High- and Low-Side need to have the correct dead time. Both Evaluation Driver Boards do not provide dead time generation. For suggested gate resistor values according to Table 5 on page 24, the recommended minimum dead time t_{TD} is 1µs. If larger gate resistors are used please refer to [1].

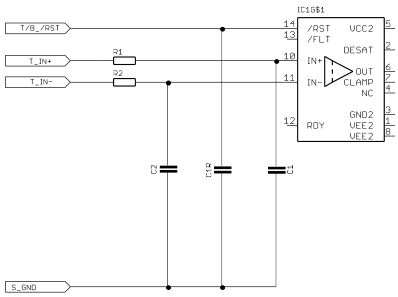


Figure 6 Schematic detail of the input circuit for a single driver.

The schematic in Figure 6 shows parts of the driver circuit with positive logic. IN+ is used as signal input whereas IN- is used as enable signal. Therefore a +5 V signal on the IN+ input pin and a GND signal on the IN- input pin is necessary to turning-on the IGBT. To operate the whole circuit with negative logic the capacitors C1 and C2 on the input pins have to be swapped. Otherwise this would cause an additional delay. IN+ will then operate as an enable signal.

3.3 Maximum switching frequency

The switching frequency of an IGBT is limited either by the maximaum output power of the driver voltage supply or by the maximum temperature of the PCB due to the power losses in the external gate resistors. These power losses in the gate resistors depend on the IGBT gate charge, gate voltage magnitude and on the switching frequency of the IGBT. Due to the power losses in the external gate resistors, heat will be generated, which leads to an increase of the PCB temperature in the neighborhood of these resistors. This temperature must not be higher than the maximum temperature of the PCB, i.e. 105°C for a standard FR4 material.

The calculation of the power losses in the gate resistors can be done by utilizing Equation 1:

$$P_{dis} = P(R_{EXT}) + P(R_{INT}) = \Delta V_{out} \cdot f_s \cdot Q_G \quad (1)$$

where:

P_{dis} = dissipated power
$P(R_{EXT})$ = dissipated power external gate resistors
$P(R_{INT})$ = dissipated power internal gate resistor
ΔV_{out} = voltage step at the driver output
f_s = switching frequency
Q_G = IGBT gate charge for the given gate voltage range

The complete gate resistor consists of the internal gate resistor together with an external gate resistor and due to that, a part of the IGBT drive power losses will be dissipated directly in the PCB, whereas the other part of the losses will be dissipated externally to the ambient air. The ratio of the losses dissipated internally $P(R_{INT})$ and externally $P(R_{EXT})$ corresponds directly to the ratio of the mentioned R_{INT} and R_{EXT} resistors. Corresponding to -8/+16V operation the datasheet value of Q_{ge} needs to be reduced by 20%.

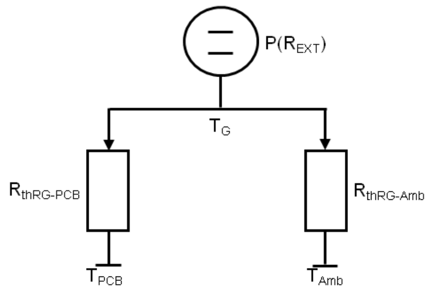
Due to the PCB temperature criteria the power dissipated in external gate resistors $P(R_{EXT})$ has to be considered for the thermal design.

Based on experimentally determined board temperatures the following thermal resistances of the Evaluation Boards have been calculated as shown in Figure 7.

Thermal resistance, gate resistors to PCB: $R_{thRG\text{-}PCB} = 45$ K/W

Thermal resistance, gate resistors to ambient: $R_{thRG\text{-}Amb} = 39$ K/W

Using these values, it is possible to determine the maximum board temperature, if the power losses of the external gate resistors, the maximum ambient temperature and the maximum PCB temperature are known:



$$T_G = T_{Amb} + \frac{R_{thRG-PCB} \cdot (T_{PCB} - T_{Amb})}{R_{thRG-Amb} + R_{thRG-PCB}} + P(R_{EXT}) \cdot \frac{R_{thRG-Amb} \cdot R_{thRG-PCB}}{R_{thRG-Amb} + R_{thRG-PCB}}$$

T_{Amb} : Ambient temperature
T_{PCB} : Board PCB temperature
T_G : PCB Temperature near the external gate resistors

Figure 7 Thermal model of the Gate resistor.

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3.4 Booster

Figure 8 shows the output stage of the driver where two complementary pairs of transistors are used to amplify the driver IC's signal. This allows driving IGBTs that need more current than the driver IC can deliver. Two NPN transistors are used for turning-on the IGBT and two PNP transistors for turning-off the IGBT.

The transistors are dimensioned to provide enough peak current to drive all 600 V and 1200 V EconoDUAL™ 3 and EconoPACK™ + modules. The peak current can be calculated according to

Formula (2):

$$I_{peak} = \frac{\Delta V_{out}}{R_{INT} + R_{EXT} + R_{Driver}} \qquad (2)$$

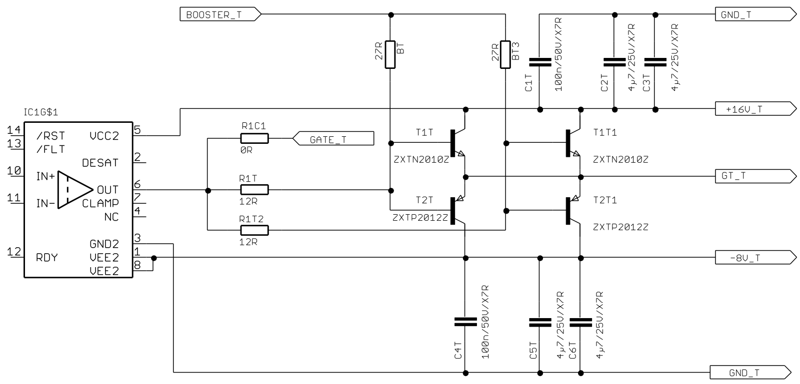

Figure 8 Driver output stage with booster

Gate resistors are connected in between booster stage and IGBT module gate connection. Suggested values are listed in table 5 on page 25 and table 7 on page 36. For some modules the value for these resistors is 0 Ω. In this case just a jumper is required. If resistors are needed, care should be taken that these resistors have a suitable rating for repetitive pulse power to avoid degradation.

3.5 Short circuit protection and active clamping

The short circuit protection of the Evaluation Driver Board basically relies on the detection of a voltage level higher than 9 V on the DESAT pin of the 1ED020I12-F driver IC and the implemented active clamp function. Thanks to this operation mode, the collector-emitter overvoltage, which is a result of the stray inductance and the collector current slope, is limited.

The overvoltage shoots during turning-off changes as a function of the stray inductance, the current and the DC voltage. Figure 9 shows the parts of the circuit needed for the desaturation function and the active clamping. The EconoDUAL™ 3 driver board is equipped with an additional diode D1 to avoid a bypass current during the turning-on sequence.

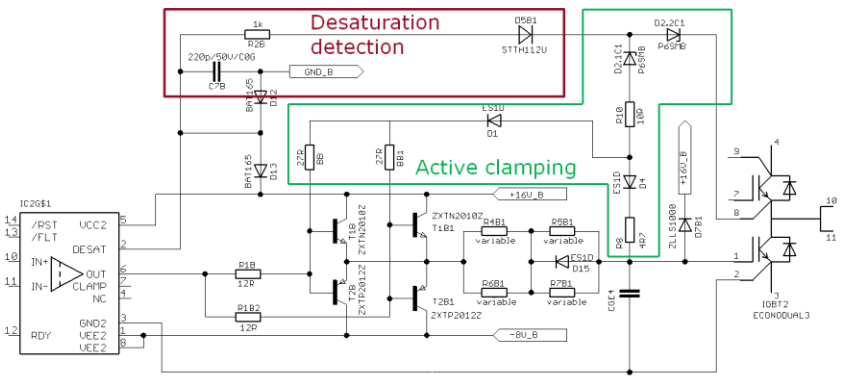

Figure 9 Desaturation detection and active clamping

Active clamping is a technique which keeps transient overvoltages below the critical limits when the IGBT turns-off. The standard approach to active clamping is to use a chain of avalanche diodes connected between the auxiliary collector and the gate of an IGBT module. When the Collector-Emitter voltage exceeds the diodes breakdown voltage the diodes current sums up with the current from the driver output. Due to the now increased gate-emitter voltage the transistor is held in an active mode and the turning-off process is prolonged. The dI_C/dt slows down which results in a limited voltage overshoot. Avalanche diodes conduct high peak currents during the time period in which the clamping is actively limiting the overvoltage.

A typical turn-off waveform under short circuit condition of a FF600R12ME4 module at room temperature without any overvoltage limiting function is shown in Figure 10a. Under short circuit condition at room temperature with active clamp function a typical waveform is shown in Figure 10b.

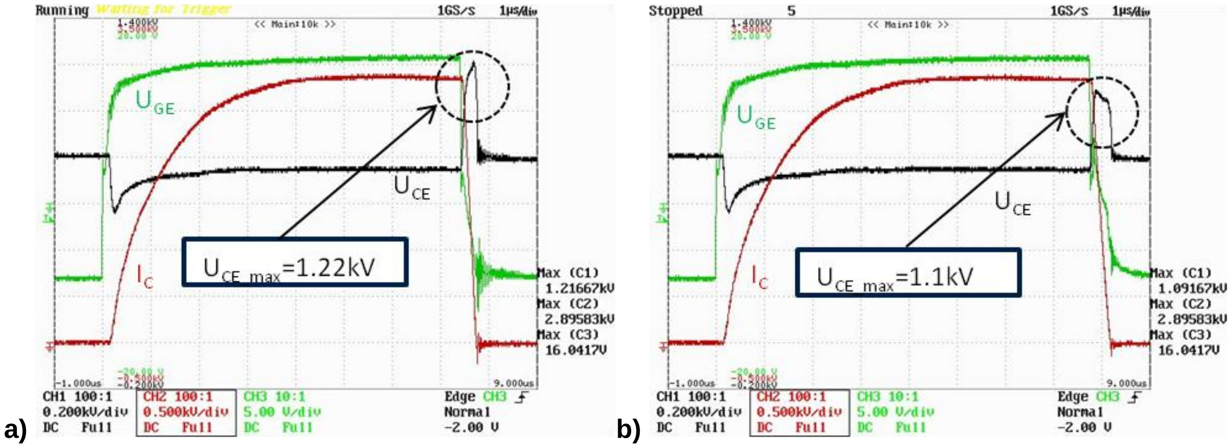

Figure 10 a) Short circuit without active clamping b) with active clamping function

3.6 Fault output

When a short circuit occurs, the voltage increase across the IGBT is detected by the desaturation protection of the 1ED020I12-F and the IGBT is turning-off. The fault is reported to the primary side of the driver as a low active signal. A red LED is turning-on to signalize the failure condition. The /FLT status remains active as long as there is no reset signal applied to the driver. The /FLT signal is active low, the according schematic can be seen in Figure 11.

