Application Note, V1.0, Feb. 2008

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2ED100E12-F2 6ED100E12-F2

Evaluation Driver Board for EconoDUAL™ and EconoPACK™+ modules

Never stop thinking

Edition 2008-02-26

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Part number explanation:

2ED 100 E12 - F2

- **F2 – Functional isolation**
- **E12 – Suitable up to 1200 V IGBTs**
- **100 – 10 A output driver**
- **2ED – 2 channel driver**

1 Introduction

The Evaluation Driver Board 2ED100E12-F2 for EconoDUAL™ 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 chapter 2.2 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 leadfree 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 Withdraw (PWD) as regular products.

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SAP number for EconoDUAL™ Evaluation Driver Board: 31165

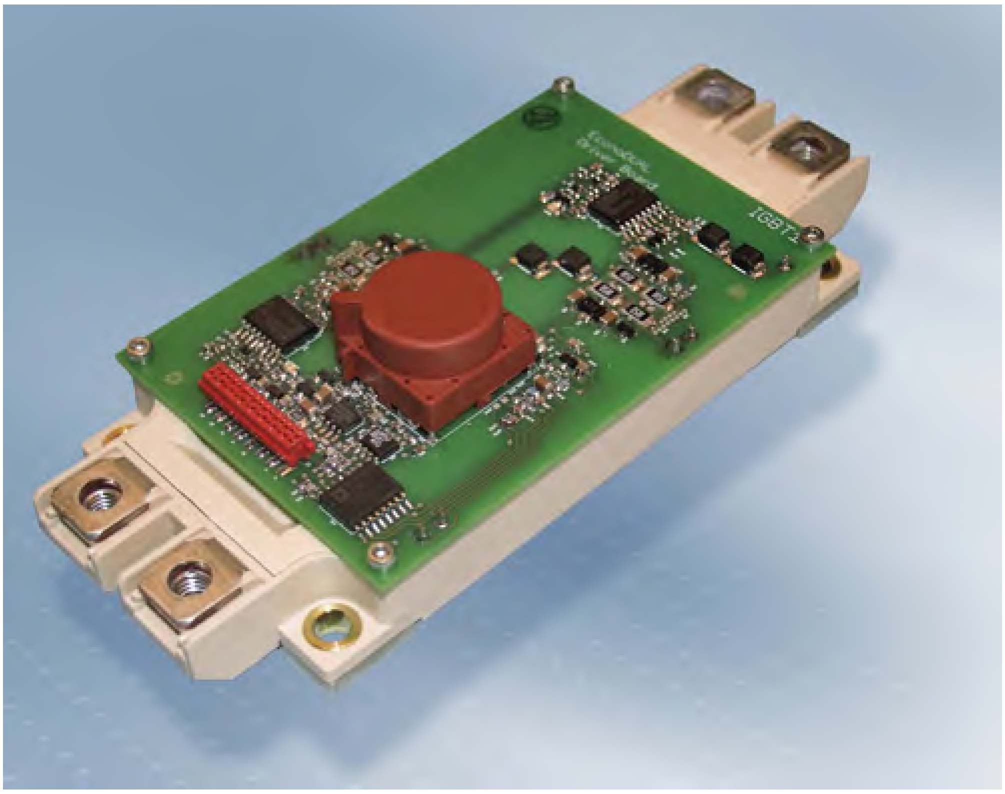

Figure 1 The 2ED100E12-F2 Evaluation Driver Board mounted on the top of the EconoDUAL™ module

The following picture shows the driver board mounted on an EconoPACK™+ module.

SAP number for EconoPACK™+ Evaluation Driver Board: 31166

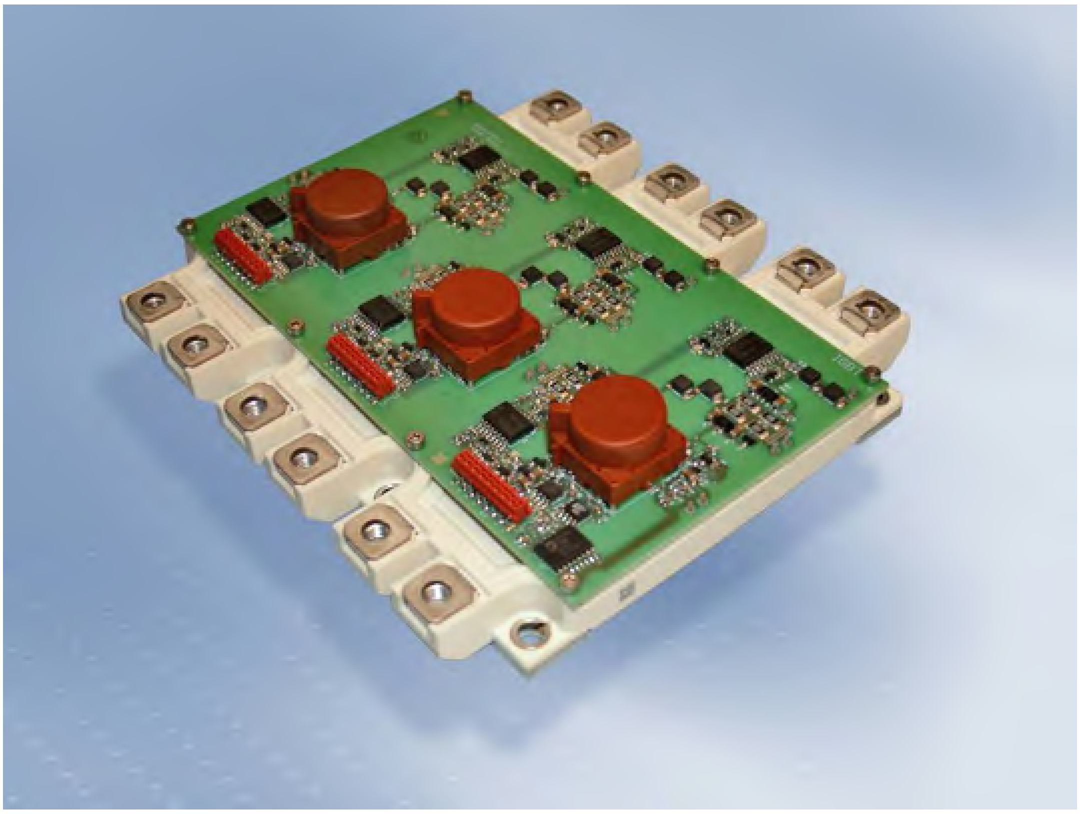

Figure 2 The 6ED100E12-F2 Evaluation Driver Board mounted on the top of the EconoPACK™+ module

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 offers the following features:

- Dual channel IGBT driver in 2ED100E12-F2 version
- Six channel IGBT driver in 6ED100E12-F2 version
- Electrically and mechanically suitable for 600 V and 1200 V EconoDUAL™ 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 fulfil the requirements of IEC61800-5-1, pollution degree 2, overvoltage category III

2.2 Key data

All values given in the table bellow 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 Top and Bottom IGBT (active high)	0 / +5	V
V_{FAULT} – /FAULT detection output (active low)	0 / +5	V
I_{FAULT} – max. /FAULT detection output load current	10	mA
V_{RST} – /RST input (active low)	0 / +5	V
I_{DC} – primary DC/DC current drawn (idle mode) per leg	40	mA
I_{CC} – primary current drawn for logic devices per leg	25	mA
V_{out} – drive voltage level for Top and Bottom channel	+16 / -8	V
I_G – max. peak output current	±10	A
$P_{DC/DC}$ – max. DC/DC output power (Top channel + Bottom channel) per leg	3	W
f_S – max. PWM signal frequency for Top and Bottom channel[1)]	100	kHz
t_{PDELAY} – propagation delay time	200	ns
t_a – Two-level turn-off time	n.a.	ns
t_{PDISTO} – input to output propagation distortion	15	ns
t_{MININ} – min. pulse suppression for turn-on and turn-off[2)]	n.a.	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)[3)]	-40…+85	°C
T_{sto} – storage temperature (design target)	-40…+85	°C
$U_{is,eff}$ – Isolation voltage[4)] (Transformer Vacuumschmelze)	500	V_{AC}
V_{IORM} – Maximum Repetitive Insulation Voltage[5)] (1ED020I12-F Driver IC)	1140	V_{peak}
V_{IORM} – Max. working insulation voltage[6)] (AD7400 Sigma-Delta Converter)	891	V_{peak}

[1)] The maximum switching frequency for every EconoDUAL™ 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)] Minimum value t_{MININ} given in 1ED020I12-F IGBT driver datasheet

[3)] Maximum ambient temperature strictly depends on load and cooling conditions. For detailed description see chapter 2.3

[4)] Values defined in datasheets: T60403-D4615-X054 (date: 21.03.2000),

[5)] 1ED020I12-F (Target datasheet, Version 1.0, November 2007)

[6)] AD7400 (9/07 – Revision A to Revision B)

2.3 Pin assignment

All external signals should be applied to connector X1 to X3, they are shown on Figure 3 and the description is given in Table 2.

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

Pin	Label	Function
X3.1	GND	Primary ground for DC/DC converter supply voltage
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 Top transistor, negative logic
X3.6	TOP IN+	PWM signal for Top transistor, positive logic
X3.7	TOP RDY	Ready signal for Top channel
X3.8	TOP /FLT	Fault detection output Top channel
X3.9	TOP/BOT /RST	Reset signal for Top and Bottom IGBT-Driver
X3.10	BOT /FLT	Fault detection output Bottom channel
X3.11	BOT RDY	Ready signal for Bottom channel
X3.12	BOT IN-	PWM signal for Bottom transistor, negative logic
X3.13	BOT IN+	PWM signal for Bottom transistor, positive logic
X3.14	TEMP-Digital	Sigma / Delta signal for futher temperature measurement
X3.15	+5V	+5 V Voltage supply for logic devices
X3.16	Signal GND	Primary ground logic devices

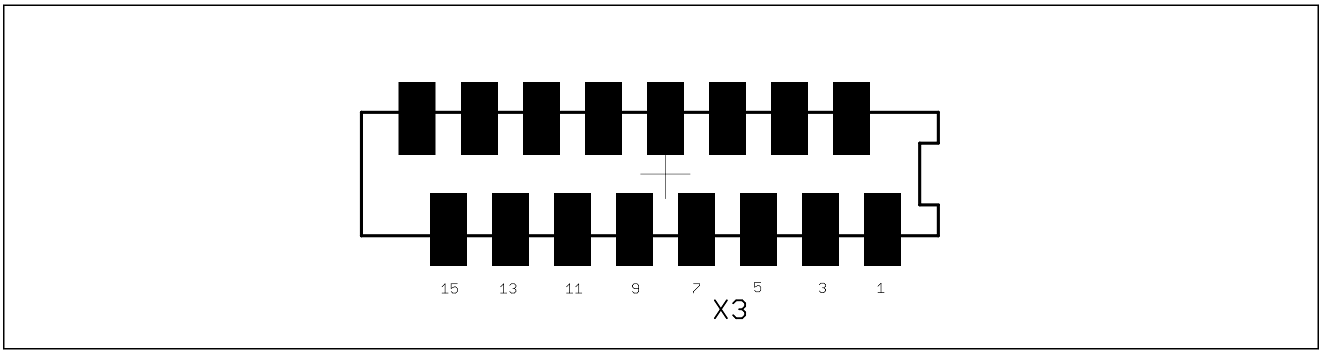

Figure 3 The 6ED100E12-F2 Evaluation Driver Board pin assignment for the third leg

Connectors X1 and X2 of the EconoPACK™+ board have the same pinning except temperature measurement. Connector X3 of EconoPACK™+ driver board has the same pin assignment as connector X1 of the EconoDUAL™ driver board.

