TO-247-3 Advanced Isolation

Infineon's new fully isolated discrete package

About this document

Scope and purpose

The TO-247-3 Advanced Isolation is a new, fully isolated package introduced by Infineon based on the standard transistor outline TO-247 3pin. This package has been developed to enable high power density by providing a reliable thermal path from the chip to the application's heatsink without the need for additional thermal grease. TO-247-3 Advanced Isolation features improved thermal resistance R_{thJH} compared to TO-3P FullPAK, TO-247-3 FullPAK versions and TO-247-3 with standard isolation foils.

Intended audience

This application note is intended for designers that intend to use the TO-247-3 Advanced Isolation package, especially in consumer and industrial applications.

Table of Contents

[1] C. Kasztelan, T. Basler, M. Mengel and E. Fürgut, "Taking Power Semiconductors to the Next Level: Novel Plug & Play High Thermal Performance Insulated Molded Power Package," in PCIM, Nuernberg, 2017.

[2] Infineon Technologies AG: AN2012-10, Electrical safety and isolation in high voltage discrete component applications and design hints, V1.0, October 2012.

[3] O. Harmon, F. Brucchi, C. Kasztelan and P. Seng, "A novel high thermal performance insulated package takes power integration to the next level" in PCIM, Asia 2017.

1 Product Description

TRENCHSTOP™ Advanced Isolation is a fully isolated package family where a material with high thermal conductivity, excellent insulating properties and integrated thermal grease is molded onto the copper thermal pad of the TO-247-3. This reduces the thermal resistance from junction to heatsink by about 50% compared to a TO-247-3 FullPAK or a TO-3P FullPAK. This performance is given without additional thermal grease. The dielectric withstand capability of this package exceeds 2.5 kV_{rms} per 60 s, which can be guaranteed by 100% final product test [1]. The TO-247-3 Advanced Isolation reveals a low coupling capacitance over the whole lifespan, accompanied by lowest leakage current and partial discharge level. The long term package material stability is excellent within the junction operating temperature range covering -40°C < T_{VJ} < +175°C.

Figure 1 Top side and bottom side of the TO-247 TRENCHSTOP™ Advanced Isolation package.

The TRENCHSTOP™ Advanced Isolation in TO-247-3 is available in the two versions: the *price/performance* and *best-in-class*.

The *price/performance* version is a suitable replacement for FullPAKs or TO-247-3 isolated by an average performance insulator film. This refers to a standard polyimide based reinforced carrier insulator film with 152 µm thickness and a thermal conductivity of 0.9 W/(mK).

The *best-in-class* version is a replacement for TO-247-3 isolated by a high performance insulator, like a polyimide based reinforced carrier insulator film with 152 µm thickness and a thermal conductivity of 1.3 W/(mK).

Product Description

The Advanced Isolation package is identified within Infineon's IGBT and Diode nomenclature by the letter "F" at the third position. The *price/performance* version is identified with the letter "E" at the last position. These are indicated in Figure 2 for an IGBT.

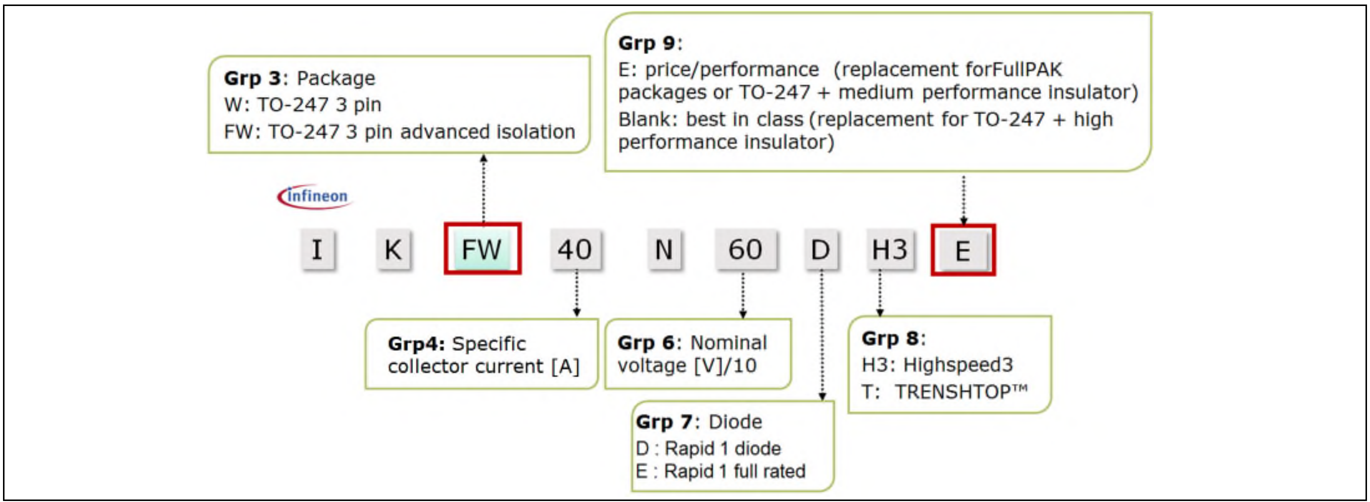


Figure 2 Infineon's TO-247-3 Advanced Isolation package, discrete IGBTs nomenclature

Figure 3 displays the nomenclature for the diode with Advanced Isolation.