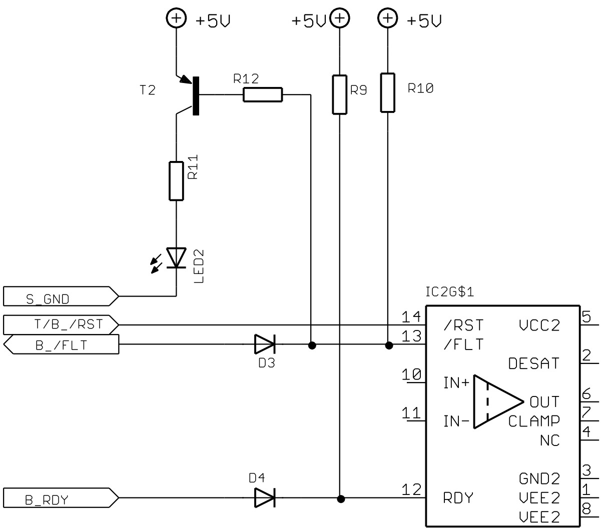

Figure 11 Fault output for a single driver

3.7 Temperature measurement

Based on the NTC built into both module types, the driver boards offer IGBT base plate temperature measurement in the range of -40 °C…150 °C. Both Evaluation Driver Boards work with a Sigma/Delta converter. Thus a digital signal is provided featuring the advantage that digital signal processing can be used without particular hardware efforts and that the subsequent error is low. However an analog signal can be produced with the use of the schematic in Figure 12.

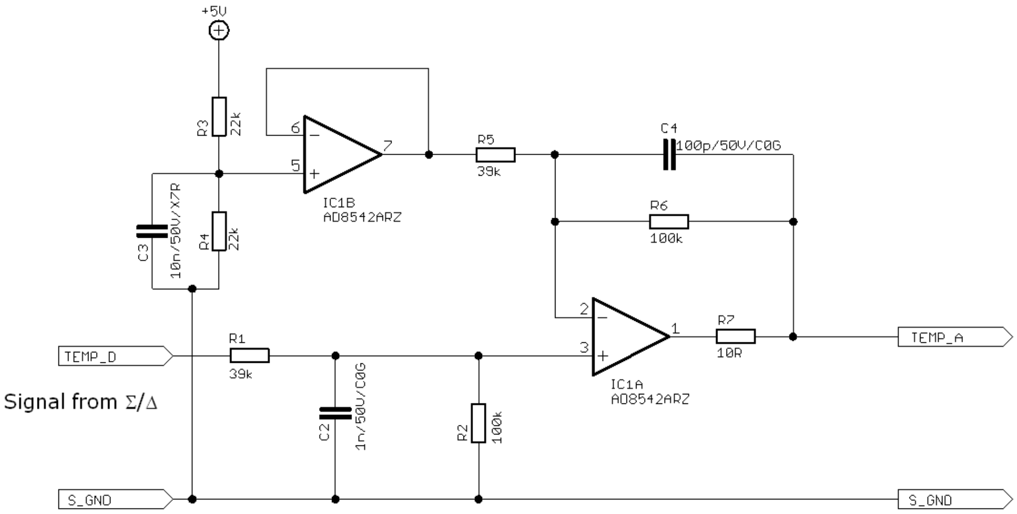

Figure 12 Schematic to convert digital Σ/Δ to analog output

Table 3 Bill of Material Σ/Δ to analog converter

Type	Qty	Value / Device	Package size imperial	Part Name	Recommended Manufacturer
Capacitor	1	100n/50V/X7R	C0603	C1	
Capacitor	1	1n/50V/C0G	C0603	C2	
Capacitor	1	10n/50V/X7R	C0603	C3	
Capacitor	1	100p/50V/C0G	C0603	C4	
Amplifier	1	AD8542ARZ	SOIC08	IC1	Analog Devices
Resistor	2	39k	R0603	R1, R5	
Resistor	2	100k	R0603	R2, R6	
Resistor	2	22k	R0603	R3, R4	
Resistor	1	10R	R0603	R7	

All electronic parts used in the design are lead-free with 260 °C soldering profile. The tolerances for resistors should be less or equal to ±1 %, for capacitors of the type C0G less or equal to ±5 % and for capacitors of the type X7R less or equal to ±10 %.

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Using the base plate temperature and a thermal model, the junction temperature can be estimated. The complexity of the thermal model needed for this purpose depends on application and heat sink conditions as well as on requirements regarding accuracy and dynamic response. In case of a broken wire the output shuts down to 0 V. The relation between output voltage and base plate temperature is shown in Figure 13.

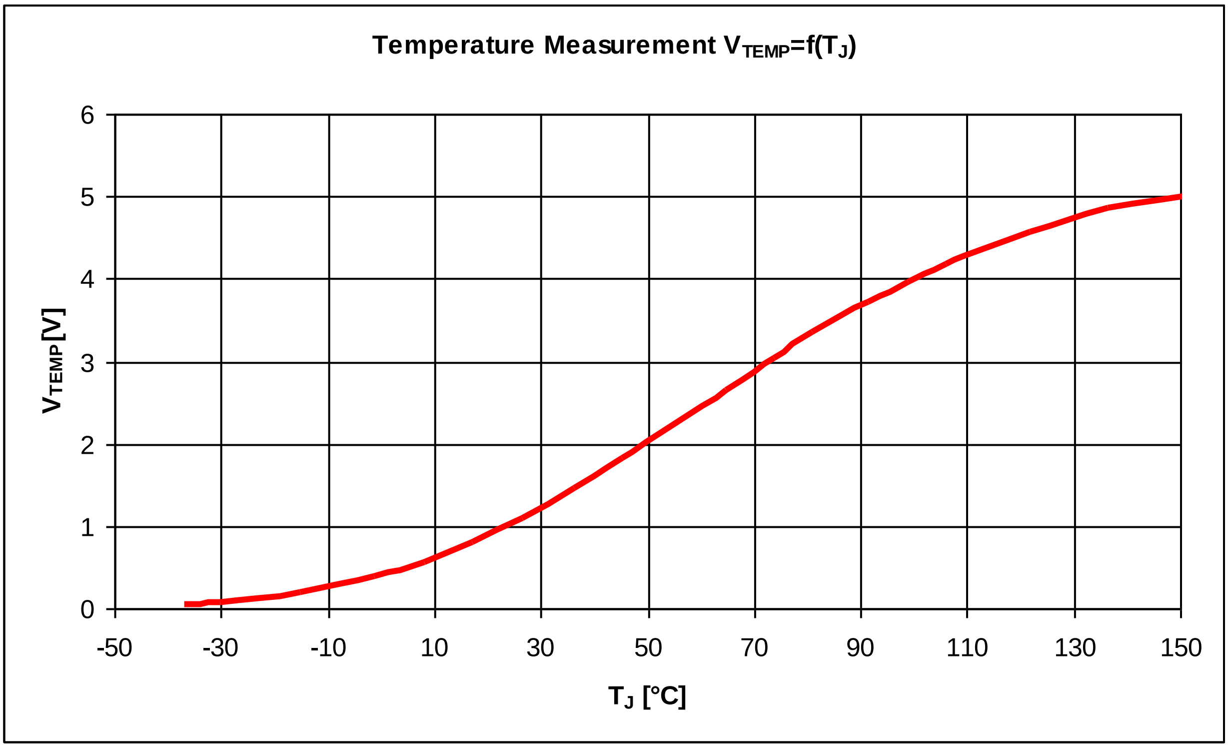

Figure 13 Characteristics of the temperature measurement

Note: This temperature measurement is not suitable for short circuit detection or short term overload but may be used to protect the module from long term overload conditions or malfunction of the cooling system.

4 Switching losses

The setup used for preparing this application note varies from the setup used to characterize the devices in three aspects

1. DC-link inductance:

   The DC-link inductance of the setup used for these test has a value of approximately 35 nH for all modules investigated here in contrast to varying values between 35 nH to 80 nH used for device characterization; see device datasheets for details. For a detailed discussion on the impact of DC-link inductance on switching losses please refer to [2].

2. Gate voltage:

   This Evaluation Board provides a gate voltage of -8 V for turning-off and 16 V for turning-on whereas characterization is done with a driver providing +/- 15 V of gate voltage.

3. Gate driver output impedance:

   According to IEC 60747-9 for characterization of an IGBT the driver used should resemble an ideal voltage source as far as possible. For the Evaluation Board a driver output stage has been chosen that considers board space as well as cost constraints. Therefore it cannot provide close to zero output impedance.

All aspects discussed above have an impact on the switching speed of the module and hence also on the switching losses. Gate resistor values have been chosen so that di/dt at turn-on is comparable to characterization conditions. Nevertheless small deviations in the turn-on losses persist.

4.1 Turn-on losses

The turn-on losses are expected to correspond to the datasheet values of the modules. As an example the measured turn-on losses for an EconoDUAL™ 3 FF450R12ME3 are shown in Figure 14.

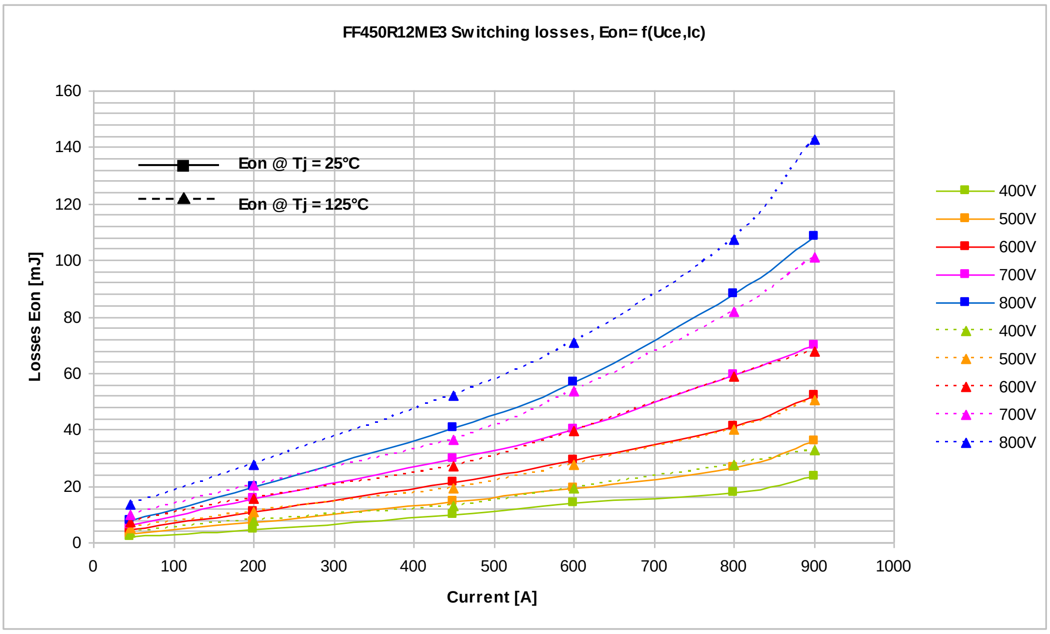

Figure 14 Turn-on losses of a FF450R12ME3 measured using the 2ED100E12-F2

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The 2ED100E12-F2 is designed to also work on IGBT4-modules as well. Figure 15 depicts the turn-on losses of a FF450R12ME4 module as an example.