2.4 Mechanical dimensions of the EconoDUAL™ Driver Board

SAP number to order Evaluation Driver Board for EconoDUAL™ modules: 31165

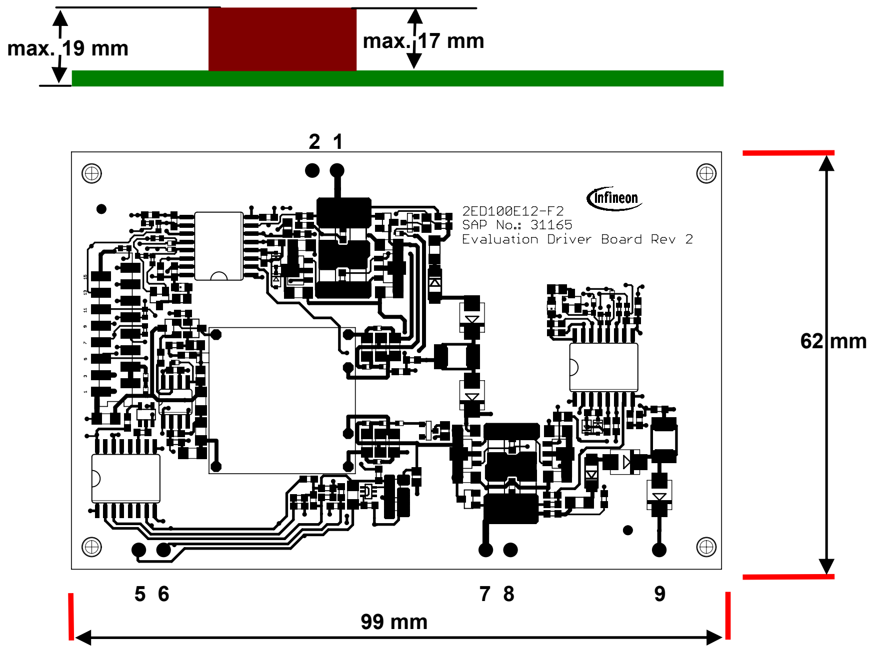

Figure 4 Dimensions of the 2ED100E12-F2 Driver Board

2.5 Mechanical dimensions of the EconoPACK™+ Driver Board

SAP number to order Evaluation Driver Board for EconoPACK™+ modules: 31166

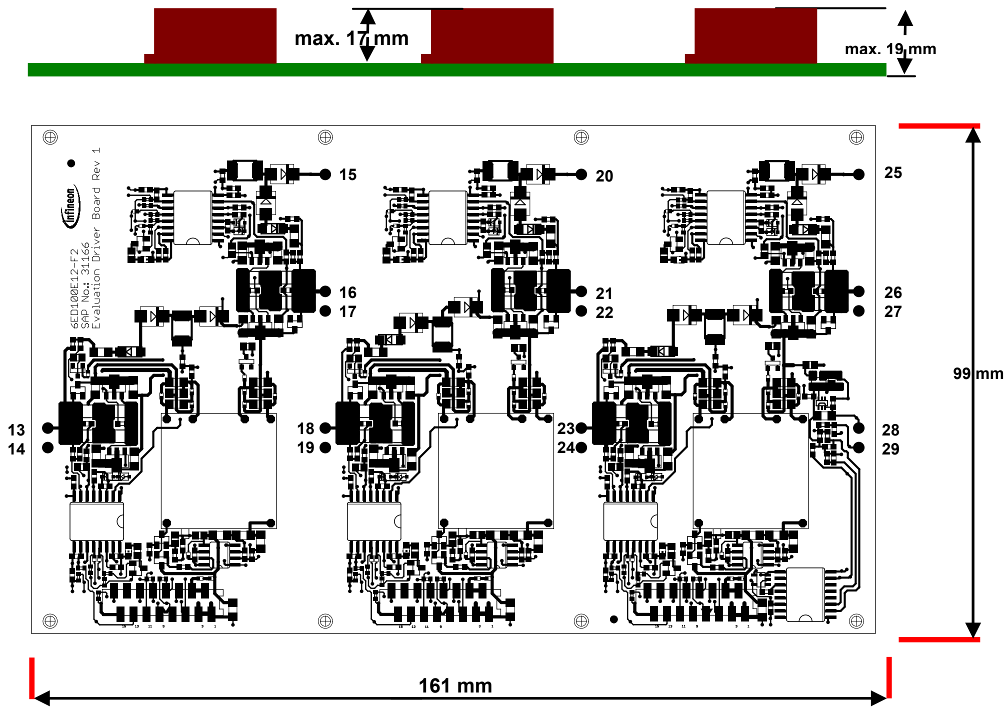

Figure 5 Dimensions of the 6ED100E12-F2 Driver Board

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™ and EconoPACK™+ Driver Boards:

Primary/Secondary is not less than 8 mm and Secondary/Secondary is not less than 4 mm.

3 Application Note

The following chapter describes the board´s operation in evaluation setup.

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. Top and Bottom 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. This Under Voltage Detection function insures gate voltages within specified range. The fault is reported to the driver’s primary side.

3.2 Input logic – PWM signals

The Evaluation Driver Boards are dedicated for a half-bridge EconoDUAL™ and sixpack EconoPACK™+ IGBT configuration, therefore it is necessary to connect two separate PWM signals or 6 separate PWM signals. Individual signals for Top and Bottom IGBT are necessary if there is a half-bridge module or rather 6 dedicated signals if there is a sixpack module. The schematic for a single driver is depicted in Figure 6. The signals need to have the correct dead time. Both Evaluation Driver Boards do not provide automatic dead time generation and recommended minimum dead times t_{TD} are given in Table 3.

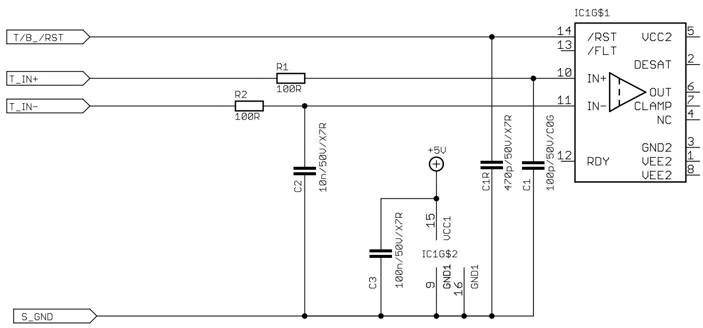

Figure 6 Schematic detail of the input circuit for a single driver.

The schematic in Figure 6 shows driver circuit with positive logic. Therefore a +5 V signal on the IN+ input pin and a GND signal on the IN- input pin is necessary to switch on the IGBT. To operate the whole circuit with negative logic the capacitors on each input pin have to be exchanced. Otherwise this causes an additional delay. IN+ will than operate as an enable signal.

3.3 Maximum switching frequency

The IGBT switching frequency is limited by the available power and by PCB temperature. According to theory the power losses generated in gate resistors are a function of gate charge, voltage step at the driver output and switching frequency. The energy is dissipated mainly through the PCB and raises the temperature around the gate resistors. When the available power of the DC/DC converter is not exceeded, the limiting factor for the switching frequency is the absolute maximum temperature for the FR4 material. The allowed operation temperature is 105 °C.

Generally the power losses generated in the gate resistors can be calculated according to formula (1):

$$P_{dis} = P_{R_{Gext}} + P_{R_{G\text{int}}} = \Delta V_{out} \cdot f_s \cdot Q_{ge} \qquad (1)$$

In this formula f_s resembles the switching frequency, ΔV_{out} represents the voltage step at the driver output P_{dis} is the dissipated power, Q_{ge} is the IGBT gate charge value corresponding to -8/+16V operation. This value can be approximately calculated from the datasheet value by multiplying by 0.8.

Most of the losses are shared between the internal $-P_{R_{G\text{int}}}$ and the external $-P_{R_{Gext}}$ gate resistors. Negligible losses are also in the driver IC itself. Due to the PCB temperature criteria the power of the external gate resistor $P_{R_{Gext}}$ is the interesting value when the thermal resistance is given.

Based on experimentally determined board temperature dependencies T_{PCB} ~ $P_{R_{Gext}}$, shown in Figure 7, it is possible to determine the maximum IGBT switching frequency, if the power losses of the external gate resistor and the maximum ambient temperature are known.

Each gate resistor has an R_{th} of approximate 100 $^{K}/_{W}$. In this alignment 1 W can be dissipated with a temperature difference of 100 K. With increasing ambient temperature the losses has to be decreased to stay below the expected PCB temperature of 105 °C. As can be concluded from Figure 7, the maximum switching frequency depended from the ambient temperature can be calculated. At room temperature the board can drive the IGBTs safely with the switching frequency limited by the available power of the DC/DC converter of 1.5 W.

Tabel 3 shows the temperature of gate resistors measured vs. maximum switching frequencies with different modules.

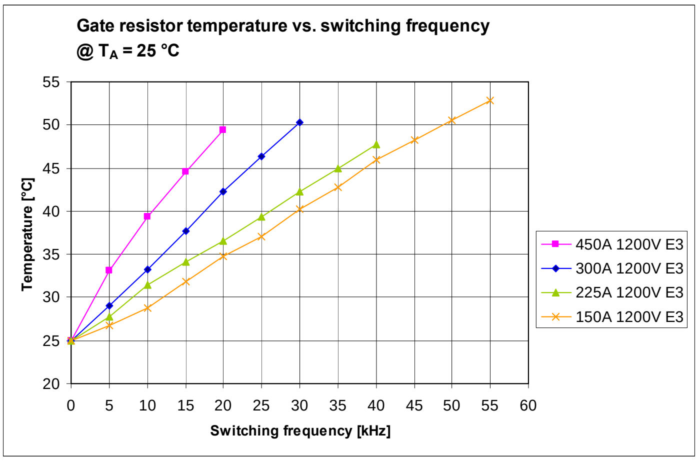

Figure 7 Temperature of gate resistors vs. switching frequency.

The curve from Figure 7 can be used for maximum switching frequency estimation of EconoDUAL™ and EconoPACK™+ modules as listed bellow. The maximum switching frequency f_{sw} @ T_A = 25 °C and @ T_A = 40 °C is limited due to the power of the DC/DC converter.

Table 3 Estimated maximum IGBT switching frequency and PWM minimum dead times for 2ED100E12-F2 and 6ED100E12-F2 with module

Module	R_{Gext} [Ω] / R_{Gint} [Ω]	f_{sw}@T_A = 25 °C [kHz]	f_{sw}@T_A = 40 °C [kHz]	f_{sw}@T_A = 85 °C [kHz] projected	minimum dead time t_{TD} [µs]
FF600R06ME3	2.0 / 0.7	12	12	6	1
FF150R12ME3 FS150R12KE3G	5.6 / 1.3	55.8	55.8	13.5	1
FF225R12ME3 FS225R12KE3	1.5 / 3.3	37.2	37.2	12	1
FF300R12ME3 FS300R12KE3	1.1 / 2.5	27.9 28.9	27.9 28.9	9	1
FF450R12ME3 FS450R12KE3	1 / 1.7	18.2	18.2	8	1
FF150R12MS4	5.1 / 1.7	48.8	48.8	11.8	1
FF225R12MS4	3 / 1.7	32.6	32.6	10.5	1
FF300R12MS4	1.5 / 1.7	24.4	24.4	9	1

3.4 Booster

Two transistors are used to amplify the driver ICs signal. This allows driving IGBTs that need more current than the driver can deliver. One NPN transistor is used for switching the IGBT on and another PNP transistor for switching the IGBT off.

The transistors are dimensioned to have enough peak current to drive all 600 V and 1200 V EconoDUAL™ and EconoPACK™+ modules. Peak current can be calculated like in formula (2):

$$I_{peak} = \frac{\Delta V_{out}}{R_{G_{int}} + R_{G_{ext}} + R_{Driver}} \quad (2)$$

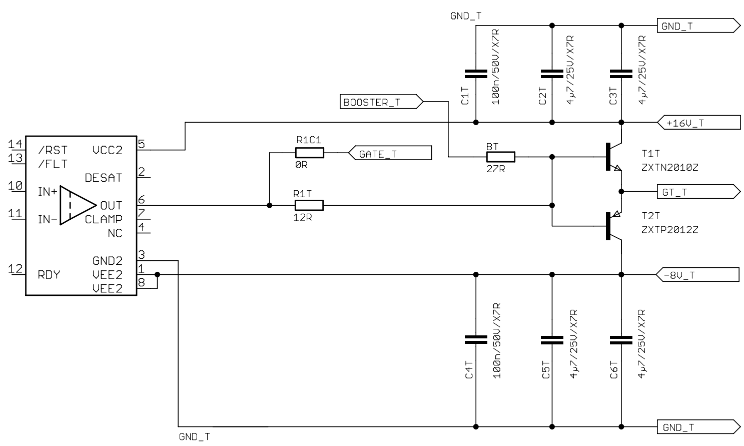

Figure 8 Booster

3.5 Short circuit protection and clamp function

The short circuit protection of the Evaluation Driver Board basically relies on the detection of a voltage level higher as 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. Depending on the stray inductance, the current and the DC voltage the overvoltage shoot during turn off changes.

Figure 9 shows the parts of the circuit needed for the desaturation function and the active clamping function.

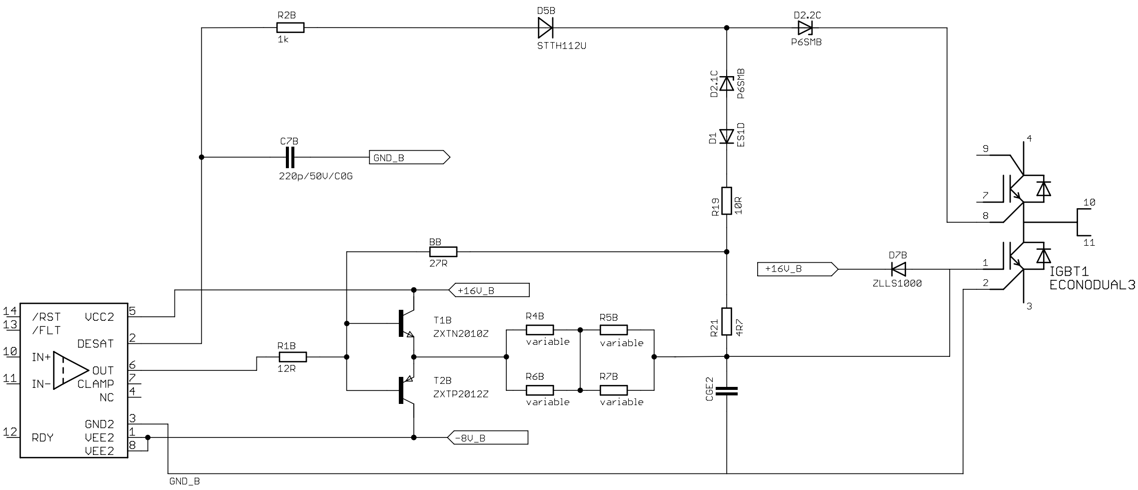

Figure 9 Desaturation protection and active clamping diodes

In case of a short circuit the saturation voltage V_{GE} will rise and the driver detects that there is a short circuit. The IGBT has to be switched off. There will be an overvoltage shoot due to the stray inductance of the module and the DC-Link. This overvoltage shoot has to be lower than the maximum IGBT blocking voltage. Therefore the evaluation driver boards consist of an active clamping function whereby the clamping will raise the voltage for the booster and also raise the voltage directly on the gate.

The typical turn-off waveform under short circuit condition and room temperature of a FF450R12ME3 module without any additional function is shown in Figure 10a.Typical waveform under short circuit condition with active clamp function is shown in Figure 10b at room temperature.