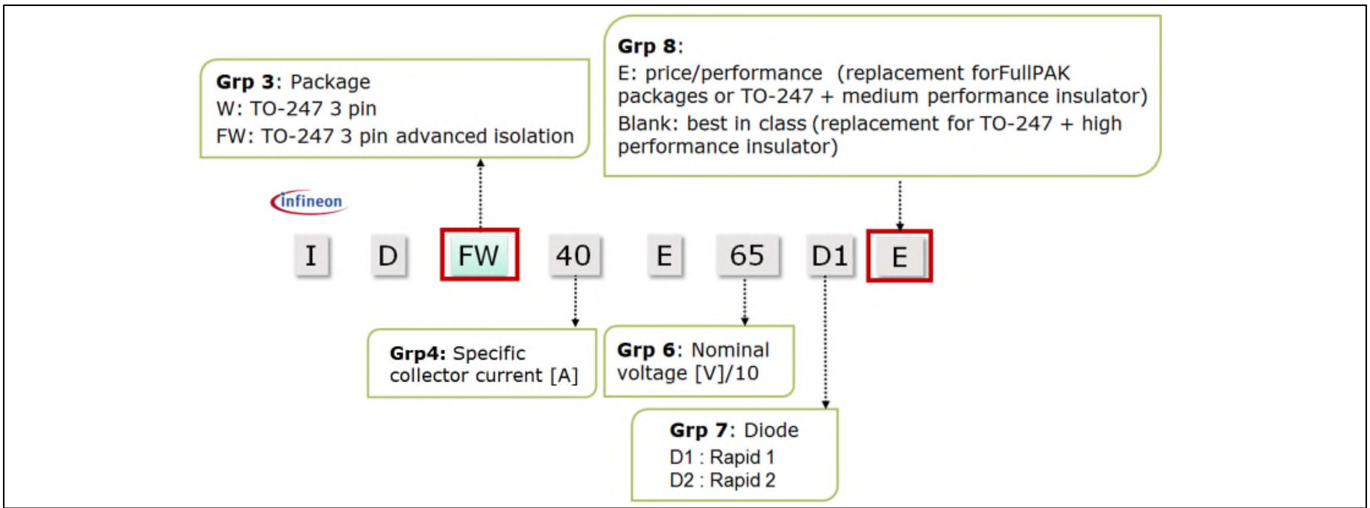
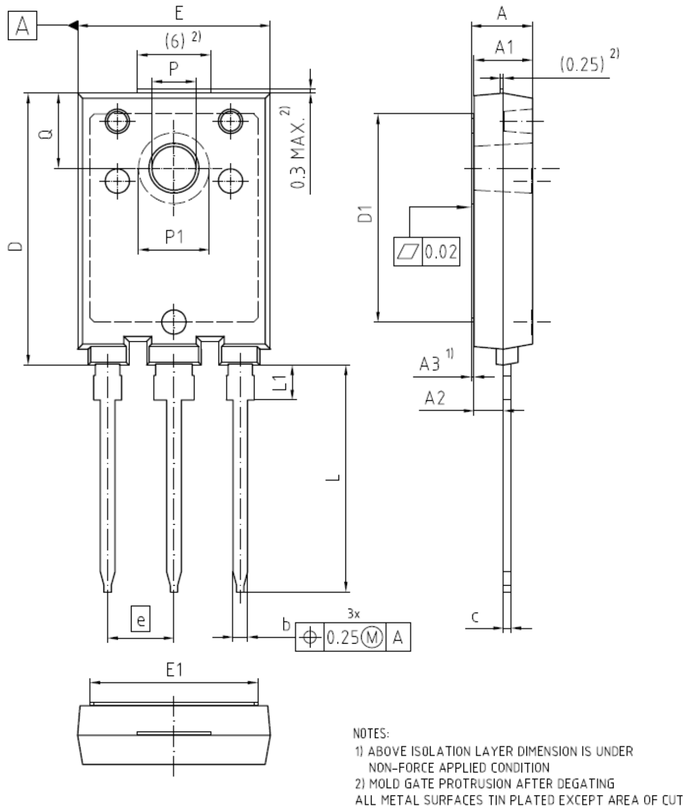


Figure 3 Infineon's TO-247-3 Advanced Isolation package, discrete diodes nomenclature

1.1 Mechanical details and main differences between TO-247-3 Advanced Isolation and TO-247-3 package

The newly introduced TO-247-3 Advanced Isolation is in form and fit similar to the transistor outline 247-3 described in the JEDEC standard. General mechanical dimensions and mechanical drawings are displayed in Figure 4. For a more detailed mechanical description, please refer to the product data sheet.



DIMENSIONS	MILLIMETERS	
	MIN.	MAX.
A	-	5.18
A1	4.70	4.90
A2	2.23	2.59
A3	0.20	0.28
b	1.10	1.30
c	0.50	0.70
D	22.20	22.40
D1	16.96	17.16
E	10.70	10.90
E1	13.68	13.88
e	5.44	
L	18.31	18.91
L1	2.76	2.96
øP	3.50	3.70
øP1	5.70	5.90
Q	5.96	6.36

Figure 4 TO-247-3 Advanced Isolation mechanical drawing and dimensions

This package has been designed with the intention to be compatible to the TO-247-3 in form and fit. Additional details can be found in Infineon's Application Note AN2012-10 "Electrical safety and isolation in high voltage discrete component - application and design hints" [2].

An important difference to be mentioned is represented by the newly introduced design of the TO-247-3 Advanced Isolation marked in Figure 5 with the red circles “1”. These plastic covers which surround the terminals increase the creepage distance between the terminals to 5.33 mm which is important in applications where a minimum creepage distance of 5.1 mm is required.

Another important difference is the missing lateral mold clamping areas, necessary for a correct mold compound deposition. These are emphasized in the Figure 5 with the red circles “2”. This is necessary to prevent a reduction of the creepage paths between device’s collector and heatsink as well as between screw or metal clip and the heatsink. These details are also explained in [2]. Comparing the TO-247-3 Advanced Isolation to the standard TO-247-3, the clearance distance from leads to heatsink is now increased up to 2.65mm.