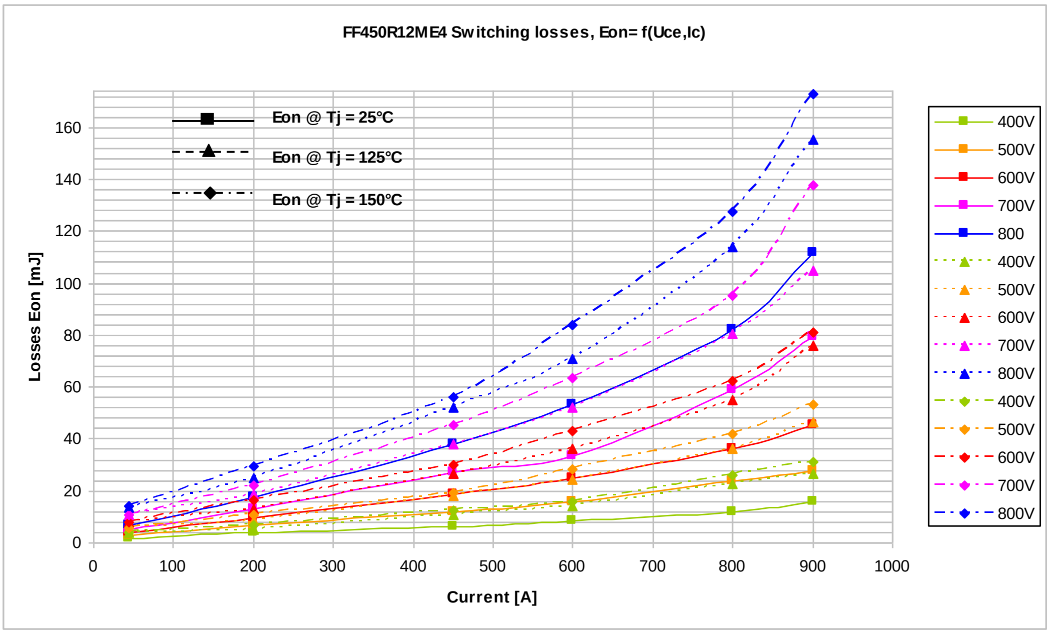
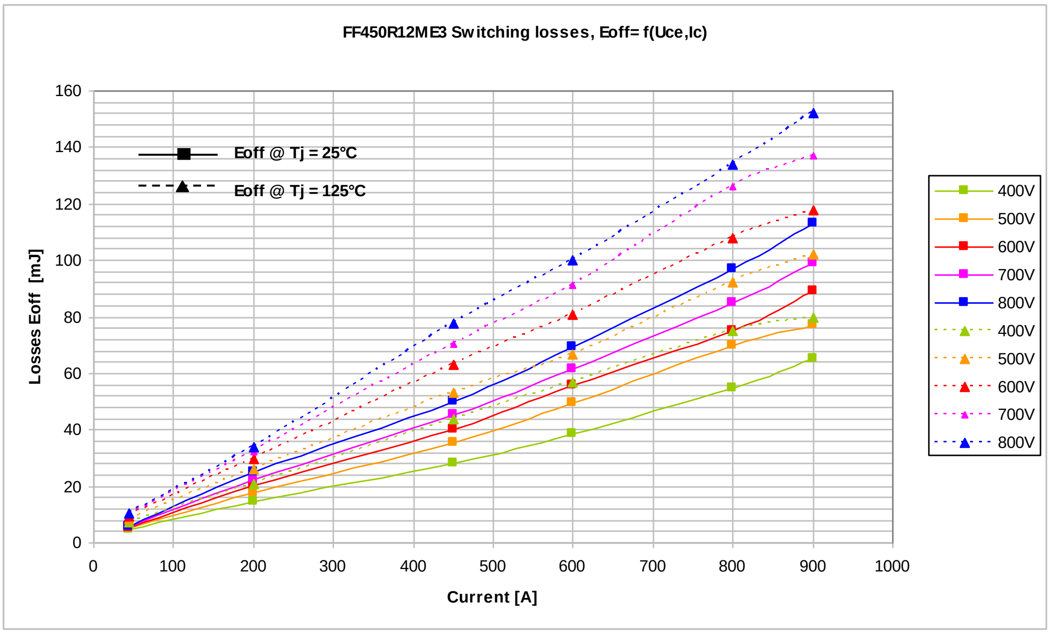


Figure 15 Turn-on losses of a FF450R12ME4 measured using the 2ED100E12-F2

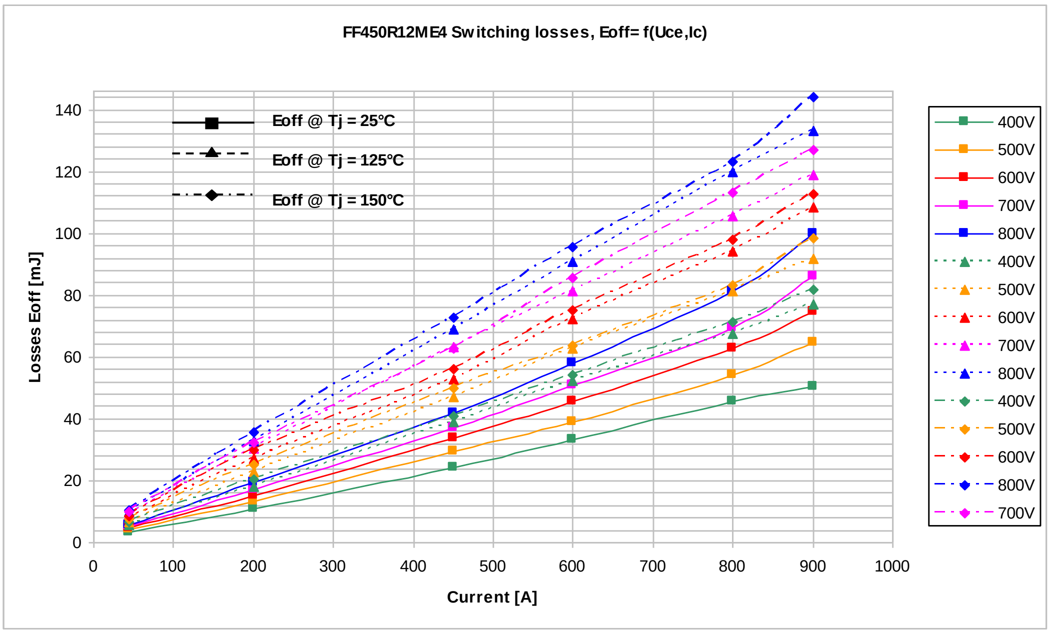
4.2 Turn-off losses

In general the turn-off losses linearly increase with the DC-Link voltage. The following Figure 16 and Figure 17 confirm these characteristics and show the dependencies of the measured turning-off losses vs. the DC-link voltage and the current.



a)

Figure 16 Turn-off losses with FF450R12ME3 module



b)

Figure 17 Turn-off losses with FF450R12ME4 module

All losses are measured according to the IEC 60747-9 standard.

5 Schematic, Layout and Bill of Material - EconoDUAL™ 3 board

Both driver boards were made by keeping the following rules for the copper thickness and the space between different layers as shown in Figure 18.

Layers:

Figure 18 Copper and isolation used

5.1 Schematic

To meet the individual customer requirements and make the Evaluation Driver Board for the EconoDUAL™ 3 module simple for development or modification, all necessary technical data like schematic, layout and components are included in this chapter.