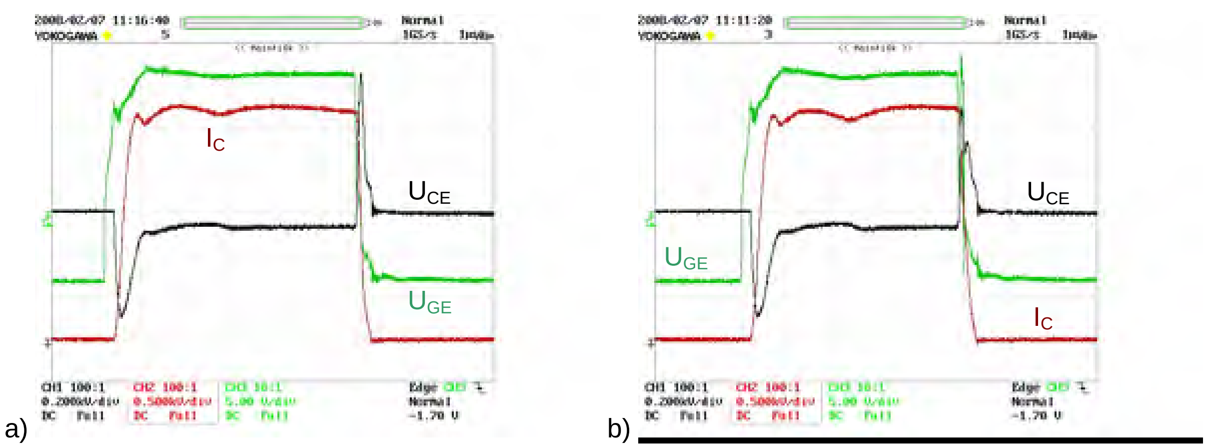

Figure 10 a) Short circuit without active clamp b) with active clamp function

3.6 Fault output

When a short circuit occurs, the voltage V_{CE} is detected by the desaturation protection of the 1ED020I12-F and the IGBT is switched off. The fault is reported to the primary side of the driver as long as there is no reset signal applied to the driver. The /FAULT signal is active low, the according schematic can be seen in Figure 11.

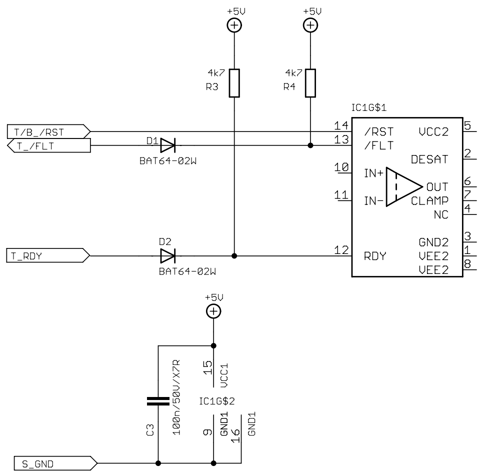

Figure 11 /Fault output for a single driver

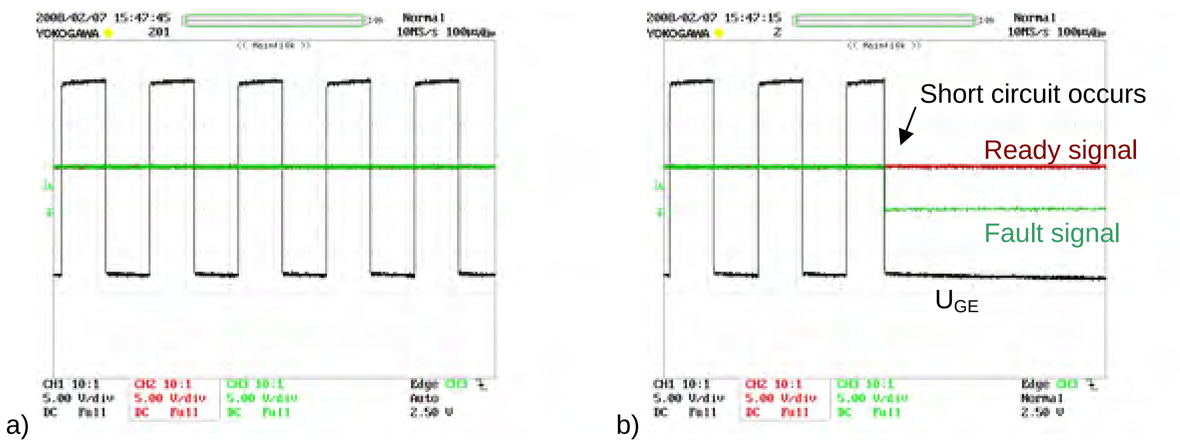

Figure 12 /Fault output during: a) normal operation b) operation under short circuit

The fault signal will be in low state in case of a short circuit until /RST is pulled down.

3.7 Temperature measurement

Based on the NTC built into both module types, the Driver Board offers IGBT base plate temperature measurement in the range of -40 °C…150 °C. The Evaluation driver boards work with a Sigma/Delta converter. Thus a digital signal is provided. This has the advantage that a normal I/O Pin on the microcontroller can be used and that the subsequent error is low. However an analog signal can be produced with the use of the following schematic.

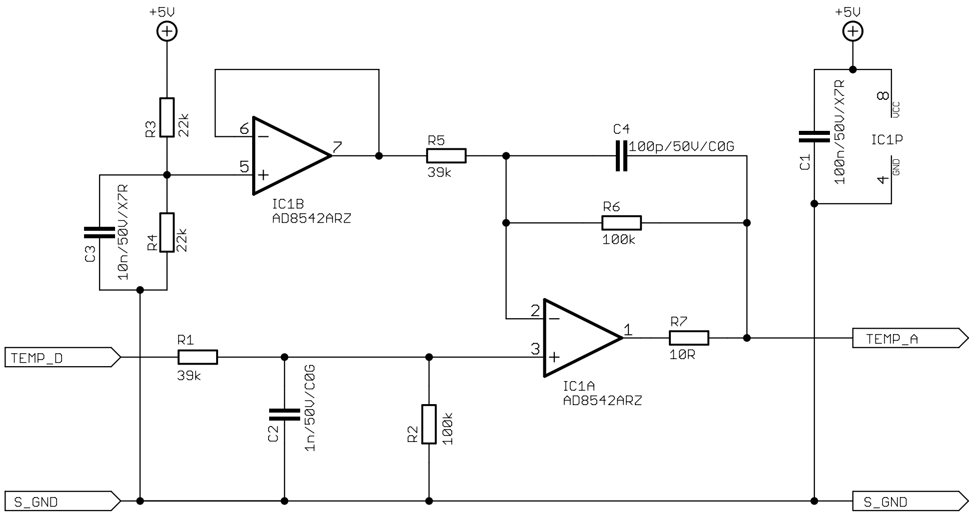

Figure 13 Schematic to convert digital Σ/Δ to analog output

Table 4 Bill of Material Σ/Δ to analog converter

Type	Qty	Value / Device	Package size imperal	Part Name	Recommended Manufacturer	Assembled
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		
Isolated Sigma-Delta Modulator	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		

The bill of material not only includes a part list, but also assembly notes. All electronic parts used in the design are lead-free with 260 °C soldering profile.

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

Assuming that there is a constant temperature difference between the junction and the baseplate the junction temperature can be estimated. In case of a broken wire the output switches down to 0 V. Output voltage vs. base plate temperature is shown in Figure 14.

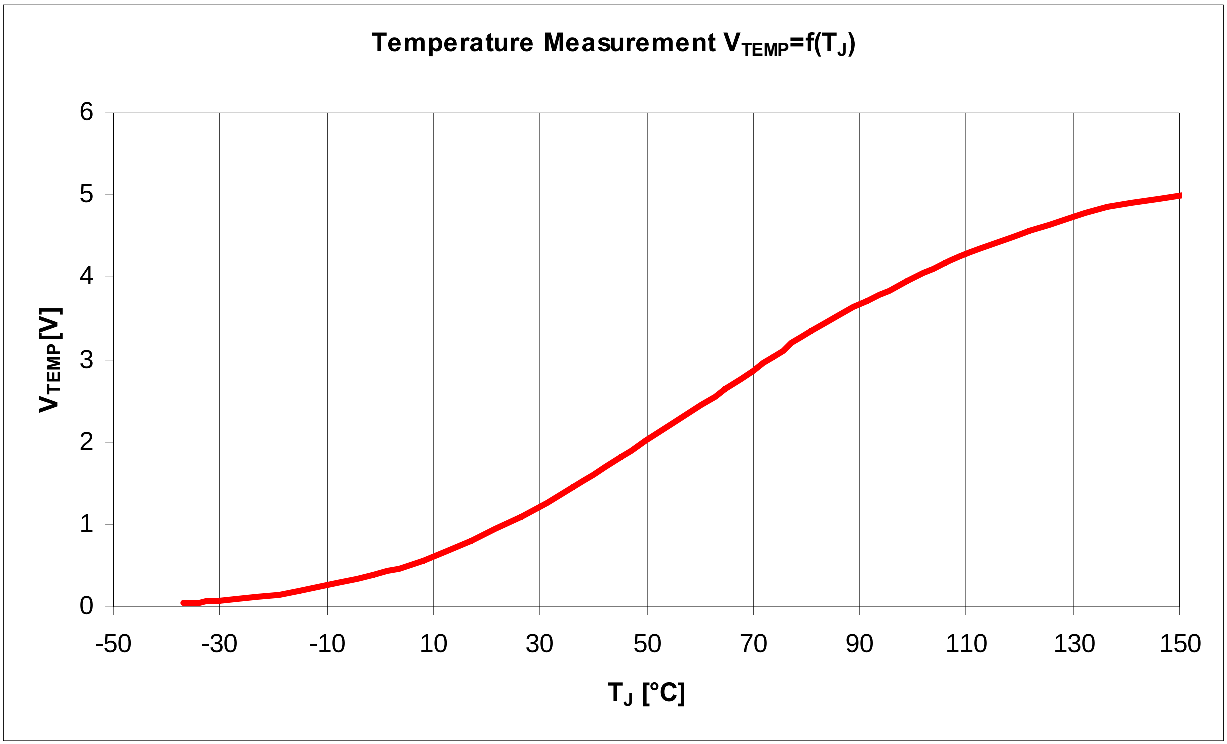

Figure 14 Characteristics of the temperature measurement

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

4 Switching losses

The switching losses can differ from the values written in the datasheet of the used module. The reason is that the Evaluation Driver Board switches with -8 V / +16 V. All modules in the power range of the EconoDUAL™ and EconoPACK™+ are characterised with a driver board that consists of ±15 V.

4.1 Turn-on losses

The turn-on losses are expected to be close to the values of the datasheet of the modules. As an example the turn-on losses for an EconoDUAL™3 FF450R12ME3 module are shown in the following diagram.

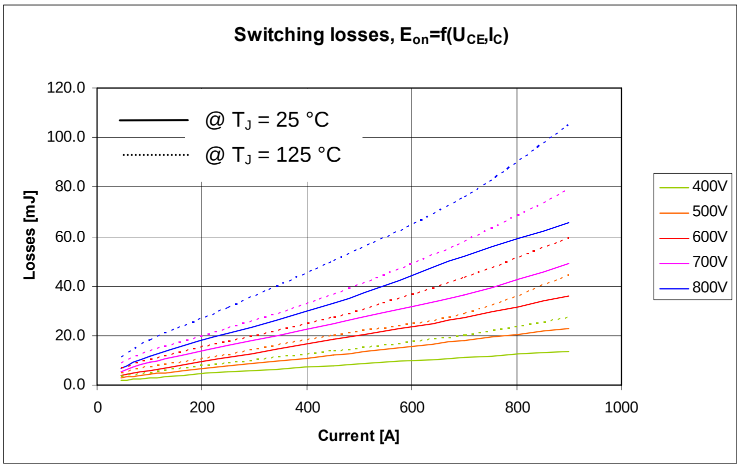

Figure 15 Turn-on losses with FF450R12ME3 module

4.2 Turn-off losses

This is different for the turn-off losses.

In general the turn-off losses increase linear with the DC-Link voltage. In the case of the driver board it does not increase linear because the active clamping function increases the turn-off losses due to a decrease of the di/dt.

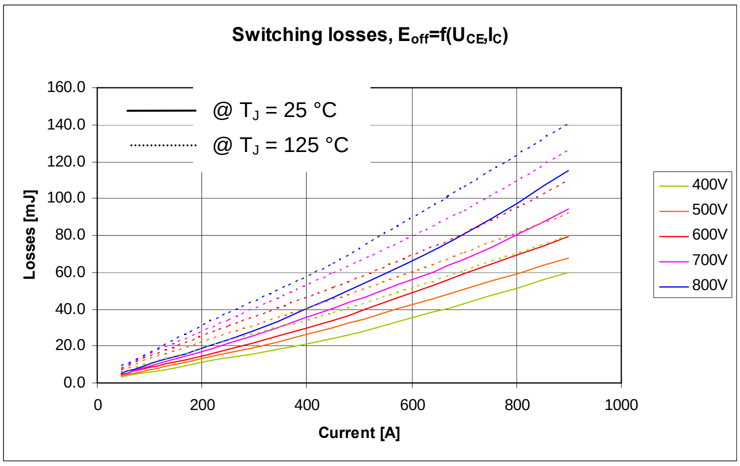

Figure 16 Turn-off losses with FF450R12ME3 module

Note: Switching losses depend on the stray inductance of the DC-Link.

All losses measured according the IEC 60747-9 standard. E_{on} is the integration of $U_{CE} \cdot I_C$ from 10% of U_{CE} and 2% I_C. For E_{off} it is vice versa. Here it is the integration from 10% of I_C to 2% of U_{CE}.

5 Definition of layers for Evaluation Driver Boards

Both driver boards were made keeping the following rules for the copper thickness and the space between different layers shown in Figure 17.