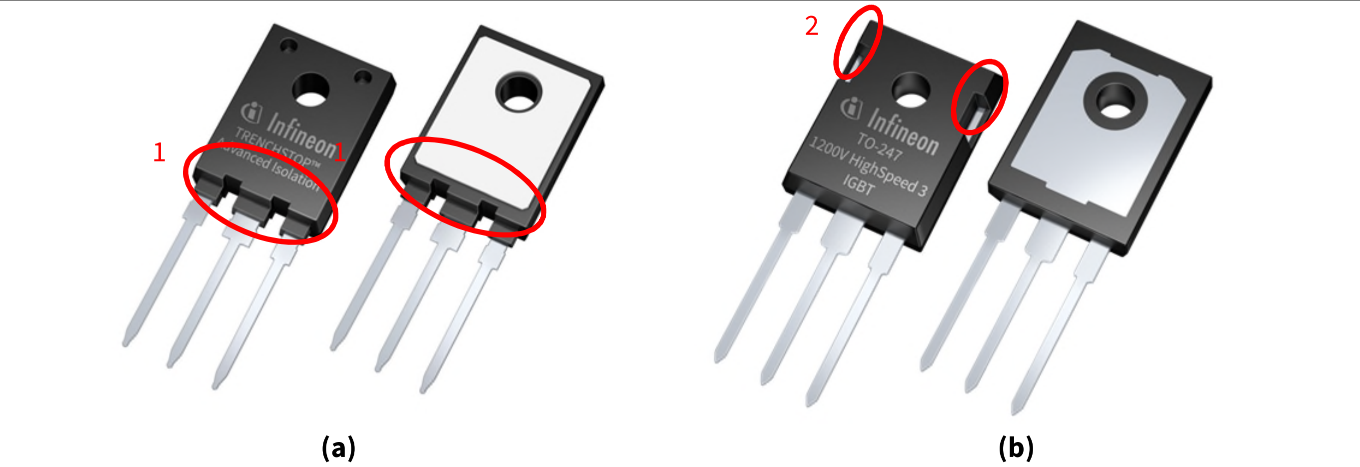


Figure 5 **Main differences between (a) TO-247-3 Advanced Isolation and (b) JEDEC TO standard 247-3**

1.2 Thermal and chemical properties

Further important thermal and chemical properties include:

The Comparative Tracking Index (CTI) of the molded body of the TO-247-3 Advanced Isolation package, as described in [2], is 400 V ≤ CTI < 600 V, material group 2.

Compressibility and elasticity of the Advanced Isolation is at 8% of the total thickness of the isolation layer. Moreover, the isolation layer is over 96% elastic.

Outgassing test results revealed no special risk of equipment contaminations introduced by processing the TO-247-3 Advanced Isolation package.

Moisture absorption. After baking the TO-247-3 Advanced Isolation material at +125°C for 24 h, the maximum packaging capturing moisture absorption of the isolation layer on a 50 mm× 60 mm sample size, at 85°C and RH=85%, resulted around 180 ppm as reported in Figure 6.

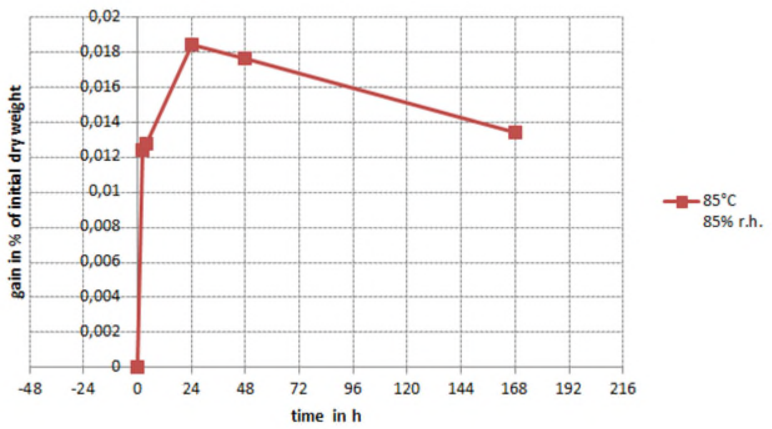


Figure 6 **Weight gain chart: moisture absorption of a 50 mm× 60 mm sample.**

Scratch Resistivity measurements were performed on TO-247-3 Advance Isolation devices. Test results showed a linear degradation of the dielectric strength of the isolation layer when a specified force was applied with a standardized pin, according to the chart in Figure 7.
The test was performed according to IEC60335-1 edition 4.1, though the insulation layer in this case is not considered as a directly accessible part (IEC60335-1-21.2). Indeed, it is important to remember that the insulation layer of the TO-247-3 Advanced Isolation package is not intended to be used as a last insulation barrier and the device must not to be used without assembly on proper heatsink as detailed in paragraph 3.

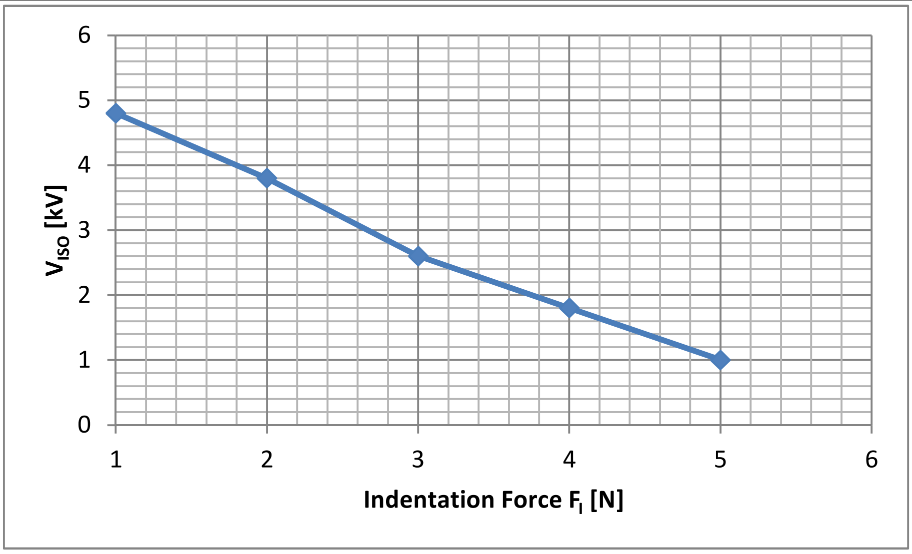


Figure 7 **Scratch Resistivity Chart**

1.3 Thermal and electrical performance

To assess the higher performance of packages featuring Advanced Isolation, thermal resistance measurements and electrical tests have been performed on complete power systems. Tests regarding capacitive coupling to the application's heatsink have also been carried out and evaluated.