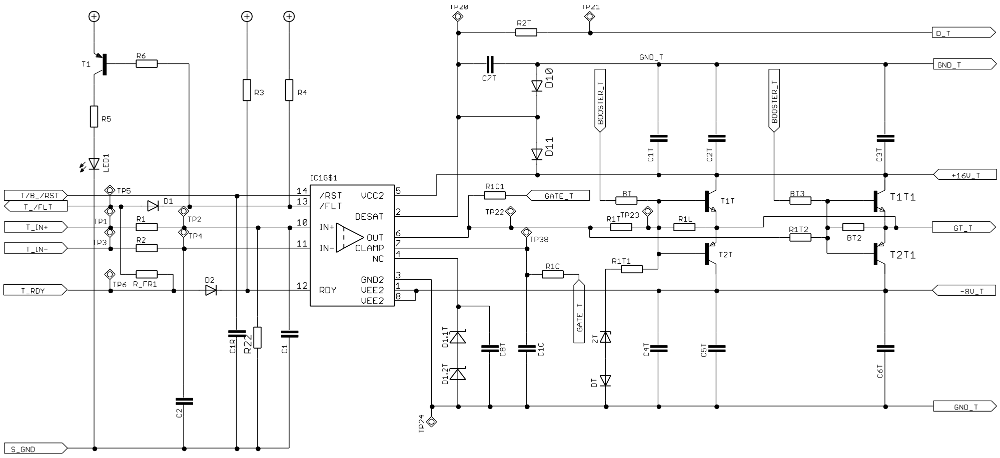


Figure 19 High side IGBT driver

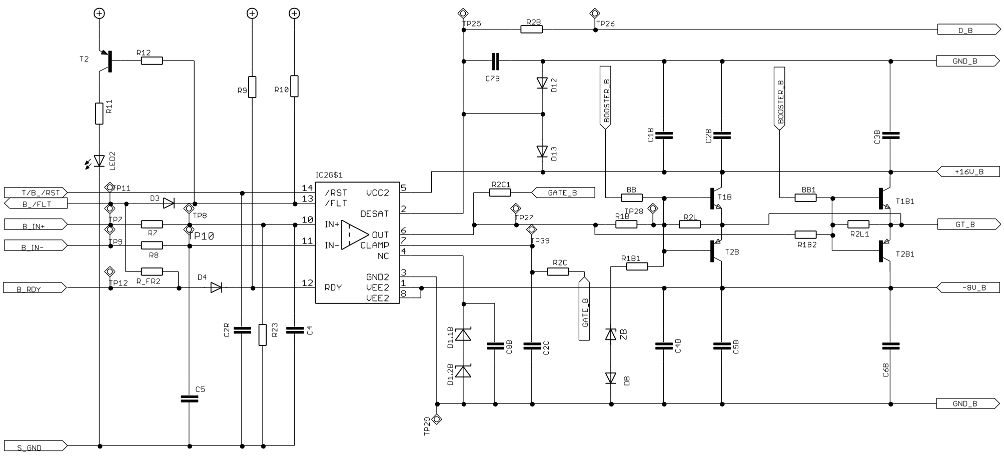


Figure 20 Low side IGBT driver

Driver Boards for EconoDUAL™3 and EconoPACK™+

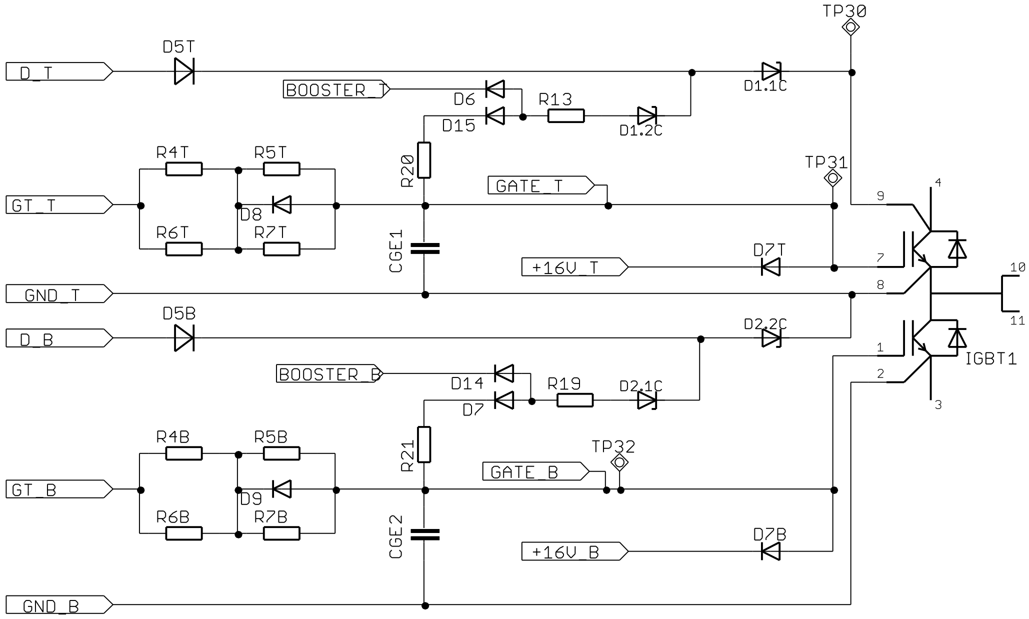


Figure 21 High and Low side IGBT driver output

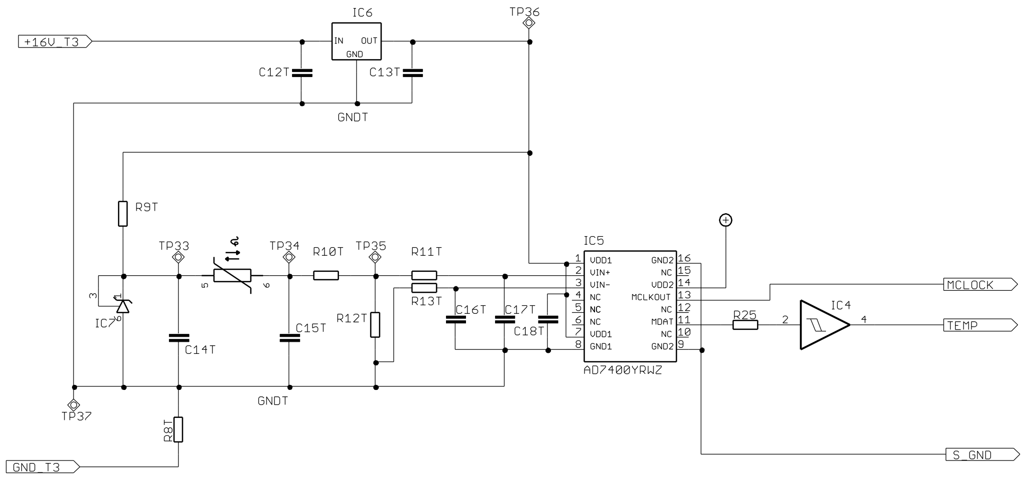


Figure 22 Temperature measurement

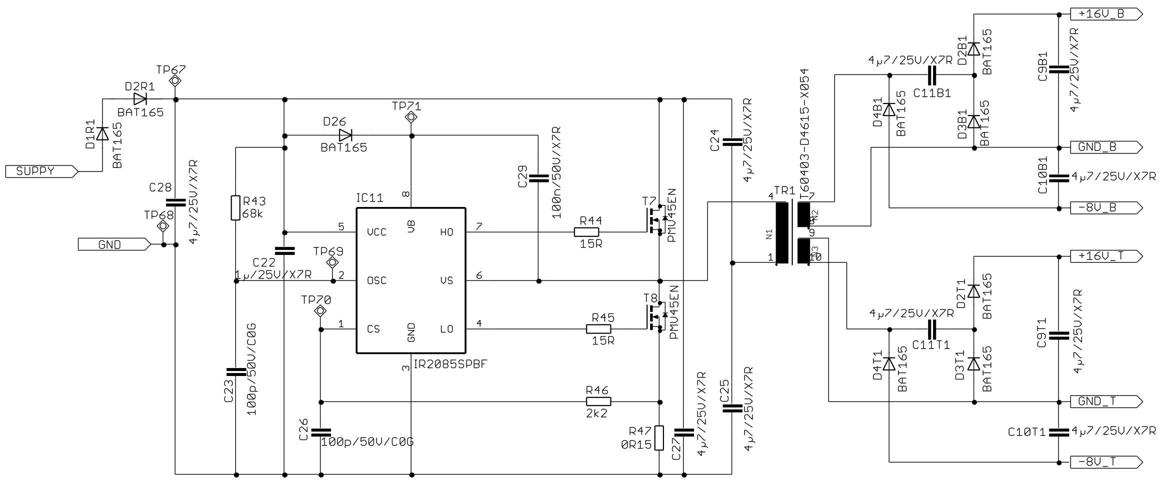


Figure 23 DC/DC converter

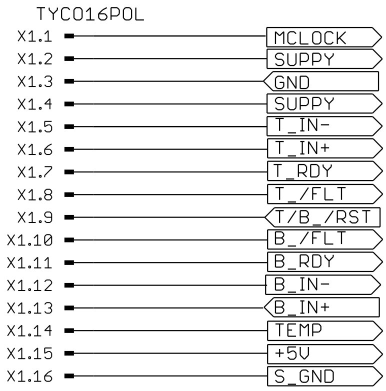


Figure 24 External connector

5.2 Assembly drawing

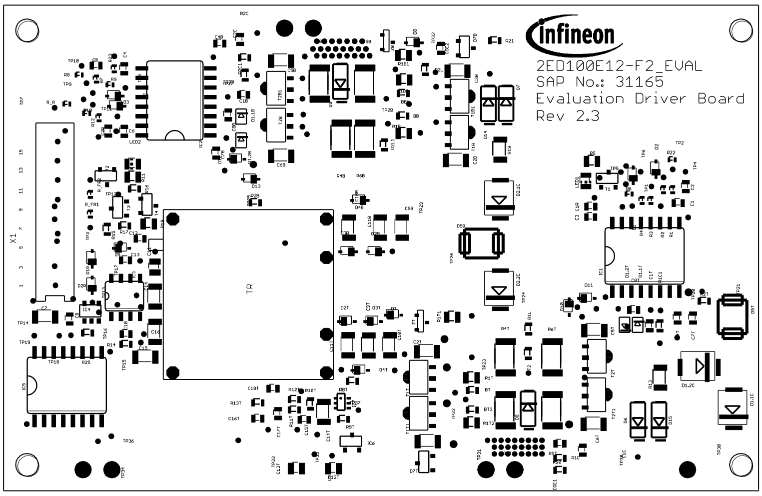
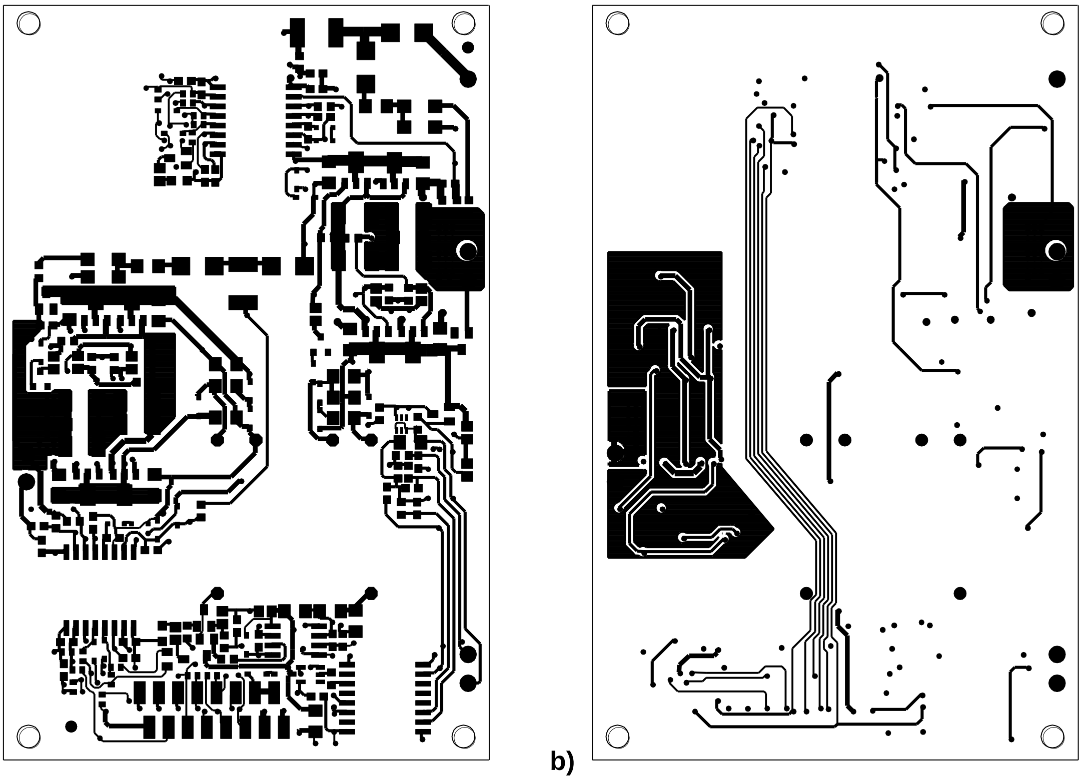