Layers:

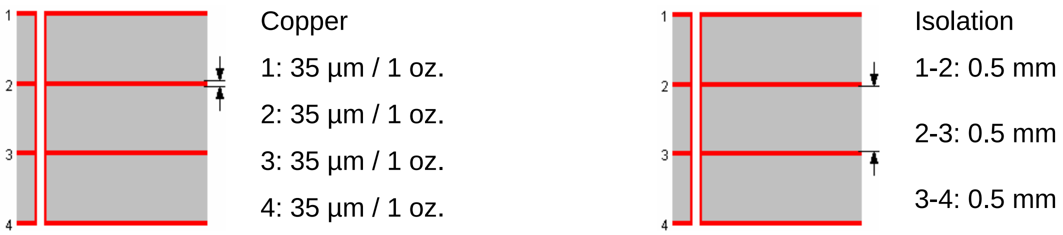

Figure 17 Copper and isolation for layers

6 Schematic, Layout and Bill of Material EconoDUAL™ board

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

6.1 Schematic

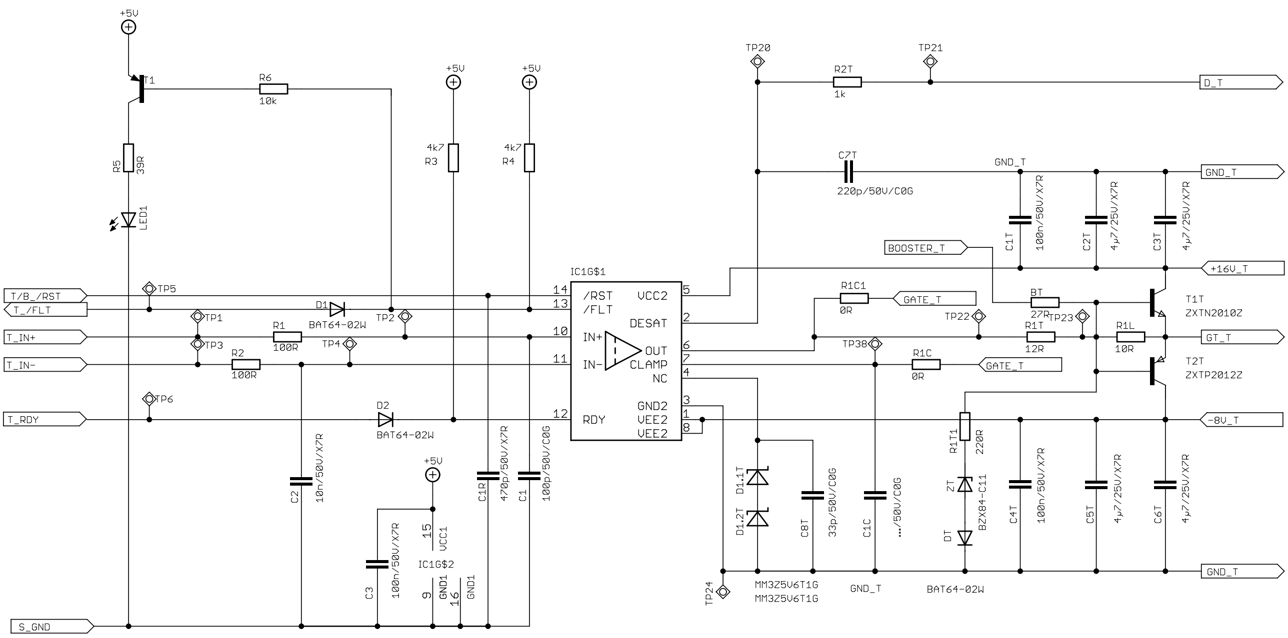

Figure 18 IGBT driver – Top transistor

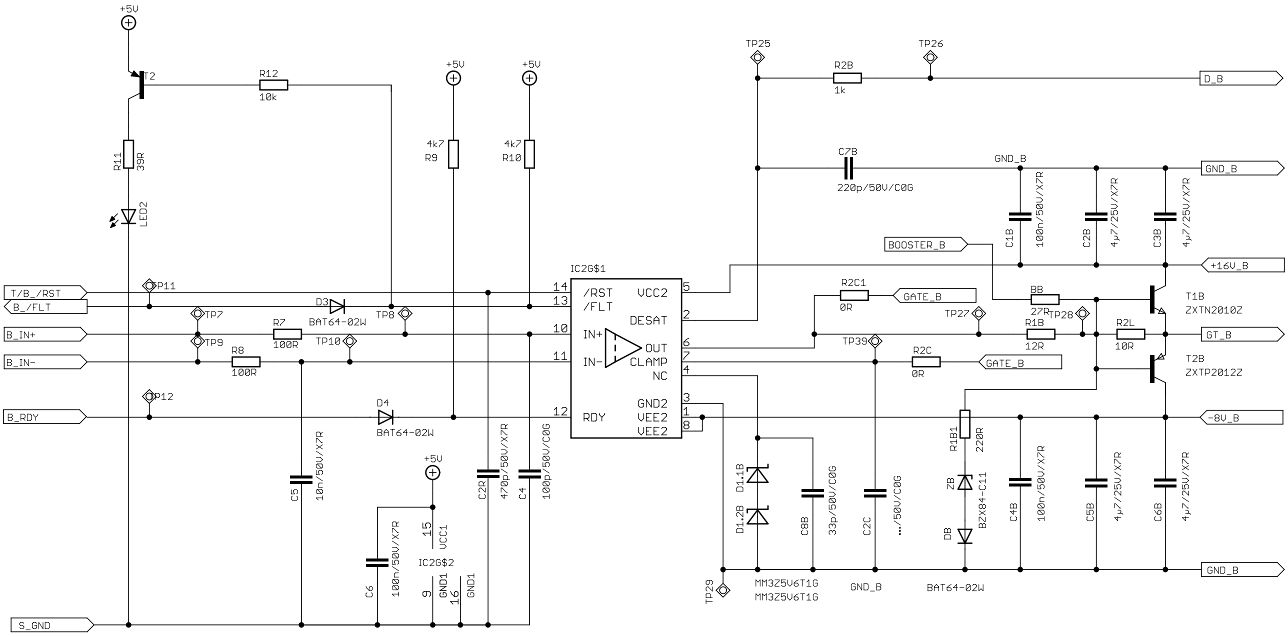

Figure 19 IGBT driver – Bottom transistor

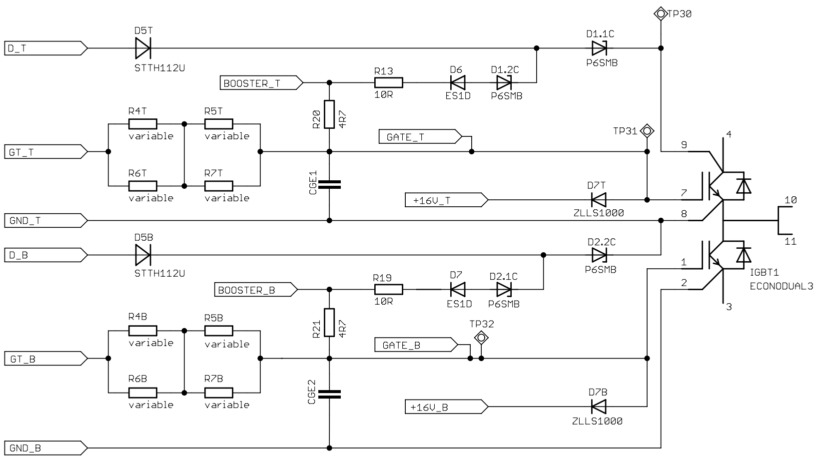

Figure 20 IGBT driver – Gate resistors

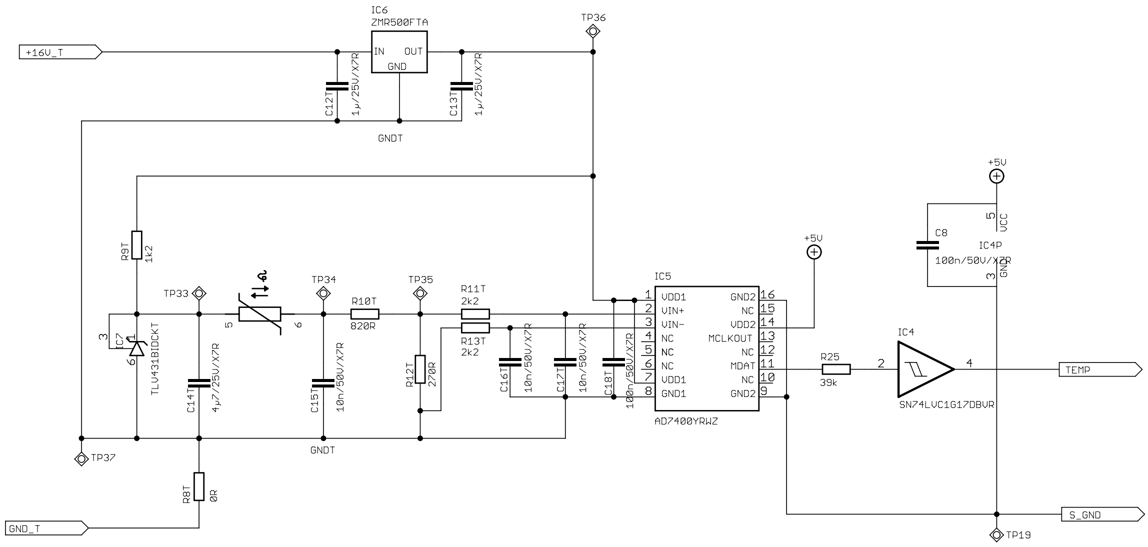

Figure 21 IGBT driver – Temperature measurement

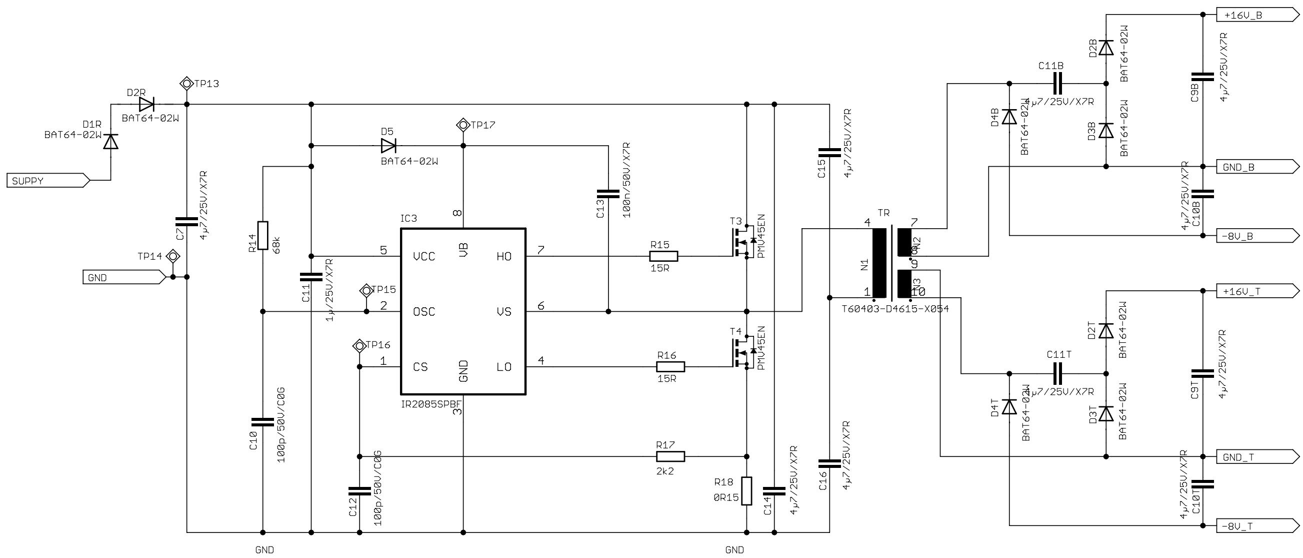

Figure 22 IGBT driver – DC/DC converter

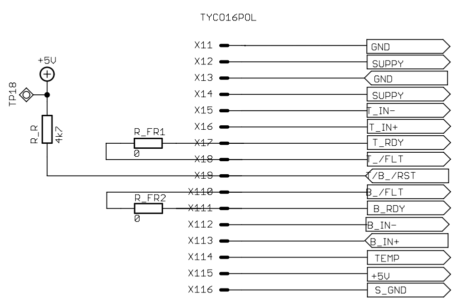

Figure 23 IGBT driver – External connection

6.2 Assembly drawing

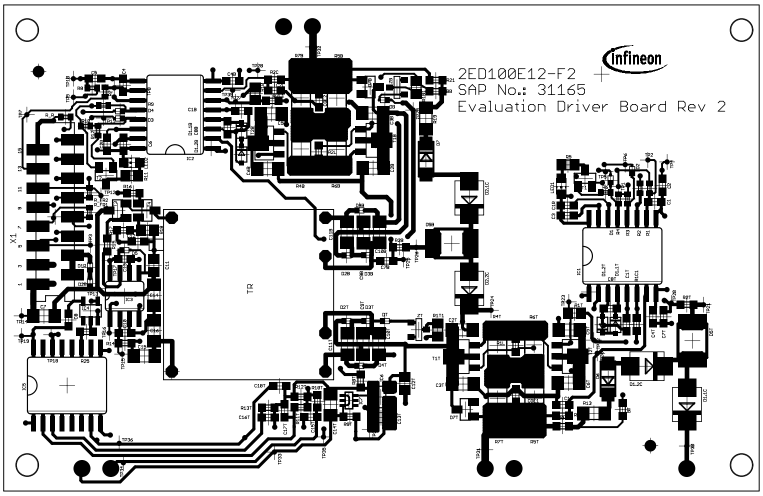

Figure 24 Assembly drawing of the EconoDUAL™ driver board

For detail information use the zoom function of your PDF viewer to zoom into the drawing.