Thermal properties

To validate the thermal properties of a TO-247-3 Advanced Isolation package, an IGBT chip was first assembled into a standard TO-247 with a thermal interface material (TIM) sheet and then compared to the same IGBT chip when assembled inside Infineon's TO-247-3 Advanced Isolation package. Tests were performed at different mounting pressures, as displayed in Figure 8. The TIM sheet is a standard polyimide based reinforced carrier insulator with 152 µm thickness and a thermal conductivity of 1.1 W/(mK).

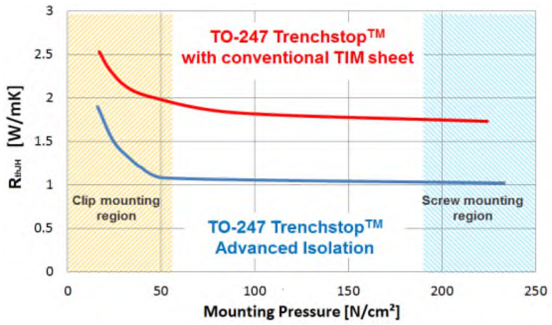


Figure 8 R_{thJH} **vs. mounting pressure for TO-247 Advanced Isolation and TO-247-3 with conventional TIM sheet.**

Both solutions exhibit a decreased R_{thJH} at increased pressure. Between 15 N/cm² and 50 N/cm² which are typical clip mounting pressures a drop of approximately 20% for conventional TIM sheets and 40% for the TO-247 Advanced Isolation was observed. The typical pressure applied by screwing the device is p_m > 180 N/cm². Here the Advanced Isolation device shows a 40% lower R_{thJH} compared to a conventional TIM sheet. The reason for the improved thermal performance is the novel package concept, almost eliminating the contact resistance $R_{th,C\text{-}TIM}$ between package die pad and isolation compared to conventional TIM sheets, as detailed in Figure 9. Both contact resistances case-TIM and TIM-heatsink become more relevant with improved thermal conductivity of the bulk material. While the bulk material's thermal resistance $R_{th,bulk}$ is mainly defined by its thermal conductivity, the contact resistance is not well defined.

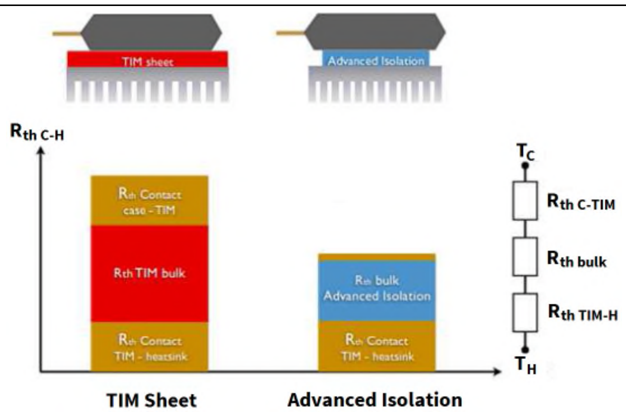


Figure 9 **Thermal resistance case-heatsink** R_{thCH} **contribution for the TIM sheet and the Advanced Isolation package concept.**

Thermal measurements and comparison between TO-247-3 Advanced Isolation and TO-247-3 with TIM-sheets

The performance of a best-in-class IGBT rated 50 A is compared to a IKW50N60H3 having the same die size, with an isolation foil between the lead-frame and the heatsink. The configuration within the test is a half-bridge AC output converter. The isolation foils used are commercially available polyimide based reinforced carrier insulators with 152 µm thickness and 1.3 W/(mK) thermal conductivity. These foils are considered higher grade isolation material. The half-bridge AC output converter operates at a maximum of 2200 W. The same gate resistor value is maintained for all tests which were chosen to limit the IGBT's overvoltage peak safely below 600 V [4]. With identical mounting force applied to the devices under test (DUT), the same heatsink size is used for the best-in-class version and the IKW50N60H3 with an isolation foil. Figure 10 shows that the case temperature is at par with the best-in-class version measured up to 2200 W compared to the IKW50N60H3 with a higher grade isolation material.

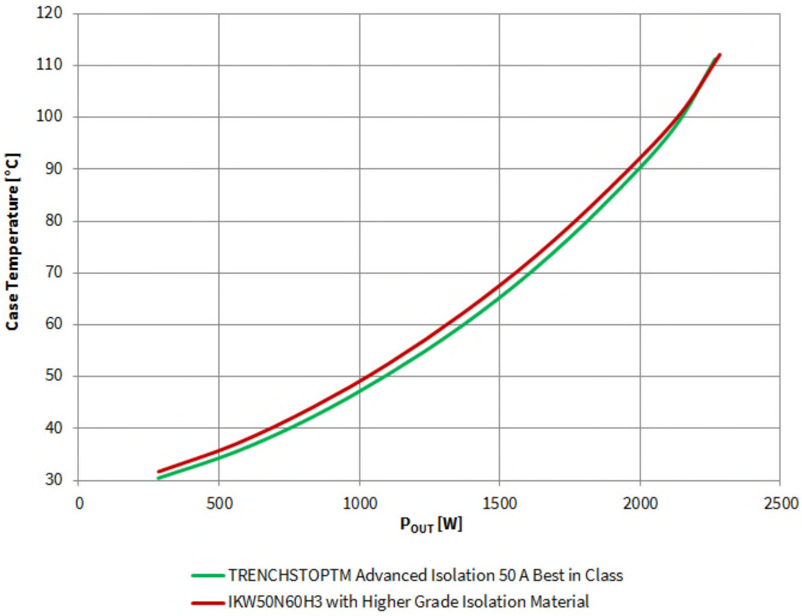


Figure 10 Thermal measurements between the best in class version vs. a TO-247 HighSpeed 3 with a higher grade isolation material in a half-bridge AC output converter.