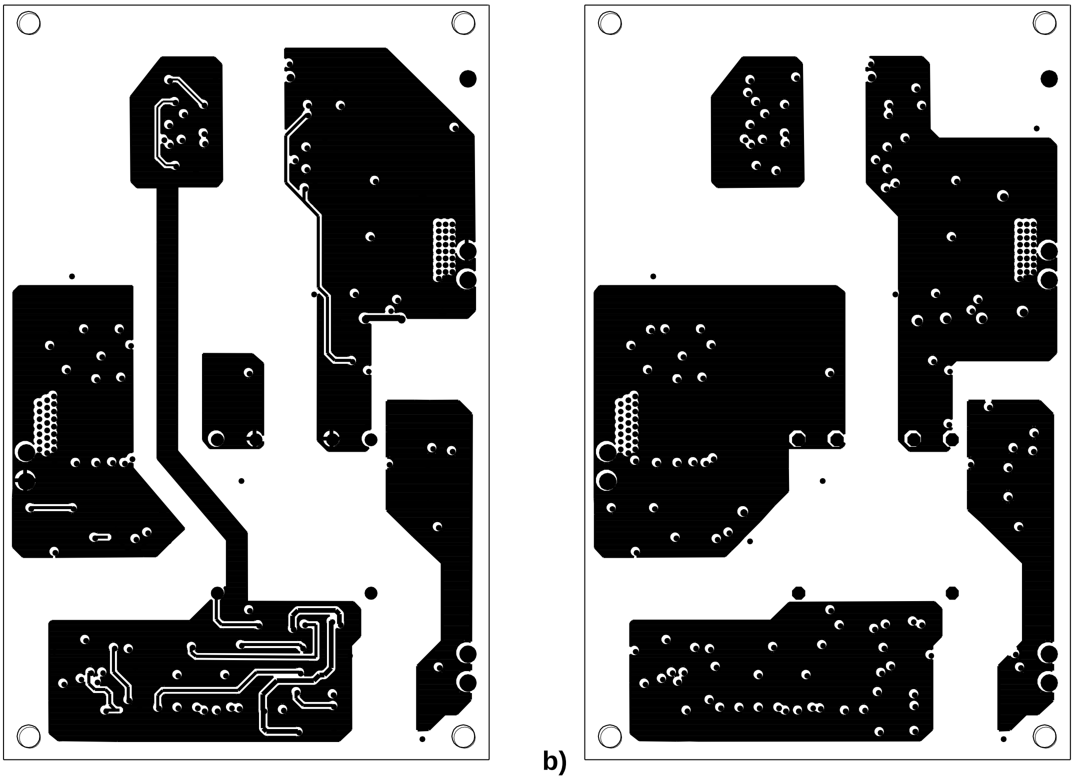
Figure 25 Assembly drawing of the EconoDUAL™ 3 driver board

5.3 Layout



a) b)

Figure 26 EconoDUAL™ 3 IGBT driver – a) Top layer and b) Layer 2



a) b)

Figure 27 EconoDUAL™ 3 IGBT driver – a) Layer 3 and b) Bottom layer

5.4 Bill of Material

The bill of material includes a part list as well as assembly notes. The external gate resistors are not assembled, a list for the resistor values is presented in chapter 6.5.

The tolerances for resistors should be less or equal to ±1 %, for capacitors of the type C0G less or equal to ±5 % and for capacitors of the type X7R less or equal to ±10 %.

Table 4 Bill of Material for EconoDUAL™ 3 Driver Board

Type	Qty	Value / Device	Package size imperial	Part Name	Recommended Manufacturer	Assem-bled	Description
Capacitor	4	100p/50V/C0G	C0603	C1,C4,C10,C12			
Capacitor	9	100n/50V/X7R	C0603	C1B, C1T, C4B, C4T, C3, C6, C8, C13, C18T			
Capacitor	2	.../50V/C0G	C0603	C1C,C2C		no	
Capacitor	2	470p/50V/X7R	C0603	C1R,C2R			
Capacitor	5	10n/50V/X7R	C0603	C2, C5, C15T, C16T, C17T			
Capacitor	19	4µ7/25V/X7R	C-EUC1206	C2B, C2T, C3B, C3T,C5B,C5T, C6B, C6T,C9B, C9T, C10B, C10T, C11B, C11T, C14T, C7, C14, C15, C16	Murata		
Capacitor	2	220p/50V/C0G	C0603	C7B,C7T			
Capacitor	2	33p/50V/C0G	C0603	C8B,C8T		no	
Capacitor	3	1µ/25V/X7R	C0805	C11,C12T,C13T			
Capacitor	2	optional/50V/C0G	C0603	CGE1,CGE2			
Connector	1	TYCO16POL	TYCO16POL	X1	TYCO	no	
Diode	2	STTH112U	SOD6	D5B,D5T			
Diode	4	ES1D	DO214AC	D6,D7,D8,D9			
Diode	2	ZLLS1000	SOT23	D7B,D7T			
Driver IC	2	1ED020I12-F	P-DSO-16	IC1,IC2	Infineon		
Half-Bridge Driver IC	1	IR2085SPBF	SO08	IC3	International Rectifier		
Schottky Diode	2	BAT165	SOD323R	DB,DT	Infineon	no	
Isolated Sigma-Delta Modulator	1	AD7400YRWZ	P-DSO-16	IC5			
LED	2		CHIP-LED0805	LED1, LED2			
Resistor	4	27R	R0603	BB, BT, BB1, BT3			
Resistor	4	10R	R0603	BT2,R1L,R2L,R2L1		no	
Resistor	4	100R	R0402	R1,R2,R7,R8			
Resistor	4	12R	R0805	R1B,R1T,R1B2,R1T2	Vishay / CRCW080512R0FKEAHP		Pulsresistor

Type	Qty	Value / Device	Package size imperial	Part Name	Recommended Manufacturer	Assem-bled	Description
Resistor	2	220R	R0805	R1B1,R1T1		no	
Resistor	5	0R	R0603	R1C,R1C1,R2C,R2C1,R8T		no	
Resistor	2	0R	R0402	R_FR1,R_FR2			
Resistor	2	1k	R0603	R2B,R2T			
Resistor	5	4k7	R0402	R3,R4,R9,R10,R_R			
Resistor	2	4R7	R0603	R20,R21			
Resistor	4	10k	R0402	R6,R12,R22,R23			
Resistor	2	39R	R0805	R5,R11			
Resistor	8	variable	R2010	R4B, R4T, R5B, R5T, R6B, R6T, R7B, R7T	TT electronics	no	Pulsresistor
Resistor	1	1k2	R0603	R9T			
Resistor	1	820R	R0603	R10T			
Resistor	3	2k2	R0603	R11T,R13T,R17			
Resistor	1	270R	R0603	R12T			
Resistor	2	10R	R1206	R13,R19			
Resistor	2	15R	R0603	R15,R16			
Resistor	1	68k	R0603	R14			
Resistor	1	0R15	R0805	R18			
Resistor	1	39k	R0603	R25			
Schmitt-Trigger	1	SN74LVC1G17DBVR	SOT23-5	IC4			
Schottky Diode	17	BAT165	SOD323R	D2B,D2R,D2T,D3, D3B,D3T,D4,D4B, D4T,D5,D10,D11, D12,D13,D1, D1R,D2	Infineon		
Shunt Regulator	1	TLV431BIDCKT	SC70-6L	IC7			
Transformer	1	T60403-D4615-X054	D4615-X054	TR	Vacuum-schmelze		
Transistor	2	BC856	SOT23	T1,T2	Infineon		
Transistor	4	ZXTN2010Z	SOT89	T1B, T1B1, T1T, T1T1	Diodes		
Transistor	4	ZXTP2012Z	SOT89	T2B, T2B1, T2T, T2T1	Diodes	1	
TrenchMOS	2	PMV45EN	SOT23	T3,T4	philips		
Unipolar TVS Diode	2	P6SMB440A	SMB	D1.1C,D2.1C	Vishay		
Unipolar TVS Diode	2	P6SMB510A	SMB	D2.1C,D2.2C	Vishay		
Zener diode	4	MM3Z5V6T1G	SOD323-R	D1.1B, D1.1T, D1.2B, D1.2T	On Semiconductor	no	
Voltage regulator	1	ZMR500FTA	SOT23	IC6			
Zener diode	2	BZX84-C11	SOT23	ZB,ZT		no	

5.5 Gate resistor list

Table 5 External gate resistors R_{Gext}, all packages are 2010 types

Module	R_{Gon} [Ω]	R_{Goff} [Ω]	R4T, R4B, R6T, R6B [Ω]	R5T, R5B, R7T, R7B [Ω]	Assembled
FF150R12ME3G	5.6	3,7	7,5	3,7	no
FF150R12MS4	5.1	3,2	6,2	4	no
FF225R12MS4	3	1,5	3	3	no
FF225R12ME3	1.5	0	0	3	no
FF225R12ME4	0	0	0	0	no
FF300R12ME3	1.1	0	0	2,2	no
FF300R12ME4	0	0	0	0	no
FF300R12MS4	1.5	0,5	1	2	No
FF450R12ME3	1	0,25	0,5	1,5	no
FF450R12ME4	1	0	0	2	no
FF600R06ME3	2.0	1,25	2,5	1,5	No
FF600R12ME4	1.5	0,6	2,5	1,5	No

6 Schematic, Layout and Bill of Material - EconoPACK™ + board

To meet the individual customer requirements and to ease the development or modification using the Evaluation Driver Board for the EconoPACK™ + module, all necessary technical data like schematic, layout and components are included in this chapter.

The tolerances for resistors should be less or equal to ±1 %, for capacitors of the type C0G less or equal to ±5 % and for capacitors of the type X7R less or equal to ±10 %.

6.1 Schematic

For the EconoDUAL™ 3 and EconoPACK™ + evaluation boards, the high and low side driver schematics including their power supplies are similar for all half bridges. Therefore it is sufficient to depict only the schematic of the EconoDUAL™ 3.