6.3 Layout

Layout for the EconoDUAL™ board

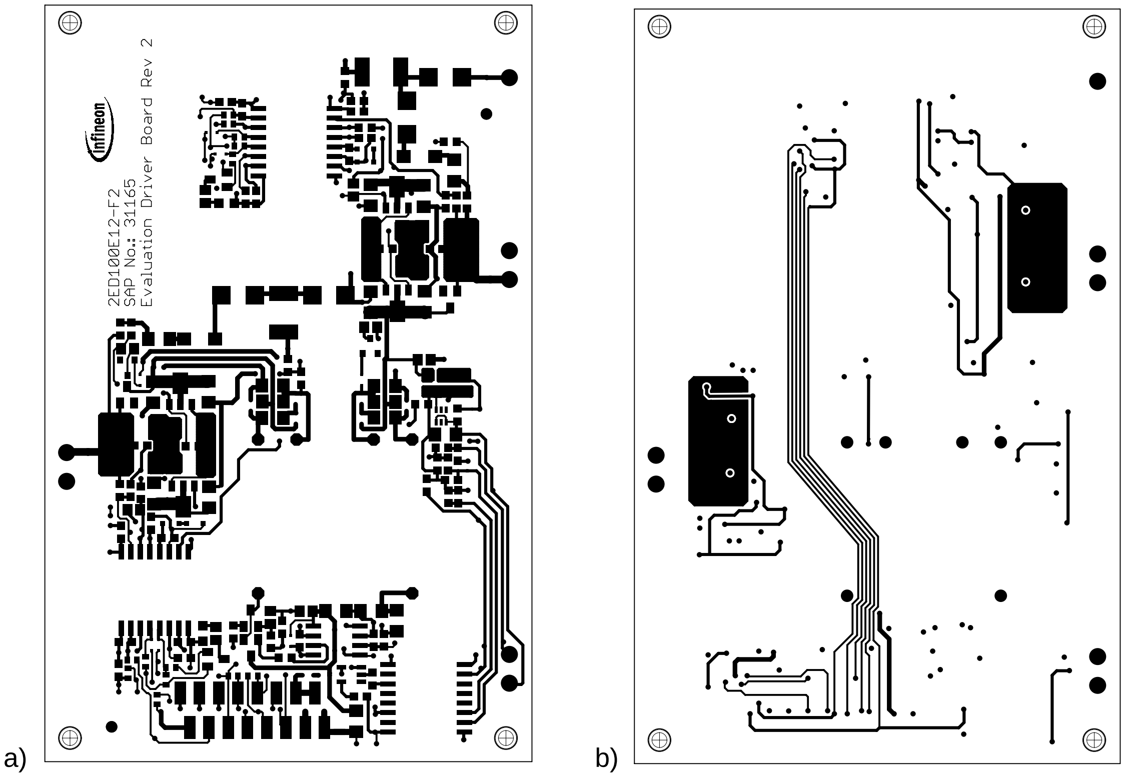

Figure 25 EconoDUAL™ IGBT driver – a) Top layer and b) Layer 2

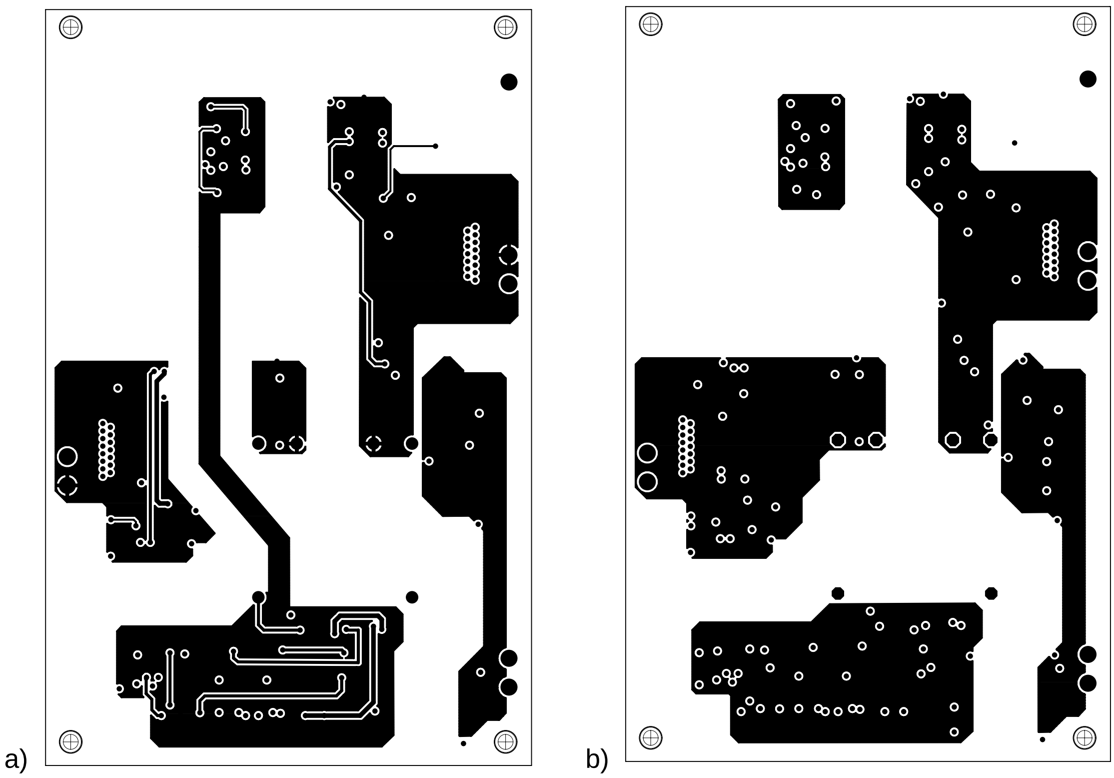

Figure 26 EconoDUAL™ IGBT driver – a) Layer 3 and b) Bottom layer

6.4 Bill of Material

The bill of material not only includes a part list, but also assembly notes. All electronic parts used in the design are lead-free with 260 °C soldering profile. The external gate resistors are not assembled, a list for the resistor values is presented in chapter 5.5.

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

Table 5 Bill of Material for EconoDUAL™ Driver Board

Type	Qty	Value / Device	Package size imperal	Part Name	Recommended Manufacturer	Assembled
Capacitor	2	.../50V/C0G	C0603	C1C, C2C		no
Capacitor	5	10n/50V/X7R	C0603	C2, C5, C15T, C16T, C17T		
Capacitor	2	33p/50V/C0G	C0603	C8B, C8T		no
Capacitor	9	100n/50V/X7R	C0603	C1B, C1T, C3, C4B, C4T, C6, C8, C13, C18T		
Capacitor	4	100p/50V/C0G	C0603	C1, C4, C10, C12		
Capacitor	2	220p/50V/C0G	C0603	C7B, C7T		
Capacitor	2	470p/50V/X7R	C0603	C1R, C2R		
Capacitor	2	optional/50V/C0G	C0603	CGE1, CGE2		no
Capacitor	3	1µ/25V/X7R	C0805	C11, C12T, C13T		
Capacitor	19	4µ7/25V/X7R	C1206	C2B, C2T, C3B, C3T, C5B, C5T, C6B, C6T, C7, C9B, C9T, C10B, C10T, C11B, C11T, C14, C14T, C15, C16	Murata	
Transformer	1	T60403-	D4615-X054	TR	Vacuum-schmelze	
LED	2	LEDCHIP-	LED0805	LED1, LED2		
Schottky Diodes	13	BAT64-02W	SCD80	D1, D1R, D2, D2B, D2R, D2T, D3, D3B, D3T, D4, D4B, D4T, D5	Infineon	
Rectifier Diode	2	ES1D	DO214AC	D6, D7		
Diode	2	BAT64-02W	SCD81	DB, DT	Infineon	no
Unipolar TVS Diode	2	P6SMB/440V	SMB	D1.1C, D2.1C		
Unipolar TVS Diode	2	P6SMB/510V	SMB	D1.2C, D2.2C		
Diode	2	STTA112U	SOD6	D5B, D5T		
Zener Diode	4	MM3Z5V6T1G	SOD323-R	D1.1B, D1.1T, D1.2B, D1.2T	On Semiconductor	no
Zener Diode	2	BZX84-C11	SOT23	ZB, ZT		no
Diode	2	ZLLS1000	SOT23	D7B, D7T	Zetex	
Driver IC	2	1ED020I12-F	P-DSO-16	IC1, IC2		
Half-Bridge Driver	1	IR2085SPBF	SO08	IC3	International Rectifier	
Schmitt-Trigger	1	SN74LVC1G17DBVR	SOT23-5	IC4		
Isolated Sigma-Delta Modulator	1	AD7400YRWZ	P-DSO-16	IC5	Analog Devices	
Voltage regulator	1	ZMR500FTA	SOT23	IC6		
Shunt Regulator	1	TLV431BIDCKT	SC70-6L	IC7		

Type	Qty	Value / Device	Package size imperal	Part Name	Recommended Manufacturer	Assembled
Resistor	2	0R	R0402	R_FR1, R_FR2		
Resistor	5	4k7	R0402	R3, R4, R9, R10, R_R		
Resistor	2	10k	R0402	R6, R12		
Resistor	4	100R	R0402	R1, R2, R7, R8		
Resistor	3	0R	R0603	R1C, R2C, R8T		no
Resistor	2	0R	R0603	R1C1, R2C1		no
Resistor	2	27R	R0603	BB, BT		
Resistor	2	1k	R0603	R2B, R2T		
Resistor	1	1k2	R0603	R9T		
Resistor	3	2k2	R0603	R11T, R13T, R17		
Resistor	2	4R7	R0603	R20, R21		
Resistor	2	10R	R0603	R1L, R2L		no
Resistor	2	15R	R0603	R15, R16		
Resistor	1	39k	R0603	R25		
Resistor	1	68k	R0603	R14		
Resistor	1	270R	R0603	R12T		
Resistor	1	820R	R0603	R10T		
Resistor	1	0R15	R0805	R18		
Resistor	2	12R	R0805	R1B, R1T		
Resistor	2	39R	R0805	R5, R11		
Resistor	2	220R	R0805	R1B1, R1T1		no
Resistor	2	10R	R1206	R13, R19		
Resistor	8	variable	R2010	R4B, R4T, R5B, R5T, R6B, R6T, R7B, R7T	TT electronics	no: See Table 6
Transistor	2	BC856	SOT23	T1, T2		
TrenchMOS	2	PMV45EN	SOT23	T3, T4	Philips	
Transistor	2	ZXTN2010Z	SOT89	T1B, T1T	Zetex	
Transistor	2	ZXTP2012Z	SOT89	T2B, T2T	Zetex	
Connector	1		16POL	X1	Tyco	
IGBT module	1		EconoDUAL™3	IGBT	Infineon	
Box	1	K1000	265 x 175 x 60		Licefa	

6.5 Gate resistor list

Table 6 External gate resistors R_{Gext} are listed bellow, all packages are 2010

Module	R_{Gext} [Ω]	R4T, R4B, R6T, R6B [Ω]	R5T, R5B, R7T, R7B [Ω]
FF600R06ME3	3.0	2.0	2.0
FF150R12ME3G	8.2	5.6	5.6
FF225R12ME3	3.3	1.5	1.5
FF300R12ME3	2.4	1.1	1.1
FF450R12ME3	1.6	1	1
FF150R12MS4	7.5	5.1	5.1
FF225R12MS4	4.7	3	3
FF300R12MS4	2.7	1.5	1.5