Thermal measurements and comparison between TO-247-3 Advanced Isolation and TO-247-3 FullPAK

One of the major advantages of the *price/performance* version is the significant improvement of the thermal resistance R_{thJH} compared to a standard molded FullPAK available today. By means of thermal tests on a power factor correction (PFC) board, the thermal performance of a 40 A rated IGBT *price/performance* TO-247-3 Advanced Isolation version is compared to a same size 40 A IGBT in TO-247-3 FullPAK. The PFC test board operates at 22 kHz switching frequency with 230 V_{ac} input and 400 V_{dc} output. The same gate resistor value is maintained during all tests, chosen to limit the IGBT's overvoltage peak safely below the rated collector-emitter breakdown voltage. With identical mounting force applied to the DUT, the same heatsink size is used for the *price/performance* version and the FullPAK. Figure 11 displays the thermal measurements at 2500 W output power showing that the FullPAK case temperature is higher compared to the *price/performance* version by 11°C.

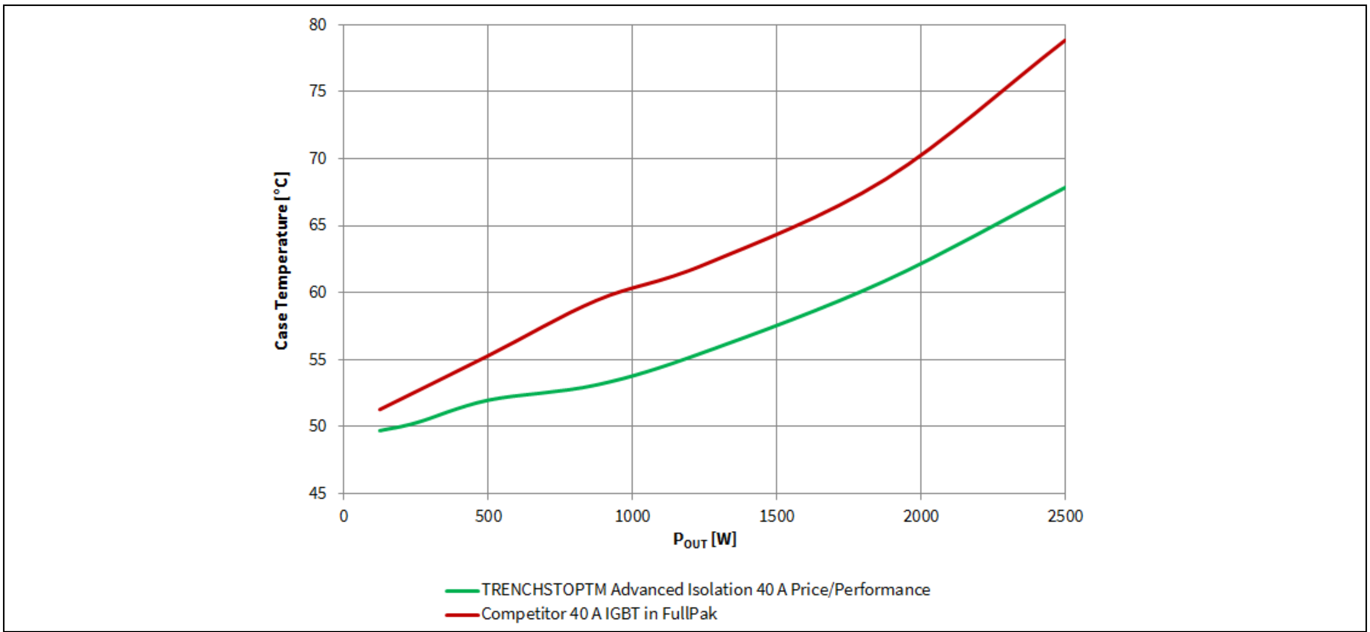


Figure 11 Thermal measurements between the TO-247-3 Advanced isolation *price/performance* version vs. a TO-247-3 FullPAK in a PFC for air conditioning.

Coupling Capacitance

High voltage power devices, operating at very high switching frequency and high voltage slopes, face the problem of power losses and radiated EMI due to capacitive coupling between the package die pad and the application's heatsink [6]. During every switching event a displacement current to the application's heatsink occurs as described by equation (1.3.1):

$$i = C_C \frac{dv}{dt} \qquad (1.3.1)$$

wherein this equation, the capacity can be calculated acc. to the correlation (1.3.2),

$$C_C = \varepsilon_o \varepsilon_r \frac{A}{d} \qquad (1.3.2)$$

The major parameters for capacitive coupling are the package die pad area A, the insulator layer's thickness d and the relative dielectric value ε_r. Package die pad area reduction and isolation thickness increase would improve the capacitive coupling, but at the cost of lower thermal performance. In contrast, a lower value in ε_r also improves the capacitive coupling but without impact on thermal performance. On the topic of radiated EMI, decreasing capacitive coupling would lead to a reduction of common mode noise current and capacitive displacement current.

Table 1 lists the coupling capacitance of the Advanced Isolation and state of the art TIM materials.

Table 1 Coupling capacitance of Advanced Isolation material and state of the art isolation foils.

Area = 177 mm^2	ε_r	Thickness [µm]	Coupling Capacitance [pF]
Advanced Isolation	6	230	38
TIM sheet	5	150	51
Al2O3 sheet	9	250	56
MICA sheet	6.5	50	209

Radiated EMI caused by very fast switching of the collector-emitter voltage of an IGBT mounted to a non-grounded heatsink decreases if the parasitic capacitance between the package die pad and the heatsink is minimized. Grounding the heatsink would also lead to an increase in common mode conducted EMI [3]. Decreasing the parasitic capacitance would lead to a reduction of EMI in a system by the relationships (1.3.1) and (1.3.2).