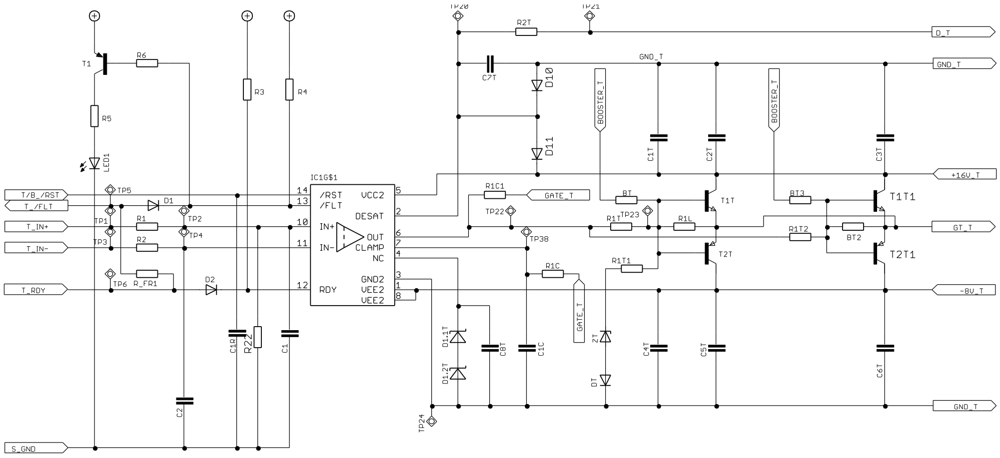


Figure 28 High side IGBT driver

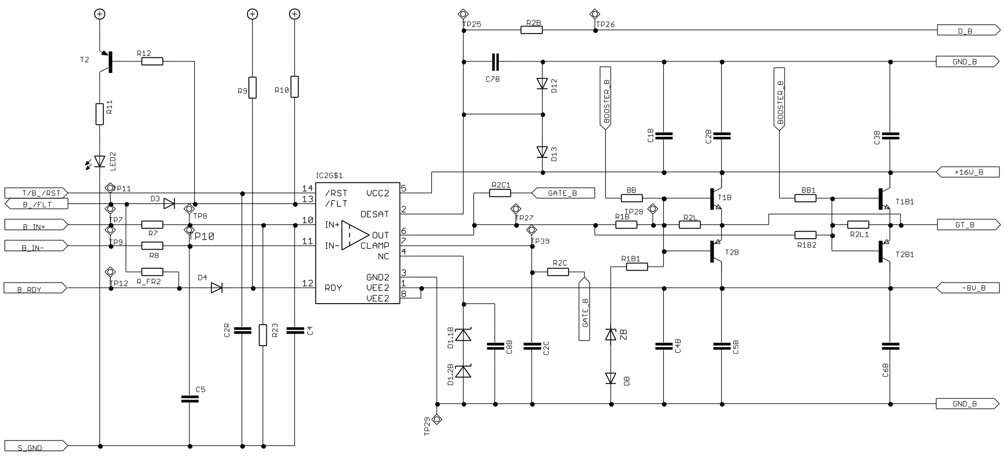


Figure 29 Low side IGBT driver

Driver Boards for EconoDUAL™ 3 and EconoPACK™ +

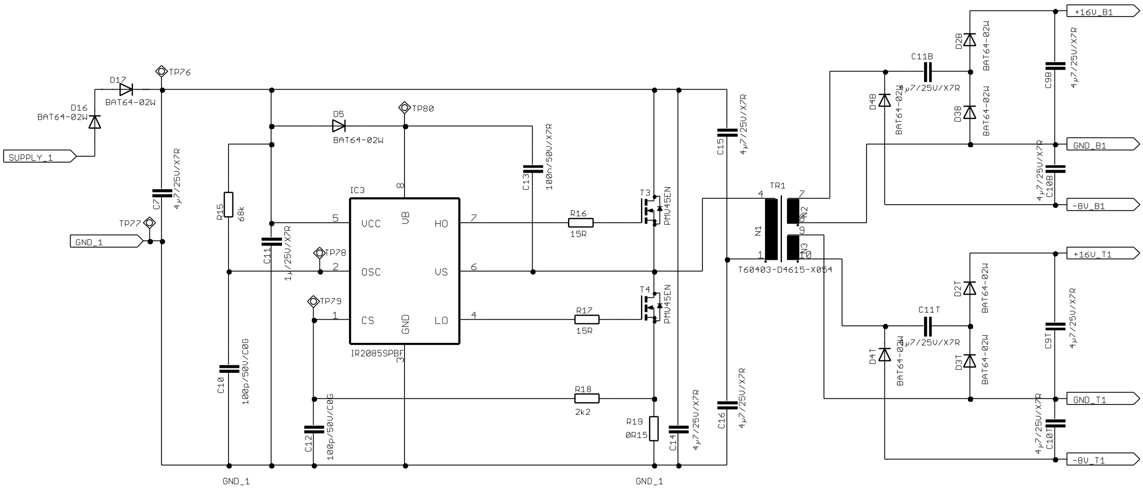


Figure 30 DC/DC converter

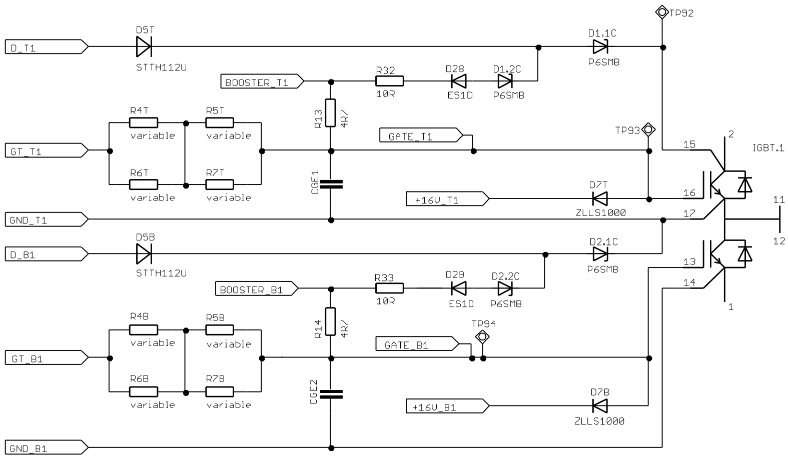


Figure 31 High and Low side IGBT driver output

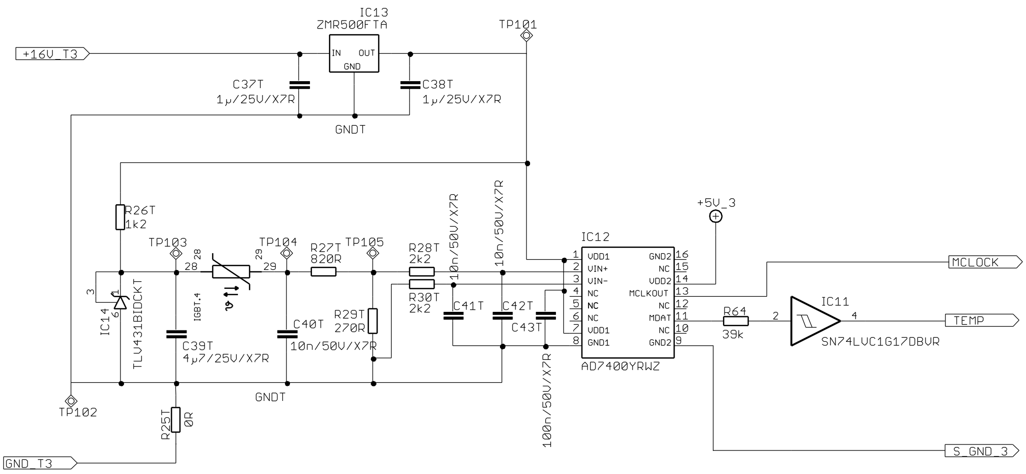


Figure 32 Temperature measurement

Driver Boards for EconoDUAL™ 3 and EconoPACK™ +

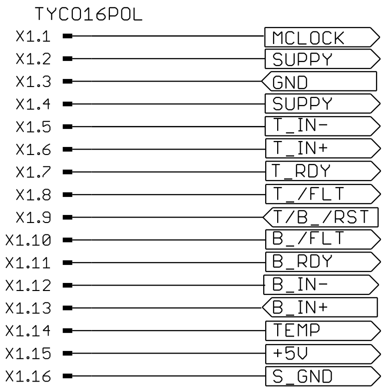


Figure 33 Connector

6.2 Assembly drawing

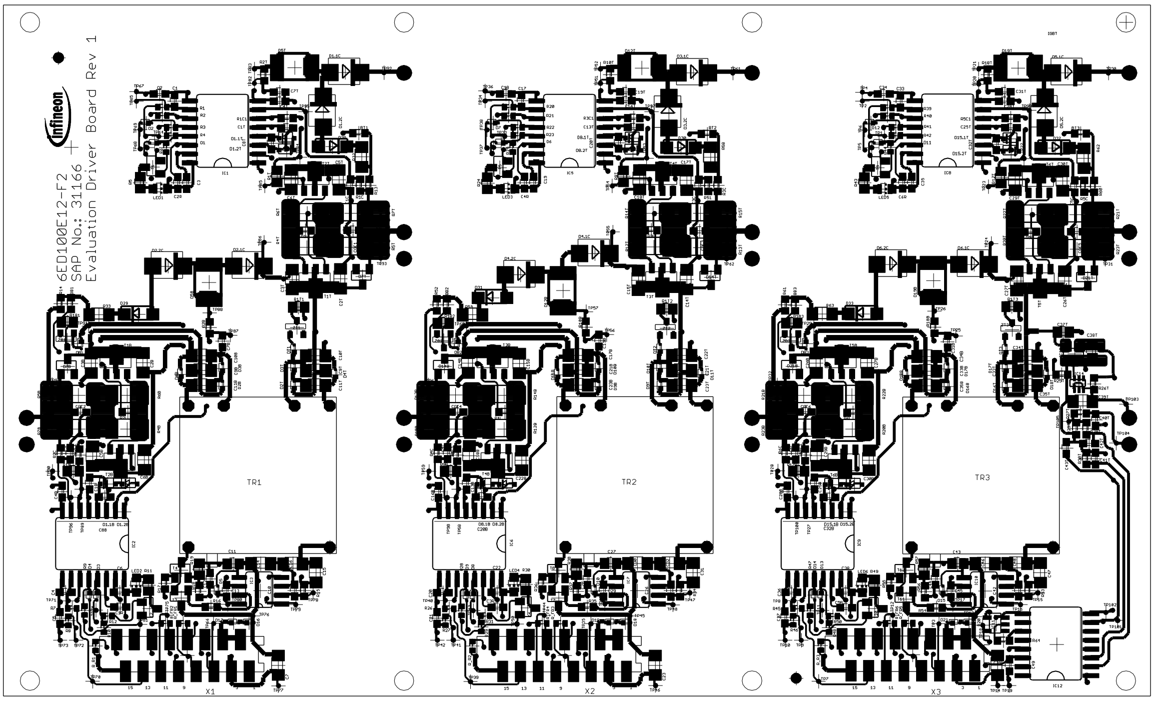


Figure 34 Assembly drawing of the EconoPACK™ + driver board

For detailed information use the zoom function of your PDF viewer.