7 Schematic, Layout and Bill of Material EconoPACK™+ board

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

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

7.1 Schematic

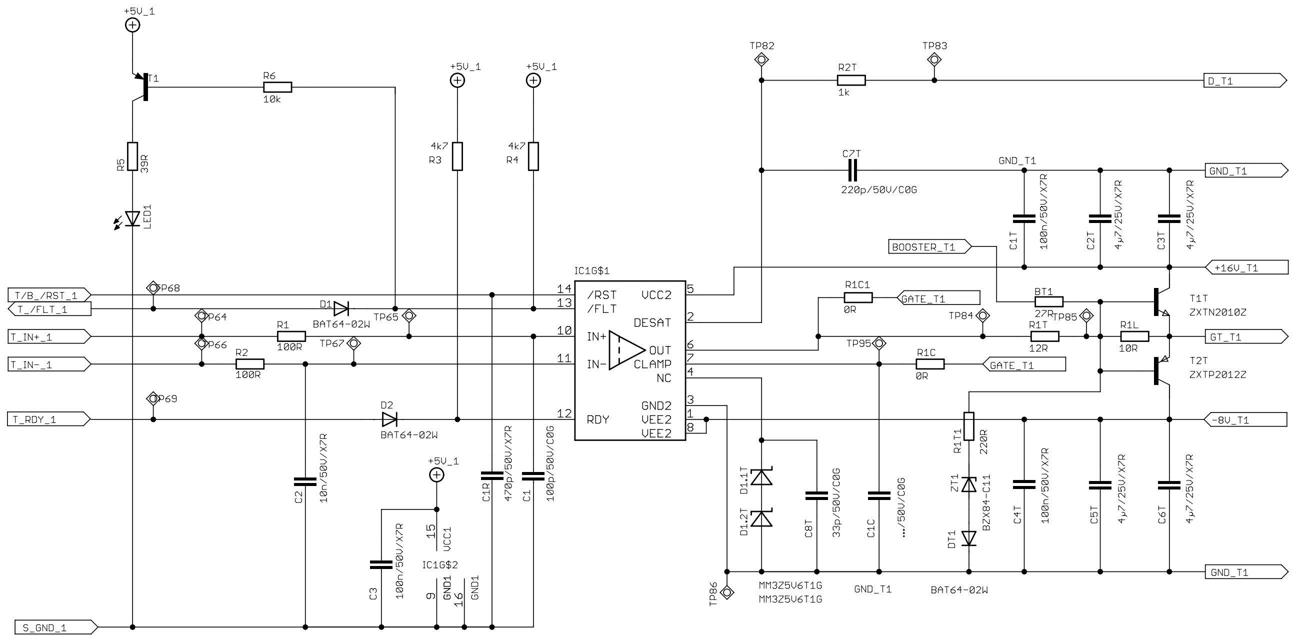

Figure 27 IGBT driver – Top transistor of first leg

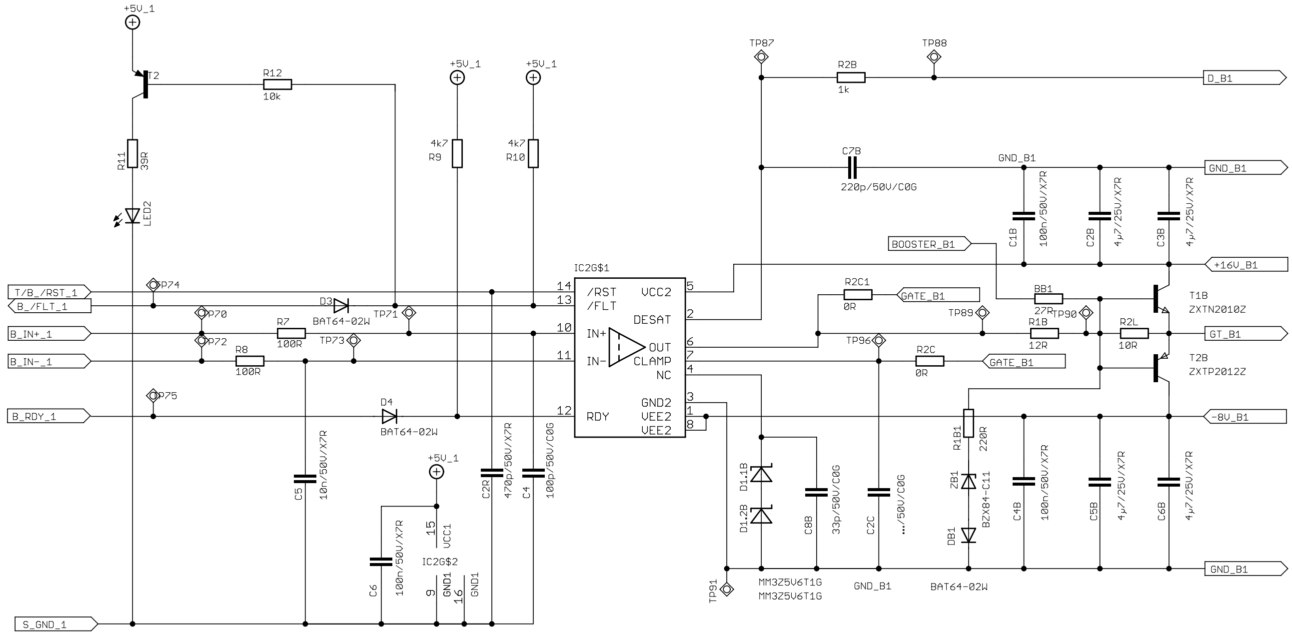

Figure 28 IGBT driver – Bottom transistor of first leg

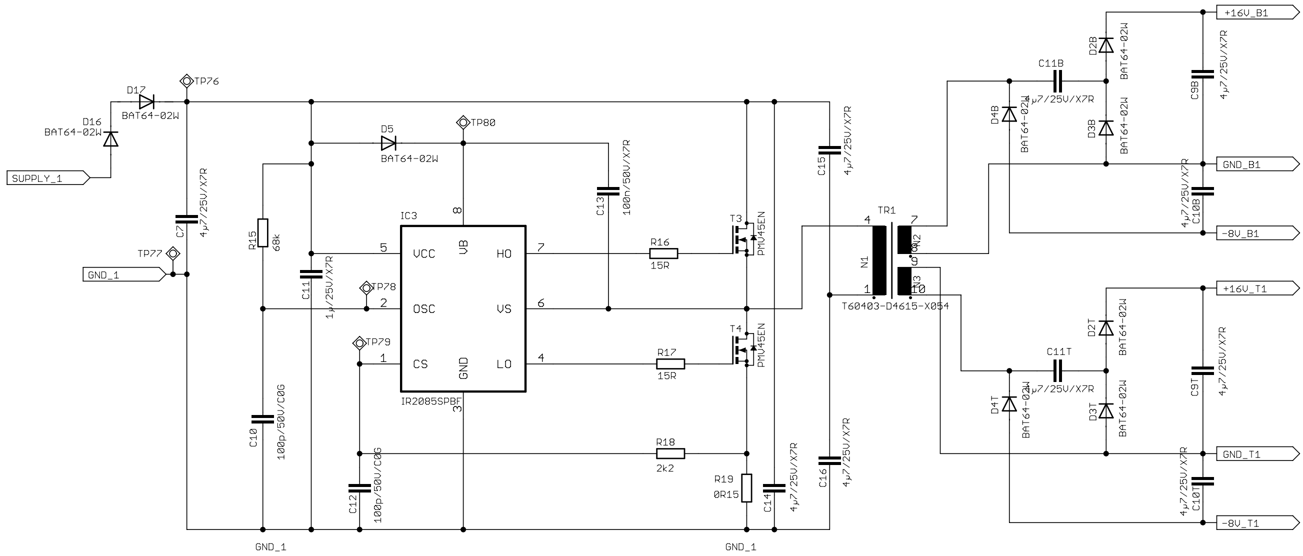

Figure 29 DC/DC converter of first leg

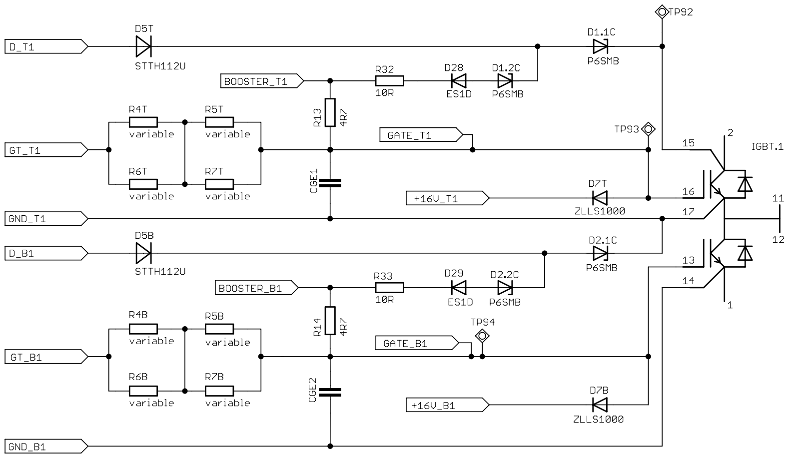

Figure 30 Gate resistors of first leg

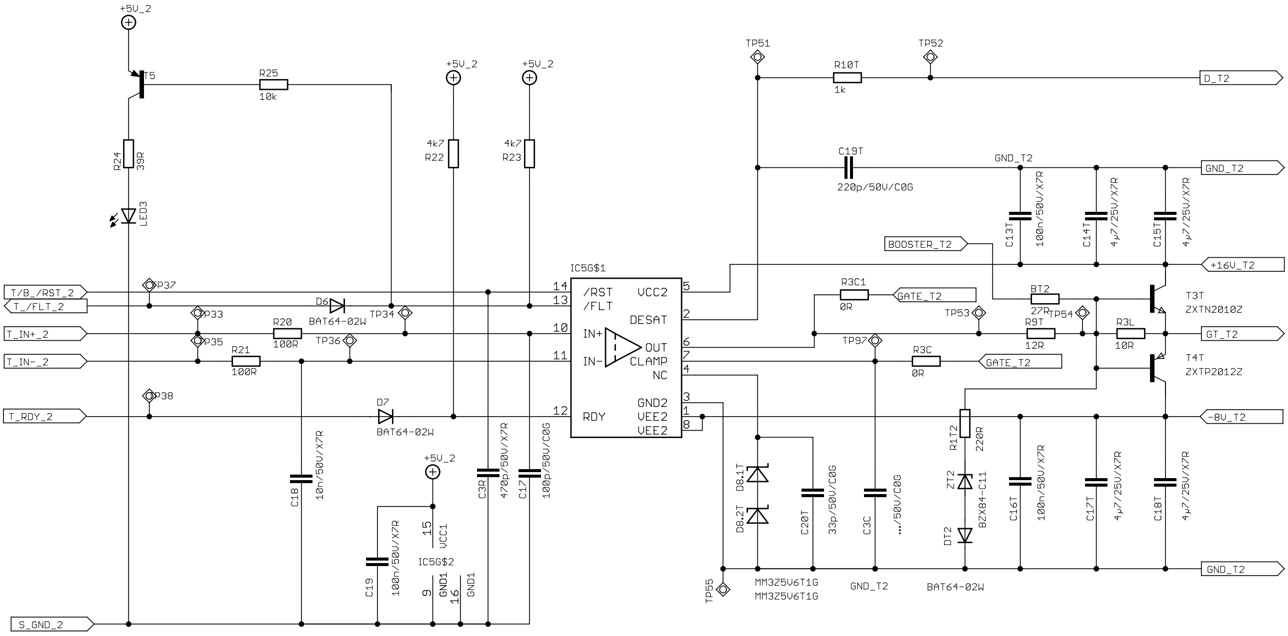

Figure 31 IGBT driver – Top transistor of second leg

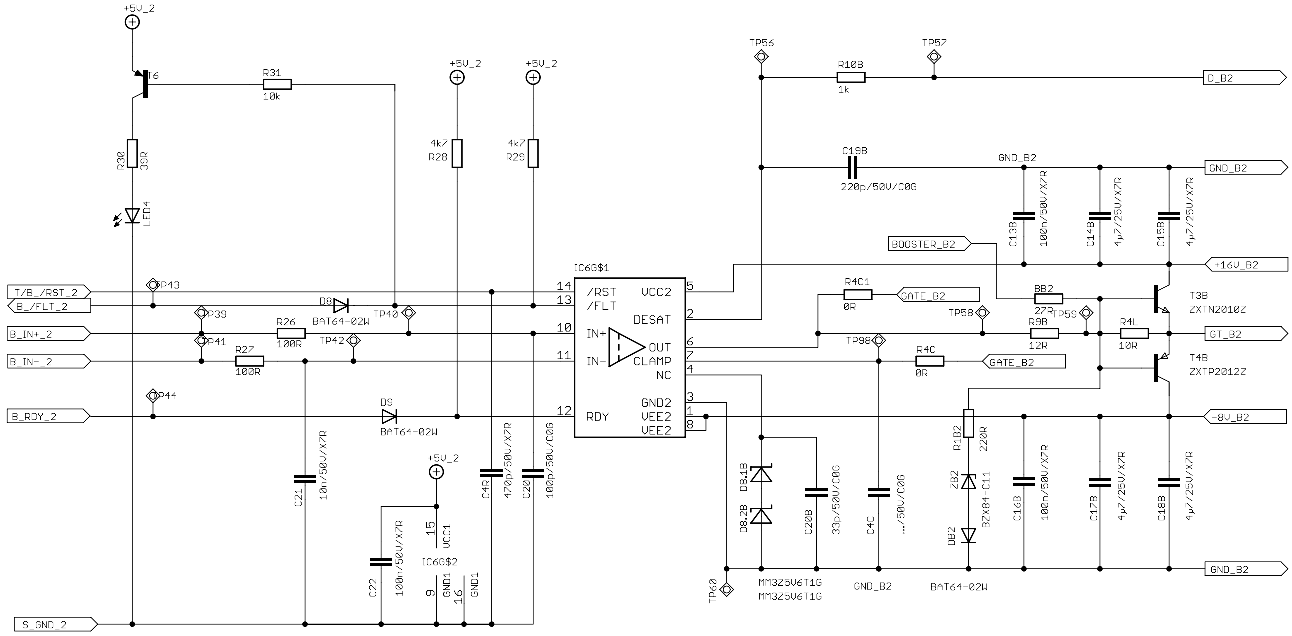

Figure 32 IGBT driver – Bottom transistor of second leg

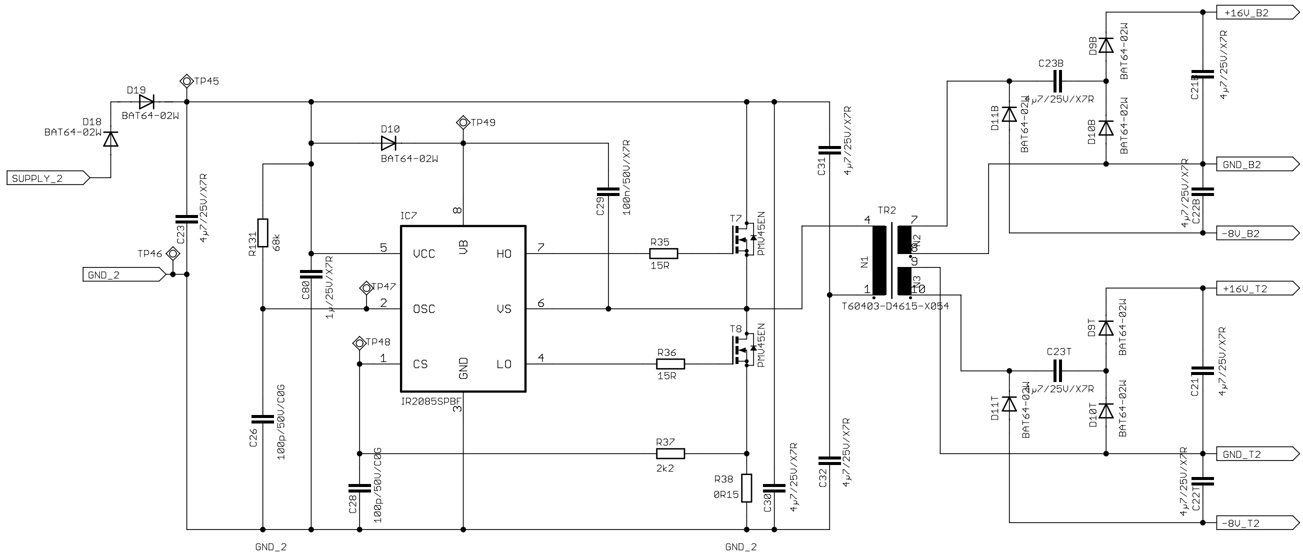

Figure 33 DC/DC converter of second leg