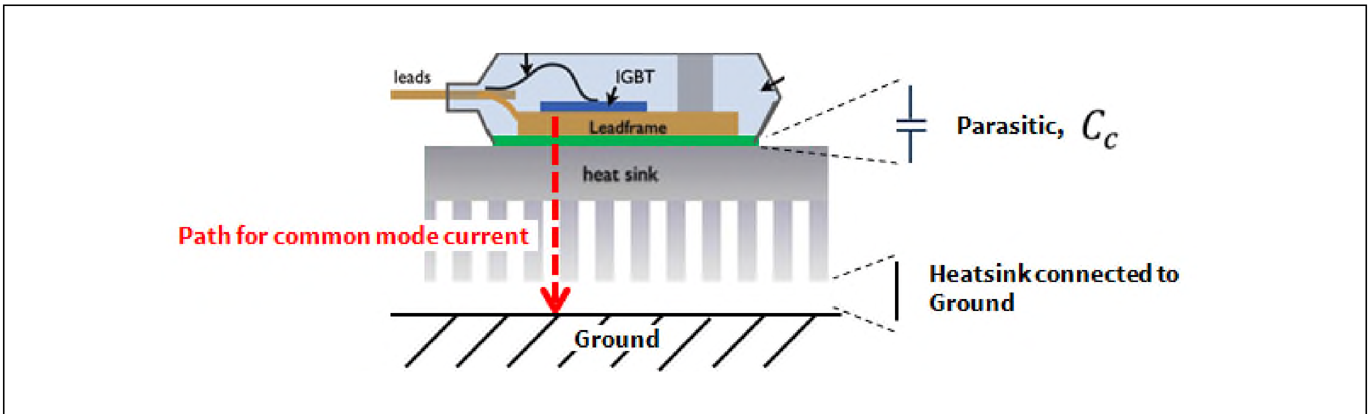


Figure 12 Common mode current path from IGBT die to system heatsink.

1.4 Description of the equivalent current

This section explains the definition of the equivalent current rating present at page 3 of an Advanced Isolation product's data sheet. Please refer to Figure 13 as an example.

DC collector current, limited by T_{vjmax}			
T_h = 25°C	I_C	34.0	A
T_h = 65°C		28.0	
T_h = 65°C		44.0[1)]	

Figure 13 Extract of maximum ratings table of Advanced Isolation product datasheet

The equivalent current represents the nominal current of a non-isolated TO247-3 product assembled with an isolation film achieving the same performance as in the Advanced Isolation package.

The reference insulation film for the *price/performance* devices is an average performance polyimide based reinforced carrier insulator with a thermal conductivity of 0.9 W/(mK) and a total thickness of 152µm, which is commonly used in Major Home Appliance applications.

The reference insulation film for the *best-in-class* devices is a high performance polyimide based reinforced carrier insulator film with 152 µm thickness and a thermal conductivity of 1.3 W/(mK), which is more commonly used in industrial applications.

The two charts in Figure 14a, Figure 14b and the related equation (1.4.1) provides the analytic description of the equivalent current definition given in the Advanced Isolation products' data sheets.

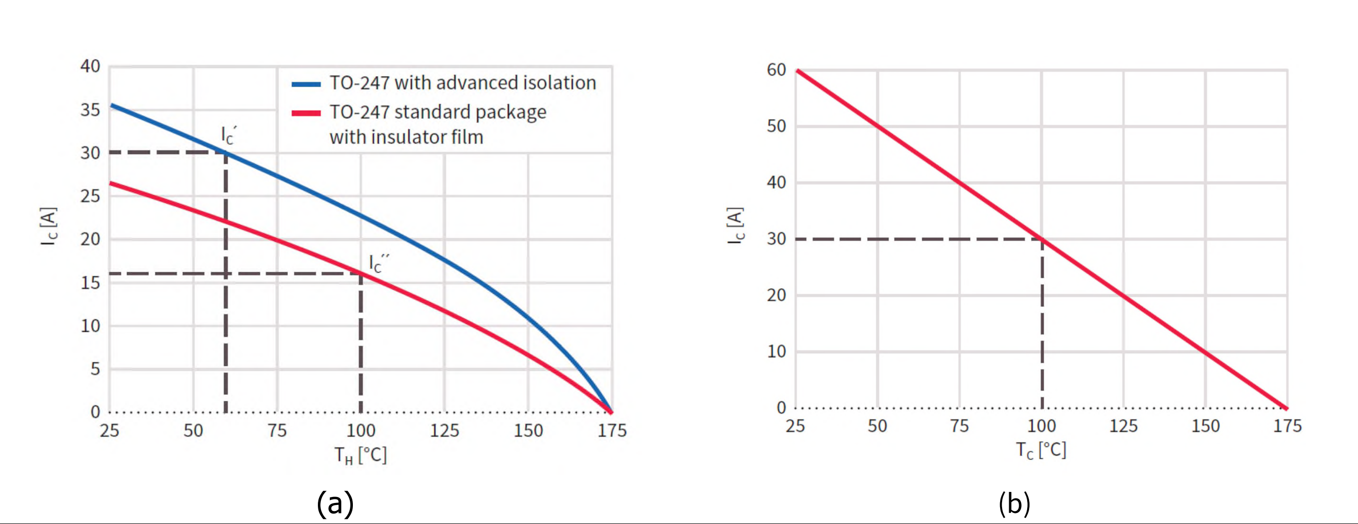


Figure 14 (a) Collector current as a function of the heatsink temperature of the IKFW40N60DH3E (blue solid line) and of a 30A HighSpeed 3 IGBT assembled in standard TO-247-3 using a reference insulation film (red solid line), $V_{GE} \geq 15V$, $T_{vj} \leq 175°C$. (b) Collector current of a 30A HighSpeed 3 IGBT assembled in standard TO-247-3 as a function of the case temperature.

The equivalent current rating (I_{Ceq}) of the IKFW40N60DH3E can be calculated using the formula (1.4.1) and the charts in Figure 14.a and Figure 14.b. The equivalent current of this advanced isolation device is calculated in comparison to the same HighSpeed 3 IGBT chip in a standard TO-247-3 package at T_H = 65°C, using the reference insulation film for the *price/performance* device mentioned above in this chapter.

$$I_{Ceq} = \left(1 + \frac{I_C' - I_C''}{I_C'}\right) \cdot I_{C100} = \left(1 + \frac{28.9 - 15.6}{28.9}\right) \cdot 30 = 44A \quad (1.4.1)$$

In (1.4.1) the I_{C100} is the nominal chip current of the HighSpeed 3 IGBT chip at 100°C case temperature as defined by the chart in Fig. 13.b. I_C' and I_C'' are the collector currents respectively of the IKFW40N60DH3E at T_H=65°C and of the same chip assembled into a TO-247-3 mounted on the heatsink at T_H=100°C with the reference insulation film.