6.3 Layout

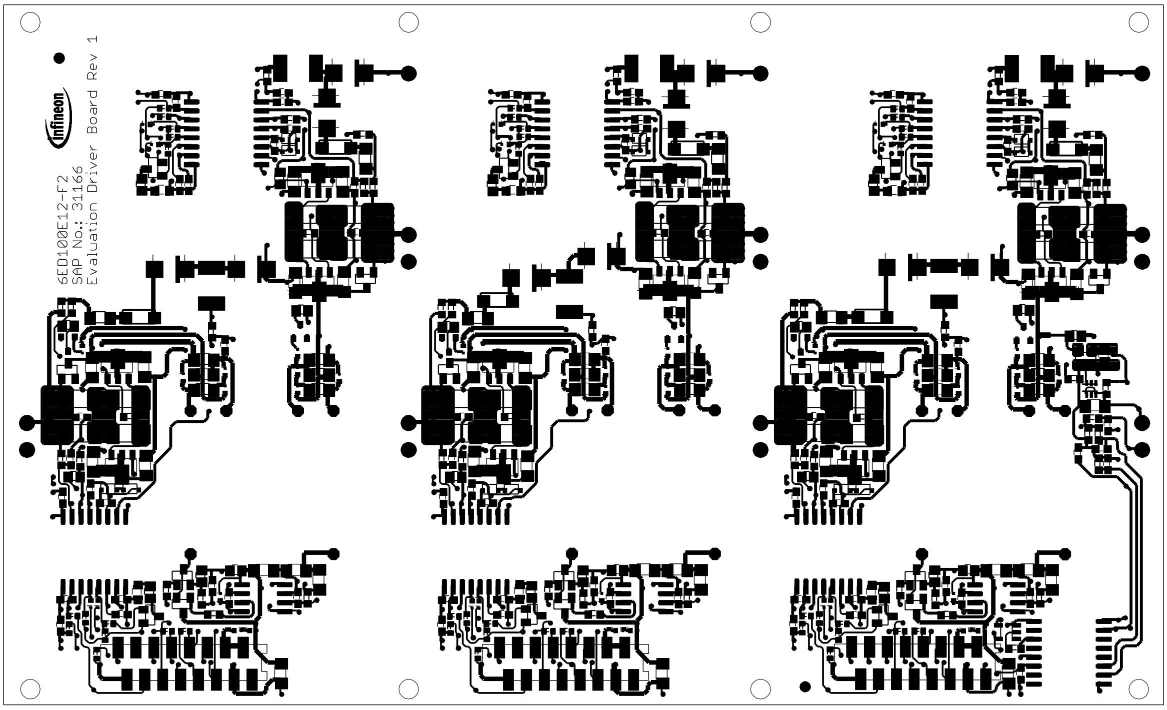


Figure 35 EconoPACK™ + IGBT driver – Top layer

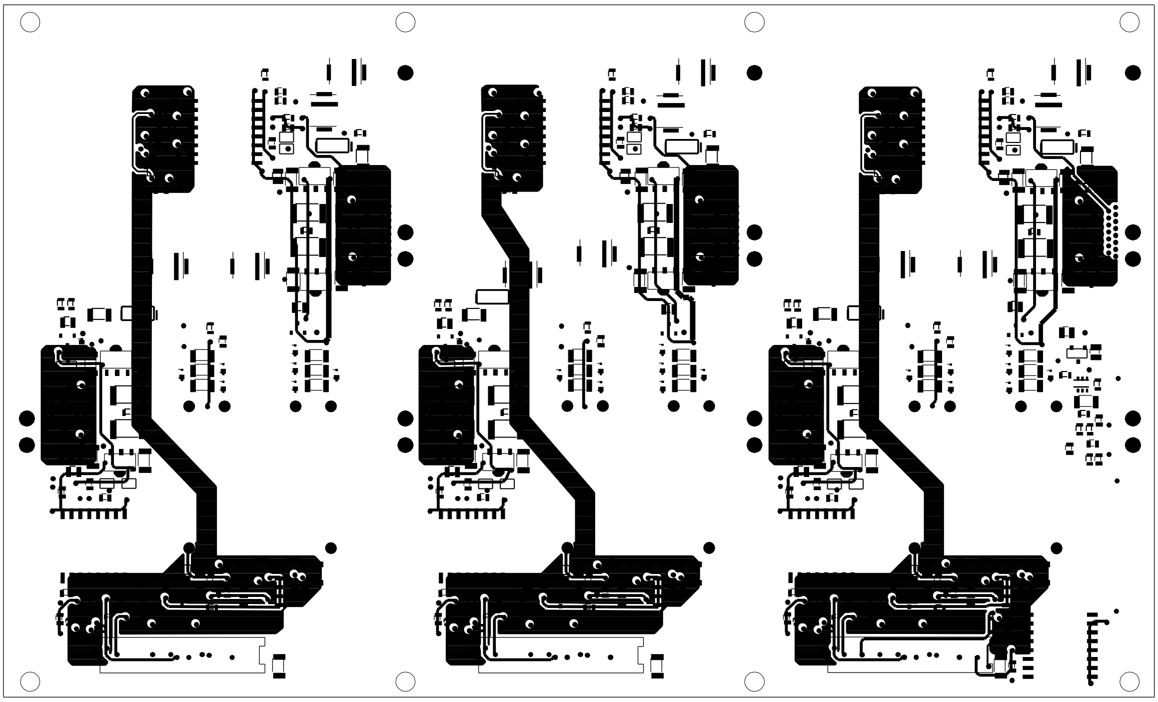


Figure 36 EconoPACK™ + IGBT driver – Layer 2

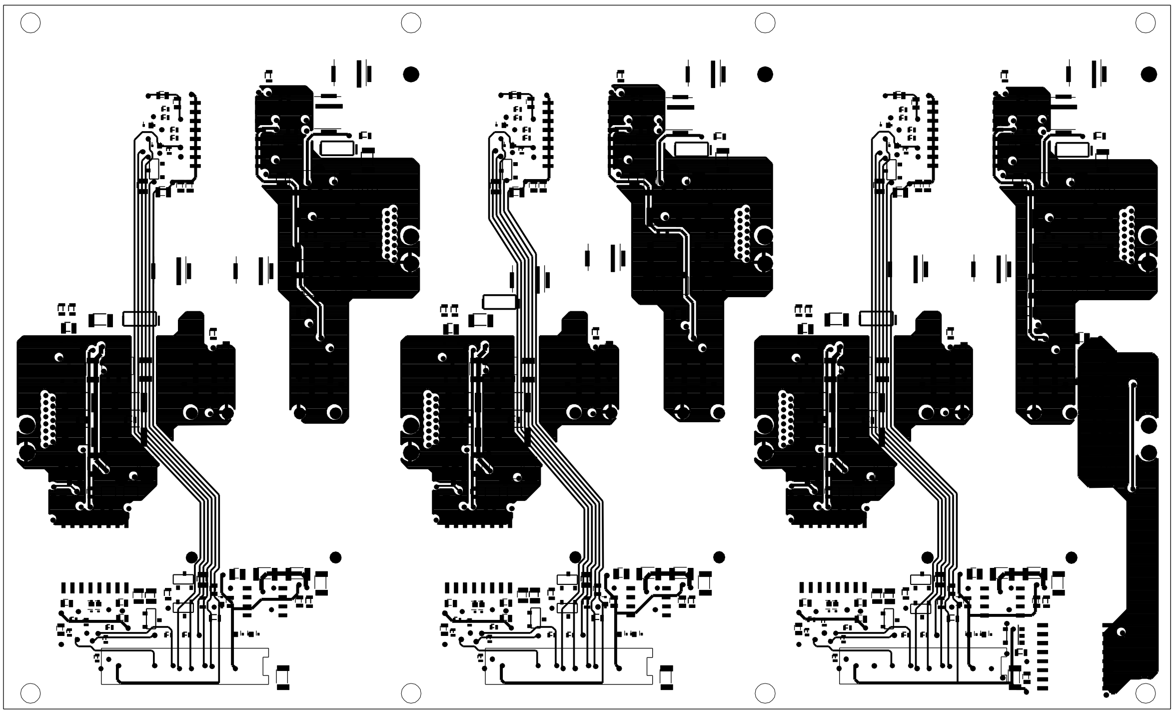


Figure 37 EconoPACK™ + IGBT driver – Layer 3

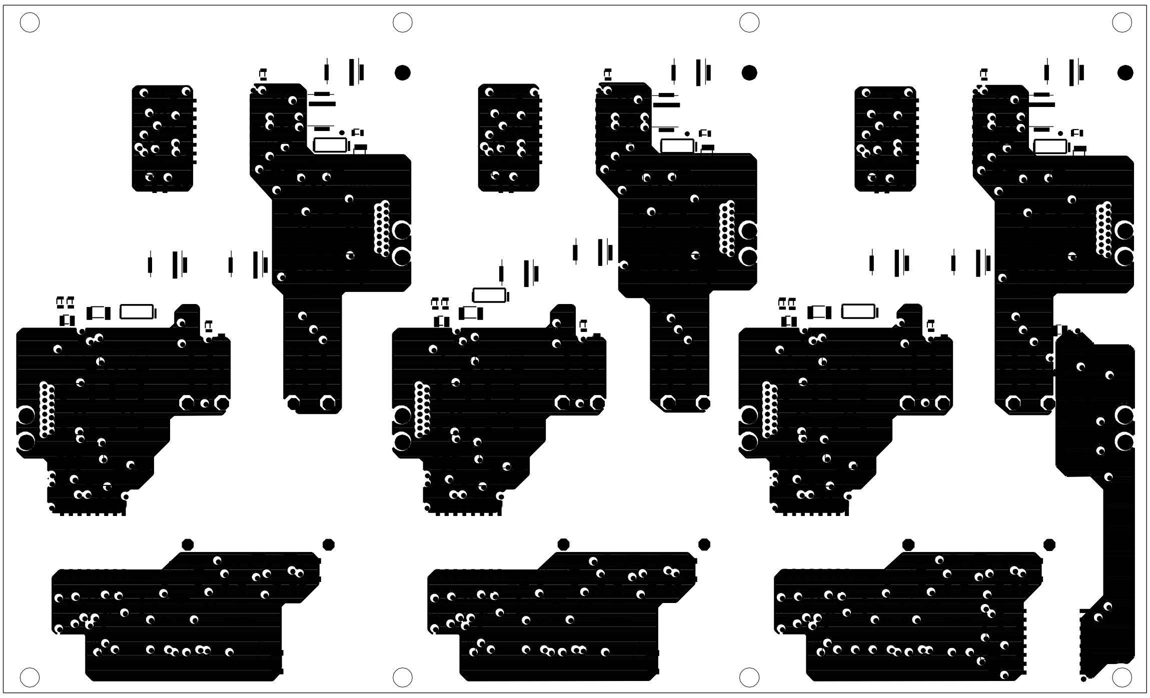


Figure 38 EconoPACK™ + IGBT driver – Bottom Layer 4

6.4 Bill of material

The bill of material includes a part list as well as assembly notes. The external gate resistors are not assembled, a list for the resistor values is presented in Table 7 on page 33.