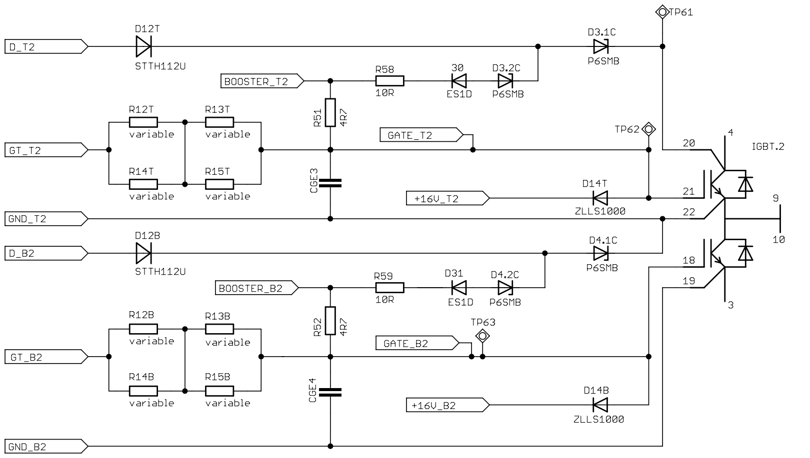

Figure 34 Gate resistors of second leg

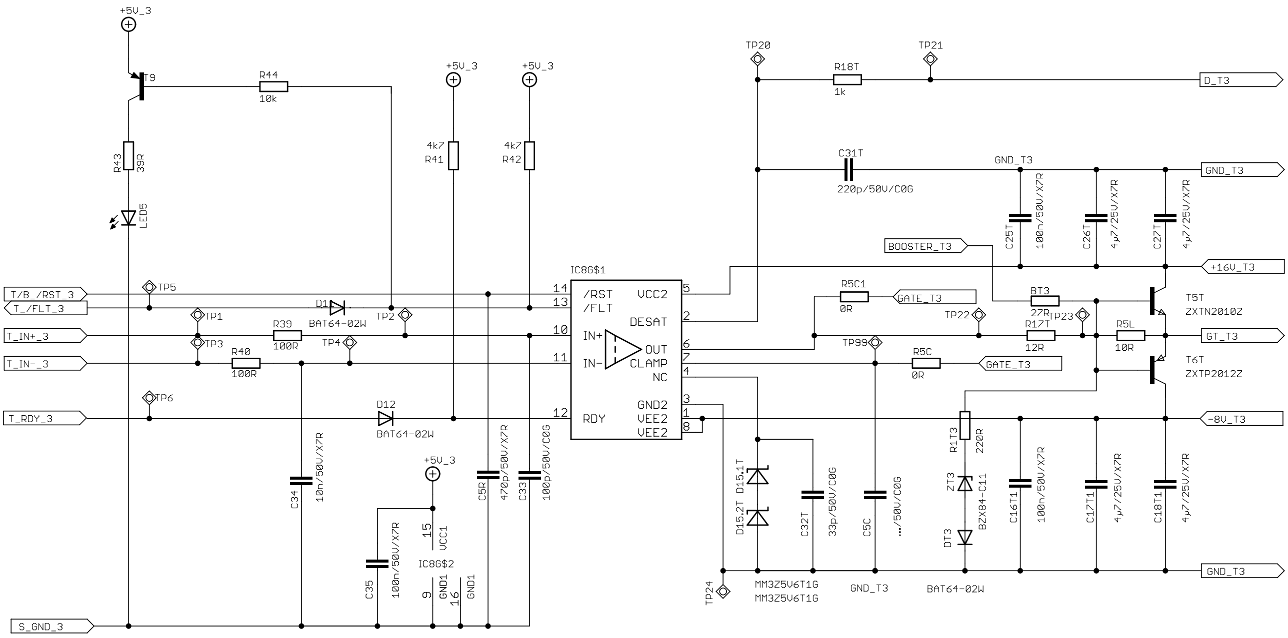

Figure 35 IGBT driver – Top transistor of third leg

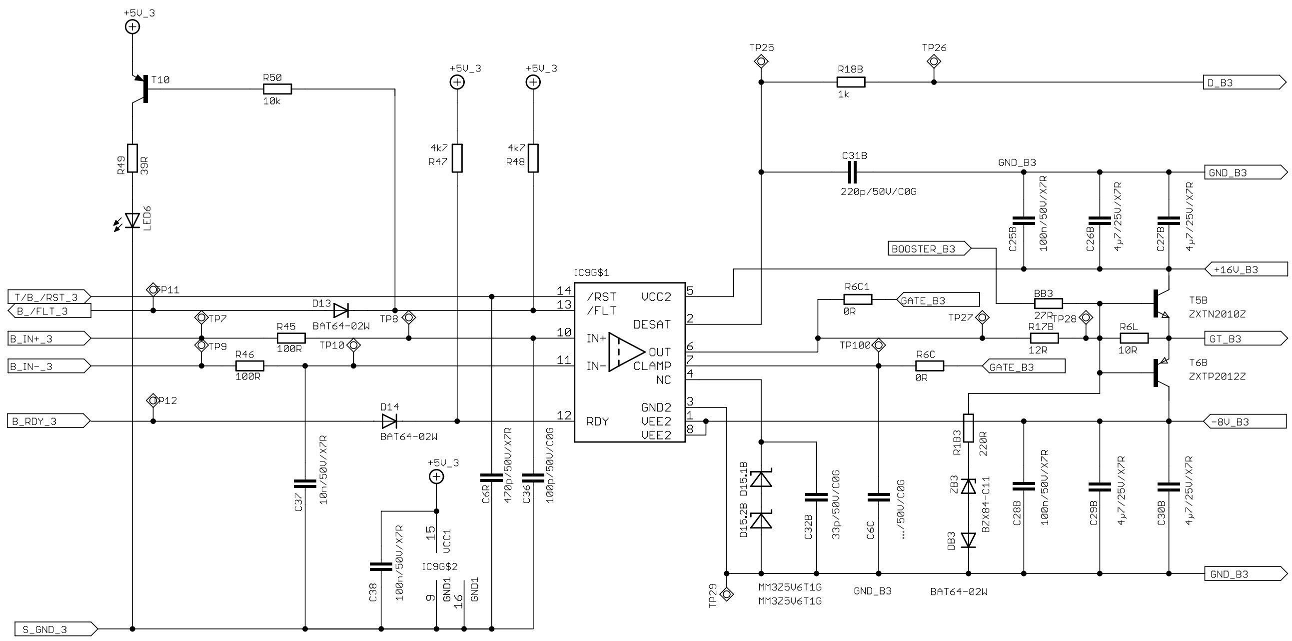

Figure 36 IGBT driver – Bottom transistor of third leg

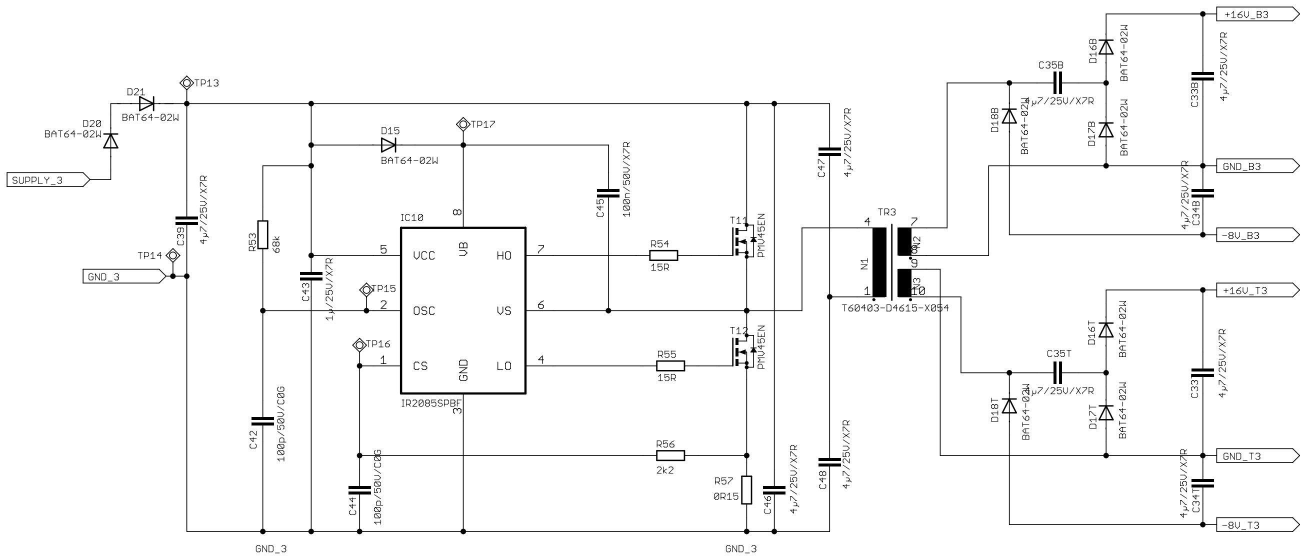

Figure 37 DC/DC converter of third leg

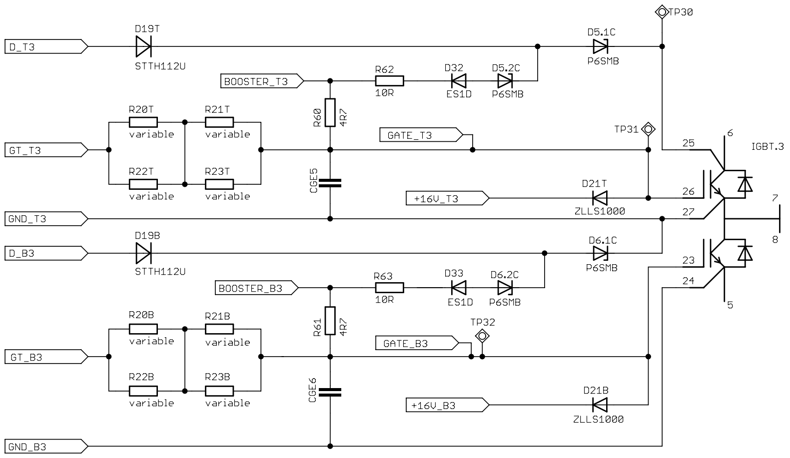

Figure 38 Gate resistors of third leg

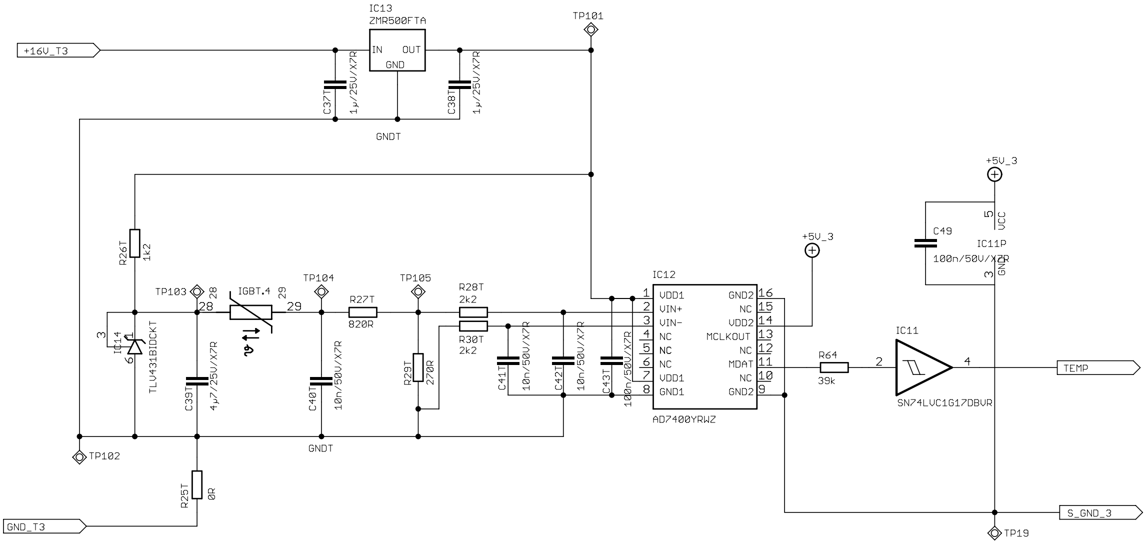

Figure 39 Temperatur measurement

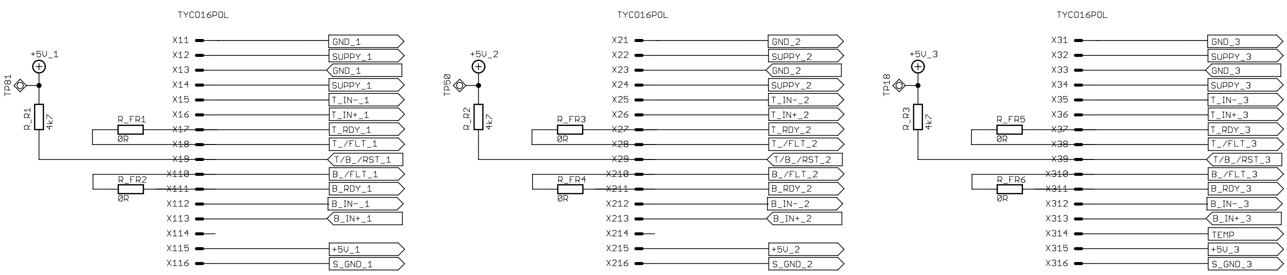

Figure 40 Connectors

7.2 Assembly drawing

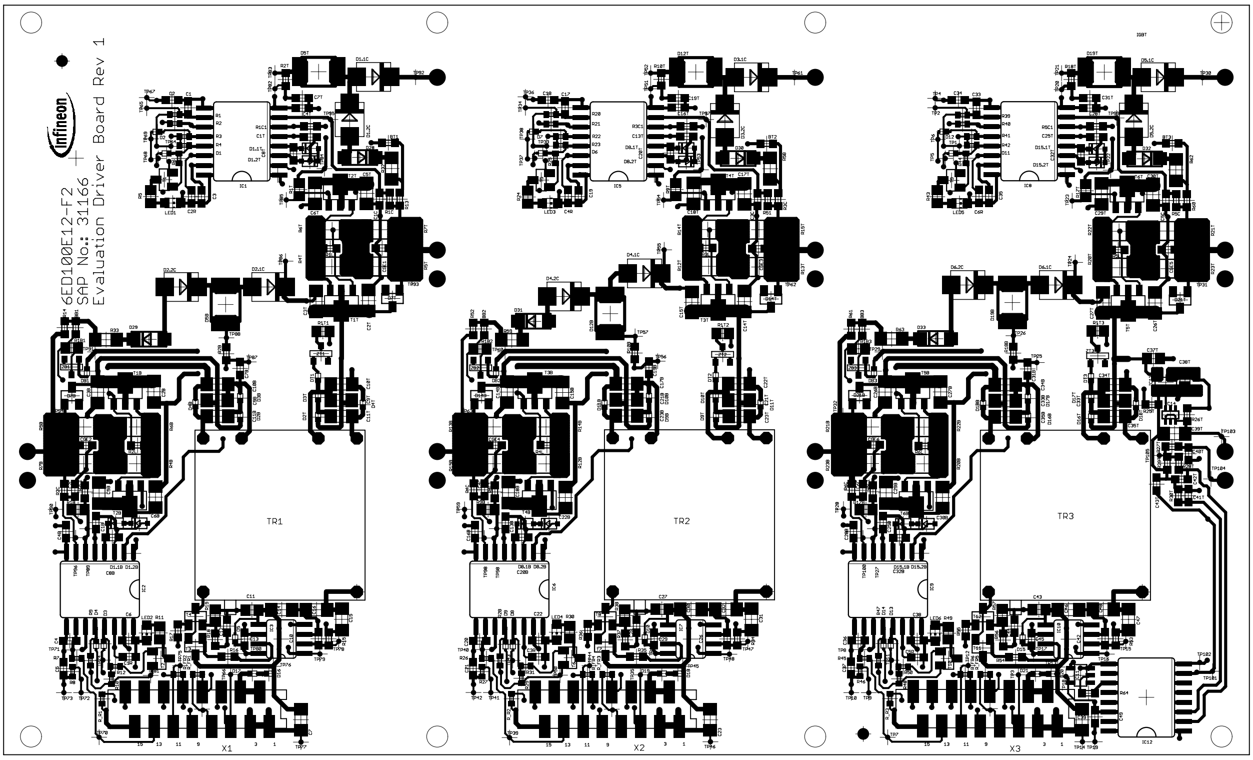

Figure 41 Assembly drawing of the EconoPACK™+ driver board

For detail information use the zoom function of your PDF viewer to zoom into the drawing.