2 Package long term performance and reliability

Table 2 summarizes the package reliability qualification tests which have been performed according to JEDEC Standard JESD22. The tests are extended to application board conditions which reflect the operation within the system. These tests include passive temperature cycling and the high temperature and high humidity storage with applied voltage of 1.4 kV between package die pad and application heatsink. The TRENCHSTOP™ TO-247-3 Advanced Isolation package shows outstanding long term stability. The mechanical and electrical properties remain unchanged even at applied overvoltage up to V = 1.4 kV between package and application heatsink in combination with moisture storage and temperature cycles.

Table 2 TRENCHSTOP™ TO-247-3 Advanced Isolation package reliability results.

Reliability Test	Conditions	Criteria	Result
Temperature Cycling	T = -55°C … +150°C	1500 cycles	Pass
Auto Clave	Ta = 121°C r.h. = 100% p = 100 kPa	196 h	Pass
Temperature Cycling on Application Heatsink	T = -55°C … +150°C Torque = 0.2 … 2.0 Nm	2000 cycles	Pass
High Temperature Storage	T = +175°C	1000 h	Pass
Low Temperature Storage	T = –55°C	1000 h	Pass
Power Cycling	ΔT_J = 100 K $I_{CE} \approx 50\% \, I_{CE\,max}$	30000 cycles	Pass
High temperature and humidity storage with DC voltage applied between package die pad and application heatsink	T = 85°C r.h. = 85% V = 1.4 kV	2000 h	Pass

2.1 Further product specific reliability tests: acidic environments and salt spray tests.

The TO-247-3 Advanced Isolation package passed the environmental testing for mixed gas corrosive atmosphere according to IEC60068-2-60: 2015-06; furthermore, it has also passed the tests related to connectors' insulation resistance at high voltage, according to IEC 60512-4-1: 2003-05 as reported in Table 3:

Table 3 Test Specification

Test	Parameter/Gas	Test Severity	Reference	Method
Voltage Proof	Voltage Duration	3000 V_{rms} per 1 s	Based on IEC 60512-4-1	4a: Insulation resistance
Flowing Mixed Gas	H_2S, 100ppb; NO_2, 200ppb; Cl_2, 20ppb.	Temperature:30°C, r.h.: 75%, duration: 10 days	IEC 60068-2-60	"Ke" Method 3: Flowing mixed gas.

2.2 High temperature high humidity isolation stress test

TO-247-3 Advanced isolation package passed the High Temperature, High Humidity Isolation Stress Test (H3TIT) under test conditions and test criteria indicated in this chapter.

Test conditions: heatsink to ground voltage: 1400 V, terminals shorted and connected to ground at 0 V, relative humidity R.H. = 85% and Temperature 85°C. Test criteria: electrical readout of the die after 0 h, 1000 h and 2000 h. Isolation test performed at 3.8 kV with no failures.

2.3 Screw mounting torque analysis

In order to simulate potential assembly situations in the field, a torque analysis test has been performed on 10 devices, divided in 5 groups. Each group is assembled onto a heatsink at different torques.

More specifically: Group 1 at 0.2 Nm, Group 2 at 0.6 Nm, Group 3 at 1 Nm, Group 4 at 1.4 Nm and Group 5 at 2 Nm and at different screwing positions, for a total of 50 tests, as shown in Figure 15.

No.	176	177	178
initial [Nm]	2,0	2,0	2,0
after TC 1000x[Nm]	0,8	0,8	0,6

after TC-Stress torque is reduced by 65%

Figure 15 DUT during screw mounting torque analysis

After mechanical assembly, and exposure to standard thermal cycles, the torque and dielectric strength of the isolation layer was measured at 3 kV_{rms} per 60 s and afterwards at 4 kV_{rms} per 60 s with no failure reported.

2.4 Mechanical Tests

Sine sweep vibration test and mechanical shock test have been positively performed on TO-247-3 Advanced isolation product, according to the test conditions and test criteria detailed at 2.4.1 and 2.4.2.

Mechanical shock test

Mechanical shock test has been performed with positive results on 10 out of 10 devices, according to IEC 60068-2-27 standard complying with the criteria:

Peak acceleration: 30 g

Shape: Half Sine

Pulse duration: 18 ms

3 shocks in each of the 6 directions

Shock pulses launched manually randomly after all transient effects from the previous pulse were settled.

DUT assembled on properly prepared heatsink with M3 screws at 0.6 Nm.

Sine sweep vibration test

Sine sweep vibration test is done according to IEC 60068-2-6 standard with positive results on 10 out of 10 devices, complying with the listed criteria, number of sweep cycles and endurance times:

Amplitude:	5 g
Frequency range:	10 – 500 Hz
Axis:	X, Y and Z axis, 3 axis
Sweep duration:	15 min, from 10 to 500 Hz
Sweep cycle duration:	30 min, from 10 to 500 to 10 Hz
Sweep cycles per axis:	4
Total duration per axis:	2 h
Total duration of the test:	6 h

DUT assembled on properly prepared heatsink with M3 screws at 0.6 Nm.

2.5 Partial discharge

TO-247-3 Advanced Isolation package was exposed to standardized voltage cycles to get the partial discharge levels of the isolation layer. The test has been performed with V_0 = 975 V and V_1 = 715 V. Devices under test, after the last readout, showed results well below 40 pC, with no isolation failure reported.

3 Assembly of TO-247-3 Advanced Isolation Package

TO-247-3 Advanced isolation can be assembled directly onto the application's heatsink either using a clip or a screw. In both cases, it is strongly recommended not to exceed the maximum clip force allowed or screwing torque specified in the data sheet.