The tolerances for resistors should be less or equal to ±1 %, for capacitors of the type C0G less or equal to ±5 % and for capacitors of the type X7R less or equal to ±10 %.

Table 6 Bill of Material for EconoPACK™ + Driver Board

Type	Qty	Value / Device	Package size imperal	Part Name	Recommended Manufacturer	Assembled
Capacitor	6	.../50V/C0G	C0603	C1C, C2C, C3C, C4C, C5C, C6C		no
Capacitor	9	10n/50V/X7R	C0603	C2, C5, C18, C21, C34, C37, C40T, C41T, C42T		
Capacitor	6	33p/50V/C0G	C0603	C8B, C8T, C20B, C20T, C32B, C32T		no
Capacitor	23	100n/50V/X7R	C0603	C1B, C1T, C3, C4B, C4T, C6, C13, C13B, C13T, C16B, C16T, C19, C22, C25B, C25T, C28B, C28T, C29, C35, C38, C43T, C45, C49		
Capacitor	12	100p/50V/C0G	C0603	C1, C4, C10, C12, C17, C20, C26, C28, C33, C36, C42, C44		
Capacitor	6	220p/50V/C0G	C0603	C7B, C7T, C19B, C19T, C31B, C31T		
Capacitor	6	470p/50V/X7R	C0603	C1R, C2R, C3R, C4R, C5R, C6R		
Capacitor	6	optional/50V/C0G	C0603	CGE1, CGE2, CGE3, CGE4, CGE5, CGE6		no
Capacitor	5	1µ/25V/X7R	C0805	C11, C27, C37T, C38T, C43		
Capacitor	55	4µ7/25V/X7R	C1206	C2B, C2T, C3B, C3T, C5B, C5T, C6B, C6T, C7, C9B, C9T, C10B, C10T, C11B, C11T, C14, C14B, C14T, C15, C15B, C15T, C16, C17B, C17T, C18B, C18T, C21B, C21T, C22B, C22T, C23, C23B, C23T, C26B, C26T, C27B, C27T, C29B, C29T, C30, C30B, C30T, C31, C32, C33B, C33T, C34B, C34T, C35B, C35T, C39, C39T, C46, C47, C48	Murata	
Transformer	3	T60403-D4615-X054	D4615-X054	TR1, TR2, TR3	Vacuum-schmelze	

Type	Qty	Value / Device	Package size imperal	Part Name	Recommended Manufacturer	Assembled
LED	6	LEDCHIP-	LED0805	LED1, LED2, LED3, LED4, LED5, LED6		
Schottky Diodes	39	BAT64-02W	SCD80	D1, D2, D2B, D2T, D3, D3B, D3T, D4, D4B, D4T, D5, D6, D7, D8, D9, D9B, D9T, D10, D10B, D10T, D11, D11B, D11T, D12, D13, D14, D15, D16, D16B, D16T, D17, D17B, D17T, D18, D18B, D18T, D19, D20, D21	Infineon	
Rectifier Diode	6	ES1D	DO214AC	D28, D29, D30, D31, D32, D33		
Diode	6	BAT64-02W	SCD80	DB1, DB2, DB3, DT1, DT2, DT3	Infineon	no
Unipolar TVS Diode	6	P6SMB/440V	SMB	D1.1C, D2.1C, D3.1C, D4.1C, D5.1C, D6.1C,		
Unipolar TVS Diode	6	P6SMB/510V	SMB	D1.2C, D2.2C, D3.2C, D4.2C, D5.2C, D6.2C		
Diode	6	STTA112U	SOD6	D5B, D5T, D12B, D12T, D19B, D19T		
Zener Diode	12	MM3Z5V6T1G	SOD323-R	D1.1B, D1.1T, D1.2B, D1.2T, D8.1B, D8.1T, D8.2B, D8.2T, D15.1B, D15.1T, D15.2B, D15.2T	On Semiconductor	no
Zener Diode	6	BZX84-C11	SOT23	ZB1, ZB2, ZB3, ZT1, ZT2, ZT3		no
Diode	6	ZLLS1000	SOT23	D7B, D7T, D14B, D14T, D21B, D21T	Diodes	
Driver IC	6	1ED020I12-F	P-DSO-16	IC1, IC2, IC5, IC6, IC8, IC9		
Half-Bridge Driver	3	IR2085SPBF	SO08	IC3, IC7, IC10	International Rectifier	
Schmitt-Trigger	1	SN74LVC1G17DBVR	SOT23-5	IC11		
Isolated Sigma-Delta Modulator	1	AD7400YRWZ	P-DSO-16	IC12	Analog Devices	
Voltage regulator	1	ZMR500FTA	SOT23	IC13		
Shunt Regulator	1	TLV431BIDCKT	SC70-6L	IC14		

Driver Boards for EconoDUAL^{TM}3 and EconoPACK^{TM} +

Type	Qty	Value / Device	Package size imperal	Part Name	Recommended Manufacturer	Assembled
Resistor	6	0R	R0402	R_FR1, R_FR2, R_FR3, R_FR4, R_FR5, R_FR6		
Resistor	15	4k7	R0402	R_R1, R_R2, R_R3, R3, R4, R9, R10, R22, R23, R28, R29, R41, R42, R47, R48		
Resistor	6	10k	R0402	R6, R12, R25, R31, R44, R50		
Resistor	12	100R	R0402	R1, R2, R7, R8, R20, R21, R26, R27, R39, R40, R45, R46		
Resistor	6	0R	R0603	R1C1, R2C1, R3C1, R4C1, R5C1, R6C1		no
Resistor	6	27R	R0603	BB1, BB2, BB3, BT1, BT2, BT3		
Resistor	6	1k	R0603	R2B, R2T, R10B, R10T, R18B, R18T		
Resistor	1	1k2	R0603	R26T		
Resistor	5	2k2	R0603	R18, R28T, R30T, R37, R56		
Resistor	6	4R7	R0603	R13, R14, R51, R52, R60, R61		
Resistor	6	10R	R0603	R1L, R2L, R3L, R4L, R5L, R6L		no
Resistor	6	15R	R0603	R16, R17, R35, R36, R54, R55		
Resistor	1	39k	R0603	R64		
Resistor	3	68k	R0603	R15, R34, R53		
Resistor	1	270R	R0603	R29T		
Resistor	1	820R	R0603	R27T		
Resistor	3	0R15	R0805	R19, R38, R57		
Resistor	7	0R	R0603	R1C, R2C, R3C, R4C, R5C, R6C, R25T		no
Resistor	6	12R	R0805	R1B, R1T, R9B, R9T, R17B, R17T		
Resistor	6	39R	R0805	R5, R11, R24, R30, R43, R49		
Resistor	6	220R	R0805	R1B1, R1B2, R1B3, R1T1, R1T2, R1T3		no
Resistor	6	10R	R1206	R32, R33, R58, R59, R62, R63		
Resistor	24	variable	R2010	R4B, R4T, R5B, R5T, R6B, R6T, R7B, R7T, R12B, R12T, R13B, R13T, R14B, R14T, R15B, R15T, R20B, R20T, R21B, R21T, R22B, R22T, R23B, R23T	TT electronics	no: See Table 8

Type	Qty	Value / Device	Package size imperal	Part Name	Recommended Manufacturer	Assembled
Transistor	6	BC856	SOT23	T1, T2, T5, T6, T9, T10		
TrenchMOS	6	PMV45EN	SOT23	T3, T4, T7, T8, T11, T12	Philips	
Transistor	6	ZXTN2010Z	SOT89	T1B, T1T, T3B, T3T, T5B, T5T	Diodes	
Transistor	6	ZXTP2012Z	SOT89	T2B, T2T, T4B, T4T, T6B, T6T	Diodes	
Connector	3	8-188275-6	16POL	X1, X2, X3	Tyco	

6.5 Gate resistor list

Table 7 External gate resistors R_{Gext} are listed below, all packages are 2010 types

Module	R_{Gext} [Ω]	R4T, R4B, R6T, R6B R12T, R12B, R14T, R14B R20T, R20B, R22T, R22B [Ω]	R5T, R5B, R7T, R7B R13T, R13B, R15T, R15B R21T, R21B, R23T, R23B [Ω]
FS150R12KE3G	8.2	5.6	5.6
FS225R12KE3	3.3	1.5	1.5
FS300R12KE3	2.4	1.1	1.1
FS450R12KE3	1.6	1	1

7 How to order Evaluation Driver Boards

Every Evaluation Driver Board has its own IFX order number and can be ordered via your Infineon Sales Partner.

Information can also be found at the Infineons Web Page: www.infineon.com

CAD-data for the board described here are available on request. The use of this data is subjected to the disclaimer given in this AN. Please contact: WAR-IGBT-Application@infineon.com

IFX order number for EconoDUAL™ 3 Evaluation Driver Board: 31165

IFX order number for EconoPACK™ + Evaluation driver board: 31166

8 References

[1] Infineon Technologies AG, AN2007-04, ‘How to calculate and to minimize the dead time requirement for IGBTs properly’, V1.0, May 2007, www.infineon.com

[2] Bäßler, M., Ciliox A., Kanschat P., ‘On the loss – softness trade-off: Are different chip versions needed for softness improvement?’ PCIM Europe 2009, Nuremberg, May 2009