7.3 Layout

Layout for the EconoPACK™+ board

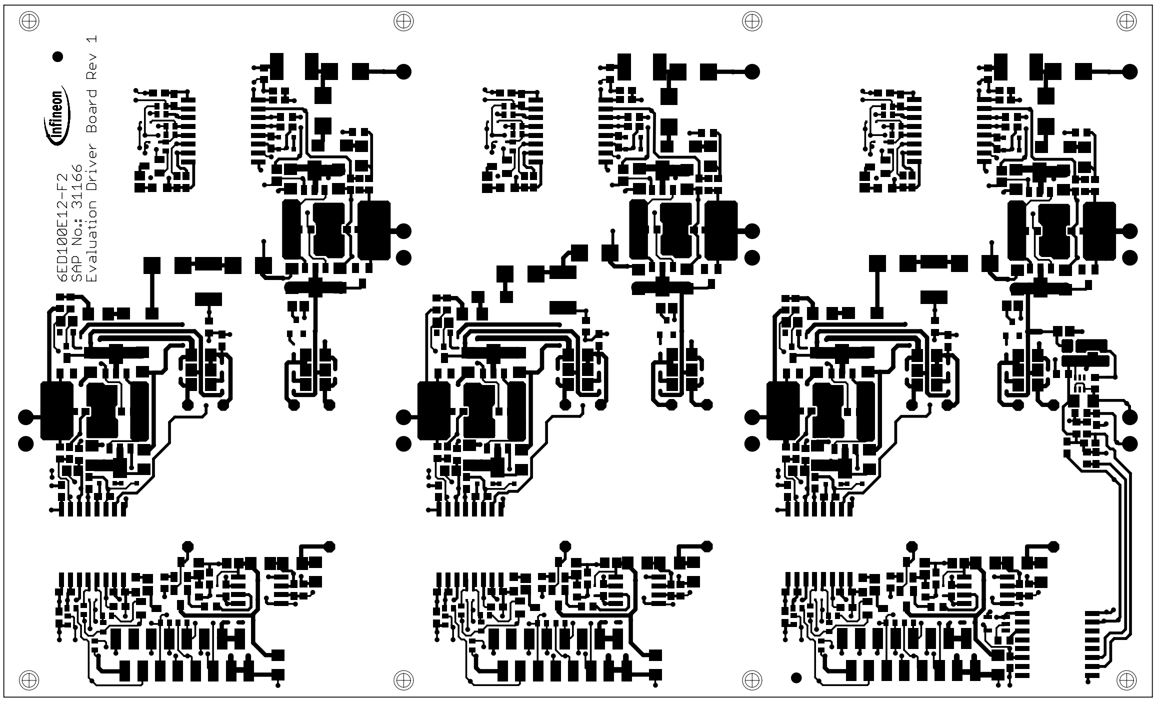

Figure 42 EconoPACK™+ IGBT driver – Top layer

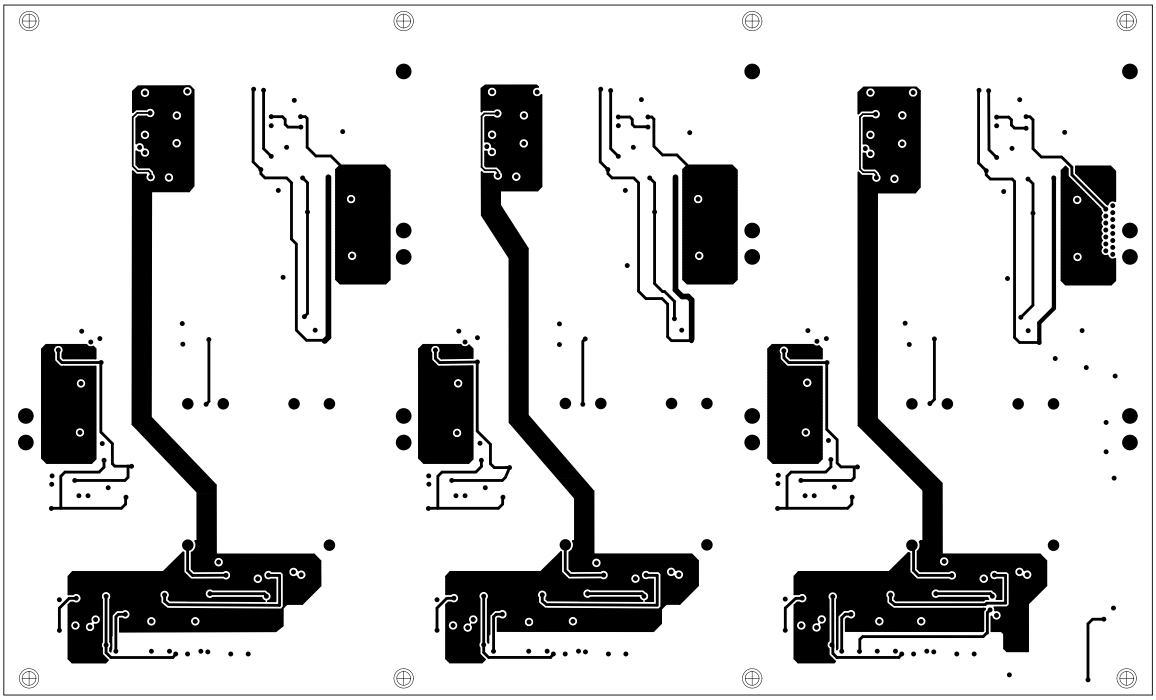

Figure 43 EconoPACK™+ IGBT driver – Layer 2

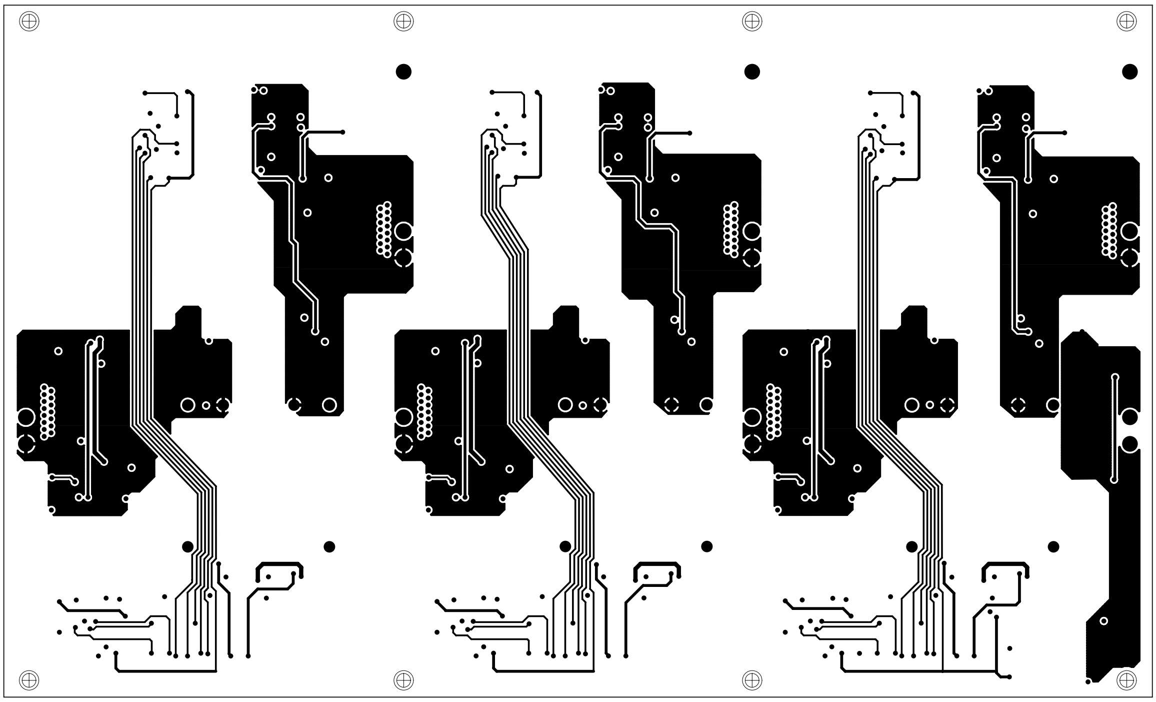

Figure 44 EconoPACK™+ IGBT driver – Layer 3

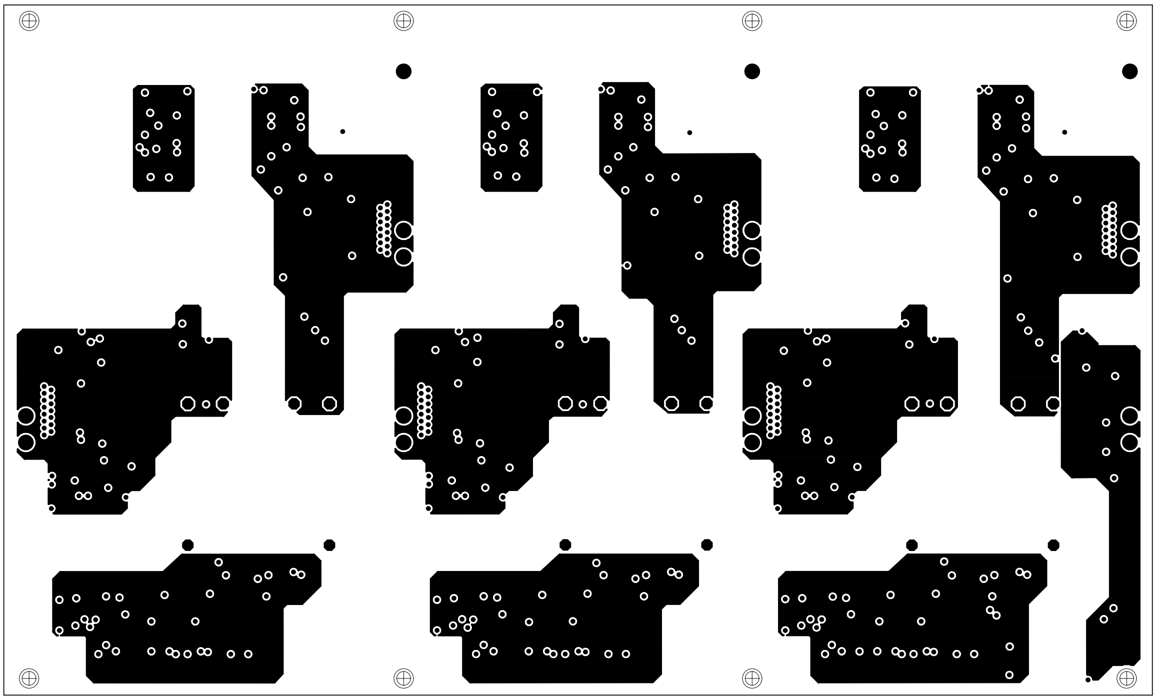

Figure 45 EconoPACK™+ IGBT driver – Bottom Layer 4

7.4 Bill of material

The bill of material not only includes a part list, but also assembly notes. All electronic parts used in the design are lead-free with 260 °C soldering profile. The external gate resistors are not assembled, a list for the resistor values is presented in chapter 6.5.

Table 7 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	TR1, TR2, TR3	Vacuum-schmelze	
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		

Type	Qty	Value / Device	Package size imperal	Part Name	Recommended Manufacturer	Assembled
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	Zetex	
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		
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	7	0R	R0603	R1C, R2C, R3C, R4C, R5C, R6C, R25T		no
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		

Type	Qty	Value / Device	Package size imperal	Part Name	Recommended Manufacturer	Assembled
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
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	Zetex	
Transistor	6	ZXTP2012Z	SOT89	T2B, T2T, T4B, T4T, T6B, T6T	Zetex	
Connector	3		16POL	X1, X2, X3	Tyco	
IGBT module	1		EconoPACK™+	IGBT	Infineon	
Box	1	K1000	265 x 175 x 60		Licefa	

7.5 Gate resistor list

Table 8 External gate resistors R_{Gext} are listed bellow, all packages are 2010

Module	R_{Gext} [Ω]	R4T, R4B, R6T, R6B [Ω] R12T, R12B, R14T, R14B [Ω] R20T, R20B, R22T, R22B [Ω]	R5T, R5B, R7T, R7B [Ω] R13T, R13B, R15T, R15B [Ω] 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

8 How to order Evaluation Driver Boards

Every Evaluation Driver Board has its own SAP 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 decribed here are available on request. The use of this data is subjected to the disclaimer given in this AN. Please contact, IGBT.Application@infineon.com.

http://www.infineon.com

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