The isolation layer of the TO-247-3 Advanced Isolation device must be handled with proper care. It must not be exposed to any mechanical impacts/shocks which exceed levels indicated in the relevant International Standards JEDEC JESD22-B110B, IEC60068-2-6 and IEC60068-2-27 as described at paragraph 2.4. TO-247-3 Advanced Isolation is intended to be assembled onto proper heatsinks, which must be mechanically prepared and machined as indicated in this chapter. The insulation layer of the TO-247-3 Advanced Isolation is not intended to be used as a last insulation barrier and the device must not to be used without being previously assembled on a proper heatsink. Furthermore, in order to avoid degradation of the dielectric strength, as described at paragraph 1.2.5, the insulation layer on the back side of the TO-247-3 Advanced Isolation must not be exposed to direct mechanical impacts. Therefore, it is strongly recommended to avoid improper use of the clamping systems, vibration tools, fixing elements for assembly or terminal bending, which may lead to scratches, cuts or damages of any kind to the insulation layer.

In case the device is correctly assembled and the heatsink is accurately prepared according to the specifications indicated in this chapter, the TO-247-3 Advanced Isolation doesn't need any external additional Thermal Interface Material. This can dramatically simplify the assembly of the device when compared to other isolated discrete devices, like FullPAKs and IsoPACK™, or when compared to TO-247-3 with external isolation foil.

One of the most important details to be carefully checked and verified when using TO-247-3 Advanced isolation, is the heatsink type and quality in order to provide the best thermal transfer between the copper tab of the component and the heatsink via the Advanced Isolation layer.

Several variables, like surface roughness, surface flatness, surface cleanliness, paint finishes and intermediate materials may affect the heat transfer. The mechanical specifications for the heatsink to reduce the impact of the mentioned variables as much as possible include:

- Roughness: $R_Z \sim 10$ µm
- Flatness: $F_Z < 20$ µm per 100 mm
- Machining without overlaps, steps or indentations
- Assembling area clean and free from dust, particles, grease, oil and other pollutants

When applying pressure to the top of the component, the thermal contact can be significantly improved. The higher the pressure, and therefore the contact force, the lower the thermal resistance. This dependency is not linear and has been shown at chapter 1.3.1; it includes a quick drop at rather low pressure values, replaced by a more gradual reduction with increased pressure.

3.1 Assembly with Clips and Screw

The thermal resistance between junction and heatsink can be dramatically improved by increasing the contact pressure between the package and the related heatsink. Increasing the mounting torque in the fastening screw, or using a clip with a high value of the spring constant, will result in better thermal connection between heatsink and isolation layer which eliminates air gaps between these two surfaces, which in turns, will result in a strong reduction of the R_{thJH} accordingly. Applying the proper mounting torque is the key factor in obtaining an adequate contact pressure along the contact surface of the package and the heatsink to minimize the thermal contact resistance. A recommended mounting pressure, as shown in Figure 16, is between 60N/cm^2 and 180N/cm^2. Mounting pressure beyond 180 N/cm^2 does not directly result in lower thermal resistance junction to heatsink R_{thJH} values, but could, in a worst case, cause package damage.

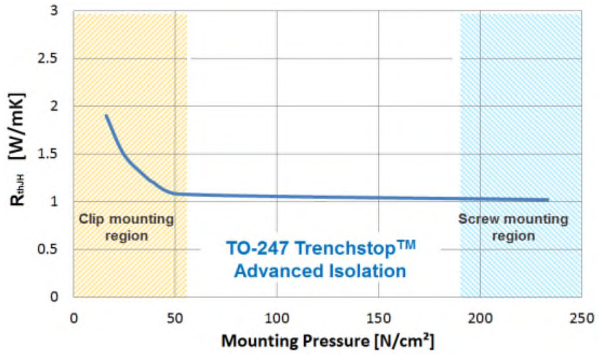


Figure 16 Effect of mounting pressure on the thermal resistance R_{thJH} of a TO-247-3 Advanced isolation.

3.2 Lead bending

To fulfill the increasing demand for higher power density, an alternative method for lead bending as described in [2] is presented in this chapter. If the bending takes place close to the package's molded body, it might happen that the mechanical stress damages the device so that the connection between lead frame and mold compound is no longer sufficient to protect the die against humidity for instance. Furthermore, especially for the TO-247-3 Advanced Isolation package, it is strongly recommended to follow the procedure for lead bending described in this chapter in order to avoid damages at the isolation layer of the package. As described in chapter 3, handling the TO-247-3 Advanced Isolation package could cause scratches or other mechanical damages which may affect the device's integrity and the related dielectric strength.

Thus, the alternative solution is based on two tools to bend the device as can be seen in Figure 17. The first tool is a fixing tool which has the purpose to reduce the stress to the device to prevent damage. The second tool bends the leads. Areas where it is allowed and areas where it is not allowed to apply mechanical clamping are indicated in Figure 16 accordingly.

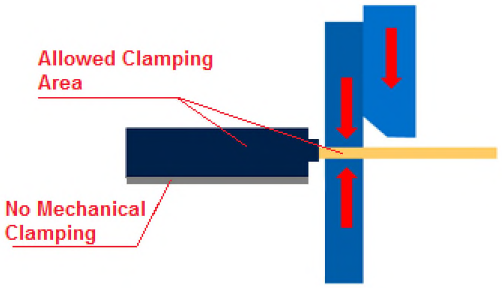


Figure 17 Schematical overview - Fixing- and bending tool.

After the leads or the lateral side of the plastic body are fixed, the final bending of the leads takes place in a second step which can be seen in Figure 18. The figure also indicates the critical areas where no mechanical stress must be applied.

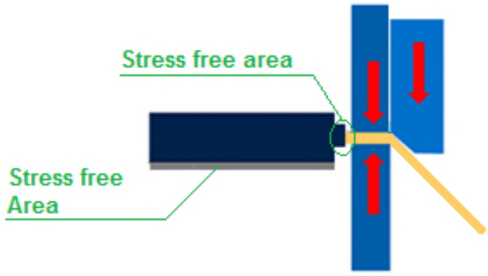


Figure 18 Bending after the leads were fixed. Stress free areas.

Revision History

Major changes since the last revision

Page or Reference	Description of change